Collaborative Development of 4D BIM for a Multistoreyed Building

Anagha Manoj[1], Christo George[2], Hanna Elisha Varghese[3], Jacob Sabu[4], Jeevan Jacob[5]

[1-4]*Final year UG students, Department of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India*
[5]*Professor, Department of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India*

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Abstract - *Building Information Modeling (BIM) represents a procedural and technological transition that emerges as a change agent in the Architecture, Engineering, and Construction (AEC) industry. 4D modeling refers to a BIM dimension that associates the 3D model of an enterprise with the planning schedule information, providing the visualization of the actual sequence of construction activity. Interactions with 3D models are discussed and debated extensively in research, when in fact, 4D modeling is less discussed, thus there is a knowledge gap that can be explored. In this way, this study aims to come up with a collaborative approach for 4D modeling which allows optimizing the construction, the placement of building structures and materials at various stages of construction, to optimize the organization of work performance, as well as to monitor the activities which result in saving money and time.*

Many project teams are now realizing and implementing 3D and 4D modeling on actual projects. It is still a complicated process that requires a coordinated effort for effective completion. This study addresses the shortcomings in collaborative work by providing guidelines that describe how to overcome the technical, procedural, and organizational issues confronted by project teams as they undertake this new way of working.

Key Words: BIM, 3D Modeling, Scheduling, Collaboration, 4D BIM

1. INTRODUCTION

Nowadays, construction building projects are becoming much more difficult and complex. The extent of the complexity of such projects is incredibly high because of the high amount of data and sophisticated consumer needs. Efficient project delivery is critical to the success of these infrastructure projects. Traditional project management systems were built on the iron triangle of project performance, time, money, and scope. Emerging measures such as quality, occupational health and safety, and stakeholder satisfaction necessitate new business models. Unfortunately, despite the fact that architects, builders, and manufacturers fail on a daily basis to produce on time, under budget, and successfully satisfy the demands of their clients, few of them accomplish the intended results.

Building Information Modelling (BIM) is a digital presentation of functional and physical characteristics of a project which is regarded as a potential solution to challenges within the design and construction stages. Therefore, BIM is an excellent technology not only in the design stage but also in the construction stage, because it saves time and improves productivity throughout the entire life cycle. Global construction projects are developing on a daily basis, and demand for resources is increasing, thus there is a growing need for a sustainable construction scheduling process to finish projects on time and within budget. A 3D model can be utilized for construction planning if time is added to it, which is known as 4D BIM. 4D Building Information Modeling (4D BIM) is a process of the intelligent interaction of a digital 3D model with time or schedule-related information. It's gaining momentum in the industry by offering both tangible and intangible benefits for it which are set out here. It provides precise and useful construction project information for teams. It has removed the challenge associated with traditional scheduling of construction sequences of misunderstanding brought by the lack of visualization. The use of 4D BIM modeling in conjunction with measuring the efficacy of project schedule delays and tracking the actual progress of the project schedule increased construction performance. Research has demonstrated that using 4D BIM for construction planning, scheduling, and production control may enhance the management of construction safety, workplaces, and waste. The tender team of the contractors might utilize 4DBIM scheduling to design actionable risk reduction methods.

Despite its well-documented benefits, the problem associated with continuous and consistent collaborative practice in BIM project over time still exists. The possible reasons contributing to this issue are due to the complexity of the organizational behavior, self-interest, isolated working practices, and trusting the old system to realize the value of digital transformation. The goal of this research is to present an overview of current developments in 4D simulation development that have influenced or are anticipated to affect construction project planning. So firstly, this study explores how a new collaborative approach for construction planning and management can be supported via 4D BIM technologies and workflows. In order to address this gap, the purpose of this study is to review the key elements of social collaboration in BIM-based construction projects, which could serve as a foundation for further understanding the movement towards successful social collaboration throughout the lifecycle of BIM-based projects. Secondly, it is intended to assess the extent of usage and understand the perspectives of key stakeholders on benefits, barriers, and drivers of 4D BIM in the Indian context. Finally, this study identifies key research challenges and suggests future areas of research.

