MOVING ON FROM THE CROSSROADS: AN AGENDA FOR RESEARCH DEVELOPMENT IN CONSTRUCTION MANAGEMENT

Ronald McCaffer and Francis Edum-Fotwe

Department of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK

Construction management is a relatively new subject area. Research development in construction management can be described as eclectic. The different themes that have dominated its research at various periods provide evidence of the progression in the development of the subject area. The paper presents a profile of such themes over the past four decades. It also identifies some of the current issues that the construction management community will have to confront in order to advance its research within the foreseeable future.

Keywords: construction management, industry, integration, multi-disciplinary, research.

INTRODUCTION

This paper highlights key research themes that have driven research development in construction management over the past four decades to define a way forward for the future of research in construction management.

Construction management can broadly be described as the application of the principles of economics and management systems to the business and production processes of organizations that operate in the construction industry. This developed as an outcome of the unique nature of the construction industry, which is characterized by large and expensive physical products, a complex industry structure and production processes, and a distinctive method of price determination. The underlying character of construction management research is therefore connected with its relationship to the wider dimension of its industry.

Construction management research focus - from past to present

Figure 1 reflects on the evolution of research themes within construction management and presents a view as to how it has developed. Over the past four decades the construction industry has experienced significant transformation in the way its projects are managed and its business activities undertaken, driven largely by changes in industry competition but also with a contribution from research effort. The various research themes that have contributed to this transformation can be associated with different periods as shown in Figure 1. Within this period research effort has not only helped to change the way the workings of construction organizations, and the industry as a whole has been perceived in the past, but also facilitated improved performance for these organizations. The past view presented of construction organizations was entities whose inner workings could not be observed, and whose actions could only be understood by *reviewing* their responses to the external business environment. The

McCaffer, R and Edum-Fotwe, F T (1999) Moving on from the crossroads: an agenda for research development in construction management. *In:* Hughes, W (Ed.), *15th Annual ARCOM Conference*, 15-17 September 1999, Liverpool John Moores University. Association of Researchers in Construction Management, Vol. 1, 3-11.

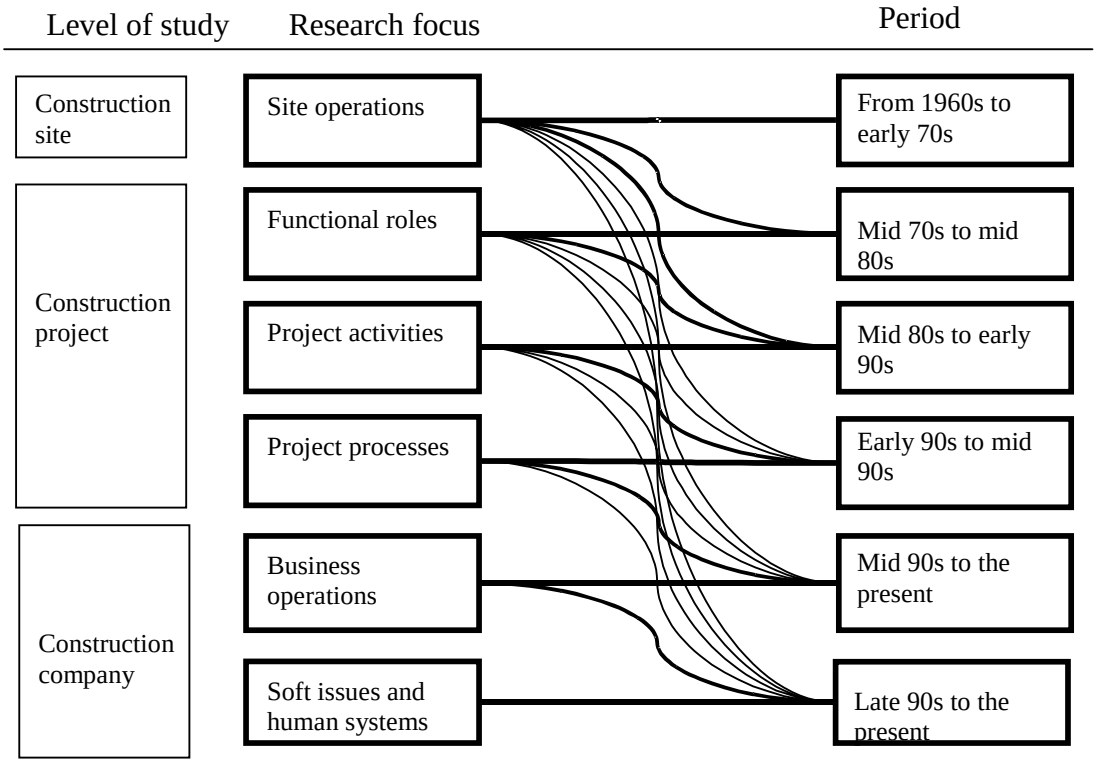


Figure 1: Evolution of research themes in CM

use of such a review technique for understanding and establishing efficiency for operational activities that form the internal workings of construction organizations was good in its own right. However, understanding such past actions within the company's operations presented little value unless it led to a more efficient implementation of future operational activities.

