BIM & PROJECT COST MANAGEMENT – IMPLEMENTATION ISSUES & CREATIVE SOLUTIONS

Dr. Peter Smith
University of Technology Sydney, Sydney, Australia, peter.smith@uts.edu.au

Abstract

This paper examines the issues related to the implementation of Building Information Modeling (BIM) and Automated Quantities technologies by the Australian Quantity Surveying profession. The findings provide lessons learnt and solutions that are relevant to the project cost management field on a global scale.

Objectives of Study: The effective implementation and use of BIM and automated quantities remains a major issue for the QS profession in Australia as it does for the construction industry generally. The purpose of this study is to investigate the main barriers and problems facing firms and, conversely, to identify approaches that are being successfully used by firms that are leading the way in the field.

Methods: The methodology for this paper is based on a review of current industry trends and issues with BIM implementation, detailed interviews with quantity surveying firms in Australia to evaluate how the profession is dealing with BIM implementation and a case study of a quantity surveying at the forefront of BIM implementation.

Results: The interviews reveal that there are considerable implementation issues. The key problem relates to quality issues with BIM models – the industry requires high quality BIM models for all professionals to be able to use the model most effectively and, more importantly, trust the accuracy of the information and data that is being generated. Liability issues for incorrect information/data generated from the models were also highlighted as a major area that needs addressing. Nevertheless, an increasing number of firms are utilizing 5D BIM tools to dramatically improve the quality, efficiency and sophistication of their cost management services particularly at the front end of projects at the cost planning stage.

Conclusions: The paper concludes with a range of creative solutions and recommendations based on the case study results and other innovative approaches adopted by the interviewed firms.

Keywords: BIM, project cost management, 5D BIM.

1. INTRODUCTION

Building Information Modeling (BIM) and automated quantities technologies provide both enormous opportunities and challenges for the project cost management profession. As quantification increasingly becomes automated and BIM models develop the role of the project cost manager will need to adapt accordingly to provide more sophisticated cost management services that incorporate 4D time and 5D cost modelling and sharing cost information/data with the project team as part of the BIM integrated project delivery approach. The implementation of Building Information Modeling (BIM) on construction projects is gaining momentum around many parts of the globe. Whilst the technology underpinning BIM has been around for well over a decade BIM implementation and take-up has been relatively slow in the construction industry compared to industries such as manufacturing and engineering. This is starting to change as building proprietors and government entities increasingly become a driving force for the adoption of BIM by mandating its use on their projects and the technology and implementation issues continue to improve.

This paper will commence with a review of current BIM implementation trends and issues in the construction industry both within Australia and globally and will then focus on the issues for the quantity surveying profession in Australia. The latter will be based on detailed interviews with Australian Quantity Surveying firms. This will then be compared with a case study of innovative BIM approaches being used by a leading quantity surveying firm in the field.

2. LITERATURE REVIEW

2.1. Global BIM Implementation Trends

North America and the Scandinavian regions are generally regarded as the construction industry leaders in BIM development and implementation (Wong et al. 2009). McGraw Hill Construction (2013) found that BIM adoption by project team professionals in the North American industry had grown from 17% in 2007 to 71% in 2012 which demonstrates that BIM is now in the mainstream in the industry. This indicates that this region is leading the way on a global scale.

The Scandinavian region also has a strong BIM development and implementation track record. Government mandates for the use of BIM on government projects have provided further impetus in countries such as Finland, Norway, and Denmark. The Finnish Government have invested heavily in IT research in the construction industry since the 1970s (Granholm 2011). They recently released a Universal BIM Guide for the industry which is being heavily supported. The Finnish public sector is the key driver in BIM adoption with Senate Properties, a major government entity with a property asset portfolio of approximately 6 billion Euros, a major leader requiring BIM on their projects and undertaking many pilot and research projects. Across the industry BIM is used on 20-30% of government projects with predictions that this will increase in the near future to 50% (Koppinen & Henttinen 2012). In Denmark the Danish Enterprise and Construction Authority established a Digital Construction Program in 2007 that has been implemented by major government entities. The program requires that BIM is used on all projects over 5.5 million Euros with information exchanged using the Industry Foundation Class (IFC) format. A number of reports and guidelines have been produced to assist firms in meeting these requirements (Building Smart 2012). In Norway Statsbygg is the Norwegian government's construction and project management representative and requires the use of BIM on all public projects. The Norwegian government is a strong supporter of BIM and invests heavily in research and development (Granholm 2011).

