



Research Article

BUILDING INFORMATION MODELING: A NEW PARADIGM CHANGE FOR CONSTRUCTION INDUSTRY

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ABSTRACT

In the construction industry, planning and scheduling are considered as an integral part of the project. The current scenario in the construction industry is the adoption of various software for planning, designing, execution and quantities take-off. Among the various software, the Building Information Modeling (BIM) has gained popularity in the construction industry. The Indian construction industry has not gained popularity with the BIM, so this study aims to simplify implementation of BIM for Indian construction industry. BIM involves the generation and management of digital representation of physical and functional characteristics of the structure. The case study involves proposed commercial complex for Palghar district. The study involves the development of a three-dimensional (3D) model in Autodesk Revit Architecture 2016 for architectural drawing, followed by the Microsoft Project 2013 for scheduling the activities for construction and simulation of four-dimensional (4D) model i.e. (3D + time) in Autodesk Navisworks Manage 2018. This study provides a stepwise procedure to develop a 4D model, with the expectation that it will allow the planners to visualize the construction with a passage of time at the planning stage itself.

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INTRODUCTION

For construction projects planning, scheduling, designing, and execution form an integral part. As of for the planning and designing stage, the interpretation of the sequence of activities and manipulation of data and knowledge is highly required by the planning manager. The current planning procedure is based mainly on a two-dimensional drawing (2D) and construal of sequencing of activities to carry out work an early planning stage. The process is often time-consuming and not very useful as the design difficulties commonly befall at a later stage of execution. For this reason, a building information modeling tool is required throughout the life-cycle of the construction project. Building Information Modeling (BIM) is three-dimensional (3D) digital representation of a building and its characteristics at the early planning stage. The Architecture, Engineering, and Construction (AEC) industry has waited for a long-sought technique to decrease the project cost, increase productivity and quality of the work and reduce the project delivery time; and BIM offers a potential to deliver these objectives, Salman. A, (2011). The ability of BIM to virtually simulate the construction prior to actual construction provides an effective means to check its constructability in the real world and resolve any uncertainties prior to the execution of the construction, Patrik. B *et al.* (2013).

This study aims to provide the owner, architects, and the out workers with the useful empirical data for utilizing the Building Information Modeling technology in the construction projects.

Objective and Significance of the work: The purpose of this study is to demonstrate the modeling of the building project by means of the Building Information Modeling technology. The project is a proposed public building i.e. commercial complex for Palghar. The scope of the work is limited to 4D modeling (3D + time) for this study.

The objective of this study is listed below:

1. To carry a literature survey about BIM in the construction industry.
2. To prepare 3D Architectural drawing in Autodesk Revit Architecture 2016.
3. To simulate the whole project for 4D work in Autodesk Navisworks Manage 2018.

Following the objectives, the significance of the work is as follows:

1. To make the stakeholders involved in the project aware of the benefits of using BIM for the project.
2. To enable the owner to develop an accurate understanding of the project.
3. Reduction of the manual data entry with a greater electronic information exchange.

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LITERATURE REVIEW

Adoption of a new technology in any industry poses a challenge, as AEC industry is undergoing under significant transition from two-dimensional (2D) Auto CAD drawings to Building Information Modelling. The base of this technology is, made up of the Graphical Information Modeling (GIM), covering the geometrical model building, names and functional components and physical properties, Rui Pedro, (2013). Building Information Modeling refers to, a virtual representation of a physical and functional characterization of a structure throughout the life-cycle of the project.

The American National Institute of Building Science defines BIM as "A facility whose physical and functional characteristics can be computable and project/ life-cycle related information be used by the open industry standards to notify business decisions and realizing better value, D. K. Smith & A. Edgar, (2006). Another definition is given by Bilal. S, (2009) as "A set of interacting policies, processes, and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building life-cycle."

