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# Improve the Productivity of Building Project using Building Information Modelling (BIM) Based 4d Simulation Model

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***Abstract:*** ***Building Information Modelling (BIM) is an emerging concept in Architecture, Engineering and Construction (AEC) industry. It is not only a tool, it is not only software, it is a new concept which model-based technology on building process, information and management of data with digital tools and constructing building virtually before it is built on construction field. The Indian Architecture, Engineering, and Construction (AEC) industry is very infancy stage with the implementation of Building Information Modelling (BIM) because they are not aware about BIM technology and its capacity. This paper attempted to explain 4D BIM for better co-ordination, communication and share information among project team which is useful for projects in terms of performance and time. This paper also presents a case study of residential building which is explains the methodology and Software's used for creating 4D BIM models which shows the graphical presentation and communication of the construction schedule of case study. In this case study, commercial software's such as Autodesk Revit 2016 and Autodesk Navisworks Manage 2016 are used. We developed 4D model with the help of software's such as Autodesk Revit and Autodesk Navisworks Manage. This paper concludes that 4D BIM is best alternative to traditional project scheduling tools like CPM networks, bar charts.***

***Keywords:*** ***Building Information Modelling, AEC Industry, BIM software's, Scheduling, 4D BIM.***

## I. INTRODUCTION

The Architecture, Engineering and Construction (AEC) industries have required techniques to reduce project delivery time, decrease project cost, increase productivity and quality so that AEC industry is applying new technology such as Building Information Modelling (BIM) to assist better the productivity of construction Project Management. Building Information Modelling (BIM) is an integrated the process of development and utilizes of a computer generated model to simulate the design, planning, construction schedule, cost information and clash detection such as physical and functional characteristics digitally before it is built on construction field. According to a recent McGraw-Hill Construction Report, BIM implementation in the USA extended from 55 Percentage in 2013 to over 79 Percentage in 2015. A Survey done by Indian RICS School of built environment and KPMG in 2014 found that 22 percentage of respondent currently use BIM, 27 percentage respondent reported that they are aware and actively considering BIM utilization in India.

BIM has been adopted by many organizations and companies and they have their own definitions of BIM. The General Services Administration (GSA) is an autonomous agency of the United States government, established in 1949 to help manage and support the basic functioning of central agencies.

### *A. GSA defines BIM as*

Building Information Modelling is the development and use of a multi-faceted computer software data model not to only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility. The resulting Building Information Model is a data-rich, object-based, intelligent and parametric digital representation of the facility, from which views appropriate to various users' needs can be extracted and analysed to generate feedback and improvement of the facility design.

The traditional planning method such CPM, Bar chart which is currently used in construction planning is found unsuccessful. Due to the problem observed in using the traditional scheduling and monitoring methods such CPM, Bar charts the construction industry has recognized that its current scheduling and progress reporting practices are in need of significant improvements in quality and efficiency so modern 4D BIM visualization have been motivated by the failure of traditional methods. 4D BIM means 3D model is



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linked with the desired schedule through particular software such like Navisworks (Autodesk Incorporated) and Project Wise Navigator (Bentley Systems Incorporated) are examples of such programs that provide a collaborative environment to extend, review, and modify the 3D model.

## II. 4D BIM

### A. *Defining 4D Modelling*

The 4D Modelling is one of the modern computer technologies that have developed into the AEC industry. A 3D model intelligently linked with time or schedule related information for a project. 4D BIM gives a graphical model that allows planners for identification of problems in early phase of projects. 4D BIM shows project schedule in visual format. It can also be used to coordinate in work with engineers, clients and subcontractors [3]. The 4D BIM allows participants to extract and visualize the movement of their activities through the lifetime of the project. Using 4D BIM technology can result in superior control over conflict detection or over the complexity of changes occurring during the course of a construction project. The 4D BIM provides methods for managing and visualizing site condition i.e. site information, change effects as well as supporting communication in different situations such as informing site staff or warning about risks.

### B. *Need for 4D Modelling*

Scheduling is the vey essential part of construction management point of view. Without proper planning and scheduling successful completion of any project of any organization will not be possible. Proper scheduling of the various activities before beginning of work and controlling the operations in systematic manner is the heart of planning.

A traditional construction schedule is a complex chart or network which consists of various activities and the time desired to deliver those activities. When project starts, the construction manager collects the data and measures the progress in order to update the schedule with respect to any change especially related to the design. The consistency of the schedule mainly relies on the accuracy of construction managers in reviewing the data and drawings and in considering the availability of resources of each time period. This process is a time consuming procedure and would lead to a high potential of errors due to the manual data collection. Traditional scheduling methods i.e. CPM Diagram, Bar charts, Gantt chart can be difficult to understand and do not identify the spatial aspect to the construction activities nor are they directly linked to a design or building model. Due to the failure these traditional methods there should be need significant improvements in construction scheduling which having the ability to watch the elements of a design come together onscreen gives the design and construction team improved accuracy in construction sequencing so that in less time and avoiding manual errors instated of traditional scheduling. So that it is necessary to apply 4D Modelling procedure overcomes the deficits and results in better collaboration and more efficient schedule.

## III. METHODOLOGY- CASE STUDY

To understand implementation of BIM, a conceptual case study (Residential Building) is taken. It consists of two flat sat each floor except ground floor. Ground floor is left for parking purpose.