The first period (1960s to 1970s)

Research efforts during the first period were focused essentially on *the construction site*. To expose the inner workings of the organizations, research effort within construction management in the 1960s to the 70s concentrated on understanding and explaining site operations, which often presented easy cases for observation and was also perceived as rather inefficient. The applications of *work-study techniques* to site operations advocated by Harris and McCaffer (1977), Calvert (1970), Oxley and Poskitt (1987) and others provide typical examples of research effort in construction management undertaken to shed a greater understanding on the nature of site operations. This naturally led on to improvements in the structure of site operations, which in turn helped to identify the need for various functional roles and their support to and inter-relationship with site operations. In particular, the need to provide greater accuracy in the estimation of cost and time for projects as a result of economic pressures became apparent.

The second period (1970s to 1980s)

The mid-70s and the 80s saw considerable research effort directed at the development of the *functional roles* such as estimating techniques, planning techniques, and contract procedures, and contributed to a shift in the research agenda from simple site operations to the project level.

Alongside the functional focus, this period also witnessed the application of operations research techniques in construction management research, including:

- Mathematical Programming (Optimization)
- Statistical Modelling
- Linear Programming; and,
- Construction of Sensitivity Ranges

to aid managerial decision-making involved in the various functional roles within construction are abundant. The main motivation for the application of these techniques was to provide a rational and structured approach to decision-making by construction managers. The underlying assumption is that to arrive at a sound decision, one must identify an *objective measure of performance*, which will then form the basis of a manager's decision (Hamdy 1996). Typical research projects included the use of forecasting and time series analysis to identify and predict resource demand and constraints for construction projects. Other examples of topics included

- Investment appraisal,
- Manpower management,
- Materials and plant inventory,
- Sequencing and Scheduling project activities
- Location, Allocation, Distribution and Transportation for materials
- Reliability and Replacement policy.

The third period (1980s to early 1990s)
The outcomes from research in the second period were dominated by recommendations of protocols, systems and models for direct application by industry. Unfortunately, in many cases there was divergence between the performance of the recommended models and real life. Evidences of such divergence can be seen in the level of take-up for these research outputs. There are a number reasons for such divergence. They include the following:

- Real-life problems are not simple, not easy to define and usually difficult to analyse and model.
- Data captured for modelling is often insufficient, and lacking in accuracy.
- Communication between researchers who develop the models and practising engineers/managers is not often effective.
- Previous models often captured only *hard factors* of issues being modelled.
- Models usually address only the issues seen as important by the manager such as equivalent savings in pounds.

Equally, the use of these systems, models and techniques in practice proved difficult because of the tedious and long procedures they involved, and often required the use of *experts*. The development of *Expert Systems* and other *Artificial Intelligent Systems*, which in many cases relied on the then fledging IT revolution of the mid-80s provided a natural solution for the deployment of these techniques. This gave rise to

the development and proliferation of construction specific computer packages to enhance the processes involved in managing projects. A major contribution of the use of IT in this way to facilitate the construction project was its emphasis on the process.

The fourth period (early 1990s to mid-1990s)
A holistic perspective for the project dominated research in this period based on the concept that the project, like any other production, is a process. As a consequence, the effective improvement of the project process required an outlook beyond the isolated activities that make up the project. This naturally called for a *Systems Approach*, which enables the modelling of complex large-scale organizations. By considering the system as a whole, rather than individual components of the system, the *Systems Approach* provides direction as to the optimal solution for the overall project.

The fifth period (mid-1990s onwards)
The recognition that construction organizations are businesses that must not only undertake their processes efficiently, but also be in the right business in the first place in order to succeed assumed importance. The Technology Foresight Programme (1995) for example provided a catalyst for construction to be view its processes from a business perspective. This was a consequence of domestic competition and emerging economic realities from increasing globalization. The deployment of various benchmarking schemes including the ECI Performance Benchmarking model provides appropriate channels for attaining such business and organizational improvement.

The sixth period (late 1990s onwards)
These issues that have driven research in construction management from the past to the present can be categories into two: *hard* and *soft* factors.

