

*Abstracts for the Proceedings of the*  
**Fourth International Conference on**  
**Construction in the 21st Century**  
*Accelerating Innovation in Engineering, Management and Technology*

July 11-13, 2007  
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## Foreword

The construction industry is widely regarded as one of the largest and most fragmented industry accounting for 10-12% of GDP in most countries. It is the second largest industry in the USA, behind health services, and the largest product producing industry. It employs more than 6.4 million people in the USA and the assessed annual construction in USA has now exceeded one trillion dollars. The annual value of construction put in place in Asia and the Oceania region which includes Australia and New Zealand is also in excess of one trillion dollars. With the growth rate hovering around 7-9% in most countries of the region, phenomenal growth and advancement is expected in the construction and allied industries in the years to come. In the light of the above, the mission of the CITC series of conferences is to bring together all the stakeholders to take a fresh look into how construction education, research and practice should be conducted to meet the challenges and opportunities of the twenty first century.

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 have created an unprecedented 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. 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.

CITC-I was held in Miami in April of 2002, CITC-II in Hong Kong in December of 2003 and CITC-III was held in Athens, Greece in September of 2005. All of these conferences were extremely successful. Just like the previous three conferences, this effort has also been extremely well supported by our friends, colleagues and well wishers from across the world. We now present to you the *Fourth International Conference on Construction in the 21<sup>st</sup> Century: Accelerating Innovation in Engineering, Management & Technology (CITC- IV, Gold Coast)*. This two and a half day conference is being held in Gold Coast, Australia at the Sofitel Gold Coast Hotel from July 11-13, 2007. 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 three countries. We proudly present ninety seven peer-reviewed papers in the proceedings.

It is our intent 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  
Salman Azhar  
Sherif Mohamed

Gold Coast, Australia, 2007



*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 1, Page: 1-8*

#### **Identifying the Benefits and Difficulties of Implementing Target Cost Contracts in the Construction Industry**

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**Abstract:** The construction industry has been traditionally beset with a number of potential problems, such as the lack of co-operation, mutual trust and effective communication, resulting in adverse overall project performance. To achieve better value for money during the project delivery process, guaranteed maximum price (GMP) and target cost contracting (TCC) with a gain-share/pain-share arrangement have been successfully applied in the United Kingdom and Australia. However, there still exhibits a lack of research evidence to evaluate the levels of success and lessons learned from those GMP/TCC projects. Based on a series of in-depth interviews on the perceptions of experienced industrial practitioners, this paper aims to explore the key characteristics of GMP/TCC including the underlying motives, perceived benefits and potential difficulties of implementing this form of project procurement in the Hong Kong construction industry. The research findings provide some useful insights to assist key project stakeholders in maximizing the benefits derived from and minimizing the detriments brought about by potential difficulties in implementing GMP/TCC concepts.

*Paper 2, Page: 9-16*

#### **Cash Flow Forecasting in International Construction Projects through Financial and Project Risk Analysis**

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**Abstract:** Construction firms have endeavored to forecast project cash flow at the initial stage of a project that quite relates to the payment contract terms and their financing schedules such that the cash borrowed and the final net-profits can be accurately measured. There are, however, diverse risk factors influencing project cash flow, especially in case of international projects that are often confounded by external as well as internal uncertainties. In this research, risk factors that can affect the cash flow are classified into two categories; financial risks and project characteristic risks. The former that is derived from the external economic conditions such as exchange rate, cost escalation, interest rates is analyzed through the stochastic method with the support of Monte-Carlo Simulation. Then, the project characteristic risks such as project-specific condition, weather and climate, resource delivery conditions are evaluated through the utility curves to represent the personal risk attitudes because the people are inclined to respond differently to the same risk amounts based on their risk perceptions. As a validation purpose, the results of cash flow forecasting conducted by the proposed algorithm are compared with the actual project cash flow. Through the proposed approach, construction firms are expected to better decide the optimum level of cash contingency and to foresight the probable net-cash at completion in more accurate and practical way.

*Paper 3, Page: 17-22*

### **Material Substitution & Building Life Cycle Costs**

**Leonora Marková, Alena Tichá, Jana Korytářová, Vít Hromádka**

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**Abstract:** Within the scope of the research we are engaged in the effect of new materials mainly made from secondary raw materials on the price of the building structure, the building structure itself, its lifetime and economic efficiency. We are focused on price impact and the whole efficiency of utilization of new materials developed within the scope of related research. The production of these materials may not be always economically profitable, but their utilization can have a great ecological importance. The main objective of this paper is to present the way in which to simulate the effect of building material substitution on the prices of building constructions and of the building life cycle efficiency on the model situation through the utilization of mathematical methods.

*Paper 4, Page: 23-29*

### **Life Cycle Cost Analysis of Highways to Assist Design and Construction Decisions**

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**Abstract:** A Quality Highway design and construction decisions have been traditionally made considering the initial construction cost with little or no attention paid to the various aspects of costs and performance during the life cycle of a road. This work aims to provide an assessment of these measures in order to assist strategic decisions for the construction of new roads or for the reconstruction of existing ones. The proposed approach incorporates three modules, one for performance prediction of critical highway elements in time,

another for estimating the resulting costs associated with the condition of each type of element, and a third one for comparative evaluation of alternative design and construction strategies. Performance prediction is obtained through a fuzzy system approach with which qualitative information from engineering judgment is converted to numerical values to provide the prediction models under different design strategies. On the basis of these models, several cost components such as construction cost, operation and maintenance costs, road user costs, as well as environmental and sustainability impacts are estimated. The life cycle costs are further used for comparable evaluation of alternative design and construction decisions.

*Paper 5, Page: 30-37*

### **GA-Fuzzy Financial Model for Optimization of BOT Investment Decision**

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**Abstract:** Financial modeling for investments to build/operate/transfer (BOT)-type projects is essentially intricate. The complexity stems mainly from two folds: multi-party involvement and uncertainty. Promoters need a systematic means for objective evaluation of financial performance measures in order to examine whether a certain level of profit margin and an attractive financial proposal to clients, are possible. A clear research gap is perceived in simultaneous evaluation of profitability and bid-winning potential from the promoters' perspective. By using a combination of genetic algorithms and the fuzzy set theory, an intelligent algorithm, is developed for optimization of conflicting financial interests in deriving the right mix of three key decision variables: equity ratio, concession length, and base price. Fuzzy sets are used to explicitly incorporate uncertainty in estimating economic and financial parameters due to lack of available data. Genetic algorithms is used for solving corresponding fuzzy objective function coupled with multiple constraints. A case study from prevailing literature demonstrates the excellent capability of the developed model to produce optimal financial scenario under uncertainty.

*Paper 6, Page: 38-45*

### **Material Focused Control during a Construction Project**

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**Abstract:** The construction industry is mostly concerned with one – of – a – kind projects. This, naturally, creates difficulties for effective management control. Nevertheless, production costs need to be monitored and controlled, if the anticipated level of profit is to be realized. One of the most difficult things to control is the variance associated with materials. All supplies and materials add to the cost parameter of the project. Thus, greater attention to controlling the materials may pay significant dividends in the form of increased profit. This paper deals with monitoring and controlling the cost of materials during project execution. Reference and review will be made to the special characteristics of the construction industry as far as the cost parameters is concerned, during project development. Then, definition of materials and its cost elements and characteristics will be given. The proposed approach for controlling this cost category is based on a spreadsheet application. The component spreadsheets are identified and analyzed and their use is explained. Special consideration will be given to the description of the information content of each spreadsheet. These spreadsheets integrate the cost parameters with time and project advancement, so that the project manager could acquire an objective view of the cost deployment.

*Paper 7, Page: 46-52*

### **An analysis of Cost Information Management in the Electrical Contracting Sector**

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#### **Yimin Zhu**

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**Abstract:** Cost information is processed by different departments and follows different paths within a company. By statistically analyzing cost data from several electrical contracting companies of different sizes in the country, the main intent is to show the similarities as well as the disparities in both cost tracking and forecasting depending on the annual revenue of the organizations under study. A discussion of the results obtained from analysis is presented to identify current practice methods and to propose future research geared towards three main areas: estimating, accounting, and project management.

*Paper 8, Page 53-60*

### **Analysis of Three Estimation Techniques for Road User Cost**

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**Abstract:** The objective of this paper is to produce a detailed review of QuickZone, QUEWZ and Arizona Model with a focus on the road user cost components, the underlying algorithms and the basic assumptions. The calculation processes are discussed. Suggestion for further study is given.

*Paper 9, Page 61-65*

### **Earth-craft Homes: Capital versus Recurring Costs**

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**Abstract:** Earth-craft is a blueprint for sustainable construction which can be applied to new and existing homes. A joint venture between Southface Energy Institute and the Atlanta Home Builders Association designed Earth-craft building standards to promote sustainable planning and construction throughout the Southeast.

The objective of this study is to present the initial cost and potential cost savings to homeowners and builders who wish to implement Earth-craft standards in their new home. The data was collected through interviews with certified Earth-craft builders. The cost data from the interviews represent the cost per square foot for an Earth-craft home versus a standard home of equal size and amenities. The additional construction cost ranged from 1-3% of the home price while potential cost savings ranged from \$400-\$750 per year in utility bills.

*Paper 10, Page 66-75*

### **The Implementation of Earned Value Management in Construction Cost Management and Audit**

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**Abstract:** Earned Value Management (EVM) is recognized as one of the best practice to track and report project performance, trend and forecast costs to completion, as well as project audit. The methodology can be extended to undertake project appraisal and evaluation, rank and select project for best financial performance. EVM is applicable to all types and sizes of projects including construction of facilities. This paper reviewed the principles of EVM and used case study to demonstrate the implementation of EVM in construction cost management and audit.

## **1.2 Decision Making and Risk Analysis**

*Paper 11, Page 76-84*

### **Potential Project Benefits From Improved Project Review Decisions**

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**Abstract:** Construction projects are high risk and frequently highly complex. Decisions made during the delivery of such projects are pivotal to the success or otherwise of the project. Project review is a powerful managerial technique to assist in the achievement of positive project outcomes. It does this through constant revision of critical decisions to control the performance of projects. This paper reports the findings of a study into the rationale for project reviews. The significance of early decisions to minimise risk is discussed and the strengths and weaknesses of existing processes, such as Gateway, are identified. A project review method is proposed to bridge gaps in the current project review processes. This process offers potential benefits to construction projects, to overcome current hurdles.

*Paper 12, Page 85-92*

## **Hurricane Wind Damage Simulation for Coastal and Inland Communities in Florida**

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**Abstract:** An unprecedented six major hurricanes made landfall along Florida and neighboring Gulf states during the past two years. The latest and by far most devastating was Katrina, the worst natural disaster in U.S. history in terms of reconstruction costs and populations displaced (>500,000). In response, the University of Florida has begun hurricane and flood damage simulations for both inland and coastal communities in Florida. The simulation software used for this study, “hazards US” (HAZUS), computes estimates of potential damage to residential, commercial, and industrial buildings as well as critical infrastructure and services based on the quantities and characteristics of these assets.

Researchers have generated hurricane scenarios based on historical storms and probabilistic storms ranging in intensity from Category 1 to 5. Simulations use population, building, topographical and tree cover data from the US Geological Survey and the U.S. Census Bureau. GIS outputs to be presented include maximum wind speed and flood level mapping, critical facilities impact, building inventory impact, shelter and temporary housing requirements and debris generation specific to hurricane intensity, track and other characteristics. The intent of this research effort is to correlate the extent of hurricane damage and debris generation to wind speed.

*Paper 13, Page 93-100*

## **A Decision Support System for Optimal Maintenance Strategies in Highway Work Zones**

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### **Makarand Hastak**

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**Abstract:** This paper describes a decision support system to evaluate the trade-offs among cost, schedule, quality, safety, and motorist/public satisfaction in highway work zone projects and to assist the user in choosing the most suitable contracting strategy for a particular project under consideration. The method described in this paper is advantageous to assist the user in considering, at a macro level, the interrelationships between the critical factors impacting the project. The proposed methodology is applicable to work zone projects on four-lane interstate highways or urban freeways.

*Paper 14, Page 101-116*

## **Long Term Multi objective Project Selection Under Uncertainty**

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**Abstract:** Project selection has traditionally been a difficult decision making problem especially for large organizations with many stakeholders. The basic problem is to reach an agreement among the different stakeholders to allocate limited resources to fund multi-year capital projects in some optimal fashion. Considering that there is uncertainty about the final cost of each project, the organization must try to prevent exceeding the budget when making the decision. The authors present a framework using the Analytic Hierarchy Process (AHP) to reach an agreement between stakeholders about the relative importance of funding the different projects available during the upcoming years. A multi-year knapsack optimization problem is solved using an equivalent non-linear deterministic constraint in lieu

of the probabilistic constraint required to maintain a given confidence level of not exceeding each year's available budget. The framework is explained and presented with an example drawn from an agency whose main forte is managing more than 80 facilities worldwide and allocating billions of dollars to operate, maintain, replace or upgrade these facilities over the years.

