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Book

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ARCOM Construction Management Abstracts

Cumulative Abstracts and Indexes of Journals in Construction Management 1983–2000

Compiled by Will Hughes

Association of Researchers in Construction Management (ARCOM)

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Dr Will Hughes
Dept Construction Management & Engineering
University of Reading, PO Box 219
Reading, RG6 6AW, UK

Introduction

The purpose of this document is to provide a single source of reference for every paper published in the journals directly related to research in Construction Management.

It is indexed by author and keyword and contains the titles, authors, abstracts and keywords of every article from the following journals:

- Building Research and Information (BRI)
- Construction Management and Economics (CME)
- Engineering, Construction and Architectural Management (ECAM)
- Journal of Construction Procurement (JCP)
- Journal of Construction Research (JCR)
- Journal of Financial Management in Property and Construction (JFM)
- RICS Research Papers (RICS)

The index entries give short forms of the bibliographical citations, rather than page numbers, to enable annual updates to the abstracts. Each annual update will carry cumulative indexes, so that only one index needs to be consulted.

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Building Research and Information

ISSN 0961–3218

This journal was commissioned by E & F N Spon in 1973 as the official journal of CIB, under the editorship of Anthony Kirk. In its early years it contained reports from national research laboratories and technical notes. In 1996 the editorship transferred to Richard Lorch, and by this time the journal had ceased to be the CIB's official journal. Moreover, it had grown into an international refereed journal. The transfer of editorship offers a useful point in time at which to begin these abstracts.

This journal is supported by the Conseil International du Batiment (CIB).

Editor's address:
Richard Lorch, 43 Saint George's Avenue, London, N7 0AJ, UK

Publishers' address:
E & F N Spon, 11 New Fetter Lane, London, EC4P 4EE, UK
Tel +44 (0)20 7842 2403; Fax +44 (0)20 7842 2131
E-mail: journals@tandf.co.uk

BRI: Volume 24, 1996

1996, **24**(1), 5–13

The impact of R-2000 building technology on Canadian housing

Friedman, A and Cammalleri, V
School of Architecture, Macdonald-Harrington Building, McGill University, 815 Sherbrooke Street West, Montreal, Quebec, H3A 2K6, Canada

Various methods of improving the energy efficiency of foundations, walls and roofs are examined including wall assemblies that can reduce conductive heat loss (from 25% to 65%), air leakage, thermal bridging and sound transmission. The advantages of a narrow-fronted terrace house with relatively small-exposed wall area are outlined.
Keywords: Canada, energy efficiency, heat flow, housing, insulation.

1996, **24**(1), 15–26

Measured heat losses through a real ground floor slab

Thomas, H R; Rees, S W and Lloyd, R M
Cardiff School of Engineering, Queen's Buildings, University of Wales, PO Box 917, Cardiff, CF2 1XH, UK

The measured variations of heat losses across the floor slab emphasize the potential benefits to be gained from the use of edge insulation. In general, thermal transmittance values calculated from the measured data are found to be in reasonable agreement with values determined from design guides.
Keywords: ground floor slab, heat loss, insulation.

1996, **24**(1), 27–30

Factors affecting construction practices in Makkah Al-Mukkaramah, Saudi Arabia

Assaf, S A[1] and Barhamain, S Y[2]
[1]*Construction Engineering & Management Department, King Fahd University of Petroleum and Minerals, Box 680, Dhahran 31261, Saudi Arabia*
[2]*Hajj Research Centre, Makkah Al-Mukkaramah, Saudi Arabia*

Each year the Hajj attracts over one million pilgrims to Makkah with all the enormous administrative, social and economic implications this signifies. The authors conclude that there are unique factors affecting construction practice in Makkah and it is apparent that early action is always needed to correct aspects of construction; less costly overruns are an inevitable consequence.
Keywords: construction practice, Holy City of Makkah, Saudi Arabia.

1996, **24**(1), 31–34

Materials control and waste on building sites

Enshassi, A
Chairman of the Civil Engineering Department, Islamic University of Gaza, Gaza Strip, Israel

The author argues that although waste occurs from many causes, it is sometimes beyond the influence of the building firm and that material control starts at design stage, as the final design should allow for the effective handling and convenient manoeuvring of materials and components of preferred sizes during construction.
Keywords: briefing, client, design, material control, scheduling, waste.

1996, **24**(1), 35–40

Observations on the use of ground waste clay brick as a cement replacement material

Wild, S
Centre for Research in the Built Environment, University of Glamorgan, Pontypridd, Mid Glamorgan, CF37 1DL, UK

The project is funded by the European Copernicus programme and involves the recycling of waste clay brick and tile material for the partial replacement of cement in mortar and concrete. The paper reports on the preliminary investigation of the effect on the strength development of concrete of partially replacing the cement with ground 'Fletton' brick and establishes that this brick does exhibit pozzolanic activity and does make a contribution to the strength development of concrete.
Keywords: Fletton brick, hydraulic index, lower Oxford clay, pozzolans.

1996, **24**(1), 41–49

Use of microsilica in concrete construction

Bubshait, A A; Tahir, B M and Jannadi, M O
College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

The advantages of using microsilica can be considerable as it reduces thermal cracking caused by the heat of cement hydration and can improve durability to attack by sulphate and acidic waters. The advantages and applications are reviewed and a number of test core illustrations are included.
Keywords: concrete, microsilica, silica fume concrete, Saudi Arabia.

1996, **24**(1), 51–58

Potential for expert systems in the assessment and repair of fire damaged buildings in India

Sarkar, A; Godbole, P N and Chakrabarti, S C
Department of Civil Engineering, University of Roorkee, Roorkee, UP, India
Research Institute, Central Building, Roorkee, UP, India

Assessment of structural damage due to fire in buildings can be a complex process plagued by uncertainty. This complexity, argue the authors, arises from subjective opinion and imprecise numerical data. Expert system technology offers significant potential for a systematic assessment and repair of fire damaged buildings through the use of expert knowledge.
Keywords: expert system, fire damage, India.

1996, **24**(1), 59–62

Professional architectural/engineering consultancy practices in Saudi Arabia

Assaf, S A; Al-Musallami, A I and Shash, A A
King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia.
King Faisal University, Damman, Saudi Arabia

The local architectural engineering firm in Saudi Arabia is handling projects up to 175m SR a year on average. It will have been in practice 13 years, employing 91 people, most holding a B.Sc. Degree. Practices are mainly selected by competitive bidding and paid under a fixed fee arrangement. The authors found that the public authorities are the major employers of local A/E design services.
Keywords: architect selection, engineer selection, consultant, project management, Saudi Arabia.

1996, **24**(2), 69–74

The introduction of the architectural scheme of York Gate (1825, Regent's Park, London) in Moscow at the beginning of the 19th century

Ruchinskaya, T
6 The Green, Willingham, Cambridge, CB4 5JA, UK

After 1812 and the end of the war with Napoleon, Moscow was rebuilt. The great fire of that year accelerated the changes and a new national enthusiasm was reflected in town planning and architecture. The author captures this spirit and introduces to western readers some of the archives of the state, previously unknown.
Keywords: architecture, history, Moscow, York Gate.

1996, **24**(2), 75–80

The contribution of the Scottish architect Adam Menelaws to Moscow architecture in the early 19th century

Ruchinskaya, T
6 The Green, Willingham, Cambridge CB4 5JA, UK

Moscow's classical architecture of this period was due to the influence of a number of architects, Bajenov and Kazakov of Russia; Bove of France; Dgiliardi of Switzerland and the two Scots, William Hastie and Adam Menelaws. This paper details Menelaws' work and draws on references in the state archives when the author was living and researching in Moscow.
Keywords: architecture, history, Moscow.

1996, **24**(2), 86–96

Future horizons in building environmental engineering

Clements-Croome, T D J
Department of Construction Management and Engineering, University of Reading, Whitenights, PO Box 219, Reading, RG6 6AW, UK

The paper brings together many current themes of interest and stimulates the reader to be aware that in creative work there has to be something beyond technical competence; there has to be a committed energy, desire and love in the work being created. The author confirms that buildings modify climate; they influence behaviour and culture; they affect the distribution of resources and the ecological pattern of our planet, whilst human aspirations can only be met when climate, buildings and people are in balance.
Keywords: environmental engineering, built environment, case study, future, low energy.

1996, **24**(2), 97–103

The greenhouse effect: impact upon and the role to be played by construction

Edwards, D J; Harris, P T and Holt, G D
School of Construction, Engineering & Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

The authors highlight several possible ways in which the construction industry could lower present emissions of the greenhouse gas, carbon dioxide.
Keywords: CO_2 emission, environment, greenhouse effect, ozone.

1996, **24**(2), 104–107

A computer model for the design of window shading devices

Bouchlaghem, N M
Department of Civil and Building Engineering, Loughborough University of Technology, Leicestershire, LE11 3TU, UK

An efficient way of determining some of the glazing related variables is described, thus enabling thermal performance to be considered easily at the early design stage when inexpensive measures of heating and cooling can be advocated and tested.
Keywords: computer modelling, thermal performance, UK, window.

1996, **24**(2), 108–112

Factors affecting the safety of the construction industry

Jannadi, M O
College of Environmental Design, King Fahd University of Petroleum and Minerals, PO Box 1978, Dhahran 31261, Saudi Arabia

It was concluded from the survey that safety officers and workers agreed on the top six factors, the first three being maintaining safe working conditions, establishing safety training and educating workers and supervisors.
Keywords: safety, UK.

1996, **24**(2), 113–123

A computer-based model for optimizing the location of a single tower crane

Zhang, P; Harris, F C and Olomolaiye, P O
School of Construction, Engineering and Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

The application of a quantitative approach to determine optimum crane position is highly desirable for construction site planning. This paper describes a stochastic (random number generation to simulate real-world event sequences) simulation model to optimize the location of a single tower crane. Readers will wish to know that this model has been expanded to deal with the location of multiple cranes.
Keywords: computer modelling, material flow, productivity, tower crane, UK.

1996, **24**(2), 124–127

The role of IT manager in construction process re-engineering

Heng Li
Department of Civil Engineering, Monash University, PO Box 197, Caulfield East, Melbourne VIC 3145, Australia

This paper argues that the benefits from IT deployment would be marginal if only superimposed on an existing construction process. Instead, the process should be redesigned and composed to maximize the use of modern IT techniques.
Keywords: construction process, information technology, leadership.

1996, **24**(3), 131–140

A review of building energy standards and implications for Hong Kong

Lam, J C and Hui, S C M
Department of Building & Construction, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong

The authors review the current work on energy efficiency in Hong Kong and discuss the prescriptive and performance-based approaches as well as looking at the obstacles and barriers in delivering energy efficiency to the marketplace. It is recognized that more research and development work needs to be done in the territory before comprehensive building energy codes can be introduced.
Keywords: commercial building, energy standard, Hong Kong, policy, review.

1996, **24**(3), 141–147

Detailed simulation of heat transfer across planar evacuated glazing

Griffiths, P W; Norton, B; Eames, P C and Lo, S N G
Centre for Performance Research on the Built Environment, The University of Ulster, Newtownabbey, BT37 0QB, Northern Ireland, UK

The centre of glass thermal performance of evacuated glazing is better than the performance of argon-filled atmospheric pressure double glazings. Mitigation, or elimination of evacuated glazing edge effects will bring total window thermal performance on par, or better than, competing "superwindow" options; thus increasing the commercial attractiveness of these glazings. The results of the computer-based thermal modelling at the Universities of Sydney and Ulster compare well with each other and with the infrared thermography measurements at Lawrence Berkeley.
Keywords: computer modelling, evacuated glazing, heat transfer, Northern Ireland.

1996, **24**(3), 148–151

Public owners' satisfaction with consultancy practices in Saudi Arabia

Al-Musallami, A I[1] and Assaf, S A[2]
[1]*King Faisal University, College of Architecture and Planning, Dammam, Saudi Arabia*
[2]*College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia*

Between 1970 and 1985 the public expenditure on three development plans in Saudi Arabia amounted to 1940 billion Saudi Riyals. This paper addresses the professional relationship between the public owners and the local architectural and engineering practices which has been measured in the form of overall satisfaction under a five-point scale ranging from excellent to poor, a second aspect identified satisfaction related to the design service and finally, a measure of satisfaction was gained from owners' response to their professional relationship with the practices
Keywords: architect, consultant, engineer, satisfaction, Saudi Arabia.

1996, **24**(3), 152–158

Value engineering in public construction projects in Saudi Arabia

Assaf, S A[1]; Al-Musallami, A I[2] and Al Sughaiyer, M[2]
[1]*King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia*
[2]*King Faisal University, Dammam, Saudi Arabia*

It was found that value engineering was in limited use since it has been introduced in 1981. The main reason for the lack of adoption being unfamiliarity with the concept among public sector organizations, as well as local architectural/engineering firms in the Kingdom.
Keywords: Saudi Arabia, training, value engineering.

1996, **24**(3), 159–163

Factors effecting construction contractors' performance

Assaf, S A; Al-Hammad, A M and Ubaid, A
College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

A number of interesting and important aspects have been achieved in this research; in particular, that quality of work should be of major concern to contractors and could become a pre-requisite in any selection process by the client body. Contract documentation should be clear and should not include ambiguous clauses and contradictory documentation, as this only leads to problems for all parties during the contract and a low performance rating from the contractor.
Keywords: contractor performance, performance evaluation, Saudi Arabia.

1996, **24**(3), 164–169

Minimum cost route for a highway in heterogeneous terrain

Razouki, S S and Al-Zubaidi, M A
Department of Civil Engineering, University of Baghdad, Iraq

This paper shows that the minimum cost route should satisfy the Snell's law of light refraction and this can be done by successive iteration, in either a forward or backward direction. The number of iterations required for full convergence depends on the geometry of the problem and the cost ratio between each of the two neighbouring cost regions.
Keywords: heterogeneous terrain, Iraq, minimum cost route, optimization, transportation cost.

1996, **24**(3), 170–175

Issues in the investigation and reporting of housing subsidence

Anumba, C J
School of Science and Technology, Construction Research Unit, University of Teesside, Middlesborough, TS1 3BA, UK

The investigation of buildings subject to subsidence damage is fraught with difficulties which can lead to erroneous diagnoses. The author's systematic approach to discussing the likely points of confusion will hopefully limit the number of errors that have been prevalent in such investigations in recent years.
Keywords: duty of care, housing subsidence, survey reports, structural investigation.

1996, **24**(3), 176–182

Ventilator air flow measurement in new houses

Eftekhari, M M
Department of Civil & Building Engineering, Loughborough University, Leicestershire, LE11 3TU, UK

The results of tests showed that placing an air ventilator at low level with no internal blade or baffle, creates a temperature difference of more than 3°C between head and ankle level for a seated person. The temperature difference is increased if any kind of heating is switched on. Placing air ventilators in cupboards, which are usually full and have the door closed is dangerous practice and should be discontinued.
Keywords: air-flow measurements, air ventilators, thermal comfort, UK.

1996, **24**(3), 183–189

A monitoring and controlling system in managing infrastructure projects

Enshassi, A
Civil Engineering Department, The Islamic University of Gaza, PO Box 223, Gaza, Gaza Strip Via, Israel

This paper aims at providing an overview of the monitoring and controlling process, followed by analysing the monitoring and control systems in infrastructure projects in Gaza Strip. The author concludes that it is highly

recommended that international management consulting firms should consider transferring know-how to Palestinian engineers to ensure that future monitoring and control systems can be effective.
Keywords: control, Gaza Strip, infrastructure, monitoring.

1996, **24**(4), 195–202

Demonstration projects and sustainable housing

Buijs, A and Silvester, S
Erasmus Centre for Environmental Studies, Erasmus University, Postbus 1738, Burgemeester Oudlaan 50, 3000 DR Rotterdam, The Netherlands

Because of the complicated structure of the built environment, it is frequently difficult to obtain good results on sustainable development projects. In The Netherlands, the Dutch government have used a range of new steering instruments which have cleverly enabled innovation to take place within a market economy. This imaginative governmental process uses covenants, network management and above all, demonstration projects to assess the feasibility of innovation. The authors describe the process and consider examples from energy efficient and sustainable housing, highlighting the importance of clear targets.
Keywords: demonstration project, energy efficiency, feedback, government policy, housing, sustainable development, The Netherlands.

1996, **24**(4), 203–208

Artificial neural networks and naturally ventilated buildings

Kindangen, J I
Centre de Thermique de l'INSA de Lyon, Equipe Equipement de l'Habitat, 20, avenue Albert Einstein, 69621 Villeurbanne Cedex, France

The author found that the results obtained were reliable and indicates that neural networks can be used as a predictor for investigating window opening configurations to study the effects on interior air motion. Further study is needed in the development of the database to cover wider architectural parameters and the implementation of new types of network is also needed, as well as the need to consider variation spatial coefficients more fully.
Keywords: artificial neural neural network, interior air motion, natural ventilation , opening configuration, tropical.

1996, **24**(4), 209–212

Assessment of structure formation in fresh concrete by measurement of its electrical resistance

Wilson, J G and Gupta, N K
Department of Electrical, Electronic and Computer Engineering, Napier University, 219 Colinton Road, Edinburgh, EH14 1DJ, Scotland

There are doubts regarding the long term durability of concrete produced using accelerated curing methods. The authors investigated the process and concluded that corrected resistance may be a suitable measure of structure formation in concrete for investigation of accelerated curing, whilst comparison between the corrected resistance of an accelerated sample and a reference sample will allow calculation of the structural gain in hours for the temperature cycle considered.
Keywords: accelerated curing, concrete, structural strength.

1996, **24**(4), 213–222

The influence of occupational stress on construction professionals

Gunning, J G[1] and Cooke, E[2]
[1]*School of the Built Environment, University of Ulster, Newtownabbey BT37 OQB, Northern Ireland, UK*
[2]*Chartered Building Surveyor in Private Practice, Northern Ireland, UK*

The majority of the respondents were happy in their work but experienced considerable stress as a result of working practices, contractual arrangements and the demands of projects and their clients. Educationalists still retained their identity as 'construction lecturers' rather than as academic staff', and to some extent felt themselves to have the best of both worlds - the interest and variety of construction coupled with the satisfaction of acquiring and imparting knowledge and skills, as well as job security of 'academic tenure'.
Keywords: conflict, professional, lecturer, occupational stress.

1996, **24**(4), 222–227

Training for Palestinian engineers to face the challenges of multinational enterprises in the Gaza Strip

Enshassi, A
Faculty of Engineering, Islamic University of Gaza, PO Box 108, Gaza Strip, Palestine

Continuing education and training is a normal part of all engineers' professional responsibility and despite the relatively high number of Palestinian universities (six in the West Bank, including an Open University and two in the Gaza Strip) there is an awareness that, in this special situation, training should be considered as a part of the implementation strategy and a national training institute should take responsibility for such work, preferably with feasibility studies to determine real needs and aims for further professional engineering training.
Keywords: engineering, further education, Gaza Strip, national training strategy, training, Palestine, West Bank.

1996, **24**(4), 228–236

Factors affecting the bidding behaviour of contractors in Egypt

Hassanein, A A G
Assistant Professor, 510 Science Building, Department of Engineering, The American University in Cairo, 113 Kasr El Aini Street, PO Box 2511, Cairo, Egypt

The financing source was determined to be the most important to the category of contractors included in the study. Other qualitative factors such as nationality of expected competitors were determined as influencing the decision. The factors and their influence on the bid/no bid decision differed between the Egyptian and foreign large size contractors operating in the country.
Keywords: bidding, contracting, decision making, decision factor, Egypt, finance.international construction.

1996, **24**(4), 237–244

A bidding decision index for construction contractors

Hassanein, A A G and Hakam, Z H R
Department of Engineering, The American University in Cairo, 113 Kasr El Aini Street, PO Box 2511, Cairo, Egypt

Results from applying the model on a sample of contractors, the majority of whom were international and operating in Egypt, reinforces the credibility of the developed methodology, claim the authors.
Keywords: bidding, contracting, decision making, Egypt, international construction, multi-attribute model, project selection.

1996, **24**(4), 245–254

Public versus private sector's assessment of problems facing the building maintenance industry in Saudi Arabia

Al-Hammad, A M; Al-Mubaiyadh, S and Mahmoud, T
College of Environmental Design, King Fahd University of Petroleum and Minerals, P O Box 222 Dhahran 31261, Saudi Arabia

In the last two decades the Kingdom of Saudi Arabia has witnessed vast growth in many areas, not least in the construction industry and as a consequence the construction maintenance industry is substantial. This paper draws a number of conclusions covering, technical problems, management and administrative problems, financial problems, human-related problems and the important aspect of training. The authors conclude that the public and private sectors generally agree on the rankings described.
Keywords: facilities management, maintenance, Saudi Arabia.

1996, **24**(5), 259–269

The Renaissance: the beginning of the end for implicit buildability

Moore, D
School of the Built Environment, De Montfort University, The Gateway, Leicester, LE1 9BH, UK

The author has produced a thoughtful and provoking paper that considers the role of the design architect in the UK and traces the progress that has been made through the centuries in connection with buildability. David Moore suggests that the time is approaching when the profession will have to return to the unresolved crisis of identity for the architect and ultimately decide if architecture is to be the practicing of technical knowledge or only artistic insight with regard to the building process.
Keywords: architect, buildability, constructor, evolution, UK.

1996, **24**(5), 270–278

Advanced wood-frame construction details in Canada

Friedman, A and Cammalleri, V
School of Architecture, Macdonald-Harrington Building, McGill University, 815 Sherbrooke Street West, Montreal, PQ, H3A 2K6, Canada

This paper investigates how durability, energy efficiency and indoor air quality can be improved through proper detailing. The energy implications of airtight construction are evaluated for terrace and semi-detached houses.
Keywords: Canada, detailing, energy efficiency, housing, timber-frame, wood-frame construction.

1996, **24**(5), 279–286

An expert-simulation system for construction productivity forecasting

Boussabaine, A H[1] and Duff, A R[2]
[1]*School of Architecture and Building Engineering, The University of Liverpool, PO Box 147, Liverpool, L69 3BX, UK*
[2]*UMIST, Department of Building Engineering, PO Box 88, Manchester, M60 1QD, UK*

Knowledge based and neural network systems provide an interesting new tool for dealing with uncertainty in decision making. The authors discuss the different sources of uncertainty for a construction planning expert system and show how the results (output) from the expert system can be used to estimate operation or project durations.
Keywords: construction, expert system, productivity, simulation, uncertainty, UK.

1996, **24**(5), 287–292

Electronic document management systems and the management of UK construction projects

Edwards, D J; Shaw, A and Holt, G D
School of Construction Engineering and Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands, WV1 1SB, UK

The authors indicate that EDMS will not replace, but complement existing facilities and thereby enhance the management of documentation within construction organizations. It is hoped that client confidence and satisfaction can be enhanced by better communication.
Keywords: computerization, document management, project management.

1996, **24**(5), 293–301

Time constraints set by prime contractors for their sub-contractors

Hassanein, A A G[1] and Melin, J W[2]
[1]*Department of Engineering, The American University in Cairo, 113 Kasr El Aini Street, PO Box 2511, Cairo, Egypt*
[2]*3129 Newmark Civil Engineering Laboratory, University of Illinois at Urbana Champaign, 205 North Mathews, Urbana, IL 61801, USA*

The concept of pacing is described in an articulate manner which will enable readers to discuss the views put forwards. The nine major activities are divided into two types and are discussed in detail together with the methods used by the prime contractors to allocate time windows and the underlying logic employed.
Keywords: contracting, Egypt, resource allocation, scheduling, sub-contracting, time, USA.

1996, **24**(5), 302–310

Project managers" perception of production problems - an Indonesian case study

Kaming, P F[1]; Olomolaiye, P O[2]; Holt, G D[2]; Kometa, S T[2] and Harris, F C[2]
[1]*University of Atma Jaya Yogyakarta, Jalan Babarsari 44, P O Box 1086, Yogyakarta, 55281, Indonesia*
[2]*School of Construction, Engineering and Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK*

The findings of the survey are to be applied as validated knowledge towards a productivity problem audit system currently being developed by the authors for construction management in Indonesia.
Keywords: developing country, high-rise, Indonesia, productivity, project management.

1996, **24**(5), 311–317

Urban housing reform in China - policies and performance

Chen, J J and Wills, D
School of Land and Construction Management, The University of Greenwich, Oakfield Lane, Dartford, Kent, DA1 2SZ, UK

The establishment of a market-based housing system to privatize housing is the ultimate objective of China"s housing reforms. Increasing rents has been the major step adopted so far since the housing reforms started in 1984. The authors discuss the phase 2 reforms and give an authoritative insight into China"s housing difficulties and highlight those areas which need more careful consideration, especially on the legal side.
Keywords: China, economic reform, housing, privatization, state-owned enterprise, urban housing.

1996, **24**(6), 323–328

Ornament and function

Morosi, J A; Boldes, U and Colman, J
Scientific Research Council, Buenos Aires Province, Casilla de Correo 32, 1900 La Plata, Argentina
Faculty of Engineering, La Plata University, 48 and 116, 1900 La Plata, Argentina

The architects and builders in the past lacked our knowledge concerning fluid dynamics, but they exhibited a deep rooted ability to observe and reflect - thus, different cultures have developed by trial and error. The authors have produced a stimulating analysis which couples the science of fluid dynamics and a sensitive understanding of past cultures. The paper is recommended reading.
Keywords: aerodynamics, Argentina, history, micro-climatic, wind.

1996, **24**(6), 329–338

Refurbishment management practices in the shipping and construction industries - lessons to be learned

Egbu, C O; Young, B A and Torrance, V B
The Bartlett Faculty of the Built Environment, University College London, Gower Street, London, WC1E 6BT, UK

The management of refurbishment work in both sectors is complex, highly specialized and contains elements of works which are unique to refurbishment and which are different from new work. Ship refurbishment clients are better informed and more knowledgeable about refurbishment processes and products than construction clients and are more involved in the planning and decision making process. The authors claim that there is very little evidence of formal or structured processes of managing risks and uncertainty in refurbishment, in both sectors, especially the quantification and evaluation of risks. There is also an urgent need for educators and refurbishment organizations to address the issue of under-provision of refurbishment management courses.
Keywords: control, decision making, planning, refurbishment, risk management.

1996, **24**(6), 339–350

Construction process performance variability: focus on labor productivity

Lema, N M and Price, A D F
Department of Civil and Building Engineering, Loughborough University of Technology, Leicestershire, LE11 3TU, UK

The authors claim that unlike most other studies, in which the variability of productivity data was shown to fall within a specific distributional shape, this work has brought into light a distribution which is flexible and yet represents in a simple form most productivity distributions. This was shown in the contrasting distributional shapes of concreting and excavation productivity distributions.
Keywords: labour, process performance, productivity, Tanzania.

1996, **24**(6), 351–357

Cause and effect 3-D model for measuring performance in construction acceleration: a decision support system

Battikha, M G[1] and Davidson, C H[2]
[1]*Department of Civil Engineering, University of British Columbia, 2324 Main Mall, Vancouver, BC V6T 1Z4, Canada*
[2]*Université de Montréal, École d'architecture, C P 6128, succursale A, Montréal, QC, H3C 3J7, Canada*

Despite the constant improvements in the management of building projects, the authors express concerns about the difficulties in controlling progress with construction, despite the availability of quantifiable and non-quantifiable data.

They believe that a decision support system would assist managers when confronted by the consequences of arising delays, and by the decision whether and how to accelerate the remaining construction activities. The system has the advantages of providing support when facing an ill-structured decision about accelerating progress when delays occur; it also helps as a predictive management tool for minimizing or avoiding delays and their consequential claims.
Keywords: acceleration, decision support, delay, time.

1996, **24**(6), 358–362

Assessment of the types of public building maintenance contracts in Saudi Arabia

Al-Hammad, A M; Assaf, S A and Al-Hazmi, T
College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

The study revealed that Fixed Price, Cost Plus and Purchased Labour contracts are the top three maintenance contracts adopted whilst Unit Price, Cost Plus A Percentage Fee contracts are alternatives used in the Kingdom. Some other types of maintenance contract were thought to be inappropriate by ministry departments.
Keywords: contract choice, maintenance, Saudi Arabia.

1996, **24**(6), 363–368

Planning and scheduling concrete repair work - a case study

Bubshait, A A and Tahir, B M
Department of Construction Engineering and Management, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

In this case study the authors demonstrate the importance of recording and studying the details of concrete repair work to enable future projects to be carried out more efficiently with less slippage in the time schedule and therefore less financial damage over the time plants, such as kilns, are shutdown. In this case study, the distress in the concrete pier was apparently due to the twisting of the platform as a result of tortional stress, as well as to diagonal shear cracks in the walls.
Keywords: concrete, maintenance, repair, scheduling.

1996, **24**(6), 369–373

Experimental study of the thermal behaviour of radiant floors

Sánchez-Romero, M and Alavedra-Ribot, P
Universitat Politècnica de Catalunya, Department of Construction Engineering, School of Industrial Engineering, c/o Colon, 11, E-08222 Terassa (Barcelona), Spain

This study focuses on the experimental analysis of the thermal behaviour of radiant floor heating in an industrial building and the authors conclude that in order to reduce costs and increase user comfort, optimum values of concrete conductivity and embedded depth of the heating element need to be selected.
Keywords: concrete, conductivity, radiant concrete floors, Spain, thermal behaviour.

1996, **24**(6), 374–378

The role of precast concrete systems in Kuwaiti housing projects

Al-Khaiat, H and Fereig, S M
College of Engineering and Petroleum, University of Kuwait, PO Box 5969, Kuwait

The study shows that precast concrete systems can play a significant role in meeting housing demand in Kuwait, provided that the tendering procedures are modified and that the life-cycle cost of the building is considered rather than just the initial cost.
Keywords: housing, Kuwait, life cycle analysis, pre-cast concrete.

1996, **24**(6), 379–382

Towards quantitatively measuring the performance of construction IT systems

Heng Li

Caulfield School of Engineering, Department of Civil Engineering, Monash University, PO Box 197, Caulfield East, Melbourne, Victoria 3145, Australia

The author discusses the difficulties and challenges involved in establishing a quantitative method to measure the performance of information technology (IT) systems and concludes that because each construction organization has its unique circumstances for prioritizing indicators, it is difficult to provide a single formula to deal with the evaluation of all construction IT systems. Research is currently in progress to empirically validate the indicators and their surrogates defined in the paper.

Keywords: Australia, construction information, performance indicator, technology.

BRI: Volume 25, 1997

1997, **25**(1), 5–10

China's construction industry and foreign investment

Jean Jinghan Chen
School of Land and Construction Management, Faculty of the Environment, The University of Greenwich, Dartford, Kent, DA1 2SZ UK

Study of the development of the construction industry since the 1980 economic reforms, analysing the investment environment for foreign construction companies and recommending efficient ways for co-operation between Chinese and overseas environment professionals. The author confirms that foreign participants will be most successful in project management, supervision and training of local construction companies in the fields of power generation, energy exploration, transportation, telecommunication and housing. Joint ventures are highly recommended for doing business in China.
Keywords: China, foreign contractor, market.

1997, **25**(1), 11–14

Evolution of cost estimating system in China: intelligent estimator for Shandong Province (IES) to general intelligent estimator (GIE)

Sha Kaixun ; Deng Xiaohong; Chen Qijun and Xie Benzheng
Shandong Institute of Architecture and Engineering, 47 Heping Road, Jinan 250014, P R China

Cost estimating using artificial intelligence techniques successfully introduced in China's Shandong Province now expanded to include general intelligent estimator to suit whole country. IES was the first knowledge-based cost estimating system with distinctive Chinese features and has been developed over the past four years, increasing the speed of estimating twelve-fold in Shandong Province. GIE, the system for the whole of China is being tested in Jiangsu Province and the authors anticipate that other provinces will adopt the method, thus raising estimating standards in China as a whole.
Keywords: artificial intelligence, China, estimating.

1997, **25**(1), 15–17

Composite masonry buildings in China

Wei Hu and Xu Xiangdong
Shandong Institute of Architecture and Engineering, 47 Heping Road, Jinan 250014, P R China

Tests, study and application of composite masonry buildings in China with reference to the 1994 masonry structure design code and building aseismic code. Masonry structures have enjoyed a long history in China, although a number of masonry buildings collapsed in the 1976 Tangshan earthquake. *ince then, twenty years of research and development have taken place and the new specification, JGJ/T13- 94, has hopefully overcome the aseismic design deficiencies of the past. In Zibo City in Shandong Province the new composite masonry structures have been built as high as 14 storeys, while construction costs have been reduced by about 40%.
Keywords: China, composite material, masonry, structural design.

1997, **25**(1), 18–24

Incorporating a 3D urban environmental model (3DUEM) into government and architectural firms

Shih Naai-Jung and Lan Wei-Jeh
Department of Architecture, National Taiwan Institute of Technology, 43, Section 4, Keelung Road, Taipei, Taiwan, Republic of China

A study on how to incorporate current modelling data with architectural design under the constraints of current computer capability of local architectural practices in relation to government operational procedures. The authors, participating in a government study, confirm that computer simulation can be used as an effective tool to evaluate design quality in an urban environment. The Taipei example is to be extended to other parts of the city and eventually to all the metropolitan areas in Taiwan with an improved application of 3DUEM
Keywords: urban modelling, architecture.

1997, **25**(1), 25–35

Three-dimensional gaseous transfer within cellular plastic insulation and its consequences

Youchen Fan and Erkki Kokko
VTT Building Technology, Box 1804, 02044 VTT, Espoo Finland

The requirement for producing environmentally friendly plastic foam results in the replacement of the traditional blowing agents, chlorofluorocarbons (CFCs). With zero ozone depletion potential alternatives, the tool to evaluate the quality of the new generation of plastic foams becomes particularly important. The authors present a 3D gaseous transfer model and a simplified mechanical model. Thermal ageing and average volume change of ozone depletion potential foams with different facings are addressed. A formula has been suggested to correlate the elastic modulus and the reduced density of rigid foams over the whole foam density range
Keywords: CFCs, insulation.

1997, **25**(1), 36–49

Integration, segmentalism and the maintenance of quality management systems in the construction industry

Low Sui Pheng and Hennie Faizathy Omar
School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent Singapore 0511

Segmentalist and integrative concepts are explored using two construction case studies. The importance of the application of the non-technical approach is emphasized. The authors concentrate on the application of the non-technical approach to help to promote an integrative environment for the development of change and innovation, with the primary objective of quality improvement. The case studies suggest that Company A is more segmentalist in nature than Company B which adopts an integrative approach
Keywords: change, integration, ISO 9000, maintenance, quality.

1997, **25**(1), 50–64

The contribution of building centres to low-cost housing in India

Kiran Keswani
120 Flensburger Burse, 24943 Flensburg, Germany

Study of Indian building centres describing factors leading to their success, working methods and reasons for replication. The author argues that the government's role could change from being the provider to becoming a facilitator. Progress in the Building Centre Programme in India has been slow and a three-pronged policy is advocated-examining archaic rules, disseminating technical information, and training in updated technologies whilst continuing with those technologies that are cost-effective.
Keywords: building centre, dissemination, India, industry development.

1997, **25**(2), 67–81

The measurement of just in time wastage for a public housing project in Singapore

Low Sui Pheng[1] and Stephanie K L Tan[2]
[2]*School of Building and Estate Management, The National University of Singapore, 10 Ridge Crescent Singapore*
[2]*Neo Corporation, 1 Irving Road, 07-01, Singapore*

This case study shows that NEO's accounting procedure is workable in practice where the productivity and time wastage of each task is identified at various stages. Just-in-time waste data is useful for a number of reasons; these include the ability to streamline operations, the ability to be more responsive to the environment, and the improvement in productivity, quality assurance, scheduling and cost savings
Keywords: case study, just-in-time, Singapore, social housing,

1997, **25**(2), 82–91

Productivity improvement in concreting operations through simulation models

Ediz Alkoc and Fuat Erbatur
Civil Engineering Department, Middle East Technical University, 06531 Ankara, Turkey

Describes simulation models developed in MicroCYCLONE, a cyclic operations simulation software. Two main methods of concreting are simulated for pouring slab, beam and column concrete. MicroCYCLONE simulation software, while not yet adopted extensively in the construction industry, has gained general acceptance in academic

research and, compared with other software, the program presents a simple graphic system that can be readily understood by engineering and field personnel. The general rules of thumb derived from these models are used in a prototype advisory expert system which is designed to present the results in a user-friendly manner to construction practitioners

Keywords: concrete, expert system, productivity, simulation, site operation, Turkey.

1997, **25**(2), 92–100

An effective safety programme for a concrete product manufacturing plant

M Osama Jannadi

Department of Construction Engineering and Management, King Fahd University of Petroleum and Minerals, PO Box 1978, Dhahran 31261, Saudi Arabia

A three-part paper with five detailed recommendations for action concerning safety confirming that the purpose of safety programmes is to prevent injury, loss of life and damage to assets. The first section of the paper discusses the organization of the safety function in terms of its size, authority and the qualifications of the safety engineer, the second section deals with plant safety statistics, and finally the low accident rates achieved in this Saudi Arabian plant are presented and discussed

Keywords: concrete, manufacturing, safety, Saudi Arabia.

1997, **25**(2), 101–106

Determinants of knowledge-based expert system success in construction engineering

Heng Li

Department of Real Estate, Hong Kong Polytechnic University, Hong Kong

Analysis and identification of five factors that largely determine the success or failure of a KBES project for construction problem-solving tasks. This study is the second part of a research project aiming at investigating important issues and factors relating to the success of a knowledge-base expert system (KBES) development. Each factor has several surrogate items as dependent variables used to measure certain aspects of the factor. Using angular fuzzy sets, values of the surrogate items can be quantitatively determined and items with values less than one are regarded as weak items. Deployment of corrective action is therefore required to enhance weak items. Despite the limitations of the study, it is believed that it represents one of the first attempts to identify and address the determinants of KBES success in the construction industry

Keywords: Australia, knowledge-based system, KBES, problem solving.

1997, **25**(2), 107–110

Foamglass as spacer in multiple-glazing

Michael Loffler

Faculty of Architecture, Department of Technical Support and Building Physics, University of Karlsruhe, Englerstrasse 7, D-76128 Karlsruhe, Germany

Detailed study for new design of edge seal in multiple-glazing significantly reduces energy consumption. The author claims that the new design for windows has a number of important advantages, including an increase in the transparent area encouraging greater solar gain; lower heat flux through a well-insulated window having a positive impact on the indoor climate and relatively high inside surface temperatures

Keywords: condensation, foamglass, glazing, Germany, structural glazing, U-value.

1997, **25**(2), 111–114

Construction projects and the environment in Palestine

Adnan Enshassi

Civil Engineering Department, Islamic University of Gaza, Gaza Strip, Palestine

A comprehensive well co-ordinated strategy involving all aspects of construction development is advocated as environmental consciousness should be considered as a culture in Palestine. Continuing the series of papers on construction in Palestine, one of the most densely populated areas in the world, the author concentrates on the need for harmonized development to sustain the environment. An analysis of the Gaza seaport project demonstrates the need to educate professionals working within the construction industry on environmental issues, in particular the steps needed in carrying out the environmental impact assessment of any construction project. The author believes that further studies to increase knowledge are needed

Keywords: environment, mega-project, Palestine, reconstruction, sustainable development.

1997, **25**(2), 115–119

Solid soilcrete blocks for low-cost buildings: a Nigerian case study

Abejide, O S
Department of Civil Engineering, Ahmadu Bello University, Zaria, Nigeria

Results of tests comprehensively indicate that solid soilcrete blocks of standard size fabricated from lateritic soils give high compressive strength similar to that of sandcrete building blocks. The main component of the investigated block is a lateritic soil deposit obtained below the layer of vegetable topsoil. The case study is a useful guide in recording case study knowledge in a number of countries and will enable low-cost housing to be constructed safely using local material and labour

Keywords: housing, lateritic tests, Nigeria, soilcrete.

1997, 25(2), 120–123

Building regulations and disaster mitigation: the Philippines

Rommel C Gavieta[1], Caesar E Onate[2]
[1]*College of Architecture, University of the Philippines, Dilman, Quezon City, Philippines*
[2]*Bureau of Research and Standards, Department of Public Works and Highways, Philippines*

The present form of building regulations in the Philippines makes it difficult to enforce a strong programme mitigating the effects of earthquakes. This lack of enforcement is discussed and recommendations show that fundamental changes will have to be made. On average a major earthquake has occurred in the Philippines once every six years since the year 1600. The annual population growth is 2.3%, while there is an annual loss of about 2% of the Gross National Product due to natural disasters. One way of mitigating against the disasters is to have stronger enforcement and seek ways of accommodating change

Keywords: building regulation, natural disaster, Philippines.

1997, **25**(2), 124–128

Socio-economic and spatial indicators for household energy for a tropical urban community in urban Manila

Rommel C Gavieta
College of Architecture, University of the Philippines, Dilman, Quezon City, Philippines

The main objective of this paper is to highlight the socio-economic and spatial indicators for urban household energy consumption for a more effective and sensitive energy planning exercise. government administrators and energy planners in the Philippines need to have a better understanding in the face of increasing urbanization. Partly based on a household energy survey, this paper highlights the need to understand the complexities of the increasing urban growthrate around the world. The community, Baranggay 557 in the city of Manila is described, including structure and energy patterns, thus leading to an approach towards indicators and the rudiments of an energy policy

Keywords: energy, Philippines, socio-economic characteristics, urban energy policy.

1997, **25**(3), 131–136

Palm kernel shell as fuel for burning bricks

Kofi Obeng, K A G Ocran and David Anaba
Building and Road Research Institute, University PO Box 40, Kumasi, Ghana

Research and demonstration project on the use of an agricultural waste product as an alternative fuel for firing bricks. The use of an agricultural waste product, palm kernel shell, as a fuel for firing bricks is explored as a means of reducing environmental degradation and depletion of scarce firewood in Ghana. A simple but efficient methodology of clamp firing bricks using the new fuel is developed and tested. The resulting bricks are analysed for physical properties and suitability for construction use. The viability of palm kernel shell as a fuel for small-scale brick industries is considered

Keywords: agricultural waste, alternative technology, brick-making, fuel, Ghana, sustainability.

1997, **25**(3), 137–141

The future of international construction

Ranko Bon
European Construction Economics Research Unit (ECERU), Department of Construction Management & Engineering, University of Reading, Reading, RG6 6AW, UK

Some survey results 1993-96. This opinion survey about the future of international construction concerns several time horizons, but only the five- year horizon is discussed in this paper. The analysis focuses on construction market attractiveness-a measure obtained by combining opinions about the rate of growth, profitability and openness to foreign competition-and construction industry competitiveness with respect to both services and materials. The results of the survey rank attractiveness of construction markets by country and city. The analysis of competitiveness of construction services and materials largely points to the same countries and indicates some important medium-term trends in the international construction market

Keywords: international construction, competitiveness, market, opinion survey.

1997, **25**(3), 142–147

A hybrid approach to house construction: a case study in Botswana

A B Ngowi
Department of Civil Engineering, University of Botswana, Gaborone, Botswana

The possibility of incorporating appropriate concepts from industrialized housing to traditional house construction is demonstrated by a case study in Botswana. This paper examines the strategy of employing a hybrid combination of indigenous and modern housing construction technologies. Using a Botswana village as a case study, this paper examines four traditional house types in relation to the household income, skills, materials and aspects which could be improved by adapting industrialized methods. Using experimental houses, the case study provides the costs, benefits, potential problems and implementation considerations. The paper discusses the weaknesses and virtues of traditional construction technologies, how appropriate aspects from modern technologies can be incorporated or adapted into traditional methods and the implications for developing appropriate, affordable housing technologies

Keywords: affordable housing, appropriate technology, housing, human factors, industrialized construction, traditional construction.

1997, **25**(3), 148–157

Design for manageability

W Bordass[1] and A Leaman[2]
[1]*William Bordass Associates, 10 Princess Road, London, NW1 8JJ, UK*
[2]*Institute of Advanced Architectural Studies, University of York, York Y01 5DD, UK and Building Use Studies Ltd, 42-44 Newman Street, London, W1P 3PA, UK*

Unmanageable complexity is a major source of chronic problems in building performance. Drawing evidence from studies of the performance of buildings in use, the authors explore the consequences of unnecessary complexity especially for usability and environmental efficiency. Briefing and designing for management and use raises strategic issues of how human and physical systems interact, how uncertainty and inefficiency in systems' operation and use can develop; how human behaviour is affected and how chronic failures occur. Attributes for more successfully briefing, designing, researching and evaluating buildings are discussed in terms of improving performance in use

Keywords: building performance, feedback, risk, briefing.

1997, **25**(3), 158–169

Quality management systems: a study of authority and empowerment

Low Sui Pheng, Chan Foong May
School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, 0511 Singapore

A survey of construction organizations in Singapore indicates that managing human factors is a key to implementing organizational change. This paper examines the types of power in organizations, authority, empowerment, organization politics, employees' resistance to change, leadership style and conflicts within construction organizations that may negate the effective development, implementation and maintenance of quality management systems. The results of a questionnaire and in-depth interviews are analysed. Diverse management factors including support of senior management, appropriate leadership style, cultivating employee's enthusiasm and participation, open communication and feedback must be managed properly to achieve quality management systems in the construction industry

Keywords: authority, effectiveness, empowerment, human factors, ISO 9000, leadership, organizational change, quality, Singapore.

1997, **25**(3), 170–175

Pozzolanic properties of a variety of European clay bricks

S Wild[1]; A Gailius[2]; H Hansen[2]; L Pederson[3] and J Szwabowski[4]
[1]*School of the Built Environment, University of Glamorgan, Mid Glamorgan, CF37 1DL, UK*
[2]*Vilnius Technical University, Vilnius, Lithuania*
[3]*Danish Technical Institute, Hasselager, Denmark*
[4]*Silesian Technical University, Gliwice, Poland*

Comparative study of pozzolanic, chemical and physical properties of clay bricks in four European countries for utilization of pulverized waste clay brick in production of mortar and concrete. Clay bricks from Britain, Denmark, Lithuania and Poland have been ground up, investigated and analysed for particle size distribution, chemical composition, mineralogical content and strength. The ground brick types have also been used to partially replace cement in mortar. Chemical tests for pozzolanic activity confirm that all the brick types investigated have good pozzolanic activity and this is supported by strength development data of the mortar bars. A significant variation in relative strength between mortars made with the different ground brick types and the reasons for this variation are discussed. The work reported involves potential utilization of waste clay bricks in the production of durable mortar and concrete.

Keywords: clay brick, concrete, mortar, pozzolans, waste.

1997, **25**(3), 176–184

Factors influencing the choice of concrete supply methods

D G Proverbs, G D Holt and P O Olomolaiye
School of Engineering and Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

Investigation of selection criteria used by UK planning engineers to decide the method of concrete supply for high rise construction. A survey of UK contractors' planning engineers was undertaken using an in situ framed building model to elicit comparable information. Rank ordering, correlations and exploratory factor analysis of the data confirm that cost is of primary consideration for UK contractors. However, quality is assuming an increasingly important role in the decision making process. A 'Quality Factor Group' is discussed as being the most significant underlying factor having a fundamental impact on the construction method chosen. This, based on the achievements of Japanese and American construction firms, could result in reduced costs and higher productivity in the future

Keywords: concrete, high rise, planning, site operation, UK.

1997, **25**(4), 190–195

Future buildings and their services

W Bordass[1] and A Leaman[2]
[1]*William Bordass Associates, 10 Princess Road, London NW1 8JJ, UK*
[2]*Institute of Advanced Architectural Studies, University of York, York YO1 5DD, UK and Building Use Studies Ltd, 42-44 Newman Street, London, W1P 3PA, UK*

Strategic considerations for designers and clients. The authors explore strategic issues in briefing, design and operation of buildings and their services. Feedback from post- occupancy surveys suggests a need for better integration, less complication, and robust rather than optimum performance, with a concentration on ends rather than means. Emphasis must be given to usability, manageability and minimizing downside risks

Keywords: briefing, comfort, control, satisfaction, post-occupancy evaluation.

1997, **25**(4), 196–201

Deterioration of concrete building structures

C Q Li
Department of Civil Engineering, Monash University, Victoria 3145, Australia

An overview of current theory and practical application of the modelling and prediction of structural deterioration over time. a design tool to model structural durability over the life of the building is required. This paper discusses the theories and designs for the structural reliability and durability of reinforced concrete structures over time. The author considers the benefits of assessing deterioration of structural performance over time in order to have a rational and cost-effective maintenance strategy. The paper focuses on how to assess building structural performance and hence predict the appropriate maintenance intervals. Ongoing research activities in structural durability are discussed. More research is required to develop design tools to model expectations of required performance exists throughout the service life of structures

Keywords: durability, maintenance, life cycle, performance.service life, structure.

1997, **25**(4), 202–209

Soilcrete blocks

D Gooding and T Thomas
Development Technology Unit, Department of Engineering, University of Warwick, Coventry, CV4 7AL, UK

Experimental work to determine whether cement or compaction pressure is more effective. This paper presents research conducted to determine the relationship between compaction pressure, cement content and cured compressive strength for soilcrete building blocks (soil-cement, cement stabilized or sandcrete). This relation is then used as the basis for a simple economic model to evaluate the economics of manual compaction to 2 and 10 MPA. Other authors have shown that higher compressive strengths result from increased compaction pressure. However, for a given compressive strength it is more usual to be interested in trading in creased compaction pressure for reduced cement content so that maximum economy is achieved. This paper describes experimental work carried out to determine an empirical relation which uses compaction pressure and cement content to define cured strength. The relationship presented in this paper suggests that cured strength is more dependent on cement content than it is on compaction pressure for a well-cured block. The economic model suggests that low pressure manual compaction using increased quantities of cement is a more economic method of block production unless the cost of high pressure compaction machinery can be reduced
Keywords: block-making, cement, compaction pressure, soil-cement.

1997, **25**(4), 210–217

The use of stabilized soil to enhance rural housing

Essel Ben Hagan
Building and Road Research Institute, PO Box 40, U.S.T., Kumasi, Ghana

An examination of the strength characteristics of lime and cement additives to soil stabilized blocks in Ghana to improve durability and meet housing demand. The rural housing problems and government housing policy in Ghana are summarized. The durability of houses using traditional methods is a key issue. Traditional earth construction supplanted by the use of lime and cement for enhanced durability is explored. The strength characteristics of stabilized blocksand mortar are examined for their suitability for house construction in Ghana. Results indicate that the use of lime and cement enhances durability and meets strength requirements. Strategies for the social promotion and adoption of the production and use of stabilized soil house construction techniques are recommended as the next steps
Keywords: earth house, Ghana, lime, rural housing, soil stabilization.

1997, **25**(4), 218–225

Window and roof configurations for comfort ventilation

Jefrey I Kindangen
University of Sam Ratulangi, Jl. Kampus Bahu, Manado 95115, Indonesia

A study modelling the influence of design elements and passive design to improve ventilation in tropical conditions. This paper assesses the applicability of some architectural design elements to provide comfort ventilation in humid tropical regions: size and location of windows, building eaves and roof shapes for a single unit house. Most window and roof configurations are sufficient to produce only a slightly more comfortable level although they can certainly increase the indoor air velocity. The improvement of indoor air velocity can minimize the physiological effect of the high humidity. Among the tested models, the room with a high gable roof combining with eaves improves significantly the indoor air velocity
Keywords: comfort, computational fluid dynamics, passive design, roof, tropical, ventilation, window.

1997, **25**(4), 226–233

Heat losses from suspended timber floors

D J Harris[1] and S J-M Dudek[2]
[1]*Department of Building Engineering and Surveying, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS, UK*
[2]*Department of Architecture, University of Newcastle upon Tyne, NE1 7RU, UK*

Laboratory experiments measuring heat losses through flooring utilizing a variety of insulation and ventilation rates to determine appropriate strategies for retrofitting insulation. Heat losses through suspended timber floors and principal heat flow paths are identified. The performance of common insulates placed within and beneath the timber floors is measured in a test rig and the results reported. Special emphasis is placed on the ability to retrofit existing floors. A simple insulated radiative barrier placed under the joists is found to be as effective as 30 mm of insulation but is easier to install in existing dwellings. The reduction in heat loss using this method is 60-80%. A simple resistance model is used to predict heat loss accurately for low ventilation rates in the void below the floor
Keywords: conduction, heat loss, housing, insulation, radiation, retrofit, suspended timber floor.

1997, **25**(4), 234–238

Selection criteria for energy-efficient windows

Avi Friedman and Vince Cammalleri
School of Architecture, McGill University, Affordable Homes Program, 815 Sherbrooke Street West, Montreal, PQ, H3A 2K6, Canada

Windows are a weak link in the thermal performance of a building envelope, and represent an important investment in the construction or renovation of any dwelling. This paper outlines some factors which affect a window unit's energy performance and introduces general guidelines for its selection, installation and integration into a Canadian domestic dwelling. Significant reductions in heat loss using higher quality windows can achieve a payback period of 3.5 years
Keywords: Canada, cost, design, energy, heat loss, housing, life cycle, window.

1997, **25**(4), 239–245

The impact of Chinese economic reforms upon the construction industry

Jean Jinghan Chen
Faculty of the Environment, The University of Greenwich School of Land and Construction Management, Dartford, Kent, DA1 2SZ, UK

Study of the rapid demands in different sectors indicates growth cannot be sustained by China's existing companies. development of the private sector in China and increased reliance on international tendering is being promoted. The increase in economic activity in China has generated and will continue to generate a heavy demand upon the construction sector. The author studies the impact of the economic reforms upon the construction industry and the consequences of fulfilling an overheating demand. The new types of construction companies and ventures in China are identified and analysed. Both local and international private sector construction companies are needed to tackle the burgeoning demand
Keywords: China, construction investment, economic development.

1997, **25**(5), 250–256

The future of national construction research organizations

George Seaden
Institute for Research in Construction, National Research Council Canada, Montreal Road, Building M 20, Ottawa, Ontario, Canada

Scenarios for the changing roles, functions, research agendas and funding. The pressures for change on National Construction Research Organizations (NCROs) are identified and linked to changes occurring in the construction sector and the role of government support for construction. Reduced government funding for research has meant NCROs are now dependent on both public and private sector funding. The implications are research priorities are shifting to the shorter-term problems confronting industry, NCROs are under pressure to collaborate internationally and to develop narrower expertise to survive. The dangers of globalized research contracts and short-term contracting with an emphasis on price competition would be to add to uncertainty with each NCRO, undermine long-term benefits, reduce the number of NCROs and their overall research quality. The future of NCROs is discussed as being best situated at a national level with a core funding by government. The requirement of stability for a long-term relationship between governments and NCROs is necessary to maintain and develop knowledge, expertise and excellence as well as capabilities for policy related and emerging issues. Far from being a 'mature' industry, construction has a positive and active role to play in presenting the case for significant government support of R&D for improved living standards, economic growth, user needs and responding to a changing agenda
Keywords: globalization, public policy, R&D trends, research organization, research policy.

1997, **25**(5), 257–267

Should governments fund construction research?

David Gann
Science Policy Research Unit, University of Sussex, Mantell Building, Falmer, Brighton, UK

This paper considers the role played by government in stimulating innovation to improve quality, profitability and competitiveness in construction activities. It questions whether governments should fund research and developmentin construction, and if so, what level and types of support might be appropriate to meet emerging needs. It addresses this with reference to the current debate on the public funding of science, citing Kealey and Pavitt. The author considers specific construction-related issues and changing conditions, indicating the need for more, rather than less funding by both private and public sectors. In conclusion, the author develops a third way, different from Kealey's and Pavitt's approaches. Construction requires a strong and vibrant research base, partly funded by government. Simultaneously, the state requires a research and knowledge base in order to fulfil its roles such as for governance of technologies in the built environment. A complementarity effect arises from both public and private funding -- which is therefore greater than the sum of the parts
Keywords: change, competitiveness, public policy, R&D, regulation, research policy.

1997, **25**(5), 268–271

Building Research Institute in Japan: past, present and future

Satoshi Kose
Housing and Building Economy Department, Building Research Institute, Tatehara, Tsukuba, Japan

What roles can public research have in the context of large private research institutes? The rise of private research institutes linked to Japanese contractors and manufacturers has divided research into either the public or private sector. This paper provides the background history and context to building research in Japan, addresses what suitable strategies exist for the publicly-funded Building Research Institute, what research topics are suitable for government funding and how public and private research organizations might develop strategies of co-operation
Keywords: Japan, public policy, R&D, research infrastructure, research organization, research policy, trends.

1997, **25**(5), 272–278

Commercial building research: threat or opportunity for customer satisfaction?

Erkki K M Leppavuori
Research Institute, VTT Building Technology, PO Box 1800, FIN- 02044 VTT, Finland

Case study of VTT building technology. This case study of VTT Building Technology comprehensively describes the reasoning, decisions and effects in the process of change caused by the transformation to improve the applicability of research results and to increase commercial income. The change in culture, management, organizational structure, organizational strategies and research, development and dissemination activities were designed to increase customer orientation, performance quality and effectiveness in all activities. The culture change from a scientific research community to a customer-oriented and flexible commercial organization is detailed. In addition to the deep vertical levels of knowledge gained from research, a horizontal capability is developed and promoted to provide applicable knowledge (know-how) in forms suitable to the Institute's customers. Clear targets for achieving the Institute's mission and financial performance have been established to gauge progress and provide incentive for rewards
Keywords: competitiveness, Finland, organizational change, R&D, research organization, research policy.

1997, **25**(5), 279–284

The National Centre for Construction in the UK

Graham Watts
Construction Industry Council, 26 Store Street, London, UK

A case study of the proposal. In response to the UK Government's intention to privatize the Building Research Establishment (BRE), the Construction Industry Council (CIC) became the author and promoter of a concept to establish a National Centre for the construction industry. As the privatization process developed, the National Centre became the potential solution to both the Government's need and the construction industry's aspiration. This paper discusses the National Centre for Construction (NCfC) concept and chronicles its development, Government and industry responses and the eventual rejection by Government of the proposal. The NCfC concept and objectives broke new ground and established a reference for evaluating current and future national construction research and technology policy and implement action strategies
Keywords: innovation, privatization, research infrastructure, research organization, research policy, technology transfer, UK.

1997, **25**(5), 285–291

Building Research Establishment: past, present and future

Roger Courtney
Building Research Establishment Ltd, Garston, Watford, UK

BRE's changing roles over time, the developments leading to its private status and BRE's future plans. The history of the changing status and research remits of the Building Research Establishment over 76 years is described as a dynamic response to changing government policies, industry needs and funding arrangements. The recent government decision to change BRE's status to a private sector body is briefly described. The move into the private sector and the creation of the Foundation for the Built Environment has created the opportunity to modify the existing organizational structure of BRE and identify emerging research, products, services and consultancy functions for the future
Keywords: organizational change, privatization, public policy, R&D, research infrastructure, research organization, UK.

1997, **25**(5), 292–300

The UK's changing research base for construction: the impact of recent government policy

Ian Cooper
Eclipse Research Consultants, The Eden Centre, 47 City Road, Cambridge, UK

Factors are identified which may destabilize the capacity and capability of the UK construction R&D base. Recent government policy on construction R&D in the UK is presented as having been a contradictory amalgam involving, simultaneously, government intervention and disengagement. Confusingly, both parts of the policy appear to have been aimed at the same purpose -- increasing the responsiveness of the sector's R&D activities to market forces. Given the noted reluctance of the UK's private sector to assume responsibility for such activities over the past two decades, there is little to suggest that this policy will prove successful. A more likely outcome, in the short to mediumterm at least, is that the speed and extent of apparent government retreat from funding could, in combination with other current changes, destabilize both the capacity and the capability of Britain's construction R&D base.
Keywords: privatization, R&D, research funding, research infrastructure, public policy, trends, UK.

1997, **25**(5), 301–312

The impact of BRE's commercialization on the research community

Peter Lansley
Faculty of Urban & Regional Studies, University of Reading, Reading, UK

An examination of the changing nature of research needs, infrastructure and contexts: influences and issues. This paper comments on the development of the infrastructure of UK building research by reference to political, economic and industrial factors which shape the needs for research. The needs of industry have not been easily met by traditional approaches to the organization of research. As a result, new types of research collaboration and organizations (institutes and clubs) have emerged. There have also been attempts to develop overarching national strategies for research and encourage collaborative academic and industrial projects. The ramifications of the recent privatization of the Building Research Establishment (BRE) are explored with reference to long-term implications for research skills, training and on the international standing of the UK's building research activities
Keywords: innovation, R&D, research infrastructure, research organization, research policy, UK, university.

1997, **25**(5), 313–317

The Building Centres: CIB's information allies

Colin H. Davidson
Faculté de l'aménagement, Université de Montréal, PO Box 6128, Montréal, Canada

A strategy for improving information flow - upstream and downstream. Research needs to be applied in practice, yet in the building sector this is difficult to attain, if only because of cultural and functional differences between researchers and practitioners. A survey of Building Centres shows that they operate primarily in the information field and that they possess good contacts with professionals and members of the public. Networking with them could improve researchers' access to information users
Keywords: building centres, CIB, dissemination, R&D, research infrastructure.

1997, **25**(6), 335–337

International trends in research and technology development

Ir Wim Bakens
International Council for Building Research Studies and Documentation, PO 1837, 3000 BV, Rotterdam, The Netherlands

A changing environment for CIB. The way in which research and technology development in building and construction is conducted in most industrialized countries is changing dramatically. Major changes include a reduced dependence on government support for R&D, the development of a partnership between the construction industry and the research community, internationalization of construction research as a market, the subsequent impact for national research programmes, increased international collaboration between national research organizations, and the impact of electronic communication. The changing role of CIB is discussed as positive response to these challenges, which include the changing composition of CIB's membership (from East Asia and North America), increased participation by industry, more focused CIB programmes which are closely aligned to industry's priorities, and new ways of creating international teams and working methods through the use of electronic participation.
Keywords: CIB, international collaboration, R&D, research infrastructure, research management, trends.

1997, **25**(6), 338–347

Refurbishment management: challenges and opportunities

Charles O. Egbu
Building Research Establishment, Bucknalls Lane, Garston, Watford, Hertfordshire, UK

A structured approach to education and training is vital for refurbishment organizations to adapt to changing circumstances. The findings from this study involving feedback from refurbishment managers and organizations identify the challenges and opportunities facing the management of refurbishment works. For refurbishment contractors, survival will be contingent upon requisite skills, knowledge and competencies of their employees, as well as innovative processes, products, services, technologies and markets. The need for a structured approach to education and training for refurbishment management is argued as a vital component for refurbishment organizations
Keywords: education, feedback, future, refurbishment, training, trends, UK.

1997, **25**(6), 348–353

Moisture permeability measurements under varying barometric pressure

G H Galbraith[1], R C McLean[1] and D Kelly[2]
[1]*Department of Building & Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, UK*
[2]*Department of Mechanical Engineering, University of Strathclyde, Strathclyde, UK*

Experimental methodology is developed for measuring moisture permeability of vapour and liquid. The development of theories to describe combined heat and moisture transport through porous media has been the subject of a large volume of research over recent years. These theories are important for many areas of study including the investigation of the hygrothermal performance of building envelopes. This paper highlights the difficulties of obtaining separate values for the material vapour and liquid transfer coefficients, a knowledge of which is essential if combined heat and mass transport models are to be accurately solved. The determination of these individual coefficients is not possible using existing measurement methods which enable only a total moisture permeability to be measured with the liquid and vapour flux components combined. The possibility of carrying out measurements under varying barometric pressures to obtain this data is investigated and experimental results using particle board as a test material are reported and compared with results from a previously developed analytical approach.
Keywords: material testing, moisture, permeability, vapour, UK.

1997, **25**(6), 354–364

Manually powered manufacture of keyed bricks

J P Modak, V V Sohoni, H V Aware
Department of Mechanical Engineering, Visvesvaraya Regional College of Engineering, Nagpur, India

A study of the functional and economic factors in brick production using manually powered machines in India. The production of bricks, one of the main components in conventional construction technology, has been carried out by either a hand moulding process or by a fully mechanized process. Both processes have limitations in developing countries. An alternative solution is the use of decentralized non-power-consuming brick making units, utilizing unconventional raw materials which do not require baking to develop strength. A manually energized brick-making machine (MEBM) has proven the feasibility of extruding various mixes including a lime--fly ash--sand mixture. The production of bricks with a keyed cross-section is investigated using the MEBM to establish the functional and economic viabilities of the technology to create a construction technology which relies on abundant resources, unskilled labour and zero energy input
Keywords: appropriate technology, brick-making, energy, housing, India material.

1997, **25**(6), 365–369

Effect of silica fume on the concrete-steel bond

Abdulaziz A Bubshait and Bassam Tahir
Department of Construction Engineering and Management, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

Laboratory study on the enhanced engineering properties obtained by using silica fume as an admixture to concrete. Silica fume is used as an admixture to concrete to improve the engineering properties. Additions of silica fume improve the bond between concrete and steel reinforcing bars. The authors describe a laboratory study that explores the ultimate pullout load of steel reinforcing bars from concrete enhanced with silica fume
Keywords: concrete additive, concrete-steel bond, reinforced concrete, silica fume concrete.

1997, **25**(6), 370–373

Construction safety issues in Gaza Strip

Adnan Enshassi
Civil Engineering Department, Islamic University of Gaza, Gaza Strip, Israel

A survey of the causes of accidents on building sites, the current safety procedures used by local contractors and recommendations for improved safety. Safety is considered a critical problem in developed and developing countries. The author examines the causes of accidents on building sites and the safety procedures used by local contractors in Gaza Strip. A wide range of recommendations are necessary if hazards are to be eliminated and accidents reduced. Recommendations include a suitable training programme, supervisory methods for product quality and working conditions on site, improved working conditions, a safety regulatory framework including a safety institution, standards, and penalties

Keywords: accident, Gaza Strip, safety.

1997, **25**(6), 374–382

Classifying construction contractors

Gary D Holt
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK

A case study using cluster analysis. It is widely accepted in construction management literature that superlative contractor selection criteria are: contractor ability to complete a project on time, within budgeted cost and to expected quality standards. Hence, contractor evaluation and selection models with the ability to highlight these attributes (i.e. help the selection decision) should be fully exploited. To date, such models have evolved based predominantly on multi-attribute analysis, case-based reasoning, and discriminant analysis, but there is scope for investigation of alternative strategies including: fuzzy set theory; neural networks; regression techniques; and cluster analysis. This paper concentrates on the latter by applying cluster analysis to real-life contractor selection data. Results indicate that the technique will simultaneously classify large numbers of contractors while identifying the most significant discriminating criteria among them. These characteristics offer potential for rationalization of contractor evaluation, classification and selection

Keywords: cluster analysis, contractor, pre-qualification, tendering.

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1998, **26**(1), 3–16

Emerging trends in building environmental assessment methods

Raymond J Cole
School of Architecture, University of British Columbia, 6333 Memorial Road, Vancouver, British Columbia, Canada

The building environmental assessment field is reviewed since it first came into prominence in the early 1990s. Key limitations of existing building environmental assessment methods are identified and the emerging importance of issues such as sustainability, life-cycle assessment, globalization and standardization are discussed. The author provides a constructive direction for emerging 'second generation' building environmental assessment methods and protocols. This includes a standardization of environmental assessment methodologies; a common, generalized framework which allows for adaptation of specific and changing explicit criteria and an increased emphasis on building performance over time

Keywords: design, environmental assessment, life-cycle, sustainability, trends.

1998, **26**(1), 17–28

The implication of urban sustainability

Steve Curwell[1] and Ian Cooper[2]
[1]*Research Centre for the Built and Human Environment, University of Salford, Salford, UK*
[2]*Eclipse Research Consultants, The Eden Centre, Cambridge, UK*

This paper critically reviews current construction industry practice in environmental assessment, identifying gaps and shortcomings in current approaches when viewed from the wider perspective of sustainable development. Lack of common understanding is a significant problem. A number of blueprints for a more sustainable lifestyle which have merged from the business and manufacturing sectors such as 'natural step' and the 'service economy' are explored in order to identify changes that will be expected in the practice and procedures of the construction industry. This presents a considerable challenge, as the questions presented by the need to assess and create more sustainable buildings and cities require wider horizons, much greater resource efficiency and effective participation in decision making

Keywords: city, development model, environmental protection, public participation, sustainability.

1998, **26**(1), 29–38

Sustainable cities in developing countries

Amitava Deb
Information and Overseas Collaboration Division, Central Building Research Institute, Roorkee, India

Sustainable cities in developing countries are explored in relation to a complex web of linked issues at the macro, meso and micro level. The eco-system is but one of many considerations. This paper presents an overview of sustainable human settlements. Social equity and quality of life are placed within the context of defining factors including public policy, regulation and performance, finance, technological development and obsolescence, cultural heritage and tradition, management and operational activities, agricultural and land policies as well as redefining professional roles and education. The linkages between the defining factors must be better understood and radically rethought, integrated and managed if cities are to be made sustainable

Keywords: developing country, sustainable development, urban planning.

1998, **26**(1), 39–45

Developing indicators of sustainability: US experience

G Bradley Guy and Charles J Kibert
Center for Construction and Environment, University of Florida, PO Box 115703, Gainesville, FL 32511-5703, USA

Sustainability indicators integrate environmental, social, and economic factors such that the complex cause-and-effect relationships between these multiple factors can be more readily investigated. The whole systems approach of sustainable development differs from traditional environmentalism by its inclusion of economic and social factors. The selection of sustainability indicators will therefore inevitably be a human value-driven process. Environmental health will nonetheless be paramount. Empirical studies in the USA have found that states with lower pollution levels and more environmental regulation have healthier economies and fewer disparities in income between economic classes (Templet, 1995). In construction, indicators of sustainable construction are a necessary parallel to the macro-national and regional-scale indicators measuring society's movement toward or away from some approximation to sustainable development

Keywords: sustainability, sustainable construction.

1998, **26**(1), 46–55

Sustainable development and the Hungarian construction industry

Gyorgy Kunszt
Institute for Building Structures and Services, Budapest Technical University, Hunoru, Budapest, Hungary

The features of the Hungarian construction industry are typical of the 'transition countries' of Central Europe changing from planned to market economies. Integration with the European Union is defined as the key issue of sustainable Hungarian development until 2010. Increased economic development is argued as a necessary strategy to pay for improved quality of life and improved environment, despite certain construction projects not being sustainable over the long term. The requirements for joining the European Union are discussed in detail in relation to the changing Hungarian construction industry and the challenges presented to Hungary's existing and proposed infrastructure, planning, human resources and research agendas
Keywords: economic development, Hungary, investment, sustainable development.

1998, **26**(2), 76–93

The use of roundwood thinnings in buildings: a case study

Richard Burton, Michael Dickson and Richard Harris
ABK Architects, 7 Chalcot Road, London, UK. Buro Happold Engineers, Camden Mill, Lower Bristol Road, Bath, UK

Case studies in the design and construction of three buildings (a prototype house, training centre and student lodge) illustrate the development and viability of innovative roundwood technology. The use of roundwood technology is an environmental response to the efficient use of small-diameter timber from forests. This provides a new, local resource for construction and reduces waste from forests, which is normally thinned out and burned. The technological development of roundwood is discussed in terms of building design, jointing, flexure, timber treatment and the construction process. This paper presents an integrated, multidisciplinary approach to the architectural design, structural design and construction process of a new technology
Keywords: alternative technology, roundwood, sustainability, timber.

1998, **26**(2), 94–101

Domestic water supply using rainwater harvesting

Terry Thomas
Development Technology Unit, Department of Engineering, University of Warwick, Coventry, UK

World-wide pressure on water resources is mounting as populations grow, consumption per capita increases, 'fossil' water resources are mined and the climate changes. Domestic water usage is a significant component of water demand. Under favourable circumstances, it can be met in part or in whole by rainwater collected close to an individual dwelling. Interest in such systems is growing especially in rural areas where either rainfall is well distributed through the year, or where surface water is absent, groundwater mineralized and centralized piped supplies unaffordable. Roofwater collection is also being practised on low-rise and high-rise buildings in some cities having wet climates. The principles and components of rainwater harvesting are reviewed. Factors leading to the growing use of domestic rainwater harvesting in three different developing countries (North China, East Africa and Singapore) as case studies are discussed along with current practices, design options for system components and considerations for water quality and treatment. The lessons from developing countries can be applied to a European context as some European towns are beginning to require rainwater collection for toilet/laundry facilities in some new buildings
Keywords: alternative technology, building services, domestic water, rainwater, roof, sustainability.

1998, **26**(2), 103–112

Radiation absorption and urban texture

Koen Steemers, Nick Baker, David Crowther, Jo Dubiel and Marialena Nikolopoulou
The Martin Centre for Architectural and Urban Studies, Department of Architecture, University of Cambridge, 6 Chaucer Road, Cambridge, UK

This paper explores the relationship between the geometry of urban neighbourhoods and the microclimatic effects of solar radiation. It presents both the modelling techniques and key findings with the aim of quantifying solar absorption and its relationship to the urban heat island effect. The impact on the urban environment and building energy consumption is discussed, which raises potential implications for design. This work discusses only one main environmental factor, solar radiation, which is part of a larger ongoing research agenda addressing wider aspects of the urban microclimatic
Keywords: modelling, solar absorption, urban form, urban microclimate.

1998, **26**(3), 146–156

Building, the suppression of seasonal response and the effects on health

Yvonne Dean and Simon Warwick
MARU (Medical Architecture Research Unit), Faculty of the Built Environment, South Bank University, London, UK

The function of a building is to provide not just shelter and comfort, but to actively promote a healthy physiology. In reviewing the fields of environmental medicine and biometereology the authors propose that as buildings providethe main climate that people live in, this may affect seasonal response and could be a prime causal agent for ill health and 'sick building syndrome'. Flexible and seasonal changes of building use are introduced and parallels are drawn with marine environments for relearning physiological systems of adaptation. Conclusions include a rationale for looking at health problems within buildings by utilizing bodies of knowledge that already make useful links between climate and health. If this knowledge can be used as a predictive tool in the design and control of the built environment then it could make a significant impact on health and assist strategic decision-making in allocating resources towards an 'engineered' health care environment, as a major factor in primary health care

Keywords: biometeorology, climate, environmental medicine, health, seasonal response, sick building syndrome.

1998, **26**(3), 157–168

Moisture permeability data presented as a mathematical relationship

G H Galbraith, R C McLean and J S Guo
Department of Building & Surveying, Glasgow Caledonian University, Glasgow, UK.
Department of Mechanical Engineering, University of Strathclyde, Glasgow, UK

A detailed statistical analysis is presented of the correlation between moisture permeability and relative humidity based on experimental data obtained by the authors and a variety of other investigators using standard gravimetric measurement methods. In total, five proposed mathematical formulations are examined for five different types of material commonly used in building construction. The suitability of each formulation is investigated using non-linear regressiontechniques including an analysis of collinearity and relative standard error. This statistical approach allows the best functional form of equation for describing the variability of moisture permeability with relative humidity to be identified for building materials. A database covering a total of ten materials is then presented on the basis of this equation

Keywords: humidity, moisture, permeability, statistical validation. vapour, water.

1998, **26**(3), 169–180

Priority setting in planned maintenance: practical issues in using the multi-attribute approach

Qiping Shen[1] and Alan Spedding[2]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Kowloon, Hong Kong*
[2]*Faculty of the Built Environment, University of the West of England – Bristol, Frenchay, Bristol, UK*

The use of the multi-attribute model for priority setting in planned maintenance of large building stocks is introduced. Practical issues related to the proper use of the model, such as selection criteria for maintenance prioritization and allocation of weightings to these criteria are discussed. Successful validation of the model in both the UK and Hong Kong is demonstrated

Keywords: multi-attribute model, planned maintenance, prioritization.

1998, **26**(3), 181–189

Client influence on contractor health and safety in South Africa

John Smallwood
Department of Construction Management, University of Port Elizabeth, Port Elizabeth, South Africa

This research indicates that clients influence contractor health and safety as their requirements and decisions occur upstream. The need for a holistic approach to Total Quality Management through a partnering process incorporating client involvement is amplified by the current high level of fatalities and injuries. Clients have a positive role to play in lowering injury rates and influencing contracts

Keywords: client, health and safety, partnering, South Africa, total quality management.

1998, **26**(4), 208–222

Predicting lighting energy use under daylight linked lighting controls

Paul J Littlefair
Building Research Establishment Ltd, Garston, Watford, WD2 7JR, UK

For daylight to make a real contribution to energy efficiency, appropriate control of electric lighting is essential. This paper outlines methods to predict electric lighting use for various different types of control, given internal daylight illuminances. Two different kinds of calculation are considered. Annual lighting use can be determined from yearly daylight data, usually in the form of a cumulative distribution. More sophisticated computer programs use hourly daylight data to give a continuous profile of lighting use and the consequent energy flows and environmental conditions within a building. For both types of application, appropriate algorithms are given to quantify the savings from various types of photoelectric and manual controls.
Keywords:, control, daylight, energy, lighting, manual switching, photoelectric.

1998, **26**(4), 223–238

Linking procurement systems to project priorities

Mohan M Kumaraswamy and Sunil M Dissanayaka
Department of Civil & Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong SAR

The main objective of this work is to assess the impacts of various procurement variables on project performance, in comparison to the impacts of non-procurement related variables, such as project conditions and team characteristics. Since the impacts of specific procurement variables, such as contract type, have been investigated before, it was decided to first develop a comprehensive framework of procurement options. This framework is based on a holistic overview of procurement systems that included, for example, sub-systems of work packaging, and type of contract. A model was next developed to link the procurement system variables to project outcomes. Additional variables such as the characteristics of the project and the project participants were incorporated into this model as 'intervening' variables. A survey in Hong Kong tested the relative strengths of such procurement sub-systems and intervening variables, in terms of their influences on project outcomes. The interim results are described in this paper. This includes observations that cost and time overruns were not significantly influenced by the chosen intervening variables. Such observations led to the identification of particular needs to further probe the influences of team performance levels, as well as of procurement sub-systems. This evaluation of the other relationships in this proposed model will assist clients and their advisers to design more appropriate procurement systems, that should be geared to their particular project priorities.
Keywords: Hong Kong, performance, procurement, project.

1998, **26**(5), 268–279

Zephyrs of creative destruction: understanding the management of innovation in construction

Graham Winch
Bartlett School of Graduate Studies, University College London, Gower Street, London, WC1E 6BT, UK

The aim of this paper is to propose a comprehensive framework for the management of innovation in construction, addressing the construction innovation problem in two distinctive ways at the institutional and firm levels. First, an institutional perspective derived from research on complex systems industries is developed which provides an alternative to the volume production model for construction innovation research. The roles of the innovation infrastructure, innovation superstructure and systems integrator are all identified and applied to construction. The paper then moves on to the firm level where the two key innovation dynamics - the top-down adoption/implementation dynamic and the bottom up problem solving/learning dynamic are identified. The paper ends by calling for more case studies of the trajectories of construction innovations.
Keywords: innovation, integration, learning, problem solving, product.

1998, **26**(5), 280–296

Do regulations encourage innovation? The case of energy efficiency in housing

David M Gann, Yusi Wang and Richard Hawkins
SPRU, University of Sussex, Mantell Building, Falmer, Brighton, BN1 9RF, UK

This paper addresses the impact of building regulations on constraints and drivers for innovation. It seeks to clarify whether a supposed shift from prescriptive to performance-based regulations has improved the environment for technical innovation in energy efficient housing in Britain. We argue that when 'performance-based' building regulations are treated as static sets of technical requirements, their effect is similar to more traditional prescriptive forms of regulation. A more progressive approach is possible in which regulations can be used as part of a portfolio of policies aimed at improving performance. In this mode, functional performance specifications can stimulate systemic innovation. A flexible 'performance-based' form of standard could provide firms with the freedom, market incentive and institutional frameworks within which to innovate. The process itself could lead to information sharing and co-

operation but for this to be achieved, competitiveness and regulatory policies need to be co-ordinated better. Regulatory objectives and mechanisms for achieving them need to match. Regulations need to accommodate technical change at different levels in the production process, including new product development and systems integration.
Keywords: energy regulation, housing, performance-based regulation, technical innovation.

1998, **26**(5), 297–301

National system of innovation in France: Plan Construction et Architecture

Elisabeth Campagnac
Laboratoire Techniques, Territoires et Sociétés (LATTS), Ecole Nationale des Ponts et Chaussés (ENPC), 6-8 Avenue Blaise Pascal, Cité Descartes, F 77.455 Marne-la-Vallée Cedex, France

This paper presents the French system of innovation in the construction sector, and points out its strengths and its weaknesses, through the analysis of a specific institution: Plan Construction et Architecture (PCA). The originality of PCA is its capacity to encourage innovation by experimentation. PCA mobilizes all the representatives of the construction sector (clients, professionals, contractors, etc.) to conceive and work together on innovation, through 'Realisations Experimentales' (REX). Independent researchers provide expertise and evaluate the results of these experimentations. This paper points out the major lessons which can be drawn for this system.
Keywords: construction industry, France, housing, innovation, public policy, research policy, research organization.

1998, **26**(6), 322–329

Genetic algorithm compared to non-linear optimization for labour and equipment assignment

Heng Li[1], Peter E D Love[2] and Stephen Ogunlana[3]
[1]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hong Kong*
[2]*School of Architecture and Building, Deakin University, Victoria, Australia*
[3]*School of Civil Engineering, Asian Institute of Technology, Thailand*

The genetic algorithm is a technique based on evolutionary optimization. A methodology for optimizing labour and equipment assignment using the genetic algorithm is presented. A number of modifications are introduced to the three operators of the genetic algorithm, namely, reproduction, crossover and mutation. Results from the genetic algorithm are compared to the nonlinear optimization technique in solving the labour and equipment assignment problem. A comparison of the two techniques indicates that the genetic algorithm has the capacity to ensure a global optimal solution. However, its computational operations take longer than the nonlinear optimization technique in obtaining near-optimal or optimal solutions.
Keywords: equipment, genetic algorithm, labour, non-linear optimization, site operation.

1998, **26**(6), 330–339

Non-isothermal moisture diffusion in porous building materials

G H Galbraith[1], R C McLean[2], I Gillespie[3], J S Guo[1] and D Kelly[1]
[1]*Department of Building & Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 OBA, UK*
[2] *Department of Mechanical Engineering, University of Strathclyde, lames Weir Building, Montrose Street, Glasgow, Cl 1XJ UK*
[3]*Yarrow Shipbuilders, Brunei Project, South Street, Glasgow, C14 OXH, UK*

The hygrothermal. performance of building envelopes has been the subject of intensive research over the past decade, culminating in the development of a series of advanced computer-based simulation models. However, in spite of the considerable progress that has been made, a question which is not, as yet, fully resolved is the coupled effect of temperature gradient on moisture diffusion rates. As a result, the material transport data used as input for these models is generally determined from isothermal permeability measurements. This paper describes two investigations in which moisture flux experiments were carried out on small-scale material samples subjected to gradients in both temperature and humidity. In each case a different experimental technique was used and different materials were tested. An analysis of the results was undertaken in an attempt to identify the significance of any temperature-driven transport compared to the concentration-driven component.
Keywords: diffusion, material transport, moisture, permeability.

1998, **26**(6), 340–350

Is construction procurement a key to sustainable development?

A B Ngowi
Department of Building and Quantity Surveying, University of the Witwatersrand, Private Bag 3, WITS 2050, South Africa

Has specialization of professional roles obstructed the holistic approach and sustainable development? A preliminary survey in Botswana involving construction professionals found that existing procurement systems have not integrated the efforts of the different project participants and also fail to fulfil the expectations of the users. A holistic approach involving the re-integration of construction disciplines by applying new procurement methods is proposed. An integrated, holistic way of working could provide a number of synergies through the consideration of the building project as an entire system. The implications include better decision making upstream, more efficient use of resources and the mitigation of negative environmental effects downstream**.**

Keywords: Botswana, concurrent engineering, procurement method, professional role, sustainable development.

1998, **26**(6), 351–357

FMEA applied to cladding systems: reducing the risk of failure

Jeremy Layzell and Stephen Ledbetter
Centre for Window and Cladding Technology, University of Bath, BA2 7AY, UK

Failure Mode and Effects Analysis (FMEA) is a systematic and analytical quality planning tool for identifying and addressing what potentially could go wrong with a product or process. The project 'Failure Mode and Effects Analysis (FMEA) in the cladding industry' describes the FMEA technique, investigates failures of cladding on a system, component and process level, and maps the cladding supply chain and cladding-related decision making. The level of knowledge of failures and the fragmented industry structure prevents rigorous use of FMEA exemplified by other industries. However, a simplified form of FMEA can be performed based on the research findings to prioritize and inform decision-making and facilitate site inspection /supervision**.**

Keywords: cladding, decision making, failure, feedback loop, FMEA, risk analysis

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1999, **27**(1), 4–19

Productivity in buildings: the 'killer' variables

Adrian Leaman[1] and Bill Bordass[2]
[1]*Building Use Studies, 42-44 Newman Street, London, W1P 3PA, UK*
[2]*William Bordass Associates, 10 Princess Road, London, NW1 8JJ, UK*

Losses or gains of up to 15% of turnover in a typical office organization might be attributable to the design, management and use of the indoor environment. There is growing evidence to show that associations between perceived productivity and clusters of factors such as comfort, health and satisfaction of staff. Some of the management, design and use characteristics which contribute towards better energy efficiency also help productivity, thereby helping to close the loop on a potential 'virtuous' circle. Unfortunately, the vast majority of occupied buildings do not have these self-reinforcing qualities and many are unmanageably complex. This paper examines which factors within the control of building designers and managers best contribute to human productivity, the 'killer' variables of the title.
Keywords: comfort, complexity, energy efficiency, productivity, workplace.

1999, **27**(1), 20–34

Application of information technologies in building design decisions

Konstantinos Papamichael
Building Technologies Department, Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley CA 94720, USA

Research and development of a new sophisticated software environment to support building design decisions are presented. This new software, the Building Design Advisor (BDA), is intended as a research tool, teaching aid and, eventually, as a practical professional tool to facilitate both strategic and detailed decision-making throughout the design process from the early schematic phases of building design through to the detailed specification of building componentsand systems. BDA supports the integrated, concurrent use of multiple simulation tools and databases, while allowing output to support multi-criterion judgement. BDA's ultimate aims are to address the data needs of whole building life-cycle analysis: design, construction, commissioning, operation, performance and demolition.
Keywords: building performance, data model, design process, information management, information technology, life-cycle analysis.

1999, **27**(1), 35–55

Developing a new military shelter system: a case study in innovation

N K Burford[1] and F W Smith[2]
[1]*School of Architecture, University of Dundee, Perth Road, Dundee, DD1 4HT, UK*
[2]*Department of Civil Engineering, University of Dundee, Perth Road, Dundee, DD1 4HN, UK*

A lightweight, rapid-erect shelter system using a new combination of composite materials and fabric diaphragms in a truss support system has been developed in response to changes in military requirements. This paper outlines the background to the project and the reasons for its inception; it follows the development of the design from initial conceptual idea to eventual solution. Decisions influencing the overall design, structure, materials, prototyping and manufacturing techniques are discussed in relation to performance criteria and client capabilities. The focus is on the problems encountered in the development programme and the innovation process, highlight how these problems were overcome and detail the benefits that were created. In particular, the resulting tent incorporates lightweight sprung glass reinforced composite beams, post-tensioned by a fabric diaphragm. The new shelter uses a minimum number of these lightweight, rigid components and consequently achieves a reduction in weight, erect and strike times and packed bulk through its innovations.
Keywords: advanced material, case study, design management, innovation, prototype, shelter, tent.

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Developing a new military shelter system: a technical study in advanced materials and structures

N K Burford[1] and F W Smith[2]
[1]*School of Architecture, University of Dundee, Perth Road, Dundee, DD1 4HT, UK*
[2]*Department of Civil Engineering, University of Dundee, Perth Road, Dundee DD1 4HT, UK*

The development of a new lightweight military shelter system is based on an unusual composite structural system utilizing the innovative use of pultrusion production techniques for plastic. The authors report on the combined development of both the structural system and the components, which are made from linear pultruded sections of

reinforced plastic, and an anticlastic stressed membrane. The shelter comprises a 'kit' of purpose-designed components, which are used to fulfill the multiple requirements of the shelter brief. This has resulted in a smaller number of component parts, less weight and enhanced ease of fabrication and assembly. Some of the techniques used in the design of components and parts indicate an alternative approach to the use of plastics in building construction.
Keywords: material, composite material, lightweight structure, reinforced plastic, shelter, tent, thermosetting plastic.

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The significance of financial risks in BOT procurement

Ka Chi Lam[1] and Wing Sing Chow[2]
[1]*Department of Building and Construction, City University of Hong Kong, Tat Chee Ave, Kowloon, Hong Kong*
[2]*Airport Authority Hong Kong, 8 Chun Yue Road, Hong Kong International Airport, Lantau, Hong Kong*

The significance of the financial risk characteristics of Build-Operate-Transfer (BOT) projects is explored. The objective was to identify and discuss the significance of the types of financial risk variables in conjunction with the different phases of procurement. A survey was therefore conducted to investigate the nature of the relationships between the financial risk variables and the different phases of BOT projects. 'Interest rate fluctuation' was the most significant financial risk variable in the pre-investment phase. For the implementation phase, both the variables 'design deficiency' and 'time overrun' were found to be highly statistically significant. The variable 'time overrun' was found to be the most statistically significant in the construction phase. The majority of the risk variables were considered to be moderately significant in the operations phase; these included 'competition', 'currency exchange restrictions' and 'defective products or facilities'. A mathematical model employing discriminant analysis was established to demonstrate the classification of financial risk variables in relation to the five BOT project phases.
Keywords: BOT, financial risk, Hong Kong, private finance initiative, procurement, risk analysis.

1999, **27**(2), 96–108

Visualization of photovoltaic clad buildings

Margaret Horne[1], Robert Hill[2] and Robert Giddings[1]
[1]*Department of the Built Environment, University of Northumbria at Newcastle, Ellison Building, Newcastle upon Tyne NE1 8ST, UK*
[2]*Newcastle Photovoltaics Applications Centre, University of Northumbria at Newcastle, Ellison Building, Newcastle upon Tyne NE1 8ST, UK*

The need to be able to visualize buildings is not new, and tools to aid architectural visualization have developed over the years, up to the current trends in computer-aided design. The emergence of complex building materials and an increase in the number of participants involved in the design process is placing more demands on visualization tools. The technology of photovoltaics, the conversion of solar energy to electricity, has resulted in the emergence of photovoltaics as a building material. Designs for photovoltaic clad buildings, new-build or refurbished, need to be viewed by client, architect, engineer, photovoltaic specialist and the public. Architects are concerned with aesthetics, engineers with structural and environmental performance. Clients are concerned with aesthetics, performance and cost. The contribution of computer-aided design technology to the visual assessment of photovoltaic clad buildings is investigated. Issues of computer representation and communication between interested parties in the design process are examined. Widely used, low cost, commercially available software can contribute to the visualization of photovoltaic clad buildings, but issues are raised relating to the credibility and appropriateness of the end results of computer visualizations to meet the needs of interested parties.
Keywords: CAD, design, software evaluation, photovoltaics, visualization.

1999, **27**(2), 109–119

Factors in formwork selection: a comparative investigation

D G Proverbs, G D Holt and P O Olomolaiye
The Built Environment Research Unit, School of Engineering & the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

Results of an investigation concerning preferred methods of construction formwork by contractors' planning engineers in France, Germany and the UK are presented. Findings confirm differences amongst preferred solutions in these international locations. French and German contractors tend to employ similar proprietary formwork methods, whilst the UK 'standalone' in preferring traditional timber solutions. It is found that company size has no significant impact on the formwork system selected. Nine formwork selection factors are identified, and ranked in terms of importance for each international group of contractors. Statistically, the rankings are shown to have significant correlation for each pair of countries. 'Relative costs', 'Specification (quality) of concrete' and 'Degree of repetition', are found to be the principal formwork selection criteria. Correlation analysis reveals association between many of these selection factors.
Keywords: concrete, contractor, Europe, formwork, planning.

1999, **27**(2), 120–123

Quasi-static testing of composite masonry construction

Hu Wei[1] and Hu Minggang[1] and He Qun[2]
[1]*Shandong Institute of Architecture and Engineering, 47 Heping Road, Jinan 250014, People's Republic of China*
[2]*Shangdong Jinn No. 4 Construction Group, Jinan 250001, People's Republic of China*

Research is introduced that investigates the effects of earthquakes on composite masonry and concrete buildings in China. The quasi-static test is used on a nine-storey composite masonry quarter-scale model. The structure is analysed under loads to assess structural ductility, power absorption ratio, damping, etc. Testing indicates important conclusions for architects and policy makers. Bending effects induced by earthquakes can be minimized and controlled by the design of the building's depth to width ratio. Composite masonry construction can be an appropriate technology for buildings of less than nine storeys in China's earthquake regions.
Keywords: China, composite masonry, earthquake resistance, quasi-static testing.

1999, **27**(3), 127–139

Using portable datafiles in the construction supply chain

Laurence E Marsh and Edward F Finch
Department of Construction Management and Engineering, The University of Reading, Whiteknights, PO Box 219, Reading, RG6 6AW, UK

Portable datafile technologies such as high density bar coding and electronic tagging now permit very high information storage capacities. Aside from anecdotal evidence, there are few examples of these technologies being used within construction. The potential advantages of using portable datafiles are explored for storing and transmitting information relating to construction materials and components. A structured methodology aids the definition of information that could be encoded within labels or tags and the stages within the supply chain where such a device would most fruitfully be employed. A case study demonstrates both the operational and financial feasibility of using portable datafiles within the scenario of a live project. Recommendations are made for the development of a construction industry standard for portable datafiles as part of a framework to promote more widespread deployment of the technologies.
Keywords: auto-ID, bar coding, electronic tagging, information management.

1999, **27**(3), 140–148

Developers, regeneration and sustainability issues in the re-use of vacant industrial buildings

Rick Ball
School of Sciences, Staffordshire University, College Road, Stoke-on-Trent, ST4 2DE, UK

The outcomes from a survey of developer and related organizations active in a local industrial property market in mid-1998 are reported in respect of the use and re-use of industrial buildings. The discussion focuses on both refurbishment and re-use and new-build sectors, and draws out some evidence on sustainability issues. Despite a relatively limited understanding of sustainability as a concept, developers are found to have a positive attitude to re-use when conditions allow it. Indeed, those more actively involved in re-use have sometimes engaged in a variety of practical, sustainable solutions to refurbishment needs. Most are open to influence on questions of good practice and sustainability. This all suggests that legislation designed to turn the development and construction industry towards brown-fleld opportunities and the sustainable re-use of existing infrastructure is likely to induce a favourable response.
Keywords: building stock, developer, industrial building, refurbishment, re-use, sustainable development, vacant property.

1999, **27**(3), 149–164

Is solar air conditioning feasible?

Sandy Halliday[1], Clive Beggs[2] and Tariq Muneer[3]
[1]*Gaia Research, The Monastery, Hart Street Lane, Edinburgh, EH1 3RG, UK*
[2]*School of Civil Engineering, University of Leeds, Leeds, LS2 9JT, UK*
[3]*Napier University, 10 Colinton Road, Edinburgh, EH10 5DT, UK*

The feasibility of desiccant cooling in UK climates is examined, using gas -solar hybrid technology for regeneration. Desiccant cooling is a heat driven system. It has potential to reduce energy costs and environmental pollution, when compared with conventional vapour compression systems. The regeneration of the desiccant can be provided by any low temperature warm air or water source including waste heat, CHP, gas or solar. Heat recovery is also available. Gaia Research worked with Napier University to develop computer codes for the simulation of solar energy collection and hot water delivery to drive the desiccant cooling system, based on real meteorological data. A solar desiccant computer model was developed with the University of Leeds, which analysed the energy consumption and costs associated with desiccant cooling using meteorological data for an inner London site in 1994. The study demonstrates that coupling the desiccant system to solar collectors produces significant savings in both running cost and CO_2 emissions. The existing models of solar contribution and desiccant cooling will be refined. This will enable an

assessment to be made of the UK opportunities for energy conservation and CO_2 emission reduction in relation to latitude, internal design conditions, and real loads.
Keywords: air conditioning, alternative technology, desiccant, efficiency, energy, passive design, solar.

1999, **27**(3), 165–182

Semi-prefabrication concrete techniques in developing countries

B L M Mwamila[1] and B L Karumuna[2]
[1]*Civil Engineering Department, University of Dares Salaam, PO Box 35131, Dares Salaam, Tanzania*
[2]*ITECO Engineering Ltd, Tanzania Branch, P.O. Box 544, Morogoro, Tanzania*

Providing housing to the general population at an affordable cost is a colossal task facing governments in developing countries. Through the adoption of semi-prefabrication techniques, concrete construction is re-appraised for enhanced quality, economy and speed. This study involved identification of areas of optimization, design and analysis of model buildings. Outcomes indicate that semi-prefabrication concrete techniques are appropriate for achieving quality, economy and speed of construction.
Keywords: appropriate technology, concrete, housing, developing country, semi-pre-fabrication, Tanzania.

1999, **27**(4), 206–220

The built environment and the ecosphere: a global perspective

William E Rees
The University of British Columbia, School of Community and Regional Planning, 6333 Memorial Road, Vancouver, BC V6T 1Z2, Canada

The human population is rapidly urbanizing, leading many observers to conclude that humans are leaving nature and the countryside behind. This is a perceptual error consistent with the technological optimism inherent in the prevailing expansionist cultural worldview. By contrast, ecological analysis reveals that modern cities are actually increasingly dependent on the goods and services of nature. This fact is merely obscured by technology and urbanization itself. Typical high-income cities appropriate the productive and assimilative capacity of a vast and increasingly global hinterland, resulting in an 'ecological footprint' several hundred times larger than the areas they physically occupy. In the next 27 years, the urban population alone is expected to grow by the equivalent of the total human population in the 1930s. This will double the 1970s urban presence on the Earth. Unfortunately, the conventional development path is biophysically unsustainable, calling for a radical transformation of our thinking about urban form and function. Buildings account for 40% of the materials and about a third of the energy consumed by the world economy. Combined with ecocity design principles, green building technologies therefore have the potential to make an enormous contribution to a required 50% reduction in the energy and material intensity of consumption globally. The needed dematerialization increases to 90% in the high-income countries. Such enormous gains in material productivity are unlikely in the absence of significant ecological fiscal (tax) reform. Ironically, then, the most effective path to green buildings and ecocities may be intensive lobbying for higher taxes on primary energy and materials.
Keywords: city, ecological footprint, green building, regulation, sustainable development, urban design.

1999, **27**(4), 221–229

GBC '98 and GBTool: background

Raymond J Cole[1] and Nils K Larsson[2]
[1]*School of Architecture, University of British Columbia, Vancouver V6T 1Z2, Canada*
[2]*Natural Resources Canada, 580 Booth Street, Ottawa, Ontario K1A 0E4, Canada*

Green Building Challenge '98 (GBC '98) was a 2-year development process involving international teams from 14 countries. The overall goal of Green Building Challenge '98 (GBC '98) was to develop, test and demonstrate an improved method for measuring building performance across a range of environmental and energy issues and then to inform the international community of scientists, designers, builders and clients about the results. 34 case study buildings from 14 countries were used to test and demonstrate this new method. As a second-generation method for assessing building performance, the GBC '98 assessment framework builds on the first generation systems developed in a number of countries. Unique to GBC '98 is the provision of an international framework capable of being adapted to national or regional circumstances. A description of the design goals and design features of the GBC '98 assessment method and GBTool is provided. Both the process and the product have served to stimulate critical debate about the scope and role of building environmental performance assessment and the actual design of green buildings.
Keywords: building performance, environmental assessment, green building.

1999, **27**(4), 230–246

Building environmental assessment methods: clarifying intentions

Raymond J Cole
School of Architecture, University of British Columbia, Vancouver, V6T 1Z2, Canada

The intentions for, and the thinking behind, the Green Building Challenge (GBC) assessment framework and its development are made explicit. Three separate roles for environmental assessment of buildings are disentagled

(stimulating owners to improve a building's performance, informing decision-makers during the design stages and delivering objective measurements of a building's impact on natural systems). Some significant lessons from the development exercise are identified and further implications and directions for developing environmental assessment methods for buildings are discussed. A distinction is made between 'green' and 'sustainable' agendas and their implications for the future development of building environmental assessment methods. This is essential in order to clarify the many roles and applications demanded of these tools. The considerable practical overlap between the 'green' and 'sustainable' agendas suggests that they can be reconciled within a single tool. 'Green' performance is most usefully described in relative terms in comparison to similar buildings in the region, while absolute energy and mass flows are a prerequisite for assessing progress towards sustainability. A fewer number of carefully elected performance measures are required to provide a measure of a building's role in ecological sustainability than to describe its green performance. The GBC process has clarified the roles and applications demanded of different tools and these lessons will be integrated into the restructuring and application of GBTool, and add significantly to the wider debate on environmental assessment.
Keywords: design tool, environmental assessment, feedback, labelling, sustainable development.

1999, **27**(4), 247–256

Regional and cultural issues in environmental performance assessment for buildings

Joel Ann Todd[1] and Susanne Geissler[2]
[1]*The Scientific Consulting Group, Inc., 656 Quince Orchard Road, Suite 210, Gaithersburg, MD 20878, USA*
[2]*Austri an Institute for Applied Ecology, Seidengasse 13, A-1070 Vienna, Austria*

The Green Building Challenge '98 (GBC '98) developed and tested an international assessment system for buildings. An underlying premise of GBC '98 was to allow for regional differences by providing flexibility and weighting of building assessment criteria within an international framework. This was considered crucial for the acceptability of the assessment system as well as for its ability to accurately reflect best local practice. Regional adaptation is complex, however, and raises many considerations that may be in conflict. This paper analyses the importance of integrating regional aspects into assessment tools on the one hand and the benefit of setting up an international assessment system on the other. An approach for achieving a balance between the regional and international levels of a universal assessment system is discussed. Issues and proposed solutions for further consideration are raised along with suggested topics for further research.
Keywords: culture, environmental assessment.

1999, **27**(4), 257–276

Customizing and using GBTool: two case-study projects

Raymond J Cole and Laura Mitchell
School of Architecture, University of British Columbia, Vancouver, V6T 1Z2, Canada

This paper highlights the differences in the customization and use of GBTool during the GBC '98 process by contrasting the assessments of two multiunit residential case-study projects: the Ekoporten project (renovation project), Norrkoping, Sweden and Co-housing project (new build), Cambridge, Massachusetts, USA. The application of GBTool in the two projects suggests that the differences between assessing new and refurbishments is much more significant than initially envisaged. The customizing of the default Performance scales was extensive. The wide range of interpretations that different National Teams placed on the various criteria reinforced the importance of regionally specific assessment methods. The Non-applicability designation was often applied due to technical difficulties in performing an evaluation rather than whether or not the performance issue was pertinent to the case-study project. The Criticality-Non-criticality designation was ineffectively used during this first testing of the assessment process, primarily due to the absence of meaningful guidance. Although an option existed for National Teams to propose the addition of a limited number subcriteria unique to the region or building type it was not used. The GBC process clearly showed that users need time to become familiar with an assessment procedure and it is evident that a much clearer and consistent set of directives must be provided to assist in any customization process than currently evident within the GBC process.
Keywords: case study, environmental assessment, green building, Sweden, USA.

1999, **27**(5), 286–293

The Green Building Challenge in the UK

S Curwell[1], A Yates[2], N Howard[2], W Bordass[3], and J Doggart[4]
[1]*Research Centre for the Built and Human Environment, University of Salford, Salford, M5 4WT, UK*
[2]*Centre f or Sustainable Construction, Building Research Establishment, Bucknalls Lane, Garston, Watford, WD2 7JR, UK*
[3]*William Bordass Associates, 10 Princess Road, London, NW1 8JJ, UK*
[4]*ECD Energy & Environment Ltd, 11-15 Emerald Street, London, WC1N 3QL, UK*

The background to and feedback from the UK team on the Green Building Challenge process in the UK is provided along with a commentary on the future development of the environmental assessment of buildings. Unique amongst the

GBC national teams, the UK team chose buildings that had undergone post-occupancy evaluation. As a consequence, buildings were evaluated on their design, construction and operation phases. This additional information on actual rather than predicted performance provides a number of important lessons for the environmental assessment of buildings. Future expectations for the development of GBC from the UK perspective include providing proper credit for design features such as low-energy passive cooling and daylighting, modifying the assessment weighting system to provide more reliable comparison or benchmarking between design solutions, providing a practical international assessment method for comparison or benchmarking, incorporating post-occupancy evaluation to validate assessment methods and tools. Ease of use is important and GBC could usefully be simplified to consider the point of application in design, post-design certification and post-occupancy. Environmental assessment of buildings in the future must evolve within a wider context of local Agenda 21 sustainable development criteria.
Keywords: BREEAM, environmental assessment, feedback, green building, post-occupancy evaluation, UK.

1999, **27**(5), 294–299

Japanese expectations for green building assessments

Nobuyuki Kimata
Kajima Design, 6-5-30 Akasaka, Minatoku, Tokyo, 107-8502 Japan

The background and feedback on the Green Building Challenge '98 process in Japan is provided by a representative from one of two Japanese teams (representing the Building Constructors' Society). The positive process of validating and adapting the international criteria to particular national circumstances and then customizing these criteria is explained. Three significant benefits to the Japanese building industry are discussed: existing technologies and methodologies were validated, it was discovered that these have potential for world-wide application, the life expectancy of Japanese buildings needs to be lengthened. Future expectations from Japan include: the ongoing refinement of the international framework for the environmental assessment of buildings; the customization of criteria requires further structure and limits, a critical review of the customization process; an expansion embracing both developed and developing nations' new and existing buildings. The prototype green building assessment from GBC '98 has the potential to be refined and adopted as a worldwide methodology and is endorsed as the fastest way to achieve world-wide consensus.
Keywords: environmental assessment, feedback, green building, Japan, longevity.

1999, **27**(5), 300–308

Building environmental assessment methods: applications and development trends

Drury Crawley[1] and Ilari Aho[2]
[1]*US Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585-0121, USA*
[2]*Motiva, P.O. Box 462, FIN-02151 Espoo, Finland*

The construction and property sector has seen the development of a number of methods for evaluating the 'greenness' of buildings in the 1990s -both for new designs and existing buildings. These range from very detailed life-cycle assessment methods, which account for all the embodied and operational environmental impacts of building materials, to higher level environmental impact assessment methods, which evaluate the broader implications of the building's impact on the environment. In between these two are environmental assessment methods such as BREEAM, BEPAC, LEED, and GBA. In this paper, we discuss the potential market applications of these systems and compare and contrast several of the major environmental assessment methods.
Keywords: building performance, environmental assessment, green building, life-cycle assessment.

1999, **27**(5), 309–320

The relevance of Green Building Challenge: an observer's perspective

Niklaus Kohler
Universität Karlsruhe, Institut für industrielle Bauproduktion, Englerstrasse 7, D-76128 Karlsruhe, Germany

The objectives and achievements of the international Green Building Challenge project are analysed. GBC is situated within the context of other international environmental methods. The differences between assessment tools, design tools, environmental management and audit tools and the large data problems entailed by these are discussed. Possible development scenarios for extending GBC into Life-cycle Assessment methodology, into other life-cycle phases (maintenance and refurbishment) and adapting GBC for use with the existing building stocks are proposed. The notion of 'green' buildings is replaced by a larger concept of sustainable development. New aggregation principles and scaleable design methods are proposed. Finally, the question of how relevant the proposed targets of GBC are in relation to the long-term sustainable development of buildings, building stock and urban environments is addressed.
Keywords: design tools, environmental assessment, green building, life-cycle assessment, sustainable development.

1999, **27**(5), 321–331

Which focus for building assessment methods: environmental performance or sustainability?

Ian Cooper
Eclipse Research Consultants, The Eden Centre, Cambridge, CB1 1DP, UK

A personal response to the Green Building Challenge '98 conference, held in Vancouver in September 1998, is presented. This is an attempt to link together conceptually - and then comment on critically - the two main challenges thrown down at the conference. These were offered at the start and end by Rees and Kohler and were, respectively: (1) that developed countries reduce the environmental impact of their built environment tenfold by 2040 (Rees, 1999: 216), and (2) that they stop constructing additional new buildings, limiting themselves instead to improving their existing stock (Kohler, 1999: 317). Although not mentioned by Rees or Kohler, both of these challenges could be tackled, for example, through adopting a Service Economy approach to improving the built environment in industrialized countries. This could allow room - in terms of both resources input and pollution output - for the rapid urbanization predicted (and already occurring) in developing countries over the next 30 or 40 years. This paper seeks to locate their challenges in the context of broader initiatives to 'dematerialize' industrial economies. This is done in order to question whether the development of methods for assessing building performance should continue to address the relatively narrow resource-efficiency agenda that has predominated over the past ten years or whether it should now be extended to begin to tackle a wider remit - the sustainability of the built environment.

Keywords: environmental assessment, green building, service economy, sustainable development.

1999, **27**(5), 332–341

Development of a building performance rating and labelling system in Canada

Nils K Larsson
Natural Resources Canada, 580 Booth Street, Ottawa, Ontario, K1A 0E4, Canada

The recent GBC '98 conference presented the results of a two-year process of developing and testing a new approach to the performance assessment of buildings. The international process is continuing, but in many jurisdictions, including Canada, there is a desire to test the implementation of a system, one that includes ratings and labelling as well as performance assessments. This paper attempts to outline some of the factors that are seen by Natural Resources Canada (NRCan) as relevant to the need, market potential and barriers to such a system. The roles of various actors are considered including industry and government organizations, investors, utilities, building information centres, standards organizations, performance assessors, building owners and operators, tenants.

Keywords: Canada, environmental assessment, labelling, market change mechanisms, performance rating, public policy, trends, voluntary system.

1999, **27**(6), 348–354

CIB Agenda 21 for sustainable construction: why, how and what?

Christer Sjo Öström[1] and Wim Bakens[2]
[1]*KTH (Royal Institute of Technology), Centre for Built Environment, P.O. Box 88, S-801 02 Gävle, Sweden*
[2]*CIB (International Council f or Research and Innovation in Building and Construction), P.O. Box 1837, 3000 BV, Rotterdam, The Netherlands*

CIB's efforts to create an Agenda 21 for the construction sector are introduced here. CIB's unique position within the international construction community allowed it to initiate a specific sectorial response to the international agendas raised by Brundtland, Habitat II, Rio and Kyoto. CIB's recognition of the problems in establishing both a framework for sustainable development; how change within industry occurs, along with CIB's past, current and proposed activities meant that CIB was perfectly suited to respond to sustainable development. This CIB-led project resulted in global collaboration and co-ordination to specifically address sustainable development for the construction community. Situated between the broad international agendas and more local and sub-sectorial agendas, CIB's Agenda 21 is a conceptual framework that serves as an intermediary and provides for comparison and co-ordination. The three principal objectives are: to create a global framework and terminology that will add value to national, regional and sub-sectorial agendas; to create an agenda for CIB activities and for co-ordinating CIB with specialist partner organizations, and to provide a source document for definition of R&D activities.

Keywords: building design, CIB, construction process, public policy, R&D, research policy, sustainability.

1999, **27**(6), 355–367

Sustainable development and the future of construction: a comparison of visions from various countries

Luc Bourdeau
Centre Scientifique et Technique du Bâtiment, BP209, F06904 Sophia Antipolis, France

This international CIB W82 Project aimed to answer the following question: 'What will be the consequences of sustainable development on the construction industry by the year 2010?' This future study investigated the relationship and defined links between the principles of sustainable development and the construction sector. Drawing on information from 14 countries, the study identified main issues, constraints and current policies, predicted changes and adaptations for the construction sectors in each country, analysed the consequences for the phases of the construction process, provided recommendations to the main actors, illustrated the need for further best practice case studies, design methods, buildings or building products.
Keywords: building design, future, public policy, R&D, research policy, sustainability, technical change, trends.

1999, **27**(6), 368–378

Sustainability and the performance concept: encouraging innovative environmental technology in construction

Jan Bröchner[1], George K I Ang[2] and Gösta Fredriksson[1]
[1]*School of Technology Management & Economics, Chalmers University of Technology, SE-412 96 Göteborg, Sweden*
[2]*Government Building Agency, P.O. Box 20952, NL-2500 EZ The Hague, The Netherlands*

Encouragement of innovation is a major reason for using the performance concept in construction regulations and specifications, mostly in the context of design-build contracts. Performance criteria aiming at sustainability emphasize long-term behaviour of built facilities, which complicates the measurement of compliance. Strategies for identifying areas with strong promises of innovative technologies should be developed, so as to concentrate the efforts in developing performance requirements. The development of standardized consensus methods and procedures should be accelerated. Finally, it is suggested that good examples of how performance requirements can be expressed and monitored should be made globally avail-able.
Keywords: innovation, life-cycle assessment, performance specification, sustainability.

1999, **27**(6), 319–390

Sustainable development demands dialogue between developed and developing worlds

Chrisna du Plessis
Division of Building and Construction Technology, CSIR, P.O. Box 395, Pretoria 0001, South Africa

The international construction community's understanding of sustainable development is compromised by a systemic communication gap between the developed and developing worlds as well as a failure to address the implications of social requirements. The inclusion of the developing world within the sustainable development debate is argued as essential and the obstacles to achieving this are considered. Initiating a real dialogue in an equal partnership between the developed and developing worlds is a key challenge to define the process, guidelines and achieve protocols for sustainable development. Although CIB has recently commenced engaging with the developing world, much more needs to be done.
Keywords: CIB, ethics, decision making, developing world, quality of life, social sustainability, sustainable development.

1999, **27**(6), 391–397

Sustainability in management and organization: the key issues?

P S Brandon
Research and Graduate College, University of Salford, Faraday House, Salford, M5 4WT, UK

An introduction is provided to some of the key issues relating to the context of sustainability. A more holistic approach to sustainability is called for, built around a consensus of an agreed definition and a philosophical framework to allow a meaningful discussion to take place, leading to improved decision making. At this emerging stage of the topic, it is recognized that even these matters are research issues and that in parallel with this debate it is important that progress at the sub-problem level must continue. These issues provide a context for many of the papers in these proceedings.
Keywords: decision making, environmental impact, sustainability.

1999, **27**(6), 398–405

Integrated delivery systems for sustainable construction

P S Barrett, M G Sexton and L Green
The Research Centre for the Built and Human Environment, Bridgewater Building, University of Salford, Salford, M5 4WT, UK

This study, based on a Delphi exercise and further analysis, provides a consensus view on sustainable development in relation to the construction industry, together with a broad improvement-oriented model. A pressure-state-response model has been infused with carefully identified priorities to give an iterative agenda for action.
Keywords: feedback, modelling, sustainable development, UK.

1999, **27**(6), 406–409

Materials and technology for sustainable construction

Michael A Lacasse
National Research Council of Canada, Institute f or Research in Construction, Building Envelope and Structure, Ottawa, Ontario K1A OR6 Canada

Research undertaken in the development of basic approaches for and dissemination of information on the design, maintenance, re-use or renewal and assessment of materials and technologies for sustainable construction were the focus of Symposium A at the 1998 CIB Gäyle Conference. Contributions have been prepared within four areas including: (i) performance, durability and service life, (ii) information technologies, (iii) life-cycle analysis and maintenance management, and (iv) environmental technologies and processes. A summary of the more significant contributions within these specific areas is provided.
Keywords: sustainability, performance, durability, life-cycle analysis, environmental technology, maintenance.

1999, **27**(6), 410–412

Legal and procurement practices for sustainable development

Christopher Pollington
CIB (The International Council for Research and Innovation in Building & Construction),P.O. Box 1837, 3000 BV Rotterdam, The Netherlands

The current relationships between post-construction liability, insurance, procurement and the concept of sustainable development were the focus of Symposium C at the 1998 CIB Gävle World Building Congress. A number of issues were identified as impacting on procurement: ethical and human rights, higher environmental standards, ecodesign principles, life-cycle implications and performance specification, understanding clients' cultural values. Alternative procurement strategies will be required to incorporate sustainability issues. The impact of environmental and sustainability issues on liability presents increased risks and this results in new forms of insurance coverage for all environmental risks.
Keywords: culture, liability, mediation, procurement, risk, sustainability.

1999, **27**(6), 413–419

The fifth EU framework programme and its consequences for the construction industry

Christian Patermann
European Commission, Directorate General XII, Rue de la Loi 200, B-1049 Brussels, Belgium

The EU's 5th Framework Programme provides significant opportunities for the construction industry to en-gage in innovation and change in many areas: preserving the ecosystem, promoting competitive and sustain-able growth, economic and energy efficiency, integrated approaches for sustainable development of cities, rational management of resources; protection, conservation and enhancement of cultural heritage, assessing strategies for sustainable urban transport. EU R&D activities (in concert with other actors) are a potent contributor to facilitate fundamental transformation not only of the construction industry's processes, products and environmental and social impacts but of the construction industry itself.
Keywords: European Union, innovation, public policy, R&D, research policy, sustainability, trends.

1999, **27**(6), 420–424

The UK's approach to sustainable development in construction

Nick Raynsford
Department of the Environment, Transport and the Regions, Eland House, Bressenden Place, London, SW1E 5DU, UK

This paper, updated from a speech delivered to the CIB World Congress on 12 June 1998 at Gävle, Sweden, outlines recent and proposed developments by the UK government on its approach to sustainable development in construction. A wide definition of sustainability includes social progress, environmental protection, prudent use of natural resources

and economic growth/stable levels of employment. A wide array of measures have been or will be implemented: an integrated national transport policy, a national programme of CO 2 reductions from new (and possibly existing) buildings, a Social Exclusion Unit, a Welfare to Work programme, demonstration projects of sustainable construction, a new sustainable development strategy, dialogue with the construction industry, waste reduction schemes, landfill and aggregate taxes, improved management of water resources, an emphasis on whole life costs rather than initial capital costs of buildings, the development of sustainability indicators.

Keywords: public policy, sustainability, UK.

1999, **27**(6), 425–431

Sustainable development for industry and society

Björn Stigson

World Business Council for Sustainable Development, 160 route de Florissant, CH-1231 Conches-Geneva, Switzerland

A holistic view is presented on the issues and challenges facing business which in its the move towards sustainable development. There is a strong shift from a few years ago when the environment and sustainable development were viewed by business as risk factors. The situation today (and even more in the future) is that these are seen as responsibilities and opportunities, sources of competitive advantage. The progressive companies have already understood this and they are grabbing the opportunity.

Keywords: business, competitive advantage, corporate responsibility, environmental performance, sustainability, trends.

1999, **27**(6), 432–436

Industry's contribution to sustainable development

Bo Berggren

Federation Of Swedish Industries, Box 16100, 103 22 Stockholm, Sweden

Swedish industry supports sustainable development and recognizes this as a business opportunity. The market economy approach along with flexible, efficient economic instruments are key factors to enable industry to positively respond to sustainable development in terms of resource efficiencies and environmental protection. Swedish industry, by virtue of its being a world leader in reducing environmental problems, can act as a catalyst and example to others for moving towards sustainable development at local, national and international levels.

Keywords: environment, industrial development, market forces, public policy, sustainability, Sweden.

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2000, **28**(1), 2–17

Implementation of construction innovations

E Sarah Slaughter
Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room 1-174, Cambridge, MA 02139, USA

Construction innovations can provide the critical component for a company's long-term competitive strategy. To capture these competitive and other expected benefits, however, a construction company needs to understand the means through which innovations are implemented, and the strategies it can employ to increase the effectiveness of these operations. Construction-related companies can follow different strategies, based upon the nature of the innovation, their capabilities, resources and overall market strategy. The six stages of implementation are generally described, followed by a description of the types of activity required for each type of innovation, with detailed case studies.
Keywords: innovation, competitiveness, case study.

2000, **28**(1), 18–30

Basing maintenance needs on accommodation policy

G Vijverberg
OTB Research Institute for Housing, Urban and Mobility Studies, Delft University of Technology, P.O. Box 5030, 2600 GA Delft, The Netherlands

Managers and maintenance consultants in The Netherlands are working to objectify the inspection of real estate, and to increase the possibilities of controlling long-range maintenance expectations and setting priorities. However, in this view maintenance policy is still largely determined from the 'bottom up'; technical maintenance requirements play a predominant role. However, maintenance and investment practice ought also to be based on a 'top-down' vision of the desired level of functional performance of a particular building and of the total stock of buildings in the future. This vision would result in accommodation scenarios for these buildings to which a maintenance policy can then be adapted. Such a maintenance policy would link together the top-down and the bottom-up approaches.
Keywords: accommodation policy, accommodation scenarios, maintenance, facilities management, building stock, The Netherlands.

2000, **28**(1), 31–41

Life-cycle energy analysis of buildings: a case study

Roger Fay, Graham Treloar and Usha Iyer-Raniga
School of Architecture and Building, Deakin University, Geelong 3217, Australia

Energy use is a widely used measure of the environmental impact of buildings. Recent studies have highlighted the importance of both the operational and embodied energy attributable to buildings over their lifetime. The method of assessing lifetime building energy is known as life-cycle energy analysis. With Kyoto target obligations necessitating the quantification of greenhouse gas emissions at the national level, it seems increasingly probable that analyses of this kind will increase in use. If conducted in primary energy terms, such analyses directly reflect greenhouse gas emissions, except for a few processes that involve significant non-energy related emissions such as cement manufacture. A Life-Cycle Assessment would include these issues, as well as other environmental parameters, though probably with a corresponding decrease in system boundary completeness. This paper briefly explains some of the theoretical issues associated with life-cycle energy analysis and then uses an Australian based case study to demonstrate its use in evaluating alternative design strategies for an energy efficient residential building. For example, it was found that the addition of higher levels of insulation in Australia paid back its initial embodied energy in life-cycle energy terms in around 12 years. However, the saving represented less than 6% of the total embodied energy and operational energy of the building over a 100-year life cycle. This indicates that there may be other strategies worth pursuing before additional insulation. Energy efficiency and other environmental strategies should be prioritized on a life-cycle basis.
Keywords: life cycle, energy analysis, residential construction, embodied energy, Australia.

2000, **28**(1), 42–50

A translucent louvre system: design concepts, modelling work and monitored data

M Davies,[1] A Jackaway,[2] R Hardy,[2] E Dewey[3] and J Littler[2]
[1]*Department of Mechanical Engineering, Brunel University, Uxbridge, Middlesex UB8 3PH, UK*
[2]*Research in Building Group, University of Westminster, 35 Marylebone Road, London NW1 5LS, UK*
[3]*Building Research Establishment Ltd, Garston, Watford WD2 7JR, UK*

A building has been constructed at the Building Research Establishment in the UK, which is intended as a model for office buildings of the future. The study enabled a research team to assist with refining an element of this building at design stage and monitor it in use. The element was the glass louvre itself within a system of automatically controlled louvers that were intended to provide solar shading to reduce heat gains. Initially it was anticipated that a secondary set of blinds would be used to control glare. However in the revised brief, the primary louvred shading system was designed to perform both functions and also, if possible, aid the penetration of daylight into the interior parts of the building. This paper considers some of the factors examined by the designers and describes a study undertaken by the researchers to investigate the shading devices using physical models. Comparisons are made between the conditions within the scale model and those experienced in the finished building. The implications of using scale models in future design studies are discussed.

Keywords: design, louvers, glazing, shading, modelling, feedback, UK.

2000, **28**(1), 51–58

The evolution of the Chinese construction industry

J Luo and A Gale
11, Deanwater Close, Manchester M13 9U5, UK

The evolution of the governance of China's construction industry is examined. The reasons for uncertainty in governmental management along with its impact on industry performance are considered. Recent changes arising after the 9th National People's Congress, including a series of restructuring of government bodies and changes in responsibilities are discussed. Government intervention is being simplified and reduced, leading to increased stability for the construction industry.

Keywords: public policy, developing country, trends, governance, China.

2000, **28**(1), 59–66

Sustainable construction in China: status quo and trends

Sha Kaixun, Deng Xiaoheng and Cui Cunbin
Shandong Institute of Architecture & Engineering, 47 Heping Rd, Jinan 250014, PR China

The structural challenges facing China's construction industry are reviewed here. China's current practical initiatives, barriers and problems in moving towards sustainable development are considered: demonstration ecological villages, innovative walling materials, research on passive solar buildings and the improvement of earth buildings.

Keywords: sustainable development, developing country, China.

2000, **28**(2), 98–108

The Dutch construction industry: a combination of competition and corporatism

W Bremer and K Kok
Ministry of Housing, Spatial Planning and Environment, IPC 450, Box 20952 250032, The Hague, The Netherlands

The development of the contracting system in the Dutch construction industry is presented in terms of the poldermodel of corporatist institutions. Although stiff competition exists between construction firms, corporatist arrangements have developed in The Netherlands to reduce high costs and risks to individual firms. The implications and benefits of these corporatist arrangements for research and development, employment, training and housing investment are assessed and concluded to provide well-balanced market competition and regulation while maintaining long-term needs. The relationships between the many parties in the construction process (clients, investors, contractors, suppliers, designers and regulatory authorities) are analysed. A particular area in which corporatist arrangements have predominated is in tendering for public works, where there is a tradition of price-ringing on the grounds that this reduces transaction costs and favours social solidarity. However, the European Commission has banned such arrangements on competition grounds. The Dutch construction industry's attempts to reform tendering arrangements on a more competitive basis, while retaining the valued aspects of the poldermodel are assessed.

Keywords: Dutch construction, research and development, training, public sector procurement, institutional change, risk, contractor, The Netherlands.

2000, **28**(2), 109–118

Effects of the law reforming public works contracts on the Italian building process

R Bologna and R Del Nord
Department of 'Processi e Metodi de lla Produzione Edilizia', Facoltà di Architettura, Università degli Studi di Firenze, Via San Niccolò 89/A – 50125 Firenze, Italy

The Italian construction industry was rocked by the scandals regarding procurement by the public sector during the early 1990s. Although not confined to construction, the role of the state in construction demand meant that it was one of the most heavily implicated sectors. Known as 'tangentopoli', the scandals have prompted a major reform of public sector procurement in the Italian industry which, combined with changes required to conform with EU directives, is leading to a profound cultural change in the industry. This paper provides an authoritative review of the changes in the procurement codes and the roles and relationships within the construction industry. It shows how the project management of public sector programmes is being strengthened, and how the procurement of the design and construction processes is being separated to provide greater transparency in the process. Although it is too soon to tell what the actual impact of these changes will be upon construction industry practice, some suggestions are made in the concluding comments.
Keywords: public sector procurement, corruption, architects, contractor, contracting system, institutional change, cultural change, project management, Italy.

2000, **28**(2), 119–130

Contractors take command: from a demand-based towards a producer oriented model in German construction

Gerhard Syben
Hochschule Bremen, BAQ-Forschungsinstitut für Beschäftigung, Arbeit, Qualifikation, Bremen, Germany

The client and its agent the architect traditionally dominate the construction process in Germany. This results in severe problems for the construction companies, which do not enter into the process until all the important decisions have been made. In particular, the rate of utilization of their facilities is more or less fully dependent on other actors rather than themselves. Recently, the larger construction companies with nationwide and international activities have initiated changes to take over the construction process and assume the leading position within the project coalition. This has been achieved by integrating parts of the construction project that have been under the command of other actors. At the beginning of the process, this concerns part of the work traditionally performed by the architect on behalf of the client, at the other end it concerns the function of the client itself. So it is the producer who – inside a deep crisis that affects the whole of the industry over the last few years – takes command inside the construction process. This will result in restructuring the entire industry and will cause severe problems for other actors, in particular the small and medium construction companies degraded to subcontractors only.
Keywords: project coalition, institutional change, tendering, construction business system, client, architect, contractor, Germany.

2000, **28**(2), 131–140

The contracting system in the French construction industry: actors and institutions

E Campagnac
Ecole Nationale des Ponts et Chaussées, 6-8 Avenue Blaise Pascal, Cité Descartes, F-77455 Marne-La-Vallée Cedex, France

An overview is presented of development in the French construction industry responding to economic, regulatory and legal changes over the last 20 years. As the French industry moved into recession in the early 1980s, the large French construction corporations increasingly moved upstream taking greater responsibility for design, and downstream becoming increasingly concerned with concessions for public works and services. The public sector clients' reactions to these developments are analysed, in particular the passing and implementation of the law on the public sector client. This safeguards a larger role for the architect in the construction process and tends to favour a shift back from general contracting to separate trades contracting system for predominance, and shows how the balance of relationships in the system is dynamic.
Keywords: construction business system, institutional change, architects, contractor, public sector procurement, contracting system, France.

2000, **28**(2), 141–155

Institutional reform in British construction: partnering and private finance

G M Winch
University College London, Bartlett School of Graduate Studies, Gower St, London WC1E 6BT, UK

The British construction industry is presently going through a period of rapid change. A combination of government-led reform initiatives, changes in government procurement strategies, and increasing exposure to international competition is focusing minds and shifting positions. This paper provides an analysis of the institutional aspects of these changes, identifying the root of the problems that the reforms are tackling, and indicating what the prospects of success might be. The paper starts with a historical overview of the evolution of what is here called the professional system, which has dominated the British industry for 150 years. This provides the context for the exploration of the two principal forces for change in the industry – the reform of contractual relations, especially the diffusion of partnering, and the shift of the government procurement towards concession contracting in the shape of the Private Finance Initiative. In conclusion, the prospects for success are discussed, noting that the British construction industry is relatively successful in international markets, but that it shares many traditional problems of other sectors of British industry – the predominance of personal capitalism has meant a failure to develop organizational capabilities – the most notable symptom being the continuing reliance on self-organizing gangs of workers for actual production.
Keywords: professional system, partnering, private finance initiative, movement for innovation, public sector procurement, institutional change, UK.

2000, **28**(3), 159–175

Defining and meeting the carbon constraints of the 21st century

Robert Lowe
Centre for the Built Environment, Leeds Metropolitan University, Leeds LS2 8BU, UK

The magnitude and implications for the construction industry of reductions in carbon dioxide emissions that will ultimately be required globally and industrialized countries are critically examined. As a result of the problem of climate change, these reductions are found to be in the region of 80-90% by 2050 – much larger than those presently under discussion in national and global political fora. The technological feasibility of buildings with low energy requirements and low carbon emissions suggests that existing technology is capable of delivering reductions in this range. Unfortunately, the progress that is being made at the cutting edge is, with very few exceptions, not carried over into building stocks as a whole. Regulatory, fiscal and market-based policy and strategy mechanisms for improving the performance both of new build and the existing stock are critically examined. The achievement of meaningful reductions will require a coordinated and strategic approach, which makes use of the complementarity between these mechanisms. Regulation alone, in the absence of clear and consistent price signals provided through mechanisms such as carbon taxation, is unlikely to deliver the reductions in carbon emissions that will be needed to stabilize the global atmosphere and climate.
Keywords: sustainability, environment, public policy, regulation, carbon tax, carbon trading, energy efficiency, building stock, trends .

2000, **28**(3), 176–183

Including recycling potential in energy use into the life cycle of buildings

Catarina Thormark
Department of Building Science, Lund Institute of Technology, Box 118, SE-221 00 Lund, Sweden

Previous life-cycle studies of buildings tended to omit the phases after demolition. If recycling is not included, the potential benefits of recycling are not possible to assess. A parametric study of a one family house is presented which focuses on the potential energy savings by recycling the various building materials after demolition. The results indicate that it can be more important to design a building for recycling that to use materials which require little energy for production, that the creation of effective recycling depends upon its consideration and inclusion at the design stage, that the re-use and adaptation of existing foundations is an important component of recycling.
Keywords: recycling, life-cycle analysis, embodied energy, environment, building material, demolition, Sweden.

2000, **28**(3), 184–195

Analysing the life-cycle energy of an Australian residential building and its householders

G Treloar, R Fay, P E D Love and U Iyer-Raniga
School of Architecture and Building, Deakin University, Geelong, 3217, Australia

Life-cycle energy analysis (LCEA) is used to assign energy values to product flows in each phase of an activity's life cycle. In the case of a residential building, this usually comprises energy embodied in the manufacture of building materials, energy used in the building's operation, and in periodic maintenance. In order to place these amounts of

energy in a national context, the energy embodied in other goods and services consumed by householders also needs to be considered. This paper uses LCEA to demonstrate the need for considering not only the life-cycle energy of the building but also the life-cycle energy attributable to activities being undertaken by actual users of the building. The life-cycle energy of an Australian residential building as well as common activities of households are analysed and simulated over a 30 year period using a worked example of a two bedroom, brick-veneer, semi-detached unit. The importance of considering the energy embodied in the initial construction of a residential building as well as the consumption of goods and services by householders is demonstrated as having long-term implications. In order to encourage sustainable living practices it is suggested that architects more closely consider the activities of householders when designing residential buildings, especially in temperate climates. The paper concludes by identifying future areas of research for LCEA in the residential sector.
Keywords: life cycle energy analysis, embodied energy, environment, housing, lifestyle, households, user, Australia.

2000, **28**(3), 196–211

The fourth house: the design of a bio climatic house in Venezuela

Maria V Machado, Pablo M La Roche, Francisco Mustieles and Ignacio de Oteiza
Instituto de Investigaciones de la Facultad de Arquitectura, Universidad del Zulia, Apartado Postal 15399, Maracaibo, Venezuela

A new prototype, bio climatic terraced (or row) house for Tamare, Venezuela is being developed to address contemporary Venezuelan urban problems of lot size, urban sprawl, urban dispersion and high energy consumption. The design is based upon principles from three previous vernacular house types in the Maracaibo Lake basin. The design of the high-density bio climate house is proposed with narrow frontage, two or three floors and an innovative interior space, which is integrated into the building as a vertical patio to generate a 'detached row building'. The resulting prototype is predicted to consume less energy and land resources while exploiting bio climate principles.
Keywords: bio-climatic, architectural prototype, environmental design, intelligent buildings, housing energy efficiency, Venezuela.

2000, **28**(4), 226–233

Computer aided analysis of qualitative data in construction management research

Andrew RJ Dainty,[1] Barbara M Bagilhole[2] and Richard H Neale[3]
[1]*School of the Built Environment, Coventry University, Priory Street, Coventry CV1 5FB, UK*
[2]*Department of Social Sciences, Loughborough University, Leicestershire LE11 3TU, UK*
[3]*Research Office, University of Glamorgan, Pontypridd, Mid Glamorgan CF37 1DL, UK*

Historically, most published research in construction management topics has been based on quantitative methods. Recent debate within the construction management research community has focused concerns on the appropriateness of quantitative methods for investigation into social aspects of the subject. In this paper, two contributory factors behind the historical reliance on quantitative or positivist methods are addressed: the practical difficulties in analysing large amounts of unstructured data within sensible time-scales; and wider issues concerning the perceived rigour, depth of understanding, consistency and methodological transparency of qualitative analytical techniques. An interesting new dimension to qualitative research methodologies is the use of computer software to aid the textual analysis of ethnographic data. This paper is a reflexive example of the use of a computer-aided method in the analysis of a 'Grounded Theory' study, within industrial organizations with commercial objectives. It is concluded that, whilst computer aided analysis does not provide a definitive solution to the wider acceptance of qualitative research methods in the field, it offers considerable potential for construction management research projects that are undertaken within defined time and resources constraints.
Keywords: qualitative research, computer aided analysis, reflexivity, grounded theory.

2000, **28**(4), 234–244

Static split duct roof ventilators

S A Gage[1] and J M R Graham[2]
[1]*The Bartlett School of Architecture, Building, Environmental Design and Planning, University College London, Wates House, 22 Gordon Street, London, WC1H 0QB, UK*
[2]*Department of Aeronautics, Imperial College of Science, Technology and Medicine, Prince Consort Road, London, SW7 2BY, UK*

Split-duct roof ventilators or windcatchers are used to provide both supply and extract ventilation to the spaces that they serve. However, buildings are often erected in conditions where there is no prevailing wind direction. An investigation into four and six segment windcatchers to determine their relative performances under different wind conditions was undertaken using scale models in a wind tunnel. Conclusions indicate that six segment windcatchers have a more predictable, reliable performance in uncertain or variable wind conditions. However, a four- segment windcatcher that is orientated 45 degrees to the prevailing wind will generate the highest-pressure differences and consequently the highest duct speeds in an installation. Further work on strategies for windless conditions are summarized, and scope for further research is indicated.
Keywords: natural ventilation, ventilators, ducts, wind, alternative technology.

2000, **28**(4), 245–259

The effect of temperature on the moisture permeability of building materials

G H Galbraith,[1] J S Guo[1] and R C McLean[2]
[1]*Glasgow Caledonian University, Department of Building and Surveying, Cowcaddens Road, Glasgow, G4 0BA, UK*
[2]*University of Strathclyde, Department of Mechanical Engineering, Montrose Street, G1 1XJ, UK*

The results of an investigation into the temperature dependence of moisture permeability for several commonly used building materials are presented. The experimental programme was conducted using the standard CEN Cup test method. In total, four representative materials – plasterboard, phenolic foam insulation, plywood and medium density fibreboard (MDF) – were tested at a minimum of three different temperatures. At each temperature, four relative humidity gradients were applied which enabled the variation of moisture permeability with relative humidity to be described mathematically using the concept of differential permeability. For each test condition, six samples were tested to provide adequate information for statistical analysis. Results indicate that the temperature influence on permeability is not only related to relative humidity but also depends upon the properties of the materials themselves and the proportion of liquid to vapour flow. For the plasterboard and phenolic foam insulation, the temperature effect was found to be minor. However, a significant difference in the differential permeability for the plywood and MDF was observed, particularly in the critical high humidity (liquid dominated) regime.
Keywords: moisture, permeability, material, plasterboard, plywood, phenolic foam, medium density fibreboard.

2000, **28**(4), 260–267

A method for reliability-based economic design of building structures

C Q Li
Department of Civil Engineering, University of Dundee, DD1 4HN, UK

In limit states design codes for building structures, the load and resistance factors are derived based on a ‘target’ reliability index, which is determined based on a code calibration process. It is not clear whether the target reliability index selected through the code calibration is optimal with respect to the cost, because through calibration the structural safety is achieved quantitatively while the economic aspects are only considered qualitatively. The intention of the present paper is to formulate a basic approach to reliability-based economic design, based on structural reliability theory. The focus of the paper is to derive an analytical solution to optimized reliability index. A parametric study is conducted for sensitivity analysis of the optimal reliability index to different variables. Finally, the application of the solution to design codes, i.e. determining load and resistance factors in design formulae, is outlined.
Keywords: economic design, structure, reliability index, optimization, cost benefit, codes, Australia.

2000, **28**(4), 268–279

Suppliers’ debt collection and contractor creditworthiness evaluation

J Nicholas, G D Holt and P T Harris
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

Results of a survey of UK construction materials suppliers’ credit control and debt collection procedures are presented. Analyses of respondent data identified methods and trends associated with: contractor creditworthiness evaluation; suppliers’ debt collection methods; and the efficiency, or otherwise, of these techniques. Trend observation highlighted a number of results, including: the minimal resources allocated to debtor evaluation; the ‘questionable’ methods used

for establishing credit limits; and the minimal use of insurance and/or factoring for protection against bad debt. A number of questions emanate from these results concerning the efficacy of current practices and the need for future research into contractor creditworthiness evaluation. The paper reinforces that construction contractor creditworthiness evaluation and debt collection procedures have received minimal research to date and, that this situation requires addressing.
Keywords: contractor, credit risk, creditworthiness, debtor, material supplier, trends, UK

2000, **28**(4), 280–290

The international performance of British construction companies 1990-1996

David Crosthwaite
Department of Construction Management and Engineering, University of Reading, Whiteknights, PO Box 219, Reading, RG6 6BG, UK

Large construction companies increasingly have to seek work on an international basis. A recent stated aim of some of the larger British construction companies has been to increase their overseas activities to counteract some of the problems within the domestic construction market. This paper examines the international performance of British construction firms during the period 1990-96. The principle findings indicate that British firms had increased their overseas activities during the study period. However despite theory to the contrary (Seymour, 1987) and contrary to the practice of some competitors, they had tended to conduct the major share of their overseas work in developed countries. This finding is put forward to suggest that the British companies' overseas operations have done little to offset the downturn in domestic workload, as developed countries historically suffer similar recessions to the UK.
Keywords: internationalization, UK, performance, location.

2000, **28**(5/6), 310–314

Sustainable construction: some economic challenges

Ranko Bon and Keith Hutchinson
Department of Construction Management & Engineering, University of Reading, Whiteknights, P O Box 219, Reading RG6 6AW, UK

Sustainable construction faces economic challenges at different levels. On the macroeconomic level, the goals of sustainable construction are being implemented most actively in industrial countries in which the share of construction output is decreasing. However in both less developed and newly industrialized countries, the share of construction output is increasing, but the goals of sustainable construction are more difficult to implement. On the mesoeconomic level, the construction sector depends on the implementation of the goals of sustainable development across the national economy as a whole. Supply chains feeding the construction sector are long and intertwined, making it difficult to assess the effect of different materials, components and procedures. On the microeconomic level, buildings are created with shorter time horizons in response to being a demand-derived commodity and increasingly dominated by mechanical, electrical and electronic equipment. Their finance is being adjusted to the short and medium term, which is in conflict with sustainable construction whose goals rely upon the long term. Two broad approaches for meeting the economic challenges of sustainable construction are considered: governance through standards, legal and regulatory practices, and market-oriented policies that influence the costs of particular forms of construction. Both approaches have a role, but it is argued that the market-oriented measures will be more effective at the strategic level.
Keywords: sustainable development, sustainable construction, policy tools, environment, regulation, economics, trends.

2000, **28**(5/6), 315–324

Informing the decision makers on the cost and value of green building

Ed Bartlett and Nigel Howard
Building Research Establishment Ltd, Centre for Whole Life Performance, Garston, Watford WD2 7JR, UK

This paper seeks to challenge the traditional way in which we assess the value of green buildings in terms of their environmental friendliness, energy efficiency and whole life cost. In the UK, quantity surveyors (or cost consultants) have a perception that more energy efficient and environmentally friendly buildings cost between 5% and 15% more to build from the outset. This common assumption is not backed up by recent research and should be questioned. Construction professionals need to be informed to the whole life cost and environmental impact of buildings so that they can encourage key stakeholders to make more sustainable choices. These emerging issues together with practical tool are considered with case studies from recent projects.
Keywords: green building, economics, life cycle analysis, property, environmental performance, finance, client, estimating, investor, UK.

2000, **28**(5/6), 325–337

Integrated design and building process: what research and methodologies are needed?

William G Reed[1] and Elliot B Gordon[2]
[1]*Natural Logic/GEO: Global Environmental Options, 4233 Leland Street, Chevy Chase, Maryland 20815, USA*
[2]*Gordon Enterprises, 3983 Rosemond Road, Cleveland Heights, Ohio 44121, USA*

The integrated design process encompasses cross-disciplinary teamwork enabling the improved integration of building, community, natural and economic systems and therefore is a key to sustainable design. The needs for further research, methodologies and validation for the integrated design process are considered by two design practitioners. A workable, replicable model demonstrating the costs and benefits is argued as having an enormous positive impact on the environment and the design and procurement processes. Assessment of some recent initiatives in Canada, Finland and the United States examines progress and identifies further research and practical needs. An agenda for research on integrated design processes is proposed, along with methodologies to codify practice.

Keywords: design process, sustainable development, research policy, procurement, green building, cost, design tools, integrated design.

2000, **28**(5/6), 338–352

Cost and value: fact and fiction

Bill Bordass
William Bordass Associates, 10 Princess Road, London NW1 8JJ, UK

Assessing the costs and benefits of any building – let alone a green one – can be elusive. This paper considers the triple bottom line of economic, human and environmental costs and benefits. It identifies inertia in the system; perceived and actual risks; areas in which value can most easily be added or subtracted at various stages in the process; and where improvements might be made. Much of the supporting information comes from recent studies of occupied UK buildings, and may not represent the situation in other countries. However, there appear to be growing similarities in today's globalization market.

Keywords: property, investment, economics, green building, procurement, specification, environmental performance, management, design, cost, estimating.

2000, **28**(5/6), 353–367

Green buildings, organizational success and occupant productivity

Judith Heerwagen
J. H. Heerwagen & Associates Inc. 2716 NE 91st St, Seattle, WA 98115, USA

Can 'green' buildings positively contribute to business performance and organizational effectiveness? Can 'green' buildings affect high-level organizational outcomes, such as profitability, customer satisfaction and innovation? How do the physical attributes of green buildings affect the physiological, psychological, cognitive and social functioning of building occupants at the individual level? This paper explores the wider context of sustainable design, integrating work form organizational effectiveness and human factors to suggest that 'green' buildings provide economic and organizational benefits for business.

Keywords: productivity, workplace, intelligent buildings, green building, business strategy, facilities management, post-occupancy evaluation.

2000, **28**(5/6), 368–375

Reconciling theory and practice of life-cycle costing

Raymond J Cole[1] and Eva Sterner[2]
[1]*School of Architecture, University of British Columbia, Vancouver, Canada V6T 1Z2*
[2]*Department of Civil and Mining Engineering, Luleå University of Technology, Luleå, Sweden*

The notion of Life-Cycle Costing (LCC) is generally recognized as a valuable approach for comparing alternative building designs – enabling operational cost benefits to be evaluated against any initial cost increases. However, a host of practical difficulties conspire to limit its widespread adoption. This limited acceptance is particularly important in green building where many of the benefits of strategic choices can often only be understood and justified when cast in a life-cycle context. This paper identifies some of the critical gaps between the theory (and promise) and practice of Life-Cycle Cost analysis to discover strategies that encourage greater use.

Keywords: life cycle analysis, building design, economics, whole life cost, risk assessment, green building, finance, procurement.

2000, **28**(5/6), 376–386

Prediction and optimization of life-cycle costs in early design

Ulrich Bogenstätter

Architect and Management Consultant, Hammelstalstraße 53, D-67098 Bad Dürkheim, Germany and Universität Karlsruhe Institut für industrielle Bauproduction, Englerstraße 7, D-76128, Karlsuhe, Germany

Operation costs over the life-cycle of a building are a multiple of the initial construction costs. Decisions in the programming stage (briefing) and design process influence life-cycle costs in terms of space, the quantity of structural elements, technical/mechanical service equipment and the choice of materials. The way that the economic and ecological goals are set will influence the efficiency and effectiveness through an appropriate design. To realize the requirements of sustainable building in daily administrative practice, characteristic values for specific building tasks are needed, which are determined through the analysis of completed buildings. The resulting target values enable architects and engineers to get a clear and consistent definition of project goals at the programming stage. An interdisciplinary team is needed to manage and guarantee these target values during the whole design process and at the beginning of the utilization phase.

Keywords: sustainable building, life cycle analysis, operating cost, interdisciplinary team, durability, occupancy, briefing, performance specification, design characteristics, Germany.

2000, **28**(5/6), 387–393

Life-cycle costing and its use in the Swedish building sector

Eva Sterner

Department of Civil and Mining Engineering, Luleå University of Technology, Luleå, Sweden

The results from a survey examining the extent that Swedish clients in the building sector use life-cycle cost (LCC) estimations are reported. The limits and benefits from the client and user perspectives are also explored. The interest in using LCC approaches for economic evaluation of investment decisions is large. However, constraints exists at a number of levels: uncertainties related to the long term forecasts used, difficulties in achieving relevant input data and lack of experience in using LCC models, incentives for consultants and contractors. Nonetheless, the LCC perspective is proving to be most useful during the design phase where the possibilities of cost reductions related to operation and maintenance are large. LCC can provide motivation for environmental progressive building despite the sometime higher initial cost. The implications for expanding the use of LCC are considered for government, clients/developers and professionals.

Keywords: building economics, life cycle analysis, building operation, maintenance, client, procurement, green building, Sweden.

2000, **28**(5/6), 394–402

Green building performance prediction/assessment

Konstantinos Papamichael

Building Technologies Department, Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

To make decisions, building designers need to *predict* and *assess* the performance of their ideas with respect to various criteria, such as comfort, aesthetics, energy, environmental impact, economics, etc. Performance prediction with respect to environmental impact requires complicated models and massive computations, which are usually possible only through computer-based tools. This paper focuses on the use of computer-based tools for predicting and assessing building performance with respect to environmental impact criteria for the design of green buildings. It contains analyses of green performance prediction/assessment and descriptions of available tools, along with discussions on their use by different types of users. Finally, it includes analyses of the cost and benefits of green performance prediction and assessment.

Keywords: cost, value, simulation, energy, environmental impact, green building, design tools, building performance.

2000, **28**(5/6), 403–407

Reducing mechanical equipment cost: the economics of green design

Kevin R Hydes and Laura Creech

Keen Engineering Co. Ltd, 116-930 West 1st Street, North Vancouver, V7P 3N4, Canada

A common misconception is that innovative design and sustainable engineering carry a capital cost premium. This need not be the case. Many architects and engineers are finding better ways of achieving energy efficient designs at or below conventional building cost. Two case studies of green buildings are discussed with a particular focus on capital cost issues. In the first case study, the extensive use of salvaged building materials and equipment results in a building with low environmental impact. Although added risk exists in using salvaged equipment, it is argued that the benefits far outweigh the challenges as substantial cost savings can be realized. The second case study is used to demonstrate a variety of design techniques that increased the thermal and lighting efficiency of the building, thereby reducing the capital and operating costs of mechanical equipment. The authors conclude that clients are demanding more efficient

designs and generally recognize the economic value of sustainable buildings. Design professionals must therefore rise to this challenge and dare to be innovative –it is worth the risk.

Keywords: green building, sustainable design, mechanical systems, innovation, energy efficiency, cost, integrated design, recycled building material.

2000, **28**(5/6), 408–412

The cost of green materials

Nadav Malin
Environmental Building New, 122 Birge Street, Suite 30, Brattleboro, VT 05301, USA

'Do environmentally preferable materials cost more?' This paper addresses the question and presents theoretical rationales for both affirmative and negative answers. Clarifications for the terms 'environmentally preferable' and 'cost' are offered in order to explore the question more thoroughly, introducing the ideas of life-cycle costs and societal costs in addition to initial capital cost. The implicit basis for comparison is dissected, revealing implications both for conventional and green products. It is shown that the cost of green materials need not dictate the cost of green buildings, and that knowledgeable designers can utilize green materials, including some that ostensibly cost more, without increasing overall project costs.

Keywords: green building, building material, economics, sustainable design, cost, performance, specification.

2000, **28**(5/6), 413–418

Incremental costs within the design process for energy efficient buildings

Nils K Larsson and Jim Clark
Natural Resources Canada, 580 Booth Street, 13th Floor, Ottawa, Ontario K1A 0E4, Canada

Two demonstration programmes by the Canadian government, C-2000 and Commercial Buildings Incentive Programme (CBIP), are described with their effects of on the design and delivery process to improve the energy performance of commercial buildings. Both programmes operated on the assumption that design for high performance requires extra design time and also incur extra costs for contracted specialists and energy simulations. This was achieved through the provision of funding additional design time and providing support to the client and design team. A survey of completed projects within these programmes was undertaken to validate this assumption. Significant cost savings for clients were demonstrated at a modest and acceptable increment in design costs. The provision of modest governmental funding for the design stage has been a successful policy, with positive feedback from clients and operating cost savings offset by modest increases in capital cost or design time.

Keywords: design management, cost, estimating, economics, environmental performance, property, green building, public policy, Canada

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E-mail: W.P.Hughes@reading.ac.uk

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CME: Volume 1, 1983

1983, **1**(1), 3–16

Factors affecting success in network applications in a developing country

Arditi, D1 and Koseoglu, H2
1 Dept of Civil Engineering, Illinois Institute of Technology, Chicago, Illinois 60616, USA
2 Middle East Technical University, Department of Civil Engineering, Ankara, Turkey

In the absence of any method of measurement by which the impact of network planning on profitability can be assessed, it is hypothesized that user satisfaction offers a 'subjective' measure of success in network applications. Various implementation characteristics and success as defined above were measured in a sample of construction companies in a developing country. The data collected indicated that neither site managers nor head-office planners were totally satisfied in most respects; further, the entire phenomenon of network planning and control was perceived differently by site managers and planners. Statistical analysis indicated that the degree of detail and the mode of presentation; the duration and extent of usage; site autonomy and the degree of formalization in site manager - head-office planner relationships; the extent of R & D activities; and finally the reason why networks were introduced in the first place seemed to affect success in network implementation.
Keywords: construction planning, critical path method, developing country, network analysis, scheduling.

1983, **1**(1), 17–29

The challenge for the UK housing industry in the 1980s and the planning system

Baron, T
Christian Salvesen (Properties) Limited, Whelmar House, Holden Rd, Leigh, WN7 1HH, UK

The factors that have shaped the housing industry in the UK over the past 30 years are reviewed. The market for new houses is described, as is the house builders' response, the influence of the costs of house building on the financial structure of firms and the development of design standards. The implications of these factors are related to the major problem of redeveloping inner cities. This in turn identifies the need for a radically new approach to planning. A new planning system is proposed in which the role of central government and the districts is modified and the counties are replaced by regional planning commissions with wider responsibilities.
Keywords: financial structure, house builder, housing market, housing design, inner city, planning.

1983, **1**(1), 31–45

Probabilistic analysis of an idealized model of construction projects

Legard, D A
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 6AW, UK

A simple, idealized model of construction projects is examined, in which projects are assumed to consist of a number of separate tasks, each of which is repeated a number of times. The concepts of randomly occurring interference, and variability in performance, are introduced, and their effect on the duration and cost of projects is examined in terms of the nature of the project. Conclusions are drawn as to the relevance of the analysis to live construction projects.
Keywords: performance, probability, stochastic network analysis, trade interference, uncertainty.

1983, **1**(1), 47–55

An evaluation of management contracting

Sidwell, A C
Department of Civil Engineering and Construction, University of Aston in Birmingham, Gosta Green, Birmingham, UK

The paper discusses the main features of the system of management contracting which has developed in the UK in the last decade and evaluates these in relation to those elements of the building process thought to influence project success. Data from a number of case studies are examined to establish the time saved and other advantages of using this system.
Keywords: building process, management contracting, , work package.

1983, **1**(1), 57–74

A case study of the construction of a terephthalic acid plant for Imperial Chemicals Limited at the Davies Works, Wilton, Cleveland, UK

Holt, L
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 6AW, UK

This study concerns the project management strategy adopted during the successful building of an £85m terephthalic acid plant for ICI. The client and many others in the Teesside region had experienced severe problems in terms of cost and time overruns on previous similar projects. The resolute application of several fundamental project management principles brought about a radical change in peoples' attitudes. The previously inefficient and frequently acrimonious situation was transformed to one of highly productive teamwork; resulting in the project meeting all of its objectives, being only three months late and several million pounds under budget. ICI rated the construction efficiency as the highest achieved for many years at Wilton. The paper is based on interviews with the main actors in the project and records the features which they regard as important to its success.
Keywords: process engineering, project management, work package.

1983, **1**(1), 75–87

Computerized method for quantity surveying

Selinger, S1 and Stamler, H2
1 Dept of Construction Management, Building Research Station, Technion, Israel Institute of Technology, Haifa, Israel
2 Snr Construction Engineering, Aviv Engineering Corporation, Tel-Aviv, Israel

The dimension take-off of building elements is the most tedious and time-consuming stage in the quantity surveying procedure. A computerized comprehensive method of quantity surveying aimed at reducing work invested in this stage has been developed. The method is based on geometric representation of the structure elements of a building (columns, beams, slabs and walls) in a three-dimensional co-ordinate system. This enables the intersections and contact areas between elements to be defined by the computer program. Consequently, the dimension take-off, to be carried out by the quantity surveyor, is significantly reduced and simplified. The method has been developed for quantity surveying of buildings with rectangular structure elements whose edges are parallel to the axes of the co-ordinate system. The general approach of this method may, however, be extended to other kinds of buildings. The approach is likely to be of value in the development of computer graphic systems.
Keywords: computing, quantity surveying, taking-off.

1983, **1**(2), 91–117

Barchester low-rise: a case study of a management contract for remedial work to a large housing scheme

Brett-Jones, A T
Dearle and Henderson, 4 Lygon Place, Belgravia, London, UK

A case study of substantial work to 580 dwellings was undertaken. Certain provisions and consequences had to be taken into account. These included: uncertainty of the extent of the defects, it was essential to remedy with tenants in occupation; a pilot contract approach taking 37 dwellings of different types and situations in order to identify the extent of defects; test buildability of design solution; monitoring of costs; refining design accordingly; monitoring costs to establish productivity on a full production run; the need for a management contract to ensure that the objectives of the pilot project were carried out; selection of a management contractor in competition; preparation of tender documents; evaluation of contractor's submissions; appointment of a management contractor; monitoring the pilot contract; measuring performance arising from revisions to design and familiarity with the work; innovative use of temporary shelters over dwellings; feasibility studies on optimum annual spend on the main contract; negotiation of main contract on a management basis; main contract documentation; post-contract cost control against target and in relation to resources used; review meetings; risk analysis.
Keywords: housing, management contracting, repair.

1983, **1**(2), 119–144

Design philosophy and practice in speculative housebuilding: Part 1

Leopold, E and Bishop, D
Building Economics Research Unit, Bartlett School of Architecture and Planning, University College London, Gordon Street, London, UK

The assumption of like with like - essential to any comparison - often obscures more profound differences between things to be compared. This was the outcome of this study. It set out to investigate two hypotheses: (a) that designs for private sector housing are significantly more buildable than are those in the public sector and (b), that the possibility exists for the effective transfer of design practice from one sector to the other. The study concluded that the differences between the sectors involved the whole processes of production rather than simply the skills and attitudes of the

respective design teams. The paper, therefore, examines the factors that enter into each of the two sectors of housebuilding; the goals, the financial, operational and managerial criteria, the influence of user satisfaction, the role of the design team, of architects especially, the built form, and the extent to which either sector reaps the benefits of continuing product development. The conclusion is that buildability, important as it is in ensuring that resources are not wasted, is less important than other changes that are taking place, in particular the adoption of space standards that fall far short of those that were recommended more than half a century ago. What then, might be done to achieve the objectives of the second hypothesis? The decisive issue is for designers serving the public sector to be made more aware of the cost and buildability consequences of their designs. Possibilities are identified each with attendant advantages and disadvantages. Whatever tactic is adopted quick results cannot be expected and no approach will be costless.
Keywords: design, housing, private sector, public sector.

1983, **1**(2), 145–156,

A practical approach to auditing organizational flexibility

Lansley, P R
Ashridge Management College, Berkhampstead, Hampshire, HP4 1NS, UK

Whilst there exists a variety of approaches to auditing the potential of firms to respond to major changes in their markets, many of these methods rest on concepts, techniques and perspectives which are not readily accessible to the practicing construction manager. An alternative auditing method has been developed specially for senior line management without heavy reliance on advanced behaviourial science concepts or on the advice of consultants. The method is illustrated by reference to two examples of the constraints experienced by construction firms in responding to a major recession. Some general conclusions about the nature of the constraints on flexible and inflexible firms are presented.
Keywords: auditing, flexibility, manpower, organization.

1983, **1**(2), 157–180

The accuracy and monitoring of quantity surveyors' price forecasting for building work

Flanagan, R[1] and Norman, G[2]
[1] *Department of Construction Management and* [2]*Department of Economics, University of Reading, Whiteknights, Reading, UK*

The performance of two public sector quantity surveying departments is examined, when forecasting the lowest tender price for proposed projects at the design stage. The reliability of any price forecast is dependant upon professional skill and judgement and the availability of historical price data derived from completed projects. The quantity surveyor also requires an effective feedback mechanism that provides information on the accuracy of previous forecasts. A simple feedback mechanism is developed, which can be used to assess forecasting performance and give an early warning of bias and identify any patterns that may emerge.
Keywords: accuracy, forecasting, monitoring, price, quantity surveying.

