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BIM EXECUTION PROCESS OF CONSTRUCTION COMPANIES FOR BUILDING PROJECTS

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Building Information Modeling (BIM) has been an emerging concept in architecture, engineering and construction (AEC) industry with a vast amount of promising benefits to construction projects. Implementation of BIM, however, requires comprehensive research and strategic planning. Industry-wide and organizational implementation guidelines and standards have been published around the world either to encourage organizations to adopt BIM or to present the minimum requirements to be followed where BIM implementation is a statutory obligation. In contrast, governments or organizations in several countries such as Turkey have not mandated BIM implementation and provide no guidance. Organizations in these countries which plan to adopt BIM processes are forced to develop their own implementation plans. The purpose of this study is to provide guidance in BIM implementation for construction companies in countries where BIM implementation has not been mandated particularly during the construction phase of the building projects. 23 BIM standards and guidelines covering the BIM execution process have been reviewed. Topics that need to be addressed by BIM implementation plans have been identified and categorized under four headings. A case study of BIM implementation at a large construction company that focuses on conducting quantity takeoff and cost estimation is presented, and unique challenges of BIM implementation in Turkish AEC industry are discussed.

Keywords: BIM implementation, Execution plan, BIM standards, BIM guidelines, Implementation guidelines, Construction management.

1 INTRODUCTION AND BACKGROUND

There have been great improvements in materials and building techniques in construction industry that are results of technological advances and innovations. However, there is still room for improvement in terms of labor productivity, energy concerns related to raw materials and energy consumption, modes of communication among project stakeholders, and standardization of deliverables to increase efficiency. BIM has been an emerging approach to replace inefficient methods of project generation and delivery in construction industry for more than a decade. Research shows that BIM utilization could significantly increase the level of collaboration on project execution (Eastman *et al.* 2011) and has a positive influence on quality and completion time in building projects (Elmualim and Gilder 2014). Structured information it provides also could facilitate to decrease the energy consumption levels related to construction industry

especially when implementation begins in design and construction phases of the project (Smith and Tardif 2009).

Business process reform to adopt BIM can be performed in two levels: (1) industry-wide changes in business practice, (2) changes in individual organizations (Smith and Tardif 2009). Several governments and institutions around the world have mandated BIM deliverables. Standards and guidelines are published to identify the requirements of those BIM deliverables. Although the scope and content of these documents vary depending on the target audience, they provide insights into the essentials of BIM execution process. This fosters BIM utilization process for companies that operate businesses in these countries or with these institutions.

Adopting BIM processes when BIM is not mandated by any organization and/or there is an absence of BIM standards and guidelines would require comprehensive research on fundamental concepts on execution process of BIM. The purpose of this study is to facilitate BIM adoption for construction companies by providing structured information on BIM execution process, and to decrease initial costs of BIM execution related to research and resource allocation. A catalog is created by reviewing, compiling, and categorizing the contents of 23 documents related to BIM execution process. Additionally, a case study on BIM implementation based on a customized BIM execution process to perform quantity takeoff (QTO) and cost estimation (CE) is presented.

2 BIM IMPLEMENTATION PLANS AND STANDARDS

Literature review of BIM execution process has been conducted to identify the commonalities and to provide a catalog for companies to design customized BIM execution processes. "BIM Guides Project" (Marie 2015) which was initiated by buildingSMART to catalogue standards and guideline documents on BIM was used as a guideline while gathering the resources to be reviewed. 81 documents have been listed there. The project is still in progress and cannot provide a structured comparison among these documents yet. Several entries in the list are individual chapters from the same document. Examination of it revealed that only 55 resources exist. The scope of this study is limited to BIM execution process. 23 out of 55 documents covered the BIM execution process and these have been reviewed (Table 1).

57 separate subjects addressed in these documents are identified. These are categorized under four groups that will be briefly discussed below: (1) scope of implementation, (2) infrastructure, (3) contracts, (4) implementation processes. Summary of the content comparison matrix for the reviewed documents is given in Table 2.

2.1 Scope of Implementation

BIM mission and vision statements facilitate companies to enhance the productivity of organization, since they identify the concept of using BIM and define the future desired state with preferably quantitative targets (Autodesk 2010, Computer Integrated Construction Research Group 2011, 2012).

Clearly defined BIM goals and uses have significant importance for success. BIM goals provide a general approach to remain competitive by providing focus on the outcomes of BIM utilization (Epstein 2012), whereas BIM uses identify the methods to achieve BIM goals (NIBS 2015).

BIM implementation process may comprise of several phases from design to demolition. It is important to specify which intended BIM uses would be performed in which phase of a project.

