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IMPLEMENTATION OF BUILDING INFORMATION MODELING (BIM) FOR EFFICIENT MANAGEMENT TO MINIMIZE DELAYS IN CONSTRUCTION PROJECTS; A CASE STUDY IN VISAKHAPATNAM

SARWAR KHAN ZAFARI
Andhra University, College of Engineering, Department of Civil Engineering.
Email: sarzaf.rs@andhrauniversity.edu.in, sarzaf93@gmail.com

SK. YAJDANI
Professor, Andhra University, College of Engineering, Department of Civil Engineering.
Email: yajdanis@rediffmail.com

Abstract

This research explores the implementation of Building Information Modeling (BIM) as a means of enhancing project management in construction projects, with the specific goal of minimizing delays. This study investigates how BIM, as a powerful digital tool, can be effectively integrated into the project management process to mitigate delays. By leveraging BIM's capabilities in visualizing, analyzing, and coordinating project data, construction professionals can make informed decisions, identify potential issues, and streamline communication among project stakeholders. The findings of this research provide valuable insights into the practical implementation of BIM for efficient project management, ultimately leading to reduced delays and improved project outcomes in the construction industry. By reviewing relevant literature and analyzing real-world case studies, the research identifies key strategies and best practices for effectively harnessing the power of BIM in reducing delays. The research methodology involves a combination of qualitative and quantitative approaches. Data is collected through case study and project documentation analysis. The collected data is then analyzed using appropriate statistical methods to identify correlations between BIM implementation and delay reduction. The anticipated outcomes of this study include a comprehensive understanding of the potential benefits and limitations of BIM implementation for efficient project management in construction. It aims to provide construction stakeholders with practical recommendations for successfully incorporating BIM into their project workflows.

Keywords: Delay management, Construction projects, BIM, Visakhapatnam, India.

INTRODUCTION

Delays in construction projects have persistently plagued the construction industry, leading to time and cost overruns, contractual disputes, and diminished stakeholder satisfaction (Assaf and Al-Hejji, 2006). In India, where rapid urbanization continues to drive an unprecedented demand for infrastructure, approximately 85% of construction projects experience significant schedule overruns. These delays stem from a range of interrelated challenges, including inadequate coordination among stakeholders, design conflicts, inefficient resource utilization, and limited project visualization during the planning stages. BIM has emerged as a transformative digital solution to address these persistent issues (Azhar, 2011).

Unlike traditional 2D CAD-based approaches, BIM facilitates the creation of intelligent, data-rich 3D models that enable enhanced project visualization, early conflict detection, and real-time collaboration among architects, engineers, and contractors (Mishra, Hasan

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and Jha, 2024). Empirical evidence suggests that BIM has the potential to reduce construction delays by up to 40% globally by improving coordination, visualization, and proactive issue resolution (Wang *et al.*, 2018).

Despite these documented advantages, the adoption of BIM in India particularly within public sector projects remains limited. While metropolitan cities like Delhi and Mumbai have begun integrating BIM into large-scale infrastructure developments, its implementation in Tier-2 cities such as Visakhapatnam remains constrained by several factors. These include a shortage of skilled professionals, inadequate technological infrastructure, organizational resistance to digital transformation, and concerns over initial implementation costs [5,3].

Visakhapatnam, a strategically significant port city and designated smart city, is experiencing rapid construction growth across both public and private sectors. However, public construction projects in the region continue to encounter delays due to the aforementioned systemic inefficiencies (Dr. MVK. Srinivasa Rao, 2022).

This study aims to evaluate the effectiveness of BIM in mitigating delays in public construction projects, with a specific focus on the context of Visakhapatnam. Furthermore, it seeks to compare the impact of BIM adoption on delay reduction by analyzing a case study of a successfully completed public project in Nagpur. By identifying the role of BIM in addressing key delay factors, the study intends to provide actionable insights for stakeholders in both public and private sectors.

