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An Overview of Building Information Modeling (BIM) & Construction of 4D BIM Model

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Abstract: ***The volume of construction output will grow by 85% to $15.5 trillion worldwide by 2030, with three countries – China, US and India – leading the way and accounting for 57% of all global growth. Construction industry largest industry worldwide comprising Architecture, Engineering and Construction professionals, Mechanical, Electrical, Plumber professionals, etc. The AEC industries have long sought techniques to decrease project cost, increase productivity and quality, and reduce project delivery time and one of the trending techniques is BIM (Building Information Modeling). BIM is intelligent model-based concept, in which buildings are built virtually before they get constructed actually on the grounds, where all the information in integrated in common platform as a result we get virtual data rich model of the structure. BIM plays crucial role in decisions making during its lifecycle. This paper describes the software's and methodology used for construction of 4D model. The BIM and normal construction process, dimensions of BIM are also explained in this paper. 4D model can be used by project managers for effectively manging tasks and resources.***

Keywords: Building Information Modeling (BIM)

I. INTRODUCTION

A. Building Information Modelling

BIM or Building Information Modelling is an intelligent a model-based process. The models are created from the inputs which are 2D drawings from which 3D data rich models are created by different professionals and stored on a common data environment which enables data sharing with the project members. The model contains graphical as well as non-graphical information. These 3D models are then integrated in a virtual environment where we get the integrated 3D data rich model. If we add time related information (Scheduling)to this 3D model then it will become 4D Model i.e. 3D + Time = 4D, similarly if add cost related information to this 4D model then it will become 5D Model, i.e. 4D + cost = 5D, we can add n no of dimensions to that model. This integrated model can be used for planning, designing, building, managing and carrying out the process of operations and maintenance throughout the life cycle of structure.[1]

Construction Industry is the largest industry worldwide where every project is unique, having multiple stakeholders and various organizations working on different platforms. Therefore, collaboration between various stakeholders becomes an important factor for the successful implementation and completion of the project, where BIM plays crucial role. BIM provides common data environment to all the project members consisting of managers, design team, contractors, Engineers where they convey information regarding coordination of tasks completed and yet to be completed and updates the changes in the project, thus ensuring the project is under control by all the project members.[2]

B. Dimensions of BIM

Dimensions are nothing but the parameters which can be added to the integrated 3D model. Depending on the content of information we can differentiate dimensions of the BIM which are as follows.[3]

1) BIM 3D - Virtual 3D parametric model - nowadays accepted by designers as a natural extension of the 2D design.

2) BIM 4D - Scheduling – it denotes to BIM 3D model extended with one extra variable- time. Scheduling is replaced by parametric modelling, in which every element is assigned in a sequence of construction. BIM 4D creates new opportunities for information modelling: the division of the project into phases, visualization of phases, simulation of schedule of works, accurate planning for delivery time and materials

3) BIM 5D - Estimating – it means BIM 4D extended with another variable - the cost of labour and material for each item. BIM 5D enables fast estimation of cost for conceptual designs and any other cost estimations. With help of BIM 5D we can easily compare execution time and total costs of various alternatives in terms of materials and technology, what can promote the optimization of the total cost of the investment.

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4) BIM 6D - Sustainability - Software compatible with BIM 6D allows for integration of data related to environment protection or energy consumption, i.e. with help of special programs the analysis of building energy consumption is possible. Models prepared in BIM 6D environments are often used as a primary tool to meet requirements defined by LEED (Leadership in Energy and Environmental Design).

5) BIM 7D – Facility management application - The information is extended with detailed information for each embedded element: building (structure), finish (e.g. types of floor) and all equipment (lamps, heaters, etc.). The relevant information is a type of the item, its specification, the time of the next maintenance or replacement, the warranty period, the time consumption. This will allow for convenient maintenance of the building, and when failure occurs, it will be able to be quickly locate the item and repaired.

C. Main Features of BIM

1) Clash Detection – Clash detection is the main feature which allows project members to identify the point of conflict between other models of different background. By doing this we can mitigate the finance & project related risk. This saves time in construction and effectively, money and labour.

2) Quantity extraction – It is another main feature which BIM provides, which enables user to quickly extract exact quantity of material needed, its rate etc. Once the quantities of materials are extracted schedule can be prepared easily. whereas if it done manually it consumes more time and money and there might be the chances of error.

