



**CCC 2016**

**CREATIVE CONSTRUCTION  
CONFERENCE**

25-28 June 2016 - Budapest, Hungary



# **Final Program & Book of Abstracts**

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# CREATING THE FUTURE



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# **FINAL PROGRAM & BOOK OF ABSTRACTS**



## **Creative Construction Conference 2016**

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**Editors-in-chief:** Miklós Hajdu; Mirosław J. Skibniewski

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## **KEYNOTE LECTURES**



## THE PROMISE AND THE CHALLENGE OF 3-D PRINTING IN CONSTRUCTION

**Behrokh Khoshnevis**

*University of Southern California, USA*

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The nature of construction has remained intensely manual throughout recorded history. Unlike in manufacturing, the growth of automation in construction has been slow. A promising new automation approach is *Contour Crafting (CC)*. Invented by the speaker, Contour Crafting is a mega-scale 3D fabrication process aiming at automated on-site construction of whole structures as well as subcomponents. The potential of CC has become evident from experiments with various materials, geometries and scales. Using this process, a single building or a colony of buildings may be constructed automatically with all plumbing and electrical utilities imbedded in each; yet each building could have a different design which can include complex curved features. The technology also has astounding environmental and energy impacts. The entry level implication is especially profound for emergency shelter construction and low income housing. NASA is exploring possible applications of CC in building on other planets. This new mode of construction will be one of the very few feasible approaches for building using in-situ material on planets such as Moon and Mars, which are being targeted for human colonization before the end of the century. CC has received international attention and could soon revolutionize the construction industry.



## **THE BIG DATA PROJECT MANAGER: ACADEMICS LIKE WHAT THEY DO AND PROFESSIONALS KNOW WHAT THEY WANT**

**Mario Vanhoucke**

*Ghent University, Belgium*

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This presentation gives an overview of the past endeavours and the recent trends in integrated project management and control, with a focus on linking scheduling to risk and control management. The presentation will give an overview on the use of project data for research and practice, and will show that the big data hype is for project management restricted to the presence of artificial sets and only one set of empirical projects. However, recent research trends illustrate that the integrated use of empirical data and advanced techniques from artificial intelligence leads to promising results, which might define the path for future research avenues. References to a literature overview of project control will be given to outline the future of the research on integrated project management and control.

## **ENHANCING OCCUPATIONAL HEALTH AND SAFETY THROUGH ANTI-HEAT STRESS UNIFORM**

**Albert P.C. Chan**

*Construction Engineering and Management, Department of Building and Real Estate,  
The Hong Kong Polytechnic University, Hung Hom, Hong Kong*

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Construction workers need to work under direct sunlight most of the time which may create health hazard when the weather is hot and humid. Wearing suitable work uniform with superior thermal-moisture functional performance is an effective measure to protect workers from heat stress. This presentation will discuss how such work uniform was developed based on a rigorous research process from a multi-disciplinary team. The impact and the real application of the anti-heat stress uniform will also be highlighted.



## VIRTUALIZING INFRASTRUCTURE

**Ioannis Brilakis**

*University of Cambridge, Cambridge, UK*

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Vertical and horizontal infrastructure is comprised of capital-intensive assets that need sizable budgets to design, construct and operate/maintain them. Cost reductions throughout their lifecycle can generate significant savings to all involved parties. Such reductions can be derived directly through productivity improvements or indirectly through safety and quality control improvements. Creating and maintaining an up-to-date electronic record of these assets in the form of rich Building Information Models (BIM) can help generate such improvements. New research is being conducted at the University of Cambridge on inexpensive methods for generating object-oriented infrastructure geometry, detecting and mapping visible defects on the resulting BIM, automatically extracting defect spatial measurements, and sensor and sensor data modelling. The results of these methods are further exploited through their application in design for manufacturing and assembly (DfMA), augmented-reality-enabled mobile inspection, and proactive asset protection from accidental damage. Virtualization methods can produce a reliable digital record of infrastructure and enable owners to reliably protect, monitor and maintain the condition of their asset.



# **CREATIVE MANAGEMENT**

**10:30 SUNDAY, JUNE 26, 2016**





## PRELIMINARY RESOURCE-BASED ESTIMATES COMBINING ARTIFICIAL INTELLIGENCE APPROACHES AND TRADITIONAL TECHNIQUES

**Borja García de Soto**

*Institute of Construction and Infrastructure Management, ETH Zurich, Zurich,  
Switzerland*

**Bryan T. Adey**

*Institute of Construction and Infrastructure Management, ETH Zurich, Zurich,  
Switzerland*

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The fate of many construction projects is determined using preliminary project cost estimates. These estimates play a key role during the conceptual phase of projects; as in many cases they are the primary element used to decide their viability. The lack of information and the high levels of uncertainty with what will be done in the project, during the conceptual phase, make it infeasible to have reliable building information models that could be used to generate quantity takeoffs for preliminary cost estimates (known in the industry as 5D BIM), in line with a Level 2 BIM maturity. This paper presents a way to combine artificial intelligence (case-based reasoning and neural networks), with traditional techniques (regression analysis), to develop accurate estimates of the resources needed in a project (e.g., construction material quantities). These estimates of resources can then be coupled with unit cost information to make preliminary resource-based cost estimates. The clear division between the technical and financial components of such an estimate give improved decision support to project managers and decision makers. This enhances the tracking and control mechanisms which could be used to check the estimates prepared in subsequent project phases. The combination of case-based reasoning with regression analysis and the use of neural networks has shown an improved performance in the estimation of the amount construction material quantities. The proposed combination was used to estimate the amount of concrete, reinforcement, and structural steel required for the construction of tall-frame structures. The results show lower errors (overall mean absolute percentage error-MAPE) for the combined models (2.55%) when compared to the regression models (12.01%), neural network models (5.84%), and case-based reasoning models (9.30%). This type of estimates will help keep construction projects on schedule and on budget.

**Keywords:** Case-based reasoning, hybrid estimation models, neural networks, regression analysis, preliminary estimates of resources



## A NETWORK-THEORY BASED MODEL FOR STAKEHOLDER ANALYSIS IN MAJOR CONSTRUCTION PROJECTS

**Margaret K.Y. Mok**

*Department of Building and Real Estate, The Hong Kong Polytechnic University,  
Hong Kong, China*

**Geoffrey Qiping Shen**

*Department of Building and Real Estate, The Hong Kong Polytechnic University,  
Hong Kong, China*

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The high complexity and uncertainty of major construction projects (MCPs) call for a rigorous approach to manage the relationships and conflicting needs of stakeholders who act a pivotal role in project success. During the past decades, there has been an unsatisfactory stakeholder management record in the construction industry. Despite a rapid advancement of stakeholder analysis methods, project teams still face challenges in completely identifying stakeholders and their concerns, and accurately evaluating their relationships and impacts. These obstacles are attributed to the weaknesses of the current stakeholder analysis practice, in which project teams categorize and prioritize stakeholders by assessing their individual attributes based on empirical knowledge of team members. The weaknesses are threefold. First, 'hidden' stakeholders are often missed out in the identification process due to cognitive limitation. Second, the accuracy of assessment is limited due to subjectivity. Third, the basis for evaluation relies heavily on the dyadic relationships between project teams and stakeholders; neglecting both the actual stakeholder interrelationships and stakeholder issue interdependencies.

In reality, a project environment can be perceived as network systems composed of interconnected stakeholders, as well as of interrelated stakeholder issues. The characteristics of and propagating effects produced by these network structures determine the perceptions, salience and impacts of project stakeholders. To overcome the limitations of current practice, this paper proposes an innovative stakeholder analysis approach based on the network theory. In this paper, the sources of stakeholder complexities in MCPs are firstly discussed. The existing stakeholder analysis methods are reviewed with their limitations highlighted. A network-theory based stakeholder analysis approach for MCPs is proposed. Its process and network analysis techniques are introduced. Taking a network perspective to analyze both stakeholders and their interests can benefit researchers and industry practitioners by improving the accuracy, completeness and effectiveness of the stakeholder management practice in construction.

**Keywords:** Stakeholder analysis, network analysis, network theory, major construction project

## CHALLENGES IN PUBLIC FACILITY MANAGEMENT: SOME REMARKS TO THE EN 15221 FM STANDARD

István Hajnal

*Budapest University of Technology and Economics, Budapest, Hungary*

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The collective of Standards of EN 15221:2011 refer to the facility management (Facility Management, FM) focusing on the FM as a product and the budget of FM. This standard was created with the aim of unification the operation of business service processes. In the public sphere, while the application of the standards arise as a great challenge, its understanding, and the lessons drawn from it might be important for both the community facility operators and managers. In the article, the Author sets up the model of the public facility management according to the descriptions of the Standard, and highlights the problems and focus points of the public utilization of the Standards by systematic examination of elements and analysis of relating literature. The article, based on the model set up, articulates suggestions for the adopters and the users of the public FM.

**Keywords:** Facility management, EN 15221 standard, public organization, SLA, building operation



## INNOVATION MANAGEMENT SYSTEM FOR CONSTRUCTION COMPANIES

### Petro Pöyhönen

*Boost Brothers Ltd, Helsinki, Finland*

### Juho-Kusti Kajander

*Boost Brothers Ltd, Helsinki, Finland*

### Matti Sivunen

*Boost Brothers Ltd, Helsinki, Finland*

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A number of innovation management systems have proven to be successful to companies in several industries from automotive to software development. These systems include for example innovation portfolio management process (Cooper, 1990) and open innovation (Chesbrough, 2004). However, these innovation management systems are not widely adapted in the construction sector. In fact, companies in the sector seem to lack a structured innovation management system. This study aims to develop an innovation management system for construction sector companies that can be applied in practice.

The study was conducted by developing and testing an innovation management system in real-life innovation projects with the top management of major publicly listed Finnish construction companies during 2012-2014. The innovation management system has four key functions, which are Strategy, Market input, Development process and Competencies and resources. Also, the results are analyzed to identify what innovation management system features gave most value for the case companies.

The main finding of this study is that construction sector companies can utilize and benefit from innovation management systems found in literature. Interestingly, the analysis of the innovation projects' results highlighted that especially the market input function added significant value to the existing innovation processes of the companies. The function complemented existing innovation processes of the companies as it was the function that was missing or that was not systematically implemented. The market input function helps to steer the development process and facilitate fact-based innovation investment decision-making. The function consists of four elements, which are Customer needs, Regulation, Technology, and Competitors. After the completion of the present study, the market input function has been widely adapted in the Finnish construction sector and applied in more than 120 major industry projects.

**Keywords:** Construction, decision-making systems, innovation, knowledge management, risk analysis



**VISUALIZATION, BIM**

**10:30 SUNDAY, JUNE 26, 2016**



## A BIM BASED APPROACH FOR QUALITY SUPERVISION OF CONSTRUCTION PROJECTS

**Zhiliang Ma**

*Department of Civil Engineering, Tsinghua University, Beijing, China*

**Na Mao**

*Department of Civil Engineering, Tsinghua University, Beijing, China*

**Qiliang Yang**

*Department of Civil Engineering, Tsinghua University, Beijing, China*

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Quality supervision is an important means to ensure the quality of construction projects. Despite the variation in relevant standards of different countries, the core of supervision is to inspect and control each major construction procedure. Up to now, some application software for quality supervision have been used in engineering. However, too many inspection items specified by the relevant standards, lack of experience of inspection personnel, and the process of entering the data in the original record into computers have led to the inefficiency of the inspection work and data falsification, which buries the seeds of risk for construction quality.

In order to solve the problems, a BIM based approach to improving the quality supervision of construction projects is proposed. Firstly, the requirements analysis of the system is carried out. Then, the IFC (Industry Foundation Classes) standard for BIM (Building Information Modeling) data is analyzed and an IFC based information model for quality supervision is established. Next, an algorithm is established to automatically generate inspection points based on BIM and the related standards. Finally, a prototype system using BIMserver.org as the platform is developed, which facilitates inspectors to check inspection points according to standards, to get smart tips when inputting data on mobile terminal at the construction sites and to automatically generate standard documents without second input. Compared with the traditional ones, the approach provides a great improvement for quality supervision of construction projects.

**Keywords:** Building information modeling, construction, quality supervision, standards



## ACCEPTANCE OF CONSTRUCTION SCHEDULING VISUALIZATIONS: BAR-CHARTS, FLOWLINE-CHARTS, OR PERHAPS BIM?

**Christian Nordahl-Rolfen**

*Oslo and Akershus University College, Oslo, Norway*

**Christoph Merschbrock**

*Oslo and Akershus University College, Oslo, Norway*

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Four-dimensional Building Information Modelling is widely viewed as the next evolutionary step in construction scheduling. Linking scheduling information to parametric object models is believed to assist a more intuitive understanding of what is to be built when. We explore how 4D BIM, as a new method of visualization, compares to other pre-existing forms of visualization like bar- and flowline- charts. Based on a series of individual and focus group interviews, this paper reports construction professionals' perceptions of the utility of the different visualization methods. Simultaneously exposed to three types of scheduling of the same building, construction professionals evaluated their ease of use and usefulness. This was done based on the Technology Acceptance Model, which explains how individuals develop an intention to use technology. Based on this work we found the three scheduling methods having strengths and weaknesses. Gantt provides the simplicity and responsiveness required for the day-to-day communication in projects, and was perceived as the easiest to use. Flowline was perceived as less intuitive; however, some argued that it provides a better overview when many different work activities need to be run concurrently. 4D BIM has the clarity required for conveying the bigger picture, yet was perceived as most useful for early project stages. Our contribution to the body of literature is that we compare the technology acceptance of new and existing scheduling methods in order to unearth their complementary roles. This work is important for managers deciding on a combination of planning tools, enabling them to better run their projects.

**Keywords:** 4D BIM, Flowline chart, Gantt chart, construction management, Technology Acceptance Model



## **FIELD BIM AND SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION: AN ON-GOING MONITORING SYSTEM**

### **Vito Getuli**

*University of Florence, Department of Civil and Environmental Engineering DICeA,  
Florence, Italy*

### **Silvia Mastrolembo Ventura**

*Politecnico di Milano, Department of Architecture, Built Environment and  
Construction Engineering ABC, Milan, Italy; Construction Technologies Institute,  
National Research Council ITC-CNR, San Giuliano Milanese (MI), Italy*

### **Pietro Capone**

*University of Florence, Department of Civil and Environmental Engineering DICeA,  
Florence, Italy*

### **Angelo L. C. Ciribini**

*University of Brescia, Department of Civil, Environmental and Architectural  
Engineering DICATAM, Brescia, Italy*

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In spite of the growing implementation of Computer-aided technologies and Building Information Modeling (BIM) in AEC industry, building activities in construction sites are ineffectively monitored even now. Current formats of reporting and communicating the construction progress (e.g., textual progress reports, progress lines, and photographs) may not properly and quickly communicate the construction progress. In the proposed research the capability to communicate progress information right away and to share an Interactive Building Model (IBModel) are identified as the key components for successful management of the site and the supply chain network. This is carried out establishing the involved actors (Owner, Site Director, Site Safety Coordinator, Construction Companies and Suppliers) and setting them several options for the information management and visualization within the BIM environment. The monitoring system comes from the integration of the building and construction site model bestowing the visualization of site conditions on a set of graphical parametric rules, such as: chromatic visualization of building components referred to objects' completion percentage; thematic views, automatically extracted and updated, representing the real site conditions; and so forth. The monitoring system, supported by the BIM-based visualization model and managed in a Cloud computing seems to be one of the right directions for improving safety condition on one hand and site productivity and control on the other one.

**Keywords:** Building information modeling, field BIM, monitoring system, site management and control, supply chain management



## A BIM TEMPLATE FOR CONSTRUCTION SITE PLANNING

**Marco L. Trani**

*A.B.C. Department, Politecnico di Milano, Milano, Italy*

**Manuele Cassano**

*A.B.C. Department, Politecnico di Milano, Milano, Italy*

**Davide Todaro**

*A.B.C. Department, Politecnico di Milano, Milano, Italy*

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Building Information Modelling is gradually becoming the standard method for building design all over the world. Its rapid development is visible not only in the many researches carried on it but also in the several standards released in different countries. The spread of the method implied continuous software improvements with the aim to comply as much as possible different design needs. Nevertheless, an insufficiency of tools specifically developed for construction site planning is still detectable among BIM panorama. The principal aim of the presented research is then to develop BIM use for making more efficient construction site design. Having defined, in an early report, the structure and the contents of the postulated Construction Site Information Model, the research goes on by customizing the available tools in order to fit the needs of a construction site designer. One of these tools is a predetermined template, useful as a starting point for the design, as it is for other design disciplines. The aim is to have at disposal, since the beginning of the project, a model completed of a series of elements, parameters, visualization tools and many other issues able to satisfy the needs of construction site design in term of information contents, level of detail and model efficiency. A step-by-step procedure is also provided to assure the correct use and guarantee the completeness of the model. In particular the research steps has been the following: (i) analysis of some software to evaluate the chances of customizing templates; (ii) creation of the template according to the defined contents and aims of the Construction Site Model; (iii) test and improvement of the tool in a project simulator specifically created for the purpose; (iv) practice in real case study and evaluation about its operation. The case study permits to evaluate how this tool make more efficient site designer task in term of time spent and mistakes avoided.

**Keywords:** Building information modelling, construction site planning, construction site information modelling, design optimization, project template



**CREATIVE SCHEDULING**  
**FOR CONSTRUCTION**  
**10:30 SUNDAY, JUNE 26, 2016**



## HOW MANY TYPES OF CRITICAL ACTIVITIES EXIST? - A CONJECTURE THAT NEEDS A PROOF

**Miklós Hajdu**

*Budapest University of Technology and Economics, Budapest, Hungary*

**Mirosław E. Skibniewski**

*University of Maryland, College Park MD, USA*

**Mario Vanhoucke**

*University of Ghent, Ghent, Belgium*

**Árpád Horváth**

*University of California, Berkeley, USA*

**Ioannis Brilakis**

*University of Cambridge, Cambridge, UK*

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Critical activities can be classified into nine categories according to the response of the critical path to a one-time-unit duration increment/decrement of an activity on the critical path. However, only six of these categories can be produced using the traditional end-point precedence relationships. There is no such arrangement of activities under the assumption of constant speed of progression and minimal end-point relations where a critical activity could be placed into one of the remaining three categories. Recent developments of the Precedence Diagramming Method (PDM) allow the use of non-linear activity production-time functions, and the use of continuous and point-to-point precedence relations for defining the temporal logic between activities. The question is whether this new development changes this classification theory or not. A project planning conjecture regarding critical activity types is given in this paper that needs a proof. This is the following: The use of increasing non-linear activity production-duration functions and continuous relations with constant relation duration in the PDM technique does not change the classification of critical activities beyond the existing six types of critical activities out of possible nine. A literature review and the mathematical model of the extended PDM model is given in order for providing frame for this conjecture.

**Keywords:** Precedence Diagramming, continuous precedence relations, classification of critical activities



## COMPARING POINT-TO-POINT PRECEDENCE RELATIONS AND LOCATION-BASED MANAGEMENT SYSTEM IN LAST PLANNER SYSTEM: A HOUSING PROJECT OF HIGHLY REPETITIVE PROCESSES CASE STUDY

**Xavier Brioso**

*Construction Management & Technology Research Group (GETEC), Pontifical Catholic University of Peru, Lima, Peru*

**Antonio Humero**

*School of Architecture, Technical University of Madrid, Madrid, Spain*

**Sarah Calampa**

*Construction Management & Technology Research Group (GETEC), Pontifical Catholic University of Peru, Lima, Peru*

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A comprehensive production system is needed to enhance the flow operations during the works. In this context, the Last Planner System® (LPS) is one of the Lean tools used more often in project management for construction, and in doing so, tries to offset the limitations of the Critical Path Method (CPM). Many tools and techniques have been correctly integrated into the LPS area, some of them required to analyze the task continuity. Over the last years, in the case of housing projects of highly repetitive processes, finding the optimal activity train, hand-offs and milestones using Location-Based Management System (LBMS) was a solution. On the other hand, research about Point-to-point Precedence Relation (PTPPR) exhibited that the main finding is that newly developed point-to-point relations are better from a theoretical and practical point of view than the solutions based on traditional precedence relationships, but they still cannot provide a theoretical perfect solution. The purpose of this paper is to analyze the use of LBMS and PTPPR in housing projects of highly repetitive processes. The research strategy is the case study. Information of a building built in Peru was studied. The first phase is a data collection through direct observation and analysis of documents to describe the work structuring, planning and control. The second phase is the application, analysis and comparison of LBMS and PTPPR. The research method has certain limitations. The results might be biased for the regional behavior of planners. The main outcome of the paper is that it provides pros and cons of both methods.

**Keywords:** Highly repetitive processes, housing projects, last planner system, location-based management system, point-to-point precedence relations

## **CASH FLOW MULTI-CRITERIA ANALYSIS IN CONSTRUCTION PROJECTS**

**Augustin Purnus**

*Technical University of Civil Engineering, Bucharest, Romania*

**Constanta-Nicoleta Bodea**

*Bucharest University of Economic Studies, Bucharest, Romania*

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The tremendous economic challenges especially due by to the persistence of the financial crisis and the continuous decline of public investments in the last years have increased the financial risks faced by construction companies. With high capital expenditures and high level of competition in the market, the construction companies have to accept a large number of risks, which make them very vulnerable. In order to stay in the market, the construction companies often participate in tenders with prices increasingly smaller, making them vulnerable to the occurrence of unforeseen events that are inherent in any construction project. In the current political, economic, social and administrative situation, the most important vulnerability of the construction companies is the lack of liquidity at the level of the contracting authority, but especially at contractor level. This financial weakness leads to delays in the project implementation, in penalties for delay and lost opportunities, with direct effect on the health status of projects and organizations. Infrastructure construction projects are mainly base on FIDIC Conditions of Contract amended through special conditions by contracting authorities. This paper aims to examine the effect of conditions of contract relating to the financial relationship between the employer and the contractor and the influence that they have on the financial management exercised by contractor, providing them a practical tool for decision-making.

