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Construction Management Research – A Case Example

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1. Introduction

The paper makes use of the writer's research experience in the field of concreting in making some observations on the nature and value of construction management research.

Research is a process whereby we add to the existing levels of knowledge and understanding of the topic under study. The academic research job is to observe, study, experiment when desirable and possible, think and ultimately to further illuminate. We may uncover useful facts, we might be able to characterise processes and materials and systems by models, identify weaknesses and uncover opportunities of a practical nature which the construction industry can act upon. But advancing knowledge and understanding for its own sake is our primary, and too many of us, sufficient objective as academics. Our job is not to set out primarily to improve construction practice although it is true that most of us probably do have the possibility of improvements to practice in mind when we select areas for study.

Not surprisingly, there exists a degree of misunderstanding between academics and practitioners. Most practitioner investors in research hope to get a return, and much applied research, has this as a deliberate objective. This applies equally to construction management research as well as to technologically based research into the hardware of materials, building elements and building systems. For instance in depth detailed work study of site production processes would undoubtedly be intended to discover how to reduce direct resource costs. Research work involving information technology as a means of improving management systems and communications is usually similar in its conscious intent to save money.

Nevertheless many construction management research issues have no obvious quick payoff but do provide areas for necessary study and illumination and increased understanding (e.g. partnering). Leaders of the construction industry itself would probably often agree that such subjects are worthy of study, but they find difficulty in funding research work because of the lack of a clear payoff from which they feel reasonably sure to get some sort of competitive benefit.

In this category also are such strategic questions as does the industry mobilise its resources in an appropriate framework, what is the appropriate degree of mechanization, what is the appropriate mix of off site and on site activity, how to assess whether an industry is cost efficient for a given product performance (i.e. competitive). These are all worth well illuminating by thorough and rigorous, and not cheap, academic studies. Who has the incentive to fund studies such as these?

The case study described below is an example of an academic study into the business of concreting, funded by government bodies in the main, but with no lack of willing industry input in kind, and some money in the case of the UK study. The study began in 1984 as research into the question of why 10% of all site concrete in the UK was placed by pump whereas the figure for West Germany was four times higher. Why should this be the case, the implication for those posing the question being that the UK was comparatively backward? That work lead into subsequent studies of site and ready mixed concrete industry working relationships and performance benchmarks, some in the UK but most of it in Hong Kong, latterly focusing on the difficulty ready mixed concrete plants find in matching deliveries of concrete to site needs.

2. Construction Management Research

Construction Management is best defined as the sum of all those managerial activities concerned with the year on year development and running of the construction industry or a component part of that industry. Much of the work for many in the industry, however, would relate to a succession of actual construction projects, and would be best described as Construction Project Management. Construction Project Management is nested within the broader Construction Management domain.

Construction Project Management itself, however, is usefully seen as existing at two nested levels.

(i) The higher level includes the financing, design, construction resourcing as well as actual site construction, i.e. all aspects of a project.

(ii) Construction site management, as the lower level, is usefully singled out because site work is easily differentiated and construction site managers are a specialist group.

The construction research community divides broadly into three types, each fitting into the layers of the onion model of Fig. 1,

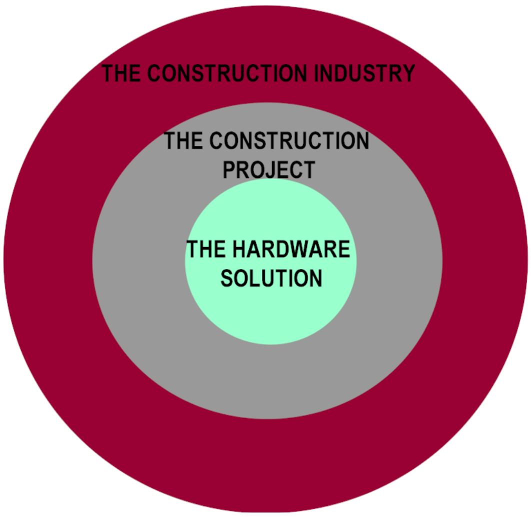

Fig 1: The Research Domain Layers

The outer layer signifies the industry and its firms as a whole and researchers at this macro level are concerned with industry structure, its economics and overall performance, its resource provision and its inputs and outputs.