1983, **1**(3), 183–197

Project management in construction

Bennett, J
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 6AW, UK

A conceptual framework for project management in construction is proposed. It comprises two distinct phases. The first is strategic, being concerned with client objectives, project description and organization. The second is concerned with the execution of basic construction tasks. The essential nature of these concepts and of the relationships between them is described. The need to regard projects as hierarchies is discussed. The paper concludes that within construction projects, management, design and construction strategies must be matched and then given expression in clearly defined tasks. Creating and maintaining that consistent framework is project management.
Keywords: briefing, organization, project management, scope.

1983, **1**(3), 199–215

The evaluation of change in the construction industry

Burrows, B G[1] and Seymour, D E[2]
[1] *Department of Engineering, University of Warwick, Coventry, CV4 7AL, UK*
[2] *Department of Transportation & Environmental Planning, University of Birmingham, Birmingham, B15 2TT, UK*

The paper describes the fortunes of a minor technical innovation - purpose-made, steel fabric reinforcement for concrete, and argues, through this example, that the discussion of change, which is formally carried on within 'technical' and 'economic' frameworks, must be extended in order to address explicitly the 'political' implications which are tacitly recognized by practitioners. The term 'political' is used in its widest sense to encompass the fact that the many parties involved within the construction process promote not only their own interests but different ways in

which benefits are described and evaluated. The use of mainstream economics, offering to provide a unitary set of criteria by which to evaluate benefit, submerges this political dimension.
Keywords: concrete reinforcement, cost benefit, economic appraisal, innovation.

1983, **1**(3), 217–231

Building maintenance planning and estimating system

Lewis, B T
Bernard T Lewis & Associates, Inc, 12728 Lincolnshire Drive, Potomac, MD 20854, USA

Building maintenance work measurement is no substitute for good management, yet without the use of time standards, maintenance departments are unlikely to operate efficiently and effectively. Such departments may have skilled craftsman and up-to-date tools and equipment but operating efficiency may be only 50% of capacity. The cause of this low productivity can often be traced to the lack of a common unit of work measurement for each job which is understood by supervisors and craftsmen when considering costs, performance and goals. A set of building maintenance time standards is described, which has been developed and published by the United States Navy, entitled Engineered Performance Standards. The time standards are used for comparative planning and estimating in either a manual or computerized mode in public or private sector organizations. The data are readily available to maintenance organizations.
Keywords: estimating, maintenance, performance, planning, productivity, time standards.

1983, **1**(3), 233–268

Design philosophy and practice in speculative housebuilding: Part 2

Leopold, E and Bishop, D
Building Economics Research Unit, Bartlett School of Architecture and Planning, University College London, Gordon Street, London, UK

Since this paper was written, the housing sector has witnessed considerable changes. In the second half of 1980 when our survey was carried out, housing production in the public sector still outstripped that in the private sector; local authorities were still able to determine, to a much greater extent, the composition of housing they supplied; public sector designs were still subject to Parker Morris standards. However, the alteration of the context in which our survey was undertaken serves only to underline the case argued in this paper for continuing the evaluation of housebuilding performance in terms of its response to the institutional motivations and constraints specific to each sector.
Keywords: design comparison, housing, private sector, public sector.

CME: Volume 2, 1984

1984, **2**(1), 1–12

Construction claims costing for owners and contractors

McDonald, P
Construction Consultants International Corp, 1607 New Hampshire Ave, MW Washington, DC 20009, USA

Although the owner may have a legitimate claim against a contractor for breach of contract, calculation and proof of damages incurred by the owner is often a difficult task. Owners should be aware of the types of damages which may be recovered from contractors for delayed project completion, defective work, or abandonment of the project, and how to prove these damages. A contractor who has a legitimate construction claim against an owner must be aware of the wide variety of damages which may have been suffered in order to be assured of a chance of maximum monetary recovery. A claim may arise on account of a delay, disruption, or termination of the contractor's performance, and recoverable costs can be analysed under these three categories. In addition, the contractor must be careful to choose the best method of proving damages if a claim is to be successfully prosecuted. Although the legal principles discussed in this article are drawn from the public and private sectors of the United States construction industry, they may be applied in arbitrations both in the United States and abroad.
Keywords: abandonment, acceleration, claim, damages, defect, delay.

1984, **2**(1), 13–24

Housing in the inner cities

Baron, T
Christian Salvesen (Properties) Limited, Whelmar House, Holden Rd, Leigh, WN7 1HH, UK

The paper looks at the interlinked physical and social problems of Britain's inner-urban areas from the viewpoint of a volume house builder. It describes the tactical failures of large scale demolition in the 1960's and 1970's and of the current policy of rehabilitation. It proposes a new, more flexible strategy based on dedicated management teams with the powers needed to match solutions to specific problems.
Keywords: demolition, house builder, inner city, management team management, rehabilitation.

1984, **2**(1), 25–36

Social policy and construction wage formation: the Alberta experience

Jenkins, A W
Department of Economics, University of Alberta, Edmonton, Canada

A number of social policies affecting the level of construction wage settlements are examined theoretically. Next, the empirical magnitude of the effects of a subset of these are estimated within a pooled cross-sectional, time-series regression analysis of wage settlements in the unionized construction industry of Alberta over the past two decades. Particularly of note are the reductions in these settlements due to the legal sanction of centralized collective bargaining and the imposition of wage controls; the increases in wages due to large upswings in government sponsored building activity (with an elasticity coefficient of 0.3): and the neutrality of wage settlement with respect to any short-term increases in government subsidized trades training and the legalization of no strike, no lockout agreements.
Keywords: building activity, inflation, social policy, wage settlements.

1984, **2**(1), 37–48

A review of the causes of recent problems in the construction industry of Trinidad and Tobago

Lewis, T M
Department of Civil Engineering, University of the West Indies, St Augustine, Trinidad and Tobago, West Indies

The rise in the price of the oil in the early 1970's provided Trinidad and Tobago with the wealth to finance dramatic push for development. Much of the development programme that was launched involved construction work. The industry was soon overwhelmed with work, and for various reasons its performance deteriorated rapidly. In order to try and improve the situation, the government decided to let all of its major projects to foreign engineering firms. Although the main intention was to complete important public works as expeditiously as possible, it was also hoped that the local firms would learn-by-example from having internationally recognized firms working in their midst. The government was to be disappointed on both counts. Whilst some if the reasons for the continued poor performance of the construction industry can be put down to physical circumstances beyond its control, there were, and are, other factors at work which the industry has allowed to develop and handicap itself.
Keywords: productivity, organization services, performance, Trinidad & Tobago.

1984, **2**(1), 49–55

Priority ranking of highway improvement projects

Akan, G T[1], Arditi, D[2] and Imre, M[1]
[1] *Middle East Technical University, Department of Civil Engineering, Ankara, Turkey*
[2] *Illinois Institute of Technology, Department of Civil Engineering, Chicago, Illinois 60616, USA*

Highway improvement investments constitute an important part of the total investment in the transportation sector. Yet the numerous proposals have to be ranked in an order of priority. The General Directorate of Highways in Turkey calculates the benefit-cost ratio for every proposal separately and ranks them in a descending order of magnitude. A regression analysis between the benefit-cost ratio on the one hand and a number of carefully selected independent variables on the other is presented. The purpose of the study is to minimize the considerable amount of time and labour spent by the General Directorate of Highways in such evaluations. The findings indicate that car traffic, construction cost per kilometre and length of improved highway are the most salient factors that affect the benefit-cost ratio under the conditions prevailing in Turkey.
Keywords: benefit-cost analysis, economic evaluation, highway, priority ranking.

1984, **2**(1), 57–75

The accuracy of quantity surveyor's cost estimating

Morrison, N
Davis Belfield and Everest, 5 Golden Square, London, W1R 3AE, UK

The accuracy of cost estimates prepared by quantity surveyors during the design stage of construction projects is examined. Since these estimates influence the feasibility and form of projects, the ability of quantity surveyors to fulfil the objectives of cost planning is considered. It concludes that the present methods of estimating used by quantity surveyors produce results that are not sufficiently accurate to meet all the objectives of cost planning. The most likely area for improvement lies in developing methods of using large cost data bases.
Keywords: estimating, cost model, quantity surveying, variability.

1984, **2**(1), 77–90

Economic evaluation of minor roading projects

Scott, D
Civil Engineering Department, University of Canterbury, New Zealand

The work reported here was undertaken to investigate alternative methods of evaluating minor roading projects with a capital cost of less than $50,000. Literature relevant to this type of project is reviewed briefly. The 21 case studies are described and evaluated using the two methods commonly used in New Zealand: First year rate of return and benefit cost ratio. The major problem of incorporating intangible benefits is discussed. An alternative method of evaluation is proposed which allows the benefits of a project to be discounted against its estimated cost and which allows the evaluator to incorporate benefits one at a time, starting with those benefits which are easily quantified and progressing to those which are less tangible. Examples of the alternative method are given.
Keywords: cost, evaluation, project.

1984, **2**(2), 93–110

Private industrial project management: A systems-based case study

Walker, A and Hughes, W P
Department of Surveying, Liverpool Polytechnic, Clarence St, Liverpool, L3 5UG, UK

The technique of linear responsibility analysis is used for a retrospective case study of a private industrial development consisting of an extension of existing buildings to provide a warehouse, services block and packing line. The organizational structure adopted on the project is analysed using concepts from systems theory which are included in Walker's theoretical model of the structure of building project organizations (Walker, 1981). This model proposes that the process of building provision can be viewed as systems and subsystems which are differentiated from each other at decision points. Further to this, the subsystem can be viewed as the interaction of managing system and operating system. Using Walker's model, a systematic analysis of the relationships between the contributors gives a quantitative assessment of the efficacy of the organizational structure used. The causes of the client's dissatisfaction with the outcome of the project were lack of integration and complexity of the managing system. However, there was a high level of satisfaction with the completed project and this is reflected by the way in which the organization structure corresponded to the model's propositions.
Keywords: case study, linear responsibility analysis, private sector, project management, systems theory.

1984, **2**(2), 111–126

Cost versus quality: A zero sum game?

Brandon, P S
Portsmouth Polytechnic, Department of Surveying, Cambridge Road, Portsmouth, PO1 2LF, UK

Cost versus quality has often been presented as if it were a zero sum game 'If I gain in terms of quality then I will have to lose in terms of the money I need to spend'. In reality most design teams would contend that this is not necessarily true but find that they lack the technique to evaluated the proper balance between cost and quality in order to achieve value for their client. The problem is outlined and a possible framework for investigating a marginal increase in design quality against cost at the critical stage drawn information in provided.
Keywords: cost model, cost planning, quality.

1984, **2**(2), 127–132

Improving the construction industry in declining developing economies

Ofori, G
Department of Building and Estate Management, National University of Singapore, Kent Ridge, Singapore 0511

The serious economic difficulties now facing many developing countries pose certain problems to their construction industries that existing theories on their improvement did not consider. The current operating environments of the construction industries and the corresponding response of their participants are reviewed. It is suggested that the industries need to be rescued and enabled to help in the on-going adjustment of national economies and to develop the capacity to adapt to future changes. Emphasis put on what the industries themselves can do, as experience has shown that it is naive to expect governments (to whom such proposals are often addressed) to shield the industry from the effects of unfavourable economic conditions.
Keywords: ability, economic adjustment, development, rationalization.

1984, **2**(2), 133–144

USA productivity and fast tracking starts on the drawing board

Gray, C and Flanagan, R
Department of Construction Management, University of Reading, Whiteknights, Reading RG6 2BU, UK

Although much has been written about the rapid rate of construction in the USA compared with the UK very little investigation has been undertaken to determine exactly how the rates of construction are achieved. The difference between the UK and USA construction industries is described, and a case study of a USA construction project is used to examine the relationship between the design of an element and the construction on site. The USA designer pays attention to the way the components will be assembled on site, being concerned with the overlap of work packages undertaken by specialty sub-contractors. Because each of the work packages is clearly defined and isolated from other work packages, the contractor has better control over the rate of production on site.
Keywords: contract, international comparison, productivity.

1984, **2**(2), 145–156

Motivating the British construction industry

Edwards, B[1] and Eckblad, J[2]
[1]*Engineering Department, North East Group, Imperial Chemical Industries plc, Billingham, Cleveland, UK*
[2]*637 Kensington Drive, Chapel Hill, NC 27514, USA*

Three guidelines are proposed for attaining and maintaining the commitment of project and design personnel, contractors and workforce to large capital project objectives. These guidelines have evolved from the authors' experience in several major capital projects in the North East of England as well as a recent visit to the USA. The paper begins with a review of the authors' experience in the UK construction industry from 1960 to 1980, moves on to describe the impact of a visit to the USA and finishes with a discussion of the specific actions that are being taken to implement the proposed guidelines.
Keywords: international comparison, motivation, UK.

1984, **2**(2), 157–176

A model for the selection of the optimum crane for construction sites

Furusaka, S[1] and Gray, C[2]
[1]*Furukawa Laboratory, Department of Architecture, Faculty of Engineering, Kyoto University, Kyoto, Japan*
[2]*Department of Construction Management, University of Reading, Reading, RG6 2BU, UK*

A method for locating a crane on a construction site, using mathematical techniques, is proposed. The optimum location and choice of the crane on a site is seen as one of the most important parts of construction planning. It proposes the algorithm which can define the least expensive cranage cost (the total cost of the hire, assembly and dismantling) by calculating the combined use of different cranes, such as truck crane, crawler crane, travelling based tower crane or fixed base tower crane. Conclusions are drawn as to the relevance of the application of the model to construction projects.
Keywords: all-zero-one, construction planning, crane, crane, dynamic programming, integer programming.

1984, **2**(2), 177–184

Studying the client's role in construction management

Cherns, A B[1] and Bryant, D T[2]
[1] *Department of Social Sciences, Loughborough University, Loughborough, Leics, UK*
[2] *Tavistock Institute of Human Relations, London, NW3 5BA, UK*

Construction industry researchers tend to oversimplify the role of the client in the construction management process. This partly results from the propensity of researchers to use 'broadcast' survey method approaches which typically achieve shallow penetration of the client's world. Obtaining access to critical data involves a different relationship between researcher and client. When the client is seen as complex rather than unitary, the history and pre-history of the project loom large. What has occurred in the past can have a crucial effect on the operations of the project team assembled to manage the construction. A pilot study to test the feasibility of obtaining valid information from building clients is described. Twenty 'points' or hypotheses about the client's role in construction management are advanced and are to be tested in a forthcoming major study.
Keywords: client involvement, communication, project team organization, temporary multi-organization.

1984, **2**(3), 185–192

Pre-tender and post-tender negotiations in Australia

Uher, T E and Runeson, G
School of Building, University of New South Wales, PO Box 1, Kensington, NSW, Australia 2033

One of the main features of the Australian building industry is the high level of sub-contracting of building works. A survey of 43 sub-contractors is reported, regarding various aspects of the relationship between sub-contractors and general contractors. In particular, the practice of 'bid shopping' is highlighted, in which the general contractor in various ways attempts to reduce the sub-contractor's price below that of the tender. Generally the sub-contractors were strongly against bid shopping attempts to tie with general contractors and negotiations in general. However, the strength of the responses was determined by the size of the firms. The larger firms were more often open to negotiations and deals than the smaller firms. The overall benefits to the general contractors who 'shop' are doubtful, most sub-contractors adjust their mark up by up to 20% to allow for such negotiations.
Keywords: bid shopping, general contractor, pricing, sub-contracting, tendering.

1984, **2**(3), 193–199

Graduate education in construction management

Arditi, D
Illinois Institute of Technology, Department of Civil Engineering, Chicago, Illinois, USA

Construction management has been in existence for many years. The graduate construction management programmes offered by departments of civil engineering in the USA are reviewed. The courses offered in such programmes are categorized and examined in twelve groups. The findings indicate that the most popular subjects are those related to laws, contracts and specifications; planning and scheduling; and operations research methods. Also, it was found that programmes differed a great deal from each other in terms of the concentration of and emphasis on the subjects treated. It is concluded that a clearer conception of the discipline is necessary both by educators and the industry for higher quality and more uniform graduate programmes in construction management.
Keywords: civil engineering education, graduate programme.

1984, **2**(3), 201–217

Construction resource models by Monte Carlo simulation

Baxendale, A
Department of Construction and Environmental Health, Bristol Polytechnic, Ashley Down Road, Bristol, BS7 9BU, UK

The application of Monte Carlo simulation is reviewed and it is recognized that the method is very useful and flexible that the method is very useful and flexible in comparing alternative systems. A case study is presented, based on data gathered from the construction site and developing an approach, showing the problems encountered in forming simulation models. The data presented can also be used as a historical record for future planning work. The need to develop a micro-computer program to avoid the repetitive calculations, once the basis os simulation is understood, is reviewed. The final discussion recommends the use of Monte Carlo simulation to augment pre-contract planning for large and complex projects or for re-planning work in progress, where the data gathered will be of particular significance to the unique situation that exists on that site.

Keywords: construction site, data collection, resource model, simulation.

1984, **2**(3), 219–224

The use and limitations of mathematical models in the planning and control of construction projects

Cusack, M M
Department of Construction and Environmental Health, Bristol Polytechnic, Ashley Down Road, Bristol, BS7 9BU, UK

There are general and specific problems associated with modelling time and cost parameters. The general problem is considered and the use and limitations of mathematical models as a basis for decision making in the planning and control of construction projects are reviewed. The two major parameters associated with the planning and control of construction projects are time and cost. Modelling these parameters separately presents many difficult problems. The problem of optimizing the relationship between the two is even more complicated and earlier researchers have suggested a variety of models. Models are, in a sense, an attempt to initiate a systems approach to problem solving and decision making. The aim is to capture the major components and the interactions of a system. Having developed the model it is possible to obtain valuable insights into the behaviour of a system with possibilities of optimizing its performance. This paper considers the general problem of modelling time and cost and examines some of the conditions and limitations of the modelling process. The overall objective of this series of papers is to find not only a way in which the time and cost parameters can themselves be modelled in dynamic and reasonably precise terms, but also to demonstrate the ways in which time and cost are inter-related and how the inter-relationship changes with the expansion or the diminution of the two parameters. The ability to capture and respond to the dynamic nature of the situation has been considerably enhanced by advances in computer technology, particularly in terms of the relatively low cost and interactive nature of the micro-computer.

Keywords: control, integer linear programming, heuristic model, planning.

1984, **2**(3), 225–263

Simulation applied to construction projects

Bennett, J and Ormerod, R N
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 6AW UK

The uncertain environment of construction activity is described, particularly the variability in productivity and the occurrence of external interferences. This paper then describes a suite of computer programs known as the Construction Project Simulator (CPS) whose features include: a hierarchy of linked bar charts, ‘preliminaries schedule’, weather data, direct costs, and resources for costing and/or resource restraint. The results of an actual project are presented to demonstrate the type and range of output available, including duration and cost predictions and cash-flow curves. The result of four varied construction projects subjected to simulation are presented, with the results demonstrating an improvement in accuracy over the common deterministic estimating procedures of the UK construction industry.

Keywords: interference, simulation, risk, uncertainty, variability.

CME: Volume 3, 1985

1985, **3**(1), 1–14

Putting organization research into practice

Lansley, P R
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

The need for more effective approaches for turning the outcomes of research into effective information and tools for managers is widely accepted, but the problems of bridging the research-practice gap are quite considerable. This paper considers briefly, one example of where traditional dissemination methods have failed to provide managers with sufficient confidence to act, and where consultancy approaches have not reached a sufficiently wide number of potential users. The approach to bridging the gap presented in this paper draws on a wide range of training and organizational development methodologies. The key ingredient is a highly flexible computer modelling system which recreates the world of the manager and models the management of the business into the medium term future. Some of the issues faced in developing this approach, the end product known as the AROUSAL system, and some of the surprises which have followed, are also reviewed.
Keywords: case study, consultant, organization, management development, research, simulation.

1985, **3**(1), 15–24

The critical path method and construction contracts: a polemic

White, A
Department of Building, Royal Melbourne Institute of Technology Ltd, GPO Box 2476V, Melbourne, Victoria 3001, Australia

The Critical Path Method, in common with other planning tools seeks to simulate technology related events and activities. One of the assumptions of the Critical Path Method is that there will be unlimited resources available enabling every task to commence at its earliest possible starting time. This rarely happens in practice. For some time, heuristic algorithms have been available for the resolution of resourcing conflicts. At the construction site level, critical path schedules are often generated from a known resource availability which dictates the network logic. The networks so produced are different from networks which model the technological relationships and then make adjustments for resource constraints. It was hoped that a resource-based network would be more rational than an activity-based network. However, there is no guarantee that the mathematics of scheduling enable the degree of inefficiency to be measured. At the construction site level, these issues tend to be irrelevant. However, if the Critical Path Method is being used to justify or disprove a construction claim, then distortions can be introduced.
Keywords: claim, critical path method, delay, mathematics, prolongation.

1985, **3**(1), 25–31

Flexible planning in construction firms

Benes, J and Diepeveen, W J
Stichting Bouwresearch, PO Box 20740, 3001, J A Rotterdam, Netherlands

The development of a business policy and plan are major tools for the management of the construction firm. The nature of a reliable business policy and the design of an operational plan have changed completely over the last ten years. Old methods are no longer acceptable. New circumstances require a strategic flexibility in both the firm's business policy and its operational plan. In the past management policies have been based on the theory of growth. Yet, no longer can economic growth be expected. Under these new circumstances the aim must not be for controlled business growth but for controlled flexibility, even controlled regression. Under these circumstances the development of short-term flexible plans and of medium term scenarios are essential for ensuring the continuity of the firm. So too are the innovation of products and processes.
Keywords: business growth, controlled regression analysis, corporate planning, flexibility, management of firm.

1985, **3**(1), 33–42

Managing construction industry development

Ofori, G
Department of Building and Estate Management, National University of Singapore, Kent Ridge, Singapore 0511

Several countries are establishing statutory bodies to manage the improvement of their construction industries. The need for and benefits to be derived from such a body are not always appreciated. This paper reviews the activity of two of these bodies, outlines their essential features and demonstrate the role an institution of this nature can play. The factors to consider in setting up such an agency, the problems it might encounter and ways of making it effective are also discussed.
Keywords: agency, control, co-ordination, continuous development.

1985, **3**(1), 43–57

The economics of fire protection: fast-response residential sprinklers

Ruegg, R T and Fuller, S K
Operations Research Division, National Engineering laboratory, National Bureau of Standards, Washington DC, USA

This paper develops and applies in selected cases a benefit-cost model for evaluating the economic efficiency of providing fire loss mitigation through the use of a newly adapted technology: Fast-response, residential sprinkler systems. The model calculates present value net benefits as they would accrue to the owner of a system. The nine selected hypothetical cases pertain to new, single-family dwellings in the United States. The cases assume an 'average' level of fire risk to the homeowner as indicated by recent USA aggregate fire loss statistics, and sprinkler system effectiveness based on the results of laboratory and field tests. Break-even values are calculated for key decision variables. The model can be used to evaluate the economic efficiency of home sprinkler investments under alternative conditions. The results that are presented here, though based on hypothetical cases, have implications of interest to members of the research and building communities who are concerned about economics of home fire protection.
Keywords: economic analysis, fire protection, life cycle analysis, net benefit analysis, risk-benefit analysis, sprinkler system.

1985, **3**(1), 59–87

The role of managerial actions in the cost, time and quality performance of high-rise commercial building projects

Ireland, V
School of Building Studies, New South Wales Institute of Technology, Australia

An analysis of the effects of managerial actions on the objectives of reducing time, reducing cost and increasing quality is undertaken. This approach is proposed as contributing to a rationale for action in the building process. A sample of 25 high-rise office buildings was used to test this theory and the results analysed by partial correlations and multiple regression. Increases in construction planning during design and co-ordination across the design-construction interface are shown to have very strong effects on reducing construction time and increases in the former variable, which also included aspects of value analysis, reduce the cost of the building. However, increases in variations to the contract, the complexity of the building, the number of storeys and the extent of industrial disputes are shown to strongly increase construction time. At the same time building cost is increased by increasing variations to the contract, the architectural quality and the number of nominated sub-contractors. Increases in architectural quality are shown to occur through generating more alternative designs, increasing the cost per square metre and planning the construction process as part of the design, the last of which included some value analysis. A methodology which could be used on an extended sample is proposed.
Keywords: buildability, cost, contingency theory, co-ordination, quality, time, variations.

1985, **3**(2), 91–104

The use of integer linear programming for modelling project control information

Cusack, M M
Department of Construction and Environmental Health, Bristol Polytechnic, Bristol, UK

The time and cost parameters are considered to be of paramount importance in the management of construction projects. This paper is concerned with the problem of optimizing the relationship between time and cost thus determining the minimum project and activity costs associated with each feasible duration of a multi-activity project. The problem is considered in two parts. The first part explores methods of finding minimum project cost associated with given project duration, when the time-cost relationship for each activity is only assumed to be continuous and totally defined in the feasible interval but not necessarily linear. A mathematical solution is explored relating earlier work of Meyer and Shaffer (1965), based on integer linear programming, to the analysis of precedence networks. In the second part the

methods of integer linear programming are also used to consider the more general problem of minimum cost for a project when, for some of the activities, the time-cost relationship may only be partially defined.
Keywords: control, integer linear programming, precedence network, time-cost optimization.

1985, **3**(2), 105–120

A graphical approach to discount payback

Marshall, H
National Bureau of Standards, Gaithersburg, Maryland 20899, USA

Construction planners and building owners use payback frequently as an index of economic performance. Discounted payback, which considers the time value of money in measuring the time to project pay-off, are more accurate index of project cost effectiveness than simple payback. But being more difficult to calculate, it is used less often than simple payback. This paper provides a unique set of graphs that helps decision makers find discounted payback quickly and easily without complex calculations. Appropriate applications of simple and discounted pay-backs are described. Examples of economic efficiency losses from using payback instead of more appropriate evaluation measures and from using simple instead of discounted payback are presented.
Keywords: building economics, cost benefit analysis, discounted payback.

1985, **3**(2), 121–144

A systematic approach to the selection of an appropriate crane for a construction site

Gray, C and Little, J
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

Research into the consequential cost implications of design decisions (Gray 1983) has highlighted the central role that the primary lifting device (predominantly cranes) has on the control and pace of construction operations. In attempting to evaluate cost effective design options the design team must, therefore, appreciate the full effect of the crane choice inherent in each design option. The expertise and knowledge of the criteria used to select the most appropriate cranage is held by a few experienced people either in specialist crane hirers or in contractors' plant operations. This paper describes one way in which this expert knowledge can be made available during the early design process to enable the designer to incorporate the construction implications. However, the subject is complex since there are many thousands of cranes available in the world market place. Never the less the process and criteria for selection are definable and the paper describes them. The description has been incorporated in a computer-based expert system.
Keywords: computing, construction planning, crane, estimating, expert system.

1985, **3**(2), 145–161

Sealed bid auctions: an application to the building industry

Flanagan, R[1] and Norman, G[2]
[1] *Department of Construction Management, University of Reading, Reading, UK*
[2] *Department of Economics, University of Leicester, Leicester, UK*

This paper examines some of the theory and practice of competitive tendering in the building industry. Allocation of building contracts by means of competitive tendering is one of type of sealed bib auction. Two main strands of the theory of sealed bib auctions are developed. The first strand identifies optimal mark-up given that each tendering and resource constraints of tenderers. It emerges that the first strand is a special case of the second. A simple optimal bid price rule is identified, which indicates that bid price for any one contractor will be affected by the resources available to the contractor and general market conditions. It is shown that bid prices will be more competitive the better the information available to tenderers, the more are fully is the tender list constructed and the greater the number of firms invited to tender. It is further shown, however, that little is gained by having more than five firms on the tender list. Some empirical evidence is examined in the light of this theory and is shown to be consistent with it.
Keywords: bidding, resource-constrained scheduling, tendering.

1985, **3**(2), 163–170

Incentives and motivation in the construction industry: a critique

Hague, D J
Department of Construction Management, Leicester Polytechnic, PO Box 143, Leicester, UK

Bonus, payment-by-results, financial incentives (or any synonymous method for systematically encouraging productivity) has been the grumbling appendix to industrial relations in the building industry, with arguments for and against its use, thoroughly rehearsed over some 70 years. Oddly, this polarization of belief, reminiscent of the Lilliputian warfare between Bigendians and Lilliputians, is not carried over into other, generally mechanistic techniques for programming, resource allocation and so on, whose veracity and effectiveness are disinterestedly investigated. A case for defining a proper role for financial incentive schemes is argued, starting with an apparent contradiction; change in the workplace disrupts group cohesion and social structures, yet building operations, by their very nature, continuously alter both work environment and workplace disrupts group cohesion and social structures, yet building operations, by their nature, continuously alter both work environment and workplace groupings, without similarly

affecting building workers. The examination proceeds by Juxtaposing the well known Herzberg hygiene/motivation theory with the generally overlooked Davis (1948) investigation of building workers, then focuses upon monotony, briefly comparing 'job-satisfaction' and 'no job-satisfaction' experienced in other industries, moving to a conclusion via the findings of Borcheding and Oglesby (1974) that good site organization engenders high job-satisfaction and productivity.

Keywords: incentive, motivation, organization, productivity.

1985, **3**(2), 171–181

Reasons for delays in public projects in Turkey

Arditi, D[1]; Akan, G T[2] and Gurdamar, S[2]

[1] *Department of Civil Engineering, Illinois Institute of Technology, Chicago, Illinois 60616, USA*

[2] *Department of Civil Engineering, Middle East Technical University, Ankara, Turkey*

The effects of construction delays are not confirmed to the construction industry but influence the state of the overall economy of a country. This is particularly so in Turkey where construction investments account for almost half of all investments and where delays have reached significant magnitudes in the 1970-80 decade. A large number of public agencies that are construction owners and a large number of contractors that undertake construction work for public agencies in Turkey were surveyed to identify and rank in an order of importance the cause for such delays. The results indicate that shortages of some resources; public agencies' and contractors' financial difficulties; organizational deficiencies and delays in design work, frequent change orders and considerable extra work are the most important sources of delay. While some of the causes are dependent on national economic policies, others may be overcome by measures to be taken by public agencies and contractors.

Keywords: delay, developing country, public sector.

1985, **3**(3), 183–198

A simplified approach to the planning and control of cost and project duration

Cusack, M M

Department of Construction and Environmental Health, Bristol Polytechnic, Bristol, UK

A simplified approach to planning and control of cost and project duration is presented. The major decisions facing management relate to problems concerning time and cost and, equally important, the intrinsic relationship that exists between them. Many attempts have been made to model these factors over the past 20 years. The majority of the models produced suffered from the mathematical complexity inherent in their structure and the consequent need for high-powered mainframe computing facilities to produce a solution. The most mathematically precise models were probably those developed by Mayer and Shaffer (1965), refined by Cusack (1984). The major difficulties with these models relate to the large number of constraints and variables generated. These were subsequently reduced by Cusack (1985) by concentrating the analysis on breakthrough points on the cost curve. Although subsequently reducing the computing time required the models were still generating a relatively large number of variables and constraints with, again, a consequent need for high-powered mainframe computers. This approach therefore still retains many of the disadvantages referred to in the Introduction. This paper describes a heuristic approach to modelling the time-cost relationship giving near optimal solutions that take advantage of the rapid technological developments in microcomputing. The implementation of the model on a microcomputer is described which, by using a phased approach makes the size of project that can be handled virtually unlimited.

Keywords: heuristic model, planning, time-costing.

1985, **3**(3), 199–215

Cost modelling and price forecasting: practice and theory in perspective

Bowen, P A and Edwards, P J

Department of Quantity Surveying and Building Economics, The University of Natal, Durban, South Africa

Various academics have pointed to the gap between research and practice in the field of building economics and suggest that the way forward may lie in terms of a paradigm shift in that a fundamentally different approach to cost modelling and price forecasting will be necessary. It can be argued that a change in thinking is required rather than an improvement in current practice. Expert systems, a form of artificial intelligence, hold exciting possibilities in this regard.

Keywords: artificial intelligence, cost model, expert system, price forecasting, simulation.

1985, **3**(3), 217–231

A comparison of contractual arrangements for building projects

Nahapiet, H[1] and Nahapiet, J[2]
[1] *French Kier Construction Management, Tempsford Hall, Sandy, Bedfordshire*
[2] *Templeton College, The Oxford Centre for Management Studies, Kennington, Oxford, UK*

This paper considers contracts from an organizational perspective, comparing the major forms of contracts available for building projects and examining the factors influencing their selection. The analysis is based on the findings of a study of ten building projects, six in the USA and four in the UK, together with the results of a survey of those prominent in the industry. A comparison of five different contractual arrangements indicate that they establish different patterns of responsibilities and relationships between clients and the various parties involved in building projects. In so doing, they are regarded clients differing combinations of expertise, risk, flexibility and cost. For the projects studied, three factors were found to be related to contract selection: The characteristics of clients, particularly their experience and expertise in construction, the level of performance required by clients and the construction complexity of projects. These findings, together with previous research, suggest that it is unlikely that there is one 'best' form of contract for building projects. Rather, which is the appropriate contractual arrangement varies according to the particular set of project circumstances, especially the type of client, his time and cost requirement and the characteristics of the projects.
Keywords: contract management, organization building.

1985, **3**(3), 233–247

Size, technology and aspects of structure in contractor firms Turkey

Sözen, Z
Faculty of Architecture, Istanbul, Turkey

The recent paper treats the relationship between dimensions of size, technology and selected aspects of organizational structure in contractor firms operating in Turkey. it is proposed that the larger the organization, and the more advanced the technology employed, the higher the level of formalization, the higher the level of standardization, the higher the level of functional specialization and the owner the level of centralization. the data collected supported these propositions, except for the proposition about centralization.
Keywords: developing country, organizational structure, size, technology.

1985, **3**(3), 249–263

Resource planning for construction

Hillebrandt, P M[1] and Meikle, J L[2]
[1] *University of Reading and Consultant, Greencourt Cottage, The Scrubs, Bisley, Stroud, Gloucestershire, GL6 7BU, UK*
[2] *Davis Belfield and Everest Consultancy Group, 5 Golden Square, London, W1R 3AE, UK*

This paper seeks to examine the planning of resource utilization for the construction industry. It commences with a definition of resource planning and then goes on to consider the reasons for undertaking it and its importance in achieving satisfactory construction programmes and for the health of the economy as a whole. Some examples are given of the consequences of failure plan and also indications of instances where resource planning has helped. The methods of planning are then described including the methods which may be adopted when available data is slight. Sources of data are given in a full list of references. Finally it is concluded that, although there are difficulties in resource planning, it is both desirable and possible.
Keywords: construction, labour, material, planning, resource.

CME: Volume 4, 1986

1986, **4**(1), 1–18

Observations on productivity and composition of building output in the United States, 1972-82

Bowlby, R L and Schriver, W R
The University of Tennessee, Knoxville, USA

Analysis of US productivity data indicates seven compositional changes in building. These are (a) a shift toward more and higher multi-storey buildings, (b) a shift toward smaller buildings, measured by floor area, (c) a shift toward rural areas and away from metropolitan ones, (d) a shift toward starts during the seasonal construction peak and away from winter, (e) a shift toward expensive end-user types, most notably office buildings, schools, hospitals and government buildings, and away from factories and warehouses, (f) a shift toward steel, concrete or reinforced concrete, and load bearing construction away from prefabricated or wall bearing construction, or (g) a shift toward Northern or (less clearly) Western states.
Keywords: industry composition, productivity,

1986, **4**(1), 19–36

Modelling construction organizations

Lansley, P R
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

This paper reports on the development of a microcomputer-based simulation system developed to assist contractors in evaluating the potential costs and benefits of implementing specific organizational policies. the main object of the paper is to present mathematical relationships used to model key parts of the system.
Keywords: management, organization, planning, research, simulation.

1986, **4**(1), 37–55

Labour recruitment strategies and selection practices on construction sites

Bresnen, M J; Ford, J R; Bryman, A E and Keil, E T
Work and Employment Research Group, Loughborough University of Technology, Loughborough, LE11 3TU, UK

Discussions of the recruitment and employment of labour in the construction industry tend to be aggregate analyses, at the level of the firm or industry. The question as to what firms do when faced with a particular set of labour requirements at the operational level so far remains largely unanswered. This paper focuses upon the patterns of recruitment and selection adopted by main contractors on 43 medium to large construction sites. The balance of directly employed (newly recruited and transferred) and sub-contracted labour is examined and variation noted by size and nature of work, firm size and location of work. Although viable, the restricted degree of employment is documented. The recruitment process adopted on site is identified as relatively informal, adaptive and based upon short-term production needs. Selection processes emphasize criteria such as work history, experience, reliability and conformity, as opposed to formal qualifications. The paper suggests that while the recruitment and selection strategies adopted on sites are both instrumental and rational from the contractor's viewpoint, they may have wider deleterious consequences. In particular the impact of such strategies on training provision, and on the development and maintenance of an adequately skilled workforce is raised.
Keywords: labour, recruitment, labour selection, site management.

1986, **4**(1), 57–74

A conventionally-managed project: A systems-based case study

Walker, A[1] and Hughes, W P[2]
[1] *Department of Building, University of Hong Kong, Pokfulam Road, Hong Kong*
[2] *Department of Surveying, Liverpool Polytechnic, Clarence Street, Liverpool, UK*

The technique of linear responsibility analysis is used for a retrospective case study of a private development consisting of an extension to an existing building to provide a wholesale butchery facility. The project used a conventionally organized management process. The organization structure adopted on the project is analysed using concepts from the systems theory, which are included in Walkers theoretical model of the structure of building project organizations. This model proposes that the process of building provision can be viewed as systems and sub-systems that are differentiated from each other at decision points. Further to this, the sub-systems can be viewed as the interaction of managing system and operating system. Using Walkers model, a systematic analysis of the relationships between the contributors gives a quantitative assessment of the efficiency of the organizational structure used. The project's organization structure

diverged from the models propositions resulting in delay to the project's completion and cost overrun but the client was satisfied with the project functionally.
Keywords: case study, linear responsibility analysis, private sector, project management, systems theory.

1986, **4**(1), 75–79

Combining risks in estimating

Beeston, D
Property Services Agency, Lambeth Bridge House, Albert Embankment, London, SE1 7SB, UK

A method is described which attempts to provide a practical way of building up an estimate which will be exceeded with a calculated probability. The stakes are high in a large project but a statistically rigorous method would be impossibly complex for projects with a large number of risks to consider. The method described is a compromise between precision and practicability. It follows the spirit of a full probability treatment but is appropriate to the level of reliability in the subjective evaluations of risk which form a large part of the input to any method of risk analysis.
Keywords: dependence, estimating risk, independence, Monte Carlo simulation, statistics.

1986, **4**(2), 87–104

Conflict and individual coping behaviour in informal matrix organizations with the construction industry

Pretorius, F I H[1] and Taylor, R G[2]
[1] *Department of Quantity Surveying, University of the Witwatersrand, Johannesburg, South Africa*
[2] *Department of Quantity Surveying and Building Economics, University of Natal, Durban, South Africa*

In this paper the use of formal and informal matrix organizations in the South African construction industry are discussed; with the specific purpose of examining inter-personal conflict and of determining the psychological coping techniques of professional personnel in these organizations are presented in the form of case study material. The general conclusion is that although such organizations may be successful in the management of construction projects in South Africa, they do not always contribute to the psychological well-being of employees.
Keywords: conflict, coping, matrix organization, organization design, stress.

1986, **4**(2), 105–134

The liability of the construction project manager

Mastrandrea, F
Northcroft Neighbour and Nicholson, St George's House, 195-203 Waterloo Road, London, SE1 8UX, UK

Construction project management is in its infancy in the United Kingdom. In its developed state it may take many configurations. This paper is concerned with consultancy project management, i.e. the use of a project manger appointed to fulfil a role independent of the client organization. The burden of the paper is to develop a framework of areas of potential civil liability of the consultant project manager. The framework builds upon a broad analysis of the work, management and organizational aids deployed by, and the likely skills and attributes of, the successful project manager. It is found that there is a good correlation between legal and management principles. Three areas of law are of particular significance: Contract, agency and the torts of negligence. The basic principles relevant to each are explored and practical analogies for project management drawn. The developed principles are tested against several construction and project management decisions in the USA. Those decisions are found to be largely consistent with those developed principles. It is concluded that such principles will be applied by the courts in England when dealing with actions involving consultancy construction project managers.
Keywords: agency, contract, liability, negligence, project management.

1986, **4**(2), 135–150

'Intelligent' construction time and cost analysis

Gray, C
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

The subject of 'buildability' has got to the point where it is known that it is advisable to involve the contractor in the early stages of the design process. However, this is very difficult to achieve unless a contract is formed between the parties, which may not be desirable in that it limits competition. The research described in this paper attempts to resolve this problem by taking the knowledge used by the contractor and making it available to the design team through an Intelligent Knowledge Based System (IKBS). In essence it has meant that a deeper understanding of the methods used by contractors to analyse the problems and risks inherent in a design has to be achieved. The work has generated the first step in this understanding by developing the rules of activity identification, thus enabling models of the construction process to be created for subsequent evaluation.
Keywords: buildability, estimating preliminaries, expert system, planning, time.

1986, **4**(2), 151–159

An improved systematic activity sampling technique for work study

Peer, S
Faculty of Civil Engineering, Technion - Israel Institute of Technology, Haifa, Israel

Organizational inefficiencies are present at every construction site, and with greater frequency than in the stationary industries. In spite of this, productivity studies in construction are still in their infancy. The paper deals with applicable work-measurement techniques in construction, and describes an effective method of manual recording of activity sampling observations, applicable to individual work studies with up to 15 workers and/or machines per observer. records are in chart form, with the following main advantages; identifiability of interrelationships between observed facts, economy in writing work during recording and analysis, and possibility of differentiation between skilled and unskilled labour. When desired, production efficiency rating is readily incorporated.
Keywords: activity sampling, productivity, recording method, work study.

1986, **4**(2), 161–177

Shovel-truck queues: a reconciliation of theory and practice

Carmichael, D G

Queuing theory offers the prospect of a useful management and planning tool for shovel-truck type operations; it is conceptually and intuitively satisfying as a model while being able to be transformed into a form usable by practicing engineers. It remains to fully examine the assumptions on which queuing theory is based in the light of available field measurements. The paper answers questions relating to the assumptions on the service discipline, on steady-state behaviour and on the probability distributions for the backcycle and service times.
Keywords: earth moving, mining, queuing theory, quarrying.

1986, **4**(3), 179–188

Formulating construction cash-flow curves using a reliability theory analogy

Tucker, S N
CSIRO Division of Building Research, PO Box 56, Highett, Victoria 3190, Australia

Prediction of cash-flows during construction of large buildings is usually based on cumulative cash-flow in the form of an S-curve. There have been several attempts to establish formulae for the estimation of such S-curves on an empirical basis. The paper draws on analogy between the probability of failure in reliability theory and the probability of payment during construction to develop a general approach to possible mathematical forms of the cash-flow during construction. An example of a new generalized alternative form of the S-curve known in Australia as the Bromilow S-curve is shown to be an excellent approximation to the empirical form.
Keywords: cost, cost planning, mathematical modelling, reliability, statistical distribution.

1986, **4**(3), 189–199

Application of a microcomputer in investment decisions using dynamic programming

Singh, G[1]; Kiangi, G E[2]; Sabah, A N A[3]; and Greenslade, O C[1]
[1] *Civil Engineering Department, University of Leeds, Leeds LS2 9JI, UK*
[2] *Civil Engineering Department, University of Dar es Salaam, Tanzania*
[3] *Ministry of Works, Power and Water, Bahrain*

Organizational and individuals are often faced with the problem of allocation of limited resources to a number of competing projects. The tendency in the past has been towards the use of cost-benefit analysis which is unsuitable for handling indivisible projects or ventures. The acceptance of much more appropriate computational difficulty. this paper presents an interactive microcomputer program, MAXCRETURN, applicable to all types of projects, indivisible or otherwise, using dynamic programming techniques. It does not require the user to have prior knowledge of dynamic programming or optimization techniques. Use of the program is illustrated with an example.
Keywords: dynamic programming, investment, optimization.

1986, **4**(3), 201–212

Some trends in relative costs of building types: description and interpretation

Powell, C
Welsh School of Architecture, University of Wales, Institute of Sciences and Technology, PO Box 25, Cardiff, CF1 3XE, UK

This study investigates the range of unit costs of different building types, as a broad approximation to building quality. Examination of the current position is followed by a view of long-term trends. The manner in which the costs of

different building types have fluctuated relative to one another over time is described in outline. Some ways in which to view possible causal influences are note, along with possible uses of further studies and interpretations.
Keywords: building type, cost, quality, unit cost.

1986, **4**(3), 213–232

A construction project cash-flow model: an idiographic approach

Kenley, R and Wilson, O D
Department of Architecture and Building, University of Melbourne, Parkville, Victoria 3052, Australia

The paper introduces and support the contention that an idiographic methodology is appropriate to the post-hoc study and interpretation of individual construction project cash-flows. A cash-flow model based on the logic transformation is proposed to be consistent with the methodology. The model is based on historical data, and yields two parameters to describe each individual project. The model is tested using two samples totalling 72 projects. Goodness of fit for the model, using a measure of standard deviation from 1.0% to 4.6%, with a median of 2.5% is found for individual projects. The experiment hypotheses (that there is substantial variation between projects) is supported by the graphical and statistical evidence of deviation, which is argued to be the result of the individual ontology of each project - Systematic error - rather than random error from an ideal. The paper concludes that forecasts of individual cash-flow are invalid when derived from analysis of grouped data.
Keywords: cash flow, construction planning, estimating, logic transformation.

1986, **4**(3), 233–243

Computer packages for construction data acquisition and processing

Touran, A
Department of Civil Environmental and Architectural Engineering, University of Colorado, Campus Box 428, Boulder, Colorado 80309 0428, USA

problems of construction site data collection are reviewed and their impact on the planning of construction projects and job productivity discussed. It is believed that utilizing current computer packages for data acquisition will provide sufficient data to justify statistical analysis and stochastic processing of construction planning and control systems. A brief history of stochastic modelling in construction management is given and the difficulties involved in stochastic analysis of construction operations discussed. Well-known computer packages for statistical analysis are presented and their limitations for construction applications identified. A special-purpose computer package for construction duration data acquisition and processing is described and possible future extension recommended. It is believed that without such a data reduction system, a large of construction scheduling and simulation models cannot be used stochastically.
Keywords: computerization, data acquisition, statistics, time, time-lapse photography, USA.

1986, **4**(3), 245–260

Images of status and performance in building team occupations

Faulkner, A C and Day, A K
School of Architecture and Building Engineering, Claverton Down, University of Bath, BA2 7AY, UK

The paper analyses the issues of social status and performance evaluation amongst the design and construction professions. Detailed results of a 1985 study of inter-occupational evaluation are presented and compared to the well-known similar study published in 1965 by the Tavistock Institute. Potential implications of the results are drawn out for education and training, working relationship, work organization and inter-professional relationships in the construction industry.
Keywords: occupation, performance, status, survey research.

CME: Volume 5, 1987

1987, **5**(1), 3–12

An analysis of the cost of compliance with the Fire Service Order, Northern Ireland, 1985

Ewart, K; Shields, T J and Silcock, G W
Department of Building, University of Ulster, Jordanstown, Co Antrim BT37 0QB, Northern Ireland, UK

This paper outlines an analysis of the cost incurred by building owners to meet the Fire Services Order. Northern Ireland, 1985. Necessary data were collected by three methods; questionnaire, inspection and detailed surveys. A statistical model is developed which enables a cost of compliance to be enables a cost of compliance to be estimated for boarding houses having more than six bed spaces. Comparisons are also made regarding cost with previous studies in England and Wales for similar boarding houses/small hotels. Finally the cost of compliance for these houses and buildings of other types is given with an estimate of the impact of this cost on the Building Industry.
Keywords: cost, fire, statistics.

1987, **5**(1), 13–20

British public expenditure on construction less than claimed?

Betts, Mike
Wise Speke & Co, Commercial Union House, 39 Pilgrim Street, Newcastle-Upon-Tyne NE1 6RQ, UK

In Great Britain the demands for increased public construction investment have been increasing. However, although it is necessary to establish the amount currently being spent before being able to consider the need for an increase, this is difficult as there are two dispatches sets of data available on public construction investment. Expenditure data are collected from public sector clients who commission construction work and output data are supplied by the contractors who undertake the work. Between 1976/7 and 1984/5 the expenditure data exceeded the output data by an average of 81.4% and the percentage difference has been increasing. This paper identifies the causes of the differences between the two sets of data and where possible quantifies them. Even after amending for these quantifies differences the expenditure data exceeded the output data by an average of 10.5% for new public housing work and 29.4% for new public non-housing work. As the remaining unquantifiable differences are clearly significant this paper concludes by examining possible future methods of compiling accurate data on the level of public construction investment.
Keywords: expenditure, output.

1987, **5**(1), 21–44

Building price-level forecasting: An examination of techniques and applications

Taylor, R G and Bowen, P A
Department of Quantity Surveying and Building Economics, The University of Natal, Durban, South Africa

Building price indices provide a means of updating cast data for estimating purposes, extrapolation from existing building cost trends, forecasting future price levels, etc, and thus a definite need exists to forecast future building price index levels. In this paper the writers examine a number of forecasting techniques from a hierarchy of forecasting techniques and assess their suitability via the vehicle of the BER building cost index. Special emphasis is placed on the ability of the forecasting methods to model a changing process.
Keywords: cost, index, forecasting, price, time series.

1987, **5**(1), 45–56

Optimization of future manpower requirements in a multi-discipline consultancy

Davis, C and Cochrane, S R
Department of Civil Engineering, The Queen's University of Belfast, David Keir Building, Stranmills Road, Belfast, BT7 1NN, UK

This paper describes the role of matrix management in project-oriented multi-discipline consultants' organizations. The conflicting goals of project managers and functional departmental managers with regard to organization manpower levels are examined. A method, using a microcomputer spreadsheet, is developed to simulate the manpower requirements of multi-discipline organizations subject to a highly variable and uncertain project intake. A simplified model organization has been used to illustrate this procedure. A selected of construction projects, representing the anticipated future workload, with durations and manpower requirements are input in an appropriate random manner into a special spreadsheet template to produce a representatives of the variability of manpower requirements for the

organization. The best combinations for each functional department, of permanent staff, overtime, and temporary staff at the peak manpower demands are studied. An optimization procedure is presented to minimize manpower costs and avoid over-staffing during through periods of workload and alternatively under-staffing for peak requirements.
Keywords: manpower, multi-discipline organization, optimization, project, simulation.

1987, **5**(1), 57–71

Monopoly and the materials supply industries of the UK

Lowe, J G
Department of Building, Heriot-Watt University, Edinburgh, EH1 1HX, UK

The materials supply industries of the UK provide some good illustrations of uncompetitive market structures. The purpose of this paper is to analyse selected materials supply industries so as to highlight the reasons for this particular market structure and the extent to which the construction industry has suffered because of this and is likely to suffer in the future. This paper identifies a number of industries within the materials supply sector where the degree of competition is limited and outlines the reasons for this but concludes that while there is potential for abuse of monopoly power, this does not appear to have been unduly misused at this time. The paper then considers whether this apparent lack of abuse stems from countervailing factors or is simply a product of the current depressed state of the UK construction industry and thus whether abuse could emerge should demand increase in the future. The paper concludes that undue advantage has not been taken of monopoly power due to the potential for countervailing power on the part of the customers, the potential for import penetration, and fear of adverse legislation or administration action from the Government or the Monopolies and Merges Commission, and that a modest increase in construction demand might not provoke a major price spiral.
Keywords: government policy, market structure, material, monopoly, UK .

1987, **5**(1), 73–90

Construction safety: economics, information and management involvement

Laufer, A
Department of Construction Management, Building Research Station, Technion, Haifa 32000, Israel

In order to induce top management of construction companies in Israel to become involved in safety, the present research undertook to prove that in Israel, too, uninsured accidents cost are very. Through in-depth interviews of 50 site managers concerning 210 accidents, complementary interviews with other officials in construction and insurance companies, study of records, and conduct of direct observations of accidents after they occurred, a conclusion contradicting the accepted view in insurance circles is reached. the research establishes that uninsured costs in construction companies with an average safety performance record amount to a mere 0.76% of the payroll. In a parallel research in large, developed companies in the USA, existing safety measurement methods feeding the information system were studies.
Keywords: accident, manager, safety, safety information.

1987, **5**(2), 95–100

The business round-table construction industry cost effectiveness task force

Roberts, J
Department of Technology, East Texas State University, Commerce, Texas, 75428, USA

The Business Roundtable, an organization founded in 1972 and formed of chief executive officers representing several leading international corporations, has had a major impact on the construction industry in the United States. Member companies are some of the major users of construction services. The business and industry leaders formed task forces to investigate, report, and recommend means by which escalating construction costs could be contained. The Construction Industry Cost Effectiveness Task Force was charged with the responsibility of investigating ways in which construction services could be improved and could be made more cost effective. The reports and recommendations of this task force have had far reaching effects on the construction industry. This paper discusses the history, structure and activities of the Business Roundtable as well as the methods of implementation of task force recommendations. Attention is also given to the ramifications concerning construction education.
Keywords: cost, cost control, inflation, management.

1987, **5**(2), 101–113

The measurement of productivity in the construction industry

Lowe, J G
Department of Building, Heriot-Watt University, Edinburgh, EH1 1HX, UK

Productivity in the use of resource inputs is of critical importance to the construction industry. This paper is intended to discuss the relative merits commonly used measures of productivity for the purpose of assessing the productive and allocative efficiency of construction in the 1980's. The paper concludes that the total factor productivity method is the

ideal against which the other approaches should be judged. Both average labour productivity method is the ideal against which the other approaches should be judged labour productivity and average capital productivity suffer from serious problems in assessing the efficiency of contracting operations. However, under certain circumstances, either can provide an adequate alternative measure. Of the two main single-factor measures of productivity, capital productivity appears to be superior in most aspects to average labour productivity as a means of assessing the overall financial management of a construction firm. Notwithstanding the problems associated in contracting activities and also the difficulties inherent in obtaining suitable data, capital productivity is recommended for most circumstances when total factor productivity measures cannot by applied.

Keywords: efficiency, productivity, resource allocation.

1987, **5**(2), 115–121

A review of finance for large-scale construction

Brownlie, S M and Harris, F C

Department of Civil Engineering, Loughborough University of Technology, Loughborough, UK

The paper describes the results of a survey conducted to determine the sources of finance used by promoters and contractor in funding construction work and projects. Bankers and other involved with finance in the City of London were also interviewed and broad outlines of their procedures for assessing loan applications and the attendant risks ascertained.

Keywords: capital, funding, international construction.

1987, **5**(2), 123–140

A project managed by a multi-disciplinary practice: a systems-based case study

Walker, A[1] and Hughes, W P[2]

[1] *Department of Building, University of Hong Kong, Pokfulam Road, Hong Kong*

[2] *Department of Surveying, Liverpool Polytechnic, Clarence Street, Liverpool, UK*

The technique of linear responsibility analysis is used for a retrospective case study of a private industrial development consisting of an engineering factory and offices. A multi-disciplinary professional practice was used to manage and design the project. The organizational structure adopted on the project is analysed using concepts from systems theory which are included in Walker's theoretical model of the structure of building project organizations (Walker, 1981). This model proposes that the process of buildings provision can be viewed as systems and sub-systems which are differentiated form each other at decision points. Further to this, the sub-systematic analysis of the relationship between the contributors gives a quantitative assessment of the efficiency of the organizational structure used. There was a high level of satisfaction with the completed project and this is reflected by the way in which the organization structure corresponded to the model's proposition. However, the project was subject to string environmental forces which the project organization was not capable of entirely overcoming.

Keywords: case study, linear responsibility analysis, private sector, project management, systems theory.

1987, **5**(2), 141–155

Corporate strategy and survival in the UK construction industry

Lansley, P R

Department of Construction Management, University of Reading, PO Box 219, Whiteknights, Reading, RG6 2BU, UK

The UK construction industry has experienced three quite different business environments during the last 30 years. These environments have demanded different corporate strategies which in turn have required firms to structure their operations in different ways, for their senior managers to adopt different styles and for management teams to draw on different problem solving skills. A simple framework for linking the environment with structure, style and skills is developed through considering the difference in the nature of the demands on construction companies during the three periods.

Keywords: environment, planning, skill, strategy, style.

1987, **5**(2), 157–168

Feasibility assessment of large-scale housing development in Saudi Arabia: a case study

Assaf, S A

Construction Engineering and Management Department, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

This paper aims to examine the relationship between real estate development in Saudi Arabia and a funding programme established by its government for increasing the housing stock. A descriptive analysis of recent activities in housing production shows that the programme has become a highly profitable vehicle for real estate investment, and yet nowadays the real estate business is facing some problems. It is suggested that a new orientation towards large-scale

estate development is needed to alleviate the difficulties. The results of a feasibility assessment of such a case using the funding programme corroborate this suggestion based on investment return.
Keywords: feasibility, funding, housing, real estate, Saudi Arabia.

1987, **5**(2), 169–181

Multi-objective economic evaluation of minor roading projects

Scott, D
Civil Engineering Department, University of Canterbury, New Zealand

Reduced funds and the need for a consistent method of choosing between many proposed schemes each with different non-quantifiable benefits has made a reappraisal of methods of evaluating minor roading projects desirable. The paper has two major sections. First, the results of a study of a study to determine the extent to which economic evaluation of any sort is used for evaluating minor works projects and to determine what other evaluation methods are currently used (56 cases were studied). Second, a revised method of evaluation, developed to take into account significant factors highlighted in the study, is presented.
Keywords: case study, economics, evaluation, project.

1987, **5**(3), 187–198

A systematic approach to stochastic scheduling

Karni, R
Faculty of Industrial Engineering and Management, Technion - Israel Institute of Technology, Israel

A systematic methodology extends CPM project planning to allow for uncertainties, decision points, alternative courses of action, and likely changes and failures while executing the plan. Stochastic scheduling is carried out in eight steps. (1) The basic process and network are defined. (2) Uncertainty conditions are specified. (3) These conditions are formulated as a set of probability states, with corresponding durations and costs. (4) An augmented stochastic network is constructed. (5) From average values, durations and costs, a deterministic network is solved to provide as approximate picture of expected outcomes. (6) The stochastic network is solved. Using a simulator; and the uncertainty effects of the stochastic conditions are analysed. (7) The effects of individual conditions on overall uncertainty are analysed. (8) An attempt is made to eliminate or modify those conditions contributing the most uncertainty. The number of alterations needed to obtain a satisfactory simulation is also discussed. The stability of time and cost distributions is found to increase as the square root of the number of iterations.
Keywords: network, probability, project, scheduling, simulation, uncertainty.

1987, **5**(3), 199–209

Principles of an integrated construction company MIS with emphasis on its quantity-based sub-system

Peer, S
Faculty of Civil Engineering, Technion - Israel Institute of Technology, Israel

This paper outlines the basic concepts and principles in the development of an integrated construction company management information system (MIS) for controlling and steering the entire operation of the firm. The system is composed of three sub-systems. Incorporation of the time parameter in cost control unnecessary complicates the control procedure. This is dispensed with by separation between the functional modules for controlling past performance, and those processing future projections and trends, as demonstrated by a more detailed description of the quantity-based sub-system.
Keywords: contractor, cost control, information system.

1987, **5**(3), 211–226

Estimates given and tenders received: a comparison

Wilson, O D[1]; Sharpe, K[2] and Kenley, R[1]
[1] *Department of Architecture and Building, University of Melbourne, Parkville, Victoria 3052, Australia*
[2] *Department of Statistics, University of Melbourne, Parkville, Victoria 3052, Australia*

Selection of the contractor and the tendering method constitute vital steps in the project procurement process. When budget approvals are based upon professional estimates, an excessive discrepancy between estimate and tender may lead to disruption of construction and budget programmes. This paper examines factors the influence the success of the tendering process within the constraints of a budgetary approval system. Three factors were found to be important in influencing the re-submit rate; namely the number of tenders, whether or not there was a Bill of Quantities, and whether the project value was less greater than $A50,000. The Procedure used for analysis was logistic regression applied to grouped and ungrouped data.
Keywords: capital budgeting , estimating, tendering, tender re-submission.

1987, **5**(3), 227–242

A change in the UK construction industry structure: implications for estimating

Abdel Razek, R and McCaffer, R
Department of Civil Engineering, Loughborough University of Technology, Loughborough, Leicestershire, UK

The paper illustrates the extent to which use of sub-contractors has grown in recent years in the UK by reviewing the growth of small firms, who in the main act as sub-contractors. In five years, 1979 to 1984, the number of one-man firms has grown by 136% and the value of work done by them has grown by 254%. Furthermore, all firms employing seven or less workers have grown by 94% in number and the value of their work has grown by 143%. The value of work being undertaken by firms employing seven or less workers represents 24.7% of the total of private contractor's work undertaken in 1984 compared with 14.1% in 1979. The effects of this change on the estimator are described with particular reference to attendances, materials wastage and disruptions. The conclusion is that the estimators' task has been made more difficult by the changes in industry structure.
Keywords: estimating, industry structure, sub-contracting.

1987, **5**(3), 243–266

Is construction project planning really doing its job? A critical examination of focus, role and process

Laufer, A[1] and Tucker, R L[2]
[1] *Department of Construction Management, Building Research Station, Technion IIT, Haifa 32000, Israel*
[2] *Construction Industry Institute, The University of Texas at Austin, ECJ 5 2, TX 78712 USA*

There is growing concern over the failure of construction planning to achieve its goals in spite of the considerable resources allocated to it. Deficient planning techniques are commonly blamed for this state. This view is challenged here following analyses of observations and studies by researchers and practitioners. The paper discusses normative planning vis à vis a deficient reality, and its probable causes. Planning effectiveness can be expected only after management modifies planning policy and prevailing practices are fundamentally changed. Future research should address planning from a wider, holistic perspective to include organizational, human and information-handling aspects, in addition to planning techniques as such.
Keywords: construction planning, control, information.

1987, **5**(4), S3-S22

Life cycle cost of university buildings

F. J. Bromilow[1] and M. R. Pawsey[2]
[1]*CSIRO Division of Building Research PO Box 56, Highett, Victoria 3190, Australia*
[2]*The University of Melbourne Parkville, Victoria 3052, Australia*

The theoretical background for a life cycle cost model of a building is described. Data relating to a 30-year-old building at the University of Melbourne are used as the basis for estimating long-term resource requirements, for comparing them with what has actually happened so far, and for future management of the building. The results demonstrate quantitatively the need to plan for substantial variability in necessary annual costs in real terms. Although the long-term (100 year) average annual cost of maintenance and rehabilitation is 2.0 % of the cost of the building studied, the pattern of expenditures is such that 1.1 % invested annually at 6 % p.a. real interest rate, would fund these operations indefinitely. Demolition and replacement of the building studied is not an economic proposition. Implications for university facility management are discussed. The basic methodology is applicable to other classes of constructed facility.
Keywords: building, cost, life cycle analysis, maintenance, university.

1987, **5**(4), S23-S30

Costs-in-use: principles in the context of building procurement

Barbara Bird
Building Research Establishment, Department of The Environment, Building Research Station, Garston, Watford, WD2 7JR, UK

The paper suggests that several factors are responsible for the relatively low level of application of the costs-in-use approach in the UK: attention has focused on costs alone, to the exclusion of performance; assumptions such as the often repeated assertion that increasing capital outlay will reduce running costs have diverted attention from the more fundamental principles of costs-in-use; while the absence of post-occupancy feedback about buildings' running costs and performance has placed a very real obstacle in the way of widespread acceptance. Ideally, statements about costs and performance should be clearly and explicitly made before the design brief is finalized, using the best information possible and with the client and other interested parties as fully aware as they can be of the commitment into which they

are entering. Some clients have recognized that the costs-in-use approach is one that may help in this respect, but their demand is so far largely not yet met.
Keywords: cost in use, design feedback, life cycle analysis, performance.

1987, **5**(4), S31–S42

Economics of university research laboratories: policy considerations

Robert E. Johnson[1], Ahmed Sherif[1] and Franklin D. Becker[2]
[1]*Architecture and Planning Research Laboratory, The University of Michigan, Ann Arbor, Michigan 48109, USA*
[2]*Facility Planning and Management Program, Cornell University, Ithaca, New York 14853, USA*

This paper reports on research to develop an understanding of how life-cycle cost models might be more appropriately applied to improve university research facility performance. Because of the wide variety of research laboratories found in universities, the project focused its efforts on chemistry facilities. The research used a three-part methodology consisting of a telephone survey, site visits and a survey questionnaire that was mailed to principal investigators. Both qualitative and quantitative factors were evaluated. The research found that the effective use of life-cycle cost analysis was limited because of the importance of non-economic qualitative policy considerations.
Keywords: life cycle analysis, decision-making, university, research facilities.

1987, **5**(4), S43–S52

Building economics in the United States

Harold E. Marshall
Applied Economics Group, National Bureau of Standards, Gaithersburg, Maryland, 20899, USA

Building economics is described in the narrow context of methods of capital investment analysis applied to building investments in the United States. The common characteristic of all the methods described is that they consider benefits (savings) and costs over the project's life cycle or study period. Eight steps involved in making an economic evaluation are presented. The process is illustrated with a problem in choosing the economically efficient thermal resistance level of attic insulation. Appropriate applications are described for the following methods: life-cycle cost; net benefits; benefit-to-cost and savings-to-investment ratios; and internal rate of return. Federal and state agencies that use these methods are identified. The role of standards societies and professional organizations in encouraging the use of these methods is described. Three projects in which these methods have been used are examined briefly in terms of methodology to illustrate the use of building economics methods. A description of difficulties in applying the methods concludes the paper.
Keywords: cost benefit analysis, benefit cost analysis, efficiency, life cycle analysis.

1987, **5**(4), S53–S71

Life cycle costing and risk management

R. Flanagan[1], A. Kendell[2], G. Norman[2] and G. D. Robinson[3]
[1]*Department of Construction Management, University of Reading, Whiteknights, Reading, England*
[2]*Department of Economics, University of Leicester, University Road, Leicester, England*
[3]*Centre for Strategic Studies in Construction, University of Reading, Whiteknights, Reading, England*

Risk and uncertainty is endemic to life cycle costing, and requires that an effective risk management system be an integral part of life cycle cost analysis. Such a system is developed, with emphasis on sensitivity and probability analysis. Its use is demonstrated by means of a case study of building finishes.
Keywords: cost in use, life cycle analysis, risk management.

1987, **5**(4), S73–S92

Capital costs versus costs-in-use: a content analysis of design team member communication patterns

W A Wallace
Department of Construction and Environmental Health, Bristol Polytechnic, Ashley Down Road, Bristol, BS7 9BW

The verbal interaction of a number of building design teams was observed, recorded and analysed using content analysis. A pilot and main study design team were observed on a longitudinal basis, while a range of validation design teams were observed on a cross-sectional basis. Variations in the communication content of individual design team members were recorded and measured in relation to a number of specific interest areas. One interest area was the measurement of the reconciliation between capital costs and expected costs-in-use, as a function of design team communication content in the pre-contract design stages. This paper considers the development of design team communication, particularly conflict development, in relation to the essential incompatibilities between capital cost minimization and cost-in-use optimization objectives and how this relates to design team development.
Keywords: content analysis, capital cost, cost in use.

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1988, **6**(1), 3–11

Contractual arrangement and the performance of the Nigerian construction industry (the structural component)

Aniekwu, A N and Okpala, D C
Civil Engineering, University of Benin, Benin City, Nigeria

The Nigerian construction industry is beset with many problems, such as uncompleted projects and poor quality work. Also the level of productivity is low, especially in projects handled by indigenous contractors. Investigation into the cause has identified two sets of variables, termed structural and systemic, as being responsible. Structural variables which are inherently related to the condition and practices within a given environment, were found to be controlled, if special provision can be made within the conditions of contract. The paper therefore examines these structural variables and relates them to provisions in the conditions of contract which undermine the performance to make them more effective.
Keywords: contract, cost, delay, structural variables.

1988, **6**(1), 13–23

A single alternative formula for department of health and social security S-curves

Tucker, S N
CSIRO Division of Construction and Engineering, PO Box 56, Highett, Victoria 3190, Australia

The formula most commonly used in the United Kingdom for prediction of cash-flows during construction of a building is that published by the Department of Health and Social Security (DHSS). The one empirical formula for the S-curve requires a series of parameters to be used for different contract costs. From a reliability theory approach, an alternative mathematical form, which includes the Weibull function, has been proposed as the basis for the S-curves. This paper demonstrates that not only can the Weibull functions be used as an excellent alternative to the DHSS formula but also that the Weibull function overcomes some of the limitations of the original formula. Relationships between the Weibull parameter values for each of the fits to the set of DHSS curves are derived empirically so that one single formula with a total of seven parameters replaces the DHSS formula and its associated tables for different project costs.
Keywords: cost, cost planning, mathematical modelling, quantity surveying.

1988, **6**(1), 25–33

An alternative payment system for major ‘fast track’ construction projects

Potts, K F
School of Construction, Engineering and Technology, The Polytechnic, Wulfruna Street, Wolverhampton, WV1 1SB, UK

In the UK, construction contractors are generally reimbursed on a monthly basis reflecting the value of work done on site plus payments for agreed off site components. If the contractor is behind programme and even if he completes late he will still be reimbursed based on the value of work done calculated using the original itemized bid price. The only way clients influence progress of the project is to claim from the contractor predetermined liquidated and ascertained damages in the event of late completion. These damages can only be charged after completion which may be hollow compensation, most clients preferring their projects completed on time. This paper describes an alternative payment system for use on major fast track projects in which the contractor is financially motivated to achieve satisfactory progress throughout the period together with completion on time. The system is based on the concept of predetermined percentages which are applied on a monthly basis to each major section of the project but only if the section’s relevant ‘milestones’ have been met during the period considered. The system as described has been satisfactorily used on a major international multi-contract, multi-disciplined fast track construction project with individual contracts up to £100m in value. The overall project was completed on time and within budget.
Keywords: bills of quantity, fast track, milestone, payment.

1988, **6**(1), 35–48

New answers and new questions in construction worker motivation

McFillen, J M[1] and Maloney, W F[2]
[1] *Department of Management, Bowling Green State University, Bowling Green, Ohio 43403, USA*
[2] *Department of Civil Engineering, The University of Michigan, Arbor, Michigan 48109, USA*

A survey of unionized construction workers was conducted in a major American mid-western city to collect data on their perceptions of the motivation climate on their jobs. The framework for the collection and analysis of the data was the expectancy model of worker motivation and performance. The findings indicated that the motivational climate is very poor. Contractors rely more on punishment and discipline than they do on positive rewards. Little is done to encourage good performance. Discipline is used to discourage poor performance. Contractors provide little in the way of rewards, even when they are not prohibited from providing a variety of rewards by their labour agreements. The workers surveyed reported very little incentive to be highly productive.
Keywords: motivation, operative, performance, personnel.

1988, **6**(1), 49–55

Methodology and method for price-level forecasting in the building industry

Runeson, G
School of Building, University of New South Wales, PO Box 1, Kensington, NSW 2033, Australia

This paper discusses the appropriate methodology for establishing a model for forecasting building price movements and interpreting building value statistics. The proposed methodology is illustrated with an ordinary least squares (OLS) multiple regression model quantifying the effects on the price level of variations in the degree of competitiveness in the industry. The dependant variable is a Market Conditions Rate of Unemployment. This model overcomes one of the most serious shortcomings of previous models in that it incorporates into the model adjustments to the capacity of the industry in response to variations in demand with the consequential improvement in accuracy.
Keywords: index, forecasting, price, time series.

1988, **6**(1), 57–70

Construction industry and economic growth in Singapore

Ofori, G
School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

The relationship between the construction industry and the economy in the course of national socioeconomic development has been studied by several writers. Singapore's recent advancement from a developing country to a newly industrializing one in less than a generation provides the opportunity to test some of these hypothesis. The article considers the role of the construction industry in Singapore's economy between 1960 and 1986. After studying the part construction played in the development process and the resulting structural changes that occurred within the industry, direct investment in construction by the public sector and its use to influence the direction of the economy as well as facilitate efforts to improve the industry are discussed. Governments attempts to manage the development of the local construction industry and the nature of the industry at present are also considered. A chronological approach is adopted under each of the main parts of the paper.
Keywords: development, export, infrastructure.

1988, **6**(1), 71–89

Which procurement system? Towards a universal procurement selection technique

Skitmore, R M[1] and Marsden, D E[2]
[1] *Department of Civil Engineering, University of Salford, Greater Manchester, UK*
[2] *Eric Wright Construction Ltd, Bamber Bridge, Preston, Lancashire, UK*

Two approaches are described which aid the selection of the most appropriate procurement arrangements for a building project. The first is a multi-attribute technique based on the National Economic Development Office procurement path decision chart. A small study is described in which the utility factors were weighted by averaging the scores of five 'experts' for three hypothetical building projects. A concordance analysis is used to provide some evidence of any abnormal data sources. When applied to the study data, one of the experts was seen to be atypical. The second approach is by means of discriminant analysis. This was found to provide reasonably consistent predictions through three discriminant functions. The analysis also found the quality criteria to have no significant impact on the decision process. Both approaches provided identical and intuitively correct answers in the study described. Some concluding remarks are made on the potential of discriminant analysis for future research and development in procurement selection techniques.
Keywords: decision making , multi-attribute model, procurement, statistics, utility theory.

1988, **6**(2), 93–115

Multi-project scheduling: a new categorization for heuristic scheduling rules in construction scheduling problems

Allam, S I G

Production and Project Management, Business Administration Department, Faculty of Commerce, Cairo University, Giza, Egypt

After more than two decades of applying CPM as a planning and scheduling technique there is growing doubt about some of the advantages initially to it. It is being discarded by both large and small construction companies, and its use limited to cases where it is required by the clients. Some planners and schedulers have begun to depend on their own experience. The author has developed a heuristic planning and scheduling model which uses two criteria; the tightness degree of completion due-dates and resource tightness degrees. Throughout the scheduling experiments, the hypothetical relationship between the performance of the proposed heuristic scheduling rules and the degrees of completion due-dates and resource tightness proved to be correct and there is a significant difference between the performance of proposed heuristic scheduling rules in the different scheduling classes. The new classification of scheduling problems proved to be practical, effective and helpful. The scheduling experiments resulted in a new categorization for the performance of the proposed heuristic scheduling rules in the different scheduling classes.

Keywords: construction planning, planning, project management, scheduling.

1988, **6**(2), 117–131

Building code assessment framework

Arlain, A G[1] and Rakhra, A S[2]

[1] *Technical Policy Advisor, Ontario Buildings Branch, Ministry of Housing, Toronto, Ontario, Canada*

[2] *Associate Research Officer, Institute of Research in Construction, National Research Council of Canada, Ottawa, Ontario, Canada*

This paper demonstrates the importance of developing and using a code assessment framework that takes into account technical, economic and social impacts of building code requirements. The effects of other regulations such as zoning laws and land-use restrictions are not discussed. The model can, however, be used for evaluating existing code requirements and for investigating the marginal impact of new or proposed code requirements that may be adopted in the future. It is expected that the development of the proposed framework will help rationalize code requirements designed to satisfy the given objectives of building codes.

Keywords: building code, framework, rationalization.

1988, **6**(2), 133–148

Major characteristics of constructed products and resulting limitations of construction technology

Nam, C H and Tatum, C B

Department of Civil Engineering, Stanford University, Stanford, California 94305-4020 USA

The products of construction differ in many important was from those of manufacturing. This paper describes five major characteristics of constructed products: immobility, complexity, durability, costliness, and high degree of social responsibility. These characteristics result in many limitations for construction technology; this paper analyses two of these limitations; the consequences of site operations and specialization. These characteristics suggest both insight regarding directions in developing construction technology and practical applications.

Keywords: integration, innovation, mass production, product, technology.

1988, **6**(2), 149–159

Replacement simulation model: a framework for building portfolio decisions

Bon, R

Department of Architecture, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

This paper presents a simple and robust replacement simulation model of potential value to organizations that possess a large building stock or portfolio. The basis of the model's conceptual framework is the recognition that facility renewal cycles are predictable. These cycles can be used to forecast the process of replacement by means of a rudimentary simulation procedure. The model allows for the sensitivity analysis of replacement expenditures to alternative maintenance scenarios. The better the maintenance programme. the longer the replacement cycles, and the lower the replacement costs per unit of time. These savings represent the upper bound on economically justified maintenance expenditures. The model also addresses the long-term fluctuations of replacement costs, which can be smoothed out by a suitable distinction between deferrable and non-deferrable replacement expenditures.

Keywords: building replacement, maintenance, portfolio, simulation.

1988, **6**(2), 161–169

Portfolio management in construction

Kangari, R and Riggs, L S
School of Civil Engineering, Georgia Institute of Technology, Atlanta, GA 30332, USA

When a construction company invests in a variety of projects, the combination can be viewed as a portfolio of projects. Such a portfolio is efficient if the contractor can diversify the projects. In general, a diversified portfolio of projects is less risky than the average of the individual projects considered alone. It is important to recognize that investment in construction projects differs somewhat from that in securities. For example, construction projects typically are not divisible, whereas securities are. These differences have caused many difficulties in the application of the portfolio theory in construction. The objective of this paper is to explore these problems and present solutions for them.
Keywords: diversification, financial management, portfolio theory, risk analysis.

1988, **6**(2), 171–182

The effect of systemic factors on contract services in Nigeria

Aniekwu, A N and Okpala, D C
Civil Engineering Department, University of Benin, Benin City, Nigeria

The productivity of the Nigerian construction industry is significantly lower than that of its foreign counterparts. Structural factors contribute to this poor performance and are dealt with in Aniekwu and Okpala (1987). This paper deals with another set of actors which are termed systemic, and which can be defined as problems arising from the application of systems not suitable to a particular environment. Through a survey, a set of these factors were identified, analysed and related to specific provisions in the conditions of contract in use. Their effects in the performance of contractors, especially local contractors, especially local contractors, are also reviewed. It is observed that the provisions of the contractual arrangements in use are of a general nature and hence are not directed at the peculiar situations in a developing economy like Nigeria; consequently a gap exists between the basic premises on which the provisions are based and the prevalent situation in the industry. It is therefore suggested that government should institute a review of these contractual provisions with a view to formulating more workable provisions designed specifically for the local context.
Keywords: contract, delay, productivity.

1987, **6**(3), 185–193

GNP, interest rate and construction investment: empirical evidence from USA data

Tan, W
School of Building and Estate management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

Economic theory suggests that construction investment varies directly with business profits and future expectations of profits and inversely with the interest rate. Time series studies using spectral analysis on USA data reveal that future expectation and business profits have a greater impact on investment decisions than the interest rate.
Keywords: GNP, interest rate, investment.

1988, **6**(3), 195–208

Design impact of construction fast-track

Fazio, P[1]; Moselhi, O[1]; Theberge, P[1] and Revay, S O[2]
[1] *Centre for Building studies, Concordia University, 1455 de Maisonneuve Blvd West, Montreal, Quebec, H3G 1M8, Canada*
[2] *Revay and Associates Ltd, Montreal, Quebec, H3Z 1P9, Canada*

Phased construction and fast-tracking have received considerable attention in recent years and have been synonymous with the development of new project delivery systems under the professional construction management approach. Many articles and even textbooks have been described only the advantages of these popular methods. Despite the differences between the two approaches, outlined in this paper, they are still being referred to interchangeably by construction professions. Through a case study, this paper also identifies the potential disadvantages of the fast-track technique. problem areas associated with the implementation of this technique are identified and further ranked with respect to their frequency observed on 28 fast-track construction contracts. A delay analysis shows the impact of this accelerated technique on construction activities. The far-reaching effects of mistakes during the early design/engineering phase in a fast-track is a major decision, and construction professional are often not aware of its implications. Based on the case study examined in this paper and other fast-track constructions previously analysed, trouble areas requiring special attention have been depicted and recommendations with regard to the effective use of this technique are presented. It has also been shown that unless considerable attention is directed to problem areas. Particularly those related to design, such a popular technique could result in unexpected delays.
Keywords: construction management, design management, fast track, phased construction.

1988, **6**(3), 209–224

The measurement of total factor productivity of the Hong Kong construction industry

Chau Kwong Wing and Walker, A
Department of Surveying, University of Hong Kong, Hong Kong

Previous research work concerning construction productivity has often been related to labour productivity. Although easy to measure and understand, labour productivity may be misleading the efficiency of utilization of resources. An alternative concept - total factor productive - is preferred. However, this concept has seldom been used in empirical research of construction productivity due to problems of measurements and availability of data. This paper presents a method of indirectly measuring the total factor productivity of the construction industry using various construction cost price indices and other statistics. Although special reference has been made to the construction industry of Hong Kong, the same approach should also be applicable to other countries.
Keywords: Hong Kong, profitability, tender price index, total factor productivity.

1988, **6**(3), 225–245

Tenders and estimates: a probabilistic model

Wilson, O D[1] and Sharpe, K[2]
[1] *Department of Architecture and Building, University of Melbourne, Parkville, Victoria 3052, Australia*
[2] *Department of Statistics, University of Melbourne, Parkville, Victoria 3052, Australia*

Problems faced by building project procurement agencies have been given only minor attention in the literature. When setting the rules of the tendering competition it is desirable that there be an appropriate balance between reasonable competition and a reasonable cost of competition. This paper examines some 410 projects obtained by a large state government instrumentally and proposes a model to describe the procurement system. It is probable that the lump sum competitive price in advance system of procurement is unsuitable for small renovation-type works. Larger projects having Bills of Quantities performed very well and satisfactorily results can be obtained by inviting four tenders per project. Some suggestions are made for improving the quality of the professional estimate.
Keywords: bidding, estimating, tendering.

1988, **6**(3), 247–258

Local business cycle severity and induced labour mobility: the case of the construction workforce

Herzog, H W and Schlottmann, A M
Department of Economics, the University of Tennessee, Knoxville, Tennessee, 37996-0550, USA

The purpose of this study is to examine inter- state labour mobility within the construction industry, a sector of the local/national economy whose output (employment) is highly cyclically sensitive. Econometric estimates of the construction work-force migration decision indicate that such workers are responsive to economic conditions throughout local labour markets when considering geographic mobility. In this regard, workers respond to both static and dynamic measures of local well being, and choose to move in the face of high local unemployment, slow growth, and high local cycle severity. In the latter respect, migration from metropolitan labour markets is significantly augmented (particularly among the unemployed) by the severity of local job loss attribute to national business cycle contractions, and stemmed somewhat by the rapidity of local job creation attributable to national expansions. The predominance of cycle-induced mobility within the construction work force (vis-a-vis static local economic conditions) has important implications to both regional and national planners concerned with stabilization aspects of public facility sitting (or closure). Thus, such worker responsiveness to local cycle severity should receive significant attention during impact assessment that precedes the construction (or closure) of large facilities such as military bases, public works and nuclear power plants.
Keywords: business cycle, labour, migration.

1988, **6**(4), 261–272

The integration of CPM and material management in project management

Shtub, A
Department of Industrial Engineering, Tel-Aviv University, Ramat Avib 69978, Israel

The problem of scheduling a project for which expensive, long-lead inventory items have to be ordered form outside vendors is addressed. A logic aimed at minimizing the cost of such projects is presented along either an illustrated example. The logic is based on adding a material management module to the CPM analysis, evaluating the feasibility of the CPM schedule, and rescheduling the project in case long-lead items make the schedule generated by CPM infeasible. An attempt to integrate CPM and material management in a large-scale construction project is reported and possible extensions of this research are suggested.
Keywords: material management, project management.

1988, **6**(4), 273–294

Management information flow in construction companies

Ndekugri, I E[1] and McCaffer, R[2]

[1] *Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK*

[2] *Department of Civil Engineering, Loughborough University of Technology, Leicestershire, LE11 3TU, UK*

The construction industry has been increasingly recognizing the need for more effective exchange of information between project participants. Not only have the manual systems failed to satisfy this need but the computer packages which have sprung up have also not allowed adequately for such communication. Integration of project information can optimize the operations of the industry as they exist currently. An even more promising but less immediate benefit of such integration is that it will form the necessary foundation for tools that advanced technology has the potential to produce. Such tools include simulation systems, knowledge-based systems and robotics which are very much in their infancy. A necessary step towards achieving the desired integration is to map out the characteristics of the flow of the information. This article analyses the flow of information among the management functions of the construction contractor.

Keywords: contractor, information, integration, management.

1988, **6**(4), 295–306

Optimum fleet size determination by queuing and simulation

Touran, A[1] and Taher, K A H[2]

[1] *Department of Civil Engineering, Northeastern University, Boston, MA 02115, USA*

[2] *Department of Civil Engineering, University of Colorado, Boulder, CO, USA*

Queuing theory applications in the field of earth-moving operations are reviewed. Using queuing theory and simulation techniques, a model is developed that can predict the productivity of one pusher and a fleet of scrapers under a given set of operating conditions. A computer program is developed for this purpose that interfaces Gaarslev's Queuing Model Program and Caterpillar's vehicle Simulation Program. The new system can consider the effect of variable inter-arrival times and bunching and road and machine conditions. The developed computer system allows the user to perform a sensitivity analysis by varying the number of scrapers, thus determining the optimum fleet size based on the lowest cost per cubic yard of production.

Keywords: modelling, plant, production, simulation, stochastic modelling, queuing theory.

1988, **6**(4), 307–337

JCT with contractor's design form of contract: a study in use

Pain, J and Bennett, J[2]

[1] *BCP Project Management, 20-24 Vachel Road, Reading, RG1 1PG, UK*

[2] *Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK*

This paper presents the results of a detailed study of projects using the JCT with contractor's Design (WCD) form of contract. Initially 49 projects were investigated to discover how the WCD contract is being used; for what kind of projects, by whom, in what circumstances, and what management approaches are being used. Fourteen projects were then selected to be investigated in more detail on their performance in terms of time, cost, quality and management. The variables were assessed in absolute terms and were then compared to what might have been expected if the contract had been managed in the conventional manner, i.e. using the JCT 80 Standard form of building contract. The conclusion of the study was that out of all the WCD projects investigated none had experienced serious problems and only a small proportion had encountered any difficulties at all in using the WCD approach.

Keywords: contractor's design, cost, management, time, quality.

1988, **6**(4), 339–355

Competence and timing dilemma in construction planning

Laufer, A[1] and Tucker, R L[2]

[1] *Building Research Station, Technion IIT, Haifa 32000, Israel*

[2] *Construction Industry Institute, The University of Texas at Austin, ECJ 5 2, Austin Tx 78712, USA*

Who should be assigned the task of planning a construction project and within what time-frame poses serious problems. Choosing between the likely candidates - manager or staff specialist and their respective strengths and weaknesses - is fraught with pitfalls. The awards and penalties linked to long lead-time planning as against short-term planning before the decision process. Many companies are vexed by the dilemmas resulting from any solution to the 'who' and 'when' questions but by side-stepping or overlooking them they invite deficiencies with dire consequences. After an analysis of these issues the article proposes a new approach for the design of the construction planning process.

Keywords: accuracy, forecasting, manager, planning.

1988, **6**(4), 357–370

An analysis of the accuracy of estimating and the distribution of tenders

Runeson, G
School of Building, University of New South Wales, PO Box 1, Kensington, NSW 2033, Australia

This paper is a statistical analysis of the distribution of tenders and how it can be derived from the distribution of estimators' cost rates. It derives equations to explain the distribution of unit and elemental rates which are found to depend on the contribution of the task to the total cost, labour content and procurement method. It further demonstrates that while there is considerable co-variance between unit rates, there is no such interdependence between either elemental or sub-contractor rates. This means that the central limit theorem can be used to forecast the distribution of tenders.

Keywords: estimating, tendering.

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1989, **7**(1), 3–18

A construction project net cash-flow model

Kenley, R and Wilson, O D
Department of Architecture and Building, University of Melbourne, Parkville, Victoria 3052, Australia

This paper proposes a construction project net cash-flow model based upon the logit transformation. The model was found to have an excellent fit to the data for 75% of the projects analysed. The proposed model is a useful tool for the post hoc examination of construction project net cash-flows. The model is very flexible and is capable of adapting to the wide degree of inter-project variability.
Keywords: cash flow, estimating.

1989, **7**(1), 19–28

Forecasting productivity by work sampling

Handa, V K and Abdalla, O
Department of Civil Engineering, University of Waterloo, Ontario, N2L 3G1, Canada

The measurement of labour inputs to the productivity process is the major subject of this study. It is concerned with the simplification of the operation of collecting labour productivity information on site where it is not a one-time task and should be a continuous effort to acquire as many measurements as possible to ensure constant field management control of the project. The study employs the simple methods of work sampling and learning curves for field management control to measure labour utilization during the construction process. Work sampling technique is simple and easy to use in the management of site resources, time and labour, but it is only an indirect measurement of actual productivity. Therefore, the study has concentrated on demonstrating the correlation between the work sampling percentages, unit rate productivities, and the learning rates of global activities through the development of productivity projection models. Thus, it is possible to quantify productivity and learning rates directly through the simple technique of work sampling.
Keywords: learning curve, productivity, regression analysis, site, unit rates, work sampling.

1989, **7**(1), 29–40

Identifying the environments of construction projects

Hughes, W P
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

A systematic technique for identifying the environments of construction projects is described. It provides a method for isolating the major variables surrounding construction projects, and is briefly applied to the industries of Britain and Jamaica to illustrate its application. From this, it is inferred that the environment of a Jamaican construction project in systems terms is broadly similar to the environment of a construction project in Britain.
Keywords: environment, industry, Jamaica, systems analysis.

1989, **7**(1), 41–51

Subsector fluctuations in construction

Tan, W
School of Building and Estate Management, National University of Singapore, Kent Ridge Crescent, Singapore 0511

Subsector analysis of short-run construction reveals that the construction cycle is fundamentally linked to the general business cycle so that moderation of the volatility of the cycle requires a more concerted national effort. Subsector starts were found to be generated by the same underlying structure and highly susceptible to random shocks; little is thus to be gained from diversification of work by construction firms.
Keywords: business cycle, construction subsector, diversification.

1989, **7**(1), 52–63

Tendering: optimization and rationality

Green, S D
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

There have been various techniques published for optimizing the net present value of tenders by the use of discounted cash-flow theory and linear programming. These approaches to tendering appear to have been largely ignored by the industry. This paper utilizes six case studies of tendering practice in order to establish reasons for this apparent disregard. Tendering is demonstrated to be a market oriented function with many subjective judgments being made regarding a firm's environment. Detailed consideration of 'internal' factors such as cash-flow are therefore judged to be

unjustified. Systems theory is then drawn upon and applied to the separate processes of estimating and tendering. Estimating is seen as taking place in a relatively sheltered environment and as such operates as a relatively closed system. Tendering, however, takes place in a changing and dynamic environment and as such must operate as a relatively open system. The use of sophisticated models to optimize the value of tenders is then identified as being dependent upon the assumption of rationality, which is justified in the case of a relatively closed system (i.e. estimating), but not for a relatively open system (i.e. tendering).

Keywords: environment, estimating, rationality, systems theory, tendering.

1989, **7**(1), 65–74

Expert systems and contractual disputes: extension of time under JCT 80

Al-Shawi, M A and Hope, A E
School of the Built Environment, Liverpool Polytechnic, Clarence Street, Liverpool, L3 5UG, UK

The resolution of contractual disputes is an area within the construction industry where complex rules and regulations are apparent and where much human expertise is currently employed monitoring and settling disputes. This paper describes research aimed at developing an expert system for the resolution of extension of time disputes arising under a UK standard form of building contract, JCT 80. The paper outlines the potential benefits of such a system, identifies how the system was developed and describes the working system and its limitations.

Keywords: contract, dispute, expert system, extension of time, knowledge base.

1989, **7**(1), 75–86

An evaluation of production outputs in key building trades in Nigeria

Olomolaiye, P O and Ogunlana, S O
Department of Building, Obafemi Awolowo University, Ile-Ife, Nigeria

Construction planners and estimators in Nigeria often guess the outputs of building tradesmen. Since it is difficult to draw reliable construction programmes or make accurate cost estimates without an adequate knowledge of production output, it is suggested that outputs should be determined scientifically. The time study technique was adopted to evaluate production output in bricklaying, steel fixing and joinery trades. The tradesmen were also approached to estimate their outputs in selected tasks. From the operatives' estimates and output measured through time study, it was found that there are varying degrees of excess production capacities yet untapped in the trades.

Keywords: equipment, productivity, work study, time study.

1989, **7**(2), 95–102

The selection of materials handling methods in construction by simulation

Wijesundera, D A and Harris, F C
School of Construction, Engineering and Technology, The Polytechnic, Wolverhampton, UK

This paper describes the development of a dynamic interactive simulation model for selecting construction equipment in building and civil engineering projects. The simulation uses real data obtained from site studies to construct operation times and equipment cycles for handling materials from all despatch points delivered to work crews. In this manner by changing variables such as crane type, size and location, skip size, delivery system and construction crew sizes the effects on utilization levels and costs can be evaluated for different methods of working. The process was facilitate by adopting the tailor-made simulation software program STELLA which uses the principle of fluid flow and tank storage analogous to stock movement of materials.

Keywords: construction planning, expert system, material handling, simulation, tower crane.

1989, **7**(2), 103–113

Project management under uncertainty

Skitmore, R M; Stradling, S G and Tuohy, A P
Department of Civil Engineering, University of Salford, Salford, M5 4WT, UK

Morris's (1986) analysis of the factors affecting project success and failure is considered in relation to the psychology of judgement under uncertainty. A model is proposed whereby project managers may identify the specific circumstances in which human decision-making is prone to systematic error, and hence may apply a number of deblazing techniques.

Keywords: project management, uncertainty.

1989, **7**(2), 115–124

An S-curve equation for project control

Miskawi, Z
M W Kellogg Limited, Stadium Way, Middlesex, UK

This paper reports a development of an S-curve equation capable of producing an envelope of S-curves . the equation could be used in a variety of applications related to project control in the petro-chemical industry. The research consisted of developing the equation then carrying out various tests; the results show that the theoretical data correlate closely to actual data collected from various petro-chemical projects executed worldwide. The equation is being used in M W Kellogg to determine construction S-curves for various projects.
Keywords: project management, S-curve.

1989, **7**(2), 125–136

Workload fluctuations and aspects of building quality

Powell, C
Welsh School of Architecture, University of Wales College of Cardiff, PO Box 25, Cardiff, CF1 3XE, UK

Relationships between workload fluctuations and quality of service, with particular reference to design, are investigated by means of a study of architects' practices. A method of experience survey is described. Conditions of temporary slackness are found to be regarded as serious, and effects almost entirely harmful. Conditions of temporary overstanding are found to be common and regarded as serious. Their effects are seen as largely harmful, but ambivalent attitudes arise from some benefits to building design. Heavy workload is believed to more likely than light workload to be associated with higher quality design.
Keywords: design, quality, workload.

1989, **7**(2), 137–153

Housing in Singapore: determinants of success and lessons for the developing countries

Ofori, G
School of Building and Estate Management, National University of Singapore, Singapore

This paper considers the successful mass housing programme implemented in Singapore since 1960. With emphasis on the central housing agency an attempt is made to outline the main features of the organizational framework and the relevant policies and procedures. The factors which contribute to the success of the housing programme are identified. These are compared with those commonly found in the developing countries, especially those in sub-Saharan Africa. It is concluded that the main aspects of Singapore's programme worth emulating include a firm government commitment, the formulation of a strong and effective executing agency, appropriate policies firmly enforced, identified of target groups, tailoring of designs to meet specific needs and, especially, resource management.
Keywords: developing country, housing, resource management, Singapore.

1989, **7**(2), 155–174

Civil engineers' managerial roles and needs: report of survey

Faulkner, A C[1]; Sargent, J H[2] and Wearne, S H[3]
[1] *World Investor, Tower House, Fairfax Street, Bristol, BS1 3BN, UK*
[2] *Senior Manager, International Business Development, Costain Group plc, UK*
[3] *Senior Research Fellow, Project Management Group, UMIST, PO Box 88, Manchester, UK*

The paper presents results from a survey of civil engineers' jobs, their organizational positions, and the managerial skills and knowledge required. Analysis of the data obtained shows great differences between these requirements and educational preparation for them. Much increased preparation through training, self study and continuing education should therefore by of benefit to civil engineers and the performance of their industry.
Keywords: civil engineer, management education, research.

1989, **7**(2), 175–186

A system for monitoring and improving construction operative productivity in Nigeria

Olomolaiye, P O and Ogunlana, S O
Department of Building, Obafemi Awolowo University, Ile-Ife, Nigeria

Survey of production outputs, production problems and motivation of construction operatives on seven sites showed that there is scope for improving productivity in the Nigerian construction industry. A system for monitoring and improving construction productivity on sites is presented. The recommended system works on a pre-potent factor principle using a simple slow-chart of necessary actions. They also introduces the concept of hyper-production into

construction productivity and advocates the development of a construction productivity expert system is developed countries where builders an afford computers.
Keywords: motivation, Nigeria, operative, productivity.

1989, **7**(3), 189–202

Architectural and economic consideration in the design of prefabricated façade components (exterior walls)

Ishai, E
Senior Lecturer, Faculty of Architecture and Town Planning, Technion, Israel

One of the important factors in the design of buildings is the visual expression of the structure as manifested in the design of façade components. This article classifies the various façade components into three groups; 'complete' flat components; and spatial (three-dimensional) components. A method is proposed for examining the geometry (sizes and shapes) of the various components that relies on both architectural and cost considerations.
Keywords: design, economics, façade, pre-fabrication.

1989, **7**(3), 203–216

Organizational responses to public sector clients in Canada to the implementation of value management: lessons for the UK construction industry

Male, S and Kelly, J E
Department of Building, Heriot Watt University, Riccarton, Edinburgh, EH14 4AS, UK

Value management is a philosophy and set of techniques that has its originals in the USA manufacturing industry of the 1940's. it has been increasingly used in the North American construction industry and is now being used in the UK construction industry by a small group of contractors and consultancy firms who are offering it as a service to clients. This paper provides a brief review of the historical development of and approaches to value management, as practiced in North America and then details two case studies of how client bodies have responded to its implementation. One case study is concerned with events at an organizational level whilst the second tracks the client response to a value management exercise on a project. The paper concludes by discussing the implications of the lessons learned from these case studies for the UK construction industry.
Keywords: building process, client , cost, design team, function, value management.

1989, **7**(3), 217–234

Project management excellence: the Shell Stanney case

Holt, L
Department of Construction Management, University of Reading, Whiteknights, Reading, RG6 2BU, UK

This study concerns the management principles applied by both the client and the management contractor during the successful design and construction of a three-storey office and laboratory block. the client was Shell research and the management contractor Wimpey Construction Management. The study demonstrates how many of the principles promoted by recent books such as In Search of Excellence are applicable. Success requires an initial ability to think creatively and be willing to try new approaches and then strong determination to apply the principles throughout the whole design and construction process. The paper is based on interviews with several of the key participants and records their perceptions of the key ingredients of success.
Keywords: administration, leadership, project management.

1989, **7**(3), 235–247

A database/spreadsheet application for equipment selection

Chan, C M R[1] and Harris, F C[2]
[1] *Dept of Civil Engineering, Loughborough University of Technology, Loughborough, UK*
[2] *Dept of Construction, Wolverhampton Polytechnic, Wulfruna Street, Wolverhampton, UK*

A computerized system of selecting construction equipment is described. A database of technical criteria for a backhoe/loader machine is assembled and analysed with a spreadsheet technique. The process of selection uses the Kepner and Tregoe method to arrive at the best choice of excavator for a particular job.
Keywords: computing, database, decision making, equipment, spreadsheet.

1989, **7**(3), 249–262

An expert system for construction contract claims

Kim, M P[1] and Adams, K[2]
[1] *Principle Investigator, US Army - Construction Engineering Research Lab, Champaign, IL 61820, USA*
[2] *Corning Glass Works, Corning, New York, USA*

An expert system for claims guidance has been developed at US Army Construction Engineering Research Laboratory. This paper describes the development of the first module of the Claims Guidance System (CGS) for analysing 'differing site condition' (DSC) claims. Also included is a selection of appropriate case and a sample consultation.
Keywords: artificial intelligence, claim, expert system, knowledge acquisition, site.

1989, **7**(3), 263–279

Accident prevention in materials handling at building construction sites

Niskanen, T and Lauttalammi, J
Institute of Occupational Health, Laajaniityntie 1, SF-01620 Vantaa, Finland

In addition to efficient scheduling of handling, accidents may be significantly reduced by ensuring that there are sufficient mechanical aids for handling construction boards, doors, windows, fittings, etc., in the machinery and equipment plan on site. The information systems of a construction enterprise should be developed in the direction of tying project planning tightly to production (i.e. actual construction) planning. Details which improve occupational safety should be carefully considered; sufficient knowledge of the machinery available and suitability to the prevailing conditions of the machine or device chosen.
Keywords: accident prevention, material handling, safety, site operation.

1989, **7**(4), 283–301

Accident risks during handling of materials at building construction sites

Niskanen, T and Lauttalammi, J
Institute of Occupational Health, Laajaniituntie 1, SF-01620 Vantaa, Finland

The aim of the study was to analyse factors influencing the occurrence of accidents in materials handling. The supervisors' and workers' opinions about deficiencies and problems in accident prevention during materials handling were surveyed. Materials handling in this study means all internal transfers at the construction site, work site storage, installation and removal of formwork, and installation of pre-cast concrete units. Altogether 422 accident report forms were analysed. Sixty-four per cent of the accidents that occurred at office and public building construction sites took place during construction of the framework. The corresponding percentage for accidents occurring during construction of the framework of high-rise apartment houses was 44%, that for terrace houses was 40%, for industrial sites 55% and for building repair and renovation 50%. In the questionnaire study the data obtained from the site supervisors can be used to search for the basic reasons behind the problems. The opinions of the workers dealt more with how the basic problems were expressed at the practical level. The serious accidents (45 cases) investigated by the National Board of Labour Protection were classified according to the type of accidents.
Keywords: accident risk, material handling, site operation, safety.

1989, **7**(4), 303–319

Organizational behaviour and safety management in the construction industry

Wilson, H A
The Construction Industry Federation, Federation House, Canal Road, Dublin 6, Ireland

This research paper examines the relationship between organizational theory and accident causation/prevention theory as applied in practice to the construction industry. Part of the research work consisted of an information survey of groups of various categories of workers, managers and owners to establish their perceptions of accident causation. The findings indicate that the emphasis of current accident prevention measures in force is more suited to mechanistic organizations than to organic types of which the construction industry is one. The conclusions reached are that the emphasis must be concentrated more on education and training and the spread of information on the hazards of the working environment and their avoidance.
Keywords: organizational behaviour, prevention, safety management.

1989, **7**(4), 321–330

Computerized reference sources in the construction industry

Gilleard, J
College of Architecture, Georgia Institute of Technology, Atlanta, Georgia 30332, USA

The 1980s have been described as the beginning of the information age, and justly so. Advances in microprocessor design, information storage systems and telecommunications have all combined to make access to accurate and up to date information a prerequisite for any successful business or research project. No longer is it necessary to laboriously scan printed abstracts, seeking out information via a limited index of keywords, when today's communication networks allow an almost instantaneous access with a user-defined mix of search parameters. Correspondingly, this shift towards computer-based search procedures has resulted in many of the traditional scientific, business and professional abstracting services, that the construction industry has relied upon in the past, offering these bibliographic databases via commercial information retrieval systems. This paper reviews the range of information services that are currently available; discusses how they work and what equipment is required; examines the typical search features; comments on the estimated cost of using on-line search methods; and, finally, describes a typical on-line search session.
Keywords: bibliographic database.

1989, **7**(4), 331–345

The construction firm and the construction project: a transaction cost approach

Winch, G
Manufacturing Policy and Strategy Unit, Institute for Management Research and Development, University of Warwick, Coventry, CV4 7AL, UK

Three of the influential perspectives for analysing construction management are reviewed socio-technical systems; organization and environment; and project management - and it is suggested that in spite of their considerable usefulness, they contain no framework for analysing the inevitable differences in interest between the different firms who are members of the project coalition. An alternative approach is then presented - the transaction cost approach - which, it is suggested, does allow these differences to be analysed. In condition, the dynamics of the contracting system are assessed in terms of the contradiction between construction firms' responses to the uncertainties inherent in the project, and those deriving from the contracting system itself.
Keywords: contracting system, transaction cost, uncertainty.

1989, **7**(4), 347–356

Organizational context, structural attributes and management systems in construction firms

Kabasakal, H E[1] and Sözen, Z[2]
[1] *Department of Management, Bogaziçi University, Istanbul, Turkey*
[2] *Department of Architecture, Istanbul Technical University, Istanbul, Turkey*

An exploratory study on contextual and structural correlates and performance implications of use of advanced management systems in construction firms was carried out. A sample of 24 Turkish general contractors was investigated. Results show that the contextual variables of domain diversity, size and technology are not directly associated with the degree to which management tools are utilized. There is evidence, however, to indicate that structural dimensions of complexity and decentralization serve as intervening variables. Of the two, internal specialization appears to be more strongly associated with management systems use. A significant positive relationship also emerges between use of management systems and company performance. Alternative explanations for this finding are discussed.
Keywords: company performance, management system, organization structure, Turkey.

1989, **7**(4), 357–365

Modelling of building production activities for multi-facility projects

Skibniewski, M J[1] and Molinski, J[2]
[1] *Division of Construction Engineering and Management, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907, USA*
[2] *Construction Management Section, 'ORGBUD' - Institute for Planning, Management and Economics in the Building Industry, Filtrowa 54, 02-057 Warsaw, Poland*

A multi-facility construction planning model, based on the Line of Balance Method was developed for use by construction firms facing shortages of production resources and varying facility delivery schedules. The model facilitates expedient updates of firm's production schedules by shifting resources between high and low priority work across multiple facilities under construction. This is particularly useful on large development projects in centralized economies, but may also benefit construction firms in market-driven economies when the demand for construction services is high and frequent shortages of qualified labour, materials, equipment and other supplies occur. The approach developed by this model has been tested on various multi-facility housing and industrial construction projects

in Central Europe. A microcomputer program incorporating the model has been developed to simulate the impact of shifting work activity between various project facilities and to endure meeting the firm's resource constraints.
Keywords: planning, resource utilization, site operation.

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1990, **8**(1), 3–11

Potential for application of plastic liner plates in tunnelling works

Skibniewski, M J[1] and Kassouf, P J[2]
[1] *Division of Construction Engineering and Management, School of Civil Engineering, Purdue University, West Lafayette, IN 47907, USA*
[2] *Triad Engineering and Construction Co, Macedonia, OH 44056, USA*

A construction method involved in the placement of a plastic liner steel plate system for a tunnelling construction project is analysed. Aspects of implementing plastics as a new material for liner plates with regard to their technical, organizational, and economic impact are evaluated. Advantages and disadvantages are presented of polyethylene in comparison with traditional steel. Finally, initial estimation of cost advantages associated with plastic liners is outlined.
Keywords: innovation, plastic liner, tunnelling.

1990, **8**(1), 13–29

The quality debate

Seymour, D E[1] and Low Sui Pheng[2]
[1] *School of Civil Engineering, University of Birmingham, Birmingham, UK*
[2] *School of Building and Estates Management, University of Singapore, Singapore*

The paper argues that there are intrinsic difficulties in defining quality. This is particularly true of construction in view of the endemic uncertainty to which it is subject. However, an institutional framework comprising a balance between technical, occupational, contractual/legal and economic orders was developed making possible the equitable negotiation of quality. This balance has been disturbed and the current debate within the industry concerns the way a new balance can be achieved. Two major tendencies in the debate about what quality is and how it is to be achieved are identified. One argues the need for market forces to operate at all levels, for tighter specification and quantification of quality standards and for the development of formal control procedures. The other argues the intrinsic limits of specification, quantification and formalization of procedures and therefore the ineluctable need for occupational discretion to be exercised at the point of production.
Keywords: economic order, occupational order, professionalism, quality.

1990, **8**(1), 31–47

The development of a rational bill of quantities

Singh, G[1] and Banjoko, O O[2]
[1] *Department of Civil Engineering, University of Leeds, Leeds, LS2 9JT, UK*
[2] *Technical Director, L.A.O. Banjoko & Co Ltd, Nigeria*

The civil engineering industry world-wide has long known that the Conventional Bill of Quantities (BOQ) is inadequate conceptually and functionally. Moreover. the only alternative to it, the Method-Related BOQ (M R Bill), is only marginally better: Its development having been constrained by inadequate analysis, problems of inertia attached to current6 practice, and lack of scientific methodology for the evaluation of comparative performance of alternative prototype forms of BOQ. An analysis and evaluation of the two forms of Bill and of six newly established others, using a newly developed scientific methodology based on worth assessment, statistics, and simulation, is presented. A suitable form of Bill, which is logical and in conformity with the principles of the Measurement Contract with Quantities, has emerged and is recommended to the industry.
Keywords: bills of quantity, civil engineering, computation, contract, financial control, simulation.

1990, **8**(1), 49–61

Research of factors influencing construction productivity

Herbsman, Z and Ellis, R
Department of Civil Engineering, University of Florida, Gainsville, FL 32611, USA

Productivity rates are among the most essential data needed in the construction industry. The accuracy of productivity rates is crucial for the determination of direct relationship between these rates and subjects such as estimating, cost control, scheduling, and resource management, among others. Past experience in the construction industry has shown that great variation in production rate values for the same construction item is attributed to the effects of project conditions which are commonly called influence factors. This paper describes the development of a statistical model that illustrates the quantitative relationships between influence factors and the productivity rates. The application of such a model will enable the user to estimate productivity rates with a higher degree of accuracy in future projects.
Keywords: estimating, productivity, project management, resource management.

1990, **8**(1), 63–75

The fixed capital stock in use by the UK construction industry

Lowe, J G
Department of Building, Heriot-Watt University, Riccarton, Edinburgh, EH14 4AS, UK

The study of technological change and productivity in the construction industry requires the development of some measures of the fixed capital stock available to the industry. There are serious theoretical and methodological weakness in the traditional neo-classical approached to valuation of the capital stock. This paper is intended to overcome some of those problems in so far as they affect the construction industry and to present a suitable method of measurement using readily available published statistics. The paper also considers a method of deriving the average age of the capital stock from the estimated value of capital so calculated. This will help to facilitate empirical checks on the assumptions used and will also provide another dimension of technical change.
Keywords: capital, depreciation, plant, vehicle.

1990, **8**(1), 77–87

Construction industry in Turkey

Tavakoli, A[1] and Tulumen, S C[2]
[1] *Construction Engineering and Management, Case Western Reserve University, Cleveland, Ohio, USA*
[2] *President, T.E. Construction Ltd, Istanbul, Turkey*

The Republic of Turkey is a major force in the international construction market. This paper presents the construction industry in Turkey. Special attention is paid to the overview of the industry; the size and structure of the construction industry; construction contracts (competitively bid, negotiated, build-operate-transfer, 'mutual construction'); selection of contractor and bidding law; management structure; construction management techniques (bar chart, progress and development outline, CPM); trend of the domestic market; and international construction.
Keywords: international construction, Turkey.

1990, **8**(1), 89–104

Identification of factors influencing implementation of construction robotics

Kangari, R[1] and Halpin, D W[2]
[1] *School of Civil Engineering, Georgia Institute of Tech, Atlanta, GA 30332, USA*
[2] *Division of Construction Engineering and Management, Purdue University, West Lafayette IN 47907, USA*

The objective of this paper is to describe major factors influencing the robotization of construction processes, and to provide a model based on fuzzy set theory for feasibility analysis of robotics. Major factors influencing implementation of construction robotics are described. The Primary factors driving the adoption of robotics in construction are identified as:(1) need-based feasibility, (2) technological feasibility, and (3) economic feasibility. In order to concentrate on process which have potential and exclude those processes which are not strong candidates for automation, brainstorming sessions were held with various parties involved in construction to examine feasibility of construction processes for automation. The participants were asked to consider construction processes from the heavy and highway, building and industrial construction areas.
Keywords: automation, equipment, excavation, material handling, pre-fabrication, robotics.

1990, **8**(2), 109–133

Advanced applications software for speculative housing companies

Ewin, N A[1]; Oxley, R[2] and Poole, F[2]
[1] *Director, Solcitec, UK*
[2] *Sheffield City Polytechnic, Sheffield, UK*

The diversity and complexity of individual building companies has meant that many prospective users have been unable to find applications systems packages which precisely meet their needs. The high cost, and long lead times associated with traditionally produced bespoke software has previously made such systems impractical for many builders. Some builders who have commissioned bespoke software have had unsatisfactory results, where systems have been unreliable, or do not fully meet the purposes for which they were intended. This paper describes a prototype advanced software development system which was constructed and then applied to produce an integrated estimating and cost control system for speculative housing companies. Spec-Builder was developed over a relatively short time period, thus at lower cost. As much of the software was generated from proven DB4GL Procedures, the resulting system was also reliable. The development techniques allow early appraisal of the system which can then be amended easily to fulfil the user's precise requirements. The system could be used for producing other applications packages.
Keywords: housing company, software, systems analysis.

1990, **8**(2), 135–146

Economic optimization of construction project scheduling

Karshenas, S[1] and Haber, D[2]
[1] *Marquette University in Milwaukee, Wisconsin, USA*
[2] *Jansen Contractors, Milwaukee, Wisconsin, USA*

Several techniques such as CPM, PERT, and time-cost trade-off are currently used in the process of project planning. None of these techniques, nor any combination of them, guarantees a project schedule that achieves one of the most important objectives of project planning, i.e. minimizing the total project cost. In this study, binary variables are used to formulate a linear integer model for optimization of project schedules. This model minimizes the sum of the cost of all resources used by a project, including time. The resultant schedule has a optimal duration, and the resource use is levelled economically. Two examples of project schedule has an optimal duration, and the resource use is levelled economically. Two examples of project schedule optimization with this method are presented. Although the proposed model in its present form cannot be easily adopted by practising engineers for large projects, it could form the basis for future automation of project scheduling and resource allocations.
Keywords: cost, optimization, resource, schedule.

1990, **8**(2), 147–158

Towards the development of a fire safety systems evaluation for public assembly buildings

Shields, T J; Silcock, G W and Donegan, H A
University of Ulster, Jordanstown, Co Antrim BT37 0QB, Northern Ireland

The application of the Delphi Technique in the development of fire safety evaluation schemes is reviewed. The Analytical Hierarchical Process is introduced and suggested as an appropriate tool for use in the development of fire safety evaluation schemes using expert opinion. A study undertaken to investigate the potential of the AHP in the development of a fire safety evaluation scheme for public assemble buildings is reported. The results obtained indicate that the AHP which incorporates a check for consistency in the decision making process is a useful tool for handling information obtained on a judgemental basis.
Keywords: analytical hierarchy process, decision making, Delphi technique, fire safety.

1990, **8**(2), 159–178

Project management: dynamics and performance

Sidwell, A C
Louis Laybourne-Smith School of the Built Environment, South Australian Institute of Technology, Australia

Construction projects follow a life-cycle that is dynamic and goal orientated. They are managed by a project team, each phase of the project life-cycle is different in nature demanding different skills, roles and responsibilities from the team. This paper explores the dynamic and changing focus of the management of construction projects and the ingredients of performance drawing on case studies of major projects in Australia.
Keywords: Australia, performance, project management, team management.

1990, **8**(2), 179–190

Expert Systems for crane selection

Warszawski, A
Building Research Station, Israel Institute of Technology, Haifa, Israel

An expert system seems to be particularly attractive as a decision tool in the unruly construction environment. Application of expert systems, to various facets of construction planning, has been described in various publications. The paper examines two expert systems applied to the crane selection and location problem, evaluates them and draws some conclusions with respect to the general applicability of expert systems to construction planning.
Keywords: construction planning, crane, expert system.

1990, **8**(2), 191–204

Professional authority, power and emerging forms of 'profession' in quantity surveying

Male, S
Department of Building, Heriot-Watt University, Edinburgh, EH14 4AS, UK

This paper presents an exploratory and theoretical analysis of professional authority and power and its impact on the future of quantity surveying as a profession. The paper argues that the professional knowledge base of quantity surveying and its relationship to the skills used by quantity surveyors in providing a service to clients forms one of the basic building blocks of professional power and authority. An analysis of the client practitioner relationship in quantity

surveying is undertaken using two models of 'profession', one concerned with client evaluation and the second with the development of mystique, cruciality and consequently professional authority. The paper concludes that quantity surveying does not currently have a base for the continued development of professional authority and power. However, the potential is there and could stem from the expansion of the resource controller or resource gatekeeper roles. Finally, the paper discusses emerging forms of 'professional' in quantity surveying and highlights that this could be affected by; the changing nature of employment in different organizations, the distinction between the professional and technician function, the issue of sub-contracting in private practice and the development of large professional bureaucracies through merger activity, that could offer multiple surveying services and exercise considerable influence over the future direction of the profession.

Keywords: client, power, profession, professionalism, quantity surveying.

1990, **8**(2), 205–218

Impacts of information technology on the structure of construction

Bröchner, J

Department of Building Economics and Organization, Royal Institute of Technology S-100 44 Stockholm, Sweden

Changes in the structure of the construction industry can be attributed in part to information costs being reduced over time. Co-ordination, inspection and the translation of client needs are facilitated, affecting employee incentives within firms, transactions between firms and the role of intermediaries. These aspects of information technology influence the optimal configuration of construction processes within each firm in the industry. Patterns of integration are seen as dependent on the interaction of aspects of information technology with attributes of each construction process. Geographic expansion, diversification or sub-contracting, integration with materials supply and into real estate are considered. An emerging industry pattern with three types of firms: specializing co-ordinating and local is indicated, while in the long run, a development towards individuals in project networks is foreseen.

Keywords: industry structure, information, integration.

1990, **8**(2), 219–228

Human issues affecting construction in developing countries

Imbert, I D C

Department of Civil Engineering, The University of the West Indies, St Augustine, Trinidad

The inhibiting effect of underdevelopment of human resources on construction in developing countries is examined and the need for education, training and research emphasized. Developed-world involvement and its often adverse effects, social and otherwise, are discussed, the provision of shelter being given as one major example. The fact that most large-scale infrastructural work is undertaken through arrangements with developed-world organizations is given prominence, the inappropriate nature of many contract procedures being emphasized. The importance and extent of informal construction is also highlighted.

Keywords: contract, education, human resource management, research, underdevelopment.

1990, **8**(3), 233–247

Historical comparison of construction sectors in the United States, Japan, Italy and Finland using input-output tables

Bon, R[1] and Pietroforte, R[2]

[1] *Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading, RG6 2BU, UK*

[2] *Department of Civil Engineering, Massachusetts Institute of Technology, Room 3-436, MIT, Cambridge, Massachusetts 02139, USA*

This paper uses the input-output tables compiled since World War II in four advanced industrial countries - United States, Japan, Italy and Finland - to analyze the role of construction in their economies. Several questions are discussed: How does the construction sector interact with other sectors of the economy? How does this interaction change over time? How does it differ from country to country? The paper first briefly introduces the input - out data and the indicators used for comparative analysis. For reasons of space, the historical values of these indicators are presented only in graphical form. Next, the paper compares the construction sector in the four countries in terms of their shares in gross national product and national income, direct and total backward and forward linkage indicators, and direct and total inputs from manufacturing and service sectors. Special attention is paid to changes in construction technology, that is, changes in the relative shares of manufacturing and service sectors in the input profile of the construction sector. For reasons of space again, the emphasis is placed on international comparisons, rather than on intersectoral comparisons. Finally, the main findings and directions for future research are summarized.

Keywords: construction technology, input-output analysis, internationalconstruction.

1990, **8**(3), 249–257

Thai construction industry: demand and projection

Tang, J C S; Karasudhi, P and Tachopiyagoon, P
Industrial Engineering & Management Division, Asian Institute of technology, GPO Box 2754, Bangkok 10501, Thailand

Thailand is fast becoming a newly industrializing country and, consequently a large number of construction works are projected for the future. This study is an attempt to gain further insight into the demand for construction activities in Thailand. Three types of construction - residential, non-residential and 'other' (mainly public project) - were considered. The demand function for each type of construction was estimated using regression analysis. Results indicate that rising per capital income, the ratio of consumer price index are the most significant factors affecting the demand for no-residential construction. The demand of other construction is found to be largely a function of rising revenues of government and of public utilities. Further, projection results indicate that total construction activities in Thailand appear to have a bright future: projected values range from an annual average of 230481 million baht to 310599 million Baht for the next 5 five years.
Keywords: demand analysis.

1990, **8**(3), 259–283

Specialist contractors: a review of issues raised by their new role in building

Bennett, J and Ferry, D
Centre for Strategic Studies in Construction, University of Reading, Reading, RG6 2BU, UK

The paper describes a study of the newly emerging role of specialist contractors in the UK building industry. It identifies a common strategy employed by specialist in dealing with the complexity and diversity of modern building. This is to maintain a consistent operating core insulated from the firm's environment. It also highlights particular problems which arise in current practice in respect of contracts, design responsibilities, co-ordination of work on site and the incidence of variations. It also shows that opportunities and problems arise from the power of modern information and the demands for quality assurance. All these individual issues give rise to a need to review the training of operatives and specialists' investment in research and development. For the rest of the industry, the study suggests a need to develop better ways of evaluating competitive design proposals from specialists.
Keywords: design contract, research and development, site co-ordination, specialist contractor, training.

1990, **8**(3), 285–300

The development of an expert system for the strategic planning of construction projects

Brandon, P S
Department of Civil Engineering, University of Salford, Salford, UK

The paper outlines the problems associated with cost models and the role of professional expertise. It then outlines the production of an expert system to be used at the strategic planning stage of the development process. The system was developed in collaboration between the University of Salford and The Royal Institution of Chartered Surveyors (Quantity Surveyors Division) and funded under the British Government's 'Alvey' IKBS programme.
Keywords: budget, development appraisal, expert system, procurement, strategic planning, time.

1990, **8**(3), 301–313

An evaluation of the relationship between bricklayers' motivation and productivity

Olomolaiye, P O
Department of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

Before a theory of construction operative motivation can be proposed that the relationship between motivation and productivity is established. This paper describes investigations aimed at establishing this relationship with particular reference to bricklayers. The investigation revealed that there is an element of motivation in every bricklayer regardless of his working environment and also confirm the nineteenth century optimal motivation theory by Yerkes and Dodson. No relationship was found between motivation and work rate but motivation has a significant influence on the proportion of working time bricklayers spend productively.
Keywords: bricklayer, motivation, productivity.

1990, **8**(3), 315–328

BOT projects: risks and securities

Tiong, R L K
School of Civil and Structural Engineering, Nanyang Technological Institute, Singapore

There has been a growing trend in recent years for governments in many developing countries to palace major public investments, particularly for infrastructure projects, into the private sector. This has meant that governments look into private sector to finance projects using the projects' anticipated revenues as security rather than relying upon a direct sovereign guarantee of the project debt. Many have adopted the 'Build-Operate-Transfer', or BOT approach, so that the private sector have to operate the plant and transfer the ownership to the government often a specified concession period. However for BOT to succeed in any major privatized project, the host government cannot withdraw or adopt a passive role: It has to ensure the right political and commercial environments in which to advance the projects. This paper deals with the various guarantees and incentives that could be provided by the government. It covers the responsibilities and undertakings that the project sponsors could commit to in order to negotiate favourable concessions from the government and to raise financing that is so vital for the BOT model to be successful. The financing, political and technical risks are discussed and the techniques that could be used to have these risks covered are suggested to ensure a smooth project implementation.

Keywords: concession, finance, guarantee, risk, security, toll.

1990, **8**(3), 329–338

An ergonomic analysis framework for construction tasks

Russell, J S[1] and Skibniewski, M J[2]
[1] *Department of Civil and Environmental Engineering, University of Wisconsin, Madison, Wisconsin 53706, USA*
[2] *School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907, USA*

This paper presents a new methodology for obtaining a quantitative measure of human task performance complexity and effort on the construction site. An example application of the developed methodology to the analysis of concrete placement tasks is provided. The developed method can be used to aid construction equipment manufacturers in understanding and assessing the automation potential for a variety of construction work tasks.

Keywords: automation, human performance, robotics.

1990, **8**(4), 341–363

The use of structured data analysis as a construction management research tool

Fisher, N
Department of Construction Management & Engineering, University of Reading, Whiteknights, Reading, RG6 2BU, UK

The flow of data between members of a construction project team is both critical and time-consuming. If progress is to continue in important areas of construction management and engineering that involve data flow or transfer - such as information technology, computer-aided design and manufacture, robotics and expert systems - the recording and identification of the best current practice will become increasingly important to the design of more efficient data flows. This paper outlines a modified form of 'structured data analysis' (SDA), a technique originally developed by the electronic data processing industry. Modifications necessary for SDA to be used as a tool in management systems research are outlined. The contextual relationship of the technique to the wider systems movement is considered. The benefits and limitations of the technique are discussed, and the conclusion is reached that SDA has the promise of being an ideal tool to assist in the task of mapping, recording and comparing data flows in different organizations.

Keywords: information technology, management, research method, systems analysis.

1990, **8**(4), 365–383

A survey of current production planning practices in the precast concrete industry

Dawood, N N and Neale, R H
Dept of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

This paper reports an initial stage of a research project in the management of precast concrete production in the United Kingdom. It describes a survey of current practices in 18 precast concrete manufacturing firms, comparing their actual practices to a theoretical model derived from published literature. It concludes that the theoretical model was too complicated, and formulates a more simple and practical model. The survey also identified the need for a good computerized system which can assist middle management in forecasting and production planning.

Keywords: construction planning, pre-cast concrete.

1990, **8**(4), 385–398

Construction management on one large project in London: a case study

Dodd, J and Langford, D A
School of Architecture and Building Engineering, Bath University, Bath, UK

This paper explores the organizational and personnel issues emerging from the relationships between the management contractor and trade contractors on one construction project in London. The aim is to provide feedback about the effectiveness of the relationship between management contractors and the trade contractors and to explore some of the factors that inhibit 'good' relationships and those that promote 'bad' relationships. Data was collected using two techniques. A short psychological test (the FIRO-B) was used to unearth the compatibility between individual managers of trade contractors and the construction manager's staff. Semi-structured interviews were used to enrich the data about sources of interpersonal conflict. The results illustrate the importance of creating compatible teams to generate effective teamwork. The research found that there was a dichotomy between trade contractors who may be described as 'traditional' and those who were 'specialist'. The latter showed a more positive approach to the new role and status. These differences influenced the outcome of the project and the research determines some forces that 'drive' or 'restrain' changes in the behaviour of trade contractors on construction management projects.
Keywords: construction management, procurement method, trade contractor.

1990, **8**(4), 399–414

Methods and data used by large building contractors in preparing tenders

Betts, M
Construction Management and Economics Research Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

The process of submitting lump sum competitive tenders continues to be commonly practised by UK building contractors. most tenders are based on a detailed analysis of project details and a detailed costing of parts of the work to be done. Considerable resources are being devoted to the preparation of tenders in this way. Any means of improving the efficiency of this process would be very welcome to contractors and to the construction industry as a whole. This paper presents a documentation of methods of tender preparation in the form of a model of the tasks executed. This model is a description of the process in its most complex possible form as currently executed and does not attempt to portray the tendering process as it is typically performed. Variations within the model have been found to occur between individual contractors and for alternative means of procurement as well as for differences in project complexity. However, the model is generally representative of the means by which tenders are prepared by large building contractors in the UK. The model as been produced with the aim of documenting items of data that are used. This has been done using techniques of structured systems analysis including data flow diagrams and a data dictionary. Resulting from this analysis is a definition of data potentially used by building contractors in tendering. This definition gives a better opportunity for the more purposeful and complete application of information systems to the tendering process as a means of improving its efficiency. The paper therefore provides a specification of data to be used in the development of information management system to support building contractors' tendering.
Keywords: contractor, information system, information management, systems analysis, tendering.

1990, **8**(4), 415–430

International contracting: a Turkish perspective

Giritli, H[1]; Sözen, Z[1]; Flanagan, R[2] and Lansley, P R[2]
[1] *Faculty of Architecture, Istanbul Technical University, Istanbul, Turkey*
[2] *Department of Construction Management & Engineering, University of Reading, Whiteknights, Reading, RG6 2BU, UK*

The rapid development of the Turkish construction industry in overseas markets provides a contrast to the internationalization of other countries' construction industries. By focusing initially on low-technology projects in difficult locations and exploiting its mobile low-cost labour force, the Turkish industry has rapidly gained in experience and sophistication, thereby enriching its domestic construction industry. The internationalization of the Turkish industry has required the development of new institutions and attitudes within Turkey and the rapid development of financial systems.
Keywords: export, international construction, labour cost, sub-contracting, Turkey.

Construction Management and Economics

1990, **8**(4), 431–436

Challenge and innovation: the challenge to the construction industry

Gale, A W[1] and Fellows, R F[2]

[1] *Department of Building Engineering, University of Manchester Institute of Science and Technology, Manchester, UK*

[2] *Department of Building Engineering, University of Bath, UK*

A one-day conference, organized by the Association of Researchers in Construction Management (ARCOM), took place in May 1989 to provide an interchange between industry and the research community. The programme was based on the premise that: 'It is necessary to go beyond superficial and self-congratulatory discussion and challenge the very basis of the construction industry as we have come to know it'. Sir Clifford Chetwood, the incoming president of the Building Employers Confederation (BEC), recently said: 'I believe we have a very fine industry but it suffers from the fact that it is fragmented, that it doesn't have a uniform platform from which to project itself. We are going to have to sit down together and think through how we can establish that unified policy basis for the whole industry.' The present construction industry consist of more than 170 000 firms, out of which 155 000 employ fewer than eight people. In 1986, new build, industrial, refurbishment, etc., accounted for about 55% of the total output of the industry, leaving 45% for repair and maintenance. Many clients put an emphasis nowadays on 'fast track' construction. Over the last 10 years, the average speed of construction has increased from over 157m^2 per week to something over 169m^2 per week. The Broadgate Project has the fastest known construction of 627m^2 per week; faster by 50% than American building projects. However, does speed preclude the inclusion of all the human and social values we wish to contain in buildings? The following report has been compiled from the transcript of the conference. The purpose of this report is to distil the essence of the speeches and discussions that followed. No attempt has been made to attribute statements to speakers or participants. The intention of this report is to identify the paramount issues raised, contradictions observed and problems emerging from discussion. The contents are intended to provide the basis for future debate and research.

Keywords: innovation, research.

CME: Volume 9, 1991

1991, **9**(1), 3–17

Project risk action management

Berkeley, D[1]; Humphreys, P C[1] and Thomas, R D[2]
[1]*London School of Economics and Political Science, Houghton Street, London, WC2A 2AE, UK*
[2]*W S Atkins Project Management, Woodcote Grove, Ashley Road Epsom, Surrey, KT18 5BW, UK*

This paper examines the requirements for project risk action management techniques which can assist clients and project managers to assess and pre-empt potential sources of risk. These sources may be external or internal to the project managers to be sensitive to these potential sources of risk, to be able to anticipate their occurrence, to appreciate their potential impacts on the project objectives and to reduce their future impact through appropriate risk action management strategies. The paper examines project management goals and objectives and discusses risks which may arise to threaten the achievement of these objectives. The conventional risk analysis approach is reviewed in the context of the need to identify and assess such risks and their potential effects. The paper reviews the direct relationship, as presented in the conventional approaches to risk analysis, between 'risk drivers' and risked consequences and demonstrates that the represents a primarily passive approach to project risk management. It argues that, if the manager is able to anticipate risks, he should also be able to take appropriate pre-emptive actions before they occur. Thus, we show how risk action management techniques, within the context of project management, can support project managers in the formulation of project strategies, planning and the achievement of project objectives.
Keywords: project management, risk, risk analysis.

1991, **9**(1), 19–38

Programmes for improving the performance of contracting firms in developing countries: a review of approaches and appropriate options

Ofori, G
Construction Management and Economics Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

Contractor development schemes have been part of the national programmes for improving the construction industries of developing countries for many years. The nature of, and results obtained from, such schemes have been different from one country to another. This paper considers the issues involved in the efforts to improve the performance of contracting firms in the developing countries. The feature of such firms and their operating environment are discussed. With the emphasis on countries in sub-Saharan Africa and South East Asia, existing contractor development programmes are reviewed. Some of the principal factors that might contribute to the success of such programmes are discussed. It is suggested that the programmes should be country-specific and incorporate specific targets. They should be based on objectives that are achievable considering the circumstances in which they will be implemented. Finally, their implementation should be monitored and periodically reviewed.
Keywords: contractor, developing country, operating environment.

1991, **9**(1), 39–49

Information management system for new construction technologies

Skibniewski, M J
Division of Construction Engineering and Management, Civil Engineering Building, Purdue University, West Lafayette, Indiana 47907, USA

This paper presents an overview of a prototype evaluation system intended for new construction technologies under consideration by the US Army Corps of Engineers. The system has been designed for implementation on MS-DOS driven micro-computers and is capable of determining the level of technology impact on the military construction programme within a given planning horizon. Potential civilian sector applications of this system are also desirable.
Keywords: evaluation, management system, technology.

1991, **9**(1), 51–61

Evaluation and selection of construction projects in Nigeria

Okpala, D C
Department of Building, University of Jos, Jos, Nigeria

Investors in the Nigerian construction industry were surveyed in four major towns in southern Nigeria in order to collect data on the evaluation and selection criteria employed when investing in construction. Their responses were analyzed based on type of developer, i.e. Individuals, companies or government agencies. The net present value (NPV), discounted cash-flow (DCF) and payback method were identified as the three most significant methods for evaluating

construction projects. Of the developers surveyed, about 19% undertook risk analysis, whereas 81% allowed for risk by multiplying by a factor whose value varies. There was closer agreement between individual investors and companies on the priorities accorded to different factors when evaluating and selecting projects, than between government agencies and any of the other two. The availability of capital was considered of utmost importance by all the investors surveyed.
Keywords: evaluation, investment, project selection,.

1991, **9**(1), 63–71

World markets in construction I: a regional analysis

Low Sui Pheng
Bartlett School of Architecture and Planning, University College of London, Wates House, 22 Gordon Street, London, WC1H 0QB, UK

The role of marketing has seldom been extolled in construction, let alone international contracting. Even where marketing has been endorsed in the process, it has been taken for granted and regarded at a passive, self-adjusting and self-generating level. This paper demonstrates that this need not be so and that the function of marketing research can be exploited and employed gainfully in the context of international construction to find out where the markets are in the world. Absolute measures (volume) and relative measures (growth) can be used in the main for this purpose. The results of a marketing research project are presented in the form of graphically distorted world maps at both the regional and national levels. While part I of this paper deals with the results of 19 global regions, part II concerns itself with the construction industries of 180 different countries and territories. It is hoped that international construction marketing opportunities may be identified in the process.
Keywords: economic development, international construction, marketing research.

1991, **9**(1), 73–78

World markets in construction II: a country-by-country analysis

Low Sui Pheng
Bartlett School of Architecture and Planning, University College of London, Wates House, 22 Gordon Street, London, WC1H 0QB, UK

The role of marketing has seldom been extolled in construction, let alone international contracting. Even where marketing has been endorsed in the process, it has been taken for granted and regarded at a passive, self-adjusting and self-adjusting and self-generating level. This paper demonstrates that this need not be so and that the function of marketing research can be exploited and employed gainfully in the context of international construction to find out where the markets are in the world. Absolute measures (volume) and relative measures (growth) can be used in the main for this purpose. The results of a marketing research project are presented in the form of graphically distorted world maps at both the regional and national levels. While Part I of this paper deals with the results of 19 global regions, pat II concerns itself with the construction industries of 180 different countries and territories. It is hoped that international construction marketing opportunities may be identified in the process.
Keywords: economic development, international construction, marketing research.

1991, **9**(1), 79–92

Managerial effectiveness and the style of management in the Middle East: an empirical analysis

Enshassi, A[1] and Burgess, R[2]
[1] *Al-Fatah University, PO Box 13528, Tripoli, Libya*
[2] *School of Architecture and Building Engineering, Liverpool University, PO Box 147, Liverpool, L69 3BX, UK*

This study aims at examining the site managers' effectiveness with relation to their managerial style when managing multi-cultural work forces in the Middle East. Data were obtained from 79 site managers working with 41 international and 38 local organizations in six Middle Eastern countries. These are: Saudi Arabia, United Arab Emirates, Libya, Bahrain, Oman and Kuwait. Managerial effectiveness was found to be related to the style of site managers. The successful site manager is one who recognized and understands cultural differences of his subordinates and combines both leadership dimensions, task and employee orientation.
Keywords: culture, effectiveness, Middle East, operative, site manager, style.

1991, **9**(2), 97–112

An agenda for cost modelling research

Newton, S
Design Computing Unit, Department of Architectural and Design Science, University of Sydney, New South Wales 2006, Australia

There is little order or formal direction to current cost modelling research. The paper proposes a basic classification system with which both to set out the overall topology of cost modelling as a distinct subject, and to provide the much needed points of reference on which individual research contributions can be located. The taxonomy is used to review

over 50 reported cost models. The analysis of this review highlights that current emphasis lies with non-specific, macro price models which use abstract units of measurement, and are intended to be used at the sketch design stage. These models generally use simulation techniques based on functional dependencies, with implicit assumptions and a deterministic outcome. On current trends, the preferred models of the future will is as-built units of measurement, and make considerably more use of stochastic techniques. One criteria for which there appears far too little concern, is in making the assumptions within the model more explicit.

Keywords: cost model, research, review.

1991, **9**(2), 113–132

Simulation of expenditure patterns of construction projects

Khosrowshahi, F

South Bank Polytechnic, Wandsworth, London, SW8 2JZ, UK

The existing models fro project budgeting and forecasting are either alienating to the user, or involve a laborious process of preparation. This is mainly due to the structure of the model, which itself is determined by the approach adopted in developing the model. In this paper, a new approach to model development based on the analysis and examination of the shape of the pattern of project expenditure is described and contrasted with the approaches that have been adopted so far. Also, the procedure for the generation of a model based on the new approach to model development is outlined. This is an attempt to overcome many of the shortcoming associated with the current models, by building on the many advantages features of these models. It is anticipated that the approach adopted and the accompanying mathematical model can facilitate the provision of a balanced combination of ease of application, user involvement and user comprehension.

Keywords: cash flow forecasting, growth curve, mathematical modelling, project management.

1991, **9**(2), 133–150

Learning from experience in design cost estimating

Ogunlana, S O

Division of Structural Engineering and Construction, Asian Institute of Technology, PO Box 2754 Bangkok 10501, Thailand

The underlying reasons responsible for failure to learn in design cost estimating are considered. A model for aiding learning from experience in design cost estimating practice is presented. Analysis of historical cost data from seven UK design offices show that learning through the use of feedback data is insufficient.

Keywords: accuracy, design estimating, development, experience, feedback, learning.

1991, **9**(2), 151–155

Lane rental contracting

Srinivasan, R[1] and Harris, F C[2]

[1] *Department of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK*

[2] *School of Construction, Engineering and Technology, Wolverhampton Polytechnic, Wolverhampton, UK*

This paper deals with the principal Lane rental systems operated in the UK and describes the merits and disadvantages of each. Issues relating to contractual arrangements, management style, contract finish times, working conditions and arrangements are covered. Comparisons are drawn with conventional contracts.

Keywords: highway, maintenance, road contract, tendering.

1991, **9**(2), 157–169

Innovative contract incentive features for construction

Ibbs, C W

215a McLaughlin Hall, University of California, Berkeley, CA 94720, USA

Incentive plans used by owners and contractors can be valuable contract administration tools to enhance project success. This article outlines many of the strategic choices available for designing and administering incentives construction contracts. The project conditions that facilitate use of particular features and some of the pitfalls associated with each are also discussed. Cost effectiveness of incentive plans also estimated, based on empirical experience from a number of plans. The importance of owner sincerity is stressed, as is the indirect impact on project performance because of more disciplined use of project control systems.

Keywords: construction, contract administration, contract, incentive, risk sharing.

1991, **9**(2), 171–186

Cost prediction using decision/risk analysis methodologies

Birnie, J[1] and Yates, A[2]
[1] *Department of Surveying, University of Ulster, Newtownabbey, Northern Ireland, UK*
[2] *Dearle & Henderson, Chartered Quantity Surveyors, 4 Lygon Place, London, SW1 0JR, UK*

The ability to make good cost predictions is a very important aspect of the construction process. The methods used have historically relied on subjective judgements based on data which have proved satisfactory. The formal methodologies of decision/risk analysis have been little used in construction. This paper looks at how the use of decision trees, utility theory and the Monte Carlo simulation technique might improve human judgement in cost prediction. The successful application of decision/risk analysis to a housing refurbishment contract is described in a case study.
Keywords: decision analysis, Monte Carlo simulation, probability, risk analysis, utility theory.

1991, **9**(2), 187–204

Escalation management: forecasting the effects of inflation on building projects

Fellows, R F
Construction Study Unit, School of Architecture and Building Engineering, University of Bath, Bath BA2 7AY, UK

Following a review of the development and use of indices which purport to measure the effects of inflation upon the building industry, the paper focuses upon the problem of forecasting. Errors in published forecasts of building cost indices and tender price indices are noted and various possibilities for achieving more accurate forecasts are evaluated. The evaluations demonstrate that stochastic time series forecasting is a useful approach. A probabilistic project cash-flow model for NEDO work categories was produced and combined with stochastic time series forecast of the NEDO category indices to yield project escalation forecasts of the NEDO category indices to yield project escalation forecast of measured variability. Although high forecasts of escalation resulted, these forecasts were of lower error than other forecasts derived from published information. Sensitivity analyses were used to consider variability and error sources in the forecasts, showing the primary variable to be the indices. It is concluded that forecasts of projects' escalation based upon stochastic time series techniques offer considerable advantages to the construction industry and its clients.
Keywords: cash flow, escalation, inflation, stochastic forecasting.

1991, **9**(2), 205–215

Cost estimation of prestressed concrete beam and reinforced concrete slab construction

Singh, S
Building Construction Program, College of Architecture, Georgia Institute of Technology, Atlanta, Georgia 30332-0155, USA

An interactive computer model has been developed for approximate cost estimation of prestressed concrete beam and reinforced concrete slab construction in high rise commercial buildings. A number of design variables like different structural schemes, grid sizes, number of storeys, grades of concrete, grid location and section of beams have been incorporated in the model to assess heir effect on cost and quantities of constituents of concrete construction. The use of the model is recommended for comparative cost estimation to determine the effect of design parameters on structural cost; for approximate structural cost estimation of an overall project; for checking of estimates for structural works; for calculation of quantity index for structural schemes and system; for budgeting of materials and finally for use in various studies in building economics.
Keywords: concrete, estimating, cost model, economic evaluation, structural system.

1991, **9**(3), 219–229

The implications of small group interactions for understanding aspects of organizational culture

Lansley, P R and Riddick, J
Department of Construction Management & Engineering, University of Reading, Whiteknights, Reading, RG6 2BU, UK

Drawing on the observation and experiences of senior management groups in the construction industry, this paper explores the relationship between the characteristics of small groups and the culture of the larger organization. It uses as a frame of reference the work of W R Bion.
Keywords: culture, organization, performance, small group.

1991, **9**(3), 231–245

Achieving and measuring flexibility in project information retrieval

Betts, M

Construction Management and Economics Research Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

Because of the diversity of people, organizations and organizations and activities involved in the management of construction, there is a need for great flexibility in the way in which project information can be presented. This paper describes how relational database technology can be used with integrated database design methodology to develop a flexible means of information retrieval. An implementation of a database of this type, for the type, for the purposes of research, has used project data from a real life project. The testing of the database has been of its ability to enable flexible information retrieval. The results show a significant improvement in flexibility measured on an ordinal scale. The paper thus shows how to gain greater flexibility in information retrieval for basic retrieval forms. It also presents a methodology by which flexibility can be measured and compared. It concludes by speculating on the consequences of extrapolating the results to more complex forms of information retrieval.

Keywords: information management, information retrieval, project information, relational database.

1991, **9**(3), 247–263

Construction contracting in theory and practice: a case study

Bresnen, M J

Cardiff Business School, University of Wales College of Cardiff, Aberconway Building, Colum Drive, Cardiff, CF1 3EU, UK

Despite the attention given over the last several years to the effectiveness of alternative contracting methods, problems of co-ordination and control still continue to plague the construction industry. The argument that is presented in this paper is that research in this area has tended to analyze the problem at one remove by essentially ignoring the reality of construction project management and the factors that commonly influence behaviour on a construction project. In particular, little systematic attention has been directed towards how goal and power differentials can affect project outcomes. Evidence is presented from a case study of a management contract to demonstrate how the motives or aims that each party to the contract brings to the relationship and the ability they have to influence successfully the decisions and actions taken can have a substantial effect upon the course of events. The economic and contractual power of the respective parties and also internal organizational conditions are singled out for attention in this respect. The paper concludes that any assessment of the efficacy of various types of delivery system ought to take into account the factors that are likely to influence the operation of those systems in practice.

Keywords: contracting, management, organizational behaviour, project organization.

1991, **9**(3), 263–289

Development of an integrated system for planning earthwork operations in road construction

Alkass, S[1] and Harris, F C[2]

[1] *Centre for Building Studies, Concordia University, Canada*

[2] *Wolverhampton Polytechnic, Wolverhampton, WV1 1SB, UK*

The objectives of existing computer programming methods of earthwork systems optimization in road construction have generally been either to minimize cost or maximize profit. However, the required computer memory needed is generally excessive and, moreover, the method demands a prior knowledge of the cost of transporting a unit of material along a given haul distance. As a consequence, the equipment resources would, by implication, have already been decided upon. Inexperienced personnel are clearly unable to reach this decision. The paper describes the development of an integrated system that combines earthwork allocation with the selection of equipment for road construction. Knowledge and experience possessed by planning engineers and equipment specialist has been captured and interpreted in a form suitable for manipulated by computer programmes. The validity of the model is demonstrated by applying it to a real case study to provide an additional tool to management in deciding the earthwork allocation and cheapest equipment fleet cost.

Keywords: computing, construction equipment, earth moving, expert system.

1991, **9**(3), 291–308

Net cash-flow models: are they reliable?

Kaka, A P and Price, A D F

Department of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

This paper discussed the development of a reliable net cash-flow model to be used by contractors at the tendering stage. The model is based on cost commitment curves instead of the usual value curves. As the model includes many simplified assumptions, there was a need a test its reliability. The model was tested on five building projects and produced good results. The possibility of building an ideal cost curve was examined by building an average curve from

the available curve from the available projects. The average curve was used to forecast net cash-flows for the five projects. The results demonstrated the validity of the model as a forecasting tool.
Keywords: contractor, cost commitment, net cash flow model, reliability, tendering.

1991, **9**(4), 311–325

Profitability of UK construction contractors

Akintoye, A and Skitmore, R M
Department of Civil Engineering, University of Salford, Salford, M5 4WT, UK

This paper describes three analyses examine differences in construction company POT profitability between (1) different financial years and (2) different sizes of companies. In the first analysis, the aggregated profitability of a sample of 80 UK general contractors was found not to differ significantly from 3.23% for each year of the period examined. The size (turnover) or companies, however, was significantly and positively correlated with profitability. The second analysis, os a sub-sample of eight very large companies, showed that profitability was associated with diversification into house building and other related activities. The third analysis of 110 speculative house builders, showed profit margins to be around four times those of general contractors with company size. Systematic changes were found, however, over the period involved. In all cases, the variability of profitability between companies was found to reduce with company size, implying a greater consistency in the financial performance of larger companies.
Keywords: company size, diversification, pricing, profitability, turnover growth.

1991, **9**(4), 327–342

Construction industry clients: a survey of their attributes and project management practices

Bresnen, M J[1] and Haslam, C O[2]
[1] *Cardiff Business School, University of Wales College of Cardiff, Aberconway Building, Colum Drive, Cardiff, CF1 3EU, UK*
[2] *Department of Social Sciences, Loughborough University of Technology, Loughborough, LE11 3TU, UK*

The recent growth of interest in the strategic decisions made by clients as to how to organize and manage their projects has not as yet been matched by any extensive and systematic analysis of clients' attitudes and approaches towards project management. This paper seeks to help redress this imbalance by presenting findings from a survey of 138 client organizations drawn from both the private and public sectors. Focusing upon their experiences on a recently completed, comparatively large (£1 million plus) project, the paper examines similarities and differences in the ways in which clients organize and manage their projects and assesses the impact of these practices on project performance. Differences in the type, size and typicality of the projects are also taken into account in the analysis. The main conclusions drawn from the data are that client experience has an important impact upon many of the decisions made, that strategic decisions are often internally driven as opposed to project-based, that additional work and inadequate briefing still continue to cause problems during construction, and that there is little direct evidence in favour of alternatives to traditional managerial and contractual arrangements.
Keywords: client, contract, organization, project management.

1991, **9**(4), 343–353

Objectives and performance in construction projects

Ward, S C; Curtis, B and Chapman, C B
Department of Accounting and Management Science, University of Southampton, Southampton, SO9 5NH, UK

This paper considers the problems associated with the identification and use of project-related objectives held by a project-owning, client organization. It is argued that the evaluation of projects, contractors, professionals or procurement methods solely on the extent to which client objectives are achieved is problematic. Difficulties include setting objectives at an appropriate level, allowing for uncertainty and interdependencies between objectives, and measuring the achievement of objectives. Proper evaluation and improvements in performance require an examination not just of project objectives but also of the processes involved in pursuing them
Keywords: management contracting, objective, project performance.

1991, **9**(4), 355–368

An appraisal of the marketing development in engineering consultancy firms

Morgan, R E and Morgan, N A
Cardiff Business School, University of Wales College of Cardiff, Aberconway Building, Colum Drive, Cardiff, CF1 3EU, UK.

This paper examines the results of an empirical study into the role of marketing in consultancy engineering service firms in the UK. The results suggest that marketing is, to some extent, considered a 'legitimate' management function within

these firms. However, evidence can be seen to illustrate that the trappings 'of marketing prevail rather than the substance', which is required if a firm is to have the market-led and customer-driven orientations fundamental to the implementation of the marketing concept.
Keywords: client, implementation, marketing orientation, professional.

1991, **9**(4), 369–381

Estimating system selection expert

Arditi, D and Suh, K
Department of Civil Engineering, Illinois Institute of Technology, Chicago, Illinois 60616, USA

Computerized quantity take-off and cost-estimating systems have proliferated in the last 4-5 years. Companies that decide to computerize estimating are faced with the problem of making the right selection. Selecting a package first involves the identification of a potential user's needs. Then, a review is made of the packages available and their capabilities and, finally, the selection of a package by matching the potential user's needs with estimating system capabilities. ESSEX, whose conceptual framework is presented in this paper, is a knowledge-based expert system that facilitates the decision to be made by a potential user of estimating software as to what package to acquire. ESSEX users an expert system shell to manipulate three main files: 'User Mod', the interface with the potential user that also develops the user's decision criteria; 'SysMod', the interface with the developers that records commercially available systems' characteristics; and 'MatchMod', that matches user and system characteristics to reach the most appropriate selections. An objective evaluation of ESSEX and suggestions for further research are made.
Keywords: estimating, knowledge-based system, quantity take-off, software selection.

1991, **9**(4), 383–400

Relationship between value and duration of construction projects

Kaka, A P and Price, A D F
Department of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

A strong relationship exists between the cost and duration of construction projects. This relationship can be used in contractors' budgeting systems and the corporate financial model developed at Loughborough University (Kaka, 1990). The client can use this relationship to estimate the approximate duration of a project and compare it with the proposed ones. Two samples were collected to model this relationship. Sample 1 contained 661 building projects with a total value exceeding £695 million, which included all types of commercial, industrial, residential and public projects. Sample 2 included 140 road contracts with a total value exceeding £120 million. The average ratio of actual time to the agreed time for road work is 1.0351. The ratio varies between a maximum value of 2 and a minimum of 1/3. The following stage of the analysis involved modelling the relationship for civil engineering and different types of building contracts. The two samples were classified according to type of project, form of contract and type of competition. Even groups were modelled and tested visually for the difference in these relationships. The type of competition was found to have no effect on the relationship. Finally, six groups were modelled and the results of the constants of the relationships are listed. Public buildings and civil engineering projects were shown to fit accurately, while private buildings varied considerably. Interesting conclusions were drawn on the logic behind these differences.
Keywords: budget, -flow, cost, cash duration, regression analysis, time.

1991, **9**(5), 403–429

The construction contract bidder homogeneity assumption: an empirical test

Skitmore, R M
Department of Civil Engineering, University of Salford, Salford, M5 4WT, UK

This paper describes an empirical study to test the proposition that all construction contract bidders are homogeneous, i.e. they can be treated as behaving collectively in an identical (statistical) manner. An examination of previous analysis of bidding data reveals a flaw in the method of standardizing bids across different size contracts and a new procedure is proposed which involves the estimation of a contract datum. Three independent sets of bidding data were then subjected to this procedure and estimates of the necessary distribution parameters obtained. These were then tested against the bidder homogeneity assumption, resulting in the conclusion that the assumption may be appropriate for a three-parameter log-normal shape, but not for scale and location.
Keywords: bidding, statistical model, tendering.

1991, **9**(5), 431–449

Performance of US contractors in foreign markets

Arditi, D and Gutierrez, A E
Department of Civil Engineering, Illinois Institute of Technology, Chicago, Illinois 60616, USA

The international construction market has shrunk considerably in the period 1980-88. US contractors' performance in this period has been less than satisfactory. This paper first discusses briefly the principal causes for this decline in international construction (the reduction in oil prices, an increase in Third World countries' external debts, local

companies becoming more competitive and governments' barriers to foreign contractors). It then uses published statistical data to identify the common features of US construction companies that undertake work overseas. Finally, it attempts to explain the factors such as financing, taxing, the Foreign Corrupt Practices Act, and foreign competition that may have affected US competitiveness abroad.

Keywords: company performance, international competition, international construction.

1991, **9**(5), 451–465

Conceptual model for manpower planning for the construction industry in developing countries

Uwakweh, B O and Maloney, W F

Department of Construction Science, College of Applied Science, University of Cincinnati, 2220 Victory Parkway, Cincinnati, Ohio 45206, USA

Developing countries are characterized by growing populations. Because of this and the initial low level of development, there is a need for infrastructures to support these populations. The industry that is most important in the development of the infrastructure (highways, utilities, industrial plants etc.) is the construction industry. The construction industry in developing countries is characterized by a large pool of untrained, unskilled labour, and is unable to access its manpower needs. Therefore, a diagnostic manpower planning model for the construction industry has been developed. A diagnostic model was used because it considers both the environment and the factors that affect the demand for, and the supply of, regional labour. The types of data required for forecasting the demand and supply of regional labour, possible sources of data and possible manpower programme are presented.

Keywords: conceptual model, diagnostic model, labour demand, labour supply, manpower planning.

1991, **9**(5), 467–479

Decision framework for fast-track construction: a deterministic analysis

Russell, A D[1] and Ranasinghe, M[2]

[1] *Department of Civil Engineering, University of British Columbia, 2324 Main Mall, Vancouver, BC V6T 1W5, Canada*

[2] *University of Moratuwa, Moratuwa, Sri Lanka*

A deterministic analysis framework that permits the computation of an upper bound on the constant dollar expenditure that should be made to fast-track a project to achieve a specified duration is presented. It employs a baseline plan which corresponds to the traditional method of sequential design, construct, commission and operate, and the economic principle that one will continue to spend as long as the return on the incremental investment equals or exceeds the minimum attractive rate of return. The analysis is based on a generalized definition of fast-track construction, which includes overlapping of the construction and revenue phases and acceleration as well as overlapping of design and construction. An example is given to illustrate application of the framework.

Keywords: cost, deterministic framework, economic analysis, fast track.

1991, **9**(5), 481–492

Cost-plus and incentive contracting: some false benefits and inherent drawbacks

Rosenfeld, Y[1] and Geltner, D[2]

[1] *Department of Civil Engineering, Technion, Israel Institute of Technology, Haifa 32000, Israel*

[2] *Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, USA*

Two problems associated with cost-plus and incentive contracts in the construction industry are discussed; the financial costs of an earlier construction start through the use of a 'fast tracked' design - build cycle, and the counter productive effects of the 'adverse selection' of competing construction firms that must occur in a cost plus or incentive contract environment. Though they stem from basic economic principles these problems are often ignored in the conventional wisdom. The authors argue that the demonstration of these serious, commonly overlooked drawbacks should result in a decrease in the use of cost-plus or incentive contracts.

Keywords: cash flow, contract, cost plus, procurement, scheduling, uncertainty.

1991, **9**(6), 495–508

Risks in sub-contracting: sub-contract conditions

Uher, T E

Construction Management and Economics Group, School of Building, University of New South Wales, PO Box 1, Kensington, New South Wales 2033, Australia

The use of non-standard, contractor-prepared sub-contract conditions is widespread in the Australian construction industry. Many conditions in such sub-contracts are harsh and are viewed by Australian sub-contractors as the most critical risk for which they make risk allowances in the bid price.

Keywords: risk, sub-contracting, uncertainty.

1991, **9**(6), 509–528

Strategies for the construction sector in the information technology era

Betts, M; Cher, L; Mathur K and Ofori, G

Construction Management and Economics Research Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

The construction industries in many countries are starting to consider seriously the strategic use of information technology (IT). The use of information technology in construction is extending beyond the stage of piecemeal application for improving the efficiency of discrete operations by individual organizations to the advanced stage where IT is applied strategically in commercial enterprises government agencies and professional institutions. Progress in construction in this regard appears to lag behind that in most other sectors of the economy. This paper considers the nature and the background of this progression in construction by examining proposals be Earl (1989) of nine basic prerequisites to the IT era which make a strategic approach timely. Each prerequisite is outlined and how it has been met in other sectors of the economy considered. The extent to which these prerequisites apply in construction and the scope for their application in the near future are examined. It is argued that all organizations involved in construction will ultimately have to think strategically about their use of IT, and how some are already doing so is described. In discussing the factors which hinder the strategic application of IT in construction, the nature of the design and construction proces5ses and initiatives that may be necessary to overcome the perceived problems are examined in detail. The strategies that are evolving at a national level in Singapore are outlined.

Keywords: construction sector, information technology, Singapore, strategic planning.

1991, **9**(6), 529–541

Setting the pace with PACES: a new concept of using an expert system for project analysis and control

Scott, D and Yang, J

School of Construction Management, Queensland University of Technology, St Lucia, Brisbane, Australia

Currently, there is a crucial problem confronting the majority of existing systems used in the construction area. This is the inability of these systems to cope with the constantly changing project conditions and vast volume of real-world knowledge and data. This inability restricts the existing applications to areas which are highly constrained and which are associated with very small elements of the whole construction process, i.e. areas which require only a limited amount of data and follow a strictly defined procedure. Paces is a Project Analysis and Control Expert System. It is an expert system design to produce a practical project-oriented system that can be adapted to suit the particular and specific needs of any construction organization. The development is aimed at increasing the flexibility and data-handling capacity of the central core to system to enable the incorporation of large-scale problems such as an overall project management procedure into an expert system. Therefore, it encapsulates the 'whole process' of such a procedure into an expert system. Its unique design of knowledge and data representation accommodates major project analysis and control procedures as well as user-defined project situations. The concept of using standard database management software presents a new approach in building expert systems for construction tasks. This paper describes the development procedures of PACES as well as the generation of a new format for composing expert systems.

Keywords: database, expert system, knowledge representation, project management.

1991, **9**(6), 543–552

Estimators' tasks and computer-aided estimating systems: a survey of FCEC member companies

Oteifa, S and Baldwin, A N

Department of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

A survey of the members of the Federation of Civil Engineering Contractors confirms the importance of estimators' experience and expertise within the estimating and tendering process. Some 56% of the respondents surveyed currently used some form of computer-aided estimating. The benefits of these systems are limited primarily to the arithmetic

functions relating to an estimator's tasks. The use of expert systems would appear to offer a route for improving existing computer-aided estimating system.
Keywords: computer-aided estimating, expertise.

