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Sustainability and Innovation in Management and Technology

December 10-12, 2003
Hong Kong

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Foreword

The construction industry is poised to make great advancements in the way we build and manage our projects in the twenty first century. Technological advances in sustainable construction techniques have created a tremendous window of opportunity for different professionals to pool their expertise for the common good of all. Public and private sector involved in construction should forge new and innovative alliances to take a hard look into the ways construction projects are organized and managed. They should scrutinize the manners in which techniques are employed, and should reconsider the mindsets in which principles are based. This new era, coinciding with the beginning of the twenty-first century, can also be the beginning of a new, global construction industry. It is imperative that we, as educators, researchers, and professionals involved in the construction industry carefully examine techniques and principles that are in use and develop a vision for bringing changes in the future. There are potentials as well as roadblocks. We must increase productivity but also adhere to the principles of sustainability. We should automate but must also keep our construction sites safe. We must decentralize our organizations but also maintain a central repository of data and information.

Thanks to our friends, colleagues and well-wishers from across the world, we were able to successfully organize the CITC-I in Miami in April of 2002. The very positive feedback we received from the participants in Miami encouraged us to start thinking about a second conference in this series. Many months of planning and coordinating the various facets of organizing an international conference and, countless hours of help from a large number of volunteers have enabled us to put this project together. Of course, this could never be a reality without the support of all of you who are present here today. The outcome is the *Second International Conference on Construction in the 21st Century: Sustainability &Innovation in Management and Technology (CITC- II Hong Kong)*. This two and a half day conference is being held in Hong Kong at the Sheraton Hong Kong Hotel and Towers from December 10-12, 2003. This event has brought together construction professionals, educators and researchers representing educational institutions, government agencies, contracting organizations, engineering consulting companies, financial institutions and other organizations from around the world representing twenty six countries. We proudly present one hundred and nineteen peer-reviewed papers in the proceeding, grouped in four major categories:

- Cost engineering and financial issues
- Construction project management
- Information technology and information systems in construction
- Construction technology

It is our intent to continue to organize the *CITC* series of conferences worldwide at regular intervals. We sincerely hope that you will continue to support this effort.

Thanks and best regards.

Syed M. Ahmed
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Hong Kong, 2003

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"Sustainability and Innovation in Management and Technology"
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Keynote Lecture 1

New Forms of Non-Adversarial Contracting Focusing upon the New Engineering Contract

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Abstract
The paper examines the theoretical basis in contract law for new forms of non-adversarial contracting focusing upon the New Engineering Contract ("NEC"). Most analysis of traditional forms of adversarial contracts is premised upon traditional contract theory. The paper will critically examine whether this foundation is appropriate in view of the changes standard forms are undergoing. It will be argued that for most part the new forms of contract do not lend themselves to analysis using traditional contractual models. It will be argued that most of traditional contract law theory operates at cross-purposes to the philosophy of these new forms of contract. A new theoretical contractual model will be postulated which is based upon relational contract law whose central element is co-operation.

Keywords
Relational contract, Partnering, Co-operation, NEC

1. The Model and Relational Contract Theory

Traditional contract law, according to Holmes and Thurmann (1987), and Macneil (1974), includes both the classical contract model and the neo-classical or realist contract model. These models dominated theoretical work during the 20th century and were developed through the work of leading American contract scholars including Karl Llewellyn (1930, 1931 and 1940), Lon Fuller (1936) and Grant Gilmore (1977 and 1995). Karl Llewellyn, who is closely associated with constructionalism and American Legal Realism, has been particularly influential because of his work on the *Uniform Commercial Code*. Their work in particular has influenced later scholars and has also usefully served as the basis of a broader regrouping of certain of the other contractual models.

For Macneil and the relational contract model it is the future that is important in theoretical terms. As suggested by one study, subcontractors were prepared to settle disputes with contractors over set-offs to avoid jeopardizing future work (Kennedy *et al.* 1997). This contrasts with the present in the classical contract model. The success of the contractual relationship depends less upon what has been agreed than upon how the parties will agree to handle events in the future. What is important in relational contract theory, and indeed what distinguishes it from neo-classical contract theory, are the values it embodies: namely, trust, mutual responsibility and connection among people (Feinman, 1992, Campbell, 2001 and Kennedy *et al.* 1997). With this understanding of relational contract theory the next step is to build upon it to create a theoretical model for the NEC.

2. Empirical Foundation

The NEC may be analyzed using a relational contract theoretical framework, emphasizing the importance of good faith, fairness and co-operation. Relational contract theory and the principles underlying the NEC are supported by empirical research. Beginning with Stewart Macaulay's seminal work (1963), there has been rising interest in empiricism. For example, the Tavistock Institute of Human Relations called for further empirical work in construction and with regard to evaluating the

forms of contract (1966). This resulted in a tremendous growth in empirical research in many disciplines that touches upon law (Nottage, 1997). More importantly, the interest in empiricism can be seen in project management literature and increasingly in the legal literature (Posner, 1995) – both of which have significant implications for the NEC and contractual paradigms in general. Martin Barnes has said: "[t]he management of projects has become a science with its own set of rules, techniques and words which are not even mentioned in the existing standard forms. If the conditions of contract were redraughted from first principles, having regard to modern management methods, a much more purposeful document could be produced" (Barber, 1986).

The essence of the work done by Macaulay was to show that contract law plays a marginal role in long-term continuing business relationships. The same conclusion was reached in the leading British article by Hugh Beale and Tony Dugdale (1975), 'Contracts between Businessmen'. It would appear from Beale and Dugdale's research that people neither plan as carefully nor pay as much attention to their contractual obligations as had previously been thought. Other research that has followed theirs, notably that of Macaulay (1977) also reflects the same sentiment. While these articles are of general application, some early empirical work was also done in construction concerning tendering: (Schultz 1952, Note, 1967 and Lewis 1982).

The conclusion, which follows, is that *relations*, the cultures at play, influences if not determines the extent to which risk may be borne by either side to a contract. Further, this research shows that people will perform disadvantageous contracts in the hope of maintaining relations or storing credits for the future. That future may be understood in terms of a subsequent contract with the same party or subsequent conduct within the same contract. People were also shown to be willing to renegotiate in circumstances that had turned out badly for either or both sides of the agreement. In practice, wider ranges of circumstances were recognized as excusable than most contracts had provided for. This accords with the view that many disputes are not dealt with or recorded in any way and that only a small proportion result in any formal mode of dispute resolution (Conlin 1995 and 1996). Research has also shown the critical role played by trust in collaborative contracts (Wood and McDermott, 2001 and Myers, 2000). The Macaulay, Beale and Dugdale research has shown that people perform contracts because of the *relational* sanctions that operate. In part, it is submitted, these relational sanctions are reflected in the number of internal remedies for breach available in construction contracts but they are also reflected in various informal and relational dispute resolution mechanisms. The NEC has built upon this process of understanding and therefore more accurately reflects the true relational norms that exist in construction contracting.

3. Key Model Elements

The key elements of the model may be summarized in this fashion:

1. Construction contracts are ideal for relational analysis. They are inherently multidisciplinary and involve a wide range of stakeholders.
2. Relational contract theory is compatible with promise-centered contract scholarship. Much of this scholarship complements relational contract theory on the question of why construction contracts are binding.
3. Relational contract theory tends to support analysis of the NEC as a long-term contract that is suitable for partnering.
4. Relational contracts and the NEC are both flexible. The former allows for, and the latter manifests, open terms, grants of discretion and various adjustment mechanisms.

4. Co-operation

Co-operation is key in both relational contracting, under the NEC and in the model proposed here. The classical contractual paradigm, supported by economic analysis, predicated upon rational, utility-minded individuals maximizing self-interest in discrete transactions in competitive markets with the

allocation of all relevant risks at the time of contracting, has come under serious challenge. Rather, the hypothesis, which does not depend upon the allocation of all risks at the time of contracting, has gained recognition. Two scholars, Campbell (2001) and Harris (1993) in particular, have made the point emphatically. Goetz and Scott (1983) also adopt this view in their description of the bargain model, even though their model takes on some of the criteria of the classical contractual paradigm. Gordon (1985) wrote in the 'relational view' of Macaulay and Macneil: "the object of contracting is not primarily to allocate risks, but to signify a commitment to cooperate." An economic rationale for assuming future obligations to co-operate is put forward by Goetz and Scott (1981):

> In outline, the argument is that in many cases it is simply not possible (or cost effective) for party A to specify in advance how the other party, B, should act in order to minimise certain risks, or even to identify all the relevant risks. Rather than assume the risk of an opportunistic refusal by B to act in a way that minimises the parties' joint costs, A will be prepared to pay in advance for B to assume an obligation to act in an efficient non-opportunistic way.

This brings out the dilemma that comes with increasing complexity and uncertainty and that there may be no ideal strategy for distributing risk at the time of contracting. In this view contracting parties will agree – either expressly or impliedly to adjust their initial risk allocation scheme in light of subsequent events. Regrettably though once the contract risks are distributed as agreed, each party will then have less incentive to accommodate the others' request for adjustment. Each party is thus faced with a difficult choice whether to adjust cooperatively, as they have originally agreed, or to respond to immediate self-interest and circumvent the responsibility (Goodard, 1997).

The foundation for all parties' actions in the NEC (save the adjudicator) is *co-operation*. The significance of beginning the contract with an affirmation of co-operation and imposing such an obligation upon the parties in clause 10 cannot be overstated. While some may argue that such a clause is devoid of content it is argued here to the contrary and that it has the fullest possible meaning because it underscores the necessity for action with regard to every single obligation otherwise imposed upon those named in the contract.

The classic statement of the requirement for co-operation in contracting comes from Lord Blackburn in *MacKay v Dick* (1881) 6 App Cas 251 at 263, HL:

> I think I may safely say, as a general rule, that where in a written contract it appears that both parties have agreed that something shall be done, which cannot effectually be done unless both concur in doing it, the construction of the contract is that each agrees to do all that is necessary to be done on his part for the carrying out of that thing, though there may be no express words to that effect. What is the part of each must depend on the circumstances.

A strong argument can be made that the express obligation to co-operate in clause 10.1 of the NEC takes future cases involving the NEC out from under any narrow interpretations of *MacKay v Dick* and other cases which have implied the term effectively as one necessary only to ensure the fulfillment of preconditions to performance and no more. The importance of clause 10.1, in both its ability to make use of co-operative jurisprudence, but at the same time to circumvent any limitations inherent in an implied term approach, cannot be overstated.

5. Partnering

The theoretical co-operative and relational model advanced here for the NEC is wholly consistent with the notion of partnering and third party adjudication. In contrast to traditional paradigms and contractual structures, which focus upon arbitral dispute resolution, the NEC focuses on non-adversarial contracting and adjudication.

Numerous NEC features noted by Roe (1995); namely, the commitment to co-operation (ECC cl 10.1), early warning (ECC cl 16), and the pre-pricing of variations (ECC cl 61) all suggest partnering and the form is being used for work under partnering agreements usually under the target contract options (Nicholson, 1997). The fit between the NEC and partnering was made clear with the release of the partnering option X12 in June 2001 and the work done lately by Bennett and Baird (2001), and Broome

(2002). The NEC supports adjudication in contrast to the traditional contract model of third party arbitration. The adjudication provisions in the NEC were part of an early trend toward alternative forms of dispute resolution in standard forms (e.g. JCT 81, cll 4.30-4.37 NSC/C, cl 24 DOM/1 and cl 59 GC/Works/1 3rd). The weakness of arbitration in the traditional forms from a relational point of view is that it often cannot be invoked until after the relationship between the parties has been brought to an end. Thus the utility in any relational sanctions that could have been brought to bear in settling the dispute during the course of the enduring relationship will have been lost (Myers, 1987). The NEC three tiered dispute resolution and avoidance procedures therefore complement rather than undermine the contractual and social controls thereby serving to promote party co-operation (Scott, 1987).

The conscious attempt by the drafters to purposefully address the avoidance and management of disputes began the distancing of the NEC from many traditional forms. This is because some commentators see disputes as more likely arising under traditional United Kingdom rather than other forms of contract (Capper, 1994). When greater co-operation, clearer allocation of risk, simpler language, clearer communication, and management procedures were added to these goals the NEC moved well beyond them. While these were the broad contours, which the drafters pursued across the form as a whole, additional, discrete choices removed the NEC further from many other forms. These choices ranged from the introduction of the schedules of cost components through to the use of activity schedules and removal of legal content to the works information. Therefore the combination of both general and specific choices by the drafters serves to significantly diminish the role of conflict on site (Heal, 1999).

6. Conclusion

The foundation for all parties' actions in the NEC (save the adjudicator) is *co-operation*. The significance of beginning the contract with an affirmation of co-operation and imposing such an obligation upon the parties in clause 10 is great. While some may argue that such a clause is devoid of content, it has been argued here to the contrary that it has the fullest possible meaning because it underscores the necessity for action with regard to every single obligation otherwise imposed upon those named in the contract. Working back from jurisprudence that has developed the meaning of co-operation in law, it has been argued that the NEC case for recognition and inclusion of an express duty of co-operation was not only warranted but also fully justified. It was also argued that the duty in clause 10.2 to co-operate takes future cases arising under the NEC out from under narrower interpretations which have implied the term effectively as one necessary only to ensure the fulfillment of preconditions to performance. The express duty to co-operate in the form permits one to make use of co-operative jurisprudence that may be helpful to elaborate upon the meaning of the term as well circumvent those limitations inherent in the cases. The NEC has been evaluated as a tool of co-operation in particular with the aim of achieving results in accordance with the purposes of the contract, the goals of the management model it prescribes and the industry in which it is used. The NEC is a precursor to what is predicted here will be wider similar trends in the construction industry as a whole.

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Keynote Lecture 2

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,

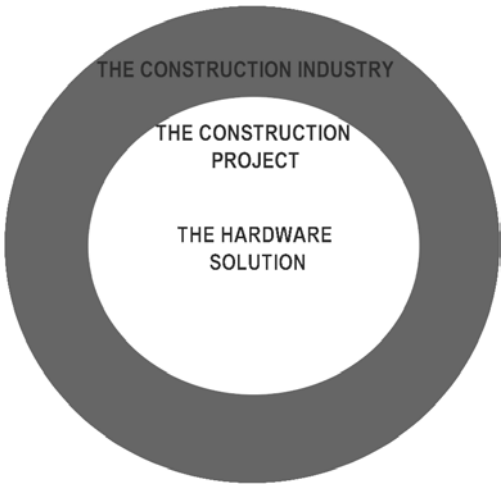

Fig 1: The Research Domain Layers

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.

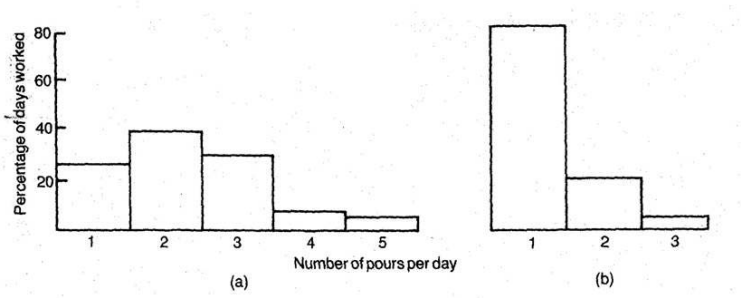

Fig 2: Number of pours per pump per day in (a) West Germany and (b) UK

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)

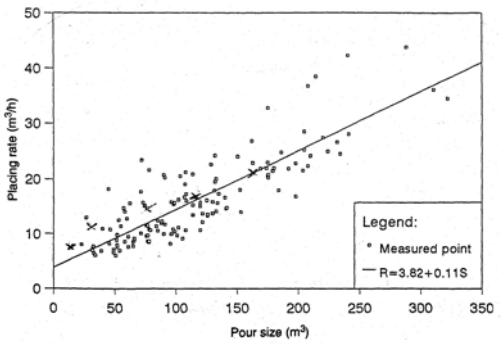

Fig 3:Relationships between Placing Rate and Pour Size

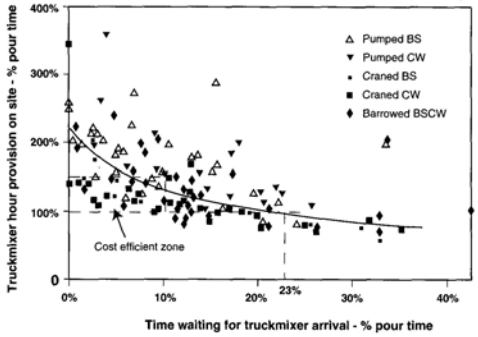

Fig 4:Relationship between truckmixer provision on site and percentage pour time without concrete (137 pours)

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

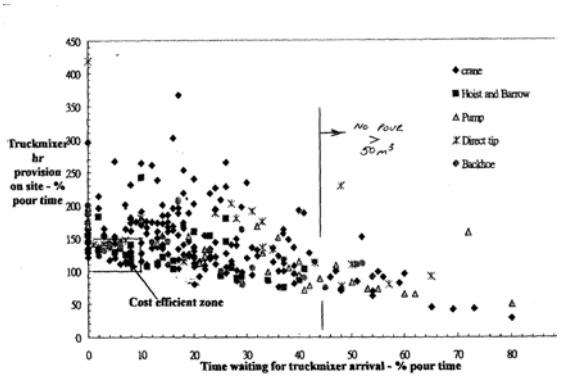

Fig 5: Actual relationship between truckmixer provision on site and percentage pour time without concrete (295 pours)

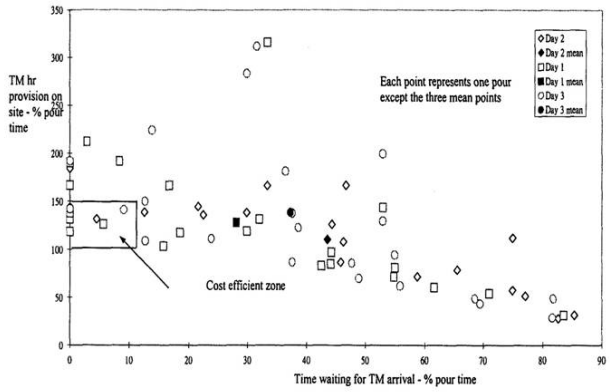

Fig 6: Simulated relationship between 'TM provision on site' and 'no concrete on site' for 63 pours

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.

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Second International Conference on Construction in the 21st Century (CITC-II)
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Keynote Lecture 3

Sustainable Development in Civil Engineering – The Hong Kong Experience

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Abstract
Concern about sustainable development has grown in Hong Kong in recent years especially for infrastructural projects and construction activities. This paper examines sustainability issues of a railway project which was refused an Environmental Permit in its first application and a highway project which initiated a public uproar when its noise barriers were being installed. It also describes how the Government and the engineering industry are attempting to reduce inert construction and demolition material being disposed in landfill. The experience gained in Hong Kong may be applicable to elsewhere.

Keywords
Sustainable development, Sustainability, Civil engineering, Hong Kong Experience

1. Introduction

Hong Kong is sometimes considered to be the civil engineer's paradise. There has been continuous intensive infrastructure development in Hong Kong since the 1970s when government decided to develop the new towns in the new territories. Since then, the mass transit system, the relocation of the international airport, the ambitious public housing programme, the highway and railway development strategies all provided ample opportunities for civil engineers to make their contribution to the development of Hong Kong.

With limited natural resources and high population densities in Hong Kong, how can civil engineers ensure that their work is compatible with sustainable development? In Hong Kong, sustainable development balances social, economic, environmental and resource needs, both for present and future generations, simultaneously achieving a vibrant economy, social progress and a high quality environment, locally and internationally, through the efforts of the community and the government (ERM, 2000).

Since 1998, the environmental impact assessment ordinance (EIAO) has come into effect in Hong Kong. Under the EIAO, designated projects, that may have a significant impact on the environment, are required to obtain an Environmental Permit (EP). The EP serves as a safeguard to the environmental aspects of sustainability.

This paper examines the sustainability issues of a civil engineering project at its planning stage and another at the implementation stage and the lessons learned. It also describes how Construction and Demolition (C&D) material, a major concern of the government and the public in Hong Kong, is being tackled with the aim of achieving sustainability.

2. Sheung Shui to Lok Ma Chau Spur Line

Due to the increasing economic activities and social interaction between Hong Kong and Guangdong in recent years, there has been an urgent need to increase the border-crossing facilities. The Kowloon-canton railway corporation (KCRC), in accordance with government's railway development strategy, proposed in 1998 to build a spur line from Sheung Shui station to Lok Ma Chau to relieve congestion at Lo Wu, which is presently the only rail-accessible crossing. The viaduct alignment of the proposed spur line, however, cuts across long valley, an ecologically sensitive wetland with a high diversity of bird species including some of conservation importance.