**Keywords:** Construction project cash flow, FIDIC conditons of contract, multi-criterial



## APPLYING POLITICAL APPORTIONMENT TO PRE-ALLOCATE FLOAT / BUFFER OWNERSHIP

Yi Su

*Department of Civil Engineering, Catholic University of America, Washington, DC, USA*

**Gunnar Lucko**

*Department of Civil Engineering, Catholic University of America, Washington, DC, USA*

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Float in project schedules can provide important protection for activities if delays occur. Traditionally, total float exists along noncritical paths and shared among these activities. This has given rise to the longstanding question of who owns float. However, by definition the critical path lacks the unique flexibility provided by float. This conundrum is newly addressed by explicitly assigning float from the project finish as a buffer. Another more specific question appears: If each critical activity is entitled to a portion, what should its share be to protect the project? And how well does it fulfill the criterion of fairness, since activities are typically performed by different companies? Political apportionment is an established area to fairly distribute parliamentary seats by the votes that representatives have received. It provides systematic quota calculation with rounding methods to give consistent integer results that consider the relative size, i.e. importance, of competing participants. Inspired by apportionment, this research adapts a methodology to solve the problem of optimizing float allocation. Its contribution to the body of knowledge is twofold: First, float allocation is integrated with various apportionment methods. Second, an index is created to compare their performance based on Monte Carlo simulation. This research thus transforms float from being a passive byproduct of schedules to an active asset with which project managers can reduce delays. It builds a foundation for future research on active float management.

**Keywords:** Critical path, float ownership, political apportionment, project float, schedule activities





# **CREATIVE MANAGEMENT**

**11:45 SUNDAY, JUNE 26, 2016**



## **B CORPORATIONS – HYPE OR HOPE?**

**J. Mark Taylor**

*McWhorter School of Building Science, Auburn University, Auburn, USA*

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One of the first legal decisions a business owner has to make is often referred to as “choice of entity”. Owners must choose a legal framework for carrying out their business purpose. Traditionally the choice has been limited to sole-proprietorships, partnerships, corporations, limited liability companies, or some hybrid form recognized by local laws. Over the past five years an alternative movement has suggested that the entity structure should be more than a legal entity, it should be a structure that provides benefits to the public, community, owners, employees as well as the clients served. These entities are referred to a B Corps and are a new type of organization that uses the power of business to impact social and environmental problems.

Construction companies increasingly stress their advocacy of and commitment to sustainability. Is this truly a dedication to sustainability, merely a marketing ploy, or maybe fear of not “keeping up” with the competition? If one’s definition of sustainability is very narrow, it may mean no more than providing services for clients who request such services. However, if one embraces a more robust definition, sustainability may incorporate ideals promoted by the B corporation movement.

The purpose of this study is to investigate the intricacies of the B corporation movement and identify paths or pitfalls that might exist for companies engaged in areas of general contracting. Is this a lot of “hype” or are there truly benefits to be achieved by all involved with a company organized as a B corporation. This paper provides background information on B corporations and reports on the current status of the B corporate movement. In addition a number of companies involved as B corporations will be interviewed in order to ascertain whether participation as B corporations has a positive impact on their overall profitability.

**Keywords:** B Corporation, corporation, legal entity, sustainability



## LINKING CENTRAL BUSINESS PROCESSES OF CONSTRUCTION COMPANIES WITH THE PERFORMANCE OF CONSTRUCTION OPERATIONS

### Alfredo Serpell

*Department of Construction Engineering and Management, Pontificia Universidad Católica de Chile, Santiago, Chile*

### José Ignacio Díaz

*Department of Construction Engineering and Management, Pontificia Universidad Católica de Chile, Santiago, Chile*

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Many studies have been performed about ways to improve the performance of construction operations, including new technologies, construction methods, and production models. However, not enough attention has been given to the impact of the central business processes and to what would be their required conditions of development to support and promote a high, long-range operational performance effectively. The focus has been mainly on the site level and not at the central business level of a construction company. This study addresses this problem looking first to identify the main central business process of the construction companies and the conditions in which they operate. Second, to the relationships between central business processes and the way those construction operations are performed. The impact of these processes and their characteristics on the production systems used in worksites are being analyzed, including aspects like: culture, governance, people, and information technologies. Finally, the perspective of business process management (BPM) is being adapted to the management of construction companies to check the applicability of this approach to construction and the contribution it can provide to this sector. As a result, it is expected that a new structure of requirements for construction business processes is going to be proposed in order to improve operational performance. The methodology of the study includes an exhaustive literature review, a case study and the application of a survey to a group of construction companies. It can be concluded preliminarily that there is a good operational improvement potential if construction central business processes are carried out in a systematic form and if the management of the construction operations at sites is also aligned with these processes in a more integrated approach.

**Keywords:** Central business processes, construction companies, operations, performance

## INCORPORATING LEAN CONSTRUCTION AGENT INTO THE BUILDING STANDARDS ACT: THE SPANISH CASE STUDY

**Xavier Brioso**

*Construction Management & Technology Research Group (GETEC), Pontifical Catholic University of Peru, Lima, Peru*

**Antonio Humero**

*School of Architecture, Technical University of Madrid, Madrid, Spain*

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There is a demand for Lean Construction in Europe; even though it is still emerging, there is a growing interest, but there are no regulations on this topic. The main objective of this research is to regulate this role when in a project, and to define and develop a Building Agent structure, according to the Building Standards Act (LOE by its acronym in Spanish), in order to be able to incorporate it into the Spanish law, protecting it from civil liabilities. In Spain there is jurisprudence in civil jurisdiction based on the LOE to acquit or convict building agents, which are defined in the courts as “constructive managers” or similar. For this reason, courts could establish in the future several liabilities between the Lean Construction Specialist and other agents of the project, depending on their actions and based on the implementation of the Lean Project Delivery System (LPDS), the Target Value Design (TVD), and the Integrated Project Delivery (IPD). On the other hand, it is possible that the level of action of the Lean Construction Specialist may comprise design management, construction management and contract management. Accordingly, one or more building agents should be appropriately incorporated into the LOE according to their functions and responsibilities and based on the levels of action of the Lean Construction Specialist. The creation of the following agents is proposed: Design Manager, Construction Manager, and Contract Manager, definitions that are developed in this work. These agents are loosely defined, since any Project Manager, Building Information Modeling (BIM) Manager or similar, may act as one or as more than one of them. Finally, the creation of the Lean Construction Manager is also proposed, as the agent that takes on the role of the Design Manager, Construction Manager and Contract Manager, but focused on the Lean Production principles.

**Keywords:** Construction manager, contract manager, design manager, lean construction, regulation



## IMPROVEMENT OF ECONOMIC EFFECTIVENESS OF ROAD HIGHWAY PROJECTS

**Radan Tomek**

*Czech Technical University in Prague, Faculty of Civil Engineering, Prague, Czech Republic*

**Stanislav Vitásek**

*Czech Technical University in Prague, Faculty of Civil Engineering, Prague, Czech Republic*

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With regards to the strategic role of transport in a country's economic development and the large investments that are required, a thorough economic appraisal of these investments is of high importance. Therefore, it is appropriate to analyze and possibly modify existing methods for evaluating the economic efficiency of road construction at the scientific level, with the support of the real practice experience. Our research concentrates on evaluation of current methods of economic appraisal, their consecutive improvement and on incorporation of the LCCA agenda into the investment decision process. Consequently, it focuses on the possibilities to improve the effectivity of both, an investment decision process and a realization phase through the proposal of very concrete measures based on results of our research and on experience of real practice construction.

**Keywords:** Economic efficiency, investment appraisal, life-cycle costs, HDM-4 software, road transport infrastructure



**VISUALIZATION, BIM**

**11:45 SUNDAY, JUNE 26, 2016**





## **INTEGRATING BIM AND WEB MAP SERVICE (WMS) FOR GREEN BUILDING CERTIFICATION**

**Po-Han Chen**

*Department of Civil Engineering, National Taiwan University, Taipei, Taiwan*

**Thanh-Chuong Nguyen**

*Department of Civil Engineering, National Taiwan University, Taipei, Taiwan*

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LEED (Leadership in Energy and Environmental Design) is one of the most popular and globally recognized green building standards. In LEED, evaluating the sustainable effects of site location and transportation to the ecosystem and human life is a critical and difficult task. Credits regarding these matters require experience, time, labor, and manual calculations. In recent years, many studies have been conducted to enhance the application of Building Information Modeling (BIM) in the LEED certification. However, the application of BIM to LEED's site location and transportation analysis is usually considered impractical due to the lack of a powerful map application in present BIM products. The aim of this research is to develop a framework for the integration of BIM and Web Map Service (WMS) technologies for LEED's location and transportation analysis. Using Autodesk Revit API and Google Maps API as the development tools, this research converts the integration model into the LEED-BIM plugin in Autodesk Revit to streamline the certification process of site location and transportation analysis in LEED.

**Keywords:** LEED, BIM, green building certification, building information modeling



## A BIM-BASED DYNAMIC MODEL OF SITE MATERIAL SUPPLY

**Qunzhou Yu**

*School of Civil Engineering & Mechanics, Huazhong University of Science & Technology, Wuhan, China*

**Kaiman Li**

*School of Civil Engineering & Mechanics, Huazhong University of Science & Technology, Wuhan, China*

**Hanbin Luo**

*School of Civil Engineering & Mechanics, Huazhong University of Science & Technology, Wuhan, China*

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Construction site material supply is one of the major issues in construction planning. Due to the space inadequacy of construction site in downtown area, material supply problems exist in almost every construction site regarding how to manage material amount, approach time and stack positions in construction activities, thus lead to low construction efficiency, high project cost and other problems. Moreover, the current material supply scheme is designed only once before construction without consideration of the dynamic nature of the supply problems. With the development of BIM technology, it provides a potentially valuable tool for these problems. This paper presents the development of a BIM-based dynamic model of site material supply that is capable of identifying optimal dynamic scheme for site material supply —what (material), how many, when, and where. The method of 4D modeling is investigated, as well as the acquisition method of site information, and the optimal scheme generation method. Contributions include the development of the BIM-based site material supply management system, and a case study for the process of the site supply scheme implementation.

**Keywords:** BIM, dynamic model, material supply, construction site

## **GEOSPATIAL DATA CAPTURE FOR BIM IN RETROFIT PROJECTS - A VIABLE OPTION FOR SMALL PRACTICES IN NORTHERN IRELAND?**

### **David Comiskey**

*Ulster University, Jordanstown Campus, Belfast, Northern Ireland*

### **John Moss**

*South West College, Omagh Campus, Omagh, Northern Ireland*

### **Fiona Brazill**

*South West College, Omagh Campus, Omagh, Northern Ireland*

### **Eoin O'Shea**

*PIMSmart, Enniskillen, Northern Ireland*

### **Mark McKane**

*Ulster University, Jordanstown Campus, Belfast, Northern Ireland*

### **Harry Walton**

*Ulster University, Jordanstown Campus, Belfast, Northern Ireland*

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Within Northern Ireland, and the UK in general, building retrofit is an area of work undertaken by many small scale architectural technology, architectural and surveying practices. The methods, techniques and technology used for undertaking such work have remained largely unchanged over the years, with labour intensive measured surveys used in conjunction with hand sketching to capture existing asset layout and information. There are problems with traditional survey techniques, with data capture time consuming, and the quality of the information largely dependent on the skill and experience of the surveyor. There can also be issues with communication, interpretation of information, and human error. The emergence of Building Information Modelling (BIM) and associated scanning and point cloud technologies has the potential to transform the data capture process, improve accuracy, and enhance the general delivery of retrofit projects. However, at present, there appears to be reluctance by industry to embrace such processes for small to medium sized projects, believing BIM and associated technologies are not adaptable or affordable for this size of project budget. This paper sets out to test the above hypothesis by presenting the findings of a work in progress study comparing modern 3D data capture and modelling with traditional surveying approaches for a small to medium sized retrofit project. The research methodology employed was a case study analysis. The results of the study showed undoubted benefits of the modern data capture approach, in terms of speed of capture, accuracy and potential use of the model for additional building analysis, but also highlighted challenges in terms of costs, file size and experience in the use of the hardware for data collection and authoring.

**Keywords:** BIM, laser scanning, retrofit



## A REVIEW OF BUILDING INFORMATION MODELLING FOR CONSTRUCTION IN DEVELOPING COUNTRIES

**Nam Bui**

*University of Agder, Kristiansand S, Norway*

**Christoph Merschbrock**

*Oslo and Akershus University College, Oslo, Norway*

**Bjørn Erik Munkvold**

*University of Agder, Kristiansand S, Norway*

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Building Information Modelling (BIM) is widely seen as a catalyst for innovation and productivity in the construction industry. BIM can assist a more sustainable construction that in turn may contribute to eradicating poverty in developing countries (United Nation Millennium Goals). While BIM is increasingly being adopted in developed countries, implementations in the developing country context are rare. Research has established how construction firms struggle from several limitations having to do with the socio-economic and the technological environment found in developing countries. Examples of issues preventing BIM adoption include a shortage of IT-literate personnel as well as an absence of national BIM implementation programs. Based on a review of recent research, this article addresses some of the hurdles and solutions for BIM implementations particular to low- and middle-income economies. Findings include that developing countries' construction firms rely on outsourcing of IT services or developing tweaks or workarounds, like using 'fake' IT licenses, for saving cost and enabling BIM. The article highlights shortcomings of existing research on BIM implementation in developing countries, and may serve as a starting point for researchers interested in how BIM technology can be adopted in a developing country context.

**Keywords:** Barriers, building information modeling, construction, developing countries, implementation strategy



# **CREATIVE SCHEDULING FOR CONSTRUCTION**

**11:45 SUNDAY, JUNE 26, 2016**



## CONSTRUCTION MATERIALS-BASED METHODOLOGY FOR TIME-COST-QUALITY TRADE-OFF PROBLEMS

**Aynur Kazaz**

*Akdeniz University, Antalya, Turkey*

**Serdar Ulubeyli**

*Bulent Ecevit University, Zonguldak, Turkey*

**Bayram Er**

*Akdeniz University, Antalya, Turkey*

**Turgut Acikara**

*Akdeniz University, Antalya, Turkey*

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Time, cost, and quality (TCQ) as a triple constraint of construction projects have dependent and conflicting objectives. Considering the limited resources, estimation of the approximate TCQ is a complex and dynamic problem. In addition, the uncertain nature of construction projects and highly variable alternatives make the decision making process a complicated issue. In order to overcome these difficulties, many researchers in the related academic literature introduced different mathematical models on the TCQ trade-off problem so far. In these models, two different approaches were used to estimate TCQ-related data. In the continuous approach, it was assumed that the relationship among these three components could be expressed by continuous functions. In the discrete approach, it was accepted that (i) the construction method, (ii) the crew formation, and (iii) the crew overtime policy have some impacts on the project TCQ and that the relationships among these three components become discrete. However, in previous studies, construction materials that have a significant impact on TCQ of construction activities and projects were not taken into account completely during the data formation process. As an exception, El Rayes and Kandil [1] considered different strengths of concrete as material alternatives in a highway construction project. In fact, all the studies focused on proving the applicability of different optimization techniques instead of optimizing TCQ of a real construction project. In this context, some simple projects including a limited number of activities were used to evaluate the applicability of the developed models. Therefore, in the present study, it is aimed to outline a new two-step methodology, including the alternative construction material utilization, for TCQ trade-off problems, especially for building projects which enable the utilization of the high variety of construction materials. For this purpose, the impact of construction materials on TCQ of a project was explained in a detailed manner.

**Keywords:** Time-cost-quality trade-off, construction material, construction management



## PROJECT & PORTFOLIO MANAGEMENT SOFTWARE USE IN CONSTRUCTION INDUSTRY

**Orcun Demirceken**

*Middle East Technical University, Ankara, Turkey*

**Basak Keskin**

*Middle East Technical University, Ankara, Turkey*

**Rifat Sonmez**

*Middle East Technical University, Ankara, Turkey*

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In recent years, a variety of software alternatives and capabilities have been made available for project and portfolio management (PPM). However, very little research has focused on the use of project and portfolio management software in the construction industry. Degree of adoption of PPM software and the reasoning behind these selections may vary among contractors, as each project's unique situation may have an impact on the contractor's decision. The objective of this research is to determine the current trends in PPM software use in the construction industry, and to investigate the reasoning behind the decisions that are related to the PPM software use. A practitioner survey is conducted to reveal the current project and portfolio management software trends of international contractors along with the adaptation of building information modelling in PPM. The questions of the survey are grouped under four sections; project management software practices, portfolio management software practices, evaluation of the PPM software, and BIM use and habits in PPM. The survey findings are presented and discussed to reveal the current trends in project and portfolio management software use within the construction industry.

**Keywords:** BIM, construction industry, portfolio management, project management, software



## **A MIXED INTEGER MODEL FOR OPTIMIZATION OF DISCRETE TIME COST TRADEOFF PROBLEM**

**Ali Can Tatar**

*Department of Civil Engineering, Middle East Technical University, Ankara, Turkey*

**Mert Bilir**

*Department of Civil Engineering, Middle East Technical University, Ankara, Turkey*

**Rifat Sonmez**

*Department of Civil Engineering, Middle East Technical University, Ankara, Turkey*

**Tankut Atan**

*Department of Industrial Engineering, Isik University, Istanbul, Turkey*

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In construction projects, activity durations can be expedited by allocating additional resources. Decreasing activity durations by means of crashing, usually leads to increase in the direct expenses. This trade-off between time and cost is called as the time-cost trade-off problem. Since in practice many resources are available in discrete units, numerous research has focussed on the discrete version of this problem called the discrete time-cost trade-off problem (DTCTP). Achieving the project schedule that satisfies the project requirements at an optimum cost is crucial for effective scheduling and management of construction projects. Despite the importance of DTCTP, very few research focused on generating and solving of large scale instances. The objective of this proceeding is to generate large scale instances that reflect the size of real-life construction projects and to solve these instances using mixed integer programming method (MIP) to enable a benchmark set with optimal solutions. Within this context, large scale instances that reflect the size of real-life-size construction projects are generated. A MIP model is developed and the majority of the instances is solved to optimal using GUROBI optimizer.

**Keywords:** Cost optimization, discrete time-cost trade-off problem, exact methods, mixed integer programming, project management



## FACTORS AFFECTING LABOR PRODUCTIVITY: PERSPECTIVES OF CRAFT WORKERS

**Aynur Kazaz**

*Akdeniz University, Antalya, Turkey*

**Serdar Ulubeyli**

*Bulent Ecevit University, Zonguldak, Turkey*

**Turgut Acikara**

*Akdeniz University, Antalya, Turkey*

**Bayram Er**

*Akdeniz University, Antalya, Turkey*

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Labor productivity has a significant impact on time, cost, and quality of a construction project. Especially the competitive environment of the construction industry forces construction companies to increase their labor productivity values in order to keep their positions in the industry. In this respect, identification and evaluation of factors that affect the labor productivity becomes a crucial issue for industrial practitioners. In the academic literature, there are many studies that investigated these factors and their relationships with the labor productivity. In these studies, the factors were categorized under different groups and ranked according to their importance levels. However, in most of these studies, both the standard deviation among these factors under the same group and the mean value of each group were neglected. In addition, perspectives of managers were taken into account in general while those of craft workers were ignored. The aim of the current study is to re-evaluate the factors under the same groups by considering their standard deviations and mean values from the craft workers' point of view. For this purpose, after a detailed literature review, 37 factors were identified and categorized under four groups such as organizational, economical, physical, and socio-physiological factors. A questionnaire survey were then applied to craft workers to obtain the necessary data which was analyzed by means of the Relative Importance Index (RII) technique. The results revealed that, although the ranking of the factors remained the same, their importance levels have changed.

**Keywords:** Labor productivity, craft workers, Relative Importance Index (RII), construction management



# **CREATIVE MANAGEMENT**

**15:15 SUNDAY, JUNE 26, 2016**



## **EXAMINATION OF JOB-SITE LAYOUT APPROACHES AND THEIR IMPACT ON CONSTRUCTION JOB-SITE PRODUCTIVITY**

**Edgar P. Small**

*American University in Dubai, Dubai, United Arab Emirates*

**Marwa Baqer**

*Dubai Aviation Engineering Projects (DAEP), Dubai, United Arab Emirates*

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In all forms of construction project delivery, job-site layout is routinely developed and designed after bid award and prior to the contractors' receipt of the notice to proceed or letter of commencement. Job-site layout decisions are made to locate temporary offices, sanitary facilities, worker rest areas, crane locations, storage and workshop areas, access points and access roads, utilities and other critical features. These jobsite design decisions affect the operational capabilities of the site and have a direct influence on both the costs and schedule through productivity. This paper will examine the various approaches utilized in practice and proposed through research for jobsite layout design and site optimization. Factors and variables considered in the identified approaches are discussed and evaluated with respect to the impact on jobsite productivity and successful contract delivery. Important factors for job-site layout are further explored through a survey of working professionals within the United Arab Emirates (UAE). Survey results are summarized, examined and discussed in relation to the variables and critical parameters identified and their effect on job-site performance and contract success. The paper concludes with a discussion of future directions for job-site benefits.

**Keywords:** Construction, jobsite, operations, productivity



## KNOWLEDGE MANAGEMENT (KM) IN CONCURRENT CONSTRUCTION PROJECTS

### **Alemu Moges Belay**

*Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway*

### **Olav Torp**

*Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway*

### **Carl Thodesen**

*Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway*

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One critical factor in construction industry is how well firms manage concurrent projects effectively and obtain desired construction benefits. However, achieving this is not easy and challenging because several activities need tacit and explicit knowledge involved. The purpose of this research is to develop a generic KM algorithm using learning from and sharing to (LXS) matrix. We discussed the main concepts and strategies for rapid learning through KM in construction projects. . Some of the concepts discussed are (set-based thinking, agile PM and planning, iteration management, etc.). Moreover, the research carried out practical discussions in one of Norwegian construction project. The research looked at key literature in the field, identify the main issues in organizing KM in construction projects, and finally discuss the case of E39 ferry-free highway construction proposed by Norwegian public road authority (NPRA). The result from the KM matrix showed smaller projects are better to learn from all project phases than the large projects. The vice versa is true from sharing perspective. The research results instigate the roles of learning and sharing and urge to intervene systemic KM in concurrent construction projects.

**Keywords:** Construction projects, knowledge management, learning, sharing, tacit and explicit knowledge

## **TIME AND COST OVERRUN IN PUBLIC CONSTRUCTION PROJECTS IN QATAR**

**Ahmed Senouci**

*Department of Construction Management, University of Houston, Houston, USA*

**Alaa Ahmad Ismail**

*Department of Civil and Architectural Engineering, Qatar University, Doha, Qatar*

**Neil Eldin**

*Department of Construction Management, University of Houston, Houston, USA*

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This paper investigate time delays and cost overruns in public construction projects in the State of Qatar using statistical relationships between project contracted costs or durations and other variables. An extensive review of regional and international case studies was conducted to get a better understanding of the phenomena and of the various methodologies used to analyze it. The data of the study, which was collected from Qatar public work authority ASHGHAL, covered 122 public roads, buildings, and drainage projects. The Analysis Of Variance (ANOVA) statistical technique was used for the data analysis and inference. Several models were developed based on project type, duration, and cost. However, the models were limited in scope. Therefore, future work will involve adding more variables into the current models.