3) Energy analysis - BIM provides energy analysis of the building when it is constructed virtually. Generally building take up 40 percent of the global energy. Therefore, by doing energy analysis of the building we can find out the direction and intensity of sunlight, rainfall and wind using the weather forecast at the site. This will help to effectively decide the orientation and type of material to be used in building. It will ultimately helpful to reduce the overall carbon emission of the building and make the building more energy efficient.

4) Cost reduction – BIM reduces the financial risks related to the construction and design. BIM quantity take-off tools/plugins share a more accurate area and material quantities information within the model. 4-D schedules are analysed and reviewed using model-based schedule visualization. 5D cost planning and target costing with model-based feedback improves the predictability and manageability of the project and reduce inaccuracies up to 3% and thus it helps to manage cost effectively.

D. BIM Process vs Normal Construction Process

BIM process provides common platform called as common data environment CDE which can be accessed by all members involved in project. The ownership of the CDE remains to the owner of the project or can be transferred. The various 3D models and 2D drawings of the respective fields are drawn and uploaded CDE in accordance and in reference with existing models in the CDE. This improves the communication between the project members. BIM facilitates clash detection by which we can detect the points of conflicts & resolve the issue at design stage therefore the time & cost can be saved. We can add the time related information (4D) & cost related information(5D) to the model then we can run the simulation and visualize construction phases.

In normal construction process the drawings are transferred from person to person therefore it consumes more time. The one-way communication between each project members brings about a conflict of designs between each drawing. These conflicts can be found out only during construction this leads to wastage of time, money and labour which causes the over budgeting of the project. There are many problems faced from this type of construction process.[2]

II. METHODOLOGY

The software's, external tools, common file formats & methodology used for creating a virtual 4D BIM model is explained in this paper. The software's used are Autodesk AutoCAD 2018 for creating and understanding the 2D drawings, Autodesk Revit 2018 for creating 3D model of respective field, Csi etabs for additional support, MS Project 2007 for creating scheduling and Navisworks manage 2014 for integrating all the information. The external tools used for data transfer between Csi etabs and Autodesk Revit is CsixRevit. The IFC (Industry foundation classes) used as a common file format for data sharing. The fig.1 shows the procedure followed to create 4D model.

CsixRevit - CsixRevit is an external tool which allows to transfer information between Csi products and other software's.

