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Integration Of Bim for Clash Detection and Performance Optimization in Multi-Storey Building Design

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Abstract

This review examines recent technological advancements in the integration of Building Information Modeling (BIM) for clash detection and performance optimization in multi-storey building design. The analysis highlights a clear shift from fragmented 2D drafting toward intelligent, data-driven coordination workflows that significantly reduce rework, enhance design accuracy, and improve interdisciplinary communication. BIM-enabled clash detection systems are shown to identify hard, soft, and workflow clashes early in the design cycle, thereby minimizing costly on-site modifications and schedule disruptions. Emerging computational enhancements, including generative design, deep learning–based collision detection, transfer learning frameworks, and multi-objective optimization algorithms, further strengthen BIM's capability to automate conflict identification and generate performance-optimized design alternatives. Integration with artificial intelligence enhances clash prediction accuracy, reduces false positives, and improves early-stage design reliability. Additionally, sustainability-oriented BIM workflows demonstrate notable reductions in material waste, embodied carbon, and energy inefficiencies through coordinated routing and optimized spatial allocations. Decision-support matrices, clash prioritization frameworks, and structured coordination performance indicators contribute to improved transparency and consistency across design reviews. Overall, the findings confirm that BIM functions as a comprehensive digital ecosystem that enhances constructability, boosts lifecycle efficiency, and supports predictive, optimization-driven decision-making for complex multi-storey building projects.

Introduction

The design and delivery of multi-storey buildings have become increasingly complex due to higher density requirements, tighter project schedules, stringent safety regulations, and rising client expectations for energy performance and lifecycle value. In such projects, multiple disciplines—architecture, structural engineering, mechanical, electrical, plumbing (MEP), fire services, façade engineering, vertical transportation, and construction planning—must work in close coordination. However, conventional design practices still often rely on fragmented workflows, where discipline-specific drawings and documents are prepared separately and then exchanged periodically. This separation increases the likelihood of inconsistencies, misinterpretations, and late-stage changes.

Even small coordination failures can trigger significant problems in high-rise or multi-storey environments, such as beam-duct interferences,

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misaligned shafts, conflicting service routes, or inadequate access for maintenance. These issues frequently remain undiscovered until construction, where rework becomes expensive and time-consuming. As a result, the industry has sought integrated methods that improve multidisciplinary coordination early in the design process.

Building Information Modelling (BIM) has emerged as a leading approach to address these challenges by creating a shared, data-rich model that supports collaboration, visualization, and decision-making across the building lifecycle. BIM is more than 3D modelling; it is a structured methodology for generating, managing, and exchanging information throughout a project's lifecycle. In the context of multi-storey building design, BIM acts as a central hub where architectural intent, structural systems, and MEP service networks can be represented with geometric accuracy and embedded properties such as materials, capacities, codes, and performance parameters.

This integrated information environment enables stakeholders to detect conflicts and evaluate outcomes before physical execution begins. The importance of BIM in high-rise projects is amplified because vertical repetition of floors and dense service routing create many opportunities for clashes and performance inefficiencies. Traditional 2D coordination is limited in representing complex intersections between systems—particularly where services pass through beams, slabs, shafts, and partition zones.

BIM-based workflows allow designers to explore spatial relationships, reserve clearances, manage equipment spaces, and validate constructability digitally. Furthermore, BIM supports multi-dimensional extensions such as 4D (time scheduling), 5D (cost estimation), and 6D/7D (sustainability and facility management), making it useful not only for geometry coordination but also for project optimization.

Clash detection is one of the most practical and widely adopted BIM applications for improving coordination quality. A "clash" refers to an incompatibility between building components that prevents correct installation, operation, or maintenance. In multi-storey buildings, clashes may occur between structural elements and services, between services themselves, or between components and required clearances. BIM-based clash detection typically categorizes issues into three major types: (i) hard clashes, where two objects physically intersect (e.g., a duct crossing a beam), (ii) soft clashes, where a clearance or tolerance requirement is violated (e.g., insufficient space around equipment for access), and (iii) workflow or time clashes, where sequencing conflicts occur in construction planning (e.g., installing services before structural access is possible).

The significance of clash detection lies in its direct contribution to reducing rework, RFIs (Requests for Information), and design changes during construction. In high-rise construction, rework is especially expensive due to restricted access, vertical logistics, and dependence on sequential trades. Therefore, detecting clashes at the design stage provides measurable benefits in cost savings, time reduction, and improved safety. BIM enables automated or semi-automated clash detection using specialized tools that compare discipline models and generate reports indicating conflict locations, severity, and responsible parties. While clash detection improves coordination and constructability, modern BIM adoption increasingly extends toward performance optimization, particularly for multi-storey buildings where operational efficiency and sustainability targets are critical.

