A Statistical Analysis of Building Information Modelling in Project Management

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Abstract- *Building Information Modeling (BIM) is becoming a comprehensive collaborative process in the construction industry. Despite its short history, BIM has had an increasing growth during the last decade. This is happening mainly due to its capabilities on construction projects. BIM can create a common language between all parties and system divisions in a project and make them an integrated team. The approach of BIM strongly matches with integrated project delivery systems. The role of BIM as a coordinator of project system is quite similar to the duties of a project manager. BIM integrates different disciplines by effective communication, analyzes the project systems for constructability, estimates the cost and time of projects at any time using quantity takeoffs, draws a big picture of projects using visualization and builds collaborative teams. All these are what a project manager does in a different scale during a project life cycle.*

This paper aims to show the correspondence of BIM and project managers' roles on construction projects. It emphasizes the importance of having proper BIM knowledge and experience for project managers to succeed. This paper also discusses the requirements of BIM knowledge and experience enrichment of project managers.

Keywords- Building Information Modelling, Project Management, Construction

I. INTRODUCTION

1-1. History

Building Information Modelling (BIM) can be defined as a reliable, digital, three dimensional, virtual representation of the project to be built for use in design decision-making, construction scheduling and planning, cost estimates and maintenance of construction projects (Words & Images, 2009).The BIM Handbook (2008) defined BIM as a computer-aided modelling technology for the purpose of managing the information of a construction project focusing on production, communication and analysis of building information models. The National Building Information Model Standard Project Committee defined the BIM as following: "A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward."

The concept of BIM theoretically emerged and was developed at Georgia Institute of Technology in the late 1970s and grew rapidly after that. The growth happened because of the increasing attention paid to construction teams and firms that found merits in using BIM in order to integrate the process of the construction projects and managing them. The term Building Information Modeling was first used in 2002 to describe virtual design, construction and facilities management (Harris, 2010).

Graphi soft in 1986 introduced its new software as a solution for virtual building. This software, Archi cad, was really a drastic improvement in CAD programs of that time since REVIT allowed the creation of three dimensional (3D) models of projects (Dey, 2010). The terms Building Information Modeling and Building Information Model and the acronym of BIM were widespread when Autodesk released the "Building Information Modeling" (Autodesk, 2003).

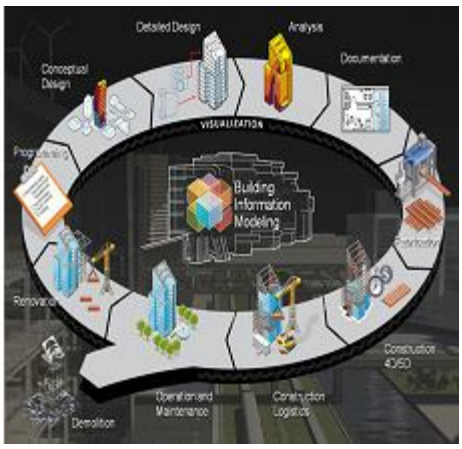

Fig No.1 Process in BIM

1-2. Construction Project Management

Construction projects constitute the main part of all disciplines projects due to their amount, variety and cost. The U.S. Census Bureau News (2013) estimated that the construction industry would spend more than $874 billion in 2013. These projects range from small residential or retail projects to mega multifunction projects. Needless to say, with any scale of a construction project, there is a necessity for managing it. The management of construction projects requires knowledge of modern management as well as an understanding of all construction processes. Along with the change in technology, organizational arrangement or procedures and new features and methods, the management of construction projects differs (Hendrickson, 2000). Construction project management is a series of activities for determining how, when and by whom the work, including all life cycle activities, will be performed.

Similar to the Project Management Body of Knowledge (PMBOK) definitions, the construction project manager handles project management planning, cost management, time management, quality management, contract administration, safety management and risk management. The project manager is also in charge of communication between all stakeholders on the project including owner, designers, engineers, professional crew and administrative staffs. Generally, construction project management shares the common and overall characteristics of general projects, therefore, the rules and methods required for general project management can be applied to this type of projects.

II. BUILDING INFORMATION MODELING ASPECTS

Technical Aspects of BIM

BIM has some specific features that can effectively be used in project management. These features, which are increasingly developed, can be summarized as follows (Lahdou & Zetterman, 2011):

- **Clash Detection**

One of the common problems of different disciplines' plans for a construction project is the geometrical design inconsistencies. This issue happens when there is an overlap between the plans of different disciplines.

Using BIM, it would be possible to bring the plans together and detect the clashes. Modifying the aesthetic problems is another possibility of this visual checking.

- **Constructability**

Using BIM, it would be possible for teammates in a project to review and handle constructability issues and (if needed) promote issues into RFIs. In addition, visual information can be provided from a vantage point to show the problems. This visual information accompanying markup allows further investigation for finding solutions and, thus, mitigates the risks.

