Building Information Modeling (BIM) Application in Architecture, Engineering and Construction (AEC) Industry

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Abstract— The Architecture, Engineering & Construction (AEC) industry has a long chase to overcome the barriers of conventional method come from project cost overrun, poor productivity, quality, and extended time. Building Information Modeling (BIM) offers the traditional approach to overcome these drawbacks in a highly integrated fashion with efficient and effective collaboration between all stakeholders. As a result, it has been acknowledged as one of the rising trends in the contemporary construction industry. However the use of BIM has not been limited only in the building construction industry, also rapidly growing for almost all type, scale and size of built environment projects. It has now exhibits promising trends to all other construction works such as bridge, roads, power plants, industry facility and so on. BIM is Single file concept collaborating various database of the project at one platform. It is a data repository for building design, construction & maintenance information combined in one convenient model to share with all the stakeholders. 3D visualizations allow customers to see historic preservation & site context with respect to the new project.

This paper highlights perspective of a planning engineer with respect to Conventional method & BIM and gives a methodology to prepare a 4D simulated model of a Gr. (Stilt) + 16th Floor residential building taking 4th dimension as time. Furthermore it includes case study references to exploit the rational findings of BIM.

Index Terms— AEC Industry, Building Information Modeling, Conventional method, Data Repository

I. INTRODUCTION

In the Architecture, Engineering, and Construction (AEC) industry, diverse people, processes and materials are brought together to construct projects that are becoming increasingly complex. Effective planning is one of the most important aspects of a construction project and influences the success of a project. Construction industry suffers with a lot of problems comparing with other industries. The reasons behind these problems are unique nature of projects, paper-based drawings and fragmentation of work and activities from involvement of different discipline and stakeholders. Technological revolution has reshaped and reengineered the construction industry with new ways of working. Construction projects are unique and a prototype within themselves. Involvements of multi-disciplinary teams often make clashing among their methodologies (e.g. working process, design review, constructability etc.). Moreover errors and omissions in paper based design documents, communication gap with other stakeholders; schedule conflict, delays and unanticipated field cost are also major concern for lower productivity of the industry (Eastman et al., 2008). 4D modeling is the integration of a 3D model with a construction schedule in order to visualize the sequence of construction. 4D models can be created to various levels of detail, from high-level zone analysis during the design phase, to detailed subcontractor coordination during construction. The same model can be updated and maintained throughout the project based on the updated schedule and 3D model.

II. BIM DEFINITION

Defining BIM is difficult because it refers to software tools, an independent created model.

BIM refers to a relatively new technology that supports visualization and communication of building design and construction processes. Rather than a software, BIM is "a systems approach to the design, construction, ownership, management, operation, maintenance, use, and demolition or reuse of buildings" (Smith, 2009). The most important part of BIM is not the software functionality, but collaboration in the design and planning process which speeds the process and clarifies design (Onuma, 2008). Depending on context "BIM" may be used to represent either of these definitions in this work.

III. THE FUTURE OF BIM

BIM usage is anticipated to continue to increase rapidly from the estimated 2-3% of the firms in the AEC industry that use BIM in a meaningful way (Bernstein, 2005). Since 2007 The Government Services Administration (GSA) and the US Army Corps of Engineers requires all physical facilities built for the government to be modeled. The effect of just these two government programs is enormous! More private owners are also requiring the use of BIM in order to increase efficiency of the building, lower costs and to enable more creative designs. High-profile projects such as the Ocean Heights Tower designed by Aedas in Dubai, 2008 Beijing Olympic National Stadium (the Bird's Nest) designed by Herzog & de Meuron, and the Frank Gehry designed Disney Concert Hall in Los Angeles have brought more attention to construction styles and types that were impractical without the use of BIM.

Once BIM has been utilized on a project, its results speak for themselves and "firms that have switched to BIM don't switch back" to 2-D (Zeiger, 2008). Many jurisdictions are pushing to adopt BIM plan checking, which will further push architects and contractors to produce models for faster approval (Wible, 2009). Virtually all stakeholders are adopting BIM usage to some degree. Ideally, BIM will become a central part of the organizational structure of the design, build, and operation process including all aspects of the lifecycle of the building. All data pertinent to the project should be included and accessible to parties that need the information.

IV. BIM HISTORY

3-D shapes enclosing a volume was developed in the late 1970's and early 1980's. Before modeling software was difficult for users to use because they were used to 2-D design tools. It was also expensive and computers where often not powerful enough to support the operational needs of the software. Since the 1990's, mechanical and steel trades rapidly embraced the modeling tools because their fabrication processes utilized the model's output very efficiently. With the advancement of computer speed and memory, designers and other contractors began adopting BIM to integrate the various components of the building. In the last decade tools available to the AEC industry have been able to relate connected components in a defined space and include information about the object being modeled. BIM has only in the last five years, however, gained enough popularity and break into the mainstream market. For a more thorough discussion of the history of BIM see BIM Handbook – A Guide to Building Information Modeling written by Eastman, Teicholz, et al. (Eastman, 2008).