Singapore is also emerging as a world leader in BIM implementation. The Singapore Building and Construction Authority (BCA) have developed a strategy to have BIM widely implemented on public projects by 2015 (Granholm 2011). The government has also established a Construction Productivity and Capability Fund (CPCF) of S$250 million with BIM a key target. In 2000 the Construction and Real Estate Network (CORENET) program was established as a strategic initiative to drive transformation in the industry through the use of information technology. CORENET provides the infrastructure for the exchange of information amongst all project participants. The CORENET e-Plan Check system for development applications is a further initiative to encourage the industry to use BIM. The system enables architects and engineers to check their BIM designed buildings for regulatory compliance through an online 'gateway'. Singapore has adopted the Industry Foundation Classes (IFC) as the standard for BIM implementation (Building Smart 2012).

In the United Kingdom the government has introduced a BIM implementation strategy for the UK construction industry that is considered by many to be the most ambitious and advanced centrally driven BIM implementation program in the world (HM Government 2012). The objective is to transform the UK industry into a global BIM leader in a relatively short space of time (Withers 2012). In May 2011 the UK Government Construction Strategy was published which detailed the government's intention to require BIM on all of its projects by 2016 through a 5 year staged implementation plan. BIM is seen as central to the government's objective in achieving a 20% saving in procurement costs (Cabinet Office 2011). This strategy has had a dramatic impact on the UK industry as firms scramble to develop the necessary technological capabilities to meet these requirements. This strategy has the potential to influence BIM implementation on a wider global scale as other countries take note of these developments.

2.2. BIM Implementation in Australia

In Australia BIM use in the construction industry is not currently widespread and there has not been any government mandates to use BIM on projects of any note. But the past five years has since interest in BIM adoption intensifying as a result of a number of initiatives to engage and inform project stakeholders about the potential productivity gains and gaining competitive advantage (CIBER 2012). These initiatives include the development of Australasian BIM guides such as the 'National BIM Guide' by the National Specification (NATSPEC), 'National Guidelines for Digital Modelling' by the Corporate Research Centre for Construction Innovation (CRC-CI), the 'Australian and New Zealand Revit Standards' (ANZRS) and the BIM-MEPAUS guidelines and models. The 'buildingSmart' organisation (previously called the International Alliance for Interoperability) continue to play a major leading role in BIM development and implementation in Australia that includes establishing an 'Open BIM Alliance of Australia' that involves an alliance with a number of software vendors to promote the concept of 'Open BIM' (CIBER 2012). Building Smart (2012) found that BIM implementation has accelerated markedly in Australia since 2008-09 due to a significant increase in the number of engineering firms adopting BIM thus facilitating multi-disciplinary BIM collaboration (as the larger architectural practices have been using BIM technologies since the late 1990s).

