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BIM - BASED COST MANAGEMENT: DEVELOPING A FRAMEWORK REAL TIME COST MONITORING AND ANALYSIS

Dr. Gaurav Shukla, A.K Gautam, Assistant Professor, Department of Civil Engineering, Maharishi University of Information Technology, Lucknow, Uttar Pradesh 226013, India.
Archit Tiwari, M.Tech Scholar, Department of Civil Engineering, Maharishi University of Information Technology, Lucknow, Uttar Pradesh 226013, India.

ABSTRACT

In today's rapidly evolving construction industry, the adoption of Building Information Modeling (BIM) has become increasingly prevalent. BIM revolutionizes the way construction projects are planned, designed, and executed by providing a comprehensive digital representation of the physical and functional characteristics of a building. While traditionally BIM has been primarily associated with design and visualization, its potential extends far beyond these realms. One such area where BIM is making significant strides is in cost management. BIM-based cost management refers to the integration of BIM technology with cost estimation, monitoring, and analysis processes throughout the lifecycle of a construction project. 4368 Sqft.

For studying the functional practice of BIM in lieu of cost based management the undergoing project of residential villa having built up area of 4368 Sqft, G+1 level with RCC frame structure has been analyzed in the software named Autodesk Revit version 2024 (student version). The estimate of structural items has been calculated with the help of the software to understand in depth challenges of the integration of the BIM the project was drawn in phases wise as per actual site condition consider actual contour level of the site and dimension of the structure has been finalized by callout option available in 3D version of the software, afterwards material take of sheet has been generated through the software to analyze the quantity take off by software vs actual required quantity as per site including planning of the resources required in phase wise.

The study focus on the development of framework for real-time cost monitoring and analysis within the BIM environment for maximizing the benefits of this technology. Such a framework encompasses various elements, including data integration, interoperability, visualization, and collaboration mechanisms, all aimed at facilitating seamless cost management processes.

Keywords: BIM Integration, Real-time Data Capture, Automated Estimation, Visualization and Reporting, Construction of Residential/ Commercial Building.

I. Introduction

Building Information Modeling (BIM) has emerged as a transformative technology in the architecture, engineering, and construction (AEC) industry, revolutionizing the way projects are planned, designed, constructed, and managed. One critical aspect of construction project management is cost control, which involves estimating, budgeting, monitoring, and analyzing project costs to ensure that they align with the predefined budgets and objectives. Traditional cost management practices often rely on manual methods and periodic reporting, which can be time-consuming, error-prone, and lack real-time visibility into project performance.

In recent years, there has been a growing recognition of the potential of BIM to enhance cost management processes by integrating cost-related data with the rich 3D model information inherent in BIM. By linking cost data directly to the digital representation of the project, stakeholders can access up-to-date information on project costs, quantities, and schedules, enabling more informed decision-making throughout the project lifecycle.

Real-time cost monitoring and analysis capabilities offered by BIM have the potential to improve cost control, mitigate risks, optimize resource allocation, and enhance project outcomes.

Therefore, this study seeks to address this gap by developing a conceptual framework for BIM-based cost management, with a specific focus on real-time monitoring and analysis capabilities. The framework will be designed to integrate with existing BIM workflows and support the seamless exchange of cost data between different project stakeholders. Key components of the framework will include cost estimation methodologies, budgeting techniques, cost tracking mechanisms, and visualization tools tailored to the unique requirements of BIM-enabled projects.

By establishing a structured approach to BIM-based cost management, this study aims to empower construction professionals with the knowledge and tools necessary to harness the full potential of BIM for improving project cost performance. Ultimately, the proposed framework has the potential to contribute to greater efficiency, transparency, and accountability in construction project delivery, leading to better outcomes for all stakeholders involved.

BIM-Based Cost Management Structural Framework

1. Inputs: The foundational data required for cost management, including BIM models, specifications, cost data, project schedules, and regulatory standards.
2. Processes: Key activities and methods for managing costs, from initial estimation to ongoing control and adjustment.
3. Outputs: Deliverables and outcomes of the cost management processes, providing essential information for decision-making and reporting.
4. Supporting Technologies: Software and platforms that facilitate efficient cost management through automation, collaboration, and analysis.
5. Stakeholders: The various parties involved in the project, each with their roles and responsibilities in cost management.