*Paper 15, Page 117-124*

### **Best Value Process in the Selection of Software Services**

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**Abstract:** Software selections and implementations have high rates of failure. Clients often perceive vendors as not providing services, not providing realistic expectations, and not providing adequate training. Software providers often consider clients as not investing enough resources to learn the system, having inadequate in-house technical knowledge, and highly liquid scopes. In this paper, best value processes developed and tested in construction, design, and facility management are transferred to the selection of software services. For the research, multiple real-time procurements and implementations were run. For the core analysis, a single selection and implementation is presented. In the analysis, the selection and installation of the primary software occurred in a highly political environment with performance metrics sometimes yielding to personal preferences. In the testing, the best value system was integrated into the selection process after the RFP had already been released to the vendors. Four vendors participated and were required, in addition to their standard technical and marketing proposals, to submit performance surveys of their key personnel, risk analysis plans, participate in individual interviews, and break out all

costs in detail. The political pressures on the selection team helped funnel the final decision of a "best value" vendor. Once selected the vendor was required to participate in a quality control/preplanning phase to map and schedule the project. In addition, the vendor was required to report weekly on project status (budget, schedule, technical, and client satisfaction), all risks, and all client required action items. The results of the research are presented.

*Paper 16, Page 125-132*

### **Transaction Costs Associated with Japanese Public Construction Procurement**

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**Abstract:** In public construction procurement in Japan, dango, a type of rotational and complementary bidding, had been a common practice and certainly had contributed to smooth implementation of many projects. To prevent illegal dango practices, the anti-monopoly law is recently strengthened. However, this law amendment is bringing side-effects: cut-throat and bottomless price competition. As a result, there is a deep concern on deterioration of quality of works. More careful risk management is now introduced; however, a new scheme is pushing up transaction costs drastically. It is now required to effectively do risk management at low transaction costs. Thus, the objectives of this paper are 1) to demonstrate that the transaction costs associated with dango practices are low and 2) to discuss a new direction of practices at low transaction costs. Achievement of the first objective is needed to move to the second objective because understanding strength and weakness of the current scheme is needed for its reform. The author first demonstrates that dango practices and the arrangement employed by De Beers to market gem-quality rough diamonds have very similar characteristics. The author second applies trust theory advocated in the field of socio-psychology, prescribing a way of minimizing the both transaction costs and opportunity costs.

*Paper 17, Page 133-140*

### **Risk and Opportunity (R&O) Assessment and Related Knowledge Transfer in the Early Phases of Construction Projects – An In-Depth Study of Practice**

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**David Radcliffe**

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**Abstract:** This paper presents the results of a series of in-depth case studies into different types of construction projects to examine how risk and opportunity (R&O) are assessed in practice. Data was gathered on how information and associated knowledge of R&O were converted and transferred across the early phases of the projects: from tender, through negotiation and onto construction start-up. The major findings of this research are: (1) While considerable effort goes into formal risk documentation during the tender phase, there seems to be a lack of continuity in how R&O assessment is tracked during construction handover phase and the subsequent design and construction phases; (2) The lack of continuity in R&O assessment across project life cycle can be explained if it is modeled as a knowledge conversion and transfer process rather than an information transfer process; (3) Viewing R&O assessment as a knowledge conversion process points to the need of the adoption of tools that are appropriate for the people involved and the techniques being used in practice.

*Paper 18, Page 141-148*

**Risk Management of Piled Foundation Projects****Paul H. K. Ho**

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**Abstract:** Risk exposure in foundation projects is substantially higher than other types of construction projects because subsoil conditions can never be precisely predicted. The objectives of this study are to identify the risks perceived by project consultants in piled foundation projects, assess the potential impact of identified risks, examine their attitudes towards risk allocation through contract provisions, and finally assess whether the contingency sum allowed is adequate to cover the potential risks. The data for this study was primarily gathered through the use of a questionnaire, together with telephone interviews. There were 60 completed project cases

returned by end December 2006. It is found that significant risks are largely allocated to the contractor and employer under the design-and-build contract and traditional contract respectively. It is also found that project consultants have over-estimated the contingency sum by 1.784% in the design-and-build contract and under-estimated the same by 4.511% in the traditional contract. This study provides a useful clue on the risk management of piled foundation projects.

*Paper 19, Page 149-156*

**Evaluating Risk Management Practices in the Pakistani Construction Industry: The Current State of Play****Tauha Hussain Ali**

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**Abstract:** The construction industry of Pakistan has experienced rapid growth in recent years due largely to stronger investment in infrastructure development. Mega projects, of a scale never experienced by Pakistani construction practitioners, require higher levels of planning and management to ensure effective procurement delivery. Moreover, construction managers need to be more meticulous when addressing construction risks, necessitating the implementation of structured risk management procedures. However, the concept of a formal and prescribed risk management process is somewhat new to these managers and they are still chiefly assessing risks through intuition, judgment and experience. While such long-established informal approaches may have been acceptable in the past, they will undoubtedly gain poor outcomes on large scale projects. This research attempts to reveal the current state of utilization of formal risk management practices in Pakistan. Specifically, a questionnaire survey instrument was adopted to ascertain current processes and procedures used to identify, analyze and mitigate risks on construction projects. The research uncovered a total of forty (40)

risks which are frequently encountered in the Pakistani construction industry as well as a range of unstructured, partially structured and structured approaches for quantifying and addressing risks. In general, this study confirmed that the large majority of Pakistani construction firms still tend to approach risk management in an ad hoc manner. Further research aims to develop a road map for improving rates of adoption of formalized risk management approaches in the Pakistani construction industry. Such a road map may have value for other developing and newly industrialized nations.

*Paper 20, Page 157-164*

### **Catastrophic Risk Analysis of Infrastructure Systems: A Research Agenda**

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**Abstract:** In recent years, the world has suffered from a series of major natural and man-made catastrophic events. The social and economic impact arising from these events were devastating. In some cases, the events severely handicapped proper functioning of affected infrastructure systems. The evaluation and risk assessment of many infrastructure projects focus mainly on “traditional” risk factors, such as construction, technology, law and regulations, demand, interest rate, foreign exchange, inflation and operation. Although many are aware of catastrophic risks, these are usually treated under the category of “force majeure risks”. To promote better economic efficiency, there is a need to re-examine whether project stakeholders can manage such risks in a more involved manner. After all, risk transfer is simply a zero sum game. This paper starts with basic descriptions of catastrophic risks before drawing the connection to project evaluation and risk management of infrastructure systems under a conceptual framework. It is suggested that the study of financial impact and management of catastrophic risks may be more readily applied to projects that are procured under a public-private partnership (PPP) financing scheme, such as Build-Operate-Transfer. This is because the terms and conditions of a long-term concession would explicitly provide a basis for evaluating the impact.

*Paper 21, Page 165-172*

### **Transitioning to an Information Environment: Performance Research in Large Capital Projects and Facility Management Group**

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**Abstract:** An information environment uses non-technical performance measurements to provide data that indicates relative efficiency and effectiveness of all key participants in a system. The movement from a traditional environment, which relies upon technical information, high levels of management and control, and large amounts of information transfer, to an information environment, which relies upon non-technical information, minimal levels of management and control, and minimizes information and communications, is difficult. In construction and facilities, the industry is predominately traditional in its characteristics and the transition to an information environment often is converse to standard practices and thinking. This paper presents research conducted at the University of Minnesota (UMN) Capital Planning and Project Management group and their movement from a traditional organization to an information environment. The UMN’s traditional management and system structure is presented along with the intermediary steps taken in the transformation to a performance information-driven system. In the transition, the UMN began with using performance measurements in small maintenance and repair requirements (specifically mechanical, electrical, and roofing services) on vendors and contractors. The system was then expanded to consider larger providers of

services and some internal assessment of department performance. As the environment evolved, the performance measurements were directed inwards, with an initial examination and tracking of project managers, designers, facility managers, etc. The resultant environment is presented along with the most recent performance results of the research.

*Paper 22, Page 173-180*

### **A Fuzzy Delphi Method in Determining the Most Advantageous Tender in Construction Projects**

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**Abstract:** There are several improvements in Greece's procurement methods in determining the most advantageous tender in construction projects specially after the Olympic Games in Athens. According to the rules of the current Government Procurement Law in Greece, the most advantageous tender is first determined based on its lowest total rank among all tenders and recently based upon a mathematical formula. These methods are criticized, however, for its violating the basic propositions of the measurement theory, being easily biased by few members in the evaluation Committee, and lack of distinct bases to discriminate the evaluation differences among the Committee members. The improved procedure suggested in this study, which is based on fuzzy delphi relations, conform to the judgment principles as well as the measurement theory. With analysis of a procurement case, the results demonstrate that the improved procedure is able to use quantitative methods to identify the evaluation differences among individual Committee members. Therefore, this improved procedure may enhance the quality in determining the most advantageous tender.

*Paper 23, Page 181-188*

### **Float Loss Impact Assessment**

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**Abstract:** Quantifying and minimizing the risks associated with delays in the construction industry are the main challenges for all parties involved. Float loss impact in non-critical activities is one of the complicated delays to assess on a project's duration and cost. This is due to the fact that the deterministic critical path method cannot cope with such delays unless they exceed the total float values. Furthermore, stochastic analysis, which is used in this research to assess the impact of such delays, is perceived by many planners to be complicated and time consuming.

This paper presents a method that was developed recently to control the risks associated with float loss in construction projects. The method uses Multiple Simulation Analysis Technique that combines the results of cost range estimates and stochastic scheduling, using Monte Carlo simulation. The proposed method quantifies the float loss impact on project duration and cost. Least-squares nonlinear regression is used to convert the stochastic results into a polynomial function that quantifies the float loss impact by relating directly the float loss value to project duration and cost at a specified confidence level.

*Paper 24, Page 189-196*

### **Decision Making in the Design Process of Refurbishment Projects**

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**Abstract:** The increasing number of ageing building, limited space for new development and financial constraints are the main factors that contributed to the importance of refurbishment sector in the Malaysian construction industry. The complexity of design process for refurbishment requires the involvement of many specialist participants with varying knowledge and orientation. This requires them to be integrated in the process through involvement in decision making. This study analyses the relationship between the degree of involvement of key participants in decision making process and the design process performance. This study concludes that the involvement of some key participants in the design process of refurbishment projects could improve the performance of the projects.

*Paper 25, Page 197-216*

### **Risk Management Perceptions and Trends Among Contractors in Pakistan**

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**Abstract:** Construction is a highly risk-prone industry with not a very good track record of coping with risks. The participants of the industry, as a result, have been enduring the agonizing outcomes of failure in the form of unusual delays in project completion, with cost surpassing the budgeted cost and sometimes even failing to meet quality standards and operational requirements. This research presents the findings of a study conducted to investigate the current state of perception and trends of risk management practices in the construction industry of Pakistan. The study was undertaken via a questionnaire survey targeted to contractors. Data was collected in ten key areas namely contractors' perception about risk, risk management policy and management support in

their organizations, risk management program and procedures used by them, risk identification process, risk assessment process, risk response strategies adopted by them, risk response control mechanisms implemented by them, risk management training structures in their organizational setups, their risk management performance, and obstacles in implementing formal risk management in their organizations. The results of the survey show that the contractors in Pakistan construction industry are not well aware of the concept of risk management. Formal risk management practices are infrequent among contractors and the projects suffer from low productivity resulting in project delays and cost overruns. In many situations, contractors perceive risks based on their own experience and judgment rather than using systematic procedures to identify, assess and tackle them. It can be concluded that contractors in Pakistan construction industry, owing to lack of systematic procedures, do not have adequate capability of retaining and mitigating risks and hence resort to mechanisms such as transferring risks. Recommendations include arrangement of formal and/or informal education and training in risk management. A change in the views and attitudes of the clients through awareness programs can bring a prominent and distinctive change in the risk management status in Pakistan, not only among contractors but also in the entire construction industry.

## **2. Construction Project Management**

### **2.1 Project Planning and Management Issues**

*Paper 26, Page 217-224*

### **A Conceptual Model for Developing KPIs for Early Phases of the Construction Process**

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**Abstract:** The pre-project stage in construction is where most of the decisions about project investment and development are taken. It is therefore very important to be able to control and influence the process at the very beginning of the project. This paper proposes a model for developing a set of KPIs for controlling the pre-project stage. The KPIs are to be identified based on a proposed framework which describes the model of the construction process. Literature reviews and interviews are used to identify the process main activities that will be used for developing the key indicators. The relevance of key process activities and some of proposed KPIs are verified by experts during a number of pilot studies. The paper describes how KPIs enable control of the processes while a project is in progress.