As the spur line is a designated project under the EIAO, an EP issued by the director of environmental protection (DEP) is required before construction can begin. The EIAO process was followed with KCRC submitting a project profile (on 23 December 1998), the Environmental Protection Department (EPD) defining the study brief, KCRC presenting a draft EIA report followed by a final report to EPD. Then followed a public consultation exercise during which EPD requested comments on the report from the public (225 sets from the public received) and KCRC supplied more information. EPD also solicited comments from the Advisory Council on the Environment and the Agriculture, Fisheries and Conservation Department (AFCD). On 16 October 2000, DEP decided not to approve the EIA report and therefore did not issue an EP. The main reasons given were the high potential direct environmental impacts, in particular during the construction stage, the doubtful effectiveness of the proposed mitigation measures and the availability of practical and reasonable alternatives (EPD, 2000).

The KCRC appealed the DEP's first ever EP refusal to the EIA appeal board. A three-member board was formed and chaired by retired High Court Justice Barry Mortimer, QC. It heard arguments from both sides from 4 April to 24 June 2001. In the hearing, KCRC submitted much new information on construction methods, mitigation measures and changed circumstances. As the new information had not been subject to the normal EIAO process, especially public scrutiny, and that the appeal board sat as an appellate tribunal, not a tribunal of enquiry, KCRC's appeal was dismissed on 30 July 2001 (cocking, 2001).

Following the appeal board decision, KCRC held extensive consultation with EPD and AFCD and selected a bored tunnel on the same alignment to pass through long valley (Figure 1). A renewed EIAO process with a revised project profile submitted in September 2001 was eventually completed with the approval of a new EIA report and the issuance of EP No. EP-129/2002/a on 11 December 2002. The bored tunnel option will cost about HK$2 billion more than the original design and the spur line will open in 2006/07 instead of 2004 as originally planned.

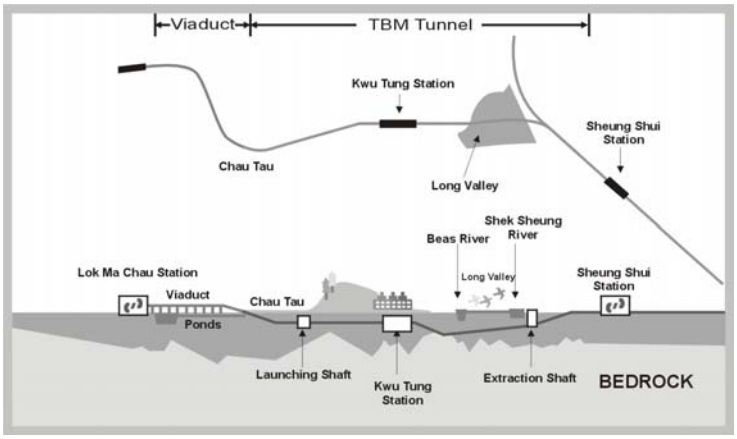

Figure 1: Lok Ma Chau Spur Line (Adopted from KCRC, 2003)

The spur line episode is a valuable experience for Hong Kong. It highlights the concerns of the public about the impacts of civil engineering projects on the environment, the need for improved communication between the regulator and the project proponents to enable the EIA report to better address the environmental issues, and the possible high economic penalty of an appeal process in terms of delayed project completion.

3. Tolo Highway Noise Barriers

Tolo Highway is one of Hong Kong's major trunk roads. Due to increased traffic, especially from cross-border activities, it is being widened from dual-three to dual-four lanes.

As part of the widening works, noise barriers were installed at the end of 2002. As required by the EIAO, these barriers were designed to take into account planned developments within the next 15 years to mitigate the traffic noise effects on the adjacent communities. Their installation, however, initiated an uproar from the public; the motorists on the highway complained about the loss of views, the spatial aspect and the visual impact of the excessive barriers; the residents of hillside dwellings nearby complained about the obstruction of their views over Tolo Harbour. Ironically, the barriers were designed to mitigate traffic noise levels for these occupants, who were considered to be Noise Sensitive Receivers (NSRs).

As some of the barriers installed were for the shielding of traffic noise from buildings which will not be constructed for some time, and as there are alternative provisions to cater for localised NSRs, the excess barriers were removed to be reused in other highways projects.

In a Legislative Council (LegCo) joint meeting of the Panel on Enviornmental Affairs and the Panel on Transport convened to consider the case, the following guidelines for road traffic noise mitigation were affirmed (LC, 2003):

- Comply with existing statutory requirements.
- Implement mitigation measures at the appropriate time.
- Consider cost-effectiveness of noise barriers for existing roads and set priority in retrofitting.
- Pay attention to the aesthetic design of noise barriers.

It is hoped that by adopting these guidelines, Hong Kong will be able to strike "the right balance among economic development, environmental protection and social acceptability" (LC, 2003).

4. Construction and Demolition Material

Tackling inert C&D material is an important component of the Environment, Transport and Works Bureau's (ETWB) overall waste management strategy. Inert C&D material is generated from civil engineering and other construction activities that should not be disposed of to landfill because of its inert and generally voluminous nature. In 2002, the total waste generation in Hong Kong was in excess of 20M tonnes, of which some 16M tonnes was classed as mixed C&D material. Of this, almost 13M tonnes (77%) was inert material comprising soil, building debris, broken rock, brick, asphalt, etc and more than 3m tonnes (23%) was non-inert C&D waste comprising timber, bamboo, plastics, packaging, etc. (EPD, 2003).

In Hong Kong, inert C&D material is used mainly as public fill for reclamation and non-inert C&D waste is disposed at landfills. In recent years, however, the mixed C&D material accounted for almost 50% of the total waste intake at Hong Kong's three strategic landfills. The current estimate is that these landfills will be filled up in 10 to 15 years (Chan and Fong, 2002) unless significant measures are taken to reduce the amount of mixed C&D material disposed there.

To ensure sustainable development in Hong Kong, there is an urgent need to reduce the generation of C&D material while achieving the economic and social needs of the community. There is also a need to recycle and reuse suitable C&D material to prolong the usefulness of these materials, to save virgin materials and to reserve the valuable landfill space for other wastes which are more difficult to recycle or reuse.

4.1 Reduction of C&D Material

Reduction of C&D material should start at the project conception stage. Can we come up with a durable yet adaptable scheme recognising the rapid changes of the need of society? "Flexibility of use, purpose and design" should be a key consideration for sustainable development if we do not "seek to impose solutions on future generations" (Brooke, 2003). Can we rehabilitate rather than demolish and rebuild a building?

Design engineers play an important role in reducing C&D material. They should, where appropriate, use lean construction, balance cut and fill, adopt modular and precast units, and incorporate recycled materials. They should also consider the constructability and de-commissioning of their designs in relation to safety, temporary work and waste generation. These considerations are compatible with sustainable construction promoted elsewhere (Guthrie and Coventry, 1998).

To enhance waste management requirements on construction sites, ETWB issued Technical Circular (Works) No. 15/2003 with an effective date of 1 July 2003. This circular requires contractors of Government capital works contracts with an estimated contract sum of HK$20M or more to prepare and update a comprehensive Waste Management Plan (WMP) with payment for its implementation under the "Pay for Safety and Environmental Scheme". The WMP has to include waste management policy, organisation structure of the environmental team, measures to reduce/minimize generation of C&D material, on-site sorting, temporary storage, recycling arrangements, record keeping, performance monitoring and provision of training. It is hoped that with Government taking the lead, similar requirements for waste management will be extended to contracts awarded by non-government developers.

4.2 Recycling C&D Material

Hong Kong is in the early stages of recycling C&D materials but has made some progress in establishing off-site sorting facilities, testing and trials of recycled aggregates, using recycled aggregates in low grade concrete and researching into recycled road pavements. Temporary recycling facilities in Tuen Mun Area 38 and Tseung Kwan O Area 137 have already been established.

While there are plenty of applications for recylced inert C&D material in concrete production, granular filters, road sub-base, blockworks etc., there are also many barriers encountered to recycling. These include readily available virgin aggregates from neighbouring areas, insufficient market for recycled materials, unfamiliar specification of recycled aggregates, limited recycling facilities and free use of landfills to dispose C&D material (Chan and Fong 2002). Government has prepared a scheme for implementing landfill charging for C&D material and has circulated this for comment within the industry, it hopes to submit this to LegCo later this year and use the funds so raised to provide incentives to help recycling.

4.3 Reuse of C&D Material

Sustainability encourages reuse of materials so as to conserve virgin natural resources. In Hong Kong, timber hoardings are now no longer acceptable by the authorities. Reusable steel hoardings are the norm in construction sites. Metal scaffoldings are encouraged as they can be reused. Friends of the Earth, a green group in Hong Kong, initiated a programme to collect surplus tiles from contingency orders by contractors to be given to organisations that are in need of them. Such a programme helped to reduce useful C&D material being disposed of in landfills (Beardsley et al, 2002).

The more common reuse of inert C&D materials in Hong Kong is for soft inert C&D material to be used as fill materials in reclamation. To co-ordinate the use of the suitable C&D material and need for

reclamation fill, the Government has set up a Fill Management Committee and a website to facilitate contractors' exchange of information.

5. Conclusions

Civil engineering projects often have significant impacts on the sustainable development in Hong Kong. Careful consideration is required during each of the project planning, implementation, operation and demolition stages to balance the social, economical and environmental aspects of the projects.

Some lessons we learn from the Hong Kong experience presented in this paper are:

- Engage the community early in project development
- Listen to stakeholder views
- Enhance communication between the regulator and project promoters
- Install mitigation measures at the appropriate time
- Adopt lean construction
- Reduce, recycle and reuse.

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Second International Conference on Construction in the 21st Century (CITC-II)
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Keynote Lecture 4

Construction in Transition: Where Are We, and Where Could We Be?

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Abstract
The magnitude of transition in construction is explored through a chronological charting of dominant managerial and allied developments that influenced improvement efforts in sector. This shows a shift from a site focus to corporate and sector-wide initiatives including emerging influences of sustainability and a re-definition of professional roles. Some current issues that are being addressed through improvement efforts are presented and potential futures also discussed.

Keywords
Construction Sector, Improvement, Design, Production, Management, ICT

1. Introduction

Global economic competition has compelled many organisations to pursue a path of exploring all possible options for achieving greater effectiveness and efficiency in the delivery of their products or services (Drucker, 1994). The availability of support technologies for such continuous productivity improvement is shifting the emphasis of this required competitive improvement from physical activities and materials to include attendant *latent* people related-factors. Up until the turn of the last two decades these latent factors had played a lesser role in the focus of improvement in the sector. For example, it is no longer sufficient to simply deploy technological tools to achieve factor productivity as this only helps to provide increased volumes of ineffective services or products. Many construction organisations are waking up to the untapped potential of the work-force as the primary distinguishing factor in organisational performance (Cooper et al., 1998). The gradual emergence of the knowledge age, which recognises construction professionals as the very embodiment of organisational knowledge assets presents clear evidence of the changing scenes in construction (Edum-Fotwe and Thorpe, 2002; Gregory and Deasley, 2002). Such a shift gives rise to a number of critical issues that construction may have to address in the present and future both at organisational and sector level. Consequently, the face of construction today in one sense could be described as being markedly altered from how it used to be two decades or so ago. A decade ago, the beginnings of such a shift was identified by McCaffer (1990; 1993) for professional careers in construction. In this paper the authors attempt a reflection of the journey of this transition by looking at how construction has changed over the last four decades to the current status of the sector. In the particular, the analysis of the 'now situation' should help to highlight some of the issues facing construction and for which efficient resolution could bring about significant progress for the sector. Equally, the trends of change in the different epochs of construction provide an indication of the direction in which the sector may progress into the future. The discussion on improvement trends concludes with suggestions of such a future direction for the construction sector.

2. Construction – A Fragmented Conversion Process

Figures 1and 2 present conceptual models of construction covering respectively the design and site production phases that make up a typical project. The two figures together depict construction as a conversion process that involves several suppliers and requires careful coordination and integration. At the design phase (pre-site production) the factor of conversion is essentially information. The inputs A, B, …, E and the outputs W, X, …, Z entail information detailed in different formats and media. This clearly makes the design phase of construction an information transaction activity or knowledge-based endeavour.

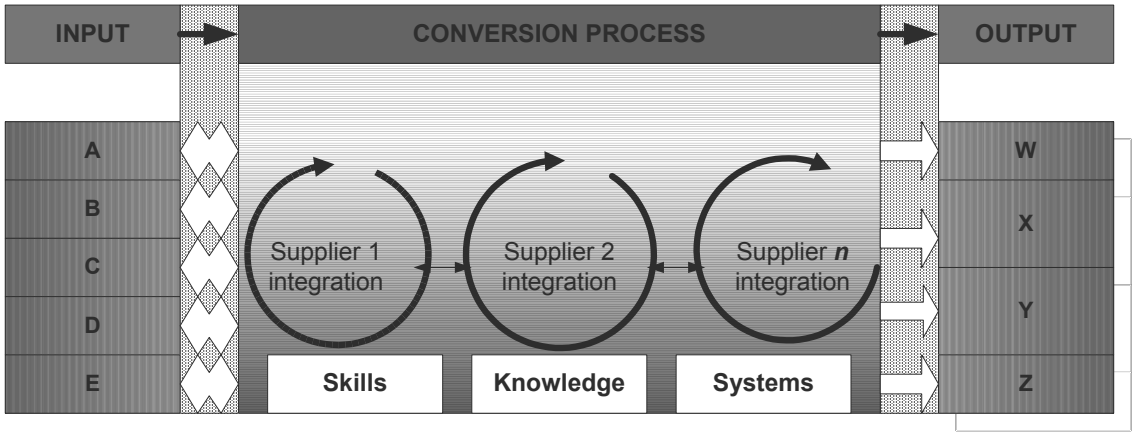

Figure 1: Model of Construction – The Design Phase

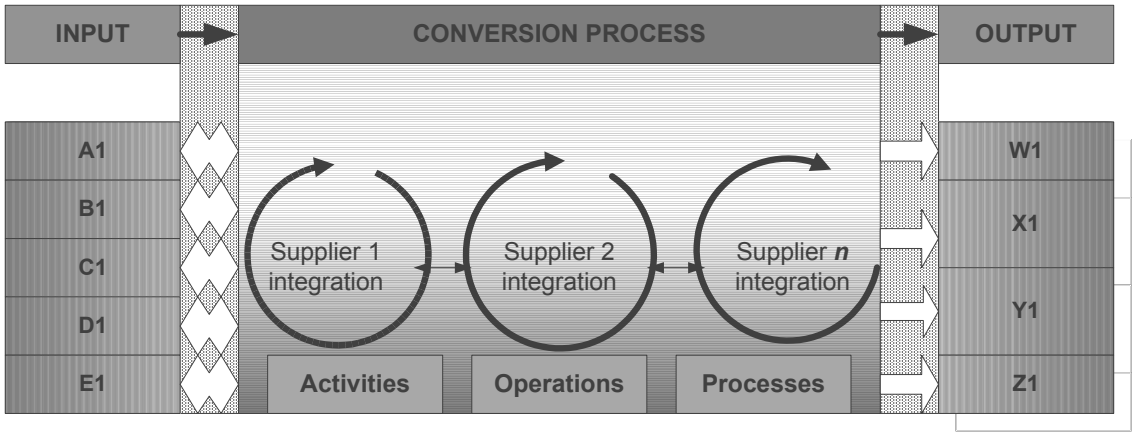

Figure 2: Model of Construction – The Production Phase

The output from Figure 1 serves as part of the input for the production phase in Figure 2. The conversion process of translating inputs to generate outputs is driven by *skills*, *knowledge or know-how*, and appropriate organisational and managerial *systems* that facilitate their integration. These factors reflect what is generally described as *soft* and their performance is less amenable to the simple input-output productivity analysis that tends to characterise the production phase depicted in Figure 2 (Checkland, 2000). The production phase on the other hand lends itself to such input-output evaluation. The inputs (A1,…, E1), outputs (W1,…, Z1) as well as their conversion involve physical and tangible resources beside the intangible knowledge resources. The tangible aspect of this phase makes it relatively easy to define productivity measures to assess discreet *activities*, a series of activities making up an *operation* or several operations coming together to form a *process* in the production phase. The significance of this ease of applying input-output analysis to the production phase has been a focusing

of improvement efforts at the production phase, with obvious accelerated benefits (Flanagan et al., 1998). While the design phase has equally witnessed some notable developments such as CAD, the take up of opportunities offered by these developments have often fallen short (Battersby and Yates, 2003). The effect has been a relatively slow growth in the improvement of systems and knowledge-related aspects of implementing construction projects especially where such capability already exists. The rather slow take up for such capabilities has been associated with a lack of or inadequate consideration for the *soft* end-user requirements in such developments for construction and engineering (Checkland and Scholes, 1990).

The models in Figures 1 and 2 also capture the essence of fragmentation between *design* and *production* phases in construction. Whilst integrated forms of procurement such as design-and-build and PFI have been explored or in some cases extensively implemented within construction, theses are predicated upon the *separated principle*. Essentially, a design solution is generated and then some thoughts are given to its production after the design has been approved (Kuprenas, 2003). While there is evidence of a growing reliance on buildability or constructability input by contractors during the design phase, the solution appears to lie in the integration of the two phases (Cooper et al., 1998). Such integration will facilitate the transfer of the essence of improvement in the production phase to the design phase, as well as the converse. In the past construction organisations were viewed as entities whose inner workings could not be observed, and whose actions could only be understood by *reviewing* their post-hoc responses to the external business environment. Research and development effort coupled with academic industry collaboration has helped to bring about a better understanding of the operational activities that form the internal workings of these construction organisations (Harris and McCaffer, 1995). However, understanding such internal operations presents little value unless it results in a more efficient implementation of future operational activities. The next section looks at areas of such improvement effort for the production phase. These areas often formed the focus of academic research at different times over the last four decades (McCaffer and Edum-Fotwe, 2001).

3. Improvement Effort and Transitions

The evolution of improvement efforts within construction has often been advanced to address the production phase. While some of the thematic issues on improvement equally addressed the design phase, the primary drive for their uptake was provided by the production phase. Over the past four decades the construction sector has experienced significant transformation in the way its projects are managed and its business activities undertaken. This is driven largely by changes in competition within the sector primarily from the production phase because of the exceptional focus on cost as a discriminant in project selection. Some of these practices are finding their way into the design phase. The various themes that have progressively contributed to this transformation can be associated with different periods. It is important to bear in mind that while the categorisations adopted by the authors reflect defined chronological boundaries, in practice, the periods extend on both sides of the timeline, with the dominant development reflected in the particular sub-section.

3.1 Site operations

Improvement efforts during the 1960s and early 70s were focused predominantly on *the construction site*. To expose the inner workings of the organisations, research effort within construction management in this period concentrated on understanding and explaining site operations, which often presented easy cases for observation and was also perceived as rather inefficient (Ministry of Public Building and Works, 1964). 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 undertaken to shed a greater understanding on the nature of site operations. Modern planning of construction projects became established in this era. This was motivated by developments in manufacturing and led on to improvements in the structure of site operations, which in turn helped to highlight 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. These pressures continue to today along with efforts to drive improvements.

3.2 Functional activities

The mid 70s and the 80s saw a shift from own-labour to labour-only subcontract arrangements. This was motivated by the need to develop a lower cost base for their activities in order to remain competitive, and this had profound impact on the structure of both the sector and companies. For example, at the sector level the responsibility for training of requisite skills shifted from major corporate organisations with a larger financial capacity to smaller enterprises with limited scope for taking on the added responsibility. The resulting decline in the number of skills within the sector has followed a consistent trend (DTI, 2002). At the company level this brought about a change in management and working practices at functional level (Finniston, 1980). For example the working practices in estimating changed from first principles to aggregating subcontractor quotations (Abdel-Razek and McCaffer, 1987). This change, while it helped to address the objective of a lower cost base, was also attended by an alteration in the role of the professionals that provided the various functional inputs such as estimating. Equally, the use of planning techniques that overcame the deficiencies of the simple Gantt chart had similar influences on the management of projects.

At the time of these structural changes computing facilities at corporate level was provided by the mainframe. These large machines were operated with bespoke software to address typical functional activities such as estimating, production programming and project accounting as well as central office functions. The emergence of the micro-computer at a later date brought about a transition in the scope and range of functional activities in the sector and consequently the make-up of the requisite skills for professionals. In particular, the introduction of micro computers saw the reduction in the mundane activities associated with the various functions, for example the many computations that estimators had to undertake. This was made possible with the availability of generic software tools such as spreadsheets and databases at the desktop level.

Also in this epoch is the quality initiative, including developments in quality assurance and total quality management (Juran, 1979; ISO, 1986; 2000). This initiative brought about a step change in the concept of the improvement agenda for sector, with attendant productivity attainments as organisations strove to attain and maintain client required TQM accreditation.