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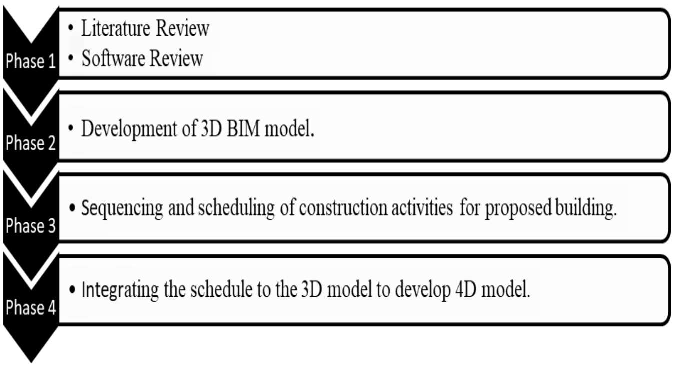
2. METHODOLOGY



3. 3D MODELING

3D model of the proposed building was developed using Autodesk Revit software 2021 version. The models were annotated with 2D drafting elements and building information was accessed from the model's database. The entire B+G+5 floor building was developed in a Revit environment by creating different levels. The 3D model development went through two stages i.e., Architectural 3D model development and Structural 3D model development. Hence Revit provided with this collaboration of architectural and structural disciplines in a single model.

