
Suzila Mohd¹, Aryani Ahmad Latiffi²

Department of Construction Management¹
Faculty of Technology Management and Business
Universiti Tun Hussein Onn Malaysia (UTHM),
86400 Batu Pahat, Johor, Malaysia.
suzilamohd@gmail.com

Department of Construction Management²
Faculty of Technology Management and Business
Universiti Tun Hussein Onn Malaysia (UTHM),
86400 Batu Pahat, Johor, Malaysia.
aryani@uthm.edu.my

Abstract—Building Information Modeling (BIM) is an emerging technology in the construction industry. It has been applied in architectural, engineering, and construction (AEC) industry since 2000 to increase performance and quality of construction projects. It can also be implemented for the entire of construction project stages which are pre-construction, construction, and post-construction. This paper aims to determine effects of BIM implementation to construction projects. A literature review was carried out to review on BIM implementation in construction projects, application of BIM tools, and BIM benefits. The data came from various sources such as books, journal articles, conference papers and material available on the internet which related to BIM. BIM is necessary to construction projects because it supports and increases accuracy of project design, project cost, and project scheduling. BIM tools such as Revit, Tekla, and Bentley System help in preparing project design, cost estimating, and project scheduling. BIM implementation in construction projects will help to increase projects performance in terms of time, cost, and quality.

Keywords—Building Information Modeling (BIM); Construction Project; Performance; Quality; Implementation

I. Introduction

Building information modeling (BIM) is a process of generating and managing building data during its life cycle [1]. BIM also known as an emerging technology which can be used to improve performances and productivities of construction players, which are client, consultants, and contractor in designing project, construction, operation and maintenance process [2]. For example, BIM has improved design management tools in AEC industry from 2-dimensional (2D) to 3-dimensional (3D) and 4-dimensional (4D) in order to increase accuracy of project design and detect design clashes [3]. The ability of BIM in managing construction projects have reduced construction problems; project delay, construction cost overrun, and disputes among construction players [4] [5] [6]. The construction players have used several types of BIM tool to increase accuracy in project design, cost estimating, and project scheduling. The tools are such as Revit, Tekla, Bentley System, Cost-X, and Vico System [7] [8].

AEC industry in the United States of America (USA), Finland, Australia, and Hong Kong (HK) have implemented BIM in their construction projects since early 2000 [1] [9] [10]. They use BIM to increase construction projects performance and quality. The capability of BIM in managing construction projects are no doubt because many successful erected construction projects have been implemented BIM [11]. The projects such as Aquarium Hilton Garden Inn, Atlanta in Georgia, USA, Cruell Bridge Helsinki in Finland, The Sydney Opera House, in Australia, and One Island East Office Tower in HK [7] [12] [13].

In the Malaysian construction industry, BIM implementation was introduced by Director of Public Work Department (PWD) in 2007 [5] [14]. The idea to encourage construction players in implementing BIM occur when Malaysian Government aware on BIM potential in reducing construction problems [5] [14]. There are several types of BIM tools that have been recommended by PWD. The tools are Autodesk Revit, Navisworks, and Cost-X. These tools are used to manage construction projects and they have been used in several BIM projects in Malaysia. The projects are National Cancer Institute of Malaysia in Putrajaya, Eudyct Sport Complex in Nusajaya, Johor and Ancasa Hotel in Pekan, Pahang [5] [14].

In order to increase BIM implementation in construction projects, it is important to explore BIM applications and its benefits to construction projects. Therefore, this paper discuss on BIM implementation in construction projects, application of BIM tools, and its benefits to construction projects. The contents of this paper were based on literature review. All information regarding BIM implementation in construction projects was obtained from books, journal articles, international conference papers, and material available on the internet.

II. BIM Implementation in Construction Projects

Construction project is a process which consists of numerous people, activities and requirement to fulfill client goals. The process can be divided into three (3) stages, which are pre-construction, construction and post-construction [15]. These stages are a process to execute construction projects...
activities. Figure 1 shows the stages and activities involve in construction project [15].

![Fig. 1. Construction Project stages](image)

Figure 1 shows construction project stages, which are pre-construction stage, construction stage, and post-construction stage. The implementation of BIM in pre-construction stage reduces construction problems in construction stage. BIM is implemented in construction projects to increase accuracy in each activity such as project design and cost estimating.

### A. Pre-Construction Stage

Pre-construction stage is a process, which consists of activities of project design, cost estimating, project scheduling and managing labor, materials as well as project equipment. This is the preliminary stage where brainstorm and ideas on projects will be gathered from design teams. The project teams consist of client, architect, structural engineer, and mechanical, electrical and plumbing (MEP) engineer in order to fulfill client desire [15] [16].

