Building Information Modeling In Construction Industry: Review

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Abstract— Due to numerous steps of construction industry and its complicated and extensive structure, errors and reworks often might happen in this section. As such, BIM (Building Information Modeling) is regarded as a beneficial tool in minimizing the waste and improving the efficiency of building construction. This paper reviews and summarizes a substantial amount of requisite information relating to BIM from the literature reviews between 2005 and 2012. It has discussed the concept, explained the history, planning and implementation process and the benefits of using BIM in construction industry. Furthermore, the application of BIM in construction process of two specific projects has been explained. Additionally, the importance of BIM for architects, engineers and construction industry has been taken into consideration. In other words ,BIM can be used by engineers ,architects, project managers ,etc. in order to achieve these goals :To decrease design errors, To reduce clash detection, To boost the integration of cost and time, To improve the integration of design and construction phase, To increase the collaboration between different construction sections and finally to improve recycling.

Keywords: Building Information Modeling, Planning And Implementation Process, Benefits Of BIM, Two Specific Projects

I. INTRODUCTION

Domain-specific tools are utilized to analyze and evaluate the design in a building project development. There are several examples that all needs specified data for their implementation, such as, evacuation simulation, lighting tools, scheduling, design of mechanical system, design of control systems, analysis of structural, energy use and analysis of cost. In an old-fashioned design, where the two dimensional (2D) drawings were produced by hand, every domain proficient had analyzed with his or her own tools at the project as well as this expert generated datasets manually from suggested design to assess the design of the consultant's view. As the design initiated, these consultants provided the trade-off between data analysis for maintaining its stability and the design. The expert advisers were not able to answer to the design decision-making timeframe because this manual procedure was time-consuming. Evaluations in the process of design were spontaneously created by experience. Moreover, the majority of computational analyses had been applied adjacent of the termination of the design to certify formerly made decisions [1].

The classical design procedures have different difficulties and disadvantages. The engineer error can be simply happened that this error influences on the work efficiency. Consequently, time losses can provide economic losses. This research considered the weaknesses of process of classical design; moreover, it constructed the design and analysis process for three dimensional (3D) information model which several modules and databases are required. Furthermore, the interface program for unifying individual module is required [2].

Because the project realization develops the model creation, it can be feasible that at a certain point in the simulation model no longer precisely reflects that (increasing) realization. This is the true moment to reconsider the continuing helpfulness with the present model and to start again a new one. It will usually take a time fraction which it takes to get to the similar development point since all the planning and considering has currently been applied and the modeling has been appropriately planned and can be executed proficiently. The consequence is going to be an innovative model which will no longer slow down growth or be imprecise in the way it displays the project [8].

One of the basic BIM characters is a development of BIM through an information feedback loop. The model progression and the information of related project is cyclical (iterative). As well as the members of a distinct project team improve the project, the information, which is available, increases the depth, scope, and relatedness. A harmonized and intellectual project can mature from the information of building which is frequently cycled through the BIM at an enormous detailed and harmonized level.

A. BIM Concept

BIM finds elements of a building for example windows, doors , slabs, stairs , and walls by applying their attributes such as usage, structures, and functions as well as utilizing parametric technology; Moreover, it can reflect any alterations in the elements of building instantly into the information about the building configuration by distinguishing the connections between those attributes. Accordingly, the building elements' specifications and their relative information can be gotten by using a simulation model, which provides it possible for making quick decisions pending a construction project. Additionally, BIM not only prepares foreseeable information with regard to amount, expenses, schedules, and materials but furthermore provides it possible to perform analyzing data that can depend on the structure and ambience [4]. A BIM is a project simulation which consists the three dimensional (3D) models of the project components by connecting with all the needed information linked to the project planning, constructing or operating, and decommissioning. This section explains the 3D models, the information included these models, and the character of the links between the individual models, the components as well the information. The charges of this various array of information containers may be intimidating, and it is essential to realize the basic character of these definitions so that it can become conceivable for scheming and managing their organizations truly [8].

