BIM Aided Real Time Progress Management Model for Construction

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Abstract*: *In developing countries like India construction industry significantly influence economic growth. Construction industry develops the infrastructure for a better world. Construction industry deals with large amount of resources. Timely planning of resources for smooth execution is important in such projects. Building Information Modeling (BIM) which was earlier used for representation of the building in 3 dimensions (3D) now aids planning process by incorporating the time and cost as 4^{th} and 5^{th} dimensions (4D & 5D) respectively. Timely planning of resources is possible by reducing the resource buffer. It also helps in improving coordination between different stakeholders in the project. 5D model is developed during the planning phase. 4D and 5D simulation helps in visually analyzing the execution process by which the errors can be optimized. Variety of software was used in developing this model. The current research is done to develop a 5D BIM simulation model to help the planning engineers to overlook the requirements or issues during the course of execution. An apartment building in Bangalore, Karnataka which is under the initial phase of construction is taken to validate the model. Construction projects involve exorbitant resources; therefore, it is important to carefully study and regulate the construction works and projects without delay and the current study provides insights for Civil engineering students and practitioners. It helps in proactive planning and holistically be prepared for any constraint or situation which may arise during the course of the project. It not only used during the course of execution but may be extended beyond that.

Index Terms: Building Information Modeling, Optimized, Simulation.

I. INTRODUCTION

Representation of functional and physical characteristics of a facility digitally is known as Building Information Modeling (BIM). Extending the BIM model beyond 3D which is the length, width and depth comes the time as the 4^{th} dimension (4D) and cost as the 5^{th} dimension (5D). Properties of building components, spatial relationships, geographic information, light analysis, quantities, etc are also cover in such models. Therefore BIM acts as an important system during the planning phase. It does not stop with the planning phase; it is extended throughout the project lifecycle like the design phase, variety of operations in the execution phase, commissioning phase, operation and maintenance, facility operation and so on. Virtual information is passed in to various stakeholders in the project like the design team, main contractor, subcontractors, and owner/ operator using BIM. Each one of them adds their respective discipline data into a single system where the entire information is stored. These data gives meaningful information which can be retrieved by different users as and when they need.

3D modeling is not limited to speeding up the process. It enables architects and designers to identify potential problems and play around with different ideas before they become actual issues. Animation and automation is possible with the help of 3D modeling. The client will be able to visualize their how their future building would look like which is not possible in regular drawings which looks more complex. Options like walk enough enables them to virtually feel how the building would look in the future. Space and structure of the building is better understood by this type of a model which is self explanatory. The context in which the client or the end user expects is shown clearly in the model.

Various participants of the project, viz., architects, designers, contractors and clients will be able to visualize the entire project with an additional attribute which is time. Progress of activities involved throughout the lifetime of the project and time series of events are visualized. Impact of design proposed on the construction schedule and work process can be assessed. 4D simulation supports construction planning by enabling faster and optimal planning as it is easier to identify the problem.BIM implementation in the growing Architecture, Engineering and Construction (AEC) field may be challenging to make them adapt to a new system. In recent years, BIM implementation started gaining momentum among different stakeholders in the construction industry. In India, real estate sector is expected to reach a market size of US$ 1 trillion by 2030 and contribute 13 per cent of the country's GDP by 2025. Therefore, BIM can be expected to achieve maximum usage in India in the upcoming years.

From past literatures, it is evident that issues and conflicts are common when it comes to file sharing. Restricting the access for the irrelevant stakeholders for securing the data is adopted by users nowadays. Most of them are not aware that BIM simplifies the entire construction process when the right option is adopted for that particular phase of construction. BIM systems call for higher cost while upgrading to their current conventional system.