The researchers relating to the next layer are concerned with levels (i) and (ii) of Construction Project Management as above. At level (i), they are interested in how projects are financed, designed, and resourced; in costs and communications and to what extent the project procurement process runs in an optimal fashion. Level (ii) is that of the site construction process and the researcher is interested in site productivity, communication techniques, and resources provision and timing. The third layer relates to the actual hardware solution being constructed for the client and does not directly include management research. The researchers, are pure scientists and engineers (in relation to new improved materials) and engineers and architects (new elements and systems and design procedures and user solutions).

3. The Value of Construction Research

Construction Management research is a relatively young academic discipline. All of us researchers, probably reflect occasionally upon whether we contribute to the development of the construction industry or not. A problem for construction management researchers is that our laboratory is the dynamic and changing construction world as it actually is, and where the variables cannot be controlled.

But, on the other hand, since we do have this vast laboratory available providing a wealth of ongoing activities to study, there is no shortage of research material.

Most construction management researchers, focus on a narrow area of the domain, adding "illuminating crumbs" of new knowledge and understanding, just as researchers in technology do. Nevertheless, researchers in the technology areas can have few doubts about their collective effectiveness over time. The developments in materials used on site for example have produced cost savings as time has advanced; research into structural behaviour and theory has provided useful structural behaviour predictive models of some generality, which make design both quicker and more precise. The same applies to fluid flow, heat transfer, and electric power as far as buildings are concerned. In most work of this 'hardware' type, researchers make steady advances to knowledge which have resulted in steady improvements in the technology of permanent construction and better value for money.

In the technology category, we have also seen huge and continuing advances in Construction Plant and in Information Technology. Both are of great significance in improving the effectiveness of the construction industry, the potential of IT in fact still very far from being realised. The effect of the research in these areas, however, does not appear as actually constructed hardware, and essentially assists construction managers because these technologies enable improved productivity.

The question remains as to whether our collective construction management research 'crumbs' have brought about improvements in industry productivity and value for money, in the same way that technology research has brought about such improvements. In a partial attempt to answer the question, the rest of the paper outlines and examines the writer's studies in 'concreting', as a case example of research into a narrow area of the Construction Management domain.

4. The Concreting Studies

There are three research components as follows, spanning the period 1984 to 2002.

1. A site study of concrete pumping comparing practice in the UK and West Germany was made in 1984-86 to try to answer the question as to why a German contractor was 4 times more likely to pump his concrete than a UK contractor and to try to understand the factors influencing the ability of Ready Mixed Concrete suppliers to provide a smooth supply of concrete to sites. UK contractors were only pumping about 10% of all in situ concrete.
2. A study of site concreting in Hong Kong in 1991-93 on large pours in buildings to provide site placing productivity benchmarks and to relate concreting performance in Hong Kong to that seen in the UK and West Germany including study of the Ready Mixed Concreting industry in Hong Kong in relation to delivery performance.
3. Because of the variability in site service being achieved in Hong Kong a simulation model based on a representative sample of typically sized pours on an ordinary day has been constructed latterly and validated. This will enable further study of the site service and truckmixer scheduling issue.

5. Concreting Studies Findings

The findings can be studied in detail in the references listed at the end of the paper.

The 1986 comparison of West Germany (WG) and UK pumping (1) used much statistical information but a true feel for the subject was gained by the direct observation of 70 UK mobile pump pours averaging 92m^3 and 32 WG mobile pours averaging 70m^3. The 70 UK pours were placed at a mean rate of 15.4 m^3/hour. The WG figure was 20.2 m^3/hour. In the UK a pumpable mix was not seen as standard by RMC suppliers and cost more than a standard mix as a result. There was no such distinction in WG. A UK tendency was to favour only the bigger pours for pumping, because they go faster, and contractors normally want to finish comfortably in the working day whereas in WG, pumping was routinely seen as an option for a pour of any size.