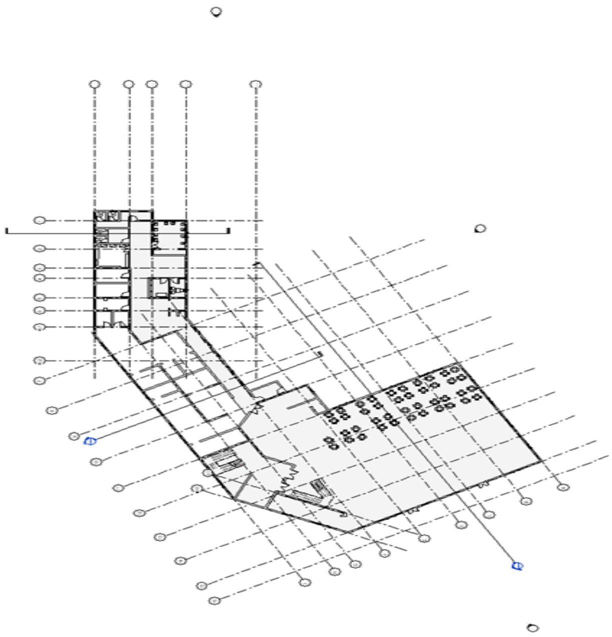


Fig -1: Basement floor plan

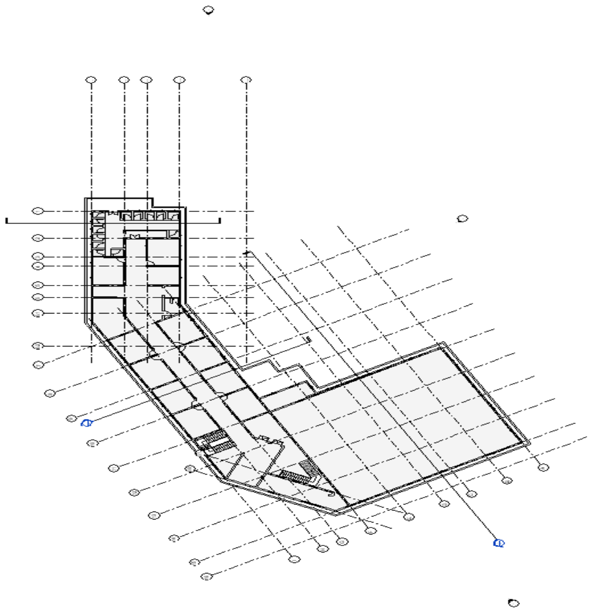


Fig -2: Ground floor plan

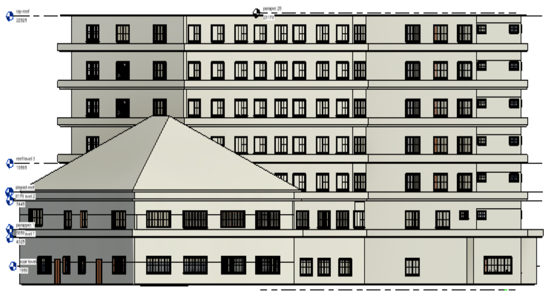


Fig -3: Front elevation

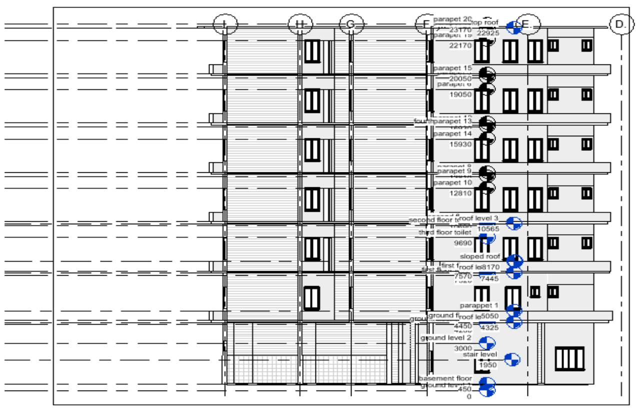


Fig -4: Sectional View

4. COLLABORATION

4.1 Need for Collaboration

Collaboration is a methodology that the construction industry has struggled to adapt in the past, but it has repeatedly been shown to benefit the sector as a whole. Collaboration on a project from the start has several advantages, including reduced time delays, better planning, better means to working, etc. it's very useful when it comes to big heavy projects. Within BIM sits the key elements for success in a construction project. Coordination with other team members or project participants is critical to ensure that nothing is overlooked and to avoid unnecessary duplication. Another significant area where teams might fall short is cooperation, which sometimes occurs by a lack of communication or sharing of critical information between team members. the security of the data shared is also so important for the firm. Plans, designs, crucial information, etc. are very important, and such data should be treated with at most care.

4.2 Techniques Used For Collaboration

The student version of Revit doesn't allow the full experience of collaboration even though a centralized model was developed. So, to develop a collaborative 3D model with 3rd level maturity, another application called Discord was used. Discord allowed creating a server entirely dedicated to this purpose. Each member then joins with their usernames to this server. When one completes the task assigned to him/her, he or she updates the model and adds the new one to the server. It supports sharing of Revit and BX3 files easily. It allows text messaging for better communication with the team member. It also allows simultaneous screen sharing along with face-to-face interaction in order to create an environment just like working next to next. This will help in detecting errors, resource sharing, easier error rectification, better communication between the team members and between the AEC processional. Detecting clashes and errors at early stages means they are addressed and handled during the earlier phase itself. Without this, issues are often picked up at major project milestones and at this point, they can be difficult, costly, troublesome, and may even cause loss of a huge number of human hours. Sharing a 3D model and working on it collaboratively with all parties like the AEC professionals, team members and the stakeholders, etc. communicates the desired result in a clear, simple, and fully understandable manner. Helping the entire project team in understanding the requirements and visualizing what they are working toward. Anytime an update is posted all the team members are notified by Discord and all the team members can go through the changes. As the data is uploaded to the cloud, any member can download the data anytime he or she wants. It helps in keeping a track of workflow. When it comes to building projects, talking about collaboration and implementing a fully collaborative project using BIM are two very different things with very different outcomes. This approach ensures the collaborative development of the 4D building model. It ensures all the project stakeholders, design team members, and AEC professionals get the most up-to-date models, hosted in one central location reducing errors in file versions and timing plans.