2.3. BIM Implementation Issues in Australia

BIM implementation issues in Australia are not dissimilar to those experienced in other countries. The AIA (2010, p.2) highlight leadership as the key requirement. 'Leadership is required to move the AEC industry forward. Users of BIM are taking different approaches to solving the issues that are presented, and the resulting fragmented approach across the industry has made it difficult to capitalise on the considerable benefits of a coordinated approach based on trust, communication and commitment'. To this end government is widely cited as the key driving force for change and that leadership should stem from that level (CIBER 2012, AIA 2010). The AIA (2010) contend that the Australian federal government should provide the leadership to facilitate a coordinated approach across all state and territory boundaries. The AIA (2010) also emphasised the need for industry and professional associations to be more proactive and to help lead the many changes required in the industry. They developed a series of key recommendations for BIM implementation which also provide insight into the industry issues: Leadership and coordination across the industry with government mandates for BIM use and industry/professional association partnerships to work together; Industry skills development with coordinated approaches to training; Multi-disciplinary approaches to education with universities and colleges providing BIM courses across disciplines and faculties; Software compatibility development ; and Client BIM awareness and education strategies (AIA 2010, p. 12)

3. RESEARCH METHODOLOGY

The literature review revealed that there has not been any current study carried out on the level of BIM adoption and implementation by the quantity surveying profession in Australia. Accordingly the research methodology adopted for this study was to undertake industry interviews with medium to large quantity surveying firms in Australia and to undertake a case study analysis of one quantity surveying firm that is providing innovative leadership in terms of BIM implementation. The quantity surveying firms comprised three medium sized firms (10-20 employees) and three large firms (20 plus employees). All of the firms had affiliated offices in Australia but focus was placed on the quantity surveying services provided by the home office. The firms were located in NSW and Queensland. Four of the firms (the three large firms and one medium sized firm) had experience with the use of BIM and automated quantities whilst the other two firms had limited experience with automated quantities and no experience with BIM on their projects to date. The interviews were conducted individually with experienced quantity surveying practitioners from each of the firms and involved general discussions on the benefits and issues surrounding BIM and automated quantities implementation. The interviews enabled a deeper interrogation and understanding of the issues than might be obtained via questionnaire surveys. The firms represented a good indicative sampling of medium and large sized firms in the Australian quantity surveying profession. The interviews were complemented by an in-depth case study of a medium sized quantity surveying firm that is one of the leading QS proponents of BIM and automated quantities adoption with a reputation for leading edge innovative approaches.

4. RESEARCH RESULTS – INDUSTRY INTERVIEWS

4.1. The Interviews

The interviewees were asked a range of questions relating to the issues, problems and benefits associated with the implementation of BIM and automated quantities. The following provides a summary of the main findings.

4.2. Automated Quantities

All of the firms interviewed used automated quantities software to prepare quantities on their projects. Four of the firms used this software extensively particularly in the cost planning stages whilst the other two firms used such software in a limited capacity. The firms used both proprietary and in-house software with the CostX program the most commonly used program. The CostX program is now the most widely used software of this type in Australia and is now used in over 40 countries around the world (Exactal 2013). The CostX program and the in-house programs were all capable of linking in with BIM models. The firms all agreed that they were on the 'automated quantities' path and that this would continue to develop as their own expertise and the software improved. The main issue that they found was in the quality of the electronic documentation (be it 2D, 3D or BIM models). The quality of documentation is critical to the development of accurate quantities and this issue has existed long before the introduction of electronic documentation. In the traditional 2D paper based days interrogation of the drawings and queries to correct design and information errors and inconsistencies was a normal part of the measurement process. The firms stressed that nothing has changed in the new electronic environment. The documentation still needs to be checked for errors and inconsistencies.

The new problem though is that it is more difficult to check the documentation accuracy despite advances in clash detection in BIM models. In the 2D days measurers would spend days and weeks measuring and 'absorbing' the project information in great detail. In the electronic 3D environment far less time is spent measuring and 'absorbing' and understanding the documentation details. There is also a new breed of young quantity surveyors who don't have that solid fundamental training in 2D paper-based measurement and may lack the experience and expertise to identify problems in CAD/BIM models as they might have done in the 2D environment. This leads to the major problem of not trusting the automatic quantities produced due to quality issues with the model. Problems may also occur where quantity surveyors are not fully conversant with the automated quantities software. This requires experience, expertise and intuition to be able to identify problems with the quantities produced.