3.3 Project Perspective

The mid 80s to the early 90s witnessed a focus on the project, with the improvement efforts in the earlier periods above being translated to the level of the project. This was dominated by the widespread introduction of prototype IT applications and non-IT based models for direct use organisations within the sector. In many cases there was divergence between the claimed performance of these prototypes and real life, leading to much frustration for both organisations and individuals within the sector. Among the reasons for the inadequacies of the available prototypes were the following characteristics:

- Data captured for developing the prototypes is often insufficient, and lacking in accuracy.
- Communication between the developers and practising engineers/managers is not often effective.
- The prototypes often reflected only *hard factors* of the phenomena that they replicate.

As such, the use of these prototypes in practice proved difficult, and this coupled with the often tedious and long procedures they involved, along with the requirement of considerable *expertise* for their effective the use weakened the efficacy of these solutions. The emergence of *Expert Systems* and other *Artificial Intelligent Systems*, which in many cases relied on the then fledging IT revolution of the mid-80s was a natural reflection of 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 the emphasis it gave to the process in each function. Most of the solutions that emerged in this era addressed single activities, for example plant selection for earthworks. The results of combining isolated and independently derived optimal solutions for the various functional areas often produced a less than optimal outcome for the project.

3.4 Process and system orientation

The early to mid 90s was characterised by a holistic perspective for project improvement efforts driven in part by the sub-optimality of combining independent optimal functional solutions that make up the project. The holistic standpoint was based on the concept that the project, like any other production activity, is a process. As a consequence, the effective improvement of the project process required an outlook beyond each of the isolated activities that make up the project. This naturally called for a *systems approach*, which enables the modelling of complex and large-scale activities. This is achieved by applying systems principles to aid a decision-maker with problems of *identifying*, *reconstructing*, *optimising*, and *controlling* a system (usually a socio-technical organisation). This involves taking into account a multiplicity of objectives, constraints and resources (Checkland, 2000). The underlying principle is to specify possible courses of *action*, together with their *risks*, *costs* and benefits for the project process. Thus, by considering the system as a whole, rather than individual components, the *systems approach* provides direction as to the optimal solution for the overall project. With its origin in the biological sciences, the systems concepts include *system-environment boundary*, *input*, *output*, *process*, *state*, *hierarchy*, *goal-directedness*, and *information*. This reflects the representation of construction project depicted in Figures 1 and 2, and makes the systems approach apt for addressing many of the management situations within the sector. The growth in the number of systems-related programmes in academia, mirrored by job positions in various industrial sectors, from the 90s is symptomatic of the relevance of this concept to modern complex managerial problems in organisations.

3.5 Construction as business

The mid to late 90s was made out by the recognition that construction organisations 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. The Technology Foresight Programme (1995) for example provided a catalyst for construction to see its processes from this business perspective. Subsequent developments, such as Egan (1998) and its Latham (1994) forerunner, adopted the view of a *customer or client is king* focus, with recommendations for improvement in the value derived by the client. This was a consequence of domestic competition and emerging economic realities from increasing globalisation. The arrival of various Benchmarking schemes including the ECI Performance and Process Benchmarking Initiative provide appropriate channels for attaining such business and organisational improvement. The concomitant Key Performance Indicators (KPIs) from the Construction Best Practice Programme, and the Movement for Innovation (M4I) were aimed at spearheading a nationwide improvement in the sector. The impact of these initiatives, along with developments that have continued from them, has been a new way of doing business in construction. For example new forms of contract, such as two-stage design and construct, contract management, private finance initiations- PFI (or its root form of public private partnerships- PPP) are fostering a new business climate for the sector (HM Treasury, 2000). These changes are contributing to a re-definition of the roles and positions of key stakeholders within the sector. For example there has been a gradual shift observed in role of the architect, which had hitherto been a *lead* for the project team in the building sub-sector of construction to *concept guardian*, with the administrative lead role subsumed by other professionals (Edum-Fotwe and Thorpe, 2002). Equally observable is the growth of supply-chain principles in the sector, spurred on by a need to bring about better alignment of the various supplier organisations that provide inputs to the project. While initial efforts on this front addressed the physical logistics, later developments saw the inclusion of information resources in this improvement initiative.

3.6 Soft and human systems

From the start of the 2000s the issues that have driven improvement efforts in construction can be categories into two: *hard* and *soft* factors.

The *hard factors* refer to the mechanical operations of planning, scheduling, estimating and controlling. Improvement efforts on *hard factors* are easier to undertake and tend to dominate the overall improvement agenda within construction. It is argued that the domination of the hard factors in construction can be explained by the fact that construction is an offshoot from engineering. Its development and research in the past has therefore been influenced by its engineering tradition.

Soft factors on the other hand reflect behaviour, attitudes, learning, and communication styles, and derive essentially from the social sciences. It forms an area that is less understood and investigated in construction. The increasing recognition for the relevance of these factors to the construction project, organisation and industry has led to a growth in teamwork and partnering both at the project and company level. The call by Egan (1998) *in Re-thinking construction* and subsequent reports including *Accelerating Change*, can be seen as essentially marshalling these soft factors in the industry to ensure the recommended level of improvements (Egan 2002). Figure 3 shows how these soft factors are associated with tangible improvement in the prospects of corporate establishments within the construction sector by Re-Thinking Construction Forum.

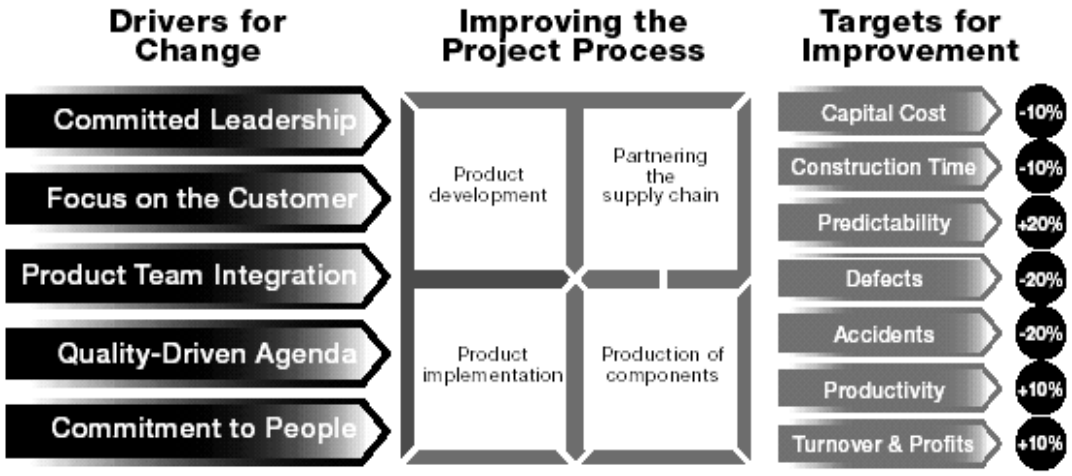

Figure 3: The Relationship between Soft Factors and Improvement in Construction (*Egan, 1998*)

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, subcontractors, suppliers and all other stakeholders in construction. The soft orientation places greater relevance on such issues as judgements and intuition, as essential elements of professional capability, and thus places a high value on the contribution that people issues make to construction. The endorsement of this human asset outlook by the Movement for Innovation emphasises the recognition of this soft orientation (M4I, 2000). Equally, the emergence of knowledge management, a systematic approach for organising and utilising the *know-how*, *memory* and *intuitive capability* within an organisation, presents a shift from the physical assets to a combined physical and knowledge assets (Malhotra, 2001).

There have been instances of *knowledge accounting* systems implemented by some organisations. The potential of this development is huge and would result in fundamental transformation of the value system that underpins the activities of the sector.

4. Current Focus of Improvement

The earlier initiatives aimed at enhancing the performance attainable in the implementation of construction projects has continued to the present. These efforts can be observed in current developments that include:

- knowledge management
- process alignments and streamlining
- cost optimisation through elimination of non-value adding elements and more accurate estimates
- design management (for example ADEPT – Austin et al., 2001)

- systems engineering
- application of the TQM to additional areas (intangible aspects of construction)
- developing alternative forms of contract (including non-adversarial options such as partnering and alliance, PPP)
- the changing role and composition of sub-contractors
- changes in construction methods through pre-assembly and standardisation
- multi-skilled workforces and team working
- distributed working at the pre-production phase (allowing specialist anywhere to combine to offer better services)
- emergence of non-corporate virtual *communities of practice*
- improving legal arrangements
- developing more compatible soft and hard technological solutions
- use of the WEB architecture as a backbone for corporate and project communication

Notable issues giving rise to these current efforts include the changing organisation dimension for construction enterprises, and the possibilities presented by, as well as the constraints posed by information and communication technologies. These are discussed further in following sub-sections.

4.1 The organisation dimension

Recent workplace innovations of a general nature such as employee involvement and empowerment, has resulted in greater recognition that workers at all levels of the organisation are a significant source of creative thinking (Kotter and Heskett, 1992). Consequently, the traditional division of work between *thinking* (white collar) and *doing* (blue collar) is gradually melding, requiring all workers to become part of an organisation-wide collaboration process (Leimeister et al., 2001). Equally, the presence of project-oriented consortia and short-term alliances in construction often means projects must be undertaken using a distributed work arrangement because of stakeholders who may be dispersed in different geographical locations. Edum-Fotwe and Thorpe (2002) provide a more detailed discussion on the emergence of such different distributed working methods that are becoming commonplace in construction. Construction and engineering organisations are increasingly looking to these collaboration efforts to make the design aspect more a part of the supply chain by doing away with design as a business-process *silo* and getting the company's designers and its suppliers working together. For example many global-oriented organisations in construction are trying to create an approach to design and production that can be described in terms of *design anywhere*, *build anywhere* in order to achieve greater efficiency.

4.2 The technology dimension

Figure 4 shows a diagrammatic representation of the transition in ICT for construction presented by McCaffer and Hassan (2002). The organisation archetypes depicted in the progression by Figure 4 is predicated upon effective and efficient systems that formally address the integration aspect required in construction.

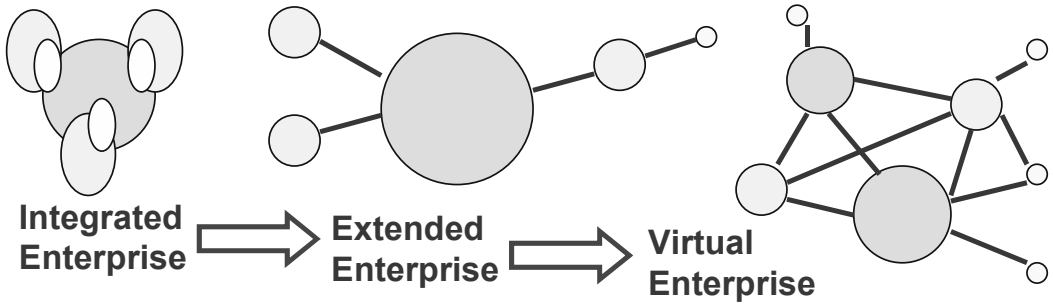

Figure 4: Construction ICT transitions (*McCaffer and Hassan, 2002*)

According to McCaffer and Hassan (2002), although a certain degree of integration already exists between some information systems within construction' organisations, there is still a need for more integration with other information systems – essentially a call for interoperability. They concede that it is not practical to expect complete compatibility between all information systems however there should be more focus on standardisation of interfaces between the different systems. They argue that ICT tools should be able to exchange digital information with other applications/systems using appropriate data exchange standards. They also highlight the need for more utilisation of existing data exchange standards such as STEP and EDIFACT as currently contractors rely on exchanging information using neutral file formats and native file formats. Neutral file formats are mainly used in exchanging information of drawings (CAD), invitations to tender, text processing and banking and accounting. Native file formats (e.g. Microsoft Office products, DWG, HTML for web technology) are mainly used to exchange information of drawings (CAD), statistical calculations (spreadsheets), estimating and virtual reality (using web technology). The emergence of generic collaborative tools at both enterprise and project levels address a significant number of the constraints identified by McCaffer and Hassan (2002). The major constraint persisting for the construction sector is the relative lack of interoperability of the different offerings available. This is being addressed at worldwide level through the Industry Foundation Classes (IFCs) that provide a bridge across the different software vendors.

The main benefits of the change brought about by IT are speed and virtual proximity, two critical elements essential for achieving success in managing construction projects. Large volumes of data can be processed faster, and distributed to disperse geographical locations much quicker (Doom, 2001). This creates a virtual proximity for distant geographical locations and has resulted in a closer world. The developments for construction have almost exclusively taken advantage of innovations achieved in other domains, and as such have moved at a pace behind IT sector. The challenge for construction however, goes beyond producing engineers who are simply computer literate and can therefore deploy the technological innovations developed by the IT sector. It calls for engineers and professionals who are astute in their areas of specialisation and equally competent to devise the IT-based innovative solutions that will address the industry's operational weaknesses from a construction standpoint.

5. Emerging Issues

In addition to the current efforts and developments in construction, there are two key aspects that potentially could bring about a major shift in the workings and structure of the sector. These are the changing role and status of professional within the sector, and the growing attention given to sustainability and green environment issues. Each of these is discussed below.

5.1 Changing role of construction professional

The growing reliance on technology as a replacement for the mundane and repetitive operations in construction, especially during the pre-production phase is bringing about a shift in the traditional role of engineers and other professionals. The availability of computer-based alternatives is in some cases rendered the role of the engineer as the only knowledgeable person capable of establishing engineering solutions for the industry less significant. Currently there are software options that provide a walk-through experience for use by non-technical persons to exercise some of the decisions of the engineer. This development is likely to grow into the future as in many cases the software serves as an aid to practicing engineers as well. The essential difference in the use of such software will be the exercise of professional judgement, an area that will help engineers not only to maintain their reputation, but also to propose relevant solutions consistent with economy, quality and their environmental context.

5.2 Sustainability

The growing awareness of the impact that the built environment has on global warming as well as the depletion of limited natural resources deployed in the construction sector is raising attention on the sector taking more responsibility for the engineering solutions they propose. Within the UK such a *responsible engineering* agenda has been encouraged by the Environment Agency through the use of environmental impact assessment undertaken on most major construction and engineering projects. More recently, a sustainability agenda has been promoted in the UK through the activities of the

Construction Best Practice Programme initiated after the Latham Report (1994) to ensure a better quality of life for everyone now and for generations to come through:

- social progress that recognises the needs of everyone;
- stable levels of economic growth and employment;
- protecting and enhancing the environment; and
- using natural resources prudently.

The agenda is underpinned by the three broad themes of environmental, social and economic accountability for construction projects. There is the need for awareness of such sustainable themes to be reflected in the training and academic development of the future engineer. This will ensure that engineering solutions proposed for the construction industry incorporate in a *strategic* way these environmental considerations, and not as an *after-thought*.

6. Where Can We Be

While the current efforts on improvement in construction have yielded considerable advancement in the sector, the full potential of the available systems and technologies available are often not exploited. A case in point is the use of ICT tools for design, whereby only a small set of the options available in most application software is exploited. There are a number of constrictions that account for this sub-optimal exploitation of the improvement potential that is available to the sector. These include the overly functional orientation within the sector coupled with the fragmentation of the project. The slow adoption of a process approach for implementing projects to overcome this fragmentation and functional orientation is beset by requisite skills to support their adoption. The contribution of requisite skills and know-how within the sector is driven by two forces, academia on the one hand and professional associations on the other. The aspirations of these two interest groups often converge, there are instances of divergence. For example, while the professional associations recognise the need for skills and knowledge renewal and strive through continuous professional development (CPD) to address this. This emphasises the growing need for a construction professional that undergoes periodic renewal of skills and re-training, and calls for academic programmes that provide periodic re-entry routes for professionals.

6.1 Defining a future agenda

The evidence from these improvement efforts combined with extraneous developments point to a future construction sector that could better exploit more efficiently the current potential of available technologies and systems. These developments include the following:
in would have

- More multi-skilled / re-trained staff, with periodic retraining being the norm.
- Skill levels will rise for some professional although these would be smaller in number as most professional roles become more routine in outlook
- More mobile workforce as the sector across different countries and regions converge, examples being NAFTA, EU, ASEAN.
- Integration of whole lifecycle of the project supported by a systems approach
- More pre-assembly/ automation/ standardisation of products
- More standardisation of design to allow designers more time to innovate
- There would have been considerable alignment of the interfaces in software and hardware as well as work processes, people materials.
- In particular, there would be considerable invasion of the production site by ICT through pervasive and emerging grid technologies
- ICT would be used as a medium instead of the supportive tool that it currently serves and facilitate virtual access to design knowledge globally at face-to-face speeds (Olofson, 2001).

These developments can be accelerated through a number of actions by the various stakeholders within the sector. These include a multidisciplinary outlook, and industry academia cross fertilisation to support both training and research, as well the widespread deployment of a soft systems approach.

7. Conclusions

The nature of construction from the sixties reflects a marked shift as a result of progressive improvement efforts that have addressed different aspects within the sector over the years. It appears that many of the earlier efforts of improvement in construction have attained maturation. For example, there is very little evidence of the earlier work study efforts facilitated the understanding of the content of work in construction. This has been replaced by a benchmarking approach to driving improvement. The rapid rate of knowledge advancement within the last four decades has resulted in a situation whereby the boundaries of various subject disciplines are extending beyond their traditional confines. As a result, a wider appreciation of construction management beyond the traditional professional requirement is increasingly becoming important for the construction manager of today. This has been exacerbated by the exponential rate of change of technological possibilities that are helping to re-define the roles of professionals and the nature of construction work itself. It is conceivable that effective exploitation of these technological and managerial tools can usher the sector into a fully fledged *grid* environment beyond the networked virtual options currently available. Clearly, academic research can facilitate the development of such a future for the sector through carefully focused investigations and developments. However, the availability of any such possibilities would not automatically translate to widespread adoption unless appropriate mechanisms are devised to ensure a continuous re-skill of the sectors employees.

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The paper number and page numbers refer to the complete paper present in the attached CD (back cover). The CD contains full version of the papers included in the proceedings.

1. Cost Engineering and Financial Issues

1.1 Cost and Financial Management

Paper 5, Page: 32-37

Impacts of Foreign Direct Investment on China's Construction Industry

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Abstract: China's national construction industry is now preparing to face the challenges, and to seize the opportunities, resulting from China's entry to the World Trade Organisation (WTO). With the foreign direct investment (FDI) hitting a record high of around US$52.7 billion in 2002, China is believed to have now surpassed the USA as the world's favourite destination for foreign investment. This fact, coupled with the huge potential for infrastructure development, indicates that the relatively large proportion of FDI flowing into the national construction industry will continue to increase in the foreseeable future. Positive aspects of FDI flowing will definetly help forging new industrial capabiliteis for China's construction industry, thus helping it to achieve the ambitiuos strategic targets set by the Governement for exporting contruction goods and services. To shed some light on the position of the national industry in the global economy, this paper briefly presents the current international standing of China's construction industry and qulatiatively appraises potential positive influences of, and challenges associated with, FDI on the national industry.

Paper 6, Page: 38-43

The Analysis on Building the Mode of Circular Economy in Chinese Construction Industry

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Abstract: To develop the circular economy is an important measure for implementing the sustainable development strategy. In this paper, based on the analysis on the characteristics of circular economy and the construction industry in China, to develop circular economy in construction industry is considered a significant way for realizing the sustainable development of the construction industry in China, at the same time, the component and current working emphases for constituting the circular economy mode in the construction industry in China are pointed out. In the end, five countermeasures on how to develop the mode of circular economy in the construction industry in China is put forward.

Paper 7, Page: 44-49

Predicting Probable Cost Allocation for Building Elements in Nigeria

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Abstract: Practitioners are usually faced with the challenge of providing initial cost solution to the design process at the inception of design process when detail design is not ready. This paper explores the possibility of relating building cost to building function and establishing a cost allocation framework that could serve as guide to practitioners at the inception of the design process. Historical data from 15 educational building, 15 residential building, 15 factory building and 20 office building were obtained and a one-way analysis of variance (ANOVA) test showed that there is a significant relationship between building function and percentage of total cost allocated to each of Roof, Substructure works, Services and Finishes. Analyses further show that such relationship does not exist for blockwork. In the case of concrete work, and painting and decoration, no inference can be drawn. Based on these results a 99% confidence interval was set up for the significant elements for educational, residential, factory and office building using the t–distribution. The study is significant because the established confidence intervals represent the percentage of total cost that could be allocated to the elements/work sections. It should guide cost advisors in arriving at a preliminary cost plan for projects. The reliability of the cost framework could be improved by using a larger data size.

