BIM Based Planning for Time and Cost Optimization with Power BI

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Abstract: *Construction projects frequently encounter delays and cost overruns due to internal and external factors. Traditional scheduling methods often struggle to manage the vast amount of heterogeneous and dynamic data generated throughout a project's lifecycle. This fragmented data makes visualization and informed decision-making challenging for stakeholders. This research proposes a novel methodology to bridge this gap by leveraging Building Information Modeling (BIM) for 4D (time) and 5D (cost) tracking, along with Power BI for data visualization. The proposed methodology employs Autodesk Revit for creating 3D models, Microsoft Project for scheduling activities, Navisworks Manage for 4D and 5D progress tracking, and Power BI for constructing project dashboards. This approach enables visualization of project progress over time (4D) and cost prediction at any stage. Power BI dashboards further facilitate data analysis of key project parameters and performance indicators, leading to improved decision-making. By implementing this methodology, construction projects can achieve better data analysis and visualization, potentially mitigating significant delays and cost overruns. The research demonstrates the efficiency and practicality of this approach through its application to a road construction project by Aurangabad Public Works.*

Keywords: Power BI, Dashboard, BIM (Building Information Modeling), 4D (Time) Tracking, 5D (Cost) Tracking

1. Introduction

The ever-evolving construction industry demands efficient and data-driven project management practices. Traditional methods struggle to keep pace with the complexity of modern construction projects, often leading to missed deadlines and budget shortfalls. This research investigates a novel methodology that utilizes Building Information Modeling (BIM) to optimize all aspects of project management.

BIM acts as a central hub for project data, embedding information about materials, quantities, and costs within the 3D model itself. This rich data environment empowers 4D (time) and 5D (cost) tracking, offering valuable real-time insights into project progress, resource allocation, and cost fluctuations.

The significance of this research lies in its potential to revolutionize construction project management by promoting informed decision-making. By strategically integrating BIM with Power BI for data visualization, we can create dynamic dashboards that translate complex data into actionable insights. Project managers gain a clear understanding of project progress, resource allocation, and potential cost fluctuations, enhancing decision-making for improved project efficiency.

This research pursues several objectives to achieve a comprehensive BIM-powered solution. First, it investigates the integration of BIM workflows utilizing Revit models and Navisworks for 4D/5D simulations. This empowers a visual understanding of project progress alongside real-time cost tracking, enabling proactive identification of potential issues and cost overruns. Secondly, the research explores the feasibility of utilizing Power BI for the creation of user-friendly dashboards. These dashboards streamline access to critical project information, fostering transparency and collaboration among stakeholders.

This improved communication and data-driven management style have the potential to revolutionize construction project management. By enabling early identification of potential issues, proactive decision-making, and real-time cost control, this research offers a pathway to streamlined project delivery, improved efficiency, and reduced risks associated with delays and cost overruns.

2. Need of Study

The construction industry faces constant pressure to deliver projects on time, within budget, and with minimal errors. Traditional methods of planning and communication often fall short, leading to delays, cost overruns, and rework. This is where Building Information Modeling (BIM) steps in, offering a powerful digital model with the potential to revolutionize construction workflows.

This research focuses on using BIM for a specific purpose: integrating 4D (time) and 5D (cost) aspects into project management in which a 4D simulation visually portrays the construction sequence, highlighting potential delays before they occur. Additionally, a 5D cost breakdown alongside the schedule reveals areas where costs might be higher than expected. This allows for proactive adjustments and informed decision-making throughout the project lifecycle.

Furthermore, integrating Power BI dashboards into this workflow offers a significant leap forward in communication. By extracting data from the 4D/5D BIM

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model, Power BI can create clear, interactive dashboards that display project progress, cost breakdowns, and key performance indicators (KPIs) in real-time. This empowers stakeholders at all levels to access and understand critical project information, fostering collaboration and ensuring everyone is on the same page.

However, despite the potential benefits, the effectiveness and efficiency of this integrated approach hasn't been fully explored. This research aims to bridge that gap by analysing the data exchange between different software programs, evaluating the clarity of 4D simulations, and assessing the user experience of Power BI dashboards in a construction management setting. By addressing these questions, this study will provide valuable insights into the real-world application of 4D/5D BIM with Power BI, ultimately paving the way for improved project planning, communication, and cost control within the construction industry.

3. Building Information Modeling

Building Information Modeling (BIM) is a digital way of creating and managing information about a construction project. It uses 3D models that include detailed data about the building's design, materials, costs, and schedule. This helps everyone involved in the project to work together more effectively, avoid mistakes, and manage the project better from start to finish.