1992, **9**(6), 553–564

Economies of scale and strategic planning for municipal waste treatment plants in Greece

Aivaliotis, V; Giannakopoulou, T; Gratsiou M and Panagiotakopoulos D
Department of Civil Engineering, University of Thrace, 67 100 Xanthi, Greece

More than 300 municipal waste treatment plants are expected to be built in Greece over the next 15 years at a running cost of US$360 million. From a strategic planning point of view, and considering that (1) a major portion of the cost corresponds to imported technology/equipment and (2) the financing of these plants will place a heavy burden on an already strained government budget, the following questions arise: How is the demand for various sizes of such plants expected to evolve? Are there economies of scale? Are there equity questions regarding government grants for such plants? This paper presents the findings of a research project (1987-88) whose objectives were to answer the above questions. It was found that the cost of a plant as a function of inflow is given by a simple multiplicative model with economies of scale up to 8000m^2 per day. On the basis of logical assumptions regarding the rate of increase in population and water consumption in Greece, the expected growth in demand for such plants and, consequently, funds is determined.
Keywords: cost, planning, plant, waste treatment.

1991, **9**(6), 565–576

What does the construction foreman do?

Shohet, I M and Laufer, A
National Building Research Institute, Technion, Haifa 3200, Israel

Despite his acknowledged role in the execution of construction projects, the crew foreman's function has received little attention. The study described here tries to answer three questions: How does the foreman divide his workday time and on what subjects? With whom does he communicated? Can a correlation be detected between the way he divides his time and the performance of his crew? The research is based on a sample of 24 foremen in the USA and 32 in Israel. The findings throw more light on the perennial discussion to what extent the foreman is manager or supervisor, and whether one can replace replanning with pre-planning.
Keywords: carpenter, communication, construction, foreman, planning, productivity.

CME: Volume 10, 1992

1992, **10**(1), 5–18

Environmental assessment of construction projects

Finch, E F

Department of Construction Management & Engineering, University of Reading, Whiteknights, Reading, RG6 2BU, UK

Building designers are increasingly concerned about the environmental impact of building projects. Coupled with this is the heightened demand of client organizations for environmentally 'friendly' buildings. Commercial buildings are often the most tangible expression of an organization's values; values it wishes to convey to employees and customers. The complexity of issues influencing a building's greenness' does present a problem for the designer. To address this problem the Building Research Establishment (BRE) produced an assessment framework entitled the Building Research Establishment's Environmental Assessment Method (BREEAM). The purpose of this method is to monitor designs and raise the awareness of designers to environmental issues. it is not for use as a comparative basis for competing designs. Instead, it provides technical guidance on the issues which need to be addressed in an environmental assessment. The author considers that this framework should be extended to assess explicitly the values of the client and the priorities of the environmental community. The methodology advocated in this paper is based on multi-attribute utility (MAUT). This allows the combining of information obtained from experts, with values elicited from the eventual building users and owners. It provides a tool to assist the designer in the briefing stage as a negotiation mechanism, and at the proposal stage as a device for advocacy.

Keywords: appraisal, green building, environmental assessment, risk.

1992, **10**(1), 19–30

Judgemental forecasting in construction projects

Al-Tabtabai, H[1] and Diekmann, J E[2]

[1]*Department of Civil Engineering, Kuwait University, PO Box 5969, 13060 Safat, Kuwait*

[2]*Department of Civil, Environmental and Architectural Engineering, University of Colorado-Boulder 80309, USA*

Forecasting is a very important strategic task within the project control framework. Forecast activity seeks to answer one of project management's prime management's prime questions: 'When will the project be completed and what will it cost?' Large variances in costs or schedules will impact the profitability, cash-flow and, in extreme cases, the viability of projects. This paper discuses a new approach to forecasting within the context of project control. The paper concerns itself with the situation wherein a project manager has observed a variance from a project goal (a wage rate, for example) and the manager must now predict (i.e. forecast) the final actual wage rate of the project. Forecasting is a difficult task because task one must understand the effect of past performance and the impact of future events. A good forecasting technique, therefore, needs to include both historical trend-based data and competent judgments based on construction experience and knowledge. This research was conducted to develop an alternative approach to forecasting which would use both historical data and human judgement in a formal forecasting model. This paper describes the adaptation of social judgement in a formal forecasting model. This paper describes the adaption of Social Judgement Theory to forecasting for construction project control.

Keywords: cost control, forecasting, project management, social judgement theory.

1992, **10**(1), 31–43

A micro view of the project planning process

Laufer, A

National Building Research Institute, Technion, Haifa, Israel, 32000

The objective was to make a descriptive study of the decision making process in the early stages of project planning as it actually takes place. Data were gathered from 27 managers affiliated with large owners in the USA. Interviewees were questioned about the degree of involvement of client, project manager, project manager's team, and design engineers, in the technical definition, organization and systems, and schedule of the project - once at the conceptual planning stage and again at the engineering design stage. Involvement was assessed also in terms of intensity, relative efforts invested by the parties in the phases of the decision making process, and by type of contract. Other variables studied included extent of disagreement among the parties, degree of interruption during the planning process and sources of uncertainty hindering the decision making process.

Keywords: client, conflict, decision making, planning, project, uncertainty.

1992, **10**(1), 45–68

Analytical approach for economic risk quantification of large engineering projects: validation

Ranasinghe, M[1] and Russell, A D[2]
[1]*Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka*
[2]*Department of Civil Engineering, University of British Columbia, 2324 Main Mall, Vancouver BC, V6T 1W5, Canada*

Validation and the computational efficiency of an analytical alternative to Monte Carlo simulation for quantifying risks in project performance measures such as time, cost, net present value and internal rate of return are explored in this paper. The analytical approach is based on the use of the Pearson family of distributions, a four moment characterization of uncertainty for input and output variables and a modified version of the PNET algorithm for modelling time uncertainty. The approach is applied to a generalized hierarchical description of a project's economic structure. Results show that the analytical approach can duplicate results of a full-scale Monte Carlo simulation with approximately 0.033 of the computational effort.
Keywords: civil engineering, Monte Carlo simulation, probability, risk quantification, validation.

1992, **10**(1), 69–80

Unbalanced bidding on contracts with variation trends in client-provided quantities

Yizhe, T and Youjie, L
Department of Civil Engineering, Tsinghua University, Beijing, China

This paper examines unbalanced contract bidding, a strategy for the allocation of rates to unit quantities for the benefit of the bidder. A mathematical model is proposed which attempts to objectively exploit variation trends in client provided quantities. It is shown that the model can be solved by two methods - linear programming and the maximum-minimum method. The maximum-minimum method is preferred for most real-world situations.
Keywords: bidding, cash flow, operations research

1992, **10**(1), 81–88

Catastrophic and strategic aspects of building processes balancing

Kaplinski, O and Meszek, W
Civil Engineering Faculty, Poznan Technical University, 60-965 Poznan, pl. Sklodowskief-curie 5, Poland

A specific approach to the problems of production processes balancing has been presented. The approach is based on an analysis of equilibrium phenomena. Discontinuity phenomena are interpreted from the viewpoint of the catastrophe theory. The usefulness of studying the problems of catastrophic transformations while analysing the effectiveness of the functioning of technical lines is pointed out. The methodology of balancing in unspecified conditions is presented. In order to present the methodology a computational tool, based on infinite strategic games, has been used.
Keywords: catastrophe theory, game theory, production.

1992, **10**(2), 93–105

Implications of perception and strategy for engineers in construction management

Prince, M W
Faculty of Business Administration, University of Windsor, Windsor, Ontario, Canada N9B 3PA

It is suggested that strategy of the firm is a result of both an objective and subjective evaluation of the environment and the subjective perceptions of the environment are a function of the cognitive style of the individual. Engineers are said to have distinctive cognitive style preferences. In this study, a sample of owners and managers of firms in the non-residential contract construction industry have been grouped according to whether or not the individuals have an engineering background. A comparison is then made of certain cognitive characteristics, perceptions of the business environment, and their choice of competitive strategies. The analysis suggests that cognitive style is related to environmental perceptions and strategy, but no differences in cognitive style were evident between the groups of executives. There were, however, differences in environmental perceptions and selections of strategy. The implications is that engineers may need to be more broadly developed in order to increase their awareness of strategic options, thus enhancing the opportunities of success for their firms.
Keywords: environment, perception, psychological type, strategy.

1992, **10**(2), 107–116

Construction cost information management in Nigeria

Akintoye, A[1]; Ajewolfe, O[2] and Olomolaiye, P O[3]
[1]*Department of Surveying, University of Salford, Salford, M5 4WT, UK*
[2]*Faculty of Environmental Design and Management, Obafemi Awolowo University, Ile-Ife, Oyo State, Nigeria*
[3]*School of Construction and Engineering, Wolverhampton Polytechnic, Wolverhampton, UK*

Quantity surveyors are the hub of construction cost control in Nigeria. A total of 29 quantity surveying firms were surveyed using a structured questionnaire, augmented with formal interviews, with a view to determine the sources of, and how, cost information are managed in the country. An analysis of contractors' tenders is the cheapest, fastest and most frequently used source of cost data. More reliable sources, such as market surveys and the technical press, are referred to less often. Greatest constraints identified against adequate management of construction cost information are with respect to insufficient design information, unavailability of relevant database and fluctuating construction input prices.

Keywords: cost information, Nigeria, quantity surveying.

1992, **10**(2), 117–135

Contractor pre-qualification data for construction owners

Russell, J S[1]; Hancher, D E[2] and Skibniewski, M J[3]
[1]*Department of Civil and Environmental Engineering, University of Wisconsin, Madison, WI 53706, USA*
[2]*Civil Engineering Department, Texas A & M University, College Station, TX 77843, USA*
[3]*School of Civil Engineering, Purdue University, West Lafayette, IN 47907, USA*

In this paper, an industry evaluation of the perceived impact of various decision factors and sub-factors on the contractor pre-qualification decision-making process has been conducted and the results are presented herein. The three organization types participating in the study were public owners, and construction managers. An analysis of the mean impact responses by organization type has been performed. An analysis of the correlation coefficients among the questionnaire items has also been completed. The mean impact responses of the various organization types were evaluated for statistical significance. The results indicate a significant statistical difference in the value of the perceived impact among public owners when compared to private owners or construction managers, while private owners and construction managers responded similarly. These results provide documented evidence of organizational similarities and differences that are, in some cases, intuitively perceived to exist. A summary of the study results is also highlighted.

Keywords: contract, decision making, owner, pre-qualification.

1992, **10**(2), 137–151

An examination of the importance of resource considerations when contractors make project selection decisions

Odusote, O O and Fellows, R F
Construction Study Unit, School of Architecture and Building Engineering, University of Bath, Claverton Down, Bath, BA2 7AY, UK

This research investigates the factors which building contractors consider when making project selection decisions and the processes they follow when making such decisions. The research is based on the premise that resource consideration is the most important factor for contractors when making project selection decisions. Literature was used to identify those factors thought to be most influential. The extent of the diversity of opinion disclosed indicated the necessity to obtain further information which was gathered from contractors by use of postal questionnaires and interviews. The information was analysed by ranking techniques and the results compared by Spearman rank correlation coefficient. The results obtained indicated the strengths of the factors identified. Spearman rank correlation coefficient showed a positive correlation for the results obtained from the findings of the literature study and those obtained from the survey. A non-weighted model of contractors' tendering decision process was developed. The model shows the inter-relationship that exists between client and contractor decisions. The model also illustrates the effect of such decisions on the actions of both clients (their representatives) and contractors. The results obtained from the survey shows that, 'the ability of the client to pay for the cost of work' is the most important factor contractors consider when making project selection decisions.

Keywords: client, contractor, project selection, resource, tendering.

1992, **10**(2), 153–177

Choosing the most appropriate method of construction with computer assistance

Scott, D[1] and Kagiri, M[2]
[1]*School of Construction Management, Queensland University of Technology, Brisbane, Australia*
[2]*Civil Engineering Department, University of Canterbury, New Zealand*

A method of analysing costs and durations of alternative methods of construction is presented as a possible way of solving some of the problems of the construction industry, especially in developing countries. The method involves simple use of any commercially available computer database package. The type of data required, the possible sources and the effects of variation of the data are presented. To demonstrate the use of the method three projects have been analysed using data from Kenya. The resulting accurate and fast assessment of the relative merits of alternative methods of construction enables selection of the methods of construction that are most appropriate for any given conditions. The methods are simple and can be applied without specialist computer knowledge.
Keywords: construction technique, developing country.

1992, **10**(3), 185–202

Decision models for analysis and evaluation of construction contractors

Russell, J S
Department of Civil and Environmental Engineering, University of Wisconsin, Madison, WI 53706, USA

The concept of a hybrid computerized decision support system for the evaluation of construction contractors' suitability to perform the work associated with a project is presented. Previously developed decision tools are summarized and justification for the creation of such a system is proposed. The system configuration is described along with the modelling techniques available for each aspect of pre-qualification decision-making.
Keywords: contract, decision making, pre-qualification.

1992, **10**(3), 203–226

Computer assisted teaching system for the diagnosis of building defects

Bright, K
Department of Construction Management & Engineering, University of Reading, Whiteknights, P O Box 219, Reading, RG6 2BU, UK

This paper describes the development of a computer assisted training system for teaching and testing surveyors. The development started with the introduction to the construction industry of early expert systems. Whilst expert systems were intended to act purely as decision systems, they were seen to offer potential as vehicles for capturing expertise and experience as well as knowledge and be used for training purposes. To enable the knowledge bases representing this process were incorporated into various shell systems and evaluated. Traditional methods of information transfer, both at the initial learning stage and for continuing professional development, were considered. It was found that shell systems had certain attributed which, whilst not part of their original design concept, could be used to capture and manipulate knowledge and train the user to solve problems. By using data given to the user in carefully structured cases studies, offering advice, guidance and knowledge gained by application to plausible scenarios, the system offers a valuable additional tool to the process of education and training.
Keywords: defect, building surveying, computer-aided teaching, expert system.

1992, **10**(3), 227–247

Competitiveness in bidding: a consultant's perspective

Drew, D S[1] and Skitmore, R M[2]
[1]*Department of Building and Surveying, Hong Kong Polytechnic, Hung Hom, Kowloon, Hong Kong*
[2]*Department of Surveying, University of Salford, Salford, M5 4WT, UK*

This paper examines the relationship between the competitiveness of contract bids entered by individual bidders through the variables of bidder size, contract value and project type. The analysis indicates that, in terms of competitiveness affinities towards particular types of projects, although apparent, appear to be weaker for the private sector than found in previous work concerning the public sector.
Keywords: bidding, competition, performance.

1992, **10**(3), 249–262

Three modes of short-term construction planning

Laufer, A[1]; Howell, G A[2] and Rosenfeld, Y[3]
[1]*National Building Research Institute, Technion, Haifa 32000, Israel*
[2]*Department of Civil Engineering, University of New Mexico, Albuquerque, NM 87131, USA*
[3]*Department of Construction Management and Economics, National Building Research Institute, Technion, Haifa 32000, Israel*

Short-term construction planning requires more than simple interpretation of the project schedule; it rests on the organization's ability to collect information, identify and solve problems, and implement change. Each of three different modes of short-term planning - foreman planning, supervisor quality circles, and operations/systems analysis - makes a unique contribution to detailed short-term planning. The need for effective short-term planning is great, since numerous factors exist which can be identified only after construction begins. These uncertainties mean that detailed work plans for individual crews can be completed only near the start of a specific job, and can cover only a limited period time. Each of the three separate planning modes involves different functions, different sources of data different problem-solving techniques - hence, three unique planning products. Using these modes in combination takes advantage of their powerful cumulative effect, assures short-term project objectives, and also supports the continuous learning required for middle-and long-term organizational improvements. Applying all three allows project administrative and organizational forces to reinforce each other, providing a synergistic effect. Construction sites need all three modes to achieve control, promote innovation, and assure high performance at all levels of the organization.
Keywords: construction method, control, planning, project management, quality circles, supervision.

1992, **10**(3), 263–269

Comparative variability in tender bids for refurbishment and new build work

Quah, L K
School of Building and Estate Management, National University of Singapore, Kent Ridge, 0511, Singapore

This paper presents the result of a comparative analysis of the variability in tender bids for refurbishment and new work. The investigation has been prompted by a suggestion by a large body of UK Contractors that they were subjected to higher risks in refurbishment work and that this was reflected in the tender bids for such work. Utilizing the premise that the risks in submitting a tender is related in some way to the dispersion in the tenders submitted by competitors, it was found that the variability in tender bids for refurbishment work was consistently higher than that for new building work, thereby supporting the Contractor's claims. Risks in the context of this investigation means both uncertainty and the results of uncertainty, and will include both the lack of predictability with regard to outcomes and all elements of the problem structure.
Keywords: new building work, risk, refurbishment work, tender variability.

1992, **10**(4), 277–301

Analytical approach for economic risk quantification of large engineering projects

Russell, A D[1] and Ranasinghe, M[2]
[1]*Department of Civil Engineering, University of British Columbia, Vancouver, Canada*
[2]*Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka*

A consistent four moment based approach for quantifying time and economic risks is presented. The goal is to produce a computationally efficient tool that can be used to explore economic feasibility and trade-offs between costs and time performance versus risk as a function of various strategies for executing and sequencing major work packages. A three level hierarchy of parameters is used, starting with time, cost and revenue performance at the work package/revenue stream level to rate of return at the overall project level. Use of a four moment approach and Pearson distributions at all levels of the hierarchy permit the formulation of a consistent and readily automated approach to risk management. Treatment of correlations is included. A modified form of PNET is presented for quantifying time uncertainty. Use of limiting values (0,1) of the PNET transitional correlation provide bounds for decision parameters.
Keywords: civil engineering, probability, risk.

1992, **10**(4), 303–320

Risk attitude and systematic bias in estimating and forecasting

Mak, S W and Raftery, J
School of Land and Construction Management, Thames Polytechnic, Oakfield Lane, Dartford, Kent, DA1 2SZ, UK

This paper describes findings from the first phase of a research project investigating the modelling of risk and uncertainty in construction estimating and forecasting. The objectives of the project are to examine current methods and, experimentally, to explore techniques which offer the potential for the production of improved information from

estimates and forecasts. Some of the causes of error and bias in both traditional deterministic and in probabilistic estimating and forecasting are described. The majority of the research in cognitive psychology estimating and forecasting are described. The majority of the research in cognitive psychology which has led to the common assumption of errors and biases has been carried out with lay people thinking intuitively about problems. The present research is an attempt to test these biases in a domain-specific, non-intuitive contact with individuals trained in the domain. The authors hypothesize that, if professional training has nay value then they should find less evidence of bias than is the case in the general literature. Empirical results are reported and discussed. The work finds empirical support for only some of the biases commonly assume to exist.
Keywords: bias, estimating, forecasting, heuristic, risk, uncertainty.

1992, **10**(4), 321–342

Measuring the ability gap for construction professionals

Barrett, P S
Department of Surveying, University of Salford, Salford, M5 4WT, UK

The importance of the ability of individuals as an organizational variable is demonstrated, both in the context of task accomplishment and in relation to motivational issues. Fieldwork to measure the abilities of construction-related professionals is described, together with multiple regression analysis which resulted in 40 equations for the prediction from factual independent variables of the abilities of individuals to do various work-types. The new concept of the 'ability gap' is then introduced to clarify the organizational implications of differing ability levels.
Keywords: motivation, organization, professional.

1992, **10**(4), 343–359

Determinants of performance in the traditional building process

Mohsini, R A[1] and Davidson, C H[2]
[1]*Department of Architecture, School of Architecture and Planning, State University of New York at Buffalo, Buffalo, NY 14214, USA*
[2]*School of Architecture, University of Montreal, Montreal, Quebec, Canada*

Even though an estimated 80% of all building projects are procured by some form of the traditional building process, the project to project variations in performance are still subjectively and individually explained. The present paper addresses this particular domain. Using inter-organizational conflict among the project's task-organizations as a yardstick, the impact of a number of conflict-inducing organizational variables upon project cost, time and quality is measured and significant determinants of performance at these three levels are identified.
Keywords: performance, process, procurement, regression analysis .

1992, **10**(5), 369–395

The environment: the fourth construction project objective?

Ofori, G
Construction Management and Economics Research Unit, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

The objectives of construction projects, from the client's point view, are well known, and techniques have been developed to help practitioners achieve them. Ensuring that projects contribute towards protecting the environment is not yet one of these objectives. However, in almost all countries, issues relating to the environment are receiving attention from governments, non-governmental institutions and commercial organizations in most sectors of the economy, as well as from the general public. Statutory measures are being taken by governments to effect pollution control, resource conservation and protection of natural ecosystems. Productive enterprises are reviewing, and where necessary, changing aspects of their operations to address these concerns and comply with the increasingly more stringent requirements. Many environment-related statutes, regulations, codes and general policies have implications for the construction industry, affecting where constructed items are located, how they are planned and designed, the materials and components used, the techniques and equipment adopted, and how the completed facilities are maintained, altered and, ultimately, demolished. After giving an overview of the factors contributing to, and the nature of, general developments relating to the environment (especially in the area of government policy), the implications of these trends for the construction industry are considered. Actions being taken by the industry in these regards are next discussed. It is suggested that the consideration of issues relating to the environment should be part of the culture of the construction industry everywhere, and that there is a case for making the environment the fourth client objective on construction projects.
Keywords: client, control, environment, objective, policy, project management.

1992, **10**(5), 397–413

Parameter prediction for cash-flow forecasting models

Skitmore, R M
Department of Surveying, University of Salford, Salford, M5 4WT, UK

The paper describes the application of the DHSS formula to 27 complete construction projects comprising four types - steel-frames low rise buildings, new build housing developments, housing refurbishment projects, and multi-house 'pre-paint' maintenance contracts. Application of the formula to individual projects indicates that the 'best' parameter values offer a ten-fold improvement over the published values based on project size. Similar results occur when using the best parameter values for other two-parameter models. Various approaches are considered in attempting to predict the best parameter values of the models based on known characteristics of the project. A multiple linear regression with project value, duration, and type independent variables is shown not to produce any significant improvement on standard DHSS formula predictions. However, a reduction in the number of independent variables by cross validation produces an approximately 25% improvement on standard DHSS formula forecasts outside the database. Examination of the models derived from this analysis indicate the type of project to be of major importance.
Keywords: cash flow, forecast, project type, regression analysis.

1992, **10**(5), 415–429

Factors affecting a contractor's mark-up size decision in Saudi Arabia

Shash, A A and Abdul-Hadi, N H
Construction Engineering and Management Program, College of Environmental Design, King Faud University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

Deciding upon the right mark-up to add to an estimate is not an easy task for a contractor. The mark-up must be small enough to ensure a good chance of winning the contract, yet big enough to realize a reasonable profit. The determination of the proper mark-up size entails the evaluation of numerous factors. This study presents 37 factors, with their relative importance to contractors operating in Saudi Arabia, underlying the mark-up size decision. The size of contract and availability of required cash, not competition, labour availability and profitability, are the most important factors that affect mark-up size decision.
Keywords: bidding, construction, mark-up, Saudi Arabia.

1992, **10**(5), 431–449

Methods of analysing risk exposure in the cost estimates of high quality offices

Newton, S
Department of Architectural and Design Science, University of Sydney, New South Wales 2006, Australia

The paper considers two non-deterministic methods of analysing the risk exposure in a cost estimate. Both methods are applied to the same data sample of eight high quality office buildings. An assessment of each method is made in the context of this practical application. The common practice of allowing for risk through an all-embracing contingency sum or percentage addition is challenged. Rather than excluding conventional, deterministic methods, they are here presented as possibly the only effective foundation on which to base risk management in cost estimating.
Keywords: estimating, risk analysis, risk exposure, simulation.

1992, **10**(6), 459–478

Analysis of conflict and change in construction projects

Gardiner, P D[1] and Simmons, J E L[2]
[1] *School of Engineering and Computer Science, University of Durham, Science Laboratories, South Road, Durham, DH1 3LE, UK*
[2] *Department of Mechanical Engineering, Heriot-Watt University, Riccarton, Edinburgh, EH14 4AS, UK*

Conflict and change can have considerable impact on the success or otherwise of construction projects. Examples of conflict and project change have been collected in structured interviews within a series of organizations which are clients of construction activities. A methodology which uses a process of hierarchical decomposition has been developed for classifying this data and rendering it suitable for subsequent analysis. The result presented in the paper are of a preliminary investigation and lend weight to the hypothesis that the creative management of conflict and change can benefit construction industry clients.
Keywords: change, client, conflict, project management, strategy.

1992, **10**(6), 479–487

Managing architectural design - a recent survey

Nicholson, M P and Naamani, Z
School of Architecture, University of Nottingham, Nottingham, NG7 2RO, UK

The complexity of building projects and the increasing sophistication of professionals involved in construction are creating new challenges to building design management, For example the clients are not only interested in value for money in relation to the project cost but in cost in use through time of their buildings. Clients must show profits in competitive markets and architects have to understand the commercial aspects of buildings as well as the more central design parameters. Coping with these challenges requires a full understanding of the wide variety of contractual relationships between all of the parties involved in building; it requires a good understanding of advanced management techniques as will as the latest advancements in technology. This paper studies the architectural design process in the UK, to discover how it is managed and the levels of performance which are currently achieved in practice.
Keywords: architectural management, design cost, organization.

1992, **10**(6), 489–509

Construction time information system for the building industry

Nkado, R N
Department of Construction Management & Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 2BU, UK

The paper describes a computerized construction time information system for time planning of buildings at early stages of design. A sample of 29 commercial, privately funded buildings was used to develop the proposed model. A procedure for extending the model to other project categories is shown. Multiple linear regression analysis of sample data shows that the durations of activity groups: substructure, superstructure, cladding, finishes, services and their sequential start - start lag times can be predicted from 12 variables: gross floor area, area of ground floor, approximate excavated volume, building height, number of storeys, end use, cladding type, presence of atrium, building location, intensity of services and site accessibility. An experiment involving nine planners and three office projects showed that the time predictions of the model fall within the distribution of planners' estimates and are statistically indistinguishable from them. Therefore, the model can produce reliable estimates of construction times.
Keywords: construction time, information system, modelling, planning, prediction.

1992, **10**(6), 511–532

Strategic planning for competitive advantage in construction

Betts, M and Ofori, G
Construction Economics Research Unit, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

This paper outlines the developments in strategic planning exemplified by the works of Porter (1979, 1985, 1990) and others. After describing the emerging concepts and techniques, it is observed that these have been applied by enterprises in other sectors of the economy in pursuit of competitive advantage. Such applications are taking place at the level of parts of an enterprise's operations and at the overall corporate level. This is contrasted with the situation in construction where strategic planning at any level is less widespread, although it is becoming more common. Several reasons are identified as hindrances to strategic planning in construction. The current and historical situation with regard to planning in construction is described. The way in which strategic planning can be applied by construction enterprises are outlined. In considerable scope for application in, construction enterprises. It is suggested that the changing nature of the task of the construction industry and the dynamism of its operating environment imply that the strategic planning techniques put forward by Porter are vital for the survival and progress of construction enterprises of all types.
Keywords: competitive advantage, construction enterprise, strategic planning.

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1993, **11**(1), 3–17

Japan's building industry: the new model

Bennett, J
Professor, Centre for Strategic Studies in Construction, University of Reading, Whiteknights, Reading, RG6 2BU, UK

Japan's big five general contractors - Kajima, Obayashi, Taisei, Takenaka and Shimizu - have developed efficient production systems for their construction site work. Earlier studies show that this has been achieved by applying a very standardized approach. Yet the Japanese building industry undertakes extensive research and development, the application of which could reasonably be expected to disrupt the efficient construction-site production systems. This paper describes a study undertaken in mid-1991 that began by exploring the relationship between the research institutes and the mainstream project work of the big five. This led to a review of established theories about the way that innovation takes place which in turn directed the study towards the interaction between the big five and their environments. Two major changes in these environments are currently under way. The first is growing demands by the big five's customers for higher standards and more fashionable design. The second is a serious labour shortage in the Japanese building industry. The big five have reacted in different ways to these two major environmental changes. This discovery finally led the study into a concern with the models that managers use in understanding their work. The paper suggest that a new model, based on using the human nervous system as a metaphor, is needed in order to understand the behaviour of the big five. It is also proposed that such a model will help in designing appropriate organizations for the big five as they face and seek to influence the rapid changes now resulting from the ambitions of Japan's increasingly affluent society.
Keywords: change, fashionable design, Japan, labour shortage, model building.

1993, **11**(1), 18–29

Forecasting methodology of national demand for construction labour

Rosenfeld, Y[1] and Warszawski, A[2]
[1] *Department of Civil Engineering, M.I.T., 77 Massachusetts Ave, Cambridge, MA 92139, USA*
[2] *Technion - Israel Institute of Technology, Haifa, 32000, Israel*

The paper presents a systematic methodology for forecasting the demand for construction labour in various skills, within a national economy. Major factors, which determine the future needs for dwelling units and for other types of construction, are discussed in detail, while the strengths and weaknesses of different forecasting approaches are highlighted. Possible sources, available in most countries, for statistical information, as well as the International Classification of Occupations and Economic Branches, are identified and evaluated. The methodology is general and may be applicable to any country. It is illustrated by an example of such a forecast for the next decade, performed by the authors in Israel, in the years 1988 and 1989. The various demand and supply parameters, which formed a basis for this forecast, significantly changed with the unexpected surge of immigration from the Soviet Union in 1990. The effects of this change are discussed separately in the paper.
Keywords: building economics, forecasting, labour statistics.

1993, **11**(1), 30–44

A new approach to the development of computer-aided estimating systems for the construction industry

O'Brien, M J and Pantouvakis, J P
Department of Computer Science, University of Nottingham, Nottingham, NG7 2RD, UK

Estimators display a diversity of approaches to their task of predicting the cost of a construction project. To design and build individualized, computer-aided estimating software to reflect this diversity is however expensive. This paper describes a new method of designing and building such products which is quick, easy and hence inexpensive. The method relies upon embedding a core estimating product into a set of software tools which can be used to reshape and enhance the core functionality. The tools have been designed to minimize the requisite technical knowledge of the user, principally through the use of declarative features. The individualistic nature of estimating is therefore reflected in this new method of developing estimating products. These resultant products are therefore more acceptable to practising estimators.
Keywords: adaptive software, computer-aided estimating, estimating, software, software development.

1993, **11**(1), 45–52

Project selection considering risk

Moselhi, O and Deb, B
Centre for Building studies, Concordia University, 1455 de Maisonneuve Blvd W., Montreal, Quebec, H3G 1M8, Canada

A number of procedures have been formulated in recent years for evaluating engineering, procurement and construction projects based on an established set of objectives. These procedures, however, have generally considered either multi-objectives without the risk associated with each objective or a single objective with some form of risk assessment. Decision aid methodologies that permit the consideration of both multi-objectives and risk have generally been associated with complex mathematics and high computational effort. The purpose of this paper is to present a simple, yet comprehensive methodology for the selection of the project under risk, avoiding time consuming analyses. The method considers multi-objective decision criteria and takes into account the uncertainties associated with each individual objective. The method is based on multi-attribute utility theory for modelling the selection criteria and treats uncertainty in a similar way to that used in Program Evaluation and Review Technique (PERT). A Numerical example is presented to demonstrate the application of the present method.
Keywords: multi-attribute model, project evaluation, risk assessment, selection criteria.

1993, **11**(1), 53–61

Diminishing non-uniformity of construction processes

Kaplinski, O
Civil Engineering Faculty, Poznan Technical University, 60-965 Poznan, Poland

Reasons for the occurrence of the non-uniformity of production processes in construction and an outline of a formal approach that makes use of the theory of stochastic processes and statistics have been given. Attention has been drawn to the necessary and satisfactory conditions for balancing these processes. The distinction between the distribution of work time and the distribution of production volume (characterized by opposite skewness) has been introduced. A few cases of diminishing the non-uniformity have been given; the existence of mutual relations between the intensity of processes, concentration (superposition) of the processes and their non-uniformity have been used for that purpose. Examples of a superposition of processes (as a case of concentration of production) have been taken from the production and deliveries of concrete mixture. Attention have been drawn to savings resulting from such actions. These savings often require only simple technical or organizational operations.
Keywords: organization, non-uniformity, site operation.

1993, **11**(1), 62–70

Economic comparison of an air-conditioner and a desert cooler for residences in arid areas

Navon, R and Arkin, H
The National Building Research Institute, Technion City, Haifa 32000, Israel

The paper compares two domestic cooling systems, namely the air-conditioner and the direct evaporative (desert) cooler, using a life cycle costing approach. Both systems are capable of providing a certain degree of cooling relief during the hot and dry conditions typical for the summer in arid regions, such as the city of Eilath, Israel. Each, however, utilizes a different thermodynamic principle, thus possessing different features that affect the expenses involved in cooling the residential apartment. The criterion for the economic evaluation is the system's Annual Equivalent Cost. This parameter represents a common denominator of annual cost involving purchase, installation, operation, and maintenance of each system. The evaluation of operating costs considers the hourly variations in the cooling pattern of the building. For the air-conditioner, the analysis accounts for the relationship between both outdoor and indoor thermal conditions and its electric energy consumption. For the direct evaporative cooler, the operating costs originate from electric energy consumed and from the cost of the water evaporated and drained to carry on the evaporative cooling process. The comparison is performed in middle-class apartments and is limited to comfort level achievable by the desert cooler. The economic model is simple yet detailed, and it has been derived in a manner that most conveniently accommodates small energy consuming systems in buildings. Such systems typically consist of one principal part - the mechanical system - and several auxiliary sub-systems (piping, wiring, etc.), the separated operating and maintenance costs of which are hard to determine. The analysis shows that for the prevalent conditions in Eilath, the desert cooler is significantly more economical to own and operate than the conventional air-conditioner. Analysis demonstrates that this superiority remains for a range of realistic changes in both economic and thermodynamic parameters. In spite of a slightly higher initial cost, the desert cooler proves to be more economical, mainly due to its significantly lower operating cost.
Keywords: air-conditioner, desert cooler, economic comparison, life cycle analysis.

1993, **11**(1), 71–72

Competitive advantage in construction: comment

Fellows, R F
Construction Study Unit, School of Architecture and Building Engineering, University of Bath, Claverton Down, Bath, UK

This comment relates to the paper published in 10(6), 511-532.

Keywords: competitive advantage, strategic planning.

1993, **11**(1), 73–74

Competitive advantage in construction: reply

Betts, M and Ofori, G
Construction Economics Research Unit, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

Response to the preceding comment.

Keywords: strategic planning, competitive advantage.

1993, **11**(2), 81–98

Forecasting the sales of precast concrete building products

Dawood, N N[1] and Neale, R H[2]
[1] *Division of Civil Engineering and Building, School of Science and Technology, University of Teeside, Middlesbrough, TS1 3BA, UK*
[2] *Department of Civil Engineering, Loughborough University of Technology, Loughborough, Leicestershire, LE11 3TU, UK*

Sales of precast concrete building products are influenced by the general demand for construction. This demand is subject to substantial fluctuations, caused by such diverse factors as capital spending by Government, the general strength of the economy, the demand for housing - which in turn reflects mortgage interest rates - and also by seasonal factors and weather. These are some of the difficulties associated with sales forecasting in the precast concrete industry. Sales forecasting is a crucial managerial practice and its accuracy is vital for any company's business survival. A survey of the current forecasting and planning practices in the industry concluded that forecasting, especially for major product groups, is fairly basic and not reliable. Against this background, a forecasting model has been developed to analyse historical data and forecast demand for 12 months ahead. Two forecasting methods were applied to historical data of 12 groups of products of a major manufacturer. The results of the forecasting model were encouraging and more accurate than the manufacturer's existing forecasting system. The author interviewed the firms, marketing and sales staff to identify the advantages and disadvantages of the forecasting system and identify the factors which affect sales and forecasting in general. Some tangible indication of the practical use of this work is the support given to this research project by staff of this company, at all levels. The work described in this paper is part of a more general computerized capacity planning system for the precast industry. This would be suitable for major companies, most of whom produce a large number of different products in a number of different manufacturing plants dispersed throughout the UK.

Keywords: building product, forecasting, pre-casting.

1993, **11**(2), 99–110

Planning repetitive construction: current practice

Lutz, J D[1] and Hijazi, A[2]
[1] *Department of Civil Engineering, Auburn University, Auburn, AL 36849, USA*
[2] *Construction Division, Al-Rasheed House Establishment, PO Box 6335, Riyadh 11442, Saudi Arabia*

This paper presents a review of existing techniques for planning and analysing linear construction operations. The family of techniques which are based on the line of balance (LOB) concept (e.g. linear scheduling method, vertical production method, line of balance scheduling, repetitive project model, velocity diagrams, and time space method) are introduced, the line of balance concept is discussed, and the barriers to implementation for LOB are addressed. Field monitoring techniques (e.g. work sampling, activity sampling, network scheduling, linear programming, dynamic programming, queuing and simulation) are described. Repetitive construction modelling requirements are introduced, and simulation applications are discussed. The evolution and capabilities of simulation programmes which lend themselves to use by the construction industry are presented. Benefits and limitations of the techniques presented are also addressed.

Keywords: linear construction, line of balance, repetitive construction, simulation, site operation.

1993, **11**(2), 111–118

Factors considered in tendering decisions by top UK contractors

Shash, A A

Construction Engineering and Management Department, College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

Decision-making involves a process by which a choice is selected from a number of options. Bid decisions by contractors are complex due to uncertainty about many factors affecting their outcomes. This study was able to identify, through a questionnaire survey, 55 factors characterizing the bid decision-making process. The questionnaire was mailed in August 1990, to 300 top contractors in the UK. The results indicate that several factors are considered equally important for bid/no bid and mark-up size decisions. Other factors are seen to have considerable importance for one decision but not for another. The need for work, the number of competitors tendering, and the amount of experience on such projects are identified as the top three factors that affect a contractor's decision to bid for a project. The degree of difficulty, the risk involving owing to the nature of the work, and the current work load are the highest ranked factors affecting markup size decisions.

Keywords: contractor, UK, decision, tendering.

1993, **11**(2), 119–130

Stereotypes and themes in building designs: insights for model builders

Atkin, B

Department of Construction Management and Engineering, University of Reading, Whiteknights, PO Box 219, Reading, RG6 2BU, UK

The use of information by designers is reviewed and design decision-making examined. A stereotyping trait in the work of designers is tested for significance in a sample of 40 office buildings. The survey reveals the frequency with which design options occur, suggesting that some may be dominant. Analysis of the patterns of occurrence of the design options highlights clusters of similar buildings, that is themes and variations on the themes, confirming a stereotyping trait. The existence of stereotypes or themes in design is felt to be of interest to model builders and users, insofar as it might help them in better defining potential solution spaces to problems of design cost evaluation.

Keywords: cluster analysis, combinatorial process, decision making, design, modelling.

1993, **11**(2), 131–141

The relationship between teaching methods and educational objectives in building education

Betts, M[1] and Liow, S R[2]

[1] *School of Building and Estate Management National University of Singapore, Singapore 0511*

[2] *Department of Social Work and Psychology, National University of Singapore, Singapore 0511*

The educational objectives of different University courses and the combination and sequence of teaching methods used for them, vary between institutions and disciplines. When designing and implementing courses in higher education, we make decisions regarding the match between educational objectives to be set and the teaching methods to adopt. We base these decisions on implicit assumptions about the relationship between teaching methods and educational objectives for the Building discipline. We tested these assumptions with a survey of staff and students involved in undergraduate courses in Building at the National University of Singapore. First, we asked both the staff and students to rank order a set of educational objectives in terms of importance. Then we asked students how effective they thought different teaching methods would be in meeting these objectives, and asked students how effective they thought a range of teaching methods had been. The teaching methods considered included lectures, seminars, quantitative assignments, and student project work. The educational objectives included preparing for a future career, understanding concepts, developing problem solving skills, preparing for examinations, developing communication skills and gathering information. The results indicated some discrepancies between staff assumptions and students perceptions of the relationship between educational objectives and different teaching methods. Two related implications of the findings are discussed: (i) choice of teaching method should be linked more closely to educational objectives and (ii) active learning through project work and tutorials is more likely to meet important objectives than the traditional lecture method.

Keywords: active learning, education, teaching.

1993, **11**(2), 143–149

MMS: a materials management system

Tavakoli, A and Kakalia, A

Construction Engineering and Management Program, Department of Civil Engineering, Case Western Reserve University, Cleveland, OH 44106, USA

The contractor's ability to manage the flow of materials has a great impact on the profitability of the firm. MMS has been developed and is presented in this article: it is an effective, practice-orientated, and automated materials

management system. MMS consist of ten modules: (1) project information module, (2) vendor information module, (3) product master list module, (4) reference numbers and description module, (5) bid quantities module, (6) materials ordered module, (7) materials received and invoice verification module, (8) materials used module, (9) submittal management module and (10) report generator module. The data entered through the first nine modules is accessed through the report generator module to produce the appropriate reports necessary to make effective management decisions and to keep abreast of daily activities. MMS was developed in conjunction with three competent local general contractors (ENR-rated top 400 contractors) and is designed for small to medium sized general contractors and large sub-contractors. The information retrieved from MMS can be used by estimators, accountants, project managers, field engineers, and materials managers. Development, acceptance, and continued use of such systems should contribute to the efficiency and profitability of contractors.
Keywords: management system, MMS, material management.

1993, **11**(2), 151–162

New construction versus maintenance and repair construction technology in the US since World War II

Bon, R[1] and Pietroforte, R[2]
[1]*Department of Construction Management & Engineering, University of Reading, UK*
[2]*Department of Civil Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts, USA*

This paper employs seven input-output tables in the comparative study of long-term changes in new and maintenance and repair (M&R) construction technology in the US from 1947 to 1982. The 1982 table was made available in 1991. Input-output analysis is used to show the differences between direct and total input requirements of the two sub-sectors. Significant differences are reported in terms of backward linkage indicators and output multipliers, as well as direct and total requirements from the key industries supplying the two construction sub-sectors. As the share of M&R construction in total construction continues to increase, these differences in technology employed by the two sub-sectors will have an important effect on the national economy as a whole.
Keywords: backward linkage indicator, construction technology, input-output analysis, maintenance and repair, output multiplier.

1993, **11**(2), 163–166

Quantifying construction claims using the differential cost method

Jergeas, G F and Revay, S O
Revay & Associates limited, Construction Management Consultants, Calgary, Alberta, Canada

In all construction claims there exist two hurdles which must be overcome before resolution can occur, i.e. entitlement and quantification. This paper addresses the latter issue (regarding productivity/impact claims) by initially presenting the differential method of quantification and then describing its application on a case study. Through this method the authors quantified a contractor's loss of productivity of a four-storey commercial building in western Canada. This was achieved by comparing productivity between a period of construction during which the contractor alleged concrete operations were completed under 'normal' conditions and a period when the contractor's productivity was affected by inclement weather. For proper application of this method, certain requirements must be met. The difficulty in satisfying these requirements frequently causes the result of the calculation to be suspect. The author's compliance with these requirements will be discussed.
Keywords: claim, contract, differential cost method.

1993, **11**(3), 175–185

Research on construction industry development at the crossroads

Ofori, G
Construction Economics Research Unit, School of Building and Estate Management, National University of Singapore, Singapore 0511

Work in the area of knowledge concerning the improvement of the construction industries of developing countries is about a generation old. Some progress was made in its initial stages, and the prescriptions offered have been applied in several countries. However, achievements, in practice, have been disappointing. Some of the approaches used, influences made and conclusions reached have been criticized. Moreover, whereas many current issues make the need to improve upon many aspects of the construction industries of the developing countries more pressing, interest in the field has waned. This paper considers the present state of affairs in 'construction industry development'. It discusses the reasons for the lack of advancement in the field and proposes measures which can be taken to improve upon the situation. It is suggested that key changes in approach are necessary. Some topics for appropriate research are suggested. The formation of a global body dedicated to the promotion, co-ordination and dissemination of works in the area is proposed.
Keywords: construction industry development., co-ordination, dissemination, research.

1993, **11**(3), 186–193

Building maintenance in the context of developing countries

Wall, D M
School of Construction Economics and Management, South Bank University, Wandsworth Road, London, SW8 2JZ, UK

This paper reviews literature about building maintenance in developing countries. A search of published sources revealed a disappointingly small and fragmented literature relating mostly to technical and managerial matters. These are presented in the paper under the headings: the effect of climate, design and materials choice, construction and maintenance personnel, managerial systems and financial systems. Few sources cover the economics of building maintenance and none discuss the important aspects of how building maintenance has an impact on broader economic and development issues. The paper discusses building maintenance in the context of the six forms of capital usually encompassed in World Bank development projects (human, institutional, cultural, natural, physical and financial) and as such contributes to the economic analysis of building maintenance. Several areas needing further research are noted.
Keywords: maintenance, developing country.

1993, **11**(3), 194–202

The concomitant evolution and stagnation of the Brazilian building industry

Werna, E
Research Fellow, London School of Hygiene and Tropical Medicine, London, UK

This paper analyses the development of the Brazilian building industry, and compares it to the situation of its counterparts throughout the developing world. It argues that the regime of accumulation prevailing in Brazil has played a major role in shaping the development of the building industry. The paper also points out that the recent trends detected in Brazil are bound to occur, to a greater or lesser extent, in other lesser developed countries. Finally, it argues that, although the Brazilian case could lead to the conclusion that the withdrawal of the state from the building scene is a necessary and positive step, this approach should not be used as a panacea.
Keywords: Brazil, development.

1993, **11**(3), 203–216

Appropriate building technologies: an appraisal based on case studies of building projects in Senegal and Kenya

Wells, J
School of Construction Economics and Management, South Bank University, Wandsworth Road, London, SW8 2JZ, UK

This paper reports the findings from three case studies of building projects where a conscious decision was taken to incorporate appropriate technologies into the structure of the buildings. The paper describes each project, documents any problems encountered in the implementation process, and assesses the success of the technologies in meeting client expectations in terms of time, cost and quality. The broader economic implications of the use of these technologies are also examined. The conclusion emerges that the benefits to the economy from the use of appropriate technologies may be greater than the benefits to individual clients.
Keywords: appropriate technology, fibre-concrete, Kenya, material, quality control, Senegal, stabilized soil.

1993, **11**(4), 221–245

Construction Management and Economics: a review of the first ten years

Betts, M[1] and Lansley, P R[2]
[1] *School of Building and Estate Management, University of Singapore, 10 Kent Ridge Crescent, Singapore 0511*
[2] *Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading, RG6 2BU, UK*

Construction management and construction economics are internationally recognized research fields which enjoy support from a strong and growing community of researchers, scholars and practitioners. Specialist academic and professional journals which serve the fields are relatively new. One of the prime journals, *construction management and economics*, celebrated ten years of continuous publication in 1992. In the ten years since its inception, *construction management and economics* has grown and has become more international. Whilst it has sharpened its focus on project-level production-oriented issues it has reflected the varied activities and interests of those involved with construction management and economics research and scholarship. Analysis of the pattern of publications in the journal and of their citations suggests a strengthening of the academic base of papers although there is little evidence that this is achieved by approaches to research that are clearly driven by, or contribute to, theory. In addition, pattern of citations

suggest that studies are becoming increasingly inward-looking. Whilst there has been remarkable stability in the general characteristics of papers there have been significant changes in the identities of frequent authors and of key contributing institutions. A new generation of contributors has emerged. The paper documents these developments in the journal. In addition, through the design of a meta-classification model, it makes tentative proposals for dimensions by which research in the discipline can be defined and described.
Keywords; bibliometrics, discipline review, meta-analysis, research trends.

1993, **11**(4), 247–259

The rationalization of quality in the construction industry: some empirical findings

Low Sui Pheng
Centre for Building Performance and Construction, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

The industry's attempt to rationalize construction quality is examined. Two schools of thought are identified. While the determinist school of thought envisages a belief that every construction element can be quantified and accounted for in writing, the deterministic school, on the other hand, suggests otherwise. The socio-political effects on quality as well as the technical safeguards taken by both the contractor and the employer are investigated. Emphasis is then directed towards workmanship and the relevance of Quality Assurance as a management process for achieving quality standards in the construction industry. The empirical results of a field study from six building sites in the West Midlands, England are presented to highlight the salient factors which influence respondents' perceptions and attitudes towards construction quality. The findings from this study tend to mirror the existence of both the rational and irrational approaches to quality in the construction industry. The industry needs to recognize this phenomenon in its attempt to institutionalize any procedure to both achieve and maintain quality construction.
Keywords: irrationality, quality, quality assurance, rationality, workmanship.

1993, **11**(4), 261–269

The use of bills of quantities in building contractor organizations

Kodikara, G W[1]; Thorpe, A[2] and McCaffer, R[2]
[1] *Department of Civil Engineering, University of Moratuwa, Moratuwa, Sri Lanka*
[2] *Department of Civil Engineering, Loughborough University of Technology, Loughborough, UK*

The prime purpose of the Bill of Quantities (BQ) is to enable all contractors tendering for a contract to price on exactly the same information. Subsequent to this, it is widely used for post-tender work such as: material scheduling; construction planning; cost analysis; and cost planning. Due to the re-work involved in the post-tender use of the BQ, the extent of use of the BQ is important. The re-work is any work such as; modification, or grouping, or breaking up of data when used for a particular task by a management group. The extent of use is defined as the direct use, after subtracting the re-work from the total use. This paper identifies the contractors current use of the BQ for post-tendering work based on eight case studies, and establishes the extent of use thus highlighting the re-working of the bill. By establishing the extent of use, the true picture of the direct use and the repetition work can be shown. The average extent of use of the BQ for post-tender work in the industry was found to be 50%. This 50% use of the BQ requires some form of re-working. This re-work needs to be reduced if improved post-tender use of estimating data is to achieved. Information stored in the BQ should be arranged in a directly useable way. It was found that, quantities, quantity units, and unit rates are the key elements of the BQ information that need to be presented in a more meaningful format if the amount of re-work is to be reduced.
Keywords: bills of quantity, case study, estimating, quantity surveying.

1993, **11**(4), 271–283

Modelling standard cost commitment curves for contractors' cash-flow forecasting

Kaka, A P[1] and Price, A D F[2]
[1] *Liverpool School of Architecture & Building Engineering, PO Box 147, Liverpool, L69 3BX UK*
[2] *Department of Civil Engineering, University of Technology, Loughborough, LE11 3TU, UK*

Cash-flow forecasting and control are essential to the survival of any contractor. The time available for a detailed pre-tender cash-flow forecast is often limited. Therefore, contractors require simpler and quicker techniques which would enable them to forecast cash-flow with reasonable accuracy. This paper identifies causes behind the inaccuracy of current standard value S-curves (which are often used as an alternative approach for cash-flow forecasting) and proposes the use of standard cost commitment models. The process of developing and testing the cost commitment models involved first collecting actual data for 150 completed projects. Several criteria were identified to classify these projects. Tests were conducted to identify which of these criteria affected the shape of the cost commitment curves. Projects were then distributed into different groups and S-curves were fitted into each using the logit transformation technique. Errors incurred when fitting these curves were measured and compared with those associates in fitting individual projects. Results showed that the difference between these errors was not significant. The reliability of selecting the cost commitment curve to model (instead of value curves) was evaluated. Results confirmed the hypothesis that cost commitment models are more accurate and reliable than value models. Finally, the paper outlines some of the practices involved in utilizing the proposed models.

Keywords: ANOVA, cash flow forecasting, cost commitment, cost control, S-curve.

1993, **11**(4), 285–291

Women in the UK construction industry

Sommerville, J; Kennedy, P and Orr, L
The Queen's University Glasgow, Cowcaddens Road, Glasgow, G4 0BA, UK

This paper considers the opportunities for, and barriers against, women in the UK construction industry. Women form the greater proportion of the economically active UK population and yet within construction, and other industries, they are under-represented. Data available clearly indicate that women are more than capable of performing the tasks undertaken by many professional male counterparts. Many of the professional bodies within the industry have a women's cohort, which may be perceived as a useful starting point, but does not fully reflect the potential available. It is suggested that women should be better represented and consideration is given to suitable methods for increasing the representation and reducing or eliminating some of the barriers to entry and eventual retention.

Keywords: career, employment, gender, UK, women.

1993, **11**(4), 293–303

Near optimal solution for resource-constrained scheduling problems

Moselhi, O and Lorterapong, P
Concordia University, 1455 de Maisonneuve Blvd. W., Montreal, Quebec, H3G 1M8, Canada

This paper presents an efficient resource allocation algorithm, and examines its performance against a number of scheduling heuristic rules, aimed at minimizing project durations in a multiple resource-constrained environment. The algorithm has been coded in BASIC and can easily interface with available planning and scheduling software systems. Unlike other heuristic network-based algorithms, resources are allocated simultaneously to sets of activities, rather than to individual activities in a sequential manner. An experiment was conducted to study the performance of the proposed algorithm and compare its results with those generated by four different heuristic scheduling rules, including those found to have the most superior performance such as the widely used least total float rule. Thirty-one network examples adopted from the literature are analysed. The results indicate that the proposed algorithm is superior to the others. The proposed algorithm provides a reasonable trade-off between the best accuracy associated with optimization techniques and the ease of computational effort associated with the simple least total float model. As such, it maximizes the benefits of the two limiting approaches.

Keywords: heuristic scheduling, project management, resource allocation, resource-constrained scheduling.

1993, **11**(4), 305–307

Extensions of time: time for change

Davenport, P
Construction Management and Economics Unit, The University of New South Wales, New South Wales, Australia

Extension of time and liquidated damages clauses have remained virtually unchanged for over a century and continue to give rise to the same problems. A new approach would be to have a target date for completion and no extensions of time or liquidated damages. The contract price would be reduced by an amount per day of overrun. There would be credits to reflect days when the contractor is prevented from working rather than the extent to which the contractor is delayed. The new approach may facilitate the administration of contracts.
Keywords: concurrent delay, contract, extension of time, liquidated damages.

1993, **11**(5), 317–325

Prediction of solvency in construction companies

Langford, D[1]; Iyagba, R[2] and Komba, D M[3]
[1] *Department of Civil Engineering, University of Strathclyde, 107 Rottenrow, Glasgow, G4 0NG, UK*
[2] *Building Department, University of Lagos, Nigeria*
[3] *University of Dar es Salaam, Tanzania*

This paper reviews two models for testing the financial security of construction companies. It discusses the utility of the ratio analysis technique and the Z model in predicting whether companies are heading for insolvency. It then applies these techniques to three construction companies which failed within the last 5 years to test whether the theoretical predictions prescribed in the techniques are applicable to the construction industry. It concludes that whilst the techniques are of value in predicting some difficulties they need to be used in conjunction with financial performance data of other construction firms, in this way comparisons may be made. The development of a refined and construction specific Z model is recommended.
Keywords: financial performance, insolvency, ratio analysis, Z model.

1993, **11**(5), 326–340

Elicitation of subjective probabilities for economic risk analysis: An investigation

Ranasinghe, M[1] and Russell, A D[2]
[1] *Senior Lecturer, Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka*
[2] *Associate Professor, Department of Civil Engineering, University of British Columbia, Vancouver, Canada*

This paper investigates three major issues regarding the elicitation of expert knowledge for economic risk analysis:(1) recognition of some of the implicit assumptions and beliefs;(2) development of an approach to elicit expert knowledge as accurate, calibrated and coherent subjective probabilities; and (3) a study to explore human ability to predict future events and the validity of the implicit assumptions and beliefs in the context of the expert judgements. The proposed elicitation approach combines the theoretical requirements for valid subjective probabilities with a practical process. The recognition that some of the implicit assumptions and beliefs in engineering risk analysis should be explored when dealing with the human ability to predict future events, and the inherent difficulties in developing experiments and methods to test such beliefs are some of the benefits of the study. Directions for future work are suggested.
Keywords: decomposition, economic risk analysis, elicitation technique, questionnaire, subjective probability.

1993, **11**(5), 341–346

Flow of estimating data in Sri Lankan building contractor organizations

Kodikara, G W[1] and McCaffer, R[2]
[1] *Department of Civil Engineering, University of Moratuwa, Moratuwa, Sri Lanka*
[2] *Civil Engineering Department, Loughbrough, Leicestershire, LE11 3TU, UK*

An estimator who prices a bill of quantities, collects, generates and assembles data (estimating data) for the purpose of establishing the cost of constructing the project. The data generated could be used by the contractor's subsequent management functions, and the use of estimating data in the contractors' post-tender management worthy of attention. Drawing information from ten case studies of the organization of Sri Lankan building contractors, this paper identifies the contractors' management functions. These flows highlight the substantial burden of re-work in the post-tender use of data. It is argued that the current format and presentation of estimating data in Sri Lanka are the major causes for such re-work. However, it was found that any revolutionary change to the conventional format would not be welcomed by the industry. Any new proposal should be developed within the limitation of acceptability to conventional practice. The recommendation is the 'unit rate' is broken down to its cost components of materials, labour and plant. The

breakdown of the unit rate would supply all the necessary data for direct use, thus reducing the re-work. Further research should be addressed to investigating the best format and structure of this breakdown.
Keywords: bills of quantity, case study, data management, estimating, Sri Lanka.

1993, **11**(5), 347–357

An expert system for assessing the performance of RC beams and slabs

Koo, T K and Tiong, R L K
School of Civil and Structural Engineering, Nanyang Technological University, Nanyang Avenue, Singapore 2263

This paper reports on the design and development of an expert system of diagnosis and repair of beams and slabs in buildings constructed of reinforced concrete. The aim of the project was to capture all the available knowledge, expertise and experience on building diagnosis and repairs in a user-friendly expert system for civil engineers and allied professionals in the Singapore construction industry. Given different levels of information, the expert system, named EXSOBDR (for EXpert System On Building Diagnosis and Repair), will attempt to identify the most probable causes of RC building deterioration and recommended appropriate strategies for repair. Reports generated by EXSOBDR have been validated on actual case studies and the results have been found to be satisfactory.
Keywords: diagnosis, expert system, maintenance, repair, Singapore.

1993, **11**(5), 358–369

The nature and effects of construction delays

Scott, S
Department of Civil Engineering, University of Newcastle upon Tyne, Claremont Road, Newcastle upon Tyne, NE1 7RU, UK

A method for assessing delay claims, regularly used in the USA, is described, together with procedures which have been proposed for dealing with concurrent delays. These treatments are reviewed to identify their shortcomings which in some instances stem from a view of the nature of delays which is not consistent with the way in which delays actually occur. The various types of delay are examined to consider how these treatments might be amended to provide more realistic solutions. It is suggested that concurrent delays need only be separately considered when they affect a single activity, and the concept of parallel critical paths in an as-built network is thought to be invalid. The delays themselves are not always fixed in when they might have their effects and it is important that this is recognized. Finally a procedure is suggested to select days of exceptional adverse weather artificially, so that critical path method (CPM) analyses may be carried out.
Keywords: claim, concurrent delay, CPM assessment of delay, delay.

1993, **11**(5), 370–383

Estimating industry-level productivity trends in the building industry from building cost and price data

Chau Kwong Wing
Department of Surveying, The University Hong Kong, Pokfulam Road, Hong Kong

A method of measuring total-factor productivity (TFP) trends in the building industry is described in this paper. This method is an improved version of the approach described in a paper by Chau and Walker in that it requires less restrictive assumptions and is theoretically less biased while requiring only slightly more data. With small modification, the same method can be used to measure other productivity trends corresponding to other productivity concepts. The data used in measuring TFP of Hong Kong's building industry are also different from those proposed by Chau and Walker. A number of modifications have been made. These modifications have been possible both as a result of work by Chau and the increased availability of statistics in recent years. One of the major difficulties in measuring TFP trends in the building or construction industry has been the lack of data. This is also one of the major reasons for the dearth of empirical studies in this area. Very few attempts have been made to solve the problem of data availability. Lowe recognizes the difficulties in obtaining suitable data for measuring TFP of the British construction industry. His suggestion, however, is to use capital productivity as the second-best alternative to TFP rather than solving the problem. Chau and Walker's solution is to develop a method for estimating TFP from construction cost and price data. The method is then used to measure the TFP of Hong Kong's building industry. Since construction cost and price data are usually more readily available in most countries, Chau and Walkers's approach is potentially useful in these countries. There are, however, certain deficiencies in Chau and Walker's approach in that some of the underlying assumptions are relatively restrictive. As more statistics are now available in Hong Kong, this has rendered Chau and Walker's approach a crude tool for making full use of the data. This paper presents a modified approach which requires less restrictive assumptions and can make better use of the newly available data.

Keywords; Hong Kong, productivity, total factor productivity.

1993, **11**(5), 384–397

Information modelling in the construction industry: the information engineering approach

Aouad, G F[1]; Kirkham, J A[1]; Brandon, P S[2]; Brown, F E[3]; Cooper, G S[1]; Ford, S R[1]; Oxman, R E[4]; Sarshar, M[4] and Young, B A[5]
[1] *IT Institute, University of Salford, Salford, Manchester, M5 4WT,UK*
[2] *Department of Surveying, University of Salford, Salford, Manchester, M5 4WT, UK*
[3] *Department of Architecture, University of Manchester, Manchester, M13 9PL, UK*
[4] *Faculty of Architecture and Town Planning, Institute of Technology, Haifa 32000, Israel*
[5] *Department of Civil Engineering, University of Salford, Salford, Manchester, M5 4WT, UK*

Modelling of knowledge in the construction industry is a cumbersome task because of the large amount of data involved and the lack of automated information-modelling tools. Adoption of a method and an automated CASE (Computer-Aided Software Engineering) tool could eliminate many problems encountered in the development of information systems in the construction industry. In particular, this approach may help to assess the information requirements and define strategies for such information systems. The Information Engineering Method (IEM) is introduced to illustrate how the conceptual models may be improved by using this method. Additionally Texas Instruments' Information Engineering Facility (IEF^{TM})CASE tool is described to illustrate the advantages of automating such a method. The introduction of conceptual modelling in the construction industry using data and process models should lead to a better structuring of information. This should result in the development of well defined and structured, not *ad hoc*, applications. This conceptual modelling approach using information engineering is currently being used at the University of Salford to study the potential development of an integrated database (design, procurement and management of construction) for the construction industry. The case study describes the information analysis phase of the procurement process included towards the end of this paper.

Keywords: CASE, computer-aided software eng'g, information, procurement.

1993, **11**(5), 398–403

The formulation of performance indicators in evaluating the implementation of automation in the construction industry

Tan, R R and Chang, D S
Graduate Institute of Business Adminstration, National Centre University, Chung-Li, Taiwan

The focus of the paper is to present the processes in formulating a system of performance indicators to evaluate the implementation of a National Construction Industry Automation Plan in the Republic of China. We approach the formulation as a 'construction automation transformation system' which consists of three major components: (1) the inputs, such as funding, manpower and supports, (2) the sub-systems, and (3) the outputs. There are three sub-systems, the receiving sub-system and the socio-economic sub-system. Corresponding to each sub-system, a set of output performance indicators is developed. Program output performance indicators are proposed to measure the effectiveness of the processing sub-system. The industry effectiveness performance indicators are recommended to measure the effectiveness of the receiving sub-systems and the socio-economic sub-system respectively.
Keywords: automation, China, national planning, performance indicator.

1993, **11**(6), 411–420

A numerical analysis method for computing schedule and resource forecasting for industrial projects

Miskawi, Z
Mobil North Sea, PO Box 4, Peterhead, Scotland, UK

The derivation of schedule curves and resource histograms from manhours is traditionally carried out on spreadsheet systems; this method proved tedious and becomes complex during the performance of 'what-if' analysis. Consequently, a new method has been developed to derive schedule curves and resource histograms from manhours and to improve the efficiency of the computations and the accuracy of the results. The new method is based on numerical analysis techniques, tested with historical data from industrial projects and used in the oil and petrochemical industry. Results obtained using the new method correlate closely to results calculated by a traditional spreadsheet method. The new method proved to be valuable to project management at the beginning of project where the availability of scheduling data is limited and during the execution of projects to perform 'what-if' analysis.
Keywords: numerical analysis, resource forecasting, scheduling.

1993, **11**(6), 421–429

The effect of contractor size on mark-up size decision in Saudi Arabia

Shash, A A and Abdul-Hadi, N H
Construction Engineering and Management Program, College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

This study is a part of a larger study addressing the bidding decisions of construction contractors in Saudi Arabia. It examines the mark-up size decisions of small, medium, and large contractors in Saudi Arabia. These groups are found to consider and evaluate many factors subjectively when they set mark-up sizes for projects. However, the importance of these factors varies as the contractor's size changes. Bidding document price, strength in the industry, time allowed for submitting bids and other factor are the greatest contributors to the discrimination between contractor size.
Keywords: bidding, discriminant analysis, mark-up, Saudi Arabia.

1993, **11**(6), 431–441

The role of advertising in marketing civil/structural engineering consultancy firms

Namo, F and Fellows, R F
Construction Study Unit, School of Architecture and Building Engineering, University of Bath, Claverton Down, Bath, BA2 7AY

This paper examines the results of an investigation into the role of advertising in civil/structural consulting engineering service firms in the UK. A questionnaire survey of clients and engineering consultants was undertaken to ascertain the current advertising practices and preferences in the methods and media used. From the survey, the results show that clients and consultants agree on the use of advertising consultants and media to achieve enhanced communication with clients. However, more advertising should b directed towards architects because the majority of clients approach architects first when launching a construction project. The results demonstrate that advertising is necessary, but is not a major factor in the selection mechanism of consulting firms by clients; further market research must be carried out to measure advertising effectiveness.
Keywords: advertising media, communication, client, consultant.

1993, **11**(6), 443–453

Electronic data interchange and the structure of the UK construction industry

O'Brien, M J and Al-Soufi, A
Department of Computer Science, University of Nottingham, NG7 2RD, UK

The UK construction industry is characterized by it fragmented nature. Information technology (IT) has had little effect on the industry, its work practices and structure. Electronic data interchange (EDI) is a standardized technology aimed at reducing the inefficiencies of trading. This paper analyses the possible impact of EDI on the structure of the industry. The main finding of this analysis is that EDI is a technology that has the capability of altering organizational interfaces to such an extent that it will change the structure of the UK construction industry.
Keywords: EDI, fragmentation, industry structure.

1993, **11**(6), 455–465

Leadership style of construction managers in Hong Kong

Rowlinson, S M; Ho, T K K and Po-Hung, Y
Department of Surveying, The University of Hong Kong, Hong Kong

Hong Kong's construction industry is one of the most dynamic in the world and the Territory has a remarkable record of completing project to budgeting seemingly impossible times. Despite the fact the 97% of the population is Chinese, the Territory remains under British Colonial rule (until 1 July 1997) making Hong Kong a meeting point for Western and Eastern cultures. The mixture of cultures raises interesting managerial issues and an issue particularly relevant to construction project management is leadership behaviour style. This paper studies the leadership styles of Hong Kong Chinese construction managers (by means of Fiedler's Least Preferred Co-worker (LPC) scale and House's styles grid) and compares these styles with those of their western counterparts. Hong Kong managers are found to be much more relationship-orientated that their western counterparts. The issue of situational variables on the style adopted is explored.
Keywords: design team leader, Hong Kong, leadership, site staff.

1993, **11**(6), 467–473

The strategic management of architectural practice

Winch, G and Schneider, E
The Bartlett Graduate School, Philips House, University College London, Gower Street, London, WC1E 6BT, UK

The paper develops a model for the strategic management of architectural practice with the aim of better understanding how practices compete with each other for work around a tripartite definition of quality. It assesses the ways in which architectural practices are distinctive as knowledge based organizations, before assessing some of the characteristics of their industrial context. Drawing on the work of Maister and Porter, it then develops a model of generic strategies for architectural practice which, it is suggested, can form the basis for further research and consultancy. Finally, some comments are made suggesting why architectural practices are reluctant to think in strategic terms.
Keywords: architectural quality, distinctive competence, knowledge-based organization, practice management, strategic management.

1993, **11**(6), 475–485

How designs develop: insights from case studies in building engineering services

MacPherson, S J; Kelly, J E and Webb, R S
Department of Building Engineering and Surveying, Heriot-Watt University, Edinburgh, UK

This study investigates the 'typical' form of design description for heating, ventilating and air conditioning systems in buildings at a point in the design development corresponding to the feasibility stage of the Royal Institute of British Architects' plan of work. Eight case studies yielded rich qualitative data on the form of design description and the process by which those design evolved. It was found that the designs developed with a fragmentary attention to detail, and did not conform to the top-down approach to design management implied by the plan of work or other prescriptive models of design. Nevertheless, patterns which emerged from the data imply that the design process behind this is not entirely idiosyncratic and unstructured, but points to a strategic approach in the use of detail which was shared by the designers. An empirical model of this strategic process, grounded in the data from the study (a 'grounded theory' model), is developed and the implications for builders of more general models of the design management process are discussed.
Keywords: case study, design detail, design development, grounded theory.

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1994, **12**(1), 3–14

Models of UK private sector quarterly construction demand

Akintoye, A[1] and Skitmore, R M[2]
[1]*Department of Building and Surveying, Glasgow Caledonian University, Glasgow, G4 0BA, UK*
[2]*Department of Surveying, University of Salford, Salford, M5 4WT, UK*

An analysis is made of private sector construction demand (quarterly new orders) grouped into housing, commercial and industrial construction, respectively and their relationship with a *priori* selected leading indicators of GNP, price level, real interest rate, unemployment and manufacturing profitability over the period 1974-1988. The results indicate that different variables explain the trends in these private sector construction demand subsectors. While construction price appeared to be an important elastic influence in housing investment, it was not found to be an important factor with respect to commercial and industrial construction. Trends in commercial and industrial constructions are explained by manufacturing profitability and economic conditions. The level of unemployment influences commercial construction only and with a negative inelastic relationship. Lead indicator forecasts of the groupings of private sector investment are above 10% accuracy due to the unusually deep cut in private construction as a result of the recession although the models expect increasing trends in these series. The implication of this level of accuracy is the need to investigate further variables for inclusion in the models to track the cut in private sectorial construction demand. This work is currently being undertaken at the University of Salford through the financial support of the Science and Engineering Research Council.

Keywords: demand, forecasting, GNP, interest rate, price, private sector, unemployment.

1994, **12**(1), 15–29

Quantification and management of uncertainty in activity duration networks

Ranasinghe, M
Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka

This paper develops a theoretical basis for three issues that are important in the quantification and management of uncertainty in activity duration networks. Firstly, the uncertainty in activity durations is quantified. Secondly, the quantification of uncertainty in project duration is developed. Thirdly, how these quantifications can be used for allocation and management of contingency in activity durations is demonstrated. A published numerical example is used to illustrate the application of this development to a construction project. While this idea challenges the popular longest path (PERT) approach, it provides a robust theoretical foundation and introduces a logical framework to the quantification and management of uncertainty in activity duration networks.

Keywords: activity duration, network, probability, uncertainty.

1994, **12**(1), 31–36

A survey of indirect cost estimating in practice

Tah, J H M[1]; Thorpe, A[2] and McCaffer, R[2]
[1]*School of Construction Economics and Management, South Bank University, Wandsworth Road, London, SW8 2JZ, UK*
[2]*Department of Civil Engineering, University of Technology, Loughborough, Leicestershire, LE11 3TU, UK*

This paper presents the findings of an investigation into the current practices of estimating the indirect costs involved in tendering for construction work. It shows the results of a survey of current practices and attitudes in seven firms towards the quantification and allocation of general overheads, risk contingencies and profit in a tender. The survey indicates that the methods used are highly subjective and are based on past experience. Quantitative methods involving statistics and probability, even though advocated, are rarely used. This suggests that future methods adopted in a computerized estimating environment should reflect the subjective nature of the process and should be simple enough to be applied.

Keywords: overheads, indirect cost, profit, risk contingency, subjective decision making.

1994, **12**(1), 37–44

Obsolescence in hedonic price estimation of the financial impact of commercial office buildings: the case of Kuala Lumpur

Khalid, G
Dept of Construction Management & Engineering, University of Reading, Reading, RG6 2BU, UK

This paper discusses the empirical findings of an analysis of the financial impact of obsolescence using the hedonic price technique. The difference between the rental price of a building and the highest rental price of office buildings in the market was used as the measure of the financial impact of obsolescence on the building. The analysis shows that the financial impact caused by obsolescence can be analysed and estimated for use in building design and investment appraisals.
Keywords: design, hedonic price, obsolescence, rent.

1994, **12**(1), 45–51

Technology transfer: a survey of international construction companies

Carrillo, P M
Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

This paper reports on a survey of technology transfer undertaken by international construction companies in developing countries. The views of construction professionals with extensive work experience in developing countries were consulted in a questionnaire survey of top UK and US consultants and contractors. The aim of the survey was to determine the areas of construction technology transfer that provide maximum benefit to local communities, the most effective way of improving technology transfer, the main obstacles experienced and how these obstacles may be overcome. The results show that several companies actively undertake technology transfer exercises in an *ad hoc* manner and their obligations to the recipients need to be specifically defined.
Keywords: developing country, international company, technology transfer.

1994, **12**(1), 53–65

The multiplicity concept in construction project planning

Laufer, A[1]; Tucker, R L[2]; Shapira, A[3] and Shenhar, A J[4]
[1]*Department of Civil Engineering, The University of New Mexico, Albuquerque, NM 87131-1351, USA*
[2]*Civil Engineering, University of Texas and Construction Industry Institute, Austin, TX 18703, USA*
[3]*National Building Research Institute, Technion, Haifa 32000, Israel*
[4]*Centre for the Development of Technological Leadership, University of Minnesota, Minneapolis, MN 55455, USA*

Why plan? Who should plan? What and when should one plan? These fundamental issues of construction planning raised by the authors 5 years ago, are revisited in this paper in the light of studies conducted recently within the construction industry. In the focus of this research program stood mature companies, advanced projects and competent and experienced practitioners of construction planning and management. The findings show that there is no one single answer to any of these basic questions and that in fact a state of multiplicity - of roles and users, plans and formats, timings and time horizons, planning parties and modes of preparation - prevail, calling upon the willing practitioner to resort systematically to situational analysis if effective planning is to be accomplished.
Keywords: construction planning, scheduling.

1994, **12**(1), 67–78

Improving safety by the modification of behaviour

Duff, A R; Robertson, I T; Phillips, R A and Cooper, M D
Department of Building Engineering and Manchester School of Management, University of Manchester Institute of Science and Technology, Manchester, UK

Safety improvement in the construction industry will only be achieved if all concerned in the operation of construction sites change their behaviour. This article describes the development and effects of behaviourally-based management techniques in improving site safety. Goal-setting and feedback methods were developed and tested on six construction sites in the Northwest of England. A longitudinal research design was adopted, in which measures of safety perforamnce were taken before, during and after the application of these methods. The measures included four categories of measurement: access to heights; site housekeeping (tidiness); scaffolding; and use of personal protective equipment. Three of these categories were used for experiments with a variety of goal-setting and feedback interventions, while the fourth was used as a control. The results show that: safety behaviour can be objectively and reliably measured; goal-setting and feedback can produce large improvements in safety performance; commitment of site management appears to enhance their effectiveness. The work was financed by the Health and Safety Executive, and a further contract to develop the techniques into a basic part of safety management for several large construction companies has begun.
Keywords: goal-setting, measurement, safety management.

1994, **12**(1), 79–88

Quantification skills in the construction industry

Fortune, C[1] and Skitmore, R M[2]
[1]*School of the Built Environment, Liverpool John Moores University, Mount Pleasant, Liverpool L3 5UG, UK*
[2]*Department of Surveying, University of Salford, Salford M5 4WT, UK*

Measurement/quantification is a core skill of the quantity surveyor and such skills need to be placed within a more appropriate educational framework to ensure their continuing relevance. This paper reports on a study that sought first, to identify the characteristics associated with measurement/quantification skills and second, to weight or rank their relative importance. A total of 37 characteristics associated with a person undertaking the measurement task were identified following a search of available literature and a series of taped interviews with practitioners. These were then classified and grouped together into a model structured according to the fundamental requirements of educational soundness, technical soundness and personal soundness. Twenty-one representative characteristics of this model were then rated for importance by 77 undergraduate quantity surveying students and 30 qualified surveyors working in private practice. The resulting analysis enabled the subsets of the characteristics of measurement skill to be ranked in the following order of importance: ability to formulate and solve problems, sufficient knowledge of salient aspects of the task, good intellect, ability to activate responses, adequate construction capability, ability to transmit information, good character, practical capability and good physical characteristics. This ranking allowed the proposed model of the characteristics of measurement skills to be weighted to show that educational soundness was more important than technical and personal soundness.

Keywords: education, quantity surveying, quantification skill, skills modelling, training.

1994, **12**(2), 97–106

Construction planning and information technology in the UK and USA construction industries: a comparative study

Aouad, G F and Price, A D F
Department of Civil Engineering, Loughborough University of Technology, Loughborough, LE11 3TU, UK

The current applications of planning techniques and information technology are compared within top UK and USA contractors and the viability of developing integrated systems within the framework of construction planning is assessed. The results are based on a questionnaire survey conducted amongst both the top 100 contractors in the UK and the top 400 contractors in the USA. This survey reveals that there is a great similarity between the different planning techniques employed by both UK and USA contractors and that information technology is applied more vigorously in the USA. However, it appears that many aspects of information technology are well within the reach of most of the companies surveyed and that may recent developments could be used to develop integrated systems as an aid to the planning of construction projects.

Keywords: construction planning, contractor, information technology, integrated system, questionnaire , survey research, UK, USA.

1994, **12**(2), 107–111

A study of the contractor's quantity surveying practice during the construction process

Cornick, T and Osbon, K
Department of Construction Management and Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 2BU, UK

Quantity surveyors in construction companies apply traditional quantity surveying practices to meet the requirements of consultant quantity surveyors acting for the client. Other practices have to be used to suit the internal cost accounting and reporting requirements of the company. The practices of construction company quantity surveyors must therefore satisfy both external and internal needs and, in order to support corporate feedback, must be standardized across the company's projects. This paper describes an investigation of the quantity surveyor's role in a construction company. It was carried out as part of the company's quality improvement process. The investigation identified the need for a number of changes to satisfy the aims of the quantity surveying practice. The paper describes these and the result of the implementation. Further improvements in cost control during the construction phase of a project can be made, thus, enabling the quantity surveyor to provide better support for the site project manager.

Keywords: cost control, quality, quantity surveying.

1994, **12**(2), 113–124

Contractors' financial budgeting using computer simulation

Kaka, A P
School of Architecture and Building Engineering, The University of Liverpool, Leverhulme Building, Abercromby Square, PO Box 147, Liverpool, L69 3BX, UK

Contractors' budgets are often performed on an overall basis. Changes in strategies and mix of contracts are very difficult to evaluate on such a basis. Thus, the accuracy of current budgets is in question. A new approach has been developed to perform contractor's budgeting, by generating and integrating individual current and future projects. The principle of simulation was introduced to generate possible scenarios according to the specified strategies and the expected environment. The model was tested using various verification techniques and was confirmed to be a reliable simulation tool.
Keywords: budget, cash flow , contractor, financial planning, simulation.

1994, **12**(2), 125–138

The fuzzy industry maturity grid (FIMG) and its application to the Singapore construction industry

Huat, T P and Low Sui Pheng
School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

This paper introduces the fuzzy industry maturity grid (FIMG) as an extension of the industry maturity grid for diagnosing an industry, to identify fast growing sectors and to map out growth strategies for sectors showing signs of maturity. By incorporating fuzzy set theory and aggregation models in decision-making, the conventional industry maturity grid is enhanced from a qualitative analysis to a semi-quantitative method which captures an expert's knowledge of the industry, inclusive of his judgement. It does this via using a linguistic scale describing the characteristics under each of the three main dimensions of the IMG to form fuzzy sets, a hierarchical aggregation of information based on fuzzy aggregation operators and a conceptual hypercube to determine the rank and ranking size of the prescribed strategies. The FIMG is illustrated using the Singapore construction industry as an example; the resulting three highest ranked prognoses for the industry are - in decreasing order of possibility - sunrise industry, technology-led diversification and new applications of technologies. This ranking of prognostic alternatives bestows policy-makers with information useful for selecting cost-effective programmes for growth.
Keywords: FIMG, fuzzy sets, industry maturity, Singapore.

1994, **12**(2), 139–154

Estimating processes of smaller builders

Skitmore, R M[1] and Wilcock, J[2]
[1]*Department of Surveying, University of Salford, Salford, M5 4WT, UK*
[2]*Department of Construction and Surveying, Fylde College of Technology and Arts, Bispham, Blackpool, UK*

The paper describes a study of the way in which smaller builders price items in bills of quantities for competitive tender. A series of interviews revealed some marked differences between normal practice and literature-based prescriptions. An experiment was conducted in which eight practising builders' estimators were separately presented with a representative sample of 36 bill of quantities items taken from groundwork, *in situ* concrete work and masonry sections. The estimators stated the method they would normally use to price each item, their 'normal' price rate and their highest/lowest price rate. The results showed that only half the items would be priced by the prescribed 'detailed' method, the remainder being priced mainly by 'experience'. Analysis by work section, item rate, item quantity, item total, item labour content, contribution to the total of the bill, the standard deviation of the interestimator intraitem rates and totals and their coefficients of variations, skewness and kurtosis indicated that the item total was the main factor determining the rating method used, although this varied in importance between work sections. An intraestimator intraitem analysis of pricing variability generally confirmed the assumption of a constant coefficient of variation.
Keywords:, bills of quantity, item rates, pricingvariability.

1994, **12**(2), 155–163

Design and build: a survey of construction contractors' views

Akintoye, A
Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 0BA, UK

Design and build (D&B) has become a popular mode of procuring construction work. A total of 52 construction firms responsible for 25% of UK construction output for 1991 were surveyed using a structured questionnaire to investigate their current views on this procurement route. The Novation D & B is widely used although not favoured by contractors. The contractors would like consultants to continue to provide them with concept design and specification and would rather support the develop and construct technique. 'Design and manage' and 'design, manage and

construct' are not attractive to clients and resented by contractors. The usage of D & B on private sector projects is ~21% of work-load from this sector compared to 12% from public sector.
Keywords: design and build, design and manage, procurement.

1994, **12**(2), 165–170

Design and development of a KBES for planning and scheduling ready-mixed concrete supply

Lam, Y T[1]; Alum, J[2] and Neale, R H[3]
[1]*School of Civil and Structural Engineering, Nanyang Technological University, Nanyang Avenue, Singapore 2263*
[2]*Centre for Advanced Construction Studies, Nanyang Technological University, Nanyang Avenue, Singapore 2263*
[3]*Department of Civil Engineering, Loughborough University of Technology, Loughborough, UK*

The aim of this research is to explore the feasibility of knowledge-based expert systems (KBES) for the planning and scheduling of ready-mixed concrete supply. Ready-mixed concrete is a product as well as a service. This implies that the supply of ready-mixed concrete should satisfy the customers' needs in relation to both quality and supply. Due to the peculiar characteristics of the product which has a 'shelf life' of only a few hours and the dynamic nature of the operating environment, the planning and scheduling problems of ready-mixed concrete supply are usually unstructured and complicated. A prototype knowledge-based expert system for the planning and scheduling of ready-mixed concrete supply developed with a leading ready-mixed concrete company in the UK will be presented. This paper begins with a brief summary of the ready-mixed concrete production and delivery process and the importance of its planning and scheduling decisions. This is followed by a discussion of the role, tasks performed, development and testing of the system developed. The paper shows the potential of KBES in planning and scheduling ready-mixed concrete supply. A full-scale version needs to be developed based upon validation and refinement of the current system. The indicators are that this will prove to be a valuable aid in decision-making.
Keywords: concreting, expert system, planning, ready-mixed concrete, scheduling.

1994, **12**(2), 171–182

Balancing construction and marketing in world economic development: the four global scenarios

Low Sui Pheng
School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0551

Planning for economic development is one of the major preoccupations of governments as well as international agencies such as the United Nations and the World Bank. Construction and marketing are individually known to have an influence on the achievement of economic goals. Unfortunately, the combined effect of construction and marketing has never been explored explicitly before. Although the pursuit of economic development has been their common objective, both disciplines have always been examined in isolation. This paper does not, however, pretend that construction and marketing are the only two factors which influence economic growth. The purpose is to help bridge the gap between construction and marketing in world economic development. For this purpose, other factors which may have an equally important influence on economic growth would, of necessity, need to be isolated. The relationship construction and marketing have with world economic development is supported through a literature review. In adopting construction and marketing as the two primary thrusts for securing economic growth, four global perspectives have been identified: scenario A, a balanced view; scenario B, weighted towards construction; scenario C, weighted towards marketing; scenario D, a deficiency model. The balanced view in scenario A mirrors the characteristic feature typical of most developed countries where mature marketing practices and construction infrastructures can be found. Scenario B, where construction attracts more attention then marketing, models the emphasis given by the governments in most developing countries. Scenario C models an economy which lacks the construction facilities necessary for the effective conduct of marketing activities. Countries which have poor construction and marketing facilities can be categorized under the deficiency model in scenario D. Adequate construction works and marketing expertise are generally found to be lacking in these countries which consequently stultifies both the local economy as well as foreign trade. Most of the poorest countries in the world appear to be affected to a large degree by scenario D. The statistical analysis supports the relationship between construction and marketing as well as the four scenarios postulated. In the light of these four global scenarios, constructors and marketers should realize that a synthesis of their two disciplines is required if future economic goals and objectives are to be achieved uneventfully.
Keywords: developing country, economic development, growth, marketing.

1994, **12**(2), 183–185

A comparison between growth in labour productivity in the construction industry and the economy

Chau Kwong Wing and Lai, L W C
Department of Surveying, University of Hong Kong, Pokfulam Road, Hong Kong

The construction industry in commonly believed to have slow growth in labour productivity. This belief is partly due to the labour intensive nature of the construction process and partly due to the inherent difficulty the industry has in adopting labour saving technologies such as the production line technique due to the one-off nature of construction projects. The 'fragmented' structure of the industry and its apparent stagnant technological progress further strengthens this belief. However, on the other hand, it can also be argued that a 'fragmented' structure facilitates the division of labour and therefore enhances the productive efficiency of labour. Furthermore, the labour intensive nature of the construction process simply means that output (in value added terms) per unit of labour, at any point in time, is likely to be lower than that in the economy. This however does not necessarily imply that growth in labour productivity in the construction industry over time will be also lower than that of the economy. Whether labour productivity growth in the construction industry compares favourably with that in the economy is purely an empirical question which this paper attempts to investigate. It presents a simple method of estimating the relative labour productivity (RLP) trend of the construction industry (labour productivity of the construction industry relative to that of the economy) from national accounting data. The method is then used to derive the trend of RLP in Hong Kong's construction industry. The results do not support the common belief that labour productivity in the construction industry grows at a slower rate compared with that in the economy.

Keywords: Hong Kong, labour productivity, price deflator, relative labour prod..

1994, **12**(3), 191–202

An anatomy of a Hong Kong project: organization, environment and leadership

Walker, A and Kalinowski, M
Department of Surveying, The University of Hong Kong, Pokfulam Road, Hong Kong

An analysis is presented of the organization structure of a large complex project in Hong Kong which involved both public and private sector participants. The project is the US$400 million Hong Kong Convention and Exhibition Centre. The analysis identifies the novel contract strategy used and the resulting relationship which existed between contributors to the project. The analysis is based on the systems approach to organization structure and focuses on the structure of decisions, differentiation and integration of the operating system, the client and the managing system. Distinction is made between the macro-and micro-environments of the project with which the organization structure has to interact. Features of the leadership styles adopted at a high level on the project are discussed. Conclusions are drawn within the context of the interplay between project environment, organization structure and leadership.

Keywords: contract strategy, leadership, organization structure, project environment, project management, systems theory.

1994, **12**(3), 203–217

Strategic planning for competitive advantage in construction: the institutions

Betts, M and Ofori, G
Construction Economics Research Unit, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

There have been developments in strategic planning techniques that various sectors of the economy have applied in pursuit of competitive advantage. In most sectors strategic planning applications are taking place at the level of parts of an enterprise's operations, at the general corporate level and at the level of the nation. In construction, strategic planning at any level appears to lag behind other sectors: it seems to be applied mainly by large enterprises keen on expansion, diversification and penetration of overseas markets. A previous paper by the authors has shown the implications of the developments in strategic planning concepts for the construction enterprise. This paper shows how strategic planning can be applied by professional institutions and trade associations in the construction sector. After defining a five-level framework to which strategic planning can be applied, the paper outlines the factors underlying change in the construction industry and the nature of that change. It then discusses briefly some of the techniques of strategic planning which can be applied by the institutions and gives detailed examples of strategic planning at the level of professional institutions and trade associations. Through recommendations of further opportunities, the paper then goes on to show how more widespread strategic planning can be followed in the future at the institutional level. It concludes by observing that the new ideas of strategic planning have relevance to and considerable scope for application at the institutional level of the construction sector.

Keywords: competitive advantage, professional institution, restructuring, strategic planning, trade association.

1994, **12**(3), 219–231

Formulating a long-term strategy for developing the construction industry of Singapore

Ofori, G
Construction Economics Research Unit, School of Building and Estate Management, National University of Singapore, Singapore 0511

The technique of strategic planning is discussed and the conceptual frameworks adopted by writers on construction industry development are categorized. Plans formulated for developing the industry in Singapore are reviewed. Finally, a more appropriate approach to the formulation of a strategy for improving the performance of the construction industry in Singapore is offered and lessons from Singapore's experience for developing countries outlined. It is suggested that the strategy should aim to exploit the nation's *total* experience and resources.
Keywords: conceptual framework, development, national planning, resource exploitation, Singapore, strategic planning.

1994, **12**(3), 233–243

Contingency allocation and management for building projects

Ranasinghe, M
Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka

A theoretical approach is presented for contingency allocation and management in building projects using the quantification of uncertainty of project cost. The uncertainty of input items to a bill of quantities, namely, quantities of bill items, usage of resources and their prices are quantified as two moments. From these, two moments for project cost are evaluated. The cumulative distribution function for project cost approximated from its two moments is used to determine the contingency allocation based on a desired probability of success. The management process of this allocation is developed using an approach that establishes initial bench-marks by distributing the allocation to individual bill item costs. By using these initial bench-marks for further distribution, sophistication is introduced to the management process.
Keywords: contingency, probability, quantification, uncertainty.

1994, **12**(3), 245–255

A survey of construction site safety in Honduras

Jaselskis, E J and Suazo, G A R
Civil and Construction Engineering Department, Town Engineering Building, Iowa State University, Ames, IA 5001, USA

This paper provides the results of a construction site safety survey conducted in Honduras. A questionnaire was used to collect safety-related information from construction workers, field management and upper management in the Home Office on residential, commercial and heavy civil construction projects in San Pedro Sula, Honduras. Data were collected using face-to-face interviews - 108 construction workers, 10 field managers and eight senior managers participated. Data were analysed using correlation, regression and analysis of variance techniques. Results demonstrated a substantial lack of awareness or importance for safety at all levels of the construction organization. Workers rarely wore personal protective equipment, used poorly constructed scaffolds, improperly used tools and ladders and disregarded good housekeeping practices. Almost three-quarters of the craftsmen suffered at least one lost-time accident; many of their injuries were in expected locations on their bodies given the nature of their work and the site conditions. Many of the field project managers stated that they did not provide workers with personal protective equipment or safety training and did not use a dedicated safety person on-site. Top level management does not appear convinced that it is in their best interests to improve safety performance either since only approximately 25% provided company-wide safety training programme, maintained accident records and provided safety incentives. Additional results, recommendations for improving construction safety in Honduras, study limitations and future research areas are also identified.
Keywords: accident, developing country, Honduras, safety.

1994, **12**(3), 257–270

A comparative analysis of three macro price forecasting models

Akintoye, A[1] and Skitmore, R M[2]
[1]*Department of Building and Surveying, Glasgow Caledonian University, Glasgow, UK*
[2]*Department of Surveying, University of Salford, Salford, M5 4WT, UK*

This paper examines the relative performance of three different systems of forecasting movements in macro building prices. The three systems analysed are the Building Cost Information Service system, the Davis, Langdon & Everest system and Akintoye and Skitmore's reduced-form simultaneous equation. A battery of accuracy measures are used to compare the forecasts published by the Building Cost Information Service and David, Langdon & Everest systems and simulated out-sample forecasts made by the Akintoye and Skitmore system. The results indicate that, during the 3 year period commencing with the first quarter of 1988, the Akintoye and Skitmore system gives the most accurate forecasts

for a zero to three quarters forecast horizon and the Building Cost Information Service system gives the most accurate forecasts for a four to eight quarters forecast horizon.
Keywords: accuracy, econometrics, forecasting, tender price index.

1994, **12**(3), 271–278

Knowledge elicitation using protocol analysis in a workshop environment

Aouad, G F[1]; Ford, S R[1]; Kirkham, J A[1]; Brandon, P S[1]; Brown, F E[2]; Child, T[1]; Cooper, G S[1]; Oxman, R E[3] and Young, B A[4]
[1]*IT Institute and Department of Surveying, University of Salford, Salford, Manchester, M5 4WT, UK*
[2]*Department of Architecture, University of Manchester, Manchester, M13 9PL, UK*
[3]*Faculty of Architecture and Town Planning, Institute of Technology, Haifa 32000, Israel*
[4]*Bartlett School of Architecture, Building and Environment Studies, University College London, London, WC1H 0QB, UK*

This paper reports on an approach used by the ICON (Integration/Information for CONstruction) project in order to elicit knowledge and information from experts in the construction domain. The approach adopted is that of protocol analysis whereby the expert is encouraged to think aloud about a certain domain area or application. The ICON project aims at the development of a framework for an integrated database for the construction industry. Such a task requires a significant amount of information and knowledge from the various disciplines involved within a construction project. A workshop was organized for experts in the fields of architecture, quantity surveying, contracting, building and information technology in order to analyse the information required to design and build a particular building. The knowledge and information extracted from these experts were used to test and approve the information infrastructure of the ICON integrated models and identify where additional information was required.
Keywords: case study, knowledge elicitation, protocol analysis.

1994, **12**(4), 287–293

Is construction an industry? Notes towards a greater analytic emphasis on external linkages

Groák, S
Research and Development Group, Ove Arup Partnership, 13 Fitzroy St, London, W1P 6QB, UK

There has been a frequent misconception in analyses of construction sectors of the national economy: the tendency to describe these activities as ‘an industry’ or a small and stable set of ‘industries’. This has led to confusion. Construction was inappropriately assimilated to various forms of manufacturing industry. Characteristics of the construction process were treated as ‘problems’, to whose solution substantial energies were unnecessarily diverted. There has been muddle about the extent to which macro-level planning is appropriate, notably on R&D strategies and innovation for improved industrial efficiency. Construction projects increasingly use unfamiliar technological bases, comparable to ‘technology fusion’ in other sectors. A more fruitful emphasis may be to regard construction as organized as agglomerations of projects - rather than as a discrete industry or a fixed constellation of firms. The idea of the ‘demand chain’ is introduced. The paper concludes that a ‘technological paradigm’ should replace the ‘industry paradigm’ and that an enduring question remains to explore what is meant by construction ‘capacity’.
Keywords: demand chain, external linkages, project, technological paradigm, technology fusion.

1994, **12**(4), 295–306

Establishing construction economics as an academic discipline

Ofori, G
Construction Economics Research Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

Despite the importance of construction in national economies and in socio-economic development, construction economics, as a field of study, is still fledgling. Its foundations are weak and there is confusion about many of its concepts and terms. Worse, there are indications that unless a conscious effort is made to advance the field further, progress will be slow. This paper considers the present state of construction economics and its causes and effects. It considers whether construction economics is a distinct academic discipline. It is observed that construction economics lacks a conceptual structure, a key attribute of a discipline. Main areas where further study is required are highlighted. It is suggested that the development of construction economics should be managed if the field is to be advanced further.
Keywords: academic discipline, competence, conceptual structure, economic theory, education, research.

1994, **12**(4), 307–313

Lies and construction statistics

Cannon, J
Construction Forecasting & Research Ltd, Princes House, 39 Kingsway, London WC2B 6TP, UK

The aim of the paper is to raise the awareness of all those who use or have an interest in construction statistics of the need to ensure that available data correctly reflect their expectations and requirements. The paper is in four sections. It first examines the reasons for the recent rise in interest in construction statistics and the claim that industry's needs for them fail to be met by existing public and private data. It goes on to illustrate the links between providers of information, processors and users of data. The third section focuses on the quantitative and qualitative aspects of statistics. The final section explains the steps which are being taken to ensure better communications between government statisticians responsible for producing construction data and users. This endeavour should foster a better understanding of each other's requirements and, hence, a more satisfactory supply of data to all interested parties. The ultimate goal is a comprehensive body of statistics which can be readily adapted to reflect the development and changing circumstances of the construction industry.
Keywords: data, statistics.

1994, **12**(4), 315–321

How long should housing last? Some implications of the age and probable life of housing in England

Meikle, J L and Connaughton, J N
Davis Langdon Consultancy, Princes House, 39 Kingsway, London, WC2B 6TP, UK

The housing stock in England is ageing. Furthermore, the long-term trend in house building indicates that the existing stock of housing is not being replaced within its design life. New houses are required largely to satisfy new demand in the form of increasing household formation. A key conclusion is that existing - and new - houses will have to last for many hundreds of years. The ownership of housing in England has changed significantly in recent years. The responsibility for maintaining and replacing the housing stock is increasingly in the hands of individual owner-occupiers who have little incentive or opportunity to replace it. The paper discusses some of the implications of these trends for those who design and construct new housing and for public policy makers. The paper concludes that further research is needed to explore the implications for construction, in particular, of the need to maintain and build housing which must last far longer than is usually envisaged.
Keywords: building stock, condition, housing, maintenance, repair, replacement.

1994, **12**(4), 323–335

Employment maximization in construction in developing countries

Ganesan, S
Department of Architecture, University of Hong Kong, Knowles Building, Pokfulam, Hong Kong

This paper presents strategies to maximize construction sector employment in labour-surplus economies. These emerge as an integral part of any technology that seeks to maximize construction output at the same time. This technology is determined in a dynamic framework by the resources available, however, without ignoring the relevant political, social and economic circumstances and related constraints. It is found to be unique for a given situation. The case study of Sri Lanka, recognizing the above principles, establishes concrete policies necessary to eliminate supply and demand side constraints and for steady growth of construction output and employment, within the bounds of this appropriate technology.
Keywords: appropriate technology, developing country, employment, labour, Sri Lanka.

1994, **12**(4), 337–348

Analysing construction organizations

Lansley, P R
Department of Construction Management & Engineering, University of Reading, Whiteknights, PO Box 219, Reading RG6 2BU, UK

When applied to construction organizations the extensive literature on organization theory can be confusing and conflicting. This paper provides a path through some of those theories of organization which have been found of value in understanding how construction organizations function. It suggests that although they may take quite different perspectives and be based on quite different assumptions there exists valuable linkages between some of the most well-known theories and their associated models of organization.
Keywords: economic theory, leadership, organization theory, problem solving.

1994, **12**(4), 349–364

A theory of ownership types applied to the construction majors

Ive, G
Bartlett School of Graduate Studies, Philips House, University College London, Gower Street, London, WC1E 6BT, UK

Two sets of firms are identified from the UK of the 1980's, as the dominant types of 'construction majors': bisectoral conglomerates (BSCs) and diversified construction groups (DCGs). These types and the phenomena of industrial structure that they describe are contrasted with other forms of industrial ownership and corporate growth. The present importance of such firms is measured and described. DCGs are considered both as a structural phenomenon, rooted in particular economic structures, and as the result of a process of corporate growth and of certain strategic choices. To illuminate the structural and institutional determinants of this form, we compare its characteristics in Britain and in France. To attempt an explanation in terms of corporate strategy, we consider various hypotheses. Two hypotheses, which we term 'cash-flow balancing' and 'profit smoothing', are considered worthy of further investigation. Finally, we consider the future competitive advantage of firms with the DCG form and the impact of structural as well as conjunctural changes upon this form.
Keywords: industry structure, ownership form.

1994, **12**(4), 365–372

The professionals' view of the Health and Safety Commission's draft Construction (Design and Management) Regulations

Bishop, D
Chairman, Construction Industry Council's Health and Safety Task Force

This paper reports the situation in early 1993 at the end of the consultation period and before negotiations between the Construction Industry Council and the Health and Safety Executive commenced. These have led to the great majority of the Council's recommendations being accepted. In June 1992 the Council of the European Communities adopted the Directive 'The minimum safety and health requirements at temporary or mobile construction sites'. This is to be transposed into UK law by new Regulations made under the Health and Safety at Work etc. Act 1974. The Directive and the Regulations set out to improve coordination of health and safety matters throughout construction, from inception to completion and beyond. New duties will be imposed on clients, designers, on planning supervisors (in fact a coordinator) and on principal contractors. Whilst professionals support the Health and Safety Commission's aims, there is great concern about the practicality of the proposed arrangements and the liability they will create. This paper sets the scene, states the Health and Safety Commission's proposals and the Construction Industry Council's recommendations to make them more practical and cost-effective and indicates ways in which academics might tackle interesting and relevant issues including options for change.
Keywords: health and safety, operative, risk management.

1994, **12**(4), 373–375

A bulletin of statistics: some considerations

Sebestyén, G
Gelebrem 10, 3068 TK, Rotterdam, The Netherlands

Each year the United Nations publishes the Annual Bulletin of Housing and Building Statistics for Europe. This constitutes an important source for information and is widely used. The objective of this paper is to demonstrate what more could be done with the bulletin. The methods proposed are in no way sophisticated; quite the contrary, only the most rudimentary logic and elementary arithmetic will be employed, combined in certain cases with a measure of technical expertise and some familiarity with housing and building. Consequently, this paper will focus 'only' on how data should be collated and presented in order to make the tables of statistics less misleading, more user-friendly and - hopefully - more directly applicable.
Keywords: housing, statistics, United Nations.

1994, **12**(5), 379–392

Construction industry development: role of technology transfer

Ofori, G
Construction Economics Research Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

For several decades, transfer of technologies from industrialized countries has been viewed as a key to addressing the low level of technological development of developing countries. This paper considers technology transfer as a mechanism for improving construction industries in developing countries. It discusses the nature of technology and its development and the relevance of its transfer. It outlines differences between construction and other sectors and their implications for the development and transfer of construction technology. Results and problems of technology transfer are discussed and the experience of Singapore outlined. Possible action to improve upon the situation is suggested.
Keywords: development, industrialization, Singapore, technology transfer.

1994, **12**(5), 393–412

Developing a production management modelling approach for precast concrete building products

Dawood, N N
Division of Civil Engineering and Building, School of Science and Technology, University of Teesside, Middlesborough, TS1 3BA, UK

Production management in this research is concerned with three key decisions: demand forecast, production scheduling and stock forecast. These three decisions are very much interrelated and cannot be made in isolation. Previous studies of precast concrete industry activities concluded that production management is fragmented. For example, production planning is done in isolation from demand forecasting and from stock forecasting. This has contributed to poor production management performance in terms of resource utilization and over-stocking. This paper goes beyond traditional production management theories and practices and develops a model to integrate all aspects of production management. The main objective is to develop an integrated production management model for the make-to-stock sector of precast concrete building products, in order to help production managers make better planning decisions and explore alternative options. The model is a factory simulator which examines and evaluates the effect of several managerial strategies on production planning and stock forecasting before actual production commences. It uses different measures of performance which facilitate the choice of planning strategies under various demands and factory conditions.
Keywords: computing, pre-casting, production planning, scheduling, simulation, stock forecasting.

1994, **12**(5), 413–422

A perspective of material management practices in a fast developing economy: the case of Malaysia

Abdul-Rahman, H and Alidrisyi, M N
Department of Civil Engineering, University of Malaya, 59100 Kuala Lumpur, Malaysia

Many management-related problems exist amongst local contractors in developing countries. Problems vary in nature and intensity but are usually associated with inefficient management of construction resources including materials, labour, plant and sub-contractors. This paper deals with material management practices in the construction industry in Malaysia. A questionnaire survey and interviews were conducted with local practising public works contractors to examine the management of materials and to identify the nature of problems associated with material management. Problems identified included delay in the delivery of materials, the lack of use of advanced planning techniques, material variances and computers. There is a need for an improved material management approach by contractors in a developing country.
Keywords: contractordeveloping country, , Malaysia, material management.

1994, **12**(5), 423–431

Experiential learning in cost estimating

Lowe, D[1] and Skitmore, R M[2]
[1] *Department of the Built Environment, University of Central Lancashire, Preston PR1 2HE, UK*
[2] *Department of Surveying, University of Salford, Salford, M5 4WT, UK*

This paper investigates experiential learning theory and the current perception of experiential factors in the accuracy of pre-tender cost prediction. It compares the preferred learning styles of a sample of experienced pre-tender cost estimators with those of novice quantity surveyors and investigates how estimators have developed as a result of their experiences. Experiential factors, those which stimulate personal development in pre-tender estimators, are considered and a mechanism to improve the accuracy of pre-tender estimates is proposed linking experiential learning theory with the introduction of feedback and self-monitoring systems.
Keywords: estimating, experience, expertise, feedback, quantity surveying.

1994, **12**(5), 433–443

Attributes of UK construction clients influencing project consultants' performance

Kometa, S T; Olomolaiye, P O and Harris, F C
University of Wolverhampton, School of Construction, Engineering and Technology, Wulfruna Street, Wolverhampton, WV1 1SB, UK

Despite numerous efforts to understand construction clients and their priorities, evidence abounds to suggest that they are largely misunderstood and dissatisfied with the performance of their consultants and contractors. The perception of poor performance may not be attributed to the consultants alone. Perhaps the clients themselves do not possess the necessary attributes to secure a successful project performance. This paper describes a survey which sets out to establish the relative importance of the attributes of clients' organizations which may influence project consultants' performance using the 'relative index ranking technique'. Project consultants were surveyed using a structured questionnaire as the main research tool and this was augmented by interviews. The most important attributes are

financial stability of client (creditworthiness, current liabilities and current assets), feasibility of the project (project priorities, feasibility study and site conditions), past performance of client (cost overrun, quality achieved and time overrun), project characteristics (time for completion, type of project, cost of project and objectives/subobjectives) and client's duties (project definition/formulation, planning and design and project finance). More successful projects may result if clients cultivate some of the attributes identified in this study.

Keywords: client, consultant, professional, project performance, risk assessment,

1994, **12**(5), 445–455

Manipulating the flow of design information to improve the programming of building design

Austin, S; Baldwin, A N and Newton, A

Department of Civil Engineering, Loughborough University of Technology, Loughborough, Leicester, LE11 3TU, UK

The increasing complexity of modern buildings and the use of fast-track methods of procurement systems has meant the expeditious and successful completion of the design phase of a project has become ever more important. This paper describes a research methodology that can help plan the building design process. Design models, based on data flow diagrams, have been developed to map information flows during the design of a modern building. These models are analysed using Steward's design structure matrix, which allows ordering of the tasks to produce schedules or design plans based solely on information flowing between design tasks. Traditional ordering is based on experience but modern complex projects require a more rigorous approach. Design is an inherently iterative activity and design structure matrix analysis reveals how to order most efficiently interdependent tasks and use estimates of design information further to improve the scheduling of design tasks.

Keywords: design, design management, matrix analysis, modelling, planning.

1994, **12**(5), 457–465

A survey of data communications in the UK construction industry

O'Brien, M J and Al-Soufi, A

Department of Computer Science, University of Nottingham, Nottingham, NG7 2RD, UK

The UK construction industry has in general been slow to adopt information technology. The tactical use of this technology for personal productivity improvement has nevertheless become generally accepted. Communications technology has the capability to alter the industry fundamentally. This paper describes a postal survey carried out in early 1993 to ascertain the current position of this particular technology within the UK construction industry; the survey not only provides statistical data but also some evaluative measures on the problems encountered by construction professionals. The survey shows that the use of electronic mail and electronic data interchange is still highly restricted in the industry. More importantly these two technologies are being used primarily to support finance and accounting processes rather than mainstream construction processes.

Keywords: communication, EDI, email, industry, information technology.

1994, **12**(6), 473–484

Global strategies: a comparison between Japanese and American construction firms

Abdul-Aziz, A R

School of Housing Building and Planning, Universiti Sains Malaysia, Penang, West Malaysia

An in-depth study on 16 major overseas contractors and desk research on 100 others from various countries revealed that some have adopted global strategies during the turbulent 1980s. The world is perceived as a single operating platform. This implies that they harbour no inhibitions to serve anywhere. Their actions include utilizing specific countries as a springboard to enter other national markets as well as sources of landbound competitive advantages. These firms associate with all sorts of private and public bodies from around the world to expedite their advancement. Proper coordination and management is required so that their organizations behave as integrated groups. This paper centres on Japanese and American contractors to indicate the possibility of the former with their global appetite capturing a greater share of the world construction market at the expense of the latter.

Keywords: American contractor, global strategy, Japanese contractor.

1994, **12**(6), 485–499

Effective construction planning

Faniran, O O; Oluwoye, J O and Lenard, D

School of Building Studies, University of Technology Sydney, PO Box 123, Broadway, NSW 2007, Australia

This paper examines the relationships between construction planning efforts and construction planning effectiveness. The influence of the project's environment and organizational characteristics of construction firms on planning efforts and planning effectiveness is also investigated. A sample of 26 building projects was studied and the results were

analysed using simple correlations. Three factors were found to have a significant effect on improving construction planning effectiveness: increases in planning time prior to commencement of work on site, the extent to which emphasis is placed on the determination of construction methods during construction planning and the frequency of revision of construction plans after commencement of work on site. Significant relationships were also found between project environment variables and organizational characteristics of construction firms and planning efforts and planning effectiveness. Implications of the results are that construction planners should systematically evaluate alternative plans, sufficient time should be allowed for proper planning, thorough reviews are needed whilst work is in progress, the planning effort needs to be relevant to the environmental context of the project and the firm should be appropriately organized. Suggestions are given for future research studies.
Keywords: client , effectiveness, environment, organizational characteristics, planning.

1994, **12**(6), 501–510

Construction site safety in Hong Kong

Lingard, H and Rowlinson, S M
Department of Surveying, University of Hong Kong, Hong Kong

The structural characteristics of the Hong Kong construction industry, most notably its elaborate system of sub-contracting and the casual basis on which labour is employed, pose serious problems for safety managers. By international standards, Hong Kong's construction industry performs very badly in the area of safety. Recent work in the UK and Finland highlights the effectiveness of behavioural techniques to improve safety performance on construction sites. Work is currently under way to test these techniques in the Hong Kong construction setting. The structural properties of the Hong Kong construction industry have been taken into consideration and labour commitments to the group and to the organization have been identified for additional consideration in research. It is expected that these variables will intervene in the application of behaviourial techniques to determine their effectiveness. This paper investigates the theoretical background to commitment at the group and organizational level and presents a site-level research model which is illustrative of the possible effects that group and organization level commitment may be round to have on the use of behaviourial techniques.
Keywords: behaviour, group, organizational commitment, safety.

1994, **12**(6), 511–520

Problem behaviour

Loosemore, M
Centre for Research in the Built Environment, University of Glamorgan, Pontypridd, CF37 1DL, UK

Unexpected problems are inevitable on construction projects because predictive and preventive techniques can never be perfect. This makes it necessary to understand how construction project organizations react to unexpected problems. Problems are solved by people and this makes the study of human problem-solving behaviour particularly important. This paper describes a research project which is currently investigating reactive problem-solving processes in construction projects. It is doing so from the client's viewpoint. The conclusions presented are based upon a qualitative analysis of data collected by diaries, observation and semi-structured interviews. The research is in its early analytical stages and whilst the findings are based upon the study of a variety of projects they must currently be treated as tentative in nature. The purpose of the paper is to start to identify a range of expected problem-solving behaviours, the conditions that lead to them and their appropriateness.
Keywords: behaviour, conflict, control, problem solving, risk.

1994, **12**(6), 521–541

Innovative construction methods

Rosenfeld, Y
Faculty of Civil Engineering, National Building Research Institute, Technion, Haifa 32000, Israel

The construction industry is relatively slow in developing and adopting new technologies and usually prefers conservative, well-known practices over innovative construction methods. The paper discusses the logic and reasons behind this behaviour, while pointing to special circumstances in recent history when the balance between risk and benefits tilted towards the benefits, providing the opportunity for innovation to flourish. Such a situation occurred in Israel between 1990 and 1992, as a continuous stream of new immigrants was arriving in the country mainly from the former Soviet Union. The urgent need for mass housing, without creating the slums of the future, stimulated unique economic approaches of risk sharing in large-scale projects and gave rise to the implementation of dozens of innovative construction methods. Three of these unconventional methods are presented and analysed as representative of three larger categories: revival of methods that performed reasonably well in the past but have lapsed for mainly economic reasons, imported methods with favourable records from other countries and totally new methods with no past experience. The paper concludes with a cross-comparison of their advantages and limitations concerning various attributes and with some generalized lessons for selection criteria, which will be elaborated on in a forthcoming paper.
Keywords: building economics, innovation, production, site method, risk.

1994, **12**(6), 543–549

A prototype computer-based design management tool

Heath, T; Scott, D and Boyland, M
Faculty Built Environment and Engineering, Queensland University of Technology, Brisbane, QLD 4001, Australia

Opportunity costs and capital mobility combine to exercise great time pressure on the design phase of major building projects. However, this phase offers the greatest possibilities for influencing the total project cost and the greatest risk of error. Anything which can be done to shorten design time while maintaining or increasing reliability thus has the potential to produce large overall savings. A key factor is increasing the effectiveness of information management. Computers now offer the possibility of improving information management. However, it will be necessary to overcome the resistance of the design culture. This paper describes the prototype of a computer-based aid which supports information management and decision processes for building design and which takes account of the attitudes of design managers.

Keywords: computer-based mgmt., cost, design, information management, risk.

1994, **12**(6), 551–556

Re-engineering construction: a new management research agenda

Betts, M and Wood-Harper, T
Department of Surveying, University of Salford, Salford, M5 4WT, UK

Construction management as an academic discipline appears to be developing in an evolutionary way based on developments in practice which appear to be largely unaffected by mainstream management theories. There appears to be little two-way flow in construction management thought between theory and practice. There is an increasing range of customer-oriented theories emerging within the management discipline which is finding increasing acceptance and application within other management domains both from a theoretical and practical standpoint. Their application within construction appears to be delayed. This short note argues generally for a wider adoption of innovative, emerging management theories to construction. It specifically attempts to do this through an assessment and analysis of the implications of emerging principles of business process analysis based on information technology. Such an analysis results in an argument being made for the re-engineering of construction processes. Business process re-engineering has been portrayed as a revolutionary set of principles that can be used to achieve large-scale productivity and efficiency improvements. Analysing the place of some of its core principles within the way construction management research is evolving shows there to be many similarities. The contribution of the note is in the suggestion of a new research agenda for construction management and a clarification of the place and significance to construction processes caused by the way that information technology and construction management interact.

Keywords: business process change, research information.

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1995, **13**(1), 3–14

The organization of building projects: an Anglo/French comparison

Winch, G[1] and Campagnac, E[2]
[1]*Bartlett School of Graduate Studies, University College London, London, UK*
[2]*Latts-Certes, Ecole Nationale des Ponts et Chaussées, France*

The paper reports the results of a comparative research project on the organization of the production of social housing in Great Britain and France. Comparing two matched projects longitudinally using the methodology croisée, the analysis compares and contrasts the structure and process of the two projects. The British project is identified as being characterized by risk shedding, cost control and the externalization of variability, while the French one is characterized by risk sharing, cost reduction and the internalization of variability. Placing the case projects in the context of the contracting systems of the two countries, the three Cs of contracting systems are identified-conception, construction and control. In conclusion, it is argued that it is from the organization of contracting systems that competitive advantage in the emerging European construction industry will be derived.
Keywords: contract, housing, France, project organization, UK.

1995, **13**(1), 15–21

The validity of the triangular distribution assumption in Monte Carlo simulation of construction costs: empirical evidence from Hong Kong

Chau Kwong Wing
Department of Surveying, The University of Hong Kong, Pokfulam Road, Hong Kong, Hong Kong

This paper investigates the validity of the triangular distribution assumption which is commonly adopted in Monte Carlo simulations of construction costs. The study begins with an examination of the asymmetric nature of the distribution of construction costs and deduces theoretically that the triangular distribution assumption leads to an upward bias in the probability of exceeding the conventional single figure estimate for the subsystem variables and therefore the system variable. This assumption is also inconsistent with the estimators' subjective perception. An experiment has been performed to generate empirical data that test the above theoretical arguments and assesses the magnitude of the bias, if it indeed exists. Subjective estimates of the construction costs of the ten major subsystems of electrical systems contracts of government clinics in Hong Kong are examined. These estimates are extracted from seven experienced estimators. The results of the analysis of the data confirm that the underlying distribution of the subsystems costs is asymmetric with a long thin tail towards the right and that the triangular distribution assumption does in fact lead to bias in the subsystem input variables and therefore the simulated output system costs. An alternative modelling approach which can reduce the bias has also been outlined in this paper.
Keywords: Monte Carlo simulation, probability density function, risk analysis, subjective estimating, triangular distribution.

1995, **13**(1), 23–32

The cost of non-conformance during a highway project: a case study

Abdul-Rahman, H
Department of Civil Engineering, University of Malaya, Kuala Lumpur, Malaysia

Poor quality resulting from non-conformance during construction leads to extra cost and time to all members of the project team. The costs of rectifying non-conformance can be high and they can affect a firm's profit margin and it's competitiveness. Construction-related firms can identify non-conformance information by employing a quality cost matrix as illustrated in a case study as a basis for improvement. Findings indicate the applicability of the matrix, the usefulness of the information for quality improvement and the positive change in attitude of personnel involved in the case study. Areas and frequency of non-conformance and the viability and importance of preventive measures are also highlighted.
Keywords: quality cost, quality management.

1995, **13**(1), 33–42

Distributed lag relationships between UK construction orders and output

Akintoye, A and Sommerville, J
Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, UK

The volume of construction orders obtained by construction contractors determines the pace of total work done by contractors. In essence, new orders lead to construction output spread over a period of time. The operation of the construction industry shows that the construction order at time t would continue to filter into the output of the industry in the subsequent periods. This paper estimates and analyses the construction output-order relationships for both private and public sector construction works. There is a significant difference in the initial impact of new order on output in the private (19%) and public sectors (5%). The new order in the public sector takes a longer period (11quarters) to filter completely into the public sector construction output whereas it takes substantially less time to filter completely (eight quarters) in the private sector. The shapes of the distributed lags are quite different for each of the sectors and these are explained by the attitudes of construction contractors to each of the sectors and the peculiar nature of the sectors themselves.
Keywords: cash flow, new orders, construction output, distributed lags, government policy.

1995, **13**(1), 43–51

Innovation in the construction industry: the dominant role of the environment

Pries, F and Janszen, F
Rotterdam School of Management, Erasmus University, PO Box 1738, 3000 DR, Rotterdam, The Netherlands

In this research paper the innovative and strategic behaviours of the construction industry and the companies within the sector are analysed. In other sectors, but in particular for builders, a clear relationship with their environment is shown. When these external circumstances are positive the industry is apparently very capable of innovation. Recently we have noticed increasing environmental turbulence, which will have an enormous impact on management. Companies in the construction industry will have to compete in a more extrovert and market-driven way and they will have to reconsider their capabilities. Specialization and diversification on various subjects are probably the most important strategic process companies will increasingly have the character of what Chandler refers to as ‘modern industrial enterprises’.
Keywords: environment, innovation.

1995, **13**(1), 53–64

An integrated knowledge-based/simulation approach to production planning: an application to the pre-cast industry

Dawood, N N
School of Science and Technology, University of Teesside, Middlesborough, UK

Production planning, in general, is the allocation of resources to jobs in a manner that should satisfy the criteria of minimizing cost and satisfying customers. It is a complicated process and demands well-defined techniques, time and experience to achieve satisfactory results. An integrated knowledge-based/simulation approach to production planning is introduced and discussed in this paper as a possible alternative to traditional operational research methods. Based on this approach a computer-based simulation model is developed to model production facilities of a pre-casting factory and integrated with knowledge-based rules that mimic the decision-making process of a human planner. The knowledge rules which were developed by eliciting knowledge from a production manager and previously published literature are of three different types: product selection rules, plant selection rules and allocation rules. In order to verify and validate the model, a thorough industrial case study has been conducted through comparing the performance of the model to that of a human planner. From the results of the study it is concluded that the model is a valuable and considerable managerial tool for exploring and testing options open to production managers
Keywords: construction planning, knowledge rule, pre-casting, scheduling, simulation.

1995, **13**(1), 65–80

Reactive management: communication and behavioural issues in dealing with the occurrence of client risks

Loosemore, M
Centre for Research in the Built Environment, University of Glamorgan, Pontypridd, UK

This paper describes a research project which is investigating the process by which construction project organizations deal with unexpected problems. It is against this background of increasing uncertainty and complexity in the building production process that this research is taking place. The research strategy employs the technique of communications network analysis (CNA) as its main analytical tool to investigate the communication and behavioural issues associated

with this process. CNA is a technique which has been used widely in many fields such as anthropology, psychology, communications, social sciences, electronics, behavioural sciences and biology, but its potential in construction management research has yet to be explored. A case study is used to demonstrate the application of CNA to the investigation of problem-solving processes in construction projects. Some suggestions are made which could improve a project's ability to deal with unexpected problems.
Keywords: communication, network analysis, problem, reactivity risk.

1995, **13**(1), 81–89

Construction time-influencing factors: the contractor's perspective

Nkado, R N
Department of Building and Quantity Surveying, University of Witwatersrand, Johannesburg, South Africa

The result of a preliminary survey of factors affecting construction time is described. The objective of the survey which was conducted in the UK was to prioritize factors which are taken into consideration by accomplished contractors in planning the construction time of buildings. A significant degree of consistency in ranking 'time-influencing factors' was found. The most important factors are apparently those which can readily be identified or deduced from project information and whose impact on construction time can generally be assessed explicitly by mathematical and judgmental analyses.
Keywords: contractor, schedule, survey research, time.

1995, **13**(2), 95–103

A fuzzy expert system for contract decision making

Chau Kwong Wing and So, A T P
Department of Surveying, University of Hong Kong, Pokfulam Road Hong Kong
Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Hong Kong

A fuzzy reasoning model is constructed and its application to contract decision making in Hong Kong is illustrated. According to professional experience, six inputs are identified as essential factors determining contract choice. They are the scale of the project, the nature of the works to be carried out, the characteristics of the client, the time constraint, the source of materials for construction and the characteristics of the building design. These factors determine whether the contract to be chosen should be in the form of a simple quotation, a lump sum contract on drawings and specifications, a schedule of rates, a management contract, a lump sum contract in standard form without quantities or one with quantities. Ten decision rules are constructed based on expert opinions. Two practical cases are investigated and presented to illustrate how the method works.
Keywords: contract, decision rule base, expert system, fuzzy sets, Hong Kong.

1995, **13**(2), 105–113

Just-in-time application and implementation for building material management

Akintoye, A
Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 0BA UK

Materials constitute a huge proportion of the cost of construction. Materials are sometimes ordered weeks or even months ahead of requirement leading to uneconomical inventory on construction sites or contractors' warehouses. Building material inventory represents cost to procure, cost to store and insure, cost to guard against theft and cost incurred when inventory becomes obsolete. This paper presents an overview of the Just-in-Time (JIT) production system and discusses application and implementation issues for the control of material inventory in building construction. JIT ensures that suppliers deliver directly to the production floor to achieve either a reduction in inventory or zero inventory and consequently a reduction in production costs. Implementation of JIT building material management in construction has the potential to realize the same far reaching benefits experienced in manufacturing. Relevant factors to consider in JIT implementation for material inventory management in construction are implications for construction output and quantities, production planning, design planning, construction contractor and suppliers' relationships, material sourcing, and education and training.
Keywords: electronic data interchange, inventory, just-in-time, material management, purchasing, supplier.

1995, **13**(2), 115–125

An integrated bidding management expert system for the make-to-order precast industry

Dawood, N N
Division of Civil Engineering and Building, School of Science and Technology, The University of Teesside, Middlesborough, TS1 3BA UK

Bidding decisions, including the estimation of optimal mark-up on price, represent major decision problems for companies formulating a successful business strategy. The objective of this research was to develop an integrated bidding management expert system to assess the suitability of incoming enquiries for a particular company and suggest a 'bid/no bid' decision. If a decision to bid is taken then the expert system should provide advice on the optimal mark-up to maximize the chance of winning potential contracts. The system developed in this paper is composed of an information system that integrates design, estimation and production planning, and a knowledge base to provide abstracted information and advice to managers in charge of bidding. The information system analyses the records of previous contracts, and present managers with vital information that minimizes the risk of poor decisions associated with bidding. The knowledge base is composed of intelligent rules which were elicited from previous contract records and experienced managers in charge of bidding. They are designed to advise managers on two major issues: bid/no bid and estimation of optimal tender price. A number of factors that affect bidding strategies were identified by reviewing previous bidding methodologies and surveying eight major companies in the UK by means of semi-structured interviews.

Keywords: bidding: information system, expert system, pre-casting.

1995, **13**(2), 127–136

Checking the project plan

Scott, S
Department of Civil Engineering, University of Newcastle upon Tyne, Claremont Road, Newcastle upon Tyne, UK

Programmes are produced by contractors on major contracts to show how they foresee their projects progressing. These programmes will typically be checked by the supervising engineer, and it is the way in which this check is implemented that is under particular scrutiny. Programmes on two major projects were studied and a questionnaire survey then carried out, to find out how supervising engineers check these programmes in practice. Armed with this information, and an understanding of the literature on the subject, a recommended procedure for carrying out these checks is offered.

Keywords: construction planning , programme, schedule, supervisor .

1995, **13**(2), 137–147

Quantifying client-generated risk by project consultants

Kometa, S T; Olomolaiye, P O and Harris, F C
University of Wolverhampton, School of Construction, Engineering and Technology, Wulfruna Street, West Midlands, Wolverhampton, WV1 1SB, UK

An assessment procedure has been developed to evaluate the attributes of construction client organizations with respect to their effects on the performance of consulting firms. It consists of quantifying the degree to which each attribute affects the performance of consultants by processing numerical values through two successive levels. Level 1 consists of client attributes of major interest to consultants in the construction process. These are subdivided at level 2into groups of mutually related attributes (sub-attributes), each requiring simple judgements from consultants based on their experience with clients. Results from level 2 are processed through level 1 into a single non-dimensional value which represents the potential risk exposure of project consultants to their clients which affords the consultants an appreciation of the risk they face in accepting work from their clients and the opportunity to take corrective action. The most important client attributes used for measuring the risk exposure of consultants were found to be: project feasibility, client's duties, financial stability, past performance, project characteristics and organizational quality.

Keywords: client , consultant, risk assessment.

1995, **13**(2), 149–161

Planning future construction skill requirements: understanding labour resource issues

Agapiou, A; Price, A D F and McCaffer, R
Department of Building and Civil Engineering, Loughborough University of Technology, Loughborough, Leicestershire, LE11 3TU, UK

Construction is a labour-intensive industry, which places heavy reliance upon the skills of its workforce. These skills need updating continually as many of the trades involved in the industry become increasingly specialized. During the 1980s, there was a rapid rise in construction activity within the UK, followed by a sudden but short-lived boom accompanied by skill shortages. The construction industry is now experiencing a deeper and longer lasting recession than originally predicted, resulting in valuable employees in all sections of the industry being lost - a high proportion of

whom will not return to the construction industry. The construction industry is predicted to grow in the period after the recession by an average of 3% per annum until the year 2001. With this growth the industry is expected to experience considerable skill shortages in both traditional and new skill areas. Construction is in a period of rapid cultural change accompanied by the introduction of new technologies and new ways of organizing construction activities. Powerful national and multinational clients will continue to influence the choice of these technologies through their demands for faster construction times. The construction industry will continue to face increased competition in search of eligible recruits to train accordingly. Employment within the construction industry will continue to move away from large and medium sized firms to small firms and working proprietors. In the 1980s, self-employment and the use of specialist labour-only sub-contractors increased as training levels declined. This trend will hamper the industry's ability to train people for future skill needs. This paper aims to assist interested parties in the construction industry understand and realize the importance of labour resource issues and the need for long-term planning of labour resource requirements, so allowing them to train and retrain people to address the predicted skill shortages.

Keywords: labour, planning, resource, skill, training.

1995, **13**(2), 163–171

Information technology (IT) and integration in the construction industry

Ahmad, I U[1]; Russell, J S[2] and Abou-Zeid, A[3]

[1]*Department of Construction Management, Florida International University, Miami, FL 33199 USA.*

[2]*Department of Civil and Environmental Engineering, University of Wisconsin-Madison, Madison, WI 53706 USA.*

[3]*Department of Engineering Technology, Western Michigan University, Kalamazoo, MI 49008 USA*

The focus of this paper is on the integration of design and construction activities. We argue that information technology (IT) can effectively promote integration in the construction industry. Recent advances in the field of IT, the increasingly global nature of the construction market and a renewed demand for quality and productivity in construction are making the issue of integration more critical than ever. Design and construction organizations can achieve integration of various construction activities by redesigning many of their organizational functions and processes and IT can facilitate redesigning of these processes. The dynamic nature of construction processes, interdependence of various participating entities and the need for teamwork, flexibility and a high degree of co-ordination suggest that IT has great potential in the construction industry. The construction industry can make effective use of communication, data accessibility and common systems designed to process data, the three major categories of IT capabilities to achieve integration. We contend that appropriate IT investment and management's commitment and ability to provide leadership under the changed atmosphere are crucial for the successful implementation of IT in the construction industry. The impact of IT on the design and construction organizations must be managed with an understanding of external and internal factors that affect business organizations. It is essential that an appropriate environment that establishes suitable reward recognition procedures, encourages teamwork and creativity and stimulates decentralization of decision-making activities be created. Thus, IT implementation is not just a technical enhancement but a managerial decision that involves re-engineering of organizational functions and operations.

Keywords: information technology, integration, organization, re-engineering, shared data resource.

1995, **13**(2), 173–183

Equipment replacement and optimal size of a civil engineering fleet

Navon, R[1] and Maor, D[2]

[1]*Department of Civil Engineering and National Building Research Institute, Technion City, Haifa 32000, Israel.*

[2]*Military PO Box 03441, Israeli Defense Forces, Israel*

This paper analyses the optimal heavy civil engineering equipment fleet size. The study was initiated by a military unit, which has a fleet of a few hundred pieces of equipment. Prior to the study only operative considerations dictated fleet size and replacement policy. An economic analysis on the individual piece of equipment level is presented, as well as the collection of data for it. The main recommendations for the first year were to sell 33% of the existing fleet and buy new equipment at the rate of 10% of the existing fleet.

Keywords: civil engineering, economic life, equipment, replacement, retirement policy.

1995, **13**(3), 189–196

A methodology for predicting company failure in the construction industry

Abidali, A F[1] and Harris, F C[2]

[1]*Department of Civil Engineering, Loughborough University of Technology, Loughborough, UK*

[2]*School of Construction Engineering and Technology, University of Wolverhampton, Wolverhampton, WV11SB, UK*

This paper describes research directed towards the development of an operational system for identifying construction companies in danger of failure. The major component of the system combines financial ratio analysis and the statistical

technique known as multivariate discriminant analysis, to produce a predictive model made up of seven variables, measuring distinct aspects of company financial structure, all transformed into a single value called the Z score. Good distinction between the scores of solvent and failed companies was provided. This technique is widely employed in the commercial sector with much of the work concentrated on failed and healthy companies. A secondary method was developed to reinforce the financial approach, whereby managerial performance aspects are weighted, combined and a cut-off, known as the A score value, determined to separate the two groups. The concept behind the A score is based on the belief that if a company is in financial difficulty the reason generally relates to inadequate management ability and errors perpetrated earlier. The A score is designed to address this aspect of failure prediction. By operating these two principal methods in conjunction, it is possible to predict with confidence who could be next to fail.

Keywords: A score, company failure, multi-variate discriminant analysis, Z-score.

1995, **13**(3), 197–208

A regulation evaluation system: a decision support system for the Building Code of Australia

Williams, P

Commonwealth Scientific and Industrial Research Organization, Division of Building, Construction and Engineering, Sydney, Australia

Building regulations have historically been developed and drafted relying on groups of experts and their particular perceptions of what was an acceptable level of risk and what costs can be afforded by the community for improved health, safety or amenity. New technology, particularly in the areas of building design and material sciences, and the development of performance-based standards and codes are demanding major changes to the way in which regulations are developed and how they are assessed to ensure that any changes are in the community's interest. The regulation evaluation system described here provides a computer-based framework on which proposed changes to the Building Code of Australia (BCA) may be systematically assessed. The system requires any proposal to amend the BCA to be clearly identified together with all alternatives which achieve the desired objective. Direct costs and benefits are identified and quantified, making use of internal and external data. Where there is inefficient data, stochastic modelling is employed. The system not only aids decision makers by providing all available information, it also provides a transparency to the decision making and regulation development process.

Keywords: building regulation, cost-risk-benefit analysis, decision support, risk management.

1995, **13**(3), 209–217

Determinants of construction duration

Kumaraswamy, M M and Chan, D W M

Department of Civil and Structural Engineering, University of Hong Kong, Pokfulam Road, Hong Kong

This paper probes the range of factors affecting construction project duration through a literature review and a pilot survey in Hong Kong. Time-cost models previously proposed in Australia and the UK are compared with data obtained in Hong Kong and similarities are noted. The 111 responses to the detailed questionnaire issued in Hong Kong and the follow-up interviews also indicate other factors that may significantly affect project duration. Of these productivity is examined here, while other factors will be probed in the second phase of this investigation. Time-floor area relationships are also examined and found to be significant. Projects are classified as public or private sector housing and other buildings, roads and other civil engineering projects. Larger samples in each category of construction project will be targeted to test the validity of the models and their parameters in Hong Kong as derived from the pilot survey. It is noted that standardization in public housing projects (as in Hong Kong and Singapore) leads to more consistency in duration, providing useful reference points for such studies. International comparisons are intended to test the models, parameters and significant factors relating to the timeframe of construction projects.

Keywords: cost, Hong Kong, productivity, schedule, time.

1995, **13**(3), 219–234

Case explorations in construction conflict management

Gardiner, P D and Simmons, J E L

Departments of Business Organization and Mechanical and Chemical Engineering, Heriot-Watt University, Riccarton, Edinburgh, EH14 4AS, UK

Empirical data from recent studies on conflict in construction projects are presented and discussed. Views of conflict management, collected during interviews with a wide range of practitioners, serve to highlight the importance of conflict as a major component in project management strategy in the construction industry. The occurrence of conflict is shown to be a common and often poorly managed phenomenon in modern construction projects, despite real progress in the organization and administration of construction projects. The research demonstrates a need to re-evaluate construction management processes in order to shift the distribution of conflict occurrences from one that peaks during construction to one that peaks in the earlier formative stages of design when the output of conflict is more likely to be creative and complementary to the overall project aims.

Keywords: business process re-engineering, conflict, project management.

1995, **13**(3), 235–241

Total systems intervention: an integrated approach to time, cost and quality management

Rwelamila, P D and Hall, K A
Department of Construction Economics and Management, University of Cape Town, Private Bag, Rondebosch, 7700, South Africa

Historically there has been an attempt within the construction industry to manage projects by attempting to find the most efficient way of managing time and cost with little recognition of the importance of the aspect of quality. This paper proposes that traditional scientific methods have been utilized in order to determine the optimum method of managing time, cost and quality. These mechanistic models have promoted concepts that lack the aspects of viability and culture associated with the human dimension of the management function. This has resulted in a heuristic, trial-and-error approach to the management of projects and the suggestion, both directly and indirectly by participants to the construction industry, that the construction industry is characterized by the 'endemic crisis'. The paper concludes that the balance between these three factors in conjunction with a consideration of the social/behavioural aspects, and therefore the endorsement of a total time, quality, cost management system can be achieved via the utilization of an approach to 'problem-solving', namely, total systems intervention.
Keywords: culture, cost, intervention, quality, time.

1995, **13**(3), 243–252

Formwork design for high elevated slab construction

Shapira, A
National Building Research Institute, Technion City, Haifa 32000 Israel

Formwork commonly constitutes about 40-60% of the overall costs of constructing concrete elements. With high elevated concrete elements, the vertical shoring for the high soffits may raise the share of formwork cost even higher, making it imperative that the formwork design be more rigorously addressed. This paper presents a method for the design of high elevated slab formwork in which shoring towers are the central element. The method defines the primary stages of the design process, determines the detailed procedure within each stage, and identifies the basic data needed for exercising the design. The proposed method is aimed at producing design solutions that meet both quality and economy criteria. The paper also identifies open issues in formwork design and practice, and consequently suggests areas for further research.
Keywords: concrete , formwork, shoring .

1995, **13**(3), 253–262

An input-output analysis of the Italian construction sector, 1959-1988

Pietroforte, R[1] and Bon, R[2]
[1]*Department of Civil Engineering, Worcester Polytechnic Institute, Worcester, MA 01609-2280 USA.*
[2]*Department of Construction Management & Engineering, University of Reading, Whiteknights, Reading, RG6 6AW, UK*

This paper employs two sets of input-output tables to analyse the role of the Italian construction sector in the national economy. The paper focuses on changes in construction technology over a period of some 30 years. A set of seven-sector input-output tables is used to show the weakening of the construction sector's effect on the economy as a whole. This trend is probably caused by the transformation of the Italian economy as a whole rather than by a loss of efficiency of the construction sector. As expected, the achieved maturity of the Italian economy is accompanied by the growing importance of maintenance and repair construction (M&R) because of the ageing building infrastructure. Another set of 23-sector input-output tables is used to analyse the input and output profiles of the construction industry, by selecting key supplying industries. Significant differences are reported in the technology of the sector with a shift toward services and away from manufacturing inputs. Finally, the main findings and directions for future research are summarized.
Keywords: backward and forward linkage, construction technology, input-output analysis.

1995, **13**(3), 263–274

An investigation into construction time performance

Walker, D H T
Department of Building and Construction Economics, Royal Melbourne Institute of Technology, 124 La Trobe Street, GPO Box 2476V, Melbourne, Victoria 3001, Australia

A systematic method for measuring construction time performance has been developed. This enables comparisons between individual project performances and best practice worldwide. Four factors affect construction time performance: construction management effectiveness, the sophistication of the client and the client's representative in terms of creating and maintaining positive project team relationships with the construction management and design team, design team effectiveness in communicating with construction management and client's representative teams, and a small number of factors describing project scope and complexity. This research has indicated that construction management team performance plays a pivotal role in determining construction time performance. It also reveals an important relationship between sound client's representative management effectiveness and good construction time

performance. Detailed findings provide useful performance indicators that may be used to assist in defining benchmark measures necessary to assess a project's performance relative to a representative population.
Keywords: benchmarking, productivity, team management, time.

1995, **13**(4), 279–289

Developing an effective approach to the procurement and management of small building works within large client organizations

Griffith, A[1] and Headley, J D[2]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Kowloon, Hong Kong.*
[2]*Weatherall, Green & Smith, International Property Consultants, Edinburgh, UK*

This paper results from a major research project supported by governmental and industry based funding sources. The research project focused on the suitability, efficiency and effectiveness of procurement, organization and management of small works. Thirty major client organizations, drawn from both the public and private sectors, contributed information to the research project. The research data gathered from client organizations was supplemented with information provided by 50 contracting companies and consulting practices. Findings indicate that efficient and effective approaches to small works procurement and management focus on clearly understanding the core business of the organization, the total small works workload, and the requirements of the individual small works themselves. From this paper client organizations should become more aware of the problematic nature of small works and of the possibilities for their more effective procurement and management in the future.
Keywords: procurement, small works.

1995, **13**(4), 291–298

Evaluation of multi-family housing systems in Poland

Kaplinski, O and Thiel, T
Poznan University of Technology, Division of Construction Engineering and Management, 60-965 Poznan, Poland

On the basis of selected statistical data, the authors briefly discuss the housing construction situation in Poland, focusing on two periods - that preceding the transition to a market economy (up to the end of 1988) and the period 1989-1994). Comparative analysis of selected systems of multi-family housing, based on specific criteria, has been presented. The analysis comprises systems which have been used for many years and continue to be used. The entropy method, one of the multi-criteria optimization methods, has been used in the analysis.
Keywords: building system, housing, multi-criteria method, Poland.

1995, **13**(4), 299–306

Serious occupational accidents in the construction industry

Salminen, S
Finnish Institute of Occupational Health, Department of Occupational Safety, Laajaniityntie 1, FIN-01620 Vantaa, Finland

The aim of this study is to examine three hypotheses based on the review of literature concerning occupational accidents in the construction industry. The data concern 102 victims of 99 serious occupational accidents. Of these 102 victims, 35 worked in the construction industry. The first hypothesis assuming the higher risk-taking tendency among victims of construction accidents than among victims from other industries was not confirmed, because the construction victims took significantly less risk at the moment of accident than the other victims. The main contractors' victims had significantly higher values on the risk-taking scale than the sub-contractors' victims. There were more falls among construction accidents than among accidents in the other industries, which confirmed the second hypothesis. In line with the third hypothesis, an increased accident risk was shown among sub-contractors' workers.
Keywords: accident , risk, sub-contracting.

1995, **13**(4), 307–318

How many jobs does construction expenditure generate?

Ball, M and Wood, A
School of Land Management and Urban Policy, South Bank University, Wandsworth Road, London SW8 2JZ, UK

Extra public expenditure on construction is a frequently cited policy to alleviate demand deficient unemployment; yet the actual number of jobs created is uncertain. This paper surveys the job creation effect for the UK. It surveys previous estimates, then a construction employment model is estimated. The results do not conform to theoretical predictions, implying only a weak link between quarterly increases in total construction output and construction employment, and no significant relationship between housebuilding and employment. It is suggested that these results arise from poor quality data, especially the estimates of changes in the number of self-employed workers. As an alternative, construction industry rules-of-thumb are used to derive more plausible employment effects. Employment

estimates are also provided for sub-sectors of the industry. To improve on these calculations we conclude that there is a need for either more accurate construction data or, failing that, periodic site-survey based estimates of construction production functions.

Keywords: cost, employment, public expenditure.

1995, **13**(4), 319–333

A study of the factors affecting construction durations in Hong Kong

Chan, D W M and Kumaraswamy, M M

Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong

This is the second phase of an investigation into the significant factors influencing construction duration of projects in Hong Kong. The results of the first phase led to the conclusion that larger samples were justified to investigate further the discerned relationships. Expanded samples were obtained in this second phase by adding some reported data from Hong Kong projects to the original surveyed sample. The second phase of this study also further investigates the relationships between different project characteristic variables such as the construction duration, construction cost, total gross floor area and the number of storeys in the case of buildings. Moreover, a case study on plant utilization level and site labour productivity was carried out on a building site to explore the 'micro-factors' that affect construction durations. The findings are of importance to all construction industry participants as the derived models help to estimate the construction duration of a project on the basis of significant macro project parameters. Additionally, the results of the case study indicate the contribution of significantly variable site productivity levels to overall construction duration and suggest an agenda for future investigations. A third phase of this study is planned incorporating more detailed data collection and analysis of significant factors, as well as international comparisons where possible.

Keywords: case study, Hong Kong, productivity, schedule, time.

1995, **13**(4), 335–352

Computer aided construction delay analysis and claims preparation

Alkass, S[1]; Mazerolle, M[2]; Tribaldos, E[1] and Harris, F C[3]

[1]*Centre for Building Studies, Concordia University, 1455 de Maisonneauve W., Montreal, H3G 1M8, Canada.*

[2]*Transportation Planning Engineer, CANAC International Inc., 1100 University, Montreal, H3B 3W7, Canada.*

[3]*School of Construction, Engineering and Technology, University of Wolverhampton, UK*

Delays are the most common and costly problem encountered on construction projects. Analysing construction delays has become an integral part of the project's construction life. To prepare for litigation, schedule documentation proving responsibility must be prepared. With present methods of tracking projects, the preparation of such schedules can be time consuming and costly. The analysis itself is usually complex and can be aided by a computerized approach. This paper describes the introduction of a computer system for delays claim analysis called computerized delay claims analysis (CDCA). The system utilizes the isolated delay type (IDT) technique. Part of this system can use existing software such as project management, cost control, database management and spreadsheets. In addition to these, an expert system tailored to the specific expertise of construction claims has been used to facilitate the decision making process. CDCA is tested against a real case study of a building project to demonstrate its effectiveness in determining the responsibility of contracting parties with respect to the project's delays. The system is expected to assist in improving the process of delays analysis, thus reducing the cost of claims preparation.

Keywords: claim, construction planning, delay, expert system, project control.

1995, **13**(4), 353–364

Forecasting the supply of construction skills in the UK

Agapiou, A; Price, A D F and McCaffer, R

Department of Civil and Building Engineering, Loughborough University of Technology, Loughborough, Leicestershire, LE11 3TU, UK

An aggregate supply model is presented for craft trainee entrants to the UK construction sector using annual data for the period 1976-1990. The theoretical framework used to formulate the equation was based on the human capital approach to analysing labour supply, as applied to new entrants to the engineering sector. In particular, the paper tests the hypothesis that the proportion of school-leavers choosing to train as construction operatives depends on the real craft wage and the long-term prospects of the construction industry. Co-integration was used to produce a long-run relationship between intakes, real wages, output and other variables. The supply equation was then reduced to a more parsimonious representation. The final restricted form of the model was tested against various diagnostic statistical criteria. The real craft wage and output were found to be the main factors determining the choice between training as a construction craft operative and any other job. In addition, demographic trends and socioenvironmental factors such as the image of the industry were found to have a strong effect on the supply of new entrants.

Keywords: forecasting, modelling, skill.

1995, **13**(5), 369–383

Monte Carlo simulation of construction costs using subjective data

Chau Kwong Wing
Department of Surveying, The University of Hong Kong, Pokfulam Road, Hong Kong, Hong Kong

This paper critically examines the problems arising from the assumptions of independence and triangular distribution in the risk analysis of construction costs. These two assumptions have been widely adopted by researchers and practitioners alike. However, they lead to bias in the analysis. With the aid of a spreadsheet and a risk analysis add-on program, the nature of the resulting bias can be illustrated using both empirical and simulated data. Various possible solutions which seek to reduce the bias are explored. Their practicality under real life constraints is examined. A tentative practical solution is proposed and evaluated against the existing approach. The method and logic of the solution are also discussed. The approach is applied to two sets of data to illustrate its use and to test the reasonableness of the approach.
Keywords: cost, Monte Carlo simulation, probabilistic estimating.

1995, **13**(5), 385–392

Risk analysis in construction: a paradigm shift from a hard to soft approach

Mak, S W
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

Risk analysis in construction is becoming more popular as competition, project size and complexity increase. Traditional risk analysis relies on rules of thumb. While this approach can work, it is neither robust nor reliable. The development of information technology has made the use of probabilistic estimating and simulation a practicable alternative. These techniques are, however, precise but not necessarily accurate as simplification and many assumptions are used. Further information technology development in expert systems and the paradigm shift in systems engineering from a hard to soft approach has promoted an alternative approach to risk analysis utilizing the theory of fuzzy sets which translates linguistic expressions (such as highly likely) into numerical membership functions. This paper introduces risk analysis in construction against characteristics of the industry. It is argued that normative theories in probability are not as applicable in the construction industry as first perceived. The concept of fuzzy sets is described and the difference of approach in modelling risk between probabilistic and fuzzy methods will be presented. Initial empirical study reveals the applicability of fuzzy sets theory in risk analysis. This is important in that a model of risk analysis can be developed requiring the user to express risk attitude linguistically. Moreover, the results are also in linguistic terms and can, therefore, be understood and interpreted correctly by the user.
Keywords: information technology, expert system, fuzzy sets, probability, risk.

1995, **13**(5), 393–400

An economic view of project coordination

O'Brien, W J; Fischer, M A and Jucker, J V
Department of Civil Engineering, Stanford University, Stanford, USA. Department of Industrial Engineering and Engineering Management, Stanford University, Stanford, USA

We introduce current thinking from the field of co-ordination economics and apply it to the co-ordination needs of construction firms working on a project. A view of construction from an economic lens provides a different view of construction from that normally taken by practitioners and researchers. Combined with cost time capacity models of construction firms, we are able to offer a new paradigm for co-ordination policy in construction. This new paradigm provides an economic basis for the development and adoption of information technology by construction firms.
Keywords: co-ordination, cost, information technology, systems analysis.

1995, **13**(5), 401–409

Data, knowledge and experience in multi-user information systems

Oxman, R E
Faculty of Architecture and Town Planning, Technion, Israel Institute of Technology, Haifa, Israel

The paper presents a classification of multi-user information systems based upon levels in which information is shared in team collaboration. In this classification are presented through a review of current approaches to information sharing. Work on the ICON system is discussed as an on-going research and development project which implements data sharing in an integrated information system. Advances in computer-supported collaborative information environments through AI methods are presented and reviewed as possibilities for the future development of knowledge sharing and experience sharing in information systems. Case-based reasoning, a subfield in AI emphasizing experiential knowledge, is introduced as a promising approach to computer-supported collaboration in information systems based on experience sharing. A research project in this field is presented as a case study.
Keywords: artificial intelligence, case-based reasoning, information system.

1995, **13**(5), 411–416

KBS-CLASS: a neural network tool for automatic content recognition of building texts

Modin, J
KBS-Media Lab, Department of Structural Engineering, Lund University, Lund, Sweden

KBS-CLASS is a tool for automatic content recognition of building texts. It may be used for finding information in large or unstructured databases, for filtering news streams and as an aid for the classification of in-house-produced texts. There is likely to be a growing need for such tools as access to building knowledge in an electronic form becomes the key to an organization's success. The KBS-CLASS tool is based on neural network technology. It is trained with texts which have been indexed according to a classification system. The tool is then able to give a contents' description of texts it has not yet seen, with tears adopted from the classification system. The tool should be able to sue any classification system, such as SfB, R-UDC, BSAB or the new ISO system under Byggtjänst (the Swedish Building Centre) using the BSAB system. A case study is presented to show how the tool may be used in a future work situation. The tool's performance is discussed. Finally, future directions for further development of the tool and similar tools are suggested.
Keywords: information retrieval, information, neural network.

1995, **13**(5), 417–426

An integrated construction planning system using object-oriented product and process modelling

Yamazaki, Y
Intelligent Engineering Systems Department, Technology Division, Shimizu Corporation, Tokyo, Japan

An interactive planning system approach poses challenges to the efficient integration of the design and construction planning process. Current research is focused on organizational knowledge processing in building design and construction, such as the representation of object-oriented planning models and constraint management incorporating design, engineering and construction planning through several planning stages. Since building construction involves cooperation among designers, engineers and project managers, comprehensive organizational planning and management tools are relevant. The integrated construction planning system (ICPS) aims to cover a wide range of knowledge processing based on formalization and representation of building and construction systems. To realize the integrated construction planning system, appropriate modelling techniques need to be introduced. This paper presents the result of research on several issues such as formalization and representation of interactive design and construction planning processes, methods for incorporating project information, knowledge and constraints and the concept of applying an object-oriented paradigm to interactive building and construction system planning. A prototype system is also presented which integrates building space planning, building system planning, construction system planning, construction activity planning and construction site layout planning.
Keywords: building system, knowledge processing, modelling, object-orientation.

1995, **13**(5), 427–434

Modelling of on-site work cells for the simulation of automated and semi-automated construction

Ibañez-Guzmán, J
Ecole Supérieure Atlantique d'Ingénieurs en Génie Electrique, Gavy Oceanis, Saint Nazaire, France

A software-based approach for the design, modelling and simulation of automated and semi-automated construction is described. Through the use of currently available software, it is possible to attain the project definition phase for new robotic devices without the need for fabricating prototypes. The use of two different models for the simulation of on-site work cells is proposed. The first looks into the physical operations of new construction robots. The second examines the influence that the automation of the target operations in the construction process could have. The paper includes a description of the logical process and sample software tools plus applications that can be used towards the development of a computer-aided design construction automation environment. Emphasis is put on the use of kinematic and discrete-event simulation techniques. A comparison of this approach with full prototyping undertaken by certain large contractors is presented.
Keywords: automation, design, robotics, simulation.

1995, **13**(5), 435–439

In search of excellence in learning: the strategic value of computer-assisted learning (CAL)

Sloan, B
Department of Building and Surveying, Napier University, Edinburgh, UK

Computer-assisted learning (CAL) was heralded in the 1970s and 1980s as the mechanism whereby educational institutions could cope cost-effectively with large numbers of students. Accordingly, many institutions brought

computing into the curriculum and taught computing for its own sake. Since those early days, academic departments have shifted their emphasis away from the acquisition of computing skills to using computers as a means of demonstration and using specific e departments within educational establishments to adopt CAL as part of their learning strategy. The paper discusses the importance of starting with the pedagogy, rather than the solution (CAL) and by so doing a correctly targeted strategy should be developed. Within the learning environment CAL should be thought of as a strategic resource which can be used to offer students a learning experience matched to their preferred learning style and which enables them to capitalize on their strengths, while minimizing the impact of their weaknesses or which assists them in developing beyond their weaknesses. The paper discusses preferred learning styles and shows that CAL is only one of a range of solutions which may be arrived at and which all have a place within the learning strategy.
Keywords: computer-aided learning, education.

1995, **13**(6), 445–455

The business environment of the construction industry in Nigeria

Aniekwu, A N
Department of Civil Engineering, University of Benin, Benin City, Nigeria

The business environment of any industry consists of systems and structures, which determine the atmosphere under which all the business of that industry is transacted. They affect directly or indirectly all practitioners of that industry, without their being able to influence it. In a scientific investigation into the problems of the construction industry in Nigeria, out of the 47 variables identified that can adversely affect the construction industry, 37 variables were classified under the environment of the construction industry. Of the 18 variables considered to constitute the most serious problems, which occur all the time, 17 variables were related to the business environment of the construction industry. The research findings are reviewed with respect to the business environment in Nigeria.
Keywords: business environment, Nigeria.

1995, **13**(6), 457–465

A model for assessing the effectiveness of public housing in Sana'a (Republic of Yemen)

Mustapha, F; Al-Abed, A and Wild, S
Department of Civil Engineering and Building, University of Glamorgan, Pontypridd, UK

A model is proposed for measuring the effectiveness of certain public housing schemes in Yemen. The suggested model assumes the measurement of housing effectiveness both subjectively, in terms of occupant satisfaction with the housing environment; and objectively, in terms of the adequacy of level of the dwelling and its environment. It is hoped that such a model will help in testing different types of public housing provisions in Sana'a, the capital of Yemen, and assist in identifying the most effective and useful type. This paper introduces the model and its development process and the outcome of its testing programme will be reported later. It is important to note that the research model has been developed to fit the conditions of Sana'a/Yemen only and its application in a different set of conditions would need further alteration and adjustment.
Keywords: Sana'a, satisfaction, housing , Yemen.

1995, **13**(6), 467–473

A comparison of strategies for reducing variations

Chan, A P C and Yeong, C M
School of Building and Planning, University of South Australia, Adelaide, Australia

Most building contracts make provisions of the contract administrator to issue orders for variations from the original design. Often, these changes involve additional cost and disruption to work already under way, leading to cost and time overruns. Thus, reducing variations is one of the prerequisites of keeping the cost within budget and completing the project on time. The main objective of this paper is to investigate methods of reducing variations. A series of structured interviews were carried out with the practitioners in the construction industry to identify the prevailing strategies of variation reduction. The identified strategies then formed the basis of a questionnaire which was sent randomly to 100 construction firms in Australia and Malaysia, respectively. The respondents were asked to rank the relative usefulness of the identified strategies for variation reduction. Thirty-two sets of questionnaires from Australia and 33 sets from Malaysia were returned, respectively, which represented an overall response rate of more than 32%. Concordance analysis was used to provide some evidence of any abnormal data source. When applied to the study data, a significant amount agreement was found on the ranking strategies for the reduction of variations amongst the respondents in each country. Respondents from both countries considered clear and thorough brief as the most useful strategy for reducing variations and avoiding the use of nominated sub-contractors as the least effective measure. However, when the rankings of the two countries were compared using the Spearman correlation coefficient, it was found that there was significant disagreement between the two sets of ranking. The significant difference might be attributable to the difference between the countries in terms of culture, politics, regulations, economic conditions and construction practice. These differences could also be reflected in their attitude towards contract claims.
Keywords: claim, concordance analysis, survey research, variations.

1995, **13**(6), 475–484

Intervention analysis and overseas trade in UK construction-related materials and components

Worrall, H[1]; Norman, G[1] and Flanagan, R[2]
[1]*Department of Economics, University of Edinburgh, Edinburgh, UK.*
[2]*Department of Construction Management & Engineering, University of Reading, Reading, RG6 6AW UK*

The UK trade deficit in construction-related materials and components increased significantly over the period 19821989 but fell during 19891992. This paper examines the extent to which the apparent reversal in the trend is associated with changes in the level of UK economic activity. Intervention analysis is used to examine the relationship between both construction output and GDP and (i) the trade deficit and (ii) imports in the construction material and components industries. The results suggest that the recent improvement in the trade balance in these industries is likely to be a consequence of the recession in the UK economy rather than any fundamental change in international competitiveness.
Keywords: intervention analysis, material, overseas trade.

1995, **13**(6), 485–491

A price-rationalized approach to item separation in the measurement of concrete work

Edwards, P J[1] and Edwards, M[2]
[1]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, Melbourne, Australia.*
[2]*Department of Mathematics, Monash University, Melbourne, Australia*

A price-rationalized approach, based on the tendency of contractors to make tender pricing errors, is used to explore the validity of the present rules relating to the measurement of separate items of concrete work for bills of quantities in Australia. The research findings suggest that simplified measurement of concrete work, by item aggregation, can be justified on unit price grounds.
Keywords: bills of quantity, estimating, pricing, quantity surveying, standard method of measurement .

1995, **13**(6), 493–500

The accuracy and optimal linear correction of UK construction tender price index forecasts

Fitzgerald, E and Akintoye, A
Department of Building and Surveying, Glasgow Caledonian University, Glasgow, UK

This paper uses a number of quantitative methods to assess the accuracy of the UK construction tender price index forecast (TPI) produced by experts for the Building Cost Information Service (BCIS) from 1980 to 1992. The text of comparative predictive accuracy shows that the BCIS forecast is less accurate than forecasts based upon a simple (naive) model which is widely regarded as the benchmark of satisfactory predictive performance. The study shows that the BCIS forecast contains systematic error which can be reduced with the use of optimal linear correction. The paper, apart from assessing the forecasting error of construction price movement, is normative in nature, producing aids for assessing forecast accuracy of the construction industry time series data.
Keywords: accuracy, forecasting, optimal linear correction, price, tender price index.

1995, **13**(6), 501–510

Resource-based model for automatic cash-flow forecasting

Navon, R
Faculty of Civil Engineering, National Building Research Institute, Technion City, Haifa, Israel

The paper discusses different approaches to, and models for, project level cash-flow forecasting. The importance of cash-flow management, both at the project and at the company level is also discussed. The paper presents a resource-based computerized cash-flow forecasting model. The main issue addressed by that model is the solution of the compatibility problem caused by the different data structures of the cost and the schedule items. The cost items are normally specified in terms of the project's physical elements (e.g. slab, beam, column, etc.), while the schedule is expressed in terms of activities (e.g. formwork erection, rebar erection, rebar placement, concrete pouring, etc.). The proposition is the automatic integration of the bill of quantities, the estimate and the schedule databases, using a non-project-specific database, which is a dynamic component of the model. The integration algorithms are presented. Additional issues addressed by the model are time lag and billing period adjustments, material supply policies, anticipated real number of working days per month, sub-contractors' payments, overhead expenses and income flow forecasting.
Keywords: cash flow, forecasting, resource-based cash-flow.

