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Roles and Responsibilities of Construction Players in Projects Using Building Information Modeling (BIM)

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Abstract. Building Information Modeling (BIM) has been implemented in construction projects to overcome problems such as project delay, cost overrun and poor quality of project. BIM enhances construction player to perform their activities in effective and efficient through the development of three dimensional (3D) model. However, BIM requires changes in current practices among construction players in terms of the processes and technology that use for managing projects. Therefore, this paper is aimed to discuss on roles and responsibilities of construction players in projects using BIM. This is a review paper that discusses on BIM, its definition, activities with roles and responsibilities of construction players in managing projects. The findings revealed that roles and responsibilities of construction players in projects using BIM are differ from conventional practice by the use of BIM tool. The findings of this paper provide useful information for construction players that considering implementing BIM in projects.

Keywords: Building Information Modeling (BIM), Roles, Responsibilities, Construction Player, Construction Projects

1 Introduction to Building Information Modeling (BIM)

The concept of Building Information Modeling (BIM) has been introduced in the Architecture, Engineering and Construction (AEC) industry to overcome problems in construction projects [1,2]. BIM is said as a new methodology to improve construction projects by the use of BIM tool [3]. The use of BIM significantly has increased across the projects life cycle from design to the operation and maintenance of the projects [1,2,3,4,6].

Each of construction player uses BIM for different purposes. BIM helps client to understand more on projects' need [1,7,8,9]. While architect and engineers use BIM for analyzing and developing projects design. Meanwhile, BIM helps contractor to manage the construction activities and scheduling by using four-dimensional (4D) model. Quantity surveyor (QS) uses BIM to produce an accurate project cost estimation [6,10] and facility manager uses BIM for managing the operation and maintenance of the facility [6,8]. In order to get the benefits offered by BIM, construction players need to aware on the changes in current practices and the use of information needed in projects using BIM. Therefore, this paper is aimed to explore on the roles and responsibilities of construction players in projects using BIM.

2 Methodology

A literature review was conducted to explore and discuss on the roles and responsibilities of construction players in projects using BIM. All information related to BIM was gathered from journal articles, international conference papers, books and material available from the internet. Results and findings from the literature review are now discussed.

3 Roles and Responsibilities of Construction Players in Projects Using BIM

Construction players use BIM to achieve better integration of project information, construction process improvement and to enhance collaboration among them from the early phase of projects [9]. Therefore, the use of BIM definitely changed the roles and responsibilities of construction players [11,12]. The literature review on roles and responsibilities of construction players in projects using BIM identifies the activities that need to be conducted by them. Table 1 shows roles and responsibilities of construction players in projects using BIM.

Table 1. Roles and Responsibilities of Construction Players

No.	Construction Player	Role and Responsibilities of Construction Players in Project using BIM
1	Client/Owner	• Defining a suitable method of using BIM
2	Architect	• To develop conceptual design. • To develop detail design and analysis. • To develop construction level information • To develop construction documents.
3	C&S and MEP Engineer	• To develop detail design. • To develop shop drawings with detail elements.
4	Contractor	• Perform constructability analysis • Scheduling and planning using 4D model • Produce cost reliability

Table Cont'

No.	Construction Player	Role and Responsibilities of Construction Players in Project using BIM
5	Quantity Surveyor (QS)	• To extract quantities and produce cost estimation from the 3D model
6	Facility Manager	• To put the information of building into the 3D model for the purpose of FM.

3.1 Client

Client or known as an owner is the person or organization that responsible for the cost of projects and get the benefits from the completed projects [13]. In project using BIM, client uses BIM to streamline the delivery of higher quality with better performing building [1]. Therefore, BIM helps client to increase building performance through the use of BIM-based energy and lighting design, reduce financial risk by obtaining earlier and reliable projects cost estimates and improves collaboration of project team [1].

In order to get the benefits of using BIM, client should concentrate on the efforts to define the process of using BIM in projects [1,9]. This is important for determining the success of using BIM in projects [1,9]. Client should specify the method of using BIM and the level of detail of the model in order to develop BIM requirement. This is because, if the BIM requirement are too broad, the outcome from using BIM will be broad and will not meet client expectation. Hence, it is vital for client to determine the deliverables based on the requirement, so that the client could lead the process and get the benefit of using BIM [1,9].