The best tool to simulate the construction project within a virtual environment is BIM. This simulation can have the benefit of taking place on a computer when we are utilizing a software package. Virtual building points that it can be possible for practicing construction, for experimenting, and for making regulations in the project before it is fulfilled. Those mistakes, which are virtual, do not normally have serious subsequences —provided that they are found and indicated early sufficient which they will be avoided "in the field". While a project is virtually planned and made, many significant features should be considered, determined and discussed as much as possible before the address instructions of construction are concluded. The computer simulations usage is revolutionary in the building construction subject. Several manufacturing in the industry have been very magnificently exerting simulation methods for many years ago. Furthermore, many companies in the construction field have currently effectively used resembling methods in the building projects, even though faultfinders assert that simulations can only profit repetitious production processes, and that construction is by explanation exclusive.

II. BENEFITS OF USING BIM

Many of the BIM advantages are observed as direct advantages; however the largest advantages really are the indirect advantages. The direct advantages include qualities, for instance the enriched imagination, conception and the concentration of building information in the project. In contrast, the indirect advantages are the essential for cooperation and giving the best result for project understanding, and reducing the project risk. Simulations authorize us that a design be planned checked virtually before the real project is constructed. A model can help us to have a visualization of the project. This visualization provides stimulation view in concerning the project needs that help to describe the project in an effective manner [8].

The three main BIM benefits, which have been organized, are the elimination, visualization, and collaboration. There is actually much overlap amongst these classifications, but they have been selected as the principal thought around which all the advantages can be better realized.

First of all, visualization mainly indicates the advantages for the improvement and an individual in her/his personal realization as a consequence of utilizing the BIM. Second of all, collaboration can be the cooperative behavior of some members in the team as the BIM is encouraging and facilitating it. Finally, elimination refers generally project-related advantages, for example decreasing the waste, risk, and conflicts [8].

Richard et al. [11] stated in brief BIM advantages and its tools which can be indexed as follows:

1) Materials take off should be simplified.
2) Complex details can be surveyed and analyzed.
3) The different trade components coordination can be reviewed for potential "hits."
4) Sequence of placing a project with each other is expanded.
5) The 4D, which added time, can be merged to demonstrate how quickly a project can be put together.
6) Site work eminences among the ultimate eminence and existing conditions could be determined.
7) The best routing could be reviewed for pipes, lights, ductwork wires, cables, and sprinklers.
8) The site preparations with the hoists and cranes location can be analyzed.
9) Lift schedules would be determined for the steel, concrete, and huge mechanical and electrical equipment placement.
10) Developing the schedules and the associated argument will be expanded.
11) Problems of potential safety would be evaluated.
12) Alternatives can be assessed in more realistic terms.
13) Coordinating the trade's former to perform the real work.

A. BIM Tools

BIM programs are offering the software companies as follows:

1) Autodesk Revit
2) ArchiCAD from Graphicisoft
3) Bently Architecture
4) Digital Project from Gehry Technologies LLC (book)

B. Phase of Planning and Pre-Construction

It is presently not unusual to identify the applications of BIM in the pre-construction a project phase. This is huge part due to the reality which easier models, and narrow information that is associated with the planning stage, will be able to provide huge advantages for the project. The argument of this stage has been divided into two segments. First of all, it is to address the design and marketing of conceptual features of the project. Second of all, it can be to plan and design during developing the finalized set of address instructions for the project construction [8].

Such simple models, which are conceptual, may furthermore be utilized for preselling a project, before construction can take place, to assist safe the financing for the project. A sales endeavor may use sophisticated images and movies illustrating the finalized virtual project. Surface modeling software produces frequently the schematic models for these purposes. It can be normally easier to utilize a surface modeler, and the consequences are fine assorted for communication purposes.

1) Model Development

It is defined as a planning nature and design phase for a project. The information feedback loop, through which the model senses are enhanced, can be an affiliate of the model itself. This model is the central point for the design process transmutation, as well as members of all project teams mainly correspond through using of the model. The advanced three dimensional (3D) provided visualization is furthermore very useful for the designers with relation to grow in their own work. All opinions approximately about the project will be mirrored in the model in a manner or another. In this phase, the project can be still justly schematic, as well as it is usually not problematic to indicate the opinions of the project group employees in the model [8].

