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BENEFITS OF BIM IN CONSTRUCTION PROJECTS

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This paper presents findings of an investigation into benefits of using Building Information Modelling (BIM) in construction projects. The research methodology includes a review of BIM development and achievement in construction industry, questionnaire survey, interview, and content analysis of secondary data. Data was collected and analyzed to identify the various benefits reflected from BIM implementation in addressing common problems experienced by the construction industry. The review and survey results indicate that a high frequency of occurrence of time and cost overruns occur in construction projects. Contributing factors were mainly rework, poor planning, documents delivery and approval, constructability issues, resources and weather condition. While some of the factors were unpreventable, BIM could be used as a tool to eliminate problems causing time and cost overruns. Various project benefits have been reflected through the content analysis of project case studies. It was found that time was the most positively influenced by the use of BIM followed by coordination, procurement, communication, cost and change of scope of the project, and lastly, risk.

Keywords: Building information modeling, Time and cost overruns, Project management, BIM benefits.

1 INTRODUCTION

Constant efforts have been made by various researchers, software developers and industry practitioners to promote and improve the implementation of BIM. As a result, BIM is now recognized as an emerging technological and procedural shift within the architect, engineering and construction (AEC) industry (Wong and Yang 2010).A study presented by Ambituuni (2011) on five causes of project delay and cost overrun shows that design error and scope change are the two main causes. The other three causes are inappropriate and inadequate procurement and faulty contractual management system, complexity of project, and slow closeout. Studies have shown that early collaboration between the design team and construction team reduces the problem of constructability issues early in the project stage, which leads to a reduced scope or design changes.

In recent years, the increase in popularity of the use of BIM tools and virtual design and construction (VDC) has enhanced the growth of Integrated Project Delivery (IPD) significantly. The key of IPD concept is that all participants in a project work together using the best collaborative tools at their disposal, from the early conceptual phase until the final product handover.

Following the growth of IPD, a great effort has also been placed on the use of BIM tools to enhance the IPD process. BIM is a software tool that used to create a 3-

dimenisonal, object based building model that contain robust database about the information of the building, including architectural, civil, mechanical and electrical data, sustainability information, scheduling information (4D), cost estimation (5D) and building operation and maintenance information. As such, BIM is said to be the necessary tool in the IPD process to serve as a platform for communicating and information sharing and exchange between parties. According to the literature, the issue of time and cost overruns has always been a serious concern in the construction industry, which requires attention from engineers and in-depth research to seek for solutions. The main purpose of this research is to provide insights into how BIM can help in addressing time and cost overruns in construction projects.

2 METHODOLOGY

A total of 10 questionnaires were sent to the industry professionals via email and 9 out of 10 were received. The objective of the questionnaire survey was to collect information from the construction industry regarding time and cost overruns issue and current construction management practices, and to identify the benefits of using BIM and its limitations experienced in the construction industry. Two interviews were conducted with industry professionals with construction management backgrounds and experience. Interviews were targeted to identify problems associated with current construction management practices.

A content analysis of secondary data forms part of this research to identify whether the use of BIM in construction projects has resulted in project benefits. This analysis as suggested by Harris (2001) to measure the project benefits has its own advantages such as reduction in distortions due to self-reporting and access to information about events. This analysis was done by establishing Key Performance Indicators (KPI) to measure the case studies against the success criterion. A review on these case studies will allow the evaluation of the real life benefits as opposed to anticipated benefits found in the literature and will show how they can be applied to local construction industry projects of a similar scale.

3 RESULTS AND DISCUSSIONS

3.1 Questionnaire

The result indicates that traditional project delivery methods are still dominating the construction industry. All the nine respondents had involved in DBB projects, 60% involved in DB and less than 20% in BIM-based projects. The frequency of occurrence of time and cost overruns in construction projects varied from one another, ranging from 30% to as high as 80%. However, most of the responses indicate a high frequency of occurrence (i.e. more than 60%). Participants' responses on factors that contribute to time and cost overruns are presented in Table 1, which are divided during design and planning and construction stages. From the data gathered, communication and changes of design and scope are most often encountered in managing construction projects, followed by rework, planning and resources as second highest and last being weather and coordination.

With regard to BIM, 72% of the participants have not been previously involved in BIM type of projects. In addition, responses received indicate participants have very

general understanding on BIM; most of them described BIM as 3D representative of a building and some described it as a new project management tool. Also, 72% of the participants are very positive about the new technology and are ready to adopt the change. The 28% of the participants who showed some resistance to change described the reason that BIM was impractical for small scale projects and different from the way traditional projects work. On the other hand, benefits are divided into two categories, which are the planning and design phase and construction phase, as listed in Table 2. It can be seen that most of the benefits are able to address factors which cause time and cost overrun. For instance, rework is a major cause of time and cost overruns, and BIM has the ability to reduce chances of rework through better communication and coordination.

3.2 Interviews

The first interviewee was a senior construction manager with 13 years' experience in traditional Design-Bid-Build (DBB) projects. The first interviewee pointed out that one of the biggest challenges as a project manager is how to ensure a project can be completed before the deadline and not exceed the budget and also without compromising the quality of the product. In traditional DBB contract, the contractor receives engineering drawings from the consulting firm and engineering drawings are the only communication tool between both parties. However, 2D and complex engineering drawings are subject to misinterpretation, consequently leads to defective work and products that do not follow original intended designs.

Table 1. Factors which contribute to time and cost overruns.

Design and Planning	Construction
Errors in design and drawings	Scope changes
Design changes	Rework
Poor planning	Shortage of resources
Incomplete documents	Materials not arrived on time
Financial problems	Weather
Documents approval and delivery	Latent conditions
	Lack of site inspections and communications
	Constructability issues

Table 2. Benefits of BIM.

