

# Cost Estimation And Cost Control of Construction Project Using BIM Technology

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**Abstract:** The integration of Building Information Modeling (BIM) into cost estimation and control represents a transformative shift in construction management. Unlike conventional methods, BIM enhances accuracy, transparency, and efficiency through real-time data integration, 3D visualization, and automated clash detection. This study highlights how BIM significantly reduced project costs by 9.06%, lowering the planned expenditure of ₹1,221,432,472 to an actual cost of ₹1,110,727,461. The savings of ₹110,705,011 were primarily achieved through precise estimation, streamlined material management, and reduction of rework, particularly in high-cost components such as RCC and site setup. By minimizing design errors, improving collaboration, and enhancing decision-making, BIM establishes itself as more than a design tool—it is a cost-optimization strategy that ensures financial discipline, operational efficiency, and long-term sustainability in construction projects. The findings confirm BIM's essential role in modern, cost-conscious project delivery by strengthening budget reliability, reducing risks, and maintaining quality within planned timelines.

**Keywords:** Building Information Modeling (BIM), Cost Estimation, Construction Management, Quantity Take-off, Material Management, Cost Optimization, Risk Reduction, Project Control, Resource Allocation, Sustainable Construction etc.

## I. Introduction

Cost overruns and ineffective budget management remain persistent challenges within the construction industry. Conventional cost estimation and control methods, which often rely on two-dimensional drawings, manual quantity take-offs, and fragmented stakeholder communication, are prone to errors, rework, and disputes. As construction projects become increasingly complex, there is a growing need for more accurate, efficient, and collaborative approaches to cost management throughout the project lifecycle. Building Information Modeling (BIM) has emerged as a transformative solution that addresses these limitations by integrating design, construction, and cost-related data within a unified digital environment. Unlike traditional practices, BIM enables the creation of intelligent three-dimensional (3D) models that can be linked to scheduling (4D) and cost information (5D), allowing for real-time visualization and dynamic data updates. This integration significantly improves the accuracy of cost estimation during the design phase and facilitates proactive cost control during construction and facility management [2].

The application of BIM for cost management enables automated quantity take-offs, early detection of design inconsistencies, simulation of alternative construction scenarios, and real-time monitoring of cost performance against budgets. Consequently, BIM enhances decision-making, minimizes cost overrun risks, and improves overall project delivery efficiency. This study investigates the role of BIM technology in cost estimation and cost control, emphasizing its benefits compared to traditional methods. Additionally, it examines challenges such as interoperability, data reliability, implementation costs, and stakeholder adoption that continue to affect the broader application of BIM-based cost management practices. By addressing these factors, the research aims to demonstrate how BIM serves as an effective framework for achieving greater accuracy, transparency, and control in construction cost management [3].

Achieving cost-effective energy performance while maintaining sustainability is a key challenge in construction projects. This study presents an IFC-based BIM framework integrating cost estimation and energy analysis for efficient retrofit planning. The approach links cost and energy data through a semi-automated workflow, improving transparency and decision-making. A residential case study demonstrates that BIM enhances cost control, interoperability, and sustainability in construction projects [1].

## II.Literature Review

The integration of Building Information Modelling (BIM) into cost estimation and control has been widely explored in recent research, with studies emphasizing both its transformative potential and the barriers limiting adoption. Scholars such as Leśniak et al. (2021) identified critical challenges hindering BIM implementation, including limited stakeholder awareness, resistance to change, and financial constraints, highlighting the need for training programs and government-backed support to accelerate adoption. Similarly, Farouk et al. (2023) underscored the role of BIM in enhancing sustainability performance in building projects, particularly in developing countries where inconsistent practices and lack of structured implementation impede progress. Complementary studies, including those by Mahajan and Narkhede (2023) and Thakkar et al. (2021), further demonstrated BIM's capacity to optimize material usage, reduce rework, and ensure timely delivery, positioning it as a key driver for efficiency and competitiveness in India's rapidly growing construction sector.

In parallel, research has expanded beyond the foundational benefits of BIM to investigate its integration with emerging technologies and complementary frameworks. For instance, Ojeda et al. (2024) combined UAVs with BIM to automate project monitoring and improve progress estimation, while Rane (2023) explored the convergence of BIM with artificial intelligence (AI) for predictive analytics and intelligent construction management. Similarly, Kenneth (2024) emphasized the synergy between BIM and strategic management for improved cost estimation, scheduling, and stakeholder coordination. Earlier comparative studies, such as Zhao and Wang (2013), highlighted how BIM-assisted cost management surpasses traditional methods in terms of accuracy, timeliness, and automation, though they also cautioned against challenges like interoperability and lack of standardized workflows. Collectively, these studies

confirm that while BIM offers significant opportunities for improving cost estimation and control, its successful implementation requires structured training, financial support, stakeholder collaboration, and continuous technological adaptation.

