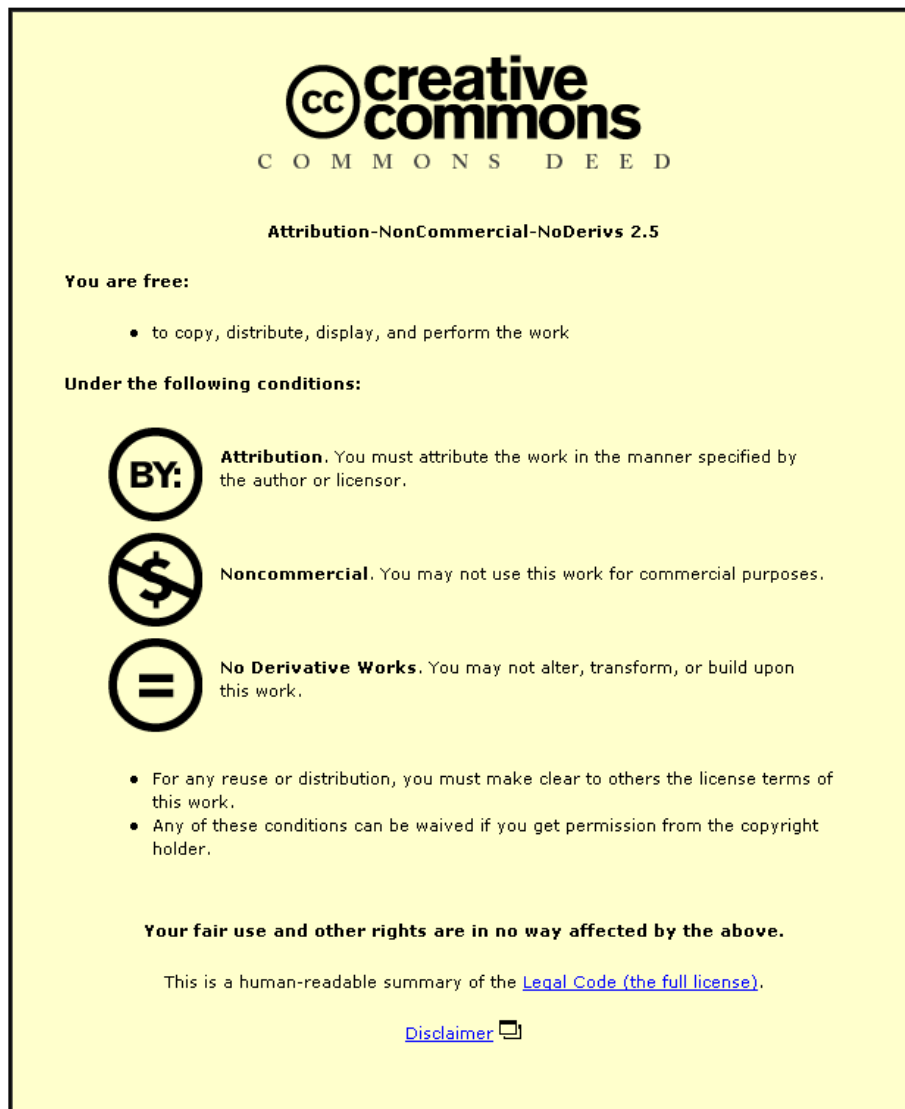


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Defining an AEC Research Agenda - a Vision from the UK

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1 Introduction

This paper outlines the current research agenda for construction, as seen from a UK perspective, and the associated government initiatives. It then presents a vision of how design and construction will be undertaken and the implications for the management of this activity, structured around four themes of management, technology, the role of clients and the role of industry and the professions. The research activity of the Department and relevant staff are outlined and the paper concludes with a brief description of how we are taking forward our industrially based research.

2 The UK perspective

The last decade has seen the research agenda for construction develop from one dominated by operational efficiency to one focused on business performance. This change in emphasis has been industry driven and is reflected in the strategic direction of UK reports such as the CRINE Report (1994), the Latham Report (1994), the Foresight Programme (1995), and the recent Egan Report (1998).

The Foresight Programme (1995) provides a national consensus on research priorities. This long-term agenda addresses important industrial interests. The current portfolio of EPSRC research grants is highly aligned to the priorities of the Foresight Programme. Within this programme the priorities for construction include: the use of IT in construction, the application of business processes, design for the whole life cycle, sustainable construction and assisted networking and dissemination between researchers and industry as key elements in the support of the Foresight Panel recommendations (EPSRC 1998).