Table 1. The reviewed documents.

	Name	Abbreviation
1.	Autodesk Organizational and Project BIM Deployment Plan	Autodesk
2.	BIM Planning Guide for Facility Owners V1.02 (Penn State University)	Penn/Facility
3.	BIM Project Execution Planning Guide V2.1 (Penn State University)	Penn/Project
4.	AEC UK BIM Protocol Project BIM Execution Plan	UK/Project
5.	Princeton University BIM Execution Plan	Princeton
6.	Indiana University BIM Guideline	Indiana
7.	The VA BIM Guide	VA
8.	State of Wisconsin	Wisconsin
9.	AEC UK BIM Protocol	UK/Protocol
10.	NBIMS US V3	NBIMS US
11.	COBIM	COBIM
12.	NBIMS Australia	NBIMS Aus
13.	AIA Documents	AIA
14.	MIT BIM Execution Plan (Pilot Use) & CAD And BIM Guidelines	MIT
15.	AEC Canada BIM Protocol	Canada
16.	CIC BIM Protocol	UK/CIC
17.	Singapore BIM Guide V2	Singapore/Guide
18.	Singapore BIM Essential Guide for BIM Execution Plan	Singapore/Project
19.	Singapore BIM Essential Guide for BIM Adoption in an Organization	Singapore/Org.
20.	GSA BIM Series	GSA
21.	Hong Kong CIC BIM Standards	Hong Kong
22.	AGC Guide to BIM V1	AGC
23.	RGD BIM Standard	Netherlands

Table 2. Summary of the content comparison matrix.

Category	Heading	Autodesk	Penn/Facility	Penn/Project	UK/Project	Princeton	Indiana	VA	Wisconsin	UK/Protocol	NBIMS US	COBIM	NBIMS Aus	AIA	MIT	Canada	UK/CIC	Singapore/Guide	Singapore/Project	Singapore/Org.	GSA	Hong Kong	AGC	Netherlands
Scope of Implementation	Mission&Vision	●	●	●							●									●	●	●		
	Goals&Uses	●	●	●	●	●	●	●	●		●	●	●	●	●	●		●	●	●	●	●	●	
	Project Phases				●	●	●		●		●	●									●	●		
Infrastructure	Organizational		●	●	●	●		●	●	●	●	●	●	●	●		●		●	●	●	●	●	
	Technical	●	●	●	●		●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	
Contracts	Data Ownership	●					●	●				●	●	●		●					●	●		
	Data Security	●						●		●			●	●		●		●			●			
Implementation Process	Process Plan	●		●	●	●	●	●	●		●	●	●	●	●		●	●	●			●		
	Info. Exchange			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Modeling Proc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Deliverables	●	●	●		●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●	●
	Archiving			●						●		●			●	●	●	●			●			

2.2 Infrastructure

BIM processes may require to define new roles and responsibilities within the organization. Developing a BIM Team is suggested in most of the BIM documents. This team is responsible for working collaboratively to accomplish project goals throughout implementation. Essential roles in a BIM Team are BIM manager/leader/champion, technical leaders, coordinators, and modeling staff (Computer Integrated Construction Research Group 2011, U.S. Department of Veterans Affair 2010). It is important to note that defining new roles to implement BIM requires not only adding new software names to the job descriptions (Joseph 2011), but also merging design and construction information with collaborative project execution practices.

BIM also requires technical infrastructure which is made up of software, hardware, system configuration and networks. To choose the optimum system, in-depth analysis must be done according to the BIM goals and uses as well as financial limitations of the organization. Testing phase is recommended, since the main expenses of BIM implementation lies behind training, consulting and integration expenses (Reddy 2011).

2.3 Contracts

Data ownership and transmission of data are two important contractual subjects that requires clear definitions. Transmitting and receiving parties, authorized uses, and data sharing procedures with 3rd parties should be identified (AIA 2013a, 2013b, Senate Properties 2012). It is suggested that copyright of the digital data belongs to the transmitting party, however once the data is transmitted, ownership of the data does not exist (AIA 2013a).

Data security is another important issue to be included in the contracts. Data loss/damages or misuse by inside or outside sources should be prevented by Teams using user access protocols (U.S. Veterans Affair 2010).

2.4 Implementation Process

Implementation process should be designed according to project requirements. Detail level of the process may vary depending on the size of the project, BIM goals and uses to accomplish, and project phases that BIM implementation is to cover.

During the planning process, it is suggested to identify potential BIM uses and their sequence of implementation, to assign relevant tasks to responsible parties, to define required information flow among responsible parties, and finally to specify validation points whether to proceed to the next step in the process (Computer Integrated Construction Research Group 2011).

