RESEARCH ARTICLE OPEN ACCESS
Website: http://ijte.americanjournal.us/index.php/ijte

International Journal of Technology & Energy
Volume 1, Number 2, 2025 | ISSN: 3066-6635

The Implementation of BIM in the Early Planning Stage of High-Rise Building Construction Projects

Nurkhasanah Rina Puspita

Politeknik Negeri Medan, Indonesia (n.r.puspita@outlook.com)

Abstract

The construction industry, characterized by complexity and multidisciplinary interdependence, has increasingly adopted Building Information Modeling (BIM) to enhance efficiency and coordination. Despite its global recognition, BIM's implementation during the early planning phase of high-rise building projects in Indonesia remains limited. This study aims to explore how early-stage BIM adoption impacts project performance, particularly in terms of design coordination, time efficiency, and cost estimation. Employing a qualitative research methodology, this paper conducts a systematic literature review drawing on peer-reviewed sources from 2020–2025. The PRISMA framework guided data identification, screening, and inclusion, ensuring methodological rigor. Thematic analysis was used to categorize findings into key themes such as BIM benefits, implementation challenges, and adoption strategies. The results show that early BIM implementation significantly enhances design coordination (85%), improves clash detection (80%), and increases cost estimation accuracy (78%). Additional benefits include schedule optimization and material waste reduction. Case studies from international projects—like the Suzhou Zhongnan Center and projects by Turner International—demonstrate that BIM integration at early planning stages helps mitigate design conflicts, streamline interdisciplinary workflows, and support informed decision-making. However, challenges in the Indonesian context include high initial costs, lack of trained professionals, minimal client demand, and cultural resistance. Strategic solutions proposed include tiered training, regulatory incentives, adoption of Common Data Environments (CDE), and national digital roadmaps. These findings underscore the urgent need for institutional and professional transformation to fully leverage BIM's potential in Indonesia's high-rise construction sector.

Keywords: Building Information Modeling, Early Planning, High-Rise Construction.

INTRODUCTION

The advancement of information technology has significantly impacted efficiency and effectiveness across various industrial sectors, including the construction sector, which is known for its complexity and high uncertainty (Sacks et al., 2018). One of the most transformative innovations is Building Information Modeling (BIM), a digital model-based approach that incorporates geometric data, time scheduling, cost estimation, and operational information into a single integrated system (Akhanova et al., 2021; Succar & Kassem, 2015). BIM has proven to enhance multidisciplinary coordination across all project phases—from planning through to building operation (Barlish & Sullivan, 2012).

Building Information Modeling (BIM) is a digital approach that revolutionizes the design, construction, and operational processes of buildings by creating intelligent three-dimensional representations of physical and functional infrastructure. BIM enables integration and collaboration across disciplines within a single information model, incorporating geometric data, scheduling (4D), cost estimation (5D), and facility operation insights. This method enhances efficiency and accuracy while reducing project risks and facilitating informed decision-making throughout the building's life cycle. According to Berlato et al. (2025), BIM is at the core of the digital transformation in the construction industry, especially through its role in connecting digital platforms across sectors and scales (Berlato et al., 2025).

The application of BIM has expanded into numerous areas, including disaster risk management, energy efficiency, and integration with artificial intelligence and robotics. Wang et al. (2025) highlight that BIM significantly supports sustainable risk management by enabling emergency scenario simulations and mitigation strategies (Wang et al., 2025). Furthermore, Odugu et al. (2025) demonstrate that the integration of BIM with robotics can automate construction tasks and enhance fieldwork precision. Recent trends also show BIM supporting sustainability through Life Cycle Assessment (LCA), as reviewed by Jalota and Ayazi (2025). Therefore, BIM is no longer just a design tool—it is a systemic innovation driver for modern construction practices (Jalota & Ayazi, 2025).

In the context of high-rise building projects, the early planning phase is critical as it forms the basis for all subsequent decisions (Wibowo et al., 2023). Failure at this stage may lead to project delays, cost overruns, and reduced construction quality (Memon et al., 2025). BIM enables early integration of data and visualization, allowing project stakeholders to detect design conflicts, assess realistic schedules, and forecast costs more accurately (Liu et al., 2025; Raduan et al., 2025).

However, the implementation of BIM in the early stages of high-rise projects is not yet a common practice in Indonesia. This is particularly concerning given that high-rise projects require intensive technical coordination and stakeholder communication (Prabowo, 2024). Barriers to BIM adoption include limited human resources, high training costs, and a lack of strategic awareness among decision-makers (Ismail et al., 2025; Luo et al., 2025). International studies have shown that the greatest cost and time-saving potential occurs when BIM is applied as early as the conceptual design stage (Zhang et al., 2025).