This structural framework provides a comprehensive view of how BIM can be integrated into cost management practices to improve accuracy, efficiency, and collaboration in construction projects.

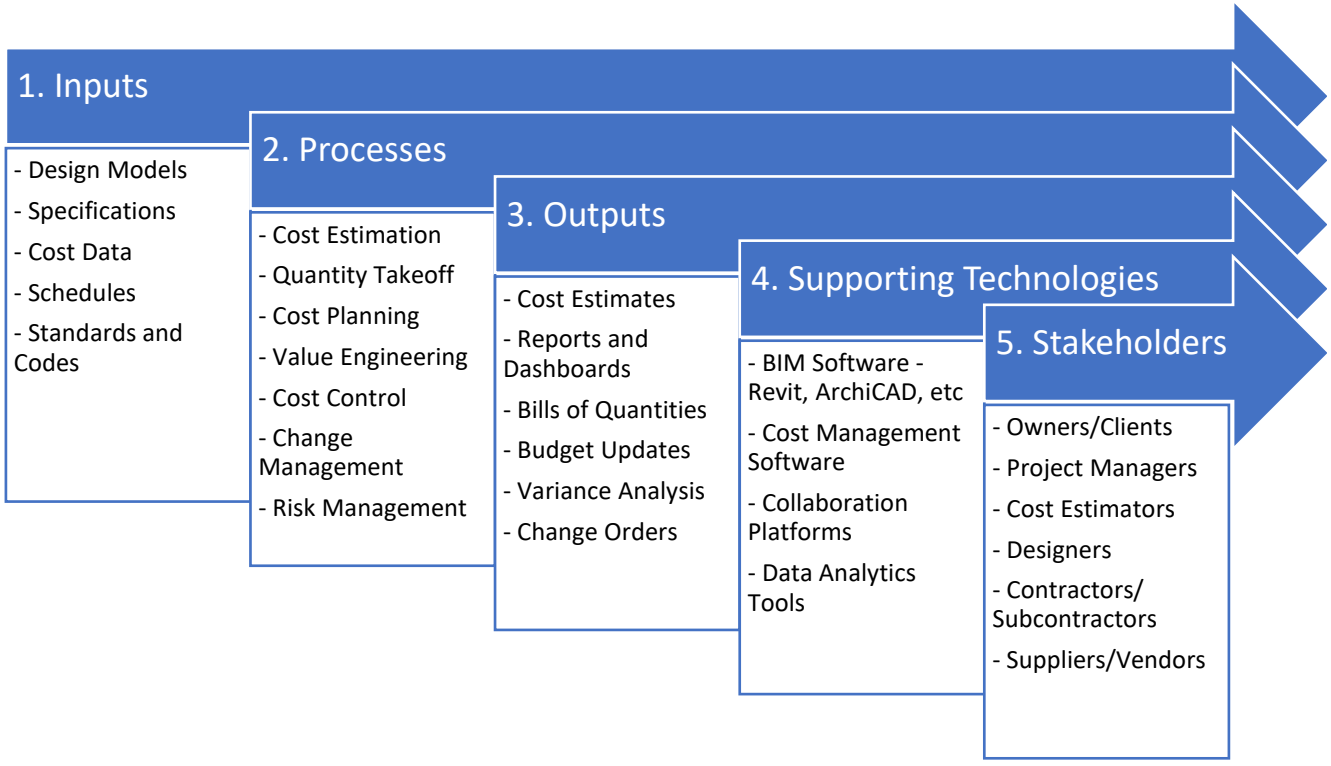

Figure 1: BIM-Based Cost Management Structural Framework

II. OBJECTIVE OF STUDY

Fill the Gap in Literature: By developing a structured framework for BIM-based cost management, this study aims to fill the gap in the existing literature, which lacks comprehensive guidance on leveraging BIM for cost control purposes. By addressing this gap, the study seeks to provide construction professionals with the necessary knowledge and tools to harness the full potential of BIM for improving project cost performance.