### A. *Software's Selected for Creating 4D Model*

The software's selected in this case study are stated as follows

1) *Autodesk Revit2016*: Revit is database structure and object definition Modelling, it is effective Modelling software the preferable work practice is of course when all the Modelling is performed internally within Revit. In order to satisfy the specific needs of the diverse types of specialist for Revit, Autodesk distributed the product into three types – Revit Architecture, Revit Structure and Revit MEP. The 3D model of case study was created in Revit Architecture 2016.
2) *Autodesk Navisworks Manage 2016:* The Autodesk Navisworks product helps architecture, engineering, and construction teams to develop better control over the outcome of their projects. Navisworks enables user to interrogate and utilize this information throughout the design, build, and operation stages without the need for a design application. For this case study exporting 3D model to Navisworks, preparing work break down structure in Navisworks and giving time to the each task.

### B. *Steps to Develop the 4D Model*

The Process of preparing the 4D model consisted of following steps

1) Creating 3D model in Autodesk Revit 2016.
2) Naming 3D components as per scheduled activity



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*3)* Import 3D Revit files into Navisworks or export files from Revit to Navisworks in NWC file format which shown in Fig 1.

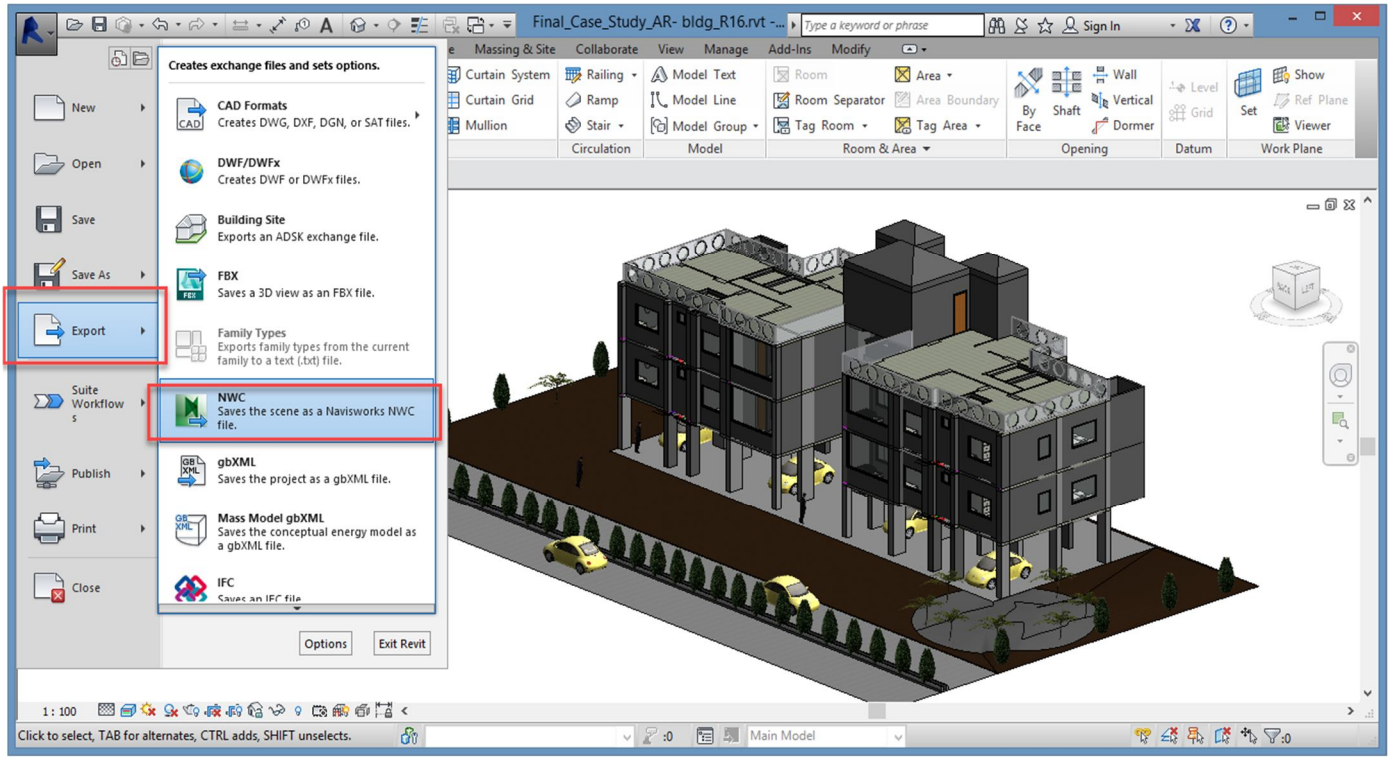



Fig 1. Converting Revit file into NWC format

*4)* Importing 3D model from Revit to 4D BIM tool i.e. Autodesk Navisworks Manage 2016 .