- **Analysis**

Helping the project managers, designers and engineers in doing more analyses and enabling better decision making is another aspect of BIM. By linking the building information models to appropriate tools, it would be possible to analyze the energy consumption of a construction project and then find better solutions such as changing materials and orientation, mass and space, etc. Moreover, light, mechanical and acoustics analyses are also available to be performed by BIM.

- **Time & Cost Estimation (4D & 5D)**

Time and cost estimation are other features of BIM which enable project managers to visualize the construction project at any point in time and have a clear understanding of project phases. Time and cost estimation, which are generally called 4D and 5D, can be properly utilized in the first stages of a project and facilitate the decision making process with minimum cost and time needed. Furthermore, BIM has the capability to simulate the various alternatives for a construction project and hence helps project managers and executives to reliably predict the consequences of their decisions.

- **Integration**

The project team can deal and interact with a unified model when a composite model is built from an amalgam of various disciplines' models. Having this capability, and through the different phases of a construction project, BIM can coordinate the design, analysis, and construction activities on a project and, therefore, results in integrity of projects.

- **Quantity Take-off**

Quantity takeoffs in a BIM model can be very helpful for the project teams and managers to analyze their decision and have a clear and reliable insight to various alternatives in the design phase or even throughout the project lifecycle. Since there is a possibility of integration between the BIM model and a database

III. ROLE OF BIM IN PROJECT MANAGEMENT

3-1. BIM vs. PMBOK Knowledge Areas

Capabilities of BIM on construction projects correspond to the PMBOK knowledge areas, since the nature and role of each item are alike. Therefore, BIM can be considered as an effective and powerful tool in project management in the construction industry.

Integration management is the first area of PMBOK, which has the same function as the BIM. BIM integrates the documents, plans and efforts of all parties involved on a project. BIM is also an object-based environment that can categorize different elements of a building and break it down into different groups, like what occurs in project scope management. Another characteristic of BIM is its capability in managing time and cost or what is allegedly called 4D and 5D. This is similar to project cost and time management areas in PMBOK standard. Although the constructability does not illustrate all risks associated with a construction project, it is a powerful tool in building a project and mitigates the construction risks. Clash detection in BIM acts as a quality process which visually recognizes, modifies and analyzes the soft and hard clashes. Collaboration and team building in BIM is what human resource management considers as a project management area. Communication is a main feature of BIM which facilitate the professional relationship between all parties including project managers, designers and engineers on a construction project by creating effective and direct communication channels. Finally, procurement management would be possible by quantity takeoffs which are produced by BIM. In addition, changes in any item can be easily reflected in cost and timeand work needed for its procurement. In spite of the extensive framework of project management, BIM can be presented as a main and effective concept corresponding to project management knowledge areas. Figure 2 shows model of PBOK knowledge areas considering BIM on construction projects.

3-2. BIM Benefits and Advantages

Different sources of construction project management identify key advantages of using BIM as follows (Qian, 2012):

- “Enhanced project collaboration and control among stakeholders
- Improved productivity (less re-work, conflicts and changes)
- Better project quality and performance
- Faster project delivery
- Reduced wastages
- Reduced construction costs
- New revenue and business opportunities”

BIM Tools available for construction practice

There are plenty of Building Information Modeling tools. This subsection will identify these products. The following table, figure 8, depicts the BIM authoring tools and their primary functions. The list includes MEP, structural, architectural, and site work 3D modeling softwares. Some of these softwares are also capable of scheduling and cost estimation.

Product Name	Manufacturer	Primary Function
Cadpipe HVAC	AEC Design Group	3D HVAC Modeling
Revit Architecture	Autodesk	3D Architectural Modeling and parametric design.
AutoCAD Architecture	Autodesk	3D Architectural Modeling and parametric design.
Revit Structure	Autodesk	3D Structural Modeling and parametric design.
Revit MEP	Autodesk	3D Detailed MEP Modeling

FLOW CHART FOR BIM

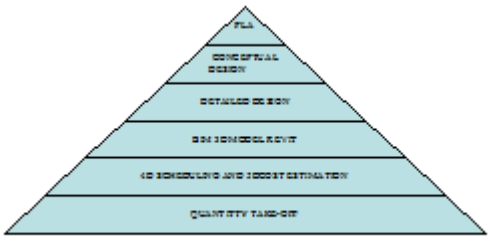

Table1: flow chart

CASE STUDTIES

Project name: Casa Magayon
Type: Residential
Location: Guanacaste, Costa Rica
Year: 2015
Size: 13,900 ft2
Software used: REVIT

Casa Magayon is located in the Península Papagayo

Resort, Guanacaste, Costa Rica, with a construction area of 1,290m². The residence is a tropical interpretation of the classic "Glass House" by Philip Johnson. Basically, the design was structured in a modular way, based on independent cubes with large, floor-to-ceiling glazed surfaces, and connected to each other by bridges that form open-air passageways, allowing constant contact with the environment. This strategy was also used as a sustainable element, since it reduces the amount of air conditioning, and allows it to operate in a modular way, consuming energy only in the spaces being used. The project is a luxury residence for vacation and to rent when the owner is not there. The residence minimizes energy consumption compared to many other examples within the resort, without compromising on luxury and finishing.