CRISP (1999a, b), the Construction Research and Innovation Strategy Panel, is the link between research funders and the research community. In February 1999 they concluded that three considerations underlie their new priorities: significant Industry Improvement, the importance of preparing for long term Construction Futures and the importance of the health of the UK construction research base. The broad topic areas identified by the CRISP Panel are: customer needs; design; technologies and components; process; and performance. Better identification of customer needs is a key driver for change in the construction industry. Research on design, which is appropriate to end user needs and to optimise the construction process is required. Improved technologies and components offer considerable scope for construction improvements. The organisation and management of the construction project process needs to focus on supply chain management, lean construction, productivity and value. It is also concerned with achieving cultural change in supply chain relationships. Performance concerns the ability of construction works on completion. Here, the requirement is to address satisfactorily the needs of both the clients and customers of construction. These broad areas for improvement are considered by CRISP to be the medium term horizon for construction.

Egan (1998) set annual targets of a 10% annual reduction in construction cost and construction time together with a 20% reduction of defects in projects. To achieve this it is recognised that there will have to be radical changes to the process by which the industry delivers its projects. There was a need to "create an integrated project process around the four key elements of the building development, project implementation, partnering the supply chain and production of components".

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Inherent in the way forward is the collaboration of all parties involved in the construction product, a culture of trust and respect that encourages the participation of all parties within the project process. It was recognised that the whole of industry needs access to both current best practice and knowledge on good practices, innovations and improved performance.

A review of all these reports highlights the advance of construction through the key issues of collaboration, concurrency and leanness. These themes permeate all construction research thinking. They necessitate greater interdisciplinary working and closer links between construction professionals and their organisations. Only then will the synergy that is possible be achieved. Collaboration between practitioners must also be matched by closer collaboration between the research community and industry.

Initiatives in the UK such as IMI and LINK have demonstrated that continued close collaboration between the research community and the construction industry is imperative to ensure that ideas originating in academia are developed to meet industry requirements. The projects within these research programmes have formed both an agenda for change and a mechanism for transferring innovation from research throughout the construction supply chain. The transfer of current best practice and knowledge is seen as a primary goal of current and future research (DETR, 1999). It is only through the knowledge of the construction clients, major construction organisations and specialist suppliers that best practice will be disseminated.

3 The vision

Our vision for the future construction industry can be structured around four themes of management, technology, the role of clients and the role of industry and the professions.

3.1 Management

This agenda places continued emphasis on integration of people, process and product. This is being improved vertically (i.e. through the process), but in the future this must be complemented by greater horizontal integration across disciplines and organisations, that acknowledges the vital contribution of design. This will require a new breed of multi-disciplinary, multi-skilled professionals who can provide a holistic approach to design, procurement and construction. Whilst retraining can service this need to some extent we believe this will require the education of new types of both AEC graduates and researchers.

The separation of design from the rest of the project process is a fundamental weakness in the construction industry: significant re-balancing is required to integrate design with construction and performance to ensure that issues such as flexibility of use, operating and maintenance costs and sustainability are considered in the design and planning stages of a project. There is considerable scope for the introduction of tools and techniques to facilitate this integration.

The changes in client needs and associated methods of designing and procuring buildings and civil engineering structures will result in a different blend of construction organisations types. Major multi-nationals will continue, but we foresee increasing specialisation according to services and product type, in design consultants, contractors and design & build organisations. The continuing development of ICT will enable truly virtual teams and environments that come together for specific projects or as part of permanent supply chains.

These new ways of working will have a major impact on organisations and appropriate working environments and cultures. The related sociological issues will require attention within education, industry and research institutions. New, flexible protocols will be necessary to facilitate these changes. These may necessitate changes in project management to meet the changing needs of the design and construction process.

3.2 Technology

Collaborative and concurrent methods of working are necessary to replace linear patterns of working. Advanced information and communications technologies must be developed and applied to construction organisations to facilitate information processing and flow, and collaborative working on construction projects. Innovative construction technologies developed using advanced analysis and design facilities will be needed to produce new construction materials and novel technologies.

A number of the changes described above are reliant on the development of more advanced ICT systems and standards, which will inevitably play an important part in the development of the industry over the next decade and beyond. Other technology trends which we predict will have a major impact include the need for adaptable buildings that can provide productive working environments for changing occupants and businesses. Occupant turn-over will increase and companies will increasingly move to hiring buildings to give flexibility and reduce capital investment and maintenance risks. At the extreme some clients will require 'hot-building occupancy'. Related to this will be the continued growth in the move towards standardisation of components and assemblies, together with increasing interest in design for re-use.

Both of the last trends will be driven by continuing environmental pressures and political demands for increased sustainability in the AEC industries. Associated construction methods will also change as off-site, factory-based manufacture takes an increasing role, as will automation of erection on site (partly because of standardisation, but also to deliver better quality and reliability).