Architect, structural engineer and MEP engineer use BIM tools such as Revit, Tekla, and Bentley System to increase accuracy in preparing project design and detect design clashes. The tools are capable to increase accuracy in cost estimating and project scheduling. It also helps design team to detect design clashes during pre-construction stage. The ability of BIM in detect design clashes during pre-construction stage can avoid project delay, construction cost overrun, and disputes among construction players [4] [12].

### B. Construction Stage

Construction stage is a process of execution construction projects. Activities involve in this stage is excavation of foundation, framing installation, roofing, and interior finishes [15] [16]. Contractor and project manager are responsible to manage those activities. During this stage, BIM can be used to reduce request for information (RFI). RFI is a sheet use by contractor to get permission to continue work from architect or client. Moreover, the sheet is filled by the contractor to gather confirmation on interpretation and specification of construction drawing details from the architect. The architect needs to give feedback based on information request in the sheet immediately to the contractor to avoid project delay.

The ability of BIM tools in detecting and eliminating all clashes in designing during pre-construction has reduced RFI in construction stage. Moreover, BIM is also capable in site coordination and reduce conflict among construction workers in using machineries at project site [5] [14] [17].

### C. Post-Construction Stage

Post-construction stage is the final stage in a construction project. The stage consists of three (3) main activities, which are final inspection, project administration, project close out and operating or facility management. BIM is used in this stage to keep track of built asset and manage facility effectiveness. BIM can also provides maintenance schedule and visualize maintenance history. Examples of BIM tools, which can be used in this stage are Autodesk FMDesktop, ArchiDATA, and ArchiFM [5] [14] [17]. Therefore, several types of BIM tools have been used in all stages. Details on the tools and their application will be discussed in following section.

## III. Application of BIM Tools in Construction Projects

The application of BIM tools has increased quality and brought effectiveness of construction projects [1] [7] [12]. There are several BIM tools that have been introduced in construction projects. The tools are Autodesk Revit, Tekla, Bentley System, Exactal Cost-X, and Vico System. Each tool has its capability in managing construction projects. The purpose of the tools are as follows:

### A. Visualize projects model.

Visualization is an important aspect in design process. It is used by construction players to visualize project model before it can be constructed [1] [18]. Several visualization approaches include 3D design, design review, documentation, rendering and graphical representation [19].

The visualization approach is benefited to construction players because it is difficult to visualize from the stack of 2D drawing [20]. 3D model is an effective way to improve communication and collaboration between construction players. Furthermore, 3D model is an excellent method for evaluating projects quality. The visualization can enhance the model usefulness as a thinking tool to improve design quality [19] [21].

### B. Generate fabrication or shop drawing for various building systems.

Fabrication or shop drawing consists of detail design illustrations of each building element. It has been prepared by structural and mechanical, electrical, and plumbing (MEP) engineer to provide information and confirmation of design intent to suppliers, fabricators or manufacturers in making each component based on the detail designs [22].

For example, the role of structural engineer is to design, analyze and certify whole building structural frame. The
structural engineer then creates 2D structural drawing. However, the drawing contains only general requirements for steel fabrication and typical steel connections [23]. The implementation of BIM can visualize and provide details information for each element of steel fabrication. It also can detect design clashes in structural and MEP designs.

The number of shop drawing for a building is exceeding the number of construction drawings. Therefore, structural engineer is required high precision to design the shop drawing. Any mistake in shop drawing could result project delay and increase construction cost [24]. Therefore, BIM has facilitated structural engineers to create the drawing in digital [1] [23].

The use of BIM can reduce time for creating details design of structural steel. It also produces higher quality of structural design. BIM also launched fabrication workflows for all building discipline [1].

C. Utilise project model parameters by using codes reviews.

Code reviews or code validation is utilized to check model parameter against project specific codes. An architect and engineers need to validate building design in compliance with specific code. Specific codes mean codes use in project design to detect design errors [25]. Examples of specific codes used in project design are International Building Code (IBC) and America with Disabilities Act guidelines (ADA) [25].

IBC is a model building code developed by the International Code Council (ICC) [24]. IBC code provides the safeguard requirement for public health and safety as well as general welfare for new, existing building and structures [26]. ADA is a standard for accessible design, which provides project scope and technical requirement for new construction projects [27].

Code reviews should be done early in design stage to reduce chances for code design errors and oversights that cause to time consuming. Moreover, cost to improve the codes in design or construction process is expensive. If any clash detection happened during design stage, all construction players can use the code reviews to preview the clash detection [1] [18].