Therefore, this research is highly relevant to better understand how BIM implementation during the early planning phase can improve overall project performance for high-rise construction. Given the complexity of such projects, BIM is expected to simplify the planning process and improve the accuracy and quality of early design deliverables.

Previous studies have explored BIM in various contexts such as apartment buildings, wastewater treatment facilities, and hospitals (Ismail et al., 2025; Prabowo, 2024; Wibowo et al., 2023). However, there is still limited literature that focuses specifically on the application of BIM in the early design phase of high-rise buildings, both nationally and globally. This indicates a clear research gap that needs to be addressed in support of digital transformation within the Indonesian construction industry.

Based on this background, the objective of this study is to explore the application of BIM in the early planning phase of high-rise building projects, and to analyze its impact on design coordination, scheduling efficiency, and project cost estimation. This study also aims to identify the challenges of BIM adoption and propose effective implementation strategies for the Indonesian construction sector.

METHOD

This study adopts a qualitative approach using a literature review method to examine the implementation of Building Information Modeling (BIM) during the early planning stages of high-rise building construction projects. This method is suitable for exploring both theoretical and practical perspectives from existing scientific literature without direct field data collection (Snyder, 2019). The research is descriptive-analytical, aiming to identify patterns, themes, and critical insights from published sources.

Data Sources

The data used in this study are secondary data obtained from peer-reviewed journal articles, conference proceedings, institutional repositories, and credible academic publications. The selected sources focus on BIM applications in pre-construction planning, especially for high-rise buildings, and are published between 2020 and 2025 to ensure relevance and currency (Kitchenham, 2004).

Data Collection Technique

Data collection was carried out through a systematic literature search using scientific databases such as Scopus, ScienceDirect, SpringerLink, MDPI, and Google Scholar. Keywords used included: “Building Information Modeling”, “early planning”, “high-rise building project”, and “BIM implementation”. The literature selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, involving several stages:

1. Identification: Initial search using keywords
2. Screening: Title and abstract relevance check
3. Eligibility: Full-text review for inclusion
4. Inclusion: Final selection for analysis

This method helps maintain transparency and rigor in selecting and evaluating the literature (Page et al., 2021).

Data Analysis Method

The data were analyzed using thematic content analysis, where the findings from each article were categorized based on key themes such as BIM benefits in early-stage planning, implementation barriers, and adoption strategies. This inductive approach allows the researcher to interpret meaning from textual data and compare findings across studies (Bowen, 2009). The identified patterns were synthesized to generate conclusions and recommendations relevant to the adoption of BIM in high-rise building projects.

RESULTS AND DISCUSSION

BIM Implementation in the Early Planning Stage of High-Rise Projects

The early planning stage of a high-rise building project is marked by critical decision-making regarding spatial layout, material selection, structural strategy, and lifecycle cost. Traditionally, these decisions were made using fragmented data and 2D CAD tools, often resulting in misalignment between architectural intent and structural feasibility. The integration of Building Information Modeling (BIM) into this phase fundamentally transforms this process by enabling collaborative, multi-disciplinary modeling that is data-rich and visually precise.

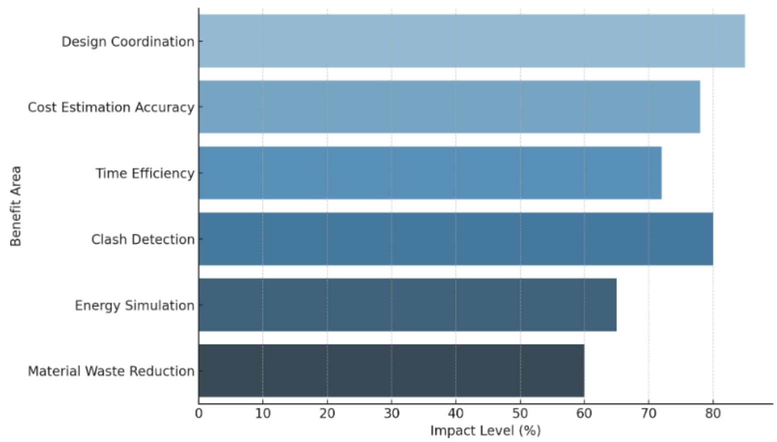

Figure 1. Impact of BIM Implementation in Early Planning Stage of High-Rise Projects

The chart illustrates that the most significant impact of early BIM implementation in high-rise projects is observed in design coordination (85%), closely followed by clash detection (80%) and cost estimation accuracy (78%). These high scores reflect BIM's strength in facilitating interdisciplinary collaboration and minimizing design conflicts. Additionally, time efficiency (72%) and material waste reduction (60%) indicate substantial project optimization through early visualization and planning. Notably, energy simulation (65%) underscores BIM's growing role in supporting sustainable design decisions from the earliest phases of development.