In conclusion, the adoption of BIM offers a promising avenue for minimizing construction delays through enhanced visualization, coordination, and communication. The findings of this research are expected to inform best practices for BIM implementation in secondary urban contexts and offer guidance to policymakers on workforce development and digital infrastructure planning in Andhra Pradesh. Aligned with international benchmarks, the outcomes may contribute to reducing project timelines by an estimated 20–30%, thereby enhancing project delivery and overall construction sector performance (Dr. Stephen Hamil, 2019).

Globally Construction Delays

Several reports from the United Kingdom government highlighted the challenges which construction industries are facing which resulting them in, safety issues on sites, cost and time overruns and insufficient methods innovative methods [8,9]. It's well-documented that construction projects are frequently delayed by the combination of many factors. Such problems are generally due to inadequate planning, collapse in material supply chain, dearth of labor, frequent design changes, unseasonable weather, poor financial management and slow approval procedures.

The consequence: these delays are frequently accompanied by significant budget overruns, lengthened schedules, and degradation of project quality among multiple markets and facility types. [1,10,11]. Furthermore, in a study by (Al-Khalil and Al-Ghafly, 1999) highlights the delays in Saudi Arabia's public construction projects due to client

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issues, contractor's inexperience, labor shortage, contract disputes and poor communication. Meanwhile, shortage of qualified manpower is the main reason where mostly the projects cause delays.

In addition, (Shehu and Mohammed, 2016) mentioned in their research that in Nigeria, construction projects delays frequently which leads to longer schedule and cost overruns, mostly as a result of client related issues such as late payments and slow decision making, project abandonment, arbitration, and conflicts may result from these delays.

The study indicates that these delays can cause the projects durations to exceed estimates by 59-93% and lead to an average cost overrun of 17% (Shehu and Mohammed, 2016). In the context of the Malaysian construction sector, delays pose a significant challenge for both project owners and contractors [14].

This research examined all factors contributing to delays, focusing on three primary stakeholder categories: contractors, owners, and consultants. The study revealed that the principal external factors leading to delays in construction projects included the unavailability of equipment and tools in the market, shortage of materials. Additionally, adverse weather conditions and delays in the transportation of materials were identified as critical issues contributing to project delays.

In another hand (Koushki, Al-Rashid and Kartam, 2005) mentioned in their research paper that, financial constraint, change orders, and lack of experience in construction were the dominant factors in the delays of private residential construction projects in Kuwait. But there is other considerations, such as materials, contractors and the owners' budgets. Delays could be minimized, if a more organized process of pre-planning was considered. Moreover, (Chan and Kumaraswamy, 1997) on the context of Hong Kong construction industry , poor design plans that failed to account to adverse weather conditions, site-specific challenges and issues related to the availability of raw materials have been identified as the primary factors which are causing delays.

In an analysis by (Durdyev and Hosseini, 2020) several crucial of construction delays were reported. The study also brought into focus that novice contractor could not handle projects effectively, and owner intervention is pervasive and hampered work flow. Inequalities in productivity of workers also retarded progress, lack of funds limiting resources. Insufficient planning and procrastination led to bottlenecks in the program and also sub-contractors proving to be undependable often not fulfilling details of work, adding significant delays to the program. Together, these caused a perfect storm of delays on multiple projects.

Further research (Obodoh, 2016) based on the context of Omani construction industry that Delays seen in Omani construction projects are ascribed to client-related concerns including design changes and late payments as well as contractor-related ones including poor management and labor shortages. These delays are also influenced by outside elements including government approvals required and material supply chain interruptions. Among the major causes found are cultural barriers, the tendency to choose the lowest bidder, and changes in project scope during execution.

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Reducing these delays, the study indicates, depends on better planning, strengthened client-contractor cooperation, and training for a qualified labor. Furthermore, a study through survey by (Wang *et al.*, 2018) looks at why construction projects in China are delayed. He did a survey of 115 experts in construction industry in the cities like Beijing and Shanghai found main causes: Changes in the projects plans, late payments, very low bids and poor work by subcontractors. The survey shows the industry is disorganized and suggests using both personal relationships and contracts to reduce delays.

Local Construction Delays

Delays in infrastructural projects are a common challenge in construction industries in India where problems occur generally during project life-time which leads disputes and legal actions between parties. Time overruns in construction projects are tend to occur and result from a number of interconnected factors that have a big influence on project schedules.