2) Analyzing the Constructability

Another valued part of the pre-construction segment is the constructability which consider on the evaluation of the needs and conditions of the construction procedure itself to attain the desired consequences. This will contain an assessment of the application of materials and systems furthermore analyzing the installation, construction, manufacture, and assembly details of all the project segments. Moreover, constructability can contain several parts, such as, addressing the construction site layout, supply deliveries accessibility, site provisions ("including excavations and backfill operations"), the job trailer place, and etc. Value engineering is able to be efficiently displayed at this early project phase. Value engineering in this meaning considers the account to maximize the project design and components value. Optimization of the project value is able to be attained thru brainstorming sessions where the entire project group cooperates, thru the three dimensional (3D) model where facilitates visualization and connection amongst group members [8].

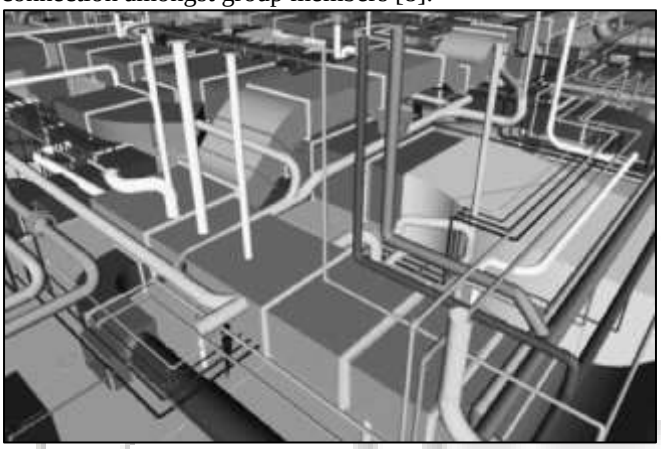

Fig. 1: MEP Coordination adapted from [8]

3) The Construction Schedule

With assistance from the 4D model, the schedule of construction can furthermore be expanded. A schematic construction sequel is simulated when a primary schedule is accessible. This will be facilitating the construction process visualization and allow the attention of other approaches to sequencing, layout of the site, and location of the crane, and etc. during the construction procedure. Furthermore, the components of the model can include information of production rates ("for all the associated work tasks") where will allow analyzing the balance schedule lines; this approach permits the fine-tuning of tasks based on their placement in the project and production rates and assists to remove starting and stopping the cycles in the tasks. For instance, if the interior partitions framers are slightly sluggish rather than the installers of sheetrock, it will find this and recommend both framers and the sheetrock workers should increase and decrease the speed of their activities, respectively; as a result, the overall production will be improved and optimized. Improving the reiterative activities and production rates can build an important discrepancy in the large project effectiveness and efficiency [8].

Investigation on a simulation of four dimensional (4D) has concentrated on the construction schedule management and implementing the dynamic simulation atmosphere for procedures. J. Tulke et al. [5] represented a framework of dynamic collaboration which spontaneously makes a construction schedule thru a business procedure re-engineering approach and simulates calculation of expenses in linking with the schedule, dynamically. Although, information about geometry is utilized just for visualizing thru the simulation of four dimensional (4D) when it is in addition linked to the system separate from the schedule of construction, which demonstrates that conventional techniques cannot be avoided. In the meanwhile, J. Tulke et al. [6] performed a simulation system of 4D which spontaneously linked to the information of geometry based on data stashed at a building model with period schedules for planning a construction sequence. Although, the system could not be able to fracture of the existing frame, which is solely an easy linking between information and schedule of geometry. K.W. Chau et al. [7] performed the essential functions to manage geometry models of 3D, schedules, and dynamic sources on the 4D information system platform which it is called "Graphics for Construction and Site Utilization". Although, this platform has not been suggested consequences to develop a genuine system or applications; this easily prepared conceptual meaning for significant factors to be comprised in the four dimensional (4D) simulation.