Construction Management and Economics

1995, **13**(6), 511–523

The culture of the industry and the culture of research

Seymour, D E and Rooke, J

School of Civil Engineering, University of Birmingham, Edgbaston, UK

Culture is increasingly cited as being in need of change if the UK construction industry is to improve its efficiency and productivity. The paper argues that the concept of culture is amenable to radically different treatments and that the research community must recognize the consequences of this choice if it is to make a useful contribution to bringing about the desired change. The dominant research paradigm in construction management is examined and compared to an alternative approach. The consequences attendant upon the choice between these two are explored with reference to four phenomena: a study of quality in the construction industry, Japanese innovation in management, Deming's concept of total quality management and the situation of the site engineer. It is concluded that the dominant rationalist paradigm tacitly endorses existing attitudes and that if researchers are to have a role in changing the culture of the industry, then the culture of research must change also.

Keywords: culture, methodology, quality, research paradigm.

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1996, **14**(1), 3–12

Periods and demand for private sector housing refurbishment

Aikivuori, A
Technical Research Centre of Finland, Building Technology, PO Box 18021, FIN-90571, Oulu, Finland

Durability failures are primary reasons for the decisions to carry out refurbishment projects. The refurbishment project is seen as a commodity that can be obtained from the market at a certain price and accordingly the reasons for the decision to initiate a refurbishment project are seen as a basis of the demand. The phenomena causing refurbishment are classified into five categories as follows: failure in the building due to deterioration; change in use; optimization of economic factors; subjective features of the decision maker; and change of circumstances. The significance of each category as a primary source of demand for refurbishment projects is quantified by the use of empirical data. In the empirical findings, only 17% of the refurbishment was initiated primarily on the grounds of deterioration. Obsolescence was found to be an overwhelmingly more important basis for refurbishment than deterioration. The pleasure seeking aspirations of the decision maker are an especially important source of the demand for refurbishment projects. According to the empirical findings, obsolescence-based refurbishment clearly occurs earlier (on average after 20.6 years of use) than deterioration-based refurbishment (which occurs on average after 28.7 years of use).
Keywords: durability, performance, refurbishment, service life, user requirements.

1996, **14**(1), 13–24

Productivity improvement in the Indonesian construction industry

Arditi, D and Mochtar, K
Department of Civil Engineering, Illinois Institute of Technology, Chicago, USA

A sectoral analysis of the construction industry in Indonesia indicates that it has grown considerably in recent years. Efforts are under way to adapt to this new situation, including exploring ways to increase productivity. A survey of top contractors indicates that certain functions including procurement practices, cost control, scheduling and management integration need much improvement. A survey of top design professionals indicates that they are concerned about design practices, computer utilization in planning and scheduling activities, and goal setting techniques. There seem to be conflicting opinions regarding the construction management project delivery system. Both contractors and design professionals are willing to cooperate in any productivity enhancement programme but neither are willing to fund such activities.
Keywords: Indonesia, productivity, sectoral analysis.

1996, **14**(1), 25–34

Residential construction demand forecasting using economic indicators: a comparative study of artificial neural networks and multiple regression

Goh Bee Hua
School of Building and Estate Management, National University of Singapore, Singapore

In recent years, demand for residential construction has been growing rapidly in Singapore. This paper proposes the use of economic indicators to predict demand for residential construction in Singapore. At the same time, two forecasting techniques are applied, namely, Artificial Neural Networks (ANN) and Multiple Regression (MR), the former being a state-of-the-art technique while the latter a conventional one. A comparative study is carried out to determine whether the use of economic indicators with the application of the ANN technique can produce better predictions than with the MR method. A total of 12 economic indicators are identified as significantly related to demand for residential construction. Quarterly data from these 12 indicators are used to develop the ANN model. In order to assess the forecasting performance of this state-of-the-art technique, the same set of data is used to develop a conventional MR model. A comparison is made between the two models, in terms of their forecasting accuracy, by using a relative measure known as the Mean Absolute Percentage Error (MAPE). The forecasting error of the ANN model is found to be about one fifth of that derived from the MR model. The low MAPE values (less than 10%) obtained for both models also indicate that economic indicators may be used as reliable inputs for the modelling of residential construction demand in Singapore.
Keywords: demand, economic indicator, forecasting, multiple regression, neural network.

1996, **14**(1), 35–44

Towards more flexible and accurate cash-flow forecasting

Kaka, A P
School of Architecture and Building Engineering, Liverpool University, PO Box 147, Liverpool, L69 3B, UK

Previous research has demonstrated significant variation in actual cash-flow profiles. However, the results from traditional cash-flow forecasting models do not exhibit these variations. This suggests that further variables are needed to enhance to flexibility of the cash-flow profiles produced. This paper presents a model designed to use more than fifty variables to calculate the cash-flow of individual contracts. In addition, some of the risk associated with construction contracting was incorporated into the cash-flow mechanism. This has been achieved by introducing stochastic simulation and extra variables that contribute towards that risk. The testing of the model demonstrated that by merging further variables, the flexibility and reliability of cash-flow forecasting are enhanced. The tests also demonstrated that contractors' cash-flow is highly sensitive to risk (variations, cost variances, duration overrun and under-measurement), which further justifies the methodology adopted.
Keywords: cash flow, financial planning, risk, S-curve, strategy, tendering.

1996, **14**(1), 45–54

Technology transfer on joint venture projects in developing countries

Carrillo, P M
Loughborough University of Technology, Loughborough, Leicestershire, LE11 3TU, UK

International joint ventures between contractors in developed and developing countries are recognized as a potential means of enhancing the construction expertise of nationals of developing countries, and offer many advantages and disadvantages to its partners. This paper reports on the technology transfer experiences of eight top UK contractors in joint ventures with contractors from developing countries. Twelve joint ventures, categorized into geographical regions, are used as case studies. The rationale for regional and inter-regional variations are analysed and discussed. The issues addressed are the need for technology transfer and the mechanisms used to transfer technology on these joint ventures. The difficulties experienced in transferring technology are discussed, with suggestions to minimize these difficulties with the aim of improving the technology transfer process on future projects. The conclusions show UK contractors are eager to demonstrate that they transfer technology but it only works to a limited extent because there is little incentive for them to do so.
Keywords: contractor, developing country, joint venture, technology transfer.

1996, **14**(1), 55–66

Flexibility in building use: the technical feasibility of converting redundant offices into flats

Gann, D M[1] and Barlow, J[2]
[1]*Science Policy Research Unit, Mantell Building, University of Sussex, Brighton, UK*
[2]*School of Construction, Housing and Surveying, University of Westminster, London, UK*

The potential for converting empty offices into housing depends upon demands for converted space, the ability to finance conversions and attitudes of owners of empty buildings, together with flexibility in planning and ability to overcome technical constraints. This article explains the reasons for the large stock of redundant office buildings in the UK and questions whether some of these can be converted to provide much needed affordable housing. Technical constraints on their own are rarely insurmountable but the cost of making necessary changes may often be higher than other options of demolition and new building. Case studies of converted buildings show that it is necessary for project managers to deal with a range of issues from planning, location and finance to the accurate assessment of technical criteria in order for successful outcomes. It has often been difficult to find sites where all the necessary variables coincide in a positive manner and for this reason, the conversion of offices into flats has limited potential. It cannot therefore be seen as a panacea for housing shortages or for the reuse of redundant office buildings. Lessons from the experience of the UK property and construction industries illustrate the need to incorporate greater flexibility to meet unforeseen changes in use in the future.
Keywords: change of use, conversion, flexibility, technical feasibility.

1996, **14**(1), 67–74

Selecting KBES development techniques for applications in the construction industry

Heng Li
Division of Construction Management, James Cook University of North Queensland, QLD 4811, Australia

Knowledge based expert systems (KBESs) have been increasingly recognized as an effective tool for solving many problems in the construction industry. When developing a KBES for a specific construction problem, it is important to understand the range of available techniques for KBES development and select the most appropriate one for the

problem. This paper discusses five widely used KBES development techniques in terms of their strengths and limitations. Potential application areas for each technique are recommended. Guidelines for selecting a development technique are presented.
Keywords: development technique, KBES, knowledge base.

1996, **14**(2), 79–92

SEMANTIC: Smart Earth Moving Analysis and Estimation of Cost

Lambropoulos, J[1]; Manolopoulos, N[2] and Pantouvakis, J P[3]
[1]*Catholic University of Leuven, Celestijnenlaan 300 A, B-3001, Heverlee-Leuven, Belgium*
[2]*Planet S.A., 64 Louise Riencourt Street, 115 23 Athens, Greece*
[3]*Plegma S.A., 31 Kaningos Street, 10682 Athens, Greece*

Earthmoving is an important activity in almost all civil engineering projects; consequently there is always the need to improve existing earthmoving operational and managerial techniques. This paper presents an integrated computer aided system for the analysis and cost estimation of various earthmoving tasks. The fully operational SEMANTIC consists of four modules. The smart module, exploiting artificial intelligence techniques, advises the user on the selection of the appropriate type of machinery for the task in question. The data management module takes advantage of extended databases containing information on types of soil and technical and cost parameters for a large number of equipment models. Based on descriptive information provided by the user, it suggests values for the many parameters required and facilitates enormously the preparation of input for analytical computations. The output and cost estimation module comprises algorithms for various earthmoving tasks and related machine types or combinations. Finally, the sensitivity analysis module provides the user with information on the magnitude of possible errors due to bad estimating of the input parameters; this module was also used to provide a comparison of the SEMANTIC output to the Caterpillar Manual output.
Keywords: civil engineering, earthwork, estimating, expert system.

1996, **14**(2), 93–101

A study of the management and procurement of building services work

Shoesmith, D R
8 Reynard Close, Roffey, Horsham, West Sussex, RH12 4GX UK

This paper is concerned with the performance of nominated and domestic sub-contractors in building services in the Hong Kong construction industry. It maps out the variables influencing overall project performance, and tests for factors involved in the selection of sub-contractors which in turn are likely to influence project performance. The study had two objectives: first to investigate the relationship between project management actions and the achievement of reduced costs and completing on time; second, to explore the most appropriate procurement method for building services for particular types of project. To achieve the first objective, the investigation used systems and contingency theory to view managerial actions, and it was hypothesized that the way that the procurement form was managed would determine the project's performance. Moreover, the nature and structure of the temporary multi-organization (TMO) would determine the most appropriate form for optimum performance. In short, appropriate organization management leads to higher performance of building services sub-contractors. The second objective was addressed by considering the roles and responsibilities afforded to the specialist contractor. The methodology for the research was a case study format that enabled the problems experienced in each project to be reviewed. Six case studies of high rise commercial buildings have been carried out. Although the sample was small, it did provide sufficient data to test the methodology. However the small sample did make it difficult statistically to test the data with confidence. The managerial actions that have been observed arose from a cross-sectional study of data collected by structured interview and a questionnaire that used a standard scoring system. Data on the profile of the sub-contractors undertaking the work were also gathered and management actions of the sub-contractor and project performances were appraised.
Keywords: domestic sub-contracting, nominated sub-contracting, procurement, sub-contracting.

1996, **14**(2), 103–119

Target budget levels for building operating costs

Macsporran, C and Tucker, S N
Commonwealth Scientific and Industrial Research Organization, Division of Building, Construction and Engineering, PO Box 56, Victoria 3190, Australia

Operating cost targets have long been needed by owners and managers of commercial buildings. The only available comprehensive operating costs of a number of office buildings were analysed and budget levels and optimal performance targets were determined, relating to both cost and consumption values. The effects on operating costs of building characteristics such as size, location and quality were examined and a methodology for determining target operating costs developed. Operating budget targets preferred were the lower quartiles of the distributions of the ratio of each cost item to annual income. These levels were selected as difficult but achievable targets independent of such factors as size, location and inflation.
Keywords: budget , operating cost, performance indicator.

1996, **14**(2), 121–129

Auto-ID application in construction

Finch, E F; Flanagan, R and Marsh, L
Department of Construction Management and Engineering, University of Reading, Reading, RG6 6AW, UK

Auto-ID technologies such as bar coding have been used in the retailing and manufacturing industries for many years, yet their use within the construction industry has been very limited. The technology has improved considerably over the past 20 years and there are opportunities for its application to construction. This paper considers the technology and the barriers to its application in construction. Consideration is given to how other industries have adopted auto-ID and the driving forces of change. A framework for the development of an auto-ID standard in construction is described.
Keywords: auto-ID, bar coding.

1996, **14**(2), 131–145

Validation of the model for evaluating client-generated risk by project consultants

Kometa, S T; Olomolaiye, P O and Harris, F C
University of Wolverhampton, School of Construction, Engineering and Technology, Wulfruna Street, West Midlands, Wolverhampton, WV1 1SB, UK

This paper reports the results of studies in 29 construction consulting firms aimed at validating a model for evaluating client-generated risks (see Kometa et al. 1995a). Validation required quantification of project outcomes in terms of time, cost, quality and fee (charged for services provided) and comparing them with risk exposure indices suggested by the model. Results indicate that the model correctly predicted project outcomes in ten cases (nearly 35%) and was found to be more conservative in predicting project outcomes in all others barring two outliers; thus confirming the applicability of the model as a helpful early warning tool for predicting client-generated risks to construction consulting firms.
Keywords: client, modelling , project consultant, risk assessment, risk management.

1996, **14**(2), 147–154

An analysis of recruitment sources and employee turnover in Scottish construction organizations

Sommerville, J
Department of Building and Surveying, Glasgow Caledonian University, UK

The aim of this research is to test the hypothesis that particular recruitment sources are associated with employee turnover within certain construction organizations. Hypothesis validity would enable management of similar organizations, through the use of more favourable recruitment sources, to reduce or eliminate the employment of individuals who may yield shortened periods of tenure. In the research, 15 recruitment sources used by construction organizations to obtain new employees are compared in terms of their influence on employee tenure and turnover. Personnel records of construction organizations were analysed and from this analysis sources identified which are associated with lower turnover rates and also of stable or longer employee tenure. For each of the organizations considered, specific sources are shown to be indicators of stable employee tenure. Conversely, each organization demonstrates sources which are shown to be associated with high levels of employee turnover.
Keywords: employee tenure, recruitment, Scottish firm.

1996, **14**(2), 155–164

A metaphorical analysis of client organizations and the briefing process

Green, S D
Department of Construction Management & Engineering, University of Reading, Whiteknights, Reading, RG6 6AW, UK

This paper reviews and critiques the current practice of classifying building clients according to their ‘type’. An alternative approach to understanding organizations is developed in accordance with the principles of naturalistic inquiry. It is contended that the complex pluralistic clients of the 1990s can only really be understood ‘from the inside’. The concept of organizational metaphors is introduced as the basis for a more sophisticated way of thinking about organizations. The various strands of organizational theory are also analysed in terms of their underlying metaphors. Different theories are seen to bring different insights. The implicit metaphors adopted by practitioners are held to be important in that they tend to dictate the adopted approach to client briefing. This contention is illustrated by analysing three different characterizations of the briefing process in terms of their underlying metaphors. Finally, the discussion is placed in a contemporary UK context by comparing the dominant paradigm of practice during the 1980s to that of the 1990s.
Keywords: briefingclient, naturalistic inquiry, organizational metaphor,.

1996, **14**(2), 165–174

Mine restoration bond for clay mining and its impact on the prices of building materials in Sri Lanka

Ranasinghe, M
Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka

In Sri Lanka at present, the mining of clay for the production of bricks and roof tiles is mechanized. The result of mechanized mining is deep pits left along river basins. These pits get filled with water during the wet season. Since pumping of water after the wet season for further mining becomes expensive, the excavator attempts to remove as much clay as possible during one dry season. Hence, the environment is changed drastically within a short period. This paper suggests a framework to analyse the social feasibility of clay mining, the feasibility of restoration (refilling) of clay pits after clay mining, and use of the mine restoration bond as a market based economic instrument to restore pits after mining. The social feasibility of clay mining is analysed by comparing net private benefits of clay mining with the social (environmental) costs of clay mining but excluding the cost of refilling. The feasibility of restoring clay pits is analysed by comparing the net benefits of clay mining including the net benefits of refilling and allowing for any reductions in the residual environmental costs of clay mining that are avoided through refilling. As a result the implementation of the mine restoration bond as a market based instrument, to internalize the externality caused by the excavated clay pit, is suggested. The impact of the mine restoration bond on the prices of clay, clay bricks and roof tiles (the basic building materials) is explored.
Keywords: mine restoration bond, social cost, Sri Lanka.

1996, **14**(2), 175–182

The impact of public construction investment upon special economic zones: the Chinese experience

Chen, J J
School of Land and Construction Management, University of Greenwich, Oakfield Lane, Dartford, Kent, DA1 2SZ, UK

Since embarking on economic reforms and the open door policy in 1979, China has been achieving rapid economic growth and development. The Chinese government has made substantial construction investment, especially in establishing the Special Economic Zones (SEZs) as test beds for development policies and homes for foreign investors. From the viewpoint of China, most of these investments are regarded as public investment. It is, therefore, of interest to examine the extent to which the investment benefits society. This paper analyses this type of investment by using a cost-benefit technique to build up a social cost-benefit model. The results indicate that the Chinese public construction investment, particularly in the case of the SEZs, is a beneficial investment from the standpoint of China's economic welfare. Although considerable public expenditure has been incurred in establishing the areas, the benefits, such as employment, foreign-exchange earnings and technical training, which the development has brought to China, have exceeded the costs. The infrastructure will remain and will benefit China in the long term. This is the main reason for the government to extend this type of development to the whole country.
Keywords: China, construction investment, foreign direct investment, special economic zones, social cost benefit analysis.

1996, **14**(3), 189–198

A review of financial ratio tools for predicting contractor insolvency

Edum-Fotwe, F T; Price, A D F and Thorpe, A
Department of Civil and Building Engineering, University of Technology, Loughborough, Leicestershire, LE11 3TU, UK

There is a variety of financial ratio analytical methodologies for evaluation of construction companies corporate performance and identifying potential insolvent contractors. These methodologies comprise traditional approaches, subjective index and ratio models. The shortcomings of the financial ratio analytical methods are highlighted and some approaches to improving their efficiency presented. It has been suggested that standardizing the assessment criteria of subjective index methods for the construction industry can reduce the variation in different expert evaluations and so lead to a more uniform assessment. Secondly, the transformation approach has been recommended as a means of improving the efficiency of ratio models.
Keywords: financial ratio, ratio model.

1996, **14**(3), 199–212

Organizational structures in the construction industry

Shirazi, B[1]; Langford, D A[2] and Rowlinson, S M[3]
[1]*Formerly a research student in the Construction Study Unit at, Bath University, UK*
[2]*Department of Civil Engineering, Strathclyde University, John Anderson Building, 107 Rottenrow, Glasgow, G4 0NG, UK*
[3]*Department of Surveying, University of Hong Kong, Pokfulam, Hong Kong*

The links between the theoretical issues influencing the structure of construction project organizations are discussed. The impact of the environment of a construction project and the technological sophistication of the project are considered in terms of how these factors shape project organizations. The environment is variously assayed for its complexity, its dynamism and its hostility. The technology used in projects is assessed by its level of certainty (whether it is well understood), its complexity and the level of interdependence between subactivities in the project. The variables are used to formulate hypotheses concerning their impact upon the structuring of construction projects and these are studied in 18 case studies. The research has been developed within an interpretive (phenomenological) paradigm. The findings suggest that complex environments lead to greater decentralization of authority, mainly by delegation. In the dimension of technology, complexity led to a wider use of liaison devices on projects with a greater number of technical functional specialists being used by projects. As projects become more technically interdependent then informality and flexibility are the principal mechanisms of project control.

Keywords: environment, organizational structure, project management, technology.

1996, **14**(3), 213–225

Project complexity: the focal point of construction production planning

Gidado, K I
Department of Construction, Geography and Surveying, University of Brighton, Mithras House, Lewes Road, Brighton, BN2 4AT, UK

Construction production planning is a paramount preoccupation of contractors and the process is rapidly increasing in difficulty with a continuous loss in confidence by clients. Today, one of the difficult issues facing practitioners in planning is that of a continuous increase in the complexity of construction projects. There seems to be no available tool or technique for assessing project complexity; consequently practitioners tend to neglect or subjectively assume its effect on project managerial objectives. This paper proposes an approach that measures the complexity of the production process in construction. The approach enables the construction practitioner to focus his or her attention on the issue of project complexity from the beginning through to the end of a project. By using a literature search and structured interviewing of practitioners, the paper has defined project complexity and identified the factors that influence its effect on project success in relation to estimated production time and cost.

Keywords: complexity, construction planning, productivity , project management , work flow.

1996, **14**(3), 227–240

Information technology and perceived competitive advantage: an empirical study of engineering consulting firms in Taiwan

Tan, R R
Institute of Industrial Management, National Central University, School of Management, Chung-li, Taiwan 32054, Republic of China

Using the 13 leading engineering consulting firms in Taiwan as samples, this empirical research adapts Bakos and Treacy's (1986) model to study the impact and linkage of information technology (IT) and competitive advantage. The five sources of competitive advantage are; competence in design and trade-off analysis, unique capability and services, switching costs, internal efficiency and inter-organizational efficiency. Twenty-five ITs are identified and classified into five categories; administration and decision support, engineering analysis, organizational communication, design and project management, and advanced computer technology. For the firms surveyed, the design and project management system and the administration and decision support system have offered very good implementation results. Different ITs are shown to impact on the sources of competitive advantage differently. The diverse relative weights attached to the different sources of competitive advantage from the individual firm match the general theory that the characteristics of the firm influences competitive strategy. The relationship between the perceived IT impact and the assessed realized competitive advantage is demonstrated. The linkage between business performance and the assessed competitive advantage is inconclusive. This research is an empirical study of IT from the perspective of competitive advantage rather than from the more usual operational perspective. The validity of some of the initial findings could be verified by further study using multiple year performance data with larger sample size or through extensive case analysis.

Keywords: competitive advantage, engineering consulting, information technology, multi-variate analysis.

1996, **14**(3), 241–252

Characteristic items: a new approach to pricing and controlling construction projects

Horner, R M W and Zakieh, R
Construction Management Research Unit, Department of Civil Engineering, The University of Dundee, Dundee, DD1 4HN, UK

Recent research has demonstrated the feasibility of identifying within any category of project, a small number of cost-significant work packages whose value represents a consistently high proportion of the total bill value. Using the allied principle of quantity-significance, it proved possible to build simple models which could predict both the cost and the duration of a project. In the course of that work, a surprisingly linear relationship between value and quantity was noted. This paper reports the background to and consequences of that finding. Quantity-significant work packages are formed by aggregating those items within a trade for which a linear regression of value against quantity yields a correlation coefficient greater than 0.99 and an intercept insignificantly different from zero. The price of packages formed in this way can be determined simply by applying to all the items within the package the rate associated with the largest quantity, the so-called 'characteristic item'. Application of the concepts of quantity-significance and characteristic items is expected to lead to simpler estimating and more effective control procedures, because there is no longer any need to allocate cost and resources to each individual item contributing to a work package.
Keywords:cost control, cost model, cost significance, estimating.

1996, **14**(3), 253–264

Changes in profit as market conditions change: a historical study of a building firm

Ming, C S;[1] Runeson, G[1] and Skitmore, R M[2]
[1]*School of Building, University of New South Wales, PO Box 1, Kensington, NSW 2033, Australia*
[2]*School of Construction Management, Queensland University of Technology, Gardens Point Brisbane, Q 4001, Australia*

The profits from 221 construction projects undertaken by an Australian building firm in the period 1910-1938 are analysed and the factors that influence the firm's profit levels are examined. This involves a series of multiple regression analyses with three dependent variables representing profit and 26 independent variables representing economic conditions and project characteristics. From these, 11 models are derived of which two are chosen as having the best explanatory power in explaining approximately 72% of the variability in profit levels movements. The results show that unemployment, interest rates, level of construction activity in the state, change of wage level, inflation rate of building material and project value significantly influenced the firm's profit level during the period.
Keywords: Australia, intrafirm profit, regression analysis analysis.

1996, **14**(3), 265–276

The LP/IP hybrid method for construction time-cost trade-off analysis

Burns, S A;[1] Liu, L[2] and Feng, C[2]
[1]*Department of General Engineering, University of Illinois at Urbana-Champaign, 104 S. Mathews Avenue, Urbana, IL61801, USA.*
[2]*Department of Civil Engineering, University of Illinois at Urbana-Champaign, 205 N. Mathews Ave., Urbana, IL 61801, USA*

Construction planners face the decisions of selecting appropriate resources, including crew sizes, equipment, methods and technologies, to perform the tasks of a construction project. In general, there is a trade-off between time and cost to complete a task - the less expensive the resources, the longer it takes. Using Critical Path Method (CPM) techniques, the overall project cost can be reduced by using less expensive resources for non-critical activities without impacting the duration. Furthermore, planners need to adjust the resource selections to shorten or lengthen the project duration. Finding the optimal decisions is difficult and time-consuming considering the numbers of permutations involved. For example, a CPM network with only eight activities, each with two options, will have 28 alternatives. For large problems, exhaustive enumeration is not economically feasible even with very fast computers. This paper presents a new algorithm using linear and integer programming to obtain optimal resource selections efficiently that optimize time/cost of a construction project.
Keywords: construction planning, critical path method, optimization, time-cost optimization.

1996, **14**(4), 281–293

The impact of stress in site management effectiveness

Djebarni, R
Centre for Research in Built Environment, University of Glamorgan, Pontypridd, CF37 1DL, UK

This paper reports on the findings of a piece of research work aimed at investigating and analysing the impact of stress on the effectiveness of site managers as leaders. The sample of the study included semi-structured interviews with 71 site managers at the sharp end of production and their superiors. The investigation was more specifically concerned

with the impact of three types of stressors, namely boss stress, job stress and environment-job stress. It was revealed, among other findings, that the impact of stress on site managers followed to a great extent the typical inverted U-shaped pattern. Moreover, the results showed that the impact of stress is contingent to a large extent upon the type of stressors.
Keywords: effectiveness, leadership, site manager, stress, stress management.

1996, **14**(4), 295–309

Public policies for managing construction quality: the grand strategy of Singapore

Low Sui Pheng and Tan, W
School of Building and Estate Management, National University of Singapore, Singapore 0511

Unlike other economic sectors, the construction industry is characterized by activities which are discontinuous, dispersed, diverse and distinct. Quality management in the construction setting is therefore rendered more difficult not only at the national level but also at the project level for a wide spectrum of reasons. In response to these concerns, the primary purpose of this paper is to show that the vulnerability of the construction industry to fluctuations in the economy requires the involvement of the government to maintain workload stability in order to deliver high quality standards in the industry. A case study of Singapore is used to propose a range of public policies for such governmental involvement and assistance. In presenting these policies adopted by the Singapore government to achieve good quality standards in the construction industry, the Singapore experience should be of interest to other developing and developed countries in search of a similar paradigm for raising quality standards in their own construction industries.
Keywords: government, public policy, quality management, Singapore.

1996, **14**(4), 311–317

Construction cost prediction for public school buildings in Jordan

Al-Momani, A H
Civil Engineering Department, Mu'tah University, Karak, Mu'tah PO Box 7, Jordan

An empirical model for predicting the construction costs for public school buildings is presented. Observations of 125 school projects were carried out in Jordan for the period 1984-1994. The results indicate that by the time a project is completed, the actual cost exceeds the original contract price by 30% while change orders result in an 8.3% cost overrun. Capital expenditure on school projects over the next 5 years is anticipated at 695.9 million JD. Out of this disbursement 208 million JD will be cost overrun and 57.7 million JD will result from issuing change orders. These figures highlight the need to improve current practices. A cooperative effort between concerned agencies is required to alleviate construction problems and could lead to new major innovations to meet the challenges ahead.
Keywords: claim, contract, cost, estimating, planning, variations.

1996, **14**(4), 319–323

Some new evidence of old trends: Japanese construction, 1960-1990

Bon, R[1] and Yashiro, T[2]
[1]*Department of Construction Management and Engineering, University of Reading, Reading, RG6 6AW, UK*
[2]*Department of Architecture, Musashi Institute of Technology, 1-28-1 Tamadutsumi, Setagaya-ku, Tokyo 158, Japan*

Using the seven input-output tables compiled in Japan to date, this paper extends earlier analysis by adding the analysis of 1985 and 1990 tables. This paper shows that the Japanese construction sector's share in GNP has declined since 1980; the GNP share of manufacturing is continuing to decline and that of services is continuing to grow; the economy-wise effect of construction activity is continuing to decline; and the construction inputs from manufacturing are continuing to decline whereas the sector's inputs from services are continuing to grow. All these are signs of a growing 'maturity' of the Japanese economy, which in this regard appears to follow the path of other advanced industrial countries.
Keywords: backward and forward linkage, input multiplier, input-output analysis, output multiplier, technology.

1996, **14**(4), 325–340

Two heuristics for scheduling multiple projects with resource constraints

Tsai, D M[1] and Chiu, H N[2]
[1]*Department of Industrial Engineering and Management, Cheng Shiu Junior College of Technology and Commerce, 840 Chen-Ching Road, Neao-Song, Kaohsiung, Taiwan 833,ROC.*
[2]*Department of Industrial Management, National Taiwan Institute of Technology, 43 Keelung Road, Section 4, Taipei, Taiwan 106, ROC.*

The purpose of this paper is to develop two efficient heuristic priority rules for the resource-constrained multiproject scheduling problem. The aptness of the two heuristic rules is analysed in terms of several dynamic characteristics of the scheduling problem. Fifteen heuristic rules presented in previous studies are used for comparison with the two heuristic rules on 4941 test problems which were generated by combining two, three or four projects from seven typical networks. The results indicate that the two proposed heuristics are superior to the other scheduling rules under the performance criteria of the minimum total project delay and the maximum number of times that a scheduling rule can obtain re the best representatives of the single priority rule method and the weighted combination search method, respectively. This study also includes a categorization process on which a project summary measure is based and then provides project schedulers with a convenient scheme to adopt appropriate scheduling rules.
Keywords: delay, heuristic rules, multi-project scheduling, resource allocation, scheduling.

1996, **14**(4), 341–452

Predicting the level of organizational effectiveness: a methodology for the construction firm

Handa, V K and Adas, A
Civil Engineering Department, University of Waterloo, Waterloo, N2L 3G1, Ontario, Canada

Researchers have offered a variety of models for examining organizational effectiveness, yet there is little consensus as to what constitutes a valid set of criteria for measurement. In today's environment it is vital for construction firms aiming to maintain and improve performance to utilize an appropriate method to predict their organizational effectiveness. This paper illustrates a methodology for predicting the level of organizational effectiveness in the construction firm. The competing values approach towards understanding organizational effectiveness and its assessment is used to identify 14 variables. These variables are conceptualized from four general categories of organizational characteristics, relevant for examining effectiveness: structural context, organizational flexibility, rules and regulations, person-oriented processes and strategic means and ends. The methodology hypothesizes a multivariate linear model of the 14 variables as predictors and effectiveness operationalized by the level of overall performance as the response variable. Cross-sectional data were collected from 76 firms operating in institutional and commercial (IC) construction. The validated model shows that five of the hypothesized 14 variables are highly significant in predicting the level of organizational effectiveness in the construction firms studied: organizational attitude towards change, multiple project handling ability, level of planning by management, strength of organizational culture and level of workers' participation in decision making.
Keywords: construction firm, organizational effectiveness, prediction.

1996, **14**(4), 353–364

The effectiveness of formal quality management systems in achieving the required cover in reinforced concrete

Shammas-Toma, M; Seymour, D E and Clark, L
School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

Much attention has been given to ways of controlling quality through formalized management systems. A study has recently been completed at the University of Birmingham, funded by the Building Research Establishment, designed to establish the extent to which construction specifications are being achieved in reinforced concrete structures and correlation's between the quality levels achieved and the site organization structure, and control procedures and supervisory and workmanship practices. The findings suggest that the existence of formal quality control systems do not have the intended, positive impact on quality. The implications of this are discussed in terms of the need to recognize the limitations of trying to remedy sporadic defects through checking and to institute procedures aimed at eliminating systemic or chronic defects. Such a strategy would involve developing greater coordination between participants and enabling a properly trained work force to do the work 'right first time'. It is recognized that for this strategy to be realized, considerable changes in attitude, culture and procurement arrangements would be necessary.
Keywords: defect, operative, quality system.

1996, **14**(5), 375–394

Construction delay analysis techniques

Alkass, S;[1] Mazerolle, M[2] and Harris, F C[3]
[1]*Centre for Building Studies, Concordia University, 1455 de Maisonneuve W., Montreal, H3G 1M8,Canada*
[2]*Transportation Planning Engineer, CANAC International Inc., 1100 University, Montreal, H3B 3W7, Canada*
[3]*School of Construction, Engineering and Technology, University of Wolverhampton, Wolverhampton, UK*

Construction projects continue to suffer delays. Things go wrong and the project's completion date gets pushed back, with someone to be blamed for it. In practice, attempts are made to identify the causes of delays and schedules are modified to incorporate revised duration and new project time. The analysis itself is usually complex and can be aided by a computerized approach. This paper discusses different delay analysis techniques that are currently used by practitioners in the construction industry. It also discusses a proposed new delay analysis technique called the Isolated Delay Type (IDT). These techniques were tested against a case example and their strengths and weaknesses highlighted. The new technique can be used as a standalone module for delay analysis or could be incorporated within a computer system for construction delay analysis and claims preparation called Computerized Delay Claims Analysis (CDCA) that integrates different software including an expert system and management software such as scheduling and a database or spreadsheet.

Keywords: claim, computing, delay, construction planning, expert system, scheduling.

1996, **14**(5), 395–404

Interpersonal communication in cost planning during the building design phase

Bowen, P A[1] and Edwards, P J[2]
[1]*Department of Construction Economics and Management, University of Cape Town, Rondebosch 7700, Cape Town, South Africa*
[2]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, Melbourne, Victoria 3001, Australia*

Effective interpersonal communication is critically important in the design phase of a building project if a successful design brief is to be formulated and appropriate cost advice prepared. This paper explores the latter process in the context of communication theory, using structured interview surveys of building clients, architects and quantity surveyors in South Africa.

Keywords: communication, cost planning, quantity surveying.

1996, **14**(5), 405–416

Between hard and soft HRM: human resource management in the construction industry

Druker, J[1]; White, G[1]; Hegewisch, A[2] and Mayne, L[2]
[1]*University of Greenwich Business School, Riverside House, Beresford Street, Woolwich, London, SE18 6BU, UK*
[2]*Cranfield School of Management, Cranfield, Bedford, MK43 0AL, UK*

The rapid change in the economic environment has not resulted in the development of sophisticated human resource management practices in the UK construction industry. There are similarities between personnel practice in construction and 'hard' models of HRM, particularly in relation to manual workers, but non-manual employment resembles more the conditions where 'soft' HRM might be expected. Focusing on the HRM levers developed by John Storey, HRM practices are examined in relation to the role of personnel departments, line management responsibility, performance management, and values and beliefs of personnel managers. The survey results suggest few signs of fundamental or far-reaching innovation in human resource management practice in the construction industry despite the changing shape of construction companies. There are some, though limited, signs of change in respect to expectations of training and employee development in the future.

Keywords: employee relations, human resource management, line management, personnel management, people management.

1996, **14**(5), 417–425

A survey of constraints on Iranian construction operatives' productivity

Zakeri, M; Olomolaiye, P O; Holt, G D and Harris, F C
School of Construction Engineering and Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands, WV1 1SB, UK

Construction productivity is rarely analysed in Iran. If productivity is to improve, current weaknesses must be identified. To this end data were collected through a structured questionnaire survey. By utilizing the relative index ranking technique, the identified problems were prioritized for detailed analysis and discussion. Results indicate that the five highest-ranking problems are: Materials shortage, weather and site conditions, equipment breakdown, drawing deficiencies/change orders, and lack of proper tools and equipment. Devastating war with neighbouring Iraq has led to a boom in construction activities leading to shortages of construction materials. The casual employment of the majority of construction operatives and poor managerial skills are the significant contributors to low productivity on Iranian construction sites.

Keywords: Iran, productivity, site operation.

1996, **14**(5), 427–436

The use of artificial neural networks in construction management: a review

Boussabaine, A H
School of Architecture and Building Engineering, University of Liverpool, PO Box 147, Liverpool, L69 3BX, UK

Artificial neural networks (ANNs) are systems that can learn. A neural system can be trained on a set of input and output data belonging to a particular problem. If new data of the same problem, but not in the training set, are presented to the system, the ANN can use the learned data to predict outcomes without any specific programming relating to the category of events involved. The fields of application of ANNs have increased dramatically in the past few years. A large variety of possible ANN applications now exist for non-computer specialists. Therefore, with only a very modest knowledge of the theory behind ANNs, it is possible to tackle complicated problems in a researcher's own area of speciality with the ANN technique. This is true in the field of construction management, the topic of this review. The review is divided into three sections: a background introduction to ANN methods, a review of the most important application of the ANN techniques to this point and a selection of construction management topics that have potential application.

Keywords: artificial neural network, automation, information technology, intelligence, neural system.

1996, **14**(5), 437–450

Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan

Gann, D M
Science Policy Research Unit, Mantell Building, University of Sussex, Falmer, Brighton, BN1 9RF, UK

In Japan, similar management practices in product development, design, supply-chain coordination, marketing and sales have been used to produce very different products: industrialized housing and automobiles. Manufacturing principles derived from the car industry have been successfully used to produce attractive, customized and affordable homes. But there are limits to which such techniques can be applied to manage the assembly of wide varieties of component parts needed to produce complex customized products. Managers must trade off the need to achieve economies of scale in the production of standardized factory parts with economies of scope in various stages of assembly in order to provide flexibility to satisfy consumer choices. The housing industries can benefit by learning more about the use of advanced manufacturing techniques developed in car production. At the same time, automobile makers may learn more about the management of customization from the way in which housing firms organize sales, design and final assembly. The paper suggests that wider ranges of choice can be delivered through managing the whole production system, balancing the use of standard components with flexibility in assembly, rather than by solely attempting to optimize control in discrete parts of the system.

Keywords: car production, economies of scale, innovation, Japanese industrialized housing, manufacturing process, technological learning.

1996, **14**(5), 451–456

Note: Portfolio selection of capital investment projects in the Durban Metropolitan Region

Gori, E
Project Management and Development Consultant, 1 The Snicket, off Florida Road, Morningside, Durban, South Africa

Linear and integer programming (LP) is used to make rational and consistent portfolio selection of a set of real projects in the Durban Metropolitan Region (DMR). The LP model balances capital funding and cash-flow restrictions against developmental preferences and the desire to achieve a healthy mix between revenue-generating and job creation projects.
Keywords: capital budgeting, linear programming, portfolio selection.

1996, **14**(5), 457–460

Note: Monte Carlo simulation of construction costs using subjective data: comment

Fellows, R F
School of Architecture and Civil Engineering, University of Bath, Bath, BA2 7AY, UK

This note supplements papers by Chau in an attempt to further the consideration of risk measures in forecasts of construction project costs. The note reviews the application of PERT-based aspects of analysis and simple portfolio theory. Consideration is given to subjective factors in cost forecasting which arise from the natures and experiences of the forecasters as well as pressures to which they (may) feel subjected. Alternative measures of risk exposure are examined and supplementary analyses of the data contained in Chau's paper are reported. Although the log-triangular distribution is confirmed as a superior means of measuring risk, the observed risk measures still exceed those calculated.
Keywords: bias, cost forecasting, Monte Carlo simulation, risk.

1996, **14**(6), 467–484

Assessing construction technology by integrating constructed product and construction process complexities: a case study of embankment dams in Thailand

Trinh, T T P and Sharif, N
Management of Technology Program, School of Management, Asian Institute of Technology, GPO Box-2745, Bangkok 10501, Thailand

Construction projects in developing countries often involve work that can be done only by contractors with a high level of technological skill. Such projects demand managerial and technological skills beyond those of the local contractors. In order to assess the complexity of the product and process for a proposed project, a conceptual framework is developed and tested with a case study. This approach enables judgements to be made about the overall technology requirements for large construction projects. Construction companies can be classified according to their ability to fulfil the technological requirements. In this way, national policy makers can identify the most appropriate kinds of intervention for particular projects.
Keywords: case study, complexity, integration, process integration, technology.

1996, **14**(6), 485–496

Some observations on the management of quality amongst construction professionals in the UK

Abdul-Rahman, H
Department of Civil Engineering, University of Malaya, 59100 Kuala Lumpur, Malaysia

The management of quality in construction is an important factor to determine the competitive edge of a construction business. Most companies in the UK construction industry are aware of the significance of BS5750-Quality System but there is no indication of how successful the implementation of quality systems have been. A questionnaire survey was conducted on a sample of professionals involved in implementing quality system in the UK construction industry to validate previous observations in an investigation on quality management. This paper describes the results of the quality management aspect of the survey and discusses several issues raised during the investigation. Amongst others, the findings show a significant awareness of quality management in civil engineering construction.
Keywords: cost, project management, quality.

1996, **14**(6), 497–504

Total project cost under inflation: a simplified model for decision makers

Ranasinghe, M
Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka

A simplified model for total project cost is developed in this paper to meet the numerous request from decision makers for a model that can be used to estimate the total project cost from the estimated cash-flows, and more importantly check the accuracy of the project cost estimates in feasibility studies that require prudent decisions. It begins with base cost estimate in constant dollars and discrete cash-flows with discrete inflation rates as practised by the construction industry. The discrete inflation rates are used to estimate current dollar costs of the project. The effects of inflation are estimated as escalation during construction. Using the future value concept, interest during construction is estimated in a simplified approach to estimate the total project cost. Data from an actual feasibility study is used to highlight the strengths and weaknesses of the simplified model. The model is extended to treat discrete cash-flows with continuos inflation rates.

Keywords: cash flow, escalation, future value, inflation, total project cost.

1996, **14**(6), 505–528

Optimizing bidding success and profitability in airport runway construction in French Polynesia

Singh, A and Shoura, M M
Department of Civil Engineering, University of Hawai'i at Menoa, Honolulu, USA

Winning a bid and making a profit deeply influence the bidding philosophy of behaviour of a construction market. Estimators commonly calculate direct costs and add overheads and profit in what is a simple arithmetic exercise. This paper studies a database of bids submitted on airport construction in French Polynesia. By analysing the distribution of bid prices placed on elemental cost items, an optimal bid is determined for overall success and profitability through using statistical techniques such as operating characteristic curves and overrun profiles. It is seen that successful and profitable contractors have overall profitability indexes in the range of 0.205-0.341 in the French Polynesian construction market. Similar analyses can be conducted for other construction markets, which can give a contractor a better grasp over their estimating technique. This process assists owners in determining whether contractors are bidding within reasonable limits and whether the contractor is a safe or unsafe risk.

Keywords: competitiveness, Monte Carlo, operating characteristic curve, probability, success, unit price.

1996, **14**(6), 529–534

Note How long should housing last? Some implications of the age and probable life of housing in England: a comment

Allen, S and Hinks, J
Department of Surveying, University of Salford, Salford, M5 4WT, UK

The objective of this comment is to supplement the paper by Meikle and Connaughton (1994), published in this journal. This paper concentrated upon the non-replacement of an ageing housing stock, and the maintenance implications of the recent shift towards owner-occupation in England. The ethics behind this trend of tenure change were not questioned, an acceptance of 'individual' ownership and responsibility seemed apparent. The relative success of public sector housing management was not considered. This comment will seek to address this. Whilst recent changes in housing tenure will create new problems to overcome, and will therefore need to be examined carefully, a multitude of existing problems remain. This comment will seek to illuminate one problem area: the effective management of multiple unit housing stocks and how this may provide a framework for the maintenance of the nation's ageing housing stock.

Keywords: housing maintenance, integrated management strategy, mass ownership.

1996, **14**(6), 535–540

Note: The elasticity of capital-labour substitution in Singapore construction

Tan, W
School of Building and Estate Management, National University of Singapore, Kent Ridge Crescent, Singapore 0511

A central issue in improving construction productivity is the flexibility in which capital and labour may be substituted. Empirical estimation using Singapore data suggests that the hypothesis of a unitary elasticity of substitution cannot be rejected, thereby providing justification for policy measures to alter the relative prices of factor inputs to encourage mechanization in construction. The finding is consistent with Cassimatis' (1969) study on the American construction industry as well as numerous production function studies conducted for other industries.

Keywords: elasticity of substitution, productivity.

CME: Volume 15, 1997

1997, **15**(1), 5–18

Price stability and the business cycle: UK construction bidding patterns 1970-1991

Rawlinson, S[1] and Raftery, J[2]
[1]*Davis, Langdon and Everest, 39 Kingsway, London, UK*
[2]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hong Kong*

Problems of competitive pricing and strategic management in the construction industry are discussed. A statistical analysis of tender spread patterns over the period 1970-91 shows that changing market conditions influence levels of risk exposure and in turn affect the establishment of a market-generated 'going rate' for construction. A pattern of increasing stability of pricing is identified during the 1980s, and this pattern is linked to developments in the strategic management of contracting organizations. Despite trenchant criticism of the sealed bid as a method of price determination, the industry's price levels do respond relatively quickly to changed economic conditions.
Keywords: bidding, business cycle, market price.

1997, **15**(1), 19–38

Criteria for contractor selection

Hatush, Z and Skitmore, R M
Department of Surveying, University of Salford, Salford, M5 4WT, UK

This paper is concerned with identifying universal criteria for prequalification and bid evaluation, and the means by which different emphases can be accommodated to suit the requirements of clients and projects. The information, assessment and evaluation strategies currently used by procurers for screening contractors are considered, and the results are reported of an extensive literature review and a Delphic interview study with a small select sample of construction professionals with extensive experience in prequalification and bid evaluation processes. The findings indicate that the most common criteria considered by procurers during the prequalification and bid process are those pertaining to financial soundness, technical ability, management capability, and the health and safety performance of contractors.
Keywords: bid evaluation, criteria assessment, information, pre-qualification.

1997, **15**(1), 39–47

Economic evaluation of materials planning systems for construction

Wong, E[1] and Norman, G[2]
[1]*Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*Department of Economics, Tufts University, Medford, MA, USA and University of Edinburgh, Edinburgh, UK*

It has been noted that many problems exist among local construction contractors owing to inefficient materials management. Problems reported include delays in the supply of construction materials, and inappropriate scheduling of materials in construction projects. There is a need for an improved materials planning approach. Efficient planning of materials not only means increased productivity and profit to the company, but also facilitates the completion of construction projects. In view of the variation in size, timing and frequency of material orders, the authors felt that the implementation of a materials planning system (MPS) in construction would produce cost savings similar to those achieved in the manufacturing industry. However, an economic evaluation of a construction MPS would probably involve the treatment of uncertain costs and savings. A practical risk analysis based on converting subjective estimates of timing and magnitude of cash-flows to beta distributions was used to illustrate the feasibility of implementing such a system in construction.
Keywords: construction, material planning, risk simulation.

1997, **15**(1), 49–57

Strategies for successful construction and demolition waste recycling operation

Peng, C L; Scorpio, D E and Kibert, C J
Centre for Construction and Environment, University of Florida, Gainesville, USA

Establishing a successful construction/demolition (C) waste recycling operation in the USA is a challenge today, especially because secondary materials markets have not yet matured. Increasingly, municipal solid waste (MSW) landfill operations refuse to accept C waste. Skyrocketing tipping fees due to the scarcity of landfill sites, and growing

concerns from regulatory agencies and the public, have placed C waste recycling operations under intense scrutiny. The experiences of regional C recyclers indicate that successful recycling operations require a minimum of 0.8 ha of clear space for processing equipment, incoming waste stockpiles, recycled materials, and manoeuvring room for mobile equipment and operations. Reasonable quality, reliable equipment suitable for these operations generally costs between $300 000 and $750 000 for a 400-500 tonne/day operation. At present, operators of these facilities make a profit almost solely ontipping fees, with the recycling operation functioning mainly to maintain materials throughput. Different categories of C recycling machinery and waste processing strategies are presented. Strategies for converting C landfills into successful C recycling operations are also examined. C waste recycling economics are presented to demonstrate the essential ingredients for successful operations.

Keywords: demolition, environmental impact, landfill, recycling, sustainability.

1997, **15**(1), 59–69

Promotional literature for competitive advantage in UK construction firms

Preece, C N and Male, S

Department of Civil Engineering, University of Leeds, Leeds, LS2 9JT, UK

This paper outlines the findings of an in-depth survey exploring the effective use of promotional brochures and other corporate literature in providing a competitive advantage in the marketing of contractual services in construction. The research project on which this paper is based involved surveys of major client organizations and their professional advisers, i.e. architects, engineers, project managers etc., who provided constructive criticism of the promotional efforts of contracting firms. The research also involved the senior marketing management responsible for promotion in construction firms, and promotional design consultants and agents employed by the industry to produce promotional brochures and other material. The principal findings are that construction firms need to give more attention to the careful targeting of their promotional literature to specific members of the client's team, tailoring material to the particular needs of the client and proposed project, and trimming material so that it concisely communicates a persuasive message concerning the firms' corporate image and the benefits of a clearly differentiated service. The paper presents practical recommendations based on the analysis for the more effective use of brochures and annual reports as part of the promotional strategies in the provision of construction contractual services.

Keywords: competitive advantage, construction, marketing, promotion.

1997, **15**(1), 71–82

Communication and governance in the building process

Pietroforte, R

Department of Civil and Environmental Engineering, Worcester Polytechnic Institute, Worcester, MA 01609-2280, USA

Through a proposed interpretative framework the relationship between forms of transactional governance and type of information processing and communication media is analysed. Building projects are successfully completed through the development of federative mechanisms, such as co-operation, informal roles and rules, that complement and circumvent the hierarchical and formal provisions of standard contracts. At present there is a dislocation between the pattern of roles and rules advocated by standard contracts and that observed in practice. During the design and engineering process, federative mechanisms are supported by the exchange of qualitative and uncertain information through personal communication media such as group meetings and direct contacts. The focus of new information technologies should be broadened from controlling contractual compliance to facilitating communication and interaction among project participants.

Keywords: building process, communication, contract, information technology, transactional organization.

1997, **15**(1), 83–94

Factors influencing construction time and cost overruns on high-rise projects in Indonesia

Kaming, P F[1]; Olomolaiye, P O[2]; Holt, G D[2] and Harris, F C[2]

[1]*University of Atma Jaya Yogyakarta, Jalan Babarsari 44, PO Box 1086, Yogyakarta, 55281, Indonesia.*

[2]*University of Wolverhampton, School of Construction, Engineering and Technology, Wulfruna Street, Wolverhampton, WV1 1SB, UK*

Many variables have an impact upon construction time and cost overruns in Indonesia. A questionnaire survey was undertaken of project managers working on high-rise construction projects in two Indonesian cities: Jakarta and Yogyakarta. The variables identified were ranked according to their perceived importance and frequencies of occurrence. Inflationary increases in material cost, inaccurate material estimating and project complexity are the main causes of cost overruns. The predominant causes of delay are design changes, poor labour productivity and inadequate planning. Using factor analysis techniques, delay and cost overrun variables were grouped into factors, and their relationships analysed. Although Indonesia specific, the results reflect construction management problems common to developing countries.

Keywords: cost overrun, delay, Indonesia, high-rise, productivity.

1997, **15**(1), 95–108

Contractor development in Nigeria: perceptions of contractors and professionals

Adams, O
Department of Building Studies, School of the Built Environment, De Montfort University Leicester, The Gateway, Leicester, LE1 9BH, UK

Foreign construction firms dominate the major projects in most developing countries as a result of deficiencies in indigenous construction capacity. A plethora of measures have been formulated and implemented to promote development of domestic contractors in these countries, but most attempts have achieved little success. This paper, arising from a larger study on management training needs of contractors in Nigeria, describes findings on constraints on indigenous contractors' performance in the Nigerian industry. Contractor-development programmes perceived as relevant and appropriate to improve their performance in the industry are also reported. The views of indigenous contractors and professionals were compared. There was a strong agreement between both groups on the major constraints in the industry and on the measures perceived as most important for the development of Nigerian contractors. Problems emanating from the business environment were generally perceived by both groups as the most severe constraints. Contractor-development programmes, perceived as very important by both groups, are also the measures required to ameliorate the most important constraints identified: obtaining interim payments, uncertainties in supplies and prices of materials, inadequate access to capital, plant and equipment. Contractor development is inevitably an integral part of a construction industry development programme, given the nature of constraints and development needs emphasized by both groups. The focus therefore should be on establishing a comprehensive programme for the development of the construction industry. More attention should be placed on contractor training to promote management development of trained construction professionals, now emerging as the new crop of construction entrepreneurs.

Keywords: contractor development, developing country, Nigeria, SME, industry development.

1997, **15**(1), 109–115

Note – Monte Carlo simulation of construction costs using subjective data: response

Chau Kwong Wing
Department of Surveying, The University of Hong Kong, Pokfulam Road, Victoria, China

This communication is a response to the insightful note by Fellows on previous papers by the author. Not only has Fellows supplemented Chau's major arguments, he has also expanded the scope of discussion and raised new issues. While the author agrees with most of the points made by Fellows, there are concepts and arguments that need to be clarified. This note is a response to certain issues raised by Fellows. It also clarifies certain concepts and gives alternative viewpoints. Most of these viewpoints complement rather than contradict those given by Fellows. It is hoped that this note will arouse readers' interest in the subject as well as contribute to the academic debate of the issue. The sequence of the discussion follows that in Fellows' note.

Keywords: cost, estimating, Monte Carlo simulation, probabilistic estimating.

1997, **15**(1), 117–119

Note – The role of theory in construction management: a call for debate

Seymour, D E; Crook, D and Rooke, J
School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

We raise a number of questions concerning the theoretical basis of construction management, and enquire into the nature of construction management theory. We highlight the dominant research paradigm in construction management, and call for attention to be paid to alternative research paradigms. We call for a scholarly debate to investigate these issues.

Keywords: management theory, management research, research paradigm, interpretive paradigm, rationalist paradigm.

1997, **15**(2), 129–147

Evaluating contractor prequalification data: selection criteria and project success factors

Hatush, Z and Skitmore, R M
Department of Surveying, University of Salford, Salford, M5 4WT, UK. School of Construction Management, Queensland University of Technology, Brisbane Q4001, Australia

A Delphic study investigating the perceived relationship between 20 contractor selection criteria (CSC) currently in use and project success factors (PSFs) in terms of time, cost and quality is described involving a sample of eight experienced construction personnel, including two validators. A consensus of the likely impact of each criterion on

time, cost and quality is established in terms of pessimistic, average and optimistic values, which are then converted into expected means and variances via the PERT approach. The ten most and ten least important CSCs are identified and examined for differences and similarities between PSFs. The results show that past failures, financial status, financial stability, credit ratings, experience, ability, management personnel and management knowledge are perceived to be the dominant CSCs affecting all three PSFs, with safety criteria (safety, experience modification rate, OSHA incidence rate, management safety accountability) and the length of time in business being perceived to have the least effect overall. Some CSCs, such as past performance, bank arrangements, project management organization, plant and equipment were perceived to affect only one or two PSFs.

Keywords: Delphic technique, pre-qualification, project success, selection criteria.

1997, **15**(2), 149–159

Choosing an appropriate research methodology

Walker, D H T

Department of Building and Construction Economics, Royal Melbourne Institute of Technology, 124 La Trobe Street, Melbourne, Victoria 3001, Australia

The choice of research methodology is a difficult step in the research process. By way of a case study, the approach adopted in one PhD study is explored. The research project involved a detailed study of 33 building projects constructed in Melbourne during the period 1987 to 1993. The principal research objective was to understand better why some buildings are constructed faster than others, by identifying risk factors and how construction managers respond to them. Multiple regression analysis was used to derive a model that predicts construction time from a representative sample of projects. The performance model was then used to compare predicted with actual construction project duration to develop a construction time performance index. This performance ratio was then used to compare 102 variable factors by testing the null hypothesis that each variable does not affect construction time performance (at the 95% confidence level). Correlation analysis of all identified variables was also undertaken to link associations between factors for those affecting and not affecting construction time performance. The contribution of this paper is to identify one research approach for a specific research problem within the construction discipline so that others may be aware of this when making a choice of methodologies for pursuing their own research work.

Keywords: case study, research methodology.

1997, **15**(2), 161–175

Practices, barriers and benefits of risk management process in building services cost estimation

Mok, C K[1]; Tummala, V M R[1] and Leung, H M[2]

[1]*Architectural Services Department, 38f Queensway Government Offices, 66 Queensway, Hong Kong*

[2]*Department of Manufacturing Engineering, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong*

The preparation of cost estimates for construction projects is not an easy job, because construction projects are subject to risks and uncertainties, particularly at the inception stage, when very limited information about the project is available. However, the cost estimates prepared at this stage are usually the most important to the client. Nowadays, the costs for building services installations contribute a significant share of the total construction cost of building projects. Thus the accuracy of the building services cost estimates plays an important role in the total building construction project cost estimates. Traditionally, building services cost estimates are prepared by a deterministic single-figure (most likely) approach. This approach is often cost-ineffective and reactionary in nature. The risk management process (RMP) provides a logical consistent framework in identifying the risk factors affecting costs and in making allowances for risks in cost estimation. A survey was conducted to find out the current building services cost estimation practices and to obtain an insight into the understanding, use and application of RMP in preparing building services costestimates within the building services industry. The results of the survey have suggested that the traditional deterministic cost estimation method is still being adopted by the majority of building services engineers in preparing cost estimates. Also, RMP has not been widely adopted by the building services industry in Hong Kong. From the analysis of building services firms and engineers with regard to the critical success factors for implementation of risk management, the survey reflects that the potential of implementing RMP for building services cost estimation is high.

Keywords: building services, cost, estimating, risk, uncertainty.

1997, **15**(2), 177–186

Safety cost optimization of building projects in Hong Kong

Tang, S L[1]; Lee, H K[3] and Wong, K[3]

[1]*Civil & Structural Engineering Department, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*

[2]*Shell Companies in China and Hong Kong .*

[3]*Binnie Consultants Ltd*

A survey was undertaken of the losses or costs incurred in building contracts because of accidents on building sites. Altogether, 576 accidents from 18 building sites were investigated. On each site, an accident occurrence index (AOI)

was calculated by dividing the total equivalent day loss by the total man-days required for the project. Using the results of the 18 projects, a relationship was obtained between the site accident costs and the AOI. Similarly, a relationship was found between the safety investment and the AOI. From these two curves, the optimal safety investment on a building site by a contractor could be determined. It was found that the minimum safety investment on a building project is about 0.6% of the contract sum. The above finding was based on accidents in which employees sustain fatal injuries or are absent from work for more than 3 consecutive days through injury. If first-aid-only and non-injury accidents were also considered, the minimum safety investment increased to 0.8% of the contract sum.
Keywords: accident, cost, safety, site operation.

1997, **15**(2), 187–200

Information technology in contractors' firms in Saudi Arabia

Shash, A A and Al-Amir, M
Construction Engineering & Management Department, College of Environmental Design, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia

The evolution of the Saudi construction industry correlated with rapid growth in Saudi Arabian oil revenues. Construction companies of all sizes were established during this rapid growth. The extent of computer use in these companies has been surveyed using a structured questionnaire. This reveals that computers are not widely used among contractors. However, all large contractors, 62% of medium-sized contractors and 41% of small contractors use computers mainly for administrative operations, such as accounting and database management.
Keywords: computer, contractor, information technology, Saudi Arabia.

1997, **15**(2), 201–212

Fit for the task: the future of the small scale domestic repair and maintenance industry in the UK

Leather, P and Rolfe, S
Faculty of the Built Environment, South Bank University, London, UK. School for Policy Studies, Bristol University, Bristol, UK

The poor condition of much of the UK's older housing stock is an important policy issue. Some disrepair arises because owners cannot afford work, because they are not aware of the need for it or because they do not know how to go about organizing it. However, the poor reputation of that sector of the building industry dealing with small scale domestic repair and maintenance is also a deterrent. If anything, the problems of this sector have worsened during the recession as the supply of unskilled 'cowboy' operators has increased. This paper reviews the factors leading to under investment and poor quality work in the privately owned housing stock and examines the extent to which the shortcomings of the building industry contribute to this phenomenon. It describes the results of a survey of firms operating in the domestic repair and maintenance sector of the UK building industry, the majority of which were very small. The survey examined the size and composition of firms, their organization and working practices, the types of work they carried out, how they went about obtaining business, the extent to which their work-force was trained and the problems they faced in competing with one another and with the cowboy sector. On the basis of the survey conclusions and discussions with a wide range of organizations representing the industry, consumers, local authorities and government, a series of options for reform are discussed with the aim of stimulating debate on the future of this sector of the construction industry. It is argued that the problems of the UK industry cannot be solved by tighter controls on builders alone, but by a range of measures designed to provide more support and training to reputable builders, measures to exert greater controls over building techniques and safety provision to reduce unfair competition and programmes to educate the consumer to demand better standards and to be willing to pay for them. Ultimately only compulsory measures may succeed in improving standards, but much could be achieved by voluntary licensing or registration schemes backed up by incentives to use qualifying firms such as guarantees. This is more likely to work if backed up for an initial period by government or local authority funding. In the long run, however, the improvements to building quality could save public money.
Keywords: industry development, licensing, maintenance, repair, SME, training.

1997, **15**(3), 223–239

Sustainable construction: principles and a framework for attainment

Hill, R C[1] and Bowen, P A[2]
[1]*Department of Environmental and Geographical Science, University of Cape Town, Rondebosch 7700, Cape Town, South Africa*
[2]*Department of Construction Economics and Management, University of Cape Town, Rondebosch 7700, Cape Town, South Africa*

The evolution of the concept of sustainable development is used as a basis for advancing understanding of sustainable construction. Principles of sustainable construction are developed and divided into four 'pillars' - social, economic, biophysical and technical - with a set of over-arching, process-oriented principles, to be used as a checklist in practice. A multi-stage framework is proposed which requires the application of Environmental Assessment and Environmental Management Systems for construction projects.
Keywords: development, environment, environmental assessment, management, sustainable construction.

1997, **15**(3), 241–258

Distributions and correlations in Monte Carlo simulation

Wall, D M
School of Construction, South Bank University, Wandsworth Road, London, UK

The use of Monte Carlo simulation in construction cost analysis is of interest to construction professionals as part of the risk analysis of construction projects. In recent high profile publications the presentation of Monte Carlosimulation based cost analysis overplays the importance of the choice of which distribution to use to represent input variables and underplays the importance of assessing and including correlations between the variables. The British literature also overplays the suitability of the beta distribution to represent input variables. This paper addresses these issues using a data set comprising elemental rates from 216 office buildings drawn from the BCIS of the RICS. Using a chi-squared test for goodness of fit it is shown that lognormal distributions are superior to beta distributions in representing the data set. Simulation runs of the cost model including and excluding correlations show that correlations must beincluded in Monte Carlo simulation otherwise the analysis leads to serious mis-assessment of risk. Simulation results show also that the effect of excluding correlations is more profound than the effect of the choice between lognormal and beta distributions.
Keywords: correlation, cost analysis, distribution, interdependence, Monte Carlo simulation.

1997, **15**(3), 259–270

Leaders and champions for construction innovation

Nam, C H[1] and Tatum, C B[2]
[1]*Ssangyong Corporation, Seoul, Korea*
[2]*Stanford University, Stanford, USA*

Based on empirical studies of the role of key individuals in the processes of ten successful innovations in the US construction industry, this paper makes three principal arguments. First, effective leadership is essential for technological innovation - in particular in construction. Second, technological competence is an utmost prerequisite for effective leadership for construction innovation - regardless of the size of the firm. In other words, an entrepreneurial role as a technical champion in a small firm does not change even as the firm grows. Lastly, the role of technical champion can be delegated only with slack resources and adequate power. This paper also highlights conclusions and practical applications to increase technological innovation in design and construction firms.
Keywords: entrepreneurship, innovation, leadership, technology.

1997, **15**(3), 271–281

Concurrent engineering in design-build projects

Anumba, C J[1] and Evbuomwam, N F O[2]
[1]*Construction Research Unit, University of Teesside, Middlesbrough, UK*
[2]*Department of Civil Engineering, University of Newcastle, Newcastle, UK*

The design and build procurement route has witnessed significant growth in the UK construction industry over the last ten years. It is now being used for both private and public sector projects of varying complexity. There are several advantages associated with this method of construction procurement including shortening of lead times, involvement of the contractor in the design process, greater price certainty, improved communication and reduced construction time amongst others. Conversely, there are also a number of disadvantages ascribed to the design and build method of procurement. Some of these include reduced design quality, inhibition of changes by clients, and high tendering costs. A new process model is proposed to address many of the procurement route's present shortcomings. In particular, the model facilitates concurrent project development in the design and build process through the integration of all project participants into a multi-functional matrix team capable of resolving potential 'downstream' problems early in the project life-cycle, and the provision of a formal mechanism for the improved abstraction of client requirements based on design function deployment (DFD) - a concurrent engineering design system.
Keywords: client, concurrent engineering, design-build, process mapping.

1997, **15**(3), 281–290

Development of urban housing policies in China

Chen, J J and Wills, D
Faculty of the Environment, The University of Greenwich, Oakfield Land, Dartford, UK

Housing in China has proved problematic for many years. Since economic reform started in the 1980s, urbanization has been a token of modernization, and consequently housing provision in urban areas has been a major social and economic issue. The major housing problem in China is the scarcity of supply of housing provision. This paper analyses the initial housing reform prior to 1993, and points out the reasons for the lack of success and the lessons drawn from it. It also studies the present reform programme from 1993, and highlights the problems associated with it. It shows that the housing reforms so far, while having moved away from a complete socialist provision of housing, have gone only a small part of the way to a free market in housing. The reforms have been proved disappointing. Although privatization of housing has been the major objective of housing reforms, the reforms are still focused on the rental sector. On the economics side, the rents are set below costs, and the link between the value that people place on housing and the cost to the country's economy has failed to be appreciated. On the management side, the critical shortcoming of the strategy is its inability to bring an end to the state-owned enterprise's direct obligations for employee housing. Several problems associated with the current reforms have also been identified, especially on the legal side.
Keywords: China, economic reform, privatization, state-owned enterprise, urban housing.

1997, **15**(3), 291–297

Note – Breaking up methodological monopolies: a multi-paradigm approach to construction management research

Raftery, J; McGeorge, D and Walters, M
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, Hong Kong. Department of Building, University of Newcastle, Newcastle, Australia

A note written in response to: Seymour D. and Rooke, J. (1995) The culture of the industry and the culture of research. *Construction Management and Economics* **13**, 511-23
Keywords: rationality, research, research method, social science, sociology.

1997, **15**(3), 299–302

Note – The role of theory in construction management research: comment

Runeson, G
School of Building, University of New South Wales, Sydney 2052, NSW, Australia

Seymour *et al.* claim that positivist research methods are unsuitable for research into construction management. On the contrary, mainstream methodology has been modified to deal with the special demands of such research and conventional research methods have been instrumental in substantial advances in science. Seymour *et al.*'s argument, ostensibly about research methods, is essentially anti-scientific, and, although it has been around for a long time, there are no positive achievements to suggest that we would benefit from adopting it. Contrary to Seymour *et al.*'s claims, positivist research methods are our best insurance against bad research.
Keywords: research method, methodology.

1997, **15**(4), 315–326

Financial management of planned maintenance for housing associations

Bowles, G[1]; Dagpunar, J S[2] and Gow, H[3]
[1]*Department of Building Engineering and Surveying, Heriot-Watt University, Edinburgh, EH14 4AS, UK*
[2]*School of Informatics, University of Abertay Dundee, Bell Street, Dundee, DD1 1HG, UK*
[3]*School of Construction and Environment, University of Abertay Dundee, Bell Street, Dundee, DD1 1HG, UK*

Since the Housing Act 1988, UK housing associations (HAs) have been responsible, with the removal of government grants, for funding all maintenance necessary for the upkeep of new stock over its lifespan. Sinking funds (SFs) have to be created, out of rental income, that are adequate to finance the long term projected maintenance demand. This paper reviews the use of SFs for building asset management with particular reference to the requirements being made of HAs. Current assumptions of what constitutes an adequate level of SF investment by their funding agencies are questioned with an analysis of case study data. Using linear-programming, the benefits of modelling an SF over merely calculating it are demonstrated. The technique is used to formulate SF strategies, some of which admit the possibility of going into deficit in the future, and these are compared with results from conventional SF projections. Finally, the effect that varying element and component lifespans can have on SF projections are investigated by using Monte Carlo methods to simulate profiles of long term maintenance expenditure, and observing how well funds projected with the original SF strategy match them. The results show the importance of reviewing regularly the SF policy in order that it remains relevant to the needs of the stock.
Keywords: housing association, linear programming, maintenance, simulation, sinking fund.

1997, **15**(4), 327–340

Assessment and evaluation of contractor data against client goals using PERT approach

Hatush, Z and Skitmore, R M
Department of Surveying, University of Salford, Salford, M5 4WT, UK
School of Construction Management, Queensland University of Technology, Brisbane Q4001, Australia

A methodology for assessing and evaluating contractor data for the purpose of prequalification and bid evaluation is presented. The PERT approach is used to develop a linear model for the assessment of contractor data. The model incorporates a multiple ratings permitting the uncertainty in contractor data to be evaluated. An empirical study investigating the importance of different contractor criteria is described. A lexicographical ordering with aspiration levels and risk analysis with sensitivity methods are used to evaluate and select or rank-order contractors against the main client goals of time, cost, and quality. A literature review is reported regarding client goals and current evaluation strategies. The assumptions, advantages and disadvantages of this work as well as an example are also presented.
Keywords: bid evaluation, client, contracting, PERT, pre-qualification.

1997, **15**(4), 341–348

Using a weighted score model as an aid to selecting procurement methods for small building works

Griffith, A[1] and Headley, J D[2]
[1]*School of Construction, Sheffield Hallam University, City Campus, Pond Street, Sheffield, S1 1WB, UK*
[2]*The John Lewis Partnership, St. James Centre, Edinburgh, EH1 1QJ, UK*

This paper focuses on the selection of procurement methods for small building works. While a range of procurement methods is needed to accommodate different types of small works, and procurement methods often are applied across different types, for any particular small works job (or group of jobs), there should be an optimum method of procurement. An optimum method is one that not only considers the characteristics of the small works in themselves, but also considersthe impact of the works upon the wider organization and its business operations. In doing so, the small works organization is assisted to deliver an efficient effective service which adds value to the client organization. The client, to bein a position to select the method of procurement that best meets a particular type of works, needs to consider the realistic measure of performance of each of the procurement methods which it could employ. This paper proposes the use of aweighted score model as an aid to selecting procurement methods for small building works. From this paper, client organizations should become more aware of the potential to select, with reliability and consistency over time, the optimum procurement method for a particular type of small works, given those criteria which they identify as being important at the time and in consideration of not only the characteristics of the small works themselves, but the works in the context of the organization's ongoing business.
Keywords: procurement method, small works.

1997, **15**(4), 349–361

A study of the growth-investment-financing nexus of the major UK construction groups

Punwani, A
Bartlett School of Graduate Studies, Philips House, University College London, Gower Street, London, WC1E 6BT, UK

This paper compares the relationship between growth, investment and financing of the contracting operations with that of the housebuilding operations in the large, diversified UK construction groups during the 1980s. A graphical presentation of a financial analysis of the contracting and housebuilding divisions' company accounts illustrates significant changes in the levels of capital investment and the sources and uses of finance of these two activities during a period of marked growth in turnover. It is established that the major contractors not only achieved significant growth in their turnover with negligible recourse to additional capital investment but in fact generated surplus funds which could be diverted into other businesses in their respective construction group's portfolio of business activities. It is shown that their 'cash-requiring' speculative housebuilding businesses relied on such intra-group funds as a main source of finance for investment in land during the 1980s.
Keywords: construction majors, contracting, growth, house building, investment.

1997, **15**(4), 363–369

An analysis of contractors' approaches to risk identification in New South Wales, Australia

Bajaj, D; Oluwoye, J O and Lenard, D
Faculty of Design, Architecture and Building, University of Technology, Sydney, PO Box 123, Broadway, NSW 2007, Australia

This study addresses the process of risk identification at the tendering and estimating stage, which is the first stage of the risk management process, and for the risk management process be of benefit and for the project objectives to be achieved, the risk identification stage should be very detailed and thorough. The aim of this study is to identify, investigate and evaluate the process of risk identification at the tendering and estimating stage for construction contractors in the NSW region. The data for this were collected during the months of December '94 and January '95 using a sample survey of a cross-section of 19 construction contractors, and the results were analysed using frequency distribution. The results show that the most frequently used methods of risk identification are the top-down approach techniques, where the project is analysed from an overall point of view. Techniques based on top-down approach lead to guesswork in terms of contingency for risks accepted by the construction contractors. Bottom-up risk identification techniques are not popular except for a questionnaire and checklist approach. Also, it was unlikely that the contractors would discussrisk allocation with the clients. All the contractors interviewed agreed that when a risk identification process is followed it improves the accuracy of their estimates.
Keywords: contracting, estimating, risk identification, tendering.

1997, **15**(4), 371–376

Note – Causal relationship between construction flows and output: evidence from Hong Kong

Tse, R and Ganesan, S
Department of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong

Granger causality methodology is used to investigate lead-lag relationships between construction activity and aggregate economy. Using data from Hong Kong, the results of this paper suggest strongly that the GDP tends to lead the construction flow not vice versa. Our finding is contrary to the view that construction is more volatile than the GDP. However, our results show that the construction volatility after 1990 is smaller than that in the period 1983-1989, a result that is particularly important for policymakers in that it is the macroeconomic policy of government that affects output, and influences the construction activity, and not vice versa.
Keywords: causation, GDP, Hong Kong, unit root test.

1997, **15**(4), 377–382

Note – Risk analysis for revenue dependent infrastructure projects

Songer, A D[1]; Diekmann, J E[1] and Pecsok, R[2]
[1]*Faculty of Civil, Environmental, and Architectural Engineering, University of Colorado CB 428, Boulder, CO 80309, USA*
[2]*Morrison Knudsen Inc., 700 15th Street South West, Auburn, WA 98002, USA*

Recent trends in the construction industry indicate continued use of alternative procurement methods such as design-build, construction management, build-operate-transfer, and privatization. Increased use of these evolving methods produces higher levels of uncertainty with respect to long term performance and profitability. The uncertainties inherent in implementing new procurement methods necessitate investigation of enhanced methods of pre-project planning and

analysis. This is particularly true for revenue dependent privatization projects such as toll roads. Poor initial performance of toll road projects suggests traditional methods of project analysis are inadequate. Sustaining investor and stakeholder support of privatized revenue dependent projects is dependent upon successful financial performance. Enhanced risk analysis tools provide improved information for pre-project decision making and performance outcome. One such risk analysis method is the Monte Carlo. Monte Carlo methods are especially useful in evaluating which of several uncertain quantities most significantly contributes to the overall risk of the project. This paper demonstrates a Monte Carlo risk assessment methodology for revenue dependent infrastructure projects.
Keywords: computer, Monte Carlo simulation, privatization, project finance, risk analysis.

1997, **15**(4), 383–385

Note – Rigour in research and peer review

Fenn, P
Department of Building Engineering, UMIST, PO Box 88, Manchester, M60 1QD, UK

This note discusses rigour in research and in the peer review of academic journals by examining current research into construction conflict and disputes. Comments are made on a paper by Alkass, S., Mazerolle, M. and Harris, F.C. (1996) Construction Management and Economics, 14, 375-94. The paucity of research in this field is discussed and the current literature is reviewed. The note concludes that: more work is required in this area; the lack of data is no excuse for subjective theorizing; basic rules of research must be complied with for research to retain its integrity; and the value of peer reviewed journals is reduced by the publication of papers which ignore these points.
Keywords: causation, conflict, dispute, methodology, research rigour.

1997, **15**(4), 387–398

Note – The ranking of construction management journals

Chau Kwong Wing
Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong

The quality of construction management journals is assessed using a questionnaire survey approach. Construction management is broadly defined to include studies of the human aspects of the construction process. Twenty-two journals related to construction management are identified. Questionnaires were sent to potential respondents by e-mail. Respondents were asked to assess the quality of the journals that they are familiar with. Although there is some evidence showing that respondents who are editorial board members or authors of a journal tend to give a slightly higher score to that journal, the relative ranking of the journals is not affected substantially by such tendency. Some statistically significant results on the ranking of the journals are obtained irrespective of the relatively small sample size compared with some surveys of other main stream journals.
Keywords: academic discipline, attitude survey, construction management, journal.

1997, **15**(5), 409–419

Organization and managerial environment of Korean construction industry

Kim, Sunkuk
Department of Architectural Engineering, Kyung-Hee University, Seocheon-ri, Kihung-eup, Yongin-si, Kyungki-do,449-701, Korea

In 1983, Korean construction contractors captured over 11% of the overseas market and twenty-five of them were listed in the top 250 international contractors. However, they have struggled against the inefficiency of their organizations, accelerating competition, and the rapid changes in the managerial environment. Although the various features of the environment had required variety in strategy and organization structure, the managers of construction firms have not kept pace with the requirement, but have shown an inability to predict what kind of influence the changes will have on their organizations and what kind of response is proper to the environmental changes they confront. These problems are mainly caused by a lack of under-standing of the suitability of their organization's structure and managerial environment. The present research shows that: the functional structure is the archetype of the Korean construction organizations; direction and delegation are the mainstream in corporate management; the critical factors for corporate management are accelerating competition, inconsistent government policy and the pressure of rising costs; and most of the contractors, except the top 5% large-sized firms, have little capability to respond to a new environment.
Keywords: Korea, managerial environment, organization structure, organizational life cycle.

1997, **15**(5), 421–428

Building economics research in PRC: a review

Lu Youjie and Zhang Qiang
Project Management Centre, Tsinghua University, Beijing 100084, People's Republic of China

Research in China into building economics is currently focused on the transition from a centrally planned economy to a market economy. Particular attention is being paid to the theoretical and practical issues arising from the economic reforms. Outside China, there is little known about the various organizations and individuals involved in this field. Their work is funded through the Ministry of Construction and the China National Science Foundation. It is difficult to

get commercial sponsorship for this kind of research. Research has focused upon such issues as the role of the construction industry in the national economy, the use of competitive tendering, price formation, urban housing, structuring of the industry and of firms, project management, expert systems and management information systems. There have been some notable successes in terms of building economics researchers influencing the way in which the construction industry is dealt with in China. Future research will be aimed at converting state enterprises to true companies and devising the means to deregulate the pricing of built facilities and construction services without disrupting the market.

Keywords: China, development, economic reform, research funding.

1997, **15**(5), 429–439

Economic evaluation of HVAC systems with ice storage designed using an optimization technique

Navon, R[1]; Arkin, H[2] and Berg, I[3]
[1]*Department of Civil Engineering, Technion City, Haifa 32000, Israel*
[2]*National Building Research Institute, Technion, Israel*
[3]*Institute of Technology, Technion City, Haifa 32000, Israel*

Thermal energy storage (TES) is recognized as an important technique for energy management in heating, ventilation and air conditioning (HVAC) systems. This paper discusses the economic aspects of the optimal design for such systems. The model for optimal design so determines the sizes of the main components of the system - namely the chiller and the storage tank - that the system's life cycle cost is minimal. The model is based on linear programming and is implemented in a computer program for HVAC systems with ice storage. This paper demonstrates that the optimal sizes of chiller and storage tanks differ from those selected using traditional techniques. It emphasizes the cost-effectiveness of the optimally designed system and also includes a sensitivity analysis pertaining to the economic feasibility of such systems under different economic conditions.

Keywords: design optimization, economic analysis, HVAC system, ice storage.

1997, **15**(5), 441–456

The financial structure and ethos of property companies: an empirical analysis

Barkham, R
Department of Land Management and Development, University of Reading, PO Box 219, Reading, RG6 6AW, UK

Property companies are a key group in the economy of the built environment. The entrepreneurs that run property companies are responsible for initiating development projects and managing them. The risk incurred by participants in the development process, such as banks and construction firms, is related not only to the risk of the project being undertaken but also to the financial risk associated with the property company that initiates and manages the project. This paper attempts to develop a taxonomy of property companies, for consideration by decision makers in the construction industry in assessing the risk of being involved in a project.

Keywords: finance, contractor, development, gearing, investment.

1997, **15**(5), 457–467

Construction project teams for TQM: a factor-element impact model

Ahmad, I U[1] and Sein, M K[2]
[1]*Department of Construction Management, Florida International University, Miami, FL 33199, USA*
[2]*Department of Information Systems, Agder College, Kristiansand, Norway and Department of Computer Information Systems, Georgia State University, Atlanta GA 30302, USA*

The factor-element impact model is a normative, theory-based contingency model. It is concerned with iden-tifying the factors that affect the success of total quality management (TQM) initiatives in construction projects. This model is based upon organizational theory, utilizing an interactionist view of organizational design. If TQM is to succeed, construction project teams should be formed with its implementation in mind. The most important factors influencing the success of particular project team configurations are project char-acteristics. Organizational characteristics of participating firms are also significant. The contingency model developed in this paper involves an iterative approach of designing construction project teams to minimize negative effects on TQM. Guidelines are offered on how to apply the model, and two scenarios are presented to illustrate its application.

Keywords: normative model, organization theory, project team, total quality management.

1997, **15**(5), 469–489

The effect of contract type and size on competitiveness in bidding

Drew, D S[1] and Skitmore, R M[2]

[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*

[2]*School of Construction Management, Queensland University of Technology, Gardens Point, 2 George Street, GPO Box 2434, Brisbane Q 4001, Australia*

Multiple regression is used to construct a prediction equation relating bidder competitiveness (the depen-dent variable) to the independent variables of bidder, contract type and contract size. The regression model shows that differences in contractor competitiveness are greater for different contract sizes than for different contract types. The most competitive contractors appear to be those with a preferred contract size range. Such a model can be used as part of amore systematic approach in prequalifying contractors. It may also be used by contractors as a basis for assessing bidding performance.

Keywords: bidding, competitiveness, contractor selection, regression analysis analysis.

1997, **15**(5), 491–494

Note – Preserving methodological consistency: a reply to Raftery, McGeorge and Walters

Rooke, J D; Seymour, D E and Crook, D

School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

Raftery, J., McGeorge, D. and Walters, M. (1977) Construction Management and Economics, 15(3), 291-297, criticise Seymour, D.E. and Rooke, J.A. (1995) Construction Management and Economics 13(6), 511-523 for setting out battle lines in their use of the terms rationalist and interpretive paradigms and argue that such dichotomies lead to a degeneration in research standards. Sharing their concern for research standards, in reply, we argue that Raftery et al.'s plea formethodological liberalism will itself undermine standards. Different research methods are required for different research purposes and are to be evaluated according to different criteria. These criteria must be made explicit. We state our own research purposes and make an initial attempt to set out some criteria against which we would wish our own research to be judged.

Keywords: methodological debate, research methodology, research paradigm.

1997, **15**(6), 505–512

At the cutting edge: conflict avoidance and resolution in the US construction industry

Stipanowich, T J

William L. Matthews, Jr. Professor of Law, University of Kentucky College of Law, Law Building, Lexington, KY 40506-0048, USA

The American Arbitration Association (AAA) has undertaken a number of reforms to the dispute resolution process, engendered by the 'quiet revolution' of alternative dispute resolution (ADR) and its impact upon traditional arbitration mechanisms. This paper appraises the procedural changes which relate to the three distinct schemes: Fast Track Rules, Regular Track Rules, and Large Complex Case Rules; it also looks at parallel progress in mediation and partnering. The author concludes that the US construction industry has undergone, and continues to undergo, a transition from private adjudication, such as arbitration, through the 'settlement-oriented interventions' of ADR to more comprehensive approaches, as exemplified by partnering.

Keywords: alternative dispute resolution, arbitration, dispute resolution, partnering, USA.

1997, **15**(6), 513–518

Conflict and dispute in construction

Fenn, P[1]; Lowe, D[1] and Speck, C[2]
[1]*Department of Building Engineering, UMIST, POBox 88, Manchester, M60 1QD, UK*
[2]*Barrister at Law, Manchester, M3 7SF, UK*

'Conflict' and 'dispute' are two distinct notions. The conceptual difference between the two is explored and further reviewed through the literature on conflict and dispute in the field of construction; a taxonomy for future study is also introduced. Conflict, it is proposed, exists wherever there is incompatibility of interest, and therefore is pandemic. Conflict can be managed, possibly to the extent of preventing a dispute resulting from the conflict. Dispute is associated with distinct justiciable issues. Disputes require resolution. This means that they can be managed: the process of dispute resolution lends itself to third party intervention. The construction industry and the chemical process industry in the UK are compared, through perceptions and experiences of conflict and disputes arising from their two sets of standard contract forms. The methodology is a review of published cases and a survey conducted among professionals with experience. The paucity of research in this field is discussed and the empirical work on the causes of conflict and dispute is reviewed. It is concluded that effective management of conflicts and disputes would be furthered by separating the two fields, and particularly by applying a more stringent structuring.
Keywords: chemical industry, conflict, dispute, standard-form contract, taxonomy.

1997, **15**(6), 519–526

Perceptions of alternative dispute resolution as constraints upon its use in the UK construction industry

Brooker, P[1] and Lavers, A P[2]
[1]*School of Social Sciences and Law, and* [2]*School of Real Estate Management, Oxford Brookes University, Headington, Oxford, OX3 0BP, UK*

Attitudes to alternative dispute resolution (ADR) among contractors and sub-contractors/specialists in the UK construction industry are analysed on the basis of an extensive survey. Positive attitudes contrasted ADR with litigation and arbitration in terms of cost, delay and damage to working relationships through confrontation. The study also examined negative perceptions of ADR which may reduce its appeal and explain its limited use to date. These include a fear that lawyers may 'colonize' ADR and that its non-binding quality may prove a deficiency. It is concluded that these perceptions will be influential in determining the extent to which ADR is used in construction disputes.
Keywords: alternative dispute resolution, arbitration, dispute resolution, litigation.

1997, **15**(6), 527–537

Resolution of disputes arising from set-off clauses between main contractors and sub-contractors

Kennedy, P[1]; Morrison, A[2] and Milne, D O[3]
[1]*Department of Building and Surveying, Glasgow Caledonian University, Glasgow, G4 0BA, Scotland, UK*
[2]*Faculty of Architecture, University of Newcastle, Callahan, Newcastle, New South Wales, Australia*
[3] *BWS International Construction Consultants, 56 Sheep Street, Northampton, UK*

Set-off relates to the situation where a main contractor raises a counterclaim against a sub-contractor's claim or where an employer raises a counterclaim against the main contractor. The alternative terms cross claim, counterclaim, contra charge, compensation and retention are explained in the context of Scots law. Set-off in the construction industry in Scotland is then discussed within the contractual frameworks upon which main contractors are entitled to exercise such rights and how these conditions of contract have been formed over recent years. A study reported shows the extent of the use of amended and unamended forms of sub-contract and main contractors' own forms of sub-contract which imposed more onerous set-off conditions than the standard forms, the reasons given by main contractors for exercising their rights of set-off, the level of satisfaction amongst sub-contractors with the sums set-off against them, the means by which main contractors and sub-contractors settled disputed set-offs, and sub-contractors' reasons for accepting unsatisfactory instances of set-off. The research was undertaken using a questionnaire to a stratified sample of sub-contractors throughout central Scotland in 1995. Forty-seven sub-contractors responded to the questionnaire and 427 instances of set-off were recorded. The study indicated that, despite the considerable protection given to sub-contractors in the standard forms of sub-contract and in common law, they were prepared to settle set-offs with which they were dissatisfied without initiating contractual proceedings which would have improved their situation. It would appear from this study that sub-contractors are reluctant to use their contractual entitlements either because of fears over the costs of disputing set-offs or because they fear that they will be denied opportunities to tender for work in the future. Until there is a culture shift in the industry, reliance on contractual conditions alone may be inadequate to meet the needs of sub-contractors.
Keywords: adjudication, conflict, counterclaim, dispute, set-off, sub-contracting.

1997, **15**(6), 539–548

Amicable dispute resolution in the People's Republic of China and its implications for foreign-related construction disputes

Chan, E H W

Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

A combined mediation/arbitration process is unique to the People's Republic of China (PRC). This paper looks at how this amicable, out-of-court dispute resolution system works if the dispute is foreign-related, as defined under the Foreign Economic Contract Law. First, it outlines Chinese culture and its relation to the PRC legal framework and also to the amicable dispute resolution system discussed. Second, the system is appraised in the context of the uncertainty of the local judicial system. Third, distinctive features of domestic and foreign-related dispute resolution mechanisms are discussed by comparison with international practice. Finally, the amicable dispute resolution system for resolving construction disputes and its enforcement mechanisms are analysed, with statistical data to explain their implications for foreign investors in the construction industry of the PRC.

Keywords: alternative dispute resolution, arbitration, award enforcement, China, construction dispute.

1997, **15**(6), 549–558

Statutory reform of aspects of construction law in Australia

Bick, P

Department of Law, University of Wales, Penglais, Aberwystwyth, Dyfed, SY23 3DY, UK

Construction contract law in the common law world is largely free of direct statutory intervention. The agenda of calls within the United Kingdom to remedy major defects in construction law is used as a framework in a series of comparisons with recent legislation and practice in Australia, notably in Victoria where a holistic approach to the industry's problems has been adopted with signal success. It is suggested that policy makers in the UK consider what Commonwealth jurisdictions have to offer to the solution of home-grown problems.

Keywords: Australia, consumer protection, construction law, Housing Grants Construction and Regeneration Act 1996, Latham, post-construction liability.

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1998, **16**(1), 5–16

A study of controlling the activity interval time in LOB scheduling

Ching-Hwang Wang and Yuh-Jiun Hwang
Department of Construction Engineering, National Taiwan Institute of Technology, Taipei, Taiwan, ROC

A new scheduling method is presented in this paper which overcomes the inability of the line of balance(LOB) method to control the interval times between adjacent activities in a repetitive construction unit. The interval times areanalysed and then expressed as functions of the number of repetitive construction units, the difference between construction times of adjacent activities and the sequence of repetitive construction units. In order to overcome the LOB problem, this paper presents a new scheduling method, the multistage linear scheduling (MLS) method, based on the concept of a multistage decision process. With the MLS method, the project's completion time is smaller or equal to that estimated with the LOB method. The sum of construction times of each activity in all units is the same as that estimated with the LOB method. However, no interval times are generated. The adjacent activities in a repetitive construction unit can progress continuously (not allowed under the LOB method). Therefore, the MLS method can be used to schedule a repetitive project which has necessary practical constraints on the interval times. This results in the retention of construction quality, safety and efficiency.
Keywords: interval time, line of balance, repetitive construction, scheduling.

1998, **16**(1), 17–29

Contributors to construction delays

Mohan M Kumaraswamy, and Daniel W M Chan
Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong

Projects can be delayed for a large number of reasons. The third phase of an investigation into such factors focused on the causes of construction delays in Hong Kong. A questionnaire was based on 83 factors identified in previous phases of the investigation. Analysis of the responses reveals differences in perceptions of the relative significance of factors between clients, consultants and contractors. There was general agreement about the relative importance of delay factors such as unforeseen ground conditions. Improving productivity is a useful approach to controlling delays. Important factors affecting productivity itself are thus examined in more depth, with a view to enhancing productivity and reducing delays. The conclusions of this phase of the investigation include a ranking of factors and factor categories that are perceived by different groups of project participants to contribute to delays. For example, higher-ranking factors, such as unforeseen ground conditions, and factor categories such as project-related factors, are found to merit special management attention in countering construction delays. The high degree of disagreement as discerned between the groups of clients, consultants and contractors is indicative of their experiences, possible prejudices and lack of effective communication. It is also confirmed that productivity and other non-scope factors such as effective communications should supplement the project scope factors incorporated into the construction time prediction models that were proposed in the previous phases of this investigation.
Keywords: delay, Hong Kong, productivity, project management, time.

1998, **16**(1), 31–39

Risk management in the insurance industry: insights for the engineering construction industry

Malik Ranasinghe
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260

A probabilistic framework is developed to analyse a risk management approach adopted by an insurance firm. The analysis shows that when the insurance firm classifies a client as 'superior' and 'most acceptable', the probability of the insurer having to pay out on those claims is negligible. Even for a policy that is classified as 'acceptable', the highest probability of a claim is only 12%. When the probability of a claim is over50%, the client is considered to be 'unacceptable' for an insurance policy. Based on that analysis, the insights that the engineering construction industry can gain from risk management in the insurance firm with respect to project duration and cost are highlighted. It is shownthat, in responding to risks and uncertainty, the engineering construction industry should not allocate contingency at a predetermined probability of success for global variables such as project cost or duration as suggested in the literature, but at the input level. It is suggested that the predetermined probability of success value to allocate contingency at the input level should be at least 70%. Then, the contingency available for project cost and duration can ensure a high probability of success in the completion of the project.
Keywords: contingency, engineering construction, insurance, risk management, target cost.

1998, **16**(1), 41–48

Estimating project and activity duration: a risk management approach using network analysis

Nashwan N Dawood

Division of Civil Engineering and Building, School of Science and Technology, The University of Teesside, Middlesborough, TS1 3BA, UK

Variations in the duration of activities are commonplace in the construction industry. This is due to the fact that the construction industry is influenced greatly by variations in weather, productivity of labour and plant, and quality of materials. Stochastic network analysis has been used by previous researchers to model variations in activities and produce more effective and reliable project duration estimates. A number of technique shave been developed in previous literature to solve the uncertain nature of networks, these are: PERT(program evaluation and review techniques), PNET (probabilistic network evaluation technique), NRB,(narrow reliability bounds methods) and MCS (Monte Carlo simulation).Although these techniques have proved to be useful in modelling variations in activities, dependence of activity duration is not considered. This can have a severe impact on realistically modelling projects. In this context, the objective of the present research is to develop a methodology that can accurately model activity dependence and realistically predict project duration using a risk management approach. A simulation model has been developed to encapsulate the methodology and run experimental work. In order to achieve this, the following tasks are tackled: identify risk factors that cause activity variations using literature reviews and conducting interviews with contractors; model risk factors and their influence on activity variations through conducting case studies and identifying any dependence between them; develop a computer based simulation model that uses a modified Monte Carlo technique to model activity duration and dependence of risk factors; and run experimental work to validate and verify the model.

Keywords: Monte Carlo simulation, network analysis, stochastic analysis, PERT.

1998, **16**(1), 49–51

Effectiveness of safety management strategies on safety performance in Hong Kong

Tam, C M and Fung, I W H

Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong

This research describes a study of safety attitudes, practices and characteristics of construction firms in Hong Kong and their relationship to safety performance on construction sites. Forty-five construction companies are compared and studied. Each adopts different safety management strategies. The 45 companies were composed of 11 small, 25 medium and 9 large-scale construction firms. Construction firms' safety performance is measured by site casualty rates. Based upon the information collected from the survey, the accident rates are first derived and compared with the industrial norms. Then the following safety measures, and strategies of contractors in Hong Kong and their associated safety performance, are compared: involvement of top management in safety management; safety orientation programmes for new workers; safety awards or incentive schemes; use of post-accident investigation systems; safety training schemes; safety committees; level of sub-contracting. The first part of the research studies the relation between these measures and the safety performance using a number of tables. The results show that these practices have indeed improved site safety. The second part uses a multiple regression analysis to study the combined effect of these schemes and practices on safety performance. The study concludes that the provision of safety training, the use of directly employed labour, the use of post-accident investigation as a feedback, and promoting safety practices by safety award campaigns and incentive schemes, are the most effective tool in mitigating site casualties.

Keywords: Hong Kong, safety, sub-contracting, training.

1998, **16**(1), 57–69

A knowledge-based system for assessing applications for house renovation grants

Brandon, P S[1] and Ribeiro, F L[2]

[1]*University of Salford, Research and Graduate College, Salford, M5 4WT, UK*

[2]*Technical University of Lisbon, Colina do Sol, Travessa Isabel Aboim Inglês No 1, 11 Direito, Brandoa, 2720 Amadora, Portugal.*

This research is concerned with the development of a knowledge-based expert system for supporting human experts in assessing applications for the house renovation grant system. The development of the system followed the task structure analysis and the client-centred approach. The task structure analysis describes the system at knowledge level in terms of tasks, problem-solving methods and knowledge types. The implementation of the system followed the client-centred approach. The resulting system implements a frame-work that integrates case-based reasoning, abductive assembly, decomposition and associative methods. In addition, this framework combines different types of knowledge, which are required by the problem-solving methods. The implementation was carried out together with verification and validation, making it possible to have the system more valid after each stage of the client-centred approach. The system has demonstrated that various problem-solving methods are required for performing the different tasks of the

assessment of application for the house renovation grant system. Therefore the system has proved to perform as accurately as human experts do for all of the tasks.
Keywords: case-based reasoning, housing, knowledge-based system.

1998, **16**(1), 71–78

Implementing a waste management plan during the construction phase of a project: a case study

McDonald, B[1] and Smithers, M[2]
[1]*Fletcher Construction Australia Limited, Level 2, East Tower, 40 City Road, Sth Melbourne, Victoria 3205, Australia*
[2]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*

The construction industry in Australia contributes approximately 15%, by volume, of all solid waste disposed in landfills each year. Similar volumes have been recorded in other countries. The Australian government, in common with many other countries, has legislation in place to reduce landfill requirements by 50% by the year 2000. As part of this programme an Australian division of a multinational construction company has developed a company policy with the aim of managing waste generated on site and, thereby, reducing the amount deposited in landfill sites. The programme has been supported by the Victorian Recycling and Resource Recovery Council. The first implementation of this policy was at the Dandenong Police and Court Complex in Melbourne. The effects of the programme have been compared against a similar project built concurrently. The results of the trial revealed substantial savings. A total volume of 15% less waste was generated on site prior to recycling and 43% less waste went to landfill. Cost savings of 50% were made in terms of waste handling charges. The savings resulted almost entirely from site based strategies for handlingwaste.
Keywords: landfill, recycling, waste audit.

1998, **16**(1), 79–90

Planned and unplanned schedule compression: the impact on labour

Noyce, D[1] and Hanna, A[2]
[1]*Department of Civil Engineering, Texas A and M University System, College Station, TX 77843, USA*
[2]*Department of Civil and Environmental Engineering, University of Wisconsin-Madison, Madison, WI 53706, USA*

Constructors confronted with the need to compress or accelerate a construction schedule face the potential for extreme difficulties. Unfortunately, a limited knowledge base exists for determining the techniques, methods, or concepts to be employed in mitigating these potential negative outcomes of lower labour productivity rates and higher project costs. This paper explores the impacts of planned and unplanned schedule compression on labour productivity. Additional impacts of schedule compression related to project costs and schedule duration are also evaluated. Telephone interviews and questionnaire surveys primarily were used as the means for data collection to determine which methods of schedule compression identified are most effective in each of the aforementioned areas. Members of the National Electrical Contractors Association(NECA) were used as the data source for this investigation because of their diversified experience and because of the support received from NECA management. A number of schedule compression methods are presented that have been shown to be effective.
Keywords: duration, labour, productivity, project cost, schedule, schedule acceleration.

1998, **16**(1), 91–98

A needs-based methodology for classifying construction clients and selecting contractors

Chinyio, E A; Olomolaiye, P O; Kometa, S T and Harris, F C
School of Engineering and The Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

Clients' needs are inadequately evaluated in project schemes. Without a precise establishment of clients' preferences, the essential criteria for project implementation and especially contractor evaluation cannot be appreciated fully. It is not surprising therefore that subjective decisions have prevailed in tender evaluations and clients' needs have not been satisfied completely. Objective contractor evaluation will be realized only when clients' needs and contractors' capabilities can be quantified and matched reliably. The methodology described herein rests on identifying clients' needs preferences as comprehensively as possible at project inception and progressing to identifying contractors who cansatisfy them optimally; relying on 'multidi-mensional scaling' and 'cluster analysis' techniques. The investigations suggest that clients' project needs are not along the traditional classifications of private, public and developer clients; a reclassification of clients into five needs-based groups is proposed. A new contractor evaluation methodology matching client satisfaction to attainment of established needs in project schemes has been developed for bidding purposes.
Keywords: bidding, briefing, client, tender evaluation.

1998, **16**(1), 99–104

Note – The baby and the bathwater: research methods in construction management

Chau Kwong Wing[1]; Raftery, J[1] and Walker, A[2]
[1]*Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong.*
[2]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hunghom, Hong Kong*

A note written in response to: Seymour, D., Crook, D. and Rooke J. (1997) The role of theory in construction management: a call for debate, Construction Management and Economics, 15, 117-19.This note is written in response to Seymour, D., Crook, D. and Rooke, J. (1997) Construction Management and Economics, 15(1), 117-19. We argue against their narrow focus on the interpretative approach. Also, Seymour et al. are incorrect in implying that the 'rationalist approach' is necessarily quantitative. Our contention is that the choice of research approach in construction management depends on the nature of the problem. However, whatever choice of approach is adopted, it is important that the problem and associated key concepts are defined clearly and that the methods used, underlying assumptions and limitations are transparent and defensible. It is difficult to argue in favour of any single approach based purely on epistemological grounds as what constitutes knowledge is still an unsolved philosophical issue. Since construction management is a practical subject, we suggest that the choice of approach should be a pragmatic one: the approach that is likely to generate practical solutions should be adopted. Seymour et al.'s suggestion serves only to limit our choice of research tools. Furthermore, a lot of the research issues in construction management are practical problems which involve generalization of experience and formulation of hypothesis that can generate empirically testable implications. For problems of this nature, testability of hypothesis and reproducibility of results are important, and the naturalist approach (which is labelled 'rationalist paradigm' in Seymour et al.) of discovering causal relationship is more likely to produce general practical solutions. However, this does not deny the value of the interpretative approach, as it may be more suitable for certain types of problem. Moreover, in practice, an understanding of human behaviour 'from within' often provides useful insights for formulation of empirically testable hypotheses, despite the philosophical incompatibility of the interpretative and naturalist approaches.

Keywords: epistemology, interpretive approach, research method.

1998, **16**(1), 105–108

Practices, barriers and benefits of risk management process in building services cost estimation: comment

Edwards, P A[1] and Bowen, P A[2]
[1]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, GPO Box 2476V, Melbourne 3000, Victoria, Australia*
[2]*Department of Construction Economics and Management, University of Cape Town, South Africa*

This note is a comment on Mok, C.K., Rao Tummala, V.M. and Leung, H.M. (1997) Practices, barriers and benefits of risk management process in building services cost estimation, Construction Management and Economics, 15(2), 161-75, which describes research into the risk perceptions and risk management practices of building services engineers in Hong Kong. The note questions statements made in the paper and parts of the research design and data analyses.

Keywords: cost, estimating, risk management, survey research.

1998, **16**(1), 109–112

The role of theory in construction management: reply to Runeson

Seymour, D E; Rooke, J D and Crook, D
School of Civil Engineering, University of Birmingham, Birmingham, B15 2TT, UK

In his comment on Seymour, D.E., Crook, D.J. and Rooke, J.A. (1997) Construction Management and Economics, 15, 117-19 (Construction Management and Economics, 15, 299-302) argues that positivism provides the best insurance against bad research in construction management studies. He claims that positivist methods of theory building have been modified sufficiently to cope with the demands of management research. He accuses Seymour et al. of being anti-scientific in questioning the viability of these methods. In this short reply, we refute these assertions, pointing out some remaining obstacles to the application of positivist methods to management research.

Keywords: management theory, positivism, research methodology, research paradigm.

1998, **16**(1), 113–116

Why research without theory is not research: a reply to Seymour *et al.*

Harriss, C
School of Construction & Building Sciences, University of Western Sydney, Quakers' Hill, NSW 2763, Australia

Construction management researchers have for too long ignored the centrality of theory to human activity. A simple analogy from everyday life, the quest for a suitable life partner, will demonstrate that all productive action depends on

theory if it is to be shared and form a worthwhile addition to the body of knowledge. This analogy provides a useful introduction to the philosophy of science, and a criticism of those who propose a non-scientific approach to construction management research.

Keywords: philosophy of science, scientific paradigm, sex.

1998, **16**(2), 131–137

The role of logistics in the materials flow control process: experiences from abroad

Agapiou, A[1]; Clausen, L E[2]; Flanagan, R[3]; Norman, G[4] and Notman, D[4]

[1]*Faculty of Architecture, Building and Planning, University of Melbourne, Parkville, Melbourne, Victoria 3052, Australia*

[2]*Materials and Structures Division, Statens Byggeforskningsinstitut, PO Box 119, Dr. Neergaards Vej 15, DK-2970, Hørsholm, Denmark*

[3]*Department of Construction Management & Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 6AW, UK*

[4]*Department of Economics, University of Edinburgh, William Robertson Building, 50 George Square, Edinburgh, EH8 9JY, UK*

Frequently, the supply of building materials to the construction site is fraught with difficulties that can have a significant effect on productivity. Major productivity gains are possible, particularly if the building process is planned from a logistics perspective. The concept of logistics was developed initially within the manufacturing industry, and now constitutes an important management tool to ensure an overall strategic perspective on the flow of materials in the production process. This paper contends that logistics are relevant also to the construction industry, and describes the development of a logistics model to manage the flow of materials from suppliers to installation on-site and its application to a Danish house building project. The case study evidence suggests that the primary focus of the logistics concept in construction is to improve co-ordination and communication between project participants during the design and construction phases, particularly in the materials flow control process. The logistics concept requires accurate scheduling of materials to programmed delivery dateskeyed to actual site layout and storage arrangements. The logistics approach also involves a new role for materials suppliers, including early involvement in the design phase and overall responsibility for the flow of information relating to materials.

Keywords: Denmark, flow control, house building, logistics, material.

1998, **16**(2), 139–140

Note – Rigour in research and peer-review: a reply

Alkass, S[1]; Mazerolle, M[2] and Harris, F C[3]

[1]*Centre for Building Studies, Concordia University, 1455 de Maisonneuve Blvd W, Montreal, H3G 1M8, Canada*

[2]*CANAC International Inc., 1100 University, Montreal, H3B 3W7, Canada*

[3]*School of Engineering and Built Environment, University of Woverhampton, UK*

Discussion and constructive criticism of research work when based on facts and sound scientific arguments are good practice which not only enrich research work but potentially improve the findings. For these reasons, they should be encouraged. However, when discussions are put forward out of ignorance for the sake of criticism to attack the integrity of some particular research, and to that matter the integrity of its researchers and the reviewers' ability to judge researchers' contributions, then it not only becomes dangerous but is on the verge of being irresponsible. This should not go unchallenged. This note addresses the issues brought forth in Fenn, P. (1997) Construction Management and Economics, 15(4), 383-5.

Keywords: delay analysis, research method, project management.

1998, **16**(2), 141–145

Sustainable construction: comment

Ofori, G

School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 118418

Hill and Bowen (*Construction Management and Economics*, **15**: 223-39) discuss the evolution of the concepts of 'environmentalism' and 'sustainability', highlighting their importance in today's context. They relate these concepts, especially the latter, to construction, and provide a framework for environmental management in the construction process. This is a comment on the contents of Hill and Bowen, and endorses their stress on the importance of environmental considerations in the construction process. The paper suggests that other areas relating to the subject of sustainability in construction also require attention, and highlights, in particular, the need to take cognisance of the perspective of developing countries.

Keywords: developing country, progress, sustainable construction.

1998, **16**(2), 147–157

Model for forecasting construction cost indices in Taiwan

Ching-Hwang Wang and Yong-Ho Mei
Department of Construction Engineering, National Taiwan Institute of Technology, Taipei, Taiwan, ROC

A new approach to the forecasting of construction cost indices in Taiwan is presented. Construction cost indices have always been used to assess the variations in construction labour and material costs. These indices have been traditionally based on historical statistical information in Taiwan. However, the indices fall short in forecasting the future cost trends in the construction industry. By investigating the characteristic data that make up the construction costindices, the major determining factors were identified as (1) 'the number of difference', (2) the required periods of preceding construction cost indices, (3) the weight associated with each preceding construction cost index, (4) the mean value of the series of construction cost indices that have been converted into a stationary series, and (5) the estimation of the errors between the predicted values of construction cost indices and the observed values of construction cost indices. An analytical model has been established to forecast the present and future construction cost indices based on these factors, and its feasibility tested by using the observed data of the construction cost indices obtained from the Executive Yuan of the Republic of China. The results suggest that this model is reasonably adequate in forecasting the trend values of construction cost indices in Taiwan.
Keywords: cost index, forecasting, modelling, Taiwan

1998, **16**(2), 159–175

Macro-economic leading indicators of construction contract prices

Akintoye, A; Bowen, P A and Hardcastle, C
Department of Building and Surveying, Glasgow Caledonian University, Glasgow, G4 0BA, UK

An understanding of future trends in construction prices is likely to influence the construction investment strategy of a variety of interested parties, ranging from private and public clients to construction contrac-tors, propertyspeculators, financial institutions, and construction professionals. This paper derives leading indicators for construction prices in the United Kingdom. These indicators are based on two experimental methods: turning points of the basic indicators in relation to construction price turning points; and predic-tive power of lags of the basic indicators. It is concluded, based on the analyses, that unemployment level, construction output, industrial production, and ratio of price to cost indices in manufacturing are consistent leading indicators of construction prices. Building cost index and gross national product constitute coincident indicators. 'Popular' macro-economic time series such as nominal interest rate, inflation rate, real interest rate, all share index and money supply produced inconclusive results. © E & F N Spon 1998
Keywords: forecasting, macro-economic variables, price, tender price index, time series.

1998, **16**(2), 177–192

Obstacles to implementing total quality management in the UK construction industry

Shammas-Toma, M; Seymour, D E and Clark, L
School of Civil Engineering, The University of Birmingham, UK

Since at least the Tavistock studies, the need to improve communication and coordination in the construction process has been stressed. This paper reports from a study of 25 construction projects where QA and a number of procedureswere in use which might have been expected to bring such improvement. The finding was, however, that coordination was poor. The purpose of the paper is to consider how this finding is to be explained. With reference to the markets/hierarchy theoretical framework, it is proposed that the use of this and other similar frameworks in fact obscures the empirical reality which they are intended to explain. It is accepted that the meta-language which such frameworks supply may enable researchers and those practitioners who choose to use this language to share their interests and concerns. However, the relationship between the abstract and global concepts which feature in such talk and the reality to which they refer needs closer enquiry. This paper proposes that our knowledge of the impact of QA has been compromised by the lack of such attention. The paper then inspects the global proposition that QA has been a step in the right direction towards TQM. With the aim of giving this proposition a stronger empirical referent, six key principles of TQM are used as a benchmark against which to assess the significance of the empirical data drawn from the study. It is proposed that greater attention to such data is necessary to provide a sounder basis for establishing what needs to be done to stimulate change.
Keywords: concurrent engineering, lean construction, market hierarchy, process re-engineering, sub-contracting, total quality management.

1998, **16**(2), 193–207

Towards total project quality: a gap analysis approach

Winch, G; Usmani, A and Edkins, A
Bartlett School of Graduate Studies, University College London, Gower Street, London, WC1E 6BT, UK

This paper presents a critique of existing approaches to the management of projects and the definition of project success, arguing that these are both fragmented and fail to place the client at the centre of the process. In this critique, the paper focuses on quality management, and places the minimization of client surprise at the heart of the assessment of project

success. As an alternative, a gap analysis approach, derived from the service quality management literature, is developed which, it is argued, provides a better way of under-standing the challenge of managing projects. The model is then applied empirically to the Glaxo project, the largest building project in the UK in recent years. The Glaxo project was remarkably successful, and the lessons can be learned well through the perspective of the gap analysis model. In conclusion the paper concludes that quality on construction projects is a negotiated order, and that design reviews are the principal means by which this order is negotiated.
Keywords: client satisfaction, gap analysis, Glaxo, project management, quality.

1998, **16**(2), 209–219

Evaluation of project outcomes

Liu, A and Walker, A
Department of Real Estate and Construction, University of Hong Kong, Pokfulam Road, Hong Kong

The evaluation of the outcome of construction projects has been the subject of unresolved debate for many years. This paper argues that previous views have tried to find a simple solution to a complex problem. The complexities of the issues which underlie the evaluation of project outcomes are derived from project goals, participants' behaviour and the performance of project organizations. Earlier studies did not recognize the manner by which individuals' perceptionsof project outcomes were influenced by the range of factors in each person's perception. A model is constructed with two levels of outcome developed from the fundamental behaviour-to-performance-to-outcome (B-P-O) cycle in industrial/organizational psychology. It is postulated that the valence of the first-level outcome (project success) is dependent on the instrumentality relating to the second-level outcome (participant satisfaction). The identification of factors of influence, such as self-efficacy, project complexity, commitment, expectancy, rewards, goals and environmental variables, are shown to be fundamental in understanding an individual's perception of the merit of the outcome of a project.
Keywords: evaluation, outcome, performance, success, satisfaction.

1998, **16**(2), 221–233

Selecting a suitable procurement method for a building project

Love, P E D[1]; Skitmore, R M[2] and Earl, G[2]
[1]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*
[2]*School of Construction Management, Queensland University of Technology, Brisbane, Queensland 4000, Australia*

Building procurement has become a fashionable term with industry practitioners and researchers. It deter-mines the overall framework and structure of responsibilities and authorities for participants within the building process. Itis a key factor contributing to overall client satisfaction and project success. The selection of the most suitable procurement method consequently is critical for both clients and project participants, and is becoming an important and contemporary issue within the building industry. The problem, nevertheless, lies in the fact that there has been limited empirical research in this field of study. Postal questionnaire surveys of 41 clients and 35 consultants were carried out, and were used to obtain experience of and attitudes to a variety of procurement methods and the criteria used for selection. The findings indicate that a simple set of the criteria generally is adequate and sufficient for procurement path selection, and that there is a reasonable consensus on the appropriate weighting for each path. Moreover, it is shown that, contrary to expectations, similar clients generally do not have similar procurement needs.
Keywords: client needs, procurement.

1998, **16**(2), 235–244

An application of the risk management process (RMP) in capital investment decisions for an EHV transmission line construction project

Burchett, J F[1] and Tummala, V M R[2]
[1]*Network Development Department, China Light & Power Company Ltd, Kowloon, Hong Kong*
[2]*Department of Manufacturing Engineering, City University of Hong Kong, Kowloon, Hong Kong*

This paper reviews the viability of applying a risk management process to enhance capital investment decisions, when planning the construction of an extra-high voltage (EHV) overhead transmission line project that could be designedand built in the next 10 years by China Light & Power Company Limited, Hong Kong. Different project proposals will be considered for this transmission line as well as different completion dates. Each scenario will be investigated to determine the rate of return and expected cost to customer, using the net present value model. The lowest 'cost to customer' approach would be the normal criterion for project selection, assuming all proposals are technically viable and compatible with Hong Kong Government infrastructure plans.
Keywords: capital investment, decision analysis, EHV transmission line, risk management.

1998, **16**(3), 257–267

Hierarchical indices for measuring the effectiveness of construction automation implementation

Ching-Hwang Wang[1], Mei-Wei Wang[2] and Yu-Chun Huang[3]
[1]*Department of Construction Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan, ROC*
[2]*Department of Banking and Insurance, National College of Business, Taipei, Taiwan, ROC*
[3]*Department of Architecture, Hwa Hsia College of Technology and Commerce, Taipei, Taiwan, ROC*

The construction industry in Taiwan is reaching the turning point of industry upgrade and is confronted by such problems as slow productivity growth; increases in labour costs, and awareness of environmental protection requirements. In addition, Taiwan is vigorously preparing to join the World Trade Organization (WTO), and the Agreement on Government Procurement will be signed. Then the market of local public works will be able to be opened. After Taiwan has joined the WTO, local contractors will no longer enjoy special protection, and will compete with foreign contractors on equal grounds. To address these problems, Taiwan is launching the first phase of a construction automation plan (1990-2000), trying to assist local contractors in boosting their global competitiveness through automation. This paper establishes a Taiwanese approach to measuring the overall effectiveness of automation implemented in the construction industry in Taiwan. With this approach, 30%, 71% and 94% increases in commitment aspects and 15%, 20% and 24% increases in benefit aspects have been achieved from 1991 to 1993 (taking 1990 as the base year): significant improvements after the launch of the construction automation plan. The effectiveness of the commitment aspects, however, is far greater than that of the benefit aspects.
Keywords: construction automation, effectiveness, Taiwan, World Trade Organization.

1998, **16**(3), 269–281

Testing the validity of liquidated damages clauses: measuring the application preference and consistency of the intent test as applied by the United States court system

Jensen, D
Department of Construction, Southern Polytechnic State University, 1100 S. Marietta Parkway, Marietta, GA 30060-2896, USA

Although the general principles for ascertaining the validity of a liquidated damages clause are well understood, the courts seem inconsistent in their interpretation of whether a clause is valid or not. Judicial opin-ions dating from 1858 to 1991 formalize the study population. Retrieval of judicial opinions are from official and unofficial legal reporters for the United States. Of the 223 selected appellate court cases, 175 met the population parameters. Data derived from these judicial opinions were tested statistically by: (a) the chi-square test for binomial data, and (b) the Stuart-Cox sign test for trend analysis. The chi-square tests reveal that, at present, the courts demonstrate a preferred pattern of movement away from applying the intent test when construing the validity of a liquidated damages clause. Based on the Stuart-Cox sign test, however, the current pattern of application preference does not display the presence of a statistical trend for future application preference. Additionally, when the courts do apply the intent test, the application preference is at the time of contract formation. Further, there is no statistical trend that indicates that this will be the preferred application in the future.
Keywords: contract, delay, liquidated damages, penalty clause.

1998, **16**(3), 283–293

Claims for extension of time in civil engineering projects

Yogeswaran, K[1]; Kumaraswamy, M M[1] and Miller, D R A[2]
[1]*Scott Wilson Kirkpatrick (HK) Ltd, Hong Kong.*
[2]*Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam, Hong Kong*

This paper focuses on the principles and practices in formulating and assessing claims for extensions of time due to excusable delays. Typical frequency and magnitude profiles of claims for extensions of time are derived from a surveyed sample of 67 civil engineering projects in Hong Kong, and major categories of claims for extensions of time have been identified from the data obtained. Recommendations are made to minimize claims for extensions of time and to achievemore consistent assessments of the unavoidable claims, for example those relating to inclement weather.
Keywords: civil engineering, claim, delay, Hong Kong, time.

1998, **16**(3), 295–302

From Ptolemy to Heisenberg: quantitive models and reality

Raftery, J

Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

An aspect of methodology in research in the field of design economics and cost modelling is described, discussed and evaluated. This review is designed for post-graduate students and built-environment professionals embarking on a PhD in that field. Models, built using methods regarded as 'scientific' at the time, have enabled us to solve specific problems and to learn more about the world. A generalized approach to building and testing symbolic models is outlined. Inconclusion, a number of limitations are identified which are inherent in the conventional quantitative modelling approach.

Keywords: modelling, research method.

1998, **16**(3), 303–313

The impact of TAMRA '88 on US construction accounting practices

Jensen, D[1] and Craig, J W[2]

[1]*Department of Construction, Southern Polytechnic State University, 1100 S. Marietta Parkway, Marietta, GA 30060-2896, USA*

[2]*College of Architecture, Texas A University, College Station, TX, USA*

This article addresses the accounting process for a long term construction contract and the effect of recent income tax reform on revenue recognition for income tax liability purposes. The Tax Reform Act of 1986 (TRA '86) introduced several significant changes in tax accounting for long term construction projects. Further tax legislation reform was promulgated via the Technical and Miscellaneous Revenue Act of 1988 (TAMRA '88). Prior to the promulgation of these income tax reform acts, a US contractor could use the percentage-completion method for reporting income to creditors and investors, while using the completed-contract method for income tax recognition purposes. After TRA '86 and ending with TAMRA '88 tax legislation, the contractor is now required by law to utilize a 90/10 split for an income recognition schedule if a contract is longer than two years and the contractor has sales of more than $10 million per year. An intent of this article is to create an awareness of these rules and resulting practices, so that international readers may gain a better understanding of any global implications.

Keywords: accounting, accrual basis accounting, long-term construction, TAMRA 88, Technical and Miscellaneous Revenue Act of 1988.

1998, **16**(3), 315–325

Planning and control methods, tools and techniques used by refurbishment management

Egbu, C O[1]; Torrance, V B[2] and Young, B A[1]

[1]*Building Research Establishment Ltd, Bucknalls Lane, Garston, Watford WD2 7JR, UK*

[2]*Department of Building, School of Architecture, Planning & Surveying, Mara Institute of Technology, 40450 Shah Alam, Selangor D.E., Malaysia*

Using a case study approach involving four refurbishment projects from both the construction and shipping industries (hospital, warship, hotel and passenger ship), 36 semi-structured interviews with key functionaries from both sectors and 49 completed postal questionnaires, this paper attempts to shed light on the function of planning and control by examining the various systems, methods and techniques associated with refurbishment management in both industries. The conclusion is that there is a substantially longer planning lead-time in the ship refurbishment sector than in construction. The state of completion of design before refurbishment work commences is higher in the shipping industry. Site managers from the ship refurbishment sector are brought into the planning and control processes earlier than their counterparts from the construction industry. In both industries, however, schedules and bar charts are the most frequently used formal planning techniques, in comparison with computer based techniques such as PERT, GERT and expert systems; the main reasons being familiarity, the relatively low levels of skill and knowledge needed to understand them as much as their perceived flexibility and relative cheapness for their production and updating. Planning and control involving the management of risks and uncertainty by improving the quality and timing of relevant information for the works, and the timely integration of key functionaries in the refurbishment process, help to improve planning accuracy and effectiveness.

Keywords: control, planning, refurbishment.

1998, **16**(3), 327–337

A methodology for assessing construction project delays

Bordoli, D[1] and Baldwin, A N[2]
[1]*HBG Kyle Stewart Limited, Merit House, Edgware Road, London NW9 5AF, UK.*
[2]*Department of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK*

Different categories of delay and the different types of delay found on construction projects are identified. Existing methods for assessing the effect of delaying events are reviewed and the results of an industry survey presented. None of the commonly recognized methods for delay analysis allow the assessment of three important issues at the same time: the progress of the project at the time the delay occurred; the changing nature of the critical path; and the effects of action taken (or that should have been taken) to minimize potential delays. A new method of delay analysis is presented. This method takes into consideration all these issues, and is a clear, straightforward step-by-step approach to the calculation of the expected delay in the completion of the project as a result of delays in activities encountered during the project. It uses a dynamic model considered by both experts and practitioners to be the best method to take account of progress and form the basis of delay claims.
Keywords: claim, critical path method, delay, project delay.

1998, **16**(3), 339–349

Human error in the management of building projects

Atkinson, A R
School of Construction, South Bank University, London, SW8 2JZ, UK

This paper seeks to improve the understanding of human error as it is applied to the generation of defects in construction projects. It reviews the literature concerning human error, commencing at the psychological basis of errors. From this, the review is expanded to include literature from forensic engineering, industrial safety, reliability engineering, sociology and quality management. Based on the literature, a model of the factors influencing the incidence of errors in project based industries is constructed. This model proposes that errors leading to defects and more dramatic failures can be generated from all levels of project organizations. They stem from primary factors (related to the performance of the individual), management factors (related to a range of managerial tasks) and global factors (related to wider external influences). These factors can be displayed as a hierarchy with primary factors at the base and global factors at the top. The paper reports on the results of an initial test of this model by reference to a survey of a sample of construction industry practitioners. The findings of the survey support the model, with some modifications. Additionally, some differences in view were noted: in particular, respondents from a construction background emphasized managerial factors more strongly than those from a design background.
Keywords: defect, human error, project management.

1998, **16**(3), 351–361

The changing role of builders' merchants in the construction supply-chain

Agapiou, A[1]; Flanagan, R[1]; Norman, G[2] and Notman, D[2]
[1]*Department of Construction Management & Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 6AW, UK*
[2]*Department of Economics, University of Edinburgh, William Robertson Building, 50 George Square, Edinburgh, EH8 9JY, UK*

Builders' merchants are an integral part of the construction industry, yet rarely are they consulted when discussions take place on the future of the construction industry. Throughout history, builders' merchants have played a dominant role in the construction industry, initially as an intermediary between the artisan and the buyer, and more recently as a source of working capital for contracting firms. The merchanting industry currently is undergoing considerable change. The depressed construction market and the failure of the housing repair and maintenance sector to recover in the first half of the 1990's as activity in the private non-housing repair and maintenance sector has increased, has raised competition between merchants. The major building merchants are becoming larger by acquisition and merger, the smaller merchants are seeking niche areas, and the medium-size firms are under serious threat from acquisition by the larger merchanting firms. The trend towards consolidation in the sector, driven by the need to reduce costs, has meant that the large merchanting firms now control around 60% of the building materials market sales. Factoring is a growing trend, particularly with smaller companies sourcing goods from the cheapest source. The larger merchants have to respond by sourcing goods from the lowest cost base, irrespective of whether they buy from overseas markets. This paper analyses the UK builders merchants sector and evaluates the important role played in the supply chain.
Keywords: material, builders' merchant, component, import.

1998, **16**(3), 363–372

Improving the management of claims on construction contracts: consultants perspective

Vidogah, W and Ndekugri, I E
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

There is tremendous scope for improving claims management practice. This research comprised a postal questionnaire survey of contractors, project owners' architects, quantity surveyors and engineers, case studies on actual claims situations on projects, and structured interviews with consultants and contractors. Although based mainly on consultants' views although contractors' views are brought in occasionally for corroboration and clarification. The main findings are that: (i) claims management is still performed in an ad hoc manner; (ii) contractors' management information systems are ill designed to support claims; (iii) the products of basic good management practice, such as diaries, timesheets, and programmes, often are inadequate in content even if available; and (iv) some aspects of claims are impossible to quantify with precision even with the best information available at reasonable cost. Main remedial measures suggested include: (a) greater emphasis on the quality of claims management practice and information systems during evaluation of tenders; (b) agreeing figures usually in contention as terms of contracts; (c) implementation of electronic document management systems; and (d) stricter contractual provisions on the quality of programmes, timesheets and content of claims.

Keywords: claim, contract, contractor, dispute, project management.

1998, **16**(4), 383–388

Note – Attitudes towards auto-ID technologies within the UK construction industry

Marsh, L and Finch, E F
Department of Construction Management & Engineering, University of Reading, Whiteknights, PO Box 219, Reading, RG6 6AW, UK

Automatic identification (auto-ID) technologies such as bar coding have become widespread within manufacturing, medicine and retailing. Bar coding has also attracted many applications within the US construction industry, providing tangible cost savings through improved speed and accuracy of data entry. However, over the past decade the rate of adoption of auto-ID among UK construction firms has been significantly lower than the US. This paper presents the findings of a UK survey of construction organizations, designed to ascertain key factors which attract firms to use auto-ID, the barriers which have prevented some from doing so, and future developments which are perceived as important in encouraging more widespread adoption of the technology within the UK construction supply chain. Key issues identified include a low level of awareness of auto-ID technologies and the absence of appropriate industry standards. Recommendations include the establishment of a standards body and educational initiatives to promote auto-ID solutions.

Keywords: auto-ID, bar coding, labelling standards, survey.

1998, **16**(4), 389–395

Note – The internationalization of British construction companies 1990–1996: an empirical analysis

Crosthwaite, D
Department of Construction Management & Engineering, University of Reading, Whiteknights, PO Box 219, Reading, RG6 6AW, UK

The internationalization of British construction companies is not a new phenomenon. A recent stated aim of some of the larger companies has been to increase their overseas activities in an attempt to counteract some of the problems within the domestic construction market. This paper examines the international performance of British construction firms during the period 1990-1996, and is based on a questionnaire survey of senior executives of the largest British construction companies in an attempt to analyse their perceptions of the overseas market. The survey was concerned with the companies' general views, reasons, objectives, conditions, location and future expectations with regard to their overseas operations. The principal findings indicate that British firms had increased their overseas activities during the study period. However, despite theory to the contrary and relatively high levels of construction demand in some developing countries, they had tended to conduct the major share of their overseas work in developed countries. The reasons given for this bias were that developed countries provided: a secure environment in which to evaluate risks; financial security; and less corruption. The results suggest further that shareholder influence is an important factor affecting the respondent companies location overseas. It was concluded that while market demand is a factor for overseas location by British construction companies, it is only one of many.

Keywords: contractor, internationalization, location, UK.

1998, **16**(4), 397–408

Flexible management of operatives in the Singapore construction industry

Ofori, G [1]and Debrah, Y A[2]
[1]*School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore*
[2]*Cardiff Business School, University of Wales, Colum Drive, Cardiff, CF1 3EU, UK*

The human resource management literature has covered the issues relating to labour market flexibility (LMF), and highlighted a trend in many sectors towards increasing reliance on peripheral workers. Construction has been cited as a model in terms of its ability to exploit the benefits of LMF in its widespread use of peripheral workers as a response to an uncertain operating environment. This paper examines employers' quests for LMF in the construction industry in Singapore, explores the prevailing approaches to labour use in the industry, considers the rationales for the reliance on peripheral workers, and evaluates the merits and disadvantages of this practice. It argues that Singapore's construction firms have always relied on a traditional form of employment based on a labour sub-contracting system, but recent years have witnessed changes in the structure of the system as well as an increase in the proportion of foreign workers in the labour force. In addition, it is argued that the conditions for the increasing use of these peripheral workers are different from those suggested to be underlying the quest for 'flexibility' in industrialized countries. The practice is observed to have considerable adverse effects, although firms derive some of the benefits relating to LMF. Possible measures are put forward for improving construction labour use strategies in Singapore.
Keywords: employment, labour market, Singapore, sub-contracting.

1998, **16**(4), 409–416

A time-series analysis of UK annual and quarterly construction output data (1955-1995)

Norman, G[1]; Notman, D[1]; Flanagan, R[2] and Agapiou, A[2]
[1]*Department of Economics, University of Edinburgh, William Robertson Building, 50 George Square, Edinburgh, EH8 9JY, UK*
[2]*Department of Construction Management & Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 6AW, UK*

United Kingdom construction output makes a vitally important contribution to the gross domestic product of the UK economy. Nevertheless, despite the obvious importance of UK construction, very little is known about the output behaviour of the industry. This paper endeavours to redress the imbalance by analysing the post-war time-series behaviour of annual and quarterly UK construction output. The primary technique of analysis is to estimate an autoregressive integrated moving-average (ARIMA) model of UK construction output. Such a model proxies the stochastic or random process that underlies UK construction output data. Also, a review is given of the methodology of estimation and diagnostic checking of ARIMA models in the context of UK construction output, together with ex-post and ex-ante forecasts of UK construction output using the estimated ARIMA models.
Keywords: ARIMA model, forecasting, output, time series.

1998, **16**(4), 417–432

Holistic enhancement of the production analysis of bituminous paving operations

Singh, A; Gowda, R and Connolly, M
Department of Civil Engineering, University of Hawaii at Manoa, 2540 Dole Street, Honolulu, Hawai'i 96822.

The construction and repair of highways are becoming very important in these days of crumbling infra-structure. Costs for these projects have continued to increase. In order for contractors to stay competitive, it is essential that their construction operations be as productive as possible. Money for research usually does not exist for the average contractor. An inexpensive solution for production studies is process simulation, which can help improve the productivity of construction operations. This paper focuses on the paving cycle of a highway resurfacing project, using MicroCyclone simulation software. The process modelling using MicroCyclone is applied readily to any construction cyclic process, and aids the engineer in determining the most economical and efficient way to plan resources for processes. Different production parameters are measured and translated to a utility factor that indicates the performance of the system. Results from the utility factor perspective are considered more sensitive in decision making, owing to the holistic nature of the utility factor. Numerous statistical runs were undertaken, and parameters were weighted and averaged. Based on the holistic analysis, it was possible to establish that 12 trucks were optimal for the system, a determination that cannot be made using deterministic analysis, but that a 7% waste of resources was unavoidable with the existing system of resources. This paper highlights the analytical method of using MicroCyclone output to generate useful information that can be used to compare in detail the performance of different scenarios.
Keywords: cyclone, modelling, process, productivity, simulation, utility factor.

1998, **16**(4), 443–446

Resource-driven scheduling of repetitive activities

El-Rayes, K and Moselhi, O
Centre for Building Studies, Concordia University, 1455 de Maisonneuve Blvd, Montreal, H3G 1M8, Canada

Repetitive activities are found commonly in the construction of high-rise buildings, pipeline networks and highway and housing projects. Construction crews assigned to these activities often perform the work sequentially, moving from one repetitive unit in the project to the next. Because of this frequent crew movement, construction of repetitive activities should be scheduled in such a way as to enable prompt movement of crews among the repetitive units so as to minimize idle crew time. In order to maximize the efficiency of crew utilization, the schedule of repetitive activities should be resource driven, and should satisfy the crew work continuity constraint in addition to precedence relationships and crew availability constraints. This paper presents a flexible algorithm for resource-driven scheduling of repetitive activities that satisfies the three constraints, and considers the impact of a number of practical factors encountered commonly during the construction of this class of projects. The algorithm is applied in two stages: the first achieves compliance with logical precedence relationships and crew availability constraints, and the second achieves compliance with the crew work continuity constraint. A numerical example of a highway project is analysed to illustrate the use of the algorithm and demonstrate its capabilities.

Keywords: construction planning, continuity, repetitive construction, resource scheduling, scheduling.

1998, **16**(4), 447–457

Quality managers, authority and leadership

McCabe, S[1]; Rooke, J D[2]; Seymour, D E[2] and Brown, P[3]
[1]*School of Property & Construction, University of Central England, Perry Barr, Birmingham, B42 2SU, UK*
[2]*School of Civil Engineering, University of Birmingham, Birmingham, B15 2TT, UK*
[3]*AMEC Construction (Southern) Ltd, Stratford-upon-Avon, UK*

Some quality managers in the construction industry are attempting to institute total quality (TQ) manage-ment. Having established quality assurance (QA) systems, these managers have realized that the benefits to be gained from this bureaucratic approach are limited. They now aim to transform the culture of the industry, making it less adversarial and more customer centred. Using a sociological analysis based on the forms of legitimation of power identified by Max Weber, the institutional situation of quality managers is examined and their consequent ability to introduce innovation is assessed. Weber suggests that there are three forms of authority: traditional, charismatic and rational. These are considered in the light of some modern organization theory and with reference to the particular problem of cultural change. Managers have the best hope of successfully introducing TQ when they can establish a measure of charismatic authority. This is consistent with the centrality given to the concept of leadership by writers on TQ. The practicalities of this are investigated through an account of the process of setting up a quality circle.

Keywords: change management, charismatic authority, culture, leadership, quality management.

1998, **16**(4), 459–470

Modelling the running costs of buildings

Al-Hajj, A[1] and Horner, R M W[2]
[1]*School of Construction Property and Surveying, The Robert Gordons University, Garthdee Road, Aberdeen, AB10 7QB, UK*
[2]*Construction Management Research Unit, Department of Civil Engineering, The University of Dundee, Dundee, DD1 4HN, UK*

The Building Maintenance Cost Information Service (BMCIS) offers a comprehensive and rigorous framework for collecting data about the running costs of buildings. Nevertheless, it is pitched at such a level of detail that the amount of data collected and analysed may be constrained. This paper describes the development and testing of a novel technique which reduces the amount of data to be collected without any unacceptable reduction in utility. It draws on the principle of cost-significance to create a simple model of maintenance and operating costs (together called running costs) from a rare and consistent set of data for 20 buildings at York University. The model contains only 11 elements yet can predict the total running costs of each of four categories of building to an accuracy of about 2 1/2 %. It can also predict annual costs to about 7%, despite variations in the periodicity of costs such as painting and insurance. The model was tested using the jacknife method and on virgin data. It proved to be extremely robust, predicting the running costs of 12 new buildings to within 5%. The model offers a simple framework for collecting and analysing reliable and consistent data on running costs.

Keywords: cost significance, life cycle analysis, maintenance cost, operating cost.

1998, **16**(4), 471–479

A neural networks approach for cost-flow forecasting

Boussabaine, A H and Kaka, A P
School of Architecture & Building Engineering, University of Liverpool, Leverhulme Building, Abercromby Square, Liverpool, L69 3BX, UK

Artificial neural networks, which simulate neuronal systems of the brain, are useful methods that have attracted the attention of researchers in many disciplinary areas. They have many advantages over traditional methods in situations where the input-output relationship of the system under study is not explicitly known. This paper investigates the feasibility of using neural networks for predicting the cost flow of construction projects, explains the need for cost flow forecasting, and demonstrates the limitation of the existing models. It then introduces neural networks as an alternative approach to those mathematical and statistical methods. The method used in collecting data and modelling the cost flow is described. Results of the testing are presented and discussed.
Keywords: artificial intelligence, cash flow, cost model, forecasting, neural network.

1998, **16**(4), 481–488

Behaviour-based safety management in Hong Kong's construction industry: the results of a field study

Lingard, H[1] and Rowlinson, S M[2]
[1]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, GPO Box 2476V, Melbourne 3000, Victoria, Australia*
[2]*Department of Real Estate & Construction, University of Hong Kong, Pokfulam Road, Hong Kong, China*

Hong Kong's construction industry has had a poor site safety record for over a decade. Behaviour-based methods of safety management (BSM) have proved successful in other industries and in other countries. Hence, this study aimed to test the effectiveness of BSM by applying goal setting and feedback interventions to specific areas of safety performance on Hong Kong Housing Authority construction sites. Using a within-group experimental design and with the use of a proportional rating safety measurement instrument, data were collected on the effectiveness of BSM on Hong Kong sites. The data were recognized as time series data; this has been a serious methodological oversight in much previous research. The data were analysed using autoregressive moving averages models, and the results were mixed in that a significant improvement in safety performance occurred in the housekeeping category of intervention but no improvement was observed in the access to heights and bamboo scaffolding categories. Based on these results a goal setting/expectancy theory model of site safety improvement has been synthesized, and the lack of provision of an adequate safety infrastructure has been identified as a serious impediment to improvement.
Keywords: behaviour, feedback, goal-setting, motivation, safety.

1998, **16**(4), 489–498

Continuous and combined event-process models for simulating pipeline construction

Shi, J J[1] and AbouRizk, S M[2]
[1]*Dept of Building & Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong*
[2]*University of Alberta, Alberta Construction Industry Professor, Department of Civil Engineering, University of Alberta, Edmonton, Alberta, T6G 2G7, Canada*

A continuous model and a combined event-process discrete model are developed by employing the Slam II general purpose simulation language. The continuous model addressed the on-going progress of the construction process on a higher level; and the combined event-process discrete model describes the pipeline construction on the operational level. Resource sharing and related issues also are investigated in the two models through an actual gas line project adopted for the purpose of this research. A comparison of the two models provides insights into the modelling approaches. It is concluded that the combined event-process model is more flexible and more powerful for modelling complex construction operations than the continuous model, but at the price of requiring a better understanding of the actual operations and more detailed information.
Keywords: linear construction, modelling, pipeline, planning, simulation, slamsystem.

1998, **16**(5), 511–520

A review of recent developments in construction operative training

Agapiou, A
Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, Melbourne, Victoria 3052, Australia

Future skill requirements and training initiatives designed to meet them, are highly topical issues in the construction industry. The pace of change affecting the structure of training generally has created consider-able confusion among employers in the construction industry. In the mind of the average employer there is still uncertainty about the nature

and value of competence-based qualifications (NVQs) which are still at a relatively early stage of implementation. Training provision has been decimated by the effects of the recession. The range of options for training routes has become more complex due to continuing government initiatives and frequent changes in funding policy. This paper traces the prevailing trends in the provision of craft training in the UK construction industry, highlighting the fragmentation of funding arrangements and its effects on the structure of training. First, recent developments in government policy for youth training in the UK in general are reviewed. Second, formalized training procedures and the roles of the different training organizations in the construction industry are discussed. This forms an important backdrop for understanding issues affecting the introduction of new vocational qualifications. Finally, the aims, objectives and key characteristics of these qualifications are presented. Factors that have constrained the implementation and delivery of the new qualifications are identified also.
Keywords: skill, training, vocational qualification.

1998, **16**(5), 521–530

Construction workers in developing countries: a case study of Sri Lanka

Jayawardane, A and Gunawardana, N D
Department of Civil Engineering, University of Moratuwa, Moratuwa, Sri Lanka

This paper addresses human resource development (HRD) issues in the Sri Lankan construction industry. It reports an analysis of the occupational structure and characteristics of the construction work force as an aid to meeting the challenges of maintaining a skilled craft work force. Information was collected through on-site structured interview surveys of 3300 construction workers and a questionnaire survey of contractors, consultants and clients which included 56 organizations. Results indicate that the work force consists of 51% unskilled workers, 33% masons, 10% carpenters and 1-2% each of plumbers, bar benders, painters and electricians. The highest percentage of skilled workers is aged 30-39 years. Approximately 80% of the work force is casually employed, only 40% is fully utilized and 86% of the skilled work force have received informal training only. More than 20% of the work force is dissatisfied due to low income, lack of job security and difficulty in finding regular work. Comparing HRD practices to those in the USA and the UK indicates that Sri Lanka needs to adopt a more structured approach, including a more formal training system and proper grading of the skilled work force.
Keywords: human resource development, labour force structure, Sri Lanka.

1998, **16**(5), 531–542

The growth of self-employment in construction

Winch, G
Bartlett School of Architecture, Building, Environmental Design & Planning, University College London, Philips House, Gower Street, London, WC1E 6BT, UK

This paper explores the issues around the remarkable growth in labour-only sub-contracting on a self-employment basis in the British construction industry over the last 30 years. Following a presentation of the available data from the Department of Employment, the paper explores the reasons behind this remarkable development, and concludes that the main reason for the growth of self-employment since 1977 is the strategic choice of construction companies to emphasize flexibility over productivity as sources of competitive advantage. The paper also explores the implications of this strategic choice, and concludes that, as a result, the ability of the industry to increase productivity and quality is compromised due to the ways in which labour-only sub-contracting and self-employment hinder training and innovation.
Keywords: labour-only sub-contracting, safety, self-employment, productivity, training, UK.

1998, **16**(5), 543–552

The propensity for employee participation in construction

Coffey, M[1] and Langford, D A[2]
[1]*School of Land & Construction Mgmt, University of Greenwich, Oakfield Lane, Dartford, Kent, DA1 2SZ, UK*
[2]*Department of Civil Engineering, University of Strathclyde, John Anderson Building, 107 Rottenrow, Glasgow, G4 0NG, UK*

Employee participation has attracted scant attention in the construction industry, yet the experience of firms in many other industries indicate that considerable benefits in terms of improved quality, lower production costs and greater competitiveness can be achieved from formal employee participation. Studies show that there are numerous examples of employee participation, in a variety of forms, being used successfully in other industries, but none in construction - why? One possible explanation is that some fundamental aspects of the construction industry prevent the application of participation. This paper reports on research that explored whether a propensity for participation exists in the construction industry, and if so, how significant is it. The research established a conceptual model of the factors that contribute towards participation in any given workplace and established the relationship between the main variables and their constituent subvariables and subsubvariables. The model was used to determine the propensity for participation in the construction industry. The results revealed that a significant amount of informal (direct) participation already occurs in the construction industry, and a strong propensity for direct participation exists. Workers are shown to have a strong

desire to participate and to have significant potential for participation in defining and controlling their everyday work (defined as the 'task'). The contextual variables of 'environment' and 'organization' are shown to be non-preventive and conducive to participation, respectively. The conclusion is that there are no inherent reasons that prevent participation being successfully applied in the construction industry.
Keywords: employee, human resource management, involvement, participation.

1998, **16**(5), 553–567

British construction skills training in the context of European developments

Clarke, L and Wall, C
Faculty of Business, Management & Social Studies, University of Westminster, 35 Marylebone Road, London, NW1 5LS

A critical examination is made of the ways in which UK construction skills training contributes to and diverges from the dynamic of European developments. In identifying aspects increasingly shared by different countries, the paper is intended to help in the formulation of a common training policy. These aspects include: (i) comprehensive training systems covering all aspects of construction work on site and subsumed under broad skill groupings, with the 'traditional trades' assuming a 'universal' character and labourers becoming a residual category; (ii) three locations for learning - the college, the site and the training work-shop - with increasing prominence being given to workshops and trainee sites; (ii) a modular training system with broad-based foundation followed by gradual specialization; (iv) social partnership between employers and employees in the regulation of training, the maintenance of skill standards, and the administering of the industrial levy; (v) training and skill categories linked to wage grades, so providing an incentive to training and further training, and recognized additionally through certification; (vi) training for life, with greater emphasis on adult and further training; and (vii) equality of access to training and employment in construction to open up this largely white male preserve. The UK construction training system is out of step with many of these developments, being employer-led, largely confined to the traditional trades and dominated by qualifications broken into narrow task-related units. Nevertheless, a framework still exists which, if built on, would bring the UK training system into line with European developments.
Keywords: Europe, labour, training, skill.

1998, **16**(5), 569–580

Construction skills training for the next millennium

Gann, D M[1] and Senker, P[2]
[1]*Science Policy Research Unit, University of Sussex, Mantell Building, Falmer, Brighton, BN1 9RF, UK*
[2]*I.P.R.A. Limited, 17 Varndean Gardens, Brighton, BN1 6WJ, UK*

Construction skills and training needs have changed with the introduction of new business processes, different forms of organizing production and technical innovation. In the UK, training provision has failed to adapt fully to the needs of a modernizing industry. Formal training programmes have been inappropriate in content and inadequate in quantity. Many of them are out of date. An assessment is provided of the types of skill and training required to implement innovative approaches for improving construction performance. It is based on analysis of work carried out during a major national review of construction operative and supervisory skills training in the UK undertaken for the Construction Industry Board. It seeks to provide a frame-work for analysing skill needs in the context of modern performance targets, together with policy recommendations for decision-makers in firms, government and training institutions. The conclusion that a new generic training programme is required is of general relevance to practitioners, trainers and researchers in the UK and in other countries.
Keywords: business process change, skill, innovation, training, new technology.

1998, **16**(5), 581–592

Qualifications in the German construction industry: stocks, flows and comparisons with the British construction sector

Richter, A
Centre for Economic Performance, London School of Economics, Houghton Street, London, WC2A 2AE, UK

The paper provides an overview of qualifications in the German construction workforce and draws comparisons with the situation in the British construction industry. The German system of general education and vocational training is outlined. Data from a variety of sources are used to describe both the stocks and the flows of qualifications in the German construction workforce. Particular attention is paid to vocational qualifications, such as apprenticeships and the Meister qualification. Key findings are that the majority of German construction workers are qualified up to apprenticeship level, and that most of these employees have achieved a general schooling certificate from at least a lower secondary school prior to their vocational training. These factors are taken as signs of strength of the German construction workforce. Comparisons between the stocks of qualifications in the construction industry in the two countries suggest that intermediate qualifications of the apprenticeship type are far less prevalent in the British construction workforce.
Keywords: apprenticeship, education, Germany, qualification, vocational training.

1998, **16**(5), 593–601

A qualifications trap in the German construction industry: changing the production model and the consequences for the training system in the German construction industry

Syben, G
BAQ, Germany, BAQ, Wachmannstr. 34, 28209 Bremen, Germany

German construction companies traditionally rely on qualified workers. This has influenced both their production model (work organization on site) and their policy towards training and education. Due to the massive inflow of workers from countries with low labour costs, firms may fundamentally change this model to a new one which is distinguished by the combination of less qualified workers with a larger number of managers for instruction, supervision and control. This change is initially likely to have a considerable knock-on effect on the training system. However, what is even worse is that the new model is not likely to work in the long run. To date the construction industry has acquired its site managers and supervisors directly from the pool of qualified workers. By reducing training it produces a shortage of the very resource inevitably needed to be able to reduce training. The industry will fall into a qualifications trap. What is more significant is that this trap is shown as a first step towards lowering corporate image, quality of human resources, productivity and, in the end, competitiveness.
Keywords: Germany, labour market, training.

1998, **16**(6), 621–635

How 'just-in-time' wastages can be quantified: case study of a private condominium project

Low Sui Pheng[1] and Tan, S K L[1]
[1]*School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511*
[2]*Neo Corporation, Singapore*

Compared with the manufacturing sector, the construction industry suffers from relatively lower productivity, although some attempts are being made to overcome low construction productivity by introducing manufacturing-based concepts to the construction industry. The just-in-time (JIT) concept is one of the manufacturing-based concepts introduced to streamline construction operations and help raise productivity in the industry. The fundamental philosophy of JIT is to eliminate wastes from delays, transportation, unnecessary processing and unnecessary motion. This is because any activities that do not add value to a process are considered wasteful. Construction productivity therefore can be enhanced if these activities are eliminated. This paper presents an accounting procedure for measuring JIT wastes. The case study of a private condominium project, where this accounting procedure was applied, shows that indeed JIT wastes can be identified and eliminated to raise construction productivity.
Keywords: just-in-time, productivity, waste quantification.

1998, **16**(6), 637–649

The construction industry and macroeconomy in Sub-Saharan Africa post 1970

Lopes, J
Department of Surveying, University of Salford, Salford, M7 9NU, UK

A model of interdependence between the construction sector and the national economy is established, based on a long term trend, for the developing countries of Sub-Saharan Africa. This study follows research undertaken by previous writers who have investigated the relationship between the construction sector and economic development and found a positive relationship between the share of construction in gross domestic product (GDP) and the level of per capita national income. In addition, recent economic and demographic trends in Sub-Saharan Africa are presented and significant events that have had a great impact in this region are highlighted. Evidence is presented that a long term decreasing growth in GDP per capita corresponds directly to a relative decrease in construction volume. The converse does not appear to be true.
Keywords: economic development, Sub-Saharan Africa.

1998, **16**(6), 651–660

Pre-qualification and multi-criteria selection: a measure of UK contractors' opinions

Jennings, P and Holt, G D
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands, WV1 1SB,UK

The procurement of a construction contractor normally involves some form of prequalification. The better prequalification regimes adopt a structured multi-criteria approach (i.e. contractor evaluation based on a multiple of

factors over and above cost). This research solicits contractors' viewpoints on prequalification, in contrast to earlier works that have tended to present clients' perspectives. Contractors are dissatisfied with the frequency and adequacy of current prequalification regimes. An investigation of the mutual benefits of multi-criteria selection leads to the suggestion that such benefits could be better capitalized upon. Contractors' perceived levels of importance (with respect to selection criteria considered by clients during the selection process) are evaluated and show that, in line with earlier findings, 'cost' is still the predomi-nant selection factor, followed by 'contractor experience' and 'company reputation'. A comparison between contractors' rankings of the selection criteria with similar rankings derived from an earlier survey of clients, finds significant correlation, indicating that contractors agree with clients' importance levels of multi-criteria selection factor.
Keywords: contractor, multi-criteria method, pre-qualification, procurement, tendering.

1998, **16**(6), 661–671

The influence of communication structure upon crisis management efficiency

Loosemore, M
Faculty of the Built Environment, The University of New South Wales, Sydney 2052, Australia

A construction crisis stimulates a network of communications within its host organization, the structure of which influences crisis management efficiency. It does so by determining the effectiveness of information transfer between project participants, and thereby the level of uncertainty, misunderstanding and ultimately conflict that materializes. These conclusions arose from research that was concerned specifically with the patterns of communication and behaviour that emerge in response to construction crises. The methodology adopted a longitudinal, multiple case study approach and combined the complementary techniques of content analysis and social network analysis.
Keywords: communication, crisis management, efficiency, network, structure.

1998, **16**(6), 673–679

Assessment of the factors influencing the maintenance programme of large university buildings in Riyadh

Idris, M M
College of Architecture and Planning, King Saud University, Riyadh, Kingdom of Saudi Arabia

The amount of money invested in the building industry in the last two decades in Saudi Arabia is about SR 1251 ($234) billion. The result is a stock of large projects in housing, hospitals, universities (seven in number) etc. These buildings require efficient maintenance programmes to enable them to be serviced prop-erly. Such programmes are handicapped by a number of interrelated factors. Such factors, like the harsh climatic conditions, presence of chlorides and sulphates in soil and water, contracting systems and lack of codes and building standards, have varied influences in maintenance. This paper, attempts to examine these factors through an analysis of the maintenance programmes of a university campus building in Riyad.
Keywords: contractor classification, maintenance programme, procurement, spare parts.

1998, **16**(6), 681–692

The Singapore buildable design appraisal system: a preliminary review of the relationship between buildability, site productivity and costs

Poh, P S H[1] and Jundong Chen[2]
[1]*School of Civil and Structural Engineering, Nanyang Technological University, Blk N1, 1A-37 Nanyang Avenue, Singapore 639798*
[2]*Prefab Technology Pte Ltd, Singapore*

The relationship between site productivity, construction costs and the 'buildable score' of a buildable design appraisal system has been examined by the Singapore Construction Industry Development Board. The buildable score for a building is computed by taking into account the level of standardization, simplicity and extent of integrated elements used in the design of a building. The stated objective of the appraisal system is 'to promote more buildable designs in the industry through assessing the contribution of design to site efficiency and produc-tivity'. Empirical results from 37 completed building projects provide support for the appraisal system's proposition that 'a design with a higher buildable score will result in more efficient labour usage in construc-tion and therefore higher site labour productivity'. However, the relationship between construction costs and buildable score is less distinct.
Keywords: buildability, cost, productivity.

1998, **16**(6), 693–702

Priority setting in maintenance management of public buildings: a modified multi-attribute approach using AHP

Qiping Shen[1], Kak-Keung Lo[1] and Qian Wang[2]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*Research Institute of Project Administration and Management, Tongji University, Shanghai 200092, China*

In the current economic climate, budgets for the maintenance of public buildings are unlikely to meet the ever-increasing maintenance needs. Although it is unlikely that this problem can be overcome completely without an injection of further resources, it is possible for government maintenance authorities to improve the situation by ensuring that the best solution in terms of 'value for money' is achieved in the planned maintenance programme. A maintenance plan that is based on a rational assessment of priorities and up-to- date knowledge of the condition of the property stock will help to ensure the best use of available resources. Based on the multi-attribute maintenance prioritization model developed by Alan Spedding, Roy Holmes and Qiping Shen at the University of West of England, which is simple in practice and flexible from management point of view, this paper presents the results of some further research into this area by modi-fying the original model using an analytical hierarchy process in deciding the weightings of the criteria set out in the prioritization model. This modified model is more quantitative and objective than the original model. The validation of the framework is also discussed.

Keywords: analytical hierarchy process, multi-attribute model, planned maintenance, priority setting, public sector.

1998, **16**(6), 703–709

Effective client management control of small works and minor maintenance

Griffith, A[1] and Headley, J[2]
[1]*School of Construction, Sheffield Hallam University, City Campus, Pond Street, Sheffield, S1 1WB, UK*
[2]*The John Lewis Partnership, Edinburgh, UK*

The management dimension of small building works is investigated in terms of the efficiency and effectiveness of procurement methods, organizational systems and management approaches to small works and minor maintenance projects. The findings indicate that management for small works must be exerted at two levels. One is within the organization of the work itself. The second is the development of a framework and organization, which considers the implication of the works upon the organization's ongoing business. Effective small works management requires that an organization responds promptly to an identified situation, determines the cost of the work, ensures that the work is undertaken successfully, and gives value for money within the context of the organization's current business circumstances.

Keywords: minor works, maintenance, organization structure, small works, workload.

1998, **16**(6), 711–719

The characteristics and current status of china's construction industry

Chen, J J
University of Greenwich, School of Land and Construction Management, Dartford, Kent, DA1 2SZ, UK

The development of China's construction industry is presented by describing its current status and high-lighting its achievements, identifying the main constraints preventing the industry from playing a more effective and efficient role in the country's economic development. Fundamental changes occurred in the construction industry after the economic reform, and the industry has been playing a very important role in the national economy, having made impressive progress and been developed at an amazing speed. However, reforms in the construction industry are difficult since this industry is not a single sector. The reform process by its very nature is not systematic. The challenges ahead are serious, and deeper reforms of the economic system are required.

Keywords: business environment, China, economic reform.

1998, **16**(6), 615–619

Note – The effect on contingency allowances of using risk analysis in capital cost estimating: a Hong Kong case study

Mak, S W[1]; Wong, J[2] and Picken, D[3]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*Mass Transit Railway CorporationKowloon Bay, Hong Kong*
[3]*School of Architecture and Building, Deakin University, Geelong 3217, Australia*

In 1993 the Hong Kong Government implemented a methodology for capital cost estimating using risk analysis (ERA) in its estimating for the planning of public works projects. ERA is a simple approach and is used to estimate and calculate an amount of money to allow for uncertainties associated with a project. This calculated amount of money replaces the pre-1993 contingency allowance, which was merely a percentage addition on top of the base estimate of a project. A team approach is adopted to identify, classify and cost the uncertainties associated with a project. The sum of the 'average risk allowance' for the identified risk events thus becomes the 'contingency'. A study of the effect of ERA was carried out to compare the variability and consistency of the contingency estimates between non-ERA and ERA projects. This paper presents preliminary results of a survey, which compares a total of 72 non-ERA, and 19 ERA projects. The result shows a significant difference in variation and consistency between these groups. It indicates initial success in using the ERA method for public works projects to reduce unnecessary and exaggerated allowance for risk. Further improvement and refinement of the ERA method is suggested.
Keywords: contingency, risk analysis, quantitative risk analysis, variations.

1998, **16**(6), 721–727

Developing a theory of construction problem solving

Heng Li[1] and Love, P E D[2]
[1]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*

Construction problem solving characterizes much of construction management practice and thus is an important research domain. Nonetheless, research in construction problem solving has not yet crossed the threshold into a mature discipline, as there is no universally accepted theory for construction problem solving research. In exploring the possibility of establishing such a theory, this paper reviews existing research works in two important research categories: cognitive science and decision support systems. A strategy for building a theory for construction problem solving, focusing on the existing models and techniques developed in the two research categories, is proposed. Future research needs and opportunities are identified.
Keywords: cognitivism, decision support, information processing, problem solving.

1998, **16**(6), 729–737

Globalization, comparative advantage and industrial policy: implications of recent developments in the construction sector in Asia

Raftery, J; Pasadilla, B; Chiang, Y H; Hui, E C M and Tang, B S
Economics and Finance Group, The Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

Recent developments in the construction sector in the Asian region demonstrate three trends: (1) larger private sector participation in infrastructure projects, (2) increasing vertical integration in the packaging of construction projects, and (3) increased foreign participation in domestic construction. This paper attributes the trends to the globalization and deregulation of markets necessitated by fiscal, technological and managerial constraints. Although these trends present intra-Asian opportunities, there are also areas of concern. The trends have helped polarize the financial and technical superiority of the developed countries and the corresponding inferiority of the developed countries in the region of the developing ones. In the long term, this gap could be filled through technology transfer. In the short term, however, there are concerns that imported construction services could grow at the expense of the indigenous sectors of the developing countries. This paper illustrates this dilemma with the case of Japan as a world leader in international construction services. Its dominance has apparently come through the orchestration of industrial and corporate policies, implemented in a highly regulated and protected domestic market. However, construction industries in other Asian economies (such as China) will have to leapfrog in technology, finance and management know-how (e.g. through joint ventures with developed countries' construction companies) before they can become formi-dable powers in an environment that has become much more global, more de-regulated, more open and more competitive than befor
Keywords: Asia, globalization, industry development.

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1999, **17**(1), 5–7

A needs based methodology for classifying construction clients and selecting contractors: comment

Martin Skitmore[1] and Anthony Mills[2]
[1]*School of Construction Management and Property, Queensland University of Technology, Brisbane Q4001, Australia*
[2]*Faculty of Architecture, Building and Planning, University of Melbourne, Parkville, Victoria 3052, Australia*

This note is a comment on Chinyio, E A, Olomolaiye, P O., Kometa, S T and Harris, F.C (1998) *A needs based methodology for classifying construction clients and selecting contractors,* Construction Management and Economics, **16**(1), 91-98, which describes research aimed at classifying clients by their needs rather than by the traditional public/private/developer approach. The paper also proposes a new method of selecting contractors by matching clients' needs to contractors' ability to satisfy them. The note offers constructive criticism of some aspects of the analysis.
Keywords: classification, client, contractor, tender evaluation.