D. Preview design clashes detection.

Clash detection known as a process of finding the clash between models from each discipline such as structural design and MEP design. It is also known as a process in which clash detection tool is used during coordination process to determine field conflicts by using 3D model of building systems [24]. Clash detection is important to eliminate major clashes prior to installation [7] [28].

E. Assist in planning for asset management.

Asset management is a process in which an organized management system will efficiently aid in maintenance and operation of a facility. Asset management of construction projects consists of physical building, MEP ductworks systems, building landscape, and building interior facility. The assets must be maintained, operated and upgraded to satisfy both, owner and users at the lowest appropriate cost [1] [24]. BIM assists asset management to determine cost implications of changing or upgrading building assets. Moreover, BIM can also assist facility management department in creating idea for renovation, managing space planning, and facilitate maintenance operations [1] [24] [29].

F. Assist in preparing cost estimating.

Cost estimating is a process of approximating cost for each element in a project. An estimator typically doing manual take-off from architecture drawing. Some estimators prefer to begin their work with digitizing architect drawing or importing computer aided design (CAD) drawing into a cost estimating package and count each element manually[1] [7] [24].

BIM is used to generate an accurate quantity take-off and increase accuracy in cost estimating. Moreover it also provides better solution for estimators to do take-off and measurement of a project. The estimators no longer need to do manual take-off. Moreover, the estimator can avoid mistake in take-off process [8].

G. Assist in preparing project scheduling.

Project scheduling involves sequencing activities in space as well as time, considering procurement, resources, and spatial constraint [1] [7]. Project manager or planner engineer is typically used several tools such as Microsoft project and Primavera to create, update, and communicate with client on project scheduling [7].

Sometimes, client or project stakeholders face difficulties to easily understand project schedule. To overcome this problem, BIM has introduced 4D CAD which contain time associations. 4D CAD is allowed planner engineer to visually plan and communicate activities in the context of space and time [1] [7]. Moreover, project planner can also coordinate expected time and space flow of trades on site as well as coordination of work in small spaces [7].

IV. Benefits of BIM

Implementation in Construction Projects

BIM provides benefit to construction projects. The key benefits of BIM are as follows [4] [30]:

A. Faster and more effective process

- All information based on construction projects such as project design, cost estimating, project scheduling are easily shared among construction players. The information can also be changed and reuse among them.

B. Produce better project design

- The ability of BIM in reducing design clashes can improve quality of project design and avoid RFI during construction stage.
C. Better production quality

- BIM has the ability to detect potential problems as early as in pre-construction stage. Its can avoid construction problems during construction stage and increase quality of construction projects. Its increases accuracy in cost estimating as well as project scheduling.

D. Better customer service

- Detail designs are better understood through accurate visualisation. BIM helps client to understand on project design through visualisation, which is 3D better than refer to a stack of design drawing.

v. Findings

BIM is a new technology which has been used by AEC industry to manage construction projects. It is also a new innovative way in managing project design, construction and facility management.

Therefore, BIM is seen as an approach which can be used for the entire of construction project stages which are pre-construction, construction, and post-construction. It also has been utilized in construction projects to manage the continuous and availability of construction projects activities. The activities are such as project design, cost estimating, project scheduling, site coordination, and facility management. The implementation of BIM in construction projects also increase performance in term of time, cost, and quality.

Moreover, the application of BIM tools such as Autodesk Revit, Naviswork, Cost-X, Vico System, and Bentley System assist construction players to manage all activity in construction project stages. The tools have been used in preparing accurate project design, cost estimating, project scheduling, site coordination, and facility management.

The benefits provided by BIM tools in managing construction project activities have increase efficiency in managing construction projects and effectiveness in constructing a construction project. Therefore, the effects of BIM implementation in construction projects could overcome project delay, construction cost overrun, and disputes among construction players. The implementation of BIM is getting increase because of its benefits to construction projects.

VI. Conclusion and Further Works

It is undeniable that BIM in construction projects can increase performance and quality. The ability of BIM in reducing construction problems such as project delay, construction cost overrun and disputes among construction players during projects execution are main factors in increasing performance and quality of construction projects. BIM should be encouraged to be implemented in construction projects because of the benefits offered. It is important to study the application of BIM in construction projects to encourage and increase awareness among construction players to implement BIM in construction projects. Further works for the research will be carried out by conducting semi-structured interviews with several construction players which are clients, architects, engineers, and contractors. The purpose of interview is to gain information on BIM practices in Malaysian construction projects and to purpose a framework on how to implement BIM in construction planning.

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