# Application of Building Information Modeling in Construction Management with 5D Modeling

**[1]Yash K. Patel, [2]Prof. Tirth D. Patel**

[1] Post-Graduate Student, [2]Assistant Professor
[1]Civil Engineering Department,
[1]U. V. Patel College of Engineering, Ganpat University, Mehsana, Gujarat, India

***Abstract :*** ***This research includes application of 5D BIM by the means of hands on modelling of a commercial building on one of the most popular BIM tools. A commercial building is selected as a study subject to simulate the major stages of 5D BIM digital workflow. The whole process starts with developing digital model (3D) based on available information and data and is followed by the incorporation of time (4D) and cost (5D). The integration of information not only enhanced the efficiency and accuracy of processes in all stages, but also enabled decision makers to have a sophisticated interpretation of information which is almost impossible with conventional 2D CAD workflow. Although it is possible to incorporate more than 5 dimensions of information, it is foreseeable that excessive information may escalate the complexity unfavorably for BIM implementation. 5D BIM has achieved a significant level of practicability; further research should be conducted to streamline implementation. Once 5D BIM is matured and widely accepted, it is foreseeable that additional BIM dimensions of information will be incorporated into sophisticated digital building model to achieve specific project outcomes.***

***Index Terms - Building Information Modeling, 3D Modeling, 4D Modeling, 5D Modeling, Simulation, Building Life Cycle***

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## I. INTRODUCTION

Building Information Modeling (BIM) is most developing improvements in Architecture, Engineering and Construction (AEC) industry. One or more virtual models of buildings are created with BIM technology. Which helps to design via allowing higher evaluation and management than manual procedures. These virtual models consist of accurate geometry and data to assist construction, manufacturing, and procurement practices. Moreover, BIM has the capacities to illustrate the lifecycle of a building. A greater coordinated plan and construction processes are encouraged by BIM which results in bringing down cost and reduced project duration.

According to National Institute of Building Sciences (NIBS), BIM is a computable illustration of all of the physical and practical characteristics of a building and its associated project/lifecycle information, which is meant to be a foundation of information for the building owner/operator to use and preserve for the duration of the lifecycle of a building (NIBS 2007). Physical geometry and other practical parameters of building materials are presented by BIM as a virtual illustration. These information is collectively composed by designers to outline a building model, which consists of each physical and functional information saved in BIM objects. Moreover, as soon as the building model is generated; information contained in model can be used for fabricating, analyzing, construction scheduling (4D BIM), cost estimating (5D BIM) and for facility management for operation phase duration of building lifecycle.

Construction industry's paradigm is shifting from 2D based drawing information to 3D based object information system with the help of BIM technology. This transformation changes the documentation process used in building design and construction, from manual conducts that are human-readable and integrates virtual descriptions of building elements with different information which include time and cost that are computer readable. This process is called as n-dimensional (n-D) Modeling, where virtual building model contains different dimensions of information.

Building Information Model is digital illustration of proposed design scheme. It is the enhancement of 2D to 3D model and 4D (time) with datasets collected from building lifecycle.

- **Three Dimensional Model:** This illustrate any surface into three dimensions. In BIM, there are different type of models:1) Construction Models i.e. construction sequencing 2) Design Models – MEP, Architecture, Structure model
- **Four Dimensional Model:** This model is generated by integrating 3D model to time i.e. 4th dimension. This model integrates 3D model element to timeline to illustrate simulation of project.
- **Five Dimensional Model:** This model is generated by integrating 3D model to cost i.e. 5th dimension. This model delivers more accurate project cost estimation.

## II. RESEARCH OBJECTIVE

To study BIM and its framework. Moreover, to prepare a four dimensional model by using time as 4th dimension and cost as 5th.

## III. RESEARCH SCOPE

This study will be done on a commercial building situated in Surat, Gujarat.