Some firms claim to be using BIM but are doing only 3-D images with no real ability to aid in construction planning. These are useful for visualizing finished appearance, but nothing more. (Eastman 2008) defines what BIM is not. These are needed so that actual BIM usage by firms can be evaluated:

1. Models that have only 3-D data but no object attributes or intelligence at the object level.

2. Models with object definition but no proportion or positioning because they have no parametric intelligence.

3. Models composed of multiple 2-D CAD that must be combined. Intelligence with respect to relationships cannot be guaranteed.

4. Models that allow dimensional changes in one view that are not automatically reflected in other views.

There is no single software tool that performs all functions listed above, although several are approaching. Most firms prefer to use an authoring tool that is best suited for their needs rather than to work with a totally integrated systems which is slower and less intuitive.

V. LIMITATIONS OF BIM

A. Cost of Software and Hardware

Every organization currently utilizing 2D or 3D CAD drafting software can attribute a cost element against purchasing, maintaining and upgrading software licenses to keep a competitive market advantage. Current trends show that the cost of BIM software packages tends to be more expensive than CAD software packages available on the market.

B. Cost of Training

With new software, there is a great demand to train staff quickly so that the investment can be justified. It is not realistic to assume professionals with CAD proficiency will be able to learn new BIM software quickly or without specialized training. Given the fundamental differences between BIM and CAD, training should be considered a requirement for all professionals involved with designing and producing documentation.

C. Transition from Drafting to Modeling

When moving from a CAD-based drafting environment to a BIM-based modeling environment, a change in the workflow will surround what used to be simple drafting tasks such as copying markups or picking up redlines. These tasks now require a higher-level skilled design drafter who has an understanding of the project and the materials used. The costs associated with training and maintaining a skilled design modeler are higher than a draftsman with no knowledge of the trade. Some companies may even be compelled to stay out of the BIM world altogether due to the time- and knowledge-intensive nature of BIM.

Industries have a few different business models to consider when thinking about staff training with respect to BIM.

1. It involves the training of current designers to undertake all of their design work in the BIM environment.

2. It involves up-skilling all of their staff to a higher technical level to undertake design responsibilities.

3. It is a combination of the first two where there is a specific set of rules and guidelines for mark-ups so that design mark-ups can be translated into the model clearly and efficiently.

D. Innovation

Since a goal of BIM is to assign constraints and parameters to intelligent objects to improve efficiency, there is a potential to inhibit innovation which would possibly otherwise occur without the automated processes and shared knowledge that BIM now provides. Those firms implementing BIM should view the parameters and metadata constraints as a global database that allows designers to save time associated with updating and configuring product-specific data repetitively on different projects, hence increasing the amount of time spent on system design and innovation.

VI. METHODOLOGY ADOPTED AND CASE STUDY

Table 1: Project Case Study Details

Name of Project	Proposed redevelopment property of plot bearing C.S. no. 2031
Structure details	Gr. (Stilt) + 16th Floor Residential Building
Location	Building no. 162-164-166, 2nd Fanaswadi at Sitaram Poddar Marg, Bhuleshwar division- 'C' ward, Mumbai, 400002
Name of Client (builder)	M/s Gini Citycorp Realty LLP
Name of Architect	Jangid Architects
Name of Structural Consultant	Con Arch India
Name of Contractor	M.R Construction
Project start & end	September 2014 to January 2016
Project Duration	16 months

Various software used for making a 4D model are AutoCAD 2013, Autodesk Revit 2013, Microsoft Project 2007/Primavera, Autodesk Navisworks Manage 2013.Following are the steps for creating a 4D model.

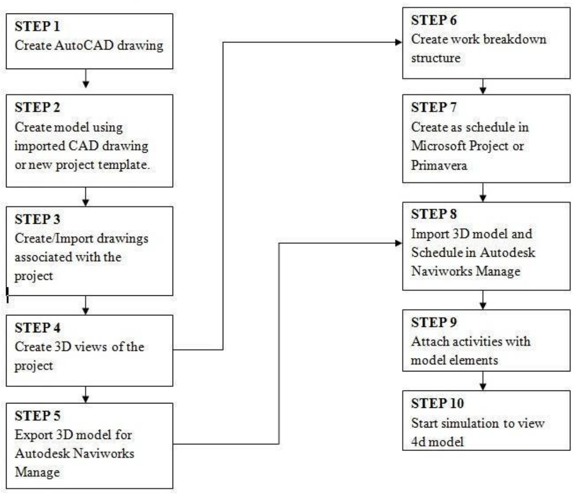

Fig 1: Design and Information Flow Chart for Creating 4D

1. Creating Architectural Design Drawing by using AutoCAD 2013.
2. Creating a 3D model by using Autodesk Revit 2013 by starting using a new template file or importing 2D CAD file and then raising model on it.