BIM offers several key functionalities:
1) 3D Visualization: Provides a visual model of the project, enabling clash detection and spatial coordination for smoother construction.
2) Time Scheduling (4D): Links the 3D model with the project timeline to visualize construction sequences, identify potential delays, and optimize schedules.
3) Cost Estimation and Tracking (5D): Integrates cost data with the BIM model for real-time cost estimation and tracking, supporting proactive cost management.
4) Sustainability Analysis (6D): Analyzes the environmental impacts of materials and systems, promoting sustainable construction practices.
5) Facility Management (7D): Assists in post-construction maintenance planning and efficient asset management throughout the building's lifecycle.

4. Power BI

Power BI, a business intelligence software by Microsoft, connects to various data sources like BIM models, spreadsheets, databases, and cloud-based applications, transforming this data into interactive dashboards and reports with visualizations such as charts, graphs, maps, and tables. Its dynamic, user-friendly dashboards allow users to filter data, drill down into specifics, and gain deeper insights, making complex data sets more accessible and patterns and trends more identifiable than traditional static reports. This accessibility and interactive functionality make Power BI a valuable tool for construction professionals, enhancing data-driven decision-making, improving stakeholder communication and collaboration, and contributing to project success.

5. Methodology

This methodology has been implemented in a road construction project managed by the Aurangabad Public Works Department. The project, costing ₹2,60,82,703, covers a length of 3 kilometers and spans approximately 7 months, starting on November 20, 2023, and ending on June 3, 2024. Project progress tracking has been conducted up to May 10, 2024. All schedule and cost-related details up to the tracking date are presented in the results and discussion section.
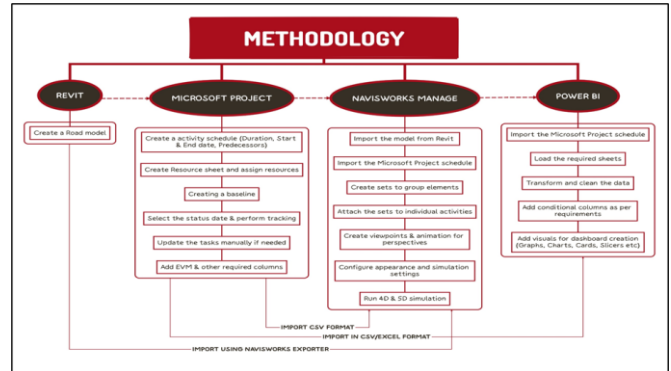

Figure 1: Methodology

1) Revit:
Initially, a detailed road model is developed in Revit, consisting of following layers (Subgrade, Granular Sub-base, Water Bound Macadam Grading- 1 & 2, Modified Penetration Macadam, Final Layer)
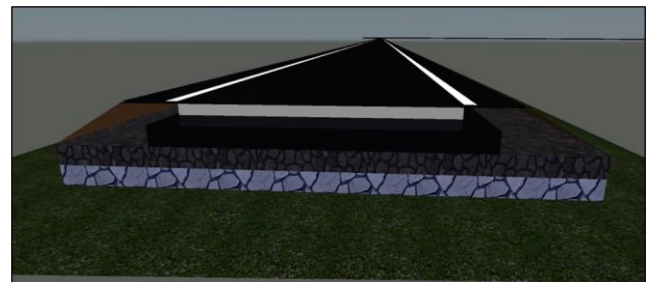

Figure 2: Model of road showing different pavement layers

2) Microsoft Project
The scheduling process involves several steps. First, create a detailed task schedule with start/end dates and dependencies. Then, assign resources based on availability and skills. Establish a baseline to benchmark the initial project plan, track progress against this baseline, update tasks as needed, and incorporate performance measures like Earned Value Management (EVM) to monitor project health.

3) Navisworks Manage:
Begin by importing the Revit model into Navisworks. Then, convert and import the project schedule to sync it with the 3D model. Group model elements into sets for better management, link these sets to corresponding schedule activities, and create viewpoints and animations to visualize construction sequences. Adjust visual settings and simulation parameters to enhance realism and run 4D/5D simulations to visualize construction progress and costs.
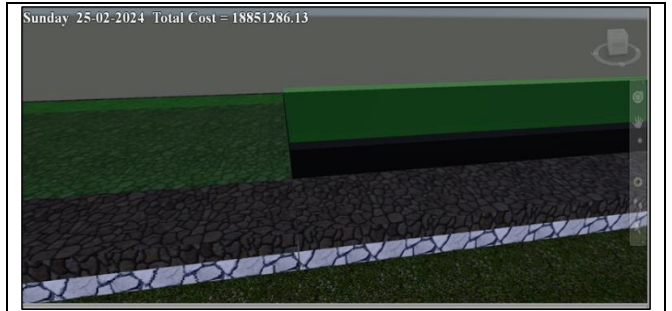
4) Power BI:

Import the project schedule from Microsoft Project into Power BI. Load relevant data sheets, transform and clean the data, add conditional columns for specific insights, and use various visual elements to create an interactive dashboard for analyzing and visualizing project data.