3.2 Architect

Architect is the principal designer in most of construction projects [13]. Architect is responsible to translate and develop the design concept based on the client's requirement. The roles of architect in project using BIM are to develop conceptual design, detail design and design analysis as well as to develop construction-level information [1,9,14]. Conceptual design is a basic framework of design that brings all aspects of the project in terms of its function, cost, construction methods, materials, environmental impact as well as aesthetic considerations. The architect uses BIM tool such as Revit Architecture to perform conceptual level design. Figure. 1 shows the example of conceptual design using Revit Architecture.

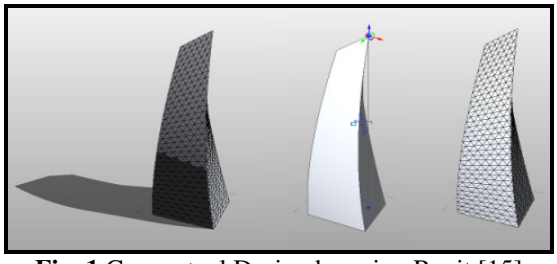

Fig. 1 Conceptual Design by using Revit [15]

Based on the figure, architect develops conceptual design to explore early design concepts before creating details of project model. Revit Architecture automatically helps architect to build a parametric framework around the most complex forms and giving greater levels of creative control, accuracy and flexibility [15]. In addition to that, architect could convert any individual face of building masses into building components such as walls, roofs, floors and curtain system [16]. Moreover, Revit Architecture could also maintain the relationship between conceptual model geometry with building component.

As soon as the conceptual design is established, the architect will develop design analysis [1, 15]. It is a measure of physical parameters that can be expected in the real building. It covers on the functional aspect of building performance, temperature and ventilation air flow [1,14]. The information regarding the building component in the model is used to conduct an analysis.

Fig. 2 Design Analysis on Sustainability of Building using Revit [15]

Figure 2 shows the example of design analysis to determine whole building energy, day lighting, water and carbon emission analysis based on the conceptual design [15]. By using BIM tool, it allows architect to analyze the location of building that could contribute to the use of electricity and water usage cost. This activity is concerned with collaboration and coordination of other construction players such as civil and structural engineers (C&S Engineers) as well as mechanical, electrical and plumbing engineers (MEP Engineers) as the analysis will be made by using technical information from other players [1].

The role of architect in project using BIM also to produce construction documents. This process involves the integration of design and construction. The architect should determine the level of detail required in the model before proceeds for construction of documents [1,9]. The architect uses BIM tool for placement and composition rules so that it can expedite the generation of standard construction documentation. Therefore, the use of BIM tool helps architects to speed the production of documents in more efficient.

3.3 Engineers

Engineers are also known as professional designer that design the projects [17]. The engineers can be categorized into civil and structural (C&S), mechanical,

electrical and plumbing (MEP) [14]. The C&S and MEP engineers use BIM tool such as Revit Structural and Revit MEP to develop design analysis coordination process. Figure 3 (a) and (b) show example of design analysis for C&S and MEP engineers.

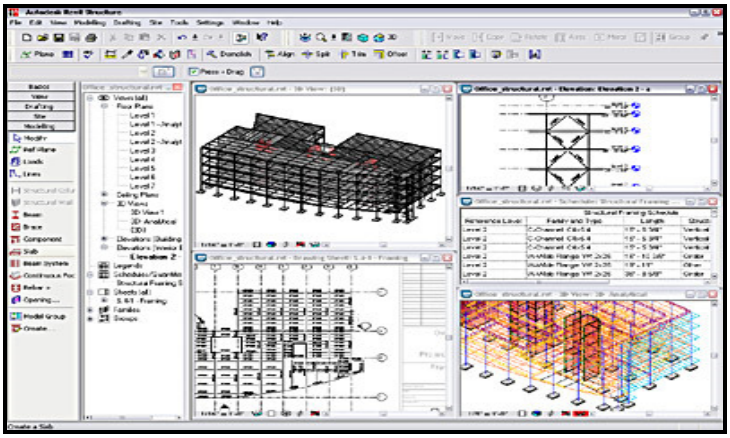

Fig. 3 (a) Examples of Design Analysis for C&S [15]