1999, **17**(1), 9–19

A grounded theory of construction crisis management

Martin Loosemore
The School of Building, The University of New South Wales, Sydney, 2052, Australia

Construction crisis management research is in an exploratory state where contemplated questions are of more value than hasty answers. For this reason, this paper is more concerned with theory formulation than theory testing. More specifically, it derives a grounded theory of construction crisis management which forms a useful basis for future research. It does so from an investigation of the complex patterns of communication and behaviour which emerge in response to construction crises. The conclusion is that construction crisis management is about the effective control of social and behavioural instability and the conflict which arises out of it. However, effective crisis management is made difficult by the in-built defence mechanisms which construction crises appear to have. The grounded theory also is contrasted with current crisis management theory and thereby, the uniqueness of crisis management in a construction context is identified.
Keywords: behaviour, conflict, crisis management, grounded theory, power, uncertainty.

1999, **17**(1), 21–27

Quasi-rational behaviour in the property and construction market

John Raftery
The Hong Kong Polytechnic University, Department of Building and Real Estate, Hung Hom, Kowloon, Hong Kong

The notion of quasi-rationality is discussed and some new empirical evidence of actual (as revealed in experiments) rather than theorized behaviour is presented. Results from a series of experiments show evidence of money illusion in perception of salary levels and frame dependent risk aversion in agreeing contracts for property development. The implications for the property and construction markets and for research in property and construction economics are discussed.
Keywords: human behaviour, money illusion, quasi-rationality.

1999, **17**(1), 29–43

Skills, knowledge and competencies for managing construction refurbishment works

Charles Egbu
School of the Built Environment, Leeds Metropolitan University, Brunswick Building, Leeds LS2 8BU

An appropriate body of management skills and knowledge for construction refurbishment is established: a skills and knowledge inventory. Of the 75 types of management skill and knowledge, the six most important are leadership, communication (oral/written), motivation of others, health and safety, decision-making, and forecasting and planning. Refurbishment managers' jobs as defined by their application of skills/ knowledge are, on the whole, homogeneous, with some overlap across levels of management and types of organization, and this dispels the view that management tasks are totally different across management strata. A comparison of the relative importance of management skills/knowledge for refurbishment and management skills for general construction shows that the skills/knowledge associated with forecasting and planning, managing conflict and crisis, tenant welfare, team building, and decision

making are higher than in general construction management; reflecting the uncertain nature and the relatively higher levels of risks associated with refurbishment works.

Keywords: competence, education, knowledge, refurbishment, skill, training.

1999, **17**(1), 45–52

Productivity rates and construction methods for high rise concrete construction: a comparative evaluation of UK, German and French contractors

David G Proverbs, Gary D Holt and Paul O Olomolaiye

School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB

Recent investigations concerning the productivity of the UK construction industry and its performance compared with other European and worldwide nations have reported conflicting endings. These investigations have utilized various methodologies in attempting to measure and compare productivity levels. The present investigation uses a customized method to gauge the productivity at site level of three European national construction industries, namely Germany, France and the UK. Analysis of variance is employed to compare the productivity rates used by contractors' planning engineers for a specific concreting operation. The performance of UK contractors is found to be more disparate than those of contractors in either France or Germany. Although leading UK contractors can compete with the best on the continent, there are a number of companies whose performance is far worse than any in France and Germany, due mainly to the construction methods used by UK contractors. It is concluded, therefore, that a best practice recommendation for UK contractors would be for them to avoid using traditional timber formwork methods to beams, and instead adopt more productive approaches afforded using either proprietary or prefabricated systems.

Keywords: analysis of variance, construction method, European comparison, formwork, productivity.

1999, **17**(1), 53–62

Construction work and education: occupational health and safety reviewed

Tuula Laukkanen

University of Helsinki, Department of Education, Centre of Activity Theory and Developmental Work Research, PL47, 00014 Helsinki, Finland

An overview is given of occupational safety and health and of training in the construction sector, summarizing the findings of different researchers. The studies discussed emphasize safety instruction and on the job training at sites, especially the teaching of first aid skill s and accident prevention. Construction workers regard occupational training as important in maintaining work ability. Present developments of vocational training with new flexible pathways are described. Rehabilitation needs are found to be a further important target of work ability promotion. The study provides support for comprehensive occupational health and safety measures. New feedback safety measures (LIIKKUVA, TR- safety audit), which are based on goal setting and a follow up in collaboration, seem to improve considerably both the safety and the development of construction work.

Keywords: construction occupation, occupational safety and health, on the job training, vocational education, safety instruction.

1999, **17**(1), 63–76

Modelling client business processes as an aid to strategic briefing

Stuart D Green and Stephen J. Simister

Department of Construction Management & Engineering, The University of Reading, PO Box 219, Whiteknights, Reading RG6 6AW

The briefing process can be divided into two stages. The first is referred to as strategic briefing and is concerned with understanding the client's business processes. The second stage comprises the conceptualization of built solutions and issues of performance specification. It is the first of these two stages that often is the most problematic. Several authors have established a relationship between strategic briefing and business process re-engineering (BPR), but doubts remain regarding both the originality of BPR and the extent of its theoretical justification. A social constructivist interpretation of BPR is presented and the connection is made with soft systems methodology (SSM). It is argued that SSM offers a rigorous framework for modelling client business processes that subsumes the principles of BPR. A participative research seminar is described which evaluates the potential use of SSM using case study material. Feedback from the seminar participants provides strong support for the contention that SSM could indeed provide the basis for a significant enhancement of current briefing practice. However, there is a danger that practitioners may adopt the techniques of SSM without necessarily buying in at the methodology level. The terminology of SSM also is likely to present a barrier to those construction professionals who are unwilling to make the necessary intellectual investment.

Keywords: briefing, business process re-engineering, client, social constructivism, soft systems research.

1999, **17**(1), 77–90

A world-wide survey of current practices in the management of risk within electrical supply projects

J. F. Burchett[1], V. M. Rao Tummala[2] and H. M. Leung[3]
[1]*Transmission Projects Department, Transmission Business Group, China Light & Power Company Limited, Kowloon, Hong Kong*
College of Business, Eastern Michigan University, Ypsilanti, MI 48197 USA
Department of Manufacturing Engineering and Engineering Management, City Polytechnic of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong

A survey is described which examines the current risk handling practices in evaluating capital development projects (transmission, generation and distribution) within the electricity supply industry worldwide. As risk perception is an important aspect of risk management, the attitudes towards and the barriers created by management to risk management plus the benefits perceived are examined and compared with the results of previous surveys. The survey will assist also in determining the need and feasibility of applying a risk management process to capital budgets in investments such as transmission construction works and other appropriate applications. The survey has demonstrated that a formal risk management process is more likely to apply to large, complex projects with potential of cost overrun. However, the criteria for application are likely to depend more on overcoming managers concerns about time involvement, human/organizational resistance and understanding of quantitative techniques, such as assessing probability distributions, deter-mining and interpreting expected values, variances, and risk management output results, so as to appreciate the benefits and enable effective decisions to be made. The worldwide survey confirms that there is a drive towards a more thorough assessment of risks than previously recorded, with a formal risk management process that will meet the expectations of business growth and project sponsors and ensure that all risks are actively managed throughout the life-cycle of a project.

Keywords: electricity supply industry, power generation, power distribution, risk management, survey.

1999, **17**(1), 91–98

Inducing rules for selecting retaining wall systems

Nie-Jia Yau, Jyh- Bin Yang and Ting- Ya Hsieh
Department of Civil Engineering, National Central University, Chungli 320, Taiwan (ROC)

Rule induction is a paradigm of machine learning that governs how knowledge is acquired from experience. This paradigm not only classifies existing data into logical sets, but also expresses them by `if ± then' rules. Rule induction can be applied to the experience-oriented construction industry. A typical example would be to select an appropriate retaining wall system at the project planning stage, in which engineers normally employ certain empirical laws or select from the types for which they have relevant expertise in making appropriate selections. This work presents a novel rule induction approach, capable of inducing from 254 retaining wall cases in engineering design reports into 181 rules, thereby allowing for an appropriate retaining wall system to be selected. A system referred to herein as RULES is also constructed with an illustrative example provided as well. Test results of the system demonstrate that the rule induction approach can effectively resolve retaining wall selection problems at the project planning stage. The approach proposed herein is highly promising for resolving experience-oriented problems in the construction industry.

Keywords: artificial intelligence, knowledge discovery, retaining wall selection, rule induction.

1999, **17**(1), 99–106

The likelihood and impact of changes of key project personnel on the design process

Robert J. Chapman
W.S. Atkins Project Management Division, Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW

Both the construction and the risk analysis and management literature have overlooked the highly disruptive influence of the loss of key project personnel. It is clear from other industries involved in managing projects, such as information technology, that the likelihood of this adverse event is openly recognized. The construction literature looks at a series of issues which all relate to communication and information transfer but fails to isolate one of the key issues which, when it materializes, seriously undermines the essence of design: the complete integration of the creative contribution of all the participating design disciplines. The risk analysis and management literature recognizes the significance of risk identification but pays scant attention to discontinuity, and the borrowed identification techniques are reliant solely on subjective judgements. Propositions for examination are tested against a documentary analysis of twenty-two projects to establish the existence of this threat to a project' s objectives. Of the sample of projects examined, changes to personnel are commonplace, and clearly lead to project overruns.

Keywords: design management, key project personnel, risk.

1999, **17**(1), 107–119

ISO 9000 standards: perceptions and experiences in the UK construction industry

Ramin Moatazed-Keivani, Ali R. Ghanbari-Parsa and Seiichi Kagaya
School of Urban Development and Policy, South Bank University, Wandsworth Road, London SW8 2JZ

With the adoption by construction firms of BS EN ISO 9000 there has been much debate concerning its effectiveness and value as a quality management system. In spite of the reported benefits of ISO 9000 certification, however, concerns regarding its overall benefit to construction firms due to unnecessary bureaucracy and paperwork, increased costs, stilling of innovation, etc. still persist in the industry. This paper reports on the results of a research carried out on the implementation of BS EN ISO 9000 as a continuation of BS5750 in the UK construction industry from the viewpoint of the experiences and perceptions of quality assurance managers of selected construction firms.
Keywords: quality assurance, quality management, ISO 9000, certification, construction firm.

1999, **17**(2), 129–132

Construction cost and building height

Willie Tan
School of Building and Real Estate, National University of Singapore, Kent Ridge Crescent, Singapore 119260

A simple neo-classical production function model is used to determine the incremental cost of each floor as building height increases. This analytic method provides an alternative to earlier studies using computer simulation and more cumbersome attempts at measuring the cost variation directly. By modelling construction costs analytically, it is possible to identify and assess the impacts of particular variables more explicitly. There are two main findings. First, cost variation with building height is not only affected by technology; building design, demand and institutional factors also play important roles. Secondly, the model may be used to estimate construction cost variation with building height from readily avail able data. In this sense it is an improvement over previous methods using simulated or direct cost measurement.
Keywords: building height, construction cost, productivity.

1999, **17**(2), 133–137

The missing arguments of lean construction

Stuart D Green
Department of Construction Management and Engineering, The University of Reading, Whiteknights, P.O. Box 219, Reading, RG6 6AW, UK

The emerging concept of lean construction is concerned with the application of lean thinking to the construction industry. The ideas of lean thinking seem set to dominate the UK construction industry' s quest to improve quality and efficiency. However, the current debate is based on a highly selective interpretation of the available literature. The extent to which the Japanese model of lean production is applicable in Western contexts remains hotly debated. An extensive body of critical opinion equates the Japanese model of lean production with technocratic totalitarianism. Whilst the claims of productivity achievements in Japanese manufacturing transplants are impressive, the rhetoric of flexibility, quality and teamwork too often translates in practice to control, exploitation and surveillance. Furthermore, it cannot be taken for granted that any increases in productivity necessarily serve the interests of the end customer. The current agenda for the implementation of lean thinking in the UK construction industry notably ignores the extensive critical literature on lean production. In the absence of a more balanced research agenda, there is a danger that dogma rather than a balanced appraisal of the available evidence will drive construction policy.
Keywords: critical theory, customer responsiveness, human resource management, lean construction, technocratic totalitarianism, total quality management.

1999, **17**(2), 139–153

Ethics in tendering: a survey of Australian opinion and practice

Richard S Ray, John Hornibrook, Martin Skitmore and Anna Zarkada-Fraser
School of Construction Management, Queensland University of Technology, Gardens Point, CMEsbane Q4001, Australia

The main issues in the philosophical foundations of ethics and tendering ethics are outlined, and an introduction is provided to the Australian codes of tendering practice. A questionnaire survey is then described which sought to ascertain the extent to which ethical behaviour in tendering is supported and practiced in Australia. The results of the survey indicate that most companies support the use of codes of tendering; defend the right of withdrawal of tenders; disapprove of bid shopping, cover pricing and union involvement in the tendering process, and support the principals' right to know what is included in a tender as well as the self-regulation of the tendering codes. It is also shown that most companies have developed, and follow, idiosyncratic ethical guidelines that are independent of, and often contrary to, the nationally prescribed codes. The conclusions recommend a need for the development of a theoretical frame of reference that can be tested through a more detailed empirical approach to the development of future ethical prescriptions in the field.

Keywords: ethics, restrictive practice, tendering.

1999, **17**(2), 155–167

Modelling information flow during the conceptual and schematic stages of building design

Andrew N Baldwin, S A Austin, T M Hassan and Antony Thorpe
Department of Civil Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK

The aim of this research was to study, model and simulate the information flow at the conceptual and schematic stages of building design. The development of a generic model of the conceptual and schematic design process for buildings is described. This model comprising design tasks and their information requirements was produced using data flow diagrams. Examples from several levels of the model are provided. Details are then given as to how the model may be used to assist the management of the design process both directly and by providing primary data for other tools and techniques. Industry feedback on the data modelling and these tools and techniques is then discussed. It is concluded that it is only by a better understanding of the flow of information among project participants that the management of design may be improved, and that although the generic data flow model provides immediate benefits to design managers these can be enhanced greatly by the use of the model as a primary data source for other tools and techniques including the design structure matrix and simulation.

Keywords: conceptual design, schematic design , data flow diagram, design structure matrix, information flow, simulation.

1999, **17**(2), 169–176

Combining rule-based expert systems and artificial neural networks for mark-up estimation

Heng Li[1] and Peter E D Love[2]
[1]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Hong Kong*
[2]*School of Architecture and Building, Deakin University, Geelong, Victoria, 3217 Australia*

Rule-based expert systems and artificial neural networks are two major systems for developing intelligent decision support systems. The integration of the two systems can generate a new system which shares the strengths of both rule-based and artificial neural network systems. This research presents a computer based mark-up decision support system called InMES (integrated mark-up estimation system) that integrates a rule-based expert system and an artificial neural network (ANN) based expert system. The computer system represents an innovative approach for estimating a contractor' s mark-up percentage for a construction project. A rule extraction method is developed to generate rules from a trained ANN. By using the explanation facility embedded in the rule-based expert system, InMES provides users with a clear explanation to justify the rationality of the estimated mark-up output. Cost data derived from a contractor' s successful bids were used to train an ANN and, in conjunction with a rule-based expert system, select the expected mark-up for a project. The combination of both ANN- and rule-based expert systems for estimating mark-up allows significant benefits to be made from each individual system, such as understanding why and how the estimated mark-up was derived and also the effects of imposing rules and constraints on a company's mark-up estimation. The mark-up decision support system presented can assist contractors in preparing a rational mark-up percentage for a project. Moreover, InMES as proposed will assist contractors in their tender decision making, that is, whether or not to submit a bid for a project considering the estimated mark-up.

Keywords: explanation facility, hybrid system, mark-up decision, rule extraction.

1999, **17**(2), 177–188

Bargaining tactics in construction disputes

Martin Loosemore
School of Building, University of New South Wales, Sydney, 2052, Australia

Bargaining is the initial and informal means by which parties attempt to resolve their differences during a construction dispute. However, knowledge of the bargaining process in construction projects is scant, with most attention being given to developing more formal, costly and reactive means of dispute resolution. This approach is questioned, in favour of a more ef® cient one based upon a better understanding of bargaining behaviour and improved bargaining skills. To this end, the behavioural complexities of the bargaining process during construction disputes are investigated. It is concluded that the majority of construction disputes are unintentional and escalate as a result of misunderstandings and tactical miscalculations during the bargaining process. A series of recommendations is set out to reduce the potential for unintentional escalation during a construction dispute.
Keywords: bargaining, behaviour, claim, conflict, dispute, negotiation.

1999, **17**(2), 189–196

Modelling building durations in Hong Kong

Albert P C Chan
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

The duration of Australian construction has been modelled by a time and cost formula expressed in the form of T = KC B , where T is the actual construction time in working days, C is the final cost of contract in millions, K is a constant characteristic of building time performance, and B is a constant indicative of the sensitivity of time performance to cost level. This paper applies the relationship to building projects in Hong Kong using time and cost data from 110 projects. Regression analysis was used to compute the values of K and B and check how well the model actually is, and the best predictor of average construction time of building projects in Hong Kong is found to be T = 152C 0.29. It is also found that the Hong Kong private sector takes a shorter time (120 days) to complete a hypothesized project with a contract sum of HK$1 million (at December 1994 price) than its government counterpart (166 days). The time and cost relationship serves as a convenient tool for both project managers and clients for predicting the actual optimum time required for delivery of a building project.
Keywords: project, Hong Kong, regression analysis, time cost relationship.

1999, **17**(2), 197–204

The quality of accident and health data in the construction industry: interviews with senior managers

Diane E Gyi1[1], Alistair G F Gibb[1] and Roger A Haslam[2]
[1]*Department of Civil and Building Engineering, Loughborough University, Leicestershire, LE11 3TU, UK*
[2]*Department of Human Sciences, Loughborough University, Leicestershire, LE11 3TU, UK*

Despite recent changes in legislation and advances towards an integrated project-wide approach, health and safety management in the construction industry is still a major problem, involving a substantial cost to business, society and individuals. A prerequisite to improving the situation and developing an effective management strategy is monitoring, providing a detailed understanding of the effectiveness of different approaches to intervention. This paper describes a feasibility study using in-depth interviews with senior managers to explore the quality of accident and health data of nine large, high profile companies from the engineering construction sector. The interview dialogue comprised a series of questions and issues to be explored on the organization' s accident reporting systems (e.g. what is reported, analysis performed, computerization), unsafe act and near miss auditing (e.g. definition, validity), failure type indicators (e.g. auditing, quantification) and safety culture indicators (e.g. commitment, health). Although safety was a priority for companies, health (i.e. medicals and monitoring systems) had not been given the same consideration, especially with regard to sub-contracted labour. This study shows that the validity of accident statistics as a measure of safety remains a limitation and that there is a requirement for a consistent and integrated approach to the measurement of health and safety performance.
Keywords: accident data, health, interview, safety.

1999, **17**(2), 205–213

Risk response techniques employed currently for major projects

Scott Baker, David Ponniah and Simon D Smith
The Department of Civil and Environmental Engineering, The University of Edinburgh, The Kings Buildings, Edinburgh, EH9 3JN, UK

Risk management is fundamental to the success of a major project. However, the variations in using risk management practices are considerable and are dependent on numerous factors such as the industry sector, the size of the project, and the stage in the project life-cycle. One of the major constituents of successful risk control is the use of risk response. This paper concentrates on the choice and use of the most successful risk response techniques within the oil and gas

industry and compares them with the use of those chosen by the construction industry. Results were ascertained through a survey of over one hundred companies within these two sectors by use of an extensive questionnaire. The main conclusions are that risk reduction as a response to assessed risks is most commonly used by both sectors; and that the construction industry concentrates almost exclusively on reduction of financial risk. It is proposed that the construction industry can benefit greatly from the more experienced oil and gas industry in managing technical risk which, with the advent of private funding, is likely to become a more predominant part of construction procurement.
Keywords: risk management, risk response.

1999, **17**(2), 221–230

European construction contractors: a productivity appraisal of in situ concrete operations

David G Proverbs, Gary D Holt and Paul O Olomolaiye
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB, UK

Site productivity levels for high-rise, in situ concrete operations are compared among three groups of European construction contractors. Results confirm significant differences between the contractor' s productivity rates for each of the three countries investigated (Germany, France and the UK). German firms are the most efficient at reinforcement and concrete placing operations, whereas French firms are most productive at formwork. UK firms are the l east productive for two operations, namely form work and concrete. French firms are least productive at fixing reinforcement. Based on a specific model project, it is determined that French and German firms require significantly fewer man-hours to carry out the said concrete operations than do UK firms. UK contractors achieve the lowest levels of labour productivity for the operations involved. The UK also exhibited greater productivity variation, i.e. providing evidence of extreme (most and least efficient) levels of labour output for several concrete operations. Leading on from these analyses, a construction (labour) cost comparison indicates that French contractors are the least expensive. Furthermore, the ideal solution for clients would be to have French firms build their projects in the UK, since this combination provides the most economic solution to the model building overall.
Keywords: analysis of variance, Europe, in situ concrete, labour cost, productivity.

1999, **17**(2), 231–241

An evaluation of the accuracy of the multiple regression approach in forecasting sectoral construction demand in Singapore

Goh Bee Hua
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260

In the current state of research in construction demand modelling and forecasting there is a predominant use of the multiple regression approach, particularly the linear technique. Because of the popularity, it may be useful at this stage to gain an insight into the accuracy of the approach by comparing the forecasting performance of different forms of regression analysis. It is only through such formal means that the relative accuracy of different regression techniques can be assessed. In a case study of modelling Singapore' s residential, industrial and commercial construction demand, both linear and non-linear regression techniques are applied. The techniques used include multiple linear regression (MLR), multiple log-linear regression (MLGR) and auto regressive non-linear regression (ANLR). Quarterly time-series data over the period 1975-1994 are used. The objective is to evaluate the reliability of these techniques in modelling sectoral demand based on ex-post forecasting accuracy. Relative measures of forecasting accuracy dealing with percentage errors are used. It is found that the MLGR outperforms the other two methods in two of the three sectors examined by achieving the lowest mean absolute percentage error. The general conclusion is that non-linear techniques are more accurate in representing the complex relationship between demand for construction and its various associated indicators. In addition to improved accuracy, the use of non-linear forms also expands the scope of regression analysis.
Keywords: construction demand, forecasting accuracy, non-linear, model evaluation, regression analysis.

1999, **17**(3), 251–267

Studies on the impact of functional analysis concept design on reduction in change orders

Samuel N Stocks and Amarjit Singh
Department of Civil Engineering, University of Hawaii at Manoa, Honolulu, HI 96822, USA

Functional analysis concept design (FACD) is a method by which owners and designers can `partner' during the design phase of projects. Much has been written and reported about partnering on construction projects, but little is avail able on the applications and results of FACD. While FACD has been mentioned in the literature to be a valuable tool, evidence on its effectiveness has been missing. Consequently, FACD has not hitherto emerged as a common management system used during design. Management processes on its implementation also had not been developed fully until the United States Navy carried out research, much involving tedious trials and revisions. This paper describes processes that have been found suitable. The economic benefits of FACD have never been directly evaluated,

but by examining and testing the quantum of change orders on projects, this study finds that FACD is a viable method that can reduce construction costs overall. Whereas value engineering and constructability review are other common tools, FACD is distinct from them both. FACD is allied to functional analysis system technique (FAST); regulations, and specifications have been developed to implement FACD to ensure its success.
Keywords: ANOVA, change order, cost, design, functional analysis.

1999, **17**(3), 269–283

Construction costs in The Netherlands in an international context

Henk M Vermande[1] and Peter-Hein van Mulligen[2]
[1]*PRC Bouwcentrum, P.O. Box 1051, NL 2410 CB Bodegraven, The Netherlands*
[2]*Groningen Growth and Development Centre, University of Groningen, P.O. Box 800, NL 9700 AV Groningen, The Netherlands*

OECD purchasing power parities (PPPs) are used regularly in strategic governmental policy papers to compare the performance of construction industries among countries. These PPPs suggest that the relative competitiveness of the Dutch construction sector is fairly weak compared with surrounding countries. This contradicts the general view that the Dutch construction industry is very productive and efficient, especially in house building. For the member countries of the European Union the OECD uses data from Eurostat, the statistical office of the European Union. In this paper the methodology followed by OECD/Eurostat in their calculation of PPPs for construction is reviewed. The data for five European countries (Netherlands, Belgium, UK, France and Germany) are analysed. Next, the Eurostat results are placed alongside the results of other international building cost comparisons. The differences are observed and the conclusion is that the Eurostat PPPs do not reflect the real construction price or cost differentials among the five EU countries. It appears that the basic construction price data used by Eurostat are not very accurate, that the comparison methodology applied by Eurostat itself is insufficient to express and explain building cost differences among countries, and that the Eurostat figures for construction are the result of a complex statistical weighting and processing procedure in which corrections are not applied for extreme deviations. The conclusion is that the Eurostat data cannot be used for comparison purposes. Proposals for improvement of the comparison methodology are reviewed.
Keywords: cost, international comparison, statistics, purchasing power parity.

1999, **17**(3), 285–296

Tendering theory revisited

Göran Runeson[1] and Martin Skitmore[2]
[1]*School of Building, University of New South Wales, Sydney 2052, Australia*
[2]*School of Construction Management, Queensland University of Technology, Brisbane, Australia*

The content, origin and development of tendering theory are considered in terms of a theory of price determination. Tendering theory determines prices and differs from game and decision theories. In the tendering process, with non-cooperative, simultaneous, single sealed bids with individual private valuations, extensive public information, a large number of bidders and a long sequence of tendering occasions, there develops a competitive equilibrium. The development of a competitive equilibrium means that the concept of the tender as the sum of a valuation and a strategy, which is at the core of tendering theory, cannot be supported, and that there are serious empirical, theoretical and methodological inconsistencies in the theory.
Keywords: bidding, price determination, tendering, tendering theory.

1999, **17**(3), 297–303

The Italian residential construction sector: an input-output historical analysis

Roberto Pietroforte[1] and Ranko Bon[2]
[1]*Department of Civil and Environmental Engineering, Worcester Polytechnic, 100 Institute Road, Worcester, MA 1609–2280, USA*
[2]*Department of Construction Management and Engineering, University of Reading, Whiteknights, P. O. Box 219, Reading, RG6 6AW, UK*

Two sets of input-output tables are employed in this paper to analyse the role of the Italian residential construction sector in the national economy. The analysis focuses on changes in construction technology over a period of some 30 years, ending in 1985, the last year for which such data are available. A set of eight-sector input-output tables is used to show the weakening of the residential construction sector' s effect on the economy as a whole. This trend is caused by the progressive saturation of the residential construction market and the transformation of the overall Italian economy. As expected, the achieved maturity of the Italian economy is accompanied by the growing importance of maintenance and repair construction because of the ageing building infrastructure. Another set of 24-sector input-output tables is used to analyse the input and output profiles of the residential and non-residential construction sectors, by selecting key supply industries. Significant differences are reported in the technology of the residential sector, with a shift towards services and away from manufacturing inputs.
Keywords: backward and forward linkage, construction technology, input-output analysis, residential construction.

1999, **17**(3), 305–314

Prediction of hoisting time for tower cranes for public housing construction in Hong Kong

Arthur W T Leung and C M Tam

Division of Building Science and Technology and 2 Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong

Material transportation for high-rise building construction relies heavily on tower cranes. Hence the proper use of tower cranes is of paramount importance for high-rise residential building construction. In planning and monitoring crane usage in Hong Kong, a schedule is usually prepared to co-ordinate hoisting operations. Apart from that, little research in optimizing crane usage has been carried out previously, except on operation cycle times, e.g. concreting using a crane and skip and form work erection. Allocation of time for the hoisting schedule is based on the planners' and operators' experience. The accuracy of the hoisting schedule for crane dominated construction works has significant effects on the materials supply and on concreting operations. Imbalance in the allocation of crane usage for sub-contractors may lead to conflicts between trades and idling of workers due to a shortage of materials. Although planners understand that the load hoisting time is proportional to hoisting height and other factors, floor construction cycles usually, for simplicity, are assigned to be constant six day, eight day or ten day cycles without making the necessary compensation for the longer hoisting times for upper floors. The prediction of hoisting times is of great importance to planners to ensure the accuracy of the construction schedule for crane-dominated construction. This paper describes the derivation of a mathematical model to predict the hoisting times for a tower crane for public housing construction. Work measurement is used to collect hoisting times data for analysis. Twelve factors considered to influence hoisting time are identified for the model. Multiple regression models are built for predicting supply hoisting times and return hoisting times. The effects of the variables on hoisting time are reviewed. Estimated hoisting times calculated from the models are compared with actual hoisting times, and a worked example illustrating the application of the models is presented.

Keywords: hoisting time, multiple regression, public housing, tower crane.

1999, **17**(3), 315–327

A model for sub-contractor selection in refurbishment projects

M. I. Okoroh[1] and V. B. Torrance[2]

[1]*School of Engineering, Division of Construction, University of Derby, Kedleston Road, Derby, DE22 1GB, UK*

[2]*School of Architecture, Planning and Surveying, MARA Institute of Technology, Malaysia*

A model is presented for analysing the sub-contractor' s risk elements in construction refurbishment projects. The system is based on the use of fuzzy set theory with the fuzzy set representing the overall weighted average rating of refurbishment contractors' criterion for the selection of sub-contractors. A prototype knowledge based expert system is described, which provides a systematic and objective approach to the selection of sub-contractors. Knowledge elicitation methodology using the `repertory grid' technique is detailed. The implementation of a sub-contractor selection and appointment Model for refurbishment contractors (SSARC) in linguistic terms allows the user to interact with the system in a very friendly manner using natural language expression.

Keywords: knowledge-based system, fuzzy sets, refurbishment, repertory grid, sub-contractor.

1999, **17**(3), 329–340

A participative research strategy for propagating soft methodologies in value management practice

S. D. Green

Department of Construction Management and Engineering, The University of Reading, P. O. Box 219, Reading, RG6 6AW, UK

The emerging methodologies of `soft operational research' have been developed for the purposes of structuring multi-perspective problems characterized by uncertainty, ambiguity and conflict. A participative research project is reported that sought to propagate the three most established `soft' methodologies within UK value management practice. The adopted research strategy consisted of four key stages. Following an initial literature review, an insight into existing value management was gained by twelve semi-structured interviews with leading practitioners. This was followed by a series of six participative research seminars, which used simulated case studies to evaluate the potential application of the three methodologies within the context of value management. A final series of interviews then determined the extent to which the three methodologies subsequently had been adopted in practice. The results are encouraging in that already the research has had an influence on UK value management practice. However, doubts remain as to whether the practitioners have assimilated the methodologies fully, or simply have adopted individual techniques in the absence of any theoretical understanding.

Keywords: briefing, group decision support, participative research, risk management, soft operational research, value management.

1999, **17**(3), 341–350

Assessment of construction processes and innovations through simulation

Sarah Slaughter
Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room 1-174, Cambridge, MA 02139, USA

The objectives of this research are to represent construction activities accurately, and to provide a means for assessing the impacts from using innovations. The research approach is the detailed characterization of construction processes, and the development of system and material specific dynamic process simulation models. The ongoing research program is developing a set of specific models, based on extensive empirical data, to enable the accurate modelling of all of the construction processes for a complete facility construction project. A specific process model, glass/metal curtain wall erection, demonstrates the approach, with an analysis of the impacts from a related innovation.
Keywords: construction innovation, construction process improvement, dynamic process simulation, estimating, simulation model, safety.

1999, **17**(3), 351–362

Modelling and predicting construction durations in Hong Kong public housing

Daniel W M Chan and Mohan M Kumaraswamy
Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong

Construction time performance is provoking worldwide concern and discussion within the industry. This paper reports the results of a survey in the fourth stage of an investigation seeking to identify a set of significant variables influencing construction durations of projects in Hong Kong, the stage addressing the formulation of standard norms for overall construction durations of public housing projects by modelling the primary work packages in the building process, namely piling, pile caps/raft, superstructure, E and M services, finishes and their respective sequential start-start lag times, on the basis of the identified groups of critical factors. Data were collected from a sample of 56 standard `Harmony' type domestic blocks of the Hong Kong Housing Authority; (the `Harmony' series of block design having become popular for average quality public housing blocks in the 1990s, ranging from 30 to 40 storeys and containing about 16 residential units on each floor). These data were analysed through a series of multiple linear regression exercises that helped to establish the time prediction model. This model was then tested and validated using information from a further nine projects from the Housing Authority. Both the usefulness and shortcomings of the model are briefly presented and discussed. It is concluded that the model is applicable to the public housing industry in Hong Kong, and that the methodology used may be applied to develop similarly useful models in other subsectors, and in other countries.
Keywords: construction duration, Hong Kong, public housing, modelling, multiple linear regression, prediction.

1999, **17**(3), 363–374

Energy impact analysis of building construction as applied to South Africa

Daniel K Irurah[1] and Dieter Holm[2]
[1]*Department of Architecture, University of Witwatersrand, Private Bag 3, Wits, 2050, South Africa*
[2]*Division of Environmental Design and Management, University of Pretoria, Pretoria, 0002, South Africa*

Basic embodied-energy intensities of building construction materials/systems by various units and building types are shown to produce conflicting results and are not directly applicable at a national policy-intervention level. Using building construction and the allied sectors in South Africa, this paper demonstrates the extension of basic energy intensities derived through an improved input-output (I-O) method into a sectoral energy conservation framework. The framework is based on sectoral total-embodiment energy impact coefficients derived through the multiplication of the total-embodiment energy intensity coefficients with the use-intensity coefficients. A ranking of building construction and the al lied sectors in South Africa according to their energy impact coefficients is used to formulate a priority listing of critical sectors for energy conservation measures. The framework is used also to identify generic conservation measures for further investigation and evaluation.
Keywords: building construction, embodied energy, input-output analysis, South Africa, use-intensity.

1999, **17**(3), 375–382

A survey of the site records kept by construction supervisors

Steve Scott and Sami Assadi
Civil Engineering Department, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU, UK

A number of writers have cited poor records as limiting the ability of supervisors, and indeed of contractors, to carry out some of their most important functions. The study reported in this paper aimed to identify the problems in detail. This was achieved by conducting a mail-shot survey of construction supervisors working for firms of civil engineering consultants. The results indicate that there is considerable room for improvement in the records kept on most sites, where guidelines are said to be inadequate and the problems of enforcing these inadequate guidelines were also recognized. The main source data for progress records was identified as the site diaries kept by individual members of the supervisor' s team, and these were found to be particularly difficult to access for a number of reasons. Since the site diaries are such an important source of information, it is argued that most benefit may be gained by taking steps to improve these daily logs, which, in turn, will allow better overviews of progress to be produced.
Keywords: claim, documentation, progress records, site operation, role, supervisor.

1999, **17**(3), 383–391

Strategies for insuring sub-contracted works

Hisham K Gaafar and John G Perry
School of Civil Engineering, The University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

In the UK construction industry there are different strategies used in practice for the insurance of sub-contracted work of which two predominate: one is for sub-contracted work to be insured by both main contractor and sub-contractor (model A) and the other is for only the main contractor to insure the sub-contracted work (model B). The extent of use of these approaches is discussed and the rationales for them are presented in the context of research undertaken by questionnaire surveys and structured interviews. A background is provided to the requirements for sub-contractor insurance found in commonly used forms of contract, including FIDIC. Four possible model s of sub-contractor insurance are identified and their relationship to the contract provisions in model forms is outlined. Two of the models have little practical relevance to sub-contractor insurance and the reasons for this are given. About 75% of the main contractors in the research sample were found to adopt model A for all disciplines, although the reasons given were not entirely consistent. About 15% of the sample adopt model B for all disciplines and the remainder use different models for different disciplines. Again, the rationales for these choices were not found to be robust. The main conclusions are first that the choice of strategy for sub-contractor insurance is highly independent of both the discipline and the selected form of sub-contract, and second that some commercial decisions in this area may be sub-optimal. There is an unreconciled argument over the immediate commercial advantages claimed by many for model A and the potential for longer term reduction in insurance costs which might arise from the widespread adoption of model B.
Keywords: discipline, form of contract, insurance, sub-contractor, works.

1999, **17**(3), 393–401

Cash farming in building and construction: a stochastic analysis

Russell Kenley
Faculty of Architecture, Building and Planning, University of Melbourne, Parkville, Melbourne, Australia 3052

Cash flow management is a significant issue in the management of a building or construction firm. This paper steps back from the well researched area of poor cash management and its relationship with failure, to focus on the funds which are generated through operations, and the positive benefits which can follow in a well managed organization. A stochastic model is developed which illustrates how an average of 16% of turnover can be available for reinvestment. This is sufficient to allow investment in non-liquid assets, provided that this is managed carefully and precautions are taken against a severe reduction in turnover. This level of funds is sufficient to encourage firms to enter the industry with the motivation of generating funds, rather than a desire to build. This has implications for large clients and for government when dealing with the industry.
Keywords: cash farming, liquidity, Monte Carlo simulation, net cash flow, stochastic modelling.

1999, **17**(4), 441–447

Allocation of contingency in activity duration networks

Terry Williams
Department of Management Science, Strathclyde University, Graham Hills Building, 40 George Street, Glasgow, G1 1QE, UK

This paper describes a method for apportioning contingency in a probabilistic network. It distinguishes between two requirements for contingency: for high variance crucial activities, and for high ¯ oat non-critical activities. This enables a logical two-step apportionment, the first based upon the idea of `cruciality', which has become established as an important indicator of an activity' s importance in risk terms, and the second based upon standard ideas about ¯ oat. A numerical example is given based on data used by previous work, so that a comparison of the methods can be made.
Keywords: construction planning, contingency, CPM, network analysis, stochastic network analysis.

1999, **17**(4), 449–461

ISO 14000: its relevance to the construction industry of Singapore and its potential as the next industry milestone

Alan Tan Tong Kein[1], George Ofori[2] and Clive Briffett[2]
[1]*Housing and Development Board, 3451 Jalan Bukit Merah HDB Centre, Singapore 159459*
[2]*School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 118418*

ISO 14000 is a series of standards defining a formal and structured approach to environmental management. It demonstrates, with assurance, that an organization complying with current policy and legislation actively addresses environmental issues. Construction activities have a myriad of environmental implications. Hence, construction entities must manage their environmental performance. ISO 14000 represents a possible solution. This study considers the relevance of environmental management to construction organizations. After an overview of the environmental impacts of construction, ISO 14000 and its principles are explored. A field study is reported that was set up to assess the level of commitment of construction enterprises in Singapore to environmental management. Contractors in Singapore are aware of the merits of environmental management, but are not instituting systems towards achieving it. A framework for the development and implementation of an environmental management system (EMS) is proposed.
Keywords: construction industry, environmental management, implementation, ISO 14000, Singapore.

1999, **17**(4), 463–471

A neural network-based system for predicting earthmoving production

Jonathan Jingsheng Shi
Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Ave, Kowloon, Hong Kong

An artificial neural network based system (NN_earth) is developed for construction practitioners as a simple tool for predicting earthmoving operations, which are model led by back propagation neural networks with four expected parameters and seven affecting factors. These networks are then trained using the data patterns obtained from simulation because there are insufficient data available from industrial sources. The trained network is then incorporated as the computation engine of NN_earth. To engender confidence in the results of neural computation, a validation function is implemented in NN_earth to allow the user to apply the engine to historic cases prior to applying it to a new project. An equipment database is also implemented in NN_earth to provide default information, such as internal cost rate, fuel cost, and operator' s cost. User interfaces are developed to facilitate inputting project information and manipulating the system. The major functions and use of NN_earth are illustrated in a sample application. In practice, NN_earth can assist the user either in selecting a crew to minimize the unit cost of a project or in predicting the performance of a given crew.
Keywords: artificial neural network, back propagation, earthmoving, prediction, simulation, site operation.

1999, **17**(4), 473–482

On the issue of plan shape complexity: plan shape indices revisited

Chau Kwong Wing
Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong

Plan shape indices are based on the geometry of the plan shape rather than on empirical data, and are problematic as they embrace implicit assumptions that are not tested empirically nor justified theoretically. Empirical research using data in Hong Kong confirms that these plan shape indices are much poorer predictors of unit construction costs than the variables used to construct the indices. This study also develops a method for constructing a plan shape index that is free from the unjustified assumptions implicit in existing plan shape indices; it involves an empirical cost model. Different functional specifications of the cost models are tested. The result rejects the linear model and other special case models such as semi-log and log-linear models. However, the reciprocal model is not rejected. This result suggests that a linear plan shape index can predict the amount of floor area that can be constructed with a fixed sum of money better than the construction cost per floor area.
Keywords: cost model, Box-Cox transformation, construction cost, design, plan shape.

1999, **17**(4), 483–492

Examination of relationships between building form and function, and the cost of mechanical and electrical services

Lisa M Swaffield and Christine L Pasquire
Department of Civil and Building Engineering, Loughborough University, Leicestershire, LE11 3TU

This paper describes analysis work undertaken to examine relationships between building function, building form and mechanical and electrical services cost, including the collection of raw data, and the transformation work undertaken to

enable analysis. Relationships are identified between building form parameters, e.g. perimeter of external walls, gross floor area, storey heights, percentage of glazing, and the mechanical and electrical services costs for buildings of different functions (commercial, industrial and residential). There are relationships between the costs of the mechanical and electrical services installations and some building form descriptors, but the particular descriptors and the strength of the relationships vary according to the function of the building.
Keywords: form, function, cost planning, mechanical services, electrical services, tender cost.

1999, **17**(4), 493–503

Age-dependent business failures in the US construction industry

Serdar Kale and David Arditi
Department of Civil and Architectural Engineering, Illinois Institute of Technology, Chicago, IL 60616, USA

Age-dependent failure in the construction industry is explored over two 11-year periods (1973-1983 and 1984-1994) by analysing the age distribution of failed construction companies in each year and computing age-specific failure probabilities over a 10 year period (1985-1994). The conflicting perspectives of organizational theory are reconciled by taking advantage of the complementary nature of the adaptationist and organizational ecology theories while the effects of the characteristics of the construction industry are also considered. The research findings reveal an age-dependent business failure pattern in the US construction industry where the risk of failure increases initially with increasing age, reaches a peak point and decreases thereafter as companies grow older. Newness of a construction company, which implies lack of organizational l earning and lack of legitimacy, appears to be the main factor explaining this pattern.
Keywords: adaptation, business failure, construction company, inertia, learning, legitimacy.

1999, **17**(4), 505–517

Determining the causal structure of rework influences in construction

Peter E D Love[1], Purnendu Mandal[2] and H Li[3]
[1]*School of Architecture and Building, Deakin University, Geelong,Victoria, 3217 Australia*
[2]*School of Engineering and Technology, Deakin University, Geelong,Victoria, 3217 Australia*
[3]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hong Kong*

One of the most perplexing issues facing organizations in the construction industry is their inability to become quality focused. As a result sub-standard products and services often emanate, which inadvertently result in rework. Typically, rework is caused by errors made during the design process. These errors appear downstream in the procurement process and therefore have a negative impact on a project' s performance. The lack of attention to quality, especially during the design process, has meant that rework has become an inevitable feature of the procurement process, and the costs have been found to be as high as 12.4% of total project costs. Such costs could be even higher because they do not represent schedule delays, litigation costs and other intangible costs of poor quality. To reduce the cost and effect of rework, an understanding of its causal structure is needed so that effective prevention strategies can be identified and the effects of rework reduced or eliminated. A case study approach based upon deductive and inductive reasoning is used to identify the major factors that influence rework in projects. From the findings and with reference to recent literature, the concept of system dynamics is used to develop a series of influence diagrams, which are then integrated to develop a conceptual causal loop model that is used to determine the overall causal structure of rework. Once an understanding of the causal structure of rework events has been acquired, effective strategies for rework prevention can be designed and implemented in order to improve project performance. This paper contributes to study of quality in construction by capturing the complexity and dynamism of those factors that influence rework and project performance in a holistic manner.
Keywords: causation, quality management, re-work, systems dynamics.

1999, **17**(4), 519–527

Selection of mobile cranes for building construction projects

Aviad Shapira[1] and Clifford J Schexnayder[2]
[1]*Department of Civil Engineering and National Building Research Institute, Technion--Israel Institute of Technology, Haifa 32000, Israel*
[2]*Del E. Webb School of Construction, College of Engineering and Applied Sciences, Arizona State University, Tempe, AZ 85287, USA*

The complicated process of selecting cranes for construction projects can be divided roughly into two main phases: (1) a general decision on the type of crane, mobile or tower; and (2) selection of the particular model according to the required size and technical specification. Several determinants of this second phase of the selection process in a typical mobile crane culture were investigated through on-site interviews with representatives of major construction companies. Factors affecting mobile crane selection were identified, classified, and rated according to their degree of influence. The involvement in equipment planning and crane selection was characterized with regard to project stages and planning parties. The findings were analysed with a view to the changing participation level of each party throughout project life. The conclusions of the study portray a picture that is different from the common assumptions about mobile crane selection, with respect to both influencing factors and the process itself. The study underlines the weight of non-project-specific factors, and shows that equipment planning is not merely a one-time technical exercise executed by a planner, but rather a process carried out throughout project life by a joint effort of several parties.
Keywords: building construction, crane, equipment, mobile crane, planning party.

1999, **17**(4), 529–536

Gate-keepers or judges: peer reviews in construction management

Göran Runeson and Martin Loosemore
School of the Built Environment, University of New South Wales, Sydney 2052, NSW, Australia

Peer review has a momentous influence upon the lives of those who seek to publish, upon the credibility of an academic discipline and upon the way it develops. It is used widely within the academic community on the assumption that it encourages high standards of scholarly writing by providing an informed, fair, reasonable and professional opinion about the merits of research work. This paper reports an experiment which tested the extent to which peer review in construction management serves this function. The results indicate that the outcome of the peer review process is not significantly different from random, and that there is little consistency in the reasons advanced for rejection or revision.
Keywords: peer review, publication, research.

1999, **17**(5), 589–602

Modelling financial decisions in construction firms

Ka Chi Lam[1] and Göran Runeson[2]
[1]*Department of Buildings and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong*
[2]*Faculty of Built Environment, The University of New South Wales, Sydney 2052, Australia*

Some contractors predict their corporate cash flow on the basis of individual contracts without considering the relationships between the overall before-tax profit, risks, other crucial qualitative factors, or the allocation of resources within the company. Moreover, some contractors, in predicting their cash flow, focus only on the early-start progress in the project and their predictions of progress are too pessimistic, or result in the overuse of resource in order to make up for delays. In the present research a decision model is established for a contracting firm. It provides a methodical system for construction financial decision-making, and a way of solving a financial decision problem under qualitative and fuzzy circumstances. The model can be applied to the management of corporate cash flow, thereby facilitating the minimal use of resources. The information provided by the model allows the planner to eliminate excess use or idleness of resources during the scheduling of a project. Financial forecasting may also suggest the best time to invest in a new project. Four projects for a medium size construction firm in Hong Kong were employed as case studies in order to evaluate the mathematical model. The cases involve two objectives: maximize profit margin and minimize construction risk (consider in a qualitative factor). The model leads to a compromize optimal schedule that provides the contracting firm with the optimal schedule for achieving optimal profit and construction risk by making optimal use of the contractor' s resources.
Keywords: cash flow, fuzzy sets, multiple objective programming, optimization, qualitative decisions.

1999, **17**(5), 603–612

Effects of high pre-qualification requirements

Wei Lo[1], Raymond J Krizek[2] and Ahmad Hadavi[2]
[1]*Department of Construction Engineering, National Institute of Technology, Kaohsiung, Taiwan, ROC*
[2]*Department of Civil Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3109, USA*

When designing a set of pre-qualification requirements, the first objective is to select the basic factors that are deemed appropriate to scrutinize, and the second objective is to establish the threshold for each of these factors to evaluate the

capability and capacity of the bidders on a given project; together, these factors and the limits imposed on each constitute the basis for qualifying or disqualifying each of the bidders. To obtain the desired pre-qualification results and the consequent quality delivery of a project, both selecting the factors and determining the limits for each factor are crucial and must be given careful attention with due consideration of the prevailing environment (including market conditions, deadlines, need for technology transfer, etc.). In this study it was found that an improper design of pre-qualification requirements seriously affected the progress and cost of projects, provided opportunities for collusion, and encouraged the obtaining of contracts through improper practices. Based on an analysis of data from 30 Taipei Mass Rapid Transit projects, together with information gleaned from numerous interviews with contractors, consultants, and clients, it is shown that a risk-taking attitude by the Government and the establishment of relatively low pre-qualification requirements would be more conducive to achieving a desirable balance among (a) satisfying the schedule and sequence of contracting, (b) obtaining lower prices by an increase in competition, (c) procuring the timely del ivery of a quality project, and (d) fostering the growth of local contractors.
Keywords: economic development, government policy, pre-qualification, Taipei Mass Rapid Transit.

1999, **17**(5), 613–623

Private sector participation in infrastructure projects: a methodology to analyse viability of BOT

Malik Ranasinghe
School of Building and Real Estate, National University of Singapore, 10, Kent Ridge Crescent, Singapore, 119260

Many developing countries are now attempting to finance new infrastructure projects through private sector participation. This paper outlines a methodology based on financial and risk analyses that a government or a government utility can use to analyse the viability of private sector participation in new infrastructure projects. The water supply projects in Sri Lanka are used for the case study to outline the methodology. Financial analyses of a bulk water supply project and a water distribution project are carried out to estimate subsidy percentages that are required to make the projects viable, using a model developed for the investment analysis of all types of infrastructure project. This analysis looks at four pricing options for the bulk supply project, and sixteen procurement options for the distribution project, from the view point of the utility, for three cases of non-revenue water (35% as base case, 50% and 25% as extreme cases). The risk analysis takes into account the risk and uncertainty in non-revenue water, cost and demand estimates, rate of debt and forecasts of escalation. These analyses show that the best option for the util ity is to obtain both bulk supply and distribution projects through private sector participation using BOT arrangements.
Keywords: BOT, developing country, financial analysis, infrastructure, investment, risk analysis, utility, water supply.

1999, **17**(5), 625–633

Matching housing supply and demand: an empirical study of Hong Kong' s market

Raymond Y C Tse[1], C W Ho[2] and Sivaguru Ganesan[2]
[1]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, PRC*
[2]*Department of Architecture, University of Hong Kong, Hong Kong, PRC*

This paper has the objective of improving on the issue of forecasting new housing construction, and highlights differences between space demand and investment demand in housing markets. Further, it indicates how these differences will affect construction decisions. The first step is to identify the factors associated with estimating residential property prices in Hong Kong, based on a demand-supply adjustment process. Specifically, this study examines the role of population growth, transaction volume, inflation and interest rate in determining house prices. Second, based on these estimations, a methodology is developed to estimate the investment demand schedule and new construction of residential property.
Keywords: housing demand, house price, Hong Kong, transaction volume.

1999, **17**(5), 635–646

Comparative analysis of pre-bid forecasting of building prices based on Singapore data

John Gunner[1] and Martin Skitmore[2]
[1]*Montville, Queensland, Australia*
[2]*School of Construction Management and Property, Queensland University of Technology, Gardens Point, Brisbane 4001, Queensland, Australia*

An analysis is described of a sample of pre-bid forecasts for 181 Singapore building contracts awarded between 1980 and 1991 in comparison with previous research results in this topic. Despite the apparent contradictions that occur between findings, it is shown that such differences could be illusionary due to a general lack of reported significance levels together with, in some cases, small sample sizes. As a result it is suggested that a general commonality in outcomes may exist in the form of a single underlying variable.
Keywords: accuracy, building, estimating, pre-bid estimating, statistical analysis.

1999, **17**(5), 647–655

Important causes of delay in public utility projects in Saudi Arabia

Mohammed I Al-Khalil and Mohammed A Al-Ghafly
King Fahd University of Petroleum and Minerals, KFUPM Box 426, Dhahran 31261, Saudi Arabia

This study was conducted to determine the most important causes of delay in public utility projects, based on the frequency and severity of the causes. A survey of randomly selected samples of contractors, consultants, and owners was carried out to assess the frequency of occurrence and the severity of impact of sixty potential delay causes. A frequency index and a severity index were determined for each cause. An importance index for each cause was then computed as the product of the frequency and severity indices. The results showed that the three parties surveyed generally agree on the importance ranking of delay causes. The causes were grouped also into six major categories of delay. The analysis showed lack of agreement among the parties on the ranking of the major categories of delay.
Keywords: claim, delay, Saudi Arabia, time, utility project.

1999, **17**(5), 657–668

The application of JIT philosophy to construction: a case study in site layout

Low Sui Pheng and Mok Sze Hui
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260

The just-in-time (JIT) philosophy has been used in the manufacturing industry for some forty to fifty years. This system increased not only the productivity of the industry but also the quality of its products. Explorative studies have been completed in recent years to see how JIT can be applied into the construction industry to reap the benefits of the system. Most of these studies have concluded that it is possible to apply the techniques of JIT in the construction industry with some modifications. Taking into consideration that one of the key components of site management is concerned with waste management (i.e. bringing wastage down to the minimum), this study focuses on applying JIT for site layout to improve productivity and quality. By eliminating waste on site, controlling the movement of inventory coming into the site and within the site, and controlling the usage of mechanized plant and equipment, smooth work flow can be achieved.
Keywords: just-in-time, productivity, quality, site layout.

1999, **17**(5), 669–677

The practical application of delivery methods to project portfolios

John B. Miller and Roger H. Evje
Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, Room 1-172, Cambridge, MA, 02139-4307, USA

The rebirth of design-build, design-build-operate, and build-operate-transfer as viable alternatives for the delivery of major capital projects is symptomatic of dynamic changes in the relationship between producers and clients throughout the construction industry. In the private sector, these delivery methods offer clients the chance to shift emphasis towards core functions and away from real estate development and operations. In the public sector, where capital budgets are constrained, delivery alternatives offer clients the chance to combine construction skills and technology to meet infrastructure needs in innovative ways. However, for those clients with numerous facilities and a steady flow of projects over long periods of time, a critical problem is emerging: how to effectively match each project in the portfolio to a preferred delivery method. This paper presents a tool called CHOICES, which permits convenient comparisons of alternative delivery scenarios for a portfolio of capital projects and services. CHOICES is designed to help formulate a portfolio infrastructure strategy, test that strategy, and adjust it to meet strategic goals within capital constraints.
Keywords: portfolio management, procurement method, project delivery.

1999, **17**(5), 679–687

Sustainability and the impact of Chinese policy initiatives upon construction

Jean Jinghan Chen[1] and David Chambers[2]
[1]*School of Management Studies, University of Surrey, Guildford, Surrey, GU2 5XH, UK*
[2]*School of Law, University of Greenwich, Oakfield Lane, Dartford, Kent, DA1 2SZ, UK*

The environment has been perceived as an international issue, and ways of attaining sustainability are becoming important for countries seeking sustainable development. The international community has been active in developing policy frameworks towards achieving the sustainability, such as an ecological modernization approach and environment assessment. Developing countries deserve special attention in the effort to make sustainability an operative criterion in their development activities. Given the difficulties that developing countries are facing, their perceptions of the concept and principles of sustainability differ in various contexts from those of developed countries, and the attainment of sustainability is much more difficult. Therefore, the establishment of a global partnership is important for the vision of sustainability to be realized and operationalized in the world. The current stage of economic development in China provides an opportunity to incorporate environmental provisions into the national development strategies from a relatively early stage, rather than attempt retrofit to strategies. However, at present China' s pol icy initiatives expressed in its Agenda 21 remains only a visionary concept. A comprehensive policy framework and realistic implementation measures are needed. The environmental impacts of the construction industry are extensive, particularly in developing countries. However, as in many developing countries, China' s sustainable construction is still at its primary stage and current practice is unsatisfactory.
Keywords: China, policy, sustainable development.

1999, **17**(6), 699–709

Responsibility, power and construction conflict

Martin Loosemore
School of Building, University of New South Wales, Sydney 2052, NSW, Australia

Responsibilities in construction projects are not entirely predetermined by construction contracts. Many emerge arbitrarily from the resolution of power struggles between opposing interest groups who are trying to minimize their exposure to an unexpected resourcing demand. These struggles contain the seeds of conflict because those with relatively little power tend to emerge with relatively high levels of responsibility. For the weak, this inequality causes financial strain, anxiety, resentment, frustration and malevolence.
Keywords: authority, behaviour, conflict, contract, power, responsibility, risk.

1999, **17**(6), 711–720

Impact of employee, management, and process issues on constructability implementation

Neil N Eldin
Civil Engineering Department, Oregon State University, 108 Apperson Hall, Corvallis, OR 97331, USA

This paper reports the findings of a study that examined five projects in which implementation of constructability concepts was viewed as a schedule reduction tool. The study attempted to determine the benefits, success factors, and implementation barriers across the case studies. The data suggested that adopting constructability concepts has the potential for significantly reducing the project delivery time compared with the historical performance of the participating companies. Success factors, implementation barriers, and lessons learned were viewed as management, employee, and process-related issues. These issues were ranked further according to their apparent significance in the cases studied. When such a ranking is verified by additional studies, the efforts of present and future implementations will focus on the issues that yield the highest payoffs.
Keywords: constructability, duration, schedule compression, schedule reduction, time, value engineering.

1999, **17**(6), 721–730

The impact of change orders on mechanical construction labour efficiency

Awad S Hanna[1], Jeffrey S Russell[1] and Paul J Vandenberg[2]
[1]*Department of Civil Engineering, University of Wisconsin, 1415 Engineering Drive, Madison, WI 53706, USA*
[2]*Civil Engineer Corps, United States Navy, Norfolk Naval Base, VA, USA*

Change orders impact many areas of a construction project. However, the impacts that change orders have on labour efficiency are much harder to quantify than other impacts and therefore are a significant risk to contractors. Little research has been completed in the past quantifying these impacts, so disputes are common between owners and contractors regarding the actual cost of change. This study used data from 43 projects to develop a linear regression model that predicts the impact of change orders on labour efficiency. The input factors needed for the model are (1) total actual project hours, (2) total estimated change hours, (3) impact classification, and (4) timing of change. The

model calculates the labour loss in efficiency for a particular project so that owners and contractors will better understand the true impact of change on labour efficiency. The research is limited to the mechanical trade, but does include specific work in plumbing, HVAC, process piping, and fire protection.
Keywords: change order, labour efficiency, mechanical contractor, productivity.

1999, **17**(6), 731–743

To instruct or not? The engineer's dilemma

Kumaru Yogeswaran[1] and Mohan M Kumaraswamy[2]
[1] *Scott Wilson, (Hong Kong) Ltd.*
[2] *Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong*

A recent research project explored the sources of relatively higher value and/or more frequent construction claims in civil engineering projects in Hong Kong. Fourteen common sources of claims were cited to seek views from the industry as to the perceived frequencies, magnitudes and avoidabilities of claims from such sources. One of the significant sources was identified as `instructions not being issued', with reference to the provision in most standard civil engineering contracts that `the engineer' shall issue necessary instructions for the purposes of completion of the Works. The study reported here focuses on the possible responses of `the engineer' when the contractor requests instructions/information. Also the study examines the possible generation of construction claims therefrom. Eleven practitioners who were familiar with such matters were issued a questionnaire which described ten typical construction problem scenarios (cases) where contractors may request instructions. The responses are summarized and the basis for reaching each of these decisions is analysed. An example of the eleven detailed responses to one of the cases is presented to demonstrate the divergence of perceptions on each issue and the consequent different recommendations. Strategies to minimize the claims and disputes arising from such scenarios are developed, based on resolving the evident conflicts between the reasons for such divergences.
Keywords: claim, Hong Kong, instruction, engineer.

1999, **17**(6), 745–755

Applying fuzzy techniques to cash flow analysis

A H Boussabaine and Taha Elhag
School of Architecture and Building Engineering, University of Liverpool, Leverhulme Building, Abercromby Square, Liverpool, L69 3BX, UK

Construction managers are interested in the direction of movement of cash flow at valuation periods rather than its forecast value, and fuzzy set theory applied to decision making might help in this process. Fuzzy models are particularly suited to making decisions involving new technologies where uncertainties inherent in the situation are complex. The problem of healthy cash flow at valuation periods relates to the proper estimation of cash in and out flows and project progress. The paper presents an alternative approach to cash flow analysis for construction projects. This project is based on the assumption that cash flow at particular valuation stages of a project is ambiguous. The paper discusses the weaknesses of existing methods for cash flow and establishes the need for an alternative approach. Using an example of 30 cash flow curves, the advantage of fuzzy cash flow analysis is demonstrated. Results of the analysis are presented and discussed. The model can be used to analyse the cash flow curve of projects at any progress period to make sure it is reasonable.
Keywords: cash flow, fuzzy technique, progress, valuation.

1999, **17**(6), 757–765

Survey of construction lawyers' attitudes and practicein the use of ADR in contractors' disputes

Penny Brooker
Department of Law, School of Social Sciences and Law, Oxford Brookes University, Headington, Oxford, 0X3 OBP, UK

Continuing a survey of contractors' perceptions about alternative dispute resolution (ADR) this paper seeks to report an investigation of the level of involvement of legal advisors to the construction industry in the dispute resolution process and the perceptions that legal professionals have about the use of ADR in construction disputes. The research findings are that contractors are likely to involve lawyers in the dispute resolution procedure, particularly when disputes concern a legal issue, when the parties to the dispute are entrenched in their argument, or when the other party insists on using legal professional assistance. In these defined circumstances, legal advisors will be influential in determining the potential use of ADR. The paper concludes that lawyers are unlikely to recommend ADR for most disputes between contractors, particularly if the dispute resolution process is perceived to involve the use of delay by main contractors, if the parties are fixed in their arguments or if they are exhibiting adversarial behaviour in their approach to the dispute. In these circumstances lawyers and their clients prefer the force of the formal systems over conciliatory ADR procedures.
Keywords: alternative dispute resolution (ADR), contractor, dispute resolution, lawyer.

1999, **17**(6), 767–776

A genetic-algorithm-based resource-constrained construction scheduling system

Sou-Sen Leu and Chung-Huei Yang
Department of Construction Engineering, National Taiwan University of Science and Technology, 43 Keelung Road, Section 4, Taipei, Taiwan, 10672

Resources for construction activities are limited in the real construction world. To avoid waste and shortage of resources on a construction job site, scheduling must include resource allocation. A new resource-constrained construction scheduling system is proposed in this paper. A GA-based searching technique is adopted in the system. In this paper, new GA crossover and mutation operators, UX3 and UM3, are presented. These new operators overcome the drawback of traditional GA operators for sequencing problems. The system effectively can provide the optimal combination of construction duration, resource quantities and minimum project duration under the constraint of limited resources.

Keywords: genetic algorithm, multiple objective programming, resource allocation, resource-constrained scheduling, scheduling.

1999, **17**(6), 777–787

Development of a customer focused strategy in speculative house building

Rajat Roy and S P Cochrane
School of Engineering, University of Warwick, Coventry, CV4 7AL, UK

The UK housing industry has been slow to adopt new working practices which have brought improvements in product quality and customer focused operations to many sectors of manufacturing industry. Instead, the dominant business driver has been land and house price inflation, with the market characterized by pronounced boom-and-bust cycles. Reports on the sector often have highlighted the need for research and action aimed at bringing about fundamental changes in its operations, both to satisfy social needs and benefit the companies in the industry. This paper examines the drivers needed for implementing new customer focused business processes in the sector. Of particular importance is the development of a product strategy based on an understanding and analysis of the market. Results are presented from a large market survey that was carried out, and their implications for the industry are discussed.

Keywords: house building, market research, mass customization, product development, strategy.

1999, **17**(6), 789–798

A non-results-based effectiveness index for construction site managers

Campbell Fraser
School of Management, Griffith University, Brisbane Q4111, Australia

A method is presented for non-results-based effectiveness indexing of construction site managers (CSMs). The 52 competence element index is based on previous research on construction-specific competency elements and stakeholder assessment systems. The method was qualitatively assessed through industry focus groups and quantitatively validated through an empirical study. The performance of 61 Australian CSMs was evaluated by 329 peers, superiors and subordinates. The measurement tool successfully measured each individual' s level of ability on each competence element and produced an individual effectiveness score for each CSM. The application of the method resulted in the identification of three levels of effectiveness: a distinct and homogeneous `elite' group of very effective CSMs; a very low performing control group of former CSMs; and a group of CSMs that are adequately effective. The development and validation of the method are provided, plus some insights into the characteristics of each of the groups identified.

Keywords: competence, effectiveness, index, site manager, stakeholder.

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Quality practices in design organizations

Abdulaziz A Bubshait[1], Gulam Farooq[2], M Osama Jannadi[1] and Sadi A Assaf[1]

[1]*Department of Construction Engineering and Management, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia*

[2]*Centre for Economics and Management Systems, Research Institute, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia*

Design organizations play a major role in the construction industry: they are the media that transfer the requirements of the client to the contractor and ensure that they are met. Thus they need to provide a high quality of service to ensure that their client's project achieves the best possible standards of cost, time and quality. Seventy quality practices (QP) were identified as having a bearing on the quality of service provided by the local design organizations. These quality practices were grouped into fifteen sections termed quality sections (QS). The prevalence of these practices among the local design organizations was surveyed and determined. The results indicate a significant need for improvement in the quality sections 'working relationship' , 'employee training and education' , and 'performance quality audit'. The study reveals the need for the establishment of a design code, and evaluation standards for local design organizations.

Keywords: design organization, quality practice, Saudi Arabia.

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2000, **18**(1), 5–9

A hybrid life cycle assessment method for construction

G J Treloar, P E D Love, O O Faniran and U Iyer-Raniga
School of Architecture and Building, Deakin University, Victoria 3217, Australia

Life cycle assessments (LCAs) are used to evaluate the environmental impacts attributable to products and processes. For construction projects, LCAs can be used to assess the pollution associated with the manufacture of building materials for the construction process. Despite the reliability of traditional LCA data, many upstream processes are excluded, which adversely affects overall reliability. Input-output analysis is systemically complete, but is subject to inherent errors when applied to the LCA of specific products. Analysis of an input-output LCA model provides a basis for more informed decision making regarding processes which can be ignored during the collection of traditional LCA data. This paper proposes a hybrid LCA method for construction in which national input-output data fill those 'gaps' not accounted for by traditional LCA data. Regardless of the level of detail at which data are collected, LCAs can now be performed at similar overall levels of framework completeness
Keywords: input-output analysis, life cycle analysis.

2000, **18**(1), 11–14

The impact of contract duration on the cost of cash retention

Will Hughes,[1] Patricia Hillebrandt[1] and John Murdoch[2]
[1]*Department of Construction Management and Engineering, University of Reading, PO Box 219, RG6 6AW, UK*
[2]*Department of Law, University of Reading, PO Box 217, RG6 2AH, UK*

Cash retention is a common means of protecting an employer from a contractor's insolvency as well as ensuring that contractors finish the work that they start. Similarly, contractors withhold part of payments due to their sub-contractors. Larger contracts tend to be subjected to smaller rates of retention. By calculating the cost of retention as an amount per year of a contract, it is shown that retention is far more expensive for firms whose work consists of short contracts. The extra cost is multiplied when the final payment is delayed, as it often is for those whose work takes place at the beginning of a project. This may explain why it is that main contractors are a lot less interested than sub-contractors in alternatives to cash retention, such as retention bonds
Keywords: bonds, cash flow, contract, finance, retention.

2000, **18**(1), 15–27

Trends in productivity improvement in the US construction industry

David Arditi and Krishna Mochtar
Illinois Institute of Technology, Department of Civil and Architectural Engineering, Chicago, IL 60616-3793, USA

Surveys of the top 400 US contractors were conducted in 1979, 1983 and 1993 to identify the areas with potential for productivity improvement in the construction industry. The trends in the findings of these surveys are observed and interpreted. The results indicate that cost control, scheduling, design practices, labour training, and quality control are the functions that consistently over the years are perceived as having considerable room for productivity improvement, whereas materials packaging and foreign developments in construction technologies are perceived consistently as functions that do not have much effect on improving construction productivity. The functions that were identified as needing more improvement in 1993 compared with the previous surveys were prefabrication, new materials, value engineering, specifications, labour availability, labour training, and quality control, whereas those that were identified as needing less improvement than in the previous surveys were field inspection and labour contract agreements. Also, respondents indicated consistently over the years that they are willing to participate in activities related to improving construction productivity but are not interested in funding any such activities
Keywords: productivity trends, survey, USA.

2000, **18**(1), 29–36

The influence of personal characteristics on effectiveness of construction site managers

Campbell Fraser
School of Management, Griffith University, Brisbane, Queensland, 4111, Australia

It has been suggested that construction site managers' career progression may be affected because of the existence of certain personal characteristics that conform to industry stereotypes. These stereotypes need to be identified and examined in a systematic manner to ensure that the rationality of human resource management policy is indeed

justifiable. A set of 26 personal characteristics believed to influence the effectiveness of construction site managers is identified by senior construction managers using the nominal group technique. These characteristics are tested for correlation with effectiveness using a non-results-based effectiveness index. A questionnaire survey was completed by 61 site managers for this purpose. The results suggest that of 26 identified personal factors believed to be important the only ones which may actually be related to effectiveness are: involvement in continuing professional development, number of firms worked for, use of addictive substances, education level, membership of professional bodies, job satisfaction, motivation level, career aspiration, stress level, leadership style and the need to work. The findings will assist those recruiting, retaining or promoting site managers to make a more informed judgement of key factors influencing effectiveness.
Keywords: effectiveness, personal characteristics, site management.

2000, **18**(1), 37–44

The positive use of power on a major construction project

Anthony Walker[1] and Robert Newcombe[2]
[1]*Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong*
[2]*Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading, RG6 6AW, UK*

Although reasonably well developed in the general management literature, the source and use of power in organizations has received little attention in relation to its effect on the management of construction projects. This paper reviews the literature on power and its relationship to both formal and informal authority, and its manifestation as organizational politics, and relates them to construction projects in general. Reward, coercive, expert and referent (prestige) power and the role of resources are covered in this general review. A closer examination is then made of power through a case study of the development of the Hong Kong University of Science and Technology, which identifies the positive use of power and its implications for the outcome of the project.
Keywords: authority, case study, Hong Kong, power, project organization.

2000, **18**(1), 45–54

Segmenting the Korean housing market using multiple discriminant analysis

Jae-Chan Kim,[1] Dae-Ho Kim,[1] Jae-Jun Kim,[1] Jong-Suk Ye[1] and Hyun-Soo Lee[2]
[1]*Department of Architectural Engineering and Department of Business Administration, Hanyang University, 17 Haengdang-Dong, Sungdong-Gu, Seoul, 133-791, Korea*
[2]*Department of Architecture, Seoul National University, Seoul, 151-742, Korea*

The business environment of the Korean housing industry has changed recently from a supplier's market to a buyer's. Establishing and implementing proper marketing strategies has increasingly become an important part of the managerial process. This research attempts to offer a characteristics profile and a forecasting model that classify the housing purchase consumers into three groups: a single-family housing purchase group, an apartment housing purchase group, and a non-purchase group. These groups can be classified and predicted by using the discriminant function: a linear combination of demographic, socio-economic, and residential characteristics. Findings in this research can provide valuable information for future efforts in identifying distinct target segments of the Korean housing market.
Keywords: Korea, housing, market segmentation, multiple discriminant analysis, strategy, target marketing.

2000, **18**(1), 55–63

Benchmarking for construction: theory and practice

Naomi Garnett and Simone Pickrell
Department of Construction Management & Engineering, University of Reading, Reading, RG6 6AW, UK

The UK construction industry has identified benchmarking as one of a number of initiatives to assist in the drive for major improvements in efficiency and economy. At the outset, the industry struggled to see how a technique based upon comparison of similar goods and processes could be used effectively in a project based industry where products, processes and teams changed regularly. This paper discusses the development and testing of a benchmarking model and study methodology for use in construction. The model was derived from an extensive literature review which considered the underlying theoretical basis of benchmarking. The case is made that, to be successful, the benchmarking process is as important as the benchmarks themselves, and that it is based upon constructivist foundations, rather than positivist. As such, any methodology for undertaking benchmarking must take place in a similar vein, i.e. be interactive, team based and flexible but with an underlying rigour provided by the benchmarking model. The paper outlines two case studies to test the benchmarking model and study methodology, discusses the learning and benefits that accrued and introduces further developments.
Keywords: benchmarking, process mapping, case study, social constructivism.

2000, **18**(1), 65–75

A model for predicting plant maintenance costs

David J Edwards, Gary D Holt and Frank C Harris
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV1 1SB, UK

A model is presented that predicts the total cost of plant maintenance (i.e. direct cost of maintenance plus indirect cost of lost production) and is derived studying a random sample of tracked hydraulic excavators. Analysis is based on the machine history file data of 33 plant items, modelled using multiple regression (MR) analysis. Validation of the model was determined via the combination of an observed high R^2 at 0.94 and various statistical tests which confirmed the prerequisites of a rigorous MR analysis. Machine weight, type of industry and company attitude towards predictive maintenance were found to be the best predictor variables of total plant maintenance cost. The paper also discusses reasons underlying the inclusion of predictor variables in the final model, and concludes with clear directions for future research in this field.

Keywords: maintenance cost, plant, productivity, tracked hydraulic excavators.

2000, **18**(1), 77–89

Analysis of factors influencing project cost estimating practice

Akintola Akintoye
Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow G4 0BA, UK

Although extensive research has been undertaken on factors influencing the decision to tender and mark-up and tender price determination for construction projects, very little of this research contains information appropriate to the factors involved in costing construction projects. The object of this study was to gain an understanding of the factors influencing contractors' cost estimating practice. This was achieved through a comparative study of eighty-four UK contractors classified into four categories, namely, very small, small, medium and large firms. The initial analysis of the 24 factors considered in the study shows that the main factors relevant to cost estimating practice are complexity of the project, scale and scope of construction, market conditions, method of construction, site constraints, client's financial position, buildability and location of the project. Analysis of variance, which tests the null hypothesis that the opinions of the four categories of companies are not significantly different, shows that except for the procurement route and contractual arrangement factor there is no difference of opinion, at the 5% significance level, on the factors influencing cost estimating. Further analysis, based on a factor analysis technique, shows that the variables could be grouped into seven factors; the most important factor grouping being project complexity followed by technological requirements, project information, project team requirement, contract requirement, project duration and, finally, market requirement.

Keywords: estimating, factor analysis, tendering.

2000, **18**(1), 91–100

Re-engineering the tender code for construction works

Ron Craig
Department of Civil and Building Engineering, Loughborough University, Leicestershire LE11 3TU, UK

The UK's NJCC Code of Procedure for Single Stage Selective Tendering (now withdrawn) and its successor, the CIB's Code of Practice for the Selection of Main Contractors are criticized in the light of decisions of the common law courts with regard to regulation of the tendering process. It is argued that a new 'Tendering Code' should be produced in the style and format of a contract document which reflects not only the statutory regulation imposed on public bodies, but common law decisions of the courts. The nature of this tendering contract is explained as a means of regulating the tendering process. Issues discussed are: dealing with errors and irregularities found in tenders; dealing with non-compliant tenders; dealing with tender withdrawal prior to its acceptance or rejection; making provisions as to time for submission of tenders and dealing with late tenders; making provision for submission of tender by fax or other electronic means; making provision for evaluation of tenders received; and imposing or negotiating reductions in price with tenderers prior to acceptance. The paper concludes that the common law obligations placed on the owner to treat all tenderers equally and fairly and to apply the tender conditions when evaluating tenders and awarding contracts seems to be good common sense and of commercial advantage, not only to the immediate parties concerned but also to the wider community.

Keywords: contract, equal opportunity, fair dealing, law, tendering.

2000, **18**(1), 101–111

Decisions with moral content: collusion

Anna Zarkada-Fraser[1] and Martin Skitmore[2]
[1]*School of Marketing and International Business, Queensland University of Technology, Gardens Point, Brisbane Q4001, Australia*
[2]*Queensland University of Technology, School of Construction Management and Property, Gardens Point, Brisbane Q4001, Australia*

Morality is fast becoming an integral part of the mandate for business through both societal and regulatory pressures. Collusive tendering is one of the moral choices facing decision-makers in the construction industry. This paper describes an empirical investigation of the attitudes and behavioural intent towards collusive tendering of key individuals in the tendering process. It also explores the factors that determine these attitudes. The results of the empirical investigation indicate that there is a minority of decision-makers that admit they would consider participating in some form of collusive tendering agreement under certain circumstances. These people form a distinct group in their demographic as well as decision-making profile.
Keywords: Australia, collusion, ethics, moral decision, tendering.

2000, **18**(1), 113–121

Women in construction: the untapped resource

Sandra L Fielden, Marilyn J Davidson, Andrew W Gale and Caroline L Davey
Manchester School of Management, UMIST, PO Box 88, Manchester, M60 1QD, UK

Currently there are over 11 million women employed in the UK, accounting for 49.5% of the workforce. However, despite increases in the number of women employed in the construction industry over the past decade, they still constitute only 13% of the industry's workforce. This means that construction continues to be the most male dominated of all the major industrial groups. A review is presented of the literature relating to the current position of women in the construction industry. It identifies and examines the barriers preventing women's entry into the industry, the subsequent barriers faced by those working within the construction industry, and initiatives committed to promoting equality for women and men in construction. These barriers arise from a number of sources including: the construction industry's image; career knowledge amongst children and adults; selection criteria and male dominated courses; recruitment practices and procedures; sexist attitudes; male dominated culture; and the work environment.
Keywords: employment, equality, labour, women.

2000, **18**(2), 131–138

Property rights implications of public-private joint ventures

Wong Kwok-Chun and Anthony Walker
Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong, China

When a public institution contracts with a developer for a co-development project, there are two main options for arrangements: the equity or the cooperative joint venture. Equity is basically a shareholding arrangement, whereby inputs are valued at market worth in exchange for respective shares of ownership of the joint development. Under cooperative joint ventures, however, shares of ownership are not necessarily based on the values of the inputs. The partners simply draw up a contract that defines the inputs and apportions the outputs of the joint development. This paper argues that a cooperative joint venture between a public institution and a private developer is basically an arrangement to reduce dissipation of rent under public ownership. Unlike the equity arrangement, cooperative joint ventures necessarily lead to an apparent transfer of shares from the public institution to the private developer. Evidence found thus far in Hong Kong and China is consistent with this hypothesis. Variations of the cooperative joint venture are discussed together with examples.
Keywords: Hong Kong, joint venture, property rights, public ownership, rent.

2000, **18**(2), 139–149

Overcoming the problems associated with quality certification

P E D Love[2] and H Li[2]
[1]*School of Architecture and Building, Deakin University, Geelong, Victoria, 3217 Australia*
[2]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*

Serendipitous findings are reported from an on-going research project that seeks to determine the effectiveness of quality assurance systems certified under the ISO 9000 series in Australian contracting organizations. In Australia, certification has become mandatory for all organizations wishing to do business with government agencies and major private companies. While certification was designed so that purchasers could have confidence in the quality of the vendor's product or service, not all organizations have been able to implement certification processes in a way that supports this original intent. Instead, most construction organizations have opted to go through the motions without an underlying sustainable continuous improvement philosophy. They simply wish to gain marketing benefits, while others have been overcome by the mass of paperwork required for achieving the quality 'seal of approval'. This paper uses a

case study to examine the experiences of a major building and engineering contractor threatened by the paperwork dilemma. However, by adopting a radical shift in the management of the certification programme the contractor was able to implement a quality system that reduced rework significantly and brought about marketing benefits. This case study is used to present a company's experiences in solving problems associated with the certification process, and offers a learning opportunity for other organizations facing similar difficulties.
Keywords: continuous improvement, documentation, ISO 9000, quality certification, re-work.

2000, **18**(2), 151–159

Regional development and construction in Italy: an input-output analysis, 1959-1992

Roberto Pietroforte,[1] Ranko Bon[2] and Tullio Gregori[3]
[1]*Department of Civil and Environmental Engineering, Worcester Polytechnic Institute, Worcester, MA 01609-2280, USA*
[2]*Department of Construction Management & Engineering, University of Reading, Reading, RG6 6AW, UK*
[3]*Dipartamento di Scienze Economiche e Statistiche, Università di Trieste, 34127 Trieste, Italy*

Using two sets of input-output tables, this paper analyses the role of the construction sector in the North and South regions of Italy, from 1959 to 1992. As expected, the sector has had differing impacts on the two regional economies over the years. In the highly developed North its importance has been declining, similarly to the case of other highly developed countries. In the less developed South, instead, construction has a relatively higher propulsive role in the creation of goods and income. This role is significantly diminished since most of the construction inputs are imported. Some differences are reported in the sector's input and output profiles of the two regions. From the technological and organizational points of view, in the South construction projects appear to be less complex than those in the North.
Keywords: backward and forward linkage, construction technology, economic development, input-output analysis.

2000, **18**(2), 161–172

A survey of current cost estimating practices in the UK

Akintola Akintoye and Eamon Fitzgerald
Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow G4 0BA, UK

The results are documented of an investigation into current cost estimating practices of contractors for construction projects. A questionnaire survey of contractors was undertaken, in which the respondents are classified into four groups based on their turnover namely: very small, small, medium and large firms. The survey indicates that contractors, irrespective of size, continue to undertake cost estimating predominantly for construction planning purposes, including the preparation of tenders and cost control of projects during the execution stage and, to a lesser extent, for construction project evaluation. Recent developments in cost estimating methods and tools that consider risks and variability in cost estimates, such as the use of range estimating and parametric estimating techniques, have not been adopted by contractors. The practice of cost estimating does not differ from conventional techniques based on the use of labour and material constants to obtain prices for bills of quantities items on an item by item basis. The study shows that the major causes of inaccuracy in cost estimating continue to be the lack of practical knowledge of the construction process by those responsible for the estimating function, insufficient time to prepare cost estimates, poor tender documentation and the wide variability of sub-contractors' prices.
Keywords: analysis of variance, estimating, performance appraisal, tendering.

2000, **18**(2), 173–182

Analytical design planning technique (ADePT): a dependency structure matrix tool to schedule the building design process

Simon Austin, Andrew Baldwin, Li Baizhan and Paul Waskett
Department of Civil and Building Engineering, Loughborough University, LE11 3TU, UK

Current planning practice takes little account of the interdisciplinary, iterative nature of the building design process. This leads to a compromised design process containing inevitable cycles of rework together with associated time and cost penalties in both design and construction. The analytical design planning technique (ADePT) is a planning methodology which helps to overcome these difficulties. The central part of ADePT is a dependency structure matrix (DSM). This paper describes DSM techniques and a tool developed to optimize the design process.
Keywords: ADePT, design, design management, matrix analysis, planning.

2000, **18**(2), 183–195

Simulation modelling for logistics re-engineering in the construction company

Anna Sobotka
Faculty of Civil and Sanitary Engineering, Technical University of Lublin, 20-618 Lublin, Nadbystrzycka 40, Poland

Much attention is being paid to the significant role of logistics in the construction industry, with reference both to the total supply chain and to its individual links, called the 'internal logistic system'. Rationalization of activity in the logistics sphere leads to lowered production costs and increased quality. However, rationalization of logistic processes often involves re-engineering, i.e. reconstruction or making changes, for instance in the structure of supply chains, in the organization of physical and information flows, in ways of taking up decisions, etc. This paper describes the effectiveness of a simulation modelling approach in improving logistic systems in construction, by applying information collected from Polish construction practice. Graphical and analytical models of company logistic systems are the basis for making simulators using GPSS World™. Two models of different structures from the point of view of physical and information flow were chosen, several different strategies for controlling these flows were worked out, values of particular parameters of the model were defined and the optimum solution was sought. The assumed optimization criterion is minimizing logistics costs. An analysis of the research results can be used to indicate re-engineering needs for the internal models of the logistic systems investigated.
Keywords: building material, internal logistic system, re-engineering, simulation research.

2000, **18**(2), 197–207

Evaluation and management of foreign exchange and revenue risks in China's BOT projects

S Q Wang,[1] Robert L K Tiong,[2] S K Ting[2] and D Ashley[3]
[1]*Department of Building and Real Estate, National University of Singapore, Singapore*
[2]*School of Civil and Structural Engineering, Nanyang Technological University, Signapore*
[3]*College of Engineering, Ohio State University, Columbus, OH 43210, USA*

China is actively investigating ways to introduce project financing, specifically through the build-operate-transfer (BOT) scheme to meet the needs for the country's infrastructure and to be attractive to foreign investors and lenders. The advent of concession agreements, backed by new BOT laws, will be a positive move forward to achieving project-financed infrastructure projects. There are thus opportunities especially in the power sector for foreign investors. However, it is important to identify and manage the unique or critical risks associated with China's BOT projects. This is especially so after policies were introduced in late 1996 when the first state-approved BOT project, the US$650 million 2 x 350 megawatt (MW) coal-fired Laibin B Power Plant (Laibin B), was awarded. They include a competitive tendering process and 100% foreign ownership of the operating company. This paper is based on the findings from an international survey on risk management of BOT projects in developing countries, with emphasis on power projects in China. It discusses specifically the criticality of foreign exchange and revenue risks which include exchange rate and convertibility risk, financial closing risk, dispatch constraint risk and tariff adjustment risk. The measures for mitigating each of these risks are discussed also.
Keywords: BOT, currency convertibility, foreign exchange, risk, management.

2000, **18**(2), 209–217

Evaluating the performance of combining neural networks and genetic algorithms to forecast construction demand: the case of the Singapore residential sector

Goh Bee Hua
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, 119260 Singapore

In recent years, forecasting demand for residential construction in Singapore has become more vital, since it is widely perceived that the next trough of the real estate cycle is approaching. This paper evaluates the use of a combination of neural networks (NNs) and genetic algorithms (GAs) to forecast residential construction demand in Singapore. Successful applications of NNs, especially in solving complex non-linear problems, have since stimulated interest in exploring the capabilities of other biological-based methods such as GAs, and in exploiting the synergy of these two techniques to create more problem-solving power. In the study, a basic NN model is used as a benchmark to gauge the performance of the combined NN-GA model. A relative measure of forecasting accuracy, known as the mean absolute percentage error (MAPE), is used for the comparison. The models are checked also for internal validity by allowing each to be trained twice and having a set of forecasts generated after each training. Both models are found to produce accurate forecasts, because their MAPE values consistently fall within the acceptable limit of 10%. However, the combined model out-performs the basis model remarkably by reducing the average MAPE from about 6% to a mere 1%. For each model, the marginal difference in the MAPE values (i.e., 0.5% for the NN model and 0.06% for the NN-GA model) of its two forecasts indicates consistency in performance, hence establishing internal validity as well. The

findings reinforce the reliability of using NNs to model construction demand and reveal the benefit of combining NNs and GAs to produce more accurate models.
Keywords: accuracy, construction demand, forecasting, genetic algorithm, artificial neural network.

2000, **18**(2), 219–228

A new earthworks estimating methodology

Simon D Smith,[1] Graeme S Wood[2] and Martin Gould[3]
[1]*School of Civil and Environmental Engineering, University of Edinburgh, The King's Buildings, Edinburgh, EH9 3JN, UK*
[2]*Department of Civil Engineering, The University of Sydney, NSW 2006, Australia*
[3]*Commercial Management Consultants Ltd., 37 Highfield Road, Dartford, DA1 2JS, UK*

Earthworks and earthmoving operations are a major part of many civil engineering construction projects. Because of their labour and plant intensity, the planning and estimating of such operations is crucial to both the cost and duration of the project; earthworks are considered by many practitioners to be indicators to the success or failure of the project as a whole. Traditionally, a mixture of manufacturers' data (through published charts or computer databases) and historical company data are used in the estimating of earthworks. This process has two main drawbacks. First, plant haul velocity is dependent on the rolling resistance at the soil-wheel interface, which is notoriously difficult to determine; second, the stochastic interface between types of plant provides a non-deterministic system, resulting in estimates of output which may be unrealistically high. An alternative system of earthworks estimating is presented based on a combination of work undertaken in both the soil/vehicle and stochastic estimating fields. This system is demonstrated via a case study based on an actual highway project. The main conclusion to be drawn is that the traditional estimating approach results in a scheme costed well below realistic values.
Keywords: earthmoving plant, earthworks, hauling, plant cycle times, rolling resistance.

2000, **18**(2), 229–237

Partnering in construction: a critical review of issues, problems and dilemmas

Mike Bresnen[1] and Nick Marshall[2]
[1]*Warwick Business School, University of Warwick, Coventry CV4 7AL, UK*
[2]*Complex Product System Innovation Centre (CoPS), Centre for Research in Innovation Management (CENTRIM), University of Brighton, Brighton BN1 9PH, UK*

Partnering in construction has been presented as a potentially important way of improving construction project performance through the direct benefits it can bring to both clients and contractors. However, there is still considerable debate about the nature and merits of a partnering approach. This paper attempts to contribute towards this debate by exploring the presumed link between partnering and cultural change within the industry, at both organizational and interorganizational levels of analysis. To do so, it draws upon theory and research from the social sciences (especially organizational theory) to explore some of the issues, problems and dilemmas which emerge when full and proper account is taken of the complexities of organizations, as well as some of the subtleties and intricacies of the concept of organizational culture. The paper concludes that it is only by fully appreciating the effects of such complexity that a more realistic and practical approach to the development and implementation of partnering will emerge.
Keywords: alliancing, culture, partnering.

2000, **18**(2), 239–250

A grounded theory of women's career under-achievement in large UK construction companies

Andrew R J Dainty[1], Barbara M Bagilhole[2] and Richard H Neale[3]
[1]*School of the Built Environment, Coventry University, Priory Street, Coventry CV1 5FB, UK*
[2]*Department of Social Sciences, Loughborough University, Leicestershire LE11 3TU, UK*
[3]*University of Glamorgan, Pontypridd, CF37 1DL, UK*

In response to impending skills shortages and changing employment patterns, the UK construction industry recently has made considerable efforts to attract more women to its professions. However, despite their increasing representation, there are indications that women experience difficulties in developing their careers within the industry. This research investigated the careers of men and women working for large construction companies, in order to establish the gender determined influences on women's career progression. A primarily qualitative methodology was employed for the research, in which career profiles were developed through ethnographic interviews with 41 matched pairs of male and female employees. This allowed the gender specific determinants of careers to be established across a range of different organizations, and from informants at different vocational and life-cycle stages. The analysis resulted in the formulation of a set of eight interrelated theoretical models, from which a theory of women's career development was constructed. The theory reflects the belief that the construction workplace is a competitive and conflictual environment, where women are overtly and covertly discriminated against by men, who use structural systems to undermine their participation. The women interviewed were found to have dealt with these barriers in a way which perpetuated existing work cultures. If reflected throughout the industry, this would suggest the existence of a self-fulfilling cycle of women's

continued under-achievement. The paper puts forward the radical proposition that women should not be attracted to the industry unless steps are taken to moderate its exclusionary and discriminatory culture.
Keywords: career development, discrimination, grounded theory, human resource management, women.

2000, **18**(3), 257–262

Globalization and construction industry development: research opportunities

George Ofori
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, 119260 Singapore

Raftery, J., Pasadilla, B., Chiang, Y. H., Hui, E. C. M. and Tang, B. S. (1998) *Construction Management and Economics*, 16, 729-37 review recent developments in the construction industries in Asia. They discuss the main causes and effects of key trends in globalization and their impact on the industries. This paper considers some of the points raised by Raftery *et al*. It starts with an overall review of their paper. It then considers construction industry development in general, technology transfer and joint ventures, and the impact of policy reform on the industries. It suggests additional relevant issues, and highlights some areas where further research would be appropriate.
Keywords: Asia, construction industry development, developing country, globalization.

2000, **18**(3), 263–268

A systematic approach to the evaluation of indirect costs of contract variations

Denise Bower
Centre for Research in the Management of Projects, UMIST, PO Box 88, Manchester M60 1QD, UK

A mechanism is proposed for the evaluation of compensation due in the event of a variation order under contracts for construction work. It demonstrates how the indirect costs of a variation can be derived by the use of influence curves. Commonly it is accepted that such costs are very difficult to evaluate systematically, and hence the parties to the contract have been left to argue over the cost and time effects of a variation and the compensation due. The technique suggested provides a simple solution to this problem.
Keywords: change, contract, cost, variations.

2000, **18**(3), 269–280

'Clusters' of innovations in recent long span and multi-segmental bridges

E. Sarah Slaughter[1] and Hikaru Shimizu[2]
[1]*Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA*
[2]*Kajima Corporation, International Division, Civil Engineering Department, Tokyo, Japan*

The system-level impacts of innovations often can be more significant than the direct, primary impacts in certain industries. In particular, these system interactions can be seen with large, complex multi-system constructed facilities. Approximately half of the 200 specific innovations identified in eleven recent long span and multi-segmental bridges are linked to other innovations. Three general types of 'cluster' interaction are system, actualizing, and complementary links. The system interactions are nurtured through coordinated innovation development programmes. The actualizing links connect one set of innovations to another set, to aid in their realization of the innovation and project objectives. The complementary links provide additional benefits through the joint use of multiple innovations. The results of these analyses provide significant new insight for innovation theory into the system-level interactions of innovations. Since the frequency of the linkages among the innovations appears to reflect the relative stability of the design and construction parameters, recent innovation trajectories may be more difficult to link effectively to other innovations. These innovation interactions can provide critical capabilities for achieving the project objectives, but must be identified and managed effectively to achieve desired performance levels.
Keywords: innovations, long span bridge, system interactions.

2000, **18**(3), 281–294

Factors affecting clients' project dispute resolution satisfaction in Hong Kong

S O Cheung, C M Tam, I E Ndekugri and F C Harris
Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Hong Kong

The use of project dispute resolution satisfaction (DRS) as a project success measurement responds to the increasing concern over the spread of the dispute epidemic within the construction industry in Hong Kong. The DRS of a project is considered as favourable where disputes are resolved within the site level. With the use of 48 project data sets and the

technique of multivariate discriminant analysis, a discriminant model function was derived to classify projects into favourable DRS and adverse DRS. The multivariate discriminant analysis model function identified eight discriminating variables, among which the degree of design changes offered the highest separation power. The reliability of the discriminating variables was reinforced by a separate relative importance index study. Through the use of principal component factor analysis, these variables were grouped into three factors generically described as substantive influence, facilitation and indirect influence.
Keywords: discriminant analysis, dispute, Hong Kong, project.

2000, **18**(3), 295–310

Design practice and volume production in speculative housebuilding

Alan Hooper and Chris Nicol
Department of Building and Environmental Health, Faculty of Construction and the Environment, Nottingham Trent University, Burton Street, Nottingham, NG1 4BU, UK

The design of new residential development in the UK is castigated routinely in both the technical and broadsheet press, and has in the past few years become the focus of governmental policy initiatives intended to improve the overall standard of design in new housebuilding. Remarkably, however, there has been very little empirical research into the process of housing design in the private sector, and hence even academic commentaries have had to extrapolate from a hitherto very limited number of research studies. Moreover, the private sector housebuilding industry has undergone significant change in the last two decades, with considerable concentration and hence domination of production by large firms. With the private housebuilding sector responsible for over 80% of new production in the 1990s, it is timely to revisit the design practices of large speculative housebuilding firms, in order to better understand current practices and the system of constraints and opportunities in which these practices are situated. Furthermore, it is necessary to place design practice in the context of construction technology, for design criticism all too often abstracts from the technology of building practice and innovation. Therefore, this study examines, by means of a nationally representative questionnaire survey of housebuilding firms, the dominant design practices currently utilized in the industry. The focus is the extent to which volume housebuilding firms (defined as those producing in excess of 1000 units per annum) utilize standard designs, and the interrelationship between such designs and the construction technology employed. In-depth interviews with a representative sample of senior personnel from leading housebuilding companies complement the national survey, and provide insights into the system of constraints and opportunities which the housebuilding industry faces. At the heart of current debates is the conflict between the alleged prominence of the criterion of buildability in private sector housebuilding, at the expense of individuality in design, regard for the overall design context and the requirements of the housing consumer. Each of these issues is investigated in the context of the prevailing practice in the private sector housebuidling industry in the UK in the 1990s.
Keywords: design, private sector, volume house building.

2000, **18**(3), 311–320

Foreign exchange and revenue risks: analysis of key contract clauses in China's BOT project

Shou Qing Wang,[1] Robert L K Tiong,[2] S K Ting[2] and D Ashley[3]
[1]*School of Building and Real Estate, National University of Singapore, Singapore*
[2]*School of Civil and Structural Engineering, Nanyang Technological University, Singapore*
[3]*College of Engineering, Ohio State University, Columbus, OH 43210, USA*

Despite the Asian financial crisis, there was still growing international interests by sponsors in China's infrastructure projects financed on build-operate-transfer (BOT) concession contracts. With the closure of the Guangdong International Trust and Investment Corporation (GITIC), foreign banks have become cautious towards new loan applications by Chinese companies and they were confused about government support and guarantees. Therefore it is important to analyse and manage the unique or critical risks associated with China's BOT projects. This is especially so after new policies were introduced in late 1996 when the first state-approved BOT project, the US$650 million 2 X 350 megawatt coal-fired Laibin B Power Plant (Laibin B), was awarded. The findings are reported from an international survey on risk management of BOT projects, with emphasis on power projects in China, with a discussion of the adequacy of the key contract clauses used in the Laibin B's concession agreement (CA) in addressing the foreign exchange and revenue risks, which include exchange rate and convertibility risk, financial closing risk, dispatch constraint risk and tariff adjustment risk. Areas for improvements to these contract clauses are suggested.
Keywords: BOT, currency convertibility, foreign exchange, risk, management.

2000, **18**(3), 321–331

Total quality management and the learning organization: a dialogue for change in construction

Peter E D Love,[1] Heng Li,[2] Zahir Irani[3] and Olusegun O Faniran[4]
[1]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*
[2]*Department of Information Systems and Computing, Brunel University, Uxbridge, UB8 3PH, UK*
[3]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[4]*School of Civil Engineering, University of New South Wales, New South Wales 2052, Australia*

Many construction organizations have misunderstood the reality that total quality management (TQM) based on continuous improvement requires a commitment to learning and that essentially it is the means to a learning organization. The paper argues that if the construction industry is to improve its performance and competitiveness, then there needs to be a cultural and behavioural shift in the mind-set of practitioners, academics and the professional institutions. Their focus should be on re-thinking their approaches to TQM so that learning becomes the norm. It is demonstrated that a relationship exists between the constructs of TQM, organizational learning, and the learning organization. Based on a review of existing literature, a conceptual model for a learning organization in construction is presented and discussed. The paper proposes some refinements to the concept of the learning organization, directed at clearly positioning the critical focus of learning at the organizational level in construction.
Keywords: change, learning organization, organizational learning, total quality management.

2000, **18**(3), 333–342

Using Electre III to aid the choice of housing construction process within structural engineering

Martin Rogers
Department of Engineering Technology, Dublin Institute of Technology, Bolton Street, Dublin 1, Ireland

The Electre III model may be considered as a decision-aid technique suited to the appraisal of complex civil/structural engineering projects. This conclusion is based on an assessment that the model permits a general ordering of alternatives, even when individual pairs of options remain uncompared where there is insufficient information to distinguish between them. Also, the technique is capable of dealing with the mix of both quantitative and qualitative information obtained within an engineering project appraisal. Electre III is applied to the evaluation of 11 alternative multi-family housing systems on the basis of 7 criteria covering labour, material and energy demand. Using this case study, the benefits of Electre III over other decision models in the selection process concerned are emphasized.
Keywords: Electre III, multi-criteria method, structural engineering.

2000, **18**(3), 343–353

A decision support framework for project sponsors in the planning stage of build-operate-transfer (BOT) projects

Irem Dikmen Ozdogan and M Talat Birgonul
Middle East Technical University, Civil Engineering Department, 06531 Ankara, Turkey

Every decision-making problem is oriented towards the selection of the correct strategies for achieving objectives, and depends on the assumptions associated with different scenarios. Project planning in a buildoperate-transfer (BOT) project is a complicated decision-making problem because the model has a complex financial and organizational structure which is influenced also by the socio-economic environment in a country. A decision support framework is reported, as used in the planning stage of a hydropower plant project in Turkey, which helped the project company to check project viability against some predefined critical success factors, define the risk sharing scenarios under which a project becomes viable, incorporate risks into cash flow analysis and, finally, define effective risk mitigation strategies. Key challenges in the realization of BOT projects, particularly in developing countries, are discussed together with possible risk sharing principles between the private and public sector participants.
Keywords: BOT, Monte Carlo simulation, risk management.

2000, **18**(3), 355–362

The Coasian market-firm dichotomy and sub-contracting in the construction industry

Lawrence Wai Chung Lai
Department of Real Estate and Construction, University of Hong Kong, Bonham Road, Hong Kong, China

This is a contribution to the debate on the contractual nature of sub-contracting in the construction industry by arguing, contrary to certain views in the literature on institutional and construction economics, that the Coasian firm-market dichotomy is not blurred or pointless. By reference to the type and number of contracts, the study offers a way to distinguish the firm from the market as well as the precise nature of sub-contracting in terms of such distinction. Sub-

contracting is shown to be a nexus of Coasian firms interacting through the main contractor with a monopsony consumer in a Coasian market.

Keywords: Coasian firm, Coasian market, firm, sub-contracting, transaction cost.

2000, **18**(3), 363–372

Comparison of the concreting productivities in Hong Kong and Beijing and a proposed comparison methodology

Shou Qing Wang[1] and Michael Anson[2]
[1]*School of Building and Real Estate, National University of Singapore, 119260 Singapore*
[2]*Faculty of Construction and Land Use, The Hong Kong Polytechnic University, Hong Kong*

The ready mixed concrete (RMC) industry is an important sector of the construction industry in many places. Its level of development in terms of size and performance may be taken as an index representative of the development level of a particular construction industry taken as a whole. Therefore comparisons between different places are of interest, and of potential economic benefit. As part of a larger research study in Hong Kong on the productivity of concreting, data have been obtained on the RMC industries in Hong Kong (HK) and Beijing (BJ). Both are large cities at different stages of economic development. The study involved close observation in the early 1990s of 154 pours on building construction sites in HK and 38 days spent at 38 RMC plants, one day at each, together with 34 site pours and 20 days at RMC plants in BJ. Much detailed performance information has been derived, and a comparison methodology is proposed which could have general application in this industry. It is demonstrated that the RMC industry in HK is more productive than the industry in BJ.

Keywords: benchmarking, concrete placing, performance, ready-mixed concrete.

2000, **18**(4), 383–393

Employee perceptions of the solid waste management system operating in a large Australian contracting organization: implications for company policy implementation

Helen Lingard[1], Peter Graham[2] and Guinevere Smithers[2]
[1]*Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, Victoria 3052, Australia*
[2]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, Melbourne, Victoria, Australia*

A survey of employees' perceptions of a large contracting firm's waste management system was conducted. Results were factor analysed and an eight-factor model of the waste management climate was identified. Perceptions were found to differ between employee groupings. Managerial staff had a less positive perception of the waste management climate than did site workers. Qualitative interview data were analysed using a content analysis approach. Managers were found to perceive environmental issues as being less important than cost, time or quality objectives. Construction workers believed environmental issues to be of greater importance than these other objectives. Differences in perceptions of managers and site workers have implications for the implementation of any company waste management policy. There is a need to involve workers in identifying waste management solutions, to provide more information to all employees about practical aspects of waste management, and for managers visibly to demonstrate commitment to waste management policy objectives.

Keywords: waste, organizational climate, solid waste management.

2000, **18**(4), 395–406

Impact of correlation and induced correlation on the estimation of project cost of buildings

Malik Ranasinghe
Department of Civil Engineering, University of Moratuwa, Katubedda, Sri Lanka

Treatment of correlation between variables is necessary for deriving any theoretical distribution of the project cost of buildings. This paper highlights some often ignored theoretical requirements necessary for a rigorous treatment of correlations. The condition for a positive definite correlation matrix is described, along with an analytical procedure and a computer program developed to verify the positive definite condition when correlation coefficients between input variables are estimated using historical data. The analytical procedure and the developed computer program can be used in any application that obtains correlation information from historical data or as subjective judgements to be used in a functional relationship. A new concept called induced correlation is suggested to define and to treat correlation between derived variables that arise from the common (shared) primary variables in their functional forms. A published numerical example is used to highlight the stages where correlation between variables can have an impact on the estimation of moments (estimated expected value and estimated standard deviation) for the project cost of buildings, and to demonstrate the improvement in the estimation of the standard deviation of project cost as a result of treating correlations in risk analysis.

Keywords: price, probability, project cost, risk.

2000, **18**(4), 407–414

A fuzzy stochastic technique for project selection

Eric T T Wong[1], George Norman[2] and Roger Flanagan[3]

[1]*Department of Mechanical Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China*

[2]*Department of Economics, Tufts University, Medford MA, USA and University of Edinburgh, Scotland, UK*

[3]*Department of Construction Management & Engineering, The University of Reading, PO Box 219, Reading, UK*

The comparison of two or more risky projects is more of a challenge than the evaluation of one project in isolation. In the numerous decision models and methods suggested in the literature, often it is assumed that the criteria as well as the decision maker's preference or utility function can be crisply defined. Multi-attribute decision aids that permit the consideration of both multi-variables and risks generally have been associated with complex mathematics and heavy consumption of resources. This paper shows how project selection problems can be dealt with when some project attributes are subject to random variations. The method incorporates fuzzy analysis into multi-attribute utility theory. The aggregate utility function for an individual project is derived as a fuzzy number (or interval) which, in turn, yields probabilistic information for stochastic dominance tests. A unique feature of the approach is that it dispenses with the task of selecting probability distributions for aggregate utility functions. A comparison of the proposed method with the expected utility approach was made and the findings showed agreement between the results.

Keywords: fuzzy sets, multi-attribute model, project risk, stochastic dominance.

2000, **18**(4), 415–426

Hybrid modelling framework for synthesizing virtual structures

Mohan R Manavazhi

School of Civil Engineering, Asian Institute of Technology, PO Box 4, Klong Luang, Pathumthani 12120, Thailand

Erecting a structure in a construction project involves the use of a number of complex, interacting processes. Systematic analysis of these processes is essential for ensuring that they are executed in the most efficient way possible. However, traditional tools like CPM and PERT and other analytical and mathematical approaches cannot capture the dynamics of construction processes. These problems could be overcome by conducting experiments on the real-world processes themselves but such experiments can be prohibitively expensive. Thus, a more feasible approach that can overcome these drawbacks is required. This paper presents a framework-based approach for facilitating the analyses of the operations required for the construction of a structure with a specific configuration by building the structure virtually in a digital computer using discrete-event simulation. The approach utilizes a hybrid framework that combines the flexibility and simplicity of semantic networks with the power of object-orientation to facilitate discrete-event simulation. A predominantly product-centric modelling approach is used in the development of the framework. A sample application is given illustrating the application of the framework-based approach for the analyses of the operations required for the construction of the structure.

Keywords: discrete-event simulation, object-oriented simulation, product modelling, product synthesis, semantic network.

2000, **18**(4), 427–435

Estimating life cycle plant maintenance costs

David J Edwards, Gary D Holt and Frank C Harris

School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV 1SB, UK

The financial success or otherwise of a maintenance strategy can be determined realistically only when actual costs are compared with target 'predicted' values. This is because, in the absence of accurate cost control mechanisms, maintenance expenditure can exceed capital cost. In order to address this problem, a methodology is presented for predicting life cycle maintenance expenditure over the useful life of tracked hydraulic excavators. First, time series analysis (using a moving centred average) illustrates that the trend in maintenance cost expenditure is difficult to isolate due to large perturbations in periodic unscheduled maintenance. Such expenditure accounts for 92% of total maintenance cost. Second, cumulative costs of maintenance are modelled using a cubic equation, with time (in hours) as the predictor (x_n) variable. Model performance is robust with a coefficient of determination (R^2) of 0.99 and a mean percentage error (MPE) of minus 3.94. The paper concludes with direction for future research in this field, particularly with respect to expanding the model's application to machines of various weights, manufacturers and machines operating in other industries, and determination of criteria with which to predict when a plant item will reach the end of its useful life.

Keywords: plant maintenance, financial management, machine cost, estimating, time series.

2000, **18**(4), 437–446

Quest for continuous quality improvement for public housing construction in Hong Kong

C M Tam, Z M Deng, S X Zeng and C S Ho
Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong

With mandatory implementation of the ISO 9000 quality system by the Housing Authority in Hong Kong, most construction firms there now claim to have initiated quality systems in their processes as defined in their quality manuals. In addition, an objective quality measuring yardstick, the Performance Assessment Scoring Scheme (PASS), has been administered by the Housing Authority of Hong Kong to monitor the performance quality of contractors. These two measures, coupled with the two other contractual requirements stipulating the use of mechanized formwork and precast facade units, are directed towards achievement of a desired quality standard. However, the PASS analysis has revealed that the general level of quality has not improved significantly and the expected continuous improvement in construction quality has not been realized over a specific time period. Quality appears far better on paper than does the actual work on site. This suggests that quality management in the construction setting is far more difficult to achieve than it is in other industries. This paper explores possible reasons for failure in the quest for quality in public housing construction, and proposes changes needed before the vision of continuous quality improvement can be realized.
Keywords: ISO 9000, public housing, quality assessment, quality management.

2000, **18**(4), 447–456

An investigation into the merits of encouraging conflict in the construction industry

M Loosemore, B T Nguyen and N Denis
Faculty of the Built Environment, University of New South Wales, Sydney 2052, Australia

Considerable energy is being directed towards an indiscriminate policy of conflict reduction in the construction industry but the problem of construction conflict may be in its management rather than in its incidence. Conflict reduction is a response to the industry's inability to manage conflict constructively, and it may be more productive to focus upon building skills in this area as a basis for encouraging conflict. This paper explores the merits of this idea. It does so by discussing the results of a survey which used two psychometric tests to investigate whether the industry has an attitudinal and socio-structural base which is receptive to such efforts.
Keywords: attitudes, conflict, dispute, organizational structure, social systems.

2000, **18**(4), 457–466

To bid or not to bid: a parametric solution

M Wanous, A H Boussabaine and J Lewis
School of Architecture and Building Engineering, University of Liverpool, Liverpool L69 3BX, UK

One of the most important decisions that has to be made by construction companies/contractors is whether or not to bid for a new project when an invitation has been received. It would be of great help if a structured model could be developed that deals systematically with different bidding situations. A simple parametric solution for the 'bid/no bid' decision is reported in this paper. This solution is based on the findings of six semi-structured interviews and a formal questionnaire through which 38 factors that affect the bid/no bid decision were identified and ranked according to their importance to contractors operating in Syria. Only the most influential factors were considered in the development process. The model was optimized using data about 162 real bidding situations. Then the optimized model was tested using another 20 real projects. It proved 85% accurate in simulating the actual decisions. Although, the proposed model is based on data from the Syrian construction industry it could be modified very easily to suit other countries.
Keywords: bidding, parametric bidding model, Syria.

2000, **18**(4), 467–477

Work-input model for assembly and disassembly of high shoring towers

Aviad Shapira and Dov Goldfinger
Department of Civil Engineering and National Building Research Institute, Technion-Israel Institute of Technology, Technion City, Haifa 32000, Israel

High shoring towers, the common shoring solution for high clearance construction, cause the entire formwork system to account for a remarkably high percentage of the cost of the constructed concrete element. However, data on work inputs in assembly and disassembly of high towers are scarce, and the reason lies in the difficulty in conducting the numerous work studies that would be needed to cover the wide variety of tower types offered by the market and the extensive range of heights to which towers are erected. A model is presented, based on a limited number of work studies, for the prediction of work inputs in the assembly and disassembly of shoring towers of two configurations, rising to heights of up to 30 m. Results of actual measured work input data for three tower models representing three tower types widely

used on construction sites are presented. An insight is provided into the anatomy of tower erection, which should make possible use of the proposed methodology for the development of similar models for additional tower types.
Keywords: construction operations, formwork, shoring, work inputs, work study.

2000, **18**(4), 479–490

Quantifying the causes and costs of rework in construction

Peter E D Love[1] and Heng Li[2]
[1]*School of Architecture and Building, Deakin University, Geelong Victoria 3217, Australia*
[2]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*

Very few construction companies and consulting firms in Australia measure their costs of quality. Consequently, it is difficult for them to prove that systems for preventing quality failures are cost-effective. Although the direct costs of a quality system can be quantified with some accuracy (salaries, costs of documentation, audits, etc.), the corresponding benefits are far more difficult to assess. Indeed quality failures have become an endemic feature of the procurement process in construction and invariably lead to time and cost overruns in projects. Thus, in order to improve the performance of projects it is necessary to identify the causes and costs rework. The research presented in this paper quantifies the causes, magnitude and costs of rework experienced in two construction projects that were procured using different contractual arrangements. The causes and costs of rework projects are analysed and discussed. The findings reveal that the cost of rework for the case study projects was 3.15% and 2.40% of their project contract value. Changes initiated by the client and end-user together with errors and omissions in contract documentation were found to be the primary causes of rework. It is recommended that construction companies and consultant firms (particularly design consultants) implement quality management practices as well as place emphasis on coordinating project documentation during the design development process so that the amount of rework in projects can be reduced or even eliminated.
Keywords: Australia, quality assurance, quality cost, re-work.

2000, **18**(4), 491–500

A proposal for construction project risk assessment using fuzzy logic

J H M Tah and V Carr
Project Systems Engineering Research Unit, School of Construction, South Bank University, Wandsworth Road, London SW8 2JZ, UK

The construction industry is plagued by risk and often has suffered poor performance as a result. There are a number of risk management techniques available to help alleviate this, but usually these are based on operational research techniques developed in the 1960s, and for the most part have failed to meet the needs of project managers. In this paper, a hierarchical risk breakdown structure representation is used to develop a formal model for qualitative risk assessment. A common language for describing risks is presented which includes terms for quantifying likelihoods and impacts so as to achieve consistent quantification. The relationships between risk factors, risks and their consequences are represented on cause and effect diagrams. These diagrams and the concepts of fuzzy association and fuzzy composition are applied to identify relationships between risk sources and the consequences for project performance measures. A methodology for evaluating the risk exposure, considering the consequences in terms of time, cost, quality, and safety performance measures of a project based on fuzzy estimates of the risk components is presented.
Keywords: common language, fuzzy logic, project performance, qualitative risk assessment.

2000, **18**(5), 509–518

ISO 9001 within the Swedish construction sector

Anne Landin
Box 118, Department of Construction Management, Lund University, S-221 00 Lund, Sweden

This study analysed how the ISO 9000 framework could be employed in the construction process. Interviews were conducted at twelve companies in Sweden that utilized the quality system standard ISO 9001. Many of the concepts contained in the quality system standard were experienced as being too abstract and too difficult to comprehend. Frequently quality management was considered as serving the function of improving the company's competitiveness and allowing the company to be more efficient. It appeared difficult, however, in view of the many stages in the construction process, and the diverging interests represented, to meet the needs of the construction sector by the use of ISO 9001 alone. Some of the paragraphs it contains also tended to be confused with one another and to be misinterpreted. Others, although useful elsewhere, appeared scarcely to find application in the construction sector. Developments in the area appear to be going in the direction away from using large bureaucratic inspection systems and quality handbooks aimed at impressing customers and towards employing more diversified systems. Certification was found to be a matter of concern to all of the companies investigated.
Keywords: certification, ISO 9000, quality management.

2000, **18**(5), 519–524

An evaluation of the use of insurance in managing construction risks

Henry A Odeyinka
Department of Building and Surveying, Glasgow Caledonian University, Glasgow G4 0BA, UK

One of the major methods of managing construction risks in the Nigerian construction industry is the insurance method. On the basis of data from some selected construction sites in Nigeria, this paper evaluates the effectiveness of the method. Also it identifies, through a questionnaire survey, the various insurable construction risks perceived to be encountered in the Nigerian construction industry and the types of insurance policy employed in managing them. High importance is placed by the construction industry on site security, construction risk, and health and welfare requirements, and the use of an all-risk insurance policy is the most prominent method for managing the identified risks. Finally it is concluded that there is a correlation between insured sum and actual replacement cost when there are losses or damages. However, the insurance claims settled could cater for only 61.1% of the replacement cost of on-going construction works studied.

Keywords: contractor, insurance, Nigeria, risk.

2000, **18**(5), 525–533

Service management in housing refurbishment: a theoretical approach

Mats G Holm
Shanka Sverige, Box 655, SE-751 27 Uppsala, Sweden and Department of Service Management, Chalmers University of Technology, SE-412 96 Göteborg, Sweden

It is unusual to find that housing refurbishment projects have been undertaken with a clear focus on customer orientation directed towards the tenants, or owners of cooperative flats or condominiums. Only recently have researchers in construction management begun to look closer at the relationship between contractors and customers. To assess the scope for customer orientation in the refurbishment industry, current thinking in service management is reviewed here in an attempt to identify principles with implications for housing refurbishment. There is a consensus among service management investigators that services are intangible; other often mentioned characteristics are heterogeneity, perishability, and the inseparability of production and consumption. Except for inseparability these characteristics are valid for refurbishment. Nevertheless, features such as the long turn-round time, the number of participants, the complexity and the uncertainty, distinguish housing refurbishment from most services. There is strong empirical support for the claim that customer satisfaction increases customer loyalty and gives the service producer a positive reputation, ultimately increasing profitability. It is concluded that this insight can be interpreted operationally for housing refurbishment projects, bearing in mind that the tenant or the owner of a cooperative flat is the customer's customer.

Keywords: customer satisfaction, housing refurbishment, service quality.

2000, **18**(5), 535–545

Contractor financial credit limits; their derivation and implications for materials suppliers

J Nicholas, G D Holt and M Mihsein
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV1 1SB, UK

Current methodologies for 'calculating' contractors' credit limits (for supply of construction materials) are discussed and critically appraised. It is highlighted that credit limit imposition should be a function of a supplier's financial characteristics as well as potential debtors' probability of defaulting upon repayment. A conceptually new approach is presented to identify whether an additional contractor's trade results in a worthwhile gain in utility for the supplier. It is identified, *inter alia*, that (i) allowing very few contractors credit facilities that account for a large proportion of suppliers' potential profits, (ii) having inaccurate creditworthiness evaluation procedures, and (iii) operating on low targeted profit margins are the characteristics that inflict maximum financial risk upon materials suppliers.

Keywords: contractors' credit limits, debtor, material supplier, risk, utility theory.

2000, **18**(5), 547–557

Final contractor selection using the analytical hierarchy process

Patrick Sik-Wah Fong[1] and Sonia Kit-Yung Choi[2]
[1]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*Levett and Bailey Chartered Quantity Surveyors, 18-20/F, Eastern Central Plaza, 3 Yiu Hing Road, Shaukeiwan, Hong Kong*

Some contractor selection methods currently in existence are criticized as incomplete and biased, and lacking consideration in terms of the contractor's ability to achieve simultaneously, time, cost, quality and safety standards. This research examines an alternative contractor selection model called the analytical hierarchy process (AHP), which will help construction clients to identify contractors with the best potential to deliver satisfactory outcomes in a final contractor selection process which is not based simply on the lowest bid. The AHP comprises three parts: hierarchic

structure, prioritization procedure, and calculation of results. This model is tested by a hypothetical scenario where three contractor candidates are evaluated. The criteria used for contractor selection in the model have been identified, and the significance of each criterion has been arrived at by conducting a questionnaire survey in public organizations in Hong Kong. Comparisons are made by ranking the aggregate scores of each candidate with regard to their performance against each of the criteria, and the candidate associated with the highest scores is the best contractor on this occasion.
Keywords: analytical hierarchy process, contractor selection, pre-qualification, tender price.

2000, **18**(5), 559–566

Occupational stereotypes in the construction industry

Martin Loosemore and Chin Chin Tan
Faculty of the Built Environment, University of New South Wales, Sydney 2052, Australia

An investigation of occupational stereotypes in the construction industry provides insights into the perceptions and expectations which different occupational groups have of each other. The results are valuable in the reduction of uncertainty, misunderstanding and conflict within construction projects and do not support the widely held view of institutionalized confrontational relationships. Instead, there appears to be a natural degree of goodwill underlying interpersonal relationships although it is delicate, precarious and easily destroyed by insensitive managerial practices.
Keywords: attitudes, beliefs, communication, conflict, culture, stereotypes.

2000, **18**(5), 567–574

Modelling the dynamics of design error induced rework in construction

Peter E D Love[1], Purnendu Mandal[2], Jim Smith[3] and Heng Li[4]
[1]*School of Architecture and Building, Deakin University, Geelong, Victoria 312, Australia*
[2]*School of Engineering and Technology, Deakin University, Geelong, Victoria 312, Australia*
[3]*Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, Victoria 3052, Australia*
[4]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hong Kong*

Rework that is experienced in construction projects is often caused by errors made during the design process. Factors that contribute to design errors are identified and used to design and develop a systems dynamics model, which is used to simulate a number of practical scenarios that can be used to reduce design errors and rework. The model presented in this paper can enable design and project managers to understand better the process of design documentation and how design errors occur in construction projects.
Keywords: design error, design management, re-work, system dynamics, time boxing.

2000, **18**(5), 575–585

Estimating using cost significant global cost models

A K Munns and K M Al-Haimus
Department of Civil Engineering, University of Dundee, Dundee DD1 4HN, UK

Cost significant models have been suggested as one way of overcoming criticisms of the amount of detail contained within the traditional bill of quantities. Recent research into these models reveals a lack of formal rules for the selection of work packages to be used within the models, and a potential to overestimate the cost of projects. This paper presents a methodology for selecting work packages, and recommends a refinement to the technique that reduces the variability in estimates produced using cost significance. Estimates are produced using both the traditional method of producing cost significant models, and a refined global cost methodology. Both techniques are tested against unpriced bills to measure the difference in results, with significant improvements being achieved with the new technique.
Keywords: bill of quantities, estimating, cost model, cost significance.

2000, **18**(5), 587–598

Motivation, commitment and the use of incentives in partnerships and alliances

Mike Bresnen[1] and Nick Marshall[2]
[1]*Warwick Business School, University of Warwick, Coventry CV4 7AL, UK*
[2]*Complex Product System Innovation Centre (CoPS), Centre for Research in Innovation Management (CENTRIM), University of Brighton, Brighton BN1 9PH, UK*

The use of incentives in partnering and alliancing has been seen as an important way of reinforcing collaboration in the short term and helping to build trust between clients and contractors in the long term. Yet only rarely has the impact of incentives on such relationships been discussed, let alone subjected to systematic investigation. This is despite a wealth of theory and research which brings into question the use of incentives and reinforcers as ways of generating motivation and commitment. Drawing upon this theoretical knowledge base and using evidence from a number of case studies of partnerships and alliances, this paper demonstrates how a number of important cognitive and social dimensions affect the use and impact of incentives, sometimes in ways contrary to those intended. The conclusion drawn is that there are

important limitations to the use of incentives as means of reinforcing collaboration and developing commitment and trust, and that this raises questions more generally about the assumptions that underlie many of the practical 'tools and techniques' commonly associated with partnering and alliancing.
Keywords: alliancing, commitment, incentives, motivation, partnering.

2000, **18**(5), 599–605

Are competitive fee tendering and construction professional service quality mutually exclusive?

Michael Hoxley
Department of Built Environment, School of Design and Communication Studies, Anglia Polytechnic University, Victoria Road South, Chelmsford, Essex CM1 1LL, UK

It is a little more than 15 years since the associations representing construction professionals in the UK surrendered to government pressure and abolished mandatory fee scales, predicting as they did so that inevitably abolition would lead to a decline in the standard of service provided to clients. Initially the abolition of fee scales had little impact on fee levels - in the UK economic and property boom of the late 1980s demand from clients in all sectors was high and fee levels remained at, or close to, pre-abolition levels. However, in the recession that followed, fee levels fell to unprecedentedly low levels, causing many commentators to be concerned that the quality of service provided to clients would fall. The main aim of this research is to establish whether clients' perceptions of service quality have declined as a result of lower fee scales. Following a literature search five hypotheses are presented namely, that clients' perceptions of service quality are: lower for fee tendered commissions; lower when the fee bid is particularly competitive; higher when the service is adequately specified by the client; higher when care has been taken with preselection of tenderers; and higher when adequate weighting to ability is given in the final selection process. The hypotheses have been tested by collecting data from 244 clients who anonymously assessed consultants, 60% of whom were chartered surveyors (just over half of these were quantity surveyors). Over half of the consultants were appointed by competitive fee tender, and although the service quality scores were lower for these consultants this result was not statistically significant. Therefore, the main hypothesis is not supported by the data but the fourth and fifth hypotheses are both supported by the study.
Keywords: professional, fee tendering, service quality.

2000, **18**(5), 607–618

Forecasting construction industry demand, price and productivity in Singapore: the Box-Jenkins approach

Goh Bee Hua and Teo Ho Pin
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, 119260 Singapore

In academic research, the traditional Box-Jenkins approach is widely acknowledged as a benchmark technique for univariate methods because of its structured modelling basis and acceptable forecasting performance. This study examines the versatility of this approach by applying it to analyse and forecast three distinct variables of the construction industry, namely, tender price, construction demand and productivity, based on case studies of Singapore. In order to assess the adequacy of the Box-Jenkins approach to construction industry forecasting, the models derived are evaluated on their predictive accuracy based on out-of-sample forecasts. Two measures of accuracy are adopted, the root mean-square-error (RMSE) and the mean absolute percentage error (MAPE). The conclusive findings of the study include: (1) the prediction RMSE of all three models is consistently smaller than the model's standard error, implying the models' good predictive performance; (2) the prediction MAPE of all three models consistently falls within the general acceptable limit of 10%; and (3) among the three models, the most accurate is the demand model which has the lowest MAPE, followed by the price model and the productivity model.
Keywords: accuracy, Box-Jenkins, construction demand, forecasting, productivity.

2000, **18**(5), 619–627

The global construction market: a cross-sectional analysis

David Crosthwaite
Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading RG6 6AW, UK

Construction is a major industry throughout the world accounting for a sizeable proportion of most countries gross domestic product (GDP). According to a recent survey, total world construction spending in 1998 was over $3 trillion. Furthermore the importance of the construction sector is related not only to its size but also to its role in economic development. This paper examines the extent of international construction activity, and is based on a cross-sectional analysis of published data pertaining to global construction spending. The principal findings suggest that the role of construction changes as economic development proceeds. It was found that the share of construction spending in GDP first grows during less developed country (LDC) status, peaks during newly industrializing country (NIC) status and then declines as countries move from NIC to advanced industrialized country (AIC) status. The research identifies the importance of construction within NICs. The regions of Asia and Latin America and the countries of China, Mexico, Argentina and Egypt are considered noteworthy in regard to various indicators concerned with construction and

economic activity. However, the conclusion is that as economic development proceeds from NIC to AIC status construction fails to maintain its share of GDP and therefore declines in importance.
Keywords: cross-sectional analysis, economic development, global construction, national markets, regional markets.

2000, **18**(6), 635–642

Strategic change and organizational learning in two 'Swedish' construction firms

Lars Huemer[1] and Katarina Östergren[2]
[1]*Norwegian School of Management, PB 580, 1301 Sandvika, Norway*
[2]*Umeå School of Business and Economics, Department of Business Administration, Umeå University, 901 87 Umeå, Sweden*

The two largest construction companies in Sweden, NCC and Skanska, previously have acted according to what here is called a multi-domestic strategy. Such a strategy implies that each market is treated essentially in isolation. Due to perceived pressures for local responsiveness, the firms have focused on utilizing local knowledge and experience, while failing to obtain economies of scale and to learn from the different localities. A combination of changing perceptions of being local and a growing number of home markets makes possible a strategic approach that is inter-domestic in nature. This approach stresses the importance of learning and of coordinating the experience a construction firm achieves in many different localities. Therefore learning is seen not only as a process of adaptation to the environment, but also as an evolutionary process built on an organization's identity, which is created by both structural and individual factors. The identity of an organization helps us to understand its ability to learn.
Keywords: evolution, industrial wisdom, organizational learning, strategic change.

2000, **18**(6), 643–650

Innovative supply-based strategies in the construction industry

Sihem Ben Mahmoud-Jouini
Assistant Professor, University Paris XI, France; Researcher, Centre de Recherche en Gestion de l'Ecole Polytechnique, Paris 75005, France

In the construction industry demand drives the design process and as a result design is structured in order to respond to this demand. However, what happens when this demand breaks down, when traditional markets are saturated, and no feasible alternative arises? Will this sector be capable of refocusing their efforts on creating new products to offer? Is it possible for industry participants to adopt a proactive strategy? These questions are investigated and it is seen that the French construction industry, and in particular major contractors, illustrate the problem perfectly. Examples are analysed of innovative offerings in this industry, two groups of which could be developed further.
Keywords: design, France, innovation, large corporations, marketing strategy.

2000, **18**(6), 651–656

Mobilizing the skills of specialist firms to reduce costs and enhance performance in the European construction industry: two case studies

Ezio Micelli
Dipartamento di Urbanistica, Istituto Universitario di Architettura di Venezia, Ca'Tron – Santa Croce 1957, 30135 Venezia, Italy

Analyses are made of procurement strategies capable of leading to cost reduction and higher quality through the contribution of specialized firms. An exploration is made of the literature concerning the procurement of manufactured goods and progress by analysing two case studies: the East Bridge of the Storebælt link and the Grand Canal Maritime bridge. Both these projects adopted procurement systems that led to a learning process capable of enhancing performance and reducing overall costs. It is evident that the success of learning-oriented procurement strategies relies on two major conditions. First, the client's tender must be issued with an open design demanding an active contribution from the firms involved in the construction process. Second, the firms bidding for the job must be able to manage two distinct sets of skills: the technical skills relating to a specific production process and the ability to connect these skills to the client's needs through a co-design process, or what is known as the strategic intermediation function.
Keywords: bridge, Denmark, France, Italy, procurement strategy.

2000, **18**(6), 657–665

A theoretical model for optimum project (time) performance based on European best practice

D G Proverbs and G D Holt
Built Environment Research Unit, University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB, UK

The authors have over recent years performed extensive empirical research into European (UK, French and German) construction contractor performance. This paper represents the culmination of that research, by presenting a model for achieving optimum project time performance based on European best practice. By removing or neutralizing the impact of external factors (e.g. procurement method), the research concentrated on contractor practices and their direct impact on construction time performance. A variety of European contractor performance data were analysed to identify optimum solutions (i.e. contractors' construction practices) for achieving fastest project completion. The principal theme of the paper is graphical presentation and description of a theoretical model for optimum project (time) performance based on European best practice. Further, characteristics of UK, French and German variants of the model are presented. The application of multiple regression analysis to the data suggests that there are other factors, not embraced by the model, that may also impact significantly upon construction time performance. European contractors and clients may wish to consider the characteristics of these model(s) in striving to achieve earliest project completion.
Keywords: best practice, construction time, contractor performance, Europe.

2000, **18**(6), 667–677

Quality management standardization in the French construction industry: singularities and internationalization prospects

Eric Henry
CRISTO-CNRS, Universitè Pierre Mendès France, PO Box 47X, 38040 Grenoble Cedex, France

Over the last 10 years quality management in the French construction industry has triggered a range of innovative ideas spanning all professions, ideas that have been developed further through action-research. The creation of quality clubs is one of the first examples of this, followed by the setting up of professional quality assurance references based on the ISO 9002 Standard, to be used first and foremost by construction contractors (QUALIBAT), but also by architects (AQC and QUALIARCH), and finally clients (QUALIMO). The clubs and QUALIBAT are today experiencing either a decrease in activity or a growth-caused crisis, made all the worse by the devastating effects of a long, drawn-out activity crisis which lasted from 1993 until 1998 and led to widespread abnormally low prices. A new impetus has been given to the sector by the Construction Branch of the French Movement for Quality (MFQ) through the combined force of the clubs' experience and the development of professional quality references. The innovation consists of drawing up an experimental standard for quality management in the construction industry and actively participating in revising the ISO 9000 Standards for the year 2000. Although specifically French, other countries in southern Europe and Latin America with whom there has been regular contact since 1996 are interested in this initiative.
Keywords: action research, France, ISO 9000, quality clubs, total quality management.

2000, **18**(6), 679–687

Developing construction logistics management: the French experience

Jean-Luc Guffond and Gilbert Leconte
CRISTO-CNRS, Centre de Recherche: Innovation Socio-Technique et Organisations Industrielles, BP47, 38040 Grenoble cedex, France

To recover from the construction crisis, major French construction firms started developing 'package building' strategies at the beginning of the 1990s. Today, their desire to open up continues, but they have also shown renewed interest in the management of construction site activities and production engineering, as witnessed by the practices of 'logistics management'. How can we justify this inward-looking attitude to construction? What place is there for innovation? Along what lines must this new approach to production management develop? These questions are addressed with reference to the analysis recently produced by a panel of experts led by the authors. The study of various experimental construction sites shows that although it may not yet be well established, this approach has resulted in significant changes in the way construction projects are organized. It places the emergence of new forms of coordination both within and between firms right at the heart of the quest for production efficiency.
Keywords: site co-ordination, France, inter-activity co-ordination, logistics.

2000, **18**(6), 689–698

Craft versus industry: the division of labour in European housing construction

Linda Clarke and Christine Wall

Education, Training and the Labour Market Research Group, Westminster Business School, University of Westminster, 35 Marylebone Road, London NW1 5LS, UK

Two distinct divisions and concepts of labour are apparent from an analysis of social housebuilding sites in the UK, Germany and the Netherlands: the craft form, based on controlling the output of labour; and the industry form, based on the quality of labour input. These are associated with different work processes, skills and training, and also different levels of mechanization and component prefabrication. In the UK, which is craft-based, low levels of mechanization and prefabrication were found compared with Germany and the Netherlands, and the range of activities for the separate trades in assembling superstructure elements was simpler. Labourers are distinct from craftsmen and remain a significant group. Skills are narrow and training provision low. A high proportion of the labour force remains self-employed, under labour-only sub-contractors, working to price or output. In comparison, in Germany and the Netherlands labour is employed directly and work processes are more complex, with more specialisms at the interfaces. The division of labour is industry-wide, training provision is extensive, and skills are broad and integrated into the grading structure. Greater speed, higher productivity and lower levels of supervision are associated with industry-wide systems compared with traditional craft forms.

Keywords: craft, Europe, house building, skill, training.

2000, **18**(6), 699–709

National collective bargaining and employment flexibility in the European building and civil engineering industries

Jan Druker[1] and Richard Croucher[2]

[1]*University of Greenwich Business School, Island Site, Wellington Street, Woolwich, London SE18 6PF, UK*

[2]*Cranfield School of Management, Cranfield MK43 0AL, UK*

Change in employment practice in the European construction industry is reviewed with particular attention to the effects of flexible working on established arrangements for national collective bargaining. Data derive from European survey research coordinated by Cranfield School of Management in 1995 and from interviews with trade union and employers association representatives in the same period. Membership and support for trade unions and employers associations has weakened, although there are significant differences between countries. The most significant changes in employment practice in construction are found in the increased use of temporary, short term and fixed term contracts; in sub-contracting, and in the use of overtime. These changing working practices tend to fragment the workforce and to undermine established systems of institutional interest representation. The distinctive commitment of UK employers to temporary or casual work and to sub-contracting is confirmed. The changes contribute to pressure on arrangements established through multi-employer bargaining, although employers and trade union representatives remained committed, at the time of our research, to multi-employer collective agreements.

Keywords: collective bargaining, employment flexibility, sub-contracting, temporary working, trade unions.

2000, **18**(6), 711–720

The European construction industry's competitiveness: a construct of the European Commission

Jörn Janssen

School of the Built Environment, University of Westminster, 35 Marylebone Road, London NW1 5LS, UK

The 'European construction industry' is a fiction that tends to obscure its heterogeneous character and to mar studies and policies of the European Commission aimed at improving the internal and external 'competitiveness' of the sector. In order to assess the process of integration in Europe under the impact of its own dynamics as well as Union policies, this paper looks at the dynamics of the sector from three different aspects: as investment, production and labour process. It shows, in particular, the persistent regional and social disparities dividing the industry into separate entities. Political attention tends to focus on a small number of construction companies competing for a few projects which represent the European dimension. Yet, these companies still rely on their respective national bases and local labour from the place where construction is carried out. Persistent divisions between the states are also reflected in the low level of transnational organization of the construction industry. The policy of the European Commission generally ignores these divisions and attempts to establish principles intended to make a whole sector more 'competitive', while its component parts, operating at hugely different levels of productivity, do not even meet on the same market. This paper argues that, instead of trying in vain to introduce a 'knock-out' system of competition in the EU Member States, a targeted approach might help raise productivity in lagging regions and thus improve the basis of competitiveness on global markets.

Keywords: competitiveness, European Commission, productivity.

2000, **18**(7), 727–732

Modelling the dynamics of design error induced rework in construction: comment

Paolo Tombesi
Faculty of Architecture, Building and Planning, University of Melbourne, Parkville, Victoria 3010, Australia

The bridging of different research disciplines such as computer modelling and design practice requires full understanding of both. Privileging one area of investigation while simplifying the other is not a feasible option. This approach is likely to produce work that scarcely reflects the actual complexity of the phenomena discussed.
Keywords: design documentation, design labour, design management, design process, design research.

2000, **18**(7), 733–745

Competition and the persistence of profits in the UK construction industry

Michael Ball, Mahtab Farshchi and Maurizio Grilli
School of Urban Development and Policy, South Bank University, Wandsworth Road, London SW8 2JZ, UK

An examination has been made of the performance of a range of medium-size publicly quoted construction firms over the five-year period 1990-1994 including evidence on the competitive nature of construction markets. The results suggest that construction markets are price competitive with mark-ups that vary positively with the construction cycle. Common arguments that competition in construction is excessive and that firms can gain from firm specific strategies are not supported by the analysis.
Keywords: competition, medium-size firm, price competitive.

2000, **18**(7), 747–756

Choice or necessity? A review of the role of DIY in tackling housing repair and maintenance

Maggie Davidson[1] and Philip Leather[2]
[1]*Building Research Establishment, Garston, Hertfordshire, UK*
[2]*Centre for Urban and Regional Studies, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK*

Do-it-yourself (DIY) is a staple element of the spare time activities of many households, but little is known about the extent to which basic repair work is carried out through DIY and about the quality of this work. Through secondary analyses of UK government data (English House Condition Survey and Family Expenditure Survey), this paper examines the scale of DIY work by owner-occupiers, how work is organized, the interrelationship of DIY work, the use of unpaid help, and the use of contractors. It considers the types of work carried out, the characteristics of those who tackle DIY or use unpaid help, the dwelling types most likely to experience DIY work, and the motivations of and constraints on those home-owners who do it. The paper concludes with a discussion on the policy implications of these findings for government and the building industry. Although most DIY work is cosmetic and does not deal with basic repair and maintenance, the sheer scale of DIY ensures that it makes a contribution to improving housing conditions. The provision of more advice, information and education by government, local authorities and the private sector could ensure that more DIY work is of better quality and that home owners give priority to essential repairs whether or not they tackle these themselves.
Keywords: building, DIY, housing, maintenance, repair.

2000, **18**(7), 757–766

Occupational bias in construction management research

Martin Loosemore and Chin Chin Tan
Faculty of the Built Environment, University of New South Wales, Sydney 2052, Australia

Biased research results occur when allowances are not made for the cultural perspectives of researchers and respondents. Occupation is a strong source of cultural differentiation in the construction industry, and this paper investigates the potential for bias to arise from people's association with a particular group. A model of occupational stereotypes is presented which expands our current understanding of how different professions perceive each other. This is useful in a research context because it provides a firmer foundation for the interpretation of past research results. Furthermore, it enables researchers to understand the potential for bias to arise from their own occupational backgrounds and to acknowledge these in their research results. A series of suggestions are made which may help researchers reduce occupational bias in their research.
Keywords: attitudes, beliefs, culture, occupation, research.

2000, **18**(7), 767–774

Lowest price or value? Investigation of UK construction clients' tender selection process

Chee H Wong, Gary D Holt and Patricia A Cooper
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB, UK

There is a growing urge for a shift from 'lowest-price wins' to 'multi-criteria selection' practices in the contractor selection process. The rationale is to achieve best value (for money) for the client. Earlier investigations have found that the tender price (i.e. capital cost) still dominates the final selection decision despite increased emphases on the need for contractor selection based on 'value'. This paper provides insights into the evaluation of contractors' attributes, particularly for project-specific criteria (PSC), that is, criteria against which tendering contractors may be considered. The importance attached by clients to the 'lowestprice wins' philosophy is also reported. The perceived importance of PSC (i.e. their influence on final selection choice) is determined through a structured questionnaire survey of UK construction clients. The results show an increasing use of PSC. It is also found that 'lowest-price' is not now necessarily the client's principal selection criterion, but rather, the realization that cost has to be tempered with evaluation of PSC in any attempt to identify value for money.
Keywords: contractor selection, lowest-price tender, multi-criteria method, project-specific criteria, tender evaluation.

2000, **18**(7), 775–782

Does quality assurance deliver higher productivity?

D A Langford, H El-Tigani and M Marosszeky
Department of Civil Engineering, University of Strathclyde, John Anderson Building, 107 Rottenrow, Glasgow G4 0NG, UK

This paper seeks to assess whether the implementation of formal quality schemes in the construction industry delivers higher productivity when measured at site level. The work reports an experiment in which the resources used by construction contractors to build housing association houses varied in accordance with the level of formal quality certification held by the contractors. It concludes that formally assured organizations use fewer resources to create the same output.
Keywords: house building, productivity, quality assurance.

2000, **18**(7), 783–796

ISO 9000 and beyond: from a Hong Kong construction perspective

Mohan M Kumaraswamy and Sunil M Dissanayaka
Department of Civil Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, PR China

Client driven 'pushes' for ISO 9000 certification in Hong Kong are observed to have overtaken any spontaneous 'pull factors' (motivators) towards quality improvements 'for their own sake'. For example, the need for ISO 9000 certification as a prerequisite for even being considered for public sector construction works appears to have distracted some organizations from a more comprehensive organization-specific development of their quality management systems. Both positive (beneficial) and negative (detrimental) outcomes from ISO 9000 certification, as observed from relevant previous studies, are summarized herein. These provide a useful background against which to present perceptions derived from the current study in Hong Kong construction. The target groups were predominantly from consultants in the initial survey and all from contractors in the second and more comprehensive survey. The more significant positive and negative outcomes from ISO 9000 certification as derived from the two current surveys are identified. Recommendations are made for realigned approaches to ISO 9000 certification and for seamless integration with other quality management approaches such as TQM, as well as with other management subsystems, such as for productivity improvement and dispute minimization.
Keywords: Hong Kong, integration, ISO 9000, quality management, total quality management.

2000, **18**(7), 797–806

Antecedents of trust in intra-organizational relationships within three Singapore public sector construction project management agencies

E S Wong, Danny Then and Martin Skitmore
School of Construction Management and Property, Queensland University of Technology, Gardens Point, Brisbane Q4001, Australia

This paper examines the role and nature of trust in construction project management performance. Three causes, or antecedents, of trust are identified: results, integrity and concern. A questionnaire survey of construction project team members employed by three public sector infrastructure organizations in Singapore is described. The results confirm the expected correlations. Concluding remarks suggest that enlightened management is needed to keep the three antecedents in reasonable balance.
Keywords: performance, trust, survey, Singapore.

2000, **18**(7), 807–817

Innovativeness in British and French construction: the evidence from Transmanche-Link

Graham M Winch
Bartlett School of Graduate Studies, University College London, Philips House, Gower Street, London WC1E 6BT, UK

This paper addresses the 'innovativeness' (the extent to which the design of the organization facilitates or inhibits innovation) of French and British project organizations. Following a review of the literature on organization design and innovativeness, data from a comparative organizational assessment of the British and French approaches to managing the Channel Tunnel construction project by Transmanche-Link are presented. These show that the British approach could well have less capacity for innovation than the French. The available evidence on the relative levels of innovation on the two sides of the Channel Tunnel are reviewed, showing that the predicted effects are found.
Keywords: UK, Channel Tunnel, construction innovation, France, mayor, project.

2000, **18**(7), 819–832

Building partnerships: case studies of client-contractor collaboration in the UK construction industry

Mike Bresnen[1] and Nick Marshall[2]
[1]*Warwick Business School, University of Warwick, Coventry CV4 7AL, UK*
[2]*Complex Product System Innovation Centre, Centre for Research in Innovation Management, University of Brighton, Brighton BN1 9PH, UK*

Despite the enormous groundswell of interest in partnering and alliancing in recent years, there has been comparatively little research that has set out to investigate systematically the nature, feasibility, benefits and limitations of forms of client-contractor collaboration. This is despite the growing recognition that conditions conducive to partnering may well vary considerably and that partnering may not be the solution for problems within the industry that many commentators have taken it to be. This paper sets out to add to the growing literature and empirical database on partnering by reporting the findings of a research project designed to explore the economic, organizational and technological factors that encourage or inhibit collaboration in practice. The paper follows on from an earlier review and critique of the literature on partnering (Bresnen, M. and Marshall, N. 2000, *Construction Management and Economics*, 18 (2) 229-37). It includes as its database nine case studies of medium-to-large-scale projects, selected from across the industry, on which processes of collaboration are examined from the viewpoints of clients, contractors, designers and sub-contractors. In contrast to much of the prescriptive work in this area, the analysis of the data and the paper's conclusions stress some of the practical problems, limitations and paradoxes of partnering and alliancing when the effects of important economic, organizational and psychological factors are taken into account.
Keywords: alliancing, client, management, partnering.

2000, **18**(7), 833–841

The effect of the workplace on motivation and demotivation of construction professionals

Guinevere L Smithers and Derek H T Walker
Department of Building and Construction Economics, RMIT University, GPO Box 2476V, Melbourne 3001, Australia

Investigations have been carried out which suggest that motivation of employees in all industries is affected by the environment or culture in which they work. Research undertaken in Melbourne, Australia investigated the effect of the workplace environment encountered on a construction site on motivation and demotivation of construction professionals. The data collected supported the hypothesis that the environment of a construction site does affect demotivation levels of site personnel. Specifically, several variables were significantly linked to this result, including long hours, chaos, non-recognition for work done and colleagues' aggressive management style. The results provide a valuable basis for indicating how the construction industry can create a more attractive workplace environment for professional site staff.
Keywords: culture, demotivation, management, motivation, workplace.

2000, **18**(7), 843–852

Prediction of tender price index directional changes

S Thomas Ng,[1] Sai On Cheung,[2] R Martin Skitmore,[3] Ka Chi Lam[2] and Lai Yi Wong[2]
[1]*Department of Civil Engineering, University of Hong Kong, Pokfulam, Hong Kong*
[2]*Department of Building and Construction, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong*
[3]*School of Construction Management and Property, Queensland University of Technology, GPO Box 2434, Brisbane Q4001, Australia*

A multivariate discriminant analysis is described, aimed at predicting the direction of changes in the Hong Kong tender price index by utilizing the patterns of change in eight leading economic indicators. Two discriminant functions are derived which distinguish between 'upward', 'constant' and 'downward' index trends with a high degree of success. The predictive power of the discriminant model is tested by means of a simulated *ex post* holdout sample of eight index values. By comparing the group centroids, seven of the cases are correctly classified. The hit rate of the 'upward' and 'constant' groups is 100%, while the 'downward' group has a hit rate of 75%, suggesting the 'downward' trend to be a more difficult movement to predict. Despite this, the overall predictive results are considerably better than those that would have occurred by chance alone.
Keywords: economic indicator, forecasting, multi-variate analysis, tender price index, trend.

2000, **18**(7), 853–862

UK construction skills shortage response strategies and an analysis of industry perceptions

S MacKenzie, A R Kilpatrick and A Akintoye
Department of Building and Surveying, Glasgow Caledonian University, City Campus, Cowcaddens Road, Glasgow G4 0BA, UK

The construction industry is heavily dependent on the adequate supply of a skilled labour force, and as a result the skilled labour shortage in the UK has received considerable attention in recent years. With the current economic recovery the industry is expected to experience considerable skills shortages in both traditional and new skills areas. This paper analyses the views of construction employers in relation to the response strategies promoted by industry and government and identified in previous research which tackle elements of the skills shortage problem within the UK construction industry. The paper describes seven existing industry and government schemes, and a further nine alternative response strategies to the construction skills shortage. The survey analysis demonstrates that construction employers support: (i) the Construction Skills Certification Scheme, (ii) the Investors in People standard, (iii) economic stability within the industry; (iv) long term industry-wide training plans, (v) a return to direct employment; and (vi) the development of new technologies and construction techniques. It is concluded that the effectiveness of alternative response strategies is linked to the traditional approach of most contractors.
Keywords: labour shortage, skill.

2000, **18**(7), 863–871

Evaluation of enhanced design and build system - a case study of a hospital project

Albert P C Chan
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

This study involves an investigation of a hospital project which adopted an 'enhanced design and build' form of building procurement. The paper assesses the procurement system from the perspectives of the client, client's consultants, contractor, contractor's consultants, and contractor's sub-contractors. A detailed case study of North District Hospital is described to illustrate the process of this procurement system. All the interviewees generally agreed that the hospital project was successful in meeting the time, cost, quality, functional and safety requirements set by the client. As the first project adopting the 'enhanced design-build' procurement system in Hong Kong, the benefits of applying this innovative procurement system were demonstrated.
Keywords: enhanced design build, hospital, procurement system.

2000, **18**(8), 885-892

Knowledge infrastructure for sustainable building in The Netherlands

Chiel Boonstra[1] and Marjo Knapen[2]
[1]*DHV Accommodation and Real Estate, PO Box 1427, 3800 BK Amersfoort, The Netherlands*
[2]*W/E Consultants Sustainable Building, PO Box 733, Gouda, The Netherlands*

The article describes the development and expected future direction of knowledge infrastructure pertaining to sustainable building in The Netherlands with particular reference to two computer programs based on lifecycle analyses: Eco-Quantum Residential and Eco-Quantum Research. The first is a tool for architects to identify the environmental consequences of different options, while Eco-Quantum Research allows for in-depth analyses and therefore can be used

for developing innovative designs. The programs were made commercially available in November 1999 after testing by practitioners and municipalities in The Netherlands. An example of the design of an office building guided by Eco-Quantum is also given.
Keywords: building code, construction products, demolition, dismantling, environmental material performance.

2000, **18**(8), 893-902

Construction law and environmental harm: the liability interface

Anthony P Lavers and David E Shiers
Centre for Real Estate Management, School of Architecture, Oxford Brookes University, Gipsy Lane, Headington OX3 0PB, UK

Construction professionals are increasingly exposed to risk deriving from legal responsibility for environmental harm. To assess the levels of exposure to this risk, those involved in property need to understand the impact of environmental issues upon construction law. Construction law literature and specialist environmental law sources on construction can provide a basis for study. The main themes found in these sources are planning law, environmental protection, waste and waste management and contamination, including water pollution, and these are reviewed. A study of the litigation reported in the principal specialist construction law sources reinforces the significance of these themes through the identification of the case law embodying them. There are other areas of impact and potential impact: visual/aesthetic harm, harm to acoustic amenity, the use and removal of deleterious materials (such as asbestos) and other 'indirect' risks.
Keywords: construction law, environment, environmental harm, liability.

2000, **18**(8), 903-916

Construction ecology and metabolism: natural system analogues for a sustainable built environment

Charles J Kibert, Jan Sendzimir and Brad Guy
Center for Construction and Environment, University of Florida, PO Box 115703, Gainesville, FL 32511-5703, USA

Applying the principles of sustainability to human activities ultimately must result in the scrutiny of all sectors of economic activity to assess the changes required to provide for a high quality of life for future generations. A high priority for evaluation, in the light of its impacts on environmental quality and resources, is industrial activity in general and the construction industry specifically. The construction sector consumes 40% of all extracted materials in the USA, and accounts for 30% of national energy consumption for its operation. The sustainability of this industrial sector is dependent on a fundamental shift in the way resources are used, from non-renewables to renewables, from high levels of waste to high levels of reuse and recycling, and from products based on lowest first cost to those based on life-cycle costs and full cost accounting, especially as applied to waste and emissions from the industrial processes that support construction activity. The emerging field of industrial ecology provides some insights into sustainability in the built environment or sustainable construction. Construction, like other industries, would benefit from observing the metabolic behaviour of natural systems where sustainability is built in. This paper describes a view of the construction industry based on natural systems and industrial ecology for the purpose of beginning the discovery of how to shift the construction industry and its supporting materials industries onto a path much closer to the ideals of sustainability.
Keywords: construction ecology, construction metabolism, design , industrial ecology, industrial metabolism, resource efficiency, sustainability.

2000, **18**(8), 917-925

Building education for the next industrial revolution: teaching and learning environmental literacy for the building professions

Peter Graham
Department of Building and Construction Economics, Royal Melbourne Institute of Technology, GPO Box 2476V, Melbourne, Victoria 3000, Australia

Resource efficient design and construction, i.e. doing more with less, contributes to decreasing the negative environmental implications of resource consumption. However, the environmental effects of buildings arise from the combination of many design and management decisions, and good environmental design and construction can avoid more than just the damage that flows from resource use. It is therefore important that students of building professions learn how the many decisions they make can help create ecology sustaining buildings, and this awareness begins in the classroom. This paper proposes a model for teaching and learning environmental literacy for tertiary students of building professions. It also argues that, in comparison with a well recognized theory for language learning, some of the conditions required for learning environmental literacy may not be present in Australian tertiary institutions. This work was commissioned for the Australian Council of Building Design Professions for the Environment Design Guide and funded by EcoRecycle Victoria.
Keywords: profession, environmental literacy, learning, resource awareness, resource efficiency, sustainability, teaching.

2000, **18**(8), 927-934

Environmentally sustainable development: a life-cycle costing approach for a commercial office building in Melbourne, Australia

Lu Aye,[1] Nick Bamford,[2] Bill Charters[3] and Jon Robinson[2]
[1]*Department of Civil and Environmental Engineering, The University of Melbourne, Parkville, Victoria 3052, Australia*
[2]*Faculty of Architecture Building and Planning, The University of Melbourne, Parkville, Victoria 3052, Australia*
[3]*Department of Mechanical and Manufacturing Engineering, The University of Melbourne, Parkville, Victoria 3052, Australia*

A range of property and construction options is analysed using standard life-cycle costing methodology. The options are to renovate the existing building, buy an alternative building and renovate, and buy a development site and construct a new building. The do-nothing option and a hypothetical option to construct a new building on an ideal site are analysed as benchmarks. The results show that the optimum option is to buy a suitable site and construct a new building and that the least sustainable option, in the case study, is to stay in the existing property and renovate the building. Although staying in the existing building and doing nothing carries the lowest financial cost, energy consumption and greenhouse emissions are significantly worse than for the alternative options.
Keywords: accommodation, energy efficiency, greenhouse gas, life cycle analysis.

2000, **18**(8), 935-947

Impact of ISO 14000 on construction enterprises in Singapore

George Ofori, Clive Briffett, Gu Gang and Malik Ranasinghe
School of Building & Real Estate, National University of Singapore, 4 Architecture Drive, Singapore 117566

As construction activity has a significant impact on the environment it is vital to consider how to improve the environmental performance of organizations in the construction industry. The ISO 14000 series of standards on environmental management provides construction enterprises with the tool to address in a structured manner the adverse impacts of their operations and to attain sustainable construction. In this study, a survey was conducted to ascertain the perceptions of construction enterprises in Singapore on the impact of the implementation of ISO 14000 on their operations. Major problems were identified, and recommendations are made for the future development of environmental management systems (EMS) in the Singapore construction industry.
Keywords: construction enterprise, environmental impact, environmental management, ISO 14000, Singapore, sustainable construction.

2000, **18**(8), 949-957

Building environmental assessment methods: assessing construction practices

Raymond J Cole
School of Architecture, University of British Columbia, Vancouver V6T 1Z2, Canada

This paper focuses on the environmental issues associated with the building construction process and the way in which they are currently represented in building environmental assessment methods. The primary goal is to identify the practical and methodological reasons for their scant inclusion and to offer arguments to redress this situation. Despite the difficulties of assessing management practices, their inclusion within building environmental assessment methods is critical from the standpoint of reinforcing the relationship between building design and building operation. Similar arguments relate to the importance of including construction processes. The paper argues that construction issues should be included, organized into consistent categories (e.g. resource use, ecological loadings and health issues) and clearly partitioned within the structure of assessment methods. If there are environmental benefits in engaging a broader range of players earlier in the design process, then this notion can logically be extended to include the contractor.
Keywords: best practice, construction practice, ecological loading, environment, environmental assessment, environmental management, health, resource.

2000, **18**(8), 959–968

Towards a successful voluntary building environmental assessment scheme

C K Chau, W L Lee, F W H Yik and J Burnett
Department of Building Services Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

Voluntary building assessment schemes have emerged worldwide to help assess the environmental performance of buildings. As building environmental assessment is a rapidly evolving field, the scope and details of such assessment schemes are continuously undergoing updating and refinement. Substantial efforts have been devoted to the design and

improvement of the assessment schemes to make them capable of defining an objective building profile. Although most of the existing schemes are voluntary, many fail to encourage participation of the building investors and designers. In order to widen acceptance, the design of the scheme should be oriented towards the manner in which investors make decisions. This paper provides an overview of the vital elements and changes needed, so as to make a voluntary building environmental assessment scheme more attractive and successful, and will include reforms not only in the scope and the credit weighting philosophy but also in its nature.

Keywords: environmental assessment, credit weighting, sustainability.

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ECAM: Volume 1, 1994

1994, **1**(1), 5–16

Project specific partnering

R K Loraine
Applied Project Research Ltd, Ryecroft, Upper Hartfield, East Sussex, TN7 4DN, UK

The scope of this paper covers the development of partnering since 1985. It starts with the early associations that were formed in the petrochemical and process industries between owners and contractors. This period was amply covered by a National Economic Development Office (NEDO) paper (NEDO 1991). Partnering at that stage was principally considered to be a relationship that lasted for a term and not a single contract. However, in the NEDO paper, there was brief mention of two projects being carried out by the US Army Corps of Engineers where the relationship was for individual contracts only. Since then the real growth of partnering in the USA has been on a project by project basis mainly within the public works sector, and this paper argues that this is the type of partnering arrangement that has the greatest potential. The application of partnering to the UK public works sector is affected by the EU public procurement regulations. As partnering on a project specific basis includes an element of price competition, the paper contends that there will be no difficulty in complying with the regulations. Using recent examples of partnering for specific projects in the USA, the paper concludes by making proposals for developing partnering arrangements in the UK public works sector. In the course of this, particular attention is drawn to the key elements of partnering associations in the USA that have contributed largely to their success.
Keywords: continuous improvement, facilitation, quality, safety, workshop.

1994, **1**(1), 17–27

Concession contracts for power generation

A Merna and N J Smith
Project Management Group, UMIST, Manchester, UK

Concession contracts provide a mechanism for transferring the traditional public sector client roles of market research, project appraisal, project financing, operation and maintenance, and revenue generation associated with power station projects to the private sector organizations, formerly only responsible for turnkey design and construction. The recent research work undertaken in the Project Management Group, UMIST, has developed and validated a mechanism for the rapid appraisal of concession contracts. A case study example is presented to illustrate the significant features of the procurement of power projects using concession contracts.
Keywords: BOOT, concession, investment appraisal, power generation, risk management.