Paper 8, Page: 50-55

Implication of Catalytic Role of Current Development Finance on Private Infrastructure Project Finance in Developing Countries

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Abstract: Current approach of development finance to create an enabling environment for market based-financing rather than directly providing investment funds focuses on public and private sector working approach to optimize development impact. Multilateral and bilateral agencies' participation in private infrastructure project (PIP) finance indicates this phenomenon in developing countries (DCs). Development agencies' intervention works to ease constraints in promoting PIPs through market based financing mechanisms, namely project finance (PF) arrangements in weak institutional environments. In addition to the development agencies' role as an additional financial intermediation, created institutions are in place to promote PIPs through PF arrangements in DCs. Based upon this premise, this paper examines implication of development agencies' instruments on PIP finance when arranged though PF arrangements within specifically created institutions. Empirical evidences confirm that those development agencies' instruments, namely credit support/enhancement and guarantees function to improve the debt capacity of PIP finance and thereby improve the viability of PIPs in weak legal, political and financial environments. These results shed light into the structuring of PIP finance arrangements in underdeveloped institutional environments. Thus findings highlight effectiveness of current development finance towards a sustainable public and private working approach to achieve development goals in DCs.

Paper 9, Page: 56-61

Process Cost Model for Construction Quality Measurement: Feedback and Case Study

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Abstract: A Quality Management system implemented in any construction project addresses various issues and helps achieve customer satisfaction through improved construction processes. The assessment of quality improvement (quality measurement) in a company therefore becomes important. This paper reports a study on the "Process Cost Model" as a tool to measure quality improvement. The study is based on questionnaire surveys and in-depth interviews conducted in the United States and Hong Kong. The feedback regarding the feasibility and practicality of the proposed "Process Cost Model" is presented in the paper. A case study showing how the proposed PCM can be used to measure quality improvement for a construction process is also presented.

Paper 10, Page: 62-67

Measuring Costs of Poor Quality as Short Projects: The Case of a Construction Company

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Abstract: Costs of poor quality are those costs that would disappear if the company's products and processes are perfect. It is evident that avoidance of costs of poor quality is essential to long-term organizational survival. Of that reason several researchers and practitioners argue that those costs should be tracked continuously. This paper takes a different position. It presents a case study in which costs of poor quality were measured in a construction company using a quite simple and fast method including a brainstorming session and ten individual interviews. The 56 cost elements of poor quality identified amounted to 7.1% of the annual turnover. Effects achieved were increased knowledge about costs of poor quality and increased motivation for reducing those costs.

Paper 11, Page: 68-72

A Proposed Cost-Based Approach to Building Design

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Abstract: Cost estimates of a building project need to be maintained and monitored throughout the project life cycle. While current computer applications in estimating are helpful in assisting estimators with the creation of estimates by taking off quantities automatically, they are insufficient in supporting the collaboration between estimators and other project participants (i.e. architects, engineers, and project managers) in regard to maintaining the cost estimates as the design evolves and changes throughout the course of the project. Furthermore, existing software tools are unable to explicitly rationalize how a building component or system selected by a designer affects the overall project cost. This makes it difficult for the estimator to determine when and how to adjust the cost information in the case of design changes so that the cost estimate and project scope are in balance. This paper outlines a framework for a collaborative building design environment where all project participants, during the design process, are able to keep track of the affects of their designs on the overall cost of the project. Such a computerized tool will be helpful in not only assisting estimators in creating automatically cost estimates as well as making decision on cost adjustments to ensure the budget limit, but also allowing building designers to consider cost-efficient alternative designs during the design process.

Paper 12, Page: 73-78

Risk and Reward of the Private Finance Initiative in the UK

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Abstract: To date, the Private Finance Initiative (PFI) forms one of the key elements of the UK government's strategy to deliver modern, better quality public services and to reduce public investment by increasing private sector investment. Prior to April 2003, 570 projects have been let within the UK as PFI contracts, comprising a total capital investment of over £52 billion. Almost every central government department and local authority has used PFI contracts. It is claimed that most PFI projects have two main benefits: value for money and risk transfer from the public sector to private organisations. The PFI approach provides not only an asset, but also the long-term services required to run that asset over the life of the contract. Further, while the approach brings high potential benefits to both the purchaser and the supplier, it also generates addition risks over the long term and is thought to significantly increase the workload of contractors. This paper reviews the development of PFI in the UK, analyses the potential benefits and risks of the PFI approach and examines the problems currently encountered with PFI contracts. It concludes the most main benefits to be derived from PFI projects are the promotion of a clear sustainable strategy and the development of long-term operation skills within the private sector.

Paper 13, Page 79-83

Cost Variances: Identification and Remediation

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Abstract: An ongoing concern within the construction industry is the ability to control costs. The objective of the study was to identify areas that are relatively difficult to estimate accurately. The study findings lead to prediction of those Construction Specifications Institute (CSI) divisions, which tend to have higher cost variances. Site Work and General Requirements divisions are the most likely areas for cost variances in most projects. Based on the analysis conducted, estimating inaccuracies in the two divisions were found to be the most likely cause of cost variances in projects ranging from $5 million to nearly $60 million.

1.2 Decision Making and Risk Analysis

Paper 14, Page 84-89

A Decision Support Model for Maintenance of a High Speed Railway System

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Abstract: This paper reports on a Maintenance Decision Model which has been developed to provide a structured approach to decision-making early in the design phase for the maintenance of a high speed railway system. The model functions as a decision support tool and focuses on the analysis of risks, and life cycle costs (LCC) of the maintenance phase.

A literature study on aspects related to life cycle costing and decision analysis concerning high speed railway systems was carried out and a maintenance risk regime of the Dutch part of the trans-European high speed railway system 'HSL South' was analysed.

Based on the above studies and knowledge acquired from experts a maintenance model was developed that acts as a decision support tool. The starting point of the developed model is a base case scenario, which reflects basic values of maintenance costs and risks of the system to be analysed. The model allows 'What-If' analysis to be carried out in order to determine the effects of possible design choices and risks on the costs of maintenance of the system in relation to the base case scenario. The developed system uses Monte Carlo simulation for analysing the influences of various scenarios on the maintenance costs.

Experiments using the proposed system have shown that the model produces useful analysis that supports effective decisions with regards to the maintenance of the high-speed railway system.

Paper 15, Page 90-95

The Role of CPM Scheduling in Project Risk Analysis and Decision Making

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Abstract: As engineered and constructed projects worldwide become more technically and contractually complex, the challenges associated with risk analysis and critical project management decision making are enhanced. These challenges are further exacerbated by the current international trend of streamlined project delivery mechanisms, increased multi-firm project execution, and alternative contracting arrangements. Critical Path Method (CPM) scheduling is one tool that when utilized properly can significantly increase the effectiveness of the project management decision making and risk analysis process. The use of CPM schedules in the construction industry has increased dramatically over the past 20 years. However, while this scheduling tool has become widely utilized as a mechanism for establishing a plan for executing a project, its ability to serve as an effective decision making and risk analysis tool has routinely been ignored by a majority of project managers. This paper offers insight and discussion relative to the potential ways CPM scheduling can be utilized as an effective project management tool throughout the life cycle of a typical engineered and constructed project. Specific examples are detailed to offer insight to contractors, construction managers and owners involved with international engineered and constructed projects in order to allow for an understanding of how CPM scheduling can assist in the project risk analysis and decision making process.

Paper 16, Page 96-101

Human Risk Factors in Construction

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Abstract: Human factors are sometimes recognized as the main reason or catalyst for disasters in the construction industry. They also have a considerable influence on the implementation of construction projects on a day-to-day basis. The importance of appreciating and understanding the unpredictable effects of human factors is therefore vital for project or operational success. This paper reports on the results of a research project which was aimed at identifying the significant human factors that influence construction projects. For this purpose a questionnaire survey was designed and distributed to construction practitioners. Through a formal ranking process, the importance of each factor was identified to determine the most significant human risk factors

in the procurement of construction projects. The results obtained are presented and discussed with the aim of assisting the industry to take a more holistic view of uncertainty early in projects. The findings of this research will form the basis for an extended investigation which aims to systematically model and simulate the behaviour of these human risk factors and their effects.

Paper 17, Page 102-107

Managing Value in the Construction Project Development Process

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Abstract: Value management (VM) has been practised for over 50 years but has only penetrated into the construction industry much more recently. As discussed in this paper through reflective experience of real-life case studies at different stages of the project life cycle, the benefits of the process incorporate principles of stakeholder selection, knowledge creation, team learning and effective facilitation. In addition, VM promotes the development of a sense of ownership, supports initiatives by all stakeholders, addresses the cumulative effects of whole-life impacts, and implements an integrated service delivery approach by considering all the interrelated elements that affect the project through the collaboration of all stakeholders. Value management involves reviewing past and assessing current and future issues, threats, and needs to identify priority management intervention activities that will sustain ecological, economic, and other values; it balances multiple and often incompatible objectives; it achieves sustainable development; and it fulfils institutional, policy, and stakeholder needs. In particular, its transparency greatly aids decision-making and consensus development.

2. Construction Project Management

2. 1 Supply Chain and Procurement Management

Paper 18, Page 108-113

Weak Links in 'Partnering' Supply Chains? Consultants' and Subcontractors' Views on Project Partnering

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Abstract: Many previous studies on partnering have focused on the attitudes and concerns of clients and main contractors. This paper aims at examining the views of consultants and subcontractors and investigating the ways in which they can affect the success of partnering arrangements. An initial questionnaire survey was conducted to compare and contrast the criteria and contributory factors for partnering success, together with the associated benefits, as perceived by different parties with experience in public housing projects in Hong Kong. The findings were supplemented by a partnering case study on a specific project. A project-based questionnaire survey of the participants was conducted, in parallel with interviews with the partnering 'champions' on this project. Preliminary suggestions are formulated based on the clustered consultant-specific and subcontractor-specific viewpoints on partnering. These initially suggested strategies, which need to be tested further, aim to enhance partnering success by integrating the consultants and subcontractors more closely into the envisaged client-main contractor partnership team. It is proposed that more attention is needed on these aspects, in order to fill any critical gaps and weak links in the 'partnering chain' that can otherwise reduce the potential benefits from partnering in construction projects.

Paper 19, Page 114-120

Current Practice and Concerns of the Small- and Medium-Sized Construction Enterprises towards Supply Chain Management

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Abstract: Small- to medium-sized enterprises (SMEs) constitute the majority of firms in the construction industry and are therefore of prime importance in the construction supply chain. Despite this fact, little attention has been paid to SMEs with respect to supply chain management (SCM). SMEs in Australia were surveyed (via a postal questionnaire) to identify business strategies, current SCM practices, the concerns and the barriers which SMEs encountered in developing an integrated supply chain. Amongst the research outcomes it was found that the SMEs' business strategies are mainly focused on improving profit growth, providing a high quality product and lowering total deliver costs. The SCM practice by the SMEs typically aims to reduce the delivery time of materials, as well as determine customers' future needs. At the same time SMEs are concerned with the lack of interest among suppliers and customers, lack of sophisticated information systems and competition from other supply chains. SMEs do not seem to be concerned with a lack of trust and cooperation among supply chain members as this is usually covered by contractual relationships. Despite the above provisos the findings reflected that supply chain integration is an important issue for construction SMEs.

Paper 20, Page 121-126

Extending Knowledge Management across the Supply Chains in the Construction Industry: Knowledge Sharing in Construction Supply Chains

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Abstract: Supply chain management and knowledge management have emerged as two distinct business philosophies in the last decade. Both are making rapid inroads into the construction industry. The premise of this paper is that knowledge management would make it possible for all the trading partners in a supply chain to reap benefits. Current research in knowledge management in the construction industry is generally targeting those big organisations that are main contractors. This has restricted the scope of knowledge management, and limits the benefits to a few, rather than the whole industry. If the construction industry as a whole is to prosper and improve its productivity, strategies for knowledge management strategy at the industry level must be established. This paper argues the case for extending the scope of knowledge management across the full extent of the supply chain, and attempts to identify the benefits that may arise out of sharing knowledge across the supply chain.

Paper 21, Page 127-132

Improving Concrete Delivery Performance between Concrete Plant and Construction Sites - Hong Kong Experience

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Abstract: A questionnaire survey was conducted in the first quarter of 2003 to investigate the matching of concrete supply between concrete batching plant and construction sites in Hong Kong. Fifty-one respondents provided useful information and it was found that reducing on the time of truckmixer queuing on site is essential for rectifying the inefficiency in matching. The 'miscellaneous waiting time' on site, which is the time between 'the truckmixer arrival on site' time and 'the beginning to unload concrete' time less any time spent actually queuing, was found to be of an average of about 3 minutes. It is suggested to adjust the time of arrival of truckmixer at site by 3 minutes. Hence, it is estimated that queuing time on site will then be shortened by 22%. Besides adjusting the miscellaneous waiting time, the inter-arrival time of consecutive truckmixers should be more accurately estimated by considering the truckmixer volume and the placing method.

Paper 22, Page 133-138

Measuring the Parameters of Logistics in Construction

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Abstract: Effective planning of the logistics function has for some years been considered to be an integral part of an efficient manufacturing process. The issue and practice of efficient logistics is similarly starting to attract interest in the construction sector. Construction is uniquely placed to benefit from improved logistics since construction components and materials are generally of relatively low value and high volume. At present, research in and understanding of the logistics function is addressed through the current fashion for discussing supply chain management (SCM) in the construction industry. However, in order to discuss SCM and its implications, there is an implicit assumption that the logistics function is well understood. This has to be the case since the concept of SCM is that of fully integrating the activities of both suppliers and consumers with an already known and understood logistics process. At present little work has been conducted to ascertain the workings of the logistics process in the construction industry. The aim of this paper is therefore to examine and identify the key parameters that need to be measured in order to start the process of optimisation. The paper then goes on to discuss a proposed methodological framework and research instrument for the conduct of this research.

Paper 23, Page 139-144

Global Trends in Construction Procurement

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Abstract: This paper sets out the results of recent research into the current and possible future trends in public sector construction procurement practices around the world. The study is one of the few truly global reviews of public sector procurement and provides a comprehensive guide as to who is doing what in construction procurement and what are the most likely future trends. The study involved input from practitioners actually working in each country studied and included real life experiences.

The results of this study have been placed into a global context through the use of the apportionments of global construction output for each of the studied nations. In total close to 88% of the global public sector construction output has been studied in detail. It is hoped that this review will provide construction practitioners around the world with a true reflection of both where public sector construction expenditure occurs as well as the methods used to procure construction contracts.

Following on from this basic research further detailed study and consideration has been given to the applicability of the identified new procurement trends and approaches within the context of the Hong Kong and China construction markets. This has been aimed at identifying the key barriers and benefits associated with the alternative approaches.

Paper 24, Page 145-150

Capturing and Reusing Unstructured Experiential Knowledge for Construction Procurement Selection

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Abstract: The process of selecting an appropriate procurement system for a construction project is influenced by a diversity of factors including the specific requirements of client and project and the dynamic features of environment. Procurement selection can, therefore, be regarded as an unstructured domain with inherent difficulties in capturing, representing or generalising the knowledge simply by a set of decision rules. Instead, decision-makers usually rely on intuition and past experience (through success or failure of previous similar cases) for making procurement selection decisions. While the use of valid experiential knowledge has been advocated by many researchers and practitioners as a key aspect for project success, capturing and representing such knowledge in a logical manner is never an easy task. Building upon the notion of recalling and adapting mega experiential knowledge, the case-based reasoning (CBR) approach might have a high potential in capturing, retrieving and reusing valuable procurement selection decisions for future projects. This paper discusses how experiential knowledge on procurement selection is captured and structured in a CBR format. A framework for reusing and adapting the previous cases for formulating the procurement

selection criteria and selecting an appropriate procurement system for a new project will then be proposed. Notably, a case-based procurement selection system which has incorporated the linguistic retrieval mechanism would be a first step in structuring this crucial but dynamic process.

Paper 25, Page 151-157

Reducing Construction Logistics Costs through Reverse Logistics

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Abstract: The profitability of construction materials delivery and construction and demolition (C&D) waste removal are usually considered to be separate entities – indeed separate issues entirely. However, fundamentally they have at their heart the same core values, i.e. profitability is given by subtracting costs from revenues. In both cases revenue will be dependent on the number of load-carrying journeys undertaken by the contractor. Conversely, not carrying a load on any vehicle is a non-value added activity – rather it is a cost adding activity. Transportation cost pressures on both materials delivery and waste removal are identical, made up of fuel price, direct taxation, maintenance and overheads. The pressure on all these factors is universally upwards and increases with inflation. Conversely, the pressure on revenues is always down, since both activities are subject to extreme competition as a result of the large numbers of small businesses vying for trade. In the future it will be necessary to increase the utility of transportation fixed assets, reduce unit costs, reduce total vehicle movements and hydrocarbon use. There is apparent scope to integrate the two separate functions of materials delivery and waste removal. The logic appears clear since each type of vehicle, when moving to or leaving a construction site, moves full in one direction and empty in the opposite direction. There is therefore a significant opportunity to utilize some of the concepts of reverse logistics pioneered in the fast moving consumer goods (FMCG) industries. This paper discusses some of the possibilities for using reverse logistics in a construction context in order to improve general construction sustainability.

Paper 26, Page 158-163

Determinants of Construction Manpower Demand: A Review from Literature and Practitioners' Experience

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Abstract: Manpower forecast has become an important management tool for decision makers and policy makers to match and structure the skills of the workforce. National planners are also increasingly aware that the competitiveness and growth of the nation, as well as its social welfare, depend in no small degree on the full exploitation of the skills of its people. Although numerous potential variables can be found from the literature, there have been only a few studies to identify the factors affecting the employment level in the construction labor market. This paper probes a range of factors influencing construction manpower demand through a literature review at both project and industry levels. Semi-structured interviews were also carried out in both public and private sectors to grasp the factors from the practitioners' experience. The identified determinants are vital for the development of manpower demand forecasting models in construction. It is expected that the factors will be considered and involved in the forecasting models.

Paper 27, Page 164-169

Responsibility of Design for "Buildablity" of Construction Projects

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Abstract: The construction industry has been familiar with the allocation of design responsibility among the parties with the contractual arrangement of the traditional procurement method. However, many clients are seeking other methods of procurement, such as Design-build (D&B) to meet their more exacting needs. One of the major advantages of the D&B method is the improvement of "buildablity". With the mixed roles of tradesman and design consultant under the D&B system, this

contractual arrangement is drastically different to the concept in the traditional procurement method. Indeed it tends to reverse the risk and the role of team members in a development project. This paper examines the development on "buildablity" and critically reviews the issue of design responsibility relating to "buildability" of a construction project under the traditional procurement method and the D&B procurement method. It focuses on the current issues experienced in Hong Kong and Singapore. It identifies the important issues and provides the groundwork for in-depth research on the issues related to this topic.

2.2 Construction Productivity

Paper 28, Page 170-175

Forecasting Productivity under Thermal Environment Variations

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Abstract: Many attempts have been made to establish mathematical models reflecting the relationship between the thermal environment and construction labour productivity. Once established, the models were used to forecast the change in productivity due to thermal environment variations. The models, however, failed to accurately capture the complex nature of such a relationship for a number of reasons, including a consideration of the nature of the task being performed and the effect of all known variables of the thermal environment. This paper presents an advanced thermal environment/productivity forecasting model that takes into consideration all thermal variables such as air temperature, mean radiant temperature, relative humidity and metabolic rate. Also, the developed model is capable of reflecting the nature of the construction task being performed. The paper reports on experimental as well as field data gathered to assess the predictive power of the developed model.

Paper 29, Page 176-181

Critical Factors Influencing Construction Productivity in Thailand

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Abstract: Factors affecting construction in Thailand were disclosed in previous studies carried out by the authors, which confirmed that the construction industry in Thailand has experienced productivity problems like many other countries (Makulsawatudom and Emsley, 2001a and 2001b). The objective of this paper is to identify factors that should be focused upon, when productivity improvement is to be initiated. To do so, 34 project managers working in the construction industry in Thailand completed a structured questionnaire survey and the factors were ranked according to their perception of their levels of influence and their potential for improvement based on their overall experience in managing projects in the industry. To supplement the questionnaire data, in depth interviews were conducted with some project managers. This study is intended to create the foundation for further study of construction productivity measurement and improvement in Thailand, which aims to lead to overall productivity improvement.

Paper 30, Page 182-188

Construction Foremen and Their Effect on Productivity Improvement

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Abstract: Foremen fulfill a critical role in the construction process. In this paper we address some aspects regarding construction supervision and its effect on productivity. A company should encourage the development of foreman skills which have a favorable influence on productivity. An attempt was made to summarize the traits of productive foremen. More research and training development programs in the arena of productivity improvement for construction supervisors needs to occur at the international level and made it available to the common constructor.