The firms only use automated quantities to the extent that is feasible – whilst ideally suited to cost planning measurement there are still limitations with more detailed measurement for Bills of Quantities, Builders Quantities and other detailed estimating requirements. Automatic quantities will also only reflect what is detailed in the model – the need to identify information and quantities not in the electronic model is critical. It is also of note that with all of the interviewed firms a considerable amount of measurement is still done via traditional means (i.e. not automated quantities) particularly with respect to detailed measurements for Bills of Quantities and Contract/Claims Administration. All firms saw automated quantities as a 'journey' as they evolve with the technology and use it where practical and useful. They all agreed that there has been a significant increase in the use of automated quantities over the past few years within their firms.

4.3. Quality of the BIM Model

As mentioned with automated quantities, all interviewees cited the quality of BIM models as their major concern. The use of BIM models require the input of vast amounts of interconnected data and information that is typically complex. Whilst BIM models have clash detection facilities there are limitations in terms of checking all information in the model. Clients also need to be prepared to invest in the proper development of a quality model – often the limitations are brought about by consultancy fees that are insufficient to develop the model to the level required. The concept of 'Rubbish In Rubbish Out' certainly holds true for BIM models. The liability for the use of inadequate or incorrect information in the model is also a major concern.

4.4. Business Changes

The move towards BIM capability and expertise requires quantity surveying firms to re-evaluate and re-engineer their business practices. The interviewees all agreed that this is nothing new for quantity surveying firms who have typically had to adapt and rebrand their services to meet the changing demands of clients and the industry generally. A trend has emerged whereby the larger quantity surveying firms are forming alliances with other firms to form global management consultancy practices that provide services well beyond the traditional domain of the quantity surveying practice. Nevertheless the business impacts of moving to BIM and automated quantities are significant. Whilst the software and technology does require significant up-front investment the greatest cost lies in staff training and development. Whilst the aim is for this to reap benefits and competitive advantage in the longer term these development costs are significant particularly in the current climate where market activity in many sectors of Australia are at relatively low levels and fee cost-cutting amongst quantity surveyors and other construction professionals is common-place. Many firms have limited financial scope to invest in current and future digital technologies and capabilities. The added complication is that the technology is always evolving and the interviewees commented that a lot of time and expense can be spent on software and training with uncertain outcomes. The 'pioneering' path can be high risk as firms become 'test pilots' for certain technology whilst their competitors wait in the wings to see if the 'testing' will result in commercial value and competitive advantage. But all interviewees agreed that the 'wait and see' approach is no longer viable for firms that want to be key players in the construction market particularly at the top end.

Cultural business change is another challenge for firms - changing the mind-set of staff to embrace and evolve with this new technology. This is seen by many firms as the significant inhibitor to major change – the conservatism and inability to adapt by staff members. However the interviewees commented that they have noticed clear shifts in attitudes in the past couple of years as professional staff realise that if they do not evolve with this technology and develop expertise they will be left behind. The younger quantity surveying generation moving into the profession are more amenable to digital technologies and change and in many ways represent a threat to more senior personnel resistant to change.

The issue here raised by interviewees was whether this younger QS generation are moving too quickly with this technology without developing fundamental QS competencies and skills. Traditionally young quantity surveyors would spend much of their time physically measuring and 'absorbing' project details and documentation. The more progressive firms are now getting their young QSs to use automated quantities software immediately but there is a question of whether they are moving too fast and are not developing the analytical and checking skills and competencies required to evaluate and critique the information being automatically generated.