**Keywords:** Cost overrun, construction delays, Qatar Public Projects, statistical analysis

## ARRANGEMENT OF MATERIAL DEPOTS AT CONSTRUCTION SITE BY USING CONTINUOUS CONDITIONS

**Attila Pém**

*Department of Construction Technology and Management, Budapest University of Technology and Economics, Budapest, Hungary*

**Levente Mályusz**

*Department of Construction Technology and Management, Budapest University of Technology and Economics, Budapest, Hungary*

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In this paper, we are introducing a model for optimizing the arrangement of final material depots at a construction site that uses continuous conditions. The target is to minimize the construction time, cost and resources by minimizing the delivery distances. In this model, the feasible positions of the material can be used in a continuous or discrete way as the known models do, but the structures are used in a continuous way. A simple example demonstrates that the product can be modeled as a group of 2D elements (lines, curves) with third dimensional information and the calculated result is compared with an expert's solution. The usability and the further generalization of the model are declared. It needs less input data than the discrete model does so it can be an alternative model to the discrete model if the number of the units that build up the structure is large or unknown.

**Keywords:** Construction site layout planning, continuous demand, facility location allocation





**VISUALIZATION, BIM**

**15:15 SUNDAY, JUNE 26, 2016**



## **BIM AND LEAN CONSTRUCTION CHANGE DESIGN MANAGEMENT PRACTICES**

**Matti Tauriainen**

*Aalto University, Lujatalo Oy, Espoo, Finland*

**Pasi Marttinen**

*Sweco Structures, Helsinki, Finland*

**Bhargav Dave**

*Aalto University, Espoo, Finland*

**Lauri Koskela**

*Aalto University, Espoo, Finland; University of Huddersfield, Huddersfield, UK*

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Arguably, Design Management can be improved by utilizing new tools and methods introduced by Building Information Modeling (BIM) and Lean Construction. However, in the projects that use BIM, roles of personnel, design methods and the practice of communication between designers often derive from the era of document based Design Management and can only be partially adapted to a new way of working. In managing building design, the use of Lean Management tools can be seen a driver increasing value to the customer, improving operations and removing activities that do not add value.

In this context, the article discusses a study into the problems and improvement methods of structural and building services design management. The objectives were to identify typical design management problems that occurred on the operational level of BIM projects; to remove and decrease the frequency of identified problems by suggesting improvement methods and tools based on lean construction theory. Designers and design managers were interviewed in three case projects. The interviews were analyzed dividing problems in six categories, and the seriousness of problems was decoded. Recommendations for improvements were given to design teams.

In the end, 13 major and 6 average serious level problems were identified in the research. The most important causes for the problems were, an unclear sharing of responsibilities between designers in teams, inadequate BIM instructions, and insufficient BIM experience and knowledge of the design manager. The lack of communication between design team was seen as an important factor for the problems. By creating project environment that supports collaboration and communication, a design project can be improved. Lean tools, especially big room, knotworking, last planner and set based design can significantly facilitate collaboration.

**Keywords:** Building information modeling, collaboration, design management, design team, lean construction



## **CURRENT ISSUES OF BIM-BASED DESIGN CHANGE MANAGEMENT, ANALYSIS AND VISUALIZATION**

**Michał Juszczyk**

*Faculty of Civil Engineering, Cracow University of Technology, Cracow, Poland*

**Andrzej Tomana**

*Datacomp sp. z o.o., Cracow, Poland*

**Maja Bartoszek**

*Faculty of Civil Engineering, Cracow University of Technology, Cracow, Poland*

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The BIM-based design process is dynamic in its nature as the models typically need to evolve. This paper addresses the problems of a BIM-based design change analysis, design change management and visualization of the changes made to BIM models. A concise discussion of the general problems of design change management in terms of BIM is presented. The authors also briefly discuss the current advancement of native BIM tools and their functionalities dedicated specifically to design change management; namely, tracking and analysis of design changes on the basis of BIM models. Subsequently, a number of examples are presented to illustrate the results of recent developments in the visualization of design changes.

**Keywords:** Design change management, design change analysis, design change visualization, BIM

## **ANALYZING DESIGN WORKFLOW: AN AGENT-BASED MODELING APPROACH**

**Malak Al Hattab**

*Department of Civil and Environmental Engineering, American University of Beirut, Beirut, Lebanon*

**Farook Hamzeh**

*Department of Civil and Environmental Engineering, American University of Beirut, Beirut, Lebanon*

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Variability embedded in the architecture, engineering, and construction industry often results from inefficient planning strategies, sub-optimal levels of coordination, and poor flow of information and resources. This inherent variability disrupts workflow in design, results in longer cycle times, increased costs, and rework; thus undermining design, as well as, construction performance. This paper addresses design workflow at the intersection of the social and process aspects of the design phase. These aspects have been studied separately in previous research works, which prevented capturing a comprehensive and realistic understanding of the design process. Accordingly, this study develops a new approach to qualitatively and quantitatively model the exchange of information between design players and pave the way to assessing the impacts of Building Information Modeling and new project procurement strategies on improving design workflow. Agent-based modeling is used to dynamically represent the relationship between social interactions and the diffusion of information between individuals and teams. The study presents a novel design workflow management approach that bridges the gaps in previous studies as it focuses on team structures, interaction dynamics, and information diffusion.

**Keywords:** Design workflow, agent-based modeling, Building Information Modeling (BIM), collaboration, social networks



## AN INVESTIGATION ON BUILDING INFORMATION MODELING ROLE IN INDUSTRIALIZATION OF BUILDINGS

**Javad Majrouhi Sardroud**

*Department of Civil & Construction Engineering, Central Tehran Branch, Islamic Azad University, Tehran, Iran*

**Reza Mohajeri Borje Ghaleh**

*Department of Civil & Construction Engineering, Central Tehran Branch, Islamic Azad University, Tehran, Iran*

**Mohsen Kameli**

*Department of Civil & Construction Engineering, Central Tehran Branch, Islamic Azad University, Tehran, Iran*

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The traditional methods of construction are not optimized from various aspects. This lack of efficiency throughout the lifetime of a project is evident during the planning, design, implementation and operation phases. To achieve ideal conditions in the construction industry to meet the annual housing demand on the one hand and manage the optimal conditions on the other hand, revisions need to be made in production of construction materials and products, design and implementation methods, construction technologies and incorporation of machinery. Meanwhile, industrialization of buildings could make great contributions to the housing demand where prefabrication and modular construction in factories and then assembling them within the workshop could increase the quality of project implementation and reduce the project time. The Building Information Modeling (BIM), which collects and documents all the required building information from the initial phase of planning till the operation phase during the entire lifecycle of the project in a data base, could be hired as an effective and efficient tool within the construction industry. Therefore, incorporation of BIM in industrialization of buildings could be used as a basis for investigation and assessment of construction projects. Also, it could improve the strengths and weaknesses of the industrialization process and addresses the design (integration) and construction (improved efficient management capability) phases. In this study, the role of Building Information Modeling (BIM) in industrialization of buildings and their interactions have been investigated.

**Keywords:** Building Information Modeling (BIM), construction management, industrialization of buildings



**CREATIVE SCHEDULING**  
**FOR CONSTRUCTION**  
**15:15 SUNDAY, JUNE 26, 2016**





## AN EFFECT OF THE LEARNING CURVE IN PROJECT SCHEDULING

**Levente Mályusz**

*Budapest University of Technology and Economics, Budapest, Hungary*

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In this paper a simple effect of the learning curve (or experience curve) in project scheduling is shown with a help of an example. Although learning is an essential part of our life, traditional scheduling technique can not handle efficiently the learning curve effect. Learning curve theory can be applied to predicting cost and time to complete repetitive activities. If we take into account the effects of learning curve (or experience curve) we can get better future prediction on project duration time and can save money and time. This effect normally takes shorter project duration time. Although the effect is “simple” unfortunately if we use traditional project scheduling techniques like Critical Path Method, or Precedence Diagramming Method (or calculate longest path algorithm in mathematical terms) we have only an exponential time algorithm to solve this problem correctly.

**Keywords:** Learning curve, project scheduling, precedence diagramming method



## DEFINING A MATHEMATICAL FUNCTION FOR LABOR PRODUCTIVITY IN MASONRY CONSTRUCTION: A CASE STUDY

**Laura Florez**

*Engineering and Built Environment, Northumbria University, Newcastle Upon Tyne, UK*

**Jean C. Cortissoz**

*Department of Mathematics, Universidad de los Andes, Bogotá D.C, Colombia*

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Labor productivity has a profound impact on construction management. The accurate prediction of productivity is essential to effectively plan operations that depend on time and cost and is critical for the success of a construction project for both the contractor and the owner. However, predicting productivity of operations is challenging due to the multiple characteristics of workers, the interrelationships between workers, and the site conditions that impact the performance of crews and affect project goals. This paper proposes a methodology to quantify the factors that affect productivity in masonry construction. We have considered three factors: compatibility, suitability, and craft. Standardized data-collection techniques are used to consolidate data from three masonry sites and mathematically define a productivity function that relates workers characteristics and crews with site conditions. The function, increasing in its arguments, determines the factors that most affect masonry productivity and the factor's effects. The most interesting part is to be able to identify the convexity properties of this function because its theoretical interpretation will have implications on the impact of the superintendent's decisions when forming crews. The proposed mathematical function can enable superintendents to better plan, schedule, and manage masonry crews.

**Keywords:** Crew formation, labor management, masonry construction, productivity function

## FLOYD-WARSHALL IN SCHEDULING OPEN NETWORKS

**Zoltán A. Vattai**

*Budapest University of Technology and Economics, Budapest, Hungary*

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CPM, PERT, MPM, PDM are well known abbreviations and techniques extensively used at estimating and managing time performance of different kind of - amongst them of construction - projects. Common in them is that they are based on and demonstrated by the analogy of a special problem in Graph Theory namely the problem of finding The Longest Path(s) between two nodes in a weighted directed graph. It is less frequently mentioned that the problem has its pair as a 'dual' problem that is known as The Minimal Potentials' Problem interpreted on a set of potentials having pair-wise relative restrictions (lower and/or upper bounds) amongst the potentials. Main differences of the techniques mentioned at the beginning are in preparing and interpreting input and output data and in correspondence of graph elements and of time characteristics (events, processes, lead and lag times) of project components. It is also common in them that determining feasible solution(s) is usually based on a kind of roll-on typed algorithm (e.g. Dijkstra's Algorithm) calculating early and late times via series of consecutive steps starting from a base point (from start or from finish) increasing the set of examined elements of the graph step by step in an appropriate order (forward pass and backward pass), thus solving actually the 'dual' problem. Applying a modified Floyd-Warshall algorithm all-pair longest paths can be determined and identified, and all difficulties of and restrictions on composing the logical time model of the project (represented by the graph) can be eliminated except of the only thing: exclusion of positive loops in the weighted directed graph.

The paper discusses application of modified Floyd-Warshall algorithm to calculate the time model of the project with no concern on whether it has one or more starting and/or ending point(s), whether it includes logical loop(s) or not, whether it is a connected model or not, whether it necessitates positive (lower bound) or negative (upper bound) or multiple restrictions amongst the time data of the project elements or not – that is: to schedule open networks.

**Keywords:** Construction management, network techniques, open networks, Floyd-Warshall, scheduling

## SHOULD TIME BE THE ONLY SCALE REQUIRED FOR RELATIONSHIP AND MARGIN CALCULATIONS?

**Adel Francis**

*École de Technologie Supérieure, Notre-Dame West, Montreal (Qc), Canada*

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Precedence logic's four types of relationships, four types of margins and by simulating the work production through lags present several shortcomings that affect the accuracy of the schedule and margin calculations, as is well documented in the literature. To overcome these gaps, the Chronographic Method has proposed many developments over several years, including allowing for split activities with internal divisions according to quantities. Internal divisions extend the relationships between activities to deterministic and probabilistic point-to-point, by-section or continuous relations, generating realistic dependencies and new types of floats (Complete, Start, Finish and Partial floats). Activities and divisions may also have external and internal scales. External horizontal scales may designate the measuring unit of the x-axis for an orthogonal system and should be unique for the entire project (e.g. time that defines the external horizontal scale unit of the bar chart diagram). Internal horizontal scales can be distinct for each activity or section. External and internal scales may be based on time, cost, work progress, quantity, risk or performance. For the purposes of calculation, this paper uses time as the external scale and the amount of work as the internal scale. Relations and margins can then be calculated according to the external scale (time) or the internal scale (quantity). The calculation constraints and project tracking can then be based on either time or quantity. This paper explains this concept and the calculation equations for these new types of margins; discusses the limitations of the traditional margins and the use of time as the only scale required for relationship and margin calculations; and demonstrates the relevance of using other measures, including the amount of work, Site occupations for scheduling calculations. The proposed chronographic logic and margin calculations can then be used to simulate the project's real conditions.

**Keywords:** Chronographic method, construction, margin, Precedence diagram



# **CREATIVE MANAGEMENT**

**16:45 SUNDAY, JUNE 26, 2016**



## MARKET PENETRATION AND THE INCENTIVES OF RESIDENTIAL SOLAR ELECTRICITY IN THE UNITED STATES

**Matthew A. Tibbs**

*Auburn University, Auburn, Alabama, USA*

**Scott W. Kramer**

*Auburn University, Auburn, Alabama, USA*

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This paper studies the market penetration of residential photovoltaic (PV) electricity generation in the United States. The federal government and many of the state governments of the U.S. are motivated to reduce dependence on fossil fuel technology and reduce greenhouse gas emissions. Photovoltaic systems on the commercial and residential scale have been touted as part of the solution to the problem. One obstacle to adoption, is that residential PV systems have not yet reached a *cost per installed watt of capacity* equal to that of utility power companies in the U.S. Therefore, state governments and utilities are using economic incentives to drive adoption. In this research, a survey was undertaken of available incentives and compared to available data on solar installations per state in the U.S. The result of this comparison showed a strong correlation between the states with the most generous subsidies and the highest number of residential PV systems installed per capita. It appears that economic incentives and energy costs are the two main drivers of residential PV system adoption in the U.S.

**Keywords:** Incentives, net metering, photovoltaic, residential, solar



## EXAMINING HAPPINESS: TOWARDS BETTER UNDERSTANDING OF PERFORMANCE IMPROVEMENT

**Djoen San Santoso**

*Asian Institute of Technology, Paholyothin Highway, Pathumthani, Thailand*

**Hewagamage Eranga Ravihara Kulathunga**

*Asian Institute of Technology, Paholyothin Highway, Pathumthani, Thailand*

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It is well accepted that happiness can provide immense motivation for someone to achieve higher performance. Generating happiness in the workplace is one way of empowerment to induce productivity. This empowerment has been widely studied and explored in many industry sectors but only limited studies have been done for construction industry. This research tries to enrich this topic by conducting study to engineers of construction firms. In the study, in addition to happiness, psychological well-being and stress were included to cover better understanding of the subject. For the performance side, two perspectives were considered: a self-performance assessment by the engineers and a performance assessment by engineer's supervisor (project manager). A total of 114 engineers and 21 project managers from 21 construction sites in Sri Lanka were surveyed for the purpose of this research. The result revealed that a significant positive strong relationship between psychological well-being and performance can be identified. The same also applied to happiness and performance, only at a lesser degree. As expected, stress had a negative association with performance; however, the degree was only weak and not statistically significant. The study also found that age, marital status, salary, and construction experience have similar and different roles in defining the level of happiness, psychological well-being, and stress at work. For example, single engineers are significantly happier and perform better in their work than married engineers. Meanwhile, years of experience are significantly associated with performance and stress but not with happiness and psychological well-being. Therefore, it is important to understand how happiness, psychological well-being, and stress levels are differently associated with the socio-economic and experience of engineers. Each factor may relate uniquely in defining the happiness, psychological well-being, and stress at work as different level of engineers has different concerns, and needs different motivational approach to improve their performance.

**Keywords:** Happiness, empowerment, engineer, motivation, performance



## URBAN RENEWAL PROJECT SELECTION USING THE INTEGRATION OF AHP AND PROMETHEE APPROACHES

**Gul Polat**

*Istanbul Technical University, Istanbul, Turkey*

**Atilla Damci**

*Istanbul Technical University, Istanbul, Turkey*

**Asli Pelin Gurgun**

*Yildiz Technical University, Istanbul, Turkey*

**Ilayda Demirli**

*Istanbul Technical University, Istanbul, Turkey*

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Appropriate project selection has a significant impact on construction companies' success. Selecting the appropriate project is complicated due to uncertainties related to many factors that may influence the project selection process. The uncertainties related to a construction project may vary according to the type of the construction project. Therefore, having a project selection tool, which assists construction companies in selecting a particular construction project, can be a significant advantage in achieving success. Urban renewal projects constitute a significant portion of the projects that are carried out by construction companies in Turkey. This study aims to propose an integrated approach for selection of urban renewal projects. The proposed approach combines analytic hierarchy process (AHP) method and PROMETHEE, to help construction companies in selecting the appropriate urban renewal project. AHP and PROMETHEE were used to find the weights of the selection criteria and to rank the alternative projects, respectively. The proposed approach is used to solve a project selection problem of a Turkish construction company, which is mainly specialized in urban renewal projects. In the case study, twelve different projects were ranked according to seventeen evaluation criteria by using the proposed approach. The findings of this study revealed that the proposed approach can be a useful tool for construction companies, which are especially specialized on urban renewal projects.

**Keywords:** Analytic hierarchy process, case study, project selection, promethee, urban renewal projects



## BRIDGE MAINTENANCE AUTOMATION

Vladimir Križaić

*School of Building and Crafts – Community College Čakovec, Podturen, Croatia*

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The investment maintenance of valuable buildings is nowadays performed continuously and by means of automated technologies and softwarized construction business systems organizations. For the purpose of the sustainability of traffic and buildings, the automation of technologies requires a matching automation of works- performing systems logistics within business operations as a whole. However, besides the information flow softwarizing, there are as well technological and organizational novelties aimed at the rationalization of the activities. Namely, the technological novelties are new machines-robots-and the organizational ones are the new formulae-the equations of procedures. Thus the vector methods provide for the fulfillment of investment supported by the scientific procedures that are in turn to contribute to the upgrading of indices to show the economic quality of not only a particular company but of state institutions as well. In other words, the aforementioned automation processes provide the possibilities for further scientific research and the development of society.

**Keywords:** Investment, technology, organization, management, robot, software, vector norm, vector organization



# **SUSTAINABLE CONSTRUCTION**

**16:45 SUNDAY, JUNE 26, 2016**



## THE ROLE OF EMOTIONAL INTELLIGENCE IN MANAGING CONSTRUCTION PROJECTS

**Lauren Satchwell**

*Nelson Mandela Metropolitan University, Port Elizabeth, South Africa*

**John Smallwood**

*Nelson Mandela Metropolitan University, Port Elizabeth, South Africa*

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The success of any construction project is dependent on a range of factors. An often overlooked aspect is the role of emotional intelligence (EI) in ensuring the sustainability of a firm and promoting success and excellence. However, limited research has been conducted regarding the status and role of EI within the construction industry.

A literature survey pertaining to the role of EI in managing construction projects informed the development of an interview protocol, which was used to interview representatives of construction firms that are members of the East Cape Master Builders Association (ECMBA).

The salient findings include: most construction firms do not implement stress management strategies during the execution of construction projects; supervisors and workers do not necessarily develop negative attitudes on construction projects due to management's poor intrapersonal skills, however employees believe that EI is important and management need to be emotionally intelligent to be successful in construction; short-comings between levels of management exist during the execution of construction projects due to differences in opinions and personalities, and management encounter unforeseen problems and changes during the construction process and contain little knowledge of the improvements which can be made within the firm to adapt to changes. The EI competencies in the form of self-awareness, self-management, social awareness, and relationship management are important in terms of the managing of construction, and thus managers need to be emotionally intelligent, and for that matter employees too.

Conclusions include: the level of EI in construction is not ideal; the construction industry is stressful; there is a need to 'target' and manage stress, and there are underlying or root causes of stress.

Recommendations include: tertiary construction management programmes and construction firms should focus on the development of EI; communication should be promoted and forums directed towards promoting teamwork should be arranged; construction firms should develop stress management strategies and implement related programmes in order to help management and employees deal with stress.

**Keywords:** Construction, emotional intelligence, performance



## **BIM AND SAFETY RULES BASED AUTOMATED IDENTIFICATION OF UNSAFE DESIGN FACTORS IN CONSTRUCTION**

**Guo Hongling**

*Tsinghua University, Beijing, China*

**Yu Yantao**

*Tsinghua University, Beijing, China*

**Zhang Weisheng**

*Tsinghua University, Beijing, China*

**Li Yan**

*Tsinghua University, Beijing, China*

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Design for Safety (DfS) has been considered as an effective approach to improving construction safety performance via taking into account safety problems during design. The approach, however, is not yet implemented effectively and efficiently in practice. This research tries to develop a practical DfS approach, which can automatically identify potential safety problems resulted from design by integrating BIM (Building Information Modeling) with design safety rules. Design safety rules related to construction safety is defined and built based on design regulations or codes, and a BIM and safety rules integrated approach developed to implement the automated identification of safety problems. Furthermore, a test-bed project is presented to test the validity of this approach. As a result, the unsafe factors in design can be detected during construction to aid in construction safety management on site. Compared with traditional safety management methods, the BIM-based DfS approach is automated, thus reducing the time and labor cost spent on safety checking and improving the performance of construction safety management.

**Keywords:** Building Information Modelling (BIM), construction safety, design for safety(DfS), safety rules

## OPTIMIZATION OF CONSTRUCTION SITE SAFETY SUPERVISION ACTIVITIES

**David Dagan**

*Department of Structural Engineering, Ben-Gurion University of the Negev,  
Beer-Sheva, Israel*

**Shabtai Isaac**

*Department of Structural Engineering, Ben-Gurion University of the Negev,  
Beer-Sheva, Israel*

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A proposed safety management methodology for large and complex construction sites is presented. The methodology includes a risk control process based on continuous improvement, which utilizes data collected in an audit program to evaluate the safety performance of different crews on site. The methodology utilizes information on ratios that can be determined between different types of safety events in order to identify deviations that require control actions, and in order to reduce the number of severe safety events by reducing the number of unsafe acts that lead to such events.