*Paper 27, Page 225-232*

### **Proposed Approach for Developing Process-based KPIs for Project Control During the Pre-project Stage**

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**Abstract:** In recent years a great deal of attention has been made to measuring different aspects of construction project performance. Some of the tools used for this purpose are the Key Performance Indicators (KPIs). The main shortcoming of these however is that most of them are end product oriented and hence are of little use for controlling the project performance while it is in progress.

The pre-project stage in construction is where most of the decisions that greatly influence the project as a whole are taken. To be able to monitor and influence the performance of the process at the very beginning of the project is hence very beneficial. This paper describes a theoretical framework for developing KPIs to be used for project control in the pre-project stage. The theoretical framework is based on mapping the sub-processes within the pre-project stage and their main activities. The sub-

processes and their activities are identified using literature and then validated by experts. A system dynamic (SD) approach to model the link between these and the project final objectives is proposed. The paper discusses the basis of the theoretical framework and the research methodology.

*Paper 28, Page 233-239*

### **Organizational Structure & Management Procedure in Pakistan Public Works Department**

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**Abstract:** It is essential to Pakistan's national economic prosperity that infrastructure is constantly developed at rates comparable with other developed economies, as well as a policy is devised for efficient and effective infrastructure management in the country to preserve country's national asset. This paper attempts to present the jurisdiction, organizational structure, culture and the project management application procedures to construction projects of a major public infrastructure development and maintenance organization in Pakistan, the Public Works Department (PWD). The paper initially focuses on describing the organizational structure of PWD and the culture within the organization that affects the development, implementation and managerial procedures adopted on projects. It then examines the funding and bidding mechanisms involved that largely affect the selection, resource development, and quality and risk management control of projects. The paper further attempts to delve into the policies and procedures usually implemented by the organization for the selection, planning, monitoring and control of projects, in particular the team development, responsibility assignment and training mechanisms for the management control of projects. To illustrate the mechanisms and procedures, a number of project case studies have been included for the purpose of examining the organizational project management setup and approach from a neutral perspective.

*Paper 29, Page 240-247*

### **Empowering Project Teams: Towards an Integrative Conceptualization of Empowerment**

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**Abstract:** Despite its long history, empowerment still remains a diffuse concept; a characteristic that has retarded its development and appropriate use. The theoretical underpinnings of empowerment are explicated in order to provide a thorough understanding and the much needed clarity. Towards this, two distinct approaches to the empowerment concept, structural and psychological, are differentiated and their complementarities articulated. Integrating the managerial or organisational acts/practices supportive of empowerment (structural approach) and employee cognition of empowerment (psychological approach) presents a unifying perspective that facilitates better understanding of the dynamics of the empowerment process. A multilevel perspective that exposes a paradox of empowerment in project teams is also explored and the implications for research and practice of such an integrative-multilevel conceptualization consequently outlined.

*Paper 30, Page 248-255*

### **Duration-Profit Trade-Off Analysis of Construction Projects**

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**Abstract:** This paper presents a multi-objective optimization model with the capability to generate and evaluate optimal/near-optimal construction scheduling plans that simultaneously minimize the duration of construction projects and maximize their profits. The computations in the present model are organized in three major modules: (1) a scheduling module that develops practical schedules for

construction projects; (2) a profit module that computes the total project profit; and (3) a multi-objective module that searches for and identifies optimal/near optimal tradeoffs between project duration and profit. An application example is analyzed to illustrate the use of the model and to demonstrate its capabilities in generating and visualizing optimal trade-offs between construction duration and profit.

*Paper31, Page 256-270*

### **Delays in Construction-An Empirical Study of Contractors' Perceptions in Pakistan Construction Industry**

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**Abstract:** Delay is generally acknowledged as the most common, costly, complex and risky problem encountered in construction projects. Because of the overriding importance of time for both the Owner (in terms of performance) and the Contractor (in terms of money), it is the source of frequent disputes and claims leading to lawsuits. This paper attempts to identify the major causes of delays in construction projects in Pakistan through a structured survey. The primary aim is to identify the perceptions of contractors regarding the causes of delays and the allocation of responsibilities to the parties for each delay. The preliminary data for this research was collected through extensive literature review, which was aimed at identifying causes of delays that may be encountered in a construction project. Based on the findings, a check list for causes of delay is prepared, which was classified into nine broad categories depending on their nature and mode of occurrence. These are financial/ economic delays, design related delays, contract related delays, management/ administrative delays, construction

site related delays, equipment related delays, labor related delays, material related delays, and subcontracted work related delays. Based on the survey findings, the frequency of occurrence and severity of each delay cause as indicated by contractors, the most critical delay causes under each category were identified and the share of responsibility was gauged. A delay value and a delay criticality index was used to identify the major delay causes in the industry which, in descending order of criticality, were found to be: change orders, labor productivity issues, poor site management and supervision, inspections/ audits, poor cost estimation & control, inadequate project scheduling, defective design, inefficient construction methods, delayed payments, and incomplete construction drawings. The percentage allocation of responsibility for overall delay causes, according to contractors' perceptions, was as follows: contractors = 48.75%, consultants = 17.5%, owners = 16.25%, government = 8.75%, and shared = 8.75%

*Paper 32, Page 271-278*

### **An Artificial Neural Network Approach in Service Life Prediction of Building Component in Malaysia Based on Local Environment and Building Service Load**

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**Abstract:** The degradation of building and its components are influenced by whole set of factors such as environmental degradation agents, quality of material, protective treatment, design of building, quality of work and maintenance. Selection of suitable materials for the building components can prolong the service life of particular building components and in certain cases require less maintenance and replacement activity. Emphasis on material characterisations at the design stage is limited because most of the time great emphasis is given on delivering with lowest initial building cost

rather than lowest life cycle cost. In this study, an artificial neural network is used to predict the service life of building materials with the basis study on deterioration of building components affected by its surrounding environment and factors that accelerate its aging process. The advantages of artificial neural network is employing as a prediction tool. The back-propagation learning algorithm is used as learning model. The environment load factors, workmanship, design, usage and level of maintenance are used as input variables in training process of the neural network model. The results are encouraging and potentially useful for further application of the service life prediction.

*Paper 33, Page 279-287*

### **Factors Influencing Project Success: Perspective From Client, Consultant and Contractor**

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**Abstract:** Success has always been the ultimate goal for every construction project. The study of project success is considered to be a means to improve the effectiveness of project. Generally, successful project can be defined as the overall achievement of project goals and expectations. This goal and expectation relate to a variety of elements including technical, financial, educational, social and professional issues. However, the definition of project success is differing for each construction professionals. Due to this reason, this study is conducted to gather information and feedback from construction professionals to determine the factors influencing the successful completion of construction project. This paper aims to investigate the perspective of Client, Consultant and contractors on factors that influence project success. Questionnaire survey was administered to Client, Consultant and Contractor throughout Peninsular Malaysia, Sabah and Sarawak. The methodology of the study involved questionnaire survey, administered to the Client, Consultant and Contractor throughout Peninsular Malaysia, Sabah and Sarawak. From the analysis shows that the

factor which has the most influence to the success of construction project is cost overrun. The discussion focuses on the extent of these major factors, types of procurement, types of project and stages of construction that influence the successful completion of construction project. This study also concluded that there is a significant differences in all the three perspectives with the influence factors. The discussion on all of the three different perspectives i.e. Client, Consultant and Contractor would shed some light in achieving successful completion of construction projects in Malaysia.

*Paper 34, Page 288-296*

### **Investigation of Site Managers' Constraints on Construction Resources Utilisation**

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**Abstract:** The capability of controlling and monitoring construction resources and the application of production information to achieve predetermined objectives of scope, cost, time, quality, and clients' satisfaction are the primary function of project managers. However, the applications of this production information are usually hindered by their complexity, ambiguity and inadequacy of information provided by the design team. These often results in various conscious, unconscious, or unavoidable resource wastage. Thus, this paper addresses the restraints on project managers in the optimal minimisation of resource

wastefulness during the building production process. The investigation and discussions are based on an action survey, comprising structured verbal interviews and informal discussions with project managers. The research identifies and evaluates problems associated with site managers' constraints and resultant effects upon on cost of construction, time of project delivery and quality of the end product. Design team attitudes towards project change, implication of inefficient communication to effect change, production documents inadequate information and due process protocol constraints the implementation of change at occurrence, are identified as the facilitators of this predicament. The suggestion made in this paper will provide the opportunity for significant waste minimisation procedure. Thus, the implementations will lead to more proactive and efficient building production

*Paper 35, Page 297-304*

### **Perception of Thai Professionals on Key Performance Indicators (KPIs) for Mega Construction Projects**

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**Abstract:** Performance measurement criteria of mega projects vary from project to project. Though there is no general agreement among the researchers on key performance factors on mega projects, this research targets to investigate such factors in context of Thailand construction industry. The study explores the significance of key performance indicators in perspective of various construction stakeholders. Findings indicate that traditional triangle of 'on time, under budget and according to specification', is no more a standard of performance measurement on mega projects. Other factors such as safety, efficient use of resources, and other

qualitative measures are increasingly becoming important. This implies that Thai construction industry is slowly departing from traditional measures of performance to a rather mix of qualitative and quantitative performance measures.

*Paper 36, Page 305-312*

### **Major Factors Affecting Highway Construction Productivities**

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**Abstract:** This paper presents the identified major factors affecting highway construction productivities and their effects on construction production. The analysis indicates that the production rates are statistically different for different construction firms. Generally, the production rates in rural areas are higher than those in urban areas. This should be attributed to the fact that the traffic volumes in urban areas are much higher than those in rural areas. The traffic conditions in urban areas would require different traffic control, limit the number of roadway lanes to be closed for construction, cause traffic congestion and material delivery delays, and put more restrictions on time periods for construction. Adverse climatic conditions negatively affect many highway construction activities. The results exhibit that the production rates increase as the air temperature increases up to 70oF. Then the production rates tend to slowly decrease beyond 70oF. Air temperatures are directly related to the seasons. Thus, the effects of air temperatures on production rates imply that the season is one of the major factors affecting production rates. The study reveals that the production rates are highest in the summer and lowest in the winter.

## **2.2 Procurement Management**

*Paper 37, Page 313-325*

### **Project Inception: A Workshop Approach for Preparing the Strategic Brief**

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**Abstract:** The project inception stage has become the focus of intense research activity in design, project management and facilities management for a number of years. The need to establish the project parameters and performance requirements is crucial to the success of any construction project – large or small. Many organizations and facilities and project managers have been developing approaches and approaches to assist in this process. Pre-design processes and activities that work through the client's business case, strategic and organisational issues, identifying and refining the needs and requirements before the design team is involved are becoming routine. These approaches aim to prepare a clear and workable statement of the project requirements in performance terms that the client and user groups have committed themselves to. This strategic (or performance) brief can then provide a sound basis for the documentation of the favoured strategy and provide a sound basis for the development of the design.

*Paper 38, Page 326-333*

### **Developing a Procurement Case for Project Partnering Management: The Space Approach**

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**Abstract:** It is noted that project management and partnering have been treated as separate procurement systems to aid project success through the effective development and use of project team structures. Both the Latham (1994) and Egan (1998) reports advocated for partnering and project focused collaborated systems as a conflict resolution mechanisms. This paper seeks to identify the overlapping themes, which in turn can form a

common model thus termed Integrated Project Partnering Management (IPPM) system.

This research paper aims to identify whether project teams and partnering were of the same variation; and investigate the contribution of project managers to the partnering process in terms of promotion and assistance to the process. Using a triangulated approach, data was collected from a survey of 20 construction professions from the UK Construction Industry and an extensive literature, this paper presents a framework (SPACE) as a basis for developing an integrated Project Partnering Management Systems. The stages of the framework for 'Strategy Principles Application Concepts and Execution' (SPACE) are described, and the findings from the quantitative study investigating the role of project managers in the partnering process are presented.

This paper concludes with the identification of the overlap that exists between partnering and project management and the role played by project managers in the promotion and assistance of the partnering process. It has also attempted to highlight how the aspirations of the Egan and Latham reports in resolving the internal and external conflicts within the project teams and among the parties within the construction process are addressed by the two systems.

The paper has major implications as it will contribute towards the development of a generic model which can be of considerable value to project managers and furthermore there is scope for general practitioners within the Construction Operational Environment to reap the benefits from the dual systems as opposed to the individual systems.