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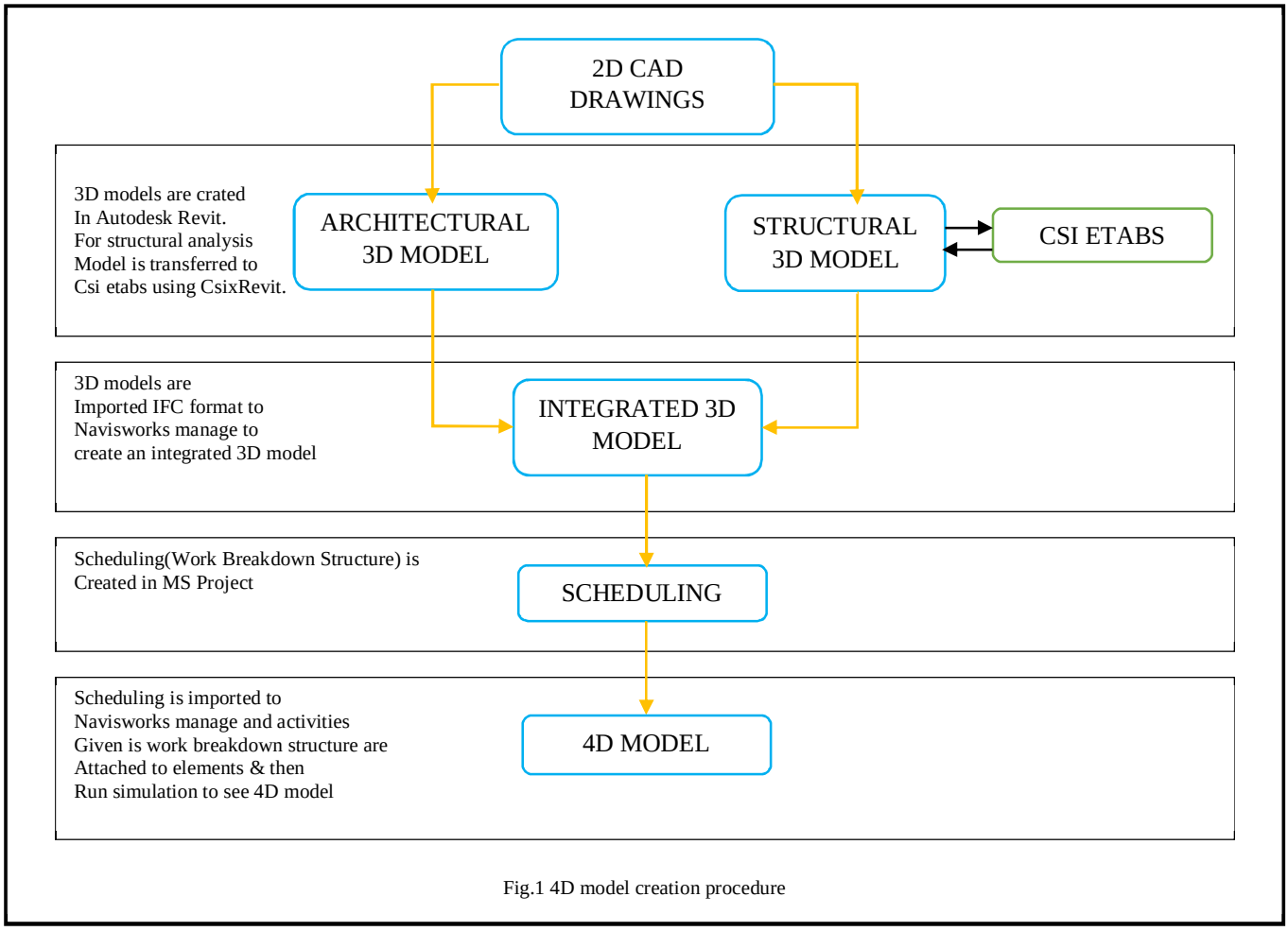


Fig.1 4D model creation procedure

A. Exploratory 4d Model

The exploratory 3D model is created in Autodesk Revit 2018. The model is G+4 story multi-family residential building(framed structure). The models only contain architectural and structural information; therefore, the model is used for civil construction related works only, however other information like mechanical, electrical and plumbing can also be added in the model. Fig.2 & Fig.3 shows the architectural and structural model respectively. For analysis and design purpose the structure is also transferred from Autodesk Revit 2018 to Csi etabs 2018 by using external tool called as CsixRevit.[5][6]