**Keywords:** Construction safety, optimization, site supervision, statistical analysis

## **ENERGY EFFICIENCY HOUSING IN SOUTH AUSTRALIA – A GAP ANALYSIS BETWEEN THE EXPECTED AND ACTUAL BENEFITS**

**Christy Chan**

*University of South Australia, North Terrace, Adelaide, Australia*

**Tony Ma**

*University of South Australia, North Terrace, Adelaide, Australia*

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In Australia, the trend of being energy efficient within modern multi-storey buildings has been more popular in recent years. However, lack of attention has been given to the residential housing in terms of the perceived benefits and actual performance. The purpose of this research is to investigate the gap between the original expectation and the occupants' satisfaction in residential energy efficient dwellings. This research also aims to analyze the relationship between the satisfaction level and both the initial as well as the ongoing cost of energy efficient dwellings in South Australia. Finally, it determines whether the initial cost of residential green building is proportional to the financial savings. The research methodology comprised a literature review and data collection through the use of questionnaires. The literature review provides a background of knowledge that has been studied on green buildings. The findings of this research have indicated that South Australians were satisfied with the perceived benefits of the residential energy efficient buildings since occupation. However, the higher up-front cost has brought the households various concerns including their affordability and actual financial savings. The major benefits that are brought by energy efficient housing including reduced in energy cost and consumption, and improved thermal performance. Through the gap analysis, a positive outcome has been found, indicating that actual performance of energy efficient housing is exceeding the users' expectation. It is suggested that the State Government as a leader of the energy efficient housing promotion needs to provide more financial incentives in order to disseminate the housing option while moving towards a sustainable future. Meanwhile, the local builders need to improve their understandings on energy efficient housing, while providing more energy efficient housing options to the South Australian market.

**Keywords:** Energy efficient housing, green buildings, South Australia



## RESPONSIBLE RESEARCH AND INNOVATION IN CONSTRUCTION

Žiga Turk

*University of Ljubljana, FGG, Ljubljana, Slovenia*

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The issue of ethics and responsibility is gaining attention among the creators of scientific policy, funding agencies and society at large. Responsible research is defined as research that aligns both the process and the outcomes with the values, needs and expectations of society. In an EU funded project “Responsible Research and Innovation in Information and Communication Technology (ICT)” a four dimensional framework for defining and monitoring responsibility in that kind of research projects has been defined. The four dimensions are (1) actors who are responsible or to whom research is responsible, (2) kinds of responsibility – in what way are they responsible, (3) how much they are responsible and (4) in what area of ICT responsible research and innovation can take place. After presenting the framework we apply the concept of responsibility to research in the field of architecture, engineering and construction (AEC). We are finding that the particular feature that sets responsibility in construction apart from other research topics is the impact it has on life and safety of large number of people and on the critical infrastructures. While responsibility is important we conclude with a warning that the first responsibility of research is scientific quality and that other responsibilities cannot be a substitute for that.

**Keywords:** Construction research, research policy, innovation, responsibility, social responsibility, scientific method





**CREATIVE SCHEDULING**  
**FOR CONSTRUCTION**  
**16:45 SUNDAY, JUNE 26, 2016**



## MULTI-OBJECTIVE CONSTRUCTION SITE LAYOUT PLANNING USING GENETIC ALGORITHMS

**Ioanna N. Papadaki**

*Department of Civil Engineering, University of Patras, Patras, Greece*

**Athanasios P. Chassiakos**

*Department of Civil Engineering, University of Patras, Patras, Greece*

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Efficient layout planning of a construction site is fundamental for successful project undertaking as it enhances both productivity and safety in construction sites. This task usually consists of identifying the temporary facilities needed to support construction operations, determining their size and shape, and optimally positioning them in the unoccupied areas within the site boundaries. The site layout planning problem is a complex combinatorial optimization problem involving multiple objectives and it grows significantly in size as the number of facilities and constraints increases. The existing literature includes a variety of analytical, heuristic, and meta-heuristic techniques for solving the problem but existing studies usually examine a small number of facilities and focus on travel distance minimization, ignoring generally cost related or other decision parameters. The objective of this study is to develop feasible and efficient site layout solutions in a realistic representation scheme taking into consideration not only the total distance traveled but also cost and safety parameters as well. A multi-objective optimization model is developed aiming at minimizing a generalized cost function which results from the construction cost of a facility placed at alternative locations, the transportation cost among locations, and any safety concern in the form of preferred proximity or remoteness of particular facilities to other facilities or work areas. The development integrates the required robust search objective with the optimization capabilities of the genetic algorithms (GAs). The model has been tested on several test cases and the results of a comparative study with existing methods from the literature are presented. The evaluation indicates that the proposed model provides effective and rational solutions, in response to decision parameters and problem constraints, and that it results in more robust layout planning than previous methods both qualitatively and quantitatively.

**Keywords:** Construction site, genetic algorithms, layout planning, optimization, safety



## TIME ANALYSIS FOR PRECEDENCE DIAGRAMMING METHOD WITH CONTINUOUS PRECEDENCE RELATION

Miklós Hajdu

*Budapest University of Technology and Economics, Budapest, Hungary*

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Precedence Diagramming Method (PDM), the prevailing scheduling technique of our time is with us since the sixties. During these decades it has hardly changed despite of the criticism its has received due to his modeling capabilities. Recent developments of the Precedence Diagrammig Method like continuous relations and non-linear activities greatly enhance the modeling capabilities of the technique, however proper time analysis of the network with non-linear activity time functions and continuous precedence relations is still missing. This paper presents the mathematical model of the generalized PDM technique. The contribution of this paper is to derive an algorithm for activity pairs that are connected by a continuous relation and can be nonlinear.

**Keywords:** Network scheduling technique, continuous precedence relation, singularity function

## REMOVING CONSTRAINTS TO MAKE TASKS READY IN WEEKLY WORK PLANNING

### **Farook Hamzeh**

*Civil and Environmental Engineering Department, American University of Beirut, Beirut, Lebanon*

### **Emile Zankoul**

*Civil and Environmental Engineering Department, American University of Beirut, Beirut, Lebanon*

### **Fatima El Sakka**

*Civil and Environmental Engineering Department, American University of Beirut, Beirut, Lebanon*

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The Last Planner System (LPS) have been used on construction projects to improve reliable work planning. Lookahead planning is intermediate process that connects the master or phase schedule to the weekly work plan. Construction teams employ lookahead planning to achieve various objectives including a breakdown down of activities into the level of operations, operations design, and constraint removal to make tasks ready for execution. Tasks Made Ready (TMR) measures the performance of lookahead planning in identifying and eliminating constraints to make activities ready for implementation. The purpose of this paper is to study through computer simulation the impact of TMR on task execution, reliability of weekly work planning, and project duration. Results show that TMR is a good predictor of project duration. These results advise planners on the importance of the constraint removal process, how it influences the reliability of construction planning, and its impact on project duration.

**Keywords:** Constraints, last planner system, lookahead planning, tasks made ready, workflow

## INITIAL ANALYSIS, PLANNING AND CALCULATION OF VERTICAL TRANSPORTATION IN CONSTRUCTION

**Simo Sudić**

*Belgrade Waterfront, Belgrade, Serbia*

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The tower crane is one of the major (key) equipment used in high-rise buildings construction. The main challenge encountered in the construction of high-rise buildings is the transportation of construction materials vertically and horizontally to the required or specific areas of the project. To tackle this challenge various equipment such as tower cranes, mobile cranes, hoists, etc., are used and out of all these equipment tower crane plays a vital role in the logistics of construction materials in the construction projects. Investors and General contractors very often use technical and commercial offers from the crane renting companies to make decisions concerning the number of cranes and period of engagement in the project. There is always a commercial and time risk involved to the Clients in the selection of cranes based on the offers from crane companies, as mostly these crane companies would try and sell what they have in their hand opposed to the most time and cost efficient options for the project. The main reason for that risky approach is a lack of standardized methodologies for the tower crane productivity calculation and decision-making on the selection of models for different proposed solutions by specialists. Identifying optimal number, location and duration of operations on the site are the major factors that can reduce the possibilities of the project outrun over the budgeted time and cost by increasing the productivity and lessen the time of construction. Often tower cranes operate with overlapping works zones, and under time, cost and labor constraints. Therefore, proper planning to be considered, while choosing a tower crane, based on different production parameters such as optimal space per worker, concrete production per crane or worker, lifting time, crane booms overlapping, health and safety measures, and crane operators well-being during the crane operation with maximum visibility to the work areas. In this paper, the methodologies for the number of crane calculation and their optimal positioning in three different construction phases are discussed - underground structures, above ground structure, façade, MEP and finishes work. CPM planning techniques (Primavera P6 software) is used for the proposed model, considering leveling and optimizing of crane usage. An actual case example is provided to demonstrate the planning model for the selection and positioning of tower cranes.

**Keywords:** Construction, optimization, planning, tower crane



## MODELS FOR LEARNING CURVE AND FATIGUE EFFECT

**Levente Mályusz**

*Budapest University of Technology and Economics, Budapest, Hungary*

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In this paper learning curve models with fatigue effect are investigated. If we take into account the effects of learning curve (or experience curve) and fatigue we can get better future prediction on project duration time and can save money and time. This effect normally takes shorter project duration time. The objective of this paper is to give a model for learning curve with fatigue effect which generally occurs at the end of repetitive works. Failure, for most parts of an operation, is a function of time. Plotting the failure rate against a continuous time scale, the results will constitute the so-called 'bath tub' curve. Mathematical learning curve models can be used in construction to predict more accurately the time or cost required to perform a repetitive activity. Our evaluation was based on a survey conducted in the spring of 2009 in Budapest and data obtained from literature.

**Keywords:** Learning curve, fatigue effect, project scheduling





# **CREATIVE MANAGEMENT**

**10:30 MONDAY, JUNE 27, 2016**



## COMPARISON OF ANN AND MRA APPROACHES TO ESTIMATE BID MARK-UP SIZE IN PUBLIC CONSTRUCTION PROJECTS

### **Gul Polat**

*Istanbul Technical University, Maslak, Istanbul, Turkey*

### **Befrin Neval Bingol**

*Istanbul Technical University, Maslak, Istanbul, Turkey*

### **Asli Pelin Gurgun**

*Yildiz Technical University, Istanbul, Turkey*

### **Bulent Yel**

*Istanbul Technical University, Maslak, Istanbul, Turkey*

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The intense nature of the competition in the construction industry is commonly acknowledged by professionals and researchers. Moreover, the owners commonly select the contractors based on how low they offer their bid prices and outbid their rivals. Gaining competitive advantage in order to win a contract is largely based on considering all cost components very carefully and systematically in estimating the bid price. A typical bid price consists of three main cost components, which include: direct costs (e.g., materials, equipment, labourers, etc.), indirect costs (e.g., salaries of the engineers and technical personnel, security, etc.), and bid mark-up (i.e., general overhead, profit and contingency). In the literature, various tools and techniques have been proposed for estimating bid mark-up size in construction projects. This study compares the prediction performances of the artificial neural network (ANN) and multiple regression analysis techniques (MRA). For this purpose, 52 factors that may affect the size of bid mark-up were identified and actual data of 80 public construction projects were obtained from 27 Turkish contractors in public projects in Turkey. The ANN and MRA based models were developed via MATLAB Neural Net Fitting and SPSS software programs, respectively and their prediction performances were evaluated using several statistical measures.

**Keywords:** Artificial neural network, bidding, mark-up, multiple regression analysis, public construction projects



## SMART HOME SUBCONTRACTOR SELECTION USING THE INTEGRATION OF AHP AND EVIDENTIAL REASONING APPROACHES

**Gul Polat**

*Istanbul Technical University, Istanbul, Turkey*

**Fatih Cetindere**

*Istanbul Technical University, Istanbul, Turkey*

**Atilla Damci**

*Istanbul Technical University, Istanbul, Turkey*

**Befrin Neval Bingol**

*Istanbul Technical University, Istanbul, Turkey*

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Subcontracting is a very common practice in the construction industry. The large portions of actual production work are carried out by subcontractors. Therefore, main contractors have focused on selection of the appropriate subcontractors to increase the performance of their business. Finding the most suitable alternative among these subcontractors is another complex task because assimilating a large number of aspects is not simple without using any selection tools. In order to understand this better, breaking down the problem into smaller parts and building a model is one of the best ways in the selection process. Companies want to make differences to increase buyers' interest; this is to obtain better position in the competitive construction market. Recently, the popularity of smart home and home automation has importantly increased in modern societies in Turkey. This has lead construction companies to import the smart home system into their business investments. This study aims to propose an integrated model for selection of smart home subcontractor. The proposed model integrates Analytic Hierarchy Process (AHP) and Evidential Reasoning (ER) techniques. In this study, AHP is used to find the weights of the criteria that are considered in the smart home subcontractor evaluation process and ER is employed to rank the alternative subcontractors. The proposed approach is applied in a construction company that has completed many projects in Turkey. In the case study, twenty evaluation criteria are considered and eight alternative smart home companies are evaluated. The result of this study demonstrated that the suggested model is applicable.

**Keywords:** Analytic hierarchy process, case study, evidential reasoning, smart home, subcontractor selection

## EVALUATING BARRIERS TO EFFECTIVE IMPLEMENTATION OF PROJECT MONITORING AND EVALUATION IN THE GHANAIAN CONSTRUCTION INDUSTRY

**Tengan Callistus**

*Department of Construction Management and Quantity Surveying, University  
of Johannesburg, South Africa*

**Aigbavboa O. Clinton**

*Department of Construction Management and Quantity Surveying, University  
of Johannesburg, South Africa*

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Construction projects monitoring and evaluation is a vital process in the project delivery which is aimed at ensuring the major objectives and goals are achieved. However, the implementation of monitoring and evaluation in the Ghanaian construction industry have seen numerous challenges and as a result, the poor performance of the industry. This paper identifies and evaluates the barriers faced by projects in the implementation of monitoring and evaluation in the Ghanaian construction industry. Literature was reviewed and subsequently, a semi-structured questionnaire developed to stimulate the relevant response from the major stakeholders in the Ghanaian construction industry. The collected data were analysed using the one sample t-test. Literature revealed ten (10) challenging factors to the implementation of monitoring and evaluation. Weak institutional capacity, limited resources and budgetary allocations for monitoring & evaluation, weak linkage between planning, budgeting and monitoring & evaluation, weak demand for and utilisation of monitoring and evaluation results and finally, poor data quality, data gaps and inconsistencies were identified as the most significant contributing factors to the implementation of PM&E in Ghana construction projects. The study contributes to the body of knowledge on the challenges to effective monitoring and evaluation of construction projects.

**Keywords:** Construction industry stakeholders, effective project implementation, project monitoring and evaluation, Ghana



## IMPLEMENTATION OF SCRUM IN THE CONSTRUCTION INDUSTRY

### **Thomas Streule**

*ETH Zurich, Zurich, Switzerland*

### **Nino Miserini**

*ETH Zurich, Zurich, Switzerland*

### **Olin Bartlomé**

*SWISS PROPERTY AG, Zurich, Switzerland*

### **Michael Klippel**

*Institute of Structural Engineering, ETH Zurich, Zurich, Switzerland*

### **Borja García de Soto**

*Institute of Construction and Infrastructure Management, ETH Zurich, Zurich, Switzerland*

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The way in which construction projects are managed has not changed significantly in the last decades; however, stakeholders, materials, competition, and user requirements are continuously changing. This creates a gap between the current managerial view on how construction projects are conducted and how they could be managed to increase efficiency.

The construction industry could use new frameworks for action in the project and product management, and learn from the experiences of other industries. With this background in mind, some construction companies are enhancing the performance of their project teams to improve their competitiveness and increase the added value to their clients and themselves.

This paper investigates the implementation of a framework from the IT sector into the construction industry: Scrum. Conducting a case study, the implementation and application of Scrum was analysed through the evaluation of its different artifacts. This research covers the following questions: Can Scrum be implemented in the design phase of construction industry? What adaptations are needed to use Scrum to improve the design phase of construction projects? How and where could Scrum, or parts of it, be used by the design and planning departments of construction companies?

The results from this study show that Scrum has great potential in the design and planning departments of construction firms. From the analysis of the applications of Scrum in the case study, tangible benefits and weaknesses of the implementation, and its different artifacts, were identified. Finally, this paper gives recommendations about the use of Scrum in the design phase and proposes an outlook to implement Scrum in other phases of construction projects.

**Keywords:** Agile, design phase, process model, project management, scrum



## THREE ENTITIES TO MAXIMIZE CREATIVE CONSTRUCTION QUALITY

### **Nuno Dinis Cortiços**

*Centro de Investigação em Arquitetura, Urbanismo e Design at Faculdade de Arquitetura, Universidade de Lisboa, Lisbon, Portugal*

### **Miguel Baptista-Bastos**

*Centro de Investigação em Arquitetura, Urbanismo e Design at Faculdade de Arquitetura, Universidade de Lisboa, Lisbon, Portugal*

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Creativity in construction is somehow intrinsic to the nature of designers. Never, as today, was there such a demand for newness. In Portugal, the situation is no different, where there is a body of young professionals eager to unveil a reality never before attempted or, simply, unknown to them. The momentum supports their motivation to experiment, with greater or lesser awareness, though not always with the desired results, either for lack of: training; information; handling of materials and products; openness of the Project Owner; specific and cross-cutting knowledge of other sciences (present in the maturation processes / sinterization solutions); accuracy in the use of technical terminology; professional and productive environment; test systems, prior validation, construction methodology, approval, robustness assessment, assurance and documentation for registration.

At times, news about the construction sector are disconcerting, even on outstanding works that evoke architectural creativity - supported by creative construction - as a purpose. Those are often awarded in international competitions, of recognised merit, by partners, operators and future professionals.

The creative construction, by principle, is based on the reassessment dogmas! This statement, in the reality of contemporary construction, widely systematized, may translate into an overwhelming success but also into its opposite. The repetition of a defective solution can lead to the collapse of the whole, exponentially. Only a system equipped with tools that allow control over the decisions, in the different stages, can prevent failure, through the evaluation of those and consistent report on their impact, particular and overall. The involvement of fundamental entities, in the different phases, makes it possible to anticipate the robustness of the solution, a.k.a. creative construction, by the different operators, with general skills in diverse areas of knowledge, such as: assessment, monitoring and validation in the design stage or construction work; and assumption of guarantees, including corrective, if need to minimize the overall impact.

**Keywords:** Construction, guarantee, products, roughness tests, certification and approval, labs





# **SUSTAINABLE CONSTRUCTION**

**10:30 MONDAY, JUNE 27, 2016**



## SEVERITY PREDICTION MODELS OF FALLING RISK FOR WORKERS AT HEIGHT

**Hainan Chen**

*Department of Architecture and Civil Engineering, City University of Hong Kong,  
Hong Kong SAR*

**Xiaowei Luo**

*Department of Architecture and Civil Engineering, City University of Hong Kong,  
Hong Kong SAR*

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Construction industry has one of the highest accident and fatality rates among other major industries, with more than 60,000 fatal accidents each year worldwide. Falling from height is one of the leading causes of fatalities and injuries in construction. Passive protection devices (e.g., safety net) have been used to minimize the impact of falling from height for ages, while proactive warning systems appear recently to alert the workers when they are at risks of falling. To provide appropriate warnings to the worker but not to distract them due to the false alarm, the falling risk needs to be carefully evaluated. In this paper, the authors introduced algorithms for falling risk prediction and evaluated their performance. Injuries records during 2005 to 2015 were extracted from the OSHA database and 1161 intact falling-related record were used in this study. K-Modes, RBF network and Decision Trees are chosen to build three risk prediction models, and the performance of those three proposed models were evaluated using the OSHA injuries record data. The results indicate that the DT-based falling risk prediction model has the best performance of 75% and the top three critical factors of falling event's severity are distance from the ground, worker's occupation and the source of the falling. The delivered severity prediction model provides the foundation of more accurate real time risk evaluation for workers at height.

**Keywords:** Falling from height, machine learning, serverity of injury, risk prediction



## PERFORMANCE OF LEED ENERGY CREDIT REQUIREMENTS IN EUROPEAN COUNTRIES

### **Asli Pelin Gurgun**

*Yildiz Technical University, Department of Civil Engineering, Davutpasa Campus, Esenler, Istanbul, Turkey*

### **Gul Polat**

*Istanbul Technical University, Department of Civil Engineering, Istanbul, Maslak, Turkey*

### **Atilla Damci**

*Istanbul Technical University, Department of Civil Engineering, Istanbul, Maslak, Turkey*

### **Hasan Gokberk Bayhan**

*Istanbul Aydın University, Department of Civil Engineering, Florya Campus, Küçükçekmece, Istanbul, Turkey*

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Construction industry influences the environment a great deal by using different resources. Efficient use of resources is important for sustainability considerations. Heavy consumption of energy is one of the reasons causing adverse impacts on the built environment. The interest in sustainable construction is growing worldwide. Green building systems are used to certify the projects as green buildings in different countries. All these systems have similar approaches to build sustainably and they all highlight requirements related to energy consumption with a significant emphasis. One of the most recognized green building certification systems, LEED addresses energy optimization, green power and on-site renewable energy in much detail. The maximum credit points can be achieved from “energy and atmosphere” category in LEED. However, the use of LEED in countries other than the U.S. can be difficult as local conditions and practices are influential in earning credentials. This study aims to review the practices of “energy and atmosphere” category of LEED v3 2009 New Construction in European countries. Analysis of practices in selected countries is made based on credit performances, which can display variations depending on local conditions. It is expected that practitioners in these countries will benefit from the credit patterns, providing improved insights about on-site real applications.