II. SCOPE AND OBJECTIVE

Planning of any project should be done holistically so that all the constraints which may affect the construction activities are covered during the planning process. BIM helps in visually understanding the project better and take timely decisions regarding the requirements of the project. Time and cost are the two major factors which influence the

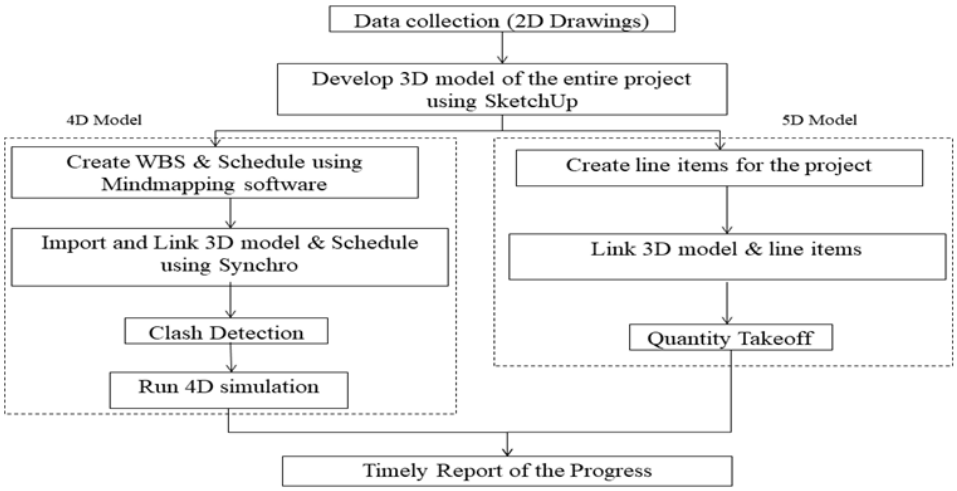

Fig. 1 ***Methodology***

construction activities. These two factors are taken as the 4th and 5th dimensions of the current study. The scope may be extended beyond the 5th dimension by taking sustainability as 6th dimension (6D), facility management as 7th dimension (7D) and so on. In this study the scope is restricted to the 5th dimension.

The main objectives of the study are:

1. To develop a 5D BIM model in the planning phase.
2. To run the 5D simulation to understand and improvise better planning strategies in construction.
3. To enable holistic planning of resources by considering all the constraints and optimising it.

III. METHODOLOGY

The research is divided into two major categories, viz., 4D modeling and 5D modeling. Initially, data is collected from the engineers and architects involved in the project. From the obtained data, the 3D model of the building is developed. Further by linking schedule with the developed 3D model, 4D BIM model is developed. Similarly, by linking line items of Bill of quantities (BOQ), 5D BIM model is developed. The research is validated by taking a real-time apartment project which is under the planning phase. Variety software and tools were used in this research, namely, SketchUp to develop the 3D model of the building, Synchro Pro for 4D modeling and Estimator for 5D. Fig. 1, represents the methodology adopted in the current research.

A. Data Collection

The site is located in Bangalore, Karnataka. 2D drawings like the plan, section, elevation, structural details, electrical details, and plumbing details were collected from the architects and the design engineers. Along with this the site inspection details and layout of the plot were collected for better understanding of the project. This acts the base upon which a holistic 3D model can be developed for better visual representation. These drawings were prepared using AutoCAD, which is the most common software used for design and detailing purpose, whose file format is supported in 3D modeling software.

B. Developing 3D Model

With the help of the collected 2D drawings, 3D modeling is done using the SketchUp software, widely used software by architects for design purpose nowadays. Levels and groups are created in each level and group to facilitate importing and linking the file in other levels of modeling software. Any type component like RCC components, block work, slabs, reinforcements, plumbing and electrical fixtures of any dimension can be developed with the help of this software. It is a good practice as it makes it easier to work with the model and reduces chaos while detailing with a large number of components.

Contractor's scope in this project was restricted up to block work and providing electrical and plumbing services. In this model, electrical and plumbing services were also incorporated to test the clashes between various components and services in the building. Fig. 2, is the 3D model developed using SketchUp.