4) Cost of Projects

The Cost of the project can be predicted and tracked by using BIM throughout all stages of project planning. In the early project phases, it can be useful to establish the budget areas; these are represented as square footage expenses in a very easy model. A model of schematic 5D is going to prepare the schematic quantities, as well as outline expenses estimation can be produced. While the expenses of project estimation and budget are followed thru usage of the model throughout the design stage, it will be referred to as a goal of value design. As the models develop, cost tracking is able to be refined with the enlarged the model detail levels; moreover, the expense implications for design alternatives can be able to be estimated at any design development phase. Many of analyzing the cost will be based on the connection between the components of the model and an exterior database which includes the real cost information. In the model, the quantities are compounded with the connected cost data; accordingly an estimation of project cost is produced. The databases are editable and they can be customized for the users' options. Many firms will be basing their expenses estimate on the historical data and can utilize previously known data of a private database. Furthermore, it can be possible to apply commercially accessible cost data [8].

C. Construction Phase

In the construction phase, both the management of project team ("people-related") and management of process can be applied by the BIM process. Moreover, the BIM tries to be helpful to plan the purposes which carry over at the stage of construction.

The BIM usage in the case of construction management is presently starting to get popularity. Nowadays, the preliminary applications of BIM in the construction phase are: connecting, identifying and

resolution of coordination subjects, construction sequencing plan, and replacing the fabrication shop drawings by a detailed three dimensional model as can be seen from the figures (1-4). All these usages need a just great level of detail in the components of model, as well as they are frequently performed with models which a sub- contractor might previously have generated specially for these causes [8].

During the construction phase, the most vital task is preparing a schedule which is created at the onset of a project by a member of the construction management team. The flaws of the aforementioned schedule would be decreased through using BIM due to two facts. First, there would be more time for construction manager to coordinate other tasks.

Second, through enhanced visualization which is linked the schedule to the vital construction, many of schedule misinterpretations mitigated. In consequence, there is a necessity to use a powerful tool for construction managers allowing a design team to share, combine, review and correct a BIM model. To achieve these goals, Nawiswork would be fully beneficial; however, it is not modeling software. It is capable of compiling and linking modules to a schedule in order to have a schedule animation [10].

1) Managing the Project Team

Managing the project team applies to the interplays leading between the contributors on the project for design and construction procedures. It can be significant to remember that the project groups are working for the possessor and require keeping the possessor's objective obviously in mind when implementing the parameters of construction management in the project. The project's BIM plan should provide these targets and be the method with which the group understands its objectives. In this case, the main concerns can be the connection and coordinating subjects between the members of the project team.

Providing the work coordination between members of the project team is an extremely precious BIM feature. Hence, a 3D diagram for a detailed project can rapidly and simply disclose many project characteristics which otherwise can be hard to imagine in the model of conventional 2D drawing. As well as, there are some model views that encourage the interplay amongst the persons, who are responsible, to resolve obvious conflicts, or converse other design and construction-related subjects. A conversation between the adviser of design and sub-contractors based on the three dimensional (3D) formats can help with communication of the designer's intention and visualization of the special construction or installation of processes before they can be to get placed in the field. As a result, the BIM can act as a central point to relate and communicate amongst all members of the construction team. The model is able to accommodate for visualizing the orderly construction schedule update; moreover, the look-ahead thoughts practiced at Lean Construction [8].

2) Management of Construction Process

As expressed in the Modeling of Building Information: the construction project management and planning with "4D CAD and simulation" (2008), managing the construction procedure refers to the management of the procedures needed to make to be able the building project's construction. These procedures are frequently pertaining to the mobilization of construction, scheduling and sequencing, purchasing, expense control and analyzing the cash flow, material handling and ordering, and fabricating and installing the component. All these procedures have been evolving out of a require to do these activities more efficiently, as well as this could only mean removing what is not necessary something likes misusing in the form of time, in the materials, and resources; as adding what can be desirable in the terms of materials, and techniques to a procedure and project [8].

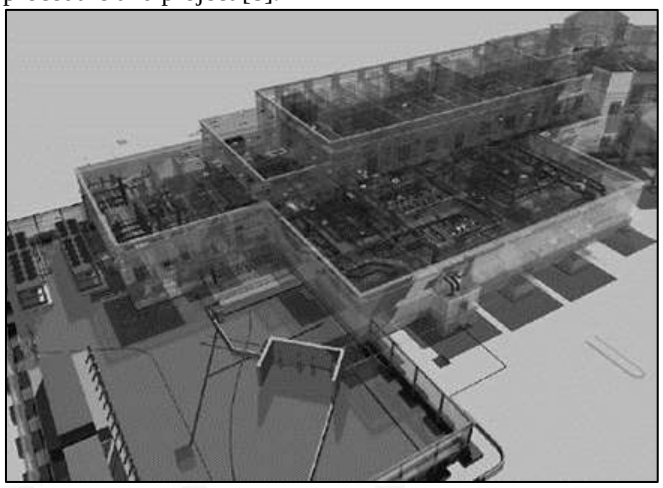

Fig. 1: Courtesy of construction adapted from [8]