Improve Decision-Making: Real-time monitoring and analysis of project costs are essential for enabling informed decision-making throughout the project lifecycle. By developing methodologies and tools for capturing, analyzing, and visualizing cost data in real-time within the context of BIM models, this study aims to empower project stakeholders to make timely and data-driven decisions to mitigate risks, optimize resource allocation, and ensure project success.

Enhance Collaboration and Communication: Effective cost management requires seamless communication and collaboration among project stakeholders. By establishing standardized workflows and protocols for exchanging cost-related information within BIM environments, the study aims to facilitate transparent communication, alignment of cost objectives, and collaboration among owners, designers, contractors, and subcontractors.

Drive Innovation and Industry Adoption: By providing construction professionals with a practical and scalable framework for BIM-based cost management, this study aims to drive innovation and promote the widespread adoption of BIM technology in the AEC industry. By demonstrating the benefits of integrating BIM with cost management practices, the study seeks to catalyze positive change and foster a culture of continuous improvement in construction project delivery.

Contribute to Project Success: Ultimately, the purpose of this study is to contribute to the overall success of construction projects by enhancing cost management practices. By equipping project teams with the knowledge, methodologies, and tools necessary to effectively manage project costs in real-time using BIM, the study aims to improve project outcomes, minimize cost overruns, and deliver value to project stakeholders.

III. METHODOLOGY

Literature Review: A comprehensive review of existing literature on BIM, cost management, and related topics will be conducted to establish a theoretical foundation. This literature review will identify current practices, methodologies, tools, and challenges in BIM-based cost management and provide insights into gaps in the literature.

Qualitative Data Collection: Qualitative research methods such as interviews, focus groups, and case studies are used to gather insights from industry experts, practitioners, and stakeholders. These methods will help understand current practices, challenges, and opportunities related to BIM-based cost management, as well as identify requirements and preferences for a framework.

Quantitative Data Collection: Surveys and structured questionnaires are distributed to a diverse range of construction professionals to collect quantitative data on their experiences, perceptions, and preferences regarding BIM-based cost management. This quantitative data will complement the qualitative findings and provide statistical validation for the framework.

Framework Development: Based on the findings from the literature review and empirical research, a conceptual framework for BIM-based cost management will be developed. This framework will incorporate best practices, methodologies, and tools identified through the research process, as well as insights and feedback from industry stakeholders.

Validation and Refinement: The developed framework will be validated and refined through iterative cycles of testing, feedback, and refinement. This validation process may involve applying the framework to real-world construction projects, conducting usability testing with stakeholders, and soliciting feedback from industry professionals through workshops or focus groups.

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Documentation and Dissemination: The final framework, along with the research findings and recommendations, will be documented and disseminated through academic publications, industry reports, presentations, and workshops.