## IV. RESEARCH METHODOLOGY

### *4.1 Literature Review*

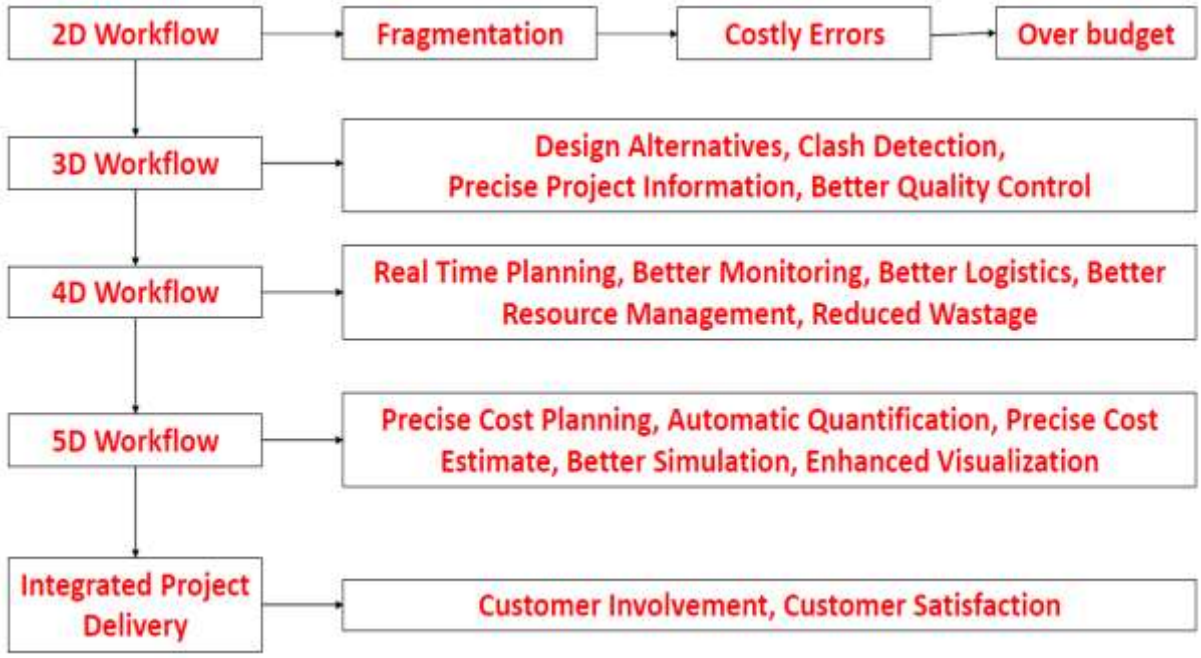
Building Information Modeling is a digital illustration of the physical and functional characteristics of any facility which is built, analyzed, documented and assessed virtually. These procedures are followed until the most effective and efficient model is finalized. Building Information Model is not only a virtual model but also a virtual database of any facility. This database can be used in realistic way by construction managers.

Building Information Modeling is not just only 3D Virtual Modeling but also 3D Engineering Modeling. This representation of any facility can be used in all aspect of construction management such as budget management, decision management, information management, material

& equipment management, project management, quality management, resource management, risk & safety management, and schedule management.

Within space coordinate system and 4D (4D is a combination of 3D coordinates and the time as a 4th dimension) & 5D (5D is a combination of 4D model and cost as the 5th dimension), BIM had been employed in many construction projects wherein significant enhancements in those tools to enhance the building process have been found. 3D, 4D, and 5D techniques improve the execution of construction in the multidisciplinary and multi-organizational field to a great extent, however using these tools on an actual project is a complicated process wherein a great deal of coordination is needed.

As soon as the 3D model of the construction object is finished, the contractors may additionally execute the cost estimates and the project schedule. Whilst the building model is upgraded with appropriate input data, the contractors may obtain in each moment, for each building element, all relevant information for the execution of works. Such model of the construction item can include information about the type of building elements, the geometrical quantities, the number of items, the resources needed for implementation, the execution times of project activities, the technology implementation, etc. The most important advantage of BIM is that the information about the construction item is saved in a single place and stored up to date. Hence, the usage of modern software that allows BIM in construction projects represents a technological progress with many advantages for all participants.




### *4.2 Data Collection*

Project under consideration for application of Building Information Modelling is a commercial building located in Surat, Gujarat, India. Software adopted for BIM model creation is Autodesk Revit and Microsoft Project is used for construction scheduling, and NavisWorks Manage is used for simulation purpose. Information was collected for Data Modeling and Analysis such as drawings, budget, planned schedule. The background of the research project and software adopted are summarized in below table:

*Table 4-1 Project Information*

| | |
|---|---|
| Building Type | Commercial Building |
| Number of storey | Basement + G + 6 + Terrace |
| Location | Surat, Gujarat |
| Plot Size | 465 sq.m. |
| Construction Area | 1738 sq.m. |
| Project Status | Completed |
| Planned Project Duration | 1.5 years |
| Estimated Cost | Rs. 7,78,54,126/- |
| Actual Cost | Rs. 7,86,50,844/- |
| Software used for Model creation | Autodesk Revit 2018 |
| Software used for construction scheduling | Microsoft Project 2013 |
| Software used for simulation | Autodesk NavisWorks Manage 2018 |

### *4.3 Data Modeling and Analysis*

In this research work, a 3D model and a schedule was prepared based on available drawings and data. Then, these model and schedules were used to prepare 4D & 5D simulation. Autodesk Revit 2018 (student version) was used to create the 3D model. Microsoft Project 2013 was used to create schedule for the project. Autodesk NavisWorks Manage 2018 (student version) was used to create 4D & 5D simulation.