**Keywords:** LEED, energy and atmosphere, Europe, sustainable construction, credit

## **AN ANALYSIS OF PROBLEMS WITH CURRENT INDICATORS FOR EVALUATING CARBON PERFORMANCE IN THE CONSTRUCTION INDUSTRY**

**Pan Lee**

*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong*

**M. Chong Wang**

*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong*

**Hon-wan (Edwin) Chan**

*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong*

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“Low-carbon” is well acknowledged as one of the key factors contributing to sustainable urban development, and also an effective approach for tackling climate change. Since the building sector accounts for a high proportion of carbon emissions, the construction is regarded as one of the most potential industry for reducing carbon emissions. However, there is no standardized indicator to measure carbon performance in the construction industry. As a result, the choice of various indicators may result in significantly different carbon performances which determine whether an industry is considered truly “low carbon”. In this paper, the current indicators for assessing carbon performance in the construction industry are reviewed. The pros and cons of the current indicators are also highlighted. The problems of using the current indicators are discussed, and these problems are often related to accuracy of indicator, data availability and definitions of specific terms. Suggestions are made to focus on carbon emissions at building operation stage first as it accounts for a significant amount of carbon emissions during the whole building life-cycle. It should be highlighted that embodied emissions of buildings are also important during the whole building life-cycle. However, due to the challenges in data acquisition for calculating embodied emissions, attention should be paid more to the operational stage first as smart meters can be used to facilitate data collection processes. The findings provide clues for industry practitioners to develop an indicator which is more practical in use to assess carbon performance in the construction industry.

**Keywords:** Carbon emissions, low-carbon performance, indicators, construction industry



## **EXPLORATORY FACTOR ANALYSIS OF EMPLOYEE'S ACTIONS TOWARDS HEALTH AND SAFETY COMPLIANCE IN CONSTRUCTION**

**Zakari Mustapha**

*Department of Construction Management and Quantity Surveying, Faculty of Engineering and the Built Environment, Johannesburg, South Africa*

**Clinton Ohio Aigbavboa**

*Department of Construction Management and Quantity Surveying, Faculty of Engineering and the Built Environment, Johannesburg, South Africa*

**Wellington Didi Thwala**

*Department of Construction Management and Quantity Surveying, Faculty of Engineering and the Built Environment, Johannesburg, South Africa*

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Unreasonable rates of accidents both permanent and non-permanent disabilities and even fatalities are found to be common among the construction industry. The purpose of the study was to determine employee's actions towards Health and Safety (H&S) compliance in construction. Delphi survey method of data collection was used to generate information from academicians and construction professionals (experts). Questionnaires were completed by respondents based on provided indicator or measurement variables to predict employee's actions towards H&S compliance in construction. The ratings of the questionnaire were based on either the impact was considered to be very high, high or medium. The analysis of the data was done using Microsoft EXCEL and the results were presented in charts. Findings from the study showed three measurement variables to have reached consensus using Inter-Quartile Deviation (IQD) with strong consensus and very high impact. Further Exploratory Factor Analysis (EFA) showed five indicator variables to be the determinant of H&S compliance. It can be concluded from the findings that employee's actions are very significant in deriving health and safety compliance in the construction industry.

**Keywords:** Exploratory factor analysis, employee's actions, compliance, health and safety



## TOWARDS ZERO FATALITIES, INJURIES, AND DISEASE IN CONSTRUCTION

**John Smallwood**

*Nelson Mandela Metropolitan University, Port Elizabeth, South Africa*

**Fidelis Emuze**

*Department of Built Environment, Central University of Technology, Bloemfontein,  
South Africa*

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This study explores the 'holy grail' of health and safety (H&S) - zero fatalities, injuries, and disease! Although, the logic of pursuing such a goal is obvious there are many 'non-believers' in the sense that they do not believe it is achievable. However, the literature indicates that such a goal is an integral part of H&S culture, and is complementary to the vision of fatality, injury, and disease free construction. Furthermore, it is the only 'transparent' goal.

A study conducted among a convenience sample of 'better practice H&S' general contractors determined that client contributions, 'designing for construction H&S', integration of design and construction, appropriate procurement, contractor planning, risk assessment, an optimum interface between H&S, quality, and the environment including the respective management systems, H&S education and training for all stakeholders, core competencies, and consciousness and mindfulness, will contribute to the realisation of 'zero'.

Conclusions and recommendations include the achieving of 'zero' requires a multi-stakeholder effort on a project basis, including a partnering type process, and synergy between groups of actions / beliefs / interventions / practices / states i.e. the requisite 'cocktail' of factors must be in place and to an optimum extent.

**Keywords:** Construction, fatalities, Health and Safety (H&S), injuries, zero





# **AUTOMATION AND ROBOTICS IN CONSTRUCTION**

**10:30 MONDAY, JUNE 27, 2016**



## **ON-SITE MOBILE APPLICATION FOR COMMAND, CONTROL AND COMMUNICATION OF SAFETY AND QUALITY**

**Igal M. Shohet**

*Department of Structural Engineering, Ben-Gurion University of the Negev,  
Beer Sheva, Israel*

**Lorenzo Ciabocco**

*Department of Structural Engineering, Ben-Gurion University of the Negev,  
Beer Sheva, Israel*

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Safety and quality are two factors that play an important role in construction projects success. Management involvement in safety, effective communication and control during the construction phase have been identified as fundamental parameters that lay the foundations for effective construction. Focused on the emerging mobile computing technology, smartphones and tablet, an application for command, control and communication of construction safety and quality management was developed. The application makes use of tags, which are physically attached to the workers and equipment (such as scaffoldings, formworks and crane). All safety procedures can be implemented using the application, including, safety specifications, safety and quality checklists, forms, reports, safety risk assessment and safety and quality audits and records. The information can be accessed on real-time by all members of the project management team and senior company levels. To evaluate the applicability, the system was implemented in a pilot project. Safety and quality key performance indicators were established and implemented prior, during and following the implementation in order to examine and quantify the potential benefits. The observation of the key performance indicators provided a clear evidence of the potential of the proposed mobile application in improving both safety and quality of construction activities.

**Keywords:** Communication, control, mobile application, quality, safety management



## **A CLOUD-BASED MOBILE SYSTEM TO MANAGE LESSONS-LEARNED IN CONSTRUCTION PROJECTS**

**Ximena Ferrada**

*Pontificia Universidad Católica de Chile, School of Civil Construction, Santiago, Chile*

**Daniela Núñez**

*Pontificia Universidad Católica de Chile, Department of Computer Science, Santiago, Chile*

**Andrés Neyem**

*Pontificia Universidad Católica de Chile, Department of Computer Science, Santiago, Chile*

**Alfredo Serpell**

*Pontificia Universidad Católica de Chile, Department of Construction Engineering and Management, Santiago, Chile*

**Marcos Sepúlveda**

*Pontificia Universidad Católica de Chile, Department of Computer Science, Santiago, Chile*

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Knowledge and experience are vital assets within the construction industry. Nevertheless, small and medium construction companies still have problems to transfer the knowledge acquired in their projects to the rest of the organization. Lessons-learned are elements of knowledge management that could help companies to improve this process, and therefore, their global performance. This research presents a cloud-based mobile shared workspace to support knowledge management in construction. The article presents the original system and the modifications made to it based on an initial evaluation by construction professionals. The main upgrades were to include a notification system, letting user's know when an action is required from them, and to improve the synchronization process for a better offline experience on site. The evaluators considered these were essentials features to be able to use the system on site. The 2.0 version of the system was validated with construction experts. The article concludes that one of the most relevant features of the system is its capacity to save information on site without an internet connection for later synchronization. Also, the proposed cloud-based shared workspace is a feasible option to improve knowledge management in small and medium Chilean construction companies, mainly because of mobility, usability and investment-related factors.

**Keywords:** Cloud computing, knowledge management, mobile information systems, shared workspaces

## **A MECHATRONIC SLIP COMPLEX CONTROL WHEN ERECTING MONOLITH OBJECTS**

**Alexey Bulgakov**

*Southwest State University, Kursk, Russia*

**Sergei Emelianov**

*Southwest State University, Kursk, Russia*

**Natalia Buzalo**

*Platov South-Russian State Polytechnic University (NPI), Novocherkassk, Russia*

**Oleg Parshin**

*Don State Technical University, Rostov on Don, Russia*

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The paper considers the principles of a mechatronic slip complex (MSC) control for monolith construction, which features the availability of two groups of effectors requiring coordinated work. It has been shown that for the MSC control it is advisable to use a two-level structure; the upper level tasks of which are planning the complex hoisting and synchronizing the operation of control mechanisms, while the tasks of the lower level incorporate the development of control signals formed at the previous level. In order to remove the complex deviation from the designed location it is suggested to apply the method of the MSC movements planning with due account of limitations for control and effects of disturbing influences on the structure being erected.

**Keywords:** Monolith building, slip forms, automation, mechatronic complex, control



## MAINTENANCE STRATEGY OF MULTI-EQUIPMENT NETWORK SYSTEMS BASED ON TOPOLOGY VULNERABILITY ANALYSIS

Lieyun Ding

*School of Civil Engineering & Mechanics, Huazhong University of Science and Technology, Wuhan, China*

Qi Fang

*School of Civil Engineering & Mechanics, Huazhong University of Science and Technology, Wuhan, China*

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A great variety of mechanical and electrical equipment are distributed along the whole metro line. Equipment maintenance plays a very important role for metro operation safety. But how to ensure the scientificity and rationality of the maintenance plan remains a problem. Maintenance plan is theoretically supported by existing maintenance strategies. This paper proposes a new maintenance strategy which focuses on multi-equipment network systems based on topology vulnerability analysis. BIM is used as an object-oriented database to store the topological relations of network devices, express the equipment maintenance plan, and form a maintenance information storage and data analysis platform. Then vulnerability analysis of the topological structure is carried out. According to the results of the vulnerability analysis, the maintenance plan of the equipment with high degree of topology vulnerability could be optimized. A case study shows that the optimal maintenance plan based on the proposed maintenance strategy can improve the system reliability and reduce cost.

**Keywords:** Equipment maintenance, BIM, complex network, vulnerability



## **THE POSSIBILITIES FOR AUTOMATED ONLINE PROJECT TRACKING BASED THE NEW DEVELOPMENTS OF PRECEDENCE DIAGRAMMING**

**Shabtai Isaac**

*Ben Gurion University of the Negev, Beer Sheva, Israel*

**Miklós Hajdu**

*Budapest University of Technology and Economics, Budapest, Hungary*

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Schedule control processes are implemented in construction projects to identify and mitigate deviations of the actual execution of activities from the planned dates. The availability of automated data collection technologies, which can provide real-time data on the progress made in the project, has led to a number of studies on their possible use to support construction project control. However, it is not sufficiently clear how automatically collected data can be compared with the planning data, given the differences between these two datasets in terms of their level of detail and temporal accuracy. There is, moreover, usually a difference between the formal planning of construction projects prior to their execution, and the daily onsite planning during actual execution, with the latter often being governed by informal ad-hoc solutions that are defined by the site management.

The goal of the present research is to analyze how existing scheduling methodologies need to be adjusted so that they can better support effective real-time schedule control, and fully take advantage of automated data collection technologies. In particular, it investigates how an extension of the existing project activity network model can be used to produce construction schedules with new types of relationships, which will be more suitable for real-time schedule control purposes. This extension will include the definition of planned internal control points for activities, and of relations between those points. In other cases, monitoring will be based on the definition and tracking of continuous relations, rather than on specific control points. In addition, algorithms are developed for the adjustment of the schedule according to the actual deviations that are identified.

**Keywords:** Automation, scheduling, control, tracking





# **CREATIVE MANAGEMENT**

**14:15 MONDAY, JUNE 27, 2016**



## DRIVERS FOR AND OBSTACLES TO ENTERPRISE RISK MANAGEMENT IN CONSTRUCTION FIRMS: A LITERATURE REVIEW

**Berenger Y. Renault**

*Department of Construction Management & Quantity Surveying, University  
of Johannesburg, Doornfontein, Johannesburg, South Africa*

**Justus N. Agumba**

*Department of Construction Management & Quantity Surveying, University  
of Johannesburg, Doornfontein, Johannesburg, South Africa*

**Olanrewaju Abdul Balogun**

*Department of Construction Management & Quantity Surveying, University  
of Johannesburg, Doornfontein, Johannesburg, South Africa*

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Regardless of the increased number of studies on Risk Management (RM) in several industries, limited studies have strived to reveal the components are driving and obstructing ERM implementation in construction firms. These firms are constantly exposed to business risks, thus requiring not only project risk management (PRM) but also a more integrated, comprehensive focused risk management approach to managing risks on an enterprise basis defined as enterprise risk management (ERM). Therefore, this study aims to identify the drivers and obstacles to ERM implementation. The work methodology included a comprehensive literature search relating to ERM. The review spanned a decade and lustrum between January 2000 and December 2015 and was based on a combination keyword search in three databases namely; Science Direct, Taylor and Francis Online, and Emerald and in Google. Thirty-one quantitative and mixed methods research were justified to be relevant in this study. The study revealed that empirical studies have identified various important drivers for ERM implementation namely; legal and regulatory compliance requirements, non-mandatory reports, credits rating agencies' requirements, reduced earnings volatility, reduced cost and losses, increased profitability and earnings. The study further revealed that lack of support from top management, management priorities, reluctance to discuss sensitive information, difficulties in quantifying the risks, lack of common risk language, lack of quality data and limited access to data were key obstacles to ERM. The identification of the obstacles enables the management to be clear about the challenges encountered by the ERM program and take corrective actions to reduce their undesirable effect. Furthermore, construction firms can use the drivers and obstacles revealed in this treatise to prepare their customized list of drivers and obstacles. The findings of this study contribute to global knowledge relating to ERM and allow the management to overcome the challenges posed by the significant obstacles.

**Keyword:** Construction firms, drivers, Enterprise Risk Management (ERM), obstacles



## DETERMINANTS PREDICTING CREDIT ACCESSIBILITY WITHIN SMALL AND MEDIUM-SIZED ENTERPRISES IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

**Olanrewaju Abdul Balogun**

*University of Johannesburg, Johannesburg, South Africa*

**Justus Ngala Agumba**

*University of Johannesburg, Johannesburg, South Africa*

**Nazeem Ansary**

*University of Johannesburg, Johannesburg, South Africa*

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The contribution of Small and Medium-sized Enterprise (SME) sector in economic development, job creation and income generation has been recognized worldwide. These contributions are effectively articulated in South Africa construction industry discourse. However, the main problem limiting the SMEs sector to contribute fully in the mainstream economy is the shortage of finance. This study examines the impact of firm characteristics in access to credit by the South African SMEs in the construction industry. A deductive methodological approach was used to examine this problem. This paper utilises a combination of primary data emanating from structured survey questionnaires supplemented by secondary source of data from an extensive literature review, in order to present insightful commentary about credit accessibility within SMEs in South Africa. The structured survey questionnaire was administered to 179 construction small and medium organizations to elicit relevant data about their credit accessibility. Binary logistic regression was applied to determine the influence of demographic variables on credit accessibility. The equation specified access to credit as dependent variable while firm and personnel characteristics as independent variable. The statistical package for social science version 22 was used. The results indicate that firm characteristics influence access to finance. The study recommends that South Africa SME contractors should maintain attractive firm attributes to stimulate lenders to extend finance to their investments.

**Keywords:** Accessibility, characteristics, construction, credit, firm, small and medium

## A REAL OPTION MODEL TO EVALUATE INVESTMENTS IN COMBINED HEAT AND POWER (CHP) PROJECTS

**Farzad Abdi Nian**

*Construction Engineering and Management, Department of Civil Engineering,  
Sharif University of Technology, Tehran, Iran*

**Hamed Kashani**

*Construction Engineering and Management, Department of Civil Engineering,  
Sharif University of Technology, Tehran, Iran*

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Cogeneration technologies such as Combined Heat and Power (CHP) have promising features for providing the electrical energy that various industries require while reducing emissions and other environmental impacts of these industries. Investments in CHP systems require substantial implementation costs followed by a relatively long period of recovering the invested capital through savings in utilities bills. Appropriate timing of CHP system investments can reduce capital expenses and enhance returns on investments. An appropriate investment valuation method is needed to identify the appropriate time to implement a given CHP system and to find the values of properly scheduled investments. Real options analysis provides the ability to deal with investment timing under uncertainty. Existing real options models have several limitations when it comes to decision making about investments in CHP systems. In this research, some the theoretical limitations of current real options models are overcome. A new real options model to evaluate investment options for CHP systems under uncertainty is created. This model is tailored to the context of investment decision making for cogeneration technologies including CHP systems. The primary contribution of this research to the body of knowledge is the application of a method to estimate the volatility of CHP investments subject to uncertainty; and an investment valuation approach to identifying the best time to implement CHP systems and to determine the investment value. It is expected that this work will contribute to the state of practice by presenting a new valuation tool that help in making hard investment decisions and will therefore increase the likelihood of achieving global sustainability goals.

**Keywords:** Combined Heat and Power (CHP), flexibility, investment evaluation, Real Option Analysis (ROA), uncertainty



## REAL OPTION APPLICATION IN ENERGY PERFORMANCE CONTRACTS

**Farnaz Khaghani**

*Sharif University of Technology, Tehran, Iran*

**Hamed Kashani**

*Sharif University of Technology, Tehran, Iran*

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Energy Performance Contracts (EPCs) are mainly designed to facilitate energy saving and greenhouse gas emission reduction. Despite their numerous benefits, EPCs have not been utilized to their full potential. A variety of factors hinder the adoption of EPCs including long time investment, uncertain market, technology and credit and performance risks. These barriers discourage stakeholders and parties to invest in energy sector. Owners and Energy Service Companies (ESCOs) can overcome the barriers to adoption of EPC by making adjustments to current EPC schemes. Flexible design of the contract enables managers and parties of the EPCs to adapt project to circumstances that develop. Improvement on EPC schemes is essential to achieve the success in implementing EPC contracts. Research is needed in order to identify and evaluate various approaches to improve current EPC schemes. This study proposes the incorporation of real options in order to enhance the flexibility in EPCs and thus, encourage ESCOs and investors to participate in energy efficiency and saving endeavors. The real options approach incorporates a learning model, such that management makes better and more informed strategic decisions when some levels of uncertainty are resolved through the passage of time. This study focuses on two conventional types of EPCs, Guaranteed Saving (GS) and Shared Saving (SS). As part of this study, option to expand that can be incorporated in EPCs is identified. In addition, the opportunity to embed this option in two main contract types is explored. Various scenarios are considered, and the challenges and benefits of incorporating each option are evaluated. The findings of this study enhance the understanding about the possibility of incorporating real options into EPC contracts in order to increase the investment value for various projects stakeholders.

**Keywords:** Sustainability, real option, Energy Performance Contract (EPC), flexibility, energy efficiency



## **HUMAN RESOURCE MANAGEMENT PRACTICES IN QUANTITY SURVEYING FIRMS**

**Ayodeji E. Oke**

*Federal University of Technology Akure, Nigeria*

**Clinton O. Aigbavboa**

*University of Johannesburg, Auckland Park, South Africa*

**Oamen M. Odia**

*Federal University of Technology Akure, Nigeria*

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It is vital for organizations to carefully design and implement the right mix of Human Resource Management (HRM) practices to achieve the desired result in terms of productivity and performance among members of staff. Literatures point to the fact that failure to understand and meet what staff expect and require from the organization will lead to deterioration in commitment and loyalty, stress, lack of motivated workforce and eventually, low productivity. This study therefore examined HRM practices in Nigerian quantity surveying firms. Various HRM practices in quantity surveying firms were assessed, taking a look specifically at staff strength, staff welfare, staff training, staff mentoring and succession. A total of 44 questionnaires were administered on quantity surveying firms in Lagos state, Nigeria using convenient sampling method. The study revealed that firms are not giving staff welfare and mentoring the expected attention, while the level of staff training is below average. It was recommended that quantity surveying firms should ensure proper recruitment and selection process, improve staff training, staff welfare, a strong/stable/increasing staff strength, staff mentoring and succession in order to enhance productivity and performance of the firms. There is therefore a need for quantity surveying firms to be active in the management of their human resources, as this will enhance their innovation and competitiveness in both local and international market.

**Keywords:** Human Resource Management (HRM), mentoring, Nigeria, quantity surveying firms, quantity surveyors





# **SUSTAINABLE CONSTRUCTION**

**14:15 MONDAY, JUNE 27, 2016**



## **PASSIVE HOUSE PERFORMANCE STANDARDS AND CLIMATE CONSIDERATIONS**

**J. Mark Taylor**

*Auburn University, Auburn, AL, USA*

**Kelli A. Polzin**

*Auburn University, Auburn, AL, USA*

**Scott W. Kramer**

*Auburn University, Auburn, AL, USA*

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Optimizing energy performance of buildings requires a multi-disciplinary team approach to integrating architecture with the systems that condition the environment inside the building. The popularized passive house design criteria have provided a road map to achieving lower energy use in buildings for almost two decades in Germany and for nearly a decade in the United States. Passive House standards have been formally utilized and documented in certification of buildings and informs the design of low-energy buildings through the use of scientific analysis of weather and climate data along with solar exposure of the site to inform the building's site orientation, shape, and envelope level of insulation and glazing to drive requirements for energy and electricity lower in buildings. There has been criticism in the past however, that the standards for passive houses were developed without regard to extreme climate conditions outside of temperate climate typically found in Germany. In recent years, with a wide variety of climate zones represented in the United States, the Passive House Institute of the United States (PHIUS) formed a Technical Committee in conjunction with Department of Energy (DOE) to study climate zones in relation to the established standards and propose variations appropriate for those locations that are better suited for optimized energy performance. The acknowledgement and study of Passive House Standards and climate zone application by the PHIUS Technical Committee and the DOE is a step in the right direction for inspiring design teams and owners in other regions to pursue nearly net zero and net zero designs.

**Keywords:** Passive house, energy efficiency, superinsulation, building envelope, airtightness, climate



## **A RISK ASSESSMENT AND MANAGEMENT METHODOLOGY FOR THE IMPROVEMENT OF SAFETY AND PROTECTION OF AMMUNITION AND EXPLOSIVE FACILITIES**

**Sima Michal Elkabets**

*Department of Structural Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

**Igal M. Shohet**

*Department of Structural Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

**D. Ornai**

*Department of Structural Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

**R. Levy**

*Department of Structural Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

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Ammunition and Explosive (A&E) facilities are inherently prone to high hazard potential because of internal accidental explosion that can lead to tremendous and irreversible consequences to life and property. This research introduces the development and the implementation of a comprehensive risk analysis model for a typical A&E facility subjected to accidental explosion. The risk analysis model incorporates blast-response models and a Benefit-to-Cost-Ratio (BCR) analysis that assesses the economic benefits of the alternative protective solutions across the expectancy of casualty, the direct and indirect economic losses. The model consists of four phases: (1) scenario analysis – six different scenarios were developed and analyzed as follows: Three TNT charges at the weight of 1, 10, and 50 Kgs were detonated, each at two positions: (I) Spherical charge, at one meter above the floor surface; and (II) Hemispherical charge at the floor level. The blast waves arises from the examined scenario were simulated and analyzed by BLASTX software for two cases: typical A&E building with or without openings. (2) Pressure impulse diagrams analysis – the assessment of personnel harmed at different levels of severity (body and lung damage); (3) Risk Analysis and (4) Benefit-to-Cost-Ratio-Analysis (BCRA) for the examination of the economic feasibility of several alternative protective solutions such as: addition of steel plates to exterior walls and interior partitions, polymer sheets, or reinforced concrete (RC) internal partitions. Based on the literature review, the annual probability of an accidental explosion in A&E facilities was assumed to be  $4.7 \times 10^{-3}$ - $4.7 \times 10^{-2}$ . The BCR ratios of all the suggested alternative protective solution ns were found to be between 1.25 (1 Kg - opened openings A&E building) and 14.75 (50 Kg - opened openings A&E building). The risk analysis reveals that all protective solutions examined are highly effective in terms of expectancy of risk. It is recommended that the Safety regulations of A&E facilities be upgraded in light of the current research.