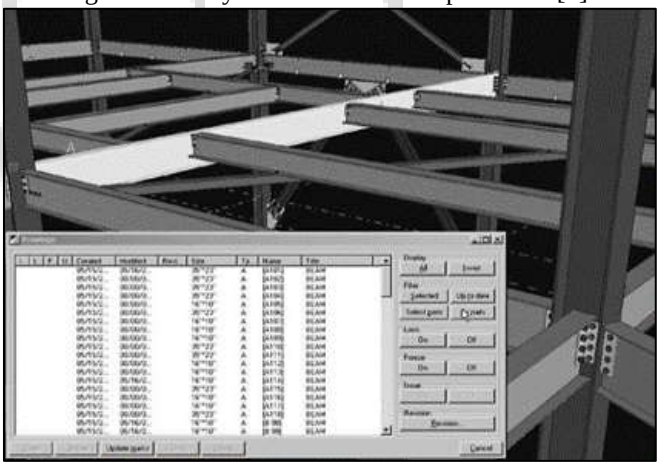

Fig. 2: Structural design model adapted from [8]

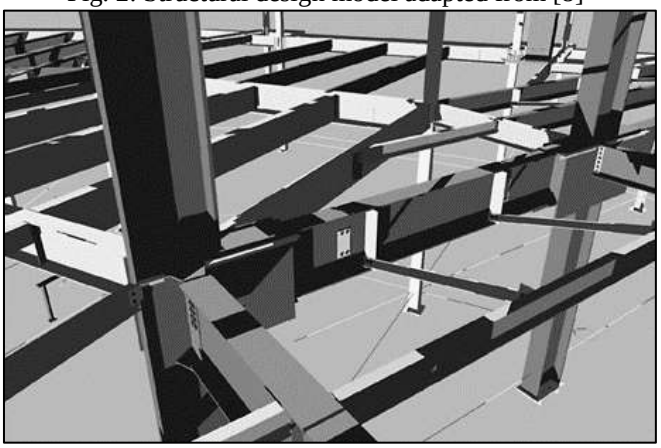

Fig. 3: Structural design model adapted from [8]

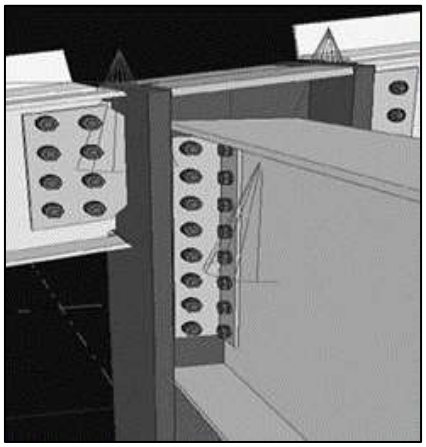

Fig. 4: Fabrication model adapted from [8]

D. Post-Construction Phase

Models of Building information are dramatically increasing to be popular with the tasks of facilities management (FM). The ability of BIM for containing vast visual information quantities has absorbed a huge amount of interest from units of facilities managers, operations and maintenance. The advantages are homogeneous to those listed for the other project stages. It can be frequently simpler for managing the tasks visually; utilizing the three dimensional (3D) model, to enable to view definite features of management, helps one in visualizing it oneself, and to connect it to others. This part is going to emphasize that control can be more important than planning— data, operations, and process control [8].

1) Operations Control

It considers the capability and ability for managing, for instance, project maintenance. The BIM components can demonstrate that there are plenty of different kinds of information of maintenance-related, for example, replacing the parts ordering, scheduling the maintenance, past records of maintenance, as well as installing and maintenance instructions. Other data in control definition can include furniture inventories, energy use data, allocating the space, locations of personnel, and schedules of space utilization, etc. [8].