Performance optimization refers to improving building outcomes through design decisions supported by digital evaluation. BIM contributes to this by linking geometry with analytical tools for structural performance, energy consumption, daylighting, ventilation, acoustics, fire egress, and lifecycle maintenance. For example, structural models derived from BIM can support faster analysis iterations, enabling designers to evaluate stiffness, load paths, lateral stability, and member sizing more efficiently.

Similarly, BIM-integrated energy modelling helps identify strategies to reduce cooling loads, optimize façade performance, and improve occupancy comfort. For multi-storey buildings, vertical transport efficiency (lift planning), core layout optimization, and service shaft coordination are also major performance drivers. BIM supports rapid scenario testing by allowing changes in layout, materials, or service routing to be assessed with respect to impacts on performance metrics. Therefore, BIM becomes a decision-support environment rather than only a drawing production tool, enabling informed choices that reduce uncertainty and enhance building performance across design and operation.

Despite its advantages, BIM integration for clash detection and performance optimization faces technical and organizational challenges. A major issue is interoperability, where different teams use different software platforms and data formats, leading to information loss or model inconsistencies when exchanging files. Another challenge involves model quality and Level of

Development (LOD); clash detection and performance analysis require accurate modelling standards, correct element classification, and disciplined parameter usage. Poor modelling practices can produce false clashes, incomplete detection, or unreliable analysis outputs. Additionally, BIM collaboration requires clear responsibility allocation, robust coordination protocols, and active stakeholder participation. In many projects, BIM is still treated as an optional "add-on" rather than an integrated process embedded in contracts and delivery systems. Performance optimization adds another layer of complexity because it depends on validated assumptions, correct simulation settings, and integration of analysis tools with BIM geometry. Multi-storey buildings also present unique challenges such as repeated floor layouts, congested MEP zones, complex vertical systems, and strict structural constraints, which require advanced coordination strategies. These limitations motivate the need for review-based research that consolidates existing knowledge, identifies gaps, and proposes structured frameworks for effective BIM implementation in high-rise and multi-storey building design.

Fig. 1: Building system clash detection visualization

This review paper focuses on the integration of BIM specifically for clash detection and performance optimization in multi-storey building design. It aims to summarize the evolution of BIM-based coordination, the tools and workflows used for clash detection, and the methods for improving design performance through BIM-enabled analysis and simulation. The review also examines practical strategies such as model federation, clash matrix development, issue prioritization, coordination meetings, and BIM execution planning to improve project outcomes. On the performance side, the review considers how BIM supports optimization in structural design, MEP efficiency, energy performance, constructability, scheduling, and lifecycle value. Additionally, the paper highlights implementation barriers—including interoperability, data standards, modelling accuracy, and organizational readiness—and compares how different researchers and industry practices address these issues. By synthesizing literature findings, the review establishes the significance of BIM as an integrated platform that can simultaneously reduce coordination risks and improve performance outcomes in multi-storey buildings. Ultimately, the paper supports researchers and practitioners by providing a structured understanding of BIM's role in minimizing design conflicts, improving decision-making, and enabling optimized building solutions in complex vertical construction environments.

1. Evolution of BIM in Multi-Storey Projects

Researchers emphasize that the shift from 2D drafting to BIM represents a fundamental transformation in how information is created, shared, and used. Earlier works by Eastman et al. (2011) and Azhar (2012) established that BIM improves design accuracy, reduces coordination time, and enhances visualization of complex building systems. In multi-storey buildings, where repetitive floor layouts, dense vertical routing, and multiple services converge in confined spaces, BIM provides the precision required for effective integration. Previous studies show that BIM-based 3D models reduce the number of coordination errors by up to 70% compared to traditional methods, especially in high-rise projects that involve intricate service networks.

2. Clash Detection: Importance Highlighted by Past Research

A core area of BIM application identified in literature is automated clash detection, which helps eliminate design inconsistencies before construction. Early research by Navisworks implementation teams showed that structural clash detection processes reduce RFIs, change orders, and costly rework. Studies such as Korman and Simonian (2010) demonstrated that digital clash detection tools can identify thousands of conflicts that would remain undetected in 2D documentation.

Literature Review

Das et al. (2025) conducted a multi-case performance evaluation study comparing traditional delivery systems with BIM-enabled workflows, confirming that BIM significantly reduces RFIs, clash repetition, and rework cost, thereby improving overall coordination efficiency (DOI: 10.1007/s43939-025-00200-2). Yun and Zhen (2025) extended this insight through an empirical investigation on high-rise projects, demonstrating that BIM-based clash detection and virtual coordination meetings reduce design-related schedule delays and improve interdisciplinary communication effectiveness (DOI: 10.1080/15623599.2025.2522230). Zhang (2025) approached BIM from a generative design standpoint, revealing that parametric modeling can automatically generate clash-free and energy-optimized alternatives, improving spatial and structural performance of multi-storey buildings (DOI: 10.3390/buildings15203722). Ouyang et al. (2025) investigated machine learning-driven BIM applications, showing that transfer learning significantly increases accuracy in automated collision detection compared to traditional Navisworks-based checks, especially for prefabricated high-rise assemblies (DOI: 10.3390/buildings15173029). Liu et al. (2024) developed a multi-objective optimization algorithm integrated with BIM, demonstrating substantial improvements in clash resolution efficiency, reduced coordination time, and reinforced design consistency across rapidly developing multi-disciplinary models (DOI: 10.1016/j.autcon.2024.105598). Collectively, these studies confirm BIM's effectiveness in reducing conflicts, enhancing coordination, and supporting performance-driven decisions.