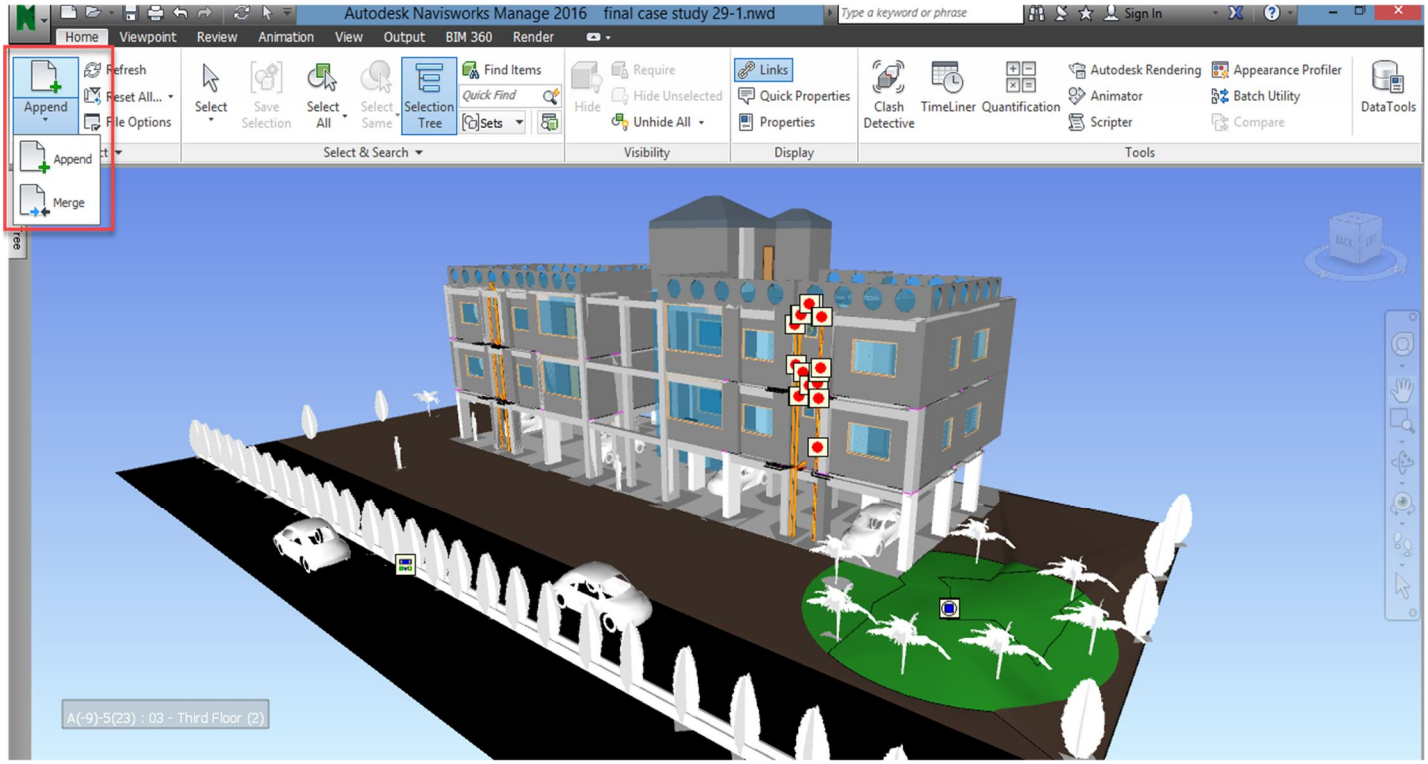



Fig 2 .Append Icon for importing file and opening model in Navisworks


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*5)* Selection of sets each element of 3D model, adding task manually in Navisworks , creating schedule which is used for preparing scheduling to 4D BIM tool which shown fig 3.