Salman. A, (2011) from his work identified the various benefits, risks, and trends of BIM utilization within the AEC industry. Through the study, he stated that with the adoption of BIM collaboration between different project team benefits in cost reduction, improvement in productivity, improved management, and better client-customer relationship. As to gain such benefits it is necessary that the different project team be involved in the early stage to determine inevitably errors and inconsistencies in the plan. In another work Salman. A. *et al.*, (2011) demonstrated various ways planners and designer may use BIM to pursue LEED (Leadership in Energy and Environmental Design) certification and validating of the framework through a case study. For BIM-based sustainability analysis, they used Virtual Environment (VE)TM which is a more versatile tool for sustainable analysis. For which conclusion was made that no one-to-one relationship exists between LEED certification process and BIM-based sustainability because lack of LEED integration features in the existing software.

JVinoth. K. & Mahua. M, (2009) carried out a survey on acceptance of BIM tool in Indian construction industry. A questionnaire was prepared and expert advice was consulted for the support to acquire greater feedback from the industry. From the respondent, the author concluded the Indian industry is ready to adopt the BIM in the industry.

BIM as an emerging tool gaining popularity within the AEC industry, however, there is no instruction strategy of teaching BIM in the AEC related curriculum. So, Jeong. H. W, (2006) demonstrated residential and commercial design courses employing Autodesk Revit Building version 8.0, BIM-based software, to its current undergraduate students in Construction Management program. Followed by Jeong H. W, (2006), Rafael. S & Ronen. B, (2010) conducted a work of teaching BIM to Engineering Bachelor students as an integral part of their curriculum. For which, a course was introduced into curricula for the different semester with a fixed number of hours for lectures and practical dedicated for teaching BIM. For which they concluded, that BIM shall be taught to the students and not to the extension of CAD because if the students learn BIM they shall not require CAD.

In another work Rafael. S. *et al.*, (2010) demonstrated BIM in lean production management system for construction, where the production was hampered due to different targets set by the trade teams hampering the production rate because of lack of visualization in the workflow. Thus, with an implementation of BIM-enabled software Last Planner SystemTM, functional mock-ups were proposed to analyse the system shortfalls.

Kevin. C, (2005) demonstrated the use of 4D modeling benefiting to project completion within budget and time as compared to other similar projects not implementing BIM. Sheryl. S-F & Atul. K, 2007 demonstrated significance of 3D and 4D modeling in the execution of the project. Two case studies were carried out to validate the impact on BIM during the planning and the execution stage of the construction of the project. With the help of which the author was able to make a conclusion that with the implementation of BIM lead to increase in productivity, lesser cost growth, decrease in time from start of construction and elimination of field interferences.

Atul. P & Kausan. H, (2013) contributed their work to the adoption of BIM in the Canadian construction industry. A case study of 'Early BIM Partnering' for a publicly funded project, which used the traditional design-bid-build method with lowest bid procurement. Thus, realizing the potential of BIM the author suggested that with early adoption of BIM in the project improves the built of the model and clearance of execution problems as the same. Yu Cheng. L. & Yu-Shih. S, (2013) proposed a new and practical methodology with application to Facility Maintenance Management (FMM) using BIM technology. With the adoption of which, the maintenance staff can get access and review of the 3D model for updating maintenance record in digital format. Patrik. B *et al.*, (2013) with his research initiated for use of BIM in sustainable design & construction and fill existing gap of knowledge about the use of BIM. With the survey conducted with a questionnaire based on previous research and expert advice out of 123 respondents over half (51%) used BIM for over more than 3 years, while (63%) strongly agreed that sustainable design and construction practices are important within their company. But most still believed that sustainability is not a primary application of BIM and that project coordination and visualization instead were more important.

Zbigniew. K & Kepa. T, (2014) from the work came to a decision by using Autodesk Revit 2015, BIM with no doubt allows for the realization of every project and always these effects will be time-saving compared to the traditional workflows with CAD- 2D.

Thus, the application of BIM in the construction industry provides a wide range right from pre-construction stage to post-construction stage. As it creates a digital model with all the physical and functional characteristics of a building in virtual world prior to the construction of a project, it makes the planner understand with shortfall in construction at early planning stage itself. With a review of the literature survey, Rafael. S & Ronen. B, (2010) in their work mentioned about teaching BIM in Bachelor of Engineering curricula with theory and practical sessions, Jeong. H. W, (2006) demonstrated the residential and commercial design for undergraduate students of the construction management program while Zbigniew. K & Kepa.T, (2014) in his work mentioned about stepwise procedure to form a 4D model. Limiting the research for the

stepwise procedure for creating a 4D model, this study aims to bridge the gap for the same.