BIM at this early stage serves not merely as a digital representation, but as a centralized knowledge repository that allows stakeholders from architectural, structural, mechanical, and electrical disciplines to co-develop a federated 3D model. This early coordination minimizes clashes, anticipates spatial constraints, and allows for performance simulation (energy, lighting, ventilation) before construction begins. As noted by Omrany et al. (2023), BIM at the pre-design and schematic stage supports applications such as net-zero energy design, cost optimization, and smart technology integration—an approach particularly valuable in the vertical complexity of high-rise construction (Omrany et al., 2023).

One illustrative case is the Suzhou Zhongnan Center in China, a megaproject that adopted a BIM-based POPi (Product-Organization-Process-Infrastructure) framework during its conceptual and design phases. By digitizing both physical elements and inter-organizational processes, the project achieved streamlined coordination and reduced rework, particularly in the interaction between facade design and structural cores. Xie et al. (2023) describe how the digital model served not only design but also early procurement and scheduling simulations, offering a strategic advantage during the project's planning cycle (Xie et al., 2023).

Another notable example is from Turner International's project in Turkey, where BIM was used during the schematic design of a complex high-rise. Interviews conducted during the study revealed that integrating BIM at the early stage helped identify mechanical shaft conflicts, reassess elevator core sizing, and reduce material wastage projections. The authors emphasize that for high-rise structures—where core-to-perimeter ratios are crucial—early BIM integration allows for accurate simulation of vertical transport and energy systems before committing to costly structural decisions.

Mattern & König (2018) further argue that BIM's early-stage impact lies in its ability to facilitate design option management. Their study developed a data structure for comparing multiple design alternatives within a unified model. Applied in a German high-rise design competition, this approach allowed architects and engineers to test structural systems (e.g., core walls vs. outrigger bracing) and visualize cost-time implications concurrently (Mattern & König, 2018).

In the Indonesian context, although empirical case studies are limited, a growing body of research—such as those by Purwanto et al. and Bappenas' roadmap—calls for BIM integration as early as pre-feasibility to mitigate chronic design inefficiencies in public high-rise housing and commercial towers. The lack of early-stage BIM is frequently linked to redundant re-design, inaccurate BOQ (bill of quantities), and failure in clash detection across design packages.

BIM and Design Coordination in High-Rise Projects

In high-rise construction projects, where spatial density and system interdependence are complex, achieving effective multidisciplinary design coordination is critical. Traditionally, each discipline—architecture, structure, MEP (mechanical, electrical, plumbing)—would develop their designs separately, often resulting in overlapping geometries or incompatible systems when models were merged. This fragmentation historically led to a high incidence of "clashes" discovered only during or after the construction phase, driving up costs and project delays.

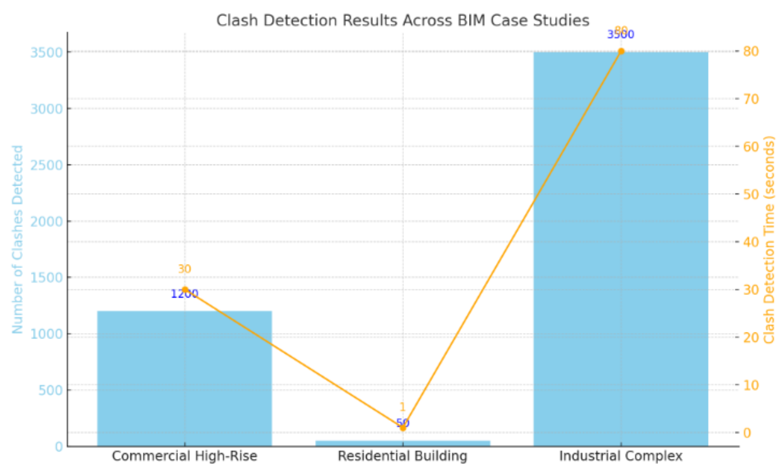

Figure 2. Clash Detection Results Across BIM Case Studies

The chart reveals a strong correlation between model complexity and the number of clashes detected during the early BIM coordination process. The industrial complex, with the highest model complexity (10), produced over 3,500 clashes and required the longest detection time (80 seconds), highlighting the intensity of coordination required in such projects. In contrast, the residential building, with low complexity (3), had only 50 clashes and completed detection almost instantly. The commercial high-rise, moderately complex, revealed 1,200 clashes within 30 seconds. These findings demonstrate how early clash detection through BIM enables proactive resolution of design conflicts, particularly vital in complex high-rise construction.