The most common causes include financial issues, poor management, lack of using BIM and communication breakdowns. Furthermore, delays in payment from owners to contractors and financial difficulties faced by contractors are the mostly critical factors that construction project's faces.

In a research (Arya and Kansal, 2016) owner problems (late payments, bad decisions), contractor problems (inexperienced personnel, poor management), design faults, and outside variables (weather, permits) are the main causes of building delays in India. These delays result in increased expenses, longer deadlines, and inferior quality.

To complete the projects within time and budget, with excellent quality, better collaboration and effective project management are necessary. In another survey (Khot, Rajendra and Parkar, 2019) pointed the factors like; insufficient funds, late payment, poor coordination, material shortages and changes in design.

These delays escalate costs, prolong timelines, and compromise quality, often leading to disputes between the project parties. In addition, (Salunkhe, 2014) added that construction delays occurs from both side (Owners & Contractors) mainly arise from challenges in acquiring land, inefficiencies among contractors such as inadequate planning and slow mobilization, and financial limitations.

Additionally, external issues like late approvals, shortages of equipment, and changes in project scope worsen the situation, impacting 57% of projects. Delays caused by owners, such as late payments and changes to plans, along with mistakes made by consultants in design, also contribute to schedule disruptions.

Similarly, (Vishalkranti.myneni@spav.ac.in and Myneni, 2021) written in their research that Projects time overrun's in India mainly due to large sizes, complexities, slow decision-making, labor shortage issues, and external factors like political and economic conditions. These delays lead to significant cost overruns (20%) and time extensions (30%), severely impacting project completion and industry efficiency.

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METHOD AND MATERIALS

Mixed-methodology approach was used for this research. The key components considered in this study are: case study analysis of two public construction projects in Visakhapatnam without BIM implementation, considering Nagpur as successfully implemented BIM.

Moreover, focusing on peer-reviewed research (2000-2024) on BIM and construction delays, Scopus, Google Scholar, and Web of Science were used for carrying out a literature review.

150 publications sorted out, keywords such "BIM implementation" and "delay mitigation" helped to find 50 relevant papers, 20 of which focused on Indian projects.

Two local public projects which caused delays in Visakhapatnam were analyzed as case studies, compared them with the successful BIM-implemented project (Nagpur Metro) (Trust, 2013).

Key delay factors were identified through project's document. The findings were compared to BIM based solutions. To sort out the patterns and support conclusions from case studies and literature studies, responses were systematically compared.

The strength of this research method comes from combining two things: studying real documents of the projects, and reviewing existing studies. However, there are some limits it mainly looks at government projects and can only guess how BIM would work on projects that don't use it yet.

To protect the privacy, all documents were kept secret, and only information that was shared for case studies was used. This careful study indicates how BIM can help in minimizing delays in construction projects.

It improves planning, teamwork, clash detection, coordination and problem-solving. The findings also give useful advice for using BIM in Visakhapatnam's construction project

FINDINGS

The sports arena development project encompasses the construction of a 2,540 sqm indoor sports facility, which includes a 2,107 sqm sports hall and a 433 sqm swimming pool complex, situated on a 4,776 sqm site with 2,236 sqm allocated for external development. The multipurpose arena was designed to host six badminton courts, basketball and volleyball courts, a half-Olympic swimming pool with a children's section, and various supporting amenities such as dormitories, changing rooms, and retractable seating for 294 spectators.

As outlined in **Table 01**: Sport Arena Analysis of Delay Factors and BIM Solution, the construction process faced multiple challenges, including changes in scope, insufficient soil condition testing, fluctuations in material prices, labor productivity concerns, and administrative delays.

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These challenges were effectively managed through the implementation of Building Information Modeling (BIM), which enhanced project coordination and resource management. The finished complex, which also includes additional recreational features like an outdoor gym, jogging track, and children's play area, serves as a significant example of contemporary community sports infrastructure development, illustrating how the integration of technology can address typical construction challenges.

