Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (39) No. (3) july, 2017

The Impact of Applying Building Information Modeling on Design and Construction Stages

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ملخص البحث

يعتبر الهدف الرئيسى من اية مشروعات هو تحقيق عملية اتزان بين الوقت ، التكلفة و الجودة . يحاول كل عناصر المشروع سواء (مديرين ، مهندسين ، عمال ... الخ) فى ايجاد الطرق المناسبة لتحقيق أقل وقت مع أقل تكلفة وأفضل جودة . عبر مر السنين يحاول معظم الافراد المنتمين الى خدمات التصميم والتنفيذ الى تطوير الطرق ، الاداوات و الوسائل لتحقيق عناصر ادارة المشروع وهما الوقت ، التكلفة و الجودة .

مع تطور الحضارات معظم المشروعات اصبحت اكثر تعقيدا وتحتاج الى طرق اكثر علمية وتطورا لملائمة التطور المصاحب للمشروعات . بدأت فى الظهور طرق ونظريات عديدة الهدف منها هو عمل تحكم كامل على ادارة المشروعات لمواجهة الانواع الحديثة من المشروعات التى ظهرت مؤخرا . يعتبر نمذجة معلومات البناء هو أحد الطرق الحديثة التى ظهرت لملائمة التطور المصاحب للمشروعات .

يهدف هذا البحث الى دارسة تأثير استخدام نمذجة معلومات البناء فى مرحلتى التصميم والتنفيذ وكيف يساعد تطبيق نمذجة معلومات البناء فى زيادة جودة التنسيق بين كل الاقسام المشتركة فى المشروع مما ينعكس ذلك على انتاجية المشروع اثناء عملية التنفيذ .

ABSTRACT

The main aim for any construction projects is to make balance between time, cost and quality. All members in construction projects (managers, engineers, workers...etc.) try to find the ideal methods to achieve less time with less cost and best quality. Over the years all people belong to design and construction services tried to improve methods and instruments to achieve project management triangle; time, cost and quality.

With the development of civilization, the projects become more complicated and need more scientific and development methods to satisfy the new development. Many methods and theories began to appear to make full control on project management and to face the new types of construction projects. Building Information Modeling (BIM) is one of the new methods which appeared to satisfy the development of construction projects.

This research studies the impact of applying BIM in design and construction stages, and how it increases the quality of co-ordinations between all disciplines in projects, which reflects directly on the productivity of construction projects.

Keywords: Building Information Modeling, Collaboration, Design, Construction.

1. Introduction

There are many types of construction projects which staff of engineers can design and build .These construction projects are not only residential buildings as most of people think, but also include many types , such as administration buildings, service buildings …etc.), Engineers work for finding best methods to make accurate design which satisfies for all construction requirements.

The main aim for any construction projects is to make balance between time, cost and quality, all members in project including managers, engineers, workers, builders...etc, try to find out the best methods to achieve less time with less cost and best quality. Over years, people belong to construction services tried to improve methods and strategies to achieve project management triangle; time, cost and quality.

The main parameter to achieve success of any construction project is time, cost and quality to make balance between the projects parameters and to make accurate studies and co-ordinations between all disciplines.

With the development of civilization, the projects become more complicated and need to more scientific and development methods to satisfy the new development. Many methods and theories begin to appear to make full control on project management and to face the new types of constructions projects.

Building Information Modeling is one of the new methods, which appear to satisfy the development of constructions projects.

Construction always face low productivity with other industries due to poor planning and co-ordination problems. BIM is a process which is used to overcome these problems by controlling co-ordinations between project team members, making design more clear, presenting a full information about design process and showing most conflicts between disciplines before performing construction process so that conflicts will be solved before starting construction process.

Applying BIM process will make project more productive depending on how BIM process is circulated and managed from project members. Improvement of productivity will appear and affect construction process according to many indicators that show productivity improvement. Key indicators of increased and Improvement productivity are reduction in RFIs, minimization the amount of re-work, compliance of project time schedule, and reduce of changes resulted from conflicts plan.

2. History of Building Information Modeling

Three-dimensional space that used in modeling based on geometric and parametric modeling or three-dimensional shapes include a volume was developed in the late 1970's and early 1980's. Early software used for modeling was difficult for users to use because they were used to two-dimensional modeling tools. It was also too expensive and computers where often not have powerful and qualification enough to meet requirements needs and support the operational.