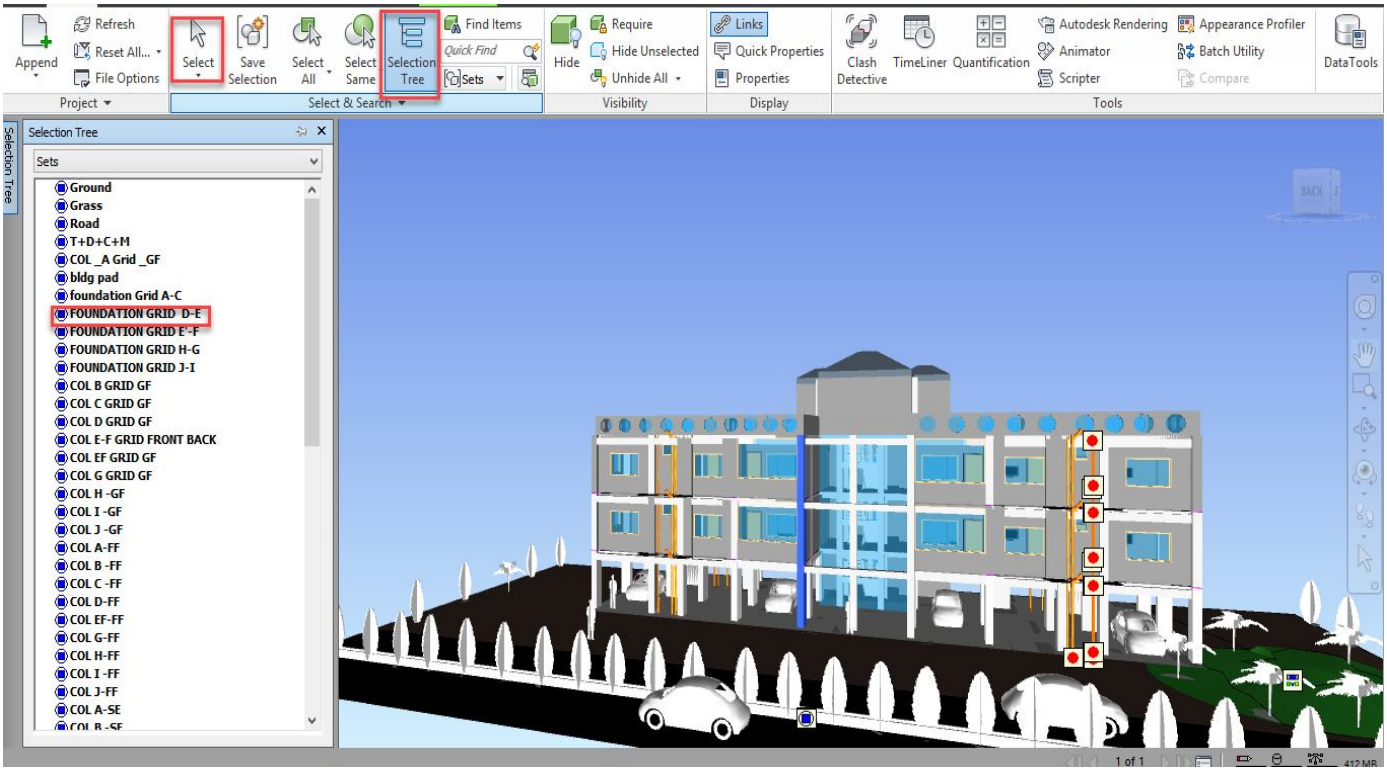



Fig 3 Creating selection Sets

*6)* Link all tasks to 3D model with help of rules and search sets in software.

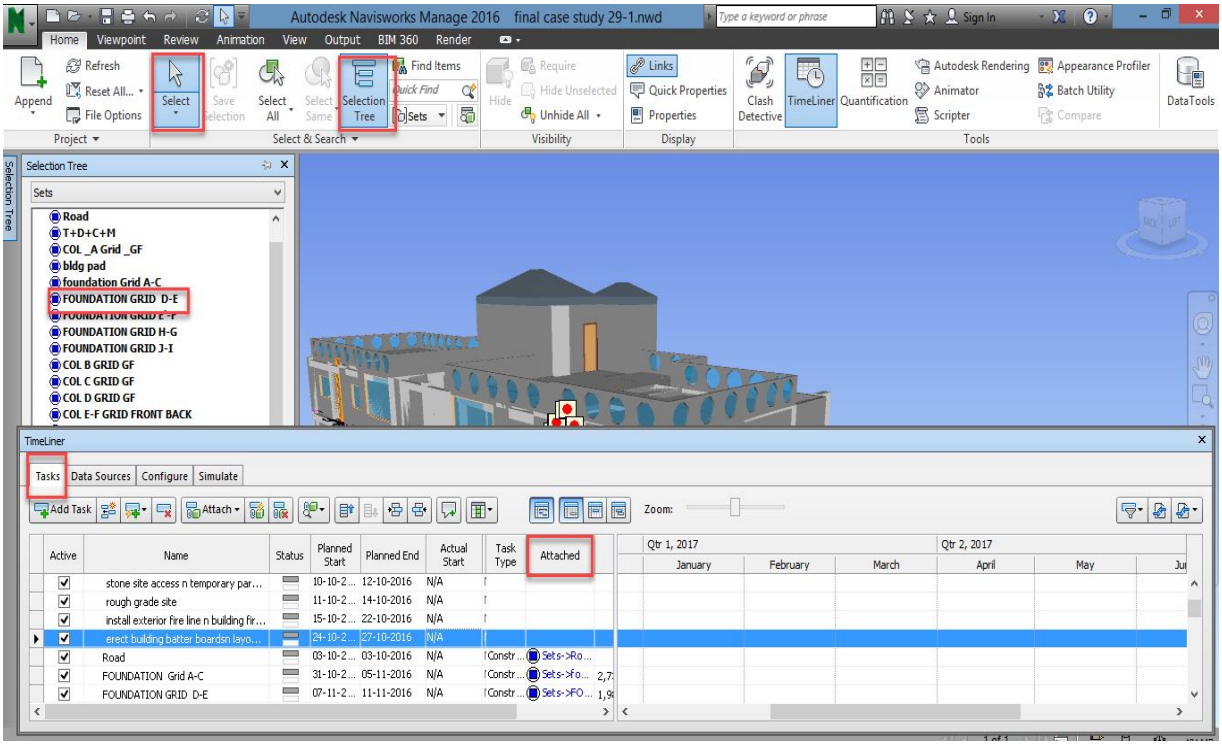



Fig 4. Assigning Tasks and linking activities to the 3D model.


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*7)* Then, Configure task is doing which is useful to know elements are still under construction versus completed activities.