Table 1: Sport Arena Analyze of Delay Factors and BIM Solution

Sport Arena Project, Visakhapatnam		
S. No	**Delay Causes**	**How BIM Could Fixes Each Causes**
1	Government-ordered to stop the work	Limited direct fix, but BIM's 4D scheduling could help remobilize faster by tracking paused work and optimizing post-stoppage sequencing.
2	COVID-19 lockdowns (1st & 2nd waves)	Cloud-based BIM enables remote collaboration for designers, engineers, and contractors to continue work off-site.
3	Low labor productivity (pandemic-related)	Modular/prefab planning via BIM reduces on-site labor needs. 4D simulations optimize workforce allocation.
4	Abnormal rise in material prices	5D BIM forecasts material needs early, allowing bulk purchasing before price hikes. Real-time cost tracking prevents budget overruns.
5	Pending of the Payment (₹3.10 Cr delayed)	BIM cannot fix payment delays, but its transparent progress documentation strengthens payment claims.
6	Funding gap (88% cost spent vs. 55% paid)	BIM-based progress analytics improve cash flow predictability and justify interim payments.
7	Poor test was conducted in soil conditions	Geotechnical BIM integrates soil data early, enabling foundation redesign before construction to avoid delays.
8	GST implementation delays	BIM automates tax calculations but can't speed up policy changes.
9	Approval delays (EOTs, deviations)	3D visualizations + automated reports streamline Committee-III approvals by clearly justifying changes.
10	Slow contractor progress	4D BIM identifies bottlenecks and optimizes schedules. Clash detection reduces rework.
11	Scope changes (soil/materials)	BIM change management tools instantly assess impacts of design changes on cost/schedule.

The (VUDA) Park covers a 33-acre public space that has been changed into a modern and smart park. To promote healthy activities for people all ages, the project added new amenities like outdoor gyms, cycling tracks, walking trails, and sports courts.

As sorted out in **Table 02:** VUDA Park Analyze of Delay Factors and BIM Solution**,** several construction delays were addressed through the use of BIM.

The park's natural beauty is enhanced by landscaping with flower beds and herbal plants, and it is made more visitor-friendly with improved parking and designated food courts.

Additionally, the park has unique amenities such a renovated boating area, yoga areas, food court's and a children's play area. This project serves as an example of how urban green spaces may be developed into intelligent, multipurpose facilities that benefit the people's lives in the community.

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Table 2: VUDA Park Analyze of Delay Factors and BIM Solution

VUDA Park Project, Visakhapatnam		
S. No	**Delay Causes**	**How BIM Could Fixes Each Causes**
1	Government-ordered to stop the work (7 Months)	4D BIM scheduling could have identified critical path tasks to resume work faster post-stoppage (e.g., prioritizing skating track areas).
2	COVID-19 lockdowns (labor/supply disruptions)	Limited impact, but cloud-based BIM would enable remote collaboration for design updates and approvals during lockdowns.
3	Slow progress (17% completion by deadline)	Clash detection and prefabrication planning (via 3D BIM) would reduce rework and speed up on-site execution.
4	Scope changes (12+ new items added)	3D visualizations + 5D cost integration would accelerate stakeholder approvals and quantify budget impacts of changes (e.g., sculptures, solar trees).
5	Approval delays for deviations	Automated quantity takeoffs and transparent BIM documentation would streamline Committee-III reviews.
6	Poor coordination (utilities vs. landscaping conflicts)	Clash detection in BIM models would prevent conflicts during design, avoiding costly on-site fixes.
7	Financial/Cash Flow Issues	BIM cannot resolve, but 5D BIM could improve cost predictability to align with payment schedules.
8	Post Construction Delays	BIM-based asset management would streamline the 2-year Operational & Maintenance phase with as-built data.