2) Process Controls

It considers the model used for controlling the heating and cooling systems, controls of security system, access analysis, consumed energy analysis, and functional applications of the project.

In many applications, managing the object model-based has been utterly novel yet, moreover undoubtedly there will be wide improvements in the future. If any post-construction while it is using the BIM, is predicted, it can be effectively worthwhile for the project team to get this survey in planning of BIM stage, accordingly, in the long run, it can be accomplished efficiently [8].

E. Implementation of BIM

The implementation plan will be straightly following from the desirable objectives for the BIM and the characteristics of the model. This plan can explain the deliverables, the procedure needed to create the desirable consequences and output from the BIM, and the resources compulsory for accomplishing these objectives.

For succeeding the plan at this stage, it can be significant to identify the determined requirements for information as well as the associated formats. Each objective should have an obvious result explaining the methods and efforts needed to understand it.

First of all, describing the deliverables is important. Second of all, results the needed procedures for accomplishing the deliverables should be done. Finally, last task includes the person's selection on the team who can have best ability to provide the first two steps. It is difficult to predict the future output; however, having a plan with detailed information will help to better answer to the process circumstances as they present themselves. The procedure of BIM is a planning and managing procedure in the building construction projects, as well as it is significant for this procedure itself to be attentively planned and managed [8].

F. BIM for Architects and Engineers

During the design stage, there is collaboration between design team and engineers and technical specialist's consultants which involves providing the proper project information relating to design, its use and context to the specialists to review and gaining advice for changes [9]. This aforementioned collaboration sometimes is considered as new service that can be grouped into two following areas:

1) Concept design development
2) Integrating design with construction leading to improve coordination between the project members such as structural, mechanical and electrical engineers.

G. Recycling

When it comes to recycling, using BIM would be useful in two ways. First, through using site logical plans which identifies the location of bins and roll offs on the site in order to the team to these locations and subcontractors being informed to take care of scraps. Second, reducing the amount of printed documents by persuading users to utilize digital tools in order not to run into serious expenses [10].

H. Two Specific Projects Using BIM

In this section, two specific projects in which BIM played a vital role has been presented. The different aspects of the BIM process in order to maximize efficiency within the projects have been identified [9].

1) Lint Global V6 Engine Plant Expansion

In 2000, the area of Flint Engine south plant was 76000 sq. which was extended by 442000 in 2005 and began production in September 2006. General motor was concerned about restricting the design and construction time while streamlining the cost and maintaining quality. To achieve these goals, lean construction through integration of BIM was used. Therefore, employing BIM throughout the projects life cycle was formed from the onset of project. All project team members must use digital models to optimize the advantageous of BIM. In addition to this, providing input to the 3d model from fabrication to field installation need to be done by the subcontractors. To recap, employing BIM have had numerous benefits in this project as follows:

1) Around 3000 to 4000 interferences were discovered and resolved through using BIM in different sections such

as architectural components, structural steel, HVAC mechanical equipment, ducts and lighting.

2) Minimizing onsite requirements through having a detailed collision free 3d model resulting in saving time and material. For instance, the completion date for steel structure erection was 35 days earlier and without any changes during construction. Ultimately, 3% to 5% of the overall cost was saved due to the automated collision detection.

2) One Island East Project (OIE)

OIE is an enormous commercial office building which has 70 floors in Hong Kong. This building was constructed by one of the most prominent developers called Swire. Swire properties implanted BIM to manage the functional and financial relationships between design, construction and facility management in three stages: pre-tendering, tendering and post-tendering. Some upsides through implementing BIM are identified and listed on the following:

1) Visualizing sequence of creation building elements leading to save time and cost over the project life-cycle through using primavera.
2) Visualizing construction sequence called 4D CAD which was a useful tool for the contractor.
3) Enabling team members to prepare the proper bill of quantities.
4) Identifying the safety issues prior to construction.

I. Conclusion

To recap, BIM can be used by engineers ,architects, project managers ,etc. in order to achieve these goals : To decrease design errors, To reduce clash detection, To boost the integration of cost and time, To improve the integration of design and construction phase, To increase the collaboration between different construction sections and finally to improve recycling.

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