	2D/3D CAD Drawing	3D Model
System	Vector-based drafting system	Three-dimensional representation of an object as solids and/or surfaces
Geometry	Independent geometries drawn in any sequence irrespective of their meaning (e.g. symbols for a wall and a door can be drawn independently)	Dependent parts modeled in the sequence that resembles the creation of the physical part. (e.g. in order to place a door, first a wall must be present)
Geometry updates	Manual updates to the geometry result in corresponding updates to dimension values	Geometry can be changed by controlling the dimensional values
Constraints	No constraints or relationships between geometric-primitives (typical, can be programmed)	When assembling components, constraints or "rules" can be placed on components to restrict their movement
Updates	Updates to one view do not propagate to the rest of the views (e.g. changes in plain view have to be manually edited in the elevation or 3D view)	Changes are made to the object; hence, corresponding updates to all views happen simultaneously
Data	Data reuse is in the form of "blocks" placed as external references or "Xref's" to the master drawing	A project file is typically associated with a "library" file path, which stores parts or assemblies of components

Table 2.1 - Drawing vs. Model - 2D to 3D Comparison

Building Information Modeling has only started in the last ten years in Middle East, however, BIM gain more popularity into the mainstream market in construction.

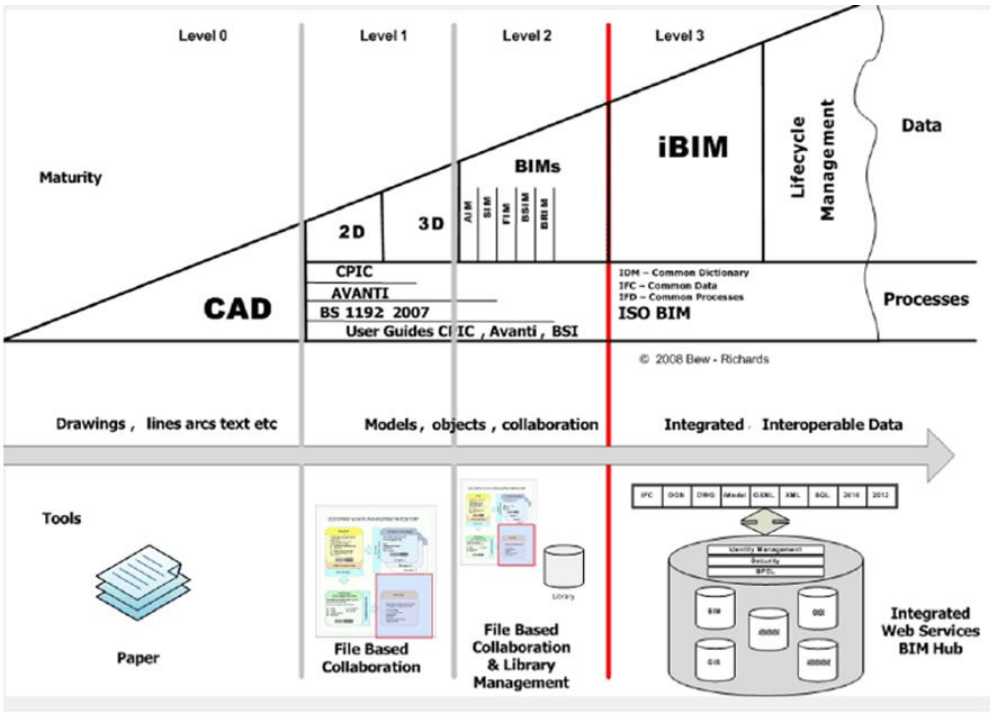

Figure 2.1 - BIM maturity diagram (UK Government BIM strategy document)

3. Managing Design and Construction Processes

Coordination in design stage is a key to reduce conflicts and clashes in production processes on building projects. Construction clashes that result from miss co-ordinations between systems is source of production disruptions. The risk of miss co-ordinations problems is highest on construction building projects that have utilities such as mechanical, electrical, and plumbing requirements.

In multiple building construction projects, the coordination process between disciplines is most often performed by comparing or combining shop drawings in a squad check or co-ordinations meeting.

Co-ordinations between drawings of all disciplines such as architectural, structural, mechanical, electrical, and plumbing performed and detected by visual inspection, so some clashes and conflicts between disciplines may be avoiding or neglected and this will reflect and appear during construction.

New co-ordinations technologies such as three dimensional and four dimensional modeling try to improve coordination efforts by making design clashes and conflicts more visible to designers and construction planners.