Hard factors refer to the mechanical operations of planning, scheduling, estimating and controlling. Research on *hard factors* is easier to undertake and tend to dominate the overall research in construction management. It is argued that the domination of research based on hard factors in construction management can be explained by the fact that construction management is an offshoot from engineering. Its research in the past has therefore been influenced by its engineering tradition.

Soft factors involve behaviour, attitudes, learning, knowledge management, and communication styles and derives essentially from the social sciences. It forms an area that is maybe under-researched in construction. The increasing recognition for the relevance of these factors to the construction project, organization and industry has led to a growth in teamwork, partnering both at the project and company level.

But both aspects are necessary for a vibrant development agenda in construction management research and to advance its industry in the future. The take-up of this theme in construction management research is recent. They include research and developments in alternative forms of business to business relationship, such as partnering and team-working. The anecdotal benefit from the impact of these soft and human aspects on project delivery in cost/time savings as well as quality enhancement indicates their relevance to the construction industry. The call by Egan (1998) *in Re-thinking construction* can be seen as essentially marshalling these soft factors in the industry to ensure the recommended level of improvements. This includes a greater collaboration along the project supply-chain, a business aspect that embodies the intangible elements of trust, openness, close relationships between clients, contractors, sub-contractors, suppliers and all other stakeholders in construction. The Egan Report

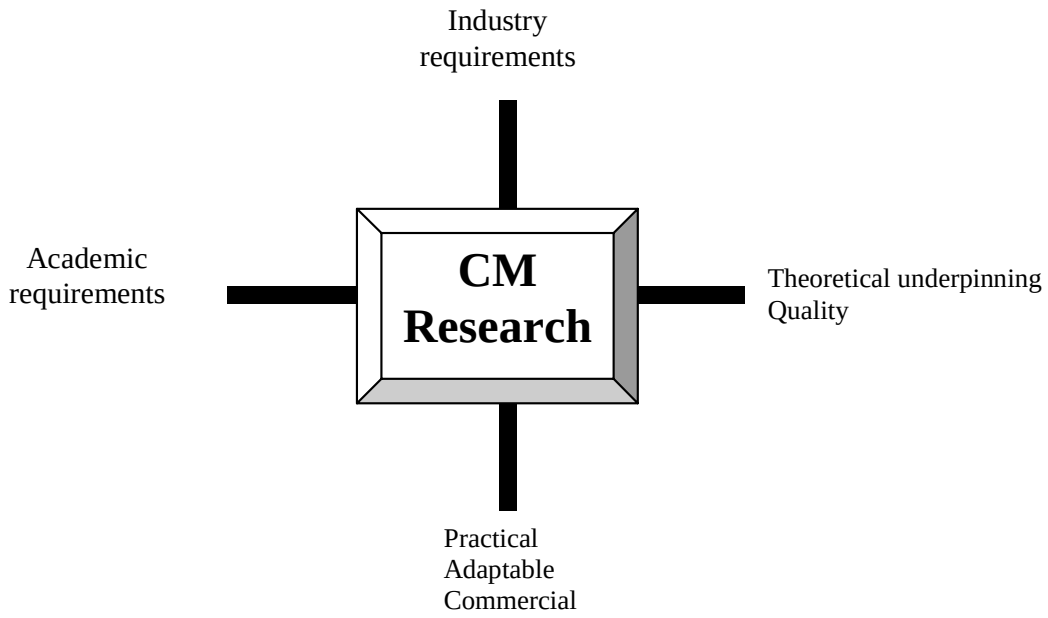


Figure 2: CM research at crossroads

however, can be seen as an implicit criticism of the contribution of research to improvements within the industry. The report defines no direct role for, nor support from academic research in the proposed machinery for achieving improvements in the project delivery beside documentation of the pilot projects.

CONSTRUCTION MANAGEMENT RESEARCH: THE PRESENT AND FUTURE

Current construction management research is at a crossroads in several respects. The Construction Research and Innovation Strategy Panel (Austin *et al*. 1999) identifies a number of the issues, which if attained should take the industry forward. Figure 2 also presents two of such issues. On the one axis there is the academia industry 'divide', on another axis there is the philosophical issues surrounding its research. Since the issues of philosophical underpinnings have been dealt with considerably in recent times, this paper will focus on the academia industry relations. Although construction management research is undertaken predominantly within academia, there are several commercial research organizations such as BRE, CIRIA, BOMEL, that actively engage in its research. Also some of the larger construction organizations maintain their own internal research staff. However, this research effort is normally tailored to the competitive needs of a specific organization and comprises a modicum of overall research effort in construction management.