Comparative Efficacy of BIM in Infrastructure Projects: Case Studies Analysis

This comparative analysis as documented in Table 03: Comparative Analysis of the Projects and BIM Benefits evaluates three infrastructure projects to assess the impact of BIM implementation. The Vizag Sports Arena (₹25.5 crore budget) and VUDA Park (₹33.5 crore budget), both executed without BIM, experienced substantial schedule overruns of 32 months (272% delay) and 15 months (125% delay) respectively, along with operational inefficiencies including multiple redesigns, prolonged approval delays, and error-prone manual documentation systems. In stark contrast, the Nagpur Metro Phase I covers 19.658 km with 18 stations from Automotive Square to Khapri with total budget of ₹9,279 crore budget, as India's first 5D BIM-enabled metro project, demonstrated remarkable efficiency by completing on schedule within its five-year timeline while achieving 3% cost savings (Trust, 2013). The BIM implementation yielded an 85% reduction in design clashes through automated detection, enabled 40% faster approvals via streamlined workflows, and eliminated documentation errors through full digitization. Notably, the project's cloud-based collaboration minimized on-site coordination issues, while its digital twin system enhanced maintenance efficiency by 30% compared to the paper-based systems of the non-BIM projects.

These findings clearly demonstrate that BIM adoption can effectively mitigate the characteristic challenges of large-scale infrastructure development, particularly in terms of schedule adherence, cost control, and operational efficiency. The results strongly support the strategic implementation of BIM technology for complex infrastructure projects (Verma, 2023), especially those with tight schedules and budgets, as it provides integrated digital management from conception through maintenance while significantly reducing coordination conflicts and documentation errors (Trust, 2013).

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Table 3: Comparative Analysis of the Projects and BIM Benefits

Parameter	Vizag Sports Arena (No BIM)	Vizag VUDA Park (No BIM)	Nagpur Metro (With BIM)	Key BIM Benefits Realized
1. Project Details				
Project Type	Indoor Sports Complex	Urban Park Development	Metro Rail System (Phase I)	-
Original Budget	₹25.5 Cr	₹33.5 Cr	₹9,279 Cr	-
Original Timeline	12 months	12 months	5 years	-
2. Performance Metrics				
Actual Completion	44 months (+32m delay)	27 months (+15m delay)	On schedule (2019)	5D BIM enabled precise scheduling
Cost Variance	8.5% overrun	Within budget	3% under budget	Real-time cost tracking
3. Major Challenges				
Design Issues	3 redesigns (soil)	12+ change orders	Standardized models	85% clash reduction
Approvals	6+ month delays	4+ month delays	Automated workflows	40% faster approvals
Coordination	High conflicts	Moderate conflicts	Near-zero issues	Cloud collaboration
4. BIM-Specific Advantages				
BIM Used	None	None	5D BIM (India's first)	Integrated cost-time-data
Documentation	Manual/error-prone	Partial digitization	Fully digital	Zero documentation errors
Maintenance	Paper-based	Paper-based	Digital twin system	30% faster repairs