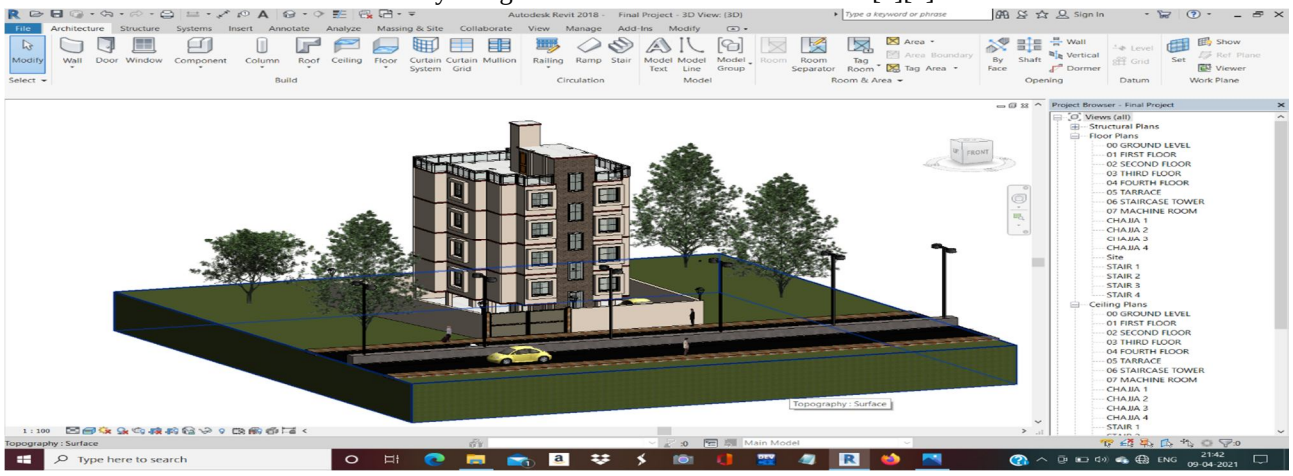


Fig. 2 Architectural 3D model

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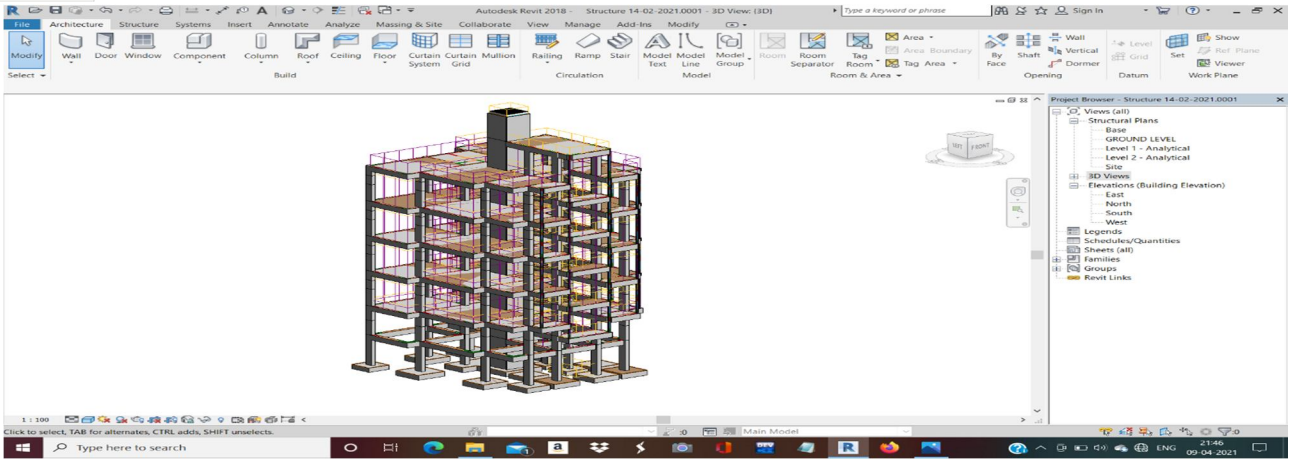


Fig.3 Structural 3D model

The exported 3D models and scheduling are then imported in Navisworks manage 2014 using import option and then both imported 3d models are merged together in order to obtain integrated 3D model shown in Fig.4.