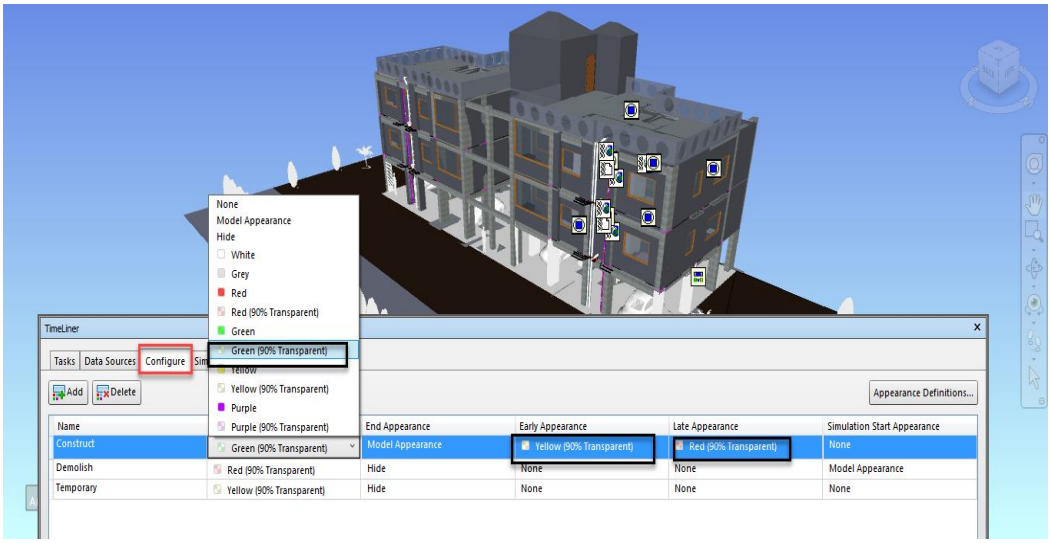



Fig5. Configure tab with Early and Late color settings

*8)* Simulating 3D BIM objects in model to activities in time liner schedule.

*9)* Checking the relationship between 3D object and schedule.

*10)* Once the 4D model linking was completed, play focused time for making animation could be utilized to create videos of the 4D BIM and finally, the video file could be exported as an avi movie format.

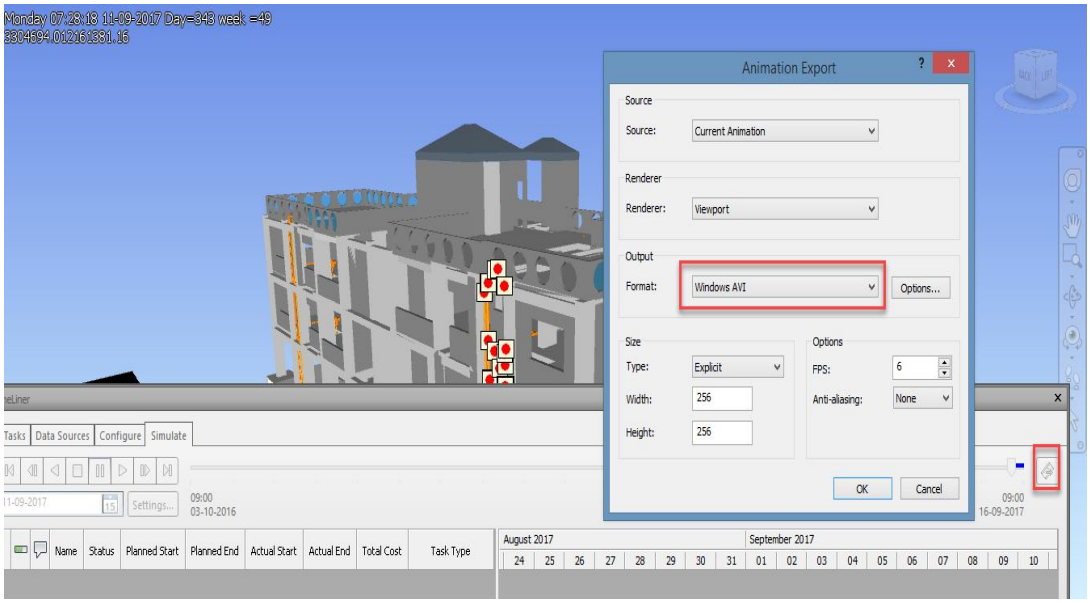



Fig 6: Exporting Simulation as Video File

*C. Time Required for Developing 4D Model*

In this case study Man–hours spent to generate a 4D model of Case study building having the following elements of the building as footing, plinth beam, columns, floor beam and slab, Brick masonry, curtain wall, plastering, plumbing. In building 3D model total 3526 elements were used. Table no-I show the hours were distributed across the stages. The hours were broken into the following stages.

*1)* Study and learning of software's

*2)* Transposing the 2D drawing into 3D model

*3)* Preparing 4D model



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TABLE I .Time Taken for Transposing 2D Drawing to 4D Model

| Development stages | Workflows | Time Taken (Man- Hrs.) | |
|---|---|---|---|
| 1.Study & learning of software's | Personnel study | 30 | 30 |
| 2. Transposing the 2D drawing into 3D model | Importing the building plan from Auto-cad into Revit | 0.5 | 2D to 3D workflows 32.5 Man-Hrs. |
| | Preparing element of 3D model | 22 | |
| | Making group of3D elements as per scheduled activity | 8 | |
| | Modifying & corrections for errors in the 3D model | 2 | |
| 3. Creating 4D model | Exporting 3D model from Revit to Navisworks | 0.5 | 3D to 4D workflow 15.5 Man-Hrs. |
| | Preparing the schedule In Navisworks | 10.5 | |
| | Linking 3D model objects to activities in time schedule | 3 | |
| | Checking the relationship between 3D object and schedule | 1 | |
| | Making animation video of the 4D BIM. | 0.5 | |
| Total | | 78 | |

## IV. DISCUSSION OF RESULTS

For this case study creating 4D model which useful application of BIM for construction planning .For developing 4D model linking of schedule activities with the corresponding 3D elements in Navisworks, type definition of each activity i.e. Construction, demolition, temporary and the colour use to represent the activities status i.e. early, as planned and delayed, so it was useful to simulate the construction schedule for planning analyses, physical advance monitoring, activities execution construction sequence and layout of the construction site.