Academic research

Its is currently driven by two major forces, academic excellence on the one hand, and exigencies of the industry on the other. It is important to recognize that in very many cases the industry based research counterparts are *complimentors* and not strictly *competitors*. They invariably rely on academia for issues of quality and rigour in research. In this regard the role that is played by academic research, and for that matter ARCOM, in the advancement of the industry cannot be over -emphasized.

Funding shifts
Over the years there has been a shift in the emphasis placed on the requirements by Funding Bodies. A demonstration of the relevance of the proposed research to industry, often evidenced by matching cash input by industry, has become an essential element in most research grant awards. Crucially, these *complimentor* research organizations provide the link for a direct deployment of construction management research outcomes within industry. This link to industry has over the years ensured that research in construction management delivers outcomes that are relevant to the prevailing context of the industry. As a result, although research can be pursued in the three areas of pure, strategic and applied, construction management tends to be of an applied nature.

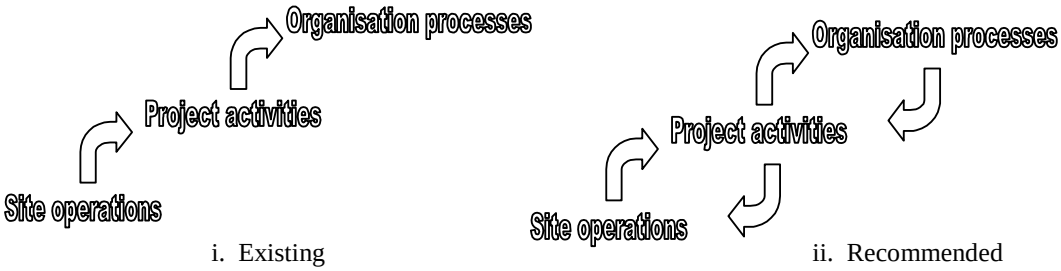
Impact of IT
The application of IT systems to achieve improvements in the existing processes provide ready answers for such strategic and applied research, which can be readily deployed by industry. While such application of IT to construction processes is novel in its own right, it does not address why those processes are employed by construction. In particular the current professional and functional specialization within the industry have come under question as a result of possibilities provided by IT. With the use of IT now becoming as widespread as *writing* or perhaps the *typewriter* was in its day, construction management research will have to confront the fundamental issues that should drive its business improvement. The industry is already seeing organizations that do not simply make use of IT support for its processes but are built around IT. This will certainly impact not only on the processes of construction, but its industry structure, company to company relations, and the role of the professions (Bennett 1999).

If it is to see significant advancement in its research it is important therefore that a *total organizational* agenda should be pursued into the future.

TOTAL ORGANIZATION RESEARCH FOR CONSTRUCTION

This involves an integrative research programme that on combines the various foci of research in balance to address improvements and also to avoid a re-invention of the wheel. To ensure that the CM community can attain this, and provide continued relevance and advancement in its research, there is the need to address certain fundamental issues. These include:

Training
The CM community will have to promote better research training practices to match the needs of industry whilst ensuring that researchers are endowed with an innovative capability that can be adapted to the changing needs of industry. This formed the motivation for the formation of the Centre for Innovative Construction of Engineering (CICE) at Loughborough, funded by the EPSRC and sponsored by a number of industry partners. The rationale is that research as an educational experience ought to transcend the current arrangement of student-supervisor activity so that it can deliver better value to the end-user of its products - industry (Baghai *et al*. 1999). At the same time the CM community will have to address its own research quality in an emerging *virtual* environment - for example achieving acceptable levels of significance in surveys conducted over the Internet.



i. Existing ii. Recommended

Figure 3: Progression of CM research

Integration

The promotion of greater integration in research can be addressed at four key levels:

- Focus of research
- Multidisciplinary
- Academia-academia collaboration
- Industry academia cross fertilization

Focus of research

The progression of research as outline in the earlier sections of this paper can be characterized by Figure 3(i). The need to integrate research on site operations into the organization's business and processes will be essential in defining new working practices for the industry. Research efforts should be directed at ensuring that whatever improvements are achieved at the organization level not only informs the operations on site, but also contributes to defining a new working agenda at the latter level as depicted in Figure 3 (ii).