The integration of BIM fundamentally redefines this workflow. BIM platforms allow multiple disciplines to collaboratively work within a federated 3D model, making real-time spatial and systems conflicts visible and addressable during the early planning phase. Clash detection algorithms, most notably implemented in tools like Autodesk Navisworks, enable teams to identify interferences between different design components automatically. More importantly, these tools allow for clash avoidance when used proactively as part of a shared modeling environment, rather than relying on post-design audits.

Akponeware and Adamu (2017) conducted a global study on clash detection and coordination workflows, concluding that early collaboration and open information sharing are more effective than traditional "clash report" mechanisms. Their research highlighted that isolated workflows—often a byproduct of poor integration in Common Data Environments (CDEs)—remain a primary cause of high clash frequency in MEP systems. They advocated for an "Open Work in Progress" (OWIP) model within CDEs, allowing disciplines to see each other's evolving designs and respond dynamically (Akponeware & Adamu, 2017).

One practical example is a clash detection case study reported by Ramya and George (2022), where architectural, structural, and MEP models of a commercial high-rise were merged in Revit and analyzed in Navisworks. The BIM process identified over 1,200 critical clashes—ranging from HVAC ducts intersecting beams to fire sprinklers overlapping with lighting fixtures—before construction commenced. Resolving these virtually saved significant costs and time, and prevented field rework (Thomas et al., 2022).

In another large-scale application, Juszczyk et al. (2023) conducted a performance analysis of clash detection across multiple IFC-based BIM models, ranging from residential buildings to industrial complexes. They found that early-phase clash detection not only reduced the number of site errors but also improved stakeholder communication by offering visual, data-driven coordination sessions. The number of reported clashes in their test cases varied from zero (for simple models) to several thousand (in complex, multi-discipline models), with analysis time ranging from under a second to over a minute depending on model complexity (Juszczyk et al., 2025).

These findings emphasize that clash detection is not simply a post-modeling QA tool—it is a powerful collaboration mechanism when embedded into a shared, interoperable BIM workflow. The success of clash avoidance relies not only on software tools but on organizational culture and training. As such, early involvement of all stakeholders in a CDE framework and transparent sharing of "work-in-progress" models becomes essential for the full potential of BIM to be realized.

Time Efficiency and Cost Estimation through BIM in High-Rise Construction

In high-rise construction projects, time and cost overruns are among the most persistent challenges due to their scale, complexity, and interdependencies across trades. Traditional project management tools often fall short in anticipating and coordinating these complexities, especially during early planning. However, Building Information Modeling (BIM), particularly in its 4D (time) and 5D (cost) dimensions, has emerged as a transformative approach that enhances predictability and efficiency from the outset of a project.

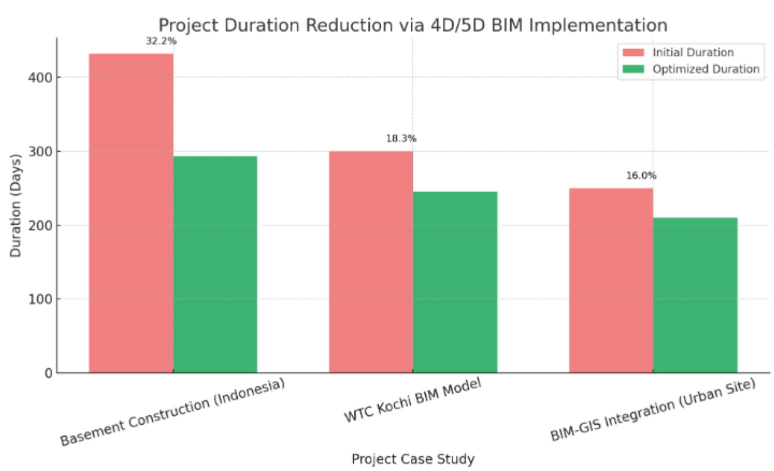

Figure 3. Project Duration Reduction via 4D/5D BIM Implementation

The chart demonstrates how integrating 4D and 5D BIM technologies into high-rise construction projects can significantly reduce execution time. In the basement construction project in Indonesia, BIM application led to a 32.17% reduction in duration, highlighting the power of dynamic scheduling and buffer management. Similarly, the World Trade Center project in Kochi and an urban site using BIM-GIS integration achieved 18.33% and 16% time savings respectively. These outcomes affirm that BIM's real-time planning and visualization capabilities contribute meaningfully to time efficiency in complex construction environments.