2.3 Safety and Quality Management

Paper 31, 189-193

Communication of Safety-Related Information in Construction

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Abstract: In the attempt to improve the performance of construction firms, one of the most important areas for attention is that of safety. According to a previous research on safety practice in Hong Kong (Wong 2002), there are 5 major factors affecting safety on sites, namely Communication, Safety Committee, Safety Training, Practice & Procedure, and Participation & Consultation. Wong showed that Communication, which is subtle, pervasive and for which not much study has been done before, holds the key for preventing safety hazards. Thus Communication can prevent problems and is crucial between main contractors and sub-contractors, the focus of this study. In this context, the paper reports on a stage of the study which aims to find out the factors that affect communication and thus identify areas for improvement.

Paper 32, Page 194-201

Life Safety Plan Review at the Miami International Airport

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Abstract: This paper presents the different approaches to the life safety at the Miami International Airport, Miami Dade County, Florida, USA. The main codes used to enforce the above are the South Florida Building Code and the South Florida Fire Prevention Code. A subset of the above requirements created by the owner is the life safety master plan and the guidelines for the designers. The South Florida Building Code and the South Florida Fire Prevention Code is used as the base of the life safety. (Code NFPA 101, NFPA= National Fire Protection Association). The main elements of life are fire rated exits, stairs, corridors, exit lights, emergency lights, for a prompt evacuation from the buildings. For fire suppression, the use of fire sprinklers, deluge, foam, clean agents (FM-200) are in accordance with the codes NFPA 13, 14, 231, 11, 12, 17, 2001. For fire detection, the installation of smoke detectors, beam detectors in accordance with NFPA 72 are utilized. Audiovisual devices are installed in accordance with ANSI A-117.1, ADA requirements, NFPA 70, NFPA 72.

Paper 33, Page 202-207

Dimensions of Product Quality and Client Satisfaction for a Large Construction Company

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Abstract: Obstacles for achieving high product quality from a contractor's perspective, e.g. inefficient work processes, attitude problems, and stress, have been scrutinized and debated for many years. However, obstacles for achieving high product quality from a client's perspective are seldom investigated. Since contractors normally work for clients in several lines of businesses, with various requirements and expectations, the implication of "high product quality" is ambiguous for the contractor. Addressing all expectations in all projects is impossible, or at least very costly, and therefore contractors must prioritize what to focus on. The purpose of this paper is to investigate how product quality affects client satisfaction in the field of commercial buildings for a large construction company. The study uses an approach that combines eight dimensions of product quality, proposed by Garvin and Kano´s model for characterizing attributes for client satisfaction. Results show that quality requirements tend to be individual, and dimensions of product quality affect client satisfaction differently. Hence, there exist no general

"high product quality" formula for a contractor. Instead a contractor needs to understand client expectations in each project, and act accordingly, in order to satisfy its clients.

Paper 34, Page 208-213

An Investigation of Ethical Behavior of Construction Professionals in Quality Management

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Abstract: In the context of improving the performance of the construction industry, the values and attitudes of the major stakeholders have been shown to be of particular significance (Fox, 1999). In essence, the level of corruption can determine the efficiency and effectiveness of construction operations in all aspects, but especially in managing quality of construction output. To counter this negative influence, the construction professions have a major part to play in establishing and upholding ethical patterns of behaviour. The aim of this research is to explore the major factors and forces affecting the decision of construction professionals in facing ethical dilemmas and study the ethical decision-making steps they adopt. The research study began with a literature review, and was followed up through empirical data using case studies. A set of Hong Kong cases, which involved corruption in the HK construction industry, were substantially reviewed and significant cases during 1997 to 2001 were selected for study. The major source of the Cases was the 'Reason of Sentence' from The District Court, The Government of Hong Kong Special Administration, supplemented with the press release of the Independent Commission Against Corruption (ICAC), Hong Kong. In this paper we present our initial findings about what kind of forces and factors drive professionals to betray the road of ethics and professionalism. Our findings tentatively evaluate the Ethics-Plus model for use by practitioners to help them in making ethical decisions.

Paper 35, Page 214-219

From QA to TQM in the Hong Kong Construction Industry

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Abstract: Certification to ISO 9000 quality management system has become a pre-requisite in the Hong Kong construction industry since nearly 10 years ago. However, benefits obtained after certification were found not very significant in previous research studies. Resorting to implementing Total Quality Management (TQM) in the industry has therefore increased. After December 2000, the time of the emergence of the ISO 9000:2000 quality management system, which is closer to TQM philosophy, construction organizations in Hong Kong already certified to the year 1994 version will need to be re-certified to this new year-2000 version before the end of 2003.

This paper reports a research study conducted to identify key successive factors for the construction industry in Hong Kong to upgrade their quality management systems from quality assurance (QA) concept to TQM concept (or upgrading from existing ISO 9000:1994 to new ISO 9000:2000). The respondents' views on the present status of applying both QA and TQM in the industry and their practical experiences have been evaluated through questionnaire surveys.

Paper 36, Page 220-225

A Survey of TQM Implementation within UK Construction SME's

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Abstract: This research paper focuses on the practical issues associated with implementing TQM Systems within Small and Medium Sized Construction Related Organizations. The findings of the paper are based upon a comprehensive literature search and empirical studies conducted with 63 construction firms either adopting the TQM process or intending to.

Thirty-four different quality features are correlated with four different performance measures. The study used Canonical correlation methods to correlate simultaneously the quality features to the assessment of performance measures. In summary it can be stated that the rate of implementing quality related initiatives is high in organizations having a formal TQM system. Where as for those organizations that may not be implementing TQM, the findings suggest that these organizations do have some informal TQM in place based on the relative advancement indices.

This paper concludes by presenting a new methodology for classifying organizations based on the spiral approach. It involves nine new different classifications. It further introduces a new grouping called middle of the road organizations and splits the existing Award winners, Improvers and Drifters into six mirror images new groupings.

Paper 37, Page 226-231

TQ-SMART: Total Quality- Self Monitoring & Assessment Rating Tool

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Abstract: This paper presents the development of TQ-SMART, a model designed for assessment and monitoring levels of advancement in Total Quality Management (TQM), in Construction-related small and medium-sized organizations. Many small and medium sized organizations opt not to adopt TQM principles, while inherently exhibiting some of the quality initiatives. This study was designed to assess the levels of advancement of implementation constructs in both TQM and non-TQM organizations. The result of the study show that while TQM deploying organizations were more advanced in the observation of the deployment constructs, non-TQM organizations exhibited marked levels of achievement of implementation constructs. Though various assessment models exists, and literature has examined issues such as organizations needing to identify the unused capabilities, there is lack of formal methods of working out the unused capabilities or conducting empirical studies.

Paper 38, Page 232-238

Learning by Organisations: A Study of the Attitude of Professional Services Firms in Construction towards Clients' Feedback

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Abstract: Quantity surveying (QS) companies, which are a kind of professional service firm, depend on quality service and satisfied clients to succeed. As professional advisors to their clients, their traditional role as "the expert" who knows what is best for the client has changed greatly. The Royal Institution of Chartered Surveyors has urged QS firms to shift from their traditional services-offered orientation to a more client-centred orientation (RICS, 2000). The main aim of this study is to investigate various facets of QS firms' attitude towards clients' feedback in four regions: Australia, Hong Kong, the UK and the USA. A questionnaire survey was considered appropriate for collecting the opinions of QS practitioners selected through random sampling. The findings show that they are generally positive to client feedback. More than half like to solicit such information. The respondents agree that client feedback is beneficial in many ways. The main obstacles to seeking client feedback include taking the risk of offending clients, as well as the fact that clients are sometimes reluctant to provide feedback to their consultants.

2.4 Partnership and Contractual Issues

Paper 39, Page 239-244

Comparative Study of Partnering Practices in Hong Kong – A New Research Initiative from CII-HK

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Abstract: Greater interest in construction partnering has been detected in recent years. Some of the interests follow the success of partnering in non-construction fields such as manufacturing and professional services. Hong Kong has followed this trend and partnering arrangements can be found

among some of the major players and authorities. Building works have been procured in a traditional manner where clients appoint design consultants to represent them to produce design and supervise the construction work. The adversarial relationship between clients and construction contractors inherited in this delivery system has been criticized by the Construction Industry Review Committee (CIRC, 2001) as one of the major stumbling blocks to endanger the success of the construction industry. Partnering, which aims to generate an organizational environment of trust, open communication and employee involvement, has been advocated as an effective means to achieve value for construction procurement.

To respond to the CIRC's recommendation the Construction Industry Institute of Hong Kong (CII-HK), a research institute established by the practitioners and academia in 2001, initiatives a research study to compare the project partnering practices in both the public and private sectors. The study is supported by the Hong Kong Housing Society (HKHS), the Hong Kong Land Ltd. (HKL) and the Mass Transit Railway Corporations (MTRC). It aims to compare the partnering practices in the public and private sectors of the Hong Kong construction industry.

The aim of this paper is to provide an interim report of this research study. A concise review of the partnering practices in Hong Kong will be discussed, followed by an outline of the research framework. It is anticipated that useful and practical conclusions will be drawn from this comparative study. Lessons learned from this study will be broadly disseminated to help improve the well being of the construction industry.

Paper 40, Page 245-250

Application of Delphi Method on Critical Success Factors in Joint Venture Projects in Malaysian Construction Industry

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Abstract: This paper discusses the application of the Delphi Technique to validate the findings from previously administered questionnaire surveys and in-depth interviews into joint venture projects in Malaysia. The aim of the Delphi Technique is to achieve consensus of opinion amongst the selected expert panelists in Malaysia on the primary factors in JV projects. It is primarily concerned with using selected expert panels to assist in gathering data and information to achieve research objectives, by designing a progressive series of questions to which a selected panel of expert responds. A rationale for the use of Delphi is given, its benefits and limitations and recommendation for its use are provided. The main crucial to joint venture success was identified from literature review identified twenty-one factors as critical to the success of the joint venture projects. The Delphi Panel confirmed that inter-partner trust, mutual understanding, criteria for partner selection, agreement of contract, compatibility of objectives, conflict and commitment were the critical success factors and fourteen factors were also identified as Failure Reduction Criteria. The application of Delphi Techniques helped to identify the primary factors, which will be useful to support the successful application of joint venture arrangements in construction projects in Malaysia.

Paper 41, Page 251-256

Interaction Dynamics of Cooperative Alliance Relationship in Construction

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Abstract: Construction alliance formation has been proliferating both in the industry and research. However, extant research in cooperative alliance relationship has been static and has underplayed the complexities and dynamics of cooperation. It is still a myth that some alliances successfully engineer cooperation among partners while some fail. The process and mechanism to built cooperative alliance relationship has been largely ignored. This paper addresses these issues by adopting a social network approach to examine cooperative alliance relationship from two different aspects: (1) engineering of cooperation by interaction; and (2) dynamic evolution of cooperation. Construction project is consisted of interconnected network of human and physical resources and the interactive relationship between them. This study argues that cooperation in alliance is fostered by frequent communication. Communication structure changes when construction project moves to different construction phase. Hence, this study also argues that alliance relationship evolves alongside with different construction stages. Case study approach has been adopted. Relational data was collected through documentary evidences and questionnaire survey. A

versatile social network analysis software package UCINET 6.0 was used for data analysis.

Paper 42, Page 257-262

The Governmental Role in the Development of PFI/PPP Scheme

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Abstract: Nowadays, global trends of privatisation as well as reduced governmental roles continuously lead to the promotion of infrastructure development under the PPP/PFI scheme. However, privatisation has political as well as economic dimensions. Both successful and unsuccessful PFI/PPP-based projects testify to the truism that appropriate, legal and economical environments are a pre-requisite for the initiation of such schemes. Such environments must, of course, be fostered by the host government. 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. Specific literature discussing governmental practices in managing PFI/PPP projects is scarce. It is therefore meaningful, in this paper, to study the governmental role of successful PPP formulation in terms of corporate development including the development of project documentation and procedures, human resources and technology, and to examine thoroughly the technology know-how and the barriers that have to be overcome such as: political, regional, social, religious, ethical and economic. The aforementioned factors in accordance with the operations of translational firms under PPP contract and configuration of their partnering organizational structure and culture and the European region construction competitiveness will identify the appropriate government roles regarding the formulation and administration of PPP projects.

Paper 43, Page 263-268

Possible PFI/PPP implementation in a Variety of Greek Industrial Sectors

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Abstract: This paper addresses the location of possible economic sectors of the Greek National Economy where the PPP/PFI scheme can be implemented. It presents all those possible public sector investments, the implementation of which can be undertaken by suitably selected bodies of the private sector. Specifically, as PPPs can embrace a wide range of structures and concepts, both in 'hard services'-such as the execution of roads, bridges and airports- and in soft services'-like hospitals, prisons, defence and IT services' projects – the research examines the degree of investment attractiveness by the private sector taking into account a number of primary and secondary value for money drivers applied to the Greek market and culture. The methodology process follows a certain structure, relevant to the Arthur Andersen and LSE Report. The paper concludes with the findings of the most prosperous PPP projects and the barriers to be overcome regarding value for money drivers in the Greek market.

Paper 44, Page 269-274

Construction Management Practice of Joint-venture Projects In Shanghai and China

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Abstract: As the largest city in China, Shanghai is developing rapidly. A large amount of foreign capital has been invested in Shanghai every year. Because of risk and policy tendencies, most of foreign investment is combined with local companies or government. Following with foreign investment, more and more foreign contractors come to compete for the joint venture projects. In order to win a joint venture project and keep it go smoothly, a contractor must obey the national and local laws. This paper describes a typical construction organization and some characteristics of joint venture projects. Also some questions in practice are discussed in the end.

Paper 45, Page 275-280

Managing and Resolving Conflict in Project Environment

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Abstract: Conflict is a part of project life; therefore conflict is inevitable in any organizations, primarily due to the ever-increasing complexity of our modern society, the innate nature of human beings and the interaction of the two. As the complexity of society increasing the classical, tradition organization styles are becoming more relevant to today's business and government environments. Inherent in these never organization styles are the high incident of rapid change and in congruent by the nature of the project work. The project manager, the person with the key responsibility to make the project successful, has no choice but to deal with this high level of conflict. Project management is in fact management in a highly conflictive situation and in many ways can be considered almost synonymous with conflict management. The main objective of this paper is to examine the main causes of conflict in project environment, and suggest the best way of handling as well as solving them.

Paper 46, Page 281-286

Client-Consultant Relationship in Building Development Projects in Singapore

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Abstract: Good client-consultant relationship is the capstone in today's building development industry, which faces the challenges from technological advances, dynamic market conditions and global competition. Healthy relationships are absolutely necessary for clients to meet or exceed project goals and for consultants to secure future contracts and useful references. This paper examines the state of the client-consultant relationship in building development projects in Singapore, using survey questionnaire and interviews. The study found that clients perceive consultants as not spending sufficient time on projects, expecting them (clients) to know exactly what they want and are reluctant to make changes once detailed design commences. In contrast, consultants perceive clients to be giving unreasonable timeframe for assignments, slow and indecisive in authorization and not valuing efforts made by the consultants. The study suggests that clients and consultants adopt a partnership mindset and work proactively towards common projects goals; have mutual respect, trust and understanding through formal and informal communications to enable both parties to work for project success. Other inherent conflicts between clients and consultants are analyzed and advantages arising from such a partnership approach are discussed.

Paper 47, Page 287-292

Modeling the Satisfaction of Clients and Architects Based on the Performance of UK Contractors

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Abstract: An assessment of the performance of UK contractors as considered by clients and architects is

presented and used to develop models of client and architect satisfaction respectively, using the artificial neural network technique. The models suggest that contractors should prioritise their attempts to complete projects on budget and on time. Further, the models highlight the importance of the procurement of the contractor which needs to be carefully considered. Due to its adversarial nature, the competitive tendering approach is likely to discourage good performance and hence lower satisfaction levels. In this case, a contractor selection methodology based on negotiation and previous working relationships would encourage higher satisfaction levels. The models demonstrate accurate and reliable predictive power as confirmed by validation tests. Although several variables identified were uncontrollable (i.e. dependent on the subjective perceptions of the assessors and the type of project), coalition participants could use the models to help improve contractor performance leading to more successful project implementation. This will also promote the development of harmonious working relationships within the construction project coalition.

Paper 48, Page 293-298

Subcontractor Bidding Practices in Multiple Invitations to Tender vis-à-vis Service Trades

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Abstract: Bidding practices of seven New Zealand subcontractors involved with service trades were investigated with specific reference to multiple invitations to tender (under the same job). Most subcontractors submitted bids to all 'invitations'. Consequently, factors that affect decision to tender appeared to be of little value. Main contractors who pay on time, provide efficient site management, who establish and maintain good relationships, and have good reputation received favoured (or same) prices whilst others were discriminated by 0-10% depending on the level of risks associated with these attributes.

Paper 49, Page 299-304

International Management in Construction: Organizational Issues and Selected Empirical Findings

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Abstract: Global ventures are always full of challenges, opportunities and risks. For international engineering and construction businesses, the risks of internationalization are traded against an upsurge in new opportunities and potential returns that evolve with deregulation of industries and increasing liberalization of emerging markets such as China, India and Eastern Europe. In academic and research studies, international management stands out as a multidisciplinary field with considerable intellectual diversity and non-uniform empirical findings shaped by differing industrial contexts. Given the wide spectrum, this paper focuses only on selected aspects of international management within the context of construction. The first part presents some interesting empirical results extracted from a more comprehensive study of twenty-four large international engineering and construction firms. Specifically, the revenue composition of these firms – classified by geographical regions, sheds some light on the behavioral aspects of firms towards internationalization. The appropriateness of four different mechanisms of coordination (multi-domestic, international, global, transnational) to construction is briefly commented, while it is suggested that in the long run, the transnational organizational model is the most ideal setting to strike a balance between global integration and local responsiveness. Finally, an evolutionary pattern of organizational models is proposed for moving along the internationalization process.

2.5 Project Management Issues

Paper 50, Page 305-311

Construction Industry's SMEs in the 21st Century Findings of a Case study on SMEs in the Dutch Steel Construction Industry (SCI)

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Abstract: Small and Medium scale Enterprises (SMEs) are of high importance for economies of many countries. This also applies for the SMEs of the Construction Industry where they make up a large portion of the total number of establishments as well as in terms of contribution to GDP, turnover, employment and innovation potential. As such, the SME sector will remain the backbone of virtually every economy in the world and of the construction industry in the foreseeable future. In the development context of the global economy SMEs and, in fact, all business firms have to manage growth and competitiveness in an environment where the pace, patterns and organization of production have changed since the last decennia. The competitive strengths of SMEs in the globalizing market my be found in their internal capabilities as well as the strength of their external linkages in the innovation system with a network that enhances their access to certain critical resources like finance, technology and managerial skills. This paper discusses the findings of a study on the factors of competitiveness of SME´s in the Dutch Steel construction Industry and their challenges for development. Given the economic importance of SMEs support measures are necessary to nurture SME growth and competitiveness.

Paper 51, Page 312-317

A Soft Approach to Solving Hard Problems in Construction Project Management

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Abstract: Construction projects are faced with a challenge that must not be underestimated. These projects are increasingly becoming highly competitive, more complex, and difficult to manage. They become 'wicked problems', which are difficult to solve using traditional approaches. Soft Systems Methodology (SSM) is a systems approach that is used for analysis and problem solving in such complex and messy situations. SSM uses "systems thinking" in a cycle of action research, learning and reflection to help understand the various perceptions that exist in the minds of the different people involved in the situation. This paper examines the benefits of applying SSM to wicked problems in construction project management, especially those situations that are challenging to understand and difficult to act upon. It includes relevant examples of its use in dealing with the confusing situations that incorporate human, organizational and technical aspects.

Paper 52, Page 318-323

An Assessment Framework for Project Success in Healthcare Projects

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Abstract: Completed on time, within budget, and with specified quality standard have been widely recognized as the predominant targets of a successful construction project. As time goes by, the criteria of project success are becoming more demanding. A project can be considered successful only when it achieves all its functionality and purposes, environmental friendliness, being completed with low accident rates, and free from any claims and litigation. High level of profitability and satisfaction of various contracting parties are also important indicators for project success. This paper aims to

identify the success criteria for healthcare projects in Hong Kong. A general framework for measuring project success was established after a comprehensive literature review. A series of detailed structured interviews were conducted with a group of practitioners who had hands-on experience in hospital projects. Their views on the success criteria were collected and a set of Key Performance Indicators (KPIs) for healthcare projects were developed. Findings from this study could help to develop a benchmark model for evaluating the performance of a healthcare project. Further detailed case studies should be launched to assess the usefulness and advantages of such benchmark model to the construction industry.