Development of the BIM model

Generation of the 3D model

The development of the 3D model can be started using the Auto CAD 2D file and importing it to the Autodesk Revit Architecture 2016, or else 3D model can be directly generated in Autodesk Revit Architecture 2016. The plan of the building shall be designed as per the Development Control Plan Rues (DCPR). The author has generated the 3D model in Revit Architecture 2016 referring to the 2D drawing drafted by the author itself.

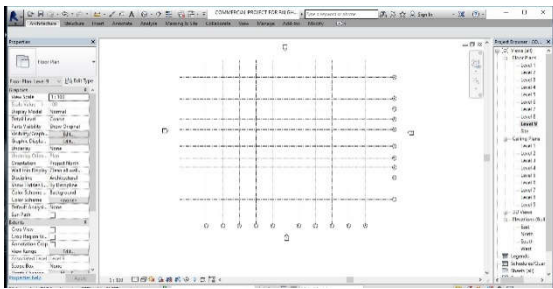


Fig 1 Layout of grids for column and beams

The formation of the 3D model starts with laying of the grids for the location of the site, footings, and column.

The grids for the site are prepared referring to the setback and side margins, while the grids for column and footings represent the centre-to-centre distance between them. The grids are prepared by selection of option Architecture → grid. For the vertical height of the structure, the East Elevation shall be selected in the Architecture. Once the layout of the site and the foundation is done, the different components shall be placed as per the requirements of the materials, sizes, and finishes. After layout of the building, the topography is defined. This done by selecting from the ribbon tab Massing & Site → topo-surface. And form the grids created defining the building pad i.e. the area for the construction.

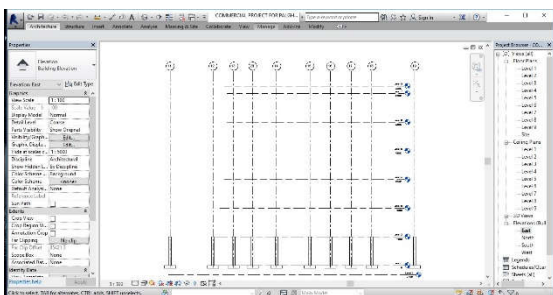


Fig 2 Layout for the vertical height of commercial complex

Followed by topography the structural element can now be placed one-by-one. Starting with the foundation, to the column, plinth beam, slabs, staircases, partition walls, doors, and windows. The structural components can be inserted from the option Structure. Various structural elements can be used with the standard dimensions. While for specified dimensions, it can be edited from the Edit option in the properties tab. The dimension of each component, height constraints i.e. its elevation on each floor, and the material are to be selected from the properties tab. The structural components are then placed starting from foundation, columns, beams, slabs, and staircases. Similarly, the partition walls for each floor is

defined by selecting the option of Architecture → walls by components.

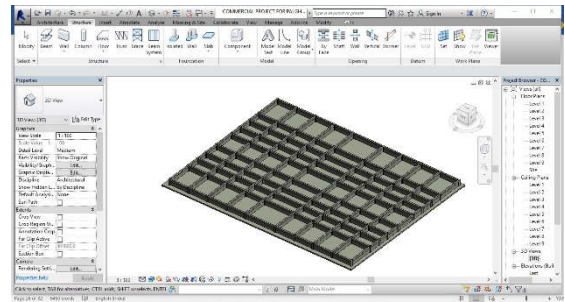


Fig 3 Plinth beam for commercial complex

Also, the doors and windows are placed in a similar manner defining the type of doors and windows. For the external face of the building, structural glazing is used, which is selected in the same manner as for the partition walls. After placement of the components, the 3D view can be obtained by selecting View 3D in the ribbon tab.

Any component which is not available in the list of any tab given in the Revit Architecture can be searched by selecting Insert → Load family → libraries → US metric followed by any category of the structural element. Also, the sequencing the structural component is important, as these will help in synchronization of the schedule and simulation run of the 4D model.