Casa Magayon modeled in REVIT

Casa Magayon was modeled entirely using REVIT, from its initial concept; the entire 2D documentation process was generated from the "live" REVIT model, with absolutely no content drawn in 2D. During the process, MEP was also incorporated to model the air conditioning and storm drains to confirm that there were no collisions. All the built-in furniture is modeled entirely in REVIT, with the assistance of the Cadimage Cabinets tool. Teamwork was incorporated throughout its development process, and BIMx was used as an essential communication tool with the client during the construction process and on site.

Fig.2 Revit Architecture Model

Fig.3 Revit MEP Model

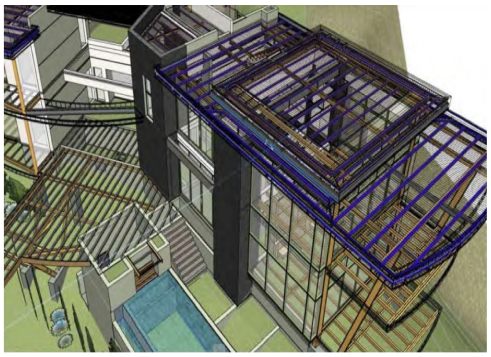

Fig.4 Revit STRUCTURE Model

Fig.5 ACTUAL CONSTRUCTION

RESULT AND DISCUSSION

A G+4 proposed residential building has been taken for BIM analysis schedule is prepaired to import in BIM model and cut sections, 3D BIM is prepaired in BIM

TOTAL SCHEDULED DAYS	266 DAYS
SITE CLEARANCE	2DAYS
COMPOUND WALL	1DAYS
SETTING OUT FOUNDATION AND PITS	3DAYS
DIG OUT(KHODAI)	1DAYS
PCC	1DAYS
BAR BENDING	2DAYS
COLUMN ERECTION,CENTERING,FORMWORK	2DAYS
CASTING OF FOOTING	4DAYS
CHECKING OF PLINTH LEVEL	1DAYS
PLINTH BEAM	4DAYS
MURUM FILLING,COMPACTION	4DAYS
PCC LAYER	2DAYS
COLUMN STARTER	1DAYS
COLUMN ERECTION,CENTERING,FORMWORK	2DAYS
BEAM BOTTOM WORK	2DAYS
SLAB NO.1	21DAYS
SLAB NO.2	21DAYS
SLAB NO.3	21DAYS
SLAB NO.4	21DAYS
BRICK WORK	30 DAYS
PLASTERING	15DAYS
ELECTRIFICATION	15DAYS
TILING ,PLUMBING,WATER PROOFING	30 DAYS

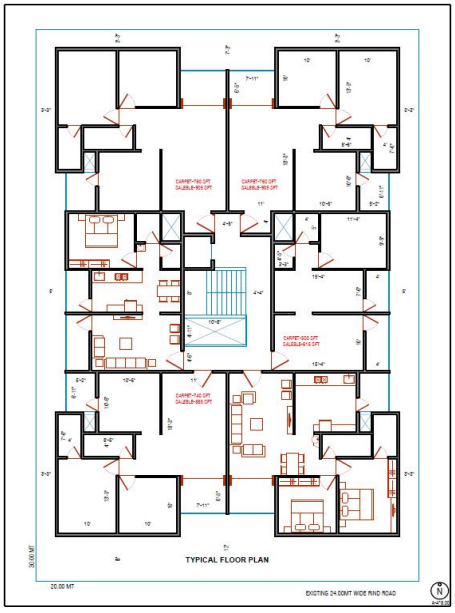

Fig.6 REVIT PLAN model

Fig.7 revit architecture model

Fig.2 revit CUT SECTION model

IV. CONCLUSION AND RECOMMENDATIONS

This papers studies effectiveness of building information modelling for effective project management and to reduce cost overruns. The following conclusion can be drawn after questionnaires survey and case studies

- The project studied six BIM utilization activities: visualization, 3D coordination, cost estimation, prefabrication, construction planning and monitoring, and record model. The visualization is generally the simplest use of a Building Information Model such as renderings

- As soon as the Building Information Model are produced, the quantity takeoffs can be generated to provide cost estimations on a construction project. Furthermore, the 3D coordination was utilized to detect and eliminate trade clashes and conflicts. In addition to that, detailed prefabrication drawings can be generated to review and coordinate work between trades.

- Once the drawings are designed to build, the prefabrication of the components of the construction facility can be built to design. BIM based 4D scheduling

helps understanding of the construction components and schedule progress that in turn results better construction planning.

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