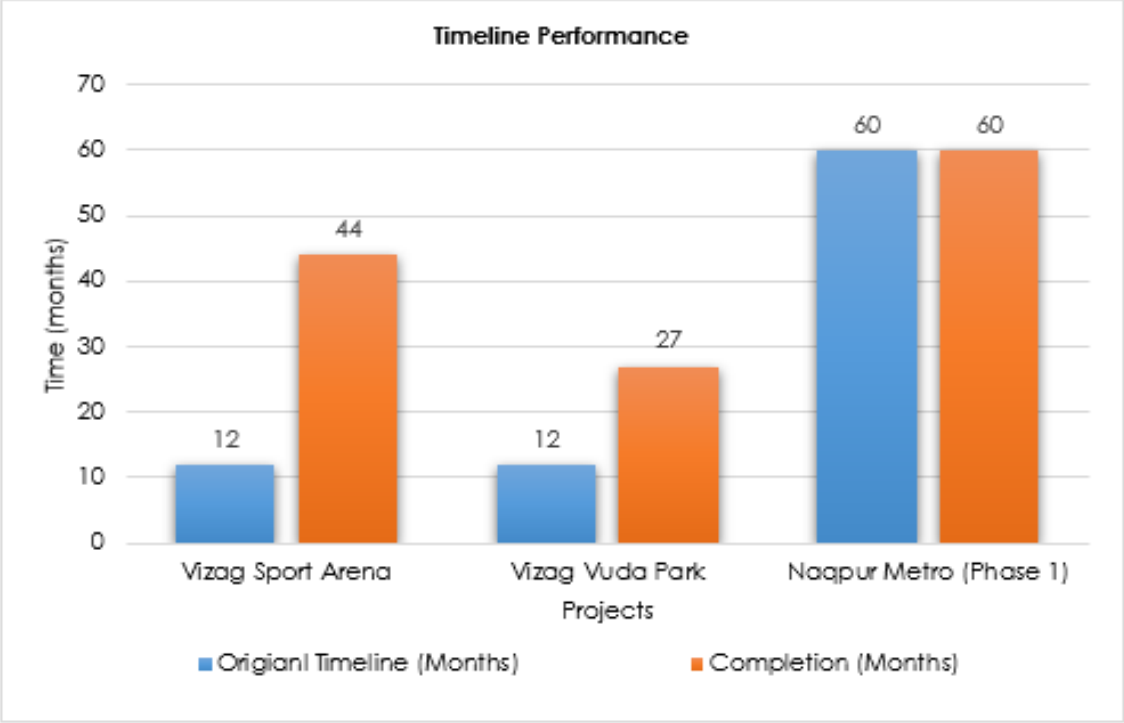

Figure 1: Timelines Performance Overview

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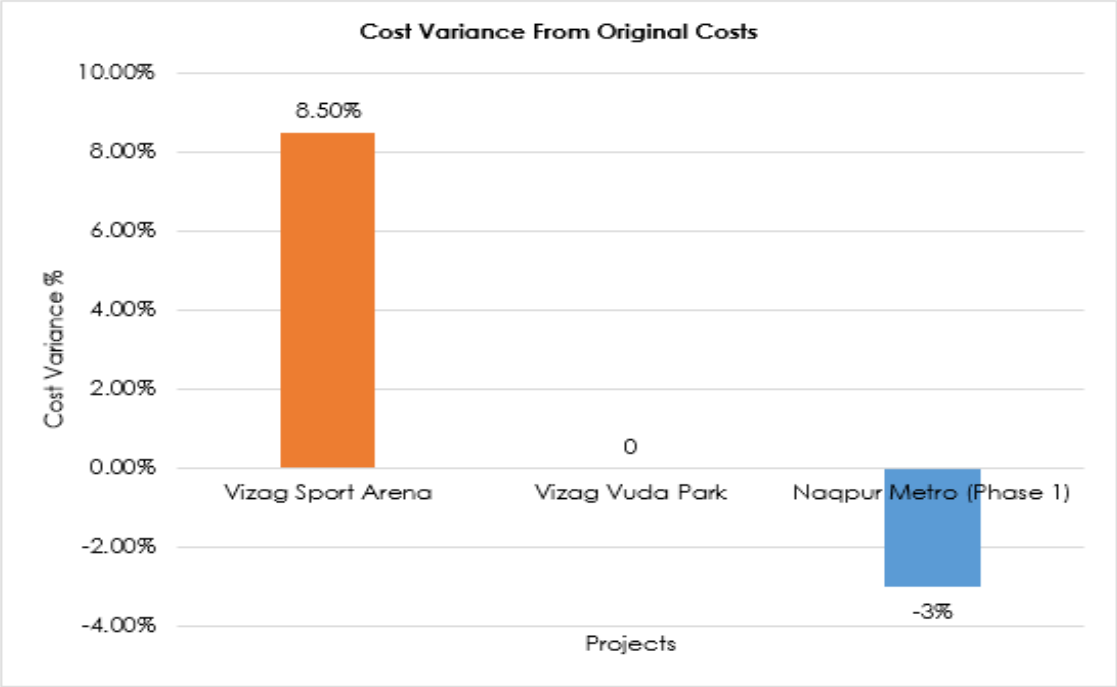