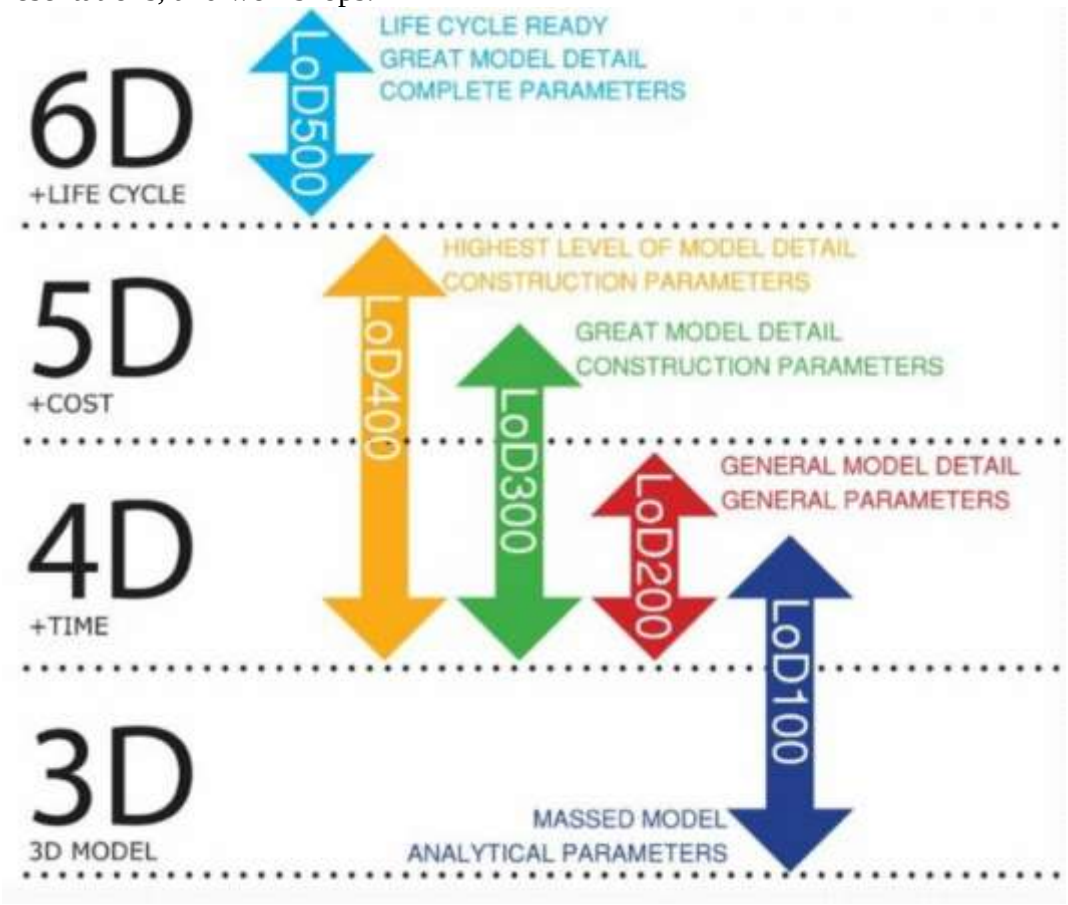

Figure 2: Level of Development (LoD) of BIM Integration

In summary, the research methodology for developing a framework for BIM-based cost management with a focus on real-time cost monitoring and analysis involves a systematic and comprehensive approach that integrates both quantitative and qualitative methods. The methodology encompasses several key steps, including a thorough review of existing literature to establish a theoretical foundation and identify gaps in the literature. This is followed by primary data collection through structured surveys and in-depth interviews targeting a diverse range of construction professionals to gather insights into current practices, challenges, and opportunities related to BIM-based cost management.

Quantitative data collected through surveys are analyzed using statistical techniques such as descriptive statistics, inferential statistics, and correlation analysis to identify patterns, trends, and relationships between variables. Qualitative data from interviews are analyzed using thematic analysis to identify recurring themes, patterns, and insights. The findings from both quantitative and qualitative data analyses are integrated to develop a comprehensive understanding of BIM-based cost management practices.

Validation strategies such as member checking, peer debriefing, triangulation, and comparison with existing literature are employed to ensure the accuracy, reliability, and credibility of the findings. Ethical considerations, including informed consent, confidentiality, protection of participants, respect for diversity and inclusion, and disclosure of conflicts of interest, are carefully addressed throughout the research process to uphold the rights and well-being of participants.

By following this research methodology, the study aims to develop a robust and practical framework for BIM-based cost management that supports real-time cost monitoring and analysis in construction

projects, ultimately contributing to improved project outcomes and the advancement of knowledge in the field.

Process for integration of BIM at Residential project of 4368 Sqft area, G+1 level with RCC frame structure is as follows:

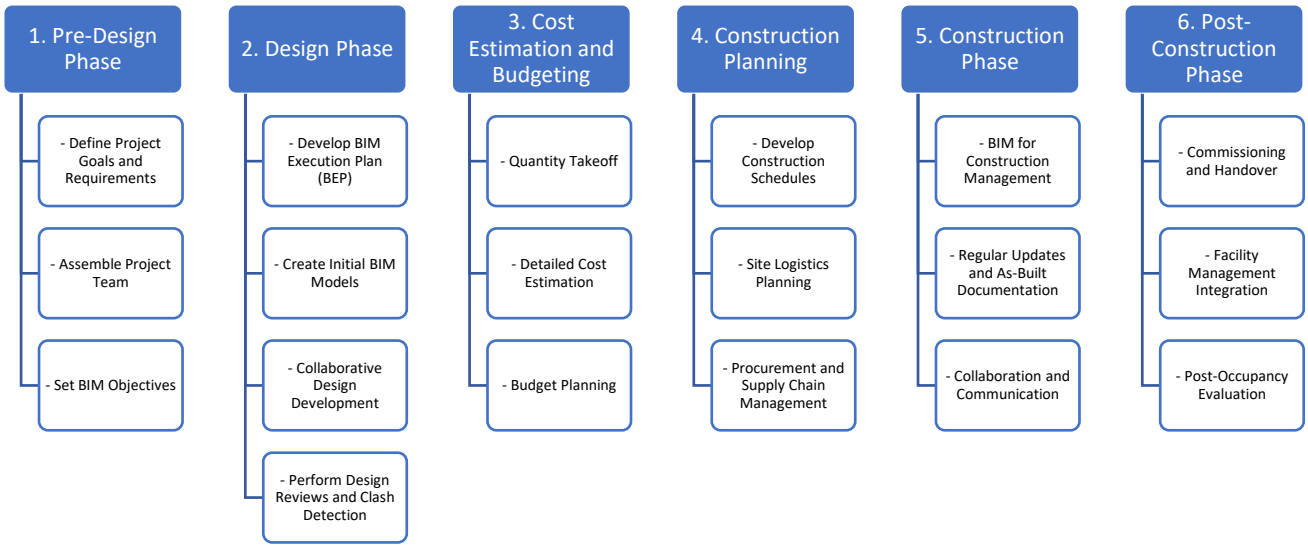

Figure 3: Workflow diagram of BIM integration at different phases of construction.

1. Pre-Design Phase
   - Define Project Goals and Requirements: Outline the objectives of the project, including budget, timeline, and key deliverables.
   - Assemble the Project Team: Bring together architects, engineers, BIM specialists, contractors, and stakeholders.
   - Set BIM Objectives: Establish specific goals for BIM use, such as improved coordination, accurate cost estimation, and efficient project management.