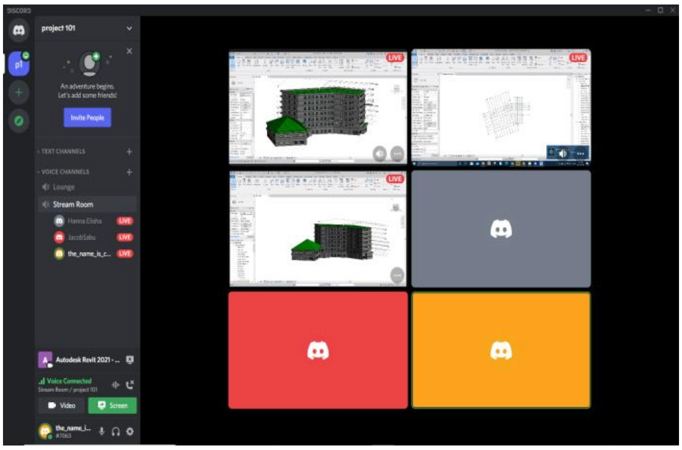


Fig -5: Revit Collaboration on discord

5. SCHEDULING AND INTEGRATION

5.1 Schedule Development

5.1.1 Creation of Selection Sets

At first, the model from Revit was imported as an IFC file and opened in Bexel Manager, with all of the properties and the elements. Then the process of sorting elements by leading groups of works can be done using selection sets. Here a selection set can correspond to a task or a group of tasks in the schedule. So segregation with all of the building elements in the model was started, then the next level was the families of each category were by building a custom breakdown of the activities. When a selection set is created it appears in the selections palette. The selection palette shows all the subsequent task sets with their master task set. Now the manage selection sets tab was used to arrange it.

A selection set is a group of elements that are grouped together according to certain rules that one has set or because one has previously selected them. The group of elements created based on rules is called a smart selection set and a group of elements created by randomly selecting them is called a regular selection set. The main difference is that with the update of the model all elements that apply to certain rules of a selection set will be automatically placed in the corresponding smart selection set.

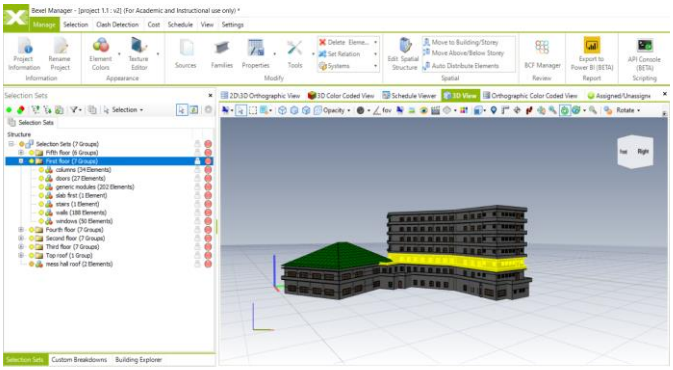


Fig -6: Selection Palette

The created selection sets can be used in all phases of a BIM model development. They can be used while performing quality checks, in the process of creating analysis for clash detection, generating a 4D model in Bexel Manager, or in the process of creating an as-built model for the facility maintenance, where the linking of documentation with the BIM model is done.

5.1.2 SMART SCHEDULING

The schedule is structured according to rules defined in the construction zone and methodology created by a user. All the tasks have duration value and during the schedule creation process, this could be easily adjusted by the user through a smart schedule. Generally, construction phases are dimensioned in such a way to achieve an even distribution of available resources throughout the construction execution period. So, duration should be more or less uniform but some works are faster than others and some level of fine-tuning is necessary. This is easily achievable through smart scheduling.

Procedure:

First of all, a new blank schedule was created in the schedule editor. After that, a calendar was created by defining working hours and days for the working week.