6. Result and Discussion

For the purpose of monitoring progress and costs (4D and 5D tracking), two specific dates were chosen: February 25, 2024, and February 20, 2024. To gain a clear visual representation of construction progress at these chosen dates, we're leveraging Navisworks software. Navisworks generates three visual representations, each with a dedicated purpose.

1) Actual Progress: This visualization depicts the actual state of construction activities on the chosen dates. Green color-coding highlights activities currently underway or in progress.
2) Planned Progress: This visualization portrays the planned state of construction activities on the chosen dates, allowing us to compare the intended schedule with reality.
3) Planned vs. Actual Progress: This visualization provides a side-by-side comparison of the planned and actual progress, offering valuable insights into potential deviations from the schedule.
4) Color-coding allows for easy identification of construction progress: areas ahead of schedule are marked in yellow, those behind schedule in violet, and green represents ongoing activities. A more transparent green indicates just-started activities, while a solid green color shows activities nearing completion. Each of the three Navisworks visualizations includes two crucial pieces of information displayed in the corner:
   a) Date: This clearly identifies the specific date represented by the visualization.
   b) Cost: This displays the total construction cost incurred up to the date represented by the visualization.

Navisworks visualizations with color-coded representations of actual, planned, and actual vs. planned progress (including early and late activities) provide project managers with a comprehensive view of construction progress. This tool helps compare progress over time in terms of both schedule and cost, identifying delays and early completions. It supports informed decisions on resource allocation, schedule adjustments, and mitigation strategies to address any delays or unforeseen circumstances. The integration of cost data further aids in cost control, ensuring the project remains on budget. In essence, 4D/5D tracking with Navisworks enables efficient project execution and informed decision-making, leading to a successful project outcome.
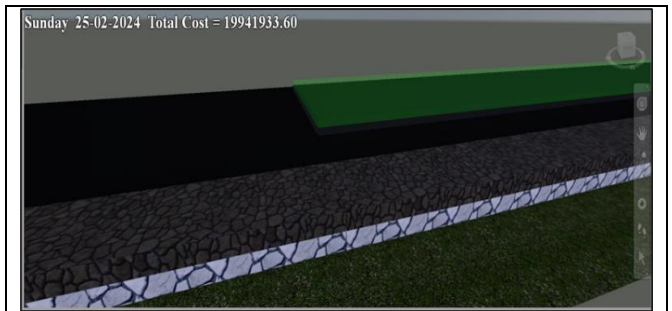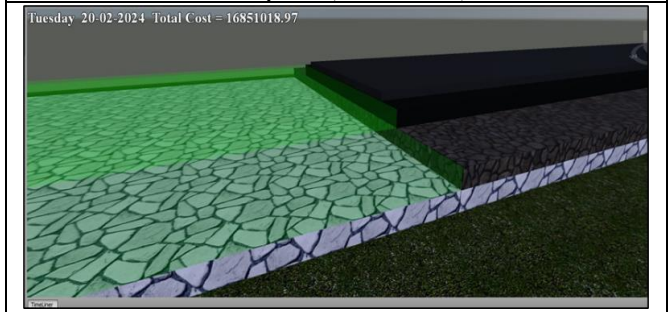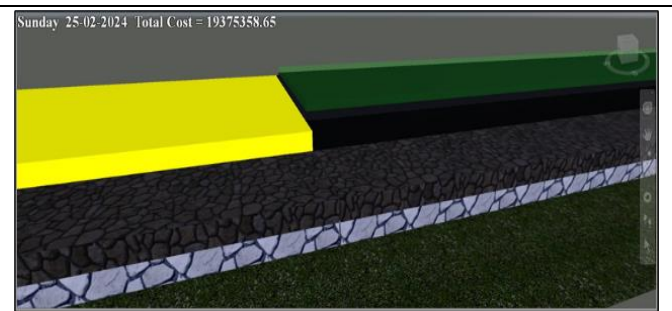