The core benefit of 4D BIM lies in its ability to link the construction schedule with the 3D model, enabling dynamic visualization of project sequencing. Planners can simulate construction stages, detect potential delays, and optimize workflows before ground is broken. In a case study of a high-rise basement project in Indonesia, Sinaga and Husin (2021) applied 4D BIM integrated with the Critical Chain Project Management (CCPM) method. Their implementation resulted in a remarkable 32.17% reduction in construction duration, shortening the structural work from 432 to 293 days. This efficiency gain was largely attributed to early identification of sequencing conflicts and buffer time optimization (Sinaga & Husin, 2021).

Similarly, 5D BIM enhances cost estimation by integrating material quantities, labor, and equipment data directly into the model. This allows for continuous and automated cost updates as design changes occur—eliminating the delays and inaccuracies of manual BOQ adjustments. In a real-world implementation involving the World Trade Center in Kochi, India, Gopal Naik (2019) developed a full BIM model in Autodesk Revit and Navisworks, linking it with scheduling and cost databases. The project demonstrated not only more accurate budgeting but also proactive financial planning as design iterations were directly reflected in the updated cost forecasts (Naik, 2019).

Moreover, the integration of BIM with Geographic Information Systems (GIS) adds an additional layer of value, especially for site layout, logistics, and route optimization. Basir et al. (2023) demonstrated this in a construction management study using Feature Manipulation Engine (FME) to merge 4D/5D BIM and GIS data. Their results show improved control over schedule and cost in geospatially sensitive projects, such as urban high-rise developments where traffic access and crane placement have time-cost implications (Saad et al., 2023).

These studies collectively underscore that early integration of BIM significantly reduces the risk of cost overruns and schedule slippage by enabling real-time feedback loops between design, scheduling, and budgeting. Rather than relying on static Gantt charts or spreadsheets, project teams can visually explore construction scenarios and cost consequences, promoting smarter, faster decisions.

Implementation Challenges in Indonesia

1. High costs: Software licenses, hardware, and training are expensive, especially for small firms.
2. Limited skilled workforce: Many professionals lack BIM knowledge and experience.
3. Low client demand & weak regulation: BIM is not yet a requirement in most public or private projects.
4. Cultural resistance: Traditional work practices and organizational inertia hinder digital adoption.

Strategic Recommendations for Effective BIM Adoption

1. Tiered training & certification: Upskill professionals in BIM tools like Revit and Navisworks.
2. Government mandates & incentives: Introduce BIM regulations and support early adopters.
3. Use of CDE & open standards: Adopt IFC and BCF for better collaboration and data sharing.
4. Phased national roadmap: Follow stages—Adoption → Digitalization → Collaboration → Integration.
5. Change management strategy: Apply leadership frameworks (e.g., Kotter's model) to guide organizational transition.

CONCLUSION

The study concludes that the implementation of Building Information Modeling (BIM) during the early planning stages of high-rise construction projects offers substantial benefits. These include improved design coordination, accurate cost estimation, time efficiency, and enhanced interdisciplinary collaboration. BIM acts not only as a visualization tool but also as a centralized data platform enabling real-time decision-making and performance simulation. Despite its advantages, the Indonesian construction industry faces several barriers to adoption, including limited BIM expertise, financial constraints, and lack of regulatory mandates.

Practical Suggestions

For effective BIM implementation in Indonesia, several actionable strategies are recommended. Firstly, institutions and professional bodies should establish tiered training programs and certifications to build human capital. Secondly, government agencies need to enforce BIM as a standard in public construction projects while offering incentives for private sector adoption. Thirdly, the use of Common Data Environments (CDE) and open standards like IFC should be encouraged to foster collaboration across disciplines. Additionally, leadership-driven change management should be employed to overcome organizational inertia and resistance to digital workflows.

Research Recommendations

Future research should expand beyond literature reviews to include empirical case studies of BIM implementation in Indonesian high-rise projects. There is also a need for cross-country comparative studies to understand how different regulatory environments influence BIM adoption. Furthermore, research into the integration of BIM with emerging technologies such as artificial intelligence, digital twins, and GIS in early-stage planning could reveal new dimensions of construction optimization and sustainability.

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