1994, **1**(1), 29–50

Evaluating performance potential in the selection of construction contractors

G D Holt, P O Olomolaiye and F C Harris
School of Construction Engineering & Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV1 1SB, UK

A quantitative contractor selection technique which embraces the prequalification, evaluation and final selection processes is being developed. The emphasis is on evaluating contractors' performance potential in terms of their ability to achieve time, cost and quality standards. This approach is in contrast to the majority of current selection techniques which tend to pre-qualify, then discriminate predominantly on the cost component of tenders. The conceptual model is applied to a hypothetical but realistic scenario a contractor competing for a small industrial contract. This illustrates the mechanics of the new technique, emphasizing that contractor selection should include identifying the contractor with the best performance potential and not merely the lowest bidder.
Keywords: contractor performance, contractor selection, decision making, multi-attribute model.

1994, **1**(1), 51–67

Estimator: a prototype of an integrated bid preparation system

T Hegazy[1] and O Moselhi[2]
[1]*Assistant Professor, Centre for Building Studies, Concordia University, Montreal, Canada, and formerly, Res. Asst., Suez Canal Research Centre, Ismailia, Egypt*
[2]*Professor of Construction Engineering and Management, Centre for Building Studies, Concordia University, 1455 De Maisonneuve Blvd, West Montreal, Quebec H3G 1M8, Canada*

Compiling bid proposals for construction projects is a process that depends on extensive computation as well as on experience-based judgement. Despite the proliferation of estimating tools, bid proposals focus primarily on the computational component and leave the more difficult aspects of risk assessment and mark-up estimation to estimators'

judgement. This may lead to unrealistic estimates that do not account for the operational environment of projects. Such estimates often result in either losing bids or inflicting undesirable cost overruns. In an effort to circumvent such drawbacks, this paper presents a structured system for cost estimation and bid preparation. Unlike current tools, the proposed system supports a holistic bid-preparation process, accounting for a number of quantitative as well as qualitative factors that are used in practice for bid preparation. The system incorporates three principal features: (1) Integrated cost and schedule computation, (2) Adequate risk assessment and mark-up estimation, (3) Optimum bid unbalancing and cash flow optimization. The developments made in the integrated system are described along with a PC-based prototype Estimator, developed to automate the process. An example application is presented to illustrate the capabilities and essential features of the prototype and demonstrate its practicality.
Keywords: bid preparation, bidding strategy, computer application, estimating.

1994, **1**(1), 69–84

A facility programming information framework

G M Perkinson[1], V E Sanvido[2] and F Grobler[3]
[1]*Captain, United States Air Force, 341 CES, Malstrom AFB, MT 59402, USA*
[2]*Associate Professor of Architectural Engineering, Penn State, 104 Engineering Unit A, University Park, PA 16802, USA*
[3]*Principal Investigator, USACERL, Champaign, Illinois, USA*

This paper presents a conceptual framework to store, manage and retrieve facility programming information called a Facility Programming Product Model (FPPM). The FPPM represents an 'open' information framework that members of the facility team (owner, planner, designer, constructor and operator) can utilize to satisfy their individual information needs as providers or users of the facility. The FPPM is a systematized approach to creating, organizing, and presenting facility programming information. The framework allows the owner's representative to review the programming product (the programme) for completeness by establishing a structure designed to access programming criteria at varying levels of abstraction, during any phase of the building life cycle. The result is a programme which can be used as a tool to assist decision making and to evaluate objectively performance criteria during the life of a project.
Keywords: architectural programme, framework, planning, product modelling, programme.

1994, **1**(2), 91–101

Pre-contractual investigation and risk aversion

J Bröchner
The Development Fund of the Swedish Construction Industry (SBUF), Nybrokajen 7 6 tr, S 111 48 Stockholm, Sweden

This paper presents an analytical framework for determining efficient levels and durations of pre-contractual investigation. Economic efficiency in the allocation of investigation tasks between client and tenderer is shown to depend on how closely related the technologies of investigation and construction are. Moreover, risk aversion and the interest rate affect the efficient allocation. The framework is also used as a basis for an investment analysis of the balance between client's investigation efforts and expected claims in the future. Finally, the framework is used to show how the optimal length of the investigation period can be derived from the expected cash f low associated with a project over its total life cycle, from inception to demolition. Results indicate the economic potential of tailoring risk sharing in construction procurement, according to the type of construction project and the attitudes to risk among client and contractors.
Keywords: contract, construction process, contract claim, investigation, risk allocation.

1994, **1**(2), 103–114

The evaluation of construction disputes: a risk approach

M P O'Reilly[1] and M J Mawdesley[2]
[1]*Department of Civil and Structural Engineering, University of Sheffield, PO Box 600, Mappin Street, Sheffield, SJ 4DU, UK*
[2]*Department of Civil Engineering, University of Nottingham, University Park, Nottingham, NG7 2RD, UK*

Disputes frequently occur on engineering and construction projects. In this paper it is argued that these disputes need to be evaluated and managed, with proper attention being paid to planning of time and money. Since the way in which dispute management is approached will depend on the perceived self-interest of the parties, it is imperative that disputants have a sensible measure of their self-interest. 'Traditional' probabilistic risk assessment techniques are shown to be of assistance and can be used to compute appropriate dispute management strategies. By way of example, a Monte Carlo simulation of a dispute is performed and discussed.
Keywords: arbitration, dispute, evaluation, risk, simulation, uncertainty.

1994, **1**(2), 115–137

Dealing with unexpected problems-do contracts help? A comparison of the NEC and JCT 80 forms

M Loosemore

Centre for Research in the Built Environment, University of Glamorgan, Pontypridd, Mid-Glamorgan, CF37 1DL, UK

This paper considers the impact that contractual procedures have upon the client's control system's ability to deal with unexpected problems. An analysis is made of the relevant procedures set out in the New Engineering Contract (NEC) and a comparison is made to those set out in the Standard Form of Building Contract 1980 Edition (JCT) 80). The comparative analysis is based upon a model of problem solving which identifies four critical stages in the problem solving process. The objective of the paper is to identify the strengths and weaknesses of JCT 80 and N EC in relation to the stages of this model. The aim of the paper is to make some recommendations which could be incorporated into future contracts to improve problem solving effectiveness. This work is a continuation of a research project which is considering the communication and behavioural aspects of the problem solving process in construction projects.

Keywords: contract, control, problems, risk, uncertainty.

1994, **1**(2), 139–146

Information for the management of the building-materials flow

E R Poortman and H N M Bons

Technische Universiteit Eindhoven, Faculteit Bouwkunde, t.a.v.ir. E.R. Poortman postbus 513, postvak 8, 5600 MB Eindhoven, The Netherlands

This paper deals with the materials flow to the building site and how to make it meet the requirements of right quality, quantity, time and place. It offers a way to systematically map materials flow to the building site and send the right information to the supplier in order to get the right materials to the building site.

Keywords: information flow, logistics, material flow.

ECAM: Volume 2, 1995

1995, **2**(1), 5–16

The current status of environmental management systems in construction

A Griffith
Department of Building and Real Estate, Hong Kong Polytechnic University, Kowloon, Hong Kong

Many organizations within the construction industry are becoming increasingly aware of the growing need for improved environmental performance within the scope of their business activities. Their interests are twofold, first in anticipation of increasingly stringent governmental legislation, both national and international, and second in response to the rising concern demonstrated by the general public for environmental issues. To meet increasing future expectations, a number of organizations within construction have implemented or are considering the development of a formal and structured environmental management system. This paper examines some of the principal issues associated with the development of environmental management systems within construction. Drawing upon a series of interviews with major construction clients, consultants and contracting organizations within the UK, investigation identifies the present level of awareness, raises current concerns and issues and looks at the likely future orientation of environmental management systems within the construction industry.
Keywords: environmental management, organization.

1995, **2**(1), 17–26

Safety: behaviour and culture in construction

W S Dester and D L Blockley
Department of Civil Engineering, University of Bristol, Bristol BS8 1TR, UK

The construction industry has a poor safety record. There is a common perception that this is because it is an inherently dangerous industry. It is suggested that the industry would be better characterized as one with a poor safety culture and that attempts to improve the safety record will not be fully effective until the safety culture is improved. The relationship between unsafe behaviour and safety culture is discussed together with the difficulties of assessing and managing safety culture. Some of the influences on safety culture in construction are described. The initiative to develop an improvement in the safety culture of construction needs to come from within the industry through a genuine commitment to safety.
Keywords: behaviour, culture, health and safety, safety,

1995, **2**(1), 27–44

Design and build: a survey of architects' views

A Akintoye and E Fitzgerald
Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 OBA, UK

Design and build has increased in its use for construction procurement in recent times. However, its performance as a procurement method has been widely criticized by professionals in the construction industry. This paper reports a survey of 40 architects, using a structured questionnaire to investigate the performance of contractor-led design and build in project procurement. Although 20% of architects' private sector workload (and 8% of public sector) is derived from D&B, they perceive this procurement type to involve sacrificing product quality and design innovation. Where clients insist on a choice of D&B, architects generally prefer the use of either novation D&B or develop and construct, rather than 'traditional' D&B.
Keywords: architect, design and build, procurement.

1995, **2**(1), 45–56

Buildability as a design concept for architects: a case study of laboratory buildings

R Hyde
Department of Architecture, University of Queensland, Queensland 4072, Australia

The concept of buildability is an approach to architectural design which relates to the awareness of the designer for the method of construction of the building. It is the taking into consideration of the process of construction to a high degree in the construction of the building. The opposite of this approach could be loosely called an 'artistic' method, where the designer hands a concept drawing to somebody else and says 'build that', with little concern for how the design should be built (definition contributed by James Harrison, Senior Lecturer, Department of Architecture, National University of Singapore). In addition to this design orientation, buildability as viewed by the building industry, is the ease with which the building can be built. Yet these definitions seem to lack precision when placed into operation in the design

environment. To understand the notion of buildability further, a study of concrete construction techniques, pre-cast or in situ, were used to evaluate the extent to which buildability techniques were employed by the designers and the effectiveness of the approaches. The methodology used followed existing approaches to studying buildability but expanded and focused on two case study buildings. In this way, a more holistic picture of the influence of the construction system and its buildability could be gained.

Keywords: architectural design, buildability, laboratory.

1995, **2**(1), 57–76

An evaluation of clients' needs and responsibilities in the construction process

S T Kometa, P O Olomolaiye and F C Harris

University of Wolverhampton, School of Construction Engineering and Technology, Wulfruna Street, Wolverhampton, West Midlands, WI 1SB, UK

The importance of clients' responsibilities in the construction process, as perceived by both clients and consultants, was assessed through a structured questionnaire survey. Using the relative index ranking technique, clients' fundamental needs and responsibilities in the construction process were analysed and ranked. Results indicate that the four most important needs are: functionality of the building, safety of the building, quality of the building, and completion time. The four most important clients' responsibilities identified by clients themselves are: planning/design, project finance, project implementation/management, and project definition/formulation. The four most important clients' responsibilities to project consultants are: project finance, project definition/formulation, planning/design, and project implementation/management. If both consultants and clients understand the fundamental needs of construction clients and if clients themselves are prepared to take an active role in the construction process, the chances of producing more successful projects will improve.

Keywords: client needs, client responsibility, consultant, project management, success.

1995, **2**(2), 83–92

Invited paper: Competitive advantage through alliancing

R Scott

BP Exploration Technology Directorate, 4–5 Longwalk, Stockley Park, Uxbridge, Middlesex, UB11 1BP, UK

Since 1990, BP Exploration Europe has been developing a significant track record in substantially reducing the costs of new oil and gas development projects. This is allowing fields which were once highly marginal to be transformed into attractive 'investment opportunities and has opened up the prospect of a future in the North Sea stretching well into the next century. At the same time safety and quality standards are being maintained or enhanced, and the design and construction contractors, as well as suppliers of materials and equipment, are sharing in the success by attaining enhanced levels of profitability.

A fundamental shift in the nature of the relationships between client and contractors lies at the heart of this transformation - a shift which has seen all parties put aside their previous adversarial approach to each other and, instead, pool their skills, expertise and resources to find creative solutions which allow their individual business goals to be achieved.

Underpinning this are so called 'alliancing' contractual arrangements. These are specifically designed to align the business objectives of client and contractors, to promote efficiency in all activities and at all interfaces, to ensure that risks are shared in a balanced, equitable way and to link rewards firmly and clearly to the outcome of a project as a whole. Alliancing is also affording those companies which participate, the incentive and opportunity to improve their own individual competitiveness to levels which enhance their ability to access the global market. The principles involved can be adapted and applied to any industrial sector to give access to radically improved performance and competitiveness.

Keywords: alliancing, contract, partnering.

1995, **2**(2), 93–104

EDI's role as an enabler for electronic commerce and information integration

C Molad and W E Back

PlantSTEP, Houston, Texas and Constructed Facilities Division, Department of Civil Engineering, Texas A&M University, College Station, Texas 77843-3136, USA

Electronic Data Interchange (EDI) is a form of electronic communication designed to permit trading partners (customers and suppliers), in two or more organizations, to exchange business transaction data in electronic, structured formats. Unique to EDI, the electronic transmission of the transaction information can be processed directly by the applications within the receiving computer systems. The transmission of data in machine readable form eliminates the need for manual intervention in the data entry or data manipulation process. EDI is a tool for the electronic transmission and integration of information inter-organizationally. A growing number of leading edge engineering and construction companies from around the world are implementing EDI applications to improve operational efficiency, enhance information quality, and achieve reductions in processing time of project critical information. EDI facilitates electronic

commerce and is particularly useful in international construction endeavours. This paper provides an overview of EDI, discusses EDI applications in engineering and construction (E & C), outlines the status of international EDI standards development as it relates specifically to the E & C industry, and summarizes corporate benefits commonly attributable to EDI implementation.
Keywords: electronic commerce, electronic data management, information integration, message standards.

1995, **2**(2), 105–120

Examination of the eclectic paradigm as applied to international contracting: with emphasis on the internalization dimension

A R Abdul-Aziz
School of Housing Building and Planning, Universiti Sains Malaysia Minden, 11800 Penang, West Malaysia

Seymour's application of the eclectic paradigm to the international construction industry is examined. As with other theories on multinational enterprise, the paradigm was conceived by Dunning to explain the phenomenon of foreign direct investment in the manufacturing sector. In retaining it to explain international involvement of construction companies, certain conventional economic reasoning was modified. It is the contention of this paper that Seymour's conceptualization is incongruent with the peculiarities of international contracting. Neither does it reflect the extensive debate on the suitability of well-grounded economic thoughts to international services. In the course of preparing this paper, it was found that a few government and international agencies have had to confront the difficulties of applying the existing theoretical framework to the services sector. Refinements are proposed here to make Seymour's theoretical construct more robust as a tool for future research, simply by referring to direct observations and materials which were at his disposal.
Keywords: eclectic paradigm, foreign direct investment, internalization theory, international construction, non-equity foreign involvement, trade.

1995, **2**(2), 121–139

Cost-significant modelling: potential for use in South-East Asia

P S H Poh[1] and R M W Horner[2]
[1]*School of Civil & Structural engineering, Nanyang Technological University, Singapore*
[2]*Department of Civil Engineering, University of Dundee, Dundee, UK*

A rich variety of cost models is used in the world's construction industries. In countries exposed to British practice, the use of traditional bills of quantity is common. Elsewhere, bills of quantity may not be used at all. This paper briefly reviews the nature and purpose of cost models both in the UK and in south-east Asia. It explains how the principle of cost-significance can lead to a simplified method of measurement which is both well-structured and sufficiently accurate-a half-way house between traditional bills and a single lump sum. By way of example, the derivation of a cost-significant model for student hostels in Singapore is presented. Representing no more than a first step, the problems still to be resolved are outlined. Nevertheless, the techniques seem to hold much promise for the future, and others are encouraged to explore where they might most effectively be applied.
Keywords: cost control, cost significance, estimating, method of measurement, Asia, tendering.

1995, **2**(2), 141–162

Trade performance of the UK building materials and components industries

R Flanagan,[1] G Norman[2] and H Worrall[2]
[1]*Department of Construction Management & Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 2AW, UK*
[2]*Department of Economics, University of Edinburgh, William Robertson Building, 50 George Square, Edinburgh, EH8 9FY, UK*

This paper looks at the trade performance of the UK building materials and components industries. In particular it analyses recent trade performance and trends from 1980 to 1993. The recession has caused many UK manufacturers and suppliers of building materials and components to go out of business. Faced with the present slow recovery, the remaining UK companies must consider their competitiveness and ability to meet the growing demands of the domestic and overseas markets. Import penetration has left the construction materials and components industries with small capacity, less able to invest in the research and development necessary to compete effectively in the world market and to provide for increasing demand as growth in the economy picks up. The balance of trade in these goods is likely to worsen with a consequent detrimental effect on the UK balance of payments.
Keywords: building component, building material, export, import, trade performance.

1995, **2**(3), 167–178

Invited paper: improved business results through benchmarking

E W Merrow[1] and W H Croker[2]
[1]*Independent Project Analysis Inc., 1150 Sunset Hills Road, Suite 300, Reston, VA 22090, USA*
[2]*Chevron Research and technology Company, Projects and Engineering Technology, 100 Chevron Way, PO Box 1627, Richmond, CA 94802-0627, USA*

Chevron has successfully used benchmarking to improve the performance of our project management system. For many years, we at Chevron believed that we were managing our capital projects very well and that our performance was probably significantly above average for our industry. This perception was based solely on our internal comparison of projects. We routinely compared each project with the previous one we had done and, if we met the cost, schedule and start-up requirements, we thought we had performed our responsibilities with excellence. Even if we did not meet all the requirements, we attributed the deviations to special causes that were unique to the project circumstances and were not caused by our project management system. But when we analysed these assumptions carefully, we realized that completing a project within the budget and the schedule was not very significant unless we compared our results with our best competitors. Internal comparisons are based solely on how well our system performed compared to targets determined by the same system. A comparison was needed to tell us how our system was performing in relation to the best competitors in the industry.

This revelation, coupled with our desire to contribute to our corporate goal of becoming 'Better than the Best', inspired us to benchmark the performance of our project management system against the best in the industry. In mid-1990 we conducted our first benchmarking studies.

Before we describe Chevron's experience with benchmarking, let us understand whether there is room for improvement in our industry and exactly what is benchmarking. The paper will then cover the results of the Chevron benchmarking, the changes to our project management system, our progress to date, and the requirements to achieve a step change in system performance.

Keywords: benchmarking, project management.

1995, **2**(3), 179–195

The organization of construction research in British universities

P R Lansley[1]; R A C Luck[1] and S Lupton[2]
[1]*Department of Construction Management & Engineering, University of Reading, PO Box 219, Whiteknights, Reading, RG6 2AW, UK*
[2]*The Welsh School of Architecture, Bute Building, King Edward VII Avenue, Cardiff, CF1 3AP, UK*

The paper provides details of the size and scope of construction research carried out in a number of architecture, civil engineering and building related departments in British universities. After considering the level of funding, the type of research projects undertaken and the resulting outputs, especially how these benefit industry, the paper focuses on the careers of academics and researchers and the way in which research is organized at university, departmental and team levels. Finally, the paper suggests that whilst the construction research community in universities has many strengths, there is a danger that in responding to recent opportunities it may overreach itself. The end result may be disappointing for all parties involved. Some of the factors which would contribute to an effective approach to the development of links between universities and industry are discussed.

Keywords: academic performance, culture, research, university.

1995, **2**(3), 197–208

The New Engineering Contract: principles of design and risk allocation

J G Perry
School of Civil Engineering, The University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

The paper begins with a brief history of the New Engineering Contract (NEC) and outlines the response by the NEC Panel to the proposals made in the Latham Report. The main principles adopted for the design of the contract are described and the main procedures which are used to implement the design principles are outlined. Emphasis is given to the way in which the procedures are intended to stimulate good management of contracts. The final section of the paper deals with risk allocation and management in NEC. The way in which the choice of contract strategy influences risk allocation is considered first and this is followed by a discussion of the principles used for the detailed allocation of risks in NEC. Risks which are carried by the employer are described and assessed through a novel procedure in NEC.

Keywords: contract strategy, New Engineering Contract, risk management.

1995, **2**(3), 209–225

Environments of construction

Y Hammarlund
Department of Building Economics and Construction Management, Chalmers University of Technology, S-41296 Gothenburg, Sweden

Development of strategies and long-term decision making play important roles in construction due to the considerable service length of its products. In construction firms long-term decision making is normally accomplished within formal, rational processes. A considerable trust is thereby paid to public macro-economic forecasts. A different way of handling strategy formation and long-term decision making is to treat them as emergent phenomena in which organizational learning plays a key role. Effective learning requires a deep understanding of the nature of the environment of the organization. This paper presents the nature of development of construction in Sweden during this century. The presentation constitutes the basis of the 'general environment' model of construction. This model is aimed to facilitate the understanding of environmental aspects of construction.

Keywords: construction development, development, institutional change, strategy, Sweden.

1995, **2**(3), 227–238

A GIS-based pipeline planning system

S M Fenis,[1] J E Diekmann[2] and Pei-Yu Huang[3]
[1]*Assistant Professor, Institute for Public Administration, P. 0. Box205,Riyadh 11141, Saudi Arabia*
[2]*Professor, Department of Civil, Environmental and Architectural Engineering, University of Colorado-Boulder, Boulder, CO 80309, USA*
[3]*Taiwan Auto Design Go., Taipei, Taiwan*

This paper describes a research and development effort on a GIS-based pipeline planning system (GIS-based PPS). Research was first conducted to identify the aspects of pipeline planning and pipeline network design that could benefit from a computer assisted approach, and the recent advancements in information technology. This paper describes a cohesive computer environment that integrates the hydraulic analysis and geographic information processing with a graphic user interface (GUI), in order to improve the effectiveness of pipeline design functions. An interactive system prototype was implemented and is currently being applied in real-world pipeline network planning and design for municipal and industrial water conveyance.

Keywords: computer-aided design, engineering decision support, GIS, hydraulic analysis, pipeline design, spatial decision support.

1995, **2**(4), 249–269

Pioneering the NEC system of documents

A Baird
Corporate Consultant, Eskom, P. 0. Box 95, Sunninghill, 215 7, South Africa

This paper explains why Eskom a large electrical utility, has decided to adopt the New Engineering Contract system of documents and assist the owners of the NEC with its further development. It describes the effect this decision is having on Eskom's culture', the benefits the introduction is providing through the opportunity to retrain all its contract practitioners and the response from South African industry. Types of project to which NEC has been applied are discussed. Examples of problems and successes with the introduction phase are given, with particular reference to the settlement of disputes. The paper concludes with a reference to the South African Government's Procurement Reform Initiative which is seeking standardization of conditions of contract used throughout the Republic.

Keywords: contract conditions, corporate culture, New Engineering Contract.

1995, **2**(4), 271–285

Experiences of the use of the New Engineering Contract

J C Broome and J G Perry
Project and Construction Management Group, School of Civil Engineering, The University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

This paper examines the early experiences of the use of the New Engineering Contract (NEC) based on research at the University of Birmingham. It starts with a brief description of the research methodology before giving an overview of the extent of use of NEC, both in the UK and overseas, and the choices of contract strategy options which have been made. The third and main part of the paper concerns the experiences of the contract in use. The impact of the NEC on contract preparation is assessed followed by a review of the effectiveness of the new contract procedures and their implications. The changes in the roles and staffing that are required in the NEC are then considered and this leads to a discussion of the changes in culture and attitude which are stimulated by NEC. An emphasis has been put on the practical issues which a new user of the NEC will need to consider. Before concluding, the paper briefly presents the findings on whether the NEC is achieving its aims of improved clarity.

Keywords: contract conditions, contract administration, New Engineering Contract.

1995, **2**(4), 287–305

The NEC and the culture of the industry: some early findings regarding possible sources of resistance to change

J D Rooke and D E Seymour
School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT UK

This paper describes some current research into the impact of the New Engineering Contract (NEC) on the culture of the industry. The intention is to explain the purpose of this research, describe the methodology used and report on some early findings. In the early sections, the authors outline the thinking behind the research and some of the difficulties involved and briefly consider the limitations of a conventional approach and compare it with an outline of the authors' own. They then look at the analysis of data, with reference to some findings of this and a previous study. In doing so, the authors focus on some cultural patterns which may be resistant to the changes the NEC is intended to promote and they go on to discuss some of the ways in which culture is transmitted between individuals, since, if the NEC is to be successful, it will involve changes in these patterns. In the final section, the authors discuss some implications for the future of the NEC.

Keywords: change, culture, methodology, New Engineering Contract, occupation.

1995, **2**(4), 307–315

Use of the New Engineering Contract in Hong Kong

J Halliday
The Royal Hong Kong Jockey Club, 1 Sports Road, Hong Kong

The introduction of the New Engineering Contract (NEC) in the United Kingdom came at a time when the Royal Hong Kong Jockey Club were embarking on major contract works. This new contract provided the type of simple, flexible document ideal for our organization, which seeks to enter into co-operative joint ventures with contractors. This, however, has not been an example followed by other Employers in Hong Kong and this paper gives the author's views on the reasons for this and the prospects of a change in the future. The paper then summarises presentations by members of the Jockey Club's professional consultants and one of the Contractors at the Hong Kong NEC Conference. The Club's projects are described in detail, however, the timing of the paper in advance of completion of the two major projects prevents a final assessment of the use of NEC in Hong Kong.

Keywords: co-operation, flexibility, New Engineering Contract, non-adversarial, partnership.

1995, **2**(4), 317–326

The adjudicator under NEC 2nd Edition: a new approach to disputes

P N Capper
Masons, 30 Aylesbury Street, London, EC1R 0ER, UK

Disputes under the New Engineering Contract (NEC) 2nd Edition involve a new approach to the role of Adjudicator. Clauses 90-93 have been radically revised. They reflect the recommendations of Latham's Report Constructing the Team, and growing international practice (e.g. the Channel Tunnel Disputes Panel). Also clarified are some questions over the 1st Edition. The independent Adjudicator provides a mandatory third party neutral settlement process. The decision is final and binding, unless and until revised by the eventual tribunal (court or arbitration) after completion of the works, or termination. Legal drafting is achieved in the NEC style of plain English and present tense. Latham's objectives are reminiscent of traditional decisions of an independent Engineer, or of modern short form arbitration; but the new substantive approach is distinguished from both. The Adjudicator's decision determines the parties' rights and obligations. It does not depend on the Project Manager's implementation, but the latter is free to choose in accordance with the decision, e.g. by changing the Works Information as a compensation event. Distinctive of the NEC is the openness of procedure for the Adjudicator, and even-handedness between the parties as to the continuing works while the Adjudicator is acting. The parties, by contract, given the independent Adjudicator jurisdiction to settle by its decision all disputes arising under or in connection with the contract. This is neither expert determination nor arbitration. The Adjudicator is to act fairly, not judicially. Some jurisdictional issues may remain, and are explored. There must be a proper substantive characterization of the new role, according to its true context and the parties' expressed intentions. NEC 2nd edition has clarified and enhanced the definition of the first third-party stage fully to meet Latham's objectives, and to encourage by rapid but effective early resolution of disputes, within the overall NEC philosophy, a substantial reduction in the incidence of disputes.

Keywords: adjudicator, arbitration, dispute, expert, Latham, New Engineering Contract.

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Perspectives on artificial intelligence in the construction industry

T Andersen[1] and A Gaarslev[2]
[1]Associate Professor and [2]Professor, Technical University of Denmark, Department of Construction Management, Lyngby, Denmark

Based on the expectation of artificial intelligence (AI) the authors established in 1988 an umbrella for research in this area in the construction industry, named the Expert Systems Lab. This paper describes 14 research projects produced since then. For each project a short description is given and the stage and value rating given by industry is reported. It will be seen that the projects generally have been rated very attractive by industry. On the other hand, it is also reported that none of the systems have been implemented in real life. This depressing observation is the main motivation for the paper and possible reasons for the lack of implementation are examined. It is concluded that stand-alone systems as normally produced are out of harmony with industry, and main emphasis for AI should on the contrary be focused on problems concerning integration, knowledge and information management.
Keywords: artificial intelligence, expert system, information technology, knowledge management, neural network, simulation.,

1996, **3**(1/2), 15–28

The Maquette, the model and the computer: organizational futures for design and construction

A K Day
School of Architecture and Civil Engineering, University of Bath, Bath, BA 2 7A Y, UK

The introduction and use of computer-aided design (CAD) systems in a number of settings in the UK building industry is discussed with particular reference to the relationship between organizational design and computer implementation. A series of case studies are presented which illustrate that computers are currently having a limited impact on project communications and, in most instances, are supporting existing patterns of fragmentation within the industry. The paper concludes with a speculation about how the industry might be organized to make more appropriate use of new technology.
Keywords: computer-aided design, integration.,

1996, **3**(1/2), 29–46

Buildability assessment and the development of an automated design aid for managing the transfer of construction process knowledge

D Moore
Department of Building Studies, De Montfort University Leicester, The Gateway, Leicester, LE1 9BH, UK

The cause of construction problems is suggested as being the lack of industry cohesion. This can only 1 ‘be addressed successfully by design professionals and construction professionals working more closely together, i.e. considering buildability. Buildability is a problem of managing the transfer of appropriate knowledge about the construction process to the design process worker. It is not solely about the technicalities of the construction process. It is suggested that no buildability strategy which seeks to impose predetermined construction solutions will be readily accepted by design professionals. The development of a design buildability strategy which transfers construction process knowledge in such a manner as to be seen as an adviser on simplification, would not be seen by design professionals as a convergent approach to buildability. Such a strategy would ‘represent just one of a range of strategies to achieving overall project buildability.
Keywords: automated design aid, buildability, knowledge transfer.

1996, **3**(1/2), 69–81

Neural network models for intelligent support of mark-up estimation

Heng Li
Department of Civil Engineering, Monash University, Caulfiled 3145, Australia

Cost estimation is an important decision-making process where many factors are interrelated in a complex manner, thus making it difficult to analyse and model using conventional mathematical methods. Artificial neural networks (ANNs) offer an alternative approach to modelling cost estimation. ANNs are simple mathematical models that self-organize information from training data. This paper explores the use of ANNs in cost estimation. Research issues investigated are twofold. First, this paper compares the performance of ANNs to a regression-based method which leads to a better understanding of the applicability of ANNs. Second, this paper identifies the effect of different configurations of neural

networks on estimating accuracy. Experimental results demonstrate the many advantages and disadvantages of using neural networks in modelling cost estimation.
Keywords: artificial neural network, estimating, training, regression analysis.

1996, **3**(1/2), 83–95

Cost estimating practices in Australian construction

T E Uher
School of Building, (Construction Management and Economics Unit), University of New South Wales, Sydney 2052, Australia

The aim of the paper is to examine attitudes of general contractors operating in the Sydney region to the potential use of probability estimating and databases in cost estimating. A sample of 10 large general contractors with a turnover over $100m was selected for the study, which took place in 1993. Responses of the contractors to a standard questionnaire were obtained using face to face interviews. The research confirmed the popularity of traditional single value estimating and highlighted the lack of use of probability cost estimating by the general contractors surveyed. The limited availability of client-prepared bills of quantity for tendering has neither diminished their popularity among bidding contractors nor increased the use of elemental cost planning. Although databases are generally available, subjective judgements of estimators are of greater value in cost estimating. The conclusion is that a change in the estimating paradigm towards probability cost estimating is unlikely to occur in the near future.
Keywords: bills of quantity, contracting, general contractor, probabilistic estimating.

1996, **3**(1/2), 97–115

Tendering procedures, contractual arrangements and Latham: the contractors' view

G D Holt, P O Olomolaiye and F C Harris
School of Construction, Engineering and Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands, WV1 1SB, UK

The procedural and administrative aspects of UK tendering have remained largely unaltered for decades but this may soon change in light of the recent review of the construction sector, headed by Sir Michael Latham. This paper presents findings of a nationwide survey of UK construction contractors assessing their opinion of the Latham procurement recommendations, along with their opinion of the authors' proposals for alternative selection procedure. Contractor usage/opinion of current tendering methods, tendering documentation and contractual arrangements are also identified. Analysis techniques primarily involve the derivation of contractor preference, agreement and importance indices (Pri. Agi and Imi respectively). Results show that clients are attempting to cut costs by increased use of open tendering coupled with plan and specification tender documentation, but that savings are offset by clients ultimately paying for contractors' costs associated with their achieving contract award for only 1 in 5 bids. Generally, contractors are in tune with the ideals of the Latham review and characteristics pertaining to the HOLT (Highlight Optimum Legitimate Tender) selection technique.
Keywords: contract, contractor selection, Latham, procurement, tendering.

1996, **3**(1/2), 117–131

Pre-construction project partnering: developing the process

J Matthews, A Tyler and A Thorpe
Department of Civil and Building Engineering, Loughborough University of Technology, Loughborough, Leicestershire, LE1 13 TU, UK

The use of subcontracting within the modern construction industry has become commonplace with many main contractors only undertaking the management and co-ordination activities. The reliance on subcontractors has put much stress on the subcontractor - main contractor relationship. As main contractors have realized that the greatest potential for cost saving lies with subcontractors, the prevalence of unfair contract conditions, dutch auctioning and other onerous practices has increased. This paper describes a procurement approach, utilizing limited competition, developed by a top UK main contractors (MC) in order to improve its relationships with subcontractors. The approach, termed semi-project partnering, was implemented on a commercial development. The approach was supported by research which identified: what MC's employees want from subcontractors; what subcontractors want from main contractors; and a study to benchmark MC's performance with that of other main contractors. It was concluded that this approach offers a number of benefits for the client, main contractor, partnering subcontractors and professional consultants. These included an improved team approach; an improved understanding of the project; more compliant subcontractor bids; better/closer relationships; more reliable programming; less confrontation; and lower tendering costs. It was also identified through debriefing subcontractors that subcontractors were quoting 010% lower than normal due to this approach.
Keywords: contractor, pre-construction, semi-project partnering, sub-contracting.

1996, **3**(1/2), 133–145

Effect of different procurement routes on contractors' cash flows

A P Kaka[1] and F Khosrowshahi[2]
[1]*School of Architecture & Building Engineering, University of Liverpool, P0 Box 147, Liverpool, L69 3BX, UK*
[2]*School of Construction Economics & Management, South Bank University, Wandsworth Road, London, SW8 2FZ, UK*

This paper addresses the effect of different procurement methods (traditional, design and build and management contracting) on project cash flow. Historical data relating to the periodic cost of 150 construction projects were collected. Four criteria were identified to classify the projects: type of project, size, company and type of procurement. The effect of these criteria on the S-curves was then examined using ANOVA. Results confirmed that differently procured projects with different sizes produce different patterns. The company and type of project did not significantly affect the shape of the S-curve. Standard S-curves were then modelled for the three aforementioned procurement routes. These curves were used to calculate the relevant cash flows using a computer based cash flow forecasting model. A series of simulation tests were conducted to evaluate the extent of variation in cash flow, given different contract conditions. Results revealed that, in some cases, the variation in procurement routes has a significant effect on contract cash flows.
Keywords: cash flow, procurement, S-curve.

1996, **3**(1/2), 147–160

Do site managers and the head office perceive productivity factors differently?

S G Naoum and J Hackman
South Bank University, School of Construction, Wandsworth, London, SW8 2FZ, UK

This paper is based on a review of the literature on construction productivity and findings from a survey investigating, first, whether there are significant differences in opinions between head office personnel and site managers on factors that influence construction productivity and, second, to determine groups of factors that mostly influence site productivity. A critical discussion is structured under three general headings: (1) management factors; (2) employee motivation; and (3) experience and training. Twenty nine factors were extracted from the above headings and were assessed by 19 head office personnel and 17 site managers. The survey indicated that both samples regard 'ineffective project planning' and 'constraints on a worker's performance' as the most crucial factors influencing productivity. Other highly ranked factors by both samples are 'difficulties with material procurement', 'lack of integration of project information', 'disruption of site programme', 'lack of experience and training' and 'exclusion of site management from contract meetings'. Ultimately, when the factor analysis technique was applied on the 29 factors, the result shows that Resource Management Effectiveness appeared to be the most dominant group of factors influencing construction productivity.
Keywords: motivation, productivity, resource management, training.

1996, **3**(3), 163–186

Competitive strategy for quantity surveying practices: the importance of information technology

M J Jennings[1] and M Betts[2]
[1]*Davis Langdon & Everest, Boulton House, ChorIton Street, Manchester, M1 3HY, UK*
[2]*Department of Surveying, University of Salford, Salford, M5 4WT, UK*

Strategic planning in pursuit of competitive advantage has become a widespread modern business objective. The construction industry shows some evidence of strategic planning implementation; however such concepts are mainly adopted by large contracting companies that have the resources to identify and develop competitive weapons such as information systems/technology (IS/IT). For professional service firms in construction, the nature of the service, the form of client-customer relations and thus the style of competition are quite different from those followed by contractors. The relevance of competitive strategy and the competitive use of weapons such as IS/IT for professional service firms in construction has not, as yet, been quantifiably tested. Therefore this paper aims to address this imbalance in construction organization research by identifying the competitive strategies used by quantity surveyors based in the U K and assessing the support that IS/IT provides to the competitive strategies of members of this profession. A survey of quantity surveying practices questioned which competitive strategies are followed, how these strategies are implemented and the extent to which IS/IT is being used in each strategy's implementation. The results of this survey, in association with existing competitive strategy and IT literature, are used to derive a new model which proposes specific strategies that U K quantity surveyors can and are using to influence their competitive positioning.
Keywords: competitive strategy, information technology, quantity surveying.

1996, **3**(3), 187–203

Model for assessing building contractors' project performance

Ching Ming Tam[1] and F C Harris[2]
[1]*Department of Building and Construction, City University of Hong Kong, Tat Ghee Avenue, Hong Kong*
[2]*School of Construction, Engineering & Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK*

This study describes the development of operational research models for predicting contractor performance in Hong Kong, using discriminant and multiple regression analysis techniques. An important aim was to determine the underlying factors that influence contractor performance as seen from the client's point of view, and also to develop accurate models to assist clients in vetting contractors for building projects. The resultant models produced six significant variables measuring three dimensions: the inherent characteristics of the project, the contractor's internal attributes and the external influence of the project team. Specifically these were the complexity of the project, working experience of the project leaders, percentage of professionally qualified staff of the contracting firm, past performance of the contractor, origin of the contractor and the level of the architect's or client's supervision and control of the quality of work and work progress.
Keywords: contractor, discriminant analysis, multiple regression , performance assessment, project performance.

1996, **3**(3), 205–217

Review of environmental assessment in UK building construction: current awareness, concerns and issues

A Griffith
School of Construction, Sheffield Hallam University, City Campus, Pond Street, Sheffield, S1 1 WB, UK

Environmental Assessment (EA) or Environmental Impact Assessment (EIA) is the recognized procedure for ensuring that the potential environmental effects of new building or engineering development are considered before planning approval is consented. There is no doubt that all construction projects have a profound effect upon their environs and therefore accurate and reliable environmental assessment is essential. As the concept of environmental assessment perpetuates and experience grows through application, greater attention is being directed towards the evaluation of its effectiveness. This paper focuses specifically on this issue. Drawing upon a series of interviews with respondents from regional planning authorities and local planning department offices, investigation identifies current thoughts, highlights some of the principal concerns and issues that have arisen in early application, and views the likely future orientation of environmental assessment in the UK. The principal intention of this paper is to review current opinion on environment assessment procedures and practice at this time. Many aspects concerning the concept, principles and practices of EA, some of which start to emerge in this paper, remain for future research and investigation.
Keywords: environment, environmental impact.

1996, **3**(3), 219–232

Planned construction times and labour utilization: a comparison of UK and French contractors

D G Proverbs, P O Olomolaiye and F C Harris
School of Construction, Engineering & Technology University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 ISB, UK

The results of a model based survey of contractors' planning engineers in France and the UK suggest that planned completion times for constructing an identical high-rise in situ concrete framed structure are significantly and dramatically lower in France than in the UK. Average planned construction periods in France were 13 weeks, some 9 weeks faster than the UK average of 22 weeks. Since planned construction periods reflect past experience, French contractors apparently achieve superior levels of production performance whilst at the same time working fewer hours per week, utilizing directly employed workers and employing fewer supervisors. If such planned completion times are truly representative, the findings indicate comparatively poor UK contractor performance, and signify future problems for the British builder in the emerging European marketplace. The causes of such poor performance are complicated, but based on indicative French best practices: production is enhanced when scheduled overtime is avoided, a directly employed and mainly skilled workforce is engaged, and a maximum working time of 40 hours per week is the norm rather than the exception.
Keywords: best practice, time, labour, performance, planning, productivity.

1996, **3**(3), 233–248

An intelligent approach to the engineering management of subsidence cases

D Scott and C J Anumba
Construction Research Unit, University of Teesside, Middlesbrough, TS1 3BA, UK

The engineering management of housing subsidence cases is an important field of work for many UK engineers, and remains of enduring interest to householders, insurers and other parties involved in the construction and maintenance of residential buildings. There are often difficulties in the diagnosis and repair of buildings subject to subsidence damage due to several factors, including the complex interaction between the various causative agents, the lack of a systematic investigation procedure, and the large number of available courses of remedial action. In many cases, inaccurate diagnosis of the subsidence problem has resulted in expensive remedial measures which are either unnecessary or inappropriate (and fail to arrest the movement). This paper reviews the management of subsidence cases and describes the development of a knowledge-based system intended to, improve existing procedures by ensuring greater accuracy, consistency and effectiveness of the management regime adopted by engineers. The system addresses three key aspects of the management procedure: initial diagnosis, choice of an appropriate course of investigations, and the specification of effective remedial measures. The benefits of the knowledge-based system are contained in the concluding section of the paper.

Keywords: engineering management, foundation, knowledge-based system, subsidence.

1996, **3**(4), 251–269

Risk interdependencies and natural language computations

E N Wirba, J H M Tah and R Howes
School of Construction, South Bank University, Wandsworth Road, London, SW8 2FZ, UK

Risk analysis has come to be seen as a quantitative process in which risks are measured by the use of probabilities. However, since every new project is essentially unique with no previous data on it, decisions taken as to the nature of the risks are highly subjective and the actions that may be carried out to mitigate the effects of these risks are not clear-cut; a non-numerical approach can, therefore, be more useful. The risk management approach detailed here identifies the risks, checks for dependence amongst risks, and assesses the likelihood of occurrence of each risk by using linguistic variables through the medium of fuzzy sets. The use of linguistic variables is a departure from conventional risk analysis methods that rely rather heavily on statistical analysis to quantify the effects of risks on projects. The entire risk management process is explained, and a case study is carried out to demonstrate the use of the ideas treated. The case study concentrates on the activities of the substructure in a multi-storey building project. The ten largest risks are identified, and dependence among them is assessed through fuzzy set calculations. The assessment of risk dependencies brings about a reduction in the total number of risks analysed, as highly dependent risks are treated together, and the use of linguistic variables brings about a non-numeric approach to risk analysis with which project managers can be comfortable. The risk management process, through the use of fuzzy sets, is better able to handle project management knowledge on risk analysis which is highly subjective, and varies from project to project.

Keywords: decision support, fuzzy sets, linguistic variable, object-orientation, risk dependence, risk management.

1996, **3**(4), 271–288

International contractors and structural changes in host country construction industries: case of Singapore

G Ofori
Construction Economics Research Unit, School of Building and Estate Management, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511

The construction programmes of developing countries have constituted a significant part of the international construction market. However, while international contractors seek to exploit these opportunities, the host nations also wish to develop their construction industries over time. This paper shows how conflicting objectives of international contractors and host countries can be correlated for mutual benefit. It outlines strategies adopted by international construction enterprises and contrasts the approaches they adopt in industrialised countries with those in developing ones. It then compares the objectives of international construction enterprises to those of host countries. It uses Singapore's experience to illustrate likely future developments in the construction industries of emerging countries. Finally, it offers suitable approaches that international and local construction enterprises, and governments, should adopt at various stages of development of host countries' construction industries.

Keywords: corporate strategy, international contractor, structural change.

Engineering, Construction and Architectural Management

1996, **3**(4), 289–306

The pursuit of quality in Hong Kong construction

M M Kumaraswamy

Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong

Construction organizations have responded in different ways to the increasing demands for quality. An interim assessment of the benefits and costs of different approaches is useful in determining future directions for organizations that have already, -or are about to, set up construction quality management systems. Evidence from a series of surveys in Hong Kong indicates that long term strategies are needed, for example targeting 'total quality management' or comprehensive quality management systems, with ISO 9000 certification being only one step along this route. Specific issues to be addressed are identified, such as the development of construction-specific guidelines and the integration of safety and dispute avoidance systems in a comprehensive quality management system. A framework is also proposed to assist in selecting the optimal quality management route for a given construction organization. Lessons learned from Hong Kong and elsewhere can be incorporated in this framework, and will help separate rhetoric from reality in rationalizing the quality management strategies of construction organizations,

Keywords: Hong Kong, ISO 9000, quality system, total quality management.

ECAM: Volume 4, 1997

1997, **4**(1), 3–22

Limitations of the use of tolerances for communicating design requirements to site

D E Seymour, M Shammas-Toma and L Clark
School of Civil Engineering, University of Birmingham, Birmingham, B15 2 TT, UK

The paper reports an empirical study designed to establish the extent to which adequate concrete cover to reinforcement in a sample of structures was achieved. It was found that the standards fell significantly short of those specified. Two kinds of explanation are considered to account for these findings. The first accepts as given the existing divisions of responsibility and conventions for specifying quality and looks to identify the reasons for non-compliance. The second proposes that the present arrangements and conventions are inappropriate to the conditions of variability and uncertainty standardly met with in construction. On the basis of this second set of assumptions, an alternative approach, using the concept of continuous quality improvement, is described and discussed.
Keywords: communication, continuous improvement, co-ordination, lean construction, professionalism, quality, reinforced concrete.

1997, **4**(1), 23–39

Environmental sustainability in the delivery of affordable housing in South Africa

C D Dalgliesh,[1] P A Bowen[2] and R C Hill[1]
[1]Department of Environmental and Geographical Science, and [2]Department of Construction Economics and Management, University of Cape Town, Cape Town, South Africa; currently Visiting Professor to the Department of Building and Surveying, Glasgow Caledonian University, Glasgow, UK

Housing delivery systems have been classified as developmentally-orientated or conventionally-orientated. It has been claimed that a developmental ly-orientated approach to building procurement would encompass the parameters of community empowerment and participation in design, job creation via the development process, and economically and environmentally-sustainable procurement (Taylor & Norval 1995). New building procurement systems display an increasing awareness of sustainability, but concentrate on economic and social sustainability, as opposed to environmental sustainability.

The purpose of this paper is to document and evaluate the extent to which issues of environmental sustainability have been incorporated in the delivery of affordable housing in South Africa. The paper elaborates on a range of relevant principles for sustainable construction, which incorporate: minimization of resource use; maximization of reuse of resources; maximization of use of renewable and recycled resources; use of non-toxic materials; protection of nature; achievement of quality criteria; and promotion of labour intensive methods, skills training and capacity enhancement of local people. The authors examine the extent to which the principles of environmental sustainability have been applied, both in practice and in the formulation of South African housing policy. Finally, recommendations are made for the application of criteria for environmental sustainability in the delivery process of affordable housing in South Africa.
Keywords: delivery, environment, housing, procurement, resource, sustainability.

1997, **4**(1), 41–57

The assessment of applications for the house renovation grant system (HRGS): a multistrategy knowledge-based framework

P S Brandon[1] and F L Ribeiro[2]
[1]*Research and Graduate College, University of Salford, Salford, M5 4WT, UK*
[2]*Instituto Superior Técnico, Departamento de Engenharia Civil, Seco de Estruturas e Constructo, Av. Rovisco Pais 1, 1096 Lisboa Codex, Portugal*

This paper describes a multistrategy knowledge-based framework for supporting human experts in assessing applications for the house renovation grant system (HRGS). This framework integrates different problem solving strategies as set up by the task analysis. The task analysis carried out in the context of the HRGS domain decomposed the overall task into a number of subtasks and problem solving methods for performing each subtask. The framework modularises the knowledge required to solve each subtask into historical cases, objects, procedures and domain models. The framework was implemented as a computer system using Kappa-PC which is a shell designed for implementing knowledge-based systems. The implementation followed the client centred approach (CCA) method. This computer application has been successful in demonstrating that a multistrategy knowledge base can be used to support human experts in assessing applications for the HRGS. Therefore, the application has proved to perform as accurately as human experts do for all of the subtasks set up by the task analysis.

Keywords: case-based reasoning, house renovation grant, knowledge-based system, problem solving, task analysis.

1997, **4**(1), 59–79

Construction management contracts: law and practice

W P Hughes
Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading, RG6 6AW, UK

The context of construction management (CM) reveals that this method of procurement is as much a management philosophy as a contract structure. It is important to consider legal and contractual issues in this context. The interplay between management and law is complex and often misunderstood. Before considering specific issues, the use of contractual remedies in business agreements is discussed. In addition, the extent to which standardizing a form of contract detracts or contributes to the success of projects is also considered. The dearth of judicial decisions, and the lack of a standard form, render it difficult to be specific about legal issues. Therefore, the main discussion of legal issues is centred around a recently completed research project which involved eliciting the views of a cross-section of experienced construction management clients, consultants and trade contractors. These interviews are used as the basis for highlighting some of the most important legal points to consider when setting up CM projects. The interviews revealed that the advantage of CM is the proximity of the client to the trade contractors and the disadvantage is that it depends on a high degree of professionalism and experience; qualities which are unfortunately difficult to find in the UK construction industry.

Keywords: construction management, contract drafting, law, procurement, risk apportionment.

1997, **4**(2), 83–94

Distinctive winning elements in BOT tender

R L K Tiong and J Alum
School of Civil and Structural Engineering, Nanyang Technological University, Nanyang Avenue, Singapore 639798

The Build-Operate-Transfer (BOT) model of development of privatized infrastructure projects is implemented through the award of a concession to a private sector consortium which will finance, build and operate the facility. In a competitive BOT tender, the selection of the successful consortium does not depend on the lowest tolls offered by the tenderer. Rather, it is dependent on the ability of the promoter to provide the most competitive package of distinctive winning elements in its proposal during the final negotiations. The promoter must fully understand the government's needs and concerns and be able to address them through the right package of the winning elements. In this paper, these elements are developed from sub-factors of the critical success factors of technical solution advantage, financial package differentiation and differentiation in guarantees.

Keywords: BOOT, concession, operate, procurement.

1997, **4**(2), 95–111

Conflicts, claims and disputes in construction

M M Kumaraswamy
Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulan Road, Hong Kong

It is necessary and useful to differentiate destructive from constructive conflict and avoidable from necessary claims; and also to minimize disputes arising from unresolved conflict and claims in construction projects. This paper analyses

such needs and proposes means of meeting them through an appropriate classification of construction claims; an estimation of their relative significance in terms of magnitude and frequency; and an identification of the proximate and root causes of the significant claims. A hierarchy of such claims, proximate and root causes is presented, based mainly on data collected from 61 projects and on 46 responses to questionnaires in Hong Kong. Measures of the relative significance of the claims categories are also presented. The results are reinforced by observations from parallel studies in Hong Kong and elsewhere, as well as from the literature. Strategies are suggested to avoid the avoidable and mitigate the unavoidable or unavoided claims, through controlling the controllable causes. Management focus is also recommended on controlling the causes of those categories of claims and disputes that are seen to be significant in terms of higher impact and/or probability of occurrence.
Keywords: claim, conflict, dispute, project management.

1997, **4**(2), 113–125

Recurring themes in value management practice

S J Simister and S D Green
Department of Construction Management & Engineering, The University of Reading, PO Box 219, RG6 6AW, UK

This paper reports on a survey of 17 value management exercises recently carried out within the UK construction industry. Twelve leading value management practitioners were asked to describe an example of a value management study which 'worked well' and one which 'did not work well'. They were further asked to explain the underlying factors which they considered had influenced the eventual outcome of the value management study. The subsequent analysis of the interview transcripts reveals six recurring themes which were held to have had a significant influence: expectations, implementation, participation, power, time constraint and uncertainty. Whilst caution is necessary in extracting the themes from their individual contexts, they do provide a valuable insight into the factors which influence the outcome of value management studies.
Keywords: case study, ideographic interpretation, practitioner, project, value management.

1997, **4**(2), 127–142

Decision making in urban regeneration plans

P Lombardi
DAEST, University of Architecture of Venice, Santa Croce 1957, Ca Tron, 30135 Venice, Italy

Decision making at local planning level is usually concerned with evaluation of alternatives and selection of a preferred action. This can be improved with the use of multicriteria (MCA) methods which provide a systematic process for trading off effects of various alternative, synthesizing, individual contributions. This paper illustrates three MCA methods for evaluating complex planning projects where multiple criteria are taken into account. These methods are applied to an example of urban regeneration. Subjective issues, such as those related to the perception of quality of life, are taken into account alongside more quantitative data. The results obtained using the three methods are considered when applied to three alternative design solutions.
Keywords: decision making, multi-criteria method, planning evaluation, urban regeneration.

1997, **4**(2), 143–158

Latham as half-way house: a relational competence approach to better practice in construction procurement

A Cox[1] and M Townsend[2]
[1]*Centre for Strategic Procurement Management, University of Birmingham, Birmingham Research Park, Vincent Drive, Birningham, Bl5 2SQ, UK*
[2]*Environment Agency, 550 Streetsbrook Road, Solihull, Birmingham, B91 1QT, UK*

This paper is based on research being undertaken by the Centre for Strategic Procurement Management (funded by BAA) considering best practice in construction procurement. The primary aim of the study is to establish how supply chains in construction may be managed more efficiently and effectively. This involves the amalgamation of conventional views on industry problems and initiatives for improvement, the theoretical and empirical consideration of supply chain optimization, the identification of 'best practices' in the procurement process, and the development of suitable change management strategies to allow organizations to move towards better practice.

This paper discusses the that the benefits of a collaborative approach can only be realized by those clients managing 'fit for-purpose' supply relationships to satisfy their regular process requirements. An approach known as relational competence analysis is suggested as a methodology for helping clients to determine what is 'fit for their purpose, limitations behind the current thinking for reforming the UK construction industry, and how Latham's 'team' approach will not succeed where clients adopt a 'traditional' approach to procuring their construction needs. There is a need to differentiate between 'process' and 'commodity' spend in construction. It is argued
Keywords: industry structure, client, Latham, relational competence, supply relationships.

1997, **4**(3), 163–177

The private finance initiative

G Owen and A Merna
Oriel Group Practice, c/o Mrs J Carey, Department of Civil Engineering, UMIST, PO Box 88, Manchester, M60 1QD, UK

This paper outlines the concept of the Private Finance Initiative. It covers some of the basic PFI mechanisms and provides the reader with a general understanding of PFI and the purpose it serves. The paper will look at how the policy has been received specifically within the construction industry and the problems highlighted to date.
Keywords, bidding, financial structure, health care, prison.

1997, **4**(3), 179–193

The barriers to entry into the PFI market

E L Ezulike, J G Perry and K Hawwash
Project and Construction Management Group, School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

This paper reports early results of a study of construction contractors and their experiences of the PFI market. Utilizing material from semi-structured interviews with three categories of construction contractor, small, medium and large, consideration is given to the barriers to entry which contractors face when approaching the PFI market. The paper highlights six barriers of entry: lack of appropriate skills; high participation costs; high project values; high risk; lack of credibility and contacts; and demands on management time. These barriers affect the three categories of construction contractor in different ways. The findings suggest that the larger the contractor, the more able it is to overcome these barriers and to compete in the PFI market. The findings also suggest that certain barriers to entry will decline as the industry matures, whilst others will remain.
Keywords: contractor, private finance initiative.

1997, **4**(3), 195–202

Key legal issues in projects procured under the private finance initiative

H Payne
Oriel Group Practice, c/o Mrs J Carey, Department of Civil Engineering, UMIST, PO Box 88, Manchester, M60 1QD, UK

Over the last few years several projects have been procured under the Private Finance Initiative, which brought with them some challenging, often novel, legal issues. A new statutory framework has been established creating new legal entities and regulating the powers and obligations of those new entities. The public procurement regime of the European Union has had to be carefully considered by both the public and private sector parties as failure by either to adhere to the strict rules and procedures can result in the imposition of sanctions. Attitudes to the way in which contracts are structured have had to change. The public sector had to step back from the more traditional involvement and control it has exercised in the past, and permit the private sector to come up with innovative solutions to the public sector's output requirements. The issues of force majeure and change of law have had to be looked at very closely and mechanisms for the sharing of the risk negotiated between the public and private sectors. A uniform approach to these legal issues would be welcomed along with some standardization of fundamental terms.
Keywords, force majeure, law, procurement, public sector.

1997, **4**(3), 203–214

The potential for adopting the NEC's family of contracts on PFI projects

K Hawwash[1] and M Barnes[2]
[1]*Project and Construction Management Group, School of Civil Engineering, The University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK*
[2]*Cornbrash House, Kirtlington, Oxfordshire, OX5 3HF, UK*

The use of the private sector in the provision of public services under the Private Finance Initiative (PFI) is still a relatively new concept. The structure of a project under the PFI leads to the involvement of a number of parties and this necessitates the formation of a number of different contracts to regulate the relationships. These range in complexity from the main concession contract for the funding, supply, operation and maintenance of the asset, to subcontracts between the concessionaire and the various subcontractors. As the New Engineering Contract (NEC) has been designed to provide a contracting system which stimuates good management and is sufficiently flexible to be used for all the interfaces in a complex project, it is a strong candidate for adoption at all the interfaces in a PFI project. The paper concludes that there is potential for using the different contract forms in the NEC family for a number of the different relationships under a PFI project and more specifically DBFO projects.
Keywords: design build finance operate, New Engineering Contract, private finance initiative, procurement.

1997, **4**(3), 215–231

PFI in the NHS (Private finance initiative in the UK National Health Service)

D Grimsey and R Graham
W.S. Atkins Project Finance, Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW, UK

The National Health Service (NHS) hospitals in Britain are currently in a state of decay following many years of underinvestment in the estate. The NHS urgently requires billions of pounds of investment ranging from total hospital new builds to small refurbishment of existing facilities. The previous Conservative government put forward the Private Finance Initiative (PFI) as the procurement mechanism to address this problem. The new Labour government currently appear to be committing themselves to the same approach. PFI project sponsors have spent upwards of £30m bidding for around 30 major PFI schemes. Despite this, by the time of the UK election in May 1997, not one scheme had reached financial close and many sponsors were expressing their disillusionment with the process. Unlike PFI on other Government infrastructure and service schemes, each PFI hospital is tendered by a separate Trust with their own limited budgets. Many Trusts have demanded schemes without realizing that they cannot afford them and whilst these schemes may work out cheaper than publicly financed hospitals over 30 years or more, charges are higher in the early years. This is primarily due to the market for loans, the conditions attached to these loans in terms of repayment periods and cover ratios, and the requirement of the sponsors to generate a reasonable return on their investment. This paper discusses the major issues and analyses some of the technical financial problems surrounding the PFI in the NHS. The authors draw on practical experience of financial structuring and modelling hospital projects to build a generic model to analyse NHS PFI economics.

Keywords: financial modelling, national health service, private finance initiative.

1997, **4**(3), 233–246

Karachi light rail transit: a private finance proposal

S Faruqi and N J Smith
Construction Management Group, Department of Civil Engineering, University of Leeds, Leeds, UK

Light Rail Transit (LRT) systems have emerged as an attractive form of public transport both in industrialised as well as developing countries. This paper reviews the implementation mechanism of LRT projects proured by private finance, through Build Operate Transfer (BOT) type concession contracts. A case study approach is used to model an actual LRT project. The case study analysis shows that the uncertainty factor could be converted to monetary terms and the process would enhance ability of the decision makers to have a better understanding of the consequences of risks.

Keywords: light rail transit, private finance initiative, risk assessment, transport.

1997, **4**(4), 249–269

The optimum project duration and cost curve for Hong Kong public housing projects

F Khosrowshahi
School of Construction, South Bank University, Wandsworth Road, London, SW8 2FZ, UK

Project duration and cost play a significant role in fulfilling the objectives of both the contractor and the client. This paper builds upon the assumption that, for a given project quality, there exists a relationship between the project duration and the project cost. The behaviour of this relationship is very much influenced by the nature of the project. The paper proposes a general set of potential mathematical expressions for the above relationship and facilitates the identification of the project duration which yields lowest project cost. These are then applied to 'Harmony' type housing projects in Hong Kong. Moreover, while demonstrating the difference between the contractor's optimum cost-time curve and that of the client, the paper suggests that the parties can select one of three options to reach a compromise. To this end, the paper introduces a set of mathematical expressions to represent these compromise-solutions.

Keywords: activity crashing, cost time trade-off, Hong Kong, housing, optimum project cost, time.

1997, **4**(4), 271–293

Expert judgment in forecasting construction project completion

H Al-Tabtabai,[1] N A Kartam[1], I Flood[2] and A P Alex[1]
[1]*Civil Engineering Department, Kuwait University, P. 0. Box 5969, Safat 13060, Kuwait*
[2]*Assistant Professor, Department of Civil Engineering, University of Maryland, College Park, MD 20742, USA*

Construction projects are susceptible to cost and time overruns. Variations from planned schedule and cost estimates can result in huge losses for owners and contractors. In extreme cases, the viability of the project itself is jeopardised as a result of variations from baseline plans. Hence new methods and techniques which assist project managers in forecasting the expected variance in schedule and cost should be developed. This paper proposes a judgement-based forecasting approach which will identify schedule variances from a baseline plan for typical construction projects. The proposed forecasting approach adopts multiple regression techniques and further utilises neural networks to capture the

decision-making procedure of project experts involved in schedule monitoring and prediction. The models developed were applied to a multi-storey building project under construction and were found feasible for use in similar construction projects. The advantages and limitations of these two modelling process for prediction of schedule variance are discussed. The developed models were integrated with existing project management computer systems for the convenient and realistic generation of revised schedules at appropriate junctures during the progress of the project.
Keywords: artificial neural network, expert judgment, project management, regression analysis , schedule variance.

1997, **4**(4), 295-310

Development of constructability concepts, principles and practices

A Griffith[1] and A C Sidwell[2]
[1]*School of Construction, Sheffield Hallam University, City Campus, Pond Street, Sheffield, S1 1WB, UK*
[2]*Construction Industry Institute, Australia, School of Building and Planning, University of South Australia, North Terrace, Adelaide, SA 5000, Australia*

Constructability is 'a system for achieving optimum integration of construction knowledge in the building process and balancing the various project and environmental constraints to achieve maximization of project goals and building performance' (CII Australia 1993). Constructability concepts and principles, considered during conceptual planning, design, procurement, construction and use, can make the total building process easier to manage, quicker and more cost effective. When constructability becomes an implied and accepted aspect of the total building process it has the potential to deliver real benefits to clients, consultants, contractors and users. Constructability practices have developed from application and a considerable body of research conducted over the last thirty years. This paper reviews the development of constructability concepts and the identification of the key principles of constructability, and identifies the likely future developments in constructability research and practice. Historically, the attention given to constructability has been somewhat narrowly focused on individual project stages, and therefore, the multi-dimensional aspects of constructability have not been fully considered and the real benefits may have been missed. The findings presented in this paper indicate that the construction industry has begun to address more purposefully the concerns and difficulties of actively managing the interface between the various stages of the building process in addition to considering the facets of the individual stages themselves. In this way, constructability is becoming an important and powerful concept which can be applied beneficially to the total building process.
Keywords: buildability, constructability, design-construction integration, project management.

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1998, **5**(1), 3–8

Commercial viability of privately financed heating systems in Europe: a case study

C Duffield
The Department of Civil & Environmental Engineering, The University of Melbourne, Parkville, Victoria 3052, Australia

This paper presents a detailed case study of how a European heating contractor analysed the commercial viability of privately financing a critical component of the construction of new apartment heating systems in return for ongoing maintenance contracts. The adaptation of some of the concepts of more complex concession or Build Own Operate and Transfer (BOOT) contract arrangements for use on a small scale project are discussed. Some details of this simple form of privately financed contact are presented. Specifics of the funding mix between construction and fitout costs, capital equipment costs and ongoing maintenance agreements are discussed and related to the market price for energy. The example demonstrates the potential for this type of delivery mechanism for small-scale construction. The constructor maintained a reasonable margin and profit during a period of economic recession, new clientele was developed and business expanded to provide a whole of life service. The developer was able to renovate a facility for a lower capital cost than would otherwise have been possible, and the user gained a state of the art heating system without any increase in heating costs.
Keywords: BOOT, concession, contract, heating, private sector.

1998, **5**(1), 9–21

Risk analysis and management of Private Finance Initiative projects

A Akintoye, C Taylor and E Fitzgerald
Department of Building and Surveying, Glasgow Caledonian University, Glasgow, G4 OBA, UK

The Private Finance Initiative (PFI) is a recent development in the UK in which private sector organizations, design, build, finance and operate assets to deliver a service to public sector clients. The initiative is expected to bring the private sector's finance, management skills and expertise into projects which would normally be undertaken by the public sector. Equivalents of this initiative, also found outside the UK, include DBFO (Design Build Finance Operate), BOO (Build Own Operate) and turnkey projects. Two important considerations for a project to receive an approval for the initiative are that it must represent value for money and there must be sufficient transfer of risk to the private sector. his paper, based on a questionnaire survey, provided the perceptions of clients, contractors and financial institutions on risk associated with PF1 and how these determine their approach to PFI schemes. The analysis shows that design changes and the level of information on functional, performance and output requirements for PFI schemes are of major concern to the parties involved in this procurement route.
Keywords: private finance initiative, procurement, public sector, risk .

1998, **5**(1), 22–30

Aspects of funding for BOOT projects

A Saunders
Babcock & Brown (formerly Chemical Bank) Babcock & Brown Europe Limited, 1 Fleet Place, London, EC4M 7M4, UK

This paper comments on the attitude of Banks to the HM Guidelines, for PFI as well as analysing the cost of finance obtained under the Guidelines and comparing it with finance from other sources. This analysis is extended, by way of example, to the Dalmuir sewage treatment works project, as capital expenditure under EU Directives in Scotland.
Keywords: BOOT , finance, market value, risk, private finance initiative, value for money.

1998, **5**(1), 31–37

GATT, GATS and the global construction industry

A R Abdul-Aziz and A C N Tan
School of Housing Building and Planning, University Sains Malaysia, Minden, 11800 Penang, West Malaysia

On 15 December 1993, the most ambitious trade liberalization package in history was concluded, marking the end of multilateral trade negotiations under the aegis of the General Agreement on Tariffs and Trade (GATT). Among the landmark achievements of that round was the addressing of the services sector for the first time in such a setting. This paper analyses the key provisions of the General Agreement of Trade in Services (GATS) in the context of the construction industry. Despite the fact that GATS is presently a framework which requires further negotiation, there are already certain matters that corporate strategists should be conversant with in preparation for the time when full trade

surveillance is imposed on the industry. Specific reference is also made to the Government Procurement Agreement towards the end of this paper because of its galvanizing force on future GATS negotiations.
Keywords: GATT, GATS, globalization.

1998, **5**(1), 38–50

The implications of the difference in the growth rates of the prices of building resources and outputs in Hong Kong

Chau Kwong Wing
Department of Real Estate and Construction, Faculty of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong

The prices of construction resources (construction cost) have been increasing faster than construction output prices (construction price) in Hong Kong since the mid-1970s, giving rise to a long-term divergence between the two price trends. As the difference has existed for quite a long time, it cannot be adequately explained by a short-term change in supply and demand conditions. The present paper introduces the major indices that reflect the trends of the prices of construction resources and outputs in Hong Kong. It also attempts to explain, from an economic point of view, the major factors which contributed to the divergence between the long-term trends of the prices of construction resources and outputs. One of the conclusions is that, for the past 25 years, the productive efficiency of the Hong Kong building industry has benefited from and been greatly upgraded by imported construction technologies, as well as by a burgeoning quality of human resources. The data and examples quoted in the present paper are sided towards building construction. Therefore, the scope of investigation of this paper, strictly speaking, is confined to the building industry, and does not include the building services and civil engineering sub-sectors. How ever, because of the higher degree of mechanization and faster technological progress in the civil engineering and building services sub-sectors, the present author believes that the results and conclusions should also be applicable to the whole construction industry.
Keywords: Hong Kong, productivity, resource, technology, tender price index.

1998, **5**(1), 51–67

The contribution of the client representative to the creation and maintenance of good project inter-team relationships

D H T Walker
Department of Building and Construction Economics, Royal Melbourne Institute of Technology, Melbourne, Australia, and The University of Glamorgan, Pontypridd, UK

Conclusions flowing from an investigation of the literature together with the results of two recent research .studies suggest that the relationship quality between the client representative (CR), the design team and the team undertaking construction management activities is a major factor governing construction time performance (M). While the managerial performance of the manager of the construction team was found to be a pivotal factor, the interaction between the CR and the construction management team was found to be crucial in facilitating good CTP, i.e. achieving a fast build rate. One interesting and valuable insight gained from the research studies reviewed in the present paper suggests that selection of a CR should be based on the capacity of the CR to gain the confidence of the project team The CR characteristics which are significantly associated with good CTP are also discussed. It is proposed that these provide useful selection guidelines for appointing the appropriate person or team to represent the client's interests within the project coalition.
Keywords: construction time, client representative, project team coalition.

1998, **5**(1), 68–81

Worker motivation on selected construction sites in Bangkok, Thailand

S O Ogunlana and Wei Pien Chang
School of Civil Engineering, Asian Institute of Technology, PO Box 4, Klong Luang 12120, Pathurn Thani, Thailand

Many researchers on construction worker motivation have used the groundbreaking works of Maslow and Herzberg. These two classical theorists were used as the basis for a survey of needs, motivators and demotivators on high-rise building construction sites in Bangkok, Thailand. The needs and felt motivators of construction workers in Bangkok are low on the Maslow hierarchy. The agreement between workers and supervisors regarding needs is strong. However, the agreement on motivators and demotivators is rather weak. This m lead to the use of inappropriate methods for motivating workers. A comparison of the results of the present survey with other studies showed that attempts to motivate workers should take cognisance of the cultural context order to achieve good results.
Keywords: motivation, operative, performance, supervisor.

1998, **5**(1), 82–91

Implementing an integrative approach to project schedule compression

Laufer, A; Shapira, A and Goren, T
National Building Research Institute, Technion-Israel Institute of Technology, Haifa 32000, Israel

The need to provide immediate housing solutions for hundreds of thousands of people in the early 1990's faced the Israeli construction industry with an unprecedented challenge: to multiply overnight its output and drastically cut construction time. It also created a unique opportunity to observe a national-level experiment of great magnitude aimed at meeting that challenge. The present paper reports on a study that examined how construction companies managed to cut housing construction time to half of what had been accepted earlier as a normal pace. This was achieved by implementing an approach that concurrently and integratively treats environment, technology and management determinants, creating a synergetic effect. The present paper introduces and demonstrates the integrative approach to schedule compression, and highlights the role of the environment.
Keywords: construction environment, construction time, project management, housing, schedule

1998, **5**(1), 92–102

The Health and Safety Expert System (HASES): an expert system framework for building inspections

Gowri, K and Depanni, S
Centre for Building Studies and SIRICON Inc., Concordia University, Montreal, Canada 1Currently with Battelle Northwest, Richmond, WA, USA.

In order to ensure the health and safety of occupants, buildings must be inspected to cheek their compliance to current regulatory requirements prompted by occupancy changes, renovations and building code revisions. Recent inspections conducted by Public Works Canada have identified about 1700 occurrences of code violations in 19 buildings. There is an enormous amount of information that can be extracted from the study mentioned above to implement a knowledge-based expert system to assist in future building inspections. The philosophy of this expert system is to integrate both knowledge-based and hypertext representation techniques to enable building inspectors to quickly identify code violations, refer to the code text and provide case study information that can assist in resolving a problem. The present paper describes the development framework and details of a prototype implementation known as the Health and Safety Expert System (HASES). The HASES currently addresses the requirements of 'Section 3.4: Requirements for Exits' of the 1990 National Building Code of Canada. The software architecture consists of an external database of building details, an object hierarchy and a rule-base representing the code requirements, hypertext user-interface for code text and case study information. The ultimate objective is to make this system available for field inspections using notepad computers.
Keywords: building code, building inspection, expert system, knowledge representation.

1998, **5**(2), 107–114

Strategy formation in construction firms

Junnonen, J M
Helsinki University of Technology, Construction Economics and Management, Rakentajanaukio 4, FIN-02150 Espoo, Finland

The aim of the present paper was to examine strategy formation in construction firms. Strategic thinking has become increasingly important because the environment of construction has changed dramatically in recent years. An organizational strategy is the result of a formation process over time and an organization uses strategy when dealing with a changing environment. Therefore, strategies are formed in an iterative process of social interactions involving various activities. The basic unit of analysis strategy must be a distinct business and corporate entity. Corporate strategy should grow out of a deep understanding of how construction firms prosper in individual business areas, i.e. 'the parenting advantage'. Parenting advantage is a criterion for guiding corporate strategy formation. Business strategy is formed by accepted common thinking and on the basis of business strategy in general. Business strategy and competitive advantage is based on the competencies and resources of firms.
Keywords: business strategy, construction firm, corporate strategy, formation.

1998, **5**(2), 115–126

Information technology decision support and business process change in the USA

Hansen, K L[1]; Gann, D M[1] and Groák, S[2]
[1]*Science and Technology Policy Research, University of Sussex, Mantell Building, Brighton, East Sussex, BN1 9RF, UK*
[2]*Ove Arup & Partners, London, UK*

Decision-making and the nature of decisions themselves are changing with the introduction of new information technology (IT)-based systems in the construction industry. The use of IT systems relates to and can induce changes in business processes within firms as well as inter-organizational project processes between firms. In the USA, some of the world's largest hardware and software producers are developing new generations of systems. The market for such systems is potentially large, and these vendors work in close proximity to powerful engineering and construction organizations as well as leading research establishments. It is likely that some of these systems will become de facto standards. For this and other reasons of industrial competitiveness, developments in US IT decision support systems are of interest to practitioners and researchers around the world. The present paper presents the findings of a UK Department of Trade and Industry Expert Mission to assess the development and use of IT systems in the US construction industry. The mission team included seven members, each with specialist knowledge of different aspects of IT development and implementation. The team visited 18 leading organizations where detailed interviews and seminars were conducted during a 2-week period. The present paper highlights questions for researchers and systems developers. The main findings indicate fundamental changes to the timing, sequence and hierarchy of decision making.
Keywords: business process, construction process, decision support, information technology.

1998, **5**(2), 127–136

Opportunities for computer-aided design for construction

Luiten, G T[1] and Fischer, M A[2]
[1]*Department of Civil Engineering, Delft University of Technology Delft, The Netherlands*
[2]*Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA*

Many organizational approaches and technological opportunities are available or under development to improve the integration of design and construction. The opportunities offered by information technology are especially promising. Combining organizational approaches with state-of-the-art technologies in a systematic manner will allow firms to derive the full benefits of computer-aided design for construction. The present paper describes a framework that helps researchers and practitioners approach computer-aided design for construction systematically. The framework identifies six interactions between design and construction. It is based on frameworks for design for manufacture and on an analysis of current building practice. Design for manufacture has proven most effective when integrated into a cyclical product development process. The present framework serves as a road map for the building industry to formalize its information flows, to integrate design for construction into its linear facility delivery process and to approach a more cyclical delivery process.
Keywords: buildability, constructability, design-build, design, integration, project delivery, project management.

1998, **5**(2), 137–143

Industry expectations for engineering graduates

Back, W E[1] and Sanders S R[2]
[1]*Department of Civil Engineering, Texas A&M University, College Station, TX 77843-3136, USA*
[2]*Department of Civil Engineering, 200 Lowry Hall, Clemson University, Clemson, SC 29634-0911, USA*

Engineering employers are discovering that their workforce requires certain skills which seem to be in short supply. Rapid technological change, participative management and employee empowerment, global competition, and other workplace innovations have created a demand for a higher skill level for engineering graduates. Identifying industry expectations for engineering graduates is an important step in developing university curricula that are responsive to the needs of the profession. This study identifies specific industry expectations for new engineering graduates and provides practical recommendations for strategically aligning engineering curricula with the professional community. By identifying specific skills requisite for career success, universities can provide an improved service for their graduates and the engineering industry.
Keywords: education, engineering workforce, USA, professional practice.

1998, **5**(2), 144–149

The need for education in alternative dispute resolution (ADR) in the construction industry

Ezulike, E L and Hoare, D J
School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

The relative merits of alternative dispute resolution (ADR) over conventional methods of dispute resolution, namely litigation and arbitration, is well documented, but as yet, the various ADR procedures currently available are not being extensively utilized within the construction industry in the UK. The purpose of the present paper was to discover from UK experts in dispute resolution why ADR has not become a more frequently used technique for resolving disputes in the UK construction industry, and to suggest ways in which this problem can be overcome. The findings indicate that there is a lack of understanding of the principles behind ADR and a lack of experience in dispute resolution in general. The findings strongly suggest that the lack of understanding and experience in ADR can best be overcome by educating and training. This should be carried out early on in the working lives of professionals by universities, professional institutions and specialist bodies such as the CEDR.
Keywords: alternative dispute resolution, dispute, education, training.

1998, **5**(2), 150–158

Resistance to change: architectural education in a turbulent environment

Hindle, R D and Rwelamila, P D
Department of Construction Economics and Management, University of Cape Town, PO Box 34027, Rhodes Gift 7707, Cape Town, South Africa

For many decades the architectural profession has been accused of resisting change whilst defending an archaic system, and in doing so, neglecting client needs; in turn, this situation has created opportunities which others are now exploiting. Despite this resistance, change has occurred and is continuing in the profession. Several new procurement systems have evolved which pose a threat to the traditional structure and organization of the industry because the architect does not control these. All of this must have repercussions on the way in which architectural students are prepared for the future. Much of the current curriculum content at architecture schools is probably essential, but it is the development of this syllabus in isolation and what is not taught in it that is the problem. The present paper is concerned with those aspects of change which have impacted upon the global construction environment, and describes their potential effect on the architectural profession, and the vocational education and training of its recruits.
Keywords: architecture, change, education, information technology, training.

1998, **5**(2), 159–173

Simulation in concreting operations: a comparison of models and resource combinations

Alkoc, E and Erbatur, F
Department of Civil Engineering, Middle East Technical University, 06531 Ankara, Turkey

Computer simulation in construction planning has been the subject of research for the last few decades. The present paper describes simulation models geared toward improving the productivity of concreting operations. It is primarily concerned with a study of the sensitivity of concreting operations to a set of possible resource combinations. Thirteen models are examined by the two well-known methods of concreting, (1) crane and bucket; and (2) the pump. Concreting into slabs, beams and columns are considered. The simulation software MicroCYCLONE is used for the actual generation of models. Sensitivity parameters considered in resource combinations include the number of truck-mixers, buckets and labourers in concrete placing crews. The simulation models developed are compared and the results are discussed. The results enable planners to realize how the resource quantities and capacities in one cycle affect the ones in another period for cyclic operations like concreting. It can be concluded that the maximum number of resources, the interaction of work crews caused by workspace limitations and the interaction of equipment because of sharing with other activities of the project may bring limitations.
Keywords: concreting, MicroCYCLONE, productivity, simulation.

1998, **5**(2), 174–181

A comparative evaluation of concrete placing productivity rates amongst French, German and UK construction contractors

Proverbs, D G; Holt, G D and Olomolaiye, P O
School of Engineering and the Built Environment, University of Wolverhampton, Wufflwna Street, Wolverhampton, WV1 1SB, UK

The present investigation utilizes a bespoke methodology to analyse and compare the productivity rates of contractors' planning engineers for concrete placing operations amongst three European construction industries, namely Germany, France and the UK. An analysis of variance was used to investigate differences between the productivity rates. Based

on such rates, the analysis shows that German contractors achieve the most efficient levels of labour productivity for this particular operation, whilst amongst the sample surveyed, British contractors are less productive than French and German companies. Although leading British contractors can compete with the best on the continent, the least productive companies in the UK sample were inferior to the least productive in France and Germany. Using national all-in rates for labour, actual (labour) costs for this concrete operation were calculated to be lowest in France despite French wage rates being marginally higher than in the UK. This was because of the superior labour output of French contractors. The apparent lower productivity of British firms sampled in the present research concurs with the findings of two other international studies, indicating that the methodology utilized can provide meaningful and accurate productivity information.

Keywords: concrete, cost, Europe, labour, productivity, site operation.

1998, **5**(2), 182–188

Minimizing waste on construction project sites

Faniran, O O and Caban, G

Faculty of Design, Architecture and Building, University of Technology, Sydney, PO Box 123, Broadway, NSW 2007, Australia

Waste minimization strategies and the relative significance of construction waste sources were examined using a survey of 24 construction firms operating in Australia. The results indicated that a sizeable proportion of respondent firms did not have specific policies for minimizing waste. Furthermore, while a majority of firms with specific waste minimization policies made efforts to minimize waste at source, i.e. to avoid generating waste in the first place, this minimization was limited to waste generated by site offices and amenities. Potential scope exists for improving the effectiveness of waste minimization at source by addressing the sources of all waste generated during the construction phase. The survey results indicated that the five most significant sources of construction waste were design changes, leftover material scraps, wastes from packaging and non-reclaimable consumables, design/detailing errors, and poor weather. Potential opportunities for minimizing the amount of waste generated on construction project sites are identified.

Keywords: Australia, environmental impact, project management, sustainability, waste.

1998, **5**(2), 189–198

Emergency systems in construction contracts

Loosemore, M[1] and Hughes, K[2]

[1]*The School of Building, The University of New South Wales, Sydney, NSW 2052, Australia*

[2]*K H Consultants, 15 The Meadows, Magor, Newport, Gwent, NP6 3LA, UK*

During a construction crisis, traditional contracts are inflexible, restrictive and counter-productive. Consequently, project participants tend to opt out of contract procedures which, in turn, leads to a disjointed organization and a loss of managerial control. To avoid this problem, drafters of traditional construction contracts need to embrace the principles that underlie contemporary crisis management thinking. However, the construction industry culture is likely to represent a barrier to the successful implementation of more managerially astute contracts such as the Engineering and Construction Contract. As an intermediate step, emergency procedures are suggested. These could be easily incorporated into the existing traditional forms of contract, providing temporary flexibility during a crisis, while at the same time, affording an element of managerial control.

Keywords: contract, control, crisis management, emergency, flexibility.

1998, **5**(3), 210–219

Evaluation of quality systems for specialist contractors

Landin, A M and Persson, M H

Department of Construction Management, Lund University, Box 118, S-221 00 Lund, Sweden

Quality systems are being adopted by the Swedish building industry to an increasing degree. The present paper examines two categories of specialist contractors-electrical contractors, and plumbing, heating and ventilation contractors-and the introduction of quality systems in these environments. The companies were assessed in terms of the ISO 9001 standard and the Crosby Quality Management Maturity Grid. The evaluation shows that much has been accomplished in efforts to ensure quality, but that much is yet to be done. Considering the investment in resources, which the introduction of a quality system represented for these firms, it is noteworthy that none of them measured the effects of quality control in a concrete way. A specific instrument, based on ISO 9001 and the Crosby Grid, is seen as applicable. The importance of developing the evaluation of quality systems further is emphasized, an approach which can be used both by suppliers and by customers.

Keywords: evaluation, ISO 9000, management, quality system, specialist contractor.

1998, **5**(3), 220–227

Factors affecting construction quality in Egypt: identification and relative importance

Abidel-Razek, R H

Department of Construction Engineering, Faculty of Engineering, Zagazig University, Zagazig, Egypt, and House of Consultancy, 10 Nehru Street, Heliopolis Cairo, Egypt

The present paper explains the details of a study that was carried out in Egypt. The study involved the participation of 159 construction professionals representing traditional sectors of the construction industry, i.e. clients, consultants, and contractors, in addition to university professors. The Delphi technique was employed to obtain a consensus conclusion on the factors required to improve construction quality in Egypt, together with their relative importance. The respondents generated 16 factors and the relative importance of each factor was determined. For example, the first factor in order of priority was the improvement of the design and planning in the pre-construction stage, with a relative importance of 17%; the third factor was the improvement of the financial level and standard of living of employees, with 9%; and the sixteenth and last factor was the encouragement of innovation for simpler and more accurate work methods, with 2%. The analysis of the results showed that only five factors represented more than 50% of the total weight of all the factors. Improvement in the aspects of work specified in these factors should make it possible to improve construction quality progressively in Egypt.

Keywords: Egypt, improvement, quality.

1998, **5**(3), 228–237

Industry development through creative project packaging and integrated management

Kumaraswamy, M M

Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong

The findings from a set of related investigations into construction mega-project management were integrated into models, frameworks and basic guidelines that would help to improve and integrate (1) work packaging, (2) project participant selection and (3) operational management subsystems. More creative approaches to work packaging and participant selection were seen to significantly support construction industry development and the consequent longer-term benefits in developing countries. A paradigm of 'technology exchange' is proposed as the basis of more viable and mutually beneficial joint ventures that would also facilitate the innovative packaging and integrated management of mega-projects in developing countries. Additionally, it is recommended that hitherto isolated initiatives related to quality, safety or dispute resolution/avoidance should be integrated into synergistic management systems which also incorporate built-in monitoring and evaluation sub-systems. In turn, the latter would trigger both short and long-term remedial measures related to improved project packaging, for example, as well as to personnel training and organizational development programmes.

Keywords: developing country, joint venture, major project, procurement, technology transfer.

1998, **5**(3), 238–251

Site expert: a prototype knowledge-based expert system

Alkoc, E and Erbatur, F

Department of Civil Engineering, Middle East Technical University, 06531 Ankara, Turkey

The present paper reports on the development of SITE EXPERT: a prototype knowledge-based expert system. It is an advisory system. SITE EXPERT is intended to be used for productivity improvement in construction and provides advice on: (1) the productivity of three basic operations of construction, i.e. pouring and placing of concrete, erection and removal of form-work, and fixing reinforcement; and (2) human resources and site layout as productivity factors. The system uses information from construction experts, textbooks, data recorded at construction sites and the engineer's own knowledge, as well as knowledge obtained by running simulation models. In the present paper, the development, operation and evaluation of the prototype system is described. The results of this prototype system development demonstrate that artificial intelligence methodologies provide powerful facilities for capturing information about construction processes and advising the practitioners of construction on productivity improvement within a computer format close to human reasoning.

Keywords: expert system, productivity, knowledge-based system, concrete, site operation.

1998, **5**(3), 252–260

Causes of delay in the construction industry in Lebanon

Mezher, T M and Tawil, W

Faculty of Engineering and Architecture, American University of Beirut, PO Box 11-0236, Beirut, Lebanon

The present paper presents the major causes of delay in the construction industry in Lebanon and the relative importance of these postponements. A survey of a randomly selected sample of 11 owners, 15 contractors and 10

architectural/engineering (NE) firms from Lebanon was undertaken. The survey included 64 causes of delay, grouped into 10 major groups, in which the participants were asked to indicate their level of importance of each delay. The level of importance of the causes and the groups were measured and ranked by the importance index for owners, contractors and A/E firms. It was found that all three parties generally agreed on the ranking of the major categories of delay factors. Owners had more concerns with regard to financial issues, while contractors ranked contractual relationships highest, and finally, A/E firms ranked project management highest.

Keywords: claim, delay, Lebanon, project management, schedule, time.

1998, **5**(3), 261–275

Forecasting residential construction demand in Singapore: a comparative study of the accuracy of time series, regression and artificial neural network techniques

Goh Bee Hua

School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260

It is widely believed that the construction industry is more volatile than other sectors of the economy. Accurate predictions of the level of aggregate demand for construction are of vital importance to all sectors of this industry (e.g. developers, builders and consultants). Empirical studies have shown that accuracy performance varies according to the type of forecasting technique and the variable to be forecast. Hence, there is a need to gain useful insights into how different techniques perform, in terms of accuracy, in the prediction of demand for construction. In Singapore, the residential sector has often been regarded as one of the most important owing to its large percentage share in the total value of construction contracts awarded per year. In view of this, there is an increasing need to objectively identify a forecasting technique which can produce accurate demand forecasts for this vital sector of the economy. The three techniques examined in the present study are the univariate Box-Jenkins approach, the multiple loglinear regression and artificial neural networks. A comparison of the accuracy of the demand models developed shows that the artificial neural network model performs best overall. The univariate Box-Jenkins model is the next best, while the multiple loglinear regression model is the least accurate. Relative measures of forecasting accuracy dealing with percentage errors are used to compare the forecasting accuracy of the three different techniques.

Keywords: accuracy, artificial neural network, Box-Jenkins, demand, forecasting, regression analysis.

1998, **5**(3), 276–284

Mergers and acquisitions: the impact on information systems and information technology

Carrillo, P M

Department of Civil and Building Engineering, Loughborough University, Ashby Road, Loughborough, Leicestershire, LE1 13TU, UK

Recently, there have been significant corporate changes within the major contracting organizations in the UK. Mergers and acquisitions are creating large, pan-European contractors. Such changes have a fundamental impact on the way these contractors operate. The reasons behind the increased mergers and acquisitions activities, and how these corporate changes affect information systems and information technology (IS/IT) are examined. The present paper illustrates these IS/IT changes using the acquisition of two British contractors as case studies. The results show that issues such as leadership, communications and culture have a significant impact on how organizational changes are implemented.

Keywords: acquisition, information system, information technology, rationalization, strategy.

1998, **5**(3), 285–293

The methodological challenges posed by the confrontational nature of the construction industry

Loosemore, M

School of Building, University of New South Wales, Sydney 2052, Australia

The confrontational nature of the construction industry is as much a threat to effective research as it is to effective construction management. In methodological terms, it presents particular challenges of emotion, sensitivity, tension, stress, pressure and uncertainty, which a researcher has to address. This paper discusses the methodological challenges of conducting research within a confrontational environment and presents a model of solutions developed to meet these problems. This model will be of value to all researchers involved within construction projects, but particularly those interested in construction conflict.

Keywords: confrontation, conflict, emotion, research methodology, uncertainty.

1998, **5**(3), 294–303

Linear scheduling: past research efforts and future directions

Mattila, K G[1] and Abraham, D M[2]
[1]*Department of Civil and Environmental Engineering, Michigan Technological University, 112 Dillman Hall, 1400 Townsend Drive, Houghton, MI 49931-1295, USA*
[2]*School of Civil Engineering, Purdue University, 1294 Civil Engineering Building, West Lafayette, IN 47907-1294, USA*

Since the early 1960s, there have been different techniques to schedule linear projects, but for the most part, these have been overshadowed by the critical path method (CPM). Recently, there has been renewed interest in linear scheduling and in adapting some of the CPM techniques to linear scheduling. This necessitates a review of the research in the area of linear scheduling. The present paper provides an overview of linear scheduling, discusses the different approaches that have been used and expresses new avenues for research in the area of resource levelling of linear schedules.
Keywords: construction planning, linear scheduling, line of balance, resource levelling.

1998, **5**(3), 304–311

Promoting the health of construction workers

Uher, T E[1] and Ritchie, J[2]
[1]*School of Building and* [2]*School of Medical Education and Centre for Public Health, University of New South Wales, Sydney, New South Wales 2052, Australia*

The attitudes of management and site personnel of general contractors and subcontractors on the issue of health promotion in the workplace are ascertained. The main focus was on fitness and nutrition programmes, and the existence of a relationship between the health of employees and their productivity. The data were collected using questionnaires from a sample of eight large general contractors and 14 subcontractors operating in the Sydney region of the Australian construction industry. The responses in the sample were received from eight occupational health and safety (OHS) managers and 34 site workers employed by general contractors, and 14 site workers employed by subcontractors. The attitudes of the respondents toward health promotion in the workplace were found to be highly positive, and supportive of the development and implementation of health promotion programmes. In the opinion of the respondents, job performance' and productivity may be increased through health promotion programmes in the workplace.
Keywords: fitness, health, nutrition, productivity.

1998, **5**(4), 315–326

Social network analysis: using a quantitative tool within an interpretative context to explore the management of construction crises

Loosemore, M
School of Building, University of New South Wales, Sydney, NSW 2052, Australia

There is growing dissatisfaction with the static, reductionist, socially insensitive and unimaginative methods used in construction management research. The present paper challenges the emerging view that methods are strictly associated with philosophies, and in particular, that quantitative methods are at odds with interpretative aspirations. It does so by providing a practical example of social network analysis, a quantitative method that is sympathetic to these aspirations. The example is set within a crisis management context, and illustrates the dangers of using qualitative or quantitative methods in isolation. The present paper concludes by questioning the association of quantitative methods with causality and the production of universal models, and argues that both quantitative and qualitative methods have a role to play in understanding the complexity of people's changing social roles, positions and behaviours within construction organizations.
Keywords: behaviour, communication, crisis management, graph, methodology, social network.

1998, **5**(4), 327–338

An application of case-based reasoning to the planning of highway bridge construction

Tah, J H M; Carr, V and Howes, R
Project Systems Engineering Research Unit, School of Construction, South Bank University, Wandsworth Road, London SW8 2YZ, UK

Previous approaches to decision support for project planning using rule-based expert systems techniques have failed to make an impact in practice. This is primarily because of the complexity and large-scale nature of construction information, and problems with expert systems including knowledge acquisition; rule-based knowledge representation; information storage (or memory); learning; and robustness. Case-based reasoning is one area of current research that may hold the key to overcoming a number of these problems. In the present paper, previous related case-based reasoning work is examined. The key factors that influence the formulation of construction project plans are identified. This knowledge is used to develop a conceptual framework within which previous planning experiences can be captured

and reused in new situations as a means of providing system decision support in construction planning and control. A prototype system, CBRidge, developed to test and demonstrate the concepts within the framework is presented. The results are very encouraging and provide a sound basis for the further development of case-based reasoning for construction planning in practice.

Keywords: bridge, case-based reasoning, control, planning, decision support, knowledge-based system.

1998, **5**(4), 339–349

Risk and risk management in construction: a review and future directions for research

Edwards, P J[1] and Bowen, P A[2]

[1]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology University, Melbourne, Victoria, Australia*

[2]*Department of Construction Economics and Management, University of Cape Town, Cape Town, South Africa*

The literature on construction and project risk management published during the period from 1960 to 1997 is reviewed and analysed to identify trends and foci in research and practice. This analysis is used to identity gaps and inconsistencies in the knowledge and treatment of construction and project risk. The findings suggested that political, economic, financial and cultural categories of construction risk deserve greater research attention, as do those associated with quality assurance, and occupational health and safety. Temporal aspects of risk, and risk communication, are also important fields for investigation.

Keywords: procurement, communication, risk management, project management, soft systems research.

1998, **5**(4), 350–358

A comparative evaluation of reinforcement fixing productivity rates amongst French, German and UK construction contractors

Proverbs, D G; Holt, G D and Olomolaiye, P O

Built Environment Research Unit, University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB, UK

A contrast of site productivity levels for an in situ concrete operation (reinforcement fixing) on a high-rise project amongst construction contractors from Germany, France and the U K is given. The productivity rates provided by contractors' planning engineers for a model construction project form the basis of this evaluation. Conclusions drawn, based on relatively small samples, are considered approximations of the actual productivity levels in each international location. An analysis of variance based on international origin indicates significant differences between these productivity rates. Generally, amongst the sample surveyed, UK and German contractors exhibit the most efficient levels of labour productivity for the operations observed, whilst French contractors are by far the least productive. For the model building, U K contractors are the most productive, requiring less labour input than those from Germany and France. The UK contractors also demonstrate a high degree of performance variation. Leading on from these analyses, a construction (labour) cost comparison indicates the UK to be the most economic location. A comparison with previous research indicates contrasting findings. It is concluded that the performance ranking of French, German and UK contractors will vary depending upon the construction operations concerned, and therefore, assumptions regarding national contracting industries should not be based on individual operations. Contractors could benefit from developing closer links with their international counterparts since this would facilitate dissemination of European 'best practice'.

Keywords: analysis of variance, European comparison, labour cost, productivity, reinforcement, site operation.

1998, **5**(4), 359–375

Modelling loan acquisition decisions

Lam, K C[1]; Runeson, G[2]; Tam, C M[1] and Lo S M[1]

[1]*Department of Building and Construction, City University of Hong Kong, Hong Kong*

[2]*Faculty of Built Environment, University of New South Wales, Sydney, New South Wales, Australia*

Capital requirement models used in medium-size, private construction firms are explored. The decision-maker of a contracting firm can implement a cash flow forecasting model as an early warning system by using a model to identify likely cash-flow problems in advance of the occurrence of these difficulties. Arrangements for acquiring any needed funds from other sources can then be made to avoid the possibility of financial problems in the corporation. In this research, a model for financial decision-making is developed which, as demonstrated in a case study, provides a method of solving borrowing decision problems. The model includes the ability to evaluate qualitative and fuzzy circumstances. The model also assists in the selection of sources of funding, taking into consideration the capital structure ratio, the period of cash requirements, the borrowing limits and the tax conditions of the firm. The purpose of the model is to provide the decision-maker with a tool kit to analyse financial options.

Keywords: fuzzy sets, finance, loan, optimization, qualitative decisions.

1998, **5**(4), 376–386

The technocratic totalitarianism of construction process improvement: a critical perspective

Green, S D

Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading RG6 6AW, UK

The current research agenda for construction process improvement is heavily influenced by the rhetoric of business process re-engineering (BPR). In contrast to the wider literature on BPR, there is little evidence of critical thought within the construction management research community. A postmodernist interpretation is advocated whereby the reality of management practice is defined by the dominant management discourse. The persuasiveness of BPR rhetoric is analysed with particular reference to the way in which it plays on the insecurity of modern managers. Despite the lip service given to 1 empowerment' and 'teamwork', the dominant theme of the re-engineering movement is that of technocratic totalitarianism. From a critical perspective, it is suggested that BPR is imposed on construction organizations to ensure continued control by the industry's dominant power groups. Whilst industry leaders are fond of calling for 'attitudinal and cultural improvement', the language of the accepted research agenda continually reinforces the industry's dominant culture of 'control and command'. Therefore, current research directions in process improvement perpetuate existing attitudes rather than facilitating cultural change. The concept of lean construction is seen to be the latest manifestation of this phenomenon.

Keywords: business process change, research, corporate improvement, critical theory, lean construction, post-modernism, rhetoric.

1998, **5**(4), 387–398

Evaluating the client briefing problem: an exploratory study

Smith, J M[1] ; Kenley, R[2] and Wyatt R[3]

[1]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*

[2]*Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, Victoria 3052, Australia*

[3]*Department of Geography and Environmental Studies, The University of Melbourne, Melbourne, Victoria 3052, Australia*

Over the past 10 years, client briefing or facility programming of building projects, has received a great deal of attention from researchers and practitioners. Despite these efforts, tangible improvements to client briefing remain elusive. More testing and evaluation still needs to be carried out before we can judge whether or not any progress has been made. The primary aim of this paper is to present the present authors' experience of testing three potential client briefing techniques in a study conducted within the design studio of a university school of architecture and building. The authors also place the client briefing problem into context by first analysing types of problem, the client briefing problem itself, potential problem-solving techniques and the three techniques selected for this trial The current paper presents the results of a survey of student architect opinions about the processes and techniques that were trialled. It was found that more empirical research is needed with these and other techniques in the client briefing environment because no single technique is likely to provide the best solution in every situation. However, whichever technique is adopted, it seems advisable to identify the client's strategic objectives clearly so that the design team can begin its work on a firm foundation. Resistance within the design studio culture towards potential application of analytical techniques is also discussed.

Keywords: client briefing, facility programming, problem solving.

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1998, **5**(4), 399–410

Risk management of Shanghai's privately financed Yan'an Donglu tunnels

Zhang, W R[1]; Wang, S Q[2]; Tiong, R L K[3]; Ting, S K[3] and Ashley, D[4]

[1]*School of Economics and Management, Tong Ji University, Shanghai, China*

[2]*Department of Building and Real Estate, National University of Singapore and formerly School of Civil and Structural Engineering, Nanyang Technological University, Singapore*

[3]*School of Civil and Structural Engineering, Nanyang Technological University, Singapore*

[4]*College of Engineering, Ohio State University, Columbus Ohio, USA*

The build-operate-transfer (BOT) arrangement is becoming one of the prevailing ways for infrastructure development in China to meet the needs of China's future economic growth and development. Despite tremendous opportunities, the undertaking of infrastructure business in China involves many risks and problems, which are mainly caused by China's embryonic legal structure and immature economic market. Further strategies in risk allocation and management are especially important for successful investments in China. Choosing the right path for a BOT project investment is crucial since each project involves different legal rights, different obligations and different risk implications. The present paper describes the structuring and risk allocation, as well as the Government guarantees in a China BOT transport project, the Shanghai Yan'an Donglu Second Tunnel. It is also the first BOT project implemented in Shanghai. The project features and the guarantees provided by the Government are described in the present paper.

Keywords: BOOT, finance, government guarantee, infrastructure, rate of return, risk allocation, tunnel.

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The eLSEwise initiative

Fikry Garas and Ian Hunter
Taylor Woodrow Construction, 6 Amersham Hill Gardens, High Wycombe, HP13 6QP, UK
Taylor Woodrow Construction, 345 RuislipRoad, Southall, UB1 2QX, UK

Recognition of the importance of Large Scale Engineering (LSE) construction in the economics of Europe has resulted in the European Commission supporting the proposal for the eLSEwise project (Esprit 20876). eLSEwise is the European LSE Wide Integration Support Effort, which commenced in 1996 as part of the family of the 'User Reference Group' projects established by the European Commission to define the needs of the business users of ICT within several industrial areas. This paper describes the eLSEwise initiative and the approach adopted in identifying the LSE construction needs and the business processes that come together to allow an LSE project to evolve through the various phases of a project life cycle.
Keywords: communication technology, information technology, large scale engineering.

1999, **6**(1), 7–20

Trends in world markets and the LSE industry

Steven Male and Dragana Mitrovic
Department of Civil Engineering, University of Leeds, Leeds, LS2 9TJ, UK

The Large Scale Engineering (LSE) industry operates in a global market place and during recent years it has been the scene of major political and economic changes resulting in increasing market pressures. The paper outlines findings from Workpackage 1 of the European Union funded Esprit eLSEwise project. The eLSEwise project has an objective of contributing to improving the competitiveness of the European LSE industry. The paper focuses principally on trends in the LSE global industry market place and the challenges facing European LSE contractors in adapting to these changes. The paper outlines the research methodology; world market trends and LSE industry structure; critical success factors and enablers for LSE projects; the forces shaping the LSE industry and the necessary contractors' core competencies and competitive advantages for continued success.
Keywords: core competency, competitive advantage, globalization, international construction, large scale engineering.

1999, **6**(1), 21–29

Emerging clients' needs for large scale engineering projects

Tarek M Hassan, Ron McCaffer and Tony Thorpe
The European Construction Institute, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK

In recent years the Large Scale Engineering (LSE) construction sector in Europe has seen profound change. This is mainly due to increasing competitive pressures from the United States and the Asian-Pacific countries which has led in turn to increased pressures to improve competitiveness, productivity and client satisfaction. Lack of understanding of client's requirements hinders achieving such goals especially with the increasing trends of executing LSE projects in a 'virtual enterprise' environment. Different parties within the construction process need to understand and fulfil client's business and information requirements. Information and Communications Technologies (ICT) vendors and developers also need to understand clients requirements of systems and to align their products to them. This paper reports on findings from a study within the eLSEwise project to identify the emerging clients' business and ICT needs within the LSE construction industry and to identify the changes in clients' relationships with the supply chain and the gaps in ICT provision.
Keywords: business processe, client requirements, eLSEwise, information technology, information exchange, large scale engineering.

1999, **6**(1), 30–37

ICT tools for improving the competitiveness of the LSE industry

M Hannus[1], G T Luiten[2], A S Watson[3], M Deguine[4], G Sauce[5] and T P J Van Rijn[6]
[1]*VTT Building Technology, P.O. Box 1801, FIN-02044 VTT, Finland*
[2]*HBG, Netherlands*
[3]*Leeds University, UK*
[4]*Bouygues, France*
[5]*CSTB, France*
[6]*TNO Building and Construction, Netherlands*

This paper describes an analysis of Product Data and Information Technologies (PDIT) which are available to support processes in Large Scale Engineering (LSE), particularly those which are construction related. Three main areas are addressed: supporting environment; systems and technologies; and application software. On-going and future developments in these areas are considered. The findings from each of the PDIT areas examined are presented, together with their potential opportunities for exploitation within LSE in construction. The perceived barriers to the adoption of such technologies are also addressed. Considerations are given to the most significant emerging technologies within the IT industry and the potential impact these may have on the business needs within LSE. The work was undertaken within the User Reference Project ESPRIT 20876-eLSEwise-European Large Scale Engineering Wide Integration Support Effort.
Keywords: information technology, large scale engineering, product data technology, strategy.

1999, **6**(1), 38–50

Large Scale Engineering project process and user requirements

Dragana Mitrovic[1], Steven Male[1], Ian Hunter[2] and Alastair Watson[1]
[1]*School of Civil Engineering, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, UK*
[2]*Taylor Woodrow Construction Ltd, 345 Ruislip Road, Southall, Middlesex, UB2QX, UK*

This paper presents results from an analysis of Large Scale Engineering (LSE) project process conducted within the ESPRIT 20876 project 'eLSEwise'. The paper describes the LSE project processes, interfaces with business processes, the effects of the changing market place, and current process barriers. In searching how these barriers can be reduced or eliminated, the LSE industry information requirements and Information and Communications Technologies (ICT) requirements were explored.
Keywords: business process, project process, user information, information management, large scale engineering.

1999, **6**(1), 51–62

The eLSEwise vision, development routes and recommendations

Ian Hunter[1], Dragana Mitrovic[2], Tarek M Hassan[3], Angel Gayoso[4] and Fikry Garas[1]
[1]*Taylor Woodrow Construction Ltd, 35 Ruislip Road, Southall, Middlesex, UB1 2QX, UK*
[2]*Leeds University Construction Management Group*
[3]*European Construction Institute*
[4]*Tecnicas Reunidas*

ELSEwise is the acronym of ESPRIT project 20876 which investigated the Information and Communication Technology (ICT) needs of Large Scale Engineering (LSE) construction over the next 10 years. eLSEwise investigated the business needs related to market and client demands for change in the future delivery processes of LSE construction projects and how the constructors perceive their roles changing in response. It also undertook a state-of-the-art review of the existing and emergent technologies. From these investigations eLSEwise then postulated a vision how LSE construction projects may be delivered in the future, fully utilizing the benefits of emergent technology to satisfy the business needs. The project also considered how companies may progress from their present condition towards this future view, leading to basic development strategy. This paper presents the eLSEwise views of such a future. These findings are presented in three parts: the eLSEwise vision, development routes and recommendations.
Keywords: future vision, information technology, large scale engineering.

1999, **6**(1), 63–70

Impact of large scale engineering products and processes on society: the eLSEwise view

Leela Damodaran[1], Jørgen Rubek Hansen[2], Tarek M Hassan[3] and C W Olphert[1]
[1]*HUSAT Research Institute, Loughborough University, Elms Grove, LE11 1RG, UK*
[2]*Rambell, Bridges and Tunnels, Bredevej 2, DK-2830 Virum, Denmark*
[3]*Civil and Building Engineering Department, Loughborough University, Leics, LE11 3TU, UK*

The universal impact of Large Scale Engineering (LSE) projects is in evidence in diverse aspects of the personal and working lives of citizens around the globe. This does not only include the direct impact of the LSE product or facility but also encompasses the effects on society resulting from new ways of working. These new ways of working have

been visualized by the eLSEwise (European Large Scale Engineering Wide Integration Support Effort) project as part of its postulated vision of how LSE construction projects may be delivered in the future, fully utilizing the benefits of emergent information and communication technologies to satisfy the business needs. This paper describes different effects on society resulting from LSE construction products and processes based on the eLSEwise vision and provides recommendations for ensuring that the benefits to society can be achieved.
Keywords: society, eLSEwise, large scale engineering, ORDIT.

1999, **6**(1), 71–77

An approach to infrastructure client projects

Sten Melson[1] and Torben Kronstam[2]
[1]*Department of Administration, Danish National Railway Agency, Soelvgade 40 E1, DK 1349, Copenhagen K, Denmark*
[2]*Infrastructure Management, Danish National Railway Agency, Soelvgade 40 E1, DK 1349, Copenhagen K, Denmark*

Under the EU ESPRIT programme, eLSEwise is a User Reference Project. The objective of eLSEwise is to analyse the Large Scale Engineering (LSE) sector in terms of IT usage and business perspectives. Based on an analysis of the LSE sector today, the trends in the LSE world-wide market, the trends in the IT industry and a future LSE vision are defined. A 'road map' guiding the European LSE industry from where it is today to where the vision sets the goal 10-15 years ahead has been developed. This paper is about the approach adopted by the Danish National Railway Agency (DNRA) in dealing with infrastructure projects. DNRA represents one of the target business areas of eLSEwise: transportation. DNRA is the owner and manager of the Danish national railway infrastructure. Like most European railway companies DNRA is facing major changes, moving from monopoly into a profitable, self-sustained business. At the same time major infrastructure projects are planned and executed, aiming at the creation of a trans-European high speed network, and at the general revitalization of the European railway sector. After a presentation of DNRA's business and technical context and major current projects, the paper discusses the eLSEwise perspective of life-cycle oriented infrastructure management and the integrational aspects related to execution of a major infrastructure project and subsequent facility management. Finally, the paper identifies the major gaps between the current situation and the eLSEwise vision of life-cycle oriented total management of large scale engineering facilities like railway sections.
Keywords: Denmark, eLSEwise, infrastructure, integration, interoperability, large scale engineering, life-cycle, management, railway.

1999, **6**(1), 78–87

Public sector client-private sector project: transferring the state construction administration into private hands

Gottfried Zantke and Barbara Mangels
Building, Traffic and Building Development, Ansgaritostr.2, D 28195 Bremen, Germany

Due to the decreasing public budget, the Bremen state construction and building administration is undergoing serious changes. Efforts made, for more than 10 years to tighten design and construction processes by implementation of information technology have not shown the intended results. It had to be admitted that the construction authorities had not yet structured all data necessary for the whole life cycle of buildings in a way which was suitable for IT use. The IT systems do not fulfil the requirements of continuous data documentation during the life cycle of buildings and construction. Finally, it was realized that the bureaucratic organization of the building authorities will not satisfactorily support efficiency. Those findings were the motives not only for joining the eLSEwise project (Garas and Hunter (1999) Engineering, Construction and Architectural Management) but, even more importantly, for the intended privatization of the construction administration in Bremen and other German States.
Keywords: GIS, Germany, privatization, public sector.

1999, **6**(2), 91–104

Client briefing processes and procurement method selection: a South African study

Paul A Bowen[1], Rob G. Pearl[2] and Peter J Edwards[3]
Department of Construction Economics and Management, University of Cape Town, Private Bag, Rondebosch 7700, Cape Town, South Africa
Department of Property Development and Construction Economics, University of Natal, King George V Avenue, Durban 4001, South Africa
Departmentt of Building and Construction Economics, Royal Melbourne Institute of Technology, GPO Box 2476V, Victoria, Australia

An effective client briefing process and the selection of an appropriate building procurement system both contribute to the attainment of client objectives with respect to time, cost and quality for construction projects. The present paper documents the results of an empirical study into the nature and effectiveness of the project briefing process, and the selection and effectiveness of procurement methods in the attainment of client objectives. A national questionnaire survey was administered to clients, architects, quantity surveyors, engineers, project managers and general contractors

in South Africa. The results show that room for improvement exists in the manner in which project briefing is conducted and the manner in which procurement methods are selected.
Keywords: briefing, construction project, procurement method, South Africa.

1999, **6**(2), 105–111

A research model of project complexity and goal commitment effects on project outcome

Anita M M Liu
Department of Real Estate and Construction, 5th Floor, Knowles Building, The University of Hong Kong, Pokfulam Road, Hong Kong, China

Essentially, performance evaluation is a human behavioural phenomenon involving a cognitive perceptual process. Project performance has two attributes, at least: (1) the individual's expected performance (manifested as assigned goals); and (2) the individual's perceived actual performance. Evaluation comprises the comparison of these two attributes. The present paper develops a research model for project outcome evaluation designed to examine the effects of the two moderators, goal commitment and project complexity, on the perceived project performance of project participants. It is postulated that: (1) there is a positive monotonic relationship between goal difficulty and performance, but that this is moderated by project complexity; (2) difficult goals lead to higher performance, but that this will happen only when the project participant is committed to the goal; and (3) the transferability of critical success factors to enhance/improve the performance of subsequent projects has to be examined and applied in the light of the effects of these two moderators on project performance.
Keywords: goal commitment, project complexity, outcome.

1999, **6**(2), 112–120

Management errors in construction

D Wantanakorn, M J Mawdesley and W H Askew
Department of Civil Engineering, University of Nottingham, Nottingham, NG7 2RD, UK

Errors occur everywhere and research into inaccuracy has become an important area of study. Managers make errors, and the effects include poor safety, reduced quality, increased cost and decreased profit. Despite this, management errors have received almost no study. The present paper contains a review of the definition and causes of human errors, and discusses the applicability of these factors to managers and the effect of time pressure on decision making. The concept of management errors is proposed and a network-based project model is developed. This approach is used to simulate the occurrence of activity-based errors, and to determine the influence of pressure on management and the effects of inaccuracies on the project duration.
Keywords: construction duration, error, management, simulation, time pressure.

1999, **6**(2), 121–132

Using genetic algorithms to solve optimization problems in construction

Hashem Al-Tabtabai and Alex P Alex
Civil Engineering Department, College of Engineering and Petroleum, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait

Genetic algorithm (GA) is a model of machine learning. The algorithm can be used to find sub-optimum, if not optimum, solution(s) to a particular problem. It explores the solution space in an intelligent manner to evolve better solutions. The algorithm does not need any specific programming efforts but requires encoding the solution as strings of parameters. The field of application of genetic algorithms has increased dramatically in the last few years. A large variety of possible GA application tools now exist for non-computer specialists. Complicated problems in a specific optimization domain can be tackled effectively with a very modest knowledge of the theory behind genetic algorithms. This paper reviews the technique briefly and applies it to solve some of the optimization problems addressed in construction management literature. The lessons learned from the application of GA to these problems are discussed. The result of this review is an indication of how the GA can contribute in solving construction-related optimization problems. A summary of general guidelines to develop solutions using this optimization technique concludes the paper.
Keywords: genetic algorithm, optimization.

1999, **6**(2), 133–144

Application of artificial neural network to forecast construction duration of buildings at the pre-design stage

Sdhabhon Bhokha and Stephen O Ogunlana
School of Civil Engineering, Asian Institute of Technology, P.O. Box 4, Khlong Luang, Pathumtham 12120, Thailand

The application of an artificial neural network (ANN) to forecast the construction duration of buildings at the pre-design stage is described in this paper. A three-layered back-propagation (BP) network consisting of 11 input nodes has been constructed. Ten binary input nodes represent basic information on building features (i.e. building function, structural system, foundation, height, exterior finishing, quality of interior decorating, and accessibility to the site), and one real-value input represents functional area. The input nodes are fully connected to one output node through hidden nodes. The network was implemented on a Pentium-150 based microcomputer using a neurocomputer program written in C++. The Generalized Delta Rule (GDR) was used as learning algorithm. One hundred and thirty-six buildings built during the period 1987-95 in the Greater Bangkok area were used for training and testing the network. The determination of the optimum number of hidden nodes, learning rate, and momentum were based on trial-and-error. The best network was found to consist of six hidden nodes, with a learning rate of 0.6, and null momentum. It was trained for 44 700 epochs within 943 s such that the mean squared error (judgement) of training and test samples were reduced to 1.17×10^{-7} and 3.10×10^{-6}, respectively. The network can forecast construction duration at the predesign stage with an average error of 13.6%.

Keywords: artificial neural network, back propagation, duration estimate, generalized delta rule, pre-design stage.

1999, **6**(2), 145–154

Breakwater construction: an effective method for industrial waste utilization

Dulcy M Abraham[1] and M H Joanne Yeh[2]
[1]*School of Civil Engineering, 1284 Civil Engineering Building, Purdue University, West Lafayette, IN 47907-1284, USA*
[2]*Continental Engineering Company, Taipei, Thailand*

The Environmental Protection Bureau of Taiwan established the South Star Project in Kaohsiung, Taiwan, as a solution to two problems facing the city-the urgent need to dispose of industrial wastes and the need to increase land for the city. To embank land from the sea, breakwaters were constructed. The material used to construct breakwaters was a mixture of furnace slag (waste from the steel industry) and fly ash (waste from power plants). After constructing the breakwaters, the 'reclaimed land' was used as a landfill for construction and public waste. In the future, these reclaimed lands will be used for the development of a deepwater port or sea airport. Construction of breakwaters is a very repetitive process, and any improvements made would help contractors reduce the duration of the operation, improve efficiency in the process and thereby reduce costs. This paper discusses the process of breakwater construction and the utilization of industrial wastes for the concrete work on the project. Data collected from the first stage of the South Star Project is used in the modelling, simulation and analysis of the process, in order to examine the interaction between different resources.

Keywords: breakwater, industrial waste, productivity, recycling, resource, simulation.

1999, **6**(2), 155–165

Decision-makers' perceptions in the formulation of pre-qualification criteria

S Thomas Ng[1], Martin Skitmore[2] and Nigel J Smith[3]
[1]*Department of Building, The University of Newcastle, University Drive, Callaghan, NSW 2291, Australia*
[2]*School and of Construction Management and Property, Queensland University of Technology, G.P.O. Box 2434, Brisbane, Q4001, Australia*
[3]*Department of Civil Engineering, University of Leeds, Leeds, LS2 9JT, UK*

Contractor pre-qualification involves the establishment of a standard for measuring and assessing the capabilities of potential tenderers. The required standard is based on a set of pre-qualification criteria (PQC) that is intended to reflect the objectives of the client and the requirements of the project. However, many pre-qualifiers compile a set of PQC according to their own idiosyncratic perceptions of the importance of individual PQC. As a result, sets of PQC, and hence pre-qualification standards, vary between pre-qualifiers. This paper reports on an investigation of the nature of the divergencies of the perceived importance of individual PQC by different groups of pre-qualifiers via a large-scale empirical survey conducted in the UK. The results support the conclusion that there are significant systematic differences between groups of pre-qualifiers, with the individual PQC that contribute most to the differences being the method of procurement, size of project, standard of quality, financial stability, project complexity, claim and contractual dispute and length of time in business.

Keywords: contractor pre-qualification, decision criteria, discriminant analysis.

1999, **6**(2), 166–176

The relationship between construction project management theory and transaction cost economics

Anthony Walker and Chau Kwong Wing
Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong, ROC

The process of managing the design and construction of a project on behalf of a client may be analysed using project management theory based on a contingency approach. The analysis provided by this approach, whilst useful for understanding the interaction of the parts of the system, the functions of project management and the effectiveness of the organization structure, may be limited by not incorporating an economic explanation of how a project organization structure is chosen. The transaction cost approach to the study of economic organization may provide a theoretical basis for such an explanation. This approach holds that an understanding of transaction cost economizing is central to the study of organizations as it determines whether functions are provided by the market or by hierarchy. This paper seeks to explore the relationship between these two powerful approaches in explaining the structuring and management of project organizations on behalf of clients and to explain the benefits of combining these approaches in furthering construction project management theory.
Keywords: client, consultant, contractor, project management theory, systems analysis, transaction cost.

1999, **6**(2), 177–187

Differing site conditions risks: a comparison between FIDIC and the Engineering and Construction Contract

Issaka Ndekugri and Barry McDonnell
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, West Midlands, WV1 1SB, UK

A new edition of the FIDIC Red Book is under discussion. It is an issue whether this edition should be based on the current edition or there should be a complete break with tradition in favour of a contract based on a new philosophy such as that of the NEC, which is reported to be used in many countries in circumstances in which the Red Book would otherwise have been used. This article compares the two contracts in the way they deal with site conditions issues. The comparison is on equity and clarity in risk allocation, adequacy of contractual procedures for dealing with unforeseeable conditions encountered, effectiveness of contractual machinery for dispute resolution, and compliance with reported new developments in successful contractual practices in underground construction. Studies highlighting the recurring frequency of claims for unforeseen ground conditions suggest a need for such particular attention to this aspect of construction. Although a desire for some equity in risk sharing is discernible in both contracts, there is room for improvement in the clarity of both contracts. Each contract has commendable features which are not present in the other. However, a better approach involves a combination of these features with full compliance of the reported modern developments in successful contracting practices.
Keywords: contract, site conditions, dispute, FIDIC, New Engineering Contract.

1999, **6**(2), 188–196

Architectural management: an evolving field

Stephen Emmitt
School of the Built Environment, Faculty of Health and Environment, Leeds Metropolitan University, Brunswick Terrace, Merrion Way, Leeds, LS2 8BU, UK

The term architectural management has been in use since the 1960s and forms an essential part of this journal's title. However, the evolution of the architectural management field has not been a smooth affair, coming into, out of, and then back into fashion; and concise definitions continue to be illusive. Architectural management is a powerful tool that can be applied to the benefit of the professional service firm and the total building process, yet it continues to receive scant attention in the professional journals, seen as little more than a specialist interest. This paper charts the development of the architectural management field and takes a critical look at the field in relation to current research and its applicability to those who stand to gain the most from architectural management, the professional service firms. The paper concludes that architectural management is a cultural issue.
Keywords: architectural management, culture, professional service.

1999, **6**(2), 197–212

Integrated models for construction planning: object flow and relationship

M A Al-Shawi and Z Hassan
Department of Surveying, Salford University, UK

Sharing and exchanging information between project participants are basic requirements for developing construction plans. An isolated construction planning knowledge-based system is no more useful and beneficial than any another ‘island of automation’ unless the integration with other construction applications are addressed. This paper proposes

conceptual data and process models for a construction planning system, CONPLAN (Intelligent CONstruction PLANning), which works within a fully Integrated Construction Environment (ICE). An object oriented methodology (James Martin) has been used to establish generic construction models within which other construction applications can be integrated. This paper also introduces briefly the modularized approach that has been adopted to integrate the various construction applications over the project life cycle.
Keywords: building life cycle, conceptual model, construction planning, data and process model, integrated construction environment.

1999, **6**(3), 213–224

Modelling cost-flow forecasting for water pipeline projects using neural networks

A H Boussabaine, R Thomas and T M S Elhag
School of Architecture and Building Engineering, University of Liverpool, O.O. Box 147, Liverpool, L69 3BX, UK

This paper furthers work that already exists in the use of artificial intelligence techniques to forecast cost flow for construction projects. The paper explains the need for cost-flow forecasting and investigates the methods currently used to perform such a task. It introduces neural networks as an alternative approach to the existing methods. The relationship between the number of nodes used and the accuracy of the neural network in modelling the cost flow is closely examined. From this research an optimal solution is proposed for the case and a prototype system is developed. The results of the investigation of the number of nodes used and testing of the prototype neural network for sample cases are presented and discussed.
Keywords:

1999, **6**(3), 225–234

Risk management trends in the Hong Kong construction industry: a comparison of contractors' and owners' perceptions

Syed M Ahmed, Riaz Ahmad and D Darshi De Saram
Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, Hong Kong, PRC

This paper reports a study carried out to compare the attitudes and perceptions of Hong Kong construction contractors and owners on the importance of various construction risks and also how the risks should be allocated between the parties to the contract. Data were collected by a questionnaire survey on industry professionals representing contractors and owners. Both the owners and the contractors have attached high importance to risk factors such as safety, quality and financial failures. Results also indicate a readiness on the part of the contractors to allocate a greater portion of risks to themselves.
Keywords: Hong Kong, risk management, survey.

1999, **6**(3), 235–255

The need for life-cycle integration of project processes

Ali Jaafari and Kitsana Manivong
Department of Civil Engineering University of Sydney, NSW 2006, Australia

The focus of this paper is on life-cycle objective-based project management systems in general, and SPMIS in particular. SPMIS (short for Smart Project Management Information System), has been designed: (a) to facilitate the employment of life-cycle objective-based project management approaches; and (b) to support concurrent engineering and construction, thus promoting greater integration of the processes under which projects are proposed and implemented. In order to validate the functions designed for SPMIS the authors undertook a detailed case study of a large capital project. The actual project management functions employed by the project team on the case project were researched and charted using the best current PM practices as the guide. While this field research shed light on the actual needs and requirements, the design of the SPMIS functions was approached from first principles in order to incorporate the basic shift from the traditional objectives of cost, time, and quality to life-cycle objective functions, such as return on investment, facility operability, and life-cycle integration. This paper describes the fundamental philosophy and framework for the development of life-cycle objective function-based project management systems in general, and contrasts these with the existing PM methods.
Keywords: capital project, concurrent construction, life cycle analysis, project management, smart project management system.

1999, **6**(3), 256–266

The development of a benchmark model that uses historical data for monitoring the progress of current construction projects

Amar P Kaka
School of Architecture and Building Engineering, University of Liverpool, P.O. Box 147, Liverpool L69 3BX, UK

Conventional methods of project duration control primarily rely on comparing contracts programs with actual progress. Detailed barcharts are often produced and progress is measured and recorded for monitoring by site based practitioners. Head office managers that are responsible for a group or groups of contracts running simultaneously depend on the reports generated on site for their control mechanism. There are many drawbacks in relying solely on site based reports, including concerns about accuracy, misrepresentation of facts, competence of site based staff, time taken to interpret these reports, etc. This paper develops and proposes the use of a new system that can be used as an additional tool whereby significant discrepancies in projects' progress performance can be highlighted. The system is based on stochastic models developed to simulate the cost commitment curves of traditional construction projects. The paper describes how the system is developed and how it can be used. The system has been developed as part of a pilot study to validate its usefulness in principle. Hence the factors used to distinguish projects characteristics were only based on broad terms. It is hoped that an improved model would be developed when more variables are considered and incorporated.

Keywords: benchmarking, cost flow, duration control, expenditure, stochastic modelling.

1999, **6**(3), 267–275

Pre-bid building price forecasting accuracy: price intensity theory

John Gunner and Martin Skitmore
Montville, Queensland, Australia
School of Construction Management and Property, Queensland University of Technology, Gardens Point, Brisbane 4001, Queensland, Australia

A theory of pre-bid building price forecasting accuracy is proposed, based on the heuristic bias framework and with reference to the common practice of basing building price forecasts on the price per square metre of floor area, termed here as Price Intensity (PI). The main prediction of the theory, that high PI contracts will be underestimated and low PI contracts will be overestimated, is tested by a re-analysis of a set of Singapore data and in comparison with previous work.

Keywords: accuracy, judgement bias, price forecasting, price intensity theory.

1999, **6**(3), 276–286

The implications of environmental issues on UK construction management

Christine Pasquire
Department of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU

The paper identifies the broad environmental issues and legislation affecting the construction industry in the UK and goes on to place the environment firmly on the construction agenda, highlighting the major issues for concern. This paper summarizes work undertaken in five pilot studies. The work reveals that the consideration of environmental issues within a framework related to the construction process facilitates the allocation of management responsibility within the construction team. The illustrative representation of this framework forms a prototype decision-making strategy for use in construction procurement and methods for incorporating environmental issues into every day construction management are proposed.

Keywords: contractor, designer, project manager, quantity surveyor.

1999, **6**(3), 287–298

Evaluation of factors affecting time and cost performance in Hong Kong building projects

Sunil M Dissanayaka and Mohan M Kumaraswamy
Department of Civil and Structural Engineering, University of Hong Kong, Pokfulam Road, Hong Kong, China

Time and cost are usually critical to construction clients. Given the many contributory factors, improved quantitative models of time and cost may help clients to predict project outcomes at the outset, and also at different stages of the project life span. These can also help to compare deviations in significant contributory factors, and to suggest corrective actions. Multiple linear regression (MLR) and artificial neural networks (ANN) were applied in developing such quantitative models in a research project based in Hong Kong. A comparative study indicated that ANN had better prediction capabilities than MLR by itself. Significant factors identified through quantitative models developed,

indicated that time over-run levels were mainly governed by non-procurement related factors (e.g. project characteristics and client/client representative characteristics), while cost over-run levels were significantly influenced by both procurement and non-procurement related factors (e.g. project characteristics, client/client representative characteristics and contractual payment modalities). A parallel approach yielded interesting comparisons of the variations of mean time and cost over-runs, when comparing groups of projects using different procurement sub-systems, from the Hong Kong sample.
Keywords: artificial neural network, multiple linear regression, performance, procurement.

1999, **6**(3), 299–314

Design/construction integration: issues and illustrative prototype

Nabil A Kartam
Dept of Civil Engineering, Kuwait University, P O Box 5969, Safat, 13060 Kuwait, Kuwait

The architecture, engineering and construction (AEC) industry is epitomized by a wide range of project business lines, different project scopes, unique client requirements, and a rapidly changing automation technology. This current scenario requires a constant transfer of project data among the various professionals representing different specializations, project phases and interests. The implementation of improved computer techniques such as object-oriented programming and CAD reduces fragmentation and enhances the efficiency of integrating project data through all stages of generation, sharing, maintaining, and updating. This reduced fragmentation will assist in bridging the gaps between and within the project phases, thereby increasing the competitiveness of the AEC industry. This paper presents different issues related to the existing fragmentation in the AEC industry and the challenges and approaches to achieve a meaningful and smooth integration. The paper describes the development of ODCSI-an object-oriented design/construction system for integrating CAD and construction software applications. The system architecture captures design data in an object-oriented project model and acts as an intelligent CAD interface. In the hierarchy of object-oriented classes and subclasses, the design data are inherited; hence all functional, geometrical, structural, construction management, and construction engineering functions are shared across class boundaries. These design data are used as the input to various computer-based construction software applications, hence providing seamless project integration.
Keywords: CAD, design aggregation, object oriented programming, project management.

1999, **6**(3), 315–328

Neural network model for contractors' pre-qualification for local authority projects

Farzad Khosrowshahi
Department of Construction Management, South Bank University, 202 Wandsworth Road, Wandsworth, London, SW8 2JZ, UK

The way in which clients or their consultants undertake to select firms to tender for a given project is a highly complex process and can be very problematic. This is also true for public authorities as, for them, 'compulsory competitive tendering' is a relatively new concept. Despite its importance, contractors' pre-qualification is often based on heuristic techniques combining experience, judgement and intuition of the decision-makers. This, primarily, stems from the fact that pre-qualification is not an exact science. For any project, the right choice of the contractor is one of the most important decisions that the client has to make. Therefore, it is envisaged that the development of an effective decision-support model for contractor pre-qualification can yield significant benefits to the client. By implication, such a model can also be of considerable use to contractors: a model of this nature is an effective marketing tool for contractors to enhance their chances of success to obtain new work. To this end, this work offers a decision-support model that predicts whether or not a contractor should be selected for tendering projects. The focus is on local authorities because, in the absence of a viable universal selection system, there are significant variations in the way they conduct pre-qualification. The model is based on the use of artificial neural networks (ANN) and uses data relating to 42 local authorities (clients). With the aid of a questionnaire and a scaling system, the pre-qualification attributes that are considered to be important by clients are identified. The survey indicates significant variations in the level of importance given to different attributes. Statistical methods are adopted to generate additional data representing disqualified instances. Following a pre-processing exercise, the data form the basis of the input and output layers for training the neural-net model. An independent set of data is subjected to a similar pre-processing for testing the model. Tests reveal that the model has a highly satisfactory predictive accuracy and that the ANN technique is a viable tool for the prediction of success or failure of the contractor to qualify to tender for local authority projects.
Keywords: artificial neural network, decision-support system, local authority, marketing, modelling, pre-qualification, tendering.

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Tracing the African Project Failure Syndrome: the significance of 'ubuntu'

P D Rwelamila[1], A A Talukhaba[2] and A B Ngowi[3]
[1]*Department of Construction Economics and Management, University of Cape Town, Private Bag, Rondebosch 7701, South Africa*
[2]*Department of Building Economics and Management, University of Nairobi, PO Box 30197, Nairobi, Kenya*
[3]*Department of Civil Engineering, University of Botswana, Private Bag 0061, Gaborone, Botswana*

The lack of 'ubuntu' (African group solidarity) between project stakeholders in the Southern Africa Development Community (SADC) public building sector has been surrounded by controversy and strongly held opinions. The work reported in this paper attempts to indicate some salient issues affecting the relationships between project stakeholders. The Botswana public building sector is used as a main case study and follow-up studies are carried out involving another eight SADC countries. The paper addresses two propositions. *First, that the lack of 'ubuntu' between project stakeholders is primarily due to an inappropriate project organizational structure. Second, that a default traditional construction procurement system (TCPS) provides a poor relationship management system.* Information is obtained on the research areas through questionnaires to construction firm executives, contract managers, site managers, trade foremen and skilled tradespersons on the dominant procurement system used in Botswana. Furthermore, senior technical officers of Public Works Ministries of another eight SADC countries are interviewed as a follow-up to the Botswana study. The primary conclusion to be drawn is that the building procurement system purported to be in use in the SADC public building sector differs significantly from that recommended in the theory, resulting in poor relationships between project stakeholders. This is primarily due to the use of inappropriate building procurement systems. In general, the TCPS in the SADC public building sector is used as a 'default system'. This has led to a situation where project management is a 'fire fighting' activity, where group solidarity between project stakeholders is out of reach. Salient steps are proposed with a *proviso* that the SADC public building sector should establish appropriate methods of selecting building procurement systems as a prerequisite in formulating appropriate project organizational structures which will bring the spirit of real co-operation between project stakeholders towards project success.
Keywords: Botswana, Southern Africa, procurement, culture, project management.

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Partnering: incorporating safety management

Jason Matthews[1] and Steve Rowlinson[2]
[1]*Department of Civil Engineering, University of Botswana, Private Bag 0061, Botswana*
[2]*Department of Real Estate and Construction, The University of Hong Kong, Pokfulam Road, Hong Kong*

The philosophy that underpins this paper is that partnering needs the partners to set mutual objectives – these objectives are agreed upon and stipulated within a project charter. Objectives within the charter should be regularly reviewed and performance assessed. The question addressed is – can this mechanism, which has proved successful in a commercial context, assist in applying safety legislation, rules and management systems to a construction project? Also, partnering advocates an open and trusting relationship between all parties – can this 'philosophy' be used to assist the management of site safety? Implementing the partnering concept in the construction project environment provides an opportunity for the continuous improvement of safety performance. This paper addresses partnering as a concept and draws from examples of partnering in the UK and Hong Kong. A number of characteristics of partnering agreements have been identified that can all assist in promoting safety. These characteristics are: continuous evaluation, the project charter, mutual objectives and team building. The context in which partnering in safety can be undertaken is reviewed and a discussion takes place of how the global trend to move away from prescriptive legislation towards performance-based legislation in the regulation of safety provides an ideal opportunity to adopt partnering as a methodology for safety improvement.
Keywords: partnering, site safety, safety management, project charter, accident reduction.

1999, **6**(4), 358–370

Markov decision process for sewer rehabilitation

Reini Wirahadikusumah[1], Dulcy M Abraham[1] and Judy Castello[2]
[1]*School of Civil Engineering, Purdue University, West Lafayette, IN 47907, USA*
[2]*Asset Management Division, Department of Capital Asset Management, City of Indianapolis–Public Works, Project Management Section, 604 North Sherman Drive, Indianapolis, IN 46201, USA*

Finding the optimal solution to address problems in sewer management systems has always challenged asset managers. An understanding of deterioration mechanisms in sewers can help asset managers in developing prediction models for estimating whether or not sewer collapse is likely. The effective use of deterioration prediction models along with the development and use of life cycle cost analysis (LCCA) can contribute to the goals of reducing construction, operation and maintenance costs in sewer systems. When sewer system maintenance/rehabilitation options are viewed as investment alternatives, it is important, and in some cases, imperative, to make decisions based on life cycle costs instead of relying totally on initial construction costs. The objective of this paper is to discuss the application of

deterioration modelling and life cycle cost principles in sewer system management, and to explore the role of the Markov chain model in decision-making regarding sewer rehabilitation. A test case is used to demonstrate the application of the Markov chain decision model for sewer system management. The analysis includes evaluation of this concept using dynamic programming and the policy improvement algorithm.
Keywords: infrastructure, life cycle analysis, Markov chain model, optimization, rehabilitation, sewer deterioration, transition.

1999, **6**(4), 371–379

A survey of CAD and virtual reality within the house building industry

J Whyte, N Bouchlaghem, Antony Thorpe and Ron McCaffer
Department of Civil and Building Engineering, Loughborough University, Leicestershire, LE11 3TU, UK

A survey of computer use in the British house building industry was conducted by means of a postal questionnaire to 100 house builders followed-up by in-depth interviews. The research shows widely variant levels of computer use and expertise in different house building companies amongst both regional developers and the nationwide volume builders. Some housing developers have sophisticated information technology strategies and are well placed to successfully implement advanced techniques whilst many have very little or no computer use for design and visualization and rely more on traditional competitive strategies.
Keywords: CAD, design process, house building, industry survey, information technology, visualization.

1999, **6**(4), 380–390

A new generation software for construction scheduling and management

Asim Karim and Hojjat Adeli
Department of Civil and Environmental Engineering and Geodetic Science, The Ohio State University, 2070 Neil Ave., Columbus, OH 43210, USA

The authors were motivated to overcome some of the limitations and shortcomings of the existing software systems for management of construction projects. The result is a new generation software system for CONstruction Scheduling, Cost Optimization, and Change Order Management, which is called CONSCOM. CONSCOM uses the recently patented Neural Dynamics model of Adeli and Park1 as its computational engine for construction cost optimization and advanced software engineering and object-oriented programming techniques such as *framework* and *pattern*. This paper presents some of its recent and innovative capabilities and features. CONSCOM includes an Integrated Management Environment (IME) as its user interface for the effective control and management of construction projects. An example of a highway construction project is presented to demonstrate the unique modelling capabilities of CONSCOM that cannot be modelled by Critical Path Method (CPM) or CPM-like networks.
Keywords: scheduling, CONSCOM, neural dynamics, software.

1999, **6**(4), 391–402

Determinants of performance of UK universities in Built Environment and Town and Country Planning research

P R Lansley
Department of Construction Management & Engineering, The University of Reading, UK

After providing a brief review of the 1996 Research Assessment Exercise (RAE) of UK universities in the subject areas of Built Environment and Town and Country Planning, four measures are developed to represent the range of activities considered by the exercise. These have simple and strong relationships with the grades awarded to the universities. The findings suggest that the assessment method was broad and robust and that good grades were achieved through quite different activity profiles. Issues are raised about the general level of research activity and the small and static number of international-level departments in the UK.
Keywords: performance evaluation, publication, research assessment, university.

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2000, **7**(1), 3–14

A hybrid knowledge base system and genetic algorithms for equipment selection

Shamil Naoum and Ali Haidar
South Bank University, School of Construction, Wandsworth Road, London SW8 2J2, UK

This paper describes the development of a hybrid knowledge base system and genetic algorithms to select the optimum excavating and haulage equipment in opencast mining. The knowledge base system selects the equipment in broad categories based on the geological, technical and environmental characteristics of the mine. To further identify the make, size and number of each piece of equipment that minimizes the total cost of the operation, the problem is solved using the genetic algorithms mechanism. Results of four case studies are presented to show the validation of the developed system.
Keywords: artificial intelligence, earthwork, equipment, genetic algorithm, knowledge-based system, optimization.

2000, **7**(1), 15–28

Establishing and processing client requirements: a key aspect of concurrent engineering in construction

J M Kamara,[1] C J Anumba[1] and N F O Evbuomwam.[2]
[1]*Department of Civil and Building Engineering, Loughborough University, LE11 3TU, UK*
[2]*Whittman-Hart Inc., 6333 North Highway 161, Suite 100, Irving, Texas 75038, USA*

The realization that concurrent engineering can be adopted in construction has led to various efforts to develop appropriate tools and techniques for its implementation in the industry. This paper discusses the role of client requirements processing in implementing concurrent engineering in construction. Client requirements processing refers to the definition, analysis, and translation of client requirements into solution-neutral specifications for design. It is essential in maintaining focus on the client, and provides for the effective consideration, resolution and prioritization of the various perspectives within the client body. It also facilitates collaborative teamwork, compliance checking at every stage of the design and construction process, and the traceability of design decisions to explicit and implicit client requirements. The paper concludes with a description of a model for processing clients' requirements in construction, and an example of its practical application.
Keywords: client requirements, concurrent engineering.

2000, **7**(1), 29–40

Effect of registration on performance of construction sub-contractors in Singapore

Woon Hong Loh[1] and George Ofori[2]
[1]*Davis Langdon & Seah Singapore Pte Ltd, #05-01 Central Mall, 059567 Singapore*
[2]*School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore*

The construction industries of many countries rely heavily on sub-contracting. As a result, the quality of sub-contractors is important as it has a direct bearing on the performance of the main contractor on projects. A large proportion of construction work in Singapore is sub-contracted. Despite the well-known and widely regretted deficiencies in the traditional sub-contracting system, only recently have attempts been made to reform it. The most significant of these efforts is the Singapore List of Trade Sub-contractors (SLOTS). This study sought to investigate whether or not the performance of sub-contractors has been improved following the introduction of the SLOTS scheme. The research was based on a survey of project managers of main contractors. A major finding was that the SLOTS-registered contractors were perceived to perform better than nonregistered ones. Suggestions for improving the SLOTS scheme are offered in this paper.
Keywords: labour sub-contracting, performance, registration, Singapore.

2000, **7**(1), 41–51

Graphically based LP modelling for linear scheduling analysis: the POLO system

Rong-Yau Huang and Daniel W Halpin

Department of Civil Engineering, National Central University, Chung-li, Taiwan 32054, Republic of China

The traditional network scheduling methods such as the Critical Path Method (CPM), Programme Evaluation Review Technique (PERT), and bar charting are typically not effective for the planning of linear construction projects. Linear scheduling methods, on the other hand, model the progress of repetitive activities in sloping lines and are more effective for linear modelling and analysis. Nonetheless, their use in the construction industry has so far been very limited. Among other reasons for this is the unfamiliarity of construction personnel with these techniques, which plays a major role in hampering their application. This paper introduces a graphically based approach to assist in the linear programming (LP) modelling of linear scheduling analysis. The Planning & Optimization for Linear Operations (POLO) system provides a graphic LP modelling environment in which model formulation can be easily accomplished in a graphic and interactive fashion. Thus, the application of linear scheduling methods can be facilitated. The Isle of Palms Connector Bridge project in Mount Pleasant, South Carolina is used to demonstrate the use of the system.

Keywords: construction operations, linear, modelling, optimization, resource, scheduling.

2000, **7**(1), 52–62

ESTIVATE: a model for calculating excavator productivity and output costs

David J Edwards and Gary D Holt

The Built Environment Research Unit, School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV1 1SB, UK

Hydraulic excavator cycle time and associated unit costs of excavation for given input estimating data, for machines operating in the UK construction industry, are predicted. Using multiple regression analysis, three variables are identified as accurate predictors of cycle time: machine weight, digging depth and machine swing angle. With a coefficient of determination (R^2) of 0.88, a mean percentage error (MPE) of −5.49, and a mean absolute error (MAPE) of 3.67, the cycle time model is robust; this is further validated using chi-square analysis and Pearson's correlation coefficient (on predicted and actual values of machine cycle time). An illustrative example of the model's application to determine machine productivity is given. The paper concludes with a spreadsheet model for calculating excavation costs (m^3 and cost per h) which is able to deal with any combination of the three independent cycle time predictor variables and other estimator's input data.

Keywords: construction plant, estimating, hydraulic excavators, machine cycle time, productivity.

2000, **7**(1), 63–75

A computer environment to support the strategic decision-making process in construction firms

L F Alarcón and A Bastias

Department of Construction Engineering and Management, Escuela de Ingeniería, Universidad Católica de Chile, Casilla 306, Correo 22, Santiago, Chile

A computer environment to support the strategic decision-making process in construction firms is presented. The system implements modelling concepts originally developed to evaluate project execution strategies, extending and generalizing the modelling methodology to a broader range of strategic decisions. An application to a construction firm's strategic planning is used in this paper to illustrate the modelling process. The computer system is designed to help the users in building a conceptual model for the decision problem, this model is a simplified structure of the variables and interactions that influence the decisions being analysed, including internal as well as external factors. An analytical model is then designed to predict the impact of these strategies, integrating expert knowledge and assessments of the strategic planning team into a mathematical model. The mathematical component uses concepts of cross-impact analysis and probabilistic inference to capture uncertainties and interactions among project variables. The system provides multiple analysis capabilities, including sensitivity analysis, selected outcome prediction, isolated or combined effect of strategies and changes in performance due to changes in the external environment. The system allows management to test different combinations of long-term strategies and predict expected sales, market share or other measures of performance.

Keywords: construction firm, decision making, performance modelling.

2000, **7**(1), 76–92

Partnering research in construction

Heng Li,[1] Eddie W L Cheng[1] and Peter E D Love[3]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*

Since the emergence of partnering in the construction industry in the late 1980s, it has received a great deal of attention from practitioners and researchers. The published research that is presented in the major journals typically advocates guidelines and models for implementing partnering. To date, however, no paper has attempted to summarize and present a critique of the existing partnering literature. This paper, therefore, reviews the partnering literature that has been published in four high quality rating journals, these being *Construction Management and Economics*, *ASCE Journal of Construction Engineering and Management*, *Engineering*, *Construction and Architectural Management* and *ASCE Journal of Management in Engineering*. It is concluded that there were four major themes of empirical studies, which were research on project partnering, examining a dual relationship, international partnering and a special application of partnering. Moreover, non-empirical studies were classified as the types of partnering, partnering models, partnering processes and partnering structure. The review provided in this paper 'polishes the signposts' and offers new directions for partnering research and its application in construction. Future studies are recommended to emphasize on the identification of performance measures and critical success factors, development and test of partnering models and processes, and the formation and selection of partnering strategy.
Keywords: alliancing, integration, partnering, partnership, project management.

2000, **7**(1), 93–103

Assessment of working capital requirements by fuzzy set theory

Vellanki S S Kumar,[1] Awad S Hanna[2] and Teresa Adams[2]
[1]*Department of Civil Engineering, University College of Engineering (Autonomous), Osmania University, Hyderabad 500 007, India*
[2]*Department of Civil and Environmental Engineering, 2260 Engineering Hall, Madison, WI 53706, USA*

The systematic assessment of working capital requirement in construction projects deals with the analysis of various quantitative and qualitative factors in which information is subjective and based on uncertainty. There exists an inherent difficulty in the classical approach to evaluate the impact of qualitative factors for the assessment of working capital requirement. This paper presents a methodology to incorporate linguistic variables into workable mathematical propositions for the assessment of working capital using fuzzy set theory. This article takes into consideration the uncertainty associated with many of the project resource variables and these are reflected satisfactorily in the working capital computations. A case study illustrates the application of the fuzzy set approach. The results of the case study demonstrate the superiority of the fuzzy set approach to classical methods in the assessment of realistic working capital requirements for construction projects.
Keywords: fuzzy sets, membership function, working capital.

2000, **7**(2), 107–119

Information modelling for a construction project risk management system

J H M Tah and V Carr
Project Systems Engineering Research Unit, School of Construction, South Bank University, Wandsworth Road, London SW8 2JZ, UK

The construction industry is greatly plagued by risk; too often, this risk is not dealt with adequately, resulting in poor project performance. Communication of construction project risks in practice is poor, incomplete and inconsistent, both throughout the supply chain and through the project lifecycle. Part of the problem is the lack of a formalized approach to the project risk management process. Recently, attempts have been made to overcome this and this paper uses these attempts as a foundation for building a better approach to construction risk management. Underlying this approach is the development of a common language for describing risks and remedial actions. This is grounded in a taxonomy of risk based on a hierarchical risk breakdown structure. In addition, to facilitate the production of a working risk management system, a number of models have been developed using unified modelling language (UML) and IDEF0. Finally, the use of the system has been tested via a working software prototype. This prototype is being used as a basis for discussion with practitioners with regard to the practical requirements of the approach for further development.
Keywords: fuzzy logic, integration definition language, object modelling, project risk analysis and management, qualitative risk assessment, unified modelling language.

2000, **7**(2), 120–132

Business failures in the construction industry

David Arditi, Almula Koksal and Serdar Kale
Illinois Institute of Technology, Department of Civil and Architectural Engineering, Chicago, IL 60616, USA

The objective of the research presented in this paper is to explore the factors associated with company failures in the context of the construction industry. To that end, the four quadrants of an 'environment/response' matrix developed by Boyle & Desai (1991. *Journal of Small Business Management*, **29**, 33–42) are populated with Dun and Bradstreet's US business failure data for the construction industry. The study indicates that budgetary and macroeconomic issues represent 83% of the reasons for construction company failures. This implies that firms that take vigorous administrative measures to address budgeting issues and that react promptly to economic conditions by implementing appropriate strategic policies should be able to avoid failure. On the other hand, issues of adaptability to market conditions and business issues appear to have limited effects on company survivability (6% of the reasons for failure). This implies that administrative measures to fend off internal conflicts that originate for reasons beyond management's control and long-term strategic decisions to regulate the firm's adaptation to market conditions can also help to prevent failure. An 'input/output' model appears to explain the business failure phenomenon better than the 'environment/response' one.

Keywords: bankruptcies, business failures.

2000, **7**(2), 133–140

Safety behaviour and safety management: its influence on the attitudes of workers in the UK construction industry

D Langford,[1] S Rowlinson[2] and E. Sawacha[3]
[1]*Department of Civil Engineering, Strathclyde University, Glasgow G4 0NG, UK*
[2]*Department of Surveying and Real Estate, Hong Kong University, Pokfulam Road, Hon Kong*
[3]*Formerly of Brunel University, Uxbridge, Middlesex, UK*

This paper identifies the critical factors that influence the attitudes of construction workers towards safe behaviour on construction sites. It studies these attitudes by using a research model that links three themes: safety management implementation strategies, attitudes of workers about safety and behavioural factors displayed by construction workers. This model is used to frame the responses of 126 directly employed construction workers in 10 companies. Some 56 variables were identified as having a potential influence upon attitudes to safety. The initial data analysis found that 12 technical factors significantly correlated to the development of strong positive attitudes towards safety management. Second-order analysis, using factor analysis, isolated five variables that had a major influence on safety attitudes. The five factors were: organizing for safety supervision and equipment management, industry norms and culture, attitudes to risk taking and management behaviour.

Keywords: attitudes, construction safety, safety culture, safety improvement, safety management, worker behaviour.

2000, **7**(2), 141–153

Rethinking construction: the Generic Design and Construction Process Protocol

Michael Kagioglou,[1] Rachel Cooper,[1] Ghassan Aouad[2] and Martin Sexton[2]
[1]*Research Institute for Design and Manufacture, University of Salford, Centenary Building, Peru Street, Salford, M3 6EQ*
[2]*Research Centre for the Built and Human Environment, University of Salford, Salford, M5 4WT, UK*

The complexity of construction projects and the fragmentation of the construction industry undertaking those projects has effectively resulted in linear, unco-ordinated and highly variable project processes in the UK construction sector. Research undertaken at the University of Salford resulted in the development of an improved project process, the Process Protocol, which considers the whole lifecycle of a construction project whilst integrating its participants under a common framework. The Process Protocol identifies the various phases of a construction project with particular emphasis on what is described in the manufacturing industry as the 'fuzzy front end'. The participants in the process are described in terms of the activities that need to be undertaken in order to achieve a successful project and process execution. In addition, the decision-making mechanisms, from a client perspective, are illustrated and the foundations for a learning organization/industry are facilitated within a consistent Process Protocol.

Keywords: activity zones, design and construction, process mapping, process protocol, project process, stage gate.

2000, **7**(2), 154–158

Total factor productivity in Singapore construction

Willie Tan
School of Building and Real Estate, National University of Singapore, Kent Ridge Crescent, Singapore 119260, Singapore

This study uses the Tornqvist index to estimate the total factor productivity (TFP) for the Singapore construction industry between 1980 and 1996. Throughout the period, the main contribution to real construction output growth was capital accumulation. TFP was found to be negative, indicating that construction productivity growth has not been spectacular, even in a dynamic and rapidly growing economy such as Singapore. The result is in broad agreement with previous estimates of TFP for the entire Singapore economy. A lot needs to be done to improve construction productivity, as the industry cannot continue to grow by increasing factor inputs indefinitely without an accompanying rise in efficiency.

Keywords: growth accounting, learning by doing, Tornqvist index, total factor productivity.

2000, **7**(2), 159–168

Competitive pressures on middle-market contractors in the UK

Ian Stumpf
The Bartlett School of Graduate Studies, University College London, Gower Street, London, WC1E 6BT, UK

Medium-sized regional building contractors in the UK are exhibiting poorer performance in the 1980s and the 1990s and are less likely to survive than their larger or smaller counterparts. The market structure of contracting appears to be changing, putting pressure on these intermediate firms. Evidence drawn from the Department of the Environment (DoE) statistical series shows industry composition is changing, in particular the gradual decline over time of the middle market. An analysis of company accounts for a sample of approximately 200 contractors shows that medium-sized firms are also displaying inferior business ratios. Possible explanations are offered, including barriers to entry, such as capitalization, economies of scale (*pecuniary* and *market*), along with changes in construction demand.

Keywords: business ratios, competitive advantage, construction majors, contracting, market structure, middle market.

2000, **7**(2), 169–178

The compatibility of construction companies' human resource development policies with employee career expectations

Andrew R J Dainty,[1] Barbara M Bagilhole[2] and Richard H Neale[3]
[1]*School of the Built Environment, Coventry University, Priory Street, Coventry, CV1 5FB*
[2]*Department of Social Sciences, Loughborough University, Leicestershire, LE11 3TU*
[3]*Research Office, University of Glamorgan, Pontypridd, CF37 1DL, UK*

In order to retain and motivate employees, organizations must respond to their expectations, both in terms of meeting formal aspects of their employment contracts and in addressing their less formal expectations of the employment relationship. Within the current human resources management (HRM) literature, these informal expectations are known as psychological contracts. This paper reports on research that explored psychological contracts within the construction industry. In-depth interviews were held with more than 80 construction managers and professional staff who worked for five large UK contracting organizations. The interviewees were asked to describe their career histories, and to discuss any tensions between the personnel policies of their organizations and their personal career aspirations and expectations. It emerged that responsibility for human resource development (HRD) had been largely devolved to divisional and operational management. This led to HRD becoming fragmented and unresponsive, and to employees becoming disillusioned by their employers' failure to meet their expectations. It is argued that construction companies require a more sophisticated understanding of their employees' expectations of the employment relationship if they are to be retained in the long term.

Keywords: career development, human resource development, psychological contract, staff retention.

2000, **7**(2), 179–190

Structuring information on residential building: a model of preference

Ayman H Al-Momani
Civil Engineering Department, Mu'tah University, Karak-Mu'tah P.O. Box 7, Jordan

The purpose of this paper is to describe the methodological problems involved in planning and designing housing programmes and to discuss the cognitive structure and context of residential housing through a comprehensive questionnaire that examined various aspects of the housing environment. In the last two decades, Jordan has established several housing programmes consisting of multi-story buildings for the limited income group. Such new programmes yield conflicts and face cultural constraints that need to be understood and resolved. Based on 400 mailed survey questionnaires, the major focus of the study has been the determination of the needs and preferences of the clients in housing and suggesting responses that are empathetic and consistent with their lifestyles, values and family patterns.

The key to establishing a successful housing sector appears to be the ability of developers to adequately identify these issues. Several factors of cognitive structure were attained: space and the high cost of housing are the key considerations from a client's point of view; the interior design of buildings is below expectations; and outdoor space and materials used for the exterior are also important factors in determining a preference for some housing features. Other factors such as exterior appearance, functionality, kitchen size, type of community and neighbourhood, housing proximity to community facilities, and heating systems must also receive adequate consideration. Another important implication is that individuals within the same income and educational level may not necessarily share the same assumptions with regard to their needs and aspirations. Therefore, a clearly defined strategy will help designers and managers in a young expanding sector to establish various and high quality housing programmes; hence, the better the image, the more able it is to attract customers. The findings identify some of the barriers that could limit the acceptance of new housing features, and offer insights into how such features could be effectively explained and linked to the wants and needs of clients. Therefore, programme managers and developers must understand the sources of competitive advantage in the housing sector; this can make the difference in gaining and retaining customers. The customer's perception is a complex construct, and there are significant interrelations between housing design and human behaviour of which we are almost completely ignorant.
Keywords: client needs, housing, design, procurement.

2000, **7**(2), 191–201

Some empirical observations of service quality in construction

P E D Love,[1] J M Smith,[2] G J Treloar[1] and H Li[3]
[1]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*
[2]*Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, Victoria 3052, Australia*
[3]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hun Hom, Kowloon, Hong Kong*

Architectural and engineering firms (design firms) have eschewed implementing quality assurance (QA) and other subsequent aspects of quality such as continuous improvement. Their reluctance to embrace QA has been found to be a contributing factor in the production of poor quality contract documentation. Missing, conflicting and erroneous information contained within contract documentation are major sources of rework and customer dissatisfaction in construction projects. If design firms are to significantly improve the quality of the service they provide, they should implement ISO 9000 quality management and assurance standards. By implementing such standards, it is suggested that design firms will be able to contribute more effectively to the value adding process in the construction supply chain. It is argued that the service offered by design firms should be viewed as a key component of value that drives its success. Therefore, because rework is a major source of dissatisfaction in projects, a case study was used to determine how its occurrence inhibited value creation and thus the quality of service provided. From the case study findings, the need for design firms to implement ISO 9000 quality management and assurance standards so as to improve their service quality is discussed.
Keywords: design firm, ISO 9000, re-work, service quality, time boxing, value.

2000, **7**(2), 202–208

Target cost contracts: an analysis of the interplay between fee, target, share and price

John G Perry and Martin Barnes
School of Civil Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

Target cost contracts are growing in popularity but concerns remain about the interplay between fee, target, sharing ratios and the final price. This paper offers a fundamental analysis of the principles underpinning target contracts. It shows that there is scope for manipulation of tenders and that sub-optimal methods of tender evaluation are in use. The paper analyses both fixed fee and percentage fee contracts. Methods of tender evaluation are proposed that will both reduce the scope for manipulation by tenderers and increase the likelihood of the contract being awarded to the tenderer whose final price will be the lowest. The analysis reveals a strong case for setting the contractor's share of cost overrun or underrun at a value that is not less than 50%. Finally, the paper proposes two simplifications that would reduce the number of variables in target cost contracts of the future. One is for the employer to set the fee and the other requires only that a target be tendered but with the fee built into it.
Keywords: award criteria, procurement, fees, tender manipulation, target cost, tender evaluation.

2000, **7**(3), 211–220

Effects of overtime work and additional resources on project cost and quality

H Li[1], P E D Love[2] and D S Drew[1]
[1]*Department of Building and Real Estate, Hong Kong Polytechnic University, Hun Hom, Kowloon, Hong Kong*
[2]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*

Delays are an endemic feature of the construction industry. Typically, when a delay occurs in a project, the project manager often expedites progress through activity-crashing with respect to available float and time-cost relationships. An accelerated schedule is thus obtained either by prescribing overtime working hours or by procuring additional resources or a combination of both. However, excessively prolonged overtime work can generate quality problems, such as rework, and additional resources. With this in mind, there is a need for a model to assist project managers with understanding the complex nature of attaining a trade-off between overtime working and the procurement of additional resources. Thus, using system dynamics modelling, the effects of prolonged overtime work on project cost and quality are examined. To overcome project delays, several options representing various combinations of prescribing overtime work and injecting additional resources are analysed. Utility theory is then applied to determine the most appropriate solution for mitigating project delays. The modelling approach offered in this paper should be particularly useful for large projects and for projects on confined sites where potential cost savings and improved quality standards are likely to be the most significant.

Keywords: cost, quality, re-work, systems dynamics, time, utility theory.

