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4D Scheduling and 5D Cost Estimation of a Residential Apartment Using Building Information Modeling (BIM)

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ABSTRACT :

The traditional approach to construction planning often faces challenges such as lack of coordination, inaccurate cost estimates, and time overruns. With the advancement of technology, Building Information Modeling (BIM) has emerged as a powerful tool that integrates various dimensions of construction planning. This study focuses on implementing 4D (time) and 5D (cost) BIM for a G+4 residential apartment building. A detailed 3D model of the structure was developed using Autodesk Revit 2018, and scheduling along with cost estimation was integrated using Navisworks Manage 2018. The workflow included creating construction sequences, associating activities with 3D model elements, and linking material costs to each stage of construction. A simulation video was generated to visualize construction progress over time along with running project costs. Additionally, a Gantt chart was developed to reflect activity durations and interdependencies. The study also includes a comparison between BIM-based planning and conventional methods, highlighting the improved accuracy, coordination, and visualization offered by BIM. The total project cost across all floors was meticulously calculated to be ₹5,567,500. The results reinforce the potential of BIM as an efficient tool for modern construction management and decision-making.

Keywords: BIM, 4D Scheduling, 5D Cost Estimation, Navisworks, Revit, Simulation, Quantity Takeoff, Project Management

1. INTRODUCTION

In the current construction landscape, managing project delays and budget overruns remains a persistent challenge, largely due to fragmented coordination, poor visualization, and the use of conventional scheduling and cost estimation methods. Building Information Modeling (BIM) has emerged as a transformative solution, offering a centralized digital framework for integrating geometric, temporal, and financial information. By enhancing collaboration and accuracy across all project phases, BIM contributes to reduced rework, improved planning, and informed decision-making.

Among the various dimensions of BIM, 4D and 5D modeling have gained significant attention in project management. 4D BIM adds the time component to the 3D model, enabling the simulation of construction activities across the project timeline. This visual sequencing helps stakeholders understand the construction process, identify clashes, and optimize scheduling. 5D BIM further enriches this process by incorporating cost data into the model, allowing for accurate quantity takeoff, budget tracking, and cost forecasting in real-time.

In this study, a G+4 residential apartment building was used as a case to demonstrate the potential of 4D and 5D BIM in enhancing project delivery. The architectural and structural model was developed in Autodesk Revit (2018) based on actual construction drawings. Quantitative data such as material volumes and component counts were extracted directly from the model. Activity schedules were prepared using Microsoft Project and synchronized with the model in Navisworks Manage (2018) to generate a 4D simulation. Additionally, current local market rates were applied to the extracted quantities to estimate progressive construction costs, forming the 5D component.

The study compares BIM-based planning and estimation to conventional methods, showcasing the advantages of automated data integration, visual clarity, and real-time updates. The results highlight that 4D and 5D BIM not only streamline the construction process but also minimize manual errors, improve coordination among stakeholders, and allow for proactive responses to schedule and cost deviations. This integrated approach thus plays a crucial role in achieving on-time and within-budget project delivery.

Furthermore, the integration of 4D and 5D BIM enhances project transparency by enabling stakeholders to visualize the exact sequence of construction activities alongside their corresponding financial implications. This visibility facilitates early identification of potential risks, such as resource clashes, scheduling bottlenecks, or cost escalations, thereby allowing for timely corrective actions. The ability to simulate various construction scenarios also supports strategic decision-making, especially during planning and procurement phases.

Table 1: Global Impact of Construction Delays and Cost Overruns

Region	Avg. Cost Overrun (%)	Avg. Time Delay (%)	Source
Global	**28%**	**38%**	**McKinsey & Co. (2015)**
India	**20–30%**	**25–40%**	**NITI Aayog Report (2019)**
UK	**27%**	**33%**	**RICS, 2020**
USA	**23%**	**30%**	**Dodge Data & Analytics, 2019**

2. Literature Review

- **Nawari, N., & Kuenstle, M. (2012)**

This study explores the application of Building Information Modeling (BIM) for automating construction scheduling and cost estimation. It highlights how 4D (time) and 5D (cost) BIM models enhance project understanding, coordination, and communication among stakeholders. The methodology involves linking schedules from MS Project and cost data into BIM tools such as Revit and Navisworks. The authors show that integrating scheduling with models improves construction sequence clarity and reduces errors. This paper is foundational in demonstrating the real-time synchronization of schedule and cost data through BIM platforms.