Multidisciplinary

The rapid rate of knowledge advancement within the last twenty years has led to the boundaries of various subject disciplines extending beyond their traditional confines (Barnett 1990). As a result, a wider appreciation of construction management beyond the traditional professional requirement is increasingly becoming important for the construction manager of today. Organizations that operate within the industry are equally indicating their preference for such a wider management appreciation from their staff. This has manifested itself through collaborative arrangements whereby academic departments mount in-house training programmes, tailored to achieve such aims for various construction organizations. A recent survey of training requirements for managers in construction industry undertaken by the European Construction Institute (ECI), showed such a bias for more multi-disciplinary learning experiences by some companies. This move towards a wider experience beyond traditional subject disciplines is equally shared by the EPSRC (1995). In particular, the Council encourages research of a multi-disciplinary nature in response to the recommendation of the Technology Foresight Panel on Construction (1995). The panel on construction advocated for greater integration of the various academic disciplines in order to achieve greater competitiveness. Such greater multi-disciplinary collaboration will open up avenues for further advancement of research in CM.

Academia-academia collaboration
While bodies such as ARCOM provide a very necessary means for academia-academia interaction and networking, often this is under-utilized. Such interaction should foster collaboration and greater integration between academic departments. This is mentioned with caution because of the recognition given to competition for funding. However, such collaboration has the potential to reduce the burden on funding and industry, as well as minimize the duplication of research efforts. The pursuit of such collaboration and networks on an international level can deliver considerable benefits to construction management research.

Industry-academia collaboration
The role of industry academia integration has already been alluded to in the earlier sections. The importance of a closer integration in the requirements of industry with academic excellence to bring about a better and bigger research platform cannot be emphasized. Such a bigger research platform requires collaboration on a network basis on the level of the European Construction Institute (ICE) and the Centre for Innovative Construction Engineering (CICE) to shift construction management research from its current status and realize its full potential.

Functional specialization
Research will have to help to identify and define the changing relevance of functional specialization in the face of technological change. Current technological change is imposing a multi-functional demand upon professionals that call for a hybrid of functions. This calls for a re-think of the current single-specialism department, for example the separate existence of civils, building, quantity surveying. As a first step in attaining a multi-disciplinary agenda the CM community will have to create an environment where the different sections exist under the same umbrella.

Soft management systems
Research effort will also have to be directed at improving working practices both in a business sense as well as in engineering and safety health and environmental (SHE) terms. In attendance CM research will have to develop *soft managerial systems* to go with current and projected IT achievements for the industry.

SUMMARY

Research in construction management is evolving much like its industry, and is driven by the requirements and needs imposed on industry as a result of competition. The paper has presented an outline on the changes in focus of research agenda within construction management. The current issues that the construction management community will have to confront in order to advance its research within the foreseeable future should be based on a *total organization research* agenda. Achieving such a research agenda will call for greater integration for the CM community with industry as well as the areas of emphasis for its research. The integrated approach will not only ensure continued relevance for its research, but will also help to overcome the image of research implied by the Egan Report.

REFERENCES

Austin, S., Thorpe, A., Baldwin, A., McCaffer, R. and Anumba, C. (1999) Defining an AEC research agenda: a vision from the UK. *In:* Tommelein, I.D. and Fischer, M.A. (eds), *Berkeley-Stanford CE&M Workshop: Defining a Research Agenda for AEC Process/Product Development in 2000 and Beyond*, 26 - 28 August 1999, Stanford University.

Baghai, M.A., Coley, S.C. and White, D. (1999) Turning capabilities into advantages. *The McKinsey Quarterly*. **1**: 100–109.

Barnett, R. (1990) The *idea of higher education*, Buckingham: SRHE and Open University.

Bennett, J.C. (1999) Achieving professional excellence for a new century. *The Information Management Journal*, April, 36–42.

Calvert, R.E. (1970) *Introduction to building management*. London: Butterworths.

Egan, J. (1998) *Rethinking construction: report of the construction task force on the scope for improving the quality and efficiency of UK construction*, London: Department of the Environment, Transport and the Regions.

EPSRC (1995) *Annual Report 1994-1995: what's in it*. Available: http://www.epsrc.ac.uk/info/pubs/an-rep95/ar-cont.html.

Hamdy, A.T. (1996) *Operations research: an introduction*. New York: Prentice Hall.

Harris, F. and McCaffer, R. (1977) *Modern construction management*. Granada.

McCaffer, R. (1993) Towards improved management. *In:* Lewis, T.M. (ed.) *Organization and management of construction: the way forward*. *7th International Symposium, CIB-W65*, Trinidad. **1**, pp. 361–370.

Oxley, R. and Poskitt, J. (1987) *Management techniques applied to the construction industry*. Oxford: Blackwell Science.

Technology Foresight Panel on Construction (1995) *Progress through partnership, 2*. Office of Science and Technology. London: HMSO.