Example-1 (25-02-2024)
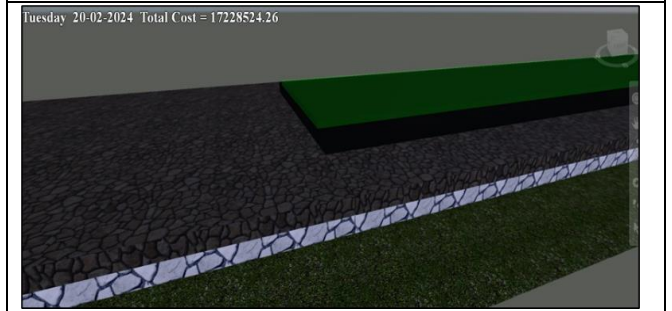
Example-2 (20-02-2024)
Figure 3: Planned Progress

Example-1 (25-02-2024)
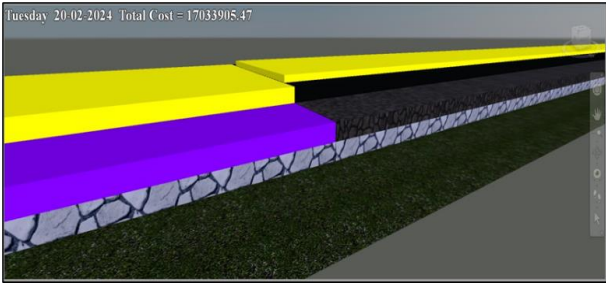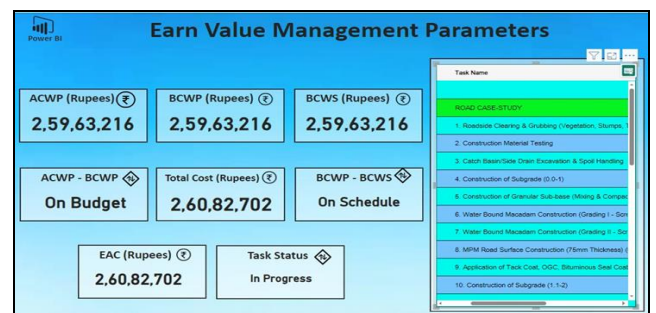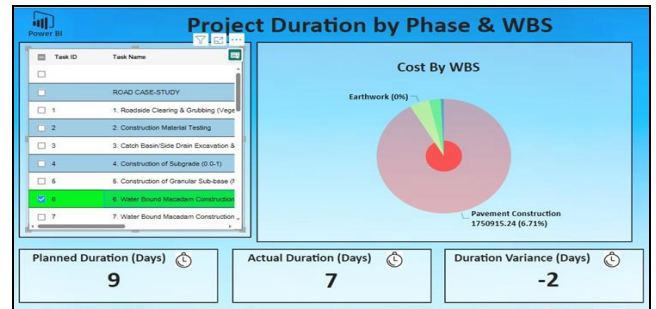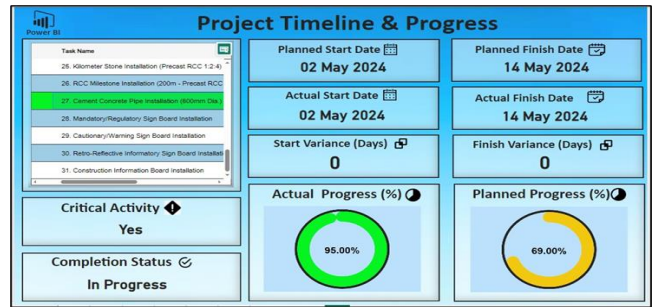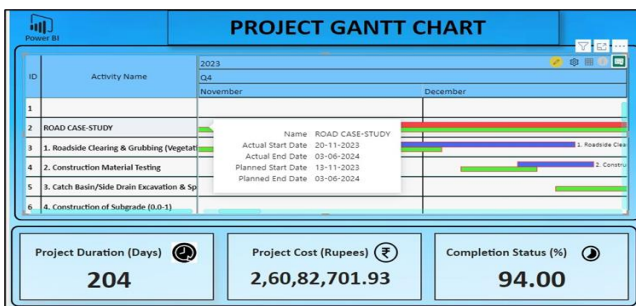

Example-2 (20-02-2024)
Figure 4: Actual Progress

Example-1 (25-02-2024)

Example-2 (20-02-2024)
Figure 5: Planned vs Actual Progress

The images presented in Fig. 7 illustrate dynamic dashboards crafted using Power BI, which prominently display tables of activities. These dashboards are designed to provide detailed parameters when any specific activity is selected, offering project managers and stakeholders a deep dive into critical aspects of the project.