2000, **7**(3), 221–231

Forecasting construction materials suppliers' financial turnover

J Nicholas, G D Holt and M Mihsein
School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV1 1SB, UK

Through the credit they furnish, materials suppliers provide a form of working capital for most construction contractors. This paper considers the implications of this for crediting organizations (i.e. suppliers). It is shown that a supplier's financial turnover movement (or lack of it) can be modelled and predicted with some accuracy by considering a number of characteristics of their credit control department. The models are developed from analysis of data obtained from a survey of 55 UK materials suppliers' credit control and debt collection procedures. The statistical technique of multivariate-discriminant analysis (MDA) is used. Predictive accuracy of the models is tested on an independent, hold-out sample of 10 suppliers' characteristics. It is found that 'risk-taking' suppliers who protect themselves from bad debt by using insurance; suppliers who employ a third-party organization to evaluate potential debtors' creditworthiness; and suppliers who service only one construction trade with materials, achieve significantly greater financial growth than those suppliers who do not exhibit these characteristics.

Keywords: contractor, credit, discriminant analysis, turnover, risk, supplier.

2000, **7**(3), 232–240

Integrated management systems: a single management system solution for project control?

Alan Griffith
Centre for the Built Environment, Sheffield Hallam University, Howard Street, Sheffield S1 1WB, UK

Over the last 25 years, the construction industry has embraced quality management systems (QMS). More recently, environmental issues and health and safety legislation have introduced additional dedicated control procedures: environmental management systems (EMS) and health and safety management systems (H&SMS). Systems, in particular those used for quality management, have been widely accused of being bureaucratic, arduous, paper driven and of questionable value to construction management. The genuine need is for improved systems that enable a contracting organization to control the key management functions of quality, environment and safety with maximum effectiveness and minimum bureaucracy. The findings presented in this paper show that a forward-looking approach can bring together these individual functions within an integrated management system (IMS). This allows an organization to move away from traditional vertical and separate management systems towards a single cross-functional horizontal system that can benefit both the corporate and the project organizations. The idea of an IMS for quality, environment and safety has only recently emerged within the UK construction industry. A small number of UK contracting organizations are, therefore, at the forefront of both national and international developments. Based on a questionnaire survey of 12 UK contracting organizations, this paper examines the purpose, characteristics, properties and intent of a single system approach, or IMS for quality, environment and safety, and considers its role within and it significance to contracting organizations.

Keywords: construction management, environment, integrated management system, quality, safety, survey.

2000, **7**(3), 241–250

SPICE: a business process diagnostics tool for construction projects

M Sarshar, R Haigh, M Finnemore, G Aouad, P Barrett, D Baldry and M Sexton
School of Construction and Property Management, University of Salford, Salford M7 9NU, UK

The construction sector is under growing pressure to increase productivity and improve quality, most notably in reports by Latham (1994, *Constructing the Team*, HMSO, London) and Egan (1998, *Rethinking Construction*, HMSO, London). A major problem for construction companies is the lack of project predictability. One method of increasing predictability and delivering increased customer value is through the systematic management of construction processes. However, the industry has no methodological mechanism to assess process capability and prioritise process improvements. Standardized Process Improvement for Construction Enterprises (SPICE) is a research project that is attempting to develop a stepwise process improvement framework for the construction industry, utilizing experience from the software industry, and in particular the Capability Maturity Model (CMM), which has resulted in significant productivity improvements in the software industry. This paper introduces SPICE concepts and presents the results from two case studies conducted on design and build projects. These studies have provided further insight into the relevance and accuracy of the framework, as well as its value for the construction sector.

Keywords: capability maturity model, process assessment, process capability, process enabler, process improvement, SPICE.

2000, **7**(3), 251–266

Decision support system for contractor pre-qualification: artificial neural network model

K C Lam[1], S Thomas Ng[2], Hu Tiesong[3], Martin Skitmore[4] and S O Cheung[1]
[1]*Department of Building and Construction, City University of Hong Kong, Hong Kong*
[2]*Department of Civil Engineering, The University of Hong Kong, Hong Kong*
[3]*Department of Hydraulic Engineering, Wuhan University of Hydraulic and Electric Engineering, China*
[4]*School of Construction Management and Property, Queensland University of Technology, Australia*

The selection criteria for contractor pre-qualification are characterized by the co-existence of both quantitative and qualitative data. The qualitative data is non-linear, uncertain and imprecise. An ideal decision support system for contractor pre-qualification should have the ability of handling both quantitative and qualitative data, and of mapping the complicated non-linear relationship of the selection criteria, such that rational and consistent decisions can be made. In this research paper, an artificial neural network model was developed to assist public clients identifying suitable contractors for tendering. The pre-qualification criteria (variables) were identified for the model. One hundred and twelve real pre-qualification cases were collected from civil engineering projects in Hong Kong, and 88 hypothetical pre-qualification cases were also generated according to the 'If-then' rules used by professionals in the pre-qualification process. The results of the analysis totally comply with current practice (public developers in Hong Kong). Each pre-qualification case consisted of input ratings for candidate contractors' attributes and their corresponding pre-qualification decisions. The training of the neural network model was accomplished by using the developed program, in which a conjugate gradient descent algorithm was incorporated for improving the learning performance of the network. Cross-validation was applied to estimate the generalization errors based on the 're-sampling' of training pairs. The case studies show that the artificial neural network model is suitable for mapping the complicated non-linear relationship between contractors' attributes and their corresponding pre-qualification (disqualification) decisions. The artificial neural network model can be concluded as an ideal alternative for performing the contractor pre-qualification task.

Keywords: artificial neural network, conjugated gradient descent algorithm, contractor pre-qualification, decision support system.

2000, **7**(3), 267–277

Creation of a new design management system based on process optimization and proactive strategy

Pertti Lahdenperä[1] and Veli-Pekka Tanhuanpää[2]
[1]*VTT Building Technology, PO Box 1802, FIN-33101 Tampere, Finland*
[2]*NCC Finland Oy, Vantaa, Finland*

There are numerous designers involved in building design, and the various parties need information from each other as a basis for their design decisions. The design co-ordinator cannot be an expert on all information needs of every design discipline. The various designers, again, focus on their current work only, and neglect the planning of forthcoming design activities. This results in a lack of information, guesswork, idling and delays in the self-steering process. The end result is extensive redesign and problems in the construction stage. This article describes a design management system developed to minimize these problems. The system includes operational systematics to be followed by all the actors involved in the design process. Another part of the solution is a reference model on typical information needs by different designers in various stages and tasks of the design process. The system was developed as part of two actual building design processes.

Keywords: design management, design process, design structure matrix, information exchange, input data, reference model.

2000, **7**(3), 278–284

Australian multi-unit residential project construction time performance factors

Derek H T Walker and Mark W Vines
Department of Building and Construction Economics, RMIT, Melbourne, Australia

Construction time performance (CTP) factors recently identified in work commissioned by the Construction Industry Institute Australia (CIIA) indicate that project team effectiveness significantly influences CTP. Project complexity also was found to significantly contribute to CTP. However, no residential projects were studied in that survey. This paper reports upon CTP research undertaken into Australian multi-unit residential construction that fills this theory gap. Results indicate that the construction management (CM) team's effectiveness in managing the construction process has a major but not predominant role in influencing CTP. Team communication effectiveness and teamwork factors are also essential factors influencing CTP. Other factors found to affect CTP include: design team's management style; intra-team working relationships; the degree of experience and expertise for the same type and size of project; procurement method; and the level of the CM team's current workload.

Keywords: construction time performance, procurement, risk, team behaviour.

2000, **7**(3), 285–299

Benchmarking contractor selection practices in public-sector construction: a proposed model

E Palaneeswaran and M M Kumaraswamy
Department of Civil and Structural Engineering, The University of Hong Kong, Hong Kong

Benchmarking of best practices has proved useful in the business and manufacturing sectors. However, benchmarking is not established in the construction industry in general and in government organizations in particular. A study of the contractor selection methodologies used by various clients confirms the multiplicity of approaches in practice. This paper aims at identifying some relevant ‘best’ practices and highlighting ‘innovative’ contractor selection approaches that have been used by large public clients. A ‘co-operative’ and ‘non-competitive’ conceptual benchmarking model is formulated and presented with a view to encouraging continuous improvement in contractor selection for construction projects.

Keywords: benchmarking, best practice, continuous improvement, contractor selection, innovative approach, public sector.

2000, **7**(3), 300–306

The conditioning effect of objective decision-making on the client's capital proposal

Roy M Woodhead and Steven P Male
School of Architecture, Oxford Brookes University, Gipsy Lane Campus, Oxford OX3 0BP, UK

The capital proposals of large experienced clients of the UK construction industry are influenced by paradigms and perspectives. Those involved in the decision-to-build process react to stimuli caused by a need to demonstrate objective decision-making. The paper is taken from a 5-year PhD study undertaken by the first author, which investigated the origins of the decision to build undertaken by leading clients. The clients sampled had a total annual construction budget of between £700 million and £1000 million in the year that data were collected. The product of the research was an explanation of what happens in the pre-project stage, why it happens, and why it will change in the future. The significance of its conclusions is that any system designed to model or improve decision-making in the pre-project stage must be capable of adaptation and modification as influences and considerations shift. Moreover, the need to justify decisions as ‘objective’ empowers paradigms and perspectives that act as conditioning influences on the people making or shaping proposals. The paper concludes by showing that an understanding of the role played by paradigms and perspectives could allow management to ‘rethink construction’ and meet the challenges put forward by Sir John Egan (The Egan Report: *Rethinking Construction*, DETR, 1998).

Keywords: client, decision-making, objective, paradigm, perspective, satisfaction.

2000, **7**(3), 307–321

Growth paths of construction enterprises in Singapore, 1980–98

George Ofori and Swee Lean Chan
School of Building & Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260

Construction companies have several possible growth paths to follow in their effort to develop. Studies show that the appropriate approach depends on the features of the company and the prevailing economic conditions, and support measures and incentives. This paper reports the results of a study on the paths which construction enterprises in Singapore have adopted since 1980. The main basis of the study was a mailed questionnaire survey. It was found that most local contractors have grown by working at home, either as main contractors or as specialist sub-contractors. Some

theoretical implications of the findings are outlined. Recommendations are offered on appropriate growth paths for Singaporean contractors under various circumstances.
Keywords: construction enterprise, growth paths, Singapore.

2000, **7**(3), 322–328

UK contractors' acquisitions strategy for Central and Eastern Europe

Patricia Carrillo and Ian Heavey
Department of Civil and Building Engineering, Loughborough University, Loughborough, Leicester LE11 3TU, UK

Large construction companies operate in geographically diverse locations, often in very competitive conditions and in a dynamic environment. A strategy for continuing growth in earnings is necessary. Acquisitions are a way of achieving external growth. The aim of this paper is to investigate the acquisitions strategies of UK contractors towards the emerging markets of Central and Eastern Europe. Five UK contractors, which had the highest turnover in overseas business, were chosen as the subject group. The paper finds that, although these contractors acknowledge that there is a potential market, they are adopting a very cautious view by not setting up permanent offices and by hoping to win work through contacts with Western clients.
Keywords: acquisitions strategy, Central Europe, Eastern Europe, construction company.

2000, **7**(4), 330–346

A decision support system specification for out-turn cost and cost escalation in the heavy engineering industry

Nashwan N Dawood and William Bates
School of Science and Technology, University of Teesside, Borough Road, Middlesbrough TS1 3BA, UK

The heavy civil engineering industry (railways, sewage treatment, chemical and pharmaceutical facilities, oil and gas facilities, etc.) is one of the major contributors to the British economy and generally involves a high level of investment. Clients in this industry are demanding accurate cost estimates, proper analysis of out-turn cost and cost escalation and a high quality risk analysis throughout the construction processes. Current practice in the industry has suggested that there is a lack of structured methodologies and systematic cost escalation approach to achieve an appropriate cost analysis at the outset of projects and throughout the construction processes. In this context the prime objective of this research work is to develop a structured cost escalation methodology for improving estimating management and control in the heavy engineering industry construction processes. The methodology is composed of a forecasting model to predict cost indices of major items in industry and a risk knowledge base model for identifying and quantifying causes of cost escalations. This paper, as part of the research, reviews and discusses a knowledge-based model for applying a cost escalation factor. The cost escalation factor is made up of market variation, a risk element and a component for bias. A knowledge elicitation strategy was employed to obtain the required knowledge for the model, The strategy included questionnaires, interviews and workshops and deliverables came in the form of influences and their effect on project cost escalation. From these deliverables, the concepts of a decision support model and system specification for applying cost escalation to base estimates is proposed.
Keywords: decision support, knowledge, out-turn cost.

2000, **7**(4), 347–361

Identification of optimal size resources for a repetitive housing construction

M Dhanasekar
Faculty of Engineering and Physical Systems, Central Queensland University, Rockhampton Campus, QLD 4702, Australia

Deployment of optimal size of resources is a key issue in repetitive construction projects. This paper describes a simulation model based on queuing theory for the resource scheduling of a real repetitive housing project involving 320 dwelling units constructed in East Delhi, India. The optimal size of resources, defined as the minimum size required to keep the project duration a minimum, has been identified from the results of a series of sensitivity analyses in which the size of the resources was varied one at a time. The duration of the project, the period of utilization of the resources, and the queue length of activities waiting for service are also reported in this paper. It has been shown that reduction in size of resources is achievable without increasing the duration of the project and queue length of activities. increase in the size of some specialised crews is also proved advantageous.
Keywords: construction operations, optimization, queuing, repetitive construction, resource, simulation.

2000, **7**(4), 362–372

Human dimensions in modelling prices of building projects

Richard Fellows[1] and Anita M M Liu[2]
[1]*Department of Building Services Eng'g, Hong Kong Polytechnic University, Hung Hom, Hong Kong*
[2]*Department of Real Estate and Constn., University of Hong Kong, Pokfulam Road, Hong Kong*

This paper supplements and extends consideration of quantitative models with application to building (costs and) prices by examining human elements inherent in modelling. In considering the concepts of modelling, attention is focused on the recently developed sociology of science, which questions the traditional perspective of total separation of a reality from the observer–the 'objective' basis of scientific positivism. It is argued that human activities are fundamental in, and inseparable from, reality and so, they are integral in modelling. The aim of modelling should be to enhance understanding and knowledge rather than to secure inert objectivity. Application to modelling of prices of building projects investigates how prices are formulated, which prices are commonly modelled and the impact of the decision-makers involved. It is concluded that new models are required, perhaps developed through methodological pluralism, which identify people-oriented variables and assumptions explicitly. Further, the models should be stochastic and with sound bases in theories of economics and human behaviour to ensure that users are aware of the major variabilities in the processes modelled and so, by realistically informing, promote better decision making.

Keywords: cost, price, human behaviour, modelling, research method.

2000, **7**(4), 373–388

Enhancing building product libraries to enable the dynamic definition of design element specifications

Jason Underwood,[1] Mustafa A Al-Shawi,[2] Ghassan Aouad,[2] Terry Child[3] and Ihsan Z Faraj[4]
[1]*School of Civil Engineering, University of Leeds, Leeds LS2 9JT UK*
[2]*School of Construction and Property Management, University of Salford, Salford M7 9NU, UK*
[3]*AremisSoft Corp., Technology House, Lissadel Street, Salford M6 6AP, UK*
[4]*Building Research Establishment, Watford, WD2 7JR, UK*

The AIC Research Group at the University of Salford has been involved in a government-funded project that has resulted in the development of an integrated rnulti-user distributed construction project database through the implementation of next-generation internet technology together with Product Data Technology - WISPIER. The objective of the project was to develop a working system capable of demonstrating the future direction of information integration with the project partners' businesses. This paper presents the development of the specification application that aims to demonstrate the potential for such technologies to enhance the specification process, enabling design elements to be specified directly from a building product database web site.

Keywords: specification, database, client-server architecture, STEP.

2000, **7**(4), 389–398

Importance of design consultants' soft skills in design-build projects

Florence Yean-Yng Ling, George Ofori and Low Sui Pheng
Department of Building, National University of Singapore, Singapore

Architects and engineers (AE) need to possess both 'hard' and 'soft' skills. Soft skills are important because AEs interact in organizational settings instead of working by themselves. Soft skills may be grouped under 'conscientiousness', 'initiative', 'social skills', 'controllability' and 'commitment'. As part of a larger study on the selection of consultants by design build (DB) contractors in Singapore, a survey was conducted to gauge whether contractors felt that soft skills are important for consultants to carry out their design tasks in DB projects. From the literature, attributes relating to these skills were identified. Data were collected via mailed questionnaire. The questionnaire requested respondents to indicate on a five-point scale the importance of various soft skills. it was found that all the soft skills, which were operationalized into 14 attributes, are important factors that contractors look for when selecting consultants. It is, therefore, concluded that contextual performance is important and relevant.

Keywords: architect, contextual performance, design build, engineer, consultant selection, soft skills.

2000, **7**(4), 399–411

Improving the performance of Earned Value Analysis as a construction project management tool

Rodney Howes
Faculty of the Built Environment, South Bank University, 202 Wandsworth Road, London, SW8 2JZ, UK

Earned Value Analysis (EVA) is an accepted theoretical technique advocated for the control of projects. This paper attempts to refine and improve the performance of traditional EVA by the introduction of a hybrid methodology based on work packages and logical time analysis entitled Work Package Methodology (WPM). The proposed WPM provides the means to periodically update project cost and time performance by restricting EVA calculations to individual work packages. These are then subjected to a logical time analysis to determine the predicted project cost and time to completion. A comparative analysis between WPM and EVA is then undertaken using adapted test data derived from knowledge of previous projects to identify the reasons for variation in the results obtained from both methods. The

evaluation of the test results indicates that when the Cost Performance Index (CPI) and the Schedule Performance index (SPI) are well above or below unity then, especially in the early stages of the project, traditionally-applied EVA predictions can be unreliable and require further investigation and evaluation. WPM provides a vehicle for judging the performance of EVA by applying an alternative logical time and cost utilizing work sequence and construction methods. The predictive performance of EVA is refined by these means.
Keywords: cost, earned value, performance, project, schedule, work package.

2000, **7**(4), 412–422

Government support and risk-return trade-off in China's BOT power projects

S Ye and R L K Tiong
School of Civil and Structural Engineering, Nanyang Technological University, Singapore

Government support plays an important part in risk-return trade-off of participants in privately financed infrastructure projects. Depending on the level of government support, risk-return trade-off of the private sponsor varies from project to project. Case studies on two of China's build-operate-transfer (BOT) power projects that were developed at different time periods illustrate that government support has a significant effect on both risk and return of the private sponsor. It is hoped that such understanding would help the private sponsor strike a desirable risk-return trade-off in structuring a BOT deal.
Keywords: BOT, government support, infrastructure project, risk allocation, risk-return trade-off.

2000, **7**(4), 423–435

Measuring the costs and benefits of information technology in construction

Laurence Marsh and Roger Flanagan
Department of Construction Management & Engineering, University of Reading, PO Box 219, Reading, RG6 6AW, UK

Information technology (IT) has been widely applied across many economic sectors in order to increase competitiveness and reduce costs. This paper identifies that uptake of IT within construction is low. It is argued that significant barriers preventing construction organizations from investing in IT include uncertainty concerning the identification and measurement of benefits associated with applications. In particular, it is argued that difficulties in quantifying benefits associated with improved information availability and decision making prevent effective IT cost/benefit analysis. Existing approaches to evaluating IT within construction are reviewed. A framework is presented which identifies metrics by which IT impacts both management and operational processes within construction in order to deliver value. An evaluation methodology tailored to one specific IT application, high-density bar coding in maintenance management, is presented to illustrate the quantification of both the costs and benefits of applying IT.
Keywords: bar coding, benefit, cost, evaluation, information technology, probabilistic modelling.

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E-mail: journalcp@ntu.ac.uk

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The influence of client and project team relationships upon construction time performance

Walker, D H T
Department of Building and Construction Economics, RMIT, Melbourne, Victoria 3000, Australia

Results from recent research (Walker 1994) revealed that contract type does not significantly affect speed of construction and that several client related factors proved more significant, particularly how well clients or their representatives relate to the project team. These results provide an interesting insight into the nature of the client/project team relationship and throws some light onto conclusions drawn by others that non-traditional forms of procurement achieve better construction time performance (CTP) results than the traditional approach.

The conclusion flowing from an investigation of the literature together with results of the Walker (1994) findings, suggests that the quality of the relationship between client, client representative (CR), the design team and construction management team is a major and significant factor governing construction time performance (CTP). Statistical evidence Walker (1994) clearly demonstrates a link between confidence of the project team in the CR. This confidence is engendered by other factors related to the CR's capacity to communicate with project teams and to have sufficient sophistication regarding the project's characteristics to understand the project, its challenges and how the project design and construction teams can best be marshalled to positively contribute and compensate for performance shortfalls of individuals. It is proposed that it is the quality of relations and team performance that significantly contributes to success rather than prescribing a particular procurement system for a given set of conditions.

Keywords: client, procurement, productivity, time.

1995, **1**(1), 21–37

An implementation model of an alliance

Badger, W W and Mulligan, D E
Del E Webb School of Construction, Arizona State University, USA

A business interpretation of the term globalization is based on the assumption that products or services being produced must be competitive in all parts of the world and they must remain competitive all of the time. This represents quite a departure from previous concepts that most likely involved some type of international expansion with perhaps a single project. As national borders become increasingly more flexible, world-wide competition for construction projects will continue to increase. This idea of participating in a global economy is changing the traditional approaches used by construction companies in their strategic planning. In addition, dwindling financial resources have caused many governments to consider alternative methods to the standard practices of generating revenue for public construction projects. The US construction industry, looking forward to the 21st century, will likely be getting more involved in international projects and is searching for the best possible vehicles to enhance their position in this market. Forming alliances with foreign firms may be one alternative. An alliance is a cooperative agreement between two entities that generally encompasses a long-term commitment from the participants and is built more on trust and mutual sharing of responsibilities than on contractual agreements. A previous article by the writers based on a research project on International Alliances dealt with why companies form alliances and the benefits derived from forming alliances. The purpose of this paper is to adapt the findings of that same research project into an implementation plan, one which will address the key issues required to formulate an alliance with a foreign firm.

Keywords: alliancing, co-operation, globalization, international alliancing, joint venture, partnership.

1995, **1**(1), 38–49

International procurement systems: assessment of required levels of client participation in construction projects

Davenport, D M and Smith, R
Department of Built Environment, University of Central Lancashire, Preston, PR1 2HE, UK

The attainment of the highest standards of client satisfaction with construction investment ought to be the priority of all constructors, if not for a range of complex socio-economic reasons, then for the simple reason that the satisfied customer will be encouraged to re-invest and subsequently re-employ the services of the construction industry sector. The European market has extended the horizons of British constructors and consultants, many of whom are grasping the opportunity to compete in a technologically and administratively varied international scenario. Recent political and ideological upheaval in Eastern Europe, in Russia and in the People's Republic of China have created further opportunities for UK contractors and consultants to collaborate and influence the development of managerial and procurement systems in the construction industries of Eastern Europe. This paper examines recent findings from UK research studies which have focussed on the role of the client in the construction industry and puts forward a proposal that greater levels of participation by the client within the procurement process will achieve correspondingly higher levels of satisfaction with construction investment.

Keywords: client, investment, participation, professional, procurement, satisfaction.

1995, **1**(1), 50–63

Relationship between the Building Team, Procurement Methods and Project Performance

Naoum, S G[1] and Mustapha, F H[2]
[1]*School of Construction Economics and Management, South Bank University, London, UK*
[2]*Department of Civil Engineering and Building, University of Glamorgan, Pontypridd, Wales, UK*

This paper presents some findings of a research project on investigating the influence of the building team on project performance. The paper has several assumptions which form the basis for the discussion of the research framework. Foremost, is the assumption that, the procurement method selected for the project effects project performance but not by itself is the only determinate. Characteristics of the building team i.e. the client, designer and the contractor can significantly influence the outcome of the project. Data from 69 case studies were collected to validate this assumption and it was found that, experience of the building team with the building process has significantly influenced the time and cost overruns, as well as the quality standard of the project. On the other hand, pre-construction time and unit cost were more associated with whether the client had selected a management or a traditional form of contract. With regard to speed of construction, this research did not provide enough evidence to conclude that alternative procurement methods can directly shorten the construction time. Construction time was more influenced by the building type and the method of construction.

Keywords: team, procurement, performance, project management.

1995, **1**(1), 64–80

Managing requests for proposal development in public sector design-build

Songer, A D and Ibbs, C W
Engineering Centre, University of Colorado at Boulder, USA

An alternative acquisition strategy receiving increased attention in US public sector markets is design-build contracting. A critical consideration during the planning of public sector design-build is how much control the owner (public sector agency) should maintain over project specifications. On one hand design-build (1313) is used to encourage innovation yet the other the owner is responsible to the public for the most economic solution. These two concepts are often at odds and therefore, some balance must be established between innovation and control when developing a request for proposal on public sector design-build projects.

This paper discusses results of research conducted to address the issue of controlling the request for proposal for public sector design-build contracting. Decision criteria for appropriate innovation/control balance are identified and discussed in detail.

Keywords: contracting, design-build, procurement, project management.

1995, **1**(2), 87–99

European procurement rules and national preference: explaining the local sourcing of public works contracts in the EU in 1993

Cox, A and Furlong, P
Birmingham Business School, University of Birmingham, UK

This article assesses the impact of the procurement rules imposed after 1992 by the European Union on public works contracts. The general conclusion of the article is that, while the new rules, which were established in the late 1980s by

the European Union, have considerably tightened up on the loopholes which had existed for public works contracts under the 1971 public works rules, there has not been - so far anyway - any significant change in the behaviour of national awarding bodies in the public sector, as far as public works contracts are concerned. This means that, while there has been some considerable change in the rules, the award of construction contracts is still predominantly in favour of construction firms located in the national country of origin. This leads us to conclude that, in this regard, 'the more things change. the more things remain the same'.

Keywords: contract, European Union, procurement, public sector.

1995, **1**(2), 100–110

A critique of the business performance measures of UK construction companies

Ramsay-Dawber, P A

Department of Building and Environmental Health, The Nottingham Trent University, Burton Street, Nottingham, UK

This paper uses previous studies to review how the business performance of companies has been measured in the past and questions the relevance of these primarily financial measures to the construction industry. It argues the case for a more comprehensive and standardised approach to the measurement of the corporate performance of United Kingdom contractors, and suggests the use a composite measure which uses quantitative and qualitative non-financial and financial measures which reflect the interests of all stakeholders of the industry, more specifically the client. This would provide a holistic approach to the measurement process which, it is suggested, would ultimately assist in the pre-selection process, and procurement of construction work.

Keywords: business performance, construction firm, UK.

1995, **1**(2), 111–123

Towards an expert system on project procurement

Chan, A P C

School of Building and Planning, University of South Australia, North Terrace, Adelaide, Australia

A great deal of attention has been directed towards the studies of individual procurement method, however few studies have focused upon a direct investigation of the factors affecting the choice of a particular procurement method. This paper reports a research study carried out in Australia on procurement selection. The study, based on a multi-attribute approach, aimed to develop an expert system to aid the selection of the most appropriate procurement system. A procurement categorization was developed to reflect the current procurement practice in Australia. The model is based on a set of utility factors derived from three local experts. A concordance analysis was used to check any abnormal data sources. Twenty six case studies were carried out in which clients were asked to indicate the relative importance of each criterion in the system. The most appropriate procurement method recommended by the model was computed and compared with the actual choices made by the respective clients. 54% of the cases were found to have the first two recommendations matching the actual selection. This demonstrates some encouraging results and suggests a favourable possibility of developing an expert system to select procurement systems.

Keywords: expert system, multi-attribute model, procurement, utility factor.

1995, **1**(2), 124–149

Work in the IT industry on usability provides an agenda for improvement of construction procurement methods

Stansfield, F R

Centre for Research in the Built Environment, University of Glamorgan, Wales, UK

Consideration of user needs during the construction procurement process should be improved for reasons including past experience where such needs have been neglected, changing work roles during the procurement process, public concern about construction industry performance, quality issues and pressures arising from internationalization. Construction can learn from the IT industry in meeting these needs, particularly in terms of evaluating usability. Experience from the IT industry suggests that ways by which construction procurement could benefit from better consideration of usability include cost-effective increases in investment in such techniques, elaboration of procurement systems to encompass usability issues, better allocation of responsibilities for user issues, and provision of a theoretical framework within which usability issues can be understood. Such developments are needed for construction as an industry to be competitive.

Keywords: information technology, participation, usability, user.

Journal of Construction Procurement

1995, **1**(2), 150–164

Latham causes conflict: institutional development in the UK construction industry

McDermott, P[1] and Quinn, B[2]
[1]*TIME Research Institute, University of Salford, UK*
[2]*J.R. Knowles, Liverpool, UK*

At the time of writing there are signs that the various interested parties, who originally gave at least tacit support to the Latham Review of the UK construction industry are beginning to break rank. The Government itself, joint sponsors of the review, has disappointed many in the industry by its apparent lack of commitment to the full range of proposals in the Department of the Environment consultation paper, Fair Construction Contracts. This paper argues that the potential for success of the Latham Review is limited, not simply because of the recalcitrance of some of the particular interested groups, but due to the process of the review and the proposed institutional framework for implementation. The paper attempts to bring a conceptual framework to an analysis of the process of the Latham Review. Drawing upon the literature in the field of institutional development generally and, more particularly from experiences in the construction industries of developing countries, the policy initiatives and proposed institutional changes are clearly separated. The institutional arrangements (particularly the new Construction Industry Board) neither supplant, replace, nor control, the existing structures. The paper argues for the United Kingdom CIB to develop as an independent institution recognizably in pursuit of the common good.

Keywords: conflict, institutional development, construction industry dev't., Latham

JCP: Volume 2, 1996

1996, **2**(1), 3–10

Reconstruction and development in South Africa: the construction industry and related procurement reform

Gounden, S
Deputy Director-General, Building Services, Department of Public Works, South Africa

South Africa is embarking upon significant policy reform initiatives related to public sector procurement. The conceptual framework that underpins the reconstruction and development programme in South Africa is addressed and the role of the construction industry in South Africa is considered, together with some of the current problems which face the sector. The procurement reform process currently taking place in South Africa is also addressed, including the primary objectives of this initiative and some of the specific focus areas which pertain to the construction industry.
Keywords: procurement, public sector procurement, reconstruction development programme, South Africa.

1996, **2**(1), 11–29

The effect of economic cycles on the development and use of alternative procurement systems in the UK construction industry during the period 1965-1995

Dowd, V G
Gardiner & Theobald, London, UK

Economics has been described as "the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses." (Robbins 1935). The link between the supply side and the demand side of the construction industry is made through the method of project procurement utilised for each particular development. The construction industry provides the service of organizing and managing the manipulation of materials and other component parts so that they combine to form a building or other works. The members of the industry, generally grouped into the functions of 'design', 'management' and 'construction' (Turner 1990), can be brought together to give the construction service in different ways known as Procurement Paths, each discrete path exhibiting particular characteristics which render it more suitable for different project types and client needs. Current thinking suggests that no procurement is best in all circumstances. The national economy and consequentially the construction sector suffers from short, medium and long term cyclical fluctuations in activity levels which manifest themselves 'm such key economic indicators as output, employment, income and demand. The altering relationship 'm the factors of supply and demand will tend to modify the type of product being sought, the services offered and consequently the appropriateness of the linking mechanism or procurement system. The most fundamental developments 'm this area have taken place 'm the past thirty years, with the period 1965-1995 encapsulating a number of excessive booms and deep depressions coupled with the popularization, and sometimes subsequent wain, of new and innovative procurement options. The relationship between the national economy and the activity of the construction sector is examined, analysing those factors that contribute to determining the nature and volume of its output. The plethora of procurement systems currently in use is viewed against the background of how they became relevant in the context of developments in the economy and in the construction industry. These factors are then considered from the viewpoint of demand and supply and the influence exerted by clients, consultants and contractors in promoting particular systems. Ultimately, a comprehensive guide may be established linking economic factors with client requirements and contractor goals resulting in a harmonious reconciliation of these two potentially conflicting aspirations and the use of more appropriate procurement systems for each particular project in the context of prevailing economic conditions.
Keywords: economy, history, procurement.

1996, **2**(1), 30–40

Team relationships and related critical factors in the successful procurement of health care facilities

Smith, A and Wilkins, B
Associate Professors, City University of Hong Kong, Department of Building and Construction, Tat Chee Avenue, Kowloon, Hong Kong

The procurement of major publicly funded health care projects is fraught with many problem. These are most acute where the competing demands of complex design and changing public and institutional perceptions of

what such buildings should be, are coupled with a need to procure buildings within tight timescales and closely defined budgets to high quality standards. In addition value for money must be seen to be obtained. Finally, the "multi-headed" client, typically represented by a wide range of end-users and interest groups emerges as a key issue. Recent research from Hong Kong, the USA and the UK is summarized to examine the possible ways in which these demands can be met such that cost effective high quality health care projects can be procured on time and within acceptable cost limits. In particular an attempt is made to identify some broad factors which appear critical to project success.

Keywords: hospital, procurement.

1996, **2**(1), 41–55

The partnering philosophy: a procurement strategy for satisfaction through a teamwork solution to project quality

Baden-Hellard, R

Chairman, Polycon Group of Consultants, Greenwich High Road, London, SE10 8LF, UK

Quality management techniques and partnering in particular involve philosophies that require changes in culture which come from previous mind-sets and procurement strategies. The evolution of cultural change is addressed through total quality management into the partnering ambience which, it is argued, is a more cost-effective and satisfactory way of procuring construction projects. It identifies the client and who the other project stakeholders are, when and how the partnering process should begin and provides the details of the process at all stages from before the tenders are called for to the projects conclusion. It looks at the benefits that will result from effective use of the concept and also at the problem areas that could lead to failure. It stresses the importance of top management commitment by all the stakeholders, good communications and of giving adequate time to the initial stages and to the partnering workshop. The workshop and the project charter are essential ingredients for success but it postulates that the intention should begin at the inception stage and be communicated to and discussed with all parties prior to their appointment to the project team, whatever format tenders and subsequent contracts take.

Keywords: culture, client, partnering, stakeholder, team management, total quality management.

1996, **2**(1), 56–65

"Intelligent" procurement of construction systems

Kashiwagi, D T; Halmrast, C T and Tisthammer, T

Performance Based Studies Research Group (PBSRG), Del E. Webb School of Construction, College of Engineering and Applied Science, Arizona State University, USA

Dr. Kashiwagi has developed a methodology to process information to reduce risk and cost and at the same time, improve construction performance and industry stability. The methodology reshapes the construction environment, changes roles and partnerships, and provides facility owners with a new method of communicating requirements to constructors based on performance information and "intelligent thinking." The new performance approach allows facility owners to communicate requirements in simple performance terms instead of material and construction standards. The methodology was developed using the industrial engineering concepts of continuous improvement, quality control, and "intelligent thinking processes. The process has been refined and tested fifteen times from 1994-1996 on the procurement of roofing systems, janitorial services, and landscaping services. Current efforts include quantifying the performance of electrical contractors, mechanical contractors, general contractors, Job Order Contractors, roofing contractors, parking deck coating contractors, and design consultants. Participants in the $450,000 research effort include Motorola, Honeywell, IBM, and McDonnell Douglas.

Keywords: intelligent procurement, performance.

1996, **2**(2), 4–18

The contribution of the construction management team to good construction time performance: an Australian experience

Walker, D H T

Department of Building and Construction Economics, Royal Melbourne Institute of Technology, Melbourne, Australia

Good construction time performance is closely associated with sound management practices. Recent research undertaken on a representative sample of 33 building construction projects in Melbourne (Walker 1994), later extended to include a further 12 civil and process engineering projects in Australia (Walker and Sidwell 1996), has revealed interesting insights into the characteristics of winning construction management teams. Important construction team characteristics are discussed which can be useful, in terms of construction time performance, to select an appropriate construction team. The findings of the research indicate that significant increases in construction time performance are associated with high levels of construction management team competence in planning, team building and communications. These findings, reported in this paper, provide useful benchmark measures with which to compare construction management teams.

Keywords: benchmarking, construction time performance, leadership, team management.

1996, **2**(2), 19–37

Construction planning models: a review of history, capabilities and limitations

Aouad, G F[1] and Kawooya, A A O[1] and Price, A D F[2]
Department of Surveying, University of Salford, Salford, UK
Department of Civil Engineering, Loughborough University of Technology, UK

The various construction planning models developed by researchers and practitioners since the beginning of this century are critically reviewed. The aim is to present an up to date review of construction planning models. The review provides a useful one stop reference for researchers during the early stages of related research, and practitioners wishing to evaluate their systems. Current construction planning developments are described and contractors' opinions regarding these developments commented on. This review is mainly based on current literature relating to different planning systems. In order to illustrate current planning practices within construction management, the review has included some of the results of a questionnaire survey conducted amongst the top 400 contractors in USA and top 100 contractors in UK. The review concludes that there is a wide variety of planning models, used by the Architecture-Engineering-Construction (AEC) industry, which range from simple techniques such as bar charts to sophisticated and complex models such as expert systems, simulation programs, CAD-based planning applications and integrated planning models.

Keywords: construction planning, integration, project management, scheduling.

1996, **2**(2), 38–51

Procurement by objectives

Kumaraswamy, M M and Dissanayaka, S M
Department of Civil and Structural Engineering, University of Hong Kong, Pokfulum Road, Hong Kong

Many researchers and construction industry analysts have examined the relative merits of options within particular sub-systems of procurement, such as organizational structures or payment modalities. This paper proposes a holistic model of a construction procurement system that provides an overview of the many sub-systems and the various protocols that may be chosen within each such sub-system. A survey of previous research into linkages between construction 'procurement' and project 'performance' leads to the formulation of a second model-which portrays such linkages and also incorporates contributory and intervening variables; and provides the basis for a recently commenced comprehensive investigation into the potential impact of procurement system selection on project performance. A third model is formulated to frame a client advisory system that would facilitate the choice of constructive procurement strategies, based on the strengths of the linkages and relationships that are expected to be elicited from the aforesaid investigation. The basis is thereby demonstrated for selecting a system of compatible and synergistic, project-specific performance-oriented procurement protocols.

Keywords: expert system, procurement, project performance.

1996, **2**(2), 52–68

The constraints to effective information flow in the construction management procurement system

Gidado, K[1] and Barter, G[2]
[1]*Department of Construction, Geography and Surveying, University of Brighton, UK*
[2]*Schal International Limited, Surrey, UK*

The construction industry seems to suffer from a general inability to manage design information. The problem is that of a lack of understanding and good communication between design and construction teams. Information is often not delivered from the design team at the right time or in the right form to the contractor to allow construction of the project to time, cost and quality objectives. The process of information flow between designers and construction managers is described in a construction management procurement setting. The constraints affecting the process are identified with regard to achieving project savings in cost and time and quality control. A conceptual model has been developed with a view to aiding effective management of information flow between the designers and construction managers. The concept proposes a model by which information can be effectively managed through the integration of design, selection and construction phases of a project. Literature search, practical experience, and structured interviews with experts in the industry form the basis of the work described in the paper.

Keywords: construction manager, designer, information flow, procurement.

Journal of Construction Procurement

1996, **2**(2), 69–82

Selection factors and success criteria for design-build in the USA and UK

Songer, A D[1]; Molenaar, K R[1] and Robinson, G D[2]

[1]*Department Of Civil, Environmental & Architectural Engineering, University Of Colorado, USA*

[2]*Centre For Strategic Studies In Construction, University Of Reading, UK*

Today's owners of constructed facilities are increasingly investigating a variety of alternative procurement methods. These methods include design-build, turnkey, and construction management. A tremendous growth in design-build and limited existence of documented research on owner's attitudes toward design-build necessitates a focus on this particular delivery strategy. To address the area of selecting design-build procurement strategies, a comprehensive research study was conducted on USA and UK owners for constructed facilities. The results from a survey of 137 owners are discussed to determine expectations of success and quantify reasons for selecting design-build. Success criteria identified and analysed include; on budget, on schedule, and conforms to user's expectations. Selection factors identified and analysed include: establish cost, reduce cost, establish schedule, shorten duration, reduce claims, large project size complexity, and constructability/innovation. The study concludes that owner's most frequently select design-build to shorten duration. Owners expect that the single point of responsibility and the ability to fast-track design and construction inherent in the design-build process will shorten the delivery process. It is also the conclusion of this study that owners judge project success by budget variation, schedule variation and conformity to expectations. Although the main motivation for choosing design-build as an alternative delivery method is to shorten duration over other procurement methods, the criteria for judging its success are the same.

Keywords: design-build, procurement, project selection, project success.

JCP: Volume 3, 1997

1997, **3**(1), 3–15

Impact of culture on construction procurement

Ngowi, A B
Department of Civil Engineering, University of Botswana, Botswana

In the traditional societies of Botswana and in many such societies, construction activities were carried out by the members of the community which owned the work. These members shared the same ways of thinking, feeling and acting, and there was general harmony in construction activities because the actions of each member of the construction team could be predicted fairly accurately. Over the years, the situation in Botswana has changed. Construction is no longer the domain of the members of the community where the work is being carried out. International finance, scarcity of skilled labour and sophistication of the works, have made it necessary to seek solutions wherever they are available. This has brought about situations in which the members of the construction team are assembled from different countries, with different cultures and hence different ways of thinking, feeling and acting. A study was undertaken in Botswana to determine the impact of cultural backgrounds of the project team members on innovations in the procurement systems adopted. The empirical findings of Hofstede (1984, 1991) and other researchers on dimensions of culture were used to predict the behaviours of team members in projects procured through the traditional procurement system (TIPS). It was found that in the projects in which the team members were from different cultural backgrounds, there were inhibitions to innovation compared to the ones in which the team members had similar cultural backgrounds. It was concluded that, cultural backgrounds of project team members should be taken into consideration in project management, to create a conducive environment for innovation.
Keywords: Botswana, communication, culture, innovation, procurement.

1997, **3**(1), 16–27

Risk allocation: an essential tool for construction project management

Cheung Sai-On
City University of Hong Kong, Department of Building and Construction, Tat Chee Avenue, Kowloon, Hong Kong

Construction project management involves the planning, organizing, directing, and controlling of company resources for the completion of a project development. Project success is usually measured by the achievement of the time, cost, quality and maximizing resource utilization objectives. The achievement of these objectives can also be measured by the incidences of claims and disputes and their resolution. Dispute prevention is then one of the major tasks in construction project management. Equitable risk allocation has been identified as one of the strategies that would reduce the incidences of claims and disputes. This paper discusses the current unified risk allocation movement in Australia. This paper also reports a study that seeks to compare and detect any divergence between the risk allocation pattern as eiicited through interviews with senior personnel in the construction industry and that as interpreted from a standard form of contract commonly used in the State of New South Wales, Australia.
Keywords: dispute, perception, project management, risk allocation, standard-form contract.

1997, **3**(1), 28–41

Strategic alliances in building construction: a tender evaluation tool for the public sector

Hampson, K and Kwok, T
School of Construction Management, Queensland University of Technology, Australia

Building construction is a highly competitive and risky business. This competitiveness is compounded where conflicting objectives amongst contracting and subcontracting firms set the stage for an adversarial and potentially destructive business relationship. Clients, especially those from the public sector, need broader tender evaluation criteria to complement the traditional focus on bid price. There is also a need for change in the construction industry-not only to a more cooperative approach between the constructing parties-but also from a confrontationist attitude to a more harmonious relationship between all stakeholders in providing constructed facilities. A strategic alliance is a cooperative relationship between two or more organizations that forms part of their overall strategies, and contributes to achieving their major goals and objectives. Strategic alliances in building construction may provide a useful tool to assist public sector construction managers evaluate tenders and concurrently encourage more cooperative relationships amongst construction stakeholders. An overview of the Australian building construction industry is followed by a review of the existing strategic alliance literature and an analysis framework, comprising six attributes of strategic alliances for application to construction organization: trust, commitment, interdependence, cooperation, communication, and joint problem solving. These attributes are currently being used to collect data from 70 building construction firms in Queensland to assess their respective levels of strategic alliance. Given the trend towards broader indicators of construction firm performance, these attributes are proposed as a tool for use in the tender evaluation process for public works.
Keywords: Australia, public sector, Queensland, strategic alliancing, tender evaluation.

1997, **3**(1), 42–55

Construction time performance and traditional versus non-traditional procurement methods

Walker, D H T
Department of Building and Construction Economics, RMIT, Melbourne, Australia

Research into construction time performance (CTP) suggests that inter-team working relationships, created and maintained when using a traditional procurement approach for construction projects, fail to create an environment where the construction team can best contribute its expertise to achieve a fast build rate. Numerous attempts have been made to explain why this may be so, using case studies as exemplars of best practice. It is generally agreed that traditional procurement approaches tend to set the constructor in a lower position of authority with respect to the design team and thus sound practical constructability advice is not properly considered. Many researchers believe that traditional procurement systems tend to isolate the clients representative from the manager of the construction process. It has also been unclear whether this applies to the construction industry in general or only to categories of construction projects such as commercial office or shopping centre construction. Recent research findings, which help bridge a gap in construction time performance knowledge, provide evidence that can be used to explore possible reasons for good construction time performance across a wide range of construction categories. The work reported upon in this paper helps to explain why traditional procurement projects perform less well than systems that include the manager of the construction process as a valued consultant, early in the projects development. Results clearly indicate that sound working relationships between the construction management team and the clients representative team help achieve good construction time performance. These results also indicate that sound planning and risk management for project time control strongly affects construction time performance. Furthermore, the research results clearly indicate that early involvement of the construction management team in project design assists with time planning and control.
Keywords: construction time, procurement, project management.

1997, **3**(1), 56–69

The role of education as an agent of change: a two-fold effect

Hindle, R D[1] and Muller, M H[2]
[1]*Department of Construction Economics and Management, University of Cape Town, South Africa*
[2]*Old Mutual Properties, Johannesburg, South Africa*

Several aspects of change to the procedures in the construction delivery process have been described in recent times, particularly those affecting building procurement systems. This paper describes the results of an investigation into one of the underlying causes of such change, particularly that which is affecting the traditional roles of the various parties that participate in the construction procurement process. It is proposed that one of the 'agents' of change is the product of tertiary education programmes that have been producing 'professional builders'. It describes how a new generation of builders, equipped with business skills and an inherent dissatisfaction with the traditional structure and procedures of the industry, are allowing leading construction companies to develop innovative construction marketing strategies and systems. These systems are based upon sound business practice, offer improved customer satisfaction and allow them to get closer to customers. In so doing they are taking over the roles of various built environment consultants who were principal agents and leaders in the traditional building procurement system. In parallel with the development of the professional builder, a decline in the numbers and calibre of craftsmen entering the industry has occurred. It is suggested that a 'cause-effect relationship may exist between these two phenomena.
Keywords: career, change, competitive advantage, education, procurement.

1997, **3**(2), 3–18

The methodology of building economics research

Runeson, G
The Building Economics and Property Research Unit, School of Building, University of New South Wales, Australia

Academic research into building economics is a comparatively new activity, and there is some confusion about both the meaning and the role of research. This paper discusses methodological issues involved in theory formulation and testing, in the context of tendering theory as a theory of pricing building projects. The aim is to demonstrate the need for a methodological debate if building economics is to progress, and that we can learn from related disciplines.
Keywords: building economics, hypothesis testing, methodology, research.

1997, **3**(2), 19–33

Designing a research methodology

Lenard, D[1]; Raftery, J[2] and McGeorge, D[3]
[1]*University of Technology, Sydney, Australia*
[2]*The Hong Kong Polytechnic University, Hong Kong*
[3]*University of Newcastle, Australia*

Using as an example of a recently completed project on innovation culture in construction, it is shown that in mature social sciences, quantitative and qualitative methods may be routinely used in tandem to achieve high levels of authenticity and generalizability. The benefits of 'triangulation' are demonstrated. The key objective is to show that opposing paradigms are

not necessarily mutually exclusive and that tangible benefits may be achieved by using methods stemming from both where appropriate.
Keywords: construction, innovation culture, post-positivism, research method.

1997, **3**(2), 34–44

Quantitative versus qualitative or positivism and interactionism: a reflection of ideology in the current methodological debate?

Root, D; Fellows, R F and Hancock, M
School of Architecture and Civil Engineering, The University of Bath, UK

Currently, there is a debate within the construction management research community which appears to have polarized into a quantitative versus qualitative argument. This paper argues that debate at this level is superficial, because it concentrates on methods rather than methodologies and reflects a lack of appreciation by many researchers of the real issues that have been raised. Underlying the debate on methods is the real issue of the applicability of positivist and interactionist paradigms in construction management research. This paper further proposes that the academic issue of paradigms is at risk of being overshadowed by what can be portrayed as a conflict between two competing 'ideologies', a conflict that is a function of the construction management community rather than the construction management discipline. The paper concludes with an explanation of current research being carried out into culture which seeks to draw together different paradigms and overcome the positivist and interactionist positions which might encourage the development of such ideologies.
Keywords: ideology, paradigm, research method.

1997, **3**(2), 45–55

Developing a more empirical approach to culture, attitude and motivation in construction management research: a critique and a proposal

Rooke, J D
University of Birmingham, School of Civil Engineering, Birmingham, UK

The problem of achieving adequate empirical accounts of culture, motivation and attitudes in construction management research is addressed. The usual association of adequacy with objectivity, causality and quantification is criticized and it is suggested that the concept of Verstehen provides an alternative guide to study. Within this conception, explanations are not primarily causal in form, but concerned with the investigation and explication of meaning. Criteria developed within the discipline of ethnomethodology (EM) and founded in the logic of Verstehen are offered as alternative standards of rigorous analysis. These consist in a requirement to remain faithful to the empirical phenomenon under study and to eschew speculation and ad hoc abstraction.
Keywords: culture, ethnomethodology, motivation, research method, paradigm.

1997, **3**(2), 56–71

Empirical enquiry or metaphysics? Re-specifying the methodological debate

Crook, D
School of Civil Engineering, University of Birmingham, UK

Recent contributions to methodological debate in construction management have highlighted arguments surrounding the use of what have been referred to as 'qualitative' and 'quantitative' approaches to research. Debate at this level is misleading and obscures the real issue at hand: whether researchers in construction management wish to pursue a programme of empirical enquiry or engage in metaphysical speculation. Drawing upon the foundational respecification of sociology offered by ethnomethodology, the construction management research endeavour is examined and requirements for empirical work are outlined.
Keywords: ethnomethodology, research methodology, sociology.

1997, **3**(2), 72–87

Using suitable tools for researching what quality managers in construction organizations actually do

McCabe, S
School of Property and Construction, University of Central England, Birmingham, UK

A study into organizational change in construction firms as a result of the introduction of quality management is presented. The research focused on quality managers. The reasons for this, as well as the decision to adopt an ethnographic research approach, are described. Essentially, this is an account of a personal journey; it provides an assessment of the appropriateness, and more importantly, the inappropriateness of two broad research approaches available to those studying (quality) managers in construction. As such, it does not pretend to be an idealized version of what can, or should be achieved in every situation. Instead, by describing the problems encountered in this study, some useful 'food for thought' is provided for those embarking on similar endeavours.
Keywords: ethnographic research, positivism, quality management, research methodology.

1997, **3**(2), 88–96

Construction research questionnaires and attitude measurement: relative index or mean?

Holt, G D
University of Wolverhampton, UK

The relative index (RI) technique, is used extensively in construction research for analysing structured questionnaire survey response data. That is, RI is frequently employed as a methodology for the measured attitude, in particular, with respect to variables impacting upon construction management issues. This short note describes the characteristics of RI and highlights caveats and limitations governing its use. Using hypothetical data, the paper compares the RI methodology with commensurate observations on 'mean response'. It is concluded that the nature of the Likert scale used within the questionnaire will directly impact the output of the RI analysis in several ways. Further, that should ordinal sorting of variables (based on sample attitude) be the only research requirement, then the more simple measure of mean response will achieve the same results as RI.
Keywords: attitude measurement, questionnaire design, research method.

1997, **3**(3), 3–26

Perceived sources and causes of construction claims

Yogeswaran, K[1]; Kumaraswamy, M M[2] and Miller, D R A[1]
[1]*Department of Civil and Structural Engineering, University of Hong Kong, Pokfulam Road, Hong Kong*
[2]*Miller Scott Wilson (Hong Kong) Ltd, Hong Kong*

Significantly increasing frequencies and magnitudes of claims have accompanied the growth of construction activities in general. A research project was mooted to study possible ways to minimize the frequencies and magnitudes of construction claims in civil engineering projects in Hong Kong. A survey was carried out to gather and compare the perceptions of construction professionals as to the common sources and causes of claims. Based on the responses, a Claim Focus Indicator (CF1) was developed to identify particular sources of claims which would warrant greater attention in minimizing their frequencies and magnitudes. The survey was supplemented by interviews with selected professionals, focusing on their perceptions of the significance and avoidability of the underlying causes of the claims from such significant sources. Relevant results from the survey and conclusions from the interviews are presented, including for example the significance of variations as a source and of 'change of design to suit site conditions' as a cause.
Keywords: claim, contract, Hong Kong, project management.

1997, **3**(3), 27–46

Risk and risk management in project related finance

Price, A D F[1] and Shawa, H H[2]
[1]*Department of Civil and Building Engineering, Loughborough University, Loughborough, UK*
[2]*Bank of Palestine Ltd., Palestine*

The concept of Project Related Finance is introduced along with the main issues that lending banks should take into account when providing a finance package. The use of Project Related Finance for funding construction projects in The United Arab Emirates (UAE) was investigated. The main areas of risk have been identified and the use of guarantees to shift specific risks to interested parties has been discussed. Based upon interviews with lending banks in the UAE, seven factors that have the most significant influence on the banks decision on whether or not to provide finance have been identified and used to provide an overall assessment. Three case studies were used to demonstrate the assessment process. Important aspects of Risk Management have been discussed along with a five-step decision making process for lending banks. A check list was developed and circulated as part of questionnaire to banks and contractors. The responses have been presented to illustrate the degree of acceptability of certain types of risk normally associated with construction projects. Banks consider many of the risks less acceptable than the contractors do. Banks are also more concerned than the contractors with respect to deficiency in working capital and adequacy of reserves. Both banks and contractors are especially concerned about the uncertainty of project completion and contractual matters.
Keywords: bank, finance, risk management.

1997, **3**(3), 47–67

A research methodology for modelling construction design service costs

Blackwood, D J[1]; Sarkar, S[1] and Price, A D F[2]
[1]*School of Construction and Environment, University of Abertay Dundee, Scotland, UK*
[2]*Department of Civil and Building Engineering, Loughborough University, UK*

The increased use of fee competition by construction industry clients has caused providers of professional design services to review their fee estimation and cost control approaches. A research methodology for determining realistic fee estimates for design work using historic cost data is described. It became necessary for the focus of the work to shift from, what appeared at first to be, straightforward applied research to a more fundamental programme of research into design process management. The project is presented as a case study and highlights the difficulty in novel research work of identifying an appropriate hypothesis. The application of a grounded theory approach that facilitated the development of a suitable methodology from a standard research template is described and key decisions on the of selection the research techniques are explained and

justified. The selection and integration of the research instruments are described and conclusions are drawn on the appropriateness of the methodological template to the research programme. Finally, the principal conclusion from the research work, that the potential for rationalization of design cost estimation exists but was limited by the availability of relevant data, is outlined.
Keywords: design cost, estimating, questionnaire, research method, survey research.

1997, **3**(3), 68–77

Ignorantes Procedite: a critical evaluation of the movement for methodological renewal

Runeson, G
School of Building, University of New South Wales, Australia

The interpretativists' argument in the current methodological debate is analysed. The basic differences between the two sides in the debate are demonstrated and some of the implications are outlined. In particular, it is suggested that the interpretativists are opposed to the concept of a social science in its traditional form. The debate is not about different research methods or alternative theoretical systems, but much more fundamental; it is about the nature of science. Hence, the proposition that it is possible to accommodate their views in the traditional research methodology, as some researchers have argued, is misguided.
Keywords: methodology, research method,

1997, **3**(3), 78–88

Construction procurement by Dutch municipalities

Dorée, A G
Faculty of Technology and Management, University of Twente, The Netherlands

Over the last decade the European Union (EU) has had a strong impact on the way public organizations introduce market philosophies in their policies. The EU directives on procurement, the battles against cartels, the globalization and harmonization of markets, all lead to extra attention to the procurement practice of public agencies. The procurement practice of one of these public organizations, the municipalities in the Netherlands, is examined. Statistical data suggest that Dutch municipalities prefer limited tendering procedures, and seem to avoid public tender procedures. Research into the reasons for such preference is reported. Analysis of municipalities' procurement and tendering practice uncovered an intricate mechanism for maintaining project control. Municipalities implicitly use the prospect of future assignments to restrain contractors' misbehaviour. By doing so municipalities reduce uncertainties and risks. Contractors' demeanour becomes more flexible, cooperative and quality orientated because of this mechanism. Through the use of this mechanism the municipality-contractor relationship has developed to a kind of co-makership relation. This phenomenon is categorically overlooked in the standard market paradigms. Bending the procurement and tendering practice towards more public tendering is expected to make project control more troublesome.

Keywords: dispute, Dutch municipality, project management, tendering.

JCP: Volume 4, 1998

1998, **4**(1), 5–15

Has contracting lost its customer focus?

Cox, A and Thompson, I
Centre for Strategy & Procurement Management, University of Birmingham, UK

Despite numerous recommendations for change within the construction industry, there is little agreement or guidance on the most appropriate contracting strategies to adopt. Recent research has indicated that traditional practices still prevail. Most clients recognise the value of a governing relationship over and above the written contract and that this cannot be determined by the content of the clauses alone. This article reports on this research and introduces the Relational Competence approach to align contractual relations with the strategic goals of the client's business.
Keywords: client, contract, relationship, relational competence.

1998, **4**(1), 16–26

Building cost planning and cost information management in South Africa

Bowen, P A[1] and Edwards, P J[2]
[1]*Department of Construction Economics and Management, University of Cape Town, Private Bag, Rondebosch 7700, South Africa*
[2]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, GPO Box 2476V, Melbourne, Australia*

The building cost planning and cost information management practices of professional quantity surveyors in South Africa are investigated through an opinion survey questionnaire. The survey deals with the nature and use of cost models and their associated cost data. The results indicate that quantity surveyors may be failing to adopt new techniques, and face the danger that both models and data may be used in inappropriate ways in cost planning future projects.
Keywords: cost, information management, quantity surveying.

1998, **4**(1), 27–44

Constraints in resources and functions within the process of construction procurement in Malaysia

Abdul-Rashid, K B[1], and Morledge, R[2]
[1]*Jabatan Kerja Raya, Malaysia*
[2]*Construction Procurement Research Unit, The Nottingham Trent University, UK*

Malaysia, through its Vision 2020, aims to become a fully developed and industrialised country by the year 2020. Among the key targets of Vision 2020 is that Malaysia's economy must achieve a rapid and sustainable rate of growth of 7% per annum in GDP for thirty years from 1991. However, due to the relatively small size of the Malaysian construction industry, inadequate construction output may be acting as a constraint on rapid and sustainable growth in the economy. To identify any constraints within the process of construction procurement, which might inhibit the level of construction output, a survey was conducted of Malaysian organizations involved in construction procurement in Malaysia. The findings of the survey indicate that within the process of construction procurement in Malaysia constraints in resources and functions are currently experienced and constraints in resources and functions are perceived to exist in the future for up to five years. The findings, reported in this paper, provide a useful basis to identify and develop strategies to boost and to sustain growth in construction output of the Malaysian construction industry.
Keywords: growth, industry development, procurement, vision 2020.

1998, **4**(1), 45–58

Adapting procurement practices to suit a host country as a probable localization tactic

Abdul-Aziz, A R
School of Housing Building and Planning, Universiti Sains Malaysia, 11800 Penang, Malaysia

Acquiring a local character is one of the cornerstones of going global. By blending into the surrounding environment, contractors are able to conduct operations deep inside national markets with minimal local hostility. Yet localization does have its limits. Excessive localization would only lead to the company losing the benefits accrued from integrating activities across national markets. The integration-localization tension therefore has to be delicately balanced. Previously documented localization tactics adopted by construction companies pertain to personnel, capital, resource utilization, office management, and relations with government administrators. This paper takes a look at another corporate affair-procurement of construction orders-in an attempt to determine whether it too is coupled in any way to the localization motive. By examining the Japanese contractors in Malaysia, this paper demonstrates that the adaptation of traditional construction management practices is the

impetus of pragmatic necessities rather than some supranational agenda. Intermingling of Japanese and Malaysian archetypal dispositions is done with prudency. For performance impact and reputation distinctiveness, on aspects which the Japanese are deemed to have a dominating edge-quality, time, cost, safety and work management-the bias is towards retaining archetypal Japanese approaches. For the same reasons, a skewed inclination towards local norms is observed in contract management due to the Japanese contractors' endogenous deficiencies. These biases become accentuated with increase in project size or complexity.
Keywords: contractor, construction management, globalization, localization.

1998, **4**(1), 59–73

Construction management research and the attempt to build a social science

Seymour, D E and Rooke, J D
School of Civil Engineering, University of Birmingham, UK

The paper challenges the view that the major theoretical and methodological issues in the social sciences have been resolved and that positivism provides the only sound basis for research in construction. By examining the relationship between specialist discourses and natural language and Weber's failure to provide a basis for objective causal explanations of social action, it is argued that the kind of theorizing that Runeson advocates is at best premature and at worst preempts the achievement of a more rigorous and thorough understanding of construction processes. Reporting some empirical research on the design and construction of reinforced concrete structures, the paper seeks to demonstrate some theoretical methodological and practical implications of an interpretive style of research.
Keywords: concrete, research methodology, reinforcement, theory.

1998, 4(2), 77–88

Delivering large scale building projects: a case study

Ribeiro, F L
Instituto Superior Técnico, Departamento de Engenharia Civil, Secção de Estruturas e Construção, Av. Rovisco Pais 1, 1096 Lisboa Codex, Portugal.

This paper aims to help clarify the major problems of project delivery methods for large scale building projects and to contribute to the body of knowledge on construction management with the lessons learned during the development and construction of the Colombo Centre project in Lisbon. Traditional project delivery methods are ill suited for delivering a large size building project. Issues such as developing a project delivery strategy and contractual relationship, project structure, selecting project participants and improving constructaibility are crucial to deliver a large size project on time and under budget. Colombo project used a project deliver approach that combines the strengths of the construction management with design-build methods. This project delivery approach and the management tools described in this paper lead to the overall success of the Combo project, including meeting owner's goals related to cost, schedule, and quality.
Keywords: case study, construction management, partnering, project delivery.

1998, **4**(2), 89–102

The impact of contractor selection method on transaction costs: a review

Lingard, H[1]; Hughes, W P[2] and Chinyio, E A[3]
[1]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology, Melbourne, Australia*
[2]*Department of Construction Management & Engineering, University of Reading, UK*
[3]*School of Construction Engineering and Technology, University of Wolverhampton, UK*

The basic premise of transaction-cost theory is that the decision to outsource, rather than to undertake work in-house, is determined by the relative costs incurred in each of these forms of economic organization. In construction the "make or buy" decision invariably leads to a contract. Reducing the costs of entering into a contractual relationship (transaction costs) raises the value of production and is therefore desirable. Commonly applied methods of contractor selection may not minimise the costs of contracting. Research evidence suggests that although competitive tendering typically results in the lowest bidder winning the contract this may not represent the lowest project cost after completion. Multi-parameter and quantitative models for contractor selection have been developed to identify the best (or least risky) among bidders. A major area in which research is still needed is in investigating the impact of different methods of contractor selection on the costs of entering into a contract and the decision to outsource.
Keywords: bid evaluation, contractor selection, pre-qualification, transaction cost.

1998, **4**(2), 103–115

Risk and risk management in construction: towards more appropriate research techniques

Edwards, P J[1] and Bowen, P A[2]
[1]*Department of Building and Construction Economics, RMIT University, Melbourne, Australia*
[2]*Department of Construction Economics and Management, University of Cape Town, South Africa*

The period 1991-1997 has seen a sharp increase in survey-based opinion research aimed at investigating the risk perceptions and risk management practices of construction clients, professional consultants and contractors. The extent of knowledge gained does not appear to match the research effort and flaws in the research are evident. In this paper the nature and findings of sixteen survey-based research publications are reviewed, and their methodological weaknesses identified. The suitability of the opinion survey research method is questioned. Case studies, with their "rich data" potential, are suggested as a better alternative; and a more effective "soft systems" approach to research and practice in construction and project risk management is advocated.

Keywords: procurement, project management, risk management, soft systems research.

1998, **4**(2), 116–131

Neo-classical micro-economics as an analytical tool for construction price determination

Runeson, G[1] and Raftery, J[2]
[1]*University of New South Wales, Australia*
[2]*The Hong Kong Polytechnic University, Hong Kong*

This paper demonstrates that neo-classical microeconomics is a suitable tool of analysis for the building industry, but that its acceptance requires some change in the way construction economists look at the industry and its output. It examine the history of economics-based discussions of construction price determination by considering the construction economics literature since 1974, and briefly outlines the mainstream economic model of price determination in the context of construction projects. It answers the main arguments which have been advanced against the application of Micro-economic model to construction price determination and demonstrates that this model is not only relevant to construction but also the gains in informative content.

Keywords: construction economics, price determination, tendering, tendering theory.

1998, **4**(2), 132–151

An information technology (IT) map for a generic design and construction process protocol

Aouad, G F[1]; Hinks, J[1]; Cooper, R[2]; Sheath, D M[1]; Kagioglou, M[2] and Sexton, M[1]
[1]*Research Centre for the Built and Human Environment, University of Salford, UK*
[2]*Research Centre for Design, Manufacture & Marketing, University of Salford, UK*

It is widely acknowledged that work undertaken later in any product development process costs relatively more than that conducted early in the process (Gause and Weinbery, 1989). Research currently underway at the University of Salford in the development of a generic design and construction process protocol has highlighted the need for greater "front-end" activity in the process. Many of the potential benefits associated with an improved process can be realised with significant Information Technology (IT) support. Indeed, the IT will only achieve profound change if its introduction and use is linked to changes in the overall conduct of the design and construction process. This paper presents an IT map that supports an improved design and construction process. This IT map should be looked at as an enabler and not as a driver of the process.

Keywords: design, information technology, process re-engineering.

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1999, **5**(1), 5–14

Private Finance Initiative (PFI): UK construction industry response

Jim Birnie
School of the Built Environment, University of Ulster at Jordanstown, Newtownabbey, County Antrim, BT37 0QB, N. Ireland, UK

Few initiatives within United Kingdom (UK) construction have received as much publicity as the Private Finance Initiative (PFI) since it was launched in 1992. The Government, while keen to highlight the amount of project work that has resulted from PFI, has also had to admit that there have been many administrative problems in the implementation. The Construction Industry, while initially interested because of the potential workload, has continued to express doubts about the likely success. This paper examines the history of PFI, and the reasons for the problems. Risk bearing is identified as a major factor and proposals are put forward which may alleviate some of the concerns of the industry.
Keywords: partnership, private finance initiative, procurement, risk, tendering.

1999, **5**(1), 15–26

How innovative is the common law of tendering?

Ron Craig
Department of Civil and Building Engineering, Loughborough University, Loughborough, Leics, LE11 3TU, UK

Traditional design-by-owner remains an important procurement option despite the advances made by design-build in recent years. Contractor-led innovation is important and desirable in both procurement options, yet traditional design-by-owner procurement processes prevent, restrict or even discourage such innovation. Developments in common law are revealed which result in contractual obligations for the procurer which might further inhibit innovation, as the procurer becomes obliged to treat all tenderers equally and fairly.
The theory of the tendering contract is introduce and the problems for the procurer discussed when presented with a non-conforming alternative tender that offers a significant cost-saving against conforming tenders. However, if accepted, puts the procurer in breach of contract to at least one aggrieved tenderer. The conclusion is reached that in order to properly consider alternative tenders without failing in its obligation to treat all conforming tenderers equally and fairly, the owner must make specific provisions within tender conditions which create the power to consider alternative proposals. The owner must also define the permitted scope of such alternatives, and set evaluation criteria and any relevant weighting of criteria which will be applied in a contract evaluation and award process. The owner needs to strike a balance between, on the one hand, restricting or inhibiting innovation, and on the other, permitting such a wide scope of innovative proposals that the solution adopted bears no relationship to the original project for which tenders were invited.
It therefore becomes important for the procurer to design the tender process rules so as to encourage contractor-led innovation, yet at the same time place some limit on the scope for such innovation. The limits must be such that the project delivered is still the project for which tenders were invited. A contract awarded to one tenderer for a product quite different from that which was tendered for probably results in the procurer's breach of the tendering contract' and consequent liability to pay damages to the other injured tenderer(s).
Keywords: competition, design innovation, obligation, procurement, tendering.

1999, **5**(1), 27–41

Strategies to remove or alleviate constraints affecting the processes of construction procurement in Malaysia

Khairuddin Bin Abdul Rashid[1] and Roy Morledge[2]
[1]*Jabatan Kerja Raya, Malaysia*
[2]*Construction Procurement Research Unit, The Nottingham Trent University, Burton Street, Nottingham, NG1 4BU, UK*

This paper is focused upon the development, appraisal and validation of strategies to remove or alleviate the constraints identified in resources and functions within the processes of construction procurement in Malaysia. This is achieved by the development of methodologies for this purpose, which could be repeated in time or adopted in other countries. Respondents in the study were Malaysian organizations involved in the processes of construction procurement in Malaysia. A range of strategies was identified which could be implemented to remove or to alleviate the constraints identified in construction procurement processes. In supporting the proposed strategies, respondents emphasize the important role of government in implementing the strategies to ensure that sufficient importance is given to the strategies and that adequate pace is achieved in their implementation.
Keywords: procurement, Malaysia, strategy.

1999, **5**(1), 58–75

Conflict management and construction project effectiveness: a review of the literature and development of a theoretical framework

Hamoud S Al-Meshekeh[1] and David A Langford[2]
[1]*The General Directorate of Military of Works, Kingdom of Saudi Arabia*
[2]*Professor of Construction, University of Strathclyde, Glasgow, G4 0NG, UK.*

A theoretical model is developed for the investigation of the relationship between construction project effectiveness and the style that project managers adopt when handling conflict. The research method uses 35 case studies in Saudi Arabia, all of them are sponsored by one client: the General Directorate Military of Works/ Ministry of Defence and Aviation (GDMW/MODA) in the Kingdom of Saudi Arabia (KSA). The research seeks to test the relationship of project performance measured by time, costs, quality, conflict intensity, conflict resolution method, and intensity of construction effort. This performance is then linked to the project managers' conflict handling styles. Project managers are employed by (GDMW/MODA) and their contractors. It is hypothesized that project managers who exhibit a conflict management style that seeks to integrate the parties to the contract will run more effective projects.
Keywords: conflict management, project manager, project performance, Saudi Arabia.

1999, **5**(1), 47–57

Risk and risk management in construction projects: concepts, terms and risk categories re-defined

Peter J Edwards and Paul A Bowen
[1]*Department of Building and Construction Economics, Royal Melbourne Institute of Technology University, G.P.O. Box 2476V, Melbourne 3000, Victoria, Australia*
[2]*Department of Construction- Economics and Management, University of Cape Town, Private Bag, Rondebosch 7700, Cape Town, South Africa*

Understanding of risk and risk management in the construction industry is erratic. An attempt is made to redress this situation by reviewing the concepts of risk and uncertainty and by re-defining the terminology. The preferred definition of risk is that it is the probability that an adverse event occurs during a stated period if time. The main context for construction risk management is found to lie in the decision-making aspects of building procurement. A source-based approach to categorizing construction and project risks is proposed, with natural and human systems as the two primary source, categories. Human risks comprise events or actions originating in humanly devised systems are further categorized as social, political, economic, financial, legal, health, managerial, technical, or cultural sources of risk.
Keywords: procurement, project management, risk, risk analysis, risk management, uncertainty.

1999, **5**(2), 88–98

Factors facilitating faster construction

Mohan M Kumaraswamy and Daniel W M Chan
Department of Civil and Structural Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong

Parallel investigations sought critical contributors to faster construction in Hong Kong, within three different building sub-sectors viz. public housing, public non-residential buildings and private sector buildings. Previously identified contributors as noted both from the international literature and from Hong Kong construction projects in general, were supplemented by preliminary interviews of industry experts. The foregoing helped to decide on the different target groups and questionnaire structures for each category. The responses are consolidated within each category using 'Relative Importance Indices'. The more important factors and 'factor categories' are identified, e.g. the 'fast information flow' factor in public non-residential buildings and the 'organization and co-ordination between project teams' factor category in 'public housing' construction. Different factors and factor categories are found to be more important within the three building sub-sectors. Comparisons are also made with the factors that emerge as significant (e.g. 'information flows', 'informal communications' and 'speed of decision making) from a model to predict public housing construction durations that was developed in another parallel study. Strategies for faster construction must focus on such factors that are found to be more significant in particular construction scenarios.
Keywords: duration, Hong Kong, speed, time.

1999, **5**(2), 99–117

Application of analytic hierarchy process to the evaluation of logistics factors and their contribution to improvements in construction materials supply

M Muya, A. D. F. Price, A. Thorpe and F T Edum-Fotwe
Department of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK

As the most important element among logistics elements is customer service, all logistics activities should ensure the highest level of customer service at any given total cost of materials supply. Achieving efficiency and cost-effectiveness in materials

supplies at any preferred level of customer service involves trade-off decision-making among various logistics elements. Thus, managing construction materials efficiently requires an understanding of elements that contribute most to customer service. An evaluation of the importance UK contractors attach to the contribution of various logistics factors to improved customer service in the supply of construction materials has been presented. The analytic hierarchy process was used to quantify the subjective assessment made by contractors on the contribution of various logistics factors to overall improved customer service. The general view of surveyed buyers was that improving contractor-supplier relationships would contribute more to improved customer service in the supply of construction materials by ensuring better reliability, cost -effective sources of supply, increased flexibility, improved lead times and greater value-added service. Traditional elements (such as capability of suppliers (viewed in terms of financial strength, technical ability, and experience), administrative and management ability, quality management systems, quoted prices and locations in relation to projects) were also considered important. The interviewed buyers considered information and communication technologies to have less influence in improving customer service, as were health and safety, and environmental records of suppliers.
Keywords: analytical hierarchy process, material, customer service, logistics.

1999, **5**(2), 118–128

Restructuring the building industry for improved performance

Pertti Lahdenperä
VTT Building Technology, Construction and Facility Management, Tampere, Finland

A fundamental restructuring of the building industry is needed. This is due, firstly, to the observed problems in the present practice. Secondly, it seems that the future business environment will present such challenges that the prevailing organization will not be able to rise to them. This paper suggests some changes to the industry's organization and operational modes, and argues why they need to be made. The suggested changes are based not only on the problems of present practice but also on different general development trends and phenomena of the market and society in general. The main motivation for the change is to accelerate development in the building industry.
The solution was arrived at by the gathering, analysis and synthesis of various actual ongoing development programmes in the building industry worldwide. It offers the best potential for improving the quality, productivity and innovativeness of construction.
Keywords: building process, development, future, innovation, organizing, project.

1999, **5**(2), 129–140

Quality issues in building project price forecasting: factors affecting model selection

Chris Fortune[1] and John Hinks[2]
[1]*School of the Built Environment, Liverpool John Moores University, Clarence Street, Liverpool, UK*
[2]*School of Building Engineering and Surveying, Heriot-Watt University, Riccarton Campus, Edinburgh, UK*

Clients considering the procurement of sustainable building projects as solutions to their accommodation problems are involved in making value-for-money business decisions. One dimension of such decisions is the need to take account of good quality early stage building project price advice. Quality in terms of the provision of early stage building project price forecasts for clients is explored in this paper, and a broader, more multi-stranded approach is advanced that will help to put current research efforts on the development of more accurate price forecasting models into context. In particular, the paper addresses one of these identified research themes, namely the selection of appropriate building project price forecasting model(s) for use. The extent to which practitioners fail to understand price-forecasting models is assessed in terms of the extent to which this creates a barrier to model selection. This is done by reference to the results of a large-scale quantitatively based study that was carried out with over two thousand three hundred practitioner organizations in England. Other, more positive criteria are identified that are suspected as affecting model selection. It concludes by developing a rudimentary framework within which the more influential of these selection criteria can be identified. It is anticipated that the eventual development of a tool to aid model selection by practitioners will contribute towards the provision of better quality building project price advice for clients.
Keywords: forecasting, price advice, modelling, quality, research theme.

1999, **5**(2), 141–158

Updating techniques for cumulative cost forecasting on construction projects

A P Kaka and A H. Boussabaine
School of Architecture & Building Engineering, University of Liverpool, P.O. Box 147, Liverpool, L69 3BX, UK

The use of standard cost/value flow curves (S-curves) in cash flow forecasting has been questioned by many construction management researchers. This is mainly due to the limited accuracy of these curves. This issue is addressed by analysing the cumulative cost flow curves of 128 construction projects. Cost flow profiles vary significantly even when projects are classified using effective criteria. Consequently, two new techniques that are capable of using cost/value flow data of current project are proposed to forecast (update the forecasts of) the remaining, future monthly values of these projects. The two techniques are tested for accuracy using eight recently completed projects. It is concluded that one of the techniques performed accurately and that it should be adopted by the construction industry.
Keywords: correlation, cash flow, cost flow curve, forecasting.

1999, **5**(2), 163–176

Partnering performance in Australia

Thomas E Uher
Faculty of the Built Environment, University of New South Wales, Sydney, New South Wales, Australia 2052, Australia

The concept of partnering was introduced into the Australian construction industry as one of the key elements of the reform strategy formulated and driven by the Australian Government. This paper assesses the performance of partnering based on three recent Australian research studies. The results of these studies are presented in both quantitative and qualitative terms. They provide a useful overview of partnering performance in the Australian construction industry. The findings suggest that partnering has significantly improved the performance of projects by lowering the frequency of disputes and by reducing project cost growth.
Keywords: Australia, cost, dispute, partnering.

1999, **5**(2), 177–186

Partnering: the propaganda of corporatism?

S D Green
Department of Construction Management & Engineering, The University of Reading, PO Box 219, Reading, RG6 6AW, UK

A critical perspective on partnering is developed with reference to current concerns regarding the increasingly corporatist nature of global capitalism. Many leading clients advocate partnering as a means of improving customer responsiveness and ensuring continuous improvement. The seductive rhetoric of partnering too often serves only to disguise the crude exercise of buying power. In the UK, the four largest supermarket chains are all leading advocates of partnering. Ironically, the grocery sector has attracted sustained public criticism regarding its exploitative supply chain management practices. Evidence suggests that the resultant savings are not automatically passed on to customers. Despite these concerns, the large supermarkets continue to preach 'customer responsiveness' to a seemingly gullible construction industry. It is argued that the doctrine of customer responsiveness ultimately owes more to corporatist propaganda than to progressive management policies. The buying power of the industry's major clients continually discourages dissent to the partnering ideal. Construction companies that are not similarly committed risk being denied access to a substantial proportion of the UK market. The increasing influence of industry on the construction research agenda also discourages academics from challenging the legitimacy of partnering discourse. There is an urgent need for research which is independent of commercial vested interests.
Keywords: continuous improvement, corporatism, critical theory, customer responsiveness, partnering, technocratic totalitarianism.

1999, **5**(2), 187–196

Procurement lessons from Solomon's temple project

Stephen O Ogunlana
School of Civil Engineering, Asian institute of Technology, Thailand

The search for new ideas capable of improving the procurement of facilities is continuing. New systems and methods are being developed within the industry and others are being adapted from other industries. There is general agreement that adversarial relationships are not beneficial and, as such, they should be avoided. Consequently, design and build and other partnering systems are in vogue. In this paper, it is argued that the industry can learn lessons from history. The Jerusalem temple built by King Solomon is a classic example of a project executed to the satisfaction of all the parties involved. The project was executed in an atmosphere of trust, good organization, recognition of expertise and good communication, thus providing valuable lessons that may help in improving harmony on today's projects.
Keywords: culture, communication, expertise, relationship, trust.

1999, **5**(2), 197–210

Future challenges in construction management: creating a symbiotic learning environment

Dennis Lenard
Faculty of Design Architecture and Building, University of Technology, Sydney, Australia

The next wave of industrial development will necessarily incorporate the adoption and utilization of innovative technological processes and developments, and see the emergence of highly focussed organizations capable of exploiting transient and niche markets. This environment demands a responsive and dynamic construction industry with the diversity to cope with and initiate change, which is capable of employing a range of approaches to the procurement and delivery of construction projects. A research study was initiated in late 1996, the aim of which was to test the hypothesis that the level of innovation is higher on projects where the client actively imparts knowledge gained from the global arena to the contracted parties involved in the construction procurement process. The study examined the role of the client and the main contractor and the nature of the relationship between these two parties. Overall the study indicates that the level of innovation and the ultimate success of a project is highly dependent on four key factors: the client's recognition of the need for innovation; contractual incentives to encourage innovation; creation of symbiotic learning environment; · open communication at all levels. Rather than one party being passive in the process, the studies suggested that the two parties assumed a symbiotic relationship, where each gained from the knowledge and experience of the other. Moreover, in these instances, rather than driving innovation the principal role of the client was to create an environment conducive to innovation and learning. Given this scope and the freedom to innovate, the main contractor would capitalize on these opportunities, once again to the benefit of both parties.
Keywords: culture, innovation, learning.

1999, **5**(2), 211–220

Procurement as a learning process

Robert Newcombe
Department of Construction Management & Engineering, The University of Reading, PO Box 219, Reading, RG6 6AW, UK

The way in which people learn from experience and conduct experiments in self-improvement has been analysed by many writers. In particular, Kolb's learning cycle and the single and double loop learning postulated by Argyris and Schon has been used to explain how learning takes place in organizations. Creating the 'learning organization' is a current preoccupation of management theory and practice. With few exceptions little of this accumulated knowledge about learning in organizations has been applied within the project context and even less within the construction project situation. This paper will argue that different procurement paths encourage or discourage different types of learning. For example, the traditional design-tender-build method based on competitive tendering does not allow original design concepts to be challenged by the builder and therefore prohibits double loop learning. Equally, learning from experience can only occur where there is opportunity to reflect on those experiences and compare them with mental models, which is then followed by experimentation; design and build methods may allow this to occur, as may some of the management methods of procurement. Partnering is clearly a vehicle for experiential learning. The link between learning and project performance is also discussed and the need for a new role of Learning Facilitator is argued. It is vital that we understand the link between learning and procurement if we are ever to improve the efficiency and effectiveness of construction projects.

Keywords: learning, organizational learning, procurement, project.

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2000, **6**(1), 4–19

Strategic procurement in the construction industry: mechanisms for public sector clients to encourage improved performance in Australia

Russell Kenley,[1] Kerry London[1] and Jeremy Watson[2]
[1]*Faculty of Architecture, Building & Planning, University of Melbourne, Melbourne, Australia*
[2]*Department of Transport and Infrastructure, Darwin, Northern Territory, Australia*

The construction industry is dominated by procurement methods that encourage short-term competitive behaviour, driven by price competition. The Australian Procurement and Construction Council has been seeking alternatives in procurement methods, designed to achieve breakthrough change in the Australian industry. This paper examines five attributes of long-term competitive behaviour desired by the APCC and uses competition theory to argue why such behaviour is desirable. Procurement strategies that involve rewards or incentives are examined from the literature, and assessed against their contribution to the desired attributes. As part of the assessment, a new performance incentive selection method is described, which involves calculation of a contractor's competitive assessment score to enable either rewards or incentives for change. Finally a table of mechanisms is described, against which it is possible to categorize rewards and incentives for change.
Keywords: procurement, strategic procurement, tendering, pre-qualification.

2000, **6**(1), 20–32

Assessing the procurement practices of housing associations: a case study of new build in Scotland

Barry Goodchild and Christina Beatty
The Centre for Regional Economic and Social Research, Sheffield Hallam University, UK

Housing association procurement practices in Scotland have been distinctive in their reliance on a combination of traditional contracts and negotiated design and build on the contractor's site. Housing associations have to use design and build if they develop on a site owned by the contractor. On the other hand, most see advantages in the traditional method for promoting community involvement and ensuring close control over the contractor. They also do not believe that cost variations are substantial. Though distinctive, the experience of procurement by Scottish housing associations provides general lessons about procurement practices. The Scottish experience of social housing points to the involvement of the contractor in land ownership as a significant variable and emphasises the varied practice requirements that influence the choice of method and constrain innovation. The experience also shows the limitations of research, given the usual difficulties in the interpretation of cost data, the importance of subjective judgements of quality and the varied conditions in which schemes are undertaken.
Keywords: cost, innovation, procurement, social housing.

2000, **6**(1), 33–43

Viability of privatized transportation projects: an evaluation tool for design/build teams

James Diekmann,[1] David Ashley,[2] Richard Bauman,[3] Jim Carroll[4] and Frank Finlayson[5]
[1]*Department of Civil, Environmental and Architectural Engineering, University of Colorado-Boulder 80309, USA*
[2]*College of Engineering, Ohio State University, USA*
[3]*MK Centennial Corporation, USA*
[4]*Fluor Corporation, Greenville, SC, USA*
[5]*Project Finance, Morrison Knudsen, Boise, ID, USA*

This article describes a tool to help potential developers of privatized design/build transportation facilities identify high quality projects; the tool is called the Project Scoring Table (PST). Development of the PST occurred after a thorough literature review and extensive fact-finding interviews. On one level, ignoring its evaluative functions, the PST provides a concise compendium of issues important to privatized transportation projects. On another level, the PST is an evaluation tool for privatized transportation projects. The PST identifies nine high-level evaluation criteria for a privatized project, ranging from the political circumstances of the project to its environmental cleanup needs. Using the PST helps both the public agency and their private partner evaluate potential projects in three ways. First, it helps establish the overall viability of the project. Second, it helps define the balance between owner and design/builder. Finally, it helps the partners define where their interests are coincident and where they diverge.
Keywords: design-build**,** public private partnerships, privatization, transportation development, infrastructure, project delivery.

2000, **6**(1), 44–55

Work-group communication patterns in design and build project teams: an investigative framework

David R Moore[1] and Andrew R J Dainty[2]
[1]*Department of Building Engineering, UMIST, Manchester, UK*
[2]*School of the Built Environment, Coventry University, Coventry, UK*

The manner of a work-groups' response to unexpected variations (change instructions) under UK design and build (D&B) arrangements is generally seen as being governed by the single point responsibility that this form of procurement promotes. Moreover, the task-oriented management structures which would be expected of the construction phase of this type of contract are typically focused upon the production process. However, these perceptions rely upon the supposition that communicative interfaces have little influence within such project environments, regardless of the level of synergy that the work-group has attained. Previous research has not informed the industry as to whether that is the case, as it has focused on the relationship of the end product with value for money, and not the formative aspects of the D&B process. This paper presents a research framework which takes a human focused perspective on D&B work-group efficiency. It suggests potential communication pattern problems within design and build work-groups, and specifically those resulting from change instructions imposed by clients. A range of potential barriers are identified, which suggest a need for a wider study examining intra-work-group cultures across a range of D&B project scenarios. An innovative methodology is put forward for such a study based on a 'systems theory' approach. Its focus is on establishing the different perspectives, attitudes and behaviours of the work-group members in responding to change. By taking a holistic view of work-group interaction, it explores the professional, communicative and attitudinal interfaces that have a detrimental effect on information flow and problem solving efficiency.

Keywords: change instruction, conflict, design and build, professional culture, work-group efficiency.

2000, **6**(1), 56–66

Identifying research requirements for collaborative design

Andrew N Baldwin and R McCaffer
Department of Civil and Building Engineering, Loughborough University, UK

Concurrent Engineering places great emphasis on input to the design process from all those involved with the product. This requires traditional approaches to the design process to be replaced by a co-ordinated collaborative approach. The construction industry lags behind other industries in this approach to the design of their products. Other industries are more customer-focused and more advanced in their practices for identifying client/customer requirements. They also require representatives from design production and maintenance functions to participate in the design process. Product design is carefully managed to ensure all relevant parties have the information they require to complete their work at the optimum time to minimize the 'time to market'. Construction industry experts, both academics and practitioners, attended a two-day workshop together with experts from other industries to discuss a new approach to design for construction. Debate was generated through: the presentation of individual papers; an 'electronic forum' whereby the attendees could comment anonymously on the issues raised; and by discussion in both an open forum and syndicate groups. Opportunities, issues and initiatives were discussed. The debate was managed by a professional facilitator. The focus of the discussion centred on three themes that emerged: briefing, quality and the management of change. The experts identified the application of focus group methods to construction and the study of client entry points to the briefing process as the priority areas for research into the briefing process. Strategies for introducing change into the design process and informed assessment of the design construction and operational process were considered the most important research areas for the management of change and improved quality of the construction product.

Keywords: collaborative working, client requirements, design, focus group.

2000, 6(1), 67–84

First steps towards achieving environmental sustainability for developed projects: a holistic life-cycle procurement objective

Peter M Graham and Derek H T Walker
RMIT University, Melbourne, Australia

The triple-bottom-line concept holds that performance should not be judged on financial measures only. Both environmental and social sustainability form part of a necessary holistic system that compliments economic performance measures of viability from a longer term perspective than current short-term financial bottom line measures. Holistic life-cycle environmental sustainability of development projects will be one of the great challenges of the third millennium. To demonstrate a positive contribution to sustainable development, any company/project must not only deliver sound financial success but must also contribute beneficial social as well as environmental outcomes. This triple, rather than single, 'bottom line' presents acute challenges to business enterprises. This paper addresses the environmental sustainability dimension of the triple-bottom-line by presenting results of research into conducting environmental sustainability performance assessments using existing environmental performance assessment techniques for building development. If clients procuring development projects are going to take environmental sustainability seriously, then they will require procurement and policy procedures to ensure that key performance criteria for sustainable construction are defined, specified and incorporated both into the selection criteria for project participants

and also into contractual documents. This is already occurring on some projects, for example the Australian National Museum project. Further, they must be aware of available tools that can measure project compliance with full life-cycle sustainable construction goals established by clients as part of a broader and more holistic set of project goals.
Keywords: sustainable construction, environmental assessment.

2000, **6**(2), 90–103

Emerging issues in procurement systems

Steve Rowlinson[1], Jason Matthews[1], Florence Phua[1], Peter McDermott[2] and Tom Chapman[3]
[1]*Department of Real Estate and Construction, Hong Kong University, Hong Kong*
[2]*Research Centre for the Built and Human Environment, The University of Salford, UK*
[3] *Hong Kong Productivity Council, Hong Kong*

A brief review of the work of CIB Working Commission 92 to date picks out past themes and major developments and culminates in a discussion of likely future directions for the working commission, in particular, and procurement systems research in general. The theme of the W92 symposium in Montreal, innovation, is addressed and the emerging issues in procurement systems analysed and discussed within this context. The aim of the discussion and analysis is to answer the question "where is procurement systems research going to?"
Keywords: procurement system, sustainability, organizational learning, partnering, culture, information technology.

2000, **6**(2), 104–120

An investigation into simulating the procurement process in the UK construction industry

Robert Newcombe
Department of Construction Management & Engineering. University of Reading, PO Box 219, Reading, RG6 6AW, UK

A contingency approach is developed for the selection of an appropriate procurement path for construction projects in the UK construction industry. After a review of the recent UK literature and construction industry reports on procurement, the design, development and testing of a construction procurement simulator is described. A description of the simulator, which requires participants to select an appropriate procurement path for four different types of client, and the procedure for running it are outlined. The results of the testing of the simulator with a sample of 172 construction managers and professionals indicate that the selection of an appropriate procurement path is not as obvious as it sometimes appears and divergent choices are sometimes argued. It is argued that the development of a science of procurement, based on completing simple matrices of client and project characteristics, is unlikely to be realized. The simulator offers the opportunity to develop skills in analysing and translating a client's needs into an apposite procurement path. The results also confirm that exposure to a course of study in which procurement approaches are examined in detail improves the consistency of the selection process due to a predictable learning curve.
Keywords: construction industry, procurement, simulation, UK.

2000, **6**(2), 121–134

Procurement system evaluation for the construction industry

M D Ambrose and S N Tucker
CSIRO Building, Construction and Engineering, PO Box 56, Highett, Victoria 3190, Australia

Successful building procurement depends upon selecting an appropriate procurement system specifically to match the requirements of the client, contractor and the project, particularly in a construction environment where new and untried systems are part of improving procurement by re-engineering the process. This does not necessarily mean that any of the existing procurement systems cannot be the best solution; indeed many have strong features that are ideally suited to many projects. However, it is important to encourage development of new systems and provide tools which enable improvement and innovation to occur. The evaluation procedure described in this paper provides an effective way of determining procurement system performance for a particular project, taking into account the interactions between client needs, project characteristics and procurement process system features. Existing and previous evaluation systems are reviewed briefly, their main characteristics identified and the few evaluation techniques appraised, as well as previous investigations of factors influencing the selection of a procurement system. A range of factors has been identified as describing the requirements of a procurement system and thus influencing the decision on which procurement system to use. The relative contributions of the factors to the success of a project are determined through an interaction matrix, and from these a single value is calculated to rank the possible procurement systems, taking into the account the client objectives and the characteristics of the project.
Keywords: construction process re-engineering, procurement, project management, project delivery.

2000, **6**(2), 135–146

The reasons why clients prefer to procure more projects based on design-bid-build than design-and-build

Y Y Ling, H Y Khee and K S G Lim
School of Building and Real Estate, National University of Singapore, Singapore

Design-and-build (DB) projects are known to achieve better performance than design-bid-build (DBB) projects. However, the use of DB is still not widespread in many countries. A survey was carried out to find out why clients are not procuring more projects using DB. Data were collected via mailed standard questionnaire. Respondents, who were clients based in Singapore, were selected based on convenience sampling. The questionnaire requested respondents to indicate on a five-point scale the degree to which they agreed or disagreed with seven performance issues relating to DB projects, as compared to DBB projects. Data obtained from the survey were processed and statistical t-test of the mean was carried out. Another survey was conducted among DB contractors in Singapore, to compare their views with those of the clients. It was found that clients did not procure more projects based on DB because they felt that they need to bear more risks, DB projects do not have price certainty nor high quality, and maintenance issues are not considered in DB projects. It was found that DB contractors did not agree with the views of the clients. It is recommended that in order to persuade clients to procure more projects based on DB, contractors should convince them that there would be price certainty and deliver high quality DB projects. They should also invite clients to attend their value engineering sessions, for clients to see first-hand that maintenance issues are considered in DB projects.
Keywords: cost, design-build, design-bid-build, quality, time.

2000, **6**(2), 147–163

A theoretical framework for selection of consultants by design-build contractors

Yean Yng Ling
Department of Building and Real Estate, National University of Singapore, Singapore

A theoretical framework based upon grounded theory is suggested for the selection of design consultants by design-build (DB) contractors. Data were collected from secondary data search and in-depth interviews with seven contractors in Singapore who have extensive experience in DB projects. The framework was constructed based on economic theory of the firm, social psychology's network theory of embeddedness, and personnel psychology's theories on selection of employees. The framework proposes four main factors that determine whether a consultant is suitable to be selected or not: 'task performance factor', 'contextual performance factor', 'relationship factor', and 'price factor'. Further criteria were developed from these four main factors. The criteria previously used by the interviewees to select consultants could be classified under the first three factors identified from the literature search. They did not identify any criteria under the 'price factor'. The constructed framework and the possible criteria may be used for the purpose of procuring the services of consultants for DB projects.
Keywords: consultant selection, contextual performance, design-build, fees, procurement, task performance, relationship.

2000, **6**(2), 164–183

Production management: the process protocol approach

Angela Lee, Michail Kagioglou, Rachel Cooper and Ghasssan Aouad
University of Salford, UK

Production management, a generic managerial discipline, has developed in an evolutionary way based upon a variety of manufacturing philosophies. For instance, there is a range of customer and supply-chain orientated principles, front-end integrated cross-functional teams, and process models that incorporate learning mechanisms for continuous improvement. These are finding increasing acceptance and application in many management domains. However, their application within the design and construction process has not been consistent or integrated fully, as there has been little work in promoting the principles of production management into the industry both in theory and practice. This article argues for the wider acceptance of all of these theories into construction and describes their incorporation in the Generic Design and Construction Process Protocol (GDCPP). The opportunities for implementing 'production management' practices within the design and construction process are also discussed against current UK procurement routes and processes.
Keywords: construction process, design process, front-end, process protocol, production management.

2000, **6**(2), 184–201

Can process capability be used to manage the construction supply chain?

M Finnemore, M Sarshar, R Haigh, J Goulding, P Barrett and G Aouad
Research Centre for the Built and Human Environment, The University of Salford, UK

Recent construction industry reports by Latham [1994] and Egan [1998] have emphasized the call for the construction industry to increase productivity and improve quality. The Egan report in particular urged the industry to focus on

construction processes. However, the industry has no recognized methodology or framework on which to base a process improvement initiative. SPICE is a current research project that is developing an evolutionary step-wise process improvement framework for the construction industry. The research has drawn specifically on the Capability Maturity Model (CMM) which has been used successfully in the IT sector for both process improvement and supplier assessment. This paper first introduces the SPICE concepts and the research to date which has investigated the validity of the framework and the suitability of the assessment. An overview of the findings is given. The paper then goes on to suggest how the SPICE framework may be used in supply chain capability assessment and supply chain integration.
Keywords: capability maturity model, construction operations, process improvement, SPICE, supply chain.

2000, **6**(2), 202–219

Assessing potential of on-line transaction for information as resource in the construction process

F T Edum-Fotwe, A Thorpe and R McCaffer
Department of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, UK

A survey is presented on the practices associated with the use information by a sample of professionals within the construction industry. From the early 1990s the role of information in the construction process has witnessed a shift from its passive supportive role in decision-making to a strategic resource that drives both the processes and competitiveness of organizations. This changing trend will continue into the future and present a situation whereby construction and engineering project companies will be required continually to increase their overall effectiveness, level of co-operation, flexibility and response time to the customer. At the same time there will be the need to meet increasing demands of competition and innovation for their processes and the industry's products. To attain such flexibility, this paper calls for construction to view information as a resource. The availability of on-line access to information as a resource required for the operation of such companies and the industry's processes should enable construction and engineering companies to better adapt to this pace of change. Adopting on-line options for managing construction as a resource will have to overcome current paper-based practices, attitudes and fears.
Keywords: information, procurement, information technology, survey, transactions on-line.

2000, **6**(2), 220–230

Feedback in competitive fee tendering

Derek Drew, Heng Li and Li Yin Shen
The Hong Kong Polytechnic University, Hug Hom, Kowloon, Hong Kong

Competitive fee tendering is gaining popularity in the construction industry as a mechanism for allocating consultancy work to architects, engineers and surveyors. It appears though that many construction industry clients are not fulfilling their responsibilities in providing their tendering consultants with sufficient tendering feedback information. This paper compares the amount of feedback that consultants are receiving from clients with the level of feedback information that consultants want from clients and seeks opinion on whether consultants would welcome certain major public sector clients publishing consultancy award details. A questionnaire sent to Hong Kong quantity surveying consultants reveals that 89% of consultancy work is allocated through competitive fee tendering. Although the majority of consultants keep systematic records of bid data, only two major Hong Kong construction clients are providing these consultants with detailed feedback information. The vast majority of consultants want information on the number of competing consultants (at the time of issuing tender documents) and identity of the successful consultant and corresponding fee and technical quality score plus the corresponding fee and technical quality scores of all the unsuccessful consultants (after award of contract). Opinion is almost equally divided on whether major public sector clients should publish consultancy award details. In addition to the job by job feedback, the vast majority of consultants would also like regular clients of the construction industry to provide them, on a periodic basis, with consolidated tender feedback information in the form of summary statistics.
Keywords: bidding, consultant, feedback, fees, quantity surveying, tendering.

2000, **6**(2), 231–145

An investigation into predicting materials suppliers' profits

J Nicholas, G D Holt and P T Harris
University of Wolverhampton, UK

For the majority of construction contractors, materials suppliers provide an intrinsic form of working capital via the credit they furnish. Generally, more than 70% of suppliers' turnover is accounted for by credit sales; thereby highlighting the importance of accurate contractor (creditworthiness) evaluation, and effective debt collection procedures. This research models suppliers' credit control and debt collection practices to predict the (average) annual profit that will result from purveying credit to a contractor. Suppliers must generate profit to ensure continued survival and retain investor commitment. Hence, understanding of potential profit enhancement would be welcomed, particularly, when one considers the volatile environment within which construction operates. Using multivariate discriminant analysis, data from a survey of UK suppliers' credit control and debt collection procedures is modelled. The developed MDA models portray good predictive performance (statistics), but their overall accuracy is hindered

somewhat by the variability of the data; this results from the substantial differences in procedures implemented by suppliers' credit control and debt collection methods.

Keywords: contractor, credit risk, discriminant analysis, profit, material supplier.

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2000, **1**(1), 1–8

Effecting safety in affordable housing projects using automation

Richard J Coble[1] and Theo C Haupt[2]
[1]*Centre for Construction Safety and Loss Control, M.E. Rinker Sr. School of Building Construction, University of Florida, Florida, USA*
[2]*College of Architecture, University of Florida, Gainesville, Florida, USA*

Automation can be used effectively to reduce accidents during the erection of affordable housing units. The consequences of automation would, *inter alia*, be to completely eliminate the exposure of construction workers to hazardous activities, reduce the amount or duration of exposure to the hazards, or reduce the number of workers exposed to the hazards. This paper discusses how safety performance can be reinforced, and even improved, through automation integrated into the field construction process through on-site multimedia training presentations. Technologies such as CAD, CAM, hand held computers, bar coding and multimedia such as simulation are referred to.
Keywords: affordable housing, automation, CAD, CAM, pre-fabrication.

2000, **1**(1), 9–17

Preliminary research into internal marketing as a strategic business philosophy in construction contracting

Christopher N Preece and Ihab I M Khalil
Construction Management Group, School of Civil Engineering, University of Leeds, UK

Internal marketing is a topic that has received little attention in construction by academics and practitioners alike. This paper, first, provides a theoretical outline of internal marketing focusing specifically on service sectors, second, defines the subject in the context of organizations operating in the highly competitive market environment of construction and third, presents the outcome of preliminary research with major contractors. The research has confirmed that a significant barrier to the successful implementation of internal marketing as a strategic philosophy is the construction industry business culture. The authors argues that unless there is a greater understanding of the internal marketing philosophy, and an appreciation of the need to integrate marketing with human resource practices, contractors will not be able to develop and sustain service strategies that satisfy their external clients.
Keywords: internal marketing, construction, contractor, strategic marketing.

2000, **1**(1), 19–31

Quality system QS 9000 for construction: is the industry in Singapore ready?

Low Sui Pheng and Raymond B L Lim
School of Building and Real Estate, National University of Singapore, Singapore

ISO 9000 quality management systems have been in place in the construction industry for some time. As part of *kaizen* or continuous improvement, there is a need for organizations with existing ISO 9000 certification to upgrade their systems. For this purpose, QS 9000 quality system requirements, which were developed from the automobile industry in the USA, are examined for application in the construction industry. Apart from tracing the background to both ISO 9000 and QS 9000, the authors also examine whether the construction industry is ready to receive the latter. A postal survey was conducted for this purpose and the study suggests that there is indeed scope for the inclusion of some aspects of QS 9000 to improve existing ISO 9000 quality management systems of construction firms.
Keywords: ISO 9000, QS 9000, quality, construction, automobile industry.

2000, **1**(1), 33–42

A study of real estate trust institutions in Korea

J Kim[1], Sang-Young Lee[2], and Denny McGeorge[1]
[1]*Faculty of the Built Environment, The University of New South Wales, Sydney 2052, Australia*
[2]*Construction and Economy Research Institute of Korea, Construction Building 9, 11F 71-2 Nonhuyn-dong, Kangnam-gu, Seoul, Korea*

In Korea, Real Estate Trust Institutions were introduced in the early 1990s with the purpose of satisfying the burgeoning demands of the property market. Real Estate Trusts were started in order to protect the real estate market from speculation and to encourage the efficient use of land. The other purpose of Real Estate Trusts in Korea was to achieve a competitive advantage in real estate development for local firms.

Despite the above intentions, the Real Estate Trust companies have, in the wake of the Korean economic crisis of 1997, been in a difficult situation because of asset deflation and recession. The authors analyse the problems of Real

Estate Trust companies in Korea and propose an alternative solution. As an alternative, the introduction of institutions similar to the Australian Listed Property Trust (LPT) or the US Real Estate Investment Trust (REIT) is considered. The proposed new institution - Listed Real Estate Investment Trust in Korea (K-REIT) – would establish new principles of real estate investment and the securitization of real estate.
Keywords: development, funding, investment, property, real estate, trust institutions.

2000, **1**(1), 43–52

The site manager: role, education and training in the UK

Peter Farrell[1] and Andrew Gale[2]
[1]*Faculty of Technology, Bolton Institute of Higher Education, Deane Road, Bolton BL3 5AB, UK*
[2]*Department of Building Engineering, UMIST, PO Box, Manchester, M60 1QD, UK*

The site manager is a key person in the construction process. Many site managers are perceived to be inadequately educated and trained. The question of whether the graduate or craft background is best for site managers is explored. The role of the site manager and the skills and knowledge required to be an site manager is examined. More work is needed to change the cultural approach in construction towards education and training. There is a need to promote a people-orientated management style.
Keywords: education, role, site manager, skill, training.

2000, **1**(1), 53–58

Application of organic learning styles to construction management

Francis T. Edum-Fotwe, Grant K Kululanga, and Ronald Mccaffer
Department of Civil and Building Engineering, Loughborough University, Loughborough, UK

The discipline of construction management is currently going through a period of introspective change. One major issue that assumes great significance in this change relates to the way research is undertaken by the discipline, and the basis for augmenting its body of knowledge with new ideas, concepts and developments discovered through research. This has manifested itself in the form of a challenge on its existing culture of research, which is predominated by the scientific approach. As a result, calls have been made to broaden the research perspectives of the discipline, by introducing paradigms from other disciplines to enrich construction management. The main argument that underlies the calls seems to be that "the pendulum must be swung to the other side" in order to bring a balance into construction management research. While this has considerable merit, it seems to overlook the fact that the solution does not simply lie in adopting paradigms. To achieve a more balanced perspective, research has to evolve to make the discipline a dynamic learning system that adapts effectively to its changing environment. This paper examines various styles of how organic systems learn as a means for adapting to the requirements of their internal and external environments, and to achieve greater effectiveness. The principles involved in these models of learning provide useful lessons for taking forward research development in construction management. A framework is developed within which the enrichment and development desired for construction management should take place.
Keywords: knowledge, learning style, paradigm, research method.

2000, **1**(1), 61–68

The relationship between GDP and construction flows: a re-examination

Raymond YC Tse[1] and James R Webb[2]
[1]*Department of Building & Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*Department of Finance, James J. Nance College of Business, Cleveland State University, Cleveland, Ohio 44114, USA*

This study re-examines the idea that construction flows and gross domestic product (GDP) are linked in a stock-flow model. Keynesians argue that increases in construction activity lead to a positive change of income. If GDP rises, so will the level of construction activity needed to meet the expanded production capacity. However, in the longer term, higher construction flows will increase the GDP by adding to the nation's capital stock.

The authors attempt empirically to establish whether a causal link between construction flows and GDP exists for two developed market economies based on co-integration and Granger-causality tests. The econometric analysis suggests that GDP will predict construction flows while not being predicted by construction flows in the short term. However, in the longer term, higher construction flows are likely to increase the GDP by adding to the nation's capital stock.
Keywords: construction flows, GDP, co-integration, causation, impulse response.

2000, **1**(1), 69–76

Streamlined life cycle assessment of domestic structural wall members

Graham J Treloar
School of Architecture and Building, Deakin University, Geelong 3217, Australia

Life Cycle Assessment (LCA) methods, while accepted as the only valid method of evaluating the environmental impacts of buildings, are generally too cumbersome for use by building designers. Therefore, streamlined LCA methods have been developed, which involve either reducing the system boundary of the analysis, reducing the breadth of environmental parameters considered, or using less reliable statistical data. However, currently available streamlined LCA data tends to be inappropriately applied, leaving gaps in the systems boundary. The development of more accurate and complete streamlined LCA data and methods is therefore required, and the author describes some recent developments. Timber wall studs and steel wall studs are compared to recycled steel wall studs, using a new hybrid LCA method based on input-output data. Compared to previous results, steel can have lower greenhouse gas emissions than timber in certain circumstances. Furthermore, the use of input-output data as the basis for the LCA means that reliable data from industry can be incorporated within a comprehensive systems boundary.
Keywords: embodied energy, life cycle analysis, building material.

2000, **1**(1), 77–86

Review of construction industry in Asia

Raymond Y C Tse, Y H Chiang, E C M Hui, J Raftery, and Theresa Y M Chan
Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Hong Kong

The authors report the labour productivity, research and development and liberalization in the construction industry with a focus on the conditions in Singapore, Hong Kong, Japan, Malaysia and Korea. A brief comparison and evaluation of their impacts on the development of construction market is also presented.
Keywords: construction productivity, liberalization, Asia.

2000, **1**(2), 87–90

From individual perspectives to a global VM potential

Roy Woodhead
Centre for Construction Management, School of Architecture, Oxford Brookes University, Oxford, OX3 0BP, UK

This special edition of the *Journal of Construction Research* begins by setting a tone of 'challenge'. It does not provide deep explanations of the historical context that links Value Analysis (VA), Value Engineering (VE) and Value Management (VM) together as stages of an evolutionary process; this is taken on board by other papers in this publication. However, it does challenge the fragmented value-community to think about the possibilities of global unity to advance value creation as the principal purpose of our endeavours. It is because of this aim that the paper's title links individual perspectives to a concept of global VM potential. The electronic discussion group named VEAMAC has allowed practitioners and academics to share their insights and communicate frequently thus allowing barriers to be recognized and challenged in a way that was not previously as accessible. The dominant research methodology in VEAMAC is ethnographic as the VM community tests its ideas in a public forum and then adapts its practice in light of the lessons learned; Value Management is thus a socially constructed reality that also attempts to influence the future. The purpose of this publication is to extend the debate beyond e-mail and draw more people into the larger action research experiment created by VEAMAC.
Keywords: action research, ethnography, value engineering, value management.

2000, **1**(2), 91–98

From scientific management to process engineering: the spontaneous theory of technological value in the design of work in organizations

Dan A Seni
School of Management, Université du Quebec à Montréal, Canada

We view the activity of design as being the "plain vanilla" or mundane, everyday-sort of invention which goes on all the time and in all the various kinds of technological practice, from medicine to architecture, to public policy planning, to organizational process change, to product and production engineering. In other words, we construe the central task of technological practice to be invention. And we understand technology to be taken in its broad or general sense. Moreover, we construe the practice of technological design to be theory-laden. In other words, we see every act of design as resting on assumptions and hypotheses concerning how a particular slice of the world is, how it works, and in particular, how can it be improved. We submit, therefore, that every kind of design practice rests on a technological theory – a theory of what is of value and how such value can be attained.

We illustrate our views in this paper by proposing the notion that *Scientific Management* as first expounded by F. Taylor in 1911 was the intellectual progenitor of a number of modern design technologies, *Process Engineering* being among them. As is true of every technological theory, both rest on a number of basic or foundational concepts even though their authors may be not have spelled them out clearly or may not even have been aware of them. Consequently, both share a common, albeit mostly implicit and spontaneous philosophy of technological value by the firm.

Keywords: design, innovation, invention, technological value, technology.

2000, **1**(2), 99–107

Facilitated team learning in value management teams

Patrick Sik-Wah Fong
Department of Building and Real Estate, Hong Kong Polytechnic University

The concept of team learning is dealt with in terms of value management study teams. The process and outcomes of learning in teams when attempting to create new knowledge are explored. Using interview, observation and document analysis, the author provides insights into team learning outcomes, processes, and phases, as well as the team and organizational conditions that facilitate or impede team learning.

Keywords: knowledge, learning, organization, soft value management, team.

2000, **1**(2), 109–122

Soft value management methodology for use in project initiation: a learning journey

Roy T Barton
University of Canberra, Adjunct Professor Queensland University of Technology, and Director of The Australian Centre for Value Management, Australia

A learning journey is described which began by investigating the application of traditional value engineering to construction projects in Australia. The journey takes the form of an action-research program in which many of value management studies of real projects were undertaken. Through two major iterations of the action-research cycle (as well as many sub-iterations) a number of key learnings were identified which led to substantial changes to the value management methodology. As the journey continued, a "soft" form of value management evolved focusing on strategic and conceptual planning and particularly upon capturing requirements in complex circumstances such as in project initiation. Major emphasis is placed upon effective facilitation.

Keywords: action research, facilitation, soft value management, value engineering, value management.

2000, **1**(2), 123–129

Management of value and uncertainty in construction projects

Jason Le Masurier, David Blockley and David Muir Wood
Department of Civil Engineering, University of Bristol, BS8 1TR, UK

Uncertainties present opportunities as well as risks. By managing uncertainties projects can achieve better value, for example through avoidance of problems that reduce value; or through identification of efficiencies that lead to increased value. Traditional approaches to risk management seek to identify and eliminate risks early in the project. However, attempts to eliminate risks can have adverse consequences. For example designing for the worst case can lead to complacency since it will be assumed that every eventuality is covered. Conditions may transpire which were completely unexpected, and with no strategy for detecting and dealing with them, can lead to a hasty redesign or sometimes a project crisis.

An alternative approach is to identify the uncertainties then monitor and manage them throughout the project life cycle. An approach used in geotechnical design provides a model for managing uncertainty. The observational method involves an initial assessment of the uncertain conditions followed by designs based on a prediction of the most likely manifestations of these conditions. Alternative designs or contingency plans are prepared to cover the worst

conceivable conditions. When combined with value management the observational method can provide an integrated system for managing various project uncertainties.
Keywords: geotechnics, observational method, risk, uncertainty, value.

2000, **1**(2), 131–138

Theory meets practice: proposal for a dynamic value and risk methodology for project management

Devadass P Mootanah
URS – O'Brien Kreitzberg, London, UK

Among the plethora of 'hard' and 'soft' value methodologies, there is little consensus on how uncertainty and risk can be identified and managed. A dynamic approach for managing value and risk is proposed within the context of participatory group decision methodologies and is derived from a conceptual model developed for integrated risk and value management. The methodological interface bridges different features from methodologies such as the 'soft' SMART VM method based on participation and perceptual decision modelling. life-cycle VM methodology, a holistic risk management methodology and the SAVE methodology. The underlying theory supporting the methodology emerged from surveys of current practice and interviews with practitioners, participant-observations of value and risk studies, document analysis of reports of VM studies and a continuous literature review. This multi-methodological research supports the interaction between theory and practice and produces an integrated approach to managing risk and value in project management.
Keywords: hard value management, soft value management, methodological interface, multi-methodological research, project management, value management.

2000, **1**(2), 139–149

Risk management in Singapore construction joint ventures

Kwon Hok Choong Andrew, Danny Then and Martin Skitmore
School of Construction Management and Property, Queensland University of Technology, Gardens Point, Brisbane Q4001, Australia

The risks of failure of construction joint ventures (JVs) are high and the financial consequences are expensive. This paper sets out to identify the nature of these risks and the means by which they are managed, through the study of the critical factors that contribute to successful JVs and the risk factors associated with JV operations. The results of a survey of JV participants in Singapore are presented. These indicate the overall risk factors facing contractors, the risk management measures that are felt to be effective, and the critical success factors involved at different stages of the project.
Keywords: critical success factor, joint venture, project stages, risk management, Singapore.

2000, **1**(2), 151–158

Learning-by-doing in Singapore construction

Willie Tan and Yahya Elias
Department of Building, National University of Singapore, Kent Ridge Crescent, Singapore 119260

The significance of learning-by-doing is examined in the Singaporean construction using the production function approach. Learning was found not to be significant, possibly as a result of the industry's high dependence on imported construction technology, industrial fragmentation as well as transient, and largely unskilled, foreign workers. Learning is socially rather than technologically driven and occurs at individual, project, corporate and industry levels. Since learning-by-doing is an important determinant of productivity, measures should be implemented at all levels to encourage it. In particular, the fragmentation of the industry is a serious impediment to learning since small firms generally do not have adequate resources to learn effectively.
Keywords: learning by doing, productivity, Singapore.

2000, **1**(2), 159–167

Predicting materials suppliers' bad debt

J Nicholas, G D Holt and M Mihsein
Built Environment Research Unit, School of Engineering and the Built Environment, University of Wolverhampton, UK

Present methods for evaluating contractor's creditworthiness have been found to be *ad-hoc* and bespoke. As such, materials suppliers place themselves in a position of considerable risk when they furnish contractors with credit. Very often, the result of this is bad debt for the supplier. By considering a UK nation-wide survey of suppliers' credit control and debt collection practices, this paper presents two multivariate discriminant analysis models. The first, models suppliers' percentage bad debt incurred in financial year 1997-8. The second model complements the first, by investigating the relationship between suppliers' targeted profit margins (minus bad debt incurred), for the same time period. The first model identifies that percentage of bad debt incurred is related to: whether suppliers implement a standard procedure for collecting overdue accounts; and their philosophy for checking contractor's creditworthiness.

The second model identifies that suppliers' targeted profit percentage (minus bad debt incurred) is related to: their standard terms of payment imposed onto debtors; whether they insure against bad debt; whether guarantees are sought for substantial orders; their financial growth trend; and method(s) used to establish contractor credit limits. The paper shows that failure by suppliers to realize the risk they expose themselves to when granting credit, is directly linked to the level of bad debt they incur.
Keywords: contractor, credit, debt, material supplier, risk.

2000, **1**(2), 169–175

Improving safety knowledge through training: the case of Hong Kong

Francis K W Wong[1], Steve C M Chan[1], Raymond Y C Tse[1] and Peter E D Love[2]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong*
[2]*School of Architecture and Building, Deakin University, Geelong, Victoria 3217, Australia*

The enhanced green card (EGC) scheme (the Scheme) for safety training was introduced in Hong Kong in 1996. As a result, those wishing to work on construction sites are required to possess an EGC to certify that they have been on an approved safety induction-training course. With this in mind this paper uses a questionnaire to determine the effectiveness of the Scheme by evaluating the enhancement of safety knowledge of construction workers on site after they have received training under the EGC training system. The findings indicate that the enhancement of knowledge after receiving the CITA enhanced Green Card Training is quite significant. Enhancement of knowledge after receiving the training has a positive relationship with academic background of the trainees. In addition, the results indicate that knowledge enhancement of the workers has no effect on reducing the accident rates in Hong Kong. The paper concludes by highlighting some limitations of safety training.
Keywords: Hong Kong, safety training, knowledge.

2000, **1**(2), 177-182

Construction management research: a blend of rationalist and interpretative paradigms

Gary D Holt[1] and Olusegun O Faniran[2]
[1]*The Built Environment Research Unit, University of Wolverhampton, UK*
[2]*School of Civil and Environmental Engineering, The University of New South Wales, Australia*

There are those who question the robustness, validity and usefulness of construction management research (CMR). In the main, this is a result of the ontological viewpoint whereas in reality CMR is as much concerned with both ontological and epistemological research paradigms. The role of CMR is reviewed and the authors suggest that is not always taken as seriously as it might be, particularly by those outside of the discipline. The role of CMR and the significance of its contribution to construction practice and the wider research community is discussed. It is concluded that CMR cannot be packaged under existing 'standard' (typically engineering biased) research domains and therefore needs to be: more clearly delineated; more seriously recognized as a research discipline *per-se;* and consequently afforded more distinct recognition.
Keywords: research, research paradigm

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Editors' Address (submissions and editorial enquires)

Professor Akintola Akintoye, Department of Building and Surveying, Glasgow Caledonian University, Glasgow G4 0BA, UK
Tel: +44 141 331 3626; Fax: +44 141 331 3696; email: akin@gcal.ac.uk

Dr Jim Birnie, School of the Built Environment, University of Ulster at Jordanstown, Newtownabbey, BT37 0QB, UK
Tel: +44 2890 366 570; Fax: +44 2890 366 826: email: JW.Birnie@ulst.ac.uk

Address other enquires (subscriptions and circulation):

Journal of Financial Management of Property and Construction, Department of Building and Surveying, Glasgow Caledonian University, Glasgow G4 0BA
Tel +44 141 331 3626
Fax +44 141 331 3696
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1996, **1**(1), 5–20

Real property valuation in a context of Knight-Keynes uncertainty

Michael Farrell
University of Quebec, Canada

The discounted cash flow method is often used to determine what a typical investor would pay for the income stream expected from a given real estate investment property. In the context of uncertainty the probability that a real estate investment will be profitable can be estimated from the Net Present Value (NPV) probability distribution. Know in the finance literature as the State Preference Model and referred to in the real estate literature as Knight-Keynes Uncertainty this concept has not as yet been presented in a form which can be used to rank prospective real estate investment projects. This article presents a practical technique which can be used to operationalize and measure the Knight-Keynes Uncertainty of a given real estate investment. This allows investors to measure the probability that a given real estate project will be profitable. In the example provided the probability of earning a profit after financing and tax is approximately 99 per cent. For an investor who has a 90 per cent profitability cutoff probability this project would be accepted.

Keywords: discounted cash flow, probability, real estate investment, risk.

1996, **1**(1), 21–36

Decision support system for plant-hirers' financial strategies

Ammar P Kaka
Liverpool School of Architecture and Building Engineering, Liverpool University, UK

A strategy evaluation and financial planning computer model for plant-hire activities is presented in this paper. This model adopts a stochastic simulation approach, in order to produce a detailed financial statement requiring minimum data entry. Individual plant is generated, simulated and integrated using implicit data entry. This enabled the evaluation of the dynamic mechanisms associated with plant-hire activities. Several assumptions were made during the design of the model, and as a result, a case study was required to verify the output. A plant-hire subsidiary of a large construction group participated in the verification process, and the model was confirmed to be a good alternative to current procedures.

Keywords: cash flow, computer simulation, decision-making, financial budgeting, plant hire.

1996, **1**(1), 37–54

Bias and financial management judgements

Jim Birnie

University of Ulster, Northern Ireland

The paper considers the psychology of human predictive judgements and how this may influence decision making in the financial management of property and construction. Relevant work in behaviourial decision making related to human bias is reviewed and the extent to which professional training may improve the quality of the judgement is examined. The findings of some empirical work which confirmed the evidence of bias is reported. The overall conclusion is that many intuitive judgements are likely to contain bias. Training, however, helps to reduce the extent of the bias, and more importantly, an understanding of human behaviour in intuitive judgement making, leads to a greater awareness of the likely existence of bias.

Keywords: bias, cost prediction, decision theory, estimating, human judgement

1996, **1**(1), 55–76

Value profile analysis of construction projects

Farzad Khosrowshahi
South Bank University, London, UK

Initially, the paper provides an in-depth analysis of the behaviour of construction project value (expenditure/income) profile. It demonstrates, in quantified terms, that the profile can be expressed in terms of a number of characteristics which are descriptive of the physical shape of the profile. The analysis shows that these characteristics fall into general and specific types. To this end, the paper introduces a general routine for data preparation and processing. In the second part of the paper, within the context of the above analysis, various types and categories of project are analyzed and 78 shape-models are developed. These models facilitate estimation of the specific characteristics of expenditure/income profile for a given project definition. This analysis is carried out at two levels, namely, global and individual project. The research reveals that in some cases the global data, containing the general features of all project categories produce better results than individual category data set. Subsequently, the shape-models have been developed on the basis of their global vs. individual project type performance.
Keywords: expenditure pattern, forecasting, income pattern, project cash flow.

1996, **1**(1), 77–88

Space modelling in healthcare properties

T J Pitt and G T T Griffith
University of the West of England, Bristol, UK

This paper brings together work that has been carried out as part of the Healthcare FM project (a collaboration between the University of the West of England and the United Bristol Healthcare NHS Trust). Healthcare delivery is in a period of flux due to the changing demography and technologies. This results in a changing demand for space. In order that NHS Trusts are able to provide efficiently the type of space required to support this complex service, the spatial requirements need to be carefully examined. In this paper space is classified in a hierarchical manner, and the facilities associated with that space are also classified (facilities are defined as physical facilities such as services and structural features, and environmental facilities that influence user perceptions). These classifications are analysed using a geographical information system to aid both data take on and the analysis itself. Further to this, the space demand side (i.e. what space is required) and the space supply side (i.e. what space needs to be delivered) are examined. The paper shows how these evaluations can be overlaid, and suggests how the figures for this evaluation can be retrieved from both the spatial and data sides of the GIS. This approach facilitates space management decisions to be undertaken in a transparent manner, thus enabling property users, such as a healthcare trust, to be more proactive in its approach to the provision of space, crucial in an environment where change is continuous and the pressure of finance is great. The paper concludes that space is an important consideration for effective delivery of core business, and that the methodology is not only relevant in an healthcare scenario but could easily be adapted to apply to other complex space users.
Keywords: facilities management, GIS, health care, methodology, property database, space management.

1996, **1**(1), 89–100

A functional cost approach in the development and use of a project budget cost limit estimator for capital building works

Brian Sloan, Brian N McLeod, Robin M Smith and William L Goodall

Napier University, Edinburgh, UK

The concept of functional cost allocation is not new having been considered in the 1960s and 70s under the title of spatial costing. The concept was sound; however, the difficulty was that the allocation of cost to functional (spatial) units (e.g. rooms) was expensive in preparing a detailed cost analysis on a function cost basis. Ferry and Brandon (1980) stated “Computer models which symbolise a particular building ... are more likely to provide a better solution in the future”. This paper will describe a system developed for a major public 'agency' client in Scotland, charged with the responsibility for the provision and operation of specialist buildings. The concept of functional analysis is developed and this work has resulted in the design of a cost limit estimator based upon the concept of functional cost. It is based upon two projects which were commissioned by a public sector client to design a cost limit estimator for defined construction schemes. Initial tests of the system have shown its accuracy in calculating the cost limit for a scheme to be within acceptable tolerances for the client, although further validation remains to be carried out .
Keywords: cost limit, estimating, function, software.

1996, **1**(2), 5–16

Life cycle energy analysis of the building resource

Colin Elliot[1] and Angela Palmer[2]
[1]*Department of Building Engineering and Surveying, Heriot-Watt University, UK*
[2]*Department of Building and Surveying, Glasgow Caledonian University, UK*

All buildings consume energy in the process of manufacture of construction materials and incorporation of them into the project. Use of this energy produces pollution in the form of carbon dioxide (CO_2) emissions. Present systems of project appraisal evaluate this energy resource in terms of cost, overlooking energy content except in so far as it directly affects that cost. Pollution, which is viewed as a social cost, is usually ignored. However, increasing emphasis on energy and environmental conservation and management means that this system of evaluation is no longer adequate, as it makes no true assessment of the resource used or its impact on the environment. This paper aims to provide an alternative system of evaluation by calculating total energy consumption and CO_2 emissions of construction components over their entire life cycle.

Keywords: resource assessment, embodied energy, energy, life cycle analysis, sustainable development.

1996, **1**(2), 17–28

A strategy for a computer-based materials management system for the building industry

N N Dawood
School of Science and Technology, University of Teesside, UK

Previous studies have indicated that materials management is a major target area where substantial cost saving can be made in the construction industry. As materials can constitute 30-50% of the cost of a project, material wastage and late ordering need to be minimised and addressed, in order to keep costs down, especially in today's competitive market. The objective of the paper is to discuss and introduce a strategy for a materials management system for the construction industry for forecasting and controlling materials. In order to achieve the objective, a survey of the current practices of materials management in the industry was conducted. The aim of the survey was to establish the current practices and the ways of improving such practices. This is followed by developing the strategy and verifying it by conducting survey interviews with project managers. It is concluded that the current practices of materials management are basic and depend on gut feeling and subjective decisions. This has contributed to late ordering and delivery of key materials and high wastage. It was also concluded that some form of systematic and integrated approach is needed to manage materials and minimise the cost associated with late delivery and wastage. Specifications of a new strategy for material management are presented.

Keywords: integrated system, material management, survey, scheduling.

1996, **1**(2), 29–38

Property derivatives: a missed opportunity?

John R Mansfield
Department of Construction and the Built Environment, Canterbury College, UK

Since the mid 1980s efforts have been made to engineer property's investment potential to correspond with the general characteristics of other financial markets. The first wave of indirect property vehicles were not successful for mainly external reasons. The innovative property derivatives can provide wider benefits to institutional investors among whom there is broad interest in investing in an established market but a general reluctance to become market makers.

Keywords: property investment, property futures, property index certificate.

1996, **1**(2), 39–56

Discounting, obsolescence, depreciation and their effects on the environment of cities

A Antwi and M Deakin
Department of Building and Surveying, Napier University, Edinburgh, UK

This paper examines the critique of discounting, which the pro-environmentalist, sustainability lobby have made in relation to property valuation, investment appraisal and the application of the principle in the income based net annual return model of land use time-horizons and the spatial configuration of building programmes. It examines the argument put forward regarding the link between the selection of a discount rate, the valuation of property, appraisal of invest7nent and inter-generational downloading of costs associated with the use of land, repair, maintenance and refurbishment of buildings. The downloading of costs, seen by some, to work against the introduction of experimental designs aimed at energy saving, clean air environments. The paper suggests there are a number of contradictions in this argument and proposes that an assessment of the impact which the redevelopment process has on the environment of cities should be based on an economic evaluation and appraisal of land use, building obsolescence and depreciation.

Keywords: depreciation, discounting, investment appraisal, land use, obsolescence, property valuation, environment, city.

1996, **1**(2), 57–64

Property values and implications of refurbishment costs

Herman Tempelmans Plat
Eindhoven University of Technology, Eindhoven, The Netherlands

The value of a property may, in a stable market situation, depend less on the supply availability of land, but more on the change in the value of the building thereon. For buildings to continue to function efficiently, they must be maintained. This involves the periodic maintenance and refurbishment of the building. This paper examines the cost consequences of this work for both present and prospective owners of property. To overcome inequitable distribution of the costs of refurbishment, the author suggests the creation of special funds. These funds would be deducted from the residual value at the point of transfer of ownership of the property and given to the new owner to pay for the necessary refurbishment work. The paper also discusses how this methodology should be used in relation to the rental levels throughout the life of the property.
Keywords: demolition, maintenance, property investment appraisal, property valuation, refurbishment, rent.

1996, **1**(2), 65–94

Technological change and construction

John G Lowe
Glasgow Caledonian University, Glasgow, Scotland

This paper presents an analysis of the process of technical change in the UK construction industry. It outlines the long-term approach of Joseph Schumpeter and the linkage between trade cycles and innovation. The paper commences with a review of the economic theory of technical change illustrated with examples from the four long Kondratieff cycles from the industrial revolution onwards. Technical change in the construction industry is analysed over this period and some distinguishing features are identified. Case studies are presented of the development of framed structures and the introduction of non-traditional housing notably system building and timber framed construction. An empirical analysis is undertaken covering the period from 1935 to 1990 to assess the impact of technical change on the construction process. The analysis appears to confirm the widely held view that the UK construction sector is remarkably resistant to change. There may be a degree of justification for this conservatism given the problems experienced with radical innovation in, for example, housing technology.
Keywords: diffusion, innovation, invention, technology.

1996, **1**(3), 5–22

Financing Real Estate in China: The Development of a Real Estate Investment Bond Market in Tianjin

Jianting Wang,[1] Jean Jinghan Chen and David Isaac[2]
[1]*Tianjin Urban Construction College, Tianjin, China*
[2]*School of Land and Construction Management, University of Greenwich, UK*

Following the establishment of the policy of reform and the opening up of the economy in the Peoples' Republic of China, the real estate industry has developed rapidly. Because of the dependency of real estate on the characteristics and immobility of property, the real estate industry has developed closely in relation to investment in it. With the scale of growth of real estate development, the problem of funding shortage has become more and more evident and this has now become a major restriction on the development of the real estate industry in China The paper takes Tianjin (one of the three municipalities under the direct jurisdiction of the central government) as its area of study. The paper examines the necessity for the issuing of bonds in the real estate industry to encourage funding; the feasibility of issuing real estate investment bonds and the strategies for such bond issues in Tianjin. The purpose of this paper is to examine ways to increase the funds thus widening investment channels and diversifying investment so that the real estate industry can establish itself. Because Tianjin has an important role to play in the economic development of China, it is a useful case study in understanding the development of the real estate sector in China.
Keywords: bonds, China, funding, investment, real estate.

1996, **1**(3), 23–42

A critique of mechanical and electrical services cost planning: existing methods and published

L M Swaffield and C L Pasquire
Department of Civil and Building Engineering, Loughborough University, UK

This paper evaluates methods used for the production of budget estimates for mechanical and electrical (M&E) services, and examines the availability and suitability of historic cost data for M&E services. The paper discusses results from multiple linear regression analysis and statistical tests that examined the significance of building form parameters in determining M&E services cost. The paper argues that current methods of budget estimating for building structure and fabric work are inappropriate for use With the M&E services elements; and that there is a needfor an improved understanding of the factors that affect the cost of M&E services. The paper concludes that the format and detail of the

cost data published by the Building Cost Information Service is inadequate for the production of budget estimates for M&E services; and that a method of collecting more appropriate information is required.
Keywords: budget, cost analysis, cost data, cost planning, electrical services, mechanical services, services classifications.

1996, **1**(3), 43–52

The current and potential use of life cycle costing in the New Zealand construction industry

Suzanne Wilkinson
Department of Civil and Resource Engineering, The University of Auckland, New Zealand

This paper examines the current and potential use of life cycle costing in the New Zealand construction industry. The paper discusses empirical research from a survey of construction companies and property owners in New Zealand which examined how the life cycle costing technique is being used and what future expansion of the technique's use is likely. The paper discusses the way in which the technique is currently being used in New Zealand extending this discussion to the types of projects, stage in the project, and appraisal techniques employed when using the life cycle costing technique. As a concept the technique appears to be understood. However, full use of the technique is currently limited. Reasons for this are discussed in this paper.
Keywords: discounted cash flow, life cycle analysis, New Zealand, payback analysis.

1996, **1**(3), 53–70

A consensus strategy for post-occupancy assessment in school design

Henry A Donegan,[1] Francis J Dodd[2] and Alan Warren[3]
[1]*University of Ulster, Northern Ireland, UK*
[2]*Former Research Student, University of Ulster, Northern Ireland, UK*
[2]*Architectural & Landscape Design Associates, Belfast, Northern Ireland, UK*

This paper outlines a strategy for assessing the client's consensus of post-occupancy opinion about existing design features prior to the architect's proposal for a significant extension or alteration to an existing public assembly building. The public assembly building in this exercise is a small rural primary school where the teaching staff, eleven in all, are considered “passive occupational experts” (in contrast to the “active external professional experts” which include principally the financial advisors, the architect, the supporting technical team and the various authorities). These formed a panel in a survey using the Delphi technique so that definitive consensus could be established, and the issues involved prioritised using several current methodologies. The conclusions are sufficient to indicate that further studies of this type could shed light on the overall design philosophy and indicate: first, how current financial thinking is perhaps a product of top-down perception rather than bottom-up appraisal and, not surprisingly, second, how more formalized evaluation strategies of this type might be used to influence the government departments dealing with financial and technical controls – especially given the popular views on the interaction of various regulations and their consequent impact on holistic design.
Keywords: analytical hierarchy process, consensus, Delphi technique, post-occupancy evaluation, school.

1996, **1**(3), 71–82

Multi level structures and housing accommodation standards for cities in China

Guan Ke,[1] Liu Changbin[1] and Richard Fellows[2]
[1]*Harbin University of Architecture and Engineering, P.R. China*
[2]*School of Architecture and Civil Engineering, University of Bath, UK*

As urbanization has advanced, especially the expansion of major metropolitan areas, housing scarcity has become a major social and economic problem world-wide. Although housing provision in cities in China has improved noticeably over recent years, provision remains far below that in most advanced countries. Judged against the standards of provision in comparable countries, housing in China is inadequate. It is no solution for China to seek to expand provision of enlarged housing units piecemeal, a strategy for provisions which can be accommodated readily within the capacity and structure of the Chinese economy is vital for sustainability. This paper postulates that the solution lies in determining moderate standards of housing provision which are appropriate to the needs of the people, distributed equitably and, hence, sustainable given the technical, social economic and political considerations. In view of the recent strategies adopted for advancing economic development in China, potential for fostering multi-level standards of housing provision is examined. Such a possibility must be examined in the context of the Chinese socio-political environment as differential standards of provision may prompt unrest between the 'advantaged' and 'disadvantage' groups of occupants created (e.g. as observed in the former USSR). Great skill and care is required to introduce such provisions to secure stable developments which are appropriate to China and, hence, are sustainable.
Keywords: accommodation, China, economic transition, housing, accommodation standards.

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1996, **1**(3), 83–94

Life cycle energy analysis of buildings revisited

W R Lawson

School of Architecture, University of New South Wales, Sydney, Australia

Much emphasis has been given to the energy consumption of buildings in use and more recently to embodied energy, the energy consumed in procuring the materials and constructing and maintaining the building. However, an energy efficient building may not necessarily be an environmentally sound building. Energy consumption is only one way in which the environmental impacts of a material or building may be assessed, albeit a relatively easy to measure way. Care should be taken in the assignment of embodied energy values to materials and buildings as they may be subject to wide variations. These may be due to the methodological assumptions underlying the assessment or reflect actual differences in technology and energy consumption. It is necessary to have the boundaries of the system being studied clearly defined to avoid possibly misleading conclusions being drawn. This is not necessarily a problem unless unlike methods or absolute values are sought rather than relative values.

Keywords: embodied energy, life cycle analysis, sustainability.

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1997, **2**(1), 5–34

Development and implementation of a system of financial planning and control for a medium-sized building contractor

D W Cheetham, A P Kaka and G Humphreys
School of Architecture and Building Engineering, University of Liverpool, UK

Previous research had established that formalized financial accounting procedures and financial planning techniques are mainly used by the larger building companies. This suggested that a system of financial planning appropriate for a medium-sized building company should be devised. This paper describes the development of such a system and evaluates its introduction to a medium-sized contracting firm. The system was developed by extending existing recording procedures to forecast turnover required to support overhead charges and to review financial performance for individual contracts. Turnover forecasts can be revised at monthly intervals as valuations occur, examples of the management decisions that can be aided by such financial information and supplementary reports are provided. The paper demonstrates how the "paper-based" system can be implemented to improve the financial control of moderately sized firms. Proposals to further improve the speed of data processing by automating the system using computer software could unfortunately not be implemented because the firm ceased to trade. The proposed system clearly demonstrated to the company the value of the work that was needed to be won in a highly competitive market. Essential information that would have been useful if the system had been applied a few months earlier.
Keywords: cash flow, contract performance, financial planning, insolvency, turnover.

1997, **2**(1), 35–44

Authorized property unit trusts: opportunities and threats

John R Mansfield
Department of Construction and the Built Environment, Canterbury College, Kent, UK

Two Authorized Property Unit Trusts (APUT) were launched in 1991 which sought to encourage the smaller or individual investor to participate in a passive, property-based opportunity. Both trusts' managers consider the opportunity to before the medium or long term although the performance in the first five years has been modest. A number of the criticisms of the existing schemes suggest that the technical and fiscal adjustments to the regulatory system – to enable APUT schemes to be traded on the Stock Exchange which were proposed in May 1996 – may not be sufficient to encourage a more active participation in the property market and attempt to alleviate the drift away from investment in direct property. There are a number of alternative opportunities emerging that may have an impact upon the nascent APUT market.
Keywords: financial services, housing investment trust, investment fund, property unit trust.

1997, **2**(1), 45–58

The costs and benefits of achieving business excellence in construction organizations

J G Gunning
School of the Built Environment, University of Ulster, Northern Ireland, UK

Business excellence links the principles of Total Quality Management (TQM) to a wider perspective of the needs of the stakeholders of an organization. It represents a holistic view of managing a business in terms of both enablers and results (causes and effects). The paper first examines the process of Total Quality Management (TQM) and the criteria normally embodied within it. It discusses how and where TQM can be applied to the construction process and investigates the requirements of a TQM programme. The benefits are then assessed, with emphasis upon the various methodologies of quantifying these. The paper looks at a range of measures of quality including benchmarking and self-assessment, and investigates the costs of implementing the business excellence philosophy within construction organizations. It sets out a framework for comparing costs and benefits, and ends with an assessment of the likely achievement of true business excellence in the construction industry using a cohesive and integrated approach to improvement of every aspect of an organization.
Keywords: business excellence, benchmarking, cost benefit analysis, construction organization, total quality management.

1997, **2**(1), 59–82

Development of computer-based information systems for local authority property management 1: underlying issues

Mark Deakin
Napier University, Edinburgh, UK

This research attempts to add to our knowledge of IT in the development of computer based information systems by studying the underlying issues and how the application of IT brings about an improvement in the standards of local authority property management. Divided along these lines, the study is presented in the form of two papers. Paper 1 focusing attention on the underlying issues, with Paper 2 concentrating on the IT applications. In the interests of setting out the issues in question, this paper will first of all set out the background to the development of computer-based information systems for the management of local authority property management. This is done under the heading of the value for money (VFM test, land audit and property review, towards the 3 E's (economy, efficiency and effectiveness). It then goes on to examine the perceived benefits of computer based information systems and issues underlying the transition to the quality-minded, pro-enterprise structure of LAPM. The paper concludes by relating towards the IT question.

Keywords: land audit, property information system, strategic management, value for money.

1997, **2**(1), 83–112

Insolvency in the UK construction industry

John Lowe
Department of Building and Surveying, Glasgow Caledonian University, UK

This paper is an analytical and empirical study of insolvency in the UK construction industry. This is of interest because of the apparently disproportionate share of insolvency affecting UK construction. A number of hypotheses are generated and tested. The principle findings of the study are that cash flow factors appear to be largely responsible for the level of insolvency in construction insolvency. Notable variables appear to be borrowing by construction firms, availability of credit and domino effects from general insolvency. Also, while profitability appears to have a measurable impact on insolvency, it is less important than cash flow factors. Fluctuations in construction output and the cost of credit appear to have no significant impact on insolvency. A robust predictive regression model of construction insolvency is generated using quarterly empirical data for construction insolvency in England and Wales over the period 1969 to 1994 against a variety of independent variables.

Keywords: company liquidations, cash flow, insolvency, working capital.

1997, **2**(2), 5–20

Joint ventures: a construction project case study

M Reszka and P J Edwards
Department of building and Construction Economics, Royal Melbourne Institute of Technology, Australia

A major Australian construction project is used as a basis for comparing the theory and practice of joint venture enterprises. The case study shows that in general, the principles and procedures advocated in the literature are supported. In addition, joint ventures may be a means of ensuring that existing client bases can be maintained, and that partner company growth is not compromised. The joint venture partner selection process may be informal as much as formal For personnel recruitment, in terms Of employee motivation it may be more advantageous to second people from the parent companies rather than break existing employees' service conditions. The case study also indicates how joint ventures can be used domestically as well as internationally.

Keywords: procurement, joint venture, partnering.

1997, **2**(2), 21–38

Exploring the hurdle rate in preparation for a value management workshop planning session

Roy Woodhead
Centre for Construction Management, School of Architecture, Oxford Brookes University, Oxford, OX3 0BP, UK

Experienced clients of the construction industry repeatedly have many property teams based within geographical regions or organizational divisions. Individual property managers often propose projects which compete for internal budgetary approval This paper explains how senior managers make capital investment decisions and evaluate the commercial attractiveness of the proposal on financial grounds. During project appraisal the capital sanctioning decision is often linked to a comparison between the project's internal rate of return (IRR) and the organization's hurdle rate. Whilst other appraisal techniques are used, this method of selecting projects is prominent. A worked example is provided in the appendix. This paper explains how the hurdle rate is established in experienced client organizations. Experienced clients are taken as those firm's with a core business outside property related industries and who have experience of major project procurement. The paper commences by placing the work in the context of a larger research

project exploring how clients of the construction industry arrive at the decision to build. The paper leans heavily towards the subject area of corporate finance in order to link capital budgeting to the commissioning of buildings. Its intention is to allow value management (VM) academics and facilitators specializing in front-end VM and pre-project VM to bring the accountant's perceptions into the decision making process.
Keywords: investment decision, procurement, project appraisal, project selection, value management.

1997, **2**(2), 39–58

Appraising the performance of long span sports halls and swimming pools in Greece

V Boutfskis and R F Fellows
School of Architecture and Civil Engineering, University of Bath, UK

This research investigates the problem of selecting the best performing constructional system-among a diverse selection of alternatives for long spanning (25-60 m) sports halls and swimming pools in Greece. Deciding the most appropriate constructional system is difficult in this sector. The literature indicates that most building appraisals terminate at the level of data analysis and draw conclusions on the individual aspects they investigate. Usually, these approaches focus on a fraction of the problem, examining it deeply and theoretically. Their drawback is a loss of comprehensiveness, inability to draw conclusions at an overall level and, consequently, inapplicability to the conditions which prevail more generally. Research on an inclusive level is sparse. This paper focuses on the problem of performance appraisals for long span buildings and, particularly, on selection of the constructional system. An inclusive appraisal approach is adopted using a combination of quantitative and qualitative data which identifies three main variables: resources, human-user .satisfaction and technical. Case studies on existing buildings are employed to assess the ritual performance of various constructional systems. A quantification model is developed which is important to aid solution of the problem of incompatibility of data, determination of overall relations of findings and drawing holistic conclusions. This model facilitates the construction of an overall index of performance by measuring the performance of each building as a whole through aggregation of performances of its components and comparison to the other buildings in the sample. The paper presents the findings of the research appraisal to a sample of differently constructed building types.
Keywords: case study, Greece, project appraisal, sports hall.

1997, **2**(2), 59–84

Development of computer-based information systems for local authority property management 2: the application

Mark Deakin
Napier University, Edinburgh, UK

This paper is the second of two papers on the development of computer-based information systems for local authority property management. The previous paper (Volume 2, Number 1 of JFMPC) discussed the underlying issues. This paper describes by means of a case study, the development of the information system for the management of property. The application to the registration of assets, valuation of property and measurement of performance is appraised. It seeks to show how the system represents an emergent form of property valuation which challenges the conventional income approach.
Keywords: asset register, information system, property management, valuation, value for money.

1997, **2**(2), 85–104

Financial implications of using natural ventilation to reduce levels of radon gas within an existing 'period' dwelling

S Goodhew, P Bird and I Paterson
University of Plymouth, UK

Radon levels within a dwelling of traditional construction located in South Devon have been monitored intermittently over a period of several years. This paper discusses the characteristics of radon gas, presents the results of a series of monitoring tests and demonstrates a broad relationship between radon concentration and the amount of naturally induced ventilation within the test house. A solution more appropriate to higher radon levels is costed, the variation in typical radon levels encountered in different rooms and the financial viability of natural ventilation systems when compared with the costed and other possible solutions, is examined.
Keywords: cost, radon, radon.

1997, **2**(3), 5–30

Illiquidity, uncertainty and the impact of the term structure of interest rates on the valuation of real estate in a context of Knight-Keynes uncertainty

L M Farrell
University of Quebec, Canada

The practice of estimating the value of a real estate asset using discounted cash flow, DCF, models, which match discount rate maturity with the investment horizon, does not account for the real opportunity cost of funds, and may produce erroneous estimates of value. When the yield curve is upward sloping the DCF model will tend to overstate the value of the subject property rights. When the long term interest rate structure is downward sloping, the estimate of value will be biased in the opposite direction. The results presented in this paper suggest that this effect may be most significant when the yield curve intersects the real estate asset's internal rate of return, IRR.
Keywords: investment decision, property, real estate, yield.

1997, **2**(3), 31–44

The causes and effects of construction delays on completion cost of housing projects in Nigeria

Henry Agboola Odeyinka and Ade Yusif
Obafemi Awolowo University, Ile-Ife, Nigeria

The paper identifies, on the basis of a questionnaire survey of general contractors, consultants and house owners in Nigeria, the construction industry's perception of the causes of construction delays on housing sites. On the basis of the cases studies, the effect of construction delays on completion cost of housing projects is investigated. It is shown that the causes of construction delays in housing projects can be nested in four layers namely: client-caused delay manifested mainly in terms of failure to meet financial obligations to the contractor as they fall due and frequent variation orders; contractor-caused delay manifested in terms of resource supply problems; extra contractual delay manifested in terms of inclement weather, acts of God, strikes, labour disputes and civil disturbances; and consultant-caused delay manifested in terms of late issue of instruction and incomplete drawings. On the basis of the case studies, it is concluded that loss and expense claims due to delay and fluctuation claims during delay period had significant effect on cost overrun and thus impact significantly on the completion cost of housing projects.
Keywords: claim, cost, delay, housing, loss and expense, Nigeria.

1997, **2**(3), 45–62

The potential for market research, property market analysis and property valuation using geographic information system technology

W G Deddis, W J McCluskey, A Mamis and R D McBumey
School of the Built Environment, University of Ulster, Northern Ireland, UK

The paper is based on research developing property analysis and valuation techniques within a geographic information system (GIS). Applications include, market research for land use and property development, general property market analysis, value mapping, and computer assisted mass appraisal models for residential property taxation. The value of land and property is a function of economic, legal, physical and location factors. Land and property markets, by their nature, exhibit high degrees of market imperfection, not least the lack of knowledge. Consequently, access to comprehensive, reliable and up-to-date transaction evidence, is a prerequisite to property research, analysis and valuation. Both market research and valuation techniques depend on the collection and analysis of relevant data. Historically, the application of these techniques took place within a non-spatial environment. Ultimately, market data supports any estimate of value. Data searches and collection can prove both time consuming and expensive in relation to the fee earning potential of a valuation report. GIS can facilitate in a spatial context, the storage, manipulation and analysis of data, in a fraction of the time previously required.
Keywords: data accessibility, GIS, housing, information, market research, property, value mapping.

1997, **2**(3), 63–76

Asian real estate markets: boom and oversupply?

C M Hui, Y H Chiang and B S Tang
Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Hong Kong

Frenzied building in the capitals of Asia has long been one of the most visible symbols of the region's spectacular economic boom. But now that the pace of growth has faltered, the sprouting skyscrapers seem a symptom less of success than of pain to come. Recent problems of over-building and vacancy facing the real estate markets in Asia are addressed. The real estate markets of some fast-growing Asian economies are reviewed. This is followed by a theoretical framework for investigating the factors underlying the over-supply of properties in the region, namely, the interaction between the dynamism of real estate investment, internationalization of capital financing and state

policy initiatives. These Asian factors are then examined in contrast to western economies. The concluding part draws out research implications for the development of Asian real estate markets.

Keywords: Asia, capital finance, global economy, internationalization, property market, state intervention.

1997, **2**(3), 77–94

Client satisfaction with construction cost: a comparative study of French and UK performance

Dee Davenport
Department of Built Environment, University of Central Lancashire, UK

Questionnaire surveys were undertaken in order to assess how the UK and French construction industries perform in relation to the level of client expectations, also defined as priorities at the inception stage, and the effect of client participation and expertise on client ratings for construction final delivery costs. Evaluation includes: statistical distribution analysis of results from each country, which examines relationships between the status of client priorities/expectations relating to construction costs, compared with other significant criteria such as time, quality, client participation in the construction process and client satisfaction with performance and client experience; the construction of a correlation matrix using Spearman's rank correlation system in order to examine the correlation between client performance ratings including cost, time, quality, participation and overall client satisfaction with performance; a comparative analysis to discover whether there are any similar trends in construction client behaviour in relation to construction costs which transcend national boundaries and may be of significance in terms of the implementation of client-led, coherent and effective strategies on an international scale. A null hypothesis which contends that there is no significant difference in the non-parametric results of the above relationships between the two countries, will be tested using the Mann-Whitney U-test for ordinal data.

Keywords: client expectations, client participation, France, UK.

JFMPC: Volume 3, 1998

1998, **3**(1), 5–26

Strategic building project price forecasting models in use: paradigm shift postponed

Chris Fortune[1] and John Hinks[2]
[1]*School of the Built Environment, Liverpool John Moores University, Liverpool, UK*
[2]*Department of Building, Engineering and Surveying, Heriot-Watt University, Edinburgh, UK*

Good quality early stage building project price advice needs to be formulated reliably and then transmitted effectively to clients in order for appropriate decisions to be made. In the UK, quantity surveyors are most often the construction professionals charged with the task of determining such early stage building project price forecasts. Little is known about the actual selection and use of the building project price forecasting model(s) used by construction professionals when formulating cost strategic advice for clients. This paper reports on research using a nation-wide mailed survey conducted with all 2,327 separate quantity surveying organizations in England. The survey attracted an overall adjusted response rate of 64%. The results indicate that, in general terms, practitioners have not yet answered the call of academia to adopt the newer-computer based stochastic models that assess project risk and uncertainty. Models that provide traditional single point deterministic building project price forecasts continue to be the most popular type of model used by practitioners involved with the formulation of strategic cost for clients. The analysis revealed that location does not have a significant impact on the incidence or use of individual models. The analysis has also indicated that organizational "type " is a significant factor in the incidence-of-use of particular models. This was especially evident in multi-disciplinary practices and project management type organizations which both had a higher incidence-of-use than expected for the newer computer-based stochastic models. The data collected from organizations based in the north of England in 1997 have also been analysed in connection with data collected from a similar survey conducted with organizations based in the north of England in 1993. These results indicate that models providing traditional single-point, deterministic, building-project, price forecasts have a reduced incidence-of-use over that time period and that there has been some increase in the use of the newer computer-based models. However, that increase is not statistically significant. The paper concludes by asserting that although the paradigm shift in practice relating to the formulation of reliable early cost advice has not yet been generally achieved there is some evidence that amongst certain organizational types it may, as yet, only be postponed.
Keywords: estimating, forecasting, price, risk, stochastic modelling, trends.

1998, **3**(1), 27–42

Marketization of state-owned housing in China: comfortable housing project in Beijing

Francis K W Wong,[1] Lucy S P Kong[1] and Rodney Howes[2]
[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong*
[2]*School of Construction, South Bank University, London, UK*

The creation of a housing market has been an objective of urban housing reform in China since 1978. In 1995, the first nationwide housing programme "National Comfortable Housing Project" (the Project) was introduced. A prime objective of the Project is the sale of state-owned housing with the aim to recoup housing investment from the individual households. Major cities such as Beijing, Shanghai, Tianjin, Chengdu and Guangzhou have started the Project. This paper aims to identify problems associated with the new housing programme. Although the Project signifies a milestone of urban housing reform, obstacles such as the work unit system and low affordability are hindering the development of the Project. This paper examines the background of the Comfortable Housing Project. Questions relating to the parties involved in the new housing project and the relationship among developers, local government, work units and the individuals will be explored. Problems encountered by the households and difficulties of implementation which may lead to inequalities will be discussed. Finally, recommendations which demonstrate the means to achieve the objective of the Project will be explained.
Keywords: affordability, China, housing finance, marketization.

1998, **3**(1), 43–72

Local authority property management: a management exercise

Mark Deakin
Napier University, UK

The papers referred to in this management exercise are taken from the Local Authority Property Management Conference, organized by the Department of Building and Surveying, Napier University and held at the Edinburgh International Conference Centre on 11 October, 1996. Under the heading of "Local Authority Property Management" Initiatives, Strategies, Re-organization and Reform, the conference brought together academics and practitioners from the property profession in the aim of exchanging views, opinions and experiences on the development of Local Authority Property Management (LAPM) since the Audit Commission's initial investigations into the matter. During the

course of the event a total of twenty-four papers were presented and the following discussion outlines them all in the interests of recording what the document will refer to as the post-Audit Commission developments in LAPM.
Keywords: local authority, property management, reform, strategy.

1998, **3**(1), 73–82

Value management as a tool of the stakeholder concept

Angela Palmer[1] and Denny McGeorge[2]
[1]*Formerly of Department of Building and Surveying, Glasgow Caledonian University, Glasgow, UK*
[2]*Department of Building, University of Newcastle, New South Wales, Australia*

Value management is a design process based on the definition of function. Function however is subjective and one aspect of value management therefore is reconciling these different views of function. In a similar vein the stakeholder concept has as its main purpose an inclusive approach to decision making, which takes account of a broader spectrum of views than has traditionally been the case. This paper examines value management as a tool of the stakeholder concept.
Keywords: function analysis, stakeholder, value management, value engineering.

1998, **3**(1), 83–92

Analysing operating costs of town councils

Lim Lan Yuan
School of Building & Real Estate, National University of Singapore, Singapore

Town councils are an evolutionary concept introduced to manage and maintain public housing developments in Singapore. One of the key functions of the tour council is maintenance management. This paper attempts to examine in detail the operating costs of town councils and the factors affecting their variations. The findings have implications on improving the efficiency of management in town councils.
Keywords: cost, financial management, maintenance, public housing, Singapore, town council.

1998, **3**(2), 5–26

Property cycles in Hong Kong: causes and impacts

Raymond Y C Tse,[1] S Ganesan[2] and H M So[2]
[1]*Department of Building & Real Estate, Hong Kong Polytechnic University, Hong Kong*
[2]*Department of Architecture, University of Hong Kong, Hong Kong*

Property cycles both influence and are influenced by broader cycles of economic activity. This paper examines the experience and characteristics of property booms and busts in Hong Kong since 1960. The booms occurred predominantly in 1961-1964, 1969-1973, and 1977-1981, and whereas the slumps followed in 1965-1968, 1969-1976 and 1982-1984. Specifically, the three major cycles in the periods: 1976-1983, 1984-1990 and 1991-1994 are examined. The property cycle is found to be more volatile than the economy in the three typical cyclical periods: 19 76-1983, 1984-1990 and 1991-1994, using annual data drawn from house price index and the GDP in Hong Kong. There is an inherent cyclic interaction between the property and employment sectors. An economic expansion leads to increases in demand for new office space and employment, which in turn increases income and housing demand. Property cycles are disturbed by a variety of factors: the movement of interest rates; availability of mortgage loans; construction costs,-speculation; and government policy on land resources. In addition, this paper explores the question of whether high population growth, regulation in the financial sector or political uncertainty contributes to the ups and downs of the property cycle in Hong Kong. Understanding of property cycle, causes and impacts is of increasing importance to institutional investors in effective real estate portfolio management.
Keywords: business cycle, Hong Kong, property cycle, technology.

1998, **3**(2), 27–40

The effective management of risk in concession projects

Devadass P Mootanah
Anglia Polytechnic University, UK

The Private Finance Initiative (PFI) allows public sector authorities to pass the risks of ownership to the private sector for periods varying between 20 to 30 years. Hence, the associated decisions to be made involve uncertain issues from many different perspectives, necessitating the adoption of a holistic approach to the identification and management of uncertainty. Therefore, the aims of this paper are to identify the strategic risks affecting the public sector and to propose a holistic risk management strategy to reduce uncertainty in the procurement of privately financed projects. The paper explains the principles behind the PFI concept and identifies the different major associated categories of uncertainty. A holistic strategy is proposed for pro-actively managing uncertainty and risks at specific points during the life cycle of a PFI project. At the early stages of a project, 'soft' issues are dealt with by the use of a qualitative risk management approach. Later in the project's life, both 'soft' and 'hard' (quantitative) risk management approaches can be relevant, depending on the nature of the problems under consideration. Thus the issues discussed in this paper will improve the structuring of risk financing, sharing and management among the different stakeholders involved in PFI procurement.
Keywords: concession, private finance initiative, project management, risk management, uncertainty.

1998, **3**(2), 41–58

Estimating at the earliest stages of design the financial cost and operational energy requirement of buildings

Y G Yohanis and B Norton
Centre for Performance Research on the Built Environment, University of Ulster, Northern Ireland, UK

A simplified model has been developed that not only determines the operational (i.e. heating, cooling and lighting) energy requirement of buildings but also gives an estimation of their effect on the capital construction cost. Traditional cost estimations methods and recent developments in cost modelling are reviewed. A cost model is proposed and incorporated in the energy model to give cost estimations in the early stages of design. The model can be used in parametric analysis to investigate the implications of varying building and cost parameters.
Keywords: BCIS, elemental cost, estimating, cost model, energy modelling.