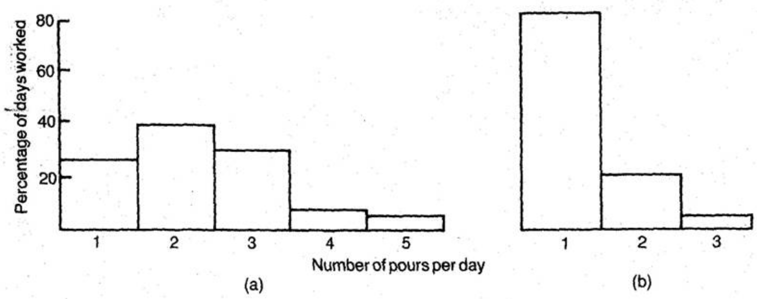

Fig 2: Number of pours per pump per day in (a) West Germany and (b) UK

One of the consequences of the fact that pumping is 4 times more likely in WG means that a WG pump will typically serve 2 or 3 sites on one day (see Fig. 2) whereas 1 site per day is the norm for a UK pump. This leads in turn to the fact that WG pump hire rates for small pours are more attractive than they are in the UK and because WG pump drivers are eager to move on to the next site there is more pressure in WG for small pours to also receive a prompt and continuous ready mixed concrete supply service. Table 1 shows that only the large pours in the UK received a supply service which is roughly in line with the service received by a WG pour of any size. Thus UK small pours do not even fully benefit from the greater productivity expected when a pump is used.

Table 1: Interruptions in Concrete Supply % of Total Pour Duration

	UK	WG
Delay % of Pour Time		
Pours > 100 m^3	14	13
Pours < 100 m^3	26	10

Thus the WG environment is one which routinely supported and encouraged pumping, whereas the UK culture linked pumping only to large pours.

Table 2: Large Pours on Hong Kong Buildings 1991-1993

Placing Method	No. of Pours	Ave. Pour Size m^3	Placing Performance		
			m^3/h	m^3/mh	m^3/th
Pumped	51	144	21.4 *(24.1; 16.1)	2.1	13.0
Crane	43	89	12.2 (14.7; 8.8)	1.2	11.2
Hoist & Barrow	43	105	13.5 (20.1; 8.0)	1.1	10.2
All three	137	114.6	16.0	1.5	11.6

*(quartiles in brackets)

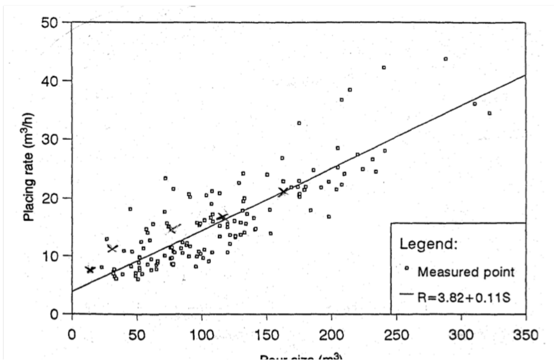

Fig 3:Relationships between Placing Rate and Pour Size

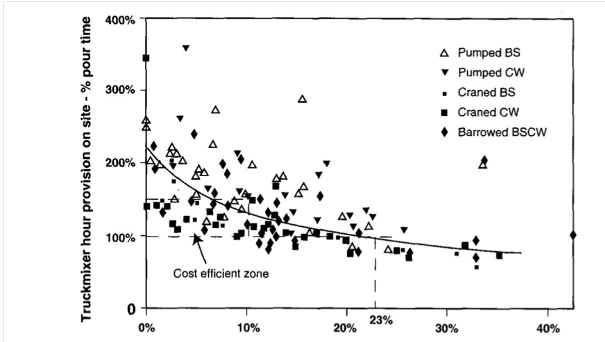

Fig 4:Relationship between truckmixer provision on site and percentage pour time without concrete (137 pours)