### **III.Implementation of BIM**

#### **3.1 Implementation of BIM –**

There are several software solutions available for estimation and quantity takeoff in construction projects. Popular tools include Planswift, Sharpsoft Estimator, Groundplan, Square Takeoff, On-Screen Takeoff and Construct Connect Takeoff. These tools support accurate measurements, cost estimation, and integration with BIM workflows. The choice of software depends on project scale, trade specialization, and level of BIM integration required [6].

The comparison of digital take-off and estimation software highlights key strengths and limitations across various platforms. PlanSwift, Ground Plan, Square Take-off, and On-Screen Take-off are user-friendly with features like Excel export, reusable templates, and online accessibility, but most suffer from drawbacks such as limited multi-user access, template availability issues, and high dependency on internet connectivity. Pricing also varies widely, with Ground Plan being more affordable, while Sharpsoft Estimator and On-Screen Take-off carry significantly higher costs, making them less feasible for smaller firms. Construct Connect Software, despite its higher annual cost, stands out due to its cloud-based collaboration, customizable templates, autosave functionality, and strong 24/7 customer support, positioning it as a preferred choice among users [7].

Construct Connect Take-off, in particular, enhances accuracy and teamwork by supporting multi-user access and reusable project libraries. Its features include real-time collaboration, scale-setting tools, and a versatile take-off viewer that supports linear, area, count, and multi-condition take-offs. The system allows customization through labels, symbols, and colors, ensuring easy audit trails and collaboration. Advanced functions like multi-condition take-offs save time by automating repetitive processes, while auxiliary tools such as the pan window and Take-off Items pane improve navigation and data organization. Overall, Construct Connect Take-off provides a comprehensive, efficient, and reliable solution for digital estimation and project management [8].

#### **3.2 Selection of site**

The site was located in Mumbai, with the area around 102904 sq. ft. including two buildings one and two with the courtyard within. The following figure shows the site view



Figure 1-Site Picture

### 3.3 Traditional Method-

In the conventional BoQ process, measurements are manually extracted from drawings, squared, and organized into abstract sheets before converting into billing units ( $m^3$ ,  $m^2$ , or linear meters). In the traditional software method, project drawings in PDF format are imported into AutoCAD, converted to DWG, and scaled as per the given reference. Using AutoCAD commands, areas and volumes are computed, which are then used to prepare the Bill of Quantities.

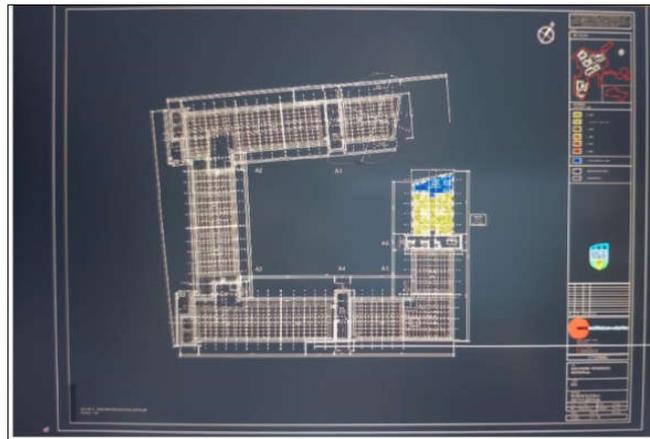


Fig. 2- Plans imported on Auto-CAD Software

### 3.4 Takeoff using Construct Connect Software-

In prior method, it was required to import a pdf and convert it into a drawing file extension. Similarly, we need upload the set of drawings which are in .pdf extension and upload it on the software. Once, the drawings are saved, the file (uploaded set of drawings) will be converted into TIFF (Tagged Image File Format) extension. All the quantities were listed out are supposed to be computed. The drawings set to a scale which was shown on the drawings, so no wrong items were calculated. All the boundaries were marked in the plan for which the line items are supposed to be taken- off. Once the boundaries were marked, we can get the areas as per the markings taken off. For volume calculations, the third dimension is supposed to be added in the condition itself and in the results tab (while preparing condition), select volume so that the results are supposed to be exported from summary tab.