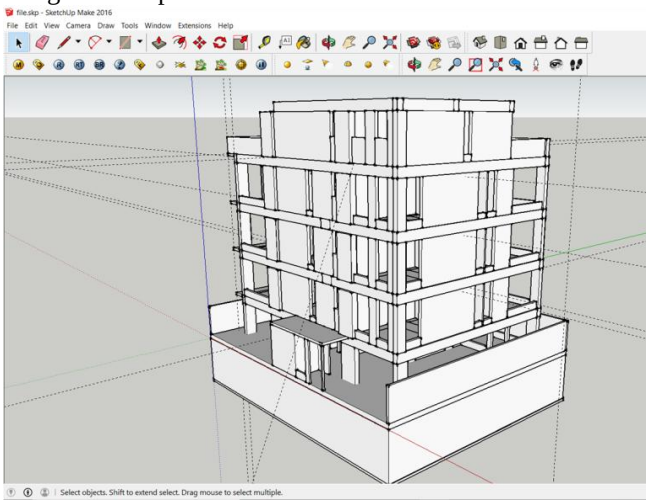

Fig. 2 ***3D model of the building***

C. Creating WBS And Schedule

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Scheduling is one of the most important activities during planning phase from which baseline plan and important milestones can be fixed. It requires a lot of experience and a variety of constraint sand parameters have to be considered while framing the schedule. Work Breakdown Structure (WBS) divides the entire project into manageable sections. Series of brainstorming sessions were conducted with the planning engineers and experts to arrive at the WBS for the project. WBS acts as a base for detailed scheduling of items in the project. Detailed schedule is developed upon elaborating the activities which are to be achieved to complete each of the components in the WBS. The Brain, which is a mind mapping tool, was used to organize the ideas and thoughts given by different participants in the brainstorming sessions. Fig. 3, shows the collection and organization of ideas in the mind mapping tool.

Based on the structure obtained from the mind mapping tool, WBS was framed as shown in Fig. 4.

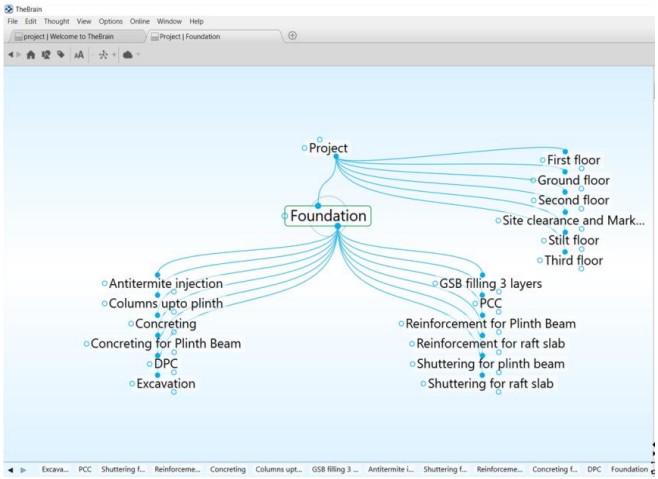


Fig. 3 ***Organizing ideas and thoughts using Mind mapping tool.***

Following the WBS, a detailed schedule (Refer Fig. 5) was drafted after interacting with the executives and planning engineers. Scheduling was done directly on Synchro Pro which is 4D modeling software. Linking of activities and adding predecessor, successor, constraints, lag and other parameters are given as inputs for each activity in the schedule. Ultimately, the entire project schedule can be planned holistically with the help of this software. Critical path and the critical activities of the project can be identified which are the most important attributes of a schedule.

D. 4D Modeling

The 3D model developed in SketchUp is imported to Synchro Pro where the 3D model and the schedule can be linked. Each component in the model is linked to its respective activity in the schedule (Refer Fig. 6). Levels and components created in the 3D model makes it easier to link the components; it is not required to select every minute detail separately in the model. Also different resources required for that particular activity is given as inputs to facilitate next level of BIM. Upon linking all the components, the 4D model is ready with all the parameters to run the simulation.

Clashes in the model are possible as the electrical and plumbing services have been integrated. Potential areas at which the clashes are possible are selected and checked. If any clashes are observed, the 3D model should be altered and the corresponding items in the schedule should be adjusted to avoid clashes.

E. 5D Modeling

Line items are a list of estimated cost for each item in the Bill of Quantities (BOQ). Line items include the cost of all resources like manpower, materials, machinery, plants, electricity, etc. involved in the project. Each of these line items is grouped together as per the requirements for a particular activity so that the building component from the 3D model can be linked to its respective grouped line items. Estimator software is used for 5D modeling; when the line items are linked to the components in the 3D model, automatic quantity takeoff and estimate is prepared. In this way, it aids the planner to precisely decide the quantity of materials required at a specific period of time.