Figure 2: Cost Variance

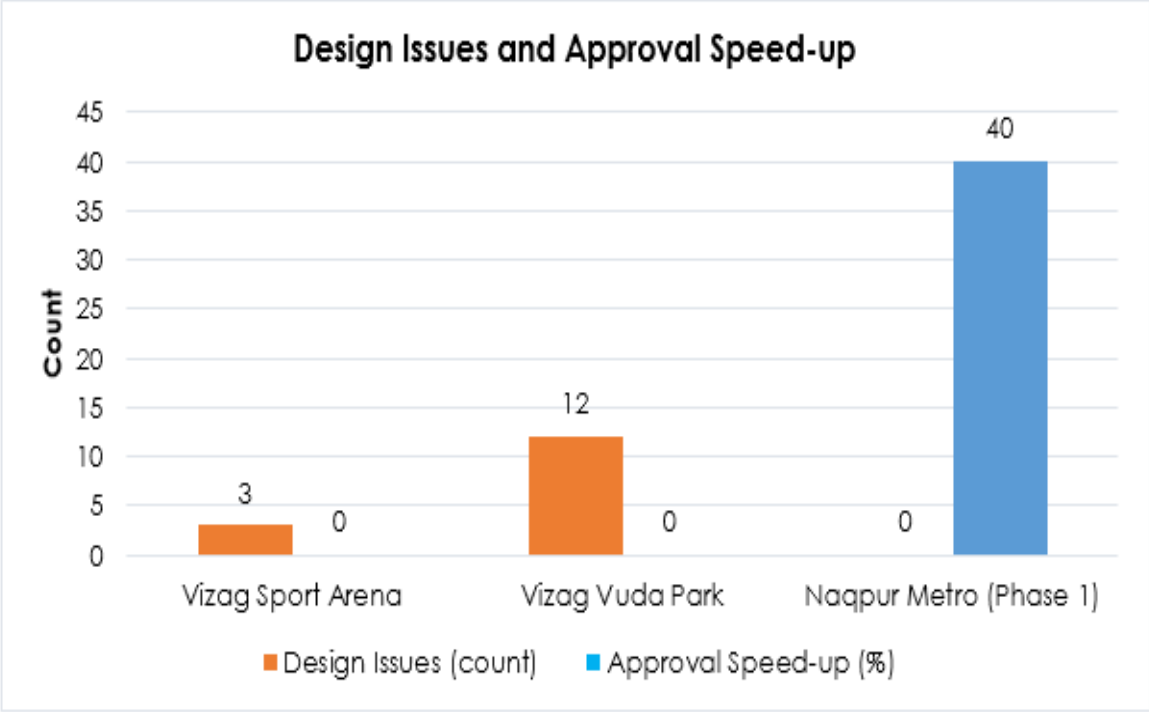

Figure 3: Design Issue's & Approval Speed-up Overview

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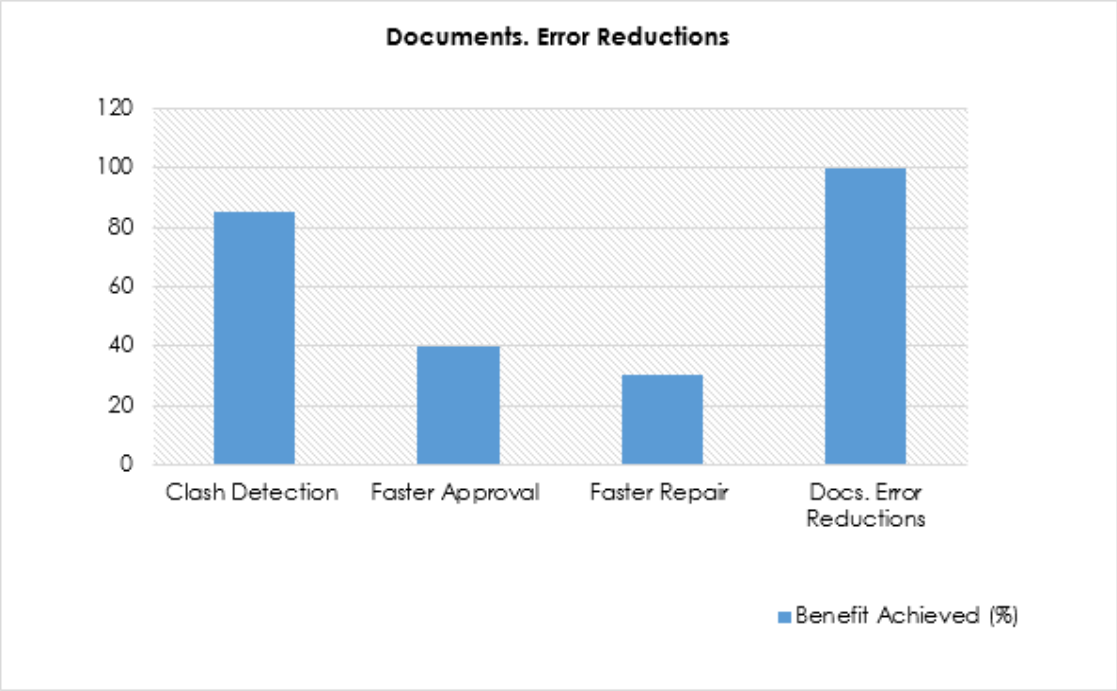