Through these dashboards, project duration, duration variance, and earned value analysis parameters are readily accessible. Project duration metrics outline the overall timeline of tasks and milestones, while duration variance highlights deviations from the planned schedule, pinpointing where adjustments may be necessary to maintain project timelines. Earned value analysis, on the other hand, assesses the value of work completed against the planned costs, offering insights into project efficiency and cost performance. The comprehensive analysis facilitated by these dashboards enhances decision-making processes across all project phases. By consolidating and visualizing key project metrics and performance indicators, stakeholders can quickly identify trends, patterns, and potential issues that may impact project outcomes. This proactive approach enables timely adjustments to scheduling strategies, and risk mitigation plans, thereby minimizing the likelihood of significant delays and cost overruns.

Moreover, the integration of advanced data visualization and analysis capabilities in Power BI empowers construction projects to achieve superior insights. By leveraging these tools effectively, project teams can enhance transparency, accountability, and communication. This ensures that all stakeholders are well-informed and equipped to make informed decisions aligned with project goals and objectives.

Figure 6: Power-BI Dashboard

Table 1: Showing comparison between actual data & software data

Parameter	Public Works Data	BIM Software Data	Accuracy (%)
Total Project Cost (Rupees)	2,60,82,703	2,60,82,701.93	99.98%
Total Project Duration (Days)	210	204	97.14%
Project Completion till date - 10/05/2024 (%)	90-95	94	% ompletion is in the range
Cost required till date - 10/05/2024 (Rupees)	2,58,00,000	2,59,63,004	99.89%
Schedule Variance till date - 10/05/2024 (Days)	9-10 days ahead	7 days ahead	70-77.78%

The comparison above highlights the impressive accuracy of the BIM software in relation to Public Works data. Specifically, the software achieves a remarkable 99.98% accuracy in estimating the total project cost and a 99.89% accuracy in calculating the cost required to date. Additionally, the BIM software's schedule variance indicates that the project is 7 days ahead, which closely aligns with the Public Works data showing the project is 9-10 days ahead. This results in an accuracy range of 70-77.78% for schedule variance. The details provided in the above table can be verified using fig. 7. This high level of precision can be further validated by the accompanying Microsoft Project image, which displays the relevant parameters for verification. Overall, the BIM software proves to be an invaluable tool for delivering reliable cost estimates, precise time management, early detection of potential issues, and accelerated project completion.
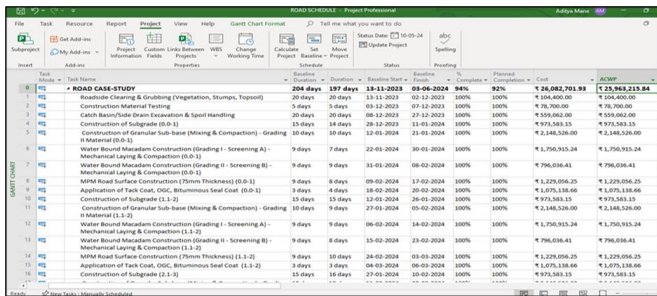

Figure 7: Microsoft Project view

7. Future Scope

While BIM is commonly employed in collaborative projects, this study specifically examines its utilization in civil engineering construction planning and scheduling. Here, we learned how time functions as the fourth dimension (4D) and cost as the fifth dimension (5D) within the BIM framework, provides a more accurate representation of the construction process.

Furthermore, the potential of BIM goes beyond these dimensions. One can also incorporate additional aspects such as sustainability, facility management, and materials. These expanded "6D" or "7D" models would offer a more comprehensive understanding of the project.

Looking forward, there are exciting prospects for integrating BIM with machine learning. This synergy could lead to applications in Virtual Reality (VR) and Augmented Reality (AR), enabling more dynamic project visualization. Moreover, the integration of Power BI with machine learning has the potential to generate advanced dashboards that provides project stakeholders with highly detailed insights.

8. Conclusion

In summary, this study highlights the importance of using BIM tools and Power BI dashboards in construction management. By leveraging software like Revit and Navisworks, alongside easy-to-use dashboards, we can improve how we monitor projects and make decisions. These technologies help us create 4D and 5D simulations and dynamic dashboards, which can enhance project oversight and planning.

The main goal of this research is to create user-friendly dashboards that give stakeholders quick access to project information. These dashboards act as a central hub where stakeholders can view project progress, costs, and risks easily. Additionally, by tracking progress and costs in real-time, project managers can be more proactive in managing timelines and expenses, reducing risks and improving project outcomes.

Ultimately, this research aims to provide project stakeholders with the tools and information they need to make informed decisions, allocate resources efficiently, and ensure the success of construction projects. By enhancing stakeholder engagement, spotting project issues early, and using predictive analysis, we can improve project management practices and achieve better outcomes in construction projects.

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