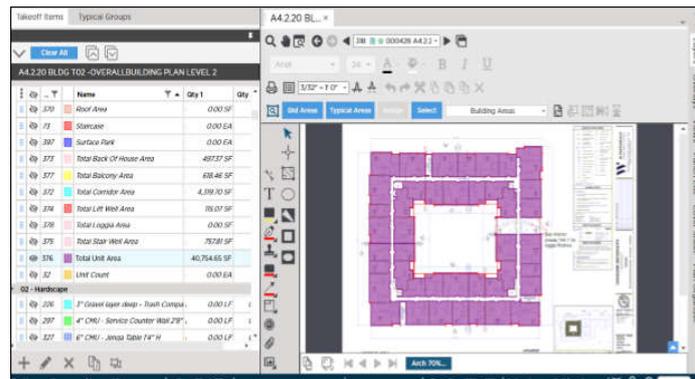


Fig. 3- Takeoff on Construct Connect Software

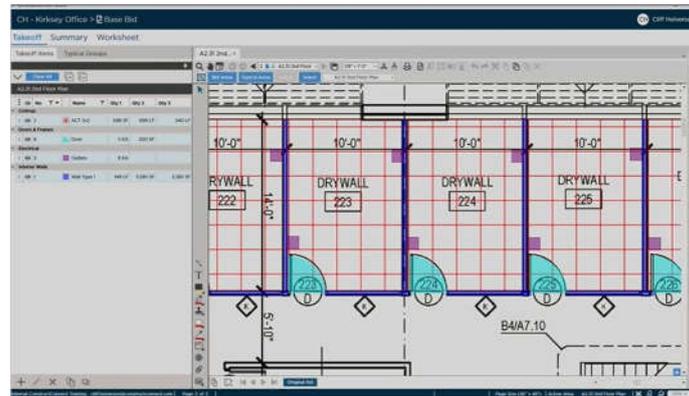


Fig. 4- Features of Construct Connect

#### IV. Analysis

This chapter presents observations of the study of performing quantity takeoffs between the Traditional Methods, Traditional Software Methods and BIM methods. The dependence of outdated or inefficient estimating software may hinder the accuracy and efficiency of the estimation process. So, there should be proper estimating software with skilled resources that can impact the estimation and tendering process smoothly. The various Software used for Quantity takeoff, estimation tendering process such as BIM, Cost X, Candy,

##### 4.1 Traditional Method, Software, BIM Method Construct Connect. -

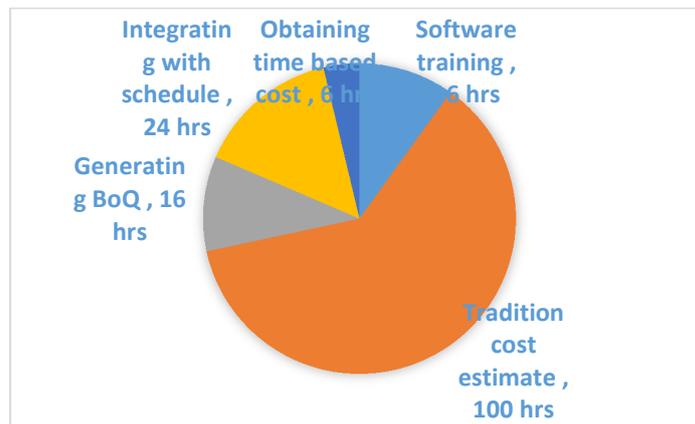
In this study, the comparison test was conducted between the traditional method (MS Excel), Software method (MS Excel, Newton, Autocad) and BIM-based method. Time consumption on learning and utilizing. From Graph 1, Graph 2 and Graph 3, it is obvious that the traditional cost control method takes more time than the BIM-based method, namely 162 hours for traditional method, 114 hours for Software method and 74 hours for BIM-based. In terms of the time required for training, the BIM-based method consumes almost twice the time that the software method would take. Proportionally, the training time takes about 23% in Software method and 65% in BIM method of the total time. However, when it comes to the stage of implementing, the Software method and Traditional method consume more time than BIM-based method. This shows that although BIM is a technology which needs more time for training, it will greatly save time when it is implemented in the cost control process. So once the user becomes competent, the efficiency of BIM method will become obvious. The figures below are the time consumption of the various methods of estimation in technology.