**Keywords:** Accidental explosion, ammunition and explosive facilities, pressure-impulse diagrams, risk

## **REDUCING OPERATIONAL COSTS FOR INHERITED BUILDINGS: CASE STUDY OF A WOMEN'S SHELTER AT THE END OF ITS LIFE CYCLE**

**Keith A. Rahn**

*Auburn University, Auburn, AL, USA*

**Kasie Elston**

*Auburn University, Auburn, AL, USA*

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Obstacles faced when utilizing adaptive reuse for an old building located in a poverty-stricken high-crime area are numerous. This study evaluates the effectiveness of adaptive reuse and recommends best practices for facility operation and maintenance. To evaluate the effectiveness of adaptive reuse in the case of a women's shelter, the investigators used five data collection methods: literature review, building assessment, resident surveys, staff interviews and utility record analysis. This research revealed that the shelter did not choose the most effective facility to adapt and reuse for their growing needs. The facility meets the basic necessities of the shelter; however, sustainability of this adaptive reuse effort remains poor. High utility costs, excessive repairs, and several opportunities for heat loss in the building have severely reduced operational efficiency and prevented optimal use of funding to benefit women in need. Structure analysis combined with expected need would better serve those embarking on a project to effectively utilize a preexisting building to its optimal potential rather than building new to exact specifications.

**Keywords:** Adaptive reuse, construction, cost, operational cost, sustainability



## DERIVATION OF SEISMIC RISK FUNCTION FOR CRITICAL INFRASTRUCTURES

**Alon Urlainis**

*Department of Structural Engineering Ben-Gurion University of the Negev,  
Beer Sheva, Israel*

**Igal M. Shohet**

*Department of Structural Engineering Ben-Gurion University of the Negev,  
Beer Sheva, Israel*

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Critical infrastructures importance to the society and the economy is constantly rising due to the increasing dependency of the private and public sector on the services they provide. Critical infrastructures are complex and interdependent systems; thus, damage to one component in the system can lead to a total failure of the CI and consequently lead to disruptions of other CIs. Therefore, there is an utmost importance to ensure reliable performance of critical infrastructures on a continuous basis and particularly after the occurrence of earthquakes. With the understanding that it is unfeasible (economically or physically) to ensure full robustness of the system for all possible scenarios, decision makers are required to plan the upgrade of the systems accordingly to the most efficient strategies and corresponding to the economic limitations.

In this study, a methodology is developed to appraise the risk that CIs are exposed in case of earthquakes and to act as a decision support tool for decision makers to manage efficiently the courses of action to mitigate this risk. In this methodology, Probabilistic Seismic Hazard Analysis (PSHA) approach is used in order to reflect a variety of possible seismic scenarios and overcome the uncertainties regarding to the timing, the location, and the magnitude of an earthquake. The seismic vulnerability of the component is evaluated by fragility curves and Fault-Tree-Analysis.

The seismic risk function of the system is derived by an aggregation of the occurrence probabilities of the earthquake, seismic vulnerability of the different components, and the expected consequences. The derived risk function expresses the expected risk of the system for a given ground motion intensities that reflect different possible earthquake scenarios. Using this methodology, different mitigation strategies can be examined and prioritized accordingly to their contribution to the risk reduction and relatively to each strategy cost.

**Keywords:** Critical infrastructures, earthquakes, fragility curves, risk assessment



## THE USE OF RECLAIMED RAIN WATER IN U.S. CITIES AND USACE INSTALLATIONS

**Ulysses L. Gracia**

*Auburn University, Auburn, AL, USA*

**Scott W. Kramer**

*Auburn University, Auburn, AL, USA*

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Currently many locations in the United States and throughout the world are facing significant water shortages resulting from climate change, drought, reduced surface aquifer levels, and competing regional requirements for agriculture, municipal consumption, energy production, and environmental requirements. For the U.S. military and the U.S. Army Corp of Engineer (USACE) installations, potential mission shifting or increased growth may be strongly impacted by water restrictions or water unavailability. In many ways, water sustainment at military installations is both a security and sustainability issue. Rainwater harvesting is specifically called out as an approach to meet Army requirements for Low Impact Development as related to storm water. On February 19, 2015, President Obama issued Executive Order 13514 on *Federal Leadership in Environmental, Energy, and Economic Performance*, which sets sustainability goals for Federal agencies and focuses on making improvements in their environmental, energy and economic performance. This paper describes several rainwater collection systems used in various communities. In addition, brief case studies are presented describing rainwater harvesting use at several USACE installations.

**Keywords:** Rainwater harvesting, reclaimed rainwater, USACE





**AUTOMATION AND ROBOTICS  
IN CONSTRUCTION**

**14:15 MONDAY, JUNE 27, 2016**



## INFORMATION AND COMMUNICATIONS TECHNOLOGY IN CONSTRUCTION: A PROPOSAL FOR PRODUCTION CONTROL

**Pablo Orihuela**

*Pontificia Universidad Católica del Perú, Lima, Peru; Motiva S.A., Lima, Peru*

**Jorge Orihuela**

*Motiva S.A., Lima, Peru*

**Santiago Pacheco**

*Motiva S.A., Lima, Peru*

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It is very easy to verify that production information systems in construction works are still based on telephone, written media and intensive use of email; likewise, tracking and monitoring are carried out by taking isolated work samples of certain activities, which often give us a local view instead of a global view of productivity, leading to erroneous diagnosis and decision-making.

This paper presents a proposal of a system and technology for production control in construction that promote the commitment of the workers themselves, who draw up their self-reports using electronic devices and web applications that permit a simple and user-friendly data collection from their worksite. Additionally, the proposal includes processing information in the web that facilitates an easy and unlimited access for all the stakeholders of the project, wherever they are in their own computers, tablets or smart phones.

Having this information available, we can keep a productivity effective control, so we can have access to highly specific levels of production. Therefore, we can find out the root causes of both losses and savings in each construction process, providing the necessary support for a good feedback and the corresponding corrective measures.

In light of the results obtained in this trial stage, we believe that the system proposed will improve the production control level in construction works and make it technological and automated, thus improving the quality and productivity of works, and achieving a holistic conception of construction, with an active participation of all stakeholders throughout its execution.

**Keywords:** Automation, information systems in construction, ICT in construction, mobile devices, production control



## APPLICATION OF UAS FOR NUCLEAR PLANT CONTAINMENT BUILDING INSPECTION: LESSONS LEARNED FROM TESTING THE FIRST APPLICATION

**Javier Eduardo Arenas Bermudez**

*Department of Construction Science, Texas A&M University, TAMU, College Station,  
USA*

**Julian Kang**

*Department of Construction Science, Texas A&M University, TAMU, College Station,  
USA*

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Inspection of cracks on the surface of tall concrete structures, including nuclear power plant containment buildings, often starts with visual monitoring, for which field crews need to climb up those cylindrical structures. In many cases, this practice takes time, cost significantly, and is dangerous. Korean Electric Power Corporation (KEPCO) has experienced this challenge for years while maintaining their nuclear power plants. Seeing how small Unmanned Aerial Systems (sUAS) are used for crop and livestock monitoring, one may be wondering if sUAS could be used to take pictures of cracks on the surface of the containment building. However, assuming that pictures need to be taken at a very close distance from the surface of the containment building, and also knowing that the line of sight has to be maintained all the time between sUAS and radio controller, one can reasonably figure out some challenges in terms of controlling sUAS manually. As a first step to handle this challenge, a research team at Texas A&M University developed a computer application that controls sUAS to fly around a simple circular building autonomously while changing its elevations. This paper presents how this application works, and what we learned from our field test.

**Keywords:** Concrete crack monitoring, unmanned aerial system, waypoint flight control

## **ONTOLOGY-BASED EMERGENCY PLAN MANAGEMENT OF METRO OPERATION AND ITS APPLICATION IN STAFF TRAINING**

**Hanbin Luo**

*Huazhong University of Science and Technology, Wuhan, P.R. China*

**Xiaofan Peng**

*Huazhong University of Science and Technology, Wuhan, P.R. China*

**Botao Zhong**

*Huazhong University of Science and Technology, Wuhan, P.R. China*

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Emergency plans play a key role in the emergency management of metro operation. Well-prepared emergency response supported by plans can greatly mitigate the significant impact of metro incidents. However, most emergency plans remain as plain-text documents, which make it difficult to conduct efficient administrative work such as plan creation, preservation and maintenance. Operational use of plans such as rapid knowledge retrieval and acquisition can't be performed as well, affecting emergency training during preparation process as well as plan review at the scene of the accident. Additionally, the knowledge coded in emergency plans are mostly depicted by texts, which are not vivid and intuitive enough to clearly display the instructions of response procedures and relative information. In this paper, an ontology-based knowledge modeling method has been proposed to improve the knowledge management efficiency, and a unified and formalized knowledge repository of plans can be built based on it to facilitate the efficient administrative and operational use of emergency plans. BIM technology has been introduced to provide a realistic visualization of the plan knowledge for better understanding. A prototype of emergency plan training system for metro staffs, which integrates BIM and the ontology-based knowledge repository, has been developed to demonstrate the feasibility and effectiveness of the method. A case study has illustrated the knowledge management process and shown how staff training can benefit from the system.

**Keywords:** Emergency plan, metro operation, ontology, training system



## **A SUITABILITY ANALYSIS OF PRECAST COMPONENTS FOR STANDARDIZED BRIDGE CONSTRUCTION IN THE UNITED KINGDOM**

**Min-Koo Kim**

*University of Cambridge, Cambridge, UK*

**Scott McGovern**

*Laing O'Rourke, Crossways Dartford, UK*

**Michael Belsky**

*University of Cambridge, Cambridge, UK*

**Campbell Middleton**

*University of Cambridge, Cambridge, UK*

**Ioannis Brilakis**

*University of Cambridge, Cambridge, UK*

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This paper analyses the suitability of precast components for standardised UK bridges. The conventional design and construction of UK bridges is often criticised for being inefficient and unsafe as the majority of the work is carried out on-site, which requires lots of time and temporary works. The concept of Design for Manufacture and Assembly (DfMA) is employed in this study to overcome the limitations of current bridge construction practice and to realize standardization of bridge construction in the UK. First, underlying DfMA criteria for bridge construction are identified and a suitability analysis of precast components based on the identified DfMA criteria is conducted via an interview and survey. Second, a case study on a bridge recently built for a highway bridge project is conducted to identify the feasibility of the potential precast components selected from the suitability analysis. The result of the case study demonstrates that the recommended precast components can be successfully used for future standardised bridges of the UK.

**Keywords:** Design for manufacture and assembly, precast components, standardised bridges, suitability analysis





# **CREATIVE MANAGEMENT**

**16:00 MONDAY, JUNE 27, 2016**



## **FOREIGN MARKET ENTRY: AN ANALYSIS OF BARRIERS AND MARKET ENTRY MODES ADOPTED BY PAKISTANI CONTRACTORS**

**Ahsen Maqsoom**

*COMSATS Institute of Information Technology, Wah Cantt, Pakistan*

**Adil Quddos Khan**

*COMSATS Institute of Information Technology, Wah Cantt, Pakistan*

**Usman Ali**

*Summit Bank, Attock, Pakistan*

**Faisal Mehmood**

*Wah HONDA Center, Wah Cantt, Pakistan*

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The construction industry plays critical role in the economic opulence of any country. Though developed country contractors occupy major share in the international markets, a number of developing country contractors are increasing expanding their overseas operations. There has been very little variety of work regarding the international market entry modes adopted by these contractors and barriers faced by them while expanding overseas. The aim of this paper is to explore the markets ventured by Pakistani international contractors and to analyze the market entry modes and critical external and internal barriers faced by these contractors. The data was collected by using questionnaire survey method. The findings of the study showed that the surveyed contractors have major presence in UAE and Saudi Arabia. Also, it shows that inaccessible market information is identified as critical external barriers, whereas start-up cost and communication issues are identified as internal critical barriers faced by these contractors. Furthermore, study shows that the two important market entry modes adopted by Pakistani contractors for expanding overseas are Subcontracting and Joint Venture.

**Keywords:** Internationalization, barriers, market entry modes, contractors, developing country



## MENTORING ON RETENTION OF EMPLOYEES IN THE CONSTRUCTION SECTOR: A LITERATURE REVIEW

**Morena William Nkomo**

*University of Johannesburg, Doornfontein, Johannesburg, South Africa*

**Wellington Didibhuku Thwala**

*University of Johannesburg, Doornfontein, Johannesburg, South Africa*

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The business world has long known and relied upon mentoring a proven technique for developing talent, mentoring is experiencing resurgence because business leaders not only recognize the benefits of transferring knowledge among employees. Organizations today face a challenge regarding the mentoring and retention of key knowledge employees. Few articles on mentoring, retention have appeared in the human resource development (HRD) literature. Changing workforce demographics, more competitive recruiting and faster turnover among young employees are creating unprecedented knowledge retention problems in many industries, threatening to reduce the capacity for innovation, growth and operational efficiency. The article aim to look at the experiences and problems contributing to retention of employees, examines practice on mentoring through the lens of HRD within construction companies. Describes better practices organizations can use to address the threat of lost knowledge caused by changing workforce demographics. Study adopted a literature review method of data collection, with a special focus on mentoring. The data in the report was mainly qualitative, based on content analysis, and historical data. The study indicated knowledge transfer assists employees in improving their skill sets which increases their marketability and potential for them to pursue career opportunities. The study provide useful lessons for the construction industry and stakeholders that knowledge retention and mentoring of employees are critical for sustaining future organizational performance, mentoring relationships assist organizations in promoting effective knowledge transfer and commitment that assist in the retention of key knowledge workers. The authors conclude with an agenda that identifies where researchers need to go with mentoring research and HRD to better inform the practice of mentoring in organizations and understand how mentoring relationships benefit organizations.

**Keywords:** Mentoring, employees, retention, skill, development

## IDENTIFYING SUCCESS FACTORS OF HEALTHCARE FACILITY CONSTRUCTION PROJECTS IN IRAN

**Reza Zandi Doulabi**

*Civil Engineering Department, Allaodoleh Institute of Higher Education, Garmsar, Iran*

**Ehsan Asnaashari**

*Civil Engineering Department, Allaodoleh Institute of Higher Education, Garmsar, Iran*

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Building of healthcare facilities are considered to be complex owing to uncertainty attached to the nature of these types of projects. Feasibility study through design and construction figured out that many intricate factors should be considered by project managers to make healthcare projects successful. Multiple building components and systems, diverse stakeholders' needs, progressive healthcare technology, specialized functions, different financing methods, and particular building codes and regulation make managing of healthcare facility construction a challenging tasks for project managers. Therefore, understanding the criteria for successful delivery of these types of projects is critical for project managers. Although, evaluating success factors of general construction projects has attracted attentions in recent years, no research has addressed specific nature of healthcare construction projects. This paper aims to identify success factors of healthcare facility projects by interviewing practitioners who have substantial experience in construction of health care facilities in Iran. The qualitative nature of the study gives an opportunity to experts to reveal their insights about projects success factors through open-ended interviews. The result can be used by project managers as a guideline to handle healthcare construction projects successfully

**Keywords:** Healthcare facilities, Healthcare Construction Projects, Iran, success factors



## **ATTITUDES OF OWNERS WHICH IMPEDES FIRM'S GROWTH: A CASE OF SMALL AND MEDIUM-SIZED CONSTRUCTION FIRMS IN GHANA**

**Bernard Martin Arthur-Aidoo**

*Department of Construction Management and Quantity Surveying, Faculty of Engineering and Built Environment, University of Johannesburg, Johannesburg, South Africa*

**Clinton O. Aigbavboa**

*Department of Construction Management and Quantity Surveying, Faculty of Engineering and Built Environment, University of Johannesburg, Johannesburg, South Africa*

**W. D. Thwala**

*Department of Construction Management and Quantity Surveying, Faculty of Engineering and Built Environment, University of Johannesburg, Johannesburg, South Africa*

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Owners of small and medium-sized construction firms are mainly classified as individual, group of people or institution ownership. Attitudes of owners who operate these firms do impact positively or negatively towards the growth of their businesses. This study sought to identify the specific attitudes of owners of construction small and medium size (SMEs) firms that impede growth. Interview with selected construction SMEs owners via snowball sampling was adopted in order to achieve the purpose of the study. Data was analyzed using descriptive analysis. The results suggested that majority of construction SME owners have an attitude of being profit oriented and do not concentrate on the growth of their firms. Also, negatively characterized owner attitudes such as anger, hatred, cynicism, inferiority, distrust, antagonism, resentment expressed towards personnel hinder growth of a firm. Further, the low level of educational qualification of owners has established attitudes that compel them to exhibit non-standardised managerial practices which result in poor human relations among employees thereby affecting firm's growth. An additional conclusion from the study indicates that attitudes of construction firm owners composed of three components namely cognitive component, affective/emotional component, and behavioral component.

**Keywords:** Attitudes, construction, growth, small and medium-size, firms

## **THE REBIRTH OF A HUNDRED-YEAR OLD PUBLIC PARK AND DEVELOPMENT OF A NEW MUSEUM DISTRICT: A PROJECT IT APPROACH**

**Zoltán Rostás**

*Department of Construction Technology and Management, Budapest University of  
Technology and Economics, Budapest, Hungary*

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Hungary's largest project is the development of a new museum district in the heart of Budapest, at the close proximity of Hero's square. Not only the magnitude of the project (around 1 billion Euro) but also the complexity, and the venue (the first public park of Europe), and the strict deadlines make this project extremely difficult. At the beginning of the project in 2015 the client has 10 employees now their number exceeds 50 and still growing. Adding to this figure the ever changing number of architects of the designing firms, and the consultants of different engineering companies more than 400 colleagues are working on this project at this moment. Handling the challenges regarding information exchange, decision making, etc. the client has developed a web based project management system called Project-Point that handles all the processes within the project, including public procurement, design tenders, documentation, project planning and controlling processes, change orders, contracts, etc. This system will be shown during the presentation.







**CREATIVE CONSTRUCTION  
TECHNOLOGY AND MATERIAL**

**16:00 MONDAY, JUNE 27, 2016**



## **A THEMATIC REVIEW OF MAIN RESEARCHES ON CONSTRUCTION EQUIPMENT OVER THE RECENT YEARS**

**Ilias Naskoudakis**

*Hellenic Open University, Patra, Greece*

**Kleopatra Petroutsatou**

*Laboratory of Construction Equipment and Management, Department of Civil Engineering, School of Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece*

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A considerable body of literature has been dedicated to research studies on construction equipment. Many topics have been discussed and analyzed with various conclusions being reported. However, research papers published in relation to construction equipment, are highly diversified and there is a lack of systematic analysis and classification. Hence, a complete understanding of the topic is not possible, nor is the assessment of any future research direction. A meta-analysis of the latest journal papers dedicated to construction machinery would not only delineate the different fields the academic research has been concentrated on, but it would additionally reveal potential gaps for future research.

In the current study, through a systematic review of the academic literature that has been published over the last decade primarily identified via online databases, main research themes such as optimization, maintenance/downtime, productivity, robotics and automation, operator's competence, innovation and environment are defined and discussed and future research directions are proffered. The outcome of this paper will facilitate future researchers to develop an appreciation of the progress on construction equipment and its potential functions and provide future research directions on this field.

**Keywords:** Construction equipment, optimization, productivity, maintenance, research



## DETERIORATION PATTERNS OF STONE CLADDINGS UNDER STANDARD CONDITIONS AND MARINE ENVIRONMENT

**Igal M. Shohet**

*Department of Structural Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel*

**Lorenzo Ciabocco**

*Department of Structural Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel*

**Irena (Rina) Wasserman**

*Department of Conservation of Sites and Monuments, Western Galilee College, Acre, Israel*

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Building facades are exposed to degradation processes because of the direct exposure to various environmental impacts. Severe service conditions such as marine environment can drastically accelerate the deterioration of stone cladding. The objectives of the study were, as follows: exploring the typical deterioration patterns of the exterior natural stone cladding implemented by wet and dry fixing and estimating the predicted service life (PSL), in course of the exposure of cladding to the impact of the standard and marine environments. Although the dry fixed method has recently become highly ubiquitous in the modern building practice, no studies have yet investigated the effect of fixing technique on the durability and service life expectancy of cladding. The research method is based on a systematic evaluation of the visual and physical performance of the components during their life cycle. 87 data points were collected and classified by a type of cladding and the service conditions. Regression analysis and prediction intervals were used for statistical analysis. The results clearly indicate that the type of fixing technique plays a crucial role in the rate of stone cladding decay in both standard and marine environment. The results have also integrated the data provided by material scientists and geologists on the mechanisms of stone deterioration, as a function of stone type, service conditions and the effect of the contact between stone and the Portland cement mortar. It could be obviously observed that the PSL of the dry-fixed stone cladding is ~ 1.3 – 1.6 time more than in case of the wet fixed technique, in both standard and marine environment, with the upper limit of 60 year service life of the dry-fixed cladding exposed to the standard service conditions. This study provides useful information for designers, construction and facility management decision-makers and for effective planning of preventive maintenance plans.