4.5. Lack of Standards/Software Incompatibility

All of the interviewees note that the lack of consistent standards and software incompatibility along the project supply chain remains an issue despite great improvements in recent years. Fully integrated project delivery with multi-disciplinary project teams working on a single integrated and compatible BIM model is essential for the optimal use of

BIM. The scope for this currently remains limited. The use of BIM is generally considered to be currently more suited to larger projects with larger clients and contractors who have the scope to demand that all project participants have the necessary technological capability and compatible software. Even then two of the interviewees spoke of working on BIM projects but effectively working outside of the BIM model due to incompatibility issues in terms of not only software but also standards and practices. This is also compounded by key parties in the project supply chain not meeting the capabilities required. All agreed that these issues will continue to improve but nonetheless are critical for successful BIM implantation across the industry.

4.6. Sharing Cost Data Information

The full implementation of BIM on projects involves the sharing of information amongst project participants. A quantity surveying firm's cost databases provide the foundation for the quality and value of the services they provide and can provide significant competitive advantage. Accordingly the concept of sharing this cost data with the project team is still being addressed by firms. Interviewees all noted that this is an issue not easily resolved but agreed that as BIM becomes more mainstream over time this concept will become a reality for firms – either share their data or not be involved.

4.7. Legal/Contractual/Insurance Issues

The legal and contractual issues relating to BIM projects are still being addressed and create considerable uncertainty for BIM participants. The interviewees agreed that this needs to be resolved before the full collaborative potential of BIM can be realised. This starts with clearly establishing legal ownership of the model and legal responsibility for errors and problems with the model through the whole life cycle of the model. The uncertainty over legal liability is also creating issues for insurers in the industry which has obvious implications for firms providing services on BIM projects. This creates uncertainty over insurance coverage and may lead to insurance exclusion for BIM projects.

4.8. Overall

Overall the interviewees all agreed that the path to BIM is inevitable but the rate of adoption and implementation remains to be seen. At the moment it appears that BIM is more suited to larger projects where the project teams have the requisite capabilities. Government mandates to use BIM on public sector projects would certainly accelerate BIM implementation but the interviewees expressed concern over whether the industry is ready for this and that it could do more harm than good.

5. RESEARCH RESULTS – CASE STUDY

5.1. The Case Study

The research interviews were then augmented by a case study analysis of the quantity surveying firm Mitchell Brandtman - one of the most innovative and progressive QS firms in Australia. The purpose of the case study is to demonstrate what is possible for the quantity surveying profession in the BIM and digital technologies fields and to highlight the visionary approaches being undertaken in relation to the role of the modern day quantity surveyor. This case study is based on correspondence with the firm's Managing Director, David Mitchell, and a variety of information published by the firm and David (Mitchell 2012, Mitchell 2013, Mitchell Brandtman 2013).

5.2. Background to Firm

Mitchell Brandtmann is a medium sized Quantity Surveying firm that was established in 1970. The main office is in Brisbane, Queensland with branches in NSW, Victoria, ACT and regional Queensland. The firm is well known for its innovative approaches particularly with respect to the use of Information Technology (IT). They are leading QS BIM specialists having been involved in the implementation and development of BIM for over a decade. They have a long history of Information Technology (IT) development having commenced their IT journey in 1981. They first began utilising CAD systems in 1997 and soon began working on automated quantities generation testing a number of systems. In 2003 they moved to the CostX automated quantities software system and have been integrally involved in the development and use of this software ever since. This has coincided with extensive research and development in the BIM field to the point where they are one of the leading QS BIM proponents in Australia. This has escalated in the past few years with the firm entrenched in 5D Quantity Surveying BIM practice. They now have a dedicated 5D Team Digital Technologies Manager. The following will outline some of the leading edge and visionary practices and directions of the firm.

5.3. 5D Quantity Surveyors

Mitchell Brandtman market their firm as '5D Quantity Surveyors and BIM Advocates and Specialists'. Mitchell (2012) contends that the modern day QS should be a 5D QS utilising electronic models to provide detailed 5D estimates and living cost plans in real time. Mitchell believes that the QS provides greatest value through their cost planning role at the conceptual front end stages of a project by providing cost advice and estimates on various design proposals and then refining those estimates as the design evolves. Using traditional 2D approaches this cost planning advice takes considerable time and inhibits rigorous comparative analysis within the allocated time frame for the design development process.