*Paper 39, Page 334-341*

### **A Research Framework for Investigating Public Private Partnerships (PPP) in Hong Kong**

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**Abstract:** PPP is a general term covering all contracted relationships between the public and private sectors to produce a public asset or to deliver a public service. Its major advantage lies in utilising resources from the private sector to alleviate some of the financial burdens of the government.

The Asian financial turmoil in the late 1990s has imposed enormous pressure on the budget of the Hong Kong Special Administrative Region (HKSAR) Government. With a continuous outcry for better public services due to the rapid development of Hong Kong, alternative financing models need to be sought to ensure sustainability. Hong Kong has the advantage of being the international gateway to Mainland China, and with this benefit has attracted overseas enterprises to base their offices in Hong Kong for the Asian market. Obviously the private sector has much to contribute. The HKSAR Government has realised the benefits of using PPP in Hong Kong as well as the success achieved overseas. But a more thorough research is needed to develop the most suitable practice of PPP in terms of project nature, project complexity, project type and project scale under which PPP is most appropriate for Hong Kong.

This paper provides an initial report of a research project being funded by the Research Grants Council (RGC) of the HKSAR. The project aims to evaluate the benefits and risks of PPP adopted in Australia and the United Kingdom, and from these previous experiences to develop a best practice framework for implementing PPP in Hong Kong. It firstly reports on the status of PPP development trend and the hands-on experiences which have been drawn in these countries. Qualitative and quantitative research methods applied in conducting the research are discussed. The likely impacts of the study are highlighted. It is believed that the construction industry and the government would benefit a lot as a result of this study, and further procurement and project financing options would be opened up for delivering better future public service.

*Paper 40, Page 342-349*

### **Motivating Contractor Performance Improvement through Measurement**

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**Abstract:** In construction, motivating systematic change and improvement is a task often met with frustration. Benefits of proposed systematic change are often hard to define, measure, and “sell” to those parties involved. If implemented, changes commonly fade from an organization’s structure and revert to the status quo. Faced with these realities, the director of the United States Army Medical Command, the division responsible for the construction and maintenance of all the hospitals in the US Army, when tasked with improving the performance of construction and facility management, decided not to adjust the system, but instead to measure the comparative performance of the critical system elements. Through the capturing and distribution of performance information, a nature competition and self-assessment ensued. Contractors, motivated by their comparative standing in relation to each other, strove to improve each performance measurement. The relative rise in efficiency has resulted in contractors seeking additional education in performance methodologies and the creation of an elite class of general contractors who are constantly rated on their project performance and report to a third party evaluator. This paper presents the research process, program, and results tracking the implementation of performance measurements, comparative analysis, and contractor responses in the US Medical Command.

*Paper 41, Page 350-357*

**A Generic Framework of Performance Specifications for Specialist Works****Patrick T.I. Lam**

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**Abstract:** With the advent of the Design and Construct procurement approach, there has been a trend of specifying construction works by performance. The perceived benefits of Performance Specifications are mainly innovation and the possibility of contribution by specialist designers. Yet, the lack of a suitable framework for specifying specialist works sometime causes bitter disputes and costly rectification works.

As part of a recently completed doctoral research by the first author, a useful generic framework of Performance-based Specifications has been proposed and established using data from 5 case studies of curtain wall installations in Australia, Hong Kong and Singapore. Curtain wall was chosen due to the specialist design and stringent testing requirements, which are often based on performance specifications. The proposed generic framework consists of two levels. The first level consists of five generic headings (i.e., General Requirements, Performance Requirements, Product Requirements, Execution Requirements and Evaluation Requirements), which can be used to group all specified details irrespective of the nature of the installation. The second level consists of work-specific details but they need only minor adaptations to suit different works. This generic specification framework has been validated as being applicable to other types of performance-based work in accordance with published criteria and tested with two different real projects in Hong Kong and Singapore.

In addition, works which are suitable for Performance Specifications are discussed and they include those for which performance criteria are measurable and achievable. The pitfalls of specifying by performance have also been identified and recommendations have been given for problem avoidance and general improvements.

*Paper 42 Page 358-365*

**The Stakeholder Relationship Measurements of Major Procurement Routes in Finland****Adekunle Sabitu Oyegoke**

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**Abstract:** The paper presents the results of the stakeholders’ relationship in major procurement routes in Finland based on empirical case-

questionnaire studies. The aim of the study is to compare procurement performance in Finland based on the level of the relationship between the major players. Construction project performance is measured via rating system along design and construction stages, and among the key stakeholders of owners, consultants, contractors, and subcontractors. The procurement methods are categorized into design and build, consulting CM, contracting CM, general contract (traditional), and general Contract (separate trades). The results show that the performance attributes are shared between different routes in different phases. For instance, the consulting CM route ranked better in owner and consultant relationship in design phase due to fiduciary role of the construction manager in the projects. The design and build ranked first in relationship between the owner and the contractor in construction phases due to single point of performance responsibility. In overall relationship average rating, the consultants and contractors relationship is rated lowest in design stage while the contractors and subcontractor rated lowest in construction stage.

*Paper 43, Page 366-372*

### **Contracting for Community Development: A Case Study Based Perspective of a Public Sector Client Initiative in Hong Kong**

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**Abstract:** The construction industry is known to be an important contributor towards the gross domestic product of many countries. Moreover, the health of the construction industry is positively correlated to the economic growth of a country and in many economies public sector clients account for a major share of construction works. Given this strength, it is important for public sector clients to initiate innovations aimed at the betterment of the industry. In this context, concern about sustainable development has been a major driver of some

innovative initiatives in construction industries worldwide. Furthermore, the Government of Hong Kong regards both sustainability and community development as important criteria when planning and procuring construction projects. This paper is based on a case study of a public sector development project in Hong Kong, and presents the salient features of the procurement and contractual systems adopted in the project, which foster sustainability and community development. The reported interim findings are based on a preliminary document analysis that is part of an ongoing longitudinal case study into the project. The document analysis takes a three-pronged approach in terms of how the procurement and contractual systems foster economic, environmental and social sustainability, and sums up their impact on the community as a whole.

### **2.3 Safety and Quality Management**

*Paper 44, 373-380*

#### **Inadequate and Unsafe Temporary Lighting in Buildings under Construction: Risks, Challenges, and Solutions**

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**Abstract:** The use of temporary lighting in buildings under construction is necessary to enhance safety and productivity of the workers. Construction sites are dynamic environments. With the constant change in environment, proper and consistent illumination is a challenge. The US construction industry has minimum guidelines for temporary lighting established by OSHA. The examination of OSHA records shows that inadequate lighting has been a contributing factor for site accidents. The question becomes whether or not construction sites in the US are meeting the minimum OSHA standards. Thirty three construction sites were visited and light readings taken inside the buildings under construction. The study showed that there are several methods, in which general contractors are providing temporary lighting for the projects, but the lighting was inadequate and most work areas did not meet the minimum OSHA standards. A discussion of possible solutions sets the groundwork for improving the temporary lighting environment.

*Paper 45, Page 381-387*

### **Health Monitoring of Civil Structures- Current Status and Perspectives**

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**Abstract:** This paper focuses on the modern concept of health assessment of structures, just like medical doctors monitoring the health of their patients during and after major illnesses via appropriate measurements. Recently, the idea of structural health monitoring (SHM) has received considerable attention worldwide due to the fact that civil infrastructures form the back bone of any modern economy. Failure of structures such as bridges, dams, high rise buildings and power plants to perform at their best might have serious repercussions on the economy. It is therefore pragmatic to instrument important structures so that they can be continuously monitored in preventive mode and any possible malfunctioning can be predicted in advance, before it gets transformed into a catastrophe. This paper provides a glimpse of the available sensor technologies and methodologies for SHM, along with several case studies. Challenges ahead, especially with respect to the state-of-the-art are also highlighted.

*Paper 46, Page 388-395*

### **Integrated Health Monitoring of Highway Bridges**

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**Abstract:** Highway bridges constitute major part of today's transport system. A sudden collapse of even a single bridge results not only huge financial losses but loss of human life as well. Hence, proper maintenance of bridges is of prime importance. Structural health monitoring (SHM) is an important aspect of maintenance, where, a structure is monitored for any incipient damage or structural abnormality. This paper presents the experimental results of our work on monitoring of highway bridges. Fiber Bragg grating (FBG) sensors, accelerometers and electrical strain gauges (ESG) were used for monitoring of the bridges. As case study, monitoring of Poincer Bridge and Tuas Link has been presented.

*Paper 47, Page 396-413*

### **Accident Investigation, Blackspot Treatment and Modeling of Federal Route F050 Malaysia**

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**Abstract:** Road accidents are one of the major contributors of human deaths in Malaysia. In the year 2006, 341,252 accidents were recorded, resulting in an average 18 deaths from road accidents every single day. Federal Route 50 from Batu Pahat to Ayer Hitam experienced 4,842 road accidents between the years 2000 and 2005, killing 244 people and injuring 1,644 people. The purpose of this study is to perform an accident analysis and to propose countermeasures at the Pintas Puding area, and to develop an accident prediction model for Federal Route 50 by using multiple linear regression analysis. The road accident trend and blackspot ranking were established at Federal Route

(F050) Batu Pahat – Ayer Hitam. It revealed that the increment of accident rates can be explained by either the rises in speed, number of major access point and traffic volume.

*Paper 48, Page 414-419*

### **Life Safety Systems: Construction of Miami Intermodal Center**

**Mario G. Berrios**

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**Abstract:** The Miami Intermodal Center (MIC) will consist of the following buildings: the Rental Car Facilities (4 million square feet); the Miami Intermodal Center Connector Building; the Metro Rail Station; the Tri Rail Station; and the Bus Station Building. An elevated enclosed glass bridge will connect all the buildings. Due to the high density of this mega-structure, 5 large buildings, and the existing buildings around plus the future buildings to be built, the life safety systems for the Miami Intermodal Center is one of major design issues. 160 gasoline pumps cannot be placed in the building according to the building codes and fire codes, as the 160 gasoline pumps inside the rental car facility makes this building an extra high hazard structure (NFPA 30, 2003). However, computer modeling simulation performance based designs are used to provide equivalence to the code. Foam fire extinguisher systems, Ultra Violet/Infrared detectors, smoke control systems, fire sprinkler systems, fire alarm systems, and heat detectors are incorporated into the life safety systems to eliminate life safety hazards and make the Miami Intermodal Center a successful project (SFPE).

*Paper 49, Page 420-437*

### **Developing Safety Culture in Pakistan Construction Industry – An Assessment of Perceptions and Practices among Construction Contractors**

**Rizwan U. Farooqui**

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**Syed M. Ahmed**

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**Kamalesh Panthi**

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**Abstract:** This paper presents the findings of a study conducted to investigate the current state of adoption and implementation of safety management practices in the Pakistan construction industry. The study was undertaken via a questionnaire survey targeted to general contractors in Pakistan. Data was collected in eight key areas namely general perception about safety, site safety, safety training, safety record keeping and strategies. Based on the findings of this study, it was possible to identify the key areas of safety management implementation that require improvement. It was found from the study that the majority of the contractors had safety policies and procedures in place; however, safety management implementation at site and worker levels was far below satisfactorily.

*Paper 50, Page 438-445*

### **Causal Relationships between Enablers of Construction Safety Culture**

**Thanwadee Chinda**

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**Sherif Mohamed**

Professor, Director, Centre for Infrastructure Engineering & Management, Griffith University, Gold Coast, Queensland, Australia

**Abstract:** Better understanding of safety culture and causal relationships between its key elements is a must for construction organizations to strategically allocate their safety resources. This paper reports the use of structural equation modelling (SEM) technique to test causal relationships between key elements of construction safety culture. These elements (five enablers and goals) were identified through the utilisation of the widely used EFQM Excellence Model. Data gathered via a questionnaire survey were analysed using SEM. The statistical results appear to support the hypothesized positive relationships between five enablers and goals. Moreover, the analysis reveals that the “people”

enabler has a positive effect on other enablers such as “partnerships and resources” and “processes”. The study findings highlight the interaction among the five enablers thus guiding construction organizations to identify which enabler(s) has the potential to maximize returns on their safety resource investment in order to achieve predetermined goals of the overall health and safety performance.