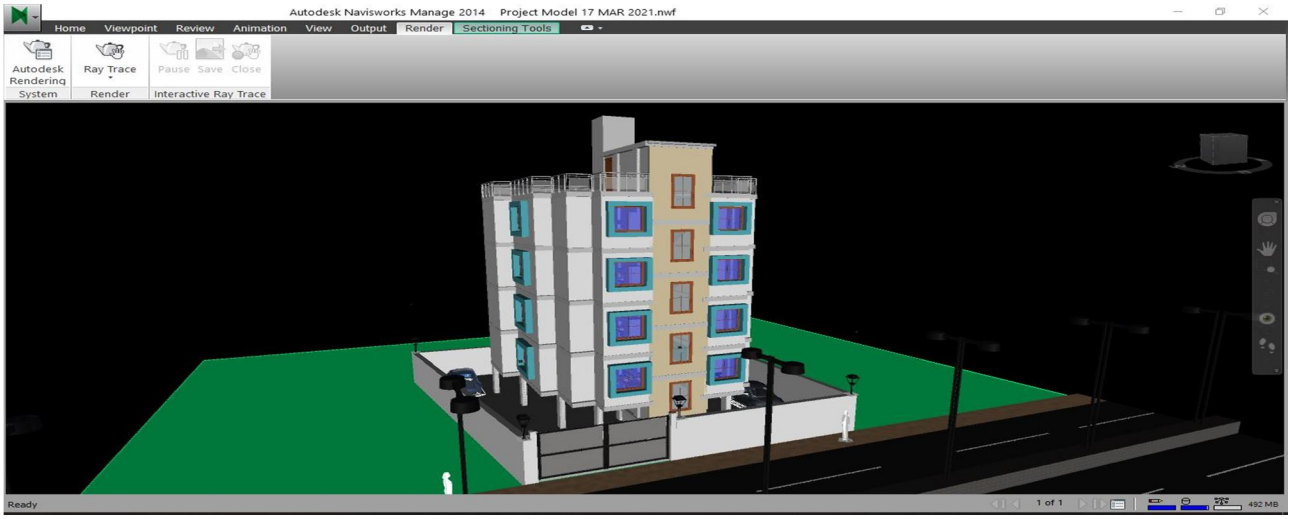
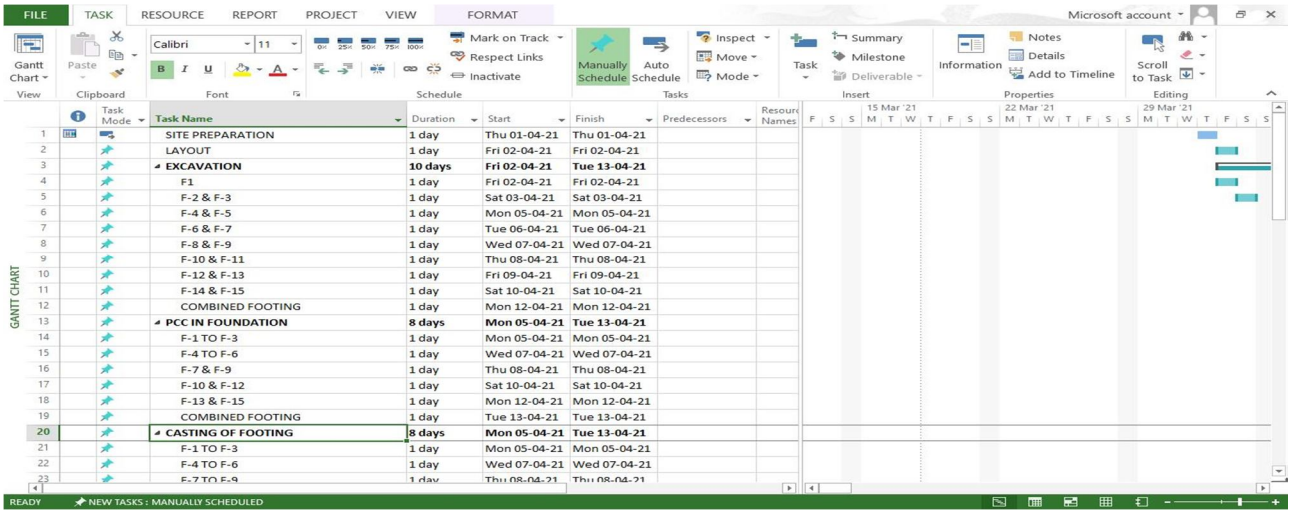


Fig.4 Integrated 3D model

Elements are listed out by creating a work breakdown structure of the 3D model and accordingly, a Construction schedule is prepared in Microsoft project 2007 as shown in Fig.5.