Table 1 – Time Consumption Comparison of Traditional, Software, and BIM-Based Methods

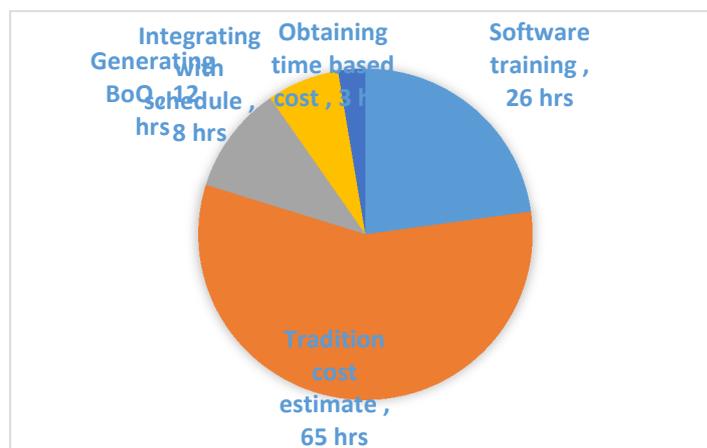
Method	Total Time (Hours)	Training Time (Hours)	Training Time (%)	Implementation Time (Hours)
Traditional (MS Excel)	162	—	—	—
Software (Excel, Newton, AutoCAD)	114	26.22	23%	87.78
BIM-Based (Construct Connect)	74	48.10	65%	25.90

\*Calculated based on percentage given in text:

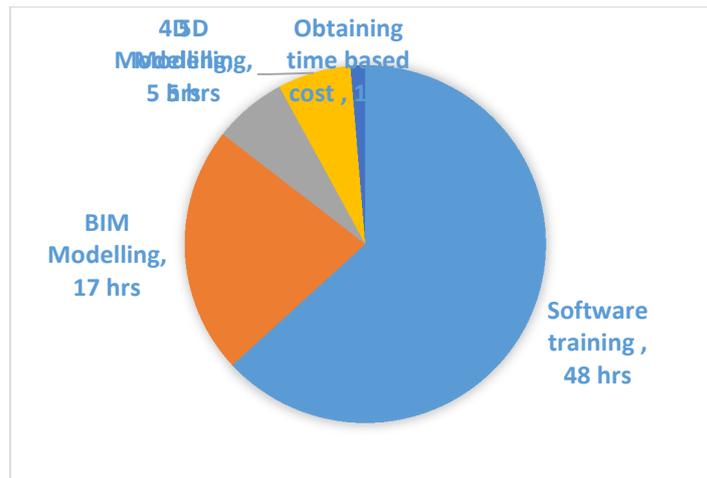
- Software Method Training Time = 23% of 114 = 26.22 hours
- BIM Method Training Time = 65% of 74 = 48.10 hours
- Implementation Time = Total Time – Training Time



Graph 1: Graphical representation of Traditional



Graph 2: Graphical representation of Software



Graph 3: Graphical representation of BIM Method

#### 4.2 Data Analysis

Data analysis was done using MS Excel, BIM Software Construct connect was used. The data is analyzed of project scope, project size, and complexity of project. The data was created on the historical cost of the project, compared with the initial estimation work of that project. Analyze the historical cost data of a similar project to identify patterns and trends in cost overruns or underestimation. Analysis of market prices for construction material, labor, and other resources. Evaluate the effectiveness of risk mitigation strategies and adjust estimation model accordingly. Analyze the adoption and utilization of the technology in estimation and tendering processes. The impact of advanced estimating software and other technological tools on accuracy and efficiency.

#### 4.3 Project Size and Complexity:

The data is analyzed to understand how changes in project scope or complexity impact the accuracy of estimates



Figure 5: Elevation 100% CD Set



Fig.6 : Elevation 95% CD Set

The Project of Apartments located in Mumbai, the project drawings in which there were scope changes occur in 95% CD set and 100% CD set. The drawings are given as above. In above drawings the Façade Tile Cladding scope increase compared to 95% CD Set. Hence the BIM Software Popup the scope changes to the resource & the difference in the quantity, time, Cost can run faster than the traditional way.

#### 4.4 BIM 3D takeoff analysis:

The data is analyzed to understand from the 3D models as shown in below fig. 5.3. The user can easily understand the item complexity and as a result the accuracy of estimates is improves.