Design and Planning	Construction
Improved communication	Reduction in request for information
Improved coordination	Reduce chances of rework through better communication and coordination
Better visualization	
Clash detection	Time and cost savings

Rework sometimes is caused by lack of clarification of the project scope because of insufficient communication between parties which usually happens early in the project planning stage. The interviewee emphasized the importance of message delivering from

one party to another and current construction practice often neglects this issue.

Other main causes contributing to the project cost overruns are inadequate planning, weather and constructability issues. Materials not delivered on time, machines breakdown, insufficient manpower to do the task, delay caused by traffic congestion are all caused by inadequate planning in the beginning. Inadequate planning is usually because of lack of experience and collaboration between the management team. The interviewee also stated that weather condition could cause a delay and have a dominant effect on subsequent and interdependent activities, especially when that particular activity is in the critical path. On the constructability issue, time and cost overruns in traditional DBB projects often caused by design deficiencies due to lack of contractor involvement during the design process. The design team tends to leave all the constructability issue to the contractor which eventually results in constructability problems. The interviewee mentioned that all these issues could have been avoided, if early collaboration of the design team and construction team were allowed.

The second interviewee was a project manager with a civil engineering degree background who had more than 10 years' experience in Design-Build (DB) projects. He discussed his philosophy of a successful project management to be: plan, execute and control. He pointed out the main causes of time and cost overruns as (i) lack of communication between the main contractor and subcontractors, (ii) delay in documents approval and delivery, and (iii) high degree of complexity, particularly in large scale projects.

3.3 Case Studies

Eight project case studies (Manning and Messne 2008, Kaner *et al.* 2008, McGraw-Hill 2009, 2009) were analyzed. A score system was used to reflect the benefits gained from using BIM in terms of the Project Management Body of Knowledge (PMBOK) knowledge areas, namely Project Coordination Management, Project Time Management, Project Risk Management, Project Procurement Management, Project Communication Management and Project Scope Management. From these case studies, BIM can be seen as an effective tool in improving overall project performance. Time was the most positively influenced by the use of BIM followed by Coordination, Procurement, Communication, Cost and Scope, and lastly Risk. Negative effects received were relatively fewer compared to the positive ones. From the data obtained, the ratio of positively influenced to negatively influenced was 38:2, which means that the chances of one could gain benefits from BIM was as high as 95% while one could negatively be affected by BIM was as low as 5%. Negative influences were mainly due to the software issues, having difficulty adopting new technology and time and money invested on training. However, the benefits and profits gained from implementing BIM tools were much larger compared to the expenses and time required for giving out courses, training, software upgrades and etc. Positive outcomes of BIM were reflected on different stages of project lifecycle, namely design phase, construction phase and post construction phase. The findings indicate that BIM is a useful tool enhancing certain key aspects of construction projects delivery.

Time savings is one of the critical and important benefits of adopting BIM tools and processes in improving overall construction project performance. Time savings can be achieved prior to the construction, by agreeing the design concept early in the project

development stages effectively eliminate late stage design changes. Faster project delivery can be done by taking advantage of intelligence and automation within the model, information exchange as well as electronic documentation control.

Cost reduction is another valuable benefit one can obtain by the use of BIM. Data from the case studies show cost savings generated by implementing BIM are much larger compared to the extra costs needed for computer upgrades and providing training courses to the employees. In fact, those extra costs will only be spent once but cost savings by the use BIM can still be obtained from subsequent projects from a long-term point of view.

Scope management has proven to be significantly improved from most of the findings. A better scope clarification was the result from the use of BIM in most of the case studies. Rework, scope changes have been reported to be substantially reduced through the 3D visualization and clash detection function. However, in one case study, the scope of project was reported to be negatively influenced through the use of BIM. This is believed to be due to the difficulty in handling new technology; 3D modeling could be extremely hard for the beginners to deal with or the ones that used to 2D drafting. This situation can be improved through the training courses.

Another key point worth mentioning would be that PMBOK knowledge areas extend beyond the project management iron triangle: time, cost and scope. The success criteria derived emphasize factors that the traditional iron triangle does not mention, which are, the coordination, risk, procurement and communication management. The PMBOK knowledge areas represent areas that need to be well controlled in order to achieve an effective project management program. The outcome of BIM on the success criteria directly reflects the influence of BIM on the construction projects. The findings certainly conclude that BIM is an effective tool to help project managers in the task of delivering successful projects.

4 CONCLUSIONS

Findings indicate a high frequency of occurrence of time and cost overruns in construction projects. Contributing factors were mainly rework, poor planning, documents delivery and approval, constructability issues, resources and weather. While some of the factors are unpreventable, most of them could have be eliminated or reduced through a better project delivery tool which is BIM.

Various project benefits have been reflected through the content analysis of project case studies. From the results, BIM can be seen as an effective tool in improving overall project performance. Time was the most positively influenced by the use of BIM followed by Coordination, Procurement, Communication, Cost and Scope, and lastly Risk. Negative effects, which were mainly due to the software issues, were relatively fewer compared to the positive ones.

Questionnaires conducted indicate that while BIM has not been widely adopted in the local industry, various benefits of BIM to the construction projects have already been realized. Implementing BIM implies a complete changeover of processes which the industry has been working with for decades. Hence, academic sector and the local industry will need to invest in BIM learning courses, workshops and training to the students and staff members. In addition, efforts are also needed to be placed on investigating and resolving model ownership issue for liability reasons.

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