### *4.3.1 3D Modeling*

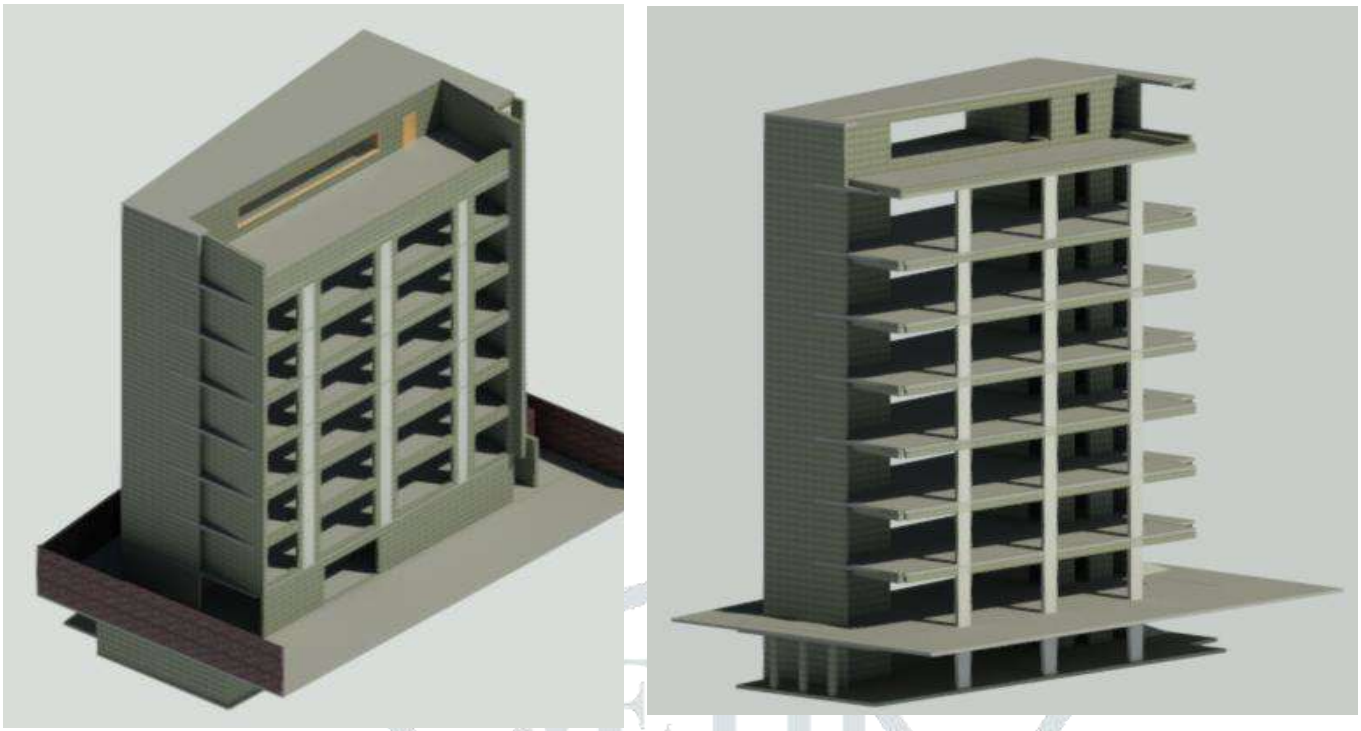


*Figure 1 Architectural (Left) and Structural (Right) 3D Model*

An intelligent architectural 3D model consists of all information about 2D, materials, documents and drawings which than assist designer to produce required drawings, elevations, material details and estimates. Various design alternatives can be applied by designers to 3D model and identify its effects on final outcome and cost. This results into a better and efficient material usage and design.

Following are the benefits of architectural 3D Modeling:

- All types of building can be visualized better.
- Errors can be checked that may occur in drawing process
- Better insight to surface patterns of Kitchen, Bathrooms, Offices, etc.
- Architectural walkthrough and virtual tours can be generated
- Tools for efficient promotions and marketing
- Rendering of custom interiors or furniture
- Reduced revisions and errors in design and RFIs
- Architects, contractors and designers can have improvised coordination
- Optimum use of materials
- Reduced project cost

### *4.3.2 4D Modeling*

4D BIM requires integration of 3D model to construction plan, which results in visualization of building and site during construction via simulating construction procedure. This allows project team to adopt alternative strategies of site layout, equipment place and scheduling and so on. Productivity can also be included as to allow line of balance schedule analysis. This allows effective integration of tasks based on productivity and location of project.

Following are the advantages of 4D Modeling:

- Testing the design against construction sequencing and therefore it can reduce difficult sequence issues.
- Improvised site coordination and planning with construction operations
- Precise lead time identification which results in reduce construction duration
- Improved constructability and safety issue identification
- Accuracy in comparing actual progress vs planned progress which results in identifications and resolving issues more quickly