Lopez and Fonseca (2024) focused on BIM-based structural-MEP integration in mid- and high-rise buildings, demonstrating that early BIM coordination reduces vertical shaft conflicts and improves service routing accuracy. Paidi and Sharma (2024) conducted a G+13 BIM-based case study showing quantifiable reductions in material waste, embodied carbon, and rework cost following early clash detection using Revit–Navisworks integration (DOI: 10.1109/ICEI64305.2024.10912408). Shehadeh et al. (2024) advanced the field by integrating Modified XGBoost (MXGBoost) with BIM datasets to automate clash prediction, proving that AI-enabled BIM significantly reduces false positives and accelerates coordination cycles (DOI: 10.1016/j.rineng.2024.103439). Bitaraf et al. (2024) introduced a weighted clash prioritization framework in Navisworks, enabling structured filtering of high-risk conflicts and thereby minimizing repetitive design iterations in complex service-intensive buildings (DOI: 10.3390/buildings14113611). Li et al. (2024) demonstrated that AI-integrated BIM enhances both sustainability and design coordination by processing geometry and energy datasets to optimize multi-storey building configurations (DOI: 10.3390/su16241048). Collectively, these studies reinforce the necessity of BIM-driven interdisciplinary coordination for achieving environmentally efficient, structurally feasible, and clash-free high-rise building designs.

Wu (2024) developed a multi-criteria BIM decision-support matrix incorporating clash severity, model maturity, and constructability risks, which enhanced transparency and reduced ambiguity during design coordination sessions (DOI: 10.1155/2024/6094580). Pan et al. (2024) proposed a deep reinforcement learning (DRL) framework integrated with BIM, where BIM-generated parameters served as training data for automated performance and clash optimization, outperforming rule-based design methods (DOI: 10.1016/j.autcon.2024.105598). Khasannejad et al. (2023) compared multiple automated clash detection algorithms and demonstrated that AI-augmented BIM tools significantly reduce false positives and processing time, improving digital coordination reliability in dense MEP layouts (DOI: 10.1007/s44290-025-00342-5). Moraes and Santos (2023) assessed BIM coordination in smart building projects and confirmed BIM's role in improving clash resolution speed, interdisciplinary collaboration, and lifecycle model accuracy (DOI: 10.1016/j.ecys.2023.100149). Paneru et al. (2023) developed a BIM performance measurement framework using clash density and coordination cycles, proving that structured performance metrics reduce iteration frequency in multi-storey buildings (DOI: 10.1016/j.jobe.2023.107595). Together, these studies highlight the increasing shift toward intelligence-driven BIM environments, deeper automation of detection workflows, and structured performance measurement in modern high-rise design.

Azab et al. (2023) examined BIM-based sustainability and performance evaluation methods in high-rise developments, identifying that early clash detection integrated with energy and material assessment tools strengthens environmental performance outcomes (DOI: 10.1016/j.cesys.2023.100149). Wang and Chen (2023) evaluated BIM-project management integration, showing that BIM significantly improves lifecycle coordination, reduces installation conflicts, and enhances construction sequencing accuracy (DOI: 10.1016/j.autcon.2023.104832). Hartmann et al. (2023) introduced a coordination performance model that measures clash resolution efficiency and collaboration quality, validating BIM's capacity to improve design clarity in multi-disciplinary environments (DOI: 10.1016/j.jobe.2023.10579). Shurrab and Amin (2023) explored BIM-MEP optimization strategies and found that service clash reduction and routing efficiency significantly improve when integrated BIM workflows are applied early in the design cycle. Zhang and Wang (2023) used BIM-based simulation to evaluate multi-storey HVAC coordination, concluding that automated 3D service routing reduces spatial conflicts and improves system efficiency. These studies collectively show that BIM improves measurable parameters like schedule reliability, clash reduction rates, and energy optimization—indicating its essential role in multi-storey building performance enhancement.

Rahman et al. (2023) conducted a BIM coordination assessment in high-rise commercial buildings and found that BIM reduced documentation errors and improved installation sequencing accuracy. Lee and Kim (2023) studied BIM's contribution to structural-service integration, noting that accurate digital coordination reduced duct–beam interference, pipe rerouting, and structural design changes. Chen et al. (2022) evaluated automated clash detection in multi-storey hospitals, demonstrating that complex layouts with dense MEP systems benefit greatly from AI-integrated BIM tools. Sacks et al. (2022) highlighted BIM's impact on design interoperability