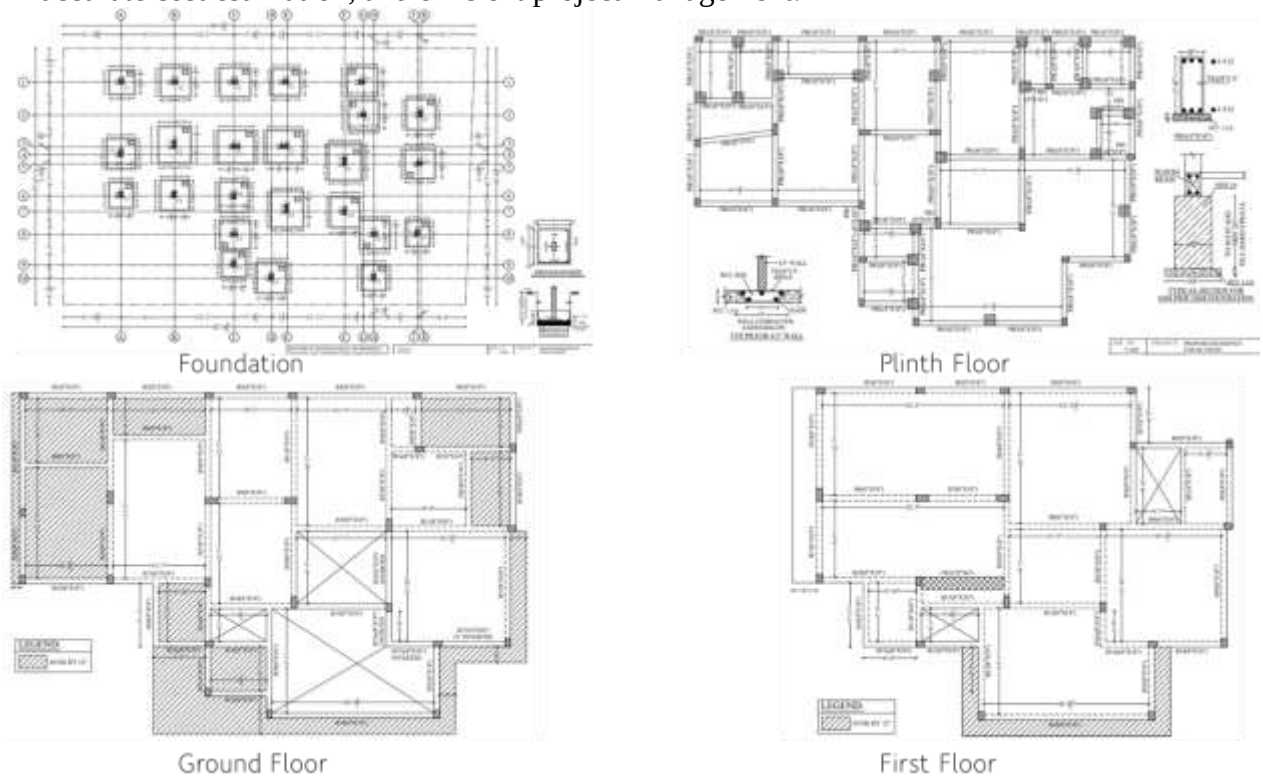

Figure 4: 2D Structural Design & Drawing of a Residential Project.

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2. Design Phase
   - Develop BIM Execution Plan (BEP): Create a detailed plan outlining BIM standards, workflows, responsibilities, and deliverables.
   - Create Initial BIM Models: Develop preliminary 3D models using BIM software (e.g., Revit, ArchiCAD).
   - Collaborative Design Development: Enable real-time collaboration among team members to refine designs, ensuring all disciplines (architecture, structural, MEP) are coordinated.
   - Perform Design Reviews and Clash Detection: Use BIM tools to identify and resolve design conflicts before construction begins.

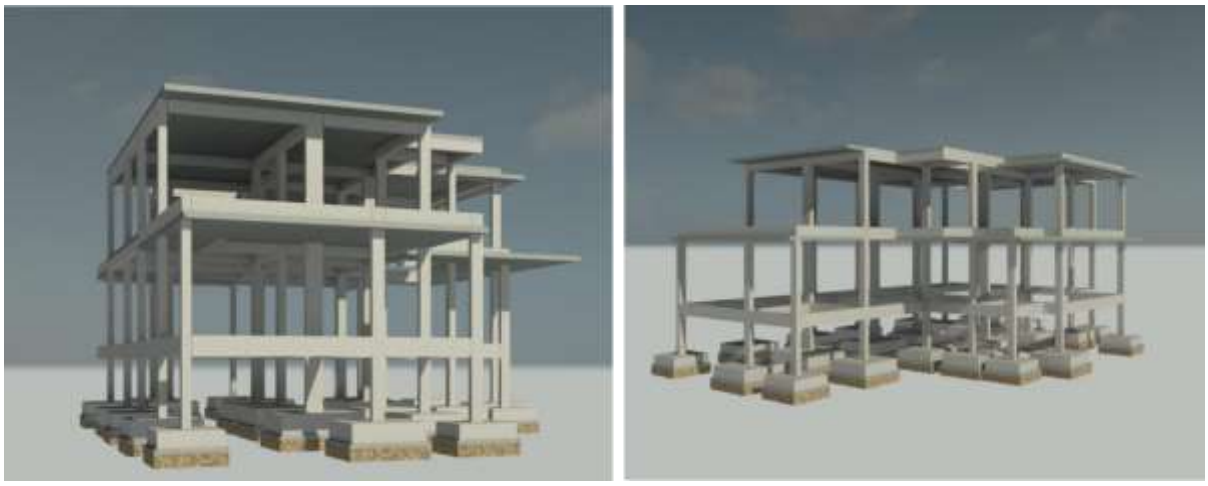

Figure 5: 3D Structural Design & Drawing in Revit with material detailing.

3. Cost Estimation and Budgeting
   - Quantity Takeoff: Utilize BIM models to automate the extraction of material quantities.
   - Detailed Cost Estimation: Integrate cost data into the BIM model to produce accurate estimates.
   - Budget Planning: Align the cost estimates with the project budget, considering contingencies for potential changes.