IV. RESULTS AND DISCUSSION

5D modeling makes the planning process simpler by popping up the issues arising due to the important constraints. More precise planning, resource allocation and resource leveling is done with the help of 5D. Estimator software gives accurate take-offs and the entire estimate of the project is arrived. Total built up area of the project is 9,604 square feet, estimated time completion is 304 days and the estimated cost of construction arrived from Estimator software is Rs. 1785 per square feet.

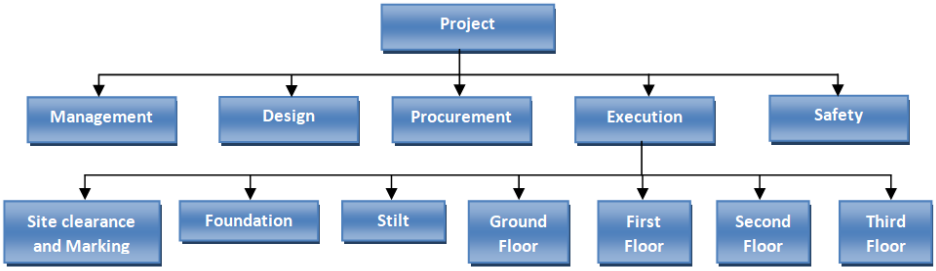
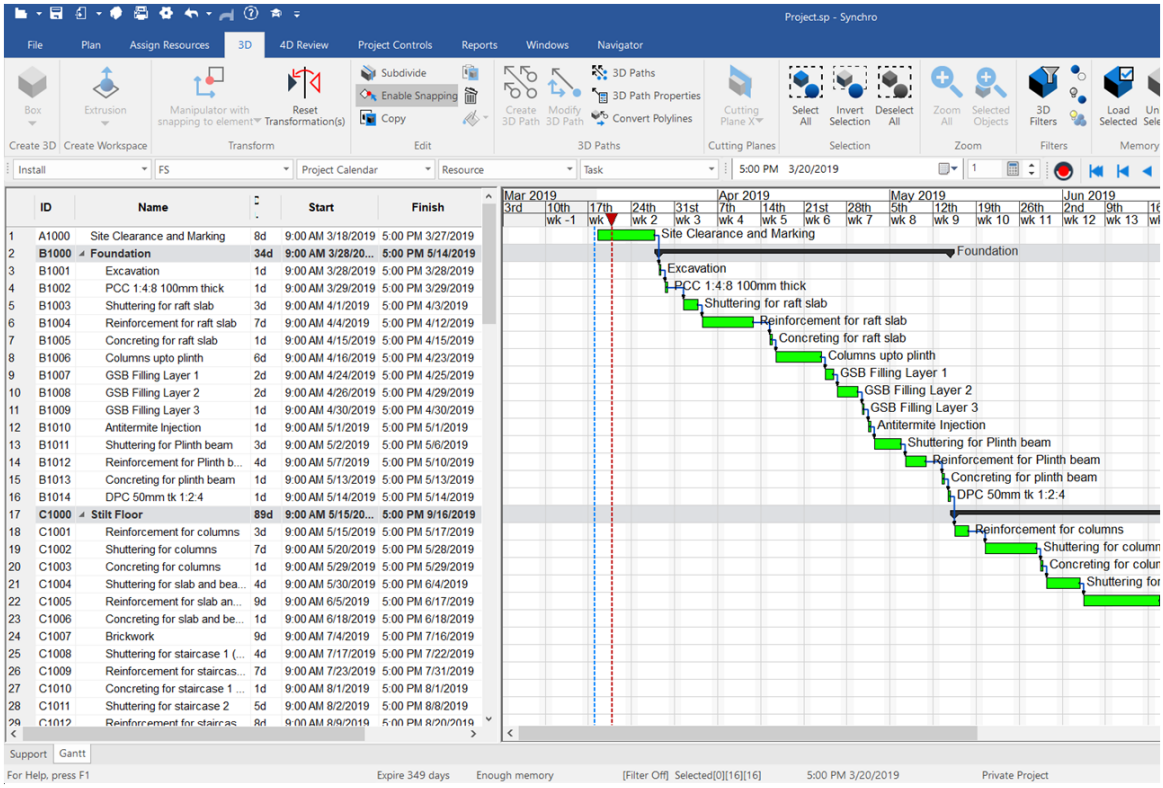