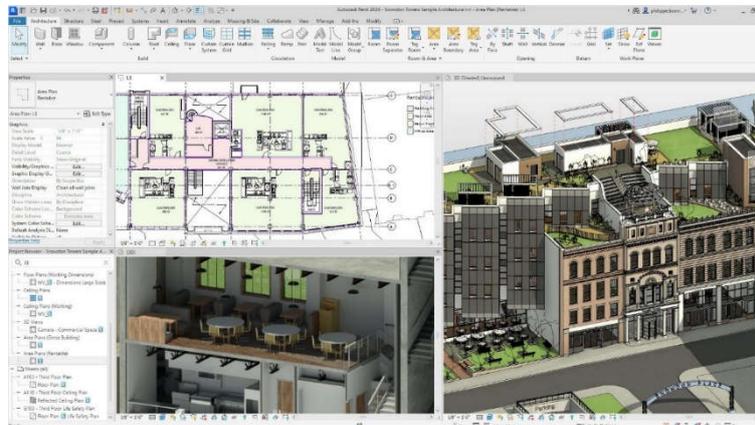
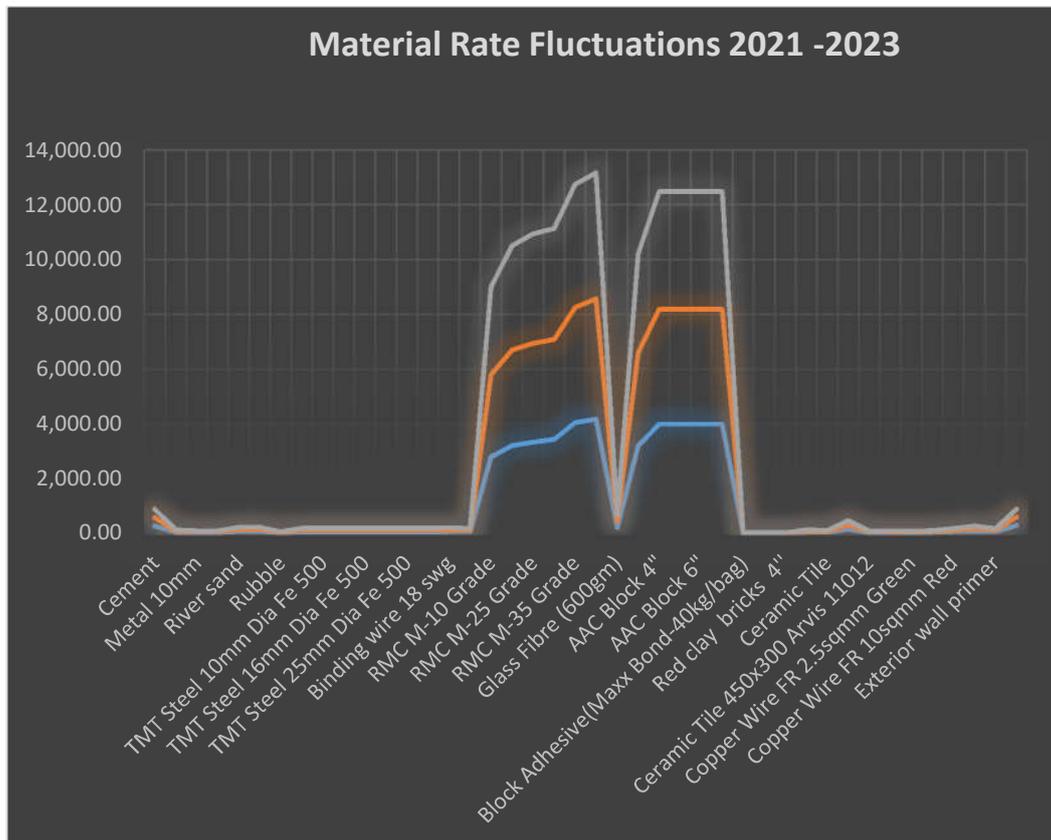