Multi-Category Material Takeoff

Count	Family	Material: Name	Material: Area	Material: Volume	Level	Type
Bolder Soling						
	1 Floor	Bolder Soling	91 m²	27.698 m³	B.O. Footing	PCC 1.3.6 & Bolder Soling
Bolder Soling: 1						
PCC						
	1 Floor	Concrete	91 m²	9.233 m³	B.O. Footing	PCC 1.3.6
PCC: 1						
Concrete						
	1 Floor	Concrete	102 m²	15.582 m³	Ground Floor Level	6" Concrete Slab
	1 Floor	Concrete	75 m²	11.458 m³	Ground Floor Level	6" Concrete Slab
	1 Floor	Concrete	156 m²	23.822 m³	First Floor Level	6" Concrete Slab
	1 Floor	Concrete	8 m²	1.238 m³	First Floor Level	6" Concrete Slab
Concrete: 4			341	52.1 m³		

Figure 6: Material Take off sheet in Revit with material detailing (Detail take off sheet attached in Annexure A for Reference).

4. Construction Planning
   - Develop Construction Schedules: Link the BIM model to project schedules to create a 4D model, visualizing the construction sequence over time.

- Site Logistics Planning: Use the BIM model to plan site logistics, including material storage, equipment placement, and worker movement.
- Procurement and Supply Chain Management: Leverage BIM data for procurement planning and to coordinate with suppliers.

5. Construction Phase
   - BIM for Construction Management: Utilize the BIM model for on-site coordination, progress tracking, and quality control.
   - Regular Updates and As-Built Documentation: Continuously update the BIM model to reflect actual construction progress and modifications.
   - Collaboration and Communication: Maintain open lines of communication among all stakeholders through the BIM platform, ensuring everyone has access to the latest information.