	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		SITE PREPARATION	1 day	Thu 01-04-21	Thu 01-04-21		
2		LAYOUT	1 day	Fri 02-04-21	Fri 02-04-21		
3		**EXCAVATION**	**10 days**	**Fri 02-04-21**	**Tue 13-04-21**		
4		F1	1 day	Fri 02-04-21	Fri 02-04-21		
5		F-2 & F-3	1 day	Sat 03-04-21	Sat 03-04-21		
6		F-4 & F-5	1 day	Mon 05-04-21	Mon 05-04-21		
7		F-6 & F-7	1 day	Tue 06-04-21	Tue 06-04-21		
8		F-8 & F-9	1 day	Wed 07-04-21	Wed 07-04-21		
9		F-10 & F-11	1 day	Thu 08-04-21	Thu 08-04-21		
10		F-12 & F-13	1 day	Fri 09-04-21	Fri 09-04-21		
11		F-14 & F-15	1 day	Sat 10-04-21	Sat 10-04-21		
12		COMBINED FOOTING	1 day	Mon 12-04-21	Mon 12-04-21		
13		**PCC IN FOUNDATION**	**8 days**	**Mon 05-04-21**	**Tue 13-04-21**		
14		F-1 TO F-3	1 day	Mon 05-04-21	Mon 05-04-21		
15		F-4 TO F-6	1 day	Wed 07-04-21	Wed 07-04-21		
16		F-7 & F-9	1 day	Thu 08-04-21	Thu 08-04-21		
17		F-10 & F-12	1 day	Sat 10-04-21	Sat 10-04-21		
18		F-13 & F-15	1 day	Mon 12-04-21	Mon 12-04-21		
19		COMBINED FOOTING	1 day	Tue 13-04-21	Tue 13-04-21		
20		**CASTING OF FOOTING**	**8 days**	**Mon 05-04-21**	**Tue 13-04-21**		
21		F-1 TO F-3	1 day	Mon 05-04-21	Mon 05-04-21		
22		F-4 TO F-6	1 day	Wed 07-04-21	Wed 07-04-21		
23		F-7 TO F-9	1 day	Thu 08-04-21	Thu 08-04-21		

Fig.5 Scheduling

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Schedule is synchronized and hierarchy is developed automatically by clicking synchronize option in the timeliner. Model elements are selected and attached with the schedule by giving commands. Different colours can be assigned to element to show the construction phases of the model. Finally, by starting simulation in timeliner we can visualise the 4D model as shown in Fig.6.

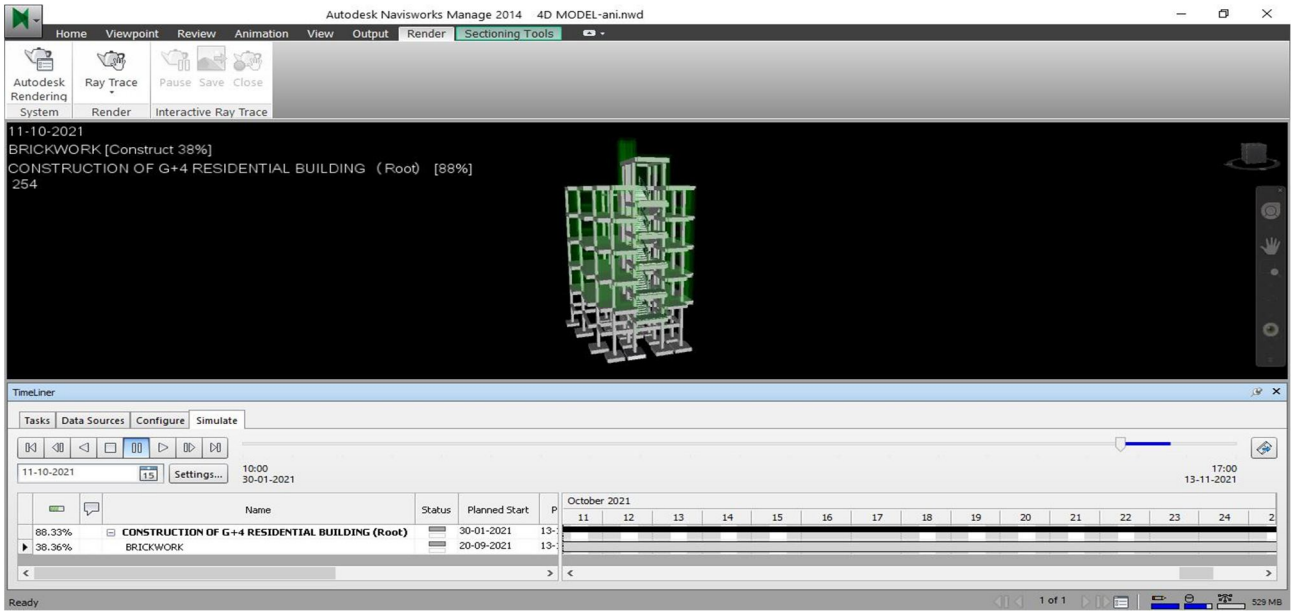


Fig.6 4D Simulation

III. CONCLUSION

Building Information Modeling process provides visualization, better coordination, efficient way of working, effective communication and single platform for collaboration which is current need of construction industry. BIM process can be used from design stage to end of utility period of the structure and significantly reduces the risk related to time and cost overrun. 4D BIM model can be used strategically by on-site management for visualization and can assist site personnel in brainstorming sessions and discussions about access, storage and sequencing of work.