To enable collaboration within BIM Team, information exchange and collaboration strategies should be developed. These have multiple dimensions. Platforms such as servers, extranets, etc. to access and share data should be set; model management methods like working on a single model or composite model should be chosen; data formats for transmission of data and information handover requirements should be specified and acknowledged by BIM Team members. Due to the fragmented nature of project implementation in construction industry and technical challenges such as interoperability issues and possible software and hardware deficiencies, it is not recommended to implement BIM via a single model (Kensek 2014). Open standards such as Industry Foundation Classes (IFC) are encouraged to be used frequently to increase the efficiency in information exchange and support a competitive environment (NIBS 2015). PAS 1192-2 and PAS 1192-3 documents can be beneficial to develop information management strategy (British Standards Institution 2013, 2014).

Data generation details such as classification of information, file naming conventions, level of development (LOD) of BIM models, minimum content requirements, and model division rules should be agreed on and specified by stakeholders prior to implementation. This would allow each BIM Team member to know what information is needed and/or included in the model at any time of the project (Hardin and McCool 2015).

Project close-down issues such as project deliverables, project validation process, and archiving are also important, since they affect the project timeline.

3 CASE STUDY

A BIM implementation process at a large construction company in Turkey is presented. The company will be referred to as LC. The actual name of the company and the projects that customized BIM execution process has been implemented in will be kept confidential.

Since BIM implementation is not mandated in Turkey, there is an absence of BIM standards and guidelines. Therefore, companies have to design their own BIM implementation processes. In LC's case, the catalog which this study provides was used in developing a customized BIM execution plan in Turkish construction industry. This plan was tested in six projects: a school, a residential building, two office buildings and two commercial buildings.

A qualitative study was conducted. The study was performed as half-structured theme interviews. Core BIM Team with its six members were interviewed to collect information on the organization's BIM standards development, current practices within the company and lessons learned throughout the implementation that improved efficiency.

3.1 BIM Execution Strategy at LC

Planning of execution process at LC comprised of 2 phases: 1) pre-implementation, 2) implementation. The former included unwritten and managerial decisions on BIM implementation which identified the scope of the implementation. Targeted BIM uses were defined as QTO and CE. Infrastructure set up was prepared and processes to implement BIM uses were designed. The reason of choosing QTO and CE as BIM uses was their significant importance in competitive industry. It was foreseen that if the case study succeeded, it would lead to an extensive ground for BIM implementation by proving other companies in the industry that BIM provides with accurate outcomes in building projects. The latter included a drafted guideline which explains how to perform QTO and CE according to the processes defined in pre-implementation phase. An internal training program with 5-day structured internal training sessions was also developed to prepare the BIM Team for implementation. It took four months to develop, improve and finalize the execution process plan.

3.2 Lessons Learned

The BIM Team achieved to produce accurate outcomes in performing QTO and CE and in supporting construction site work. There were important lessons learnt from the pilot six projects. Competitive environment of AEC industry in Turkey is one of the major challenges, since developing an effective BIM execution process requires allocation of resources. It was possible to overcome this challenge at LC due to the company size and resources available to it, but this challenge is substantial for small to middle size companies.

Lack of standardization of information in Turkey also constitutes a major shortcoming, as it hinders companies in maintaining effective collaboration among companies in design-bid-build projects. BIM data which is generated to perform different purposes such as visualization or documentation may include several problems duplicated geometries. The Team experienced that evaluating the received models to fix such problems before performing QTO and CE is a tricky and time-consuming process and re-modeling the project from scratch according to modeling rules defined by LC was easier and produced more reliable results.

Human factor was another challenge. LC had great difficulty in finding professionals who have adequate capabilities in BIM processes. That was the reason of developing an internal training process within the company. Related to training process, the Team at LC experienced resistance to change especially from construction crew and sometimes from the new members.

When people know how to implement specific tasks they tend to stick with these methods. Communication was the key to solve this challenge.

4 CONCLUSION

Effective BIM execution requires a comprehensive research due to high levels of information and collaboration necessities. Therefore, in the absence of guidelines and standards, companies should allocate resources for the development of their own customized plans and processes appropriate for local legislations they operate under. This study's aim is to facilitate this adoption process by providing a catalog of subjects that need to be addressed. These subjects related to BIM execution are collected from published BIM guidelines and standards around the world.

A case study on BIM implementation as an organizational decision has been conducted. The catalog this study offers has been used to determine a customized BIM execution plan. This plan was used in six projects. The case study shows that BIM can be implemented successfully even in countries without governmental guidance. It also shows that lack of qualified professionals who can integrate into BIM processes hinders BIM implementation.

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