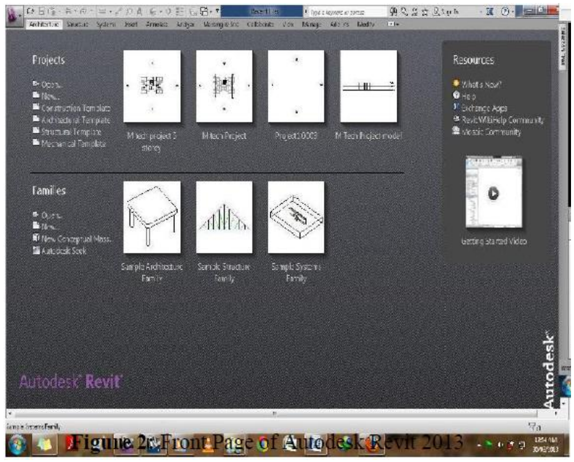

Figure 2: Front Page of Autodesk Revit 2013

3. Creating an orthographic 3D view by pressing a home shape button in the view tab. Different 3D views can be viewed by rotating the cube.

Fig 3: View Cube for 3D

4. Exporting the model from Autodesk Revit 2013 while it is opened in 3D view to link it further to make it as 4D model.

5. Creating a Work Breakdown Structure (WBS) for the given model and accordingly prepare schedule in Microsoft Project 2007/Primavera.

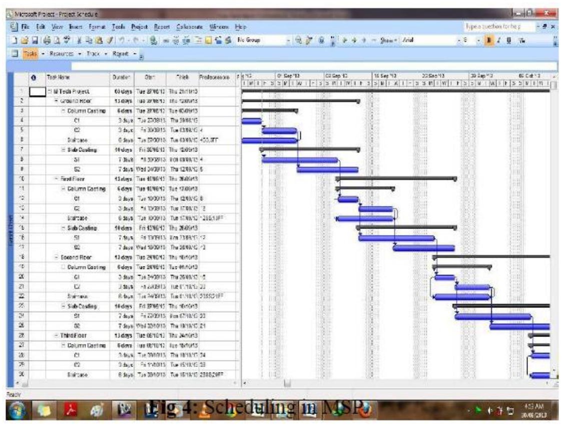

Fig 4: Scheduling in MSP

6. Import the 3D model file and construction schedule in Autodesk Navisworks Manage 2013.

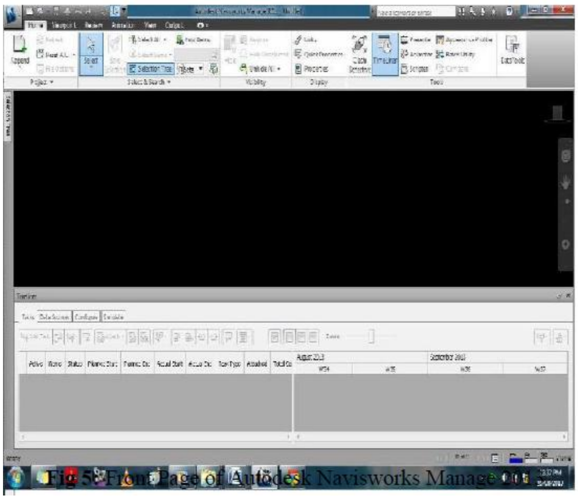

Fig 5: Front Page of Autodesk Navisworks Manage 2013

7. Link various scheduled activities with the 3D model.

8. Configure the settings for the project in the simulation tab.

9. Start the simulation for viewing the 4D model.

VII. DISCUSSION AND SUGGESTION

In the construction industry a higher productivity rate in the field will lower costs for the entire project. Productivity on the site is affected by the amount and quality of planning and coordination done before any work begins on site. Projects vary in complexity, team experience, budgets and other factors such that each has differing planning and coordination needs.

Knowing how various BIM process elements affect these rates will enable owner and contractors to intelligently and responsibly plan the appropriate amount of time and money to be spent at the project level. The purpose of this work is to make a decision making model that will help in this process.

However, Building Information Modeling is a team based work; in this paper study is restricted to civil engineering construction planning & scheduling by creating a 4D model. Current model can be further enhanced by adding various databases from other fields also like Mechanical, Electrical and Plumbing (MEP) etc. In this paper 4^{th} dimension is considered as time, further other dimensions like cost, resources, materials etc. can be taken as nth dimensions and thus creating a 5D model.

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