Paper 53, Page 324-330

Civil Engineers and Work-family Conflict: The Role of Workplace Support on their Work and Non-work Satisfaction and Well-being

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Abstract: Many of the job and organizational factors found to be negatively associated with family functioning are pertinent to civil engineers. Research suggests that work-family balance practices can enhance organizational efficiency through increased morale, higher productivity, greater company citizenship and lower absenteeism and turnover. However it has also been shown that factors embedded in the organizational culture can undermine these policies rendering them ineffective. This quantitative study examined the relationship between a supportive work culture and the work and life experiences of Australian civil engineers. Data were gathered from a sample of 1000 male and female civil engineers in a wide variety of work and family situations. The research investigated the prevalence of organizational values supportive of work-life balance and the level of work-family conflict perceived by civil engineers. In addition the relationship between the supportive work culture perceptions to other variables, such organizational commitment, work and non-work satisfaction and well-being was investigated. This paper reports initial results of the study. These indicate that civil engineers who perceive their organization's values to support both their work and personal life reported greater organizational commitment and job satisfaction as well as lower intentions to quit. In addition these engineers also reported higher levels of life satisfaction and lower levels of work-family conflict. The implications of the findings for organisations employing civil engineers are also discussed.

Paper 54, Page 331-336

Design and Build Contracts: Design Management and the Ways Forward

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Abstract: The design management process is an important part of project management in Design and Build Contracts. Under this procurement system, the team members, including client's representative, D&B contractor and designer, have to adopt the changed roles and responsibilities to cope with the increasing complexities, demands and scale of modern practice for large-scale projects. The design responsibility is transferred from the client's organization to that of the D&B contactor who is responsible for the design management of the projects. Research indicates the management of design is one of the major concerns in D&B projects. This paper presents a study carried out in Hong Kong, which reviews the concerns in design management of D&B contracts. It highlighted the concerns of three groups of project participants: clients, D&B contractors and designers. Results of the study indicated that briefing, experience of client, client change, time for design proposals and coordination of drawings are the major design concerns in management of D&B Contracts.

Paper 55, Page 337-342

Management Profiles on Empowerment of Construction Project Team in the Singapore Construction Industry

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Abstract: This paper focuses on addressing two main concerns – identifying the existing predominant management styles pertaining to the Singapore local construction industry and their perceived influence on the organizational performance. The content of this paper is derived from a study focusing on the employee side of a CPE model with data gathered from local medium to large-sized construction companies. The paper discusses and analyses some of the key results obtained from this study and identified the pattern of preference in adopting the four predominant forms of management style - the directive, supportive, empowering and contingency model. Characteristically, the study noted that on a continuum model of management style, the industry prefers to adopt a moderate approach of supportive management style over the other three models. The study also noted that it is the general perception of respondents that if companies choose to allow greater freedom of empowerment in project team, it should lead to better organizational performance.

Paper 56, Page 343-348

Searching for Success in Design-Build Projects – A Qualitative Survey of 23 Practitioners

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Abstract: Success is an abstract expression which means different things to different people. With the wider application of procurement alternatives to construction projects, industry practitioners have shown more concerns on the success criteria of the alternative procurement systems, like Design-Build (D&B). This paper investigates how 'success' is defined and achieved in design-build projects. It first provides a summary of the literature review on project success for design-build projects. An empirical study has also been carried out with twenty-three D&B practitioners in Hong Kong to further identify the criteria and factors critical for the success of D&B projects in practice. Key findings from the structured interviews indicate that the success criteria and critical success factors of D&B projects are similar to those of a construction project in a generic sense. The study is considered exploratory to reaffirm the attributes of D&B project success in literature on which the framework of the questionnaire is based. While the interim findings were delivered for the research of D&B project success in Hong Kong, further extensive research on the quantitative analysis of the success criteria and critical success factors for D&B projects is envisaged to be undertaken for achieving a successful project delivery process.

Paper 57, Page 349-354

Competitive Construction Management of Microelectronic Facilities

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Abstract: The paper presents key drivers of construction management in highly competitive semiconductor construction projects. The growing volatility of the global chip markets, the cost-intensive production, fast-track construction and GMP-contracts increase the risks of investments for design-build contractors significantly. Therefore, high innovative and complex process technology requires an integrated process-related approach for construction management to identify risks and manage components in construction successfully. The paper illustrates the scanning, planning and implementation phase of two 300 mm wafer facilities. The base-build construction for a wafer fabrication with a total volume of 1.1 Billion US$ was recently completed within 18 month. It will be emphasized generic criteria for evaluation of core competences and resource allocation. The identification of main technical risk such as soil conditions, high level of variation, complex interaction of civil, mechanical and electrical disciplines, logistic flows and procurement interfaces for the cost evaluation and the overall performance is shown.

Paper 58, Page 355-361

Determinants of Construction Durations for Building Projects: A Hong Kong Perspective

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Abstract: Construction projects are often launched in a fast changing and highly unpredictable environment. Construction Time Performance (CTP) has long provoked considerable concerns and interests of many construction researchers and project managers worldwide. This paper outlines the overall research process of the first phase of a funded research study which is being undertaken to identify significant factors influencing construction durations of building projects in Hong Kong, and to evaluate their relative importance.

Opinions of 93 project stakeholders were sought via a postal questionnaire survey and evaluated using factor analysis technique. Preliminary findings of the first phase investigation are highlighted and discussed. Such a determination of critical 'time' factors could subsequently generate a benchmark model for predicting project durations and effective strategies for mitigating project delays, which would be the main focus of the second phase of this study.

Paper 59, Page 362-367

A Benchmark Model for Construction Durations: The Case of New Cruciform Type Public Housing Blocks

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Abstract: Construction time has been recognized to be one of the most important performance measures of many successful projects. Considerable efforts have been devoted to the issue of how to benchmark best practice measures of construction time performance (CTP) for use in the industry. A research survey was undertaken to determine a set of critical factors that affect the construction durations for primary work packages of high-rise public housing projects in Hong Kong. Data were gleaned from a representative sample of 15 standard 'New Cruciform' type residential blocks via mailed standard questionnaires. Multiple regression technique was applied to data analysis and model development. The predictive accuracy of the developed model was next conducted by comparing the predicted values against the actual data set and confirmed significant. The regression model serves as a useful benchmark tool for an optimum time estimate for delivering such type of public housing projects. A comprehensive study is currently being launched for private sector housing blocks in Hong Kong by adopting similar research methodology, for national and international comparisons.

Paper 60, Page 368-375

Study on Reasons for Delays in Civil Engineering Project in China

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Abstract: Project delay is a conspicuous and common problem in the construction Industry, and it is one of the most important reasons leading to runaway in progress rate, quality, investment and dispute in related aspects. Big loss is often caused by project delays. If main factors that influence progress can be found by means of investigation and studying, a model that can forecast the rate of progress in project may be built. The model has very important significance in settling down some problems, such as project delay and blindness usually existed in Chinese project at present. First, construction duration is analyzed. Next, 8 major factor categories are determined, which include 54 main delay factors. Then, based on based on data collected from 122 valid questionnaires, 10 key factors are determined. Finally, influencing factors and consistency of delay factor categories for construction duration caused by contractors, consultants, designers and clients are worked out. Reliability of the investigation is determined and conclusions are presented.

Paper 61, Page 376-382

Is Construction Industry in China on Right Track?

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Abstract: The construction industry in China has gone through a market-oriented reform since 1984. Has the sector been made fully market-driven and institutional arrangements been made for construction markets to operate efficiently and effectively? What institutional innovations have taken place in recent years? Has the competition

raised efficiency of allocation of resources and well being of the society? Is there any problem that needs further institutional changes? This paper describes the current status and a number of problems of construction markets in China, such as "over-competition", "tendering show", and default of obligations for payments, redundant and thus inefficient institutional arrangements and finds out the institutional factors that have caused the problems. In addition, issues of making construction markets more efficient have been addressed as well.

Paper 62, Page 383-388

Comparative Analysis of Civil Construction Project Type using the Concepts of ETO (Engineering to Order)

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Abstract: Using classifications is a way of facilitating the communication between actors of a job field. In the construction sector, settle the information about material specifications, costs, customer needs, etc. The classification of production systems allows identifying administrations techniques that is adequate to the characteristics of the productive environment in each sector, helping organizations have quality rises, high levels of performance, low costs and this way being more efficient in process. The engineering to order (ETO) is the most common type of contract on construction industry being the design developed by previous definitions with the customer, but the construction only starts when the customer gives the order, between formal contracts. The product of civil construction becomes this way highly customized and the customer satisfaction depends on fundamentally the interaction organization – customer. This paper approaches the characteristics of civil construction product using the concept of ETO production.

Paper 63, Page 389-396

Virtual Team Concept and Construction Project Delivery Systems: A Compatibility Analysis

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Abstract: The concept of virtual teams (VT) is gaining increasingly more attention in the construction industry. The recent advances in information and communication technology (ICT) have increased the effectiveness of virtual teams in different construction management operations. However, the question remains – "are virtual teams appropriate for every construction project?" There is not much information available on this issue. In this paper we attempted to explore the applicability of virtual teams (VT) concept to various construction project delivery systems (PDS) by performing a compatibility analysis. A VT and PDS compatibility model is developed and analyzed using three case studies taken from real life construction projects. On the basis of this model, recommendations can be made regarding the suitability of a particular project delivery system for implementation of the virtual team (VT) concept.

2.6 Knowledge Management in Construction

Paper 64, Page 397-405

Application of Knowledge Management in Construction Production Management

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Abstract: Knowledge Management (KM) addresses the critical issues of organizational adoption, survival and competence in the face of an increasingly changing environment. Knowledge is rapidly

becoming the most important asset of every organization. Construction is no exception. The ability to manage and exploit knowledge will be the main source of competitive advantage for the construction industry of the future. In that role, knowledge management will improve production management and avoid or minimize losses and weakness that usually come from poor performance, and will increase the competitive level of a company and its ability to survive in the global marketplace. This paper is concerned with the improvement of production management theory through the application of some core principles in the construction context. The best production practices world-wide have a common core. The cores principles investigate are the "reduction of cycle time", "reduction of variability", "increased transparency" and "development of continuous improvement into the process". The fundamental rational underlying these principles is the concept of flow where production is seen as composed of waiting, transporting, inspecting and transformation (processing) activities. According to this concept, transformation activities are the only ones that actually add value. Hence, all other activities should be reduced or eliminated from the flow whilst increasing the efficiency of transformation activities. The paper suggests the development of a knowledge management model in production management appropriate for the construction industry. It is anticipated to serve as a foundation for wider applications of knowledge management in other sectors of the construction industry. The paper also aims at gathering data on the philosophy and practice of construction firms pertaining to the utilization and management of tacit and explicit knowledge. Of priority the paper is set to identify and develop a service and production system based on knowledge management.

Paper 65, Page 406-413

CLEVER_KM - An Innovative Tool to Assist in the Development of Knowledge Management Strategy

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Abstract: CLEVER_KM is an innovative knowledge management system that has resulted from the EPSRC-funded CLEVER (Cross-sectoral Learning in the Virtual Enterprise) project at Loughborough University. The project delivered a framework for supporting the implementation of Knowledge Management (KM) within any business organization to ensure that the solution(s) adopted match an organization's KM problem and its business objectives. It was developed following a study investigating knowledge management practices and processes in the construction and manufacturing sectors. This paper describes the CLEVER framework from a system viewpoint and shows how it could assist in the development of knowledge management strategy.

Paper 66, Page 414-419

CLLIS - A Lessons Learned System for Knowledge Management in Construction Organizations

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Abstract: Knowledge Management (KM) is a concept that is gaining wide acceptance and is being implemented in various industries as an enabler of better decision-making. KM can be defined as the management of knowledge-related activities involving knowledge-workers in an organization to achieve the specified organizational goals and objectives. KM concepts can be implemented to capture and reuse the construction knowledge derived from this information for improving the construction business processes in terms of time, cost, safety, and quality. This paper addresses the issues involved in the design and development of a Lessons Learned System (LLS) on the conceptual basis of Case-based Reasoning (CBR) for effective & efficient KM in construction organizations. An Internet-based prototype tool, CLLIS (Construction Lessons Learned Information System) has been developed to collect, document, store, retrieve, and reuse the construction lessons learned.

Paper 67, Page 420-425

Development of Knowledge Management System for Small & Medium-sized Construction Companies in Korea

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Abstract: Knowledge Management has become an essential need for survival in the over-all industry, not as a simple paradigm but as a critical factor for success. Construction enterprises show a strong tendency to adopt Knowledge Management, and are developing Knowledge-based Systems for Information Technology (IT) application in Korea. But small & medium-sized construction companies have many difficulties in introducing knowledge management in contrast to the large enterprises: such as the recognition for Information Technology and financial difficulties. This study is aimed to develop Knowledge Management System for small & medium-sized construction companies not having introduced knowledge management due to these difficulties. This paper analyzes present conditions of small & medium-sized construction companies through the Information Strategy Planning (ISP) method, and provides the flexible KMS model to be used by them.

2.7 Project Planning and Control

Paper 68, Page 426-431

Evaluation of Critical Path Methods For Linear Projects

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Abstract: Critical path determination in a linear schedule is essential in order to provide a widely accepted method for scheduling linear projects. The last five years, two methods have been proposed for the determination of the critical path. Research done on the comparison of the two methods, concluded that their results coincide for some simple activity configurations. This paper expands the comparison by including a third method developed by the authors and more complicated activity configurations. The results obtained are discussed.

Paper 69, Page 432-438

Development and Applications of Genetic Algorithm Enhanced Resource-Activity Critical-Path Method (GA-RACPM)

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Abstract: Development of efficient, straightforward, and computer-based methods for optimizing critical path scheduling under resource constraints is highly desired and regarded vital by construction professionals in addressing the limited availability of skilled labor and the increasing need for productivity and cost effectiveness. This paper presents follow up research of developing an enhanced version of the resource-activity critical path method (RACPM) for construction planning that minimizes the project duration using the genetic algorithm (GA). The steady-state uniform-crossover GA was adopted in optimizing the RACPM's forward pass to give the shortest project duration. A computer system called GA-RACPM was developed into an add-on tool of the MS Project to automate the GA optimization and the forward/backward pass analysis of RACPM. Applications of GA-RACPM on a benchmark project and a road improvement project in Hong Kong demonstrated the superiority of GA-RACPM over the existing resource scheduling methods, in terms of optimization performance and computing efficiency.

Paper 70, Page 439-444

Development of a Blueprint "Performance Indicators system" to Support Control Processes for Project Management

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Abstract: This paper reports on a "Performance Indicators" system to support control processes of project management within a construction organization. The purpose of Performance Indicators (PIs) is to enable measurements of project and organizational performance for benchmarking and

control purposes. This paper explains what the principle of benchmarking represents for best practice, how it may be used in a construction organization, and what it means to implement PIs in such an organization.

In recent years a set of Key Performance Indicators (KPIs) is produced and used to assess performance of an organization involved in a project or, more commonly, many projects. These KPIs provide targets for the Construction Industry against which performances can be measured. Though they appear to have had some success in improving the industry, they are too general and have little use for control of specific activities and processes within an organization.

In this work an extensive study is carried out on how and what to measure when developing specific and self-defined PIs for organization, project or process. A method for implementing indicators, which includes Information, Measurement and Action plans, is suggested.

Paper 71, Page 445-449

Value Management in Hong Kong – Its Success and Barriers for Future Development

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Abstract: As a result of economic downturn in recent years, there has been an ever-increasing demand from clients to pursuit for value for money for their construction projects in Hong Kong. In order to have optimum cost at no expense of the required quality, value management technique is developed by analyzing the functions of design components so that alternatives can be used to provide the same functions of performance. The aim of this paper is to examine the current successful use of this technique for a number of Hong Kong construction projects and its barriers for future development. The findings from the structured interviews show that value management is growing continually. Public sector clients are still acting as the main motivator and promoter for its implementation. “Lack of value management knowledge” and “Reluctant to change” are the major barriers for its growth.

Paper 72, Page 450-455

Development of an Innovative Managerial Control System: An Application to the Precast Concrete Building Products Industry

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Abstract: The monitoring of business processes and their variables has strategic importance in order to respond to today's dynamic business world. This paper introduces an ongoing research initiative, which is focussed on developing an innovative managerial control system to analyse historical and on-line information about business processes, establish relationships between internal and external business process variables and advise senior management on future decisions. Multivariate Statistical Process Control (MSPC) techniques, which have been applied in chemical and process industries to control process operations, are utilised to model, monitor and control business process variables of Precast Concrete Building Products industry. Through a detailed case study, this paper illustrates offline modelling of business process variables utilizing MSPC techniques such as Principal Component Analysis. Also, a methodology is discussed for the monitoring of business processes and dynamic feedback for corrective actions to managers if the business processes are found out of control.

Paper 73, Page 456-461

SimStock: A Stockyard Layout Planning Tool for Precast Concrete Products Industry

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Abstract: A prototype "SimStock" was developed for realising efficient stockyard layouts in Precast Concrete Products industry. SimStock consists of a process simulation model (developed in ARENA-simulation software) and the inputs to the simulation model include spatial data about the stockyard

(derived from AutoCAD 2000), MS Excel production and forecast schedules, and sales and other data stored in MS Access databases. The simulation model evaluates throughput time for loading and dispatch of the products to service customer orders, queuing and waiting times of lorries in the stockyard and cost of loading of products in the stockyard for a given allocation of products to storage locations. Genetic algorithms were developed to identify the optimum allocation of products to the storage locations.The findings from the experimentation of SimStock using a case study are analysed and discussed and the suitability of the prototype is presented.

2.8 Construction Education and Training

Paper 74, Page 462-467

Towards a Learning Construction Organization: Knowledge and Human Capitalizing through a New Paradigm of Training, "E-Learning"

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Abstract: In the past two decades the growing interest in organizational learning is evident. Many organizations worldwide seek to bear the name of 'learning organization' as a mark of achievement and competition. Construction industry is no exception. The ability to become a learning organization depends very much on the human capital, which all organizations are made up of. Being one of the largest workforce employers in most countries, construction organizations have the seeming advantage as long as it is able to capitalize on its human asset and make them the competitive advantage. This paper introduces to the construction organizations the essence of being a learning organization and discusses roles of human capital in it. It then suggests how the industry may adopt e-learning as a new means of training which will help to capitalize on the human capital.

Paper 75, Page 468-473

HIV/AIDS in Construction: Are Workers Aware?

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Abstract: The International Labor Organization (ILO) and the World Health Organization (WHO) concur that occupational health and safety in Africa needs strengthening. In support of this realization are the need to maintain and promote workers' health and working capacity, and the need to become conducive to safety and health by improving both the working environment and work. The fight against HIV/AIDS in the workplace is a continental priority. In the absence of any other definitive or similar study, this study aims to establish a valid baseline assessment of the levels of knowledge, types of attitudes, and perceptions of construction workers in South Africa regarding HIV infection and AIDS. This paper reports only on findings concerning the level of knowledge and awareness of HIV/AIDS among construction workers as determined during the first phase of an exploratory study commenced in August 2002.

Paper 76, Page 474-479

Preparing the International Construction Practitioner

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Abstract: The construction world gets smaller each day, in part due to the increasing number of multinational companies letting construction contracts in various parts of the world. This situation is often addressed in University-based construction education programs in the form of a semester- or quarter-long course. The time has passed when such a course could be viewed as elective, and therefore not important to most students graduating with construction-related degrees. Educators must now impart the skills necessary for graduating students to work in varied geographical regions; for companies owned by parties around the globe; on projects staffed by non-homogeneous and culturally-diverse groups speaking more than one language; for a client that could be based anywhere in the world. To properly address this challenge requires that

construction-related faculty build international networks and establish a structure that readily enables them to adequately prepare their students for today's global construction industry. Establishment of the international construction education team (ICET), within an internationally recognized body such as the Associated Schools of Construction, is recommended. Several key focus areas to be considered by ICET are proposed including faculty exchange programs, faculty and student e-mail and snail-mail exchange programs, contractor participation, course content and objectives, textbook selection criteria, web-based and other sources, and student team project selection. Experiences gained while teaching graduate-level international construction courses are included.

Paper 77, Page 480-485

Distance Learning Instruction to Sustain and Improve the Professional Education of Construction Managers

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Abstract: Complex communication and automation systems, web based project management, and construction oriented software systems are all being implemented at a rapid pace. To deal with these technological challenges the construction manager requires skills that were unnecessary just a short time ago. It is natural for higher education, with experience in education and with a strong technological base, to step in and help the industry fill the need for continuous professional training. The paper presents one university's experience using distance-learning and web-based courses in construction education as a substitute for more traditional teaching methods.