Fig. 4 ***Work breakdown Structure (WBS)***

With the help of all the 4D and 5D modeling data, further planning for optimizing, value addition, risk management, project



	ID	Name		Start	Finish
1	A1000	Site Clearance and Marking	8d	9:00 AM 3/18/2019	5:00 PM 3/27/2019
2	B1000	Foundation	34d	9:00 AM 3/28/20...	5:00 PM 5/14/2019
3	B1001	Excavation	1d	9:00 AM 3/28/2019	5:00 PM 3/28/2019
4	B1002	PCC 1:4:8 100mm thick	1d	9:00 AM 3/29/2019	5:00 PM 3/29/2019
5	B1003	Shuttering for raft slab	3d	9:00 AM 4/1/2019	5:00 PM 4/3/2019
6	B1004	Reinforcement for raft slab	7d	9:00 AM 4/4/2019	5:00 PM 4/12/2019
7	B1005	Concreting for raft slab	1d	9:00 AM 4/15/2019	5:00 PM 4/15/2019
8	B1006	Columns upto plinth	6d	9:00 AM 4/16/2019	5:00 PM 4/23/2019
9	B1007	GSB Filling Layer 1	2d	9:00 AM 4/24/2019	5:00 PM 4/25/2019
10	B1008	GSB Filling Layer 2	2d	9:00 AM 4/26/2019	5:00 PM 4/29/2019
11	B1009	GSB Filling Layer 3	1d	9:00 AM 4/30/2019	5:00 PM 4/30/2019
12	B1010	Antitermite Injection	1d	9:00 AM 5/1/2019	5:00 PM 5/1/2019
13	B1011	Shuttering for Plinth beam	3d	9:00 AM 5/2/2019	5:00 PM 5/6/2019
14	B1012	Reinforcement for Plinth b...	4d	9:00 AM 5/7/2019	5:00 PM 5/10/2019
15	B1013	Concreting for plinth beam	1d	9:00 AM 5/13/2019	5:00 PM 5/13/2019
16	B1014	DPC 50mm tk 1:2:4	1d	9:00 AM 5/14/2019	5:00 PM 5/14/2019
17	C1000	Stilt Floor	89d	9:00 AM 5/15/20...	5:00 PM 9/16/2019
18	C1001	Reinforcement for columns	3d	9:00 AM 5/15/2019	5:00 PM 5/17/2019
19	C1002	Shuttering for columns	7d	9:00 AM 5/20/2019	5:00 PM 5/28/2019
20	C1003	Concreting for columns	1d	9:00 AM 5/29/2019	5:00 PM 5/29/2019
21	C1004	Shuttering for slab and bea...	4d	9:00 AM 5/30/2019	5:00 PM 6/4/2019
22	C1005	Reinforcement for slab an...	9d	9:00 AM 6/5/2019	5:00 PM 6/17/2019
23	C1006	Concreting for slab and be...	1d	9:00 AM 6/18/2019	5:00 PM 6/18/2019
24	C1007	Brickwork	9d	9:00 AM 7/4/2019	5:00 PM 7/16/2019
25	C1008	Shuttering for staircase 1 (...	4d	9:00 AM 7/17/2019	5:00 PM 7/22/2019
26	C1009	Reinforcement for staircas...	7d	9:00 AM 7/23/2019	5:00 PM 7/31/2019
27	C1010	Concreting for staircase 1 ...	1d	9:00 AM 8/1/2019	5:00 PM 8/1/2019
28	C1011	Shuttering for staircase 2	5d	9:00 AM 8/2/2019	5:00 PM 8/8/2019
29	C1012	Reinforcement for staircas...	8d	9:00 AM 8/9/2019	5:00 PM 8/20/2019

Fig. 5 ***Detailed Schedule of the Project***

control, project crashing, etc. can be planned in detail.