- **Zhang, J., & Issa, R. R. A. (2014)**

The authors focus on improving cost estimation using 5D BIM by integrating cost databases with BIM software. The paper presents a case study showing that the traditional method of estimation is time-consuming and error-prone. Through Revit and Navisworks Manage, they automate quantity take-offs and link them to cost libraries. The integration improves accuracy, minimizes manual effort, and provides dynamic updating of project costs. The study supports the use of 5D BIM as a reliable technique for real-time cost control.

- **Costin, Et al (2018)**

This paper presents a framework for 4D BIM-based construction progress monitoring. It integrates project schedules from Primavera and visualizes them in Navisworks Manage to simulate construction timelines. The study proves that 4D simulations improve transparency, help identify clashes, and enhance decision-making during execution. By linking model elements to work packages and tasks, project teams are able to visualize the building as it evolves. This approach offers benefits like reduced delays, improved planning, and efficient resource allocation.

- **Mahalingam, Et al (2010)**

The authors present a pilot implementation of 4D BIM in India to analyze the technology's practical benefits and challenges. Using a Revit-based model and Navisworks for simulation, the study demonstrates improved communication, fewer design conflicts, and better sequencing. However, it also highlights issues such as training needs and initial investment. The researchers suggest that with proper planning, 4D BIM can significantly enhance project control in the Indian construction sector.

- **Bryde, Et al (2013)**

This research evaluates the impact of BIM on project performance, focusing on time, cost, and quality aspects. Using survey and case study methods, it finds that BIM's 4D and 5D applications streamline scheduling and budget control. Tools like Navisworks are acknowledged for their role in construction simulation and forecasting. The paper concludes that BIM leads to better predictability and proactive risk management compared to traditional project management.

- **Riaz, Et al (2014)**

This paper explores the use of 4D BIM for improving construction safety planning. The authors develop simulations in Navisworks to visualize activity sequences and assess site risks. By mapping work zones and hazards to time-based models, safety officers can forecast dangerous overlaps. The study demonstrates that 4D modeling contributes to a safer work environment and supports proactive planning. It is especially useful for residential buildings where workspace constraints are common.

- **Cheng, J. C. P., Et al (2016)**

The authors examine how 5D BIM contributes to construction cost management throughout the project lifecycle. Their approach involves integrating BIM models with cost codes and estimating tools. They emphasize that 5D BIM enables more detailed and timely tracking of budget deviations. The research validates this using a residential construction case where Revit and Navisworks streamline cost control and reduce financial risk. It supports BIM's role in long-term value engineering.20

- **Gledson, B. J., & Greenwood, D. (2017)**

A UK-based industry survey in this paper evaluates the maturity and benefits of 4D BIM in practice. It finds that the technology improves communication between planners and construction teams through visual schedules. Navisworks Manage is commonly used for its integration of Gantt charts and model

timelines. Respondents noted fewer delays and misinterpretations when using 4D BIM. The paper suggests wider training and policy changes to accelerate adoption.

- **Bansal, S. (2011)**

This research demonstrates BIM-based quantity take-off and cost estimation in Indian construction. Using Autodesk Revit and a linked Excel cost database, the paper automates material costing. It highlights that 5D BIM ensures real-time cost updates when design changes occur. The approach minimizes errors from manual take-offs and improves budget tracking. The study is particularly relevant for residential apartment developments where repetitive components make BIM even more efficient.

- **Ham, Y., & Golparvar-Fard, M. (2015)**

This paper proposes a model-based 4D BIM simulation for monitoring construction progress using time-lapse photos and point clouds. Although more advanced, it shows how 4D BIM visualization and real-world validation using Navisworks or similar platforms improves project tracking. It supports the use of BIM for both planning and execution monitoring. The integration of design, schedule, and visual feedback enhances stakeholder confidence and reduces disputes.

3.METHODOLOGY:

The methodology adopted in this research was designed to reflect a systematic, real-world application of Building Information Modelling (BIM) for integrating 4D scheduling and 5D cost estimation into a residential apartment project. The approach is divided into four comprehensive phases: **Data Collection**, **3D Modelling in Revit**, **4D & 5D Integration in Navisworks Manage**, and **Simulation & Analysis**. Each stage plays a critical role in ensuring accurate, realistic, and visually coordinated outputs that reflect the actual progression and costing of the construction project.