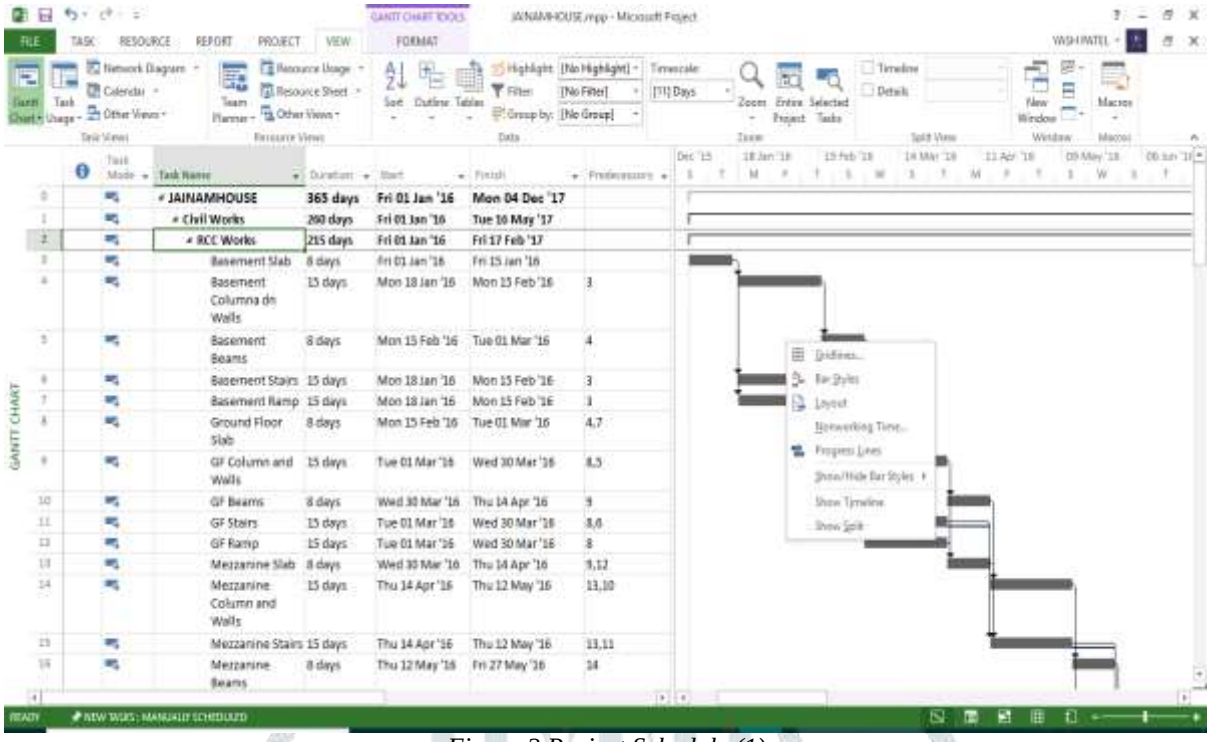



*Figure 2 Project Schedule (1)*

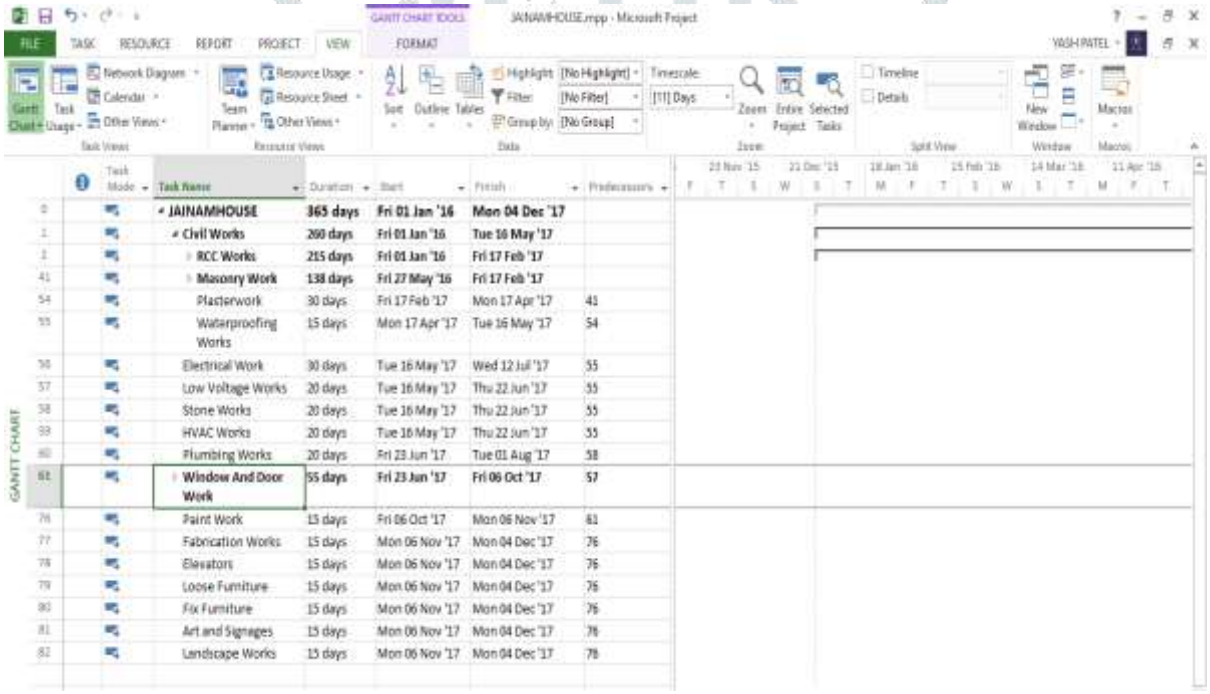



*Figure 3 Project Schedule (2)*

Steps to create 4D simulation is as follows:

- 3D model creation based on available drawings and data.
- Preparing schedule for the project based on available data.
- Importing 3D model in to Autodesk NavisWorks Manage 2018.
- Creating element sets in NavisWorks.
- Importing schedule in to NavisWorks.
- Assigning element sets to their respective activities.
- Run simulation.