However Mitchell argues that the '5D QS can do this extremely quickly, an endless number of times and in a complexity of combinations. A 5D QS can also re-estimate the developing design an endless number of times providing feedback on the estimate variances and corrective suggestions' (Mitchell 2012, p.4). The ability to simulate a range of design options with real-time cost advice sets the 5D QS apart and arguably places them at the top of the 'value chain' for project clients. This is simply not possible with the traditional 2D QS due to their labour intensive approaches – numerous 'what if' simulation cost calculations would take far too long manually. Mitchell (2012) refers to this as the 5D 'Living Cost Plan'. He argues that these modern techniques can be used within traditional frameworks but that it is the behaviour and how the technology is used that is more important than the software. He considers the following three areas to be the key for a successful 5D QS:

Wisdom - that has been developed through years of providing cost planning advice, observing construction and working with 2D and 3D design technologies, databases and knowledge sharing frameworks. **Intelligence** - this is collected and analysed via construction demand research, labour and material price research, as-built elemental building and civil cost analysis and functional performance measurement. **Technology Skills** - that interface in two directions with 3D models and enable calculation of accurate quantities and creation of dynamic links between model information, rate libraries and estimate templates. The dynamic links allow estimates to be calculated and recalculated easily and quickly every time the model information is revised and this is fundamental to Living Cost Planning (Mitchell 2012, p.5).

The Initial Concept Estimate Stage (LOD 100) involves the development of a fast initial concept estimate working with the model using programs such as Sketchup, Revit or an IFC format. The 5D QS uses their experience to factor in items that are not included in the model. Elemental cost benchmarking is established and a variety of alternative design solutions and analysis of functional performance carried out with the 5D QS providing real-time cost advice. The Schematic Design Stage (LOD 200) involves the 5D QS producing a schematic design estimate with dynamic links to model information thus forming the foundation for the 'living cost plan'. This provides the basis for providing updated estimates whenever information in the model is changed. Mitchell (2012) states that this can be used for 'forecast final cost, budget variances, value management, finance, funding, final investment decisions or in negotiations with a contractor' (Mitchell 2012, p. 6)

The Developed Design Stage (LOD 300) involves the 5D QS working with the developed design model in Revit or IFC format and providing extra levels of costing details with the cost plan broken down into sub-elemental and trade categories. The model information will typically need to be supplemented with 2D on screen measurement as required. Coding systems are used to classify and categorise the information. During the construction stage the contractor's rates and prices can be included in the model and then form the basis for variations, change orders and claims. The Cost Integrated Construction Model (LOD 400) emerges as the information in the model is revised for construction purposes culminating in the As-Built Cost Data and Facilities Management (LOD 500) stage. This requires validation and synchronisation between the as-built model and the Facility Management requirements with cost data refined and adapted by the 5D QS. Mitchell states that 'instead of spending

90% of the available QS time calculating quantities, an experienced 5D QS spends the majority of QS time applying wisdom and intelligence to generate savings and efficiencies. Once the model is established it is leveraged to calculate and recalculate costs extremely fast for different scenarios and alternative materials. 5D BIM provides the ability to drive costs for buildings, infrastructure, heavy engineering or land development in the direction that is wanted' (Mitchell 2012, p.9).

5.4. BIM Execution Plan (BEP) Cube

Mitchell Brandtman have developed a BIM Execution Plan (BEP) cube to illustrate the requirements for effective BIM implementation. It involves the Project Phase (Process), Collaboration (Behaviour) and Level of Development (Technology) and is shown in Figure 3.