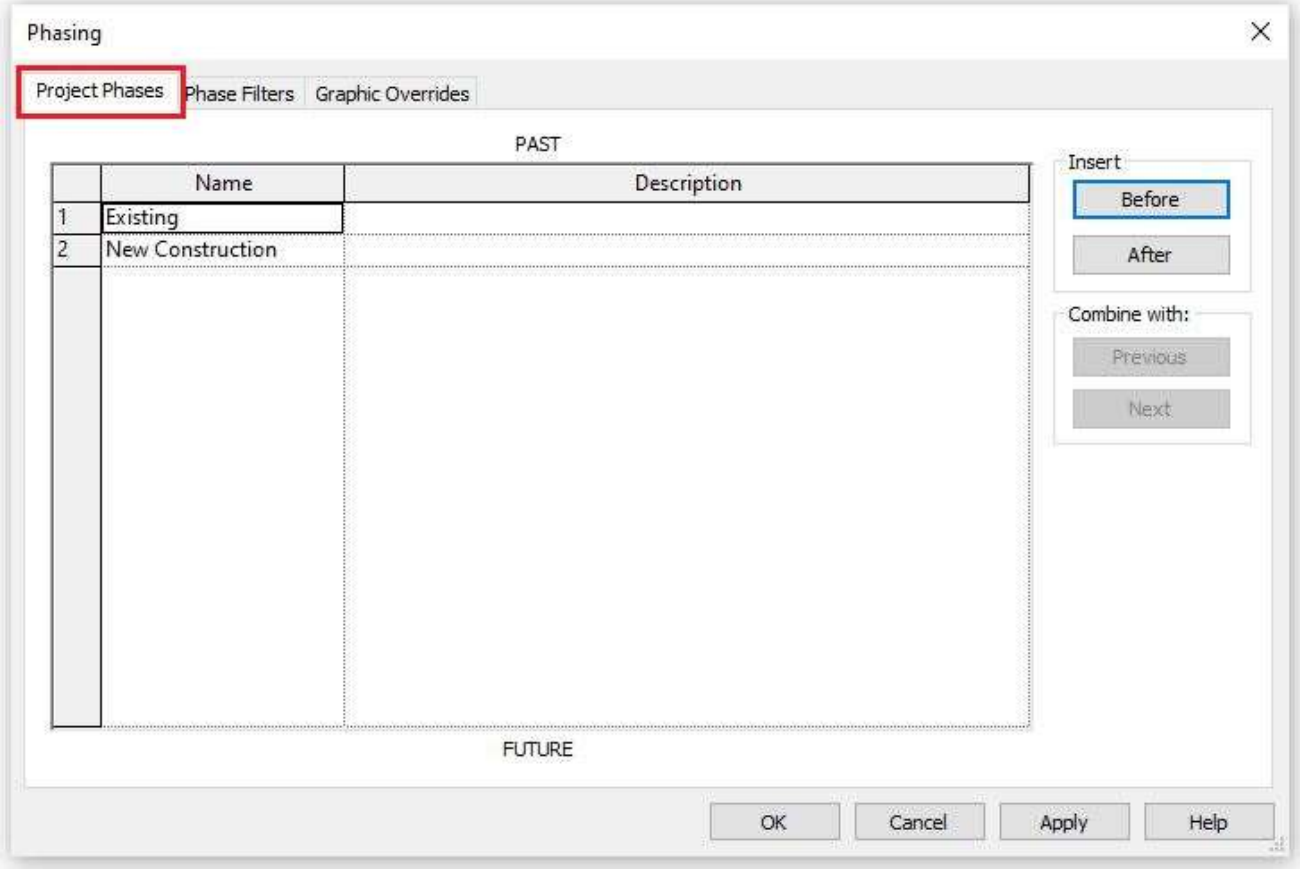

Figure 7: Phasing dialog in Revit with stage.

6. Post-Construction Phase
   - Commissioning and Handover: Finalize the as-built BIM model, including all changes made during construction, and hand it over to the owner.
   - Facility Management Integration: Integrate the BIM model with facility management systems to assist in the operation and maintenance of the building.
   - Post-Occupancy Evaluation: Use the BIM model to conduct post-occupancy evaluations, identifying areas for improvement in future projects.

Key Considerations

Software and Tools: Ensure the project team is proficient with BIM software such as Revit, ArchiCAD, Navisworks, and collaboration tools like BIM 360.

Training and Support: Provide adequate training for team members unfamiliar with BIM processes.

Data Management: Establish a robust data management strategy to handle the large amounts of data generated by BIM.

Standards and Protocols: Adhere to industry standards and protocols for BIM to ensure consistency and interoperability.

IV. CHALLENGES/RISKS FACED IN BIM INTEGRATION IN INDIA:

Sl. No.	Constraint/Challenges/Risks	Solutions
1	Data Interoperability:	Use advanced data management tools to facilitate seamless data exchange and integration between BIM-based cost management tools and other software.
2	Training and Adoption:	Comprehensive Training: Provide ongoing training programs for professionals to improve proficiency in BIM-based cost management practices.
3	Quality of BIM Models:	Establish rigorous quality control processes to verify the accuracy and completeness of BIM models
4	Integration with Other Disciplines:	Use integrated project management platforms that combine multiple disciplines for streamlined workflows.
5	Initial Costs	Conduct a cost-benefit analysis to evaluate the long-term benefits of investing in BIM-based cost management.
6	Data Security and Privacy:	Use access control measures to limit data access to authorized personnel only.
7	Model Changes and Revisions:	Maintain open and transparent communication among stakeholders regarding model changes.
8	Cost Overruns:	Include contingency plans in cost management to account for unforeseen circumstances. Utilize real-time monitoring tools to quickly identify and address cost variances.
10	Stakeholder Misalignment:	Hold regular meetings with stakeholders to align on cost management objectives and address potential conflicts.

V. CONCLUSION

In conclusion, BIM presents a transformative approach to cost management in construction projects, providing various benefits and opportunities for future research:

1. BIM allows for visualization of projects in 3D, 4D, and 5D, aiding in accurate cost estimation and tracking.
2. BIM can help identify and manage risks early in the project lifecycle, minimizing costly delays and issues.
3. BIM fosters better communication and decision-making among project stakeholders, leading to smoother project execution.

4. Integrating AI, machine learning, and IoT with BIM can lead to improved predictive cost modeling and real-time cost tracking.
5. BIM can be used to account for costs across all phases of a building's life, promoting a holistic approach to cost management.
6. Developing standardized practices and ensuring software interoperability can enhance the effectiveness of BIM-based cost management.
7. Areas such as performance analysis, cost estimation optimization, and regulatory compliance offer potential for further advancements.

By embracing these opportunities, the construction industry can achieve greater efficiency, cost savings, and better project outcomes. Collaboration among professionals and researchers will be key to unlocking the full potential of BIM in cost management.

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