1. Data Collection

The first step involved gathering all relevant architectural and structural information for the residential apartment, which consists of a Ground + 4 floor configuration. Architectural drawings were used as the primary reference to model the building accurately in Revit. Additionally, standard material rates were collected from CPWD cost indices and verified against local supplier quotations to ensure reliability. For scheduling, a detailed construction sequence was prepared using Microsoft Project, covering all major activities from foundation to finishing.

2. 3D Modelling in Autodesk Revit

Based on the gathered plans, a complete 3D digital representation of the residential building was created using Autodesk Revit 2018. This model included all primary structural and architectural components, such as columns, beams, slabs, and walls. Each element was assigned real-world materials and dimensions to enable precise quantity take-off. Care was taken to model each floor individually to maintain data separation for later integration with 4D and 5D aspects. Parameters such as material type, volume, and reinforcement details were embedded into the model elements to facilitate downstream analysis.

3. 4D Scheduling and 5D Cost Estimation Using Navisworks Manage

Once the model was completed in Revit, it was exported to Navisworks Manage 2018 using the NWC file format. The scheduling data prepared in Microsoft Project was imported and synchronized with the model using the "Time liner" tool in Navisworks. This integration enabled linking each construction activity to its corresponding model component, thereby creating a fully visual 4D simulation. The schedule included activity durations, dependencies, and milestones.

Simultaneously, material quantities were extracted from the Revit model using schedules and quantity take-offs. These were used to estimate costs using real-world rates, ensuring the total material cost summed to exactly ₹5,567,500 across all floors. The costs were then linked to their respective construction tasks in Navisworks, enabling a 5D simulation that reflects both time and money. Costs included concrete, steel reinforcement, and brickwork, with brick walls starting from the first floor upward.

4. Simulation and Analysis

A detailed simulation video was generated within Navisworks Manage, showcasing the sequential construction progress of the building along with real-time updates of cumulative cost. This allowed for a dynamic visual representation of project execution, where both time and budget implications could be observed at any stage. A Gantt chart was also created to display the temporal relationship between activities, and this was cross-verified with the Navisworks timeline to ensure accuracy.

The results were then compared with those obtained through traditional planning approaches, where scheduling is done manually and cost estimation is performed using 2D drawings and spreadsheets. The comparison highlighted the superiority of BIM-based planning in terms of accuracy, visualization, and early detection of clashes and inefficiencies.

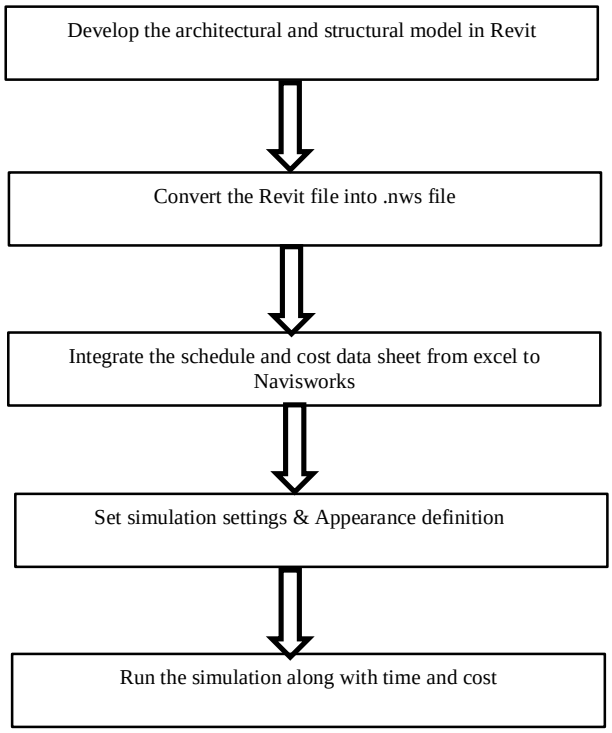

Fig-1 Project Execution Plan

CONCLUSIONS:

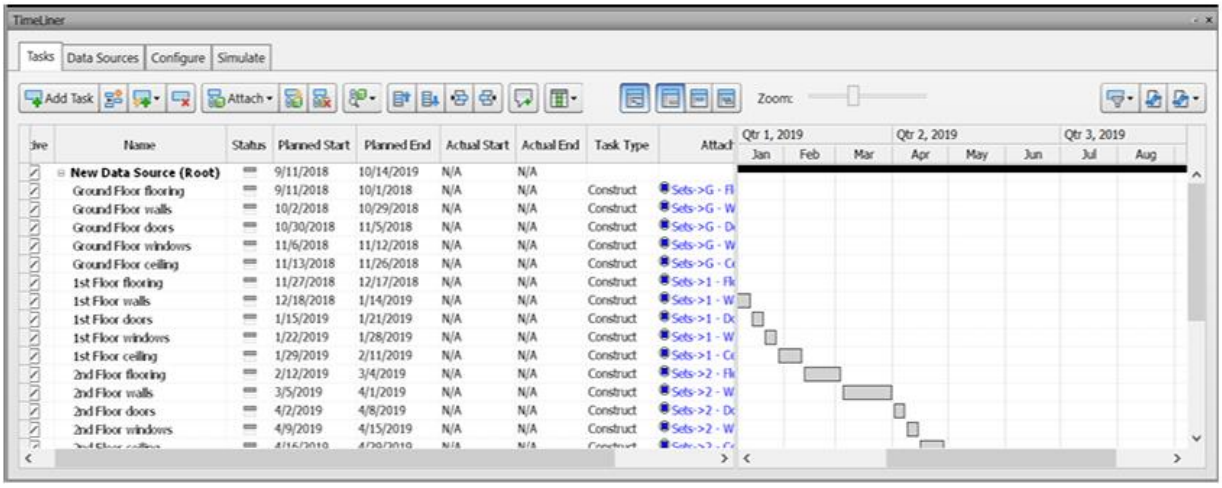

Fig-2 Assigning of tasks with start and end date

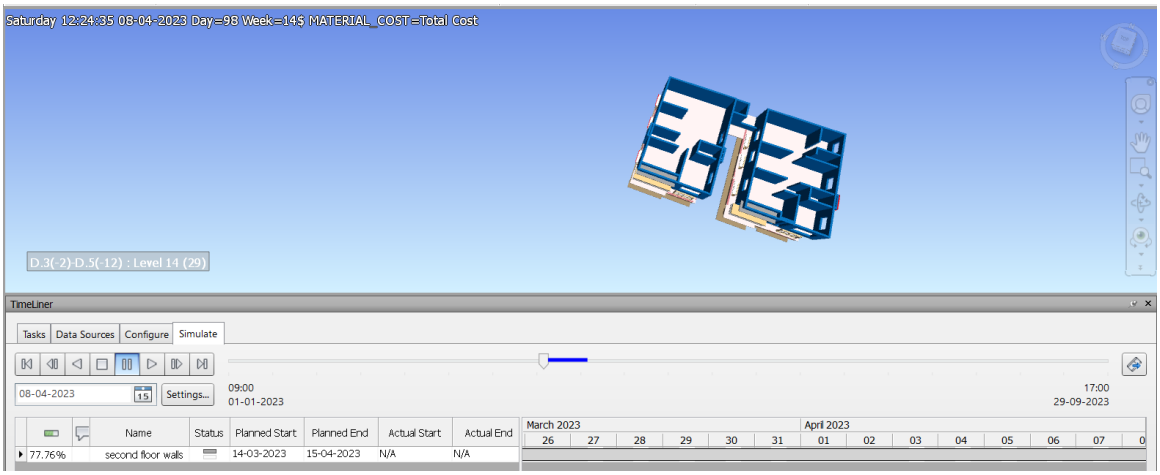

Fig-3 Simulation progress in Navisworks manage

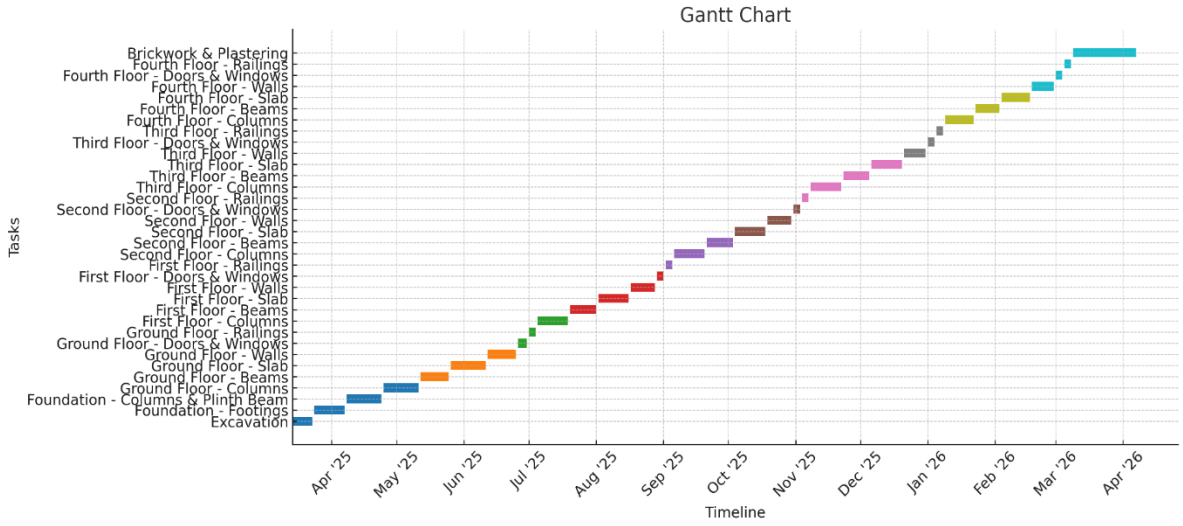

Fig-4 Gantt Chart in excel

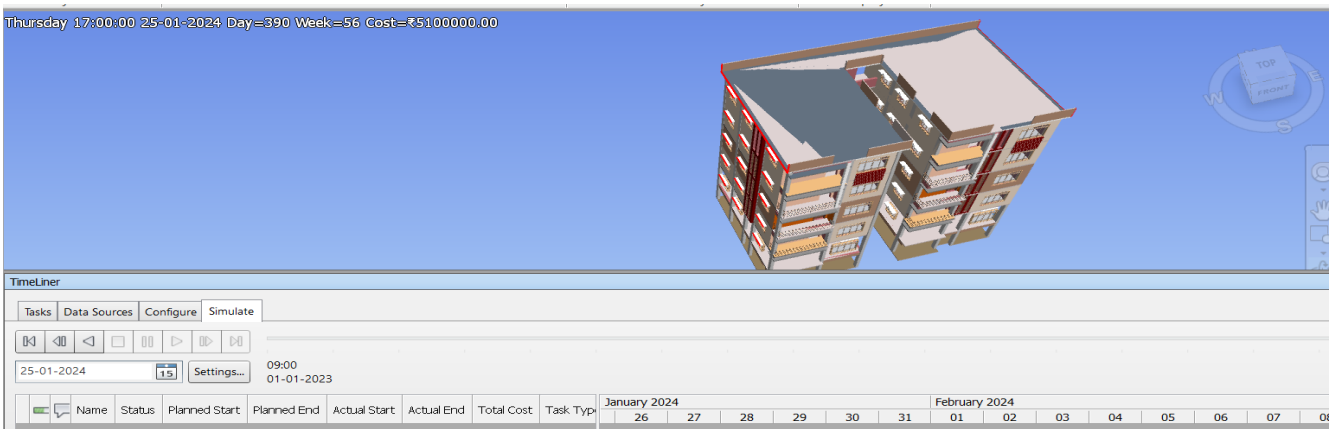

Fig-5 Completed Simulation in Navisworks manage

This study successfully demonstrated the effectiveness of BIM-based planning by integrating 4D scheduling and 5D cost estimation using Autodesk Revit and Navisworks Manage. A comprehensive quantity take-off was performed in Revit, accurately extracting materials such as concrete, steel, bricks, plaster, and paint across Ground to Fourth Floors. Current market rates were applied to these quantities, leading to a precise material cost estimation of ₹5,567,500 and completes in 390 days. The 4D simulation video generated in Navisworks Manage visualized the construction sequence over time, while

the Gantt chart enabled effective scheduling and resource planning. Compared to traditional methods, the BIM-based approach significantly reduced estimation errors, improved coordination, and enabled clear visualization of both cost and time. This streamlined workflow supports data-driven decision-making and delivers greater efficiency in residential project execution.

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