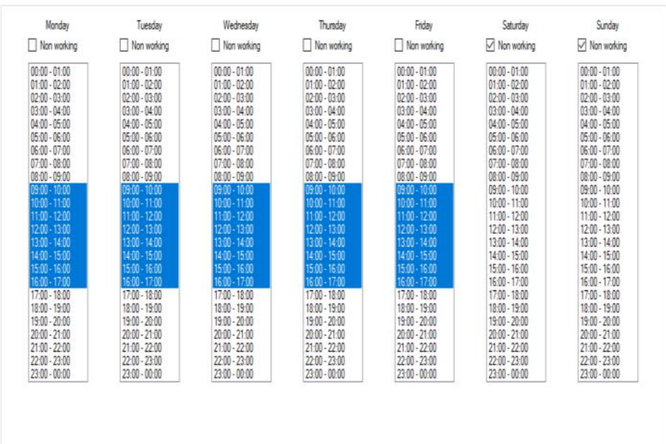


Fig -5: Calendar

A new blank task having no relationship is created automatically in this step. It will be used to describe the process of tracking progress for activities from the schedule with no geometrical presentation, which occurred during the whole project. This also means that the task will go on from the beginning of the project until the end of the project.

Afterward, each new task was created using the linked functionality which helps to export the previously defined selection sets into the schedule. The linked functionality enables to link children activities (i.e., slab, columns, wall, etc. on each floor) with their parent activity (i.e., floors). For instance, if the ground floor is the parent activity, all of its respective elements, such as columns, slabs, walls, etc. are its children activities.

Then the next step was to logically link each of the parent tasks in the order of construction. Similarly with the children tasks. This is shown in subsequent figures.

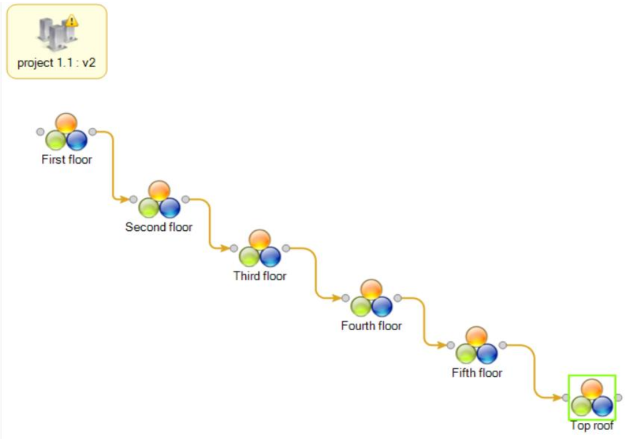


Fig -7: Linking of Parent tasks (spatial zone levels)

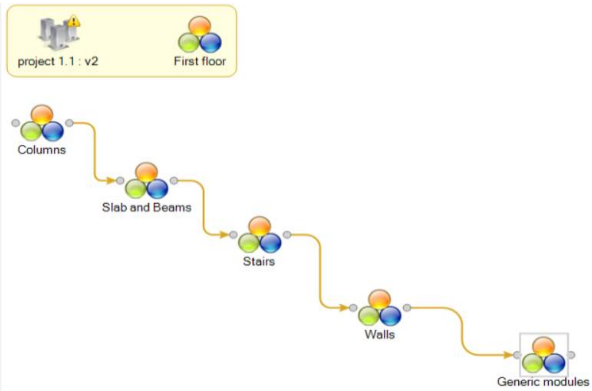


Fig -8: Linking of Children task

After that, each activity day is adjusted to obtain the desired schedule with the help of the task editor. The schedule can be analyzed in detail from the Task Report within the schedule editor tab itself. Bexel Manager also allows exporting the schedule into MS Excel.