In this way, more accurate and error free planning of schedule and cost is achieved. It saves time and cost to a greater extent compared to the conventional planning processes.

BIM is a very powerful system which serves various purposes during various stages of a project. It can be adopted during any stage, viz., pre-construction, post-construction and commissioning stages. BIM is slowly penetrating into Indian construction industry in the recent years.

V. CONCLUSIONS AND FUTURE SCOPE

The proposed model helps in simulating the construction process taking the two major factor which is the time and cost. Current study acts as a base for future enhancements in digital construction for non- linear structures. Integrating major factors like time and cost together with the dimensions of the building enable the planning engineers to holistically plan the execution by reducing the resource buffer. The time and cost savings while adopting BIM will be significant when applied on larger projects. Beyond 5D, the scope can be extended to

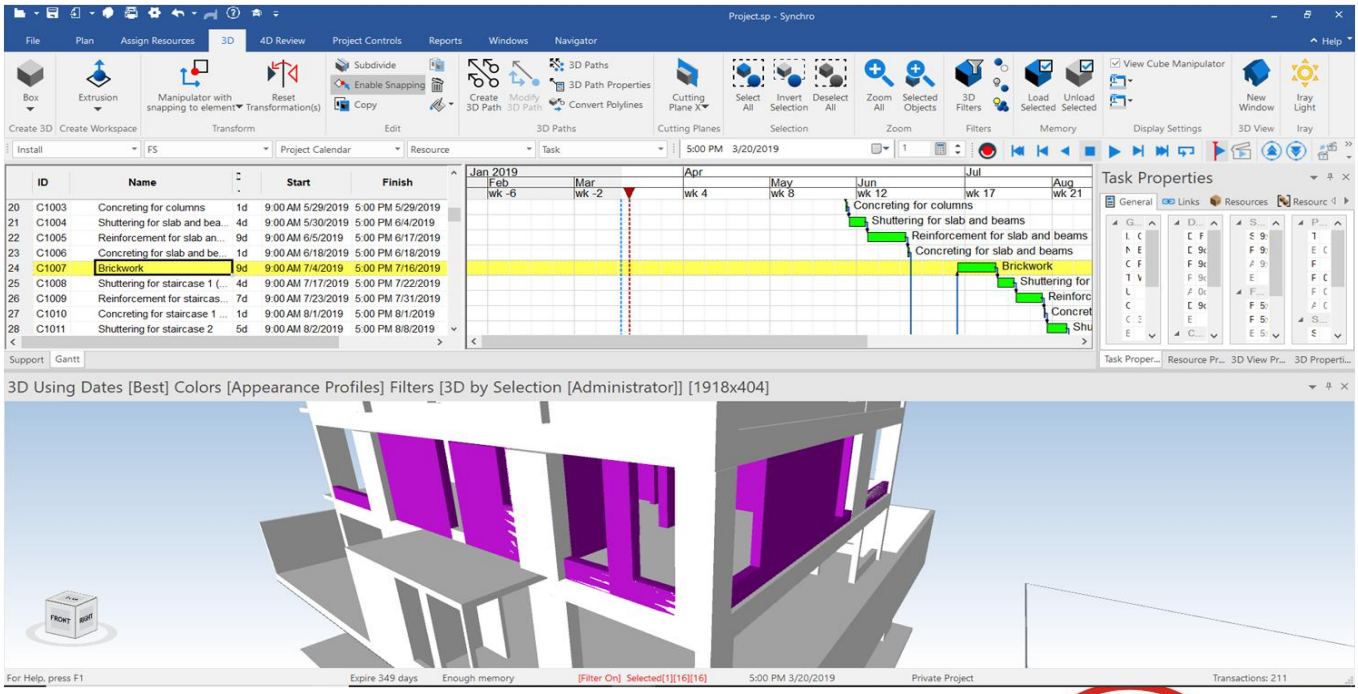


Fig. 6 ***Linking components for 4D Modeling***

other dimensions like sustainability, facilities management, lean construction, etc. Also, other services like shuttering, tower crane, etc can be designed using BIM which will enable better visualization and understanding about the execution activities prior to the start of the process.

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