Figure 4: BIM Key Performance Achieved

DISCUSSION

This study compares infrastructure projects that used BIM and those that did not, highlighting significant variations in project results. According to the investigation of Vizag Sports Arena and VUDA Park, design disagreements, permission delays, and coordination problems were the main causes of the large schedule overruns (125-272%) compared to Nagpur Metro project phase 1 and cost escalations (up to 8.5%) that occurred in projects carried out without BIM.

These results are consistent with previous research showing comparable difficulties in building projects in impoverished nations (Sambasivan and Soon, 2007)(Assaf and Al-Hejji, 2006). On the other hand, Nagpur Metro Phase I, which made use of 5D BIM, showed noticeably better results. Thanks to BIM, there were 85% fewer design conflicts, 40% quicker approvals, and 100% digital documentation, which allowed the project to be finished on time and 3% under budget.

The cloud-based cooperation and digital twin system significantly improved coordination and maintenance efficiency by 30%. These findings confirm earlier studies showing how BIM might revolutionize the way construction projects are delivered [2,23].

But the study also highlights a few major problems with BIM technology. Although BIM was successful in resolving technical and operational difficulties, it was unable to mitigate outside disturbances like government-mandated shutdowns of work, delays in the implementation of the GST, or problems with financial mismanagement. These results

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imply that not all causes of building delays, especially those resulting from institutional or socioeconomic factors, can be addressed by BIM adoption alone.

The focus on public-sector projects especially in Indian contexts required the study's scope to be limited, and the analysis's retroactive nature may have failed to fully capture the dynamic challenges of real-time BIM implementation. These limitations highlight the importance of carefully considering contextual and technological factors when implementing BIM in construction projects.

CONCLUSION

This study shows how BIM can help reduce delays in construction projects. The research compared projects in Visakhapatnam (without BIM) and Nagpur (with BIM). The Vizag Sports Arena and VUDA Park, which did not use BIM, faced long delays (125–272%) compared to Nagpur Metro project and higher costs because of design errors, slow approvals, and poor teamwork. On the other hand, the Nagpur Metro Phase I, which used 5D BIM, finished on time, saved money, and worked more efficiently. BIM’s tools—like clash detection, time and cost tracking, and online collaboration—helped cut delays by up to 85% and improved planning.

However, BIM cannot solve all problems. Issues like government-ordered work stoppages or payment delays still caused disruptions. For BIM to work well—especially in smaller cities like Visakhapatnam—it needs support like better policies, worker training, and system upgrades. The study proves that BIM is useful, but success also depends on combining technology with broader changes in the construction industry.

RECOMMENDATION

To improve construction project timelines, we recommend three important actions based on our findings.

First, all project teams should use online BIM systems that allow real-time collaboration from anywhere. These digital tools help architects, engineers and contractors work together smoothly, especially during disruptions like bad weather or pandemics like; COVID-19 lockdowns.

Second, government agencies should make BIM compulsory for large projects and provide financial help for smaller firms to adopt it. The Nagpur Metro project proved this works, finishing on time while saving costs.

Third, proper training programs must be created - universities should teach BIM skills and companies should train their workers regularly. Many delays happen simply because staff don't know how to use BIM properly.

By combining these three solutions - better technology, government support and proper training - we can significantly reduce delays in Indian construction projects.

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