3.3 Clients

There are significant pressures and initiatives underway in the UK and elsewhere from major construction industry clients and client groupings, as discussed earlier. Clients (and all construction stakeholders) will have an important role to play in ensuring some of the changes described above are realised. For instances, adaptable buildings need adaptable clients/owners who seek the advantages of such products. They are also key drivers of sustainability and re-use, along with governments and society.

We envisage that the natural culmination of the integration of supply chains is the marketing of 'branded' building types where the buyer chooses, according to their needs and budget, the equivalent of a Toyota, Ford or BMW building. Those at the cheaper end will have more standardisation, whilst the expensive brands will offer greater customisation. Clients will buy more on reputation and proven performance of components, systems and buildings/constructions. There are clearly strong links here with the pre-assembly and automation themes in 3.2.

3.4 Role of Industry and Professions

Over-arching many of the changes we foresee are opportunities and responsibilities for the industry at large. Professional institutions must break down their barriers and vested interests in order to support new workers with different skill portfolios who can help deliver the changes in work practices and attitudes. These changes will impact education needs and the providers of education and training. Research will become more industry based.

Within the construction industry designers, contractors and materials suppliers will have to meet the needs of society at large and individual clients, while becoming more efficient in an increasingly competitive global market (eLSEwise, 1998). To achieve this, they must have the following abilities:

- to respond quickly to world market opportunities and to work in multi-disciplinary teams made up of different companies sharing risk and reward
- for companies with different skills and experience to share common project goals - such as time, cost and quality - aligned to the client's needs while satisfying their own business needs
- to simulate different variations on the project both before and during construction
- to develop project processes to enable the parties in the project to act as a single team to deliver the facility and meet the shared goals
- to procure materials from the global market as well as understanding local market conditions
- to use past experiences and knowledge for the benefit of the project
- to supply and hand over accurate records and information systems to allow the client to operate and maintain the facility

4 Department research background

The Department of Civil and Building Engineering has an excellent record in attracting research funding, with the largest research grant and contract income of the Engineering Faculty. New research grants and contract income raised over the last five years has grown from £812k in 1991/92 to over £2.3 million in 1997/98, representing an 8.1% market share, ranking the Department second in the UK in terms of research income in construction. New grants and contracts for the first eight months of 1998/99 have yielded over £2.2 million. Income sources for these funds are EPSRC, Government Department and industry each providing similar amounts. Slightly lesser amounts come from the EU. Currently the Department has a research community of 132 research students and assistants.

Simon Austin is Professor of Structural Engineering and a chartered engineer with industrial and research expertise in design, information management and related technologies. He has extensive experience of working with industry and trade associations and held five IMI (EPSRC/Link/PIT) grants, six EPSRC grants and three EPSRC/DTi Teaching Companies with a total value of £3 million. Current grants include: building design process modelling, planning and management; supply chain IT management for reinforcement (part of the European Concrete Building); the Process Protocol level 2 project; and Link IDAC projects on Integrated Collaborative Design (£0.9m) IT and tools for improved construction briefing.

Andrew Baldwin is Head of Department of Civil and Building Engineering. A civil engineer by profession he has had construction industry experience with several major construction organisations. This experience includes buildings, roadworks and offshore engineering. He has extensive research experience. Current research interests are focused on the use of information and communications technology and electronic commerce to support the construction process. Current projects include the development of new tools and techniques for improving design management and the use of concurrent engineering and collaborative working and to improve supply chain communications.

Tony Thorpe is Professor of Construction Information Technology. He has held 8 EPSRC grants, 5 Teaching Company Programmes, 2 European funded projects and 5 industry/DoE funded research programmes. He has supervised 19 research students of which 12 have successfully completed and published over 100 refereed papers. He is immediate past chair of the Association of Researchers in Construction Management (ARCOM).

Ron McCaffer is Professor of Construction Management and Senior Pro-Vice-Chancellor at Loughborough University. He is also the Finance Director of the European-Construction Institute. He is a Fellow of the Institution of Civil-Engineers, the Chartered Institute of Building and the Royal Academy of-Engineering. He is author of numerous academic papers and co-author of Modern Construction Management, Worked Examples in-Construction Management, Estimating and Tendering for Civil Engineering-Works and Managing Construction Equipment.

Chimay Anumba is Reader in Computer Integrated Construction and Director-of the Centre for Innovative Construction Engineering at Loughborough-University. He worked as both a Site and a Design Engineer before undertaking postgraduate research-in Computer-Aided Engineering at the University of Leeds, UK. On completion-of his PhD in 1989, he joined Curtins Consulting Engineers and was involved in a wide range-of civil and structural engineering. This was followed by a period as a Senior Lecturer and then Reader in-Computer-Aided Engineering at the University of Teesside.