*Paper 51, Page 446-452*

### **On using Six-Sigma Principle for Quality Improvement in Construction**

**Vivian W. Y. Tam**

Lecturer, Griffith School of Engineering, Griffith University. Australia

**Khoa N. Lee**

Lecturer, Griffith School of Engineering, Griffith University. Australia

**Abstract:** The Gaussian distribution and Six- $\sigma$  principle have been widely used in the field of construction quality management with great success. Even though the Gaussian distribution has been solely used as the most dominant distribution, there exist other distributions which can be even more effective than the Gaussian distribution. This paper gives a theoretical study on a new Hyperbolic distribution using the Six- $\sigma$  principle to improve quality in construction management. The Hyperbolic and Gaussian distributions are then numerically compared by estimating their important statistical properties such as population in range, number of defects, yield percentage and defects per million opportunities. The impacts of these factors are briefly discussed to give guidance to organisations in the construction industry on how to lower cost and to improve project quality by prevention. To illustrate the theory behind these distributions and the Six- $\sigma$  principle and to also show their reliability and effectiveness, a case study using cost data from a hydro-seeding industry is presented. From that, in this particular case, the Hyperbolic distribution is shown to be more effective in quality improvement by prevention than the Gaussian distribution. This validates the Hyperbolic distribution as a suitable distribution for construction quality management.

*Paper 52, Page 453-460*

### **Comparison of Construction Quality Management Systems in Japan, Hong Kong and Singapore**

**Andrew W.T. Lau and S.L. Tang**

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**Abstract:** Infrastructure construction has always been attached to economic development and the management of quality problems associated with construction is expected to evolve continuously. This paper presents a literature review of the recent construction quality systems in Japan, Hong Kong and Singapore. All these three Asian countries have already developed high standard of construction management. The quality management concept had caught the attention of the Japanese construction industry since the 1970s. By applying the quality management tools, many Japanese contractors are practicing total quality management. In order to compete internationally, they also commenced their ISO 9000 certification programmes in mid 1990s. The awareness on construction quality in Hong Kong emerged in late 1980s. The Performance Assessment Scoring System (PASS) was introduced in 1990 for measuring building contractor performance. In 1993, the authorities commenced ISO 9000 registration requirements for contractors and consultants in Hong Kong. In Singapore, the Construction Quality Assessment System (CONQUAS) was set up in 1989 to assess the quality of construction work. In 1999, the Singapore government announced the ISO 9000 certificates requirement for contractors and consultants. The Building Design Appraisal System was also set up by the government in 2001 to assess the quality of buildability in design.

*Paper 53, Page 461-468*

### **A Model for Collaborative Industrial Engineering Support and Performance Improvement of Construction Projects**

**Lincoln H. Forbes**

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Miami, FL, USA

Also: President, Construction Division  
Institute of Industrial Engineers  
Atlanta, Georgia, USA

**Abstract:** The Construction Industry is the largest industry in many countries (approximately US\$4 trillion annually, worldwide, and over US\$1trillion in the US). Despite modest improvements in erection methods most construction is still executed through time-honored but suboptimal techniques. Studies have indicated a loss rate of as much as 30% in the construction process due to errors, wasted time, and wasted resources. These costs of poor quality are passed on to society as inherent costs in the construction process. Although Frank Gilbreth, one of the “founding fathers” of Industrial Engineering did pioneer work on construction processes in the 1890’s, the industry has not benefited from the contributions of industrial engineers to the extent experienced by the manufacturing and service sectors.

Through its Construction Division, the Institute of Industrial Engineers (IIE) has been promoting collaboration with the construction industry, and proposes to bring to it the type of improvement that Industrial Engineers (IEs) have contributed to other industries such as manufacturing, retail, and service industries. The Construction Division’s mission involves harnessing the skills and knowledge of many Industrial Engineers (IEs) who work in the construction industry, or who have an interest in it. The purpose of this paper is to:

- a) Communicate the methodologies proposed by IEs to support the construction industry and to enhance its performance
- b) Provide brief examples of IE-based improvements

*Paper 54 Page 469-486*

### **Assessing the Quality Culture in Client Organizations in Pakistan Construction Industry- A Way Forward to TQM Implementation in Pakistan**

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Professor and Dean, Faculty of Civil Engineering & Architecture, NED University of engineering & Technology, Karachi, Sind, Pakistan

**Abstract:** This paper attempts to investigate the existing quality culture, policies, procedures and formal quality management practices in construction client organizations in Pakistan with the objective to assess the acceptability and suitability of these organizations toward adoption and implementation of Total Quality management (TQM). The investigation is performed via structured interviews targeted to major public clients. Data was collected in seven key areas namely clients’ knowledge of TQM, their perception of quality, quality-related data acquisition methods used by them, partnering and teamwork approaches adopted by them, quality management and improvement strategies in their organizations, quality-related training provided to their employees, and the obstacles faced by them in implementing TQM in their businesses. Willingness and preparedness of clients as well as suitability of implementation of TQM in Pakistan construction industry is gauged from the research results. It was found that the client organizations in Pakistan are generally neither willing nor prepared to adopt TQM as a management philosophy within their organizations. The major obstacles to implementing TQM in the Pakistan construction industry were found to be lack of expertise/resources in TQM, rigid attitude and behavior of executive management toward quality, minimal management and employees’ commitment toward quality, lack of education and training to drive the improvement process, and tendency to cure symptom rather than get to the root cause of a problem. It is recommended that extensive awareness and training programs be initiated to improve the clients’ understanding and approach toward quality and hence increase their willingness to implement TQM, which would in turn improve coordination, teamwork, productivity and industry performance in the long run.

*Paper 55, Page 487-494*

### **Analysis of Construction Site Safety Education Developments in New Zealand, Where to From Here?**

**L. J. Richardson**

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**S. T. K. West**

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**K. L. Sanford**

Operations Manager, Applied Technology Institute,  
UNITEC, Auckland, New Zealand

**Abstract:** This paper discusses the New Zealand approach to developing an educational package in construction safety. As a case study, it will follow the development of a level 3 certificate programme by Unitec New Zealand and Site Safe New Zealand.

This paper describes the evolution of the Certificate in Construction Site Safety, a responsive programme developed through a consortium of construction companies, and a partnership between Site Safe and Unitec. The development of course material to meet the needs of the intended audience, goals achieved, academic quality management issues, and reflections on the success achieved are analysed.

Further discussed is the future of this educational package and delivery methodology. Having just completed the first year of operation and with students graduating in September 2006, a review of Government and private funding options and the progression for the package is surmised. In particular, conflicts between Government funding of safety courses and the legislative requirements for safe work sites highlight the continual difficulties faced offering academic programmes on site safety.

Finally the paper attempts to align the operation and delivery of construction safety education and training with those taking place in Australia, and concludes with a few possible pathways for the future.

**2.4 International Issues**

*Paper 56, Page 495-503*

**Lesson Learned Corrective Action in Internal Factors of Construction Company in Indonesia****Sudarto**

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**Bambang Trigunaryah**

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**Ismeth S. Abidin**

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**Abstract:** In improving Indonesia construction companies' ability to compete, anticipative steps by determining various improvements and corrections in construction companies are needed to increase the company's quality performance. Several factors that influence and determine the success of a construction company can be grouped into internal factors, external factors, and market forces. Internal factors in a company are important factors and have the effect of approximately 42% towards the company's success. Management, equipment, human resources, corporate culture and finance dominate the internal factors' influence towards the success of a construction company. The research objective discussed in this paper is to identify the causes of internal factor problems in construction companies and their corrective action recommendations. Corrective actions are needed to fix the problems and it depends upon the cause and the effect of the problems in construction companies. The methods used are literature studies and survey to identify the problems including their effects and causes, also their corrective actions. Analyses used in this research are Statistical Analysis, Monte Carlo simulation and Delphi Method. The results show that the corrective actions towards the problems in internal factors which are mostly corrective action during construction process and lesson-learned corrective action (preventive action).

*Paper 57, Page 504-511*

**Long Term Indonesian Construction Industry's Aggregate Productivity Simulation Considering Overall Business Environment****Hari G. Soeparto**

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Queensland, Australia

**Abstract:** Competitiveness of Indonesian Construction Industry is in question. It is necessary to address the problem soonest so that persistence situation can be improved. To find the solution for this problem this research therefore conducted. The research are conducted in two steps, the purpose of the first step is to determine the problem of the Indonesian construction industry, second step is to built a soft system dynamics model through a soft system modelling and structural equation modelling. Data were collected from various sources such as World Bank Institute, Freedom House, International Corruption Watch, UNDP, Indonesian Statistics Office and Bank Indonesia. Primary data was collected from Indonesian Construction Industry Players. This study indicates that: higher educated human resources in construction industry are not effectively support the productivity of the industry; construction industry players tend to consider short term benefit than long term sustainability and growth; strategic planning time horizon consideration contribute significantly in long term productivity. It is suggested that to improve productivity of Indonesian construction industry several step should be taken: marketing orientation should be changed toward more sophisticated project, institution for collaboration in construction industry should be initiated and high governance should be established and maintained.

*Paper 58, Page 512-517*

**An Overview of the International Construction Market****Mehmet Emre Bayraktar**

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**Irtishad Ahmad**

Professor, Department of Construction Management  
Florida International University, Miami, Florida,  
USA

**Vijay Mohan Bangaru**

Graduate Student, Department of Construction Management, Florida International University, Miami, Florida, USA

**Abstract:** The purpose of this paper is to analyze the current trends in the international construction market. The analysis will be conducted from several different perspectives. The world will be divided into various geographical regions such as the Far East, Middle East, Europe, and Latin America. Data from each of the aforementioned regions will be examined to interrupt both the extent of their own involvement in foreign construction billings as well as their domestic construction billings from other regions. In addition to the region-by-region analysis, international billings of contractors from specific nationalities will be considered in an effort to provide ideas for new construction companies seeking opportunities apart from their own respective regions. This paper will also focus on factors impacting international construction such as legal frame work, political issues, project types, and governmental investment opportunities.

*Paper 59, Page 518-524*

**Complex System Approach for Dynamic Performance Prediction of International Construction Projects****Heedae Park**

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**Seung Heon Han**

Associate Professor, Yonsei University, Seoul, Korea

**Hyoungkwan Kim**

Assistant Professor, Yonsei University, Seoul, Korea

**Du-Yon Kim**

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**Abstract:** International construction projects suffer from more diverse and complex risks, resulting in less profitable performance than that of domestic projects. An extremely unsuccessful project can put

a company into a seriously troubled financial situation. Sufficient understanding of the project's characteristics when choosing an international project leads to appropriate strategies to insure a profitable performance. In this study, a complex system approach is adopted to understand the dynamic and interrelated performances of various influencing factors of international construction projects. First, based on the literature review and our earlier work, 50 performance influencing variables are extracted. Then, using system dynamics method, a prototype model is developed where both qualitative and quantitative analyses are possible. Through the proposed model, the cause-and-effect relationship between project performance and influencing factors are effectively represented and analyzed. The model helps to systematize and evaluate factors that critically influence the project's performance. It also considers the impact of external factors and strategies to cope with the undesirable consequences of the unforeseeable events. It is expected that the model promotes better understanding about how various factors are interrelated and how variables' information flow with meaningful feedbacks, ultimately improving the performance prediction and acquiring a promising opportunity

## 2.5 Knowledge Management in Construction

*Paper 60, Page 525-532*

### **Empirical Approach to Understand the Knowledge Management Process**

#### **Le Chen**

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#### **Sherif Mohamed**

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**Abstract:** Knowledge Management (KM) is a process that focuses on knowledge-related activities to facilitate knowledge creation, capture, transformation and use, with the ultimate aim of leveraging organisations' intellectual capital to achieve organisational objectives. The KM process receives input from its context (e.g. internal business environment), and produces output (i.e. knowledge). It is argued that the validity of such knowledge should be justified by business performance. The study, this paper reports on, provides enhanced

empirical understanding of such an input-process-output relationship through investigating the interactions among different KM activities in the context of how construction organisations in Hong Kong manage knowledge. To this end, a theoretical framework along with a number of hypotheses are proposed and empirically tested through correlation, regression and path analyses. A questionnaire survey was administered to a sample of construction contractors operating in Hong Kong to facilitate testing the proposed relationships. More than 140 respondents from 99 organisations responded to the survey. The study findings demonstrate that both organisational and technical environments have the potential to predict the intensity of KM activities. Furthermore, different categories of KM activities interact with each other, and collectively they could be used to predict business performance.

*Paper 61, Page 533-540*

### **Investigating the Link between Climate for Innovation and Diffusion Outcomes in Architecture and Engineering Design Organisations**

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#### **Rodney A. Stewart**

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#### **Sherif Mohamed**

Professor, Griffith School of Engineering, Griffith University, Gold Coast, Australia

**Abstract:** Innovation is widely recognised as a driving force for a firm's economic growth. Generally, innovation can come to an organisation by means of adoption or generation. Either way, the process of innovation diffusion is involved. Diffusion is a process by which an innovation is disseminated through communication channels among members of a social system over time. In this regard, social influence, in terms of organisational climate, is conceived of as a critical innovation enabler. This paper thus focuses on studying the impacts of a facet-specific climate namely "climate for innovation" on innovation diffusion outcomes in architecture and engineering design (AED) firms. This paper argues that there are three main factors forming climate for innovation: organisation culture, leadership and

team climate. Despite the existing literature within the context of construction highlighting the importance of such factors, empirical studies addressing their impacts on firm-level innovation diffusion and business performance are sparse. To overcome this deficiency, a conceptual model was developed to be used for empirical investigation. This paper details the theoretical development of such a model and outlines a research method and plan of future research activities.