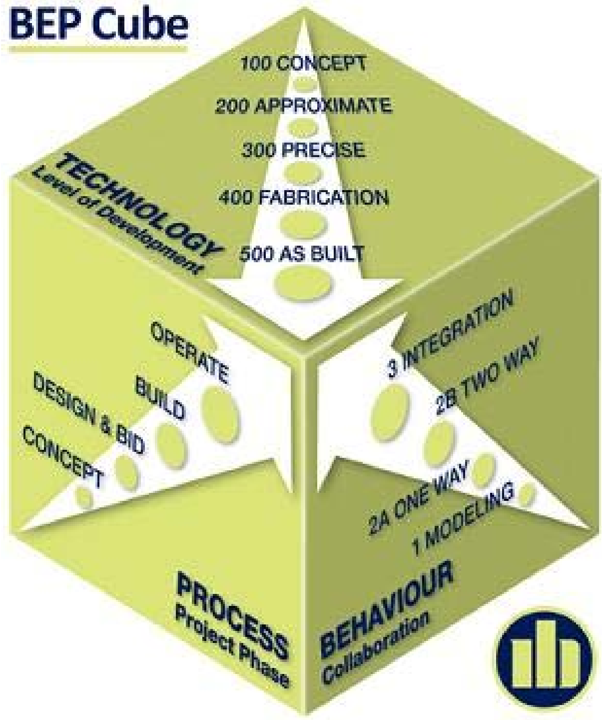

Figure 1 – BIM Execution Plan (Mitchell 2012, p. 3)

They provide the following explanation for the plan. 'When the desired project outcome is positioned on each of these scales the project team is more focused and achieves a high level of clarity about the important information to be included in the BIM. We have learnt that the best approach is to serve the right information, to the right people at the right time. When this isn't done the information can just become clutter. This is the issue at the core of the future development of BIM ie. one single integrated model versus a "federated model" comprising a collection of models. The three scales of process, behaviour and technology need to mature to better push and pull information effectively' (Mitchell Brandtman 2013, p.1)

5.5. Core Competencies

Whilst these innovative approaches are the hallmark of the firm, Mitchell contends that all of this is useless, and in many cases counterproductive, if staff do not have sufficient expertise in the core competencies of the QS profession. Developing competencies in construction knowledge, site experience, documentation understanding, measurement knowledge and other core quantity surveying knowledge areas are as important as they ever were.

6. CONCLUSION

The innovative approaches to BIM and automated quantities implementation by firms such as Mitchell Brandtman are perhaps too far ahead for many in the profession/industry who have yet to venture down this path in any meaningful form. For these firms, fundamental shifts in their business practices are required and this all takes time to develop. However, the competitive advantages already being realised by firms such as Mitchell Brandtman are likely to provide more of a catalyst for change in the profession than anything else. The longer firms delay their entry into the BIM and automated quantities world the further other firms with these capabilities will progress and add to their competitive advantage. The strategies taken by these firms to embrace these technological tools and adapt their business practices accordingly provide considerable inspiration and assistance for not only other quantity surveyor firms but for the profession generally in Australia.

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University of Technology Sydney (UTS)
University of Technology Sydney
PO Box 123
Broadway NSW 2007
Australia

Dear Dr Smith,

I am pleased to confirm that your paper “BIM & PROJECT COST MANAGEMENT – IMPLEMENTATION ISSUES & CREATIVE SOLUTIONS” has been double-blind peer reviewed and accepted by the Scientific Committee of the CC2013 Conference.

Your paper has been included in the published CC 2013 Conference Proceedings.

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Dear Colleague,

Creation is an inspiring feeling. This is especially true, when one has the opportunity to create objects of a size only a few people on Earth can. Bridges, dams, highways, skyscrapers, cathedrals are not only fascinating due to their size but also because they are able to affect the everyday lives of the people living in their vicinity for decades or even centuries. Construction... this is the real creation.

However, the creator's responsibility is enormous. These objects cost a tremendous amount of money. In addition, the creator has to meet deadlines and ensure appropriate quality. At the same time, it is getting harder to live up to the ever growing expectations: high-rises with many hundred stories are designed and built, trains compete with the speed of planes, buildings ought to produce energy instead of consuming it, and maybe in the not so distant future we are going to build in outer space... perhaps with the help of robots.