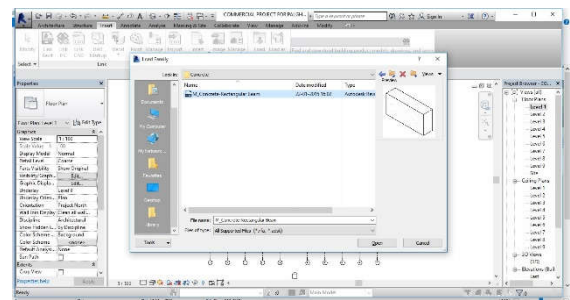


Fig 4 Insert beam from library of Revit Architecture

After the generation of the 3D model, the file is to be exported to the Autodesk Navisworks Manage 2018. For exporting it to Navisworks Manage is to be saved and this is done clicking

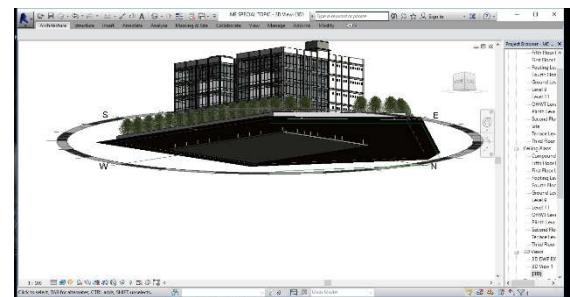
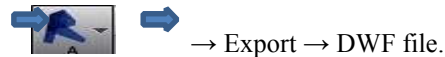


Fig 5 3D model of commercial complex

Generation of the schedule

The schedule for the project is prepared in Microsoft Project 2013. Before starting the preparation of the schedule, the calendar is to be defined which is done by selecting the option Project in ribbon tab, Change time. This is specifically important because if not done the project will select the default

calendar built-in and schedule so prepared shall have a greater number of days. The Work Breakdown Structure for the building is then created. In WBS the activities are defined and the time for activity for its commencement and completion is determined based on the experience and the relationship between activities has to be defined. Followed to this the critical path is identified to know the activities which are to be completed to avoid delay in the project.

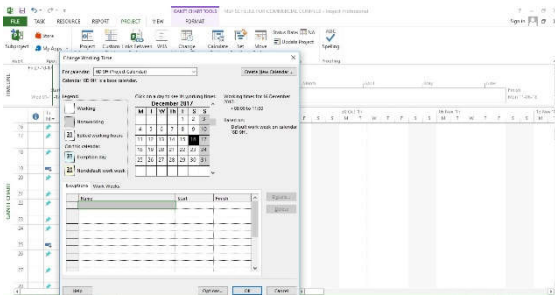


Fig 6 Creating new project calendar in MSP

After the schedule is prepared it is to be exported to Navisworks Manage 2018. The MSP file is saved in .mpp format. The schedule can even be prepared in Microsoft Excel, and the file to be saved is in CSV format.

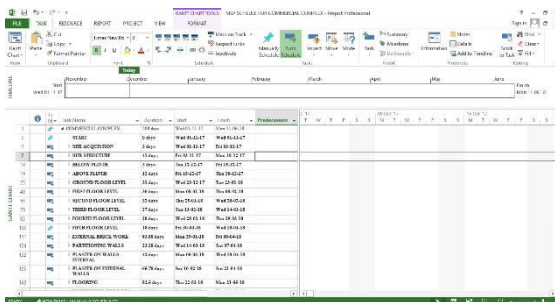


Fig 7 WBS of commercial complex

Simulation run to view 4D model

The final simulation run to be commenced has to be started by first importing the Revit Architecture file for the 3D model and Microsoft Project file for the schedule to Navisworks Manage. This is done importing the Revit file from the saved drive to Navisworks Manage and it will create a new NWF file. After the 3D model is been exported the schedule is to link with structural components for the simulation run of the model.