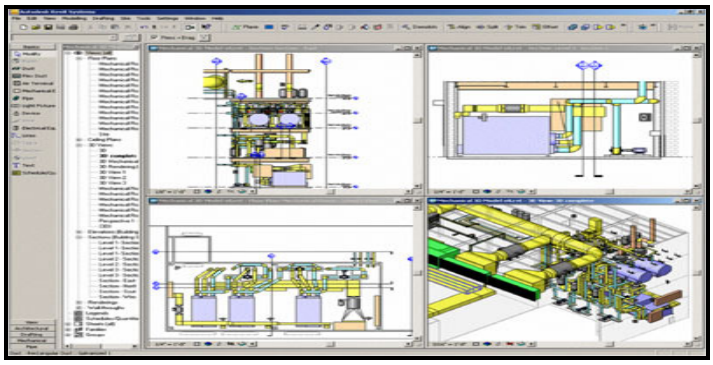

Fig. 3 (b) Examples of Design Analysis for MEP Engineers [15]

Based on the figure, C&S and MEP engineer use BIM tool to view different structural systems and alternate design option within the same digital model. Any changes made on the design will automatically coordinate the changes across other representation of the projects. In addition to that, by using BIM tool, they could create shop drawings, fabricate and installing C&S and MEP systems in more accurate [18]. The shop drawings also contain details of the items that will be manufactured, purchased and installed [18].

3.4 Contractor

A contractor is a person that has a contract with a client and responsible for the construction of a project [17]. In projects using BIM, contractor develops digital model using BIM tool such as Naviswork for identifying any design issues before the

construction take place [1,6,7]. With the digital model, the contractor could simulate the process; identify construction outcomes, any problems that affect cost, schedule and quality of projects [9]. Figure 4 shows the construction planning and scheduling using 4D model.

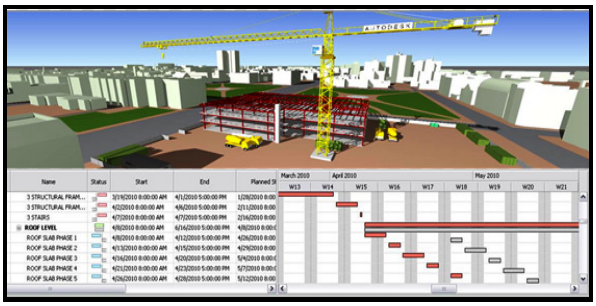

Fig. 4 Construction Planning using 4D model [15]

Based on the figure, the contractor uses BIM to conduct an analysis to see the performance levels and requirement such as structural loads, maximum shear and moments [1,19]. This analysis is vital to ensure the constructability of the projects [6,19]. The contractor could also prepare the schedule of work as well as to track the progress of work [1,6,8,19]. The status of each of component is added into a digital model for easier coordination. Then, the model could perform sequence of the work with and without appearance of facilities such as crane [1]. From the digital model, the contractor also capable to extract counts of components, area, volumes of spaces, material and quantities for producing project cost estimates [1].

3.5 Quantity Surveyors (QS)

Quantity Surveyor (QS) is a person that is responsible to perform financial control, cost and contractual administration of project [10]. A QS uses BIM-based quantity taking off to eliminate errors in conventional quantity taking off [1,20,21]. Figure 5 shows taking off from the digital model.

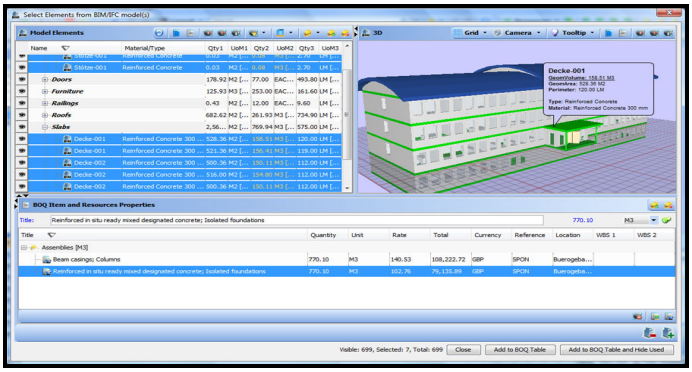

Fig. 5 Taking off using Vico [22]

By using BIM tool such as Vico [23], QS could perform automatic quantity taking off with automatic extraction of visual information such as floor plan, elevation, 2D and 3D sections including quantities, model analysis and simulation results [21]. BIM tool has a feature that link to items and assemblies annotate the model as well as create a visual takeoff diagram. However, this application requires collaboration of other construction players such as architect and engineers while developing the model [24]. This is because, the accuracy of project cost estimating, count and measurement are highly depending on the developmental digital model by architect and engineers [23,24].