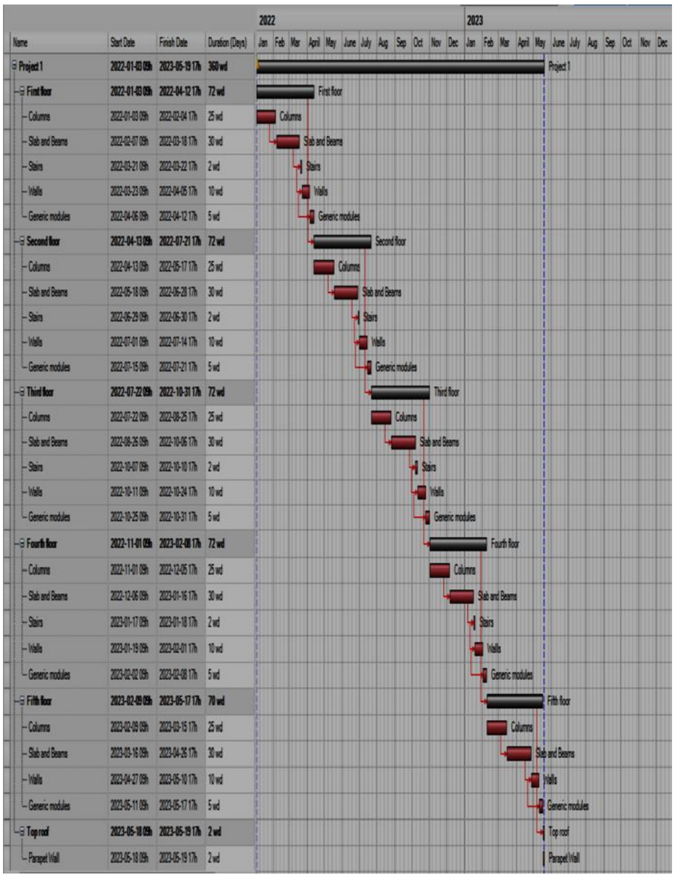


Chart -1: Gantt chart

5.2 4D ANIMATION

The schedule was imported into the Schedule animation tab, the schedule was updated for the animator to read the schedule, and the framerate was adjusted for the desired output. Finally, the 4D animation video was exported. This animation video shows the corresponding date on which each process takes place at the site as per the schedule.

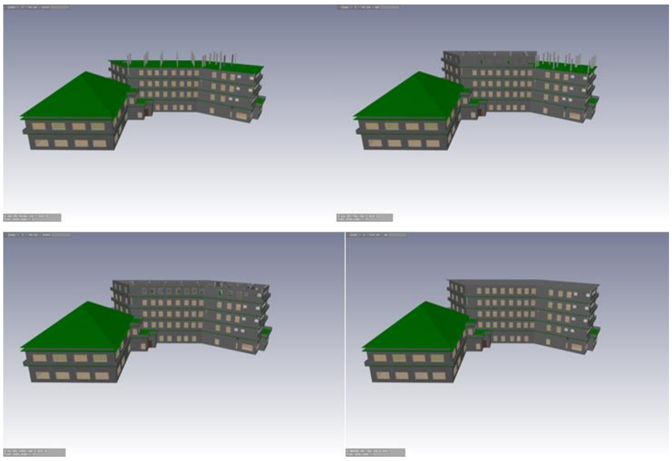


Fig -9: Simulation stills

6. CONCLUSIONS

The method devised here is a feasible approach for collaborative 4D construction planning. The importance of the paper lies in several aspects: collaboratively developing a 3D model, the unique 3D model input to foster collaboration and social interaction, direct manipulation for user-system interaction, creation of schedule for workflow, and integration of schedule to the 3D model. It has the potential to change the way facilities are constructed and administered. It offers many significant benefits in project planning, scheduling, progress monitoring, conflict prevention & resolution, data security, and construction safety. For the complete validation of the methodology and procedure, several variables including social coordination and familiarity with the operation of the software tool should also be taken into consideration. Reinforcing these aspects will strengthen the method to achieve a robust plan in collaborative 4D construction planning. Further onsite industrial testing is recommended in the future to investigate and improve the suggested system.

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