The 1991-1993 study of site concreting for 137 large pours in Hong Kong buildings averaging 114.6 m^3 in size, where again every pour was directly observed from start to finish produced the mean placing performance results of Table 2. Placing speed and pour size are related in Fig. 3 and Fig. 4 illustrates the tradeoffs which exist between trunckmixer allocation to sites and interruptions in the supply of concrete. These figures can be seen as performance benchmarks for Hong Kong. Each point on Fig.3 and 4 represents the result for one complete pour. Given the positive correlation of Fig. 3 between pour size and placing rate the 21.4 m^3 /h for pumped pours averaging 144 m^3 in HK looks disappointing when compared with the 20.2 m^3 /h for 70 m^3 pumped pours in WG (see Fig. 3). However the German pours almost all used mobile pumps whereas the HK sample contains 50% mobile and 50% fixed and without any mobile placing boom operating at the floor being pumped. A separate analysis (not shown here) indicates that a difference of about 5 m^3 /h in productivity exists between a mobile and a fixed pump and thus the HK figure for comparative purposes could be "corrected" from 21.4 to about 24.0. The study also revealed however that placing booms were not routinely placed at working floor level when fixed pumps were operating at ground level. Table 2 also shows the labour productivity gain when using pumps for placing concrete and that truckmixers are more efficiently turned round on pumped pours. The figures for m^3 /th (cubic meters placed per truckmixer hour on site) take into account both queuing time and emptying time on site.

It is suggested that Fig. 4 is a useful and compact benchmark of the service sites are receiving, combining as it does, both truckmixer provision and interruptions in supply. Average interruption in concrete supply is 12% for this sample of large pours very similar to the figures shown in Table 1 for the UK large pours and WG.

Fig. 4 suggests also, that the problem for plant schedulers is not at all easy. It is clear that even though a generous supply of truckmixers to a site is not at all uncommon interruptions in concrete supply will still occur. Any scheduling methods, and deliberate tighter coordination between sites and plants, producing less scatter in the future would benefit productivity and the economics of ready mixed concrete.

To help study this issue in more depth, a big observation and data collection follow on study was made in 2000-2001 as the basis for the construction of a simulation model of the operations for a day of a single ready mix plant supplying S sites using M truckmixers. Sites were at to be various distances D from the plant and required variable quantities of concrete Q placed by different placing methods. The user was to be able to experiment by inputting for each simulation run, his own values of S, M, D, Q and placing method. An observer spent several months on four plants and eventually emerged with good factual data for 15 days of actual operations on all of the 295 pours completed in those 15 days. Whereas the sample in 1991/93 was restricted to larger pours averaging 114.6 $m^{3\ o}$ on buildings only, the new data averages 36.4 m^3 per pour and is much more representative of the typical Hong Kong distribution of pour sizes served by plants. The data is given in Table 3.

Table 3: Size Distribution for the sample of Hong Kong Concrete Pours in 2000/01

Pour Size Range m^3	Total Quantity in the range m^3 (%)	Number of Pours in the range (%)
Less than 20	17,162 (16%)	175 (59%)
20 - 49.5	24,670 (23%)	57 (19%)
50 – 99.5	26,923 (25%)	47 (16%)
100 – 149.5	24,027 (22%)	20 (7%)
Greater than 150	14,480 (14%)	7 (2%)
All sizes	107,262 (100%)	295

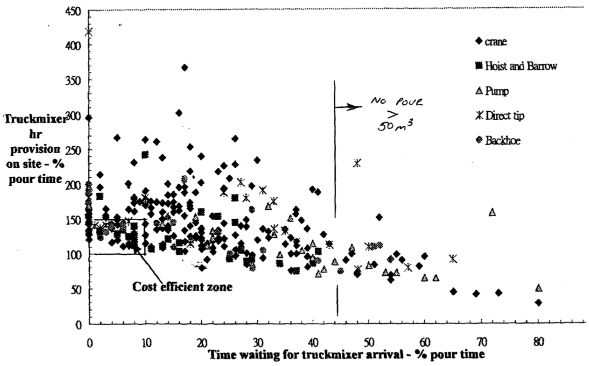

Fig 5: Actual relationship between truckmixer provision on site and percentage pour time without concrete (295 pours)

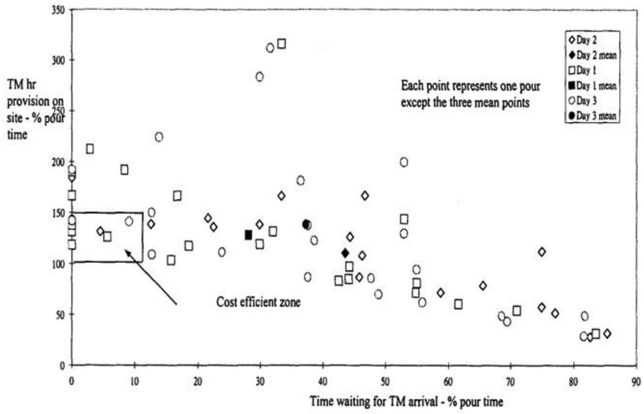

Fig 6: Simulated relationship between 'TM provision on site' and 'no concrete on site' for 63 pours