Fig.7.3-3D model

#### 4.5 Uncertain Market conditions:

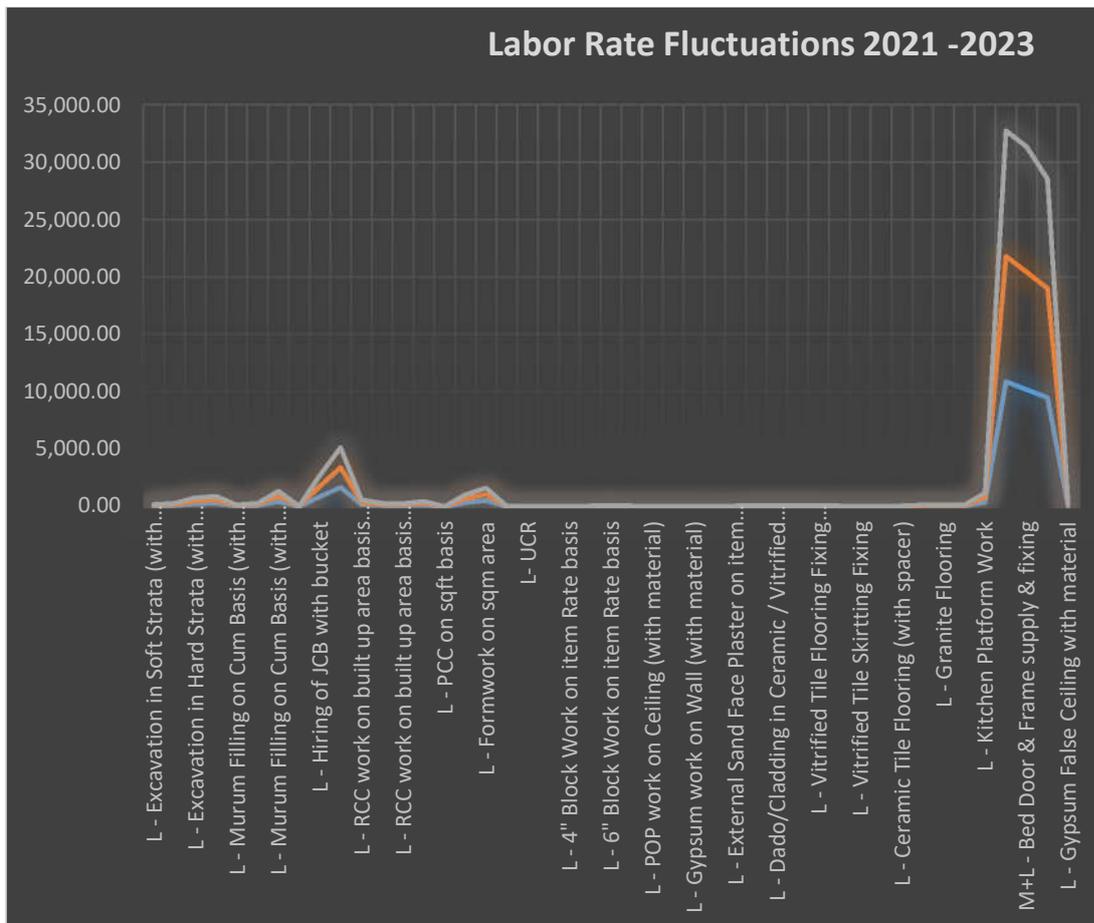
The analysis of construction material rates over the last three financial years (2021–2023) highlights significant fluctuations that directly influenced project cost estimation and control. Core structural materials such as cement and steel showed steady increases, with cement rising from ₹269.53 per bag in 2021 to ₹320 in 2023, and TMT steel across various diameters escalating from ₹51/kg to ₹68/kg, reflecting inflationary trends in the sector. Similarly, ready-mix concrete (RMC) of different grades registered substantial growth, with M-25 grade increasing from ₹3,336.09/m<sup>3</sup> to ₹4,000/m<sup>3</sup>, and M-40 grade from ₹4,169.40/m<sup>3</sup> to ₹4,600/m<sup>3</sup>, indicating heightened demand for higher-strength mixes. Finishing materials such as vitrified tiles, granite, and paints showed moderate year-on-year increments, while brick and AAC

block prices also recorded notable hikes, with red clay bricks rising from ₹7.50 to ₹10 per unit. Electrical materials, including copper wires and cables, exhibited gradual but consistent increases. Conversely, certain items like hydrophobic admixtures remained stable. Overall, these variations underline the volatility of construction markets, where both essential and finishing materials contributed to escalated project costs. Graph 2 illustrates the trend of material rate fluctuations, emphasizing their critical role in budget forecasting and cost management.



**Graph 4: Graphical representation of Material Rate**

The analysis of labor rates over the last three financial years (2021–2023) reveals noticeable fluctuations across various construction activities, directly influencing project cost predictions. Excavation works in both soft and hard strata showed moderate increases of 5–10%, while murrum filling and concreting activities recorded steady but smaller escalations. Finishing works such as POP, plastering, and tiling exhibited sharper rises, with POP and putty plaster showing more than threefold growth in certain cases. Structural activities including RCC, reinforcement, and formwork also reflected consistent upward trends, while specialized works such as granite flooring, gypsum false ceiling, and door installation displayed marginal year-on-year increases. These variations highlight the dynamic nature of labor markets in construction, where both skilled and semi-skilled work categories contributed to the overall escalation. Graph 3 illustrates these labor rate fluctuations, emphasizing their cumulative impact on project budgeting and cost control.