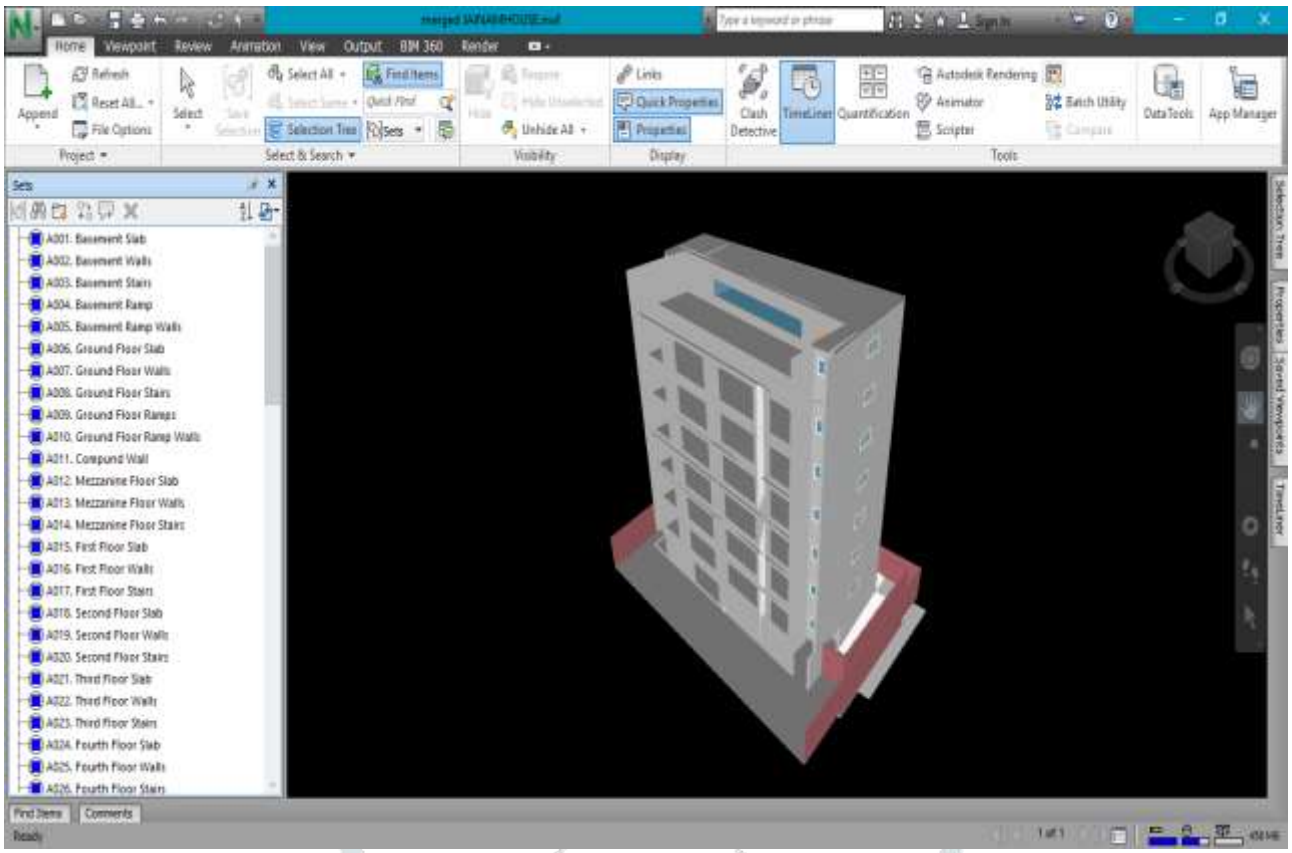


*Figure 4 Import 3D Model and Create Element sets*

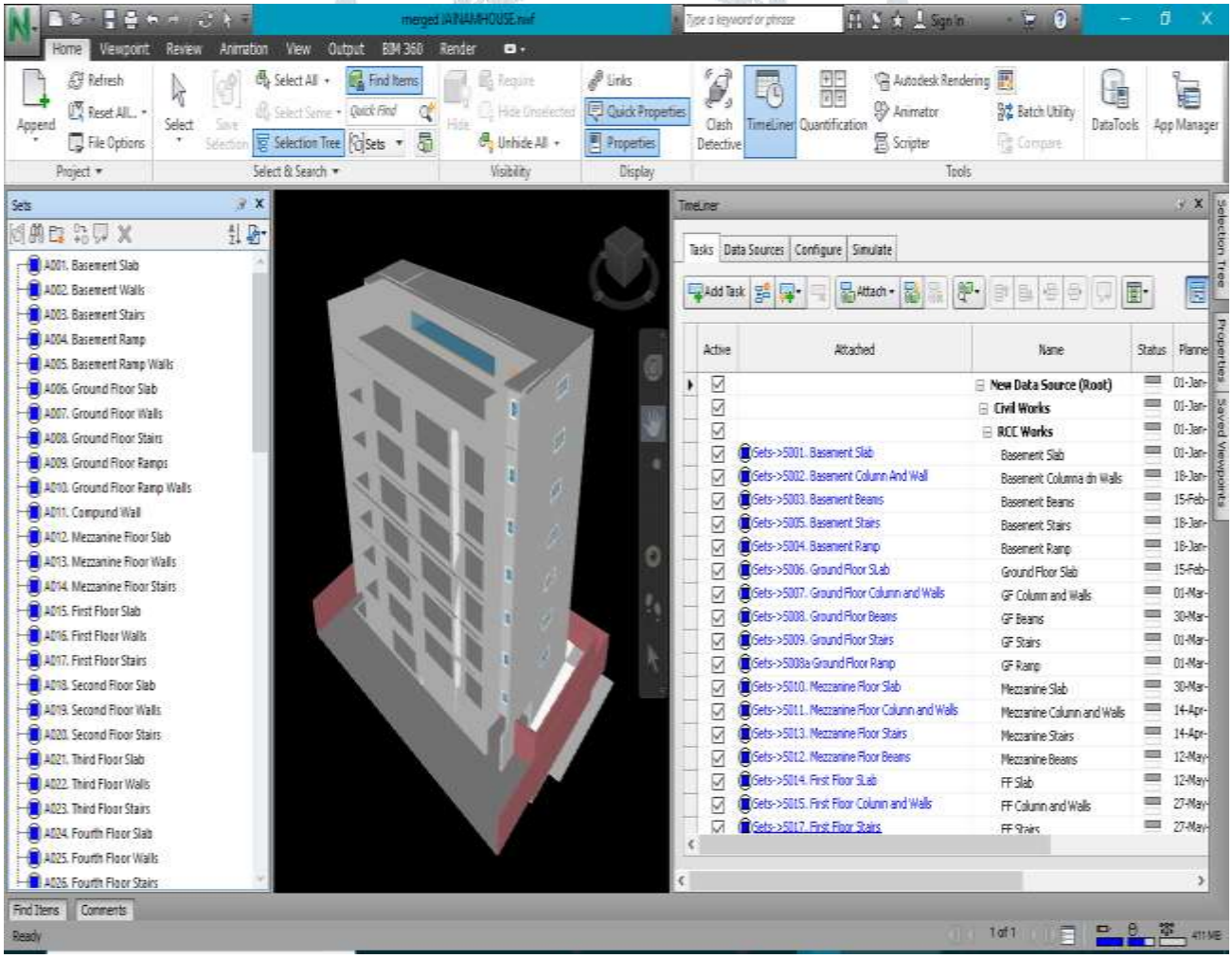


*Figure 5 Import Project Schedule and Assign Element Sets to Respective Activities*