3. Information Technology and Information Systems in Construction

3.1 Information Technology

Paper 78, Page 486-491

The Impact of Information and Communication Technology (ICT) on Project Team Dynamics and Work Design

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Abstract: Numerous reports worldwide have highlighted degrees of client dissatisfaction with the services they receive from the construction industry putting forward issues such as: consultants' performance, speedy and reliable service and value for money. Change in the industry has been significantly driven by large client organizations demanding a better service from project team participants. A key factor in achieving successful project outcomes is the nature of the relationship between members of t project teams, including clients, which needs to be established as early as possible in a project's life cycle. This paper discusses the impact of the growth of ICT usage on construction project teams, specifically in terms of how it's implementation affects such teams, and the individuals within them, taking into account process changes, work design and skills development relevant to project teams working in virtual environments. It then reports some of the outcomes of a research pilot study which investigated project team dynamics from the standpoint of "people and process" issues; concentrating on project team members' experiences and their reflections on how changes and improvements to their work situation could be facilitated in the future. The paper concludes that the key factor in achieving successful outcomes was the need for a project team strategy to implement ICT, supported by appropriate knowledge, understanding and skills to ensure that the technology was utilized to its full potential.

Paper 79, Page 492-497

Identification of Skill, Knowledge and Abilities for the Use of the Internet for Information Sharing on Construction Projects

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Abstract: Project Collaboration Websites are one of the fastest growing uses of the Internet in the construction industry. This research uses a Phenomenographic approach to analyse how this phenomena is conceived by project participants who have used the Internet for information sharing on construction projects. Six hierarchically related, qualitatively different categories of description representing different understandings of the phenomena were established. The categories of description are then represented in an outcome space linked and related in terms of effective project participation. This research starts to define how this phenomenon is conceived by project participants and what skills, knowledge and abilities are required for effective project participation.

Paper 80, Page 498-504

Identifying the Critical Factors of IT Innovation Adoption and Implementation within the Construction Industry

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Abstract: Many AEC firms aim to achieve excellence in all aspects of their work in part driven by IT innovation, which has to be continuously reviewed. It is generally believed that failure to effectively harness the benefits of IT can result in the loss of competitive advantage. This research is primarily concerned with understanding IT innovation adoption and implementation within the construction industry. A web-based survey was undertaken by senior management within leading UK companies. The purpose of the survey is to identify the particular drivers for the initial adoption of IT innovation, and criteria for decision-making linked UK companies' current practices. These critical factors will act as the inputs of a Technology-Process-Culture model to support the selection and implementation of IT innovations. It is hoped that this research project will provide a new understanding of IT innovations adoption and implementation from an integrated perspective of technology, process, and culture within the construction industry.

Paper 81, Page 505-510

CIFE iRoom—An Interactive Workspace for Multidisciplinary Decision Briefing

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Abstract: This paper presents a case study in which the CIFE iRoom (an "Interactive Workspace" at the Center for Integrated Facility Engineering in Stanford University) supports real-time cross-referencing of multidisciplinary project information and facilitates AEC professionals to complete decision-briefing tasks. In decision briefing, professionals from different disciplines describe and explain inter-disciplinary project plans or predictions to the decision makers to support multidisciplinary analysis and decision making. Conventional practice relies on individual's moderating skills and isolated domain-specific applications to represent product, organization, and process information and thus, poses decision makers with the challenges to mentally comprehend and relate multidisciplinary decision factors. In the CIFE iRoom, an internet-

enabled messaging procedure allowed users to interlink multiple personal computers and highlight inter-related information across three "Smartboard" displays. Following a retail complex construction test case, we illustrate the specific mechanisms and examples with which the CIFE iRoom facilitates informative as well as effective decision briefing through common visual foci and real-time highlighting of multidisciplinary information. The test case has demonstrated the positive impacts of iRoom decision briefing on informative formulation; while motivating the needs for clearer evaluation and quicker re-formulation of AEC alternatives.

Paper 82, Page 511-516

Investigating the Role of ICT in Improving Productivity in Construction Supply Chains in Australian Construction Industry

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Abstract: The Australian construction industry is a fragmented and profoundly competitive industry with high levels of subcontracting resulting in complex supply chain formations. Traditional methods and forms of communication are being proven as inefficient and losing their charm while participants face heavy volumes of communications that often occurs on a daily basis between trading partners in a supply chain on projects. Information Communication Technologies (ICT), due to their robustness and the ability to quickly disseminate data/information, have the capacity to address highlighted communication issues in a structured and an efficient manner. Time savings produced by these can be directly translated in terms of productivity gain. This paper presents perceptions of subcontractors working in the construction industry in Melbourne Australia on the use of ICT obtained through an exploratory study.

Paper 83, Page 517-522

Internet-based information communication and management: the Application of Project Information Portal

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Abstract: Due to the long construction period, numerous involved participants and geographical disperse, construction projects are generally faced with a lot of barriers during information communication. The ineffectiveness of information communication not only directly causes a lot of unnecessary waste, but also affects schedule and quality of construction projects indirectly. Project success relies heavily on effective communication among different participants. The paper puts forward the concept of Project Information Portal (PIP) to create an effective and efficient environment for all the involved participants. PIP, an Internet-based project communication solution, provides the single entry for involved participants per friendly and convenient interface. The paper analyzes the concept of PIP and presents the architecture and functions of PIP system. Based on business process reengineering (BPR) theory, the construction process of PIP environments is analyzed and redesigned.

Paper: 84, Page 523-528

Visual - Virtual Light Facades in the Information Age

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Abstract: The facade is the very first element of any architecture that communicates with the inhabitants of the city. It dominates the form and tells the story of the building. In this respect, besides enclosure, communication is surely an important role of facades (Zardini, 1994). In the era of digitalization, modern technology enables us to go beyond physical dimensions into a virtual world. Since information is active and interactive, there is a need for a new facade system, which must serve not just for communication but also interaction (Ranaulo, 2001). Through the use of multi-media facades, information is communicated, interacted and exchanged on an urban scale. In addition, sensors, actuators, and other information elements incorporated into a facade can inform us of the current performance of the building

enclosure, or allow it to react to changes in the environment (Howe, 1997).

In this paper, we discuss design principles for a new visual-virtual light facade system that makes use of information media in new structures, or to alter, enrich, and enhance information utilization in existing buildings and quarters in Hong Kong. The study includes a survey of recent visual-virtual light architecture applications in major cities such as New York and Tokyo, with discussion on their purposes and intended use. Further study analyzes the nature and function of facades, breaking down component functions into privacy screen, environmental barrier, information filter, day lighting source, physical protection, safety barrier, function demarcation, communication medium, and cultural statement. These component functions are analyzed to see if there are electronic or digital equivalents, and a new approach to facade design is suggested.

Paper 85, Page 529-534

Towards Wireless Web-based Facilities Management

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Abstract: For many years, paper and clipboards were the "mobile" solution for getting critical information out of, and back into, Facilities Management (FM) software systems by the mobile operative. However, with the current frenzied uptake of all things wireless, and the increasing dependency on Internet and intranet-based information submission and retrieval systems, the time is nigh for facilities management to embrace both these technologies. The widespread utilisation of wireless Web-based solutions should not be viewed as another attempt at adopting technology simple for the sake of it. Wireless Web-based solutions could offer achievable benefits to facilities managers over manual, paper-based processes and the technology existing today has matured to such an extent that it is not uncommon for high-speed wireless networks sharing and distributing broadband connections through homes as well as businesses. This paper highlights and discusses the possibilities of wireless Web-based solutions within FM and touches on some of the different wireless standards that exist.

3.2 Information Systems

Paper 86, Page 535-540

An Electronic Document Management System for Public Construction Projects

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Abstract: This paper presents the development of an electronic document management (EDM) system for public construction projects. The objective of this research is to develop a prototype system that will be able to automatically produce official documents needed during the development of such projects. The proposed system consists of a database and a user interface module. Two types of information are stored in the database. The first refers to document forms that have been developed in MS-Word format and are used as templates including text or other information that is common to all projects. The second part includes project specific information such as specifications, budget, contractor information, etc. This part has been structured on MS-Access and information related to a number of projects has been stored in it. After a user query for a specific project, data automatically fill in the corresponding template forms and the desired documents are developed. The employment of such a system is expected to enable prompt preparation of reliable documents. As a result, errors will be minimized or eliminated and the project development process will be expedited resulting in time and cost savings.

Paper 87, Page 541-546

Modeling the Dynamics of a Tunnel Construction Project

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Abstract: Even when properly employing traditional project management techniques and tools parties involved in construction projects regularly face many unexpected issues. These issues cause low project performance and poor project outcome. This paper presents a simulation model to capture the dynamics of construction projects in the construction phase. Eight key feedback structures are formulated as dynamic hypotheses. A formal simulation model is mathematically developed in terms of stock and flow maps. The model is then calibrated for a tunnel construction project. Tests show that the simulated behavior of the model and the actual behavior of the project are similar. This implies that the model is able to simulate the dynamics of the project and, thus, to enhance project control.

Paper 88, Page 547-553

Suggestion of Method of Application of Web-based Collaboration System

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Abstract: Construction Industry performs different projects geographically and timely. The present project management requires the collaborations in distributed environment. Many construction companies use web-based collaboration systems to perform the efficient collaboration. Looking into existing trend of study and practice use, they set limits to the improvement of functions of system, system development and application of solution. But, they are difficult to customize in a point of view of users because the existing system and solution are stiffened. That is, they have the lack of system flexibility. In addition, they don't offer the functions such as scheduling to be necessary for construction projects. Application of solutions and system development require much cost and time. Many companies including the small and medium construction companies don't use collaboration solutions and systems because of the above problems. As different functions are needed, the large enterprises procure the separate solutions, or develop system by themselves. Through analysis of trend of study and practice use, this study points out problems of existing solutions and systems, and present the method of application of web-based collaboration system through software improve those.

Paper 89, Page 554-559

Bridge Database Management System

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Abstract: A comprehensive framework has been outlined for the management of bridges on the road networks across Pakistan, after reviewing Bridge Management Systems (BMS) in operation in developed countries. As a core objective this Bridge Database Management System (BDMS) specifies the requirements to enable optimized bridge maintenance taking into account factors affecting bridge management and development of associated software. The developed system ably integrated existing procedures, while adopting certain principles and established new modules.

Indigenous adaptive core model of BDMS has been developed for highway and urban bridges; however, it has the capacity of coupling independent modules to make it a valuable tool for civic, highway and/or raliway agencies and similar organizations. BDMS provides quantitative assistant of bridges, based on inspections of each of the bridge components. The system can be used to determine priority on repair works to be carried. Bridges around the Karachi metropolitan area were assessed using this BDMS

Software, and data collected has been tested for prioritizing using BDMS. The results demostrated that, BDMS is an effective and versitile tool for management and maintenance.

Paper 90, Page 560-565

Electronic Document Management Systems in Large Construction Projects in Greece

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Abstract: This paper deals with the electronic document management systems in three big state owned construction management companies in Greece, namely Egnatia Odos S.A. (who is responsible to deliver the 680 Km of the Egnatia highway in Northern Greece), Attiko Metro S.A. (responsible for the construction of the Athens metro) and Ergose S.A. (responsible for the upgrade and renovation of the Greek 1,300 Km railway network). A short presentation of these companies and of their respective document management systems is made. By comparing the systems it is evident that these companies follow different document management philosophies ranging from simple electronic archiving to more sophisticated contract management ones. This discrepancy of attitude is justified by the lack of state guidelines and standards which, in turn, hinders the wider adoption of interoperable document management systems by both state regulated construction management companies and private construction contractors and, in effect, the development of nation-wide specifications related to construction projects. It is argued that such guidelines and specifications should be developed before the Greek construction industry moves to more advanced product modeling document based solutions.

Paper 91, Page 566-572

Using Adaptive Genetic Algorithms for Construction Time-cost Optimization

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Abstract: Time-Cost Optimization (TCO) is one of the greatest challenges in construction project planning and control, since the optimization of either time or cost would usually be at the expense of the other. Despite that, difficulties are still being encountered in construction TCO; as there is a lack of unique solutions for integrated constraints associated with the time and cost requirements. In this paper, adaptive genetic algorithms are proposed to automatically balance the weights of time and cost, finally achieving a compromise between population diversity and searching efficiency. In addition, a computer program called MAWA was developed as an add-on tool of MS project to automate the calculating and analyzing processes. Applications of MAWA were presented as a benchmark project and the results were compared with those from existing time-cost approaches.

Paper 92, Page 573-580

Synchronize Operations Modeling and Site Layout Modeling by Augmenting the Simplified Discrete-Event Simulation Approach (SDESA)

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Abstract: It is crucial but challenging for a construction planner to place multiple dimensions into perspective (i.e. time, space, resource, and cost, along with the 3D physical definition of structures) for describing and optimizing the complicated, interactive, and dynamic construction processes. The augmented SDESA represents an enhanced version of the simplified discrete-event simulation approach (Lu, 2003) and its computer platform. The augmented SDESA allows the spatial definition of a construction system in a 3D graphic environment, and provides a simple and cost-effective means for modeling operations in a dynamic construction system, synchronized seamlessly with the 3D construction site layout planning. The major benefit is the increased similarity of the model to the actual system being simulated. As such, the accuracy, reliability and predictability of the model are significantly improved. The augmented SDESA also features the 3D animation for post processing the simulation so as to help the user visualize and analyze the simulation results. A "Hoist and Barrow" concreting model, which was set up based on a local building site, is presented to illustrate the capabilities and features of the augmented SDESA.

Paper 93, Page 581-586

A Reactive Greedy Randomized Adaptive Search Procedure for Construction-Site Layout

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Abstract: Construction-site layout is to determine what temporary facilities are required to support construction activities and to position them in appropriate locations. A site-level facility layout has an important impact on the production time and cost savings, especially for large projects, as well as on safety of operations and on environmental aspects of the work. The construction-site layout problem is formulated as a location-allocation problem. The objective is to determine an assignment of facilities to locations in order to minimize the total cost, i.e., the sum of the total construction and removal cost of assigning a facility on a location, the total transportation cost of materials and the transportation of personnel between facilities and locations. The problem is solved by a Greedy Randomized Adaptive Search Procedure (GRASP), enhanced by a learning mechanism and a bias function for determine the next element to be introduced in the solution. The procedure has been coded in Visual Basic, and computational results are given.

Paper 94, Page 587-592

Study on Physical Construction Market Information System Based on B/S: A case study on the system of Harbin Construction Market Center

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Abstract: The physical construction market, which was exploited from practice of deepening the construction system reform and enhancing the construction market management, is an effective way to normalize the construction market activities. In order to realize the construction market competition of public, justice, fair and prevent corruption, it is necessary to carry out a set of scientific management in the physical construction market. With the development of network technology, traditional MIS development method has been far away from the demand of the users in the network environment. It will be a new popular technique to develop MIS with Web skills. In this paper, the writers analyze the Client/Server pattern and introduce the latest MIS system structure and demand of the environment based on Browser/Server. At the same time, taking the system of Harbin Construction Market Management Center as an example, the writers describe the development and analysis of the system.

Paper 95, Page 593-598

Experimental Development of Web-based Building Information Model using 3D VML Library

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Abstract: 3D visualization is known to improve the cognitive process of understanding the spatial relationship between objects. As the World Wide Web turned out an effective tool for yielding collaboration among those who locate in the physically separated places, the computer industry introduced technologies for sharing 3D vector graphics among professionals over the Internet. Vector Markup Language (VML) is an application of Extensible Markup Language (XML), which defines a format for encoding 2D vector information on the Web browser. Recently, a 3D VML library was introduced to extend the utilization of VML for Web-based 3D graphics. This research attempted to create a 3D campus model using the 3D VML library in order to investigate the merits and demerits of the 3D VML library for a large 3D Building Information Model (BIM).

4. Construction Technology

4.1 Innovative Construction Technology and Techniques

Paper 96, Page 599-604

Lessons Learned in the Design and Construction of a Wastewater Earth Liner Project

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Abstract: This paper presents a detailed forensic review into the premature failure of a series of earth-lined reed beds constructed for a wastewater treatment plant to understand the reasons and mechanism leading to excessive leakage. The review covered implications related to the initial investigation, design, material selection, construction expertise, environmental factors, workmanship together with the technical and construction know-how of the designer, constructor and supervisor. The outcomes from this case study provide some salient lessons – a good construction practice should provide opportunities for adequate communication among all parties at all stages of the project.

Paper 97, Page 605-610

The Role of Monitoring Behavior of Innovative Structural Systems

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Abstract: Landmark structures, often because they extend contempory bounds of architecture and structural engineering, pose a number of challenges in their design and construction. The recently completed Federation Square project, located in central Melbourne, is considered to be a world-class collection of landmark structures that would fall into this category. The glazed North Atrium structure of Federation Square is a complex three dimesional moment resisting space frame consisting of galvanised square hollow steel members. The steel members of these frames appear to form a random-like grid based on a "pin-wheel" geometrical formulation mimicking to a large extent, the branch-like characteristcs of natural trees that compliment the adjoining fauna. Largely because of its striking visual complexity, the North Atrium structure was selected as the subject of a field monitoring program in order to verify its structural performance during key stages of its evolving construction. Monitoring included discrete axial strain measurements of a selection of key structural members (strain gauges and Demec point measurements) in conjunction with photogrammetry-based measurement of overall deformations. Results obtained largely verified predictions made of the structural behaviour at the various stages of construction of this structure, providing re-assuring evidence to the designers, constructors and owners of this behaviour.

Paper 98, Page 611-616

Design Principles for Kinematic Architecture

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Abstract: The kit-of-parts approach is a way to formalize the essence of an artifact in a quantified, repeatable, systematic way (Howe, Ishii & Yoshida, 1999). Using design grammars, a few cleverly designed primitives can be combined in countless ways to produce many different types of useful objects and structures (Howe, 1998). We can also impose another formal order on the artifact's life-cycle timeline as well, breaking up the myriad of minute influences acting upon it into their composite primitives of translation, rotation, and spatial placement (Howe, 2000). This set of primitive events can be a parallel kit-of-parts consisting of time and motion forming the essence of the artifact's existence and function. Combining these two sets and formalizing the way they react with one another can provide a powerful language of artifact creation that encompasses not only geometry and function, but also life cycle processes for existence and behavior. Matching "geometry primitive" kit-of-parts with "motion primitives" define a form of "kinematic architecture" that includes mechanisms to construct itself, or to change the configuration or form of the structure over its lifetime.

In this paper, nine design principles are described that define a truly kinematic building architecture (Howe, 2002).

Paper 99, Page 617-622

Studying of Elastic Plastic Behavior of Concrete Ceiling, Joints, Supports by Live Load

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Abstract: In Asemaneh building, steel structure and concrete slab has occurred misfit steel members and unknown quality of concrete slab sections. Steel long plate connections in supports were replaced by angle shapes connection in joints. New Kormit concrete ceiling was executed and there is not any theoretical criterion for concrete acceptation. Two main problems were solved by Loading Test on ceiling concrete.

- It was made a strip line of live load (wet bricks) parallel the axial of concrete slab beams.
- Live load settlement was measured by accurate instrument before and after loading.
- Computer drew deflection 3D map.

Qualification of ceiling was obtained by support condition movements and maximum settlement at mid point and zero slop in support. 3D map of live load test have concluded the right shape of angel ∟ connection. Therefore this method could be used in conditional structure, where it is needed to control quality of members and joints.

Paper 100, Page 623-628

Adaptable Unitized Facade for High-Rise Office Buildings in Hong Kong

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Abstract: As a separating element between inside and outside, one of the main functions of the facade is to maintain a comfortable habitable building interior regardless of changing external conditions. Therefore, the ability to change and adapt to variances in the environment should be an important characteristic of the facade system (Yeang, 1994). This is especially true for facade orientation, where building envelope surfaces receive different amounts of solar radiation depending on the angle of direct insolation (Daniels, 1997). This paper explores concepts of adaptable unitized facade systems that improve performance by applying a modular approach that include possibilities of different regulating and energy-generating plug-ins (Compagno, 1999).

The unique high-rise urban context together with hot and humid climatic conditions in Hong Kong is the setting for the research. The focus is on the facade of office buildings, which are typically high energy loaded and require significant air-conditioning or other environmental compensation. This research aims to find out an environmentally responsive and adaptable facade system using a kit-of-parts approach, incorporating components with active control to improve both built and natural environment (Howe, 1999). The new system can help in creating environmentally friendly, energy efficient office buildings with optimal utilization of renewable energy.

Paper 101, Page 629-634

The Application of Precast Concrete Technology in Buildings and Civil Structures Construction: Hong Kong Experience

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Abstract: This paper reviewed the application of precast concrete techniques in building and civil works in the Hong Kong construction industry. The advantages and constraints of such techniques identified through the Hong Kong experience are discussed. It is anticipated that precast concrete techniques will lead to reduced construction time, improved work quality and in turn be cost-effective. On the other hand, many issues should be considered when applying such techniques, including lead time, panel transportation, on-site installation, project critical path planning and co-ordination as well as proper supply chain management. The paper finally discussed the future trends of precast concrete techniques.