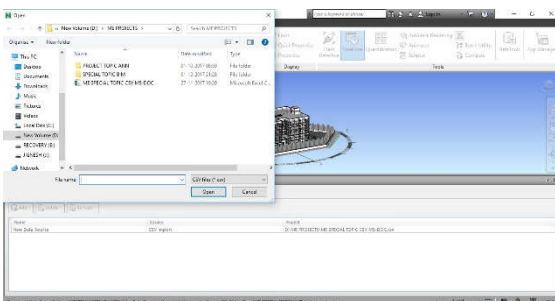


Fig 8 Import MSP file to Navisworks Manage

For linking of the activities, the time-liner option in the ribbon tab is to be selected. Then, by selecting Data Source, the file of the schedule is to be selected which can be CSV file if excel format/Microsoft Project .mpp/ Primavera P6. After selecting the file format, right clicking on the New Data Source→ Rebuild Task Hierarchy this will export contents to develop a 4D model.

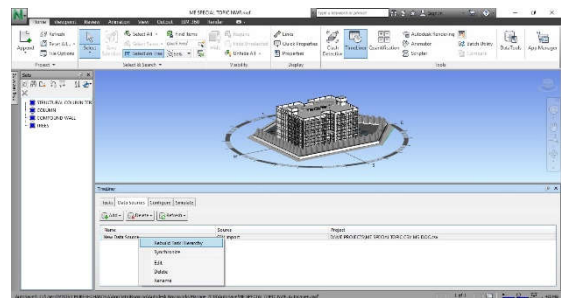


Fig 9 Exporting contents to Data Source in Navisworks Manage

After the schedule file is imported to Navisworks, each activity is to be linked with the 3D model. For each activity the category is to be defined viz are, Construct (Green), Demolish (Red), Temporary (Yellow). The three options are to be selected from Task→ Task type. And finally, the last step shall be to run the simulation model. To perform simulation, in the time-liner tab, select the Simulate, and then click the play button to watch the model run.

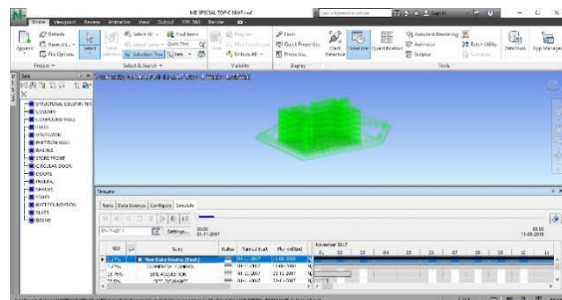


Fig 10 Simulation run of 4D model

RESULT AND DISCUSSION

The benefits of adoption and use of BIM are vast and can be organized in very different ways. Zbigniew. K & Kupa. T, (2014) swayed in his work an extension of a staircase with lift shaft for an old building in Poland using the Revit Architecture and Navisworks Manage. Whereas in this work, it is persuaded that the software can be used to generate a 4D model for other commercial buildings. Also, the communication benefits for the execution reflects in less miss communication errors and results in more effective and productive way of construction. With the reference of this study, it will be beneficial to generate a 4D model of the structure and simulate the project to help understand the sequential procedure to carry out the work. Likewise, the quantities of the various components of the structure can be generated with respect to the material used for construction. And the structured drawings can be used to communicate amongst the various stakeholders associated with the project. Correspondingly, the study was limited to developing a 4D model, but by adding the resources and cost in the Microsoft Project the fifth-dimension i.e. (3D + time + cost) model can be developed in the same steps as mentioned above.

Besides, the tools available to the authors are utilized for generation of the 4D model. The viewers are suggested to utilize the different versions of the tools available to them for generation of the BIM model.

CONCLUSION

From the study, the stepwise procedure for generation of 4D model (3D + time) is swayed. The generation of such model during the pre-construction phase can help the different

stakeholders of the project understand the complexity of the design, planning, and execution. Also, the authors suggest the different stakeholders be involved during the pre-construction phase as the flaws in design and planning can be identified. And the 2D Auto CAD drawing generation in the early planning stage can help the different stakeholders* to utilize these drawing and carry out their own schedule of work and synchronize it with the other structured work, rather than wait till the 3D model is created and from that model, the 2D drawings are drafted.

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