*Paper 62, Page 541-548*

### **Evaluating International Technology Transfer on Thai Construction Projects: A Case Study**

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**Rodney A. Stewart**

Senior Lecturer, Griffith School of Engineering, Griffith University, Gold Coast, Australia

**Abstract:** In an effort to more rapidly develop their infrastructure, economies and living standards, many newly industrialised countries, such as Thailand, have embarked on a series of international Technology Transfer (TT) initiatives within the construction and other industries. However, these initiatives have not immediately translated into enhanced capabilities and competitiveness within indigenous firms, resulting in a sustained reliance on foreign firms. With few clues as to why TT ventures have not created expected outcomes for the indigenous construction industry, these countries lack direction on how to more rapidly diffuse best-practice technology. In an attempt to improve rates of TT in the Thai construction industry, this paper reports on an attempt to appraise international TT performance on five large construction projects. A previously developed framework, developed by the authors, was utilised for this purpose and includes a total of six enabling and outcome perspectives, namely: (1) relationship building; (2) transferor characteristics; (3) transferee characteristics; (4) economic advancement; (5) knowledge advancement; and (6) project performance. A questionnaire survey was utilised to solicit TT performance scores from forty seven (47) Thai construction professionals working on these five projects. Summated TT performance scores are illustrated for the five companies using spider diagrams. Moreover, in-depth discussion on the forces driving such scores is provided. Evaluating

international TT on construction projects is the first step to assist host construction firms and government agencies to yield greater value from such initiatives.

*Paper 63, Page 549-556*

### **Fighting Organisational Amnesia: A Conceptual Framework to Investigate Knowledge Retention and Learning Practices in Australian Construction Organisations**

**Tayyab Maqsood**

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**Abstract:** This paper reports on in-progress research being undertaken at RMIT University, Melbourne Australia. In knowledge economy of today, the best strategy for construction organisations in Australia to become competitive and innovative is to enhance the management and utilisation of knowledge. In project environments such as the construction industry, it is highly desirable that knowledge and lessons learnt be captured from one project and are effectively integrated in organisational learning processes so that they can applied on subsequent projects. Failure to do so causes “Organisational Amnesia”. This leads to the ‘wheel being reinvented, repetition of mistakes and poor decision making causing reduced productivity and large expenses that cost whole Australian community. This research aims to investigate the current practices of Australian construction organisations regarding management of knowledge and identify the factors that cause organisational Amnesia. This would be helpful in developing strategies to improve the retention of knowledge and learning from past projects.

*Paper 64, Page 557-564*

### **Applying Bayesian Belief Networks to Construction Management**

**Zhong Tang**

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**Brenda McCabe**

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**Abstract:** Bayesian belief networks (BBN) is a probabilistic technique in artificial intelligence. BBN make complex system models operational by showing relationships explicitly - the structure and degree of dependence, which will facilitate the research and practice of decision making. Construction projects become more and more complex and risky in rapidly changing modern societies. Risk analysis and decision-making under uncertainty are real challenges in construction management. BBN provide a potential method to estimate risks and facilitate decision-making in construction projects. In this paper, the basic concept of BBN is presented and BBN establishment and procedure are discussed. One critical step applying BBN to construction management is knowledge elicitation from construction experts. The concerns in knowledge elicitation are examined. Finally, an example of BBN established upon the input from experts is demonstrated.

*Paper 65, Page 565-573*

### **A Knowledge Map for Delay Analysis Development**

#### **Jyh-Bin Yang**

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#### **Chih-Kuei Kao**

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**Abstract:** Schedule delays occur frequently in construction projects. There are many methodologies developed and used in the analysis and measurement of construction schedule delays. The popular and comparatively acceptable methodologies include the time impact method, the but-for technique and the windows method. However, no one method is accepted by all project participants and suitable for all situations. How to help the methodology user to select a suitable one or the researcher to develop new one is a critical issue in resolving delay claims. Several studies have provided tabular information for guiding users in selecting a suitable methodology. To provide additionally constructive information is required for new methodology development. A knowledge map is a vital tool for better knowledge management and learning. This study reviewed 28 articles regarding construction delay analysis techniques and then

developed a knowledge map with a representation of cross-citation tree for delay analysis in the construction industry to represent methodology development. For novices interested in learning delay analysis knowledge, results of this study provide worthwhile information to know the key approaches and research trends. For researchers, results of this study provide a front-end research map for reference.

*Paper 66, Page 574-582*

### **Ming Knowledge in KMS Performance Data - A Case Study of an A/E Consulting Firm**

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#### **Cheng-te Lin**

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**Abstract:** Knowledge Management System (KMS) has emerged as a popular approach not only for implementing knowledge management functions such as knowledge generation, storing, retrieval, and sharing, but also enabling an organization a tool to measure and monitor its intellectual property. Measurement of the KMS performance generates large amount of data that have profound implications for promotion of benefits resulted from the KMS both in terms of in the administration schemes and system modification schemes if the performance improvement patterns and rules can be found. In this paper, the Microsoft SQL Server® was adopted to perform Data Mining (DM) in order to dig out the abovementioned patterns and rules from

the KMS performance data. Three DM techniques (Decision trees, Clusters, and Association Rules) were employed to mine the rules and patterns (performance improvement knowledge) existing in 654 historic performance data recorded from the KMS of a leading A/E consulting firm in Taiwan. Finally, 15 meaningful rules were obtained from decision trees; 5 useful patterns were identified from clusters; and 5 important regulations were concluded from 89 association rules. Performance improvement strategies are then inferred and planned based on the knowledge discovered from the historic performance data. It is concluded that the proposed method is systematic to follow by the KMS administrator; it is also effective for finding the knowledge for improvement of the performance of KMS.

### **3. Information Technology and Information Systems in Construction**

#### **3.1 Information Technology**

*Paper 67, Page 583-590*

#### **Path Model of IT Enhanced Project Information Management in Construction: Development and Implementation**

**Rodney A. Stewart**

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Griffith University, Gold Coast, Australia

**Abstract:** Information technologies (IT) are providing construction firms with new opportunities for enhancing communication, collaboration and information management processes. Some firms have successfully grasped the opportunities enabled by IT enhanced information management systems to improve competitiveness and profitability. However, not all proactive construction businesses have been satisfied with their IT investments, largely due to their limited ability to evaluate the degree of IT-induced valued added to operational and business performance. This paper builds upon recently published work by the author, by empirically investigating the link between 'Construct IT' Balanced Scorecard (BSC) perspectives, utilising structural equation modeling. Furthermore, the validity of developed path equations for predicting IT-induced business performance and strategic competitiveness is reinforced through benchmarking studies, conducted on two large infrastructure projects constructed in Australia, where innovative web-based collaboration platforms were

implemented. The findings support that firms which provide reliable IT systems will achieve higher IT-induced performance improvement in the operational, strategic competitiveness and benefit perspectives.

*Paper 68, Page 591-601*

#### **A Review of ICT Applications for Design and Management of Construction Projects**

**Salman Azhar**

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**Abstract:** The recent innovations in Information and Communication Technology (ICT) have a polarizing effect on the design, management and delivery of construction projects. The construction industry generally believed to be fragmented and labor-intensive, now has the potential of being integrated by the use of ICT. This paper presents a review of the impact of ICT on the construction industry. Emerging trends in automated construction with ICT are examined. The state-of-the-art technologies such as integrated CAD, animated 3-D visualization, virtual designing, model based cost estimation, on-line bidding, shared project databases and on-line project management, monitoring and control are described and discussed with their benefits and implementation techniques.

*Paper 69, Page 602-607*

#### **What Really Occurs at the Construction Site?**

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National Technical University of Athens, Greece

**John-Paris Pantouvakis**

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National Technical University of Athens, Greece

**Abstract:** The visual representation of a construction project using 2D & 3D CAD is traditionally associated with the design phase where the model of the final product is developed. In recent years visualization technologies have been applied to the construction phase as well. Advancements in IT and Communications on one hand, and the need for better, cheaper and faster construction projects

on the other, are the driving forces that increase technology uptake by the construction industry. Although limitations and barriers still exist, if appropriately used, modern technology may prove to be a valuable tool to the construction manager.

*Paper 70, Page 608-614*

### **Using Augmented Reality to Support Coordination and Communication in Disaster Response**

**Xiangyu Wang**

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**Abstract:** In disaster response, there involves a large volume of coordination and communication information being transferred among diverse rescuing groups. There is a need for such information to be aggregated, presented, and assessed in an effective manner. Augmented Reality (AR) could visualize invisible disaster-relevant information such as deformed structure and injured humans buried underneath debris within the real disaster area. Furthermore, AR could mediate human-human communications because the proper blending of the real rescue task and virtual information can be tailored to enhance group-oriented communication and critical decision-making processes. This paper presents a framework that incorporates AR technology to facilitate effective coordination and communication of critical information among diverse rescuing groups by improving their situational awareness. Three focus areas — the command hierarchy, communication protocols, and communication interference — are identified and incorporated into the framework after analyzing typical disaster response procedure. Properties that the physical/technological implementation of the AR system would need to possess are also identified, so as to tailor the framework to be suitable for use for the majority of conceivable disasters.

*Paper 71, Page 615-622*

### **Monitoring Materials with GIS and RFIDs During a Construction Project**

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**Demos C. Angelides**

Professor of Marine Structures, Chairman, Department of Civil Engineering, Aristotle University of Thessaloniki, Greece

**Abstract:** One of the important factors to a construction project is the ability to monitor and trace the materials during construction. This paper is concerned with the determination and development of a system for monitoring and tracing the materials during construction as well as in a project, after the end of the construction phase and during its use. Furthermore, this system deals with monitoring the equipment which transports the materials. The technology that will be used for recording and tracing the materials is a system of Radio Frequency Identification - (RFID) technology. The RFID system uses tags and readers, which read the tags. The position of the equipment will be monitored with the help of Global Positioning System (GPS). All the data that will be collected will be analyzed with Geographic Information Systems (GIS). A suitable database will be used in order to locate and record, at any time, the materials and their history as well as the equipment that transports them. The information will be transferred to the central software system with the help of Global System for Mobile Communication - GSM technology.

*Paper 72, Page 623-630*

### **Implementation Processes of Virtual Reality in Construction Companies**

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**Abstract:** The use of virtual reality (VR) in the construction industry is seen as a major transformation from two dimensional drawings. It is currently used in many design companies to present architectural perspectives and helps the owner to obtain an ideal image of the final construction project. However, few construction companies have applied VR in simulating construction methods. In fact, the use of VR can assist all project participants to understand the sequence of construction activities and reduce the potential conflicts among project teams. This paper presents a case study of VR implementation processes in three large Thai construction cases. The six stage of IT implementation from literature is used as the framework in this study. It aims to identify the

factors and barriers that occur throughout these implementation stages. The interview is used as a research technique to collect the quantitative data. The finding found that few construction companies were applied VR for simulating their construction methods. VR was used to simulate construction methods in special complex projects. The initial adoption of VR is driven by the project manager who is interested in VR while site engineers and draftsman can encourage on the success of implementation in the following stages. In addition, this project manager establishes a team for developing and implementing this VR. All participants agree that the use of VR provides benefits in communication and coordination. The understanding of implementation processes can benefit to other contractors who are interesting in adopting VR in their organization.

*Paper 73, Page 631-640*

### **Digital Graphics Literacy for 21st Century Constructors**

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**Abstract:** In recent decades, new digital graphics technologies have been invented and significantly improved. These technologies have been adopted by almost every industry affecting our daily lives. In the world's largest industry, some contractors have started taking advantage of these new tools, such as documenting construction problems and project progress with digital images, developing site utilization plans and building layouts with 2-D graphics, demonstrating projects to clients and checking for interferences using 3-dimensional digital models. The most recent developments are merging graphics with construction information in 4d drawing and planning and controlling the lifecycle of a building with Building Information Modeling (BIM). However, acceptance and utilization of the latest digital graphics technologies in the construction industry still has a long way to go. This paper will review data gathered from a survey of the applications of digital visualization software programs in the commercial construction industry in the southeast US. Specifically the survey samples the industry for use of digital image management, 2-dimensional drawing, 3-dimensional

modeling, and BIM. Also, this paper will present some successful cases of using digital graphics tools on construction projects and provide recommendations to constructors on how to select appropriate digital graphics software and use it efficiently. The paper will also share lessons learned from a course in digital graphics for constructors developed and delivered for the last three years in a leading higher education construction curriculum.