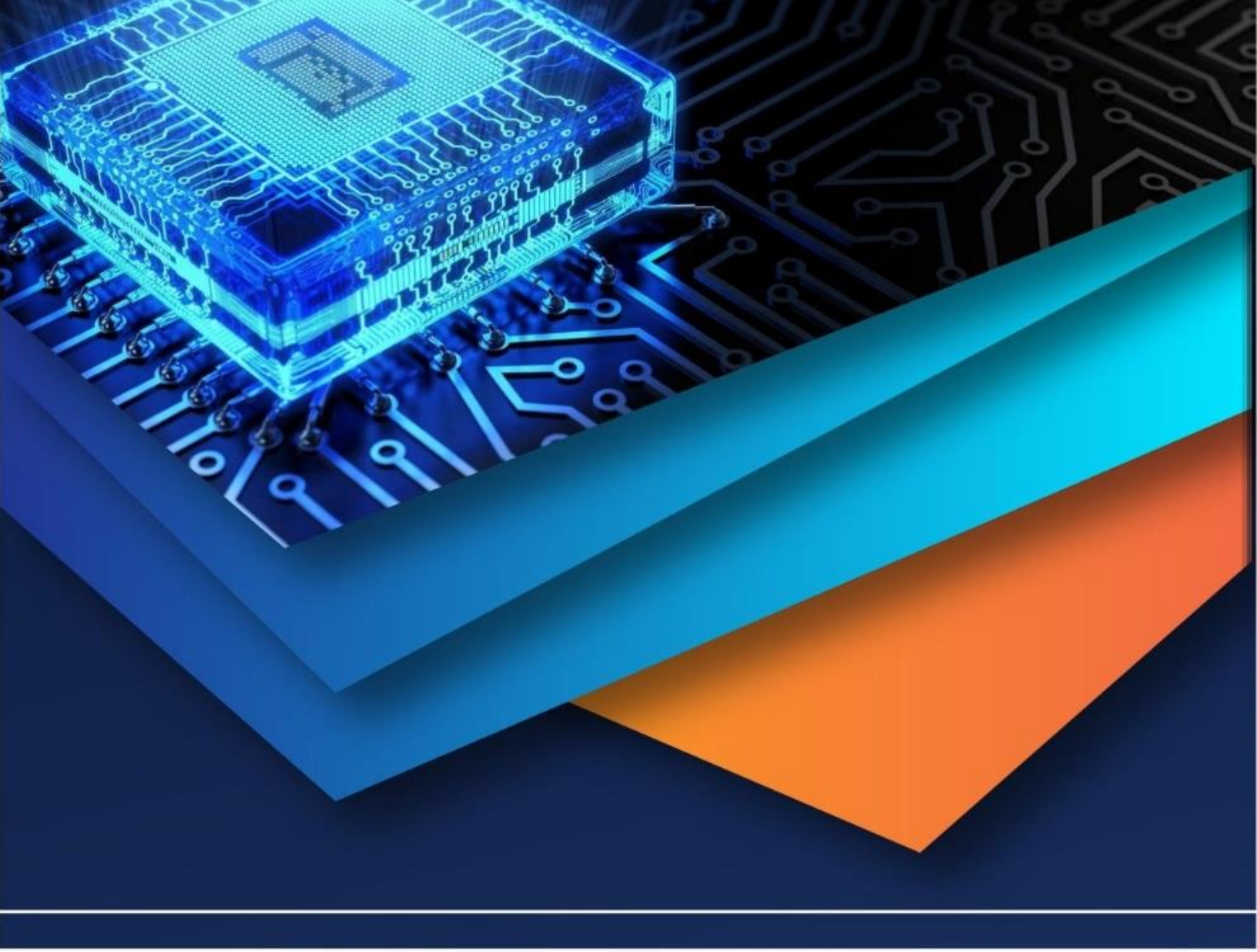
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