3.6 Facility Manager

Facility Manager's role is closely related to the project conception and planning for future facility's need [17]. Facility manager uses BIM to leverage facility data that provide safe, healthy, effective and efficient work environment [25,26].

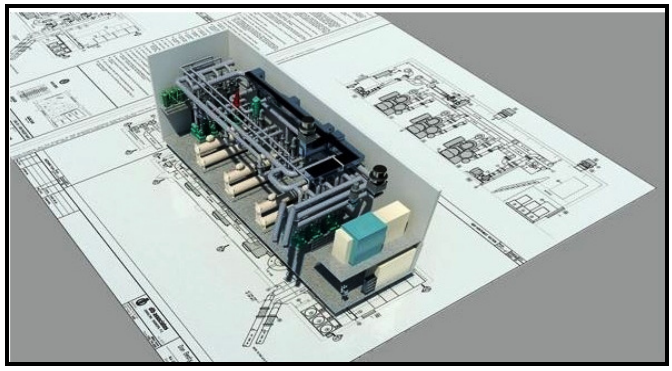

Fig. 6 Information of the Facility in Digital Model [26]

Based on Figure 6, the information in the building model associated with spaces, masses, construction level details, scope of the model (such as architectural and details of MEP elements) and facility assets [1]. The information is vital for future analysis, assets tracking as well as future maintenance schedule. Facility manager will obtain the information of the building from the contractor, so that facility manager could track any components in the building, identify any inefficiencies of building operations. As a result, facility manager could respond immediately to client based on the information in the building model [26].

4.0 Discussion

This paper is the fundamental for construction players to shows the roles and responsibilities of construction players in projects using BIM and how it differ from conventional practice. Figure 7 has been created based on the information on the roles and responsibilities of construction players in projects using BIM which has been discussed in this paper.

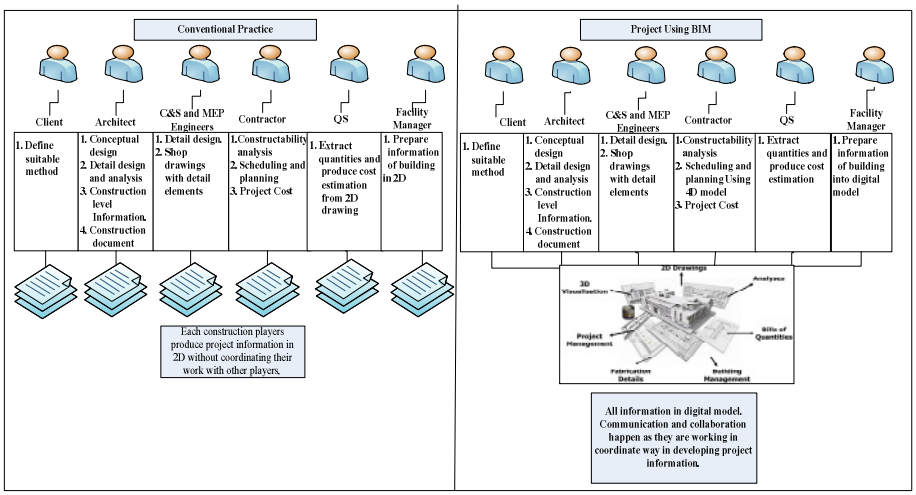

Fig. 7 Differences of Relationship of Construction Players between Conventional Practice and Project Using BIM.

Figure 7 shows the similarity of roles and responsibilities of construction players in conventional practice and projects using BIM. However, the difference of practices is the use of technology, which is BIM tool for developing projects information into digital models. The use of BIM tool helps construction players to conduct their roles and responsibilities in more efficient and effective by overtake the traditional 2D paper-based of managing project information into virtual digital model and also allow to have collaboration and communication among construction players. Compare to traditional way of working in conventional practice, construction players normally working independently without coordination of their work with other players, prone to errors in managing project information and lead to delay making a decision. By using BIM, collaboration and communication among construction players could happen as they work in a coordinate way in developing project information into digital models. The construction players could give immediate feedback and decision regarding the projects information. Consequence to that, they could improve project design, producing accurate project cost estimation, better work integration and facilities.

5.0 Conclusion and Further Work

The use of BIM has given benefits to construction players in improving their roles and responsibilities in construction projects. However, they should be aware on the changes of practices so that they could gain the benefits. Further work will be conducted with construction players that involves in projects using BIM to explore more on their current practices in projects using BIM.

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