Graph 5: Graphical representation of Labor Rate

#### IV. Optimization of Resource Allocation and Streamlining Quantity Take-Off Using BIM

Building Information Modeling (BIM) revolutionizes resource allocation and quantity take-off by integrating real-time 3D modeling, automated data extraction, and collaborative workflows within a centralized environment that connects design, planning, and estimation. Unlike traditional manual or standalone software-based methods, BIM enables accurate and automated QTO through parametric model data, dynamic updates with every design change, and minimized measurement errors. This precision supports material optimization, just-in-time procurement, efficient labor planning via 4D scheduling, and optimized equipment utilization. Furthermore, BIM fosters collaboration by providing a single source of truth and cloud-based access for stakeholders, ensuring seamless communication and rapid decision-making. By drastically reducing repetitive manual effort, enabling parallel processing, and cutting estimation timelines from weeks to hours, BIM not only improves accuracy but also enhances efficiency and cost-effectiveness across construction projects.

#### V. Cost Impact of BIM-Based QTO and Resource Planning

- **Reduction in Cost Variations**

Because material, labor, and equipment resources are allocated based on precise

quantities, the cost variation between estimated and actual expenditure is significantly reduced—often to within  $\pm 2\%$  compared to  $\pm 10\%$  or more in manual methods.

- **Lower Contingency Requirements**

With higher certainty in quantities, the need for large contingencies in procurement budgets is reduced, freeing capital for other project needs.

The provided data offers a detailed overview of the planned construction costs estimated through the traditional method, encompassing every stage of the project with activity-wise allocations. Earthwork includes ten operations such as excavation, grading, compaction, soil testing, drainage, stabilization, and final inspection, with costs ranging from 274,043 for compaction to 419,693 for excavation. Reinforced Cement Concrete (RCC) work, the most significant budget component, covers twenty operations including foundation casting, columns, beams, slabs, reinforcement, curing, and finishing, where high-value tasks like column construction are allocated 707,818,143, while lower-value operations such as curing and crack repairs have relatively smaller shares. Brickwork, Blockwork, and Plaster (BBM) activities such as bricklaying, plastering, and finishing range from 169,249 to 5,600,000. Additional provisions include consultancy services for architectural, structural, and MEP reviews; site running costs for temporary facilities, safety, and office setup; and site setup activities such as fencing, utility arrangements, equipment installation, communication, and waste management. Salaries for staff including managers, engineers, supervisors, and safety officers are listed separately, while administrative costs cover permits, insurance, marketing, and legal overheads. Other allocations include unforeseen expenses, material wastage, emergency repairs, and substantial contingency and escalation allowances to mitigate risks and inflation. Provisions for completion and maintenance reserves ensure smooth handover and future upkeep, while horizontal development work covers infrastructure like roads, drainage, utilities, landscaping, lighting, parking, and signage. Altogether, the traditional method estimates the planned cost at ₹1,221,432,472, providing a comprehensive financial framework that accounts for every operational and developmental aspect of the project from inception to final delivery.

The BIM-based cost analysis demonstrates significant optimization in resource allocation and project execution compared to traditional estimation methods, with notable savings across all major categories of work. In Earthwork, including ten activities such as excavation, grading, backfilling, and drainage setup, BIM enabled cost reductions of up to 11.50% through precise material calculations and better equipment utilization. RCC works, particularly high-cost tasks like column construction, shuttering, and reinforcement, showed savings exceeding 16%, highlighting improved formwork design, reduced material waste, and enhanced labor productivity. Brickwork and plaster activities achieved up to 40% savings in cement mortar mixing and around 10–12% in bricklaying and finishing, indicating better batching accuracy and material control. Consultancy charges, site setup, running expenses, staff salaries, and administrative costs fell in the 9–11% range due to improved coordination, reduced revisions, and efficient resource scheduling, while after-completion reserves and horizontal development works such as roads and utilities reflected similar savings. Overall, the BIM-driven approach reduced total project cost from ₹1,221,432,472 to ₹1,110,727,461, yielding a saving of

₹110,705,011 (9.06%), clearly showcasing BIM's effectiveness in accurate quantity take-offs, minimizing rework, and achieving substantial cost efficiency.