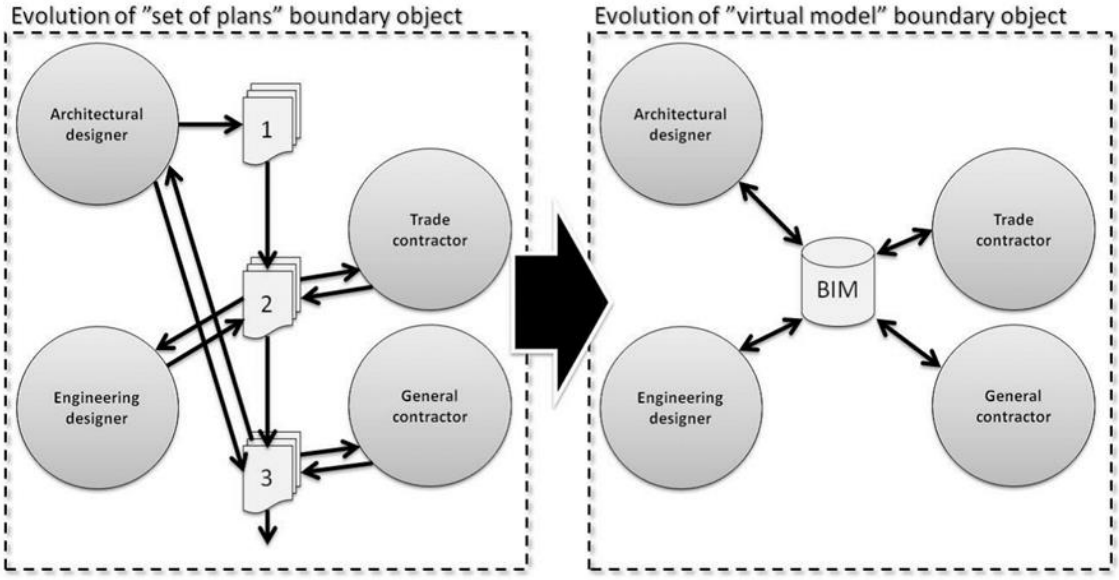

Figure 3. 1 - Coordination process from set of plans to virtual model

4. Design and Construction Processes as an Integrated System

During the planning of any construction projects, it is important to know the close link between design process and construction process. These processes should be presented as an integrated systems. Design process is a process of making the description of a new facilities, usually presented by detailed drawings plans, specific and general specifications with bill of quantities.

For making design and construction as an Integrated System, the planning for both design process and construction process should perform almost together. Review and find various alternative for design and to achieve constructability may be perform to achieve value engineering for project.

Many projects owners resort to new methods and technologies as trials to overcome about project risks with designers and contractors. Consequently, the designer's engineers and contractors are also more need to find new techniques in order to reduce the project time schedule and total cost of implantation. Usually, owners typically send a conceptual design to contractors, and contractors start to prepare detailed designs,

which are checked and reviewed by the client's engineers. Detailed designs may have many proposals, and contractors may also prepare detailed designs for alternatives.

5. How Building Information Modeling Improve Design Process

Generally, building information modeling help design members during project life cycle in quality of design, analysis of design, improving design schedule, improving communication collaboration and documentation, But how building information modeling make design members (Architecture/Engineering) during project life cycle achieve previous items?

5.1. Visualization

Building Information Modeling (BIM) is considered as a great visualization technology that can provide a virtual view and visualization of the building, the construction members can take renderings, walkthroughs, and the model sequence to make better collaboration and communication during the bidding phase of the project.
Some design engineers find that it difficult to understand concept of the project easily that reflect in the design of building and its requirements. Visualization provides design engineers by a better understanding of the final project how will look like.
Generally, visualization help and support design engineers for better understand, improve sense of decisions making and increase collaboration and communication among the project.

5.2. Three dimensional Coordination

Collaboration and coordination between the owner and the construction members with the design members are preferred to be implemented on first phases of design phase.
If the design team members are only providing two dimensional drawings, then the construction team members should convert the two dimensional drawings to three dimensional intelligent models. Contractors, especially the fabricators and the mechanical, electrical, plumbing contractors need to coordinate their work. The three dimensional coordination process can be started after the model is created to make collaboration and coordination represented in making visual , clearance and hard clashes and to ensure that conflicts are Identified and resolved.

Overall, collaboration and coordination between the construction members and contractors early before starting construction process helping to reduce design errors and make better understanding for time they need to finish work.

6. How Building Information Modeling Improve Productivity

A main advantage of applying BIM is it needs better and earlier building design which help in increasing efficiency of productivity rates, which make the time schedule of overall project reduced.
Building information modeling process help in making most decisions of design happen in earlier phases of the project. As components of construction are modeled and detailed in three dimensional, there are little conflicts and clashes in plans and this help in making more understanding and knowing of what is to be built before implementation of the actual construction process.

Building information modeling is used to make actual coordination between components of complex building and help in decreasing the number of clashes and conflicts. Co-ordinations make the amount of delays and rework decrease which resulting directly in cost overruns.