### *A. Time Required for Developing the 4D Model*

About 78 Man Hours are utilized to develop 4D model from 2D documents and schedules. Percentage time consuming for different



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stage are showing below.

1) Study & learning of software's - 38%
2) Transposing the 2D drawing into 3D model -42%
3) Establishing 4D model – 20%

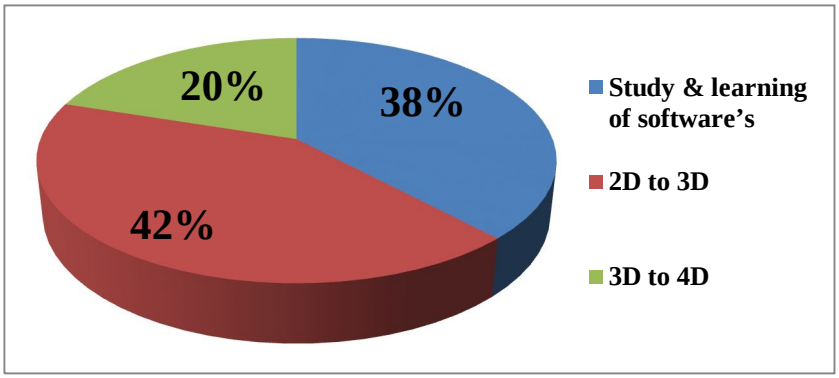



Fig 7. Breakdown of time in different stages to develop 4D model.

*B. Benefits of using 4D BIM as Project Planning Tool*

Based on the experience gained from the case study, the following section discusses the benefits and barriers of using a 4D model for construction planning

1) *More Accurate and Detailed Work Plan:* The utilization of 4D BIM allows project stakeholders to produce precise and complete work plan which would be more difficult to achieve with traditional planning methods. Sometimes traditional methods fails to cover all construction activities in the construction plan due to lack of visualization. while, 4D modelling provide a very effective tool to visualize the building project and identify all the possible construction activities leading to an accurate and detailed work plan. The 4D model capability in BIM tools that is tracking of project schedule with more accuracy such as the Actual work versus Planned schedule of project. In Fig 8, the bars of Actual and Planned Gantt charts are shown .

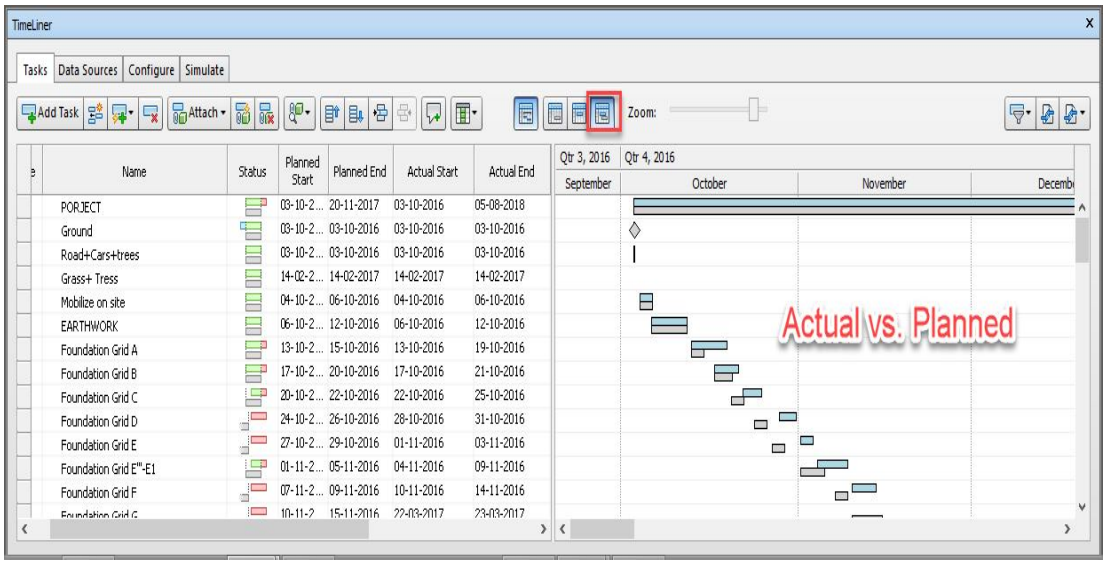



Fig 8. Actual and Planned Gantt charts in Navisworks .

2) *Better 4D Simulation with Construction Sequence:* The 4D simulation in BIM provides a virtual view of the project status and it helps adjust the project schedule according to any design change since the simulated tasks are linked to building components of 3D building model. The use of different colours code to present 3D components while simulating the schedule gives effective visualization as it shows Green transparent colour while activity in start appearance , yellow transparent colour while activity early appearance and red transparent colour when the activity late appearance which shown in fig no 9.The purpose of use different colours in 4D model that is facilitating the 4D visualisation and understanding the construction progress with day to



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day activity to the Project team. The project teams can see construction progress and tracking of project schedule with more accuracy such as the Actual start date versus planned start date and Actual end date versus planned end date. After completed 4D simulation project team, owners, contractors can see an animated video which showing the actual erection sequence of element of building model.