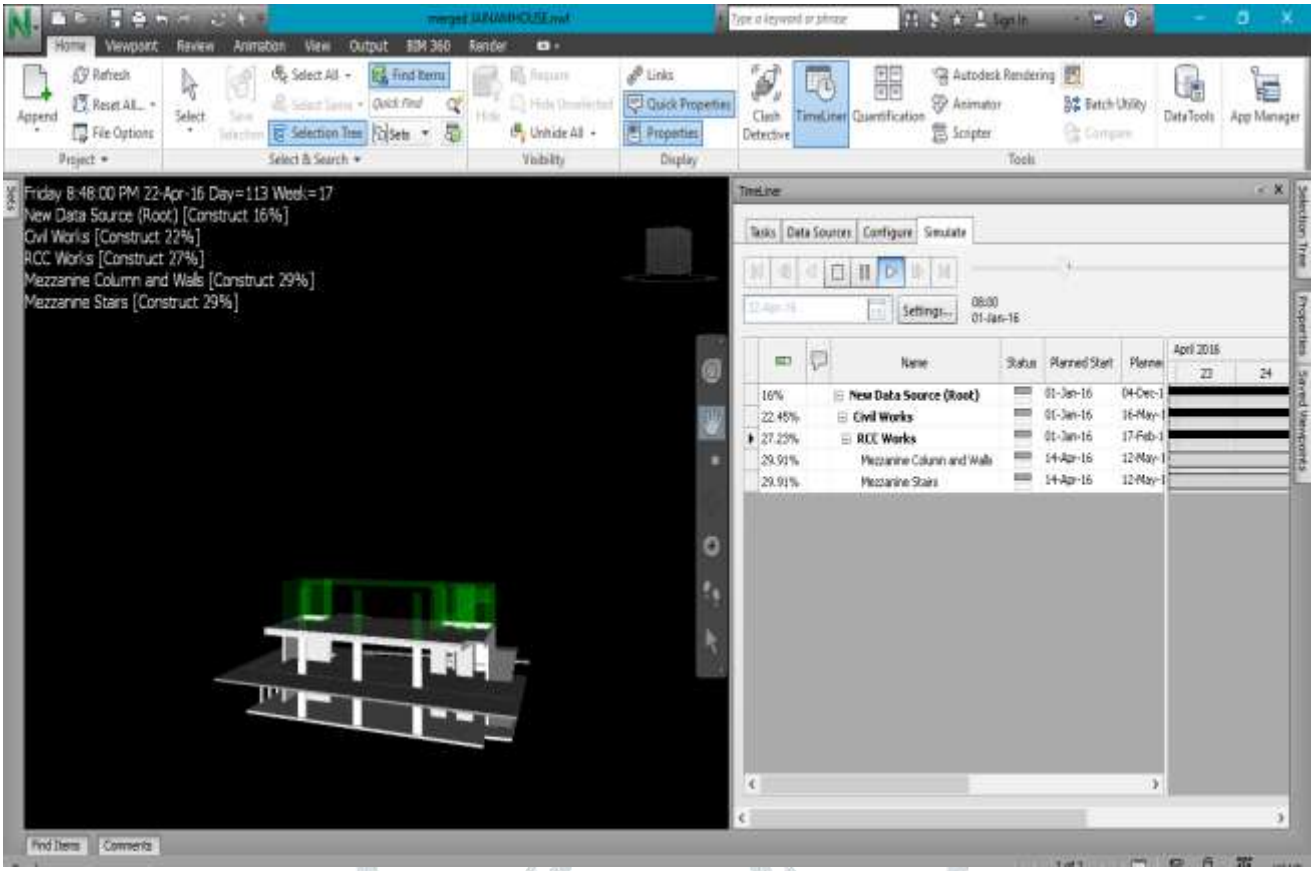



*Figure 6 Run Simulation*

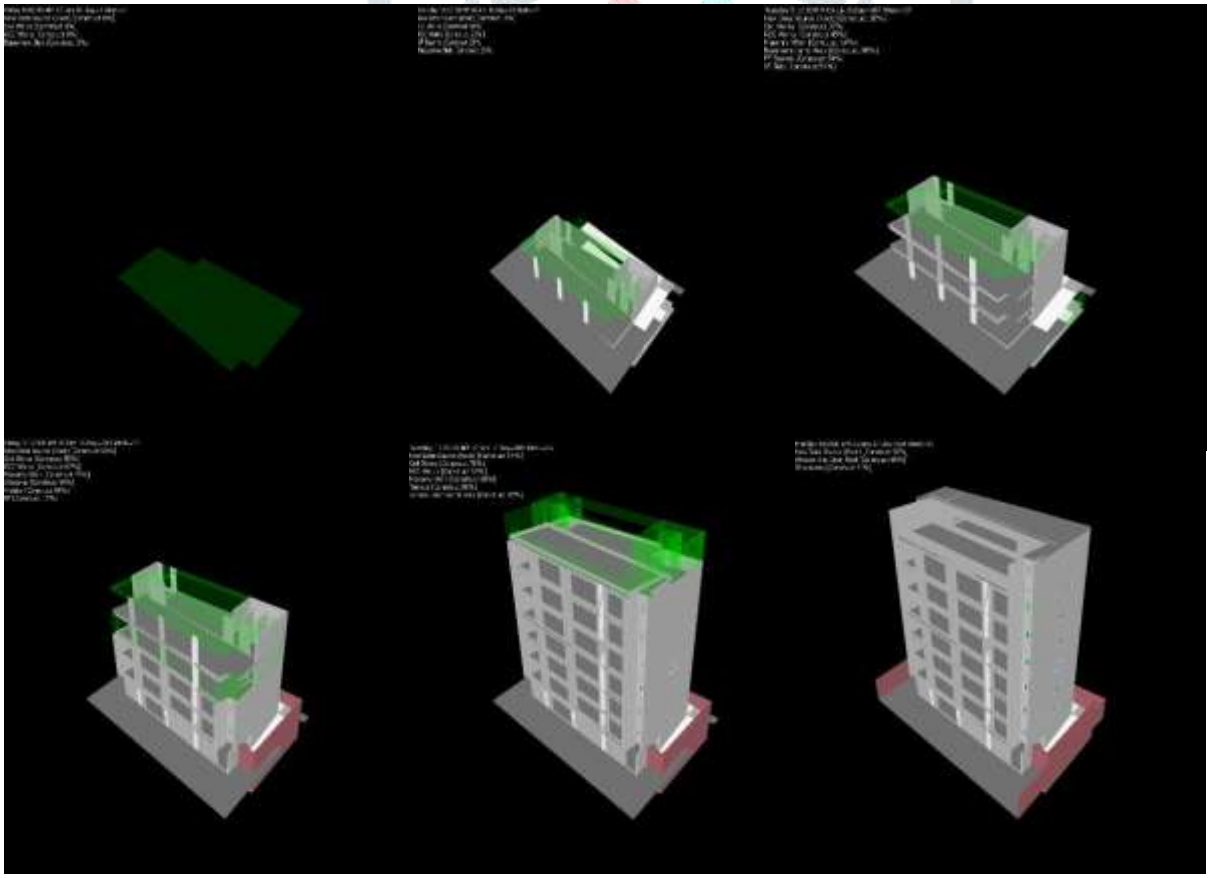


*Figure 7 4D Simulation*

### *4.3.3 5D Simulation*

5D BIM requires integration of 3D model and project cost which makes possible to track and forecast cost in all stages of construction. It is also useful in setting up budget. With the evolvement of the model, cost estimation can be enhanced with the improved level of model details and the cost implementations of different design alternatives may be estimated at any stage of the design phase. The cost information used to measure the overall financial performance of the project can be extracted from the 5D model.