The cost analysis compares traditional and BIM-based methods across construction activities, showing consistent savings. Earthwork and RCC works achieved 9–16% reductions, with notable efficiency in shuttering, reinforcement, and column construction. BBM and plaster works saved up to 40% in cement mortar mixing, while consultancy, site setup, staff, administrative, and other expenses reflected 9–11% reductions. Overall, BIM implementation delivered total savings of ₹110,705,011, marking a 9.06% reduction in project cost through optimized resource management and streamlined execution. The cost analysis compares traditional planned costs with actual costs achieved through BIM implementation across diverse construction activities, revealing consistent and significant savings. In Earthwork operations such as excavation, grading, compaction, soil testing, debris removal, backfilling, drainage setup, stabilization, leveling, and inspection, cost reductions ranged from 9% to over 11%. RCC work, including foundation casting, column construction, beam and slab casting, concrete mixing, shuttering, reinforcement, curing, and finishing, achieved notable savings above 16% in column construction, shuttering, and reinforcement. BBM and Plaster works, covering bricklaying, mortar mixing, and internal/external plaster, demonstrated efficiency, with cement mortar mixing showing the highest saving at 40%. Consultancy charges, site setup, running expenses, staff salaries, and administrative costs consistently reflected savings of 9%–11%, while unforeseen charges, contingencies, escalation provisions, post-completion reserves, and horizontal development works such as roads, utilities, landscaping, lighting, and signage followed a similar trend. Overall, BIM reduced the total project cost from ₹1,221,432,472 to ₹1,110,727,461, yielding savings of ₹110,705,011 (9.06%), highlighting BIM's role in enhancing cost efficiency, resource accuracy, and streamlined execution across all domains.

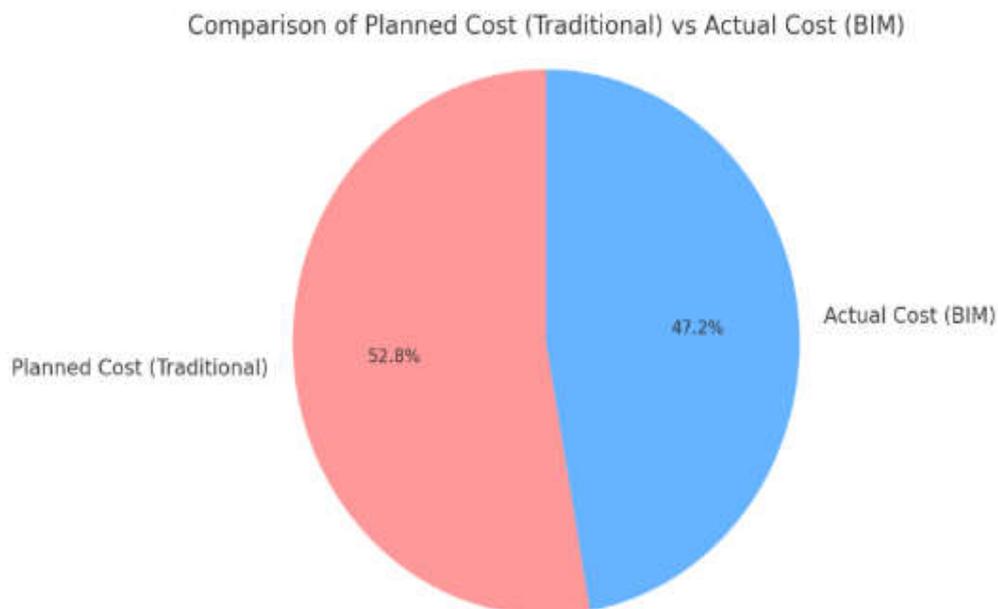


Figure 9-Comparative analysis

## VI.Conclusion

The integration of Building Information Modeling (BIM) into cost estimation and control processes has proven to be a transformative advancement in construction management by enhancing accuracy, transparency, and efficiency through real-time data integration, 3D visualization, and clash detection. Compared to traditional methods, BIM significantly optimized timelines, improved resource allocation, automated quantity take-offs, and reduced errors, leading to measurable improvements in cost efficiency and productivity. The financial analysis demonstrated clear benefits, with the planned cost of ₹1,221,432,472 under traditional methods reduced to an actual cost of ₹1,110,727,461 using BIM, yielding savings of ₹110,705,011 (9.06%). These savings resulted from precise estimation, streamlined material management, and reduced rework, particularly in high-cost components such as RCC and site setup, where variations exceeded 16%. By minimizing design errors and preventing on-site changes, BIM not only improved collaboration and decision-making but also established itself as a sustainable, data-driven solution that ensures financial discipline, operational excellence, and long-term value in modern construction projects. The results confirm that BIM is not just a design tool but a cost-optimization strategy that delivers measurable economic benefits while maintaining quality and timelines. This shift from traditional planning to BIM-based execution enhances budget reliability, reduces risks, and strengthens project control, making BIM an essential practice for modern, cost-conscious construction management.

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