**Keywords:** Double skin facades, maintenance, marine environment, natural stone claddings, service life prediction

## INVESTIGATING THE EFFECTIVENESS OF BEACH FILL PROJECTS IN THE NORTHEAST REGION OF THE UNITED STATES

**Keith A. Rahn**

*Auburn University, Auburn, Alabama, USA*

**Megan M. McMullen**

*Auburn University, Auburn, Alabama, USA*

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The Atlantic coastline is constantly evolving with the persistent pressure of hurricanes and other coastal storm surges. Hurricane Sandy was the most recent hurricane to make landfall in the Northeast and although the eye of the storm was through New Jersey, the entire Atlantic coast from Maine to Florida was impacted. Sandy was the second costliest storm in US history with some damage estimates totaling as high as 75 billion dollars [1]. The storm also resulted in 233 direct and indirect fatalities [2]. This research study examines past hurricane and storm events that have led to the construction of beach fill projects in the northeastern region of the United States. A beach fill project consists of mechanically placed sand to fill a specified area known as a beach template. These massive mounds of sand create a physical barrier between the vulnerable structures on the shoreline and the Atlantic Ocean. The beach fills are designed to absorb and disperse the ocean wave energy in order to protect property from destruction and reduce the erosion of shorelines. These projects are designed and implemented by the US Army Corps of Engineers. Objectives of this study were to investigate the factors influencing the construction of these projects, identify the unique and challenging quality assurance process and identify the benefits and risks of beach fills to towns and states. This research specifically focuses on the town of Long Beach Island and the State of New Jersey. Through literature reviews, interviews and surveys there is strong evidence that beach fill projects are favorable to invested parties, they are attributed to protecting our coastal structures and coastal economies and the benefits far outweigh the risk.

**Keywords:** Beach fill, coastline, erosion, property, quality

## USE OF RECYCLED PLASTIC WATER BOTTLES IN CONCRETE BLOCKS

**Sina Safinia**

*Middle East College, KOM, Rusayl, Muscat, Oman*

**Amani Alkalbani**

*Middle East College, KOM, Rusayl, Muscat, Oman*

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The purpose of this study is to examine the possibility of using plastic bottles in concrete block. The plastic bottles were used to create voids at equal distance between them in the masonry units. Concrete was placed around each bottle to encase it in the masonry units. The study utilized 500-mL plastic bottles placed inside concrete masonry units and analyzed the compressive strength. The testing for compressive strength was determined according to the ASTM C140 standard. Results from this study were deemed reasonable due to the testing of concrete cylinders as a control of compressive strength for the concrete blocks from Oman's market. This study shows 57% improvement of strength by using plastic bottles compared to local concrete blocks. This proves the necessity for further research regarding concrete mix design, amount of cement and properties of local concrete blocks as well as other technical and non-technical aspects to determine the appropriate mix design and feasibility in the production industry.

**Keywords:** Compressive strength, concrete, plastic bottles, recycled materials

## IMPACT BASED DIAGNOSTIC APPROACH FOR MAINTENANCE MONITORING OF HISTORIC BUILDINGS

**István Vidovszky**

*Department of Construction Technology and Management, Budapest University of  
Technology and Economics, Budapest, Hungary*

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The traditional approach of structural health monitoring and building pathology is structure-based. The usual monitoring approach of property caretakers and facility management professionals is location-based. Both approaches have advantages and disadvantages in case of monitoring and maintaining heritage buildings. The spread of the application of BIM environment in the field of heritage monitoring and maintenance management predictable provides advantageous technical background for more complex diagnostic approaches. In this paper the impact-based diagnostic approach is introduced, which implies a more suitable way to prevent superposing decay problems in case of monitoring heritage buildings. The impact-based way of analyzing damage hazards and recording deterioration of historic buildings is an attempt to provide a method for maintenance professionals, which enables to detect errors faster and to connect the occurring damages and decay failures of different structures logically.

**Keywords:** Health diagnostics, building pathology, heritage monitoring, maintenance management, historic buildings







# **CREATIVE CONSTRUCTION TECHNOLOGY AND MATERIALS**

**16:00 MONDAY, JUNE 27, 2016**



## **EXPLORING A SIMPLE VISUALIZATION TOOL FOR IMPROVING CONCEPTUAL UNDERSTANDING OF CLASSICAL BEAM THEORY**

**Eivind Johnsen**

*Oslo and Akershus University College, Oslo, Norway*

**Magnus Nilsen**

*Oslo and Akershus University College, Oslo, Norway*

**Eilif Hjelseth**

*Oslo and Akershus University College, Oslo, Norway*

**Christoph Merschbrock**

*Oslo and Akershus University College, Oslo, Norway*

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First year students struggle to understand the concepts in introductory engineering physics courses. Computer generated visualizations have proven their value for improving learning in tertiary education. However, it remains often unclear how visualization software can be effectively deployed in classrooms to best improve learning outcomes. In this paper we put a freshly developed educational software entitled “The virtual beam demonstrator” to a first test in a physics and mechanics lecture at Oslo University College. The intention of this work was to explore how to get the balance between technology, pedagogics, and content knowledge right to best support student learning. We evaluated student learning outcomes of our initial attempt to use the software in a classroom based on a student evaluation form. While initial results are promising, we cannot claim to have significantly improved student learning in our initial attempt at using the software. The evaluations showed only slight improvement in conceptual understanding by the students. This finding was not unexpected as we anticipated that finding the right approach for putting this software to use would take several attempts. To turn failure into success, we would need a stronger emphasis on customized pedagogic methods. Relevant theory is explored and an approach based on “Interactive Lecture Demonstrations” is proposed.

**Keywords:** Classical beam theory, visualization, coherence, engineering education, interactive lecture demonstrations

## CLASSIFICATION OF “I” – SHAPED GLASS COLUMNS

### **András Jakab**

*Department of Construction Materials and Technologies, Budapest University of Technology and Economics, Budapest, Hungary*

### **Kinga Nehme**

*Department of Civil Engineering, University of Debrecen, Debrecen, Hungary*

### **Salem Georges Nehme**

*Department of Construction Materials and Technologies, Budapest University of Technology and Economics, Budapest, Hungary*

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The application of glass as a modern material in construction field is highly desirable in comparison with other materials such as wood, steel or the reinforced concrete due to aesthetic purposes. Hence there is a high demand of official standards that meet the industry requirements. Glass recommendations which define the function of the materials as a load bearing element are not available as other conventional materials but only some references in the literature. In the last years the properties of glass and the interlayer foil developed at a high rate. This development is not typical if we compare it conventional building materials. However, the glass designing demands are more sensitive in material and safety as well as in comparison with the other materials. Therefore, load bearing capacity, durability and the individual properties of glass must be examined in parallel sequence. More than 120 scaled-size specimens were loaded under compression to study the buckling behavior of glass columns with plane shaped cross-section at the BME, Department of Construction Materials and Technologies. During the tests, loading behavior and properties of the columns were under examination and analysis. The measured and calculated critical buckling forces, maximum forces and strengths were analyzed in function of slenderness. The glass specimens were classified into different groups based on the experimental results because classification is a primary issue at the designing phase. Authors provide aspects to the classification in the present article. Planeness of some specimens were measured to take into account their initial geometric imperfections for the classification. The rollers affect the shape of the glass table during the heat strengthening because waves are formed on the glass at the solidification moment of glass.

**Keywords:** Buckling, columns, glass, glass planeness, stability

## **RUTTING PREDICTION OF A REINFORCED COLD BITUMINOUS EMULSION MIXTURE USING FINITE ELEMENT MODELLING**

**Hayder Kamil Shanbara**

*Department of Civil Engineering, Faculty of Engineering and Technology, Liverpool John Moores University, Liverpool, UK; Al-Muthanna University, Iraq*

**Felicite Ruddock**

*Department of Civil Engineering, Faculty of Engineering and Technology, Liverpool John Moores University, Liverpool, UK*

**William Atherton**

*Department of Civil Engineering, Faculty of Engineering and Technology, Liverpool John Moores University, Liverpool, UK*

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A three-dimensional (3D) finite element (FE) model of a reinforced cold bituminous emulsion mixture (CBEM) was built in order to investigate the effect of static wheel load on rutting formation and flexible pavement response. This model has been developed to represent a four-layer pavement structure with elastic responses and to simulate the mechanical behaviour and pavement performance under static load condition. Also, it is focused on the prediction of the contribution of glass fibre (as a reinforcement material) in the surface course to develop the tensile and shear strength of flexible pavement. Preparation and validation of the model were carried out in the pavement laboratory using experimental data. In this research, finite element analyses have been conducted using ABAQUS software in which model dimensions, element types and meshing strategies are taken to achieve a desired degree of accuracy and convergence of the developed model. In addition, this developed model has been applied to CBEMs to investigate the effects of glass fibre on the performance of a reinforced pavement surface layer, as well as to study the effects of this fibre to minimize the vertical surface deflection, and horizontal and vertical displacements for the various courses. Finally, the FE model is capable of predicting surface damage to flexible pavement and its partial recovery after application of load. The results demonstrate the capability of the model in simulating the effect of fibre on vertical surface deflection (rutting), horizontal and vertical displacements in CBEM.

**Keywords:** ABAQUS, cold bitumen emulsion mixtures, rutting, three-dimensional finite element



## INVESTIGATION OF CONSTRUCTION STAKEHOLDERS' PERCEPTION ON THE EFFECTS & COST OF CONSTRUCTION DISPUTES IN SWAZILAND

**Nokulunga X. Mashwama**

*Department of Construction Management & Quantity Surveying, Faculty of Engineering & the Built Environment, University of Johannesburg, South Africa*

**Clinton Aigbavboa**

*Department of Construction Management & Quantity Surveying, Faculty of Engineering & the Built Environment, University of Johannesburg, South Africa*

**D. Thwala**

*Department of Construction Management & Quantity Surveying, Faculty of Engineering & the Built Environment, University of Johannesburg, South Africa*

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Construction Projects are often delivered under a complex and uncertain environment, with claims and conflict being an inevitable part. It is vital to manage claims and conflict as soon as possible before they turn into disputes. The intent of this paper is to investigate the effects and cost of construction dispute in construction projects in Swaziland. The data used in this study were derived from both primary and secondary sources. The secondary data for the study was derived from the review of literature. The primary data was obtained through the use of a questionnaire which was distributed to client (government), contractors and consultant representatives (quantity surveyor, civil engineer, architects, project managers and mechanical and electrical engineers), only organizations registered with the ministry of public work and transport in Swaziland and other professional bodies were surveyed. Findings enacting from the survey revealed that the major effects of construction disputes in Swaziland construction projects were loss of productivity, loss of company reputation, loss of business viability, loss of profitability. With respect to cost of disputes, the findings revealed that hidden cost; indirect cost; direct cost, were major factor for cost of disputes. The results of this study contribute to the body of knowledge and provide valuable insight to actual effects and cost of disputes in Swaziland construction projects, hence the effects are ugly. The study recommends that every stakeholder in the Swaziland construction industry familiarise themselves with the strategies of avoiding construction dispute to avoid the occurrence. Also the government must take up an initiative of educating all stakeholders about dispute avoidance, it would save the project and company fortunes.

**Keywords:** Cost of dispute, effects of dispute, Swaziland

## TESTING THE CONNECTION BETWEEN FIRE PROTECTION AND STATIC CAPACITY OF HIGH CONSTRUCTED DRY WALLS

**György Wiesner**

*Budapest University of Technology and Economics, Budapest, Hungary*

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Testing the connection between fire protection and static capacity of high constructed dry walls.

The standard fire protection test of the gypsum board drywall partitions which are higher than 3-4 meter and are installed with 0,6 mm thick steel profile, takes place in 3 m high. According to the fire protection test, the regulation allowed the partition construction of any height up to the tested fireproof limit value. The current fire protection testing method allows to extends the test result – in the aspect of the definition of the height of wall – only with limits, up to the tested model's height or rather under strictly defined conditions in modest rate. Today the definition of the height of wall strictly connected to the testing process of the fire protection capacity. The lecture is focusing on the analyses of the process, comparative tests, and expectable R+D directions.

**Keywords:** Dry construction, EN certificate, fire protection, gypsum board system, statics, standardization







**ABSTRACTS OF POSTER  
PRESENTATIONS**



**P-01**

## **AIR CONDITIONING DUCTS INSPECTION AND CLEANING USING TELEROBOTICS**

**Alexey Bulgakov**

*SouthWest State University, Kursk, Russia*

**Daher Sayfeddine**

*Khatib and Alami and Partners Consultant Architects and Engineers, Muscat, Oman*

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This paper focuses on the importance of having clean air conditioning duct and its influence on our lifestyle. Firstly, we study health norms and memorandums that emphasize on the hygiene factors and metrics in certain building and habitats then we analyze the possibility of using telerobotic solution in order to improve the cleaning process of the air ducts by automating the cleaning process, removing debris and dust. The telerobotic solution consists of a mobile robot based on BioVac systems, armed with manipulator and spray guns. The positioning of the BioVac robot is controlled using fuzzy logic algorithm.

**Keywords:** Duct cleaning, site management, telerobotics



P-02

## HI-DEPENDABLE WIRELESS MONITORING SOLUTION FOR FREIGHT MANAGEMENT IN UNDERGROUND WORK SITES

**Raquel García Luis**

*ACCIONA Infraestructuras, Alcobendas, Spain*

**Rafael Socorro**

*ACCIONA Infraestructuras, Alcobendas, Spain*

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Many of the measures taken in underground work sites are collected manually and with the constant intervention of operators and maintenance staff. This may lead, in some cases, to errors and/or planning delays and as a result, to an increase of the final work costs. In the case of railway equipment inside tunnels, mechanisms for monitoring and management are scarce and usually insufficient for proper operation and they become critical during indoors construction work.

Therefore, it is necessary the development of a system able to immediately detect any problem in the train or in the tunnel infrastructure, react quickly and mitigate effectively the possible consequences.

In this context, the European project DEWI (Dependable Embedded Wireless Infrastructure) provides key solutions for wireless seamless connectivity and interoperability in rail domain, among others: automotive, aeronautics and buildings. A “sensor & communication bubble” using wireless technology enables less expensive and more flexible maintenance and re-configuration.

ACCIONA Infraestructuras is implementing a prototype capable of managing freight trains at construction work sites, able to prevent disasters and accidents at building (or refurbishment) stage in large underground areas by considering everyday physical parameters of the trains and their loads. This will significantly contribute to decrease project costs, operation and maintenance of the equipment and facilities, as well as to the optimization of the operation of the rail machinery in terms of time. In this paper a first approach to solve the mentioned issues is presented.

Furthermore, the proposed solution shall be able to reduce the effort and time required for integrating WSN solutions and, railway safety-related and multipurpose systems, and to reduce maintenance costs of on-board WSN services.

DEWI project has been financed by the ARTEMIS Joint Undertaking and the respective National Public Authorities under the ARTEMIS Call 2013.

**Keywords:** Efficient resource and cost control, rail, safety and security, underground work sites, wireless sensor networks

**P-03**

## **GETTING FIRED MATERIAL WITH VITREOUS BINDER USING FRAME TECHNOLOGY**

**Vladimir Erofeev**

*Mordovia State University named after N.P. Ogarev, Saransk, Russia*

**Sergey Korotaev**

*Mordovia State University named after N.P. Ogarev, Saransk, Russia*

**Alexey Bulgakov**

*Southwest State University, Kursk, Russia*

**Ilia Tretiakov**

*Mordovia State University named after N.P. Ogarev, Saransk, Russia*

**Aleksandr Rodin**

*Mordovia State University named after N.P. Ogarev, Saransk, Russia*

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There is no chance to expand kiln materials properties and scope as such materials do not have any coarse aggregate in their composition. In this regard, we decided to develop a fired material with coarse aggregate. It is only possible to add coarse aggregate in a material composition when we get unshrinkable binder that has strong adhesion to the aggregate grains. In this article, we describe a method for producing such a binder of waterglass and sodium-lime-silica glass powder during firing semifinished product. We propose to use frame technology for molding the semifinished product – the binder components are used sequentially with the gluing the frame of the coarse aggregate in the form of waterglass and impregnation of the extracted hardened frame with the glass powder suspension. The frame technology provides a large pore structure of the material and reduces the amount of binder. The impregnation of the hardened frame and the firing of the semifinished product performed at 740 - 780 ° C without molds. By using the proposed technology, we obtained the fired material with coarse aggregate on unshrinkable porous vitreous binder. Physical and mechanical characteristics of the material allow to use it for manufacturing of insulating or structural-insulating products for building purposes in the form of blocks or slabs.

**Keywords:** Coarse aggregate, waterglass, soda-lime-silicate glass, roasting

**P-04**

## **MULTI-CRITERIA DECISION MAKING TOOL FOR TECHNOLOGICAL VARIANTS OF ROAD REHABILITATION**

**Vaclav Snížek**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

**Jiří Dobiáš**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

**Daniel Macek**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

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Following the current trend of increasing buildings density, both residential and industrial, the need to strengthen and improve transport and engineering infrastructure has become essential. Despite the fact that both construction and continuous road and transport network reconstruction are vital elements in meeting the sector's criteria, numerous bodies, whether it is a state or a regional government, face various obstacles in its implementation. Having said that, it is the aim of this paper to present a valid concept of the multi-criteria decision-making software application called OptiVote. This tool is able to recommend its users the most suitable method and technological option for flexible road rehabilitation project. The first part of this article introduces several calculation tools that allow to independently evaluate different methods of reconstruction. Those are the OptiRec family software tools, solving the traditional way of reconstruction (mill and replace) and the cold and hot recycling. Further on, a description of the wide range of technological alternatives for flexible road rehabilitation follows. The main part of this paper is devoted to a case study presenting a project implementation with three different rehabilitation technologies. Particular parameters such as the emission demands of each technology are being evaluated here by the OptiRec calculation tool. Those are the input data for the newly developed multi-criteria decision making tool OptiVote. Based on the selected criteria, user receives a clear recommendation, what method and technology to choose for a specific reconstruction. It is also possible to combine several user-selected criteria. For instance, price together with the environmental impact in proportion to the given recommendation or the user's choice.

**Keywords:** Multi-criteria tool, OptiRec, OptiVote, rehabilitation, road

**P-05**

## **EVALUATION OF MATURITY OF BIM TOOLS ACROSS DIFFERENT SOFTWARE PLATFORMS**

**Robert Bouška**

*Czech Technical University in Prague, Prague, Czech Republic*

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The paper is dealing with the evaluation of usability and readiness of information modelling tools on the most common operating systems (Windows, Linux, Mac OS X). Stages of BIM maturity and availability of building information modelling tools vary dramatically on these platforms. Products are often presented only through the lenses of marketing departments, which emphasize positives and do not indicate any shortcomings and incompleteness of their solutions. In some cases, BIM is just an empty marketing phrase. What is missing is a general and impartial comparison tool, which rates the degree of maturity and usability of these tools in practice. Paper compares the current software tools, especially in terms of usability in the building process. The list of attributes that mature software platform should accommodate was created. Evaluation criteria are determined based on specific needs of the various participants of the building process, which leads to the successful project completion and subsequent management of the lifecycle of the building. Results can help facilitate orientation in the field of available tools/methodologies and help the adaptation of BIM in the construction market.

**Keywords:** BIM, building information modeling, evaluation, software

P-06

## DETERMINATION OF COMBINED RATE OF OVERHEAD AND MARKUP IN BID PRICE

Li-Chung Chao

*National Kaohsiung First University of Science and Technology, Yanchao, Taiwan ROC*

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The bid price for a construction project comprises the contractor's estimated direct cost and overhead cost plus its applied markup. Contractors often use an all-in rate to lump overhead and markup together on top of direct cost for arriving at a bid price. Such a simple method is naturally prone to inaccuracy, if the applied rate is selected subjectively. Contractors often have to cut their bids to increase the chance of winning, which however also increases the risk of making a loss. Using a combined rate of overhead and markup in competitive bidding without a sound approach certainly involves a greater risk. The present research aims to develop an improved approach to determining the combined rate of overhead and markup in the bid price for a project. Four factors, i.e., direct cost, duration, type of work, and location, were used as inputs to build a regression model from cost and bid data of 182 projects for predicting the combined rate of overhead and markup in the winning bid for a project, which, together with the model error, is used to estimate the probability of winning for a bid level. Then, based on minimization of overall loss risk proposed by a previous research, the bid preventing over-cuts in price competition is determined by comparing various bid levels using the model, the probabilistic estimates of project cost, and the probability of recovering costs if losing the bid. The approach is illustrated using an example. Comparisons of the suggested bids for the cases with those from other models are made.

**Keywords:** Bid, markup, overhead, regression, risk



**P-07**

## **DECISION MAKING IN RECONSTRUCTION PHASE AFTER WAR**

**Sonia Ahmed**

*Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic*

**Petr Dlask**

*Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic*

**Stanislav Vitásek**

*Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic*

**Bassam Hasan**

*Department of Construction Engineering and Management, Faculty of Civil Engineering, Tishreen University, Lattakia, Syria*

**Madonna Besharah**

*Department of Construction Engineering and Management, Faculty of Civil Engineering, Tishreen University, Lattakia, Syria*

**Neil Eldin**

*University of Houston, College of Technology, Houston, USA*

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Most segments of Syrian society have been affected by the results of the current war, and perhaps the most important and serious result is the unbalanced demographic distribution of the population. Syria is concerned about how to put the integral strategy for the process of reconstruction of the totally and partly destroyed areas. This strategy will be realized by putting plans for the production of an integrated map, which includes an initial perception of all communities within small or medium residential cities, with all commercial, industrial, agricultural and tourist events, rather than regulatory and non-regulatory areas which currently have become destroyed and unfit for restoration and housing.

In the stage of the housing plan, researches were done in order to assess the reality of the construction of buildings in Syria, compared with the concepts of the industrial building system (IBS), to evaluate the factors affecting this industry, and proposals of applying it in the reconstruction stage. The results were as following: cast-in-place concrete in the case of the reinforced walls got 13.1%, while in the case of the framework structure it was 34%, and templates tunneling 64%, composite order (pre-cast and Cast-in-place concrete) 61%, composite order (concrete and metallic) 67.25%, and the pre-cast concrete from 82% up to 86%. This research has also arranged the priority use of technical systems in construction in Syria using the method of AHP (Analytic Hierarchy Process), the advanced technology system (pre-cast concrete) was in the first place with 39.4%, with knowledge that it faces significant challenges in spite of its inevitability as a strategic decision in finding solutions to the problems of housing and reconstruction.