1998, **3**(2), 59–74

Financial management of construction plant: conceptualizing cost prediction

David J Edwards, Gary D Holt and Frank C Harris
Built Environment Research Unit, School of Engineering & the Built Environment, University of Wolverhampton, UK

In an attempt to augment productivity, post-war UK industry has witnessed a major shift in its utilization of labour resources, to increased use of mechanization. Consequently, plant productivity and equipment selection studies have been conducted but research into its financial management has been scarce. This paper counters this deficiency by conceptualizing prediction of the total costs of construction plant maintenance for tracked hydraulic excavators. In this context total costs equal the sum of direct maintenance costs such as replacement parts, and indirect costs such as lost production. Essentially, the proposed model combines bivariate regression (to predict indirect costs) and multivariate regression analysis (to predict direct costs). Such a financial decision model will enable construction plant managers to make optimum equipment selection based upon the premise of both forecast production rates and predicted total maintenance costs.
Keywords: financial management, maintenance cost, tracked hydraulic excavators, regression analysis.

1998, **3**(2), 75–88

Review of public housing rent policy in Hong Kong

C M Hui, M F Ho, and S H Tam
Department of Building and Real Estate, Hong Kong Polytechnic University, Hung Hom, Hong Kong

About 35%, of the Hong Kong population comprising about 700,000 households, live in public rental housing estates provided by the Hong Kong Housing Authority which is a quasi-government organization. The majority of these tenants are of the lower income group and thus social or “administrative “ rents are charged. Yet the rent of such social housing has been heatedly debated between pressure groups, political parties and the government. This paper addresses the determinants of such rents. It starts by reviewing the rationale of such social housing in Hong Kong. This is followed by a theoretical framework within which to investigate the possible determinants of such social housing rents-namely, location, social and environmental facilities, cost, inflation, relative estate value, affordability, economic factors, and political factors. The concluding part draws out the implications of the dominating or over-riding determinants of such rents and how they might affect government's decision to hold existing or build more such new housing.
Keywords: affordable housing, Hong Kong, housing, location, relative estate value, rent.

1998, **3**(2), 89–92

Geschichte der quantity surveying (baukostenkontrolle)

Jim Birnie
School of the Built Environment, University of Ulster, Northern Ireland, UK

In Grossritannien gibt es den Beruf des quantity surveyors. Er umfabt ein Tätigkeitsspektrum, das in Deutschland auf Arckitekten, Vermessungingenieure, Bauingenieure und Immobilienmakler verteilt ist. Der nachfolgende Beitrag informiert über die Ausbildung und Tdtigkeit des quantity surveyors.
Keywords: none supplied.

1998, **3**(3), 5–16

An empirical investigation of corporate growth of property companies

Liow Kim Hiang
School of Building and Real Estate, National University of Singapore, Singapore

This paper empirically examines the sustainable growth of Singapore property investment and development companies and the financial strategies employed by these firms in achieving financial stability and sustaining growth. The actual growth rates of many property firms are higher than their sustainable growth rates. These firms tend to rely on

increasing financial leverage to sustain their high growth. However, growth does not have a clear impact on the share price performance of the companies.
Keywords: growth, property firm, Singapore.

1998, **3**(3), 17–36

Financial business relationships: a conceptual model for evaluating contractors' creditworthiness

J Nicholas, G D Holt and P T Harris
School of Engineering and the Built Environment, University of Wolverhampton, UK

A conceptual model is presented to assist construction materials suppliers to evaluate contractors' creditworthiness. The model contains variables that should be considered by suppliers when quantifying the risk associated with furnishing contractors credit. It is intended that crediting organizations be able to graphically derive the 'risk profile' of a contractor, thereby enhancing the accuracy by which contractors' creditworthiness is measured. By understanding and correctly applying the model, materials suppliers will reduce their probability of incurring bad debt.
Keywords: business relationships, creditor, contractor, payment, risk.

1998, **3**(3), 37–48

A system for allocating private home owners' annual budget to housing

Anne Ruokolainen[1] and Herman Tempelmans Plat[2]
[1]*Tampere University of Technology, Construction Economics, Finland*
[2]*Eindhoven University of Technology, The Netherlands*

Private home owners base their decision making on the investment expenditure and/or the annual financing costs of the choice alternatives. Future costs due to operating, maintenance and disposal activities are often ignored and benefits expected to be gained from the alternatives are not systematically measured. The purpose of this paper is to suggest a decision support system which provides proper information about the benefits and financial consequences of the alternatives assisting future private home owners' decision making. The benefits are revealed as willingness to pay for the choice alternatives using the bidding game of the contingent valuation method. The financial consequences of the alternatives are presented as annual costs so that the costs can be compared with a household budget expressed on an annual basis. The decision support system has been tested by a small case study carried out in Tampere Area, Finland. The results of the case study emphasise the importance of the annual cost calculation and utility measurement for the choice alternatives although some improvements in the system are still needed to be made.
Keywords: annual cost, building performance, decision support system, housing, home owner, utility measurement.

1998, **3**(3), 49–70

Acquisition or divestment: UK contractors' changing business portfolio

P M Carrillo
Department of Civil and Building Engineering, Loughborough University, UK

Within the last decade, the nature of contracting activities in the UK has changed dramatically. Instead of construction services being offered, contractors now get involved with a much wider range of activities from providing finance, design, construction, operation and maintenance. The construction business is one of high risks and low profitability and contractors are being forced to adopt strategic management techniques to maintain competitiveness and profitability. This paper investigates how companies devise corporate strategy, develop their business portfolio and judge their subsequent performance with case studies from three major UK contractors. The results show that whilst corporate strategy is given serious attention, even the top UK contractors still have not implemented the use of business portfolio analysis and performance measures advocated by the rest of the business world.
Keywords: contractor, corporate strategy, portfolio analysis, strategy, UK.

1998, **3**(3), 71–83

The effect of payment for advance purchase of building materials on contractor's cash-flow projections

G O Jagboro
Faculty of Environmental Design and Management, Obafemi Awolowo University, Ile-Ife, Nigeria

As an economic activity a construction project may be considered as the utilization of material, labour, plant and human resources for the realization of building and other infrastructure. To facilitate the execution of the project on site, parties have over the years adopted the use of a mobilization fee as a way of reducing the financial risks to contractors and clients in Nigeria. The objective of this paper is to study the effect of payment for advance purchase of materials on contractor's cash-flow projections. The net present value technique, (NP VT), is adopted in assessing the present worth

of payment made under advance payment schedule vis-à-vis the projected cash flows in monthly and bi-monthly valuations. The result showed that the net present value (NPV) under the advance payment schedule (APS) was 2.7% and 9.8% higher when compared with the expected monthly and bi-monthly valuations respectively despite the inherent level of delay.

Keywords: building material, cash flow, investment, Nigeria, profitability.

JFMPC: Volume 4, 1999

1999, **4**(1), 5–30

Financial structure of UK property companies: a research agenda

Joseph T L Ooi
School of Building & Real Estate, The National University of Singapore, Singapore

This study analysed the aggregated financial statements of the UK quoted property sector between 1985 and 1996. It identified the following stylized facts concerning the sector's financial structure; (a) shareholders' equity is very sensitive to the underlying property market condition; (b) level of indebtedness has rose sharply over the study period,. (c) despite rising debt level, gearing ratios have improved in the recent years mainly because growth in property values and share capitalization have outstripped growth in debt level,. (d) interest charges dominate other outgoings;(e) debt raising capability is constrained by inability to service loans rather than from a lack of collateral,. (0 rental income provide a stable source of revenue; (g) cash flow management is critical to ensure solvency,. and (h) dividend policy is 'sticky' Discussion on the uniqueness of property companies also pointed out a number of implications on their financing decisions, where the magnitude would be different from firms in other industries. Generally, property companies would employ proportionately higher gearing, longer debt maturity, higher incidence of secured debt and heavier reliance on bank borrowings as compared to companies in other sectors. This is supported by the evidence from the analysis.
Keywords: debt, financial structure, property company, UK.

1999, **4**(1), 31–46

Predicting maintenance expenditure on construction plant: model development and performance analysis

David J Edwards, Gary D Holt and Frank C Harris
School of Engineering and the Built Environment, University of Wolverhampton, UK

Salient findings of a 12-month study, designed to predict the average hourly maintenance costs of tracked hydraulic excavators are presented. In order to achieve the research, close collaborative links were forged with numerous plant manufacturers and construction contractors operating in open-cast mining. A random sample of 33 machines was used for model development. Multiple linear regression analysis is shown to be an excellent technique for predicting the maintenance costs of tracked hydraulic excavators operating in the UK opencast mining industry. Machine weight; type of industry; regular use of predictive maintenance; and type of machine are revealed as key predictor variables due to their strong positive linear relationship with machine maintenance costs Overall the performance of the model was good, having an R^2 of 0.94, an MPE of minus 11% and a MAPE of 2.5%.
Keywords: plant, maintenance cost, multiple regression, tracked hydraulic excavators.

1999, **4**(1), 47–58

Multi-skilling as a possibility of compensating arrhythmic work loads

Jüri Sutt and Irene Lill
Department of Building Production, Tallinn Technical University, Estonia

This paper describes a simulation system for evaluating different management strategies inside construction firms. Within this context, the paper addresses the problems of identifying the most efficient forms of labour specialization and work organization, including reasonable forms of payment to workers in order to adopt their skill bases. The organizational and technological conditions of the constructing process are taken into account in form of network models. The main problem is providing the flexibility of the model towards the workers' professional structure in the firm. By changing the parameters in the models of the buildings and the models of the resources of a constructing firm, different building situations are created. The economic evaluation of executed experiments are represented in the goal function of the building enterprise activities in the model of economic assessments of calendar plan. The result of research shows the dependence of cost price on the number of combined trades. The paper concludes by assessing the economic benefits of using multi-skilled workers.
Keywords: construction management, modelling, multi-skilling, simulation,

1999, **4**(1), 59–74

A review of the application of risk assessment procedures in construction management and research

J G Gunning
School of the Built Environment, University of Ulster at Jordanstown, Northern Ireland, UK

This paper reviews the developing approaches to risk assessment in construction management and research. In addition to the well known applications in financial investment and contractual matters, it is being employed increasingly in

safety hazard analysis and in quality assessment. The author uses examples from his experience in these latter applications to cast doubt on the objectivity and validity of much risk assessment. The social aspects of risk, and the subjectivity inherent in the statistical probabilities used in risk assessment appear to have been ignored in much of the literature on the subject. A debatable certainty is implied in the reverence accorded to the results of mathematical and economic risk analysis, which is often incompatible with the reality of construction as a chaotic system. It is argued that highly quantitative methods of risk assessment are often inappropriate in construction. The use of deterministic solutions to stochastic problems provides the impression of "garbage in, garbage out"! Much has been written about the development of tools for numerical analysis of data, but there has been limited debate about the accuracy of this raw data itself. The author suggests that a more pragmatic, heuristic approach to risk assessment in practice and research would bring benefit to both, especially if founded upon well-documented case histories and shared experiences.
Keywords: heuristic, procurement, research, risk assessment, risk management.

1999, **4**(1), 75–87

Real estate and foreign investment in China

Dianchun Jiang,[1] Jean Jinghan Chen[2] and David Isaac[2]
[1]*Institute of International Economics, Nankai University, P.R China*
[2]*School of Land and Construction Management, University of Greenwich, UK*

This paper discusses the development of real estate industry in China in recent years. It argues that Hayek's theory of economic fluctuations can help to explain the contraction of the real estate market in 1994 in China as a whole. However, as a theory of the closed economy, Hayek's theory is found to be no longer robust when applied to cities where there is heavy foreign direct investment, such as Shanghai. We believe that it is the foreign direct investment that is making the real estate industry in Shanghai perform well, despite the government's tight monetary policy and the contraction of the industry in other parts of the country over the same period. It is also argued that, while most of foreign investment in real estate is classified as direct investment, it is very different from "typical" foreign direct investment except in form and in fact shares most of the characteristics of portfolio investment. Foreign direct investment in real estate reflects the imperfections of China's capital markets.
Keywords: capital markets, Chinese real estate, foreign investment.

1999, **4**(2), 5–32

The evolution of value theory and the practice of real estate valuation

L M Farrell
Université du Québec, Canada

The practice of real estate valuation and appraisal is an evolving discipline which is based on the fundamental linkages which exist between theoretical innovations, derived from financial asset valuation technology, and the expert judgement of the appraiser. The distinction between value theory, as developed over the last three or four centuries, and valuation theory, which is of more recent vintage, is significant. Economic value theory is concerned with the determination of the sources and foundations of value and provides a basis for many of the concepts and techniques of valuation theory. Real estate valuation theory is concerned with the derivation of methods to estimate the value of a real estate asset. The traditional sausage eater's caveat, which prescribes close scrutiny of the sausage making process, could also be applied to various real estate asset valuation procedures. The traditional three approaches to value were each developed at different points in time, in different geographical regions, based on different concepts and valuation techniques. There is no reason to expert that each method, while internally consistent individually, would produce a set of convergent value estimates. The evolution of the concept of value has been accompanied by a progressive abstraction of the physical entity used to represent or embody value. For example, technological change and the passage of time have altered the concept of money by making it more abstract and symbolic. While it remains a hybrid financial instrument which serves as a standard of value and as a medium of exchange, the physical form of money has evolved from gold, as physical money, to paper symbolic money, and more recently to pure, abstract money which exists as a set of electronic impulses displayed on a computer output device. The development of option pricing theory, while not directly applicable to non homogeneous real estate asset markets, provides a previously unexpected insight into the redistribution of value and wealth which can occur as a result of the financial management policies pursued by the owner of a levered real estate asset.
Keywords: asset value theory, discounted cash flow, property valuation, real estate, valuation.

1999, **4**(2), 33–48

The growing mortgage market in China

Man-Kwong Leung and Gordon Tin-yau Shing
Department of Business Studies, Hong Kong Polytechnic University, Hong Kong

Mortgage finance has been actively promoted in the socialist market economy of China in recent years. Its development has originated from the government's commitment to the commercialization of the bank and urban housing markets. The results of an empirical survey conducted among banks show that the government can facilitate the growth of the property and mortgage market by improving the conveyancing regulations, and by reducing both the various types of taxation applicable and also bureaucratic red tape. The high price of housing, relative to the low level of household incomes, has posed a major obstacle to the growth of the property and mortgage market. The prospects for the mortgage market in China are, however, viewed as promising because government has promoted the private housing

market, via mortgage finance, as a means to expand the economy since the 1997 financial crisis. The mortgage market will experience a more steady growth if incomes in China rise to a level sufficient to increase the home affordability of more households.

Keywords: China, housing market, mortgage market, rent.

1999, **4**(2), 49–62

Water efficient dwellings: do UK house builders recognise a need?

S Goodhew, D Fitzgerald, C Southcombe
University of Plymouth, UK

According to the Governments' proposed housing policy, 4.4 million new homes will be required in the UK by the 2016. Many of these dwellings will be required in areas that experience water restrictions during periods of low rainfall. This paper links the large quantities of 'potable', drinking quality water used for flushing toilets and the significant opportunities to save water within the new housing units by utilizing 'grey and rain water' systems. The financial viability and contractors' attitudes to water conservation systems were solicited, through a survey of 100 NHBC registered firms. 50 Companies, nationwide, responded. Indications were that 40% of the companies would consider installation of such systems, given a cost of between £500 and £1,000 per new dwelling. Of the 40%, 22% considered that if the water conservation systems were installed, their house sales would be likely to increase.

Keywords: housing, survey, sustainability, water conservation, water metering.

1999, **4**(2), 63–80

Corporate real estate in financial statements: evidence from Singapore hotel corporations

Liow Kim Hiang
School of Building and Real Estate, National University of Singapore, Singapore

Real estate is one of the largest assets in hotel corporations. This paper empirically assesses the absolute and relative importance of real estate in corporate financial management of Singapore hotel companies in the period 1987-1996. We find that real estate comprise over more than half of a hotel firm's total tangible assets, with some large hotel companies investing and developing properties. Average growth in real estate holdings has been remarkable. In addition, real estate is able to influence significantly shareholders' equity and market value of a hotel firm. Finally, 'property intensive " hotel firms differ significantly from "property-less-intensive" ones in key financial characteristics. For example, higher relative level of property asset holdings is associated with higher financial leverage, lower return on equity and less favourable market valuation of properties.

Keywords: corporate real estate, hotel, property assets, real estate, Singapore.

1999, **4**(3), 5–28

Hong Kong's public housing policy: a new perspective on government intervention and rationale

Eddie C M Hui
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong

This paper traces the development of government intervention from the 1950s to the 1990s with a view to bringing out the shortcomings and offering a new perspective of the underlying reasons of government intervention in Hong Kong. It sets up an analytical framework within which to challenge conventional wisdom and to offer a new perspective on the debate on government intervention. It particularly addresses three important questions. First, what have been the rationales behind government housing initiatives in Hong Kong over the past forty years or so? Second, what are the possible shortcomings in policy development as a result? Third, what are the underlying reasons for the ways of government intervention, particularly in the context of policy planning effort and political environment? This paper also serves a refreshing contribution to debate on choices between public and private provision, particularly before and after Hong Kong reverted to Chinese rule.

Keywords: Hong Kong, housing, rent.

1999, **4**(3), 28–38

Materials suppliers: the builders' banker?

J Nicholas, G D Holt and P T Harris
Built Environment Research Unit, School of Engineering & the Built Environment, University of Wolverhampton, UK

Materials suppliers are important players in the construction industry. Not only for the raw materials they provide, but also, because they furnish contractors with additional working capital by allowing them materials on credit. The purpose of this research is to identify whether materials suppliers' are indeed the 'builders' banker'. The results of a UK national survey of materials suppliers' credit control and debt collection practices, as part of ongoing research into contractor creditworthiness evaluation methods, would seem to confirm that suppliers are a vital source of contractors' working capital It is apparent that suppliers are critical to the functioning of construction activity. Through the credit they furnish

suppliers are (i) exposed to potentially high levels of financial risk, (ii) influence the number of contractors operating in the industry; and (iii) by way of item (ii) have an influence upon tender prices.
Keywords: credit, interest, material supplier, risk.

1999, **4**(3), 39–46

A study of the monetary value of extension of time in building project

G O Jagboro[1] and O R Alli[2]
[1]*Department of Quantity Surveying, Obafemi Awolowo University, Ile-Ife, Nigeria*
[2]*Department of Quantity Surveying, Federal University of Technology, Akure, Nigeria*

Contractual claims associated with building projects essentially are fluctuations, variations and contract period prolongation. While fluctuation and variations claims are quantified in monetary values, disputes arise in the computation of the monetary value of extension of time. This dichotomy is predicated on the perception of extension of time by consultants as time adjustment compensation and by contractors as time adjustment and monetary loss compensations. The posit of this paper was that the monetary value of contractual claims (CCMV), does correlate with the approved extension of contract period (TET) in the form of a regression equation such that:

$$CCMV_i = aa_0 + aa_i\, TET_i + \mu_i ;\ i = 1, 2 \ldots n$$

Cost data were obtained for 60 projects, including residential,and low rise office buildings. The coefficient of determination for the casual relationship was computed as R12 = - 0. 0070; (F–5% = 0.59). This finding has empirically established conclusively that the monetary value of extension of time is highly insignificant and reinforced the compensation approach in the resolution of disputes emanating from extension of time.
Keywords: contract, claim, cost, extension of time.

1999, **4**(3), 47–64

Motivation and risk perception in foreign and domestic real estate investments

Chin Chin Soh[1] and Seow Eng Ong[2]
[1]*Waterbank Properties*
[2]*School of Building and Real Estate, National University of Singapore, Singapore*

Project profitability is an important, but not necessarily the main factor determining project decision-making. Among other pertinent factors are less quantifiable factors such as strategic synergy and “gut feel” or judgmental evaluation. This study examines the extent to which factors other than profitability are pertinent and quantifies their relative importance using a pair-wise comparison approach. In addition, this study analyses the extent to which the motivation and risk perception differ between domestic and foreign investments. The evidence from a survey of Singapore developers shows that while project profitability is the most important factor, a myriad of other factors are considered in real estate investment decision making. Further, there exists a preference for domestic projects / home bias in that an unjustifiably low weight is given to domestic economic and country risks. Interestingly, the financing structure and debt level for foreign investments differ from that for domestic investments.
Keywords: debt structure, finance, investment, risk, Singapore.

1999, **4**(3), 65–80

Evaluating quality in construction

F Harkin and J G Gunning
School of the Built Environment, University of Ulster at Jordanstown, Northern Ireland, UK

The importance of clients obtaining buildings which are built to budget, on time and to the required quality has been recognized by the recent proliferation of procurement systems and by the increasing use of project managers to oversee the design, construction and cost control processes. While cost and time are quantifiable, the assessment and measurement of quality remain essentially subjective. This paper explores the meaning of the word 'quality' as understood by architects, and the difficulties they experience in trying to deliver it in a society driven by economics. Nine senior architects in Northern Ireland were interviewed (using semi-structured interviews) and their views recorded on tape. An analysis of the tape recordings was carried out to identify themes and categories from the answers obtained. These categories were then used to formulate a questionnaire designed to test the attitude of a group of 30 local public and private sector clients to what the architects had identified as areas of concern. The results of these two surveys were compared on a simple statistical basis. Some interesting differences of opinion between architects and clients were revealed along with a large measure of ambiguity. This simple analysis did not, however, capture the essence of the architects' voice. The sub-text was missing – its content, particularly what it had to say about quality, was not revealed through statistical analysis. This sub-text is explored in the paper from one particular philosophical interpretation of the word 'quality' – an interpretation that the researchers believe is close to architects' understanding of the word in the context of architecture.
Keywords: aesthetics, architecture, client, construction, quality.

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2000, **5**(1/2), 3–13

Improving early cost advice for mechanical and electrical services by considering functions and client/design team communication

L M Swaffield and C L Pasquire
Department of Civil and Building Engineering, Loughborough University, Loughborough, UK

The paper discusses existing methods of pre-design cost estimating for the mechanical and electrical (M&E) services elements of building projects. The paper then addresses the problem of poor communication between clients and building professionals, leading to misinterpretation of mechanical and electrical (M&E) services requirements and inaccurate cost estimates. The research hypothesised that M&E services cost was related to a building's form and function, and M&E quality. A sufficiently accurate cost estimate depended on an accurate understanding of the quality of M&E services required by the client. This paper proposes a method for improving early design stage communications, to improve interpretation of M&E services quality requirements and lead to more accurate cost estimates. The method involves introducing a briefing workshop to consider functional requirements from the building, possible M&E services solutions, and interfaces between building structure and fabric and the M&E services. The proposed method received support in principle from the field. It is suggested as a valid method of improving early design stage communications between clients and building professionals, that could lead to improved early cost advice for M&E services.

Keywords: BCIS, communication, cost, design, elemental analysis, estimating, mechanical services, electrical services.

2000, **5**(1/2), 15–31

The development of property asset management: towards a pro-investment form

Mark Deakin
Napier University, Edinburgh, UK

The paper examines the development of property asset management. It outlines the background to the development in terms of the ongoing modernization that property management has been subject to and redefinition of the terms of reference which has recently taken place in the movement towards property asset management. The paper then draws particular attention to the corporate and financial developments underlying the movement towards a pro-investment form of property asset management. After subjecting the current presentations of this development to a critical examination, the paper goes on to advance a contemporary model of property asset management which is pro-investment in the sense that it represents a structure of management common to all property assets.

Keywords: modernization, property management, property asset management, pro-investment form.

2000, **5**(1/2), 33–40

A study of housing and real estate markets in Macau

Raymond Y C Tse
Department of Building and Real Estate, Hong Kong Polytechnic University, Hong Kong

Macau, a Chinese territory under Portuguese administration has become a meeting point of East and West. The sovereignty of Macau reverts back to China at the end of 1999 with a status similar to that of Hong Kong. Economic integration between Macau, Hong Kong and China implies that the real estate market of Macau offers a great investment opportunity for developers. However, in a new and emerging market, information is important to foreign investors. There are potential returns as well as risks in the markets. This paper gives a brief review of the housing policies and provides some basic information about the current situation of the housing and real estate market in Macau. The paper also makes an assessment of the economic performance of Macau, provides fresh insights regarding its future development, and is useful to institutional and foreign investors who are interested in real estate investment in China.

Keywords: housing, infrastructure, Macau, real estate, tourism.

2000, **5**(1/2), 41–50

Money illusions and the judgements of professional quanitity surveyors

Chris Fortune[1] and Jim Birnie[2]
[1]*School of the Built Environment, Liverpool John Moores University, Liverpool, L3 5UG, UK*
[2]*School of the Built Environment, University of Ulster at Jordanstown, Newtownabbey, BT37 0QB, UK*

Clients of the construction industry need reliable professional advice. A factor that affects the quality of this advice is human judgement. The exercise of judgement is a human cognitive process that has been found to be subject to errors, bias, and heuristics. Although it is generally accepted that such errors, bias, and heuristics are used by lay people thinking intuitively there exists as yet no consensus on whether the same traits can be found in the judgements made by professionals when they consider problems within their own domain. This paper reports the results of a quantitatively based investigation into the nature of the judgements made by professionally qualified consultant quantity surveyors when they were asked to consider context-related word problems. The study is part of an international investigation of the issue and the data generated as a result of this work with practitioners based in England is capable of being compared with the results of similar studies undertaken in Hong Kong, South Africa and Australia. The paper concludes by calling for more work to be undertaken with professionally qualified construction industry practitioners in the consideration of actual rather than simulated professional problems in order to determine whether the presence of quasi-rational judgements found in the results of this study are replicated in real life situations.
Keywords: decision making, error, bias, professional judgement.

2000, **5**(1/2), 51–64

Applying quantitative techniques to evaluate residential development profitability

Roger Bollen
Urban Land Corporation , Melbourne, Australia

Within the property industry, research using regression analysis has focused on the estimation of land value. Much of this research has been conducted in the United States where it is not uncommon for this technique to be employed as a primary method of property value estimation. Within Australia however, research has looked at the use of this analysis technique as an alternative method for mass statutory valuation assignments. The existing research has identified a number of physical property attributes critical to the assessment of property value. Recognition of the importance of consumer preference has been made in passing however, little attempt has been made to explicitly include these characteristics within valuation or price estimation models. This paper utilizes quantitative techniques, not as a conventional valuation or price estimation tool, but as a tool to understand the impact on net development profit of alternative urban design solutions within a residential development. It takes the present research a step further and extends it by applying Factor Analysis to derive variables representative of consumer demand for inclusion within conventional regression analysis. The results indicate that deriving consumer preferences through the techniques employed does contribute to a better understanding of demand criteria for residential housing lots. The factors extracted provide useful insights into buyer preferences. The factors are specific to a particular subdivision and may not be applied generally.
Keywords: Australia, profitability, property industry, real estate, regression analysis, home buyer, factor analysis.

2000, **5**(1/2), 65–77

A neural network model to forecast national construction output

Sirichai Tanratanawong and Stephen Scott
Department of Civil Engineering, University of Newcastle upon Tyne, NR1 7EU, UK

Construction output forecasts have been routinely made and published to assist construction and construction related firms with their planning processes. They are typically provided by groups of experts, as it is not practical for general construction firms to produce such forecasts for their own uses. The study reported in this paper aims to develop an efficient, practical quantitative method to forecast the national construction demand using economic indicators. Back-propagation neural networks were chosen for this study due to their ability to learn from examples of historical data, to map the relations between various variables without prior knowledge and to generate outputs with relatively high accuracy. Regression models were also developed based on the same data sets. The results were then compared with existing published qualitative forecasts. It was found that the neural network models performed well in forecasting construction output in all three sectors: Housing, Non-housing, and Repair and maintenance. Indeed, in all tests, the neural network models forecasted more accurately than the regression models and were close to the published forecasts. The results show that neural network models can be effectively used as an alternative forecasting tool.
Keywords: construction output, construction demand, artificial neural network, principal component analysis, regression analysis.

2000, **5**(1/2), 79–84

Making urban renewal pay: the Hong Kong experience

David Adams[1] and E M Hastings[2]
[1]*Department of Land Economy, University of Aberdeen, St. Mary's, King's College, Aberdeen, AB24 3UF, UK*
[2]*Department of Real Estate and Construction, University of Hong Kong, Hong Kong, China*

This paper evaluates the initial operations of the Land Development Corporation, established by the Hong Kong Government in 1988 to undertake, encourage, promote and facilitate urban renewal. It demonstrates how, in the absence of significant public funding, the Corporation had to rely on innovative forms of partnership with leading private-sector developers. The LDC's initial activities were thus concentrated on projects likely to produce the highest financial return rather than necessarily contribute most to urban renewal. The paper suggests more extensive urban renewal in Hong Kong may be hard to achieve without acceptance that such activities cannot be always financially viable.
Keywords: Hong Kong, land policy, public-private partnerships, urban renewal.

2000, **5**(1/2), 85–92

Quantifying the cost of plant operators' productivity

David J Edwards and Gary D Holt
School of Engineering and the Built Environment, University of Wolverhampton, UK

The construction industry relies increasingly upon high utilization of mechanization, the main driver here being cost. This is particularly so in times of recession and increasing competition, when companies look inward to improve productivity and cost efficiencies. Nevertheless, even with the most sophisticated machines, output largely depends upon the skill and competence of the operator. It is curious therefore that research into plant operative productivity output has to date, eluded greater academic attention. This paper addresses this deficiency; specifically, a methodology is presented with which plant operator productivity output could be classified. Such a model would assist construction practitioners in their efforts to improve competitiveness, while construction clients would also benefit from less interruption to project progress, timely project completion, and reduced costs.
Keywords: cost, plant, productivity, tracked hydraulic excavators.

2000, **5**(1/2), 93–104

A fuzzy model and algorithm to handle subjectivity in life cycle costing based decision-making

M Kishk and A Al-Hajj
School of Construction, Property and Surveying, The Robert Gordon University, Garthdee Road, Aberdeen AB10 7QB, UK

A life cycle costing (LCC) algorithm that can effectively deal with judgmental assessments of input parameters is proposed. This algorithm is based on the fuzzy set theory and interval mathematics. The development of the algorithm is motivated by the need to handle in a systematic and a more objective way the imprecision in these subjective assessments. Three major issues were considered in the development of the algorithm. First, an appropriate mathematical framework for representing subjective imprecision was identified. Then, the original LCC closed-form equation was reformulated so that uncertainties in all input parameters can be modelled in an effective and convenient manner. Finally, the formulated model was implemented in the form of an efficient computational algorithm. The algorithm handles a number of alternatives with imprecise input data and ranks them automatically. The solution of a selected example problem is included to clarify the theory of the model.
Keywords: fuzzy sets, interval analysis, life cycle analysis, risk assessment.

2000, **5**(3),111–122

Cost-duration tool for policy decision on micro- and small projects

M Sohail and F T Edum-Fotwe
Department of Civil Engineering, Loughborough University, Loughborough, Leicestershire, LE11, 3TU, UK

For policy makers connected with infrastructure developments, a decision on whether a particular scheme should be pursued or abandoned will be influenced in no small measure by the overall cost and duration involved in undertaking the scheme. The speed with which such a decision can be arrived at and the cost and time involved in generating the information for making such decisions is equally crucial. For medium to large projects, the cost and time for generating this information is insignificant compared to the overall scheme cost and duration. This however, is not the case for schemes that fall into the magnitude that is categorised as micro and small. The paper presents a simple graphical tool that can be employed to facilitate the decision of policy makers involved in such small and micro projects. The tool was developed with data from 132 micro projects using statistical modelling techniques, and provides a quick and cost effective means of arriving at the information that should support policy decisions relating to small and micro projects.
Keywords: cost, decision-making, duration, infrastructure, micro-projects, non-linear regression.

2000, **5**(3), 123–133

The impact of portfolio strategy on the 'style' performance of UK property companies

Hishamuddin Mohd Ali and Les Ruddock
Research Centre for Construction and Property Management, University of Salford, Salford, M7 9NU, UK

The property portfolio allocation of property companies could be determined through a risk and return analysis of each sector considering an acceptable level of risk. This study applied a constrained multiple regression model to the examination of property portfolio exposure. An asset class factor model namely return-based style analysis (RBSA) was developed by Sharpe (1988, 1992) to measure the exposures of each component of a mutual fund's portfolio to movements in their returns. Total returns from ten public-listed property companies (PLPCs), based on their share price movements, were used to estimate the style exposures of three commercial property types - retail, office and industrial. The data used for share price movements are from the first quarter of 1987 to the fourth quarter of 1998. The study examined the relationship of the return for three commercial property types to each portfolio of PLPC. The effective portfolio allocations that are derived by RBSA are then compared with the actual average portfolio allocation of the property companies. RBSA is seen to be a particularly effective tool in the explanation of the returns of PLPCs pursuing growth or income strategies. This study also found that other aspects of portfolio allocation determinants such as gearing, the features of the property portfolio and the property market cycle were worthy of consideration.
Keywords: commercial property, portfolio allocation, portfolio strategy, real estate.

2000, **5**(3), 135–147

An evaluation of international frameworks for business self-assessment and their application in UK construction

Lawrence M Mbugua, Gary D Holt and Paul O Olomolaiye
University of Wolverhampton, Wulfruna Street,WV1 1SB, UK

Numerous Self-Assessment Frameworks (SAFs) have been proposed around the world to enable companies measure their business performance. These SAFs include ISO 9000, Investors in People, Deming Prize, Baldridge Award, Business Excellence Model, the Balanced Scorecard and the Inclusive Approach. The UK construction industry has also proposed a set of 10 Key Performance Indicators (KPIs), to evaluate the business performance of construction companies. These KPIs need to be viewed in a global context; so that lessons can be learned as they are developed. This paper extends the knowledge of these various SAFs by evaluating their application to the measurement of construction business. The major SAFs used around the world are discussed, compared, and evaluated in relation to construction business. It is concluded that although self-assessment is perceived as a powerful organizational learning technique and a means to continuous improvement, construction companies have much to learn regarding their use and are yet to maximize their potential. The construction industry KPIs are a vital step in this direction.
Keywords: business improvement, construction business, performance measurement, self-assessment frameworks.

2000, **5**(3),149–158

Corporate financial reporting of Singapore property companies: issues and evidence

Kim Hiang Liow
Department of Real Estate, National University of Singapore, 4 Architecture Drive, Singapore 117566

There are several issues surrounding property company financial accounting. The aim of this paper is to empirically examine the ways in which property and property valuations are reflected in corporate balance sheets of Singapore property companies. The areas covered include the classification of properties, accounting for properties as fixed assets, valuation of investment properties, accounting for development properties, and details of revaluation disclosure. The study reveals that although individual property companies were consistent in their property accounting practice over the five-year period, there were considerable variations between companies in the property classification, valuation and disclosure in the balance sheets.
Keywords: property assets, property company, real estate, revaluation, Singapore, valuation.

2000, **5**(3), 159–169

Highway concessions in Brazil: an analysis towards the feasibility of the securitization

Claudio T Alencari
Department of Construction, Escola Politécnica da Universidade de São Paulo, Brasil

In this paper, comes out an analyses of the feasibility of securitization of highway concessions in Brazil. Principally, we seek to identify the highway construction budget and the traffic volume necessary to render securitization feasible as a possibility for funding a prototype concession. Our analysis relies on information provided by the main federal highway

concessions under way in Brazil. The conclusion is that, under the present situation of Brazilian economy, it is possible to securitize the prototype concession, yet its implementation relies on the fall of prevailing interest rates in Brazil.
Keywords: concession, securitization, highway, economic analysis, privatization.

2000, **5**(3),171–180

Cost of the adjudication process in the UK since the introduction of the Housing Grants, Construction and Regeneration Act 1996

P Kennedy and J L Milligan
Glasgow Caledonian University, Scotland, UK

This paper presents data collected from adjudicators and Adjudicator Nominating Bodies (ANBs) since the introduction of the statutory right to adjudication in the Housing Grant, Construction and Regeneration Act 1996. This data shows the increasing trend towards adjudication in the UK and the costs associated with the adjudication process. The paper discusses the sums of money in dispute and compares these with the adjudication costs. The evidence shows that, on average, the adjudication cost amounts to approximately 3% of the sums in dispute.
Keywords: adjudication, conflict, cost, dispute resolution.

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Publisher's address:
Stephen Brown, Royal Institution of Chartered Surveyors, 12 Great George Stree, London, SW1P 3AD, UK
E-mail: sbrown@rics.org.uk

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1994, **1**(1), 1–55

Building cost management in France

Stephen Pearson
School of Construction, South Bank University, 202 Wandsworth Road, London, SW8 2JZ, UK

This paper provides an overview of cost management in the French building industry based upon published French and UK sources, interviews with French and UK nationals from a variety of building industry backgrounds and responses to a questionnaire distributed to UK quantity surveying firms with experience of the French market. The paper outlines the cultural and legal contexts within which building cost management is exercised in France, distinguishing between the public and private sectors. A review is provided of tendering procedures and contractual arrangements, procedures and techniques used for cost management and the processes of education and training for those who take responsibility for cost management on behalf of clients and contracting firms. Current activities of UK cost consultants in France are reviewed. The paper concludes with a discussion of barriers to entry and expansion which confront such firms and the strategies which they might adopt to overcome these barriers.
Keywords: cost management, France, quantity surveying.

1995, **1**(2), 1–48

A communication-based analysis of the theory of price planning and price control

Paul Bowen
University of Cape Town, Private Bag, Rondebosch 7700, Cape Town, South Africa

This paper provides a communication based analysis of the theory of price planning and control within the framework of the stages of the ISAA (1989) 'Plan of Work'. Each member of the design team is considered in terms of the components of their inter-personal communication pursuance of their respective professional functions. Attention is focused on members' roles as senders and receivers, the process of encoding and decoding, the nature and structure of messages the act of transmitting, barriers to effective communication, and the feedback mechanisms required to facilitate shared meaning. The analysis highlights clearly the need for meaningful and effective communication between the members of the design team if the quantity surveyor is to fulfil adequately the role of price consultant. An idealised model of the price planning and control environment within which price forecasting occurs is proposed. In terms of this model, the message sent is the message received and shared meaning between the participants to the communication process is maximised. Such an idealised communication environment is characterised by: minimal barriers to effective communication; high empathy and sensitivity to audience; appropriate use of terminology and levels of abstraction; mutual appreciation of roles and responsibilities; absence of defence mechanisms and minimal message distortion; the availability of appropriate price data and models; proactive quantity surveyor involvement; high quality intra- and inter-personal communication; and the effective use of feedback mechanisms. Finally, implications of this idealised model for price forecasting in general, and price modelling in particular, are drawn. Emphasis is given to the model/data/design/output interface and the need for price models and data to more fully represent the construction process.
Keywords: communication, feedback, price

1995, **1**(3), 1–48

The role of construction and marketing in economic development: a framework for planning

Low Sui Pheng
School of Building and Real Estate, National University of Singapore, 10 Kent Ridge Crescent, Singapore, 119260, Singapore

The pursuit of economic development is a major preoccupation of both developed and developing countries. Unfortunately, economic development not only has different implications for different people but also defies exact measurement. Many factors have been suggested as influencing the development process. Studies in the development process have also suggested that different countries have evolved along vastly different paths toward economic growth. Thus, the issue of economic development appears to be a multi-dimensional one. In view of the difficulties in determining what economic development is and what spurs an economy to grow faster than another, the purpose of this paper is to move sideways specifically into the construction and marketing disciplines to examine their respective and collective effect on the development process. While this paper does not pretend that construction and marketing are the only two factors which influence economic development, it aims to provide conceptual and statistical evidence to support the hypothesis that there is a need to synthesise both construction and marketing if balanced economic growth is to be achieved effectively. The themes of this paper are to argue, through statistical evidence from countries in seven different regional/economic groupings, that there is a need to balance the inputs of construction and marketing in the development process, and to examine the relationship between construction, marketing and economic development. A

heuristic framework based on an indexed approach will also be proposed for construction economists, marketeers and development planners to position construction and marketing within the context of desirable economic development. Using this framework, development planners will now be able to formulate macroeconomic strategies for any countries, both real and hypothetical, to take into account a more balanced input from the construction and marketing sectors.
Keywords: development, growth, marketing, planning.

1995, **1**(4), 1–19

Quality management for the construction professional: what a mess!

Peter Barrett
Research Centre for the Built Environment, Department of Surveying, University of Salford, Bridgewater Building, Salford, M5 4WT, UK

In "The Observer" newspaper in March 1994, an article appeared under the headline "Never mind the standard, feel the quality". A quote from this article suggested, "Quality assurance or quality destruction? The controversy surrounding BS5750, the quality management standard, is a classic example of the treachery of measurement systems in management, even well meaning ones." Is this a fair comment? It certainly represents a rising tide of negative journalistic writing in the UK and contrasts sharply with the usual positive view presented by the government, QA consultants and certified firms. It is against this confused picture that this paper presents the results of an extensive research project in the hope that the findings will clarify some of the issues. This leads on to the description of an approach named "supple systems". The last part of the paper considers the relationship between the "supple systems" approach and other initiatives in the quality field.
Keywords: measurement, quality, systems approach.

1995, **1**(5), 1–40

Research parks in Canada: a product of local circumstances and global trends

Norma Carter
Department of Historical and International Studies, De Montfort University, The Gateway, Leicester, LE1 9BH, UK

Technological progress is seen world wide as a means to economic advancement, the key to improvements in productivity, global competitiveness and ultimately employment and wealth creation. Science parks are one of the mechanisms used to encourage technological growth. They are concerned with generating a new round of investment in the locality concerned. This paper focuses on research parks in Canada to illustrate the interplay of factors, local to global, which affect their success. It examines the reasons for their growth and the extent to which they are an indication of successful local initiative and enterprise or a manifestation of international economic trends. It makes particular reference to British Columbia, Alberta, Ontario and Quebec, together with a detailed case study of the Edmonton Research Park. It demonstrates the tensions between the objectives of research parks and the need for the property development to be viable. Competition between localities may be an important ingredient in that success or may lead to duplication, frustration and failure. The paper concludes that the right local conditions for establishment and growth include continued commitment from key agencies: local government, university, industrial and business communities, and that while Canadian research parks have been part of a recent international phenomenon, they are essentially a product of local conditions.
Keywords: Canada, growth, planning, science park.

1996, **1**(6), 1–80

Commercial valuation services: client and valuer requirements in the Bristol region

Peter Hobbs[1]; Nigel Cooke[2] and Gavan O'Leary[3]
[1]*Boots Properties plc, UK*
[2]*Faculty of the Built Environment, University of the West of England, Coldharbour Lane, Bristol, BS16 1QY, UK*
[3]*Jones Lang Wootton, UK*

In the wake of the recent valuation-based litigation claims and the recommendations of the Mallinson Report, there is a clear need to improve understanding of client requirements from valuation services. It is within this context that this paper presents the results of a two-stage programme of research on valuation services in the Bristol region. The paper establishes a research framework and explains the methodology prior to analysing, first, the nature of valuation services provided by surveying practices and, second, the perceptions of clients towards the services provided. The research demonstrates the relative sophistication of the valuation service provided in the Bristol area. The market is segmented with a broad range of specialisms being provided by a combination of large and small, national and local firms. Clients are highly satisfied with the quality of service provided by valuers and this satisfaction compares well with the service provide by other professions. This satisfaction is certainly greater than suggested in earlier research and by recent statements from the leaders of the surveying profession. Despite this sophistication and client satisfaction, the paper shows there is a need to, and scope for, improving the service provided by valuers. The need to improve the service relates to factors such as the continuing pressures on costs and the national debate over the nature of the valuation

service required by the client. The scope to improve the valuation service exists in a number of areas ranging from increased differentiation to the services provided to more explicit attention to identifying client requirements. The paper concludes by examining the implications of the research for the business development strategies of valuers.
Keywords: client service, property, surveying, valuation.

1995, **1**(7), 1–21

Compensation for the compulsory acquisition of business interests: satisfaction or sacrifice?

Jeremy Rowan-Robinson
Law Faculty, University of Aberdeen, St Mary's, Kings College, Aberdeen, AB9 2UF, UK

This paper examines the purpose of compensation for compulsory acquisition using the distinction drawn by Barry Denyer-Green between premium and compensation. The paper is based on the findings of a study of compensation settlement for business loss following a city centre redevelopment. The paper finds that the majority of the claimants were dissatisfied with their settlement and all were dissatisfied with the process leading to the settlement. The paper concludes by suggesting that settlements tend towards compensation rather than premium and suggests that a number of changes to the compensation arrangement should be considered to alleviate hardship for claimants.
Keywords: compensation, compulsory acquisition, property.

1996, **1**(8), 1–32

Assessment of building surveying services - outcome or process?

Michael Hoxley
Business School, Staffordshire University, Leek Road, Stoke-on Trent, ST4 2DF, UK

This paper describes a research project which investigates the subject of service quality from the viewpoints of building surveying firms and their clients. A review of relevant literature leads to the main hypothesis of the study - that firms concentrate on outcome quality, whereas their clients are more interested in the quality of the delivery of the service. The research methodology is discussed in some detail and the results of questionnaire studies of 169 firms and 126 clients are presented. These results indicate that process quality is very important but that clients are even more concerned with the technical quality than firms themselves. The implications for building surveyors and other construction professionals are considered and recommendations for further research are made.
Keywords: building surveying, client service, service quality.

1996, **1**(9), 1–33

Turning the fish soup into fish'. Towards new land and property markets in Bulgaria

Robert Home[1]; Tatiana Ouzounova[2] and Marian Rizov[2]
[1]*University of East London, UK*
[2]*University of Architecture, Civil Engineering and Geodesy, Sofia*

As one of the countries of Central and Eastern Europe (CEE) emerging from four decades of Communist government, Bulgaria is experiencing the painful period of adjustment. Legislative and economic reforms have been undertaken, but much remains to be done. A major component of reform is the restitution of private property rights and the emergence of a private market in land and property. This research paper (based upon postgraduate research undertaken at the University of East London) examines selected aspects of these changes. It discusses the emergence of new approaches to the valuation and management of property, and the growth of a new profession of property valuers and managers. Particularly important in the reform programme has been the restitution of farmlands (formerly collectivized by state policy), and that process is analysed, together with the associated reform of cadastral and mapping organizations, and the anticipated creation of a new land registry system. The reform of local government is linked with these issues, along with the strengthening of local land use planning and environmental protection programmes. Problems associated with the consolidation of reforms initiated after 1990 are examined.
Keywords; Bulgaria, privatization, property, valuation.

RICS: Volume 2

1996, **2**(1), 1–72

Commercial property leases: a critical review of the Department of the Environment proposals

Neil Crosby; Andrew Baum and Sandi Murdoch
Department of Land Management and Development, University of Reading, Whiteknights, P.O Box 219, Reading, RG6 6AW, UK

In 1993, the Department of the Environment (DoE) prepared a consultation paper on commercial property leases which asked a number of questions concerning the operation of the landlord and tenant relationship. These questions related to the operation of upwards only rent review clauses, confidentiality agreements and dispute resolution procedures. The Investment Property Forum and the Association of British Insurers collaborated in commissioning research into the questions posed by the DoE. The Corporate Intelligence Group carried out a postal survey of the Forum's membership and the authors of this report were asked to devise a research programme to attempt to give some objective answers to many of the questions posed. The most controversial proposal of the DoE was the possible outlawing of upwards only rent reviews and the DoE sought advice on the effect on value and valuations of this proposal. They asked for similar information regarding the other two discussion areas. The research team produced a report in October 1993 and this paper is substantially that report. It has been slightly amended in the light of referees comments and the passage of time. Not least, the material in Chapter Three was drafted just before the Goode Report investigating Pension Funds was published and subsequently the Pensions Act of 1995 has been enacted. Although much of the original material has been confirmed by subsequent events, this chapter now makes reference to these developments. Although the report is written in direct response to the DoE paper (and should be read as such), it includes material of much wider relevance on the effect of lease clauses on value. It includes a lease structure breakdown of the Investment Property Databank which could be used to test a number of hypotheses. The responses to the CIG survey give valuable insights into the reactions of owners to the questions raised by the DoE and to wider questions concerning lease structures in the property market recession.
Keywords: commercial property, property, valuation.

1996, **2**(2), 1–52

The relative performance of new and traditional cost models in strategic advice for clients

Chris Fortune[1] and Mel Lees[2]
[1]*School of the Built Environment, Liverpool John Moores University, Clarence Street, Liverpool, L3 5UG, UK*
[2]*Department of Surveying, University of Salford, Bridgewater Building, Salford, M7 9NU, UK*

Clients of the construction industry need reliable strategic cost advice to enable them to assess a project's viability. The quality of the advice depends, in part, on the actual forecasting model used. This study establishes current practice in the formulation of strategic advice, determines factors that influence current practices and includes a practitioner assessment of the relative performance of the differing forecasting models currently in use. For the results to be of general application, it was essential that a large sample was used. Data was collected by postal questionnaire, with a sample of 675 organizations based in the north of England and Wales. Particular attention was given to the development and design of the measuring instrument, to ensure a high response rate, and the overall response rate achieved was 61%. The research allows conclusions to be drawn on a number of issues which include: practitioners make little use of newer computer-based cost models, factors that influence the incidence in use of such models listed were educational, organizational and operational in nature, a practitioner evaluation of forecasting techniques in terms of accuracy, reliability and value, the role of judgement in the use of forecasting models, a preliminary assessment model that may be used by researchers seeking to assess the potential value of new cost models in practice.
Keywords: client needs, computer, cost evaluation, cost model.

1996, **2**(3), 1–44

Valuation methodology and environmental legislation: a study of the UK commercial property industry

Colin Lizieri[1]; Scarlett Palmer[1]; Mark Charlton[2]; Connell Wilson[2] and Louise Finlay[2]
[1]*Department of Land Management & Development, University of Reading, PO Box 219, Reading, RG6 6AH, UK*
[2]*AMP Asset Management, UK*

There is now a trend towards stricter environmental legislation in Europe and North America. In the UK, the Town and [1]Country (Assessment of Environmental Effects) Regulations 1988 and the Environmental Protection Act 1990 reflect

broader European Union trends and concerns. A survey of major players in the UK commercial property market found that: almost all respondents were aware of the growing impact of environmental legislation and built in potential environmental costs and risk into assessments of new developments or acquisitions, but over one third of firms did not routinely assess all new projects only half of the firms sampled had completed an environmental assessment of their existing portfolios, most firms used desktop environmental surveys to provide initial warning of potential problems, though there was little evidence of the use of formal quantitative valuation models to handle environmental hazard, most firms applied estimated directly assessed value or subjectively adjusted yields, while few firms used probabilistic scenario models or formalised risk premia adjustments most respondents had investment strategies that were highly risk averse in relation to environmental problems, almost all firms considered risk on a single asset rather than on a portfolio basis. There are major impacts on the property market in terms of the relative valuation and performance of different sectors and sub-markets, the supply of space and for the attractiveness of real estate as an asset class. There are wider implications, including constraints on borrowing for capital investment, on space usage, on mergers and acquisitions and on profitability. Property-led urban regeneration strategies may also be adversely affected.

Keywords: commercial property, environmental legislation, risk, UK.

1997, **2**(4), 1–30

Electronic data interchange in the UK construction industry

Thomas McKellar[1] and Akintola Akintoye[2]
[1]*b d & g Project, UK*
[2]*Department of Building and Surveying, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 0BA, UK*

Effective information exchange is as much a pre-requisite for a successful conclusion to the construction process as it is for any other business function, and perhaps more so. The broad diversity of parties involved, allied to the varied information and documentation requirements throughout the construction cycle from inception to handover ensure its pivotal role. Electronic data interchange (EDI) involves the computer to computer transfer of structured data between trading partners. As a technology, it is reliant on an amalgam of the computer and communication industries, both of which could be said to be at the forefront of modern innovation. EDI facilitates the effective interchange of standard documents, such as invoices and purchase orders, and has been enthusiastically adopted in other industries, notably the automotive, electronics and retail sectors. Construction project documentation in the form of contracts, tender enquiries and bills of quantities are examples of documents passed between parties which may lend themselves to electronic transmission. The objectives of the research were to; examine the approach adopted by other industries towards EDI, establish the extent to which EDI is utilised in the construction industry, identify barriers and benefits of EDI in the construction industry.

Keywords: computing, electronic data interchange, UK.

1997, **2**(5), 1–32

The effect of competitive tendering on value in construction

Christine Pasquire[1] and Simon Collins[2]
[1]*Department of Civil and Building Engineering, University of Loughborough, Loughborough, Leicestershire, LE11 3TU, UK*
[2]*Taylor Woodrow Construction Ltd, UK*

This paper reports on an examination of the performance of single stage competitive tendering in terms of delivering value. The research was undertaken as it has been indicated that value for money may not be the only outcome of competitive tendering. The paper examines the three areas of; prequalification, existing tendering practice, negotiation. The research introduced issues such as the use of cover prices and negative margins, and surveyed both contracting companies and client organizations. The analysis revealed surprising attitudes towards value and competition, particularly among client bodies. The work has particular relevance, as it was undertaken just prior to and immediately after the publication of the Latham Report (1994), and investigated some of the issues which the Latham Report considered. The main conclusions of the work are that some elements of competition do indeed encourage value for money, but that there are many procedures within the competitive tendering process that adversely affected value. Both types of elements are identified. Although ostensibly confined to the UK, the work has implications within any national industry that adopts similar competitive tendering procedures.

Keywords: competitiveness, Latham, tendering.

1998, **2**(6), 1–36

Economic development and the 1989-95 property cycle in Japan: international and national explanations and interpretations

Alireza Dehesh and Cedric Pugh
School of Urban and Regional Studies, Sheffield Hallam University, City Campus, Pond Street, Sheffield, S1 1WB, UK

The internationalization of property markets and property cycles has intensified and widened during the post-1980 period. It is now even the case that property cycles can be transmitted from one country to another. This paper suggests explanation, interpretation and evaluation to these features of modern property markets. Although the focus is upon

experience in Japan, the general intellectual and professional lessons have wider geographical significance. Under modern conditions the international transmission of property cycles can affect many countries.

Keywords; internationalization, Japan, property markets.

RICS: Volume 3

1998, **3**(1), 1–22

Meeting the requirements of the Granada Convention: a review of policy for the protection of the architectural heritage in the Republic of Ireland

Rob Pickard
Department of Built Environment, University of Northumbria, Ellison Building, Ellison Place, Newcastle Upon Tyne, NE1 8ST, UK

This study examines the situation regarding the protection of the architectural heritage of the Republic of Ireland against the framework of the Convention for the Protection of the Architectural Heritage of Europe (1985) (the Granada Convention). The Granada Convention sets out a basis to achieve greater unity between member states of the Council of Europe for protecting and preserving their common heritage. The architectural heritage is recognised as an irreplaceable expression of the quality and diversity of Europe's cultural heritage. Three conditions are required to be met by the Convention which are signified by the date of signature, the date of ratification and finally the date upon which the terms of the convention are brought into force. The Republic of Ireland signed the convention in 1985 but it was not until January 1997 that the terms of the convention were ratified. Little progress has been made towards developing an effective administrative and legal basis to protect the architectural heritage until a recent policy review. Despite this, action has been slow. Work has commenced on the development of a national inventory of architecture, but the formulation of new legislation and measures to provide financial support are still under debate. This paper examines the machinery for the protection of the architectural heritage in Ireland, making a critical review of the situation in practice in Dublin and according to national and local policy issues. It considers the operation of listed building control and preservation policy for buildings of 'artistic, architectural or historical interest' including ancillary measures such as financial support and the operation of conservation policy against the backdrop of negative legislative powers. In the light of increasing condemnation of weak conservation policy, recommendations to place the system for protecting the architectural heritage on a stronger statutory footing are considered for the purpose of bringing into force the terms of the Granada Convention. In summary, statements concerning the current situation and actions required to fulfil the terms of the convention are presented.

Keywords: Granada Convention, heritage, preservation, Republic of Ireland.

1999, **3**(2), 1–24

A critical examination of the designer's role under the ICE design and construct conditions of contract and the Highway Agency's design and build conditions of contract

Geoffrey Hodgson and J A Jeffrey
Department of Civil and Building Engineering, University of Loughborough, Loughborough, Leicestershire, LE11 3TU, UK

The remarkable growth of design and build within the building industry since the introduction of JCT 81 has only now led to a similar trend within civil engineering in the 1990s. The recent introduction of both the ICE Design and Construct Conditions of Contract and the Highways Agency's (HA) Design and Build Conditions of Contract has served to address the previous deficiency. The results of the research indicated that the HA designers had far more responsibility than their ICE counterparts because of the supervisory and certifying role that is demanded by the Agency, whereas the ICE designers need not be site-based at all. These differences had a significant effect on the way in which contracts were operated, in particular with respect to the number of design representatives required to be permanently site-based. For each of the five HA contracts investigated, a permanent site presence was provided by the designer and the number of site representatives was equivalent to that of the Resident Engineer's staff on a traditional contract. In contrast, a permanent site presence was only considered necessary on the larger two of the three ICE contracts investigated and even then only a single representative was provided.

Keywords: civil engineering, contract, design, design and build, responsibility, role, UK.

1999, **3**(3), 1–34

Adjusting comparable capitalization rate evidence: guidance for practitioners

David Parker
Suncorp-Metway Ltd, UK

The process used by property practitioners to adjust evidence, derived from the analysis of comparable sales, for use in the assessment of the capitalization rate for valuation purposes is contended to be subjective, informal and heuristic, contributing to a sub-optimal level of variability in capitalization rate determination which, it is further contended, may

be reduced through the use of a deterministic approach. The determinants of the capitalization rate are identified through a literature review and an explanatory algebraic equation is proposed. Through a survey of an expert panel of property practitioners, the requisite data is collected for a sample of office properties in the Sydney Central Business District (CBD) and analysed, using cross-sectional multiple regression analysis, to produce an econometric model. When tested on a further, independent, sample of Sydney CBD office properties, the econometric model is found to produce a lower level of variability in capitalization rate assessment than that found from the expert panel using the currently advocated process. It is, therefore, contended that when seeking to adjust capitalization rate evidence for office investment property, the practitioner should have greatest regard to the relatives of the quality of the location, building attributes, occupancy level and occupant credit quality characteristics with the adoption of a deterministic approach advocated to contribute positively to the efficiency of the property investment market, valuation accuracy and the incidence of professional negligence claims.

Keywords: capitalization rate, property investment, valuation.

1999, **3**(4), 1–22

Construction demand modelling: a systematic approach to using economic indicators

Goh Bee Hua
School of Building and Real Estate, National University of Singapore, Singapore

The published literature abounds with evidence of a close relationship between the construction industry and the national economy. This study reinforces the strength of this relationship by advocating the use of economic indicators to model demand for construction. A systematic approach is proposed to identify and select economic indicators that relate to construction demand. It involves four distinct stages and they are: (1) theoretical identification; (2) data collection and pre-processing; (3) statistical selection; and (4) usage. This stage-by-stage process is illustrated on residential, industrial and commercial-type construction in Singapore. To validate the approach, regression models are built for residential-type construction to generate ex-post forecasts. The findings confirm that, firstly, demand In the construction industry is significantly related to a wide range of economic measures and, secondly, the models are able to produce accurate forecasts that satisfy the acceptable limit of 10% mean absolute percentage error. Implications for future work in demand modelling are highlighted and discussed.

Keywords: demand, modelling, Singapore.

1999, **3**(5), 1–94

Computerized maintenance management systems: a survey of performance requirements

Keith Jones, Clive Burrows and Stephen Collis
School of Land and Construction Management, The University of Greenwich, Oakfield Lane, Dartford, Kent, DA1 2SZ, UK

The role that computers play in the management of property maintenance has increased, both with the development of the technology and as a result of changes in the way that property is managed. Yet their impact has fallen short of the industry's expectations and of their true potential. This report provides information on what current users believe to be essential or desirable attributes of such systems, and indicates the current state of art or industry benchmark for current systems in terms of both performance and functionality. The benchmarks are based on an evaluation matrix methodology, which was used in conjunction with a substantive questionnaire survey of maintenance managers, to identify and evaluate the importance and performance of key computerized maintenance functions. This method may also be used to identify system attributes or functions when commissioning new computer systems from software developers. The performance of computerized maintenance management systems was evaluated and areas of weakness were identified. The report concludes that, while certain aspects of computerized maintenance management systems appear to be performing well, others need significant improvement if the full benefits are to be realized. The report also outlines a practical methodology that may be used by maintenance managers to evaluate current and potential computerized maintenance management systems.

Keywords: information technology, maintenance management, survey.

2000, **3**(6), 1–28

Can building form and function be used to predict the costs of mechanical and electrical services?

L Swaffield, C L Pasquire and A Tyler
Department of Civil and Building Engineering, Loughborough University, Leicestershire, LE11 3TU

This paper discusses existing methods of pre-design cost estimating for the mechanical and electrical (M and E) services elements of building projects. The research examined the parties involved in the early cost advice process, the information used and generated, and the relationships between building form, function, and M and E services costs. The authors found serious deficiencies in the availability, format and detail of cost information for M and E services, which prohibited further advances to research in this area. It concludes that there are relationships between building form and

function and M and E service costs, but qualifies this by saying that the influence of M and E services quality could not be examined, due to lack of suitable qualitative data.
Keywords: cost, services, pre-design, estimating, mechanical and electrical services.

2000, **3**(7), 1–40

Urban renewal in Hong Kong: the record of the Urban Development Corporation

D Adams and B Hastings

The authors evaluate the record of the Land Development Corporation, established by the Hong Kong Government in 1988 to undertake, encourage, promote and facilitate urban renewal. Following a brief historical review of urban development and renewal in Hong Kong, the paper summarizes the reasons for the establishment of the Corporation. From detailed examination of the Corporation's first two phases of projects launched in 1988 and 1992, the paper identifies three crucial institutional weaknesses which have undermined the LDC's capacity to promote urban renewal. These are official powers and procedures, the contradiction created by seeking to assemble redevelopment sites in multiple ownership principally through negotiation, and the problem of relocating existing occupiers of redevelopment areas. The paper argues that the British administration's review of urban policy in the mid-1990's insufficiently addressed these weaknesses. It suggests, in conclusion, that if the pressing need for comprehensive restructuring and renewal of older Hong Kong is to be taken seriously by the Government of the new Special Administrative Region, then it will be necessary both to ensure proper organizational arrangements for urban renewal and to accord social and environmental considerations equal importance to financial demands in urban policy.
Keywords: Hong Kong, urban design, urban regeneration.

2000, **3**(8), 1–10

Surveying flood damage to domestic dwellings: the present state of knowledge

D G Proverbs, J Nicholas and G D Holt
School of Engineering and Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB, UK

The authors present a critical review of existing knowledge in respect of surveying flood damage to domestic properties and subsequent specification of required repair works. The aim of the investigation is to highlight the need for greater standardization in respect of these issues. The authors confirm that definitive benchmarks, against which repair work could be objectively gauged, do not exist. At present, surveyors rely predominantly on experiential judgement and, while providing direction, the available literature tends to over-generalize. Key findings are: there is considerable emphasis on surveyors' individual subjective opinions towards what construction repair work is required for any given flood damage scenario; 'standard' and 'scientific' guidelines for necessary flood damage repair specification do not exist; previous research into the surveying and repairing of flood damaged properties has largely ignored significant influencing factors including the duration of a flood, the possibility of floodwater contaminants, the velocity of floodwater through or on, a building; contradiction in the literature regarding recommendations for the drying of flood damaged buildings. In view of these observations, the authors highlight a need for further research in this area. Procedures need to be developed to assist the insurance industry, the construction refurbishment sector and the surveying profession to manage the repair of flood damaged properties in a more standardized manner.
Keywords: damage, flood, housing, surveying.

2000, **3**(9), 1–59

Property market processes and development outcomes in cities and regions

John Henneberry and Steven Rowley
University of Sheffield, UK

This paper considers urban and regional property market processes, their development outcomes and the implications for economic development. Major differences between the inter-regional pattern of economic activity and the inter-regional distribution of property development, particularly for offices, are identified. Next, the spatial variation in property market strength and potential development profitability are analysed and described. The dominance of value over cost as a determinant of profitability is noted. A detailed examination of price formation in the property market follows. Differences in the temporal relationship between rents and yields are revealed. In peripheral regions, yield trends lead rent trends by longer periods than in core regions. As a result, capital values and the extent and duration of profitable development conditions are reduced. The regional and urban pattern of development is found to reflect both general property price signals and the particular way in which these signals are influenced by investors' decisions. A formal test for convergence demonstrates that the disparity between the regional distribution of development activity and the pattern of economic activity is persistent and significant, and is growing. Consequently, the property market may be considered a significant influence on regional and urban economic competitiveness. The paper concludes with a call for a better understanding of the way in which investors' perceptions of urban and regional property markets are formed and how they influence their decisions.

Keywords: development, property market, rent, urban development, yield.

2000, **3**(10), 1–36

Utility wayleaves: a legislative lottery?

Norman Hutchison and Jeremy Rowan-Robinson
University of Aberdeen, UK

Over the last 20 years in the UK, there has been a proliferation in the statutory provision for wayleaves. The utilities requiring wayleaves, such as the water, gas and electricity companies have now been joined by cable TV and a host of telecommunications providers. All have access to compulsory powers, However, there are variations between these powers and between compensation arrangements. The paper has two objectives. The first is to examine whether statutory powers (coupled with statutory compensation) are now appropriate, following the privatization of the gas, electricity, water and telecommunications companies. The second is to consider whether the powers and procedures for creating wayleaves strike a fair balance between the interests of the utilities and the landowners. The paper recommends that statutory powers should continue to be available where utilities are under a statutory duty to develop and maintain a service. In order to strike a fair balance, however, the paper advocates that the nature of the powers requires to be redefined and standardized. In addition, the paper recommends that claimants should not merely be entitled to the financial equivalent of their loss but that a consideration should be paid reflecting, in effect, a rental for the wayleave.

Keywords: privatization, statutory powers, utilities, wayleaves.

2000, **3**(11), 1–32

An international survey of macroeconomic and market information on the construction sector: issues of availability and reliability

Les Ruddock
University of Salford, UK

The place of the construction sector in the overall economy of a country needs to be placed in perspective if its function is to be fully understood. A necessary requirement for this understanding is the existence of a comprehensive information system for the sector. Problems encountered in international comparisons of the construction sector are well-documented. Data on construction activity at the national level still appear to be, in many cases, of erratic and of varying validity even with recent changes in national accounting procedures. This research was designed to investigate whether there has been any significant recent improvement in the availability and usefulness of published statistical information available to the construction macroeconomist at an international level. The paper presents an analysis of an international questionnaire survey of experts from a wide variety of countries, in terms of both construction industry and economic development. The survey was carried out during the period 1998-99. The purpose of the study is not only to permit the production of a manual of data sources, but also to elicit the opinion of local experts on the availability and usefulness of data. Based on the survey findings, conclusions are drawn and recommendations proposed regarding possible improvements.
Keywords: construction sector, development, information system, macroeconomics.

2000, **3**(12), 1–38

Change and flexibility: the role of serviced office space in office markets and corporate property portfolios

Colin Lizieri and Virginia Gibson
Department of Land Management & Development, University of Reading, UK

With the increasing pace of change, organizations have sought new property solutions which provide greater flexibility. Serviced offices appeared to be a means of gaining this flexibility and, therefore, were examined to determine both their place within the business space market and the way in which they were perceived and used by occupiers. The serviced office market is very diverse in terms of the product, services and target market. It ranges from medium-term space with the inclusion of both facilities management and office services to virtual space solely for business identity purposes. The entry of sophisticated suppliers and the growth in the provision has lead to increased credibility with occupiers and more recently with the property investment market. Occupiers, similarly, use this space in a variety of ways. Some solely occupy serviced space while others use it to complement their more permanent space. What appears to be required is not flexibility for all uses but appropriate flexibility for the volatile, risky and temporal part of a business. This is the essence of the idea behind the split between the core and periphery portfolio. The serviced office has emerged to fill the need for absolute flexibility. It appears, therefore, that the serviced office is fulfilling the role of providing periphery space for at least some occupiers. From the occupiers' point of view, the key to this space is a focus on financial and tenurial flexibility which is not provided by other types of business space on offer. The serviced office market is forecast to grow: it is also likely to become still more diverse. There appears to be ever greater augmentation of the core property product with a wider range of business related services, possibly moving it from the property sector to the business service sector. This has implications both for the skills required to be successful within the market and the way in which future research should be undertaken.

Keywords: business space, serviced offices, property development.

2000, **3**(13), 1–48

Assessing the impact of chemical treatments on the health of buildings and their occupants

David Watt, Belinda Colton and Duncan Spalding
De Montfort University, Leicester, UK

The subject of this paper has become a topic of growing concern for members of the surveying profession who have to make decisions relating to the treatment of fungal infections and insect infestations in buildings. This might include assessing buildings that have already been treated and advising clients who are either already sensitive to chemicals or concerned with the potential effects to their health. Such concerns are also of relevance to other related practitioners, including those in the environmental health, medical, health care and legal professions. The use of chemical treatments for the control or eradication of fungal or insect decay in buildings, and the effects that such treatments and their residues might have on the health of those treating or living in treated buildings, are issues that need to be considered carefully by those responsible for specifying or implementing such works. Although such a potentially emotive subject can easily become the focus for misinformed prejudice, it is the intention of the authors to present this work in an informed and informative manner. This paper is intended to raise awareness of the subject, rather than offer conclusive answers to the many questions that it poses. It is sufficient that there is a genuine level of ignorance and misunderstanding to be addressed without imposing additional, and often unsupported, anxieties upon the discussion.

Keywords: fungal infection, insect infestation, environmental health, health and safety.

2000, **3**(14), 1–44

Performance measurement of higher education facilities: the balanced scorecard approach

Dilanthi Amaratunga
University of Salford, UK

The role of facilities management in promoting organizational performance, and thereby in providing competitive advantage, is widely acknowledged. Interest among both academics and practitioners in performance measurement systems as a tool for delivering strategic objectives is now well established in the management literature. However, the mechanisms of how this happens in higher educational FM (Facilities Management) establishments are quite unclear, prompting performance evaluation researchers to question whether performance evaluation in fact does add value to higher educational institutions. Effective measurement, however, must be an integral part of the management process. The balanced scorecard, a widely popular technique, provides organizations with a comprehensive framework that translates the organization's strategic objectives into a coherent set of performance measures. This paper presents the findings of the characteristics of important aspects of a performance evaluation approach related to higher education properties, and discusses the framework developed based on the balanced scorecard methodology to measure performance.

Keywords: balanced scorecard, higher education, performance evaluation, facilities management.

2000, **3**(15), 1–49

Improving early cost advice for mechanical and electrical services

Lisa Swaffield and Christine Pasquire
University of Loughborough, UK

This paper addresses the problem of poor communication between clients and building professionals, leading to misinterpretation of mechanical and electrical (M&E) services requirements and inaccurate cost estimates. The research hypothesized that M&E services cost was related to a building's form and function, and M&E quality. A sufficiently accurate cost estimate depended on an accurate understanding of the quality of M&E services required by the client. This paper proposes a method for improving early design stage communications, to improve interpretation of M&E services quality requirements and lead to more accurate cost estimates. The method involves introducing a briefing workshop to consider functional requirements from the building, possible M&E services solutions, and interfaces between building structure and fabric and the M&E services. The proposed method received support in principle from the field. It is suggested as a valid method of improving early design stage communications between clients and building professionals, that could lead to improved early cost advice for M&E services.

Keywords; briefing, communication, cost, design, electrical services, estimating, mechanical services.

2000, **3**(16), 1–24

Model selection criteria and the building project price forecasting process

Chris Fortune and John Hinks
Liverpool John Moores University, UK
Centre for Advanced Built Environment Research, UK

This study contributes to what is known about the investigation and formulation phases of the building project price forecasting advice process. The research has developed a greater understanding of what general factors affect the selection of newer computer-based or non-traditional types of building project price forecasting models. The work adopted a two-phased combined research approach. The first phase required a mailed survey to be conducted with a sample 167 quantity surveying organizations located across England. The second phase required a total of 31 in-depth interviews to be executed, with informed practitioners, in five separate rounds of data collection. The study provided evidence that some types of quantity surveying organization were moving towards the adoption of the non-traditional models. The study then identified a number of general factors that were found to affect the selection of non-traditional types of building project price forecasting models. The paper describes the processes involved in the generation and grounding of a constraints-based theory of factors that were found to affect practitioners in the selection of non-traditional types of building project price forecasting models. The emergent theory identified the issues that need to be addressed by all types of quantity surveying organizations who wish to become involved with the selection of non-traditional models. The paper concludes by identifying issues that need to be addressed in future studies, in order to further develop this area of practice.

Keywords; cost, estimating, forecasting, quantity surveying.

2000, **3**(17), 1–49

A vision for construction IT 2005-2010

Marjan Sarshar, Martin Betts, C Abbott and Ghassan Aouad
University of Salford, UK

For many years, leading researchers and industrialists have attempted to utilize IT as an enabling technology, in order to reduce the problems of communications and information sharing within the construction industry. Due to the diversity of construction projects, and the richness of information within construction processes, these research and development efforts have remained diverse in nature. In addition, they have in many cases been directed towards a fragmented and continuously changing vision for how IT will impact upon construction projects of the future. Recently, Construct IT undertook a major review of current research and industrial best practice in the UK, in order to summarize these efforts in the form of a vision for the next 5-10 years of construction projects and the way their processes will be supported by IT. The purpose of this vision is to (i) paint a picture for industry, (ii) provide a platform for discussion and debate, (iii) serve as a platform to identify gaps between research and industrial uptake, (iv) assist in identifying barriers to vision realization, and (v) illustrate how IT could benefit the industry. This vision is not perceived as complete and final. Rather it is a live and dynamic picture, which sets a scene for future developments. The form of the vision will continuously evolve based on technology advances and a closer consensus that is likely to emerge between industry and academia. This vision was presented at a Construct IT meeting in May 2000 as a basis for discussion and debate. Representatives from 28 construction companies and organizations debated the vision and voted on views of different aspects of the vision, via remote control electronic voting handsets. This paper presents the vision and discusses some of the relevant feedback from industry.

Keywords: construction industry, information technology.

List of relevant journals

–A–

AIA Journal of the Academy of Architecture for Health

Editor(s): James G Easter Jr
Editor(s)'s Affiliation: American Institute of Architects
Editorial Board: National (USA)
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Frequency: annual
Publisher: AIA
Web site address: http://www.e-architect.com/pia/acadjour/general.asp/
Source: web site
Last updated: 13 April 2000.

American Professional Constructor

(1971–)
Editor(s): David W Goodloe
Editor(s)'s Affiliation: ?
Editorial Board: National (USA); plus one chapter in Ontario, CA, and one in Hong Kong in process.
Peer Reviewed: Yes
Coverage: Articles on technical and management issues for the professional contractor.
Frequency: ?
Publisher: American Institute of Constructors
Web site address: http://www.aicnet.org/Publications/journal.htm/
Source: web site and Ulrich's.
Last updated: 13 April 2000.

Architecture Australia

(The official magazine of the Royal Australian Institute of Architects)
Publishing assistant: Ian Close; publisher@archmedia.com.au
Editor(s): ?
Editor(s)'s Affiliation: ?
Editorial Board: None
Peer reviewed: No
Coverage: Reviews of recent commercial and public buildings and new houses in Australia or designed by Australian architects for construction overseas. Features commentary on urban design and architectural theory by the profession's leading opinion-makers. Supplies latest information on architectural competitions, designs for major projects, books, exhibitions and conferences.
Publisher: Archmedia
Frequency: bi-monthly
Web site address: http://www.archmedia.com.ac
Last updated: 13 April 2000.

Architectural Record

(1891-)
Editor(s): Robert Ivy; rivy@mcgraw-hill.com
Editor(s)'s Affiliation: American Institute of Architects
Editorial Board: ?
Peer Reviewed: No
Coverage: The leading professional magazine edited for architects, project owners and their consultants. It is the worldwide leader among Architectural Publications for over 100 Years. It is also read by corporate and government owners, builders, as well as college, faculty and students. Architectural Record presents designs from the World's outstanding architects. Staffed by professional editors,

most of who have architectural backgrounds. Architectural Record is the leading source for architectural design, technology with business and products information.
Publisher: A division of the McGraw-Hill Companies
Web site address: http://www.archrecord.com
Source: web site.
Last updated: 11 April 2000.

Architectural Review

Editor: Peter Davey; peterd@construct.emap.co.uk
Editor's affiliation: ?
Editorial Board: National (UK)
Peer Reviewed: No
Coverage: World-wide coverage of the very best in contemporary architecture
Frequency: monthly
Publisher: ABC business press/ EMAP Construction
Web site address: http://www/arplus.com
Source: web site.
Last updated: 11 April 2000.

Asian Pacific Building and Construction Management Journal

Editor: Mrs Linda C N Fan
Editor's affiliation: Hong Kong Polytechnic University
Editorial Board: National, Hong Kong
Peer Reviewed: Yes
Coverage: Forum for researchers and practitioners to present and discuss worthwhile innovations in building and construction project management in the Asian-Pacific region. The heavy involvement of the international construction industry in this region also leads it to expect significant international participation.
Publisher: A joint publication of the Asian Construction Management Association, The Chartered Institute of Building and The Building Division, Hong Kong Institute of Engineers.
Frequency: biannual
Source: Issue 1 Inaugural Issue 1995
Last updated: 12 June 1999.

Australian Journal of Construction Economics and Building

(formerly Australian Institute of Building Papers and Australian Institute of Quantity Surveyors Refereed Journal)
Editor: Different editor allocated to each issue; contact@aiqs.com.au
Editorial Board: Different editorial board for each issue
Peer reviewed: Yes
Coverage: While the journal is titled "The Australian Journal of Construction Economics and Building" it will be international in scope and standard but with particular reference to the Australasian & Pacific region.
Frequency: Bi-annual
Publisher: AIQS
Source: AIQS general mailing
Web site address: www.aiqs.com.au then follow links to publications, then Instructions/Guidelines for contributors.
Last updated: 5 December 2000

Automation in Construction

(1992–)
Editors: Y E Kalay and M J Skibnieswski
Editors' Affiliation: College of Environmental Design, Department of Architecture, University of California at Berkeley and School of Civil Engineering, Purdue University, IN, USA
Editorial Board: International
Peer Reviewed: Yes
Coverage: It includes: use of Information Technologies in Architecture, Engineering, Construction Technologies and Maintenance and Management of Constructed Facilities. Also, Robotics and Automated Machines.

Frequency: bi-monthly
Publisher: Elsevier
Web site address: http://www.elsevier.nl/inca/publications/store/5/2/3/1/1/2/
Source(s): web site
Last updated: 12 May 2000.

–B–

Building Design and Construction Magazine (Formerly Building Construction until 1958)

Editor(s): C.C. Sullivan; csullivan@cahners.com
Editor(s)'s Affiliation: ?
Editorial Board: National (USA)
Peer Reviewed: ?
Coverage: Published for the building team –architects, engineers, contractors, building owners and facilities managers involved in design and construction of non-residential buildings.
Frequency: monthly
Publisher: Cahners Publishing Company
Web site address: www.bdcmag.com
Source: Ulrich's, web site.
Last updated: 14 April 2000.

Building Economist

(Incorporated Quantity Surveyor)
(1962–)
Editor: Ian Blyth
Editorial Affiliation: AIQS
Editorial Board: ?
Peer Reviewed: No
Publisher: AIQS
Coverage: It contains data on Current Construction Costs in Australia, as well as technical articles relevant to construction economics and related subjects, contains data on current construction costs in Australia.
Frequency: quarterly
Source: March 1998, Ulrich's and website
Web site address: http://www.aiqs.com.au
Last updated: 14 April 2000.

Building and Environment

(The International Journal of Building Science and its Application)
(1965–)
Editor: E. Mathews
Editor's affiliation: Universiteit van Pretoria, South Africa
Editorial board: International
Peer reviewed: Yes
Coverage: Building research and its applications, the social, cultural and technological contexts of building research and architectural science.
Frequency: 8 issues a year
Publisher: Pergamon
Web site address: http://www.elsevier.nl/inca/publications/store/2/9/6/index.htt
Source: web site
Last updated: 14 April 2000.

Building Research and Information

(1970–)
Editor: Richard Lorch
Editorial Board: International
Peer Reviewed: Yes

Coverage: It includes environmental issues in construction; practical application of research; non-destructive testing; problems regarding healthy buildings; construction law; rise in the use of expert systems. It also includes technical papers and reviews.
Frequency: bi-monthly
Publisher: Spon
Web-site address: http://www.tandf.co.uk/journals/routledge/09613218.html
Source: web site
Last updated: 12 May 2000.

–C–

Chartered Surveyor Monthly

(Official journal of the Royal Institute of Chartered Surveyors)
CSM
Editor(s): Imogen Mcevedy; imcevedy@rics.org.uk
Editor(s)'s Affiliation: RICS
Editorial Board: ?
Peer Reviewed: No
Coverage: ?
Publisher:
Web site address: http://www.rics.org.uk/csm/
Source: web
Last updated: 14 April 2000.

Civil Engineering and Environmental Systems

Editor(s): C.B. Brown and P.W. Jowitt
Editor(s)'s affiliation: Department of Civil Engineering, Oregon State University, USA and Department of Civil and Offshore Engineering, Heriot-Watt University
Editorial Board: ?
Peer Reviewed: ?
Coverage: Civil Engineering and Environmental Systems is the only Journal devoted to the discussion, dissemination and development of systems techniques and their underlying assumptions through the spectrum of civil engineering activity and environmental decision-making and management. The Journal provides a comprehensive approach to the practical application and development of ``hard'' and ``soft'' systems methodologies. covering engineering optimization, risk assessment and decision making, system identification, numerical simulation and qualitative modelling of complex systems, safety, methods of modelling uncertainty. Attention is paid to conceptual issues as well as quantitative techniques. The Journal also deals with emerging information technology techniques such as knowledge-based systems, genetic algorithms and neural networks.
Publisher: The Gordon and Breach Publishing Group.
Web site address: http://www.gbhap.com/journals/723/723-top.htm
Source: Web site.
Last updated: 1 June 2000.

Computers and Structures

(1971–)
Editor(s): K J Bathe and B H V Topping
Editor(s)'s affiliation(s): Department of Mechanical Engineering, Massachussetts Institute of Technology, USA and Department of Mechanics and Chemical Engineering, Heriot-Watt University, UK
Editorial Board: International
Peer Reviewed: Yes
Coverage: The objective of this journal is to communicate recent advances in the development and use of computer methods for the solution of scientific and engineering problems related to hydrospace, aerospace and terrestrial structures. The word 'structures' is interpreted in the broadest sense. The journal is intended to be of interest and use to researchers and practitioners in academic, governmental and industrial communities.
Frequency: 30 issues in 2000.
Publisher: Pergamon
Web site address: http://www.elsevier.nl/inca/publications/store/3/5/9/index.htt
Source: web site

Last updated: 17 April 2000.

Computer Methods in Applied Mechanics and Engineering

(1970–)
Editors: J.H. Argyris (Princ Editor), T.J.R. Hughes and J.T. Oden
Editors' affiliation: Universitä Stuttgart, Germany; Stanford University, USA and The University of Texas at Austin, USA.
Editorial Board: International
Peer reviewed: Yes
Coverage: The journal publishes papers concerned with applications of digital or hybrid computers to problems of applied mechanics and engineering.
Frequency: 52 issues a year
Publisher: North Holland
Source(s): web site
Web site address: http://www.elsevier.nl/inca/publications/store/5/0/5/6/4/5/
Last updated: 17 April 2000.

Construction Information Quarterly

Editor(s): ?
Editor's(s') affiliation: ?
Editorial board: ?
Peer reviewed: ?
Coverage: This new publication contains the latest technical information on the best practice in construction. With 3-4 technical papers and one digest in each issue, the new Construction Information Quarterly ensures subscribers are kept abreast of all the latest developments in construction.
Frequency: 4 times a year – no fixed dates.
Publisher: Englemere Ltd, CIOB.
Source(s): Englemere.
Web site address: ?
Last updated: 9 May 2000.

Construction Innovation: Information, Process, Management

(formerly International Journal of Construction Information Technology)
(1993–)
Editors: Mustafa Al-Shawi and Martin Skitmore; m.alshawi@surveying.salford.ac.uk, r.m.skitmore@qut.edu.au
Editors' Affiliation: Department of Surveying, University of Salford and Faculty of Built Environment and Engineering, Queensland University of Technology
Editorial Board: International
Peer Reviewed: Yes
Coverage: First launched in 1993 to inform the construction industry and research community of the latest advances in construction IT, the *International Journal of Construction Information Technology* provided high quality technical papers on current developments in the rapidly changing IT environment of the global construction industry. ***Construction Innovation*** will continue to cover the fundamentals of technical issues and reflect the most recent developments in construction IT with the added benefit of greater coverage of management issues such as process modelling, bench marking, integration of design and construction, supply chain management, data exchange and e-commerce, to provide a complete picture of all aspects of construction IT. Integrating the entire field of information, process, technology and management, ***Construction Innovation*** will disseminate research results, communicate new practical ideas, applications and developments and provide case studies related to design and construction. ***Construction Innovation*** is essential for academics and researchers in building, construction, construction and property management and managers within the construction industry.
Frequency: Quarterly
Publisher: Arnold
Web site address: http://www.arnoldpublishers.co.uk/journals/Journpages/14714175.htm
Last updated: 5 December 2000

Construction Law Journal

(1984–)

Editor: Andrew Burr
Editor's affiliation: Barrister
Editorial board: National (UK)
Peer reviewed: No
Coverage: A journal tailored for lawyers, architects, engineers, surveyors and company officers who require a forum to which they and members of other professions may turn for guidance, comment and informed debate. It reports developments in case law and legislation, important changes in both law and procedure occur rapidly. Contents: Case reports –cases of interest from the UK Courts as well as from other common law jurisdictions. General information section –a short informative section covering matters of interest to the construction industry. Articles –by leading lawyers in the field of construction law, and by senior academics specializing in this area of the law. Books review.
Frequency: 6 issues a year.
Publisher: Sweet and Maxwell
Source(s): 12(5) 1996
Web site address: http://www.smlawpub.co.uk/index_catalog.cfm
Last updated: 12 May 2000.

Construction Manager

(formerly Chartered Builder, formerly Building Technology and Management))

Editor: Connal Vickers
Editor's Affiliation: CIOB
Editorial Board: ?
Peer Reviewed: No
Coverage: contains articles on technical and management aspects of building, together with reports on conferences and seminars.
Frequency: 10 times per year
Publisher: Englemere CIOB
Web site address: http://www.ciob.org.uk/
Source(s): June 1999 5(5), web site, Ulrich's and Englemere.
Last updated: 9 May 2000.

Construction Papers

Absorbed by CME
(1980-1983)
Editor: Kenneth J. Lane
Editor's affiliation: CIOB
Editorial Board: National (UK)
Peer reviewed: Yes
Coverage: Scientific and technical papers covering the full range of the various sciences applied to problems in construction. This was a high-quality, but short-lived journal with only five issues appearing in print over the four years of its existence.
Publisher: CIOB
Source: Archived issues.
Last updated: 13 June 2000

Construction Management and Economics

(1983–)
Editors: Ranko Bon and Will Hughes
Editors' Affiliation: Department of Construction Management & Engineering, University of Reading
Editorial Board: International
Peer Reviewed: Yes
Coverage: General building, housing, civil engineering, repairs and maintenance as well as the construction of other major capital products; organization and management of projects, construction companies and professional practices engaged in the construction process as well as the management of existing buildings; design economics, cost planning, estimating and cost control, the economic functioning of firms within the construction sector and the relationship of the sector to national and international economies.
Frequency: Eight times per year.
Publisher: Spon
Web site address: http://www.tandf.co.uk/journals/routledge/01446193.html
Source(s): CM&E, 18(1).

Last updated: 9 May 2000.

Cost Engineering Magazine

Editor: Kathy Deweese
Editor's affiliation:
Editorial Board: ?
Peer Reviewed: Yes
Coverage: subjects that directly relate to the Total Cost Management profession
Frequency: monthly
Publisher: AACE International (WV)
Web site address: http://www.aacei.org/newdesign/technical/welcome.shtml
Source(s): 36(12) Dec 1996
Last updated: 12 July 1999.
Notes: Indexed in Engineering index, Cambridge Scientific Abstracts and ABI/Inform Database

Cost Engineer, The

(1962–)
Editor(s): Lesley Carter (assistant); a.coste@btinternet.com
Editor's(s) affiliation: The Association of Cost Engineers
Editorial Board: ?
Peer reviewed: ?
Coverage: technology, international, project performance, estimating, training & education, quantity surveying (topic per issue all year through).
Frequency: 6 issues per year and a year book.
Web site address: http://www.btinternet.com/~A.CostE/
Source(s): web site
Last updated: 17 April 2000.

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Design-Build

Editor(s): ?
Editor(s)'s Affiliation: ?
Editorial Board: ?
Peer Reviewed: ?
Coverage: Design-Build serves design builders and owners in the world-wide non-residential construction. It is the only publication dedicated to this design-build project delivery method. It is the indispensable authority, reporting on successful design-build projects, companies and cutting-edge professionals.
Frequency: quarterly
Publisher: ?
Web site address: http://www.accessglobal.com/jas/db/index.htm
Source: Web site
Last updated: 13 February 2000.

Design Studies

(1979–)
Editor(s): N Cross; n.g.cross@open.ac.uk
Editor(s)'s Affiliation: Department of Design and Innovation, Faculty of Technology, The Open University, Milton Keynes, UK
Editorial Board: International
Peer Reviewed: Yes
Coverage: Includes design management, design methods, participation in planning and design, design education, AI and computer aids in design, design and engineering, theoretical aspects of design, design in architecture, design and manufacturing, innovation in industry and design and society.
Frequency: 6 issues a year
Publisher: Elsevier Sciences Ltd and the Design Research Society
Web site address: www.elsevier.nl/inca/publications/store/3/0/4/0/9/index.htt
Source: Ulrich's and web site
Last updated: 17 April 2000.

–E–

Engineering, Construction and Architectural Management

(1994–)
Editor: Ronald McCaffer; r.mccaffer@lboro.ac.uk
Editor's Affiliation: Department of Civil and Building Engineering, Loughborough University
Editorial Board; International
Peer Reviewed: Yes
Coverage: The Journal publishes papers on innovative developments in the management and practice of construction and original research work in all aspects of construction management.
The Journal interprets the scope of construction broadly, encompassing all capital projects including building, civil engineering and major infrastructure, as well as repair and maintenance.
The management of construction includes: the management of projects encompassing both the design and construction processes and their interrelationship; the management of construction companies, and design and architectural practices; and the management and development of the construction industry from a national and international perspective.
Frequency: quarterly
Publisher: Blackwell Science Ltd
Web site address: http://www.lboro.ac.uk/ecam/, or http://www.blackwell-science.com/products/journals/ecam.htm
Source(s): 5(4), Dec1998, web site and Ulrich's
Last updated: 9 May 2000.

Environments by Design

Editor(s): Timothy Eccles; t.eccles@kingston.ac.uk
Editor(s)'s Affiliation: School of Surveying, Kingston-upon-Thames, UK
Editorial Board: International
Peer Reviewed: Yes
Coverage: publishes research reports, criticisms and speculations about the formation, use and evaluation of the designed environment.
Frequency: 2-3 times a year
Publisher: university of Kingston
Web site address: http://www.kingston.ac.uk/~ac_s033/ebdpages/title_p.htm
Source: web site
Last updated: 17 April 2000.

–F–

Facilities

Editor(s): Dr Edward Finch; e.f.finch@reading.ac.uk
Editor(s)'s Affiliation: Department of Construction Management and Engineering,
University of Reading
Editorial Board: International
Peer Reviewed: Yes
Coverage: All areas relating to briefing, design and use of facilities; the emerging technologies that support organizational skills in the workplace; innovations in theory, tools, legislation and analysis techniques; applications of new ideas in the facilities management. Plus: space planning, relocation, maintenance, renovation, energy consumption, cost reductions; ergonomics, quality initiatives, intelligent buildings, the effects of corporate change on property, health and safety issues, and IT issues.
Frequency: 14 times/year
Publisher: MCB University Press
Web site address: http://www.mcb.co.uk/cgi-bin/journal1/f
Source: Property and 16(12/13), Dec 1998 and web site
Last updated: 17 April 2000.

–G–

Geotechnique

(1948–)
Editor(s): Dr G C Sills
Editor(s)'s Affiliation: University of Oxford, UK
Editorial Board: National (UK)
Peer Reviewed: Yes
Coverage: It contains rigorously refereed papers and technical notes in English or French in the fields of soil and rock mechanics, engineering geology and environmental geotechnics. Topics include experimental or theoretical research, novel design or construction methods, detailed geotechnical case histories, and observations and measurements during and after construction. Written by internationally renowned authors from industry and academia, papers are of outstanding quality.
Frequency: 6 issues a year
Publisher: T Telford
Web site address: http://www.t-telford.co.uk/JOL/index.html
Source: web site
Last updated: 17 April 2000.

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International Journal of Architectural Management Practice & Research

Editor(s): M P Nicholson
Editor's Affiliation: University of Nottingham
Editorial Board:
Peer Reviewed?
Coverage:
Frequency:
Publisher:
Web site address: http://www.archman.com/ampr14.html
Source: web site.
Last updated: 1 June 2000.

International Journal of Computer Integrated Design and Construction

Editor(s): Dr Chimay Anumba
Editor's Affiliation: Loughborough University, UK.
Editorial Board: International
Peer Reviewed: Yes.
Coverage: The International Journal of Computer-Integrated Design and Construction (CIDAC) is intended to provide a forum for the dissemination of information related to the use of computers and associated technologies in the integration of the design and construction processes. The journal publishes both original research papers as well as practical papers on aspects of computer-integrated design and construction. Papers on theoretical, industrial and computing developments which have a bearing on computer-integrated design and construction will also be published. The scope of the journal is wide and includes the following and related topics: computer-aided design, computer-integrated construction, concurrent engineering in construction, computer-integration of design activities, computer-aided cost planning and control, computer-aided construction process planning and scheduling; information management in integrated design and construction, organizational/human issues in integrated design and construction, intelligent systems in integrated design and construction, life-cycle design of facilities, computer-integrated facilities management, computer-aided construction site layout design, computer-aided construction safety management, communication issues in integrated design and construction, and product and process modelling.
Frequency: Four issues this year.
Publisher: SETO London, UK.
Web site address: http://www.lboro.ac.uk/cidac/
Source: web site.
Last updated: 1 June 2000.

International Journal for Construction Marketing

Editor: Hedley Smyth; hjsmyth@brookes.ac.uk
Editor's Affiliation: Oxford Brookes University
Editorial Board: International
Peer Reviewed: Yes
Coverage: It is dedicated to publishing high quality research papers on marketing in: Construction; Contracting and Subcontracting; Consulting and Consultancy; Project Management; The Design Team and Engineering Building Materials and Supply Industries, in the areas of construction, construction management, building, civil engineering and the corporate management of organizations operating in these sectors. The policy of the journal is to publish papers of that develop the theoretical understanding of construction marketing and of new case material and empirical evidence.
Frequency: twice a year, January and September
Publisher: Oxford Brookes University
Web-site address: www.brookes.ac.uk/other/conmark/IJCM/
Source: web site
Last updated: 5 December 2000

International Journal of Facilities Management

(1997-)
Editor(s): Keith Alexander; alexander@sgbs.strath.ac.uk
Editor(s)'s Affiliation: Centre for Facilities Management, University of Strathclyde
Editorial Board: International
Peer Reviewed: Yes
Coverage: A high quality, academic forum in order to advance facilities management as a discipline. An appropriate vehicle for development and discussion of theory; research and practice in facilities management. A means of recording and circulating information concerning research work and related activities in facilities management; extensive peer-reviewed articles so you can be sure that all papers are of the highest standard
Frequency: quarterly
Publisher: Spon
Web site address: http://journals.routledge.com/fm.html
Source: Web site
Last updated: 17 April 2000.

International Journal of Project Management

(1981-)
Editor(s): Rodney Turner
Editor(s)'s Affiliation: Faculty of Economic Science, Erasmus University, Rotterdam, The Netherlands
Editorial Board: International
Peer Reviewed: Yes
Coverage: Project concepts; project evaluation; team building and training; communication; project start-up; risk analysis and allocation and quality assurance. Project systems; project planning; project methods; tools and techniques; resources, cost and time allocation; estimating and tendering; scheduling; monitoring, updating and control. Contracts; contract law; project finance; project management software; motivation and incentives; resolution of disputes; procurement methods; organization systems; decision making processes; investment appraisal
Frequency: Bi-monthly.
Publisher: Pergamon.
Web site address: http://www.elsevier.nl/inca/publications/store/3/0/4/3/5/, and http://www.apmgroup.co.uk/journal.htm
Source: Copac and Ulrich's, web site.
Last updated: 12 May 2000.
Note: The journal is published in collaboration with The Association of Project Management (APM) and is its official journal.

–J–

Journal of Architectural Engineering

Editor(s): Bijan Mohraz; bijan@seas.smu.edu

Editor(s)'s Affiliation: Southern Methodist University and National Institute of Standards and Technology
Editorial Board: National (USA).
Peer Reviewed: Yes
Coverage: practice-based information on the engineering and technical issues concerned with all aspects of building design. Topics related to building such as planning and financing, analysis and design, construction and maintenance, codes applications and interpretations, conversion and renovations, and preservations.
Frequency: quarterly
Publisher: ASCE
Web site address: http://www.pubs.asce.org/journals/ae.html
Source: web site
Last updated: 17 April 2000

Journal of Architecture

Editor(s): Allen Cunningham
Editor(s)'s Affiliation: University of Westminster
Editorial Board: International.
Peer Reviewed: Yes
Coverage: Topics to be covered include the interplay between cities, building, history and economic forces; problems of gender and ethnicity in architectual. Also, production and understanding; the powers, weakness and pre-suppositions of criticism; rewriting the historical canon of architecture, problems of interpreting cities. More over, eurocentrism and the rise of nationalism; the language and rhetoric of the construction industry; the sociology and pathology of professionalism; power games and patronage. As well as, the legal and political relationships between infrastructures and superstructure, and the conservation of 20th century architecture. Finally, it covers the rise of tourism; the uses and effects of the media; issues of greening and ecosystem, and the impact of computerization.
Frequency: 4 issues per year
Publisher: Spon and RIBA
Web site address: http://www.tandf.co.uk/journals/routledge/13602365.html
Source: web site
Last updated: 17 April 2000.

Journal of Computing in Civil Engineering

Editor(s): William J Rasdorf and Sivand Lakmazaheri; rasdorf@eos.ncsu.edu, lakmazaheri@cua.edu
Editor(s)'s Affiliation: North Carolina State University and The Catholic University of America
Editorial Board: National (USA).
Peer Reviewed: Yes
Coverage: Serves as a comprehensive resource for innovative ideas in civil engineering computing. Publishes technical papers, technical notes as well as brief discussions that review software, hardware, and strategic issues involved in contemporary civil engineering computing.
Frequency: quarterly
Publisher: ASCE
Web site address: http://www.pubs.asce.org/journals/cp.html and http://www.wmich.edu/jcce/jcce.htm
Source: Web site
Last updated: 17 April 2000.

Journal of Construction Management

Editor: Gary Berman
Editor's Affiliation: Greyhawk (North America, LLC), a medium-size CM firm.
Editorial Board: International
Peer Reviewed: Yes
Coverage: Every aspect of the management of construction – scheduling, estimating, cost engineering, planning, procurement, bidding, claims, dispute resolution, research, productivity, equipment, bonds, liens, contracts, organization and much more.
Publisher: Construction Management Association of America (CMAA)
Web site address: http://www.cmaanet.org
Source: email circular <gberman@greyhawkna.com>
Notes: First issue out in March 2000
Last updated: 14 February 2000.

Journal of Construction Engineering and Management (Construction)

(1956–)
Editor: James E. Rowings
Editor's Affiliation: Iowa State University
Editorial Board: National (USA).
Peer Reviewed: Yes
Coverage: It aims to advance the science of construction engineering to harmonise construction practices with design theories, and to further education and research in construction engineering and management.
Frequency: bi-monthly
Publisher: ASCE
Web site address: http://www.pubs.asce.org/journals/co.html
Source(s): web site
Last updated: 18 April 2000.
Notes: Abstracted in Transactions of the ASCE, CE Database online

Journal of Construction Procurement

(1995–)
Editors: Peter Hibberd, David Jaggar, Roy Morledge
Editor's(s) Affiliation: Joint Contracts Tribunal, UK; Liverpool John Moores University, UK; and The Nottingham Trent University, UK.
Editorial Board: International
Peer Reviewed: Yes
Coverage: International procurement, strategic procurement management; risk analysis; risk management; facilities management; decision making processes; selection of procurement methods and contractual arrangements; performance of procurement systems; psychological sociological environmental influences and behavioural issues, philosophical and ethical influences, customer satisfaction.
Frequency: (current) semi-annual
Publisher: International Research Group Ltd
Web site address: http://www.fbe.unsw.edu.ac/JOPC/default.htm
Source: 4(2) November 1998, Copac and web site.
Last updated: 18 April 2000.

Journal of Construction Research

(2000–)
Editors: Raymond Y.C. Tse and Heng Li
Editors' Affiliation: Department of Building and Real Estate, Hong Kong Polytechnic University
Editorial Board: International
Peer Reviewed: Yes
Coverage: Provision of an international forum for the interchange of information and ideas relating to operations management and production management in the construction industry. Market and policy papers introducing and analysing the operational and institutional setting, the supply side of real estate, policy issues and related laws and regulations of construction markets are also welcomed. The aim of this Journal is to explore the interface between academic research findings alongside articles related to everyday professional practice. Papers are published in two sections, Academic Papers and Practice Papers.
Frequency: Bi-annual (March and September).
Publisher: Hong Kong Institute of Building (HKIOB)
Web site address: http://www.hkir.com/hkiob/jcr.html
Source: web site
Last updated: 18 April 2000.

Journal of Digital Information

Editor(s): Cliff McKnight; c.mcknight@lboro.ac.uk
Editor(s)'s Affiliation: Loughborough University, UK
Editorial Board: International
Peer Reviewed: Yes

Coverage: electronic journal with no paper equivalent form, digital libraries hypermedia systems intelligent agents information management interfaces to digital information social consequences of digital information digital information design Web applications.
Publisher: JoDI is supported by the British Computer Society and Oxford University Press.
Frequency: various issues per year
Web site address: http://jodi.ecs.soton.ac.uk/about.html
Source: web site.
Last updated: 18 April 2000.

Journal of Financial Management of Property and Construction

(1996–)
Editor(s): Akintola Akintoye and Jim Birnie; akin@gcal.ac.uk, jw.birnie@ulst.ac.uk
Editor(s)'s Affiliation: Glasgow Caledonian University, UK, and University of Ulster at Jordanstown, UK.
Editorial Board: International
Peer Reviewed: Yes
Coverage: JFMPC will publish original quality manuscripts (theoretical and empirical) on issues dealing with: Project and corporate finance, risk management, property market analysis, modelling and forecasting; capital structure decisions and management; building/construction economics; investment theory and practice, pricing and valuation; cost forecasting, prediction and modelling; design and construction process, financial implications of IT systems; financial aspect of statutory regulations, energy and environment; cost evaluation of alternative procurement methods. The Journal combines the disciplines of financial and managerial economics, risk management, econometrics, and accounting in property and construction contexts.
Frequency: 3 issues a year.
Publisher: Glasgow Caledonian University, UK.
Web site address: http://jfmpc.gcal.ac.uk/
Source: editor
Last updated: 2 May 2000.

Journal of Management in Engineering

(1993–)
Editor(s): Jeffrey S Russel
Editor(s)'s Affiliation: University of Wisconsin, Madison, USA.
Editorial Board: National (USA).
Peer Reviewed: ? Some peer-reviewed papers
Coverage: All the latest concepts and current practices of management in the engineering marketplace. The Journal's scope now encompasses a blend of informative feature articles, peer-reviewed papers, practical case studies, and user-oriented information to provide a comprehensive review on topics ranging from project management to budgeting and strategic planning.
Frequency: Bi-monthly
Publisher: ASCE
Web site address: http://www.pubs.asce.org/journals/me.html
Source: Web site and Copac
Last updated: 18 April 2000.

Journal of Professional Issues in Engineering Education and Practice

(1991–)
Editor(s): Mark Evans
Editor(s)'s Affiliation: US Military Academy
Editorial Board: National (USA).
Peer Reviewed: ?
Coverage: Examines topics of broad professional interest, diverse views of engineering management, professional activities, and technical problems. The journal investigates the relationships between civil engineering and other disciplines, while emphasizing the engineers' obligations and responsibilities. Social, economic, and ecological implications of technological achievements are highlighted in papers authored by both engineers and professionals from relevant disciplines. Other subjects featured include applications of artificial intelligence in civil engineering and recent developments in civil engineering education
Frequency: Quarterly.
Publisher: ASCE

Web site address: http://www.pubs.asce.org/journals/ei.html
Source: web site
Last updated: 18 April 2000.

Journal of Property Investment and Finance

(formerly Journal of Property Valuation and Investment incorporating Journal of Property Finance)
(1999–)
Joint Editors: Nick French and Gerald Brown
Editors' Affiliation: University of Reading and National University of Singapore
Editorial Board: International
Peer Reviewed: Yes
Coverage: access to international leading edge information pertaining to the property valuation and investment field. Fully refereed papers on practice and methodology in the UK, France, Germany, USA and other countries, in the following areas: academic papers on the latest research, thinking and developments, computer briefings covering the latest information technology, law reports assessing new legislation, market data for a comprehensive review of current research, practice papers - a forum for the exchange of ideas and experiences. Plus, macro and micro economics issues, appraisal methodology, legal issues relating to valuation and property finance. Portfolio theory, forecasting, rental and capital determinants. Funding and borrowing; property taxation and databases.
Publisher: MCB University Press.
Web site address: www.mcb.co.uk/jpif.htm
Source(s): Property and 16(12/13), Dec 1998 and web page
Last updated: 18 April 2000.

Journal of Property Research

Editor(s): Bryan D MacGregor; b.d.macgregor@abdn.ac.uk
Editor(s)'s Affiliation: Department of Land Economy, University of Aberdeen, Scotland
Editorial Board: International
Peer Reviewed: Yes
Coverage: expansion of research into property investment and development. The Journal will also publish regular editorials, book reviews and market review material. It provides a forum for research in the field and assists researchers, private investors and developers and public authorities to keep abreast of new developments.
Frequency: 4 issues a year
Publisher: Spon
Web site address: http://www.tandf.co.uk/journals/routledge/09599916.html
Source(s): web site
Last updated: 18 April 2000.

Journal of Property Valuation and Investment

(formerly Journal of Property Investment and Finance)
(1990–)
Editors: Nick French and Gerald R. Brown
Editorial Board: International
Peer Reviewed: Yes
Coverage: covers the full range of professional activities relating to property appraisal, investment and finance. This includes micro and macro-economic issues; appraisal methods; capital markets; and portfolio theory; property financing issues and all matters which directly or indirectly affect the attractiveness of property as an investment.
Frequency: 6 issues/year
Publisher: MCB University Press
Web site address: http://www.mcb.co.uk/jpvi.htm
Source(s): 16(1), web site, Copac
Last updated: 18 April 2000.

Journal of Real Estate Literature

Editor(s): James B. Kau and C.F. Sirmans.
Editor(s)'s Affiliation: University of Georgia, USA and University of Connecticut, USA.
Editorial Board: International (mostly from the USA).
Peer Reviewed?

Coverage: The Journal of Real Estate Literature is a publication of the American Real Estate Society in conjunction with Kluwer Academic publishers. The purpose of this Journal is to provide a source of information to encourage academic research and teaching in the field of real estate. Our scope includes, but goes beyond, that of the traditional literature journal listing published research, dissertations, and work in progress. We intend to include other information on tools, such as software and data bases, helpful to those pursuing research. Finally, we plan to support the classroom instructor of real estate by providing case studies or other teaching aids.
Frequency:
Publisher: Kluwer Academic Publishers, USA.
Web site address: http://www.aresnet.org/ARES/pubs/jrel/JREL.html, or http://www.wkap.nl/journalhome.htm/0927-7544
Source(s): web sites.
Last updated: 1 June 2000.

Journal of Real Estate Portfolio Management

Editor(s): Willard McIntosh
Editor(s)'s Affiliation: Prudential Real Estate Investors.
Editorial Board: International (majority USA)
Peer Reviewed: Yes
Coverage: all aspects of real estate investment and portfolio management
Frequency: ?
Publisher: American Real Estate Society
Web site address: http://www.aresnet.org/ARES/pubs/jrepm/EdsJREPM.html
Source: web site
Last updated: 1 June 2000.

Journal of Risk Research

(1998-)
Editor(s): Ragnar Löfstedt; r.lofstedt@surrey.ac.uk
Editor(s)'s Affiliation: Centre for Environmental Strategy, University of Guilford, UK.
Editorial Board: International
Peer Reviewed: Yes
Coverage: publishes peer reviewed theoretical and empirical research articles within the risk field from the areas of engineering, physical, health and social sciences, as well as articles related to decision making, regulation and policy issues in all disciplines. It also addresses issues outside the current focus of the North American literature, providing the reader with a variety of interesting research results.
Frequency: quarterly
Publisher: Spon
Web site address: http://www.tandf.co.uk/journals/routledge/13669877.html
Source: web site
Last updated: 18 April 2000.

Journal of Structural Engineering

(1956–)
Editor(s): David Darwin; daved@ukans.edu
Editor(s)'s Affiliation: University of Kansas, USA
Editorial Board: National (USA).
Peer Reviewed: Yes
Coverage: Engineers, consultants, and professors detail the physical properties of engineering materials (such as steel, concrete, and wood), develop methods of analysis, and examine the relative merits of various types of structures and methods of fabrication. Subjects include the design, erection, and safety of structures ranging from bridges to transmission towers and tall buildings; technical information on outstanding, innovative, and unique projects; and the impact of natural disasters and recommendations for damage mitigation.
Frequency: monthly
Publisher: ASCE
Web site address: http://www.ascepub.infor.com/journals/st.html
Source: web site
Last updated: 18 April 2000.

Journal of Urban Planning and Development

(1983–)
Editor(s): Ian Kingham; kingham@gmc1.bc.ca
Editor(s)'s Affiliation: GMK Transportation Planning and Engineering Ltd, CA, USA
Editorial Board: International (UP&D Publications Committee representing both Canada and the USA).
Peer Reviewed: No
Coverage: It covers the application of civil engineering to urban planning aspects such as area-wide transportation, the co-ordination of planning and programming of public works and utilities, and the development and redevelopment of urban areas
Frequency: quarterly
Publisher: ASCE
Web site address: http://www.pubs.asce.org/journals/up.html
Source: Web site
Last updated: 18 April 2000.

–N–

NICAR Journal of Construction Management

Editor(s): Prof. Kanwal N. Vaid
Editor(s)'s affiliation: Institution and University
Editorial board: International
Peer reviewed: ? Done
Coverage: management of civil works, energy, safety, habitat, buildings, irrigation, environment, infrastructure, transportation, social services, communications and rural development.
Frequency: Quarterly
Publisher: National Institute of Construction Management and Research, Walchand Centre, Tardeo, Mumbai 400 034.
Web site address: http://www.nicmar.org/pub.htm
Source(s): E-enquiry to the Editor and web site.
Last updated: 30 May 2000.

–P–

Proceedings of Institution of Civil Engineers-Civil Engineering

(1837–)
Editor: ?
Editorial board: Overseas corresponding members
Peer reviewed: Yes
Coverage: The Proceedings of the Institution of Civil Engineers is the oldest series of civil engineering journals in the world. Divided into six parts, Proceedings offers both engineering professionals and academics the chance to read in depth refereed papers and forms a valuable reference guide to projects and debates past, present and futures. Topics covered: Civil Engineering, Geotechnical Engineering, Municipal Engineering, Structures and Buildings, Transport, Water Maritime and Energy.
Frequency: 4 issues/year plus 2 special issues
Publisher: Thomas Telford Ltd
Web site address: http://www.t-telford.co.uk/JOL/index.html
Source(s): Feb 1999
Last updated: 18 April 2000.

Project

(Magazine of the Association for Project Management)
Editor: Jo Simpson
Editorial board: None
Peer reviewed: No
Coverage: Regular features in "Project" include: project management scene news, letters, feature articles, body of knowledge –a series of articles on various aspects of Project Management, APM Network-news of the Association, contacts, forthcoming events, and international events.
Frequency: monthly (except September and January)
Publisher: APM, Financial Business Pubs

Web site address: http://www.apm.org.uk/
Source: March 1999, 11(9)
Last updated: 18 April 2000.

Property Management

(1992–)
Editor(s): Frances Plimmer.
Editor(s)'s Affiliation: School of the Built Environment, University of Glamorgan, UK.
Editorial Board: International
Peer Reviewed: Yes
coverage: property management covers the full scope of topics in its field including: changing technology - environmental regulations - quality issues - the marketplace - legal issues - use and occupation - ethical concerns - business, commercial, industrial and residential property management - land use and development - marketing - leasing - Financial issues
Frequency: quarterly
Publisher: MCB University Press
Web site address: http://www.mcb.co.uk/cgi-bin/journal1/pm
Source(s): Property and 16(12/13), Dec 1998 and web site
Last updated: 1 June 2000.

–R–

RICS Research Papers

(1996–)
Editor(s): Les Ruddock; l.ruddock@surveying.salford.ac.uk
Editor(s)'s affiliation: Department of Surveying, University of Salford, UK.
Editorial board: International
Peer reviewed: Yes
Coverage: research and development in any area relevant to the surveying profession. Papers will range from fundamental research work through to innovative practical applications of new and interesting ideas.
Publisher: Royal Institute of Chartered Surveyors
Web site address: http://www.rics.org.uk/research/submitapaper.html
Source: Web site and ARCOM Construction Management Abstracts
Last updated: 18 April 2000.

–S–

Structural Engineer

(1922–)
Editor(s): A Lorans; istructe.lon@mail.bogo.co.uk
Editor(s)'s affiliation: Structural Engineers Trading Organization
Editorial board: ?
Peer reviewed: Yes
Coverage: Theory and practice of building design and construction
Publisher: Structural Engineers Trading Organization Ltd
Web site address: no web site
Source: Ulrich's
Last updated: 5 December 2000

Structural Survey

(1982–)
Editors: Mike Hoxley
Editors' affiliation: Department of Built Environment, Anglia Polytechnic University, UK.
Editorial Board: National (UK), and one member from Hong Kong.
Peer reviewed: Yes
Coverage: surveys of commercial and residential property, case studies of refurbishment projects, building conservation, building regulation and codes, mechanical and electrical services survey, materials and components, building and material defects, practice abroad, law and practice of dilapidation

Frequency: 4 issues a year
Publisher: MCB University Press
Web site: http://www.mcb.co.uk/cgi-bin/journal1/ss
Source(s): web site
Last updated: 18 April 2000.

Swedish Building Research

(1995–)
Editor(s): Kerstin Franklin; kerstin.franklin@bfr.se
Editor(s)'s affiliation: ?
Editorial board: ?
Peer reviewed: No
Coverage 'Swedish Building Research is the journal that will keep you, the non-Swedish-speaking reader, up to date with the development in the field.'
Frequency: 4 issues a year
Publisher: Swedish Council for Building Research
Web site address: http://www.bfr.se/default.asp
Source: Web site and Ulrich's
Last updated: 14 February 2000.

–U–

Urban Design International

(1996–)
Editor(s): Richard Hayward and Sue McGlynn
Editor(s)'s affiliation: Joint Centre for Urban Design, Oxford Brookes University, UK
Editorial board: International
Peer reviewed: Yes
Coverage: Urban Design International aims to build the first international network for all of those involved in the multi-disciplinary tasks of urban design and management. In providing a forum for the exchange of information and a vehicle for the debate which constantly redefines the scope of urban design, the journal places a primary emphasis on bringing together practice and research. It addresses current issues and aims to make a range of material accessible to all: from in-depth papers and reviews of projects, to book reviews, comments on previous contributions and a diary of international events. Some issues are themed by topic or geographic region.
Frequency: 4 issues a year
Publisher: Routledge, Taylor & Francis Group
Web site address: http://www.tandf.co.uk/journals/routledge/13575317.html
Source: web site and COPAC
Last updated: 18 April 2000.

Urban Management

(1969–)
Editor(s): Jaci Leitel
Editor(s)'s affiliation: ?
Editorial board: ?
Peer reviewed: No
Coverage: Engineering Journal covering all disciplines in the urban management sector
Frequency: monthly
Publisher: John Pattrick
Web site address: No web address
Source: Ulrich's
Last updated: 8 Dec 1999

Urban Studies

(1964–)
Editor(s): W.F. Lever, Ronan Paddison
Editor(s)'s affiliation: ?
Editorial board: International
Peer reviewed: Yes

Coverage: Contents include original articles, notes and comments, and a comprehensive book review section. Regular contributions are drawn from the fields of economics, planning, political science, statistics, geography, sociology, population studies and public administration. It also publishes the occasional 'state of the art' article, consisting of an analytical review of the major strands of contemporary thinking in a given topic area, supported by an extended bibliography of the topic. This journal deals with every kind of urban and regional problem that is susceptible to social science or other relevant analysis. These range from such problems as urban housing, employment, race, politics and crime, to problems of regional investment and transport. Although most articles published deal with problems located in the advanced industrial societies of Europe and the Americas, important articles dealing with these problems in Asia, the Third World and in Eastern Europe are also published regularly.
Frequency: 9 issues per year and an annual volume.
Publisher: University of Glasgow
Web site address: ?
Source: Vol. 33, Number 10, Dec 1996.
Last updated: 30 March 2000

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	CME 1983, **1**(3), 233–268
	CME 1983, **1**(2), 119–144
Blackwood, D J	JCP 1997, **3**(3), 47–67
Blockley, D L	JCR 2000, **1**(2), 123–129
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Bogenstätter, U	BRI 2000, **28**(5/6), 376–386
Boldes, U	BRI 1996, **24**(6), 323–328
Bollen, R	JFM 2000, **5**(1/2), 51–64
Bologna, R	BRI 2000, **28**(2), 109–118
Bon, R	CME 2000, **18**(2), 151–159
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	CME 1988, **6**(2), 149–159
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Bons, H N M	ECAM 1994, **1**(2), 139–146
Boonstra, C	CME 2000, **18**(8), 885-892
Bordass, W	BRI 2000, **28**(5/6), 338–352
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	BRI 1999, **27**(1), 4–19
	BRI 1997, **25**(4), 190–195
	BRI 1997, **25**(3), 148–157
Bordoli, D	CME 1998, **16**(3), 327–337
Bouchlaghem, N M	ECAM 1999, **6**(4), 371–379
	BRI 1996, **24**(2), 104–107
Bourdeau, L	BRI 1999, **27**(6), 355–367
Boussabaine, A H	JCP 1999, **5**(2), 141–158
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	CME 1998, **16**(4), 471–479
	CME 1996, **14**(5), 427–436
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Boutfskis, V	JFM 1997, **2**(2), 39–58
Bowen, P A	RICS 1995, **1**(2), 1–48
	JCP 1999, **5**(1), 47–57
	JCP 1998, **4**(2), 103–115
	JCP 1998, **4**(1), 16–26
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	CME 1996, **14**(5), 395–404
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	CME 1985, **3**(3), 199–215
Bower, D	CME 2000, **18**(3), 263–268
Bowlby, R L	CME 1986, **4**(1), 1–18
Bowles, G	CME 1997, **15**(4), 315–326
Boyland, M	CME 1994, **12**(6), 543–549
Brandon, P S	ECAM 1997, **4**(1), 41–57
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	CME 1990, **8**(3), 285–300
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Bremer, W	BRI 2000, **28**(2), 98–108
Bresnen, M J	CME 2000, **18**(7), 819–832
	CME 2000, **18**(5), 587–598
	CME 2000, **18**(2), 229–237
	CME 1991, **9**(4), 327–342
	CME 1991, **9**(3), 247–263
	CME 1986, **4**(1), 37–55
Brett-Jones, A T	CME 1983, **1**(2), 91–117
Briffett, C	CME 2000, **18**(8), 935-947
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Bright, K	CME 1992, **10**(3), 203–226
Bröchner, J	ECAM 1994, **1**(2), 91–101
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Bromilow, F J	CME 1987, **5**(4), S3-S22
Brooker, P	CME 1999, **17**(6), 757–765
	CME 1997, **15**(6), 519–526
Broome, J C	ECAM 1995, **2**(4), 271–285
Brown, F E	CME 1994, **12**(3), 271–278
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Brown, P	CME 1998, **16**(4), 447–457
Brownlie, S M	CME 1987, **5**(2), 115–121
Bryant, D T	CME 1984, **2**(2), 177–184
Bryman, A E	CME 1986, **4**(1), 37–55
Bubshait, A A	CME 1999, **17**(6), 799–809
	BRI 1997, **25**(6), 365–369
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Buijs, A	BRI 1996, **24**(4), 195–202
Burchett, J F	CME 1999, **17**(1), 77–90
	CME 1998, **16**(2), 235–244
Burford, N K	BRI 1999, **27**(2), 64–83
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Burgess, R	CME 1991, **9**(1), 79–92
Burnett, J	CME 2000, **18**(8), 959–968
Burns, S A	CME 1996, **14**(3), 265–276
Burrows, B G	CME 1983, **1**(3), 199–215
Burrows, C	RICS 1999, **3**(5), 1–94
Burton, R	BRI 1998, **26**(2), 76–93

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Caban, G	ECAM 1998, **5**(2), 182–188
Cammalleri, V	BRI 1997, **25**(4), 234–238
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Campagnac, E	CME 1995, 13(1), 3–14
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	BRI 1998, **26**(5), 297–301
Cannon, J	CME 1994, **12**(4), 307–313
Capper, P N	ECAM 1995, **2**(4), 317–326
Carmichael, D G	CME 1986, **4**(2), 161–177
Carr, V	ECAM 2000, **7**(2), 107–119
	ECAM 1998, **5**(4), 327–338
	CME 2000, **18**(4), 491–500
Carrillo, P M	JFM 1998, **3**(3), 49–70
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	CME 1994, **12**(1), 45–51
Carroll, J	JCP 2000, **6**(1), 33–43
Carter, N	RICS 1995, **1**(5), 1–40
Chakrabarti, S C	BRI 1996, **24**(1), 51–58
Chambers, D	CME 1999, **17**(5), 679–687
Chan Foong May	BRI 1997, **25**(3), 158–169
Chan, A P C	JCP 1995, **1**(2), 111–123
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	CME 1999, **17**(2), 189–196
	CME 1995, **13**(6), 467–473
Chan, C M R	CME 1989, **7**(3), 235–247
Chan, D W M	JCP 1999, **5**(2), 88–98
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	CME 1998, **16**(1), 17–29
	CME 1995, **13**(4), 319–333
	CME 1995, **13**(3), 209–217
Chan, E H W	CME 1997, **15**(6), 539–548
Chan, S C M	JCR 2000, **1**(2), 169–175
Chang, D S	CME 1993, **11**(5), 398–403
Chapman, C B	CME 1991, **9**(4), 343–353
Chapman, R J	CME 1999, **17**(1), 99–106
Chapman, T	JCP 2000, **6**(2), 90–103
Charlton, M	RICS 1996, **2**(3), 1–44
Charters, B	CME 2000, **18**(8), 927-934
Chau Kwong Wing	ECAM 1999, **6**(2), 166–176
	ECAM 1998, **5**(1), 38–50
	CME 1999, **17**(4), 473–482
	CME 1998, **16**(1), 99–104
	CME 1997, **15**(4), 387–398
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	CME 1995, **13**(1), 15–21
	CME 1994, **12**(2), 183–185
	CME 1993, **11**(5), 370–383

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Chau, C K	CME 2000, **18**(8), 959–968
Cheetham, D W	JFM 1997, **2**(1), 5–34
Chen Qijun	BRI 1997, **25**(1), 11–14
Chen, J J	JFM 1999, **4**(1), 75–87
	JFM 1996, **1**(3), 5–22
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	BRI 1996, **24**(5), 311–317
Cheng, E W L	ECAM 2000, **7**(1), 76–92
Cher, L	CME 1991, **9**(6), 509–528
Cherns, A B	CME 1984, **2**(2), 177–184
Cheung Sai-On	JCP 1997, **3**(1), 16–27
	ECAM 2000, **7**(3), 251–266
Cheung, S O	CME 2000, **18**(3), 281–294
Chiang, Y H	JFM 1997, **2**(3), 63–76
	JCR 2000, **1**(1), 77–86
	CME 1998, **16**(6), 729–737
Child, T	ECAM 2000, **7**(4), 373–388
	CME 1994, **12**(3), 271–278
Ching Ming Tam	ECAM 1996, **3**(3), 187–203
Ching-Hwang Wang	CME 1998, **16**(1), 5–16
Chinyio, E A	JCP 1998, **4**(2), 89–102
	CME 1998, **16**(1), 91–98
Chiu, H N	CME 1996, **14**(4), 325–340
Choi, S K	CME 2000, **18**(5), 547–557
Chow, W S	BRI 1999, **27**(2), 84–95
Chung-Huei Yang	CME 1999, **17**(6), 767–776
Clark, J	BRI 2000, **28**(5/6), 413–418
Clark, L	ECAM 1997, **4**(1), 3–22
	CME 1998, **16**(2), 177–192
	CME 1996, **14**(4), 353–364
Clarke, L	CME 2000, **18**(6), 689–698
	CME 1998, **16**(5), 553–567
Clausen, L E	CME 1998, **16**(2), 131–137
Clements-Croome, T D J	BRI 1996, **24**(2), 86–96
Coble, R J	JCR 2000, **1**(1), 1–8
Cochrane, S P	CME 1999, **17**(6), 777–787
Cochrane, S R	CME 1987, **5**(1), 45–56
Coffey, M	CME 1998, **16**(5), 543–552
Cole, R J	CME 2000, **18**(8), 949-957
	BRI 2000, **28**(5/6), 368–375
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	BRI 1999, **27**(4), 221–229
	BRI 1998, **26**(1), 3–16
Collins, S	RICS 1997, **2**(5), 1–32
Collis, S	RICS 1999, **3**(5), 1–94
Colman, J	BRI 1996, **24**(6), 323–328
Colton, B	RICS 2000, **3**(13), 1–48
Connaughton, J N	CME 1994, **12**(4), 315–321
Connolly, M	CME 1998, **16**(4), 417–432
Cooke, E	BRI 1996, **24**(4), 213–222
Cooke, N	RICS 1996, **1**(6), 1–80
Cooper, G S	CME 1994, **12**(3), 271–278
	CME 1993, **11**(5), 384–397
Cooper, I	BRI 1999, **27**(5), 321–331
	BRI 1998, **26**(1), 17–28
	BRI 1997, **25**(5), 292–300
Cooper, M D	CME 1994, **12**(1), 67–78
Cooper, P A	CME 2000, **18**(7), 767–774
Cooper, R	JCP 2000, **6**(2), 164–183
	JCP 1998, **4**(2), 132–151
	ECAM 2000, **7**(2), 141–153
Cornick, T	CME 1994, **12**(2), 107–111
Courtney, R	BRI 1997, **25**(5), 285–291
Cox, A	JCP 1998, **4**(1), 5–15
	JCP 1995, **1**(2), 87–99
	ECAM 1997, **4**(2), 143–158
Craig, J W	CME 1998, **16**(3), 303–313
Craig, R	JCP 1999, **5**(1), 15–26
	CME 2000, **18**(1), 91–100
Crawley, D	BRI 1999, **27**(5), 300–308
Creech, L	BRI 2000, **28**(5/6), 403–407
Croker, W H	ECAM 1995, **2**(3), 167–178
Crook, D	JCP 1997, **3**(2), 56–71
	CME 1998, **16**(1), 109–112
	CME 1997, **15**(5), 491–494
	CME 1997, **15**(1), 117–119
Crosby, N	RICS 1996, **2**(1), 1–72
Crosthwaite, D	CME 2000, **18**(5), 619–627
	CME 1998, **16**(4), 389–395
	BRI 2000, **28**(4), 280–290
Croucher, R	CME 2000, **18**(6), 699–709
Crowther, D	BRI 1998, **26**(2), 103–112
Cui Cunbin	BRI 2000, **28**(1), 59–66
Curtis, B	CME 1991, **9**(4), 343–353
Curwell, S	BRI 1999, **27**(5), 286–293
	BRI 1998, **26**(1), 17–28
Cusack, M M	CME 1985, **3**(3), 183–198
	CME 1985, **3**(2), 91–104
	CME 1984, **2**(3), 219–224

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Dae-Ho Kim	CME 2000, **18**(1), 45–54
Dagpunar, J S	CME 1997, **15**(4), 315–326
Dainty, A R J	JCP 2000, **6**(1), 44–55
	ECAM 2000, **7**(2), 169–178
	CME 2000, **18**(2), 239–250
	BRI 2000, **28**(4), 226–233
Dalgliesh, C D	ECAM 1997, **4**(1), 23–39
Damodaran, L	ECAM 1999, **6**(1), 63–70
Davenport, D	JFM 1997, **2**(3), 77–94
Davenport, D M	JCP 1995, **1**(1), 38–49
Davenport, P	CME 1993, **11**(4), 305–307
Davey, C L	CME 2000, **18**(1), 113–121
Davidson, C H	CME 1992, **10**(4), 343–359
	BRI 1997, **25**(5), 313–317
	BRI 1996, **24**(6), 351–357
Davidson, M	CME 2000, **18**(7), 747–756
Davidson, M J	CME 2000, **18**(1), 113–121
Davies, M	BRI 2000, **28**(1), 42–50
Davis, C	CME 1987, **5**(1), 45–56
Dawood, N N	JFM 1996, **1**(2), 17–28
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	CME 1995, **13**(2), 115–125
	CME 1995, **13**(1), 53–64
	CME 1994, **12**(5), 393–412
	CME 1993, **11**(2), 81–98
	CME 1990, **8**(4), 365–383
Day, A K	ECAM 1996, **3**(1/2), 15–28
	CME 1986, **4**(3), 245–260
de Oteiza, I	BRI 2000, **28**(3), 196–211
De Saram, D D	ECAM 1999, **6**(3), 225–234
Deakin, M	JFM 2000, **5**(1/2), 15–31
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	JFM 1997, **2**(1), 59–82
	JFM 1996, **1**(2), 39–56
Dean, Y	BRI 1998, **26**(3), 146–156
Deb, A	BRI 1998, **26**(1), 29–38
Deb, B	CME 1993, **11**(1), 45–52
Debrah, Y A	CME 1998, **16**(4), 397–408
Deddis, W G	JFM 1997, **2**(3), 45–62

Dehesh, A — RICS 1998, **2**(6), 1–36
Del Nord, R — BRI 2000, **28**(2), 109–118
Deng Xiaoheng — BRI 2000, **28**(1), 59–66
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Deng, Z M — CME 2000, **18**(4), 437–446
Denis, N — CME 2000, **18**(4), 447–456
Depanni, S — ECAM 1998, **5**(1), 92–102
Dester, W S — ECAM 1995, **2**(1), 17–26
Dewey, E — BRI 2000, **28**(1), 42–50
Dhanasekar, M — ECAM 2000, **7**(4), 347–361
Dickson, M — BRI 1998, **26**(2), 76–93
Diekmann, J E — JCP 2000, **6**(1), 33–43
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BRI 1998, **26**(4), 223–238
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Dodd, J — CME 1990, **8**(4), 385–398
Doggart, J — BRI 1999, **27**(5), 286–293
Donegan, H A — JFM 1996, **1**(3), 53–70
CME 1990, **8**(2), 147–158
Dorée, A G — JCP 1997, **3**(3), 78–88
Dowd, V G — JCP 1996, **2**(1), 11–29
Drew, D S — JCP 2000, **6**(2), 220–230
ECAM 2000, **7**(3), 211–220
CME 1997, **15**(5), 469–489
CME 1992, **10**(3), 227–247
Druker, J — CME 2000, **18**(6), 699–709
CME 1996, 14(5), 405–416
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Dubiel, J — BRI 1998, **26**(2), 103–112
Dudek, S J-M — BRI 1997, **25**(4), 226–233
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BRI 1996, **24**(5), 279–286
Duffield, C — ECAM 1998, **5**(1), 3–8

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Eames, P C — BRI 1996, **24**(3), 141–147
Earl, G — CME 1998, **16**(2), 221–233
Eckblad, J — CME 1984, **2**(2), 145–156
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Edwards, B — CME 1984, **2**(2), 145–156
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Edwards, M — CME 1995, 13(6), 485–491
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BRI 2000, **28**(1), 31–41
Fazio, P — CME 1988, **6**(3), 195–208
Fellows, R F — JFM 1996, **1**(3), 71–82
JCP 1997, **3**(2), 34–44
ECAM 2000, **7**(4), 362–372
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CME 1992, **10**(2), 137–151
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Feng, C — CME 1996, **14**(3), 265–276
Fenis, S M — ECAM 1995, **2**(3), 227–238
Fenn, P — CME 1997, **15**(6), 513–518
CME 1997, **15**(4), 383–385
Fereig, S M — BRI 1996, **24**(6), 374–378
Ferry, D — CME 1990, **8**(3), 259–283
Fielden, S L — CME 2000, **18**(1), 113–121
Finch, E F — CME 1998, **16**(4), 383–388
CME 1996, **14**(2), 121–129

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Finlay, L	RICS 1996, **2**(3), 1–44
Finlayson, F	JCP 2000, **6**(1), 33–43
Finnemore, M	JCP 2000, **6**(2), 184–201
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Fischer, M A	ECAM 1998, **5**(2), 127–136
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Fisher, N	CME 1990, **8**(4), 341–363
Fitzgerald, D	JFM 1999, **4**(2), 49–62
Fitzgerald, E	ECAM 1998, **5**(1), 9–21
	ECAM 1995, **2**(1), 27–44
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Flanagan, R	ECAM 2000, **7**(4), 423–435
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	CME 1985, **3**(2), 145–161
	CME 1984, **2**(2), 133–144
	CME 1983, **1**(2), 157–180
Flood, I	ECAM 1997, **4**(4), 271–293
Fong, P S	CME 2000, **18**(5), 547–557
Ford, J R	CME 1986, **4**(1), 37–55
Ford, S R	CME 1994, **12**(3), 271–278
	CME 1993, **11**(5), 384–397
Fortune, C	RICS 2000, **3**(16), 1–24
	RICS 1996, **2**(2), 1–52
	JFM 2000, **5**(1/2), 41–50
	JFM 1998, **3**(1), 5–26
	JCP 1999, **5**(2), 129–140
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Fraser, C	CME 2000, **18**(1), 29–36
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Fredriksson, G	BRI 1999, **27**(6), 368–378
Friedman, A	BRI 1997, **25**(4), 234–238
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Fuller, S K	CME 1985, **3**(1), 43–57
Fung, I W H	CME 1998, **16**(1), 49–51
Furlong, P	JCP 1995, **1**(2), 87–99
Furusaka, S	CME 1984, **2**(2), 157–176

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Gaafar, H K	CME 1999, **17**(3), 383–391
Gaarslev, A	ECAM 1996, **3**(1/2), 3–14
Gage, S A	BRI 2000, **28**(4), 234–244
Gailius, A	BRI 1997, **25**(3), 170–175
Galbraith, G H	BRI 2000, **28**(4), 245–259
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Gale, A W	JCR 2000, **1**(1), 43–52
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Ganesan, S	JFM 1998, **3**(2), 5–26
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Gang, G	CME 2000, **18**(8), 935-947
Gann, D M	ECAM 1998, **5**(2), 115–126
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Garas, F	ECAM 1999, **6**(1), 51–62
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Gardiner, P D	CME 1995, **13**(3), 219–234
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Garnett, N	CME 2000, **18**(1), 55–63
Gavieta, R C	BRI 1997, **25**(2), 124–128
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Gayoso, A	ECAM 1999, **6**(1), 51–62
Geissler, S	BRI 1999, **27**(4), 247–256
Geltner, D	CME 1991, **9**(5), 481–492
Ghanbari-Parsa, A R	CME 1999, **17**(1), 107–119
Giannakopoulou, T	CME 1992, **9**(6), 553–564
Gibb, A G F	CME 1999, **17**(2), 197–204
Gibson, V A	RICS 2000, **3**(12), 1–38
Gidado, K I	JCP 1996, **2**(2), 52–68
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Giddings, R	BRI 1999, **27**(2), 96–108
Gilleard, J	CME 1989, **7**(4), 321–330
Gillespie, I	BRI 1998, **26**(6), 330–339
Giritli, H	CME 1990, **8**(4), 415–430
Godbole, P N	BRI 1996, **24**(1), 51–58
Goh Bee Hua	RICS 1999, **3**(4), 1–22
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	CME 1999, **17**(2), 231–241
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Goldfinger, D	CME 2000, **18**(4), 467–477
Goodall, W L	JFM 1996, **1**(1), 89–100
Goodchild, B	JCP 2000, **6**(1), 20–32
Goodhew, S	JFM 1999, **4**(2), 49–62
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Gooding, D	BRI 1997, **25**(4), 202–209
Gordon, E B	BRI 2000, **28**(5/6), 325–337
Goren, T	ECAM 1998, **5**(1), 82–91
Gori, E	CME 1996, **14**(5), 451–456
Gould, M	CME 2000, **18**(2), 219–228
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Gow, H	CME 1997, **15**(4), 315–326
Gowda, R	CME 1998, **16**(4), 417–432
Gowri, K	ECAM 1998, **5**(1), 92–102
Graham, J M R	BRI 2000, **28**(4), 234–244
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Graham, R	ECAM 1997, **4**(3), 215–231
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Gray, C	CME 1986, **4**(2), 135–150
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Green, L	BRI 1999, **27**(6), 398–405
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Griffiths, P W	BRI 1996, **24**(3), 141–147
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Grimsey, D	ECAM 1997, **4**(3), 215–231
Groák, S	ECAM 1998, **5**(2), 115–126
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Grobler, F	ECAM 1994, **1**(1), 69–84
Guan Ke	JFM 1996, **1**(3), 71–82
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Gunawardana, N D	CME 1998, **16**(5), 521–530
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Gupta, N K	BRI 1996, **24**(4), 209–212
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Haidar, W	ECAM 2000, **7**(1), 3–14
Haigh, R	JCP 2000, **6**(2), 184–201
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Hakam, Z H R	BRI 1996, **24**(4), 237–244
Hall, K A	CME 1995, **13**(3), 235–241
Halliday, J	ECAM 1995, **2**(4), 307–315
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Halpin, D W	ECAM 2000, **7**(1), 41–51
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Hammarlund, Y	ECAM 1995, **2**(3), 209–225
Hampson, K	JCP 1997, **3**(1), 28–41
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Hancock, M	JCP 1997, **3**(2), 34–44
Handa, V K	CME 1996, **14**(4), 341–452
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Hanna, A S	ECAM 2000, **7**(1), 93–103
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Harris, D J	BRI 1997, **25**(4), 226–233
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Harris, R	BRI 1998, **26**(2), 76–93
Harriss, C	CME 1998, **16**(1), 113–116
Haslam, C O	CME 1991, **9**(4), 327–342
Haslam, R A	CME 1999, **17**(2), 197–204
Hassan, T M	ECAM 1999, **6**(1), 63–70
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Hassan, Z	ECAM 1999, **6**(2), 197–212
Hassanein, A A G	BRI 1996, **24**(5), 293–301
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Hastings, B	RICS 2000, **3**(7), 1–40
Hastings, E M	JFM 2000, **5**(1/2), 79–84
Hatush, Z	CME 1997, **15**(4), 327–340
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Haupt, T C	JCR 2000, **1**(1), 1–8
Hawkins, R	BRI 1998, **26**(5), 280–296
Hawwash, K	ECAM 1997, **4**(3), 203–214
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He Qun	BRI 1999, **27**(2), 120–123
Headley, J D	CME 1998, **16**(6), 703–709
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Heath, T	CME 1994, **12**(6), 543–549
Heavey, I	ECAM 2000, **7**(3), 322–328
Heerwagen, J	BRI 2000, **28**(5/6), 353–367
Hegazy, T	ECAM 1994, **1**(1), 51–67
Hegewisch, A	CME 1996, 14(5), 405–416
Heng Li	ECAM 1996, **3**(1/2), 69–81
	CME 1998, **16**(6), 721–727
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Henneberry, J	RICS 2000, **3**(9), 1–59
Henry, C	CME 2000, **18**(6), 667–677
Herbsman, Z	CME 1990, **8**(1), 49–61
Herzog, H W	CME 1988, **6**(3), 247–258
Hijazi, A	CME 1993, **11**(2), 99–110
Hill, R	BRI 1999, **27**(2), 96–108
Hill, R C	ECAM 1997, **4**(1), 23–39
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Hillebrandt, P M	CME 2000, **18**(1), 11–14

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Hindle, R D	JCP 1997, **3**(1), 56–69
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Hinks, J	RICS 2000, **3**(16), 1–24
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	JCP 1998, **4**(2), 132–151
	CME 1996, **14**(6), 529–534
Ho, C S	CME 2000, **18**(4), 437–446
Ho, C W	CME 1999, **17**(5), 625–633
Ho, M F	JFM 1998, **3**(2), 75–88
Ho, T K K	CME 1993, **11**(6), 455–465
Hoare, D J	ECAM 1998, **5**(2), 144–149
Hobbs, P	RICS 1996, **1**(6), 1–80
Hodgson, G	RICS 1999, **3**(2), 1–24
Holm, D	CME 1999, **17**(3), 363–374
Holm, M G	CME 2000, **18**(5), 525–533
Holt, G D	RICS 2000, **3**(8), 1–10
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	JFM 2000, **5**(1/2), 85–92
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	JFM 1998, **3**(3), 17–36
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Holt, L	CME 1989, **7**(3), 217–234
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Home, R	RICS 1996, **1**(9), 1–33
Hooper, A	CME 2000, **18**(3), 295–310
Hope, A E	CME 1989, **7**(1), 65–74
Horne, M	BRI 1999, **27**(2), 96–108
Horner, R M W	ECAM 1995, **2**(2), 121–139
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Hornibrook, J	CME 1999, **17**(2), 139–153
Howard, N	BRI 2000, **28**(5/6), 315–324
	BRI 1999, **27**(5), 286–293
Howell, G A	CME 1992, **10**(3), 249–262
Howes, R	JFM 1998, **3**(1), 27–42
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	ECAM 1998, **5**(4), 327–338
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Hoxley, M	RICS 1996, **1**(8), 1–32
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Hsieh, T	CME 1999, **17**(1), 91–98
Hu Minggang	BRI 1999, **27**(2), 120–123
Hu Wei	BRI 1999, **27**(2), 120–123
Huang, R Y	ECAM 2000, **7**(1), 41–51
Huang, Y C	CME 1998, **16**(3), 257–267
Huat, T P	CME 1994, **12**(2), 125–138
Huemer, L	CME 2000, **18**(6), 635–642
Hughes, K	ECAM 1998, **5**(2), 189–198
Hughes, W P	JCP 1998, **4**(2), 89–102
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Hui, S C M	BRI 1996, **24**(3), 131–140
Humphreys, G	JFM 1997, **2**(1), 5–34
Humphreys, P C	CME 1991, **9**(1), 3–17
Hunter, I	ECAM 1999, **6**(1), 51–62
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Hunter, J	ECAM 1999, **6**(1), 38–50
Hutchinson, K	BRI 2000, **28**(5/6), 310–314
Hutchison, N	RICS 2000, **3**(10), 1–36
Hyde, R	ECAM 1995, **2**(1), 45–56
Hydes, K R	BRI 2000, **28**(5/6), 403–407
Hyun-Soo Lee	CME 2000, **18**(1), 45–54

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Ibbs, C W	JCP 1995, **1**(1), 64–80
	CME 1991, **9**(2), 157–169
Idris, M M	CME 1998, **16**(6), 673–679
Imbert, I D C	CME 1990, **8**(2), 219–228
Imre, M	CME 1984, **2**(1), 49–55
Irani, Z	CME 2000, **18**(3), 321–331
Ireland, V	CME 1985, **3**(1), 59–87
Irurah, D K	CME 1999, **17**(3), 363–374
Isaac, D	JFM 1999, **4**(1), 75–87
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Ishai, E	CME 1989, **7**(3), 189–202
Ive, G	CME 1994, **12**(4), 349–364
Iyagba, R	CME 1993, **11**(5), 317–325
Iyer-Raniga, U	CME 2000, **18**(1), 5–9
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Jaafari, A	ECAM 1999, **6**(3), 235–255
Jackaway, A	BRI 2000, **28**(1), 42–50
Jae-Chan Kim	CME 2000, **18**(1), 45–54
Jae-Jun Kim	CME 2000, **18**(1), 45–54
Jagboro, G O	JFM 1999, **4**(3), 39–46
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Jannadi, M O	CME 1999, **17**(6), 799–809
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Janssen, J	CME 2000, **18**(6), 711–720
Janszen, F	CME 1995, **13**(1), 43–51
Jaselskis, E	CME 1994, **12**(3), 245–255
Jayawardane, A	CME 1998, **16**(5), 521–530
Jeffrey, J A	RICS 1999, **3**(2), 1–24
Jenkins, A W	CME 1984, **2**(1), 25–36
Jennings, M J	ECAM 1996, **3**(3), 163–186

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Kagioglou, M JCP 2000, **6**(2), 164–183
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Salminen, S	CME 1995, **13**(4), 299–306
Sánchez-Romero, M	BRI 1996, **24**(6), 369–373
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Sarkar, A	BRI 1996, **24**(1), 51–58
Sarkar, S	JCP 1997, **3**(3), 47–67
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Schlottmann, A M	CME 1988, **6**(3), 247–258
Schneider, E	CME 1993, **11**(6), 467–473
Schriver, W R	CME 1986, **4**(1), 1–18
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Scott, D	ECAM 1996, **3**(3), 233–248
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Scott, R	ECAM 1995, **2**(2), 83–92
Scott, S	JFM 2000, **5**(1/2), 65–77
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Shawa, H H	JCP 1997, **3**(3), 27–46
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Shen, G Q	BRI 1998, **26**(3), 169–180
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Shi, J J	CME 1999, **17**(4), 463–471
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Shields, T J	CME 1990, **8**(2), 147–158
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Shih Naai-Jung	BRI 1997, **25**(1), 18–24
Shimizu, H	CME 2000, **18**(3), 269–280
Shing, G T	JFM 1999, **4**(2), 33–48
Shirazi, B	CME 1996, 14(3), 199–212
Shoesmith, D R	CME 1996, **14**(2), 93–101
Shohet, I M	CME 1991, **9**(6), 565–576
Shou Qing Wang	CME 2000, **18**(3), 363–372
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Sidwell, A C	ECAM 1997, **4**(4), 295-310
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Silcock, G W	CME 1990, **8**(2), 147–158
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Sloan, B	JFM 1996, **1**(1), 89–100
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Smallwood, J	BRI 1998, **26**(3), 181–189
Smith, A	JCP 1996, **2**(1), 30–40
Smith, F W	BRI 1999, **27**(2), 64–83
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Smith, J	CME 2000, **18**(5), 567–574
Smith, J M	ECAM 2000, **7**(2), 191–201
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Smith, N J	ECAM 1999, **6**(2), 155–165
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Smith, N J	ECAM 1999, **6**(4), 358–370
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Smith, R M	JFM 1996, **1**(1), 89–100
Smith, S D	CME 2000, **18**(2), 219–228
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Smithers, G L	CME 2000, **18**(7), 833–841
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Smithers, M	CME 1998, **16**(1), 71–78
So, A T P	CME 1995, **13**(2), 95–103
So, H M	JFM 1998, **3**(2), 5–26
Sobotka, A	CME 2000, **18**(2), 183–195
Soh, C C	JFM 1999, **4**(3), 47–64
Sohail, M	JFM 2000, **5**(3),111–122
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Sou-Sen Leu	CME 1999, **17**(6), 767–776
Southcombe, C	JFM 1999, **4**(2), 49–62
Sözen, Z	CME 1990, **8**(4), 415–430
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Spedding, A	BRI 1998, **26**(3), 169–180
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Stamler, H	CME 1983, **1**(1), 75–87
Stansfield, F R	JCP 1995, **1**(2), 124–149
Steemers, K	BRI 1998, **26**(2), 103–112
Sterner, E	BRI 2000, **28**(5/6), 387–393
Stigson, B	BRI 1999, **27**(6), 425–431
Stipanowich, TJ	CME 1997, **15**(6), 505–512
Stocks, S N	CME 1999, **17**(3), 251–267
Stradling, S G	CME 1989, **7**(2), 103–113
Stumpf, I	ECAM 2000, **7**(2), 159–168
Suazo, G A R	CME 1994, **12**(3), 245–255
Suh, K	CME 1991, **9**(4), 369–381
Sutt, J	JFM 1999, **4**(1), 47–58
Swaffield, L	RICS 2000, **3**(15), 1–49
Swaffield, L M	RICS 2000, **3**(6), 1–28
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	JFM 1996, **1**(3), 23–42
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Taher, K A H	CME 1988, **6**(4), 295–306
Tahir, B M	BRI 1997, **25**(6), 365–369
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Talukhaba, A A	ECAM 1999, **6**(4), 335–346
Tam, C M	ECAM 1998, **5**(4), 359–375
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Tam, S H	JFM 1998, **3**(2), 75–88
Tan, A C N	ECAM 1998, **5**(1), 31–37
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bidding JCP 2000, **6**(2), 220–230
ECAM 1997, **4**(3), 163–177
CME 2000, **18**(4), 457–466
CME 1999, **17**(3), 285–296
CME 1998, **16**(1), 91–98
CME 1997, **15**(5), 469–489
CME 1997, **15**(1), 5–18
CME 1995, **13**(2), 115–125
CME 1993, **11**(6), 421–429
CME 1992, **10**(5), 415–429

	CME 1992, **10**(3), 227–247
	CME 1992, **10**(1), 69–80
	CME 1991, **9**(5), 403–429
	CME 1988, **6**(3), 225–245
	CME 1985, **3**(2), 145–161
	BRI 1996, **24**(4), 237–244
	BRI 1996, **24**(4), 228–236
bidding strategy	ECAM 1994, **1**(1), 51–67
bill of quantities	CME 2000, **18**(5), 575–585
bills of quantity	ECAM 1996, **3**(1/2), 83–95
	CME 1995, **13**(6), 485–491
	CME 1994, **12**(2), 139–154
	CME 1993, **11**(5), 341–346
	CME 1993, **11**(4), 261–269
	CME 1990, **8**(1), 31–47
	CME 1988, **6**(1), 25–33
bio-climatic	BRI 2000, **28**(3), 196–211
biometeorology	BRI 1998, **26**(3), 146–156
block-making	BRI 1997, **25**(4), 202–209
bonds	JFM 1996, **1**(3), 5–22
	CME 2000, **18**(1), 11–14
BOOT	ECAM 1998, **5**(4), 399–410
	ECAM 1998, **5**(1), 22–30
	ECAM 1998, **5**(1), 3–8
	ECAM 1997, **4**(2), 83–94
	ECAM 1994, **1**(1), 17–27
BOT	ECAM 2000, **7**(4), 412–422
	CME 2000, **18**(3), 343–353
	CME 2000, **18**(3), 311–320
	CME 2000, **18**(2), 197–207
	CME 1999, **17**(5), 613–623
	BRI 1999, **27**(2), 84–95
Botswana	JCP 1997, **3**(1), 3–15
	ECAM 1999, **6**(4), 335–346
	BRI 1998, **26**(6), 340–350
Box-Cox transformation	CME 1999, **17**(4), 473–482
Box-Jenkins	ECAM 1998, **5**(3), 261–275
	CME 2000, **18**(5), 607–618
Brazil	CME 1993, **11**(3), 194–202
breakwater	ECAM 1999, **6**(2), 145–154
BREEAM	BRI 1999, **27**(5), 286–293
bricklayer	CME 1990, **8**(3), 301–313
brick-making	BRI 1997, **25**(6), 354–364
	BRI 1997, **25**(3), 131–136
bridge	ECAM 1998, **5**(4), 327–338
	CME 2000, **18**(6), 651–656
briefing	RICS 2000, **3**(15), 1–49
	ECAM 1999, **6**(2), 91–104
	CME 1999, **17**(3), 329–340
	CME 1999, **17**(1), 63–76
	CME 1998, **16**(1), 91–98
	CME 1996, **14**(2), 155–164
	CME 1983, **1**(3), 183–197
	BRI 2000, **28**(5/6), 376–386
	BRI 1997, **25**(4), 190–195
	BRI 1997, **25**(3), 148–157
	BRI 1996, **24**(1), 31–34
budget	JFM 1996, **1**(3), 23–42
	CME 1996, **14**(2), 103–119
	CME 1994, **12**(2), 113–124
	CME 1991, **9**(4), 383–400
	CME 1990, **8**(3), 285–300
buildability	ECAM 1998, **5**(2), 127–136
	ECAM 1997, **4**(4), 295-310
	ECAM 1996, **3**(1/2), 29–46
	ECAM 1995, **2**(1), 45–56
	CME 1998, **16**(6), 681–692
	CME 1986, **4**(2), 135–150
	CME 1985, **3**(1), 59–87
	BRI 1996, **24**(5), 259–269
builders' merchant	CME 1998, **16**(3), 351–361
building	CME 2000, **18**(7), 747–756
	CME 1999, **17**(5), 635–646
	CME 1987, **5**(4), S3-S22
building activity	CME 1984, **2**(1), 25–36
building centre	BRI 1997, **25**(1), 50–64
building centres	BRI 1997, **25**(5), 313–317
building code	ECAM 1998, **5**(1), 92–102
	CME 2000, **18**(8), 885-892
	CME 1988, **6**(2), 117–131
building component	ECAM 1995, **2**(2), 141–162
building construction	CME 1999, **17**(4), 519–527
	CME 1999, **17**(3), 363–374
building design	BRI 2000, **28**(5/6), 368–375
	BRI 1999, **27**(6), 355–367
	BRI 1999, **27**(6), 348–354
building economics	JCP 1997, **3**(2), 3–18
	CME 1994, **12**(6), 521–541
	CME 1993, **11**(1), 18–29
	CME 1985, **3**(2), 105–120
	BRI 2000, **28**(5/6), 387–393
building height	CME 1999, **17**(2), 129–132
building inspection	ECAM 1998, **5**(1), 92–102
building life cycle	ECAM 1999, **6**(2), 197–212
building material	JFM 1998, **3**(3), 71–83
	JCR 2000, **1**(1), 69–76
	ECAM 1995, **2**(2), 141–162
	CME 2000, **18**(2), 183–195
	CME 1998, **16**(3), 351–361
	BRI 2000, **28**(5/6), 408–412
	BRI 2000, **28**(3), 176–183
building operation	BRI 2000, **28**(5/6), 387–393
building performance	JFM 1998, **3**(3), 37–48
	BRI 2000, **28**(5/6), 394–402
	BRI 1999, **27**(5), 300–308
	BRI 1999, **27**(4), 221–229
	BRI 1999, **27**(1), 20–34
	BRI 1997, **25**(3), 148–157
building process	JCP 1999, **5**(2), 118–128
	CME 1997, **15**(1), 71–82
	CME 1989, **7**(3), 203–216
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building product	CME 1993, **11**(2), 81–98
building regulation	CME 1995, **13**(3), 197–208
	BRI 1997, 25(2), 120–123
building replacement	CME 1988, **6**(2), 149–159
building services	CME 1997, **15**(2), 161–175
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building stock	CME 1994, **12**(4), 315–321
	BRI 2000, **28**(3), 159–175
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	BRI 1999, **27**(3), 140–148
building surveying	RICS 1996, **1**(8), 1–32
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building system	CME 1995, **13**(5), 417–426
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Bulgaria	RICS 1996, **1**(9), 1–33
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	CME 1995, **13**(6), 445–455
business excellence	JFM 1997, **2**(1), 45–58
business failure	CME 1999, **17**(4), 493–503
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business growth	CME 1985, **3**(1), 25–31

business improvement JFM 2000, **5**(3), 135–147
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ECAM 1998, **5**(2), 115–126
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CME 1993, **11**(4), 285–291
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CME 2000, **18**(1), 55–63
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CME 1997, **15**(2), 149–159
CME 1996, **14**(6), 467–484
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CME 1994, **12**(3), 271–278
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CME 1987, **5**(2), 169–181
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CME 1995, **13**(6), 501–510
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CME 1993, **11**(1), 3–17
CME 1992, **10**(6), 459–478
BRI 1997, **25**(5), 257–267
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change order CME 1999, **17**(6), 721–730
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JFM 1996, **1**(3), 71–82
JFM 1996, **1**(3), 5–22
CME 1999, **17**(5), 679–687
CME 1998, **16**(6), 711–719
CME 1997, **15**(6), 539–548
CME 1997, **15**(5), 421–428
CME 1997, **15**(3), 281–290
CME 1996, **14**(2), 175–182
CME 1993, **11**(5), 398–403

BRI 2000, **28**(1), 59–66
BRI 2000, **28**(1), 51–58
BRI 1999, **27**(2), 120–123
BRI 1997, **25**(4), 239–245
BRI 1997, **25**(1), 15–17
BRI 1997, **25**(1), 11–14
BRI 1997, **25**(1), 5–10
BRI 1996, **24**(5), 311–317
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CIB BRI 1999, **27**(6), 319–390
BRI 1999, **27**(6), 348–354
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BRI 1997, **25**(5), 313–317
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BRI 1999, **27**(4), 206–220
BRI 1998, **26**(1), 17–28
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civil engineering RICS 1999, **3**(2), 1–24
CME 1998, **16**(3), 283–293
CME 1996, **14**(2), 79–92
CME 1995, **13**(2), 173–183
CME 1992, **10**(4), 277–301
CME 1992, **10**(1), 45–68
CME 1990, **8**(1), 31–47
cladding BRI 1998, **26**(6), 351–357
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JFM 1997, **2**(3), 31–44
JCP 1997, **3**(3), 3–26
ECAM 1998, **5**(3), 252–260
ECAM 1997, **4**(2), 95–111
CME 1999, **17**(6), 731–743
CME 1999, **17**(5), 647–655
CME 1999, **17**(3), 375–382
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CME 1998, **16**(3), 363–372
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CME 1998, **16**(3), 283–293
CME 1996, **14**(5), 375–394
CME 1996, **14**(4), 311–317
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CME 1995, **13**(4), 335–352
CME 1993, **11**(5), 358–369
CME 1993, **11**(2), 163–166
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CME 1984, **2**(1), 1–12
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clay brick BRI 1997, **25**(3), 170–175
client JFM 1999, **4**(3), 65–80
JCP 1998, **4**(1), 5–15
JCP 1996, **2**(1), 41–55
JCP 1995, **1**(1), 38–49
JCP 1995, **1**(1), 4–20
ECAM 2000, **7**(3), 300–306
ECAM 1999, **6**(2), 166–176
ECAM 1997, **4**(2), 143–158
CME 2000, **18**(7), 819–832
CME 1999, **17**(1), 63–76
CME 1999, **17**(1), 5–7
CME 1998, **16**(1), 91–98
CME 1997, **15**(4), 327–340
CME 1997, **15**(3), 271–281
CME 1996, **14**(2), 155–164
CME 1996, **14**(2), 131–145
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CME 1994, **12**(6), 485–499
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CME 1992, **10**(2), 137–151
CME 1992, **10**(1), 31–43
CME 1991, **9**(4), 355–368
CME 1991, **9**(4), 327–342
CME 1990, **8**(2), 191–204
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BRI 2000, **28**(5/6), 387–393
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BRI 1998, **26**(3), 181–189
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CME 1996, **14**(5), 395–404
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