5 Departmental agenda

The Department currently has a substantial portfolio of research in the areas of construction management, design and integration (see Table 1). These are addressing some of the challenges identified in section 3. Two new initiatives that are relevant to the education and training issues are a BSc degree in Architectural Engineering and Design Management and an Engineering Doctorate Centre. The former aims to produce graduates with a new combination of skills that will allow them to integrate across disciplines within construction organisations.

The new EPSRC funded Engineering Doctorate Centre, (EDC) is one of ten in the country and the only one for the construction industry. Based within the Department it also includes input from other Departments in the Engineering Faculty, the Business School, Computer Science and the Faculty of

Social Sciences. It will provide high quality research and training for construction industry professionals and will enable construction organisations to develop innovative approaches and solutions to the problems that they, and the industry currently face. Over 20 major organisations have committed themselves to the EDC. The funding secured for the Engineering Doctorate Centre will total some £3 million over a five-year period. This will be matched by around £1m in industry contribution to provide over 200 man-years of research activity within UK construction organisations. These research engineers will spend approximately 30% of their time at the Department and 70% in industry.

There are also many opportunities for new research that can help the industry change in the manner envisaged. The Department's research agenda will be industry-based and focus on the following research themes:

- Innovative Construction Technologies - to address technical innovations that will enhance the industry's technical competence, and improve understanding and effectiveness of the project delivery process. These will include research into innovative materials (e.g. advanced composites), advanced analysis and design of facilities (e.g. finite element modelling of structures), and novel construction technologies (e.g. modular construction).
- Innovative Construction Business Processes - will focus on innovative business processes and management techniques that will improve quality, reduce cost, shorten project duration, facilitate collaboration, and ensure client satisfaction. These will include research into knowledge management (e.g. organisational learning), innovative procurement practices (e.g. partnering), and collaborative and concurrent engineering (e.g. value engineering).
- Advanced Information and Communications Technologies - with an emphasis on the development and application of these technologies to facilitate information processing and flow, and collaborative working on construction projects. Key research issues to be addressed include integration of IT systems, and communications infrastructures for virtual construction project teams.
- Sustainable Construction - this is a key issue that increasingly will have an influence on the way that construction projects are delivered. Key research issues that will be investigated include energy conservation and emissions trading, implications of climate change on construction, and recycling of materials.

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CRINE (Cost Reduction for the New Era) (1994) Report of the UK Offshore Operators Association, The Institute of Petroleum, London.

Research Title	Sponsor(s)	Value
Engineering Doctorate Centre for Innovative Construction Engineering	EPSRC/Industry	£4M
ADLIB: Agent-Based Support for the Collaborative Design of Light Industrial Buildings	EPSRC/Industry	£480,000
Cross-Sectoral Learning in the Virtual Enterprise (CLEVER) (in collaboration with Manufacturing Engineering and Human Sciences)	EPSRC/Industry	£240,000
IT Tools and Support for Improved Construction Briefing	EPSRC/DETR/Industry	£261,604
Collaborative and Concurrent Engineering in the North American Construction Industry (Engineering Foresight Award)	Royal Academy of Eng.	£22,000
Demonstration of the clients' toolbox for optimised use of standardisation, pre-assembly and modularisation	DETR/Industry	£263,184
Site and personal factors in accident causation in construction	HSE	£368,000
ADePT Technology Transfer Project	EPSRC/Industry	£115,000
COMPREST - Cost Model for Standardisation and Pre-assembly	DETR/EPSRC/Industry	£20,000
Developing Integrated Information Systems for Trent Concrete	TCS/Industry	£80,000
PP2 - Process Protocol Level Two	EPSRC/Industry	£104,000
Implementation of computer imaging and visualisation in teaching, learning and assessment	TLTP 3	£144,000
Integrated Collaborative Design'	Industry/DETR/EPSRC	£856,221
ProMICE: Product and Process Models Integration for Concurrent Engineering in Construction	British Council, France	£3945
Scoping Study of the Strategic Planning Process within Construction	EPSRC	£40,886
Recording achievement to promote the professional development of construction management students and graduates	DfEE/CIOB/CITB	£100,000
Preassembly and Standardisation	CIRIA/Industry	£80,000
Management Training by Simulation for the Construction Industry	DETR/Industry	£120,000
Standardisation of Windows and Cladding Interfaces	DETR/EPSRC/Industry	£307,000
IRIS - 'Improving Rebar Information and Supply	DETR/Industry	£120,000
ELSEWISE - European Large Scale Engineering Wide Integration Support Effort	EU/Industry	£1.8M ECU
Early Cost Advice for Mechanical and Electrical Services	EPSRC	£60,581

Table 1 Current Departmental Research in Construction Management