Many Case studies in building information modeling show that efforts and time spent on the BIM models before starting construction process help in reducing the number of delays and changes. Also case studies show that applying BIM process decreases number of requests for information (RFI) because the project after co-ordinations becomes more understood and clear. (Kymmell, 2008; Hardin, 2009; Smith, 2009; ET)
Building information modeling is a smart tool that the contractors can used it to increase their productivity rates and making actual cost estimation, all of these reflect directly in turning a profit for the contractors. Best practice of large firm show that the contractor gains a twice to third times payback when using BIM in their projects (Post, 2008).

7. Building information Modeling for Construction Managers

Construction managers start his job officially when site start to work, project time scheduling and organization structure of project is the main responsibilities of construction managers. As construction managers try to find the ideal methods to improve work path in construction project, they involved in any new technologies help to improve and make development for work. BIM is one of the new technology help to improve performance and productivity of project.

Building information modeling help construction managers in multiple tasks such as calculate and itemize bill of quantities of project to prepare actual cost estimation, also BIM models can support three dimensional view and renderings which help in co-ordination and visual inspection . When time project schedule and manner planning integrated with BIM known as four dimensional.
Building information modeling can used for time project schedule, safety analysis, making building presentation and animations, and preparing logistic site plans. Construction managers can use BIM in different ways such as coordination, finding clashes and conflicts of construction work between all disciplines of project with subcontractors which help to improve productivity and reduce time waste in construction project which affect directly in total cost of project. They can also update project time schedule and costs values with BIM models.

Finally, it can help construction managers to improve and make full control in construction projects and help in turning over an as-built BIM model to the owner's design members.

8. Co-ordinations between Design and Construction using BIM

After final coordination between all disciplines participated in project, the design stage is completed and construction stage will be ready to begin. , throughout design stage, cost estimating and time project scheduling were automatically updating according to any changes occurred during coordination phase.

The construction manager, engineers and field superintendent will work with the design team members to make sure that the design purpose is followed, and clash detections on

all models have run between all discipline models. With monitoring and workflow tools, clashes and problems that identified can be tracked, found and reported.

Using BIM correctly and with execution plan during all phases of a project will reflect directly on number of RFI in comparison with default number of RFI sent with ordinary design and construction.

Building information modeling has created a direct link and connection between design members and construction members that had never been happened before. Instead of trying to find and asking how we can get structural, architects, MEP engineers, construction managers and construction engineers to collaborate efficiently, Now trying to find and asking how can use Building information modeling for making the process even faster , accurate and more efficient.

9. Suggestions for improvement BIM in Egypt

After finishing the current research work and realizing that BIM is very important and it is the coming technology in AEC industry , we can put some outlines that help in improve applying BIM in Egypt as following:-

- Force companies to apply BIM in projects that have large areas and more utilities.
- Create code of practice for building information modeling.
- Create clear BIM strategy plan for companies and building organizations.
- Create execution plan, standards and guide plans for applying BIM in projects.
- Start to make BIM educational content that may considered in project management course in engineering faculties.
- Create annual scientific conferences in Egypt and we can invite most experienced persons in BIM.
- Study best practice for countries that have experience in BIM such as USA , UK , China , Singapore ,…etc
- Make information exchange with the previous countries that more experience than us in BIM.
- Create training courses for using BIM Software Such as Revit, Micro station, Graphi soft software… Etc
- Help more engineers to make their researches and studies in BIM.
- Translate MSC, PHD and technical Papers related to BIM into Arabic Language to make understanding concept of BIM easier.

10. Conclusions

Based on the research process obtained, the following conclusions were furnished.

- Building information modeling significantly improve collaboration and coordination between project team members during project process whether design process and construction process.
- Applying building information modeling (BIM) process will increase productivity of project, the volume of increase depending on how applying building information modeling (BIM) process is circulation and managed from project team members.

- Many engineers have wrong information’s about building information modeling.

- Architectural Engineering Construction AEC industry is not yet clear enough of what building information modeling actually is its effects in industry and its benefits.
- Using building information modeling allows companies to win more work.
- Clients increasingly insist on building information modeling adoption.
- Power of building information modeling is not in software's but in execution plan, good planning and additional training necessary to use building information-modeling tools.
- The most benefited from building information modeling is wrong expression because stakeholder of Architect Engineering Construction AEC industry whether owner, design team members and construction management members get benefits from applying building information modeling.
- Building information modeling can mandate the Architect Engineering Construction AEC industry in Middle East through next five years at the most.
- Building information modeling standards, manuals and workflow with execution plan are the main items for any firm that try to access towards building information modeling.
- Most firms try to access building information modeling, but they have not knowledge for starting.
- Building information modeling is the future of project information management.

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