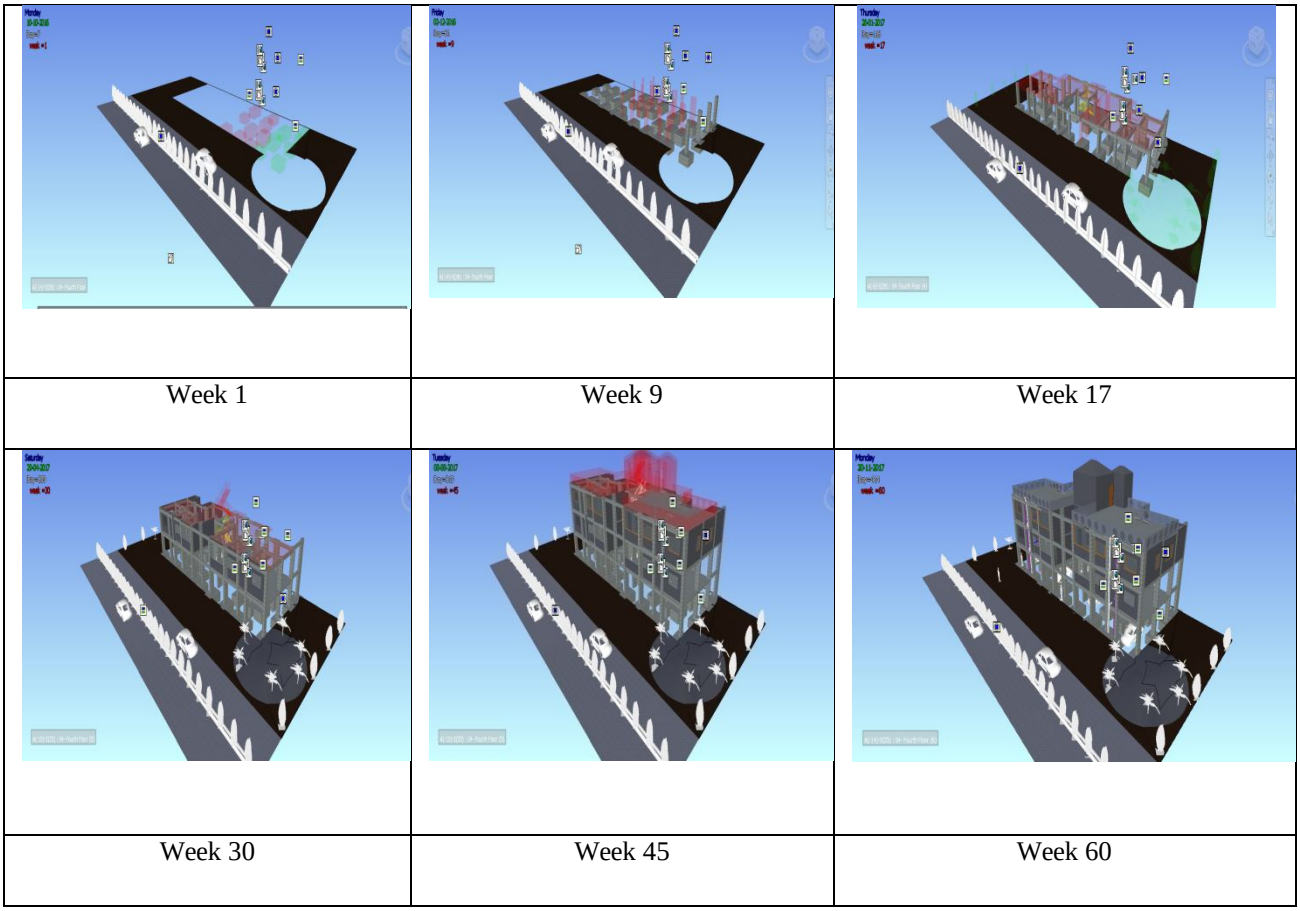



Fig 9. The interfaces of Autodesk Navisworks of 4D Scheduling in BIM

3) *4D BIM Promotes Onsite Safety:* The accident rate of building industry and the numbers of accidents and deaths remain high so safety hazards at the construction site can be one of the main causes of unexpected additional costs. The ability of 4D BIM to detect the potential safety hazards even before the construction activities actually start on-site is one of the important factors that helps develop higher safety measures. By using the 4D model simulation, project managers can able to identify areas where accidents may occur and implement prevention such as placing warning signs, restricting access, or providing safety guards etc. But most important thing realize that by viewing 4D model is time and location of the work , project managers can see how separate crews may affect one another and therefore accidentally create hazardous situations. After these problems have been found, project managers can by re-sequencing concurrent activities into subsequent activities or by adding activities that signify the installation of safety equipment or prevention measures. The utilization of 4D-BIM can result in improved occupational safety of Construction project.
4) *Better Communication Between Project Stakeholders:* 4D model can be used as an effective communication tool between different project stakeholders. 4D Modelling played an important role in communication between client and planners during the planning phase by showing visualizing the progress of project which achieved in this case study by using Navisworks 4D simulation. The 4D BIM capability to keep update information which useful for overall idea and clear vision of project progress to project Stakeholders for fast decision making process.

*C. Barriers of 4D Modelling*

There are few following section lists out the barriers of adoption of 4DBIM instead of traditional planning methods during this case


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study.