Benefits of 5D Modeling are:

- Avoiding planning collision
- Exact quantities and cost
- Target/Actual comparison

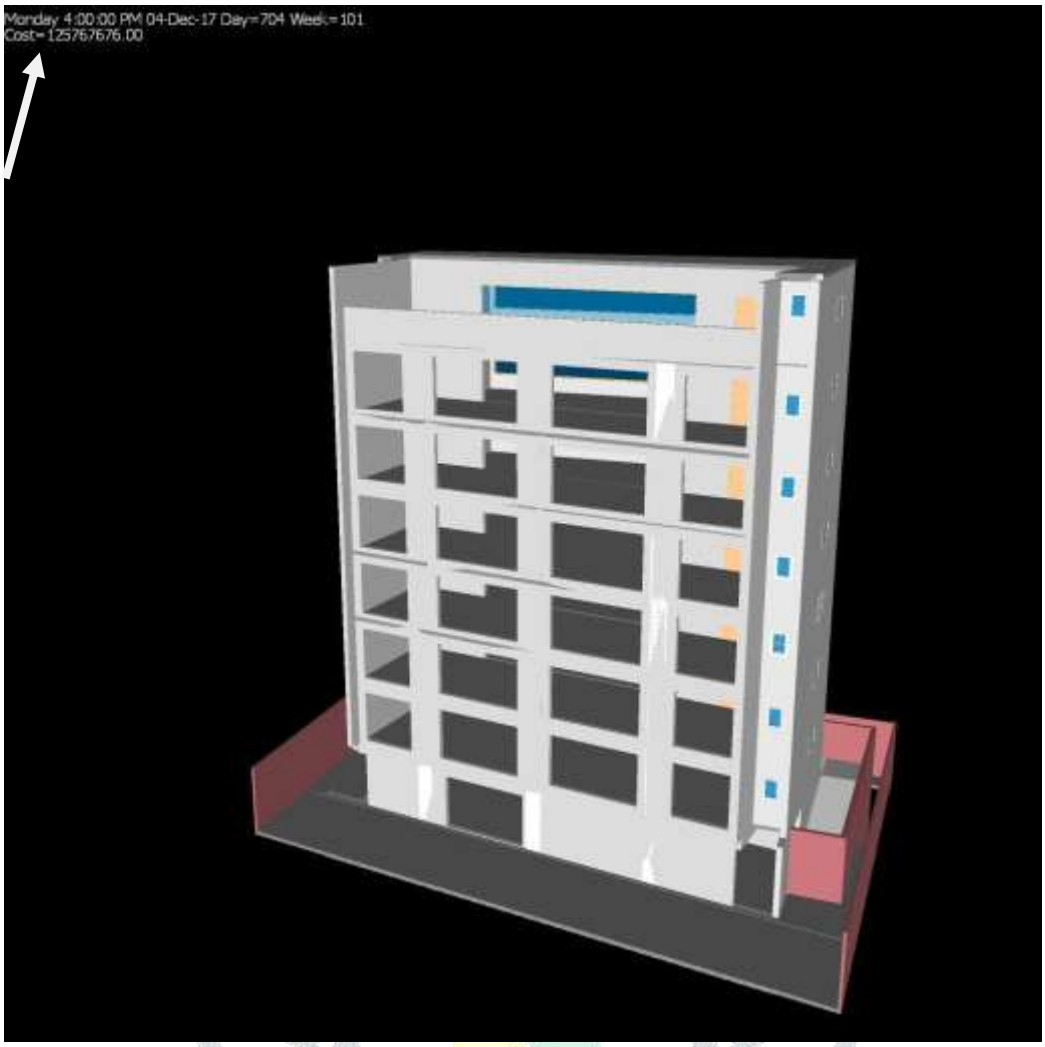



*Figure 8 5D Simulation*

## V. CONCLUSION

Building Information Modeling is a developing technique transforming the AEC industry. It is possible to integrate more than 5 dimensions of information but excessive information may increase complexity in BIM implementation. By integrating information, it will improve the performance and preciseness of system in all phase of project. Moreover, it will also allow project team to make efficient decisions. This is not possible in traditional 2D method. Technical limitations can significantly reduce for clients to take participation in process by virtualization of 5D Building Information Modeling. This results in more satisfaction of clients by bridging the gap of actual project details and expectations.

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