### **3.2 Information Systems**

*Paper 74, Page 641-648*

#### **Development of a Backward Prediction Model Based on Limited Historical Datasets**

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**Abstract:** In almost the last two decades, commercial Bridge Management System (BMS) packages have been remarkably developed. However, inconsistency between BMS inputs and bridge agencies' existing data is an obstacle to implement and to operate a BMS software application. A large number of bridge datasets for a BMS database is an essential requirement to analyze a bridge network. Among many requirements, historical structural datasets are vital to compute the prioritization of bridge stock for maintenance and repair activities and are mostly unavailable for bridges of more than 20 years in age.

This study focuses on the abovementioned difficulty to overcome the lacking historical data problem faced by bridge agencies to effectively use BMS applications. This paper proposes an artificial neural network (ANN) technique to predict missing components of time-series datasets to estimate historical bridge element condition ratings. Although this study only estimates historical condition ratings,

the proposed concept can be used to compute other historical dataset requirements in the BMS database and hence improving the reliability of various BMS analysis modules.

*Paper 75, Page 649-655*

### **Information-Centered Design Management for Effective Design Cooperation**

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**Abstract:** As construction projects become bigger and more complex, the communication and information flow among the project participants becomes a key factor in the success of a project. The concept of design management and cooperation, however, has not yet spread widely in the architectural-design field, and the design cooperation processes have not yet been clearly defined. For effective design management, a computerized design management system is needed, and work process modeling is needed to establish the system. This research aims to propose a standard process model that will set the foundation for the improvement of the design management system.

The five elements that are needed to establish an information-centered design process are defined in this research, and two templates that can be used to identify these elements in the field are suggested. Finally, based on the definition and templates presented, information-centered work process modeling is introduced to represent the design process.

This study has made the following contributions:

Although the design process model proposed herein cannot be applied to all kinds of projects, the fact that this study was able to visualize and actualize the intangible scope of the design process is nevertheless an important contribution.

The templates for identifying design work elements proposed herein can be used to reveal the information relationships of design works.

The information-centered design process model can lay the foundation for the development of a computerized design management system.

*Paper 76, Page 656-663*

### **An Overview of Enterprise Resource Planning (ERP) Systems in Small and Medium Sized Organizations: Case of Florida Contractors**

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**Abstract:** Parallel to the increasing importance of and requirement for managing construction information more efficiently, Enterprise Resource Planning (ERP) systems have become a highly appropriate data integration tool for construction organizations. With the advancements and innovations in ERP technology, these systems have not only been preferred by large organizations but also become affordable by small and medium sized organizations (SMOs). Albeit limited in number, the researchers studying ERP implementations in construction have only focused on large size organizations. Therefore, the objective of this paper is to explore SMOs' awareness of ERP systems and the current implementation practices among small and medium sized contractors. Our research has been formulated from the hypothesis that SMOs are not knowledgeable about ERP systems, and they do not have a sound plan to assess and implement ERP systems, which may lead to inappropriate decisions and unsuccessful implementation of ERP projects. This paper presents the preliminary results of a query conducted in Florida, including the level of computerization of business processes, experiences with ERP systems and the concerns of SMOs. This research concludes that SMOs, who are challenged by financial and organizational constraints, need to have an Information Strategy Plan to get the optimal return on an IS/IT investment.

*Paper 77, Page 664-672*

### **The Impact of MTO Feature on ERP Application in Construction Industry**

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**Abstract:** ERP systems have emerged as an effective tool for integrating enterprise information in the manufacturing industry, but there are studies raising the question of their effectiveness for the construction industry. Due to the Make-To-Order (MTO) nature of construction business, the existing ERP system, typically tailored for Make-To-Stock (MTS) production, encounters the difficulties to implement directly in construction enterprise. This paper analyzes the major impact of MTO feature on ERP application in construction industry, presents the potential barriers in the functionality realization of the system, and concludes with a list of suggestions for research and development of an ERP system for the construction industry. In the end, system architecture of ERP solution for construction is presented.

*Paper 78, Page 673-672*

### **Implementation of a Web-Based Multi-User Task Management System in a Civil Engineering Construction Project**

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**Abstract:** This paper presents work on applying web-based groupware or computer-supported cooperative workflow-management techniques in a civil engineering project that includes a multi-user task management system. The technique assists individuals in working together in groups to enhance the productivity of an organization and explores how information technologies can enhance efficiency among engineers with the information they need to

share. This technique has enormous potential in civil engineering, mainly in the field of construction management, which provides workflow control and a notification mechanism. Groupware and workflow are significant in all the applications and have been demonstrated efficiently at the construction site by sharing information among designers, consultants, and contractors who are working in parallel with the client. This is an encouraging tool for assisting engineers in sharing and managing knowledge.

In coordinating with consultants, contractors, vendors, and clients via the management of assigned objectives, it is necessary to focus on multipurpose management software. The entire work effort, from strategic goals, to project and task management, to individual performance, is important for effective coordination. A communication platform for consultants for enhancing their ability to view and impact client requirements and follow through on deliverables is essential for a construction project. This approach was implemented to provide task management to utilize the flow of information between the client, consultants and contractors effectively by relying on computer-assisted software engineering technology.

A method is proposed for developing workflow-based applications in a cohesive and consistent way. Several tasks required external services and the creation of subtasks; few tasks were finished within the workgroup without creating subtasks. Comprehensive research was undertaken to handle inner and outer tasks and to accomplish “sender” and “receiver” functions. A task-notification system is the core requirement for a workflow management system, which is described briefly along with a demonstration of the concept of multilevel task assignment.

*Paper 79, Page 684-691*

### **Evaluating the Design of Mobile Computing Systems in Construction through Notational Support**

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**Abstract:** Mobile computing in construction should enable smooth integration of computer capabilities into the physical objects that populate the workspace of construction workers to reach high levels of performance. Despite the growing importance of

mobile computing technologies for construction, there is little tool support for usability evaluations. This paper presents a systematic tool support — Mobile computing Evaluation Notation for Usability (MENU), which is developed to capture usability-significant features of mobile systems by considering the nature of construction. This tool could guide the development of new mobile systems and the improvement of existing systems. This paper applies MENU to describe and evaluate two real cases of mobile computing systems in construction: a mobile computing system for bridge inspection and a mobile Augmented Reality-based equipment management system. Suggestions for improving the usability of these two systems were developed based on the described methodology.

*Paper 80, Page 692-699*

### **Safety Information Management in Construction Firms: A Data Warehousing Approach**

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**Abstract:** Safety statistics for construction indicate high fatality and injury rates. Construction firms in the USA must keep detailed records of all site incidents for OSHA (Occupational Safety and Health Administration). It is found that many construction firms maintain these records just to satisfy the OSHA requirements and seldom use the data in the planning and decision-making of future projects. If the safety related data are integrated from different projects over a period of time, they can provide a good overview of the safety performance of general contractors and subcontractors involved in different trades and under different project conditions. A questionnaire survey by the author indicated that a majority of construction firms in USA use spreadsheets to record and report the site incidents. The data stored in these spreadsheets are non-integrated and often available in non-user friendly forms and formats and hence cannot be readily used by the decision-makers. In this research, a Safety Information Management System, named SafeMan, is developed using the data warehousing technique. Data warehousing is an improved approach for integrating data from multiple heterogeneous databases and other information sources. The SafeMan enables users to analyze safety data of past and existing projects to evaluate safety performance of contractors and

subcontractors. The paper first discusses the importance of safety information management and basic concepts of data warehousing technique. Next, a step-by-step methodology is presented to illustrate the different stages of the SafeMan system development. At the end, discussion is made on a prototype system developed for reporting and analyzing safety information in a construction organization.

## **4. Construction Technology**

### **4.1 Design and Construction**

*Paper 81, Page 700-708*

### **Selection of the Optimal Waterproofing Methods for the Rooftops of Domestic Multi-Family Housing Projects**

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**Abstract:** Various efforts have recently been exerted to reduce the whole life cycle costs of facilities in the construction industry. Moreover, as the domestic (South Korea) construction market is now open and as the value engineering system has been activated, the importance of economic-efficiency assessment through Life Cycle Cost (LCC) analysis has largely increased. Since rooftops are exposed to the atmosphere and are directly affected by rainwater, the waterproof performance of the rooftop largely affects the service life and maintenance cost of a

building. This study thus aimed to analyze the economic aspect of the waterproofing method applied to domestic multi-family houses through LCC analysis, and to select the optimal waterproofing method for the rooftops of domestic multi-family houses, taking into account important technological and social impact factors as well as economic considerations.

*Paper 82, Page 709-716*

### **Risk Distribution Profile for Differential Column Shortening Using a Possibility Theory Approach**

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**Abstract:** As buildings inevitably increase in height, vertical support elements (e.g. columns and shear walls) in tall buildings are required to carry vertical load increments from a number of floors. Therefore, axial shortening of vertical elements due to long term creep and shrinkage effects is inevitable in reinforced concrete buildings. However, the calculation of reliable values for axial shortening is not a straight forward task. All parameters may be uncertain or may not be available at the design stage. Recently, engineers have also become concerned with differential shortening of adjacent vertical elements, particularly in the lower and basement levels of super high rise structures. Largely varied values and rates for axial shortening of adjacent support elements is not only a concern for vertical deformation, but can critically impact on the performance of horizontal structural elements such as beams and slabs. This research aims to develop a robust possibility-based differential shortening prediction framework, and associated risk distribution profiles, which overcomes the deficiencies in the current models for predicting axial column shortening in reinforced concrete high rise buildings.

*Paper 83, Page 717-721*

### **Skyscraper Would Be Simulated to Increase Stability and Buckling Resistance Using the Palm Tree Behavior in War Condition**

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**Shabnam Ghanavatizadeh**

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**Abstract:** Palm trees are located in the NW of the Persian Gulf, Iran and Iraq. Trees were infected by war weapons during the 8 years fighting. Palm proves extra resistance and super buckling against the war effects.

Palm tree can continue natural growing after war conditions where the horizontal section area exist less than 70 percentage of gross area. This fact is meaning the stability reaction which attack forces could be applied upon the tall building and safe collapsing. Elements are defining by roots (foundation), trunk (high building) and head (vibration mass).

Main exerted loads onto the tree are demonstrated using the fruit (250kg), wind, earthquake, shaken, fire and war. Trunk skin is the main cover to guard against burning events in fire attacks. Also, old fiber layers could be prevented by weapon accidents. Picture is explained the extraordinary behavior of palm skin which would be used to promise next design of tall building and manmade load effects.

Waiting time can be defined using the duration to provide vertical collapsing. It is belonged to the degree of safety and building height. Slender ratio of palm tree will consider more than 30 therefore height of skyscraper will be simulated more than 1000 m.

*Paper 84, Page 722-729*

### **Template Design and Leveling Installation of Circular Cell Cofferdam Using the Space Structure and Pipe Piles on the Bahmanshir River**

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**Abstract:** Three branches is the intersection of the Karun, Haffar and Bahmanshir Rivers that barrages should be made to safe fresh water against salty water in the NW of the Persian Gulf. Also, sweet water will be transferred by the Mared pump station to increase fresh water in the splash zone of sea water. Bahmanshir dam will be designed to execute through web sheet piles. Cell dam should be connected to build the steel ship lock with length 60m, mid point and perpendicular to the dam axes.

Work limitations are forced to consider template structural weight less than 15tons. Design load is considered using the vertical live load 70tons, bending moment 140ton.m and wind load. Concepts of design are explained by workers accessibility, barge transmissibility, reinstallation, pipe piles adaptability, twistability and plump line accessorily. Web sheet piles should be constrained into the template temporary and is needed to made mechanical parts with fixing joints.

Original design is based on the deep foundation and space structure. Pipe piles will take the safe platform to construct the template. Template has three casing pipe that could be fixed around the piles through the three bolt and nuts at each level to produce leveling simulation.