1) Developing of 4D model from 2D documents is time consuming process if highly skilled and knowledgeable trained staff not available to execute the process of 4D model which is in short supply and expensive to bear.
2) The major task faced in this case study that is transformation from 2D to 4D model because of As model takes too much time with its checking and updating to become that model more realistic.
3) Current trends show that the cost of software's and its training for 4D model tends to be more expensive than other software available on the market.

## V. CONCLUSION

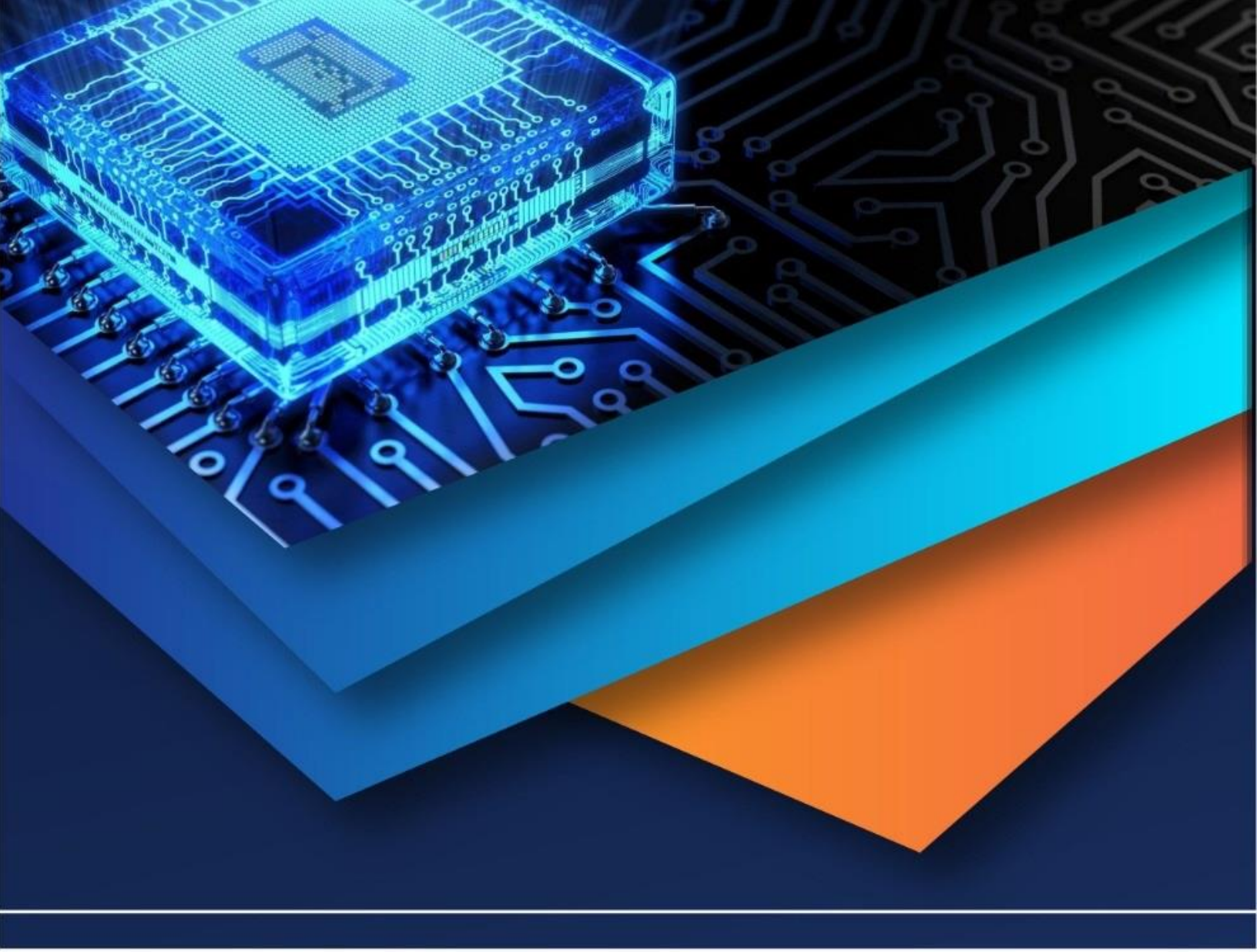
A. The case study shows that BIM technology brings many advanced construction management skills to project scheduling, monitoring and even project controls for project team.
B. Developing the 4D modelling software's Autodesk Navisworks Manage 2016 found easy to learn which helps architecture, engineering, and construction teams to develop better control over the outcome of their projects. The 3D model could obtained from Autodesk Revit 2016 which is also user-friendly.
C. In this case study, the tasks defined with planned and actual dates are represented in Gantt chart view. By comparing the planned and actual dates, the status bars can show the project team the progress of the project in a simple way.
D. The 4D modelling also useful to check the accuracy of schedule and the sequence of the activities in the work plan and their impact on each other can be simulated with utilize minimum resources and time in the construction phase with maximum benefits.
E. The 4D BIM provides an accurate representation for construction sequence and any changing of construction plan. Additionally, all construction activities are involved in the 4D model, therefore it is useful for safety analysis and improved occupational safety of Construction project.
F. During this case study also pointed out few shortcomings such as it needed highly skilled and adequate training staff, cost of software's, cost of softwares training .
G. Hence, implementation of BIM based 4D model in case study concluded that 4D modelling as a promising tool for construction planning. The most important advantage of 4D modelling determined are better visualization of construction work, better communication among project teams, increased planning efficiency , achieving detailed and accurate work plans and improved occupational safety of Construction project.

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