Paper 102, Page 635-640

Construction Automation: A Drywall Robot

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Abstract: The construction industry in the United States is suffering from a serious labor shortage. A viable solution to the labor shortage is the use of fewer workers to perform routine tasks. Therefore, the use of robots became appealing. To date, efforts have been aimed at the development of the ultimate robot (self-contained, self-learning, multi-functional, super-intelligent). In other words, efforts have focused on the creation of a robot that resembles a human worker rather than development of simpler, more achievable robots that eventually may evolve into the ultimate robot. A literature review reveals that the industry's high expectation of robotics was not met during the last decade. The industry's expectations were not met because of overly ambitious robot designs while overlooking necessary changes in facility design. This paper presents specifications for a smart Robot used to install drywall. The machine is easy to control and requires minimal skill to operate. A production comparison was made between a typical drywall crew and a crew using the Robot. The Robot provided significant productivity improvement. It is also anticipated that the use of the Robot will save money as it significantly reduces the physical demand required in drywall installation.

Paper 103, Page 641-646

Modification of Walking Bridge into Semi Heavy Load Bridge by New Steel Connection Opener

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Abstract: A walking bridge was made by KWPA at 1992, on overflow structure, south of Iran. The traffic load forced to build a new bridge on main water channel that it should be carry semi-heavy traffic load. For each span; the one of two connections of the beam was jointed in each side and the other joint was without any connection with column. The main criterion was considered by designer into separate stiffness that the old bridge should be carry the weight of the dead load and the other stiffness should be computed to carry the live load. New steel bridge should be transferring the torsion into column that it is produced by motion of traffic live load. *New opener connection* could be solved the problem and it was invented by designer Afshin Turk 2002. The cost of modify bridge would be consider 7% of total cost of wide bridge (150m).

Paper 104, Page 647-652

A New Construction and Technology for Offtake Tires, their Disc Frequencies and Testing Equipments for Fatigue Tests

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Abstract: The contents of the paper point out the necessity of combining the theoretical and experimental approaches in the investigation of tyre load in vehicles. The article deals with the loading condition analyse of the manipulator frame for offtake tyres by the working load. The model of the tyre disk was created in software Auto CAD and Cosmos M. There are calculated the first ten eigen frequencies disk in this article with the help of the software Cosmos M. The models are planar and they model the cross-section of the tyre enabling the consideration of the bottom load and the internal pressure in the tyre, as well as the influence of the lateral force.

4.2 Sustainable Construction Techniques

Paper 105, Page 653-659

A Taxonomy for Measuring Sustainability of Construction Projects

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Abstract: The property and construction sectors need tools to assess levels of waste, environmental damage, social costs, and the impact of civil engineering and infrastructure projects on the ecosystems. However, while most efforts focus on addressing sustainability at macro (institutional and organizational) levels, there is also a need to understand the various indicators and the interaction between them at the micro levels of construction and infrastructure management. This will facilitate evaluation of sustainability during the design, construction, operation, maintenance, and decommissioning stages of a project. This paper analyses the main indicators such as environmental, economic, health and safety, and resource utilization, for measuring sustainability of construction projects. It reviews current efforts, and discusses methodological and implementation issues in developing project-level indicators. It then discusses data and information requirements for measuring sustainability at the project-level, and identifies how user-friendly IT tools would facilitate integration of sustainability considerations into the decision-making processes at various interfaces in a project's life cycle. The paper concludes that robust frameworks, methodologies, and practical step-by-step implementation strategies at the micro level, are all essential for achieving sustainable environments in the property and construction sectors. Recommendations are also given for further research.

Paper 106, Page 660-665

Economic Principles of Sustainable Construction

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Abstract: The emergence of sustainable construction has been described as the largest innovation within the global construction industry at the end of last century. However, there are various concepts of sustainable construction and it is difficult to define the term in a simple uniform sentence. Basically, sustainable construction has four dimensions: environmental, social, economical and technical. While the literature establishes several diverse explanations of both ecological and technical principles, it often fails to consider economic concepts. From an economic point of view, sustainable construction is an unusual activity, which changes business patterns from a linear to a cyclic process. As the original stimulant, it is essential to detail the economic principles of sustainable construction and investigate their application in practice. This paper examines the concepts of sustainable construction and sets out the underlying economic principles and themes which apply to it. Furthermore, it highlights some economic challenges to sustainable construction: higher capital cost; lack of accurate cost information; unreliable long-term profits and invisible market value. Finally, it concludes that it is crucial to develop a green market in the built environment and a clear sustainable business strategy for construction companies who seek to implement sustainable construction.

Paper 107, Page 666-671

Improving the Sustainability of Existing Buildings

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Abstract: Achieving the goal of sustainable development continues to be one of the major global challenges of our era. To date the vast majority of work has focused on improving the sustainability of the design and construction phases of the building life cycle. Whilst the outputs from this work are beginning to have an effect on the sustainability of new buildings, because of the legacy of the existing building stock, it is unlikely that it will produce a sustainable urban environment in the short to medium term.

In reality only a small percentage of the worlds built environment is replaced each year, over the next 20 years much of the built environment will comprise that which already exists or is in the planning stage. If the built environment is to address the changing needs of society in a more sustainable manner, then the construction industry will have to work largely with buildings that already exist. Thus the challenge

facing built environment professionals is to find ways of improving the sustainable performance of existing built facilities. This paper will examine these challenges and outline a new initiative being undertaken in the UK to address them.

Paper 108, Page 672-676

Using Sustainability Related Criteria in Construction Support Systems

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Abstract: The need for better productivity measurement and materials and equipment utilization and wastage arises from the relatively new concept of sustainable development. The potential of construction support systems as an adaptive approach to more closely link sustainability with project management is discussed. This paper outlines some key institutional barriers to achieving this potential. Indices representing the above criteria are introduced to express in quantitative terms namely the total or overall productivity, material and equipment utilization and product waste recycling. Concepts of active adaptive management utilizing these criteria are being tested in a pilot study construction project in West Macedonia Greece. The data collected at real time control basis were used for the calculation of the corresponding indices. Conclusively this methodology may be implemented in achieving better productivity and desired system performance.

Paper 109, Page 677-682

Environmental Management Systems: Issues of Development and Implementation.

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Abstract: The construction and operation of buildings in Australia is responsible for some 30% of the raw materials manufactured, 42% of the energy consumed and 40% of air emissions (Industry Science Resources, 1999). This research investigated how proactive Australian construction contractors are in protecting the environment through the development and implementation of an appropriate environmental management system (EMS). The study utilised a qualitative methodology and was limited to large non-residential construction contractors, which account for seventy-five (75) percent of the output of that sector.

The research found that there are many factors that determine whether an EMS is adopted. These are; organisational experience in the civil engineering sector, company involvement in international operations, desire for competitive advantage including good corporate citizenship, the role and responsibilities assigned to the environmental manager, and the perceived benefits and barriers encountered. The level of support and commitment was found to be vital to the development and implementation from top management to personnel on site level. The key factors determining implementation successes were found to be; the development of an environmental organisational philosophy, the establishment within the organisational structure for an environmental manager, effective training for all staff and incentives for subcontractors. The benchmark of success was found to be accreditation. It is recommended that governments legislate for the mandatory inclusion of environmental management systems and strategic procurement methods be adopted, were possible, to achieve the implementation of EMS over the total design and construction process.

Paper 110, Page 683-688

Critical Review on Legal Commitments for Implementing Environmental Management among Various Construction Practitioners in Hong Kong

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Abstract: This paper is to investigate the legal commitments for implementing environmental management among various construction practitioners in Hong Kong. The legal commitments are identified under four areas, namely, air pollution controlling policies, water pollution controlling policies, noise pollution controlling policies, and waste pollution controlling policies. The investigation suggests that there is an association between the limitation of improving construction environmental performance and the insufficiency of legal commitments allocated to construction practitioners in Hong Kong. The emphasis in these commitments allocations is largely focused on contractors' operation. The paper suggests that the unbalanced allocations of legal commitments among construction professionals present difficulties for fully implementing environmental management principles. The discussions in the paper can provide a useful reference to the local government department for formulating better policies in order to improve environmental performance in the local construction. The study also provides valuable reference for other governments to examine the effectiveness of implementing their environmental management policies in construction industry.

Paper 111, Page 689-694

Cost and Value in Sustainable Building Practice: An Exploration of Perceived and Actual Impacts on Organizational Performance

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Abstract: With the recent trend toward downsizing, restructuring and an increasing competitive global environment, there is a growing realisation among businesses that property has a potential strategic role in supporting their objectives and in fostering human resource development, if relevant organisational capabilities for organisational sustainability are to be developed. It can be seen that further diffusion and commercialisation of sustainable building practice in the commercial property industry is largely contingent on client realisation of the concept's ability to align and support this emerging trend whilst mitigating environmental impacts and contributing to organisational effectiveness.

This paper presents the preliminary results of an exploration into the cost and value effects of sustainable building practice at the levels of business and organization. Literature research and interviews with client groups operating in the commercial property industry have been conducted to elicit potential links and effects influencing key decision makers in client organizations to adopt and implement sustainable building practice. An approach used to evaluate business and organizational performance, the Balanced Scorecard, is used as a tool to conceptualize the explicit and more implicit links and effects. Case study projects in Australian commercial property and construction are then elaborated upon to illustrate the perceived relationships and any measurable outcomes in the context of the four perspectives presented in this approach. The paper then evaluates the potential to identify and develop key indicators within this framework to provide a method that facilitates a more systematic and objective environmental performance assessment in and across client organizations and which support managerial decision making and sustainable operations in the long term.

Paper 112, Page 695-700

The Use of Self-compacting Concrete Technology in Sustainable Construction

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Abstract: Over the last decades there has been a tremendous growth of built environment to meet higher standards of living with growing industrialization and urbanization. The replacement and rehabilitation of aging and deteriorating existing infrastructures are the challenges of the 21st century. Concrete is the most widely used of all building materials and the cement industry is one of the major contributors to the damaging emissions of large quantities of CO_2 into the atmosphere. In the 21st century, there will be a tremendous growth in concrete construction as developing countries become developed and emission of CO_2 will be multifold. The 1997 World Earth summit in Kyoto, Japan made it clear that the unchecked increase in the emissions of greenhouse gases to the atmosphere is environmentally and socially no longer acceptable for sustainable development. Development of new environmentally friendly building materials like self-compacting concrete (SCC) incorporating high volumes of supplementary cementing materials (HVSCM) can be a solution.

The concept of SCC that can consolidate under its own weight without vibration was initially developed in 1988 in Japan. Since then remarkable progress had been made in the development and utilization of SCC. The development of SCC incorporating HVSCM is a diverse technology that can lead to lower green house gas emission, consumption of wastes, durable construction, sustainability in concrete industry and minimize worldwide infrastructure problems. This paper will discuss various aspects associated with SCC and sustainable development including environmental and economical issues. The development of new cost-effective HVSCM SCCs and their applications and performances in sustainable construction will also be described.

Paper 113, Page 701-706

Use of Volcanic Debris in Innovative Construction and for Sustainable Development of Volcanic Areas

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Abstract: This paper demonstrates how the cause of natural and environmental disaster can be transformed into natural resource that can be used for sustainable development. Comprehensive research has been carried on the use of volcanic debris such as: volcanic ash (VA) and pumice (VP) to manufacture blended cement, lightweight concrete and composite structural elements that are suitable for the construction of environmentally friendly low-cost houses and shelters especially for the volcanic areas. Recommendations and patents have been developed for the cement industry, ready mixed concrete companies and construction industries for the manufacture of such construction materials and building components. It is interesting to make practical applications of the developed structural elements and materials in the development works of volcanic disaster areas.

Paper 114, Page 707-713

Energy Saving Building Management

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Abstract: This research paper shall present the state of building stock in the Republic of Croatia from the viewpoint of its thermal quality and energy saving possibilities. The analysis of technical solutions for improving thermal quality of a typical housing building built in the second half of the 20th century will also be outlined together with the analysis of the costs and profits of such an renovation. The research paper also displays technical regulations regarding the energy saving, the governmental and institutional attempts to stimulate and implement such technical interventions, as well as the analysis of problems encountered during such implementation.

Paper 115, Page 714-719

Innovative Dwellings in Greece: Critical Review and Construction Cost Implications

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Abstract: The term innovative dwellings denotes houses incorporating intelligent and sustainable features. Social and economic factors indicate that the number of such buildings is expected to grow from around 7% today to around 40% before 2010. In this paper innovative dwellings are reviewed and analysed in their basic constituent sub-systems in order to estimate their respective costs. From the plethora of available technologies four intelligent and three sustainable sub-systems are selected and incorporated into a model innovative building. The sub-systems satisfy independently published criteria of intelligent/sustainable buildings, are expandable to cater for future requirements and are available / supported in the Greek market. Following the development of the model, quotes were collected from suitable suppliers in Greece in order to assess their cost implications. It is shown that the cost overrun of innovative dwellings is, in most cases, less than 10%, a small percentage compared to the benefits offered to their users and the environment. As such the argument that the importance of innovative dwellings is expected to grow in the future is corroborated. The potential influences of the above to construction technology and management is finally discussed in the concluding part of this paper.

Paper 116, Page 720-725

A Comparative Sustainability Assessment of Steel & Concrete Framed Housing Blocks in Hong Kong

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Abstract: This study will comparatively assess the sustainable performance of public and private sector standard housing blocks in Hong Kong. Comparisons will be made between each of the selected building types using the following indicators:

- cost:- capital/in-use
- energy & CO_2 – embodied
- energy & CO_2 - in-use
- construction waste

As the relative significance of environmental impacts emerge, it will give clear indications of where to concentrate the industry's efforts in reducing or mitigating serious impacts.

The Integer Tower proposes to use prefabricated precast modular units that form the individual living units. These are stacked upon each other, three storeys at a time inside a steel mega-frame, which provides a platform for each 3-storey section of the building. Mass production of the modular units could also have great economic benefits for the future provision of housing in Mainland China. Previous work carried out has shown the potential benefits of the extensive reuse of construction products in terms of the reduction of embodied impacts. The consequences to the construction sector and the market barriers to the wide scale adoption of reusing construction elements and components have also been assessed.

The methodology will give designers, contractors and developers a relative inexpensive means of quantitatively testing their sustainable construction conjectures. The initial study will build upon work recently carried out by Davis Langdon & Seah Management Ltd. that compared the cost of the main structure in standard public and private housing blocks and work carried out in the UK by the Steel Construction Institute.

Additional Papers

Paper 117, Page 726-731

Typical Design Considerations for Construction of Long Span Flexible Roofs

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Abstract: Whereas dwellings need small or medium span roofs, spaces like auditorium, exhibition halls, airport terminals, sport stadiums need long span roofs without intermediate supports. It is either domical or cylindrical roofs or tension structures which are employed to cover long span spaces. Amongst these types, flexible roofs made of steel strands and cables are best suited for very long span column free areas. Whereas plan shape of a cable roof for a particular application is generally decided by the functional use of the space, cross-section such as convex or concave is decided by considering relative structural efficiency of various forms of cable roofs. Present paper describes typical design considerations for construction of cable roofs in general and circular cable roof in particular to achieve efficient and economical design. These design parameters include cable diameter, cable spacing, pretension in cables and rise/sag to span ratio. Influence of these parameters on the performance of cable roof are investigated and reported in this paper. The paper also recommends a set of these parameters most suitable for the application in construction of circular long span cable roofs.

Paper 118, Page 732-740

The Impact of Construction Type on Single-Family Home Values Using Hedonic Estimation and Artificial Neural Network

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Abstract: Estimating the value of a property concerns builders, developers, homebuyers,

appraisers, economists, and policy makers among many others. Nonetheless, real estate valuation is a complex process considering the range of variables that are known to play a role in determining such a value.

This paper investigated the impact of construction quality, resembled by various types of siding materials, on residential property value of single-family homes (SFH) within the City of College Station's urban setting by employing a comparative hedonic estimation and artificial neural network (ANN) model. The study relied on a large sample of SFHs that were sold during the period from 1997 to 2000 in College Station, Texas. The study used the homes that are highly homogeneous in their structural attributes in order to eliminate their impact on the home values. The main aim of this study was to find out the impact of four main types of siding materials that included brick veneer, frame, stucco, and mixed on home values.

The results indicated that stucco siding had the most significant impact on the property value. In comparing the hedonic results and ANN results in this study found that both analytical methods support one another and have assigned similar weights to the various construction types that have been studied. In addition, ANN showed to have a higher predictive accuracy level than did the hedonic estimation. The estimated implicit values of different siding materials were a measure of the importance of such a material to the homebuyer and was resembled in the form of a paid premium. The findings extend the body of literature concerned with real estate value analysis and have significant implications in the realm of fund allocation decision making for a real estate developer.

Paper 119, Page 741-746

Status Assessment of Thai Construction Workers

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Abstract: A construction project is considered successful if it is completed within its scheduled duration and estimated cost with acceptable quality. Considering the various factors included in a construction project, there would be general agreement that the labour force is the most important to the success of the project. During the past two decades, Thailand has exported skilled construction workers to other countries. This resulted in lack of skilled construction workers in Thailand which also effects schedule, cost and quality of construction projects. The status assessment aims to identify the construction problems related to availability, quality and productivity of skilled workers. Since most construction sites were constructed in the metropolitan area, this study is focused on eight building construction projects located in Bangkok and its surrounding areas. Of the eight construction sites, four common trades of skilled workers were selected (carpenter, steelworker, bricklayer and plasterer). Data collection was made using four major techniques: questionnaire, interview, field observation and office information. It was found that the availability of all selected trades is inadequate. Among these trades, the steelworker is the most inadequate. The quality of bricklayer is the lowest among all studied trades and needs to be improved in many areas. Carpenter and steelworker achieved high productivity due to the implementation of advanced construction technology such as tools, mechanics and prefabricated components. Among the four trades studied, the productivity of plasterer is the lowest.

Construction in the 21st Century (CITC III)

3rd International Conference on Advancing Engineering, Management and Technology, Athens, Greece, September 15-17, 2005

http://www.fiu.edu/~citc

Conference Aims

The mission of CITC (Construction In the Twenty first Century) Conferences is to facilitate communication between multi-disciplinary teams and especially those involved in engineering, management and technology. In this regard, interdisciplinary integration and international cooperation are encouraged. It is the purpose of CITC to provide an international forum for the discussion of topics important to developing new knowledge in construction and engineering disciplines.

This conference follows on the 2nd International CITC Conference (CITC-II), hosted in Hong Kong and jointly organized by the Hong Kong Polytechnic University (PolyU) and Florida International University (FIU) in December 2003 and the 1st International CITC Conference (CITC-I) hosted in Florida and organized by Florida International University (FIU) in April 2002.

Expected Audience and Call for Papers

Academics, researchers, industrialists, professionals, policy makers, funding bodies concerned with *Construction, Engineering, Management and Technology* are encouraged to participate and contribute with their knowledge and experience to the conference.

Papers are invited for topics related to *Advancing Engineering, Management and Technology*. Themes of interest include, but are not limited to the following ones:

- Construction project management
- Decision Making and Risk Analysis
- Safety and Quality Management
- Contract Management & Partnership
- Information technology and information systems
- Project Management
- Construction technology
- Engineering design issues, problems and solutions
- Integration of design and construction processes
- Education and training in related disciplines

Papers can be presentation of research results, case studies, best practice and technology developments. Abstracts and full papers should be submitted in MS-Word Format by e-mail to: salman.azhar@fiu.edu

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International Scientific Committee

A number of renowned experts serve in the International Scientific Committee. Details will be available at the conference website http://www.fiu.edu/~citc

Organization of Special Sessions

To propose the organization of a special session, you may contact Dr. J.P. Pantouvakis at jpp@central.ntua.gr

Important Dates

Submission of Abstracts:	*September, 15 2004*
Submission of full papers:	*February, 15 2005*
Acceptance:	*April, 15 2005*
Submission of final camera-ready full paper:	*May, 15 2005*
Deadline for registration:	*May, 15 2005*

Refereeing Policy and Proceedings

The International Scientific Committee will review all abstracts and full papers. Accepted papers will be included in the ISBN numbered proceedings. Special issues of key journals in the field are also being considered (such as the ASCE Journal of Management in Engineering, the European Journal of Operational Research etc.)

Registration

Registration fee:	490 Euro (before *May, 15 2005*)
Registration fee:	550 Euro (after *May, 15 2005*)
Full Time Students:	390 Euro (before *May, 15 2005*)
Full Time Students:	450 Euro (after *May 15, 2005*)

Fee will include welcome reception, technical sessions, conference proceedings, lunches, coffee breaks and farewell ceremony.

Gala dinner (optional):	60 Euro (before *May, 15 2005*)
Gala dinner (optional):	80 Euro (after *May, 15 2005*)

Venue

The conference will be held at the premises of the National Technical University of Athens, Greece (http://www.ntua.gr)

Athens, the host of the 2004 Olympic Games and the Capital of Greece, is a vivid European city full of monuments from a 5,000 year long history (http://athens-today.gr)

Additional Information

Additional information and submission guidelines is available at the conference website http://www.fiu.edu/~citc

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