*Paper 85, Page 730-740*

**Influence of Asphalt Source, Polymer Modification and Geotextile Interlayers on Cracking Performance in Hot Mix Asphalt Pavements****Scott Shuler**

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**Abstract:** Non-load associated cracking in asphalt pavements has long been associated with properties of the asphalt binder (1, 2, 3, 4). However, the properties of the binder that describe this behavior

are not well understood (5). Although softer asphalt binders are often specified in cold regions to reduce the potential for cracking, this simple approach is often not acceptable since plastic deformation can then result. Various polymers have been used to modify asphalts to impart elastic properties at high temperatures while retaining plastic properties at low temperatures (6). However, the specifications for these modified asphalts are often proprietary and not useful to public agencies requiring a generic specification. Therefore, in 1987 the New Mexico Department of Transportation sponsored a research project to evaluate the performance of several polymers in asphalt to determine the effects on cracking over the long term. A controlled, full-scale experiment was designed and constructed to evaluate the long-term performance of these admixtures at two levels of modification each. Control sections were constructed in conjunction with each polymer section resulting in a total of fourteen test sections in the westbound direction of the two-lane facility. In addition, test sections to compare fabric interlayer performance were added during construction in the eastbound lanes. These fourteen test sections include pavement overlay with fabric as an interlayer and without fabric as an interlayer (7). Results of this research indicate that while differences exist in cracking performance between the different polymer modifiers, differences between fabric interlayer and non-interlayer sections are more significant and the difference in cracking performance between the unmodified westbound lanes and the unmodified eastbound lanes is very significant and may be linked to the source of the asphalt utilized. Traditional methods to predict cracking using temperature susceptibility indices of PI and PVN may be useful for unmodified asphalts but appear inconsistent with polymer modified asphalts.

*Paper 86, Page 741-748*

**Maintainability Aspects of Central Chilled Water HVAC System****M.Y.L. Chew**

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**Sutapa Das**

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**Abstract:** Heating ventilation and air-conditioning (HVAC) system is often operated and maintained inefficiently due to the knowledge gap between design guidelines and maintenance practices aided with fault detection techniques. To address this issue and to develop a guideline for good practices, this study examined the maintainability parameters for central chilled water HVAC system - most common option for modern buildings. During site investigations at eight commercial buildings in Singapore, six major components of HVAC system were studied and 87 common defects, their causes and consequences were identified. Among those, 60 were short-listed as significant, based on a questionnaire survey of 40 facility managers and maintenance personnel who ranked the common defects for frequency and impact on economy, system performance, indoor environmental quality and occupants' health and well-being. A parallel study on three buildings was focused on tangible cost implications including repair, replacement, liability and premature failure. Both surveys concluded that design followed by operation and maintenance practices were crucial. Air handling unit and/or fan coil unit was the most critical component causing 30% defects and 48.2% of total cost. Based on this research, a comprehensive guideline for good practices was developed including 48 parameters related to the whole lifecycle of HVAC system.

*Paper 87, Page 749-755*

### **Simplified Design for Torsion in Beams**

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**Abstract:** Research work is focused on suggesting a simplified and economical design for the compatibility torsion in reinforced concrete beams. Edges beams and beams supporting unequal spans or loading are usually subjected to torsion. ACI code allows 100% redistribution of compatibility torque. This research work focuses on the effect of modification of torsion constant on the final cost of steel reinforcement. Following the conclusions of this work, torsion reinforcement can either be minimized or eliminated in beams by increasing a

small amount of flexural steel in adjoining beams. Significant saving in cost of steel can be achieved by following the suggested approach.

*Paper 88, Page 756-762*

### **Simulation-Based Scheduling Model for Multiple Design Projects Considering Uncertain Design Iterations**

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**Jang-Jeng Liu**

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**Abstract:** Although slightly improving the control of the design schedule may greatly reduce the total duration of the project, but little effort has been made to control the schedule of the design project. Current practice typically uses a bar chart method or a CPM network to represent the schedule of a design project. But using those methods to plan design activities is complicated chiefly because of the design activities often have different degrees of information dependencies between each other, such that the design process involves a number of iterations. This work develops a simulation-based model to incorporate the design iterations for generating the schedule of a design project. Finally, this model is implemented and demonstrated by a real case study using STROBOSCOPE, a state and resource based simulation software.

### **4.2 Sustainable Construction Techniques**

*Paper 89, Page 763-769*

### **Resource Development for Sustainability in Construction -A Case Study**

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**Attaullah Shah**

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**Abstract:** The developing countries require extensive investment in the infrastructure sector to

provide opportunities of better living, education and employment to the people. The Public Sector Development Program (PSDP) of Pakistan has soared up from US\$1.7 billion to US\$ 8.7 billion during last eight years. Construction Industry- a major developmental index has been increasing @ 12% per annum in the period. However there is a serious threat to the sustainability of the environment due to over- consumption of natural resources, poor quality of work, and lack of awareness on the sustainable construction practices. The dilemma is common to all developing countries

The case study focuses on Human, Material and Technological Resource exploration, development and their judicious utilization in the construction industry of developing countries with special reference to Pakistan. These sustainable practices if promoted and adopted will open business opportunities to international firms in the construction market of Pakistan with an annual turnover of more than US \$5 billion.

*Paper 90, Page 770-775*

### **Implementing a Waste-Management-Plan Method in Construction**

**Vivian W. Y. Tam**

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**Abstract:** The increasing awareness of environmental impacts from construction waste has led to the development of waste management as an important function of construction project management. Various approaches for managing construction waste have been developed by many researchers around the world. The Hong Kong government started employing the implementation of a waste-management-plan method for all construction projects in 2003. During the trial period, the government received different version of feedback from the industry. The effectiveness of this approach gives less attention from the public. This paper investigates the effectiveness of the existing implementation of a waste-management-plan method in the Hong Kong construction industry. Questionnaire survey and structured interviews are conducted to explore attitudes and benefits in implementing waste management, and difficulties in implementing it. Although there are difficulties encountered in using the waste-management-plan method, effective measures in implementing it are then recommended. Furthermore, responsibilities for various project parties in effectively implementing waste management are outlined.

*Paper 91, Page 776-783*

### **Integrated Management System for Managing of Construction and Demolition Waste**

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**Abstract:** The reconstruction and redevelopment of the existing housing are greatly on the rise, according to economic growth and the improvement of living conditions. A lot of construction waste is generated, but the research of adequately handling and managing the waste is insufficient. In this regard, this study presented a deconstruction and control system as a means to minimize the generated quantity of construction waste and to enhance the recycling ratio of resources, unlike the existing traditional demolition concept. This system has been organized to plan and manage ranging from the estimation of demolition quantity to the demolition method by each structural section, and utilization plan of the generated resources by integrated computerization system. This system aims at contributing to the minimization of environmental load by devising a method to identify and reduce the quantity of the entire national construction waste. This system consists of the following four modules: a prior survey plan for demolition, estimation of demolition quantity, deconstruction plan, and waste management plan. These modules have been constructed to make it possible for users to use the system by individual module.

*Paper 92, Page 784-791*

### **A Comparative Energy Consumption Study of Air Conditioning Room Between Using Double Door and Electrical Air Curtain in Hot and Humid Climate**

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**Abstract:** In Thailand, an electrical air curtain is extensively used in commercial buildings at their entrances as a mean to save energy in operating air conditioning system. Electricity is used all the time while the air curtain is operating. Double door system, which has two sets of doors constructing next to each other, should be used instead. The objective of this research is to demonstrate to the public in Thailand, as well as to others in hot and humid climate regions, that how much of the electricity expenses can be saved using the double door system. This study was done through constructing an experimental room with nine types of doors. Electrical consumptions during experimental studies with simulating normal usage were recorded and compared in determining whether using double door system is sufficient enough in maintaining room temperature. On average, an air conditioning room with a double door system consumes electricity approximately 63% of the same room which has a single door attached with the electrical air curtain.

*Paper 93, Page 792-799*

### **On the Prevailing Waste Recycling Methods: A Southeast Queensland Study**

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**Abstract:** In Australia, waste generated from construction and building demolition work constitutes about 44% of the total amount each year. Consequently, it has created a serious waste management problem. The State Governments of

Victoria and New South Wales have been pushing for the use of recycled materials; they have promulgated specifications for the use of recycled aggregate from construction and related waste. However, in Queensland, similar specifications are not available, which explains the lack of research conducted in this important area. This paper presents an evaluation of the prevailing waste recycling methods used in Queensland. Nine sites have been visited, including two construction sites, three demolition sites, three recycling plants and one landfill in Southeast Queensland. Difficulties encountered by the recycling operators and their associates from these site visits are investigated. One of the major barriers is that the local councils disallow the use of recycled materials in construction activities! To help improve the situations, state and local authorities should implement policies encourage the use of recycled construction waste. This can be done by: (i) developing specification for the use of recycled materials; and (ii) increasing landfill disposal charges for construction and building companies to discourage dumping.

*Paper 94, Page 800-807*

### **The Construction Waste Disposal Charging Scheme in Hong Kong**

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**M. J. Hills**

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**Abstract:** Construction and demolition waste generated by construction activities in Hong Kong has increased in recent years. To tackle the problem, the Hong Kong Government introduced the Construction Waste Disposal Charging Scheme (CWDCS) in December 2005 to ensure that landfill construction waste disposal is properly priced to reduce construction waste. The charging scheme is not only intended to provide an economic incentive for contractors and developers to reduce waste but also to facilitate waste reusing and recycling, thereby to help slowing down the depletion of

limited landfill capacity. This research aims to examine the effectiveness of the charging scheme after one year of implementation in particular 'polluter pays principle'. The study also identifies possible ways to fine-tune the scheme and to further improve its effectiveness.

*Paper 95, Page 808-818*

### **The Application of Hydro Mulching Material for Ecological Rehabilitation of Rockfill Slope in Hong Kong**

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**Abstract:** Rockfill material has been used by many practicing engineers for the design of slope to minimize the risk of landslides in Hong Kong. The use of rockfill slope such as gabion wall will not only affect the aesthetic appearance of the environment but also limit the growth of natural vegetation as well as the survival of the surrounding habitants.

In recent years, ecological rehabilitation of man made slope has become a major concern in Hong Kong due to the implementation of government's green policies since 1990s. Hydro mulching is one of the most common methods for establishing green covers on non-soil surface slope. The construction method provides environmental friendly visual appearance for the slope, improve air quality, minimize sunlight reflection, serve as noise and moist absorbing agent and reduce the temperature around the slope area.

The objective of this paper is to evaluate the merits of Hydro Mulching techniques for the sustainability of rockfill slope in Hong Kong. The concept of Hydro Mulching is discussed in details with special references made to the construction industry. A case study on the application of hydro-mulching technique for the restoration of rock fill slope is highlighted.

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### **Lessons Learned From the Process of Housing Recovery after the 2003 Bam Earthquake in Iran**

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**Abstract:** On 26th December 2003, the ancient City of Bam, in southeastern of Iran, was hit by the worst earthquake over the last decades, resulting in some 30000 dead, 20000 injured and left a greater number of homeless. The devastating 6.6 magnitude quake struck at 5.28 a.m. local time, an hour at which almost all of the city's 80000 residents were in bed on the Muslim day of rest. The catastrophe leveled more than 80% of city to the ground. In addition, Bam's historical landmark – a giant medieval fortress complex of towers, domes and walls, all made of mud-brick – was totally destroyed. This Citadel (Arg-e Bam) was one of the wonders of Iran's Cultural Heritage.

According to Bam Sustainable Development Manifesto, the task of providing permanent shelter during the reconstruction phase was to make the survivors as independent of government aid as possible. It was aimed to encourage the householders to take an active part in the further relief process. Thus, it was announced that 'the responsibility of rebuilding was for the homeless, over the reconstruction period'. In practice, this task was coordinated by the Housing Foundation (H.F.) and a number of private engineering and architectural firms, trying to solve shelter problems as they saw fit. This meant that each firm put into practice specific approaches as appropriate by establishing a consultation process with householders. Another contributing factor was the individual technical and financial capacities of householders. Such methods for providing shelter increased the survivors' abilities to actively participate in the process of reconstruction. However, paperwork process was a major obstacle on the way of operations.

**Design and Construction Defects in the Buildings of Balakot (Pakistan) and Surrounding Areas in Relation to Earthquake Loading**

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**Abstract:** This study is focused on identifying the design and construction faults in the structures constructed in Balakot (Pakistan) and surrounding villages in relation to their performance under seismic loading. In most of the cases it was observed that structures were either not designed or the seismic provisions of code were not completely followed in the design and construction. Size of structural members, especially columns in one direction, was much less than what is recommended by ACI-318 (chapter 21). In some cases the least lateral dimension of column was 4.5” giving slender column behavior. The materials used for concrete construction and their proportions were below required standards. Other construction faults are improper placement of reinforcement, unequal concrete cover in same members, poor concrete compaction and substandard formwork etc. Based on all this information it is concluded that major reason of structural collapse and damage of buildings during 8th October earthquake was the insufficient strength of vertical supporting members including columns, masonry walls, un-reinforced concrete walls and bonded or un-bonded rubble masonry walls. Most of the vertical supporting members had reasonable strength against gravity loads but not against the lateral loads. Based on this study some recommendations are proposed for the improvement of future construction.