Meeting the demands of the world requires increasingly great knowledge, and more and more branches of science and engineering enter the service of building. The Creative Construction Conference invites those researchers who have realized the significance of the above points and accept that building materials, construction technology, and management, are going to change exponentially in the future and would like to contribute to this process with their own findings, and to join our collective brainstorming.

If you agree with the above statements, you are cordially invited to participate in the conference. We look forward to exploring the known and unknown boundaries of construction together.

See you in the summer of 2013 in Budapest, the capital of Hungary.

Mirosław Skibniewski
Chair of the Scientific Committee

Miklós Hajdu
Chair of the Organizing Committee

Organisers:

SZENT ISTVÁN EGYETEM

YBL

YBL MIKLÓS ÉPÍTÉSTUDOMÁNYI KAR, BUDAPEST

Deadlines

Submission of abstracts
15 February 2013

Notification on acceptance of abstracts
28 February 2013

Application for student grants
28 February 2013

Payment of early registration fee
31 March 2013

Submission of fina[l] papers
30 April 2013

Notification on acceptance of papers
15 May 2013

Hotel reservation
31 May 2013

Cancellation without penalty
31 May 2013

Submission of revised papers
31 May 2013

CC2013 CREATIVE CONSTRUCTION CONFERENCE

6-9 July 2013 Budapest, Hungary

228 days
until the conference

- Invitation
- Scope and topics
- Programme
- Location and venue
- Abstracts
- Registration
- Accommodation
- General information
- Travel and visa information
- Organizing committee
- Committees
- Social events
- Guidelines for presenters
- Gallery of CC2012

Venue (gallery)

Scope and Topics

Papers are invited on topics related to the general concept of Creative Construction. Themes of interest include, but are not limited to the list given below. The International Scientific Committee will review all abstracts and full papers. Accepted peer-reviewed papers will be included in the ISBN numbered proceedings. Expanded and fully refereed versions of selected papers will be published in a special issue of Automation in Construction, an international research journal published by Elsevier.

Creative Scheduling in Construction

• Cost optimization
• Decision networks
• New developments in traditional network techniques
• Artificial Intelligence in scheduling
• Constraint Logic programming
• New tools and algorithms for resource and cost planning
• Project monitoring and control
• Web-based project management
• Creative tools
• Case studies
• etc.

Creative Management in Construction

• Risk analysis and decision making in construction
• Construction process reengineering
• Lean construction
• Information systems in construction
• Intelligent decision support systems for construction management
• Supply chain management
• Procurement management, e-procurement
• International construction issues
• Knowledge management in construction
• Quality management in construction
• Managing international construction projects
• New tools in the education of construction management
• Case studies
• etc.

Creative Construction Technology and Materials

• Creative construction technologies
• Heavy construction (bridges, tunnels, highways, etc)
• Construction of tall buildings
• Future design and construction of tall buildings
• Creative construction materials
• Nanotechnology in construction
• Extraterrestrial construction
• Case studies
• etc.

Automation and Robotics for Construction

• Sensors and sensor based systems in construction
• Robotics for construction sites
• Artificial intelligence applications in construction
• Innovative controls for construction equipment
• Case studies
• etc.

Visualization, Virtual Reality for Design and Construction, Building Information Modeling (3D, 4D, nD)

• Visualization in design, design control
• Visualization of construction
• Construction simulation, virtual construction
• Building information Modelling and Rapid Prototyping for Construction
• New tools, creative solutions
• Case studies
• etc.

Sustainable Construction, Health and Safety

• Sustainable construction methods and technologies
• Recycling of construction waste
• Climate change issues in construction
• Green design and construction
• Creative methods in health and safety of the construction sites

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Patrick X.W. Zou *(University of Canberra, Australia)*

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