**Keywords:** Construction industry, decision making, industrial building system IBS, modern building systems, war

**P-08**

## **INNOVATIVE METHOD FOR REAL ESTATE VALUATION USING DATA MINING SOFTWARE**

**Eduard Hromada**

*Czech Technical University in Prague, Faculty of Civil Engineering, Prague,  
Czech Republic*

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This paper presents an innovative method for real estate valuation. Currently, the most common method of real estate valuation relies on comparisons with similar structures, cost and yield analysis. The innovative method proposed in this paper, called “historical market price”, uses mathematics, statistical and database-founded algorithms for valuation. Input data comes from specialized software which systematically gathers, analyses and values data connected with real estate market development. Every six months the database expands by more than 650,000 price offers (advertisements) on purchase or rent of flats, houses, commercial buildings and allotments. This method can be used for valuation of real estate which was purchased previously if rough data is known about the original transaction (especially purchase price). The method suggested in this paper is grounded in true and exact information taken from the last purchase and identifies structural and technical differences in the condition of given real estate, as well as changes in price levels for the given location (street, neighborhood, city, region, etc.). Current valuation methods are not capable of taking into account these historical, yet exact and valuable pieces of information concerning real estate. Current valuation methods are based solely on current data and present state of the real estate market. This approach may be vulnerable to manipulation by either parties of the purchase contract.

**Keywords:** Data mining, property market value, software; statistics, valuation of properties

**P-09**

## **CONFLICT SCENARIO TYPOLOGIES IN A PUBLIC CONSTRUCTION PROJECT**

**Changjun Lee**

*Department of Civil and Environmental, Yonsei University in Seoul, South Korea*

**Jin Woo Won**

*Department of Civil and Environmental, Yonsei University in Seoul, South Korea*

**Woosik Jang**

*Department of Civil and Environmental, Yonsei University in Seoul, South Korea*

**Seung-Heon Han**

*Department of Civil and Environmental, Yonsei University in Seoul, South Korea*

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Conflicts have critical effects on cost and scheduling in public projects. Due to their complexity and larger scale, public projects frequently cause a high-level conflict that can lead to cancellation. Furthermore, because most of these projects are mega-projects, economic losses caused by the conflict can be enormous. Although investigations into the causes of conflict and resolution have been conducted, their findings have not been applied to conflict solution. This paper aims to establish a conflict scenario of projects based on the causes of conflict and to suggest a mitigation strategy. Representative public projects in which the conflict has peaked are studied, and the conflict scenario is classified by the causes of the conflict. While the aspect of conflict change can be readily identified, the conflict scenario has to be distinguished by the results of the conflict aspect. In this research, five types of conflict scenarios are defined in accordance with the results of completed projects, and characteristics of the scenarios are investigated. The characteristics can be a key factor in finding solutions for conflicts. This research is expected to assist project stakeholders in developing effective strategies for addressing possible conflict.

**Keywords:** Conflict, conflict management, conflict scenario, public project

**P-10**

## **POSSIBILITY OF USING VALUE ENGINEERING IN HIGHWAY PROJECTS**

**Renata Schneiderova Heralova**

*Czech Technical University in Prague, Faculty of Civil Engineering, Prague,  
Czech Republic*

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The paper deals with the possibility of using value engineering in highway projects. The reasons for criticizing highway projects are usually three. Firstly, they do not achieve expected project goals, secondly, project delivery is not within a reasonable amount of time, and finally, costs are not in line with their budget limits. The author believes that value engineering methodology can help to find ways to improve solutions to these problems by balancing cost, schedule, and scope through the generation of innovative alternatives. It was found that a project can significantly save on costs and improve performance of project functioning by using the appropriate value engineering process at the right time. The paper summarizes the benefits and effectiveness of the value engineering methodology along with recommendations.

**Keywords:** Cost, highway construction, public projects, value engineering (VE)

**P-11**

## **PROPOSAL FOR PRACTICAL APPLICATION OF A PROJECT RANKING CRITERIA**

**Zoltán Sebestyén**

*Budapest University of Technology and Economics, Budapest, Hungary*

**Tamás Tóth**

*Budapest University of Technology and Economics, Budapest, Hungary*

**Imre Szilágyi**

*MOL Hungarian Oil and Gas Plc, Budapest, Hungary*

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Project ranking is a common management tool in the business planning process for organizations that face various resource bottlenecks, which, in most cases, is the available capital expenditure (CAPEX). Should this situation occur, the management board of the company must prioritize the projects to select a portfolio that promises the maximum added value with respect to the given bottleneck. "Value", however, is not only considered in terms of money. One may also find minimally monetizable benefits that are in compliance with strategic statements, credibility, or organizational development. Thus, it is essential to carefully select the criteria of project ranking. After reviewing the management science literature, we concluded that setting up Financial, Strategic, Stakeholder and (organizational) Learning Criteria groups gives a more sophisticated solution for the project ranking exercise and can be recommended for business entities.

The definition of sub-criteria within the criteria groups above is, however, business specific. Our study takes the oil and gas exploration business as an example. The most critical phase of the exploration process is drilling for new fields because geologists usually bring about more opportunities than what is allowed by the available CAPEX. The sub-criteria discussed in our paper are therefore exploration-drilling specific but may orientate managers of other businesses when they attempt to define their own criteria system. The sub-criteria include profitability, risk diversification, upside potential, internal and external stakeholder, and various learning opportunity approaches.

In addition to criteria definitions, it is equally important to quantify the weights belonging to each ranking criteria. As the weights should reflect management preferences, a teamwork approach is recommended for the quantification. We also suggest application of the Analytic Hierarchy Process (AHP) methodology in the ranking exercise. Our paper concludes with a case study in this respect.

**Keywords:** Project ranking criteria, exploration specific criteria, application of analytic hierarchy process, project portfolio selection



**P-12**

## **A TWO-STAGE MODEL TO SUPPORT GO/NO-GO DECISION MAKING IN THE INTERNATIONAL CONSTRUCTION MARKET**

**Jin Woo Won**

*Department of Civil and Environmental Engineering, Yonsei University in Seoul,  
South Korea*

**Changjun Lee**

*Department of Civil and Environmental Engineering, Yonsei University in Seoul,  
South Korea*

**Woosik Jang**

*Department of Civil and Environmental Engineering, Yonsei University in Seoul,  
South Korea*

**Seung-Heon Han**

*Department of Civil and Environmental Engineering, Yonsei University in Seoul,  
South Korea*

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In recent years, many construction companies have attempted to expand their businesses into the overseas market. However, a number of them face difficulties in ensuring that their international construction projects are profitable, mainly because they don't have an in-depth knowledge of their company's capabilities and the likely risk level associated with projects. This study proposes a go/no-go decision support model for construction companies. The proposed model simultaneously considers the capabilities of a construction firm, the project risk level, and the firm's business philosophy or attitude. The creation of the model can be classified into two stages. Stage 1 includes two evaluation models, namely, a corporate competency assessment model and a project risk assessment model. These models are created by an artificial neural network (ANN), and the input and target values are derived from a questionnaire. Stage 2 is a fuzzy inference model whose aim is to support go/no-go decision making. These models have two linguistic input values; one is a net competency value derived from risk score and competency factors, and the other is the company's business philosophy, which indicates corporate management tendencies. It is expected that the proposed decision support model will support companies in identifying strategies that will facilitate project customization and profit objectives by utilizing the company's qualified capabilities, complying with their business philosophies, and outlining their risk factors.

**Keywords:** Fuzzy logic, artificial neural network, risk factors, competency factors

**P-13**

## **DISCUSSION ON A REFINEMENT POSSIBILITY OF EARNED VALUE MANAGEMENT**

**Zoltán Sebestyén**

*Budapest University of Technology and Economics, Budapest, Hungary*

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The scope of this article is to come round the topic how to keep a project on track properly with the fundamental parameters, and to provide an improved time-dependent solution for monitoring. Since the milestone reporting is poor to monitor the projects, a much more sophisticated system, the earned value management is proposed to be operated concurrently. The terminology is based on the recommendations of Project Management Institute, one of the most respected international project management organizations. An EVM control system identifies and evaluates the variances from original budget and control, also taking the progress into consideration. The method provides widely used performance indices. The evaluation of the project is based on the relative positions of earned value parameters. Recently, this method is criticized severely on its financial-oriented nature, which led to its unreliability in some specific cases. Several solutions are suggested to provide an extension to earned value management that surpasses these drawbacks. The paper explores new sides of EVM, and intends to introduce drawbacks that have not been discovered, and analyzed so far. Some further research directions of finding the possible solutions are discussed as well.

**Keywords:** Schedule performance index, cost performance index, planned value, actual value, earned value

**P-14**

## **MECHANICAL SAFETY AND SURVIVABILITY OF BUILDINGS AND BUILDING STRUCTURES UNDER DIFFERENT LOADING TYPES AND IMPACTS**

**Vladimir Travush**

*GOROPROEKT, Moscow, Russia*

**Sergey Emelianov**

*Southwest State University, Kursk, Russia*

**Vitaly Kolchunov**

*Southwest State University, Kursk, Russia*

**Alexey Bulgakov**

*Southwest State University, Kursk, Russia*

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Modern construction sites are characterized by rapid pace and complicated organization of work processes. One of the important problems of a construction site is the human safety. The paper contains a categorization of human hazards during construction activities and an analysis of main causes of accidents in buildings and at construction sites. Together with general definitions of safety the paper reviews some new research trends in the field of mechanical safety and structural survivability of buildings and structures under different loads and impacts, including regular and accidental types of loading. It is shown that updating of safety regulations should mean not only the clarification of new terminology adopted in building codes and regulations on structural safety, but also supplementation of the regulations with sufficiently justified and experimentally verified provisions that should regulate the safety of buildings and structures under design and beyond-design basis loads and actions.

**Keywords:** Construction site, human safety, mechanical safety of buildings, structural survivability



**P-15**

## **EVALUATION OF BRIDGES LIFE CYCLE COSTS**

**Daniel Macek**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

**Jiří Dobiáš**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

**Václav Snížek**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

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The paper presents the evaluation method for bridge alternatives assessment. The selection was chosen multicriteria decision making method, where not only criterion cost. Faculty of Civil Engineering deals with the life-cycle costs, and in this area offers a tool to assess the LCC for bridges. In addition, the principle of self-evaluation is further described in more detail above tool designed for skilled setting and evaluation of LCC. Furthermore, the presented method takes into consideration the Czech legislation: Act No. 137/2006 Sb - Public Procurement, specifically §78 - Evaluation Criteria, which states that the main selection criteria for all bids must be either the economic benefits of the proposed bid or the lowest bid cost. The above noted indicates that the LCC may be incorporated into such tendering as part of the economic benefits evaluation. In order to calculate the LCC it is essential to establish a transparent model, which will unambiguously evaluate the proposed bids from the cost-effectiveness point of view. This paper presents the application "Bridgepass", which incorporates pre-defined requirements for the calculation of the LCC, and offers pre-determined weighting criteria for evaluating the proposed solutions of bridges and estimating the overall value of each bid.

**Keywords:** Bridges, bridgepass, life cycle costs, evaluation, tender

**P-16**

## **ENHANCING FACILITY MANAGEMENT THROUGH BIM 6D**

**Aleksander K. Nicał**

*Warsaw University of Technology, Warsaw, Poland*

**Wojciech A. Wodyński**

*Heriot-Watt University, Edinburgh, Scotland, UK*

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BIM has been widely adopted by the construction sector, though Facility Management (FM) is still based on a variety of disparate FM systems. The operational phase requires comprehensive set of well-structured information regarding the building asset. Therefore, a BIM model filled with the multifarious information from the pre-use phase ought to be exploited through its integration with existing FM systems. This paper aims to appreciate the contribution of BIM in optimizing the processes conducted conventionally within the FM practice. The importance of sustained information flow for the efficient operational stage is a pre-requisite of the further discussion. The exploration of FM application areas for BIM-enabled processes is aimed to depict the potential of the BIM for FM concept. By elaborating on the existing challenges concerning the shift from traditional FM processes to new BIM-based approach the outstanding problems are realized. On these grounds advice is provided. The study focuses mainly on new investments, where information management must be sustained from the project inception until the current operational stage. The paper proves the potential of BIM for the optimization of FM practices, presenting a wide range of application areas followed by tangible benefits for the building performance across its life-cycle. Identified barriers are assumed to be mitigated by diligent implementation of provided recommendations. It is concluded that BIM-based FM processes have the potential to shed a new light not only on the FM sector itself but on the perception of the whole industry being based on the collaborative approach towards delivery of the intelligent facilities. Nevertheless, such results demand profound cultural changes within the construction sector, with the FM appreciation as a starting point.

**Keywords:** BIM-enabled processes, BIM 6D, facility management

**P-17**

## **THE INTEGRATION OF BIM IN LATER PROJECT LIFE CYCLE PHASES IN UNPREPARED ENVIRONMENT**

**Petr Matějka**

*Czech Technological University in Prague, Faculty of Civil Engineering, Department of Economics and Management in Civil Engineering, Prague, Czech Republic*

**Vít Kosina**

*Czech Technological University in Prague, Rectorate of CTU, Department of Construction and Investment, Prague, Czech Republic*

**Aleš Tomek**

*Czech Technological University in Prague, Faculty of Civil Engineering, Department of Economics and Management in Civil Engineering, Prague, Czech Republic*

**Radan Tomek**

*Czech Technological University in Prague, Faculty of Civil Engineering, Department of Economics and Management in Civil Engineering, Prague, Czech Republic*

**Vilém Berka**

*Czech Technological University in Prague, Faculty of Civil Engineering, Department of Economics and Management in Civil Engineering, Prague, Czech Republic*

**Dalibor Šulc**

*Československá Obchodní Banka, a.s. – Facility Management Department, Prague, Czech Republic*

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The article examines the topic of Building Information Modeling (BIM) from the perspective of the owner in an environment that was not prepared correctly for later BIM integration. The best way to utilize BIM is to use this tool from the beginning of a project, according to the concept of Integrated Project Delivery (IPD). But there are many projects, which started without the opportunity to implement BIM in the beginning. The question is, whether it is possible to utilize BIM in later project life cycle phases, especially during its operational phase, even when there is no proper BIM environment from preceding phases (i.e. no model, no BEP, no common environment etc.) The paper answers this question by explaining possible benefits of BIM in later project life cycle phases. Such benefits are especially: easier data transfer from BIM model to CAFM system, possible way to maintain live as-built documentation for future use from the beginning of any building related project and possible way of future utilization (i.e. prolongation of the moral age). The paper also presents three simple case studies of various projects in later project life cycle phases (*Building A of CTU in Prague, Faculty of Civil Engineering; Czech Institute of Informatics, Robotics and Cybernetics of CTU in Prague; SHQ of ČSOB*). The BIM model was utilized in these projects for various reasons. In the end of the article, lessons, which were learned during the process are presented and they are generalized for future use.



The most important findings were 1) facility management (FM) cooperation is mandatory for the project purpose, 2) it is very important to specify requirements for deliverables, 3) there is a great value in the experience from BIM utilization even in later project life cycle phases, and 4) when BIM is used as a tool, it might be successfully utilized even later on in the project and existence of the model might have other future advantages for the project.

**Keywords:** BIM, Building Information Modeling, facility management, project life cycle, operational phase

P-18

## SUBSTANTIATION OF DECISION MAKING PROCESSES IN CONSTRUCTION MANAGEMENT AND REAL ESTATE DEVELOPMENT

**Josef Zimmermann**

*Technische Universität München, München, Germany*

**Wolfgang Eber**

*Technische Universität München, München, Germany*

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Theories of how to support crucial decisions by optimizing weighted variables and aspects are widely known. The mathematical ground is well prepared and in no way distinguishable from hard-fact optimization. However, the transformation of soft factors into solid contributions to a virtual target function is mainly left to intuition. The fuzzy approach proposed by Zadeh during the seventies has turned out to be impractical and is recently more or less being ignored. Yet, methods of weighting soft factors based on different score systems, in fact directly derived from the Zadeh approach, are gaining ground. They are used e.g. in deciding for the complexity of planning tasks in Construction Management based on the HOAI as well as in analysis of procurement criteria, the definition of factors of success or in generally investigating network structures by means of cross-impact-analysis.

However, optimizing by the application of differential calculus and integrating difficult matters by simply translating advantages and disadvantages into virtual costs and profit, furthermore, the assignment of scores by more or less arbitrarily chosen curves seems a very inaccurate approach to proper judgement. Finally, so far resulting soft optima allow for no explicit evaluation and decision-making. Yet, this approach allows for analyzing the sensitivity of such a decision towards specific aspects and variables by backward modification, which is investigated in this article.

It turns out that backward analysis provides a much better access to the reasons and arguments for or against a specific decision and thus allows for well-reasoned judgement. In particular, the scope of proper application is demonstrated with BIM-Modeling based on multi-valued logics, including the meta-level modelling of control processes in Construction Management and Real Estate Development.

**Keywords:** Decision-making, control processes, procurement, factors of success, multi-valued-BIM-modeling



P-19

## A FRAMEWORK FOR AFFORDABLE HOUSING GOVERNANCE FOR THE NIGERIAN PROPERTY MARKET

**AbdulLateef Olanrewaju**

*Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, Kampar, Perak,  
Malaysia*

**Paul Anavhe**

*CDP Partnership, Kaduna North, Kaduna, Nigeria*

**Tey Kim Hai**

*Universiti Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, Kampar, Perak,  
Malaysia*

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Nigeria is perhaps facing the worst housing deficits in its existence with a homeownership of less than 20% and a housing shortage greater than 30 million. The deficits would lead to a crisis and consequently lead to poor standards of living, unaffordable house prices, high mortgage payments, abandonment, outbreak of diseases, dilapidation, and high maintenance costs. The main research from which this study forms part aims to develop housing governance. This current study aims to identify and the categorize factors accounting for the housing deficits. Based on a cross section survey questionnaire the findings lead to the conclusion that the problems in the housing industry can be explained by policies, regulations, legal issues, market, economic and the construction industry. The discussions and results have some significant implications to the governments. For now, the government has to play multiple roles of providing housing and that of a market enabler.

**Keywords:** Procurement, government, systems management, housing deficits, median income

**P-20**

## **MARKET ANALYSIS OF HOUSING SHORTAGES IN MALAYSIA**

**AbdulLateef Olanrewaju**

*Universiti Tunku Abdul Rahman, Kampar, Perak, Malaysia*

**Abdul Rashid Abdul Aziz**

*Universiti Sains Malaysia Pulau Pinang, Penang*

**Seong Yeow Tan**

*Universiti Tunku Abdul Rahman, Kampar, Perak, Malaysia*

**Lee Lim Tat**

*Universiti Tunku Abdul Rahman, Kampar, Perak, Malaysia*

**Naoto Mine**

*Universiti Tunku Abdul Rahman, Kampar, Perak, Malaysia*

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The cost of accommodation continues to increase despite various government measures in the form of taxes and subsidies. While the market is the most efficient way to allocate resources, to determine housing price, the capital market for housing have very weak mechanism that if left unregulated will be ineffective and inefficient, because the choice may not be the best for the society as a whole. This study is based on literature review and a case study. The case study involved one of the affordable housing schemes in Malaysia. The study demonstrates that to base affordable housing price on market prices are seriously deficient in that it ignore the basic essence of affordable housing provision. There is no real basis for economists' strongly held believe that house prices must be determined by the market to be efficient. The study shows that government can intervene in affordable housing market in various ways to increase homeownership rate.

**Keywords:** Tax, subsidy, market price, affordable housing, rent ceiling, social interest

**P-21**

## **SUCCESS FACTORS OF EXPORT FINANCING UNDER THE BUYER'S CREDIT SCHEME**

**Jan Pícha**

*Department of Construction Management and Economics, Faculty of Civil Engineering, Czech Technical University in Prague, Prague Czech Republic*

**Aleš Tomek**

*Department of Construction Management and Economics, Faculty of Civil Engineering, Czech Technical University in Prague, Prague, Czech Republic*

**Renáta Schneiderova Heralova**

*Department of Construction Management and Economics, Faculty of Civil Engineering, Czech Technical University in Prague, Prague, Czech Republic*

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Buyer's credit is a very useful mode of exporting in international construction especially in relation to extensive infrastructure projects. Large projects usually require substantial amounts of liquidity provided by banks. Importers seldom have enough own resources to cover the entire capital expenditures, while only few exporters have the capacity to provide credits to their buyers. The concept usually requires the participation of financial institutions on the exporter's as well as the importer's side. Many contractors still fail in their exporting attempts at the very beginning, due to the shortage of experience in this matter. Based on the literature review, foregoing research and exploratory interviews with trade finance specialists, the list of seven factors contributing to a successful project execution under the buyer's credit scheme was compiled. This research analyses and compares the perceptions of Czech and German export finance practitioners. Research findings were derived from their empirical evaluation collected through structured questionnaires. For the purposes of this research, quantitative methodology was adopted. The main objective of this study is to prioritize these factors, increase their understanding and provide a route map to exporters considering the application of this advanced financing scheme. The authors argue that there are only minor differences between the perceptions of Czech and German exporters.

**Keywords:** Buyer's credit, export financing, international construction, success factors



P-22

## IMPACT OF THE OPERATIONAL EXPENDITURES ON THE PUBLIC SECTOR PROCUREMENT PROCESS

Jiří Dobiáš

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

**Daniel Macek**

*Faculty of Civil Engineering, CTU in Prague, Prague, Czech Republic*

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Ever-changing needs in the built environment create new incentives for enhancements in the process of building design. Increasing prices of building operations and utilities have a profound impact on the conceptual design and implementation of sustainable architecture. The main aim of this paper is to present Life Cycle Cost Inspector (LCCI), which is a tool for assessing building design in regards to the whole asset life cycle and thus promoting sustainable solutions. LCCI is a quantitative comparator of the overall planned capital investment and the operational expenditures (OPEX) over a specific period of time. This method is based on dividing the selected project into separate components (e.g. heating, plumbing or ventilation) that have their own operational characteristics. Subsequently, projected cash flows are estimated over a chosen time period based on preferred criteria, square meters and a life span of each component. An additional feature of the comparator allows calculating vice versa, which means that the investment costs can be adjusted, based on the targeted operational performance of the asset, which could be directly specified.

As any other device, LCCI is based on a simple idea – to create a tool, which enables the owner to execute the present process more efficiently. Specifically, the main aim is to transform the given and limited resources into such product, which represents the highest value for money achieved, of course in regards to the process and human limitation.

The overall process of operational expenditures assessment and optimization of the capital costs indicates higher value for money achieved through sustainable architecture; and thus, advocates higher initial capital cost during the tendering process. Therefore, within this research, the traditionally perceived concept of the lowest cost selection is questioned and a new perception of value for money is introduced and applied within the quantitative comparator's environment.

**Keywords:** Capital expenditures, operational expenditures, public sector, value for money



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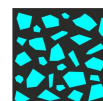
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