Fig. 5 represents the service received by sites for the 295 pours. It is similar in form to Fig. 4 but now that the sample of pour sizes includes the large number of small pours typical of a day's concreting operation, the mean interrupt in supply has stretched to 22.3% of pour time. In part confirmation of Fig. 4 however, it is the case that no pour which is greater than 50 m^3 in size suffers supply interruptions of more than about 40%. The long tail of Fig. 5 contains only results for small pours. The collected data also provided histograms for journey times, both full and empty, truck loading and unloading times etc sufficient for a simulation model to be constructed.

The service provision output for three days of simulation, where the quantities placed are 386, 545 and 697 m^3 respectively is shown in Fig. 6 for the truckmixer resources and typical range of distances and site quantities assumed. Fig. 6 merely illustrates that the service pattern seen in reality is also reproduced by the simulation model. Immediate future work will study the effects on service provision of different combinations patterns of S,D,M,Q and scheduling strategies.

6. Discussion and Conclusions

The results are now briefly assessed from the points of view of

- contribution to knowledge and understanding
- value to practitioners in industry
- relevance to the construction management research discipline

As to the first we can cite obvious factual contributions such as

a) the provision of benchmarks for concreting productivity with some comparisons between Germany, the UK, and Hong Kong.
b) highlighting the potential value of floor level placing booms and multistorey buildings in Hong Kong.
c) The UK pumped less than WG because the environments are different. Contractors can usually be assumed to make the right business decisions for them. In WG, as opposed to the UK, the pump is seen as the purpose built tool for placing concrete and delivers the best labour productivity. The result, in that the usual mixes, concrete supply systems and pump hire systems and rates are geared to suit pumping.
d) For Hong Kong there now exists a quantitative benchmark, of the concrete supply service received by sites. There is a complementary appreciation of the difficulty of the scheduling problem facing ready mixed concrete plants.
e) A simulation model representative of a Hong Kong ready mixed plant supplying many sites has been constructed and validated for future experimental study of the scheduling problem.

The research was basically curiosity driven, and any value for practitioners is incidental, although it is true that at least the UK pumping industry and the HK ready mixed concrete industry are familiar with c) and d) above, respectively and were very supportive in kind. There is hearsay evidence, also, that placing booms b) are now more commonly used in HK and it is perhaps not unreasonable to assume that the data a) has been of direct use to some individuals (probably rather a few) since reports intended for industry consumption have been circulated in parallel with publication in traditional journal papers.

Nevertheless the overall impact on practice of all this work has probably been extremely small in any direct sense. The most likely benefit is indirect, by virtue of the demonstration that real operations can be studied and produce public ‘benchmark’ information not otherwise available normally (but fairly easily could be) about management performance and the productivities actually being achieved etc. The indirect benefit is an educational one. The crumbs of research information and analysis may cause a few individuals to be more inclined than before to want objectively to measure and learn from their own experiences. Added to the many ‘crumbs’ provided by other researchers of construction management the result is to slowly help accelerate the development of a stronger management culture measuring what it is doing and becoming aware of international benchmark standards.

Finally, as to the relevance of the work to the construction management research discipline two suggested conclusions are:

- The construction industry itself does little or no management research and so curiosity driven research by academics is a necessary activity. It can reveal performance inadequacies by management and should gradually lead over the longer term to more routine self monitoring, the generation and use of bench maths, and industry/academic collaboration.
- If the industry is to be influenced, in the way that it has already been by much technological research, then it is important that construction management academics do their work well, so that practitioners respect our outputs and find them interesting, convincing and even stimulating. Our work has to be objective and rigorous with thoroughly supported conclusions as a minimum. Good work can only be evidence based, derived from extensive observation, (itself also ensuring the researcher gets real understanding of the subject area), written records, and ‘records’ obtained from people’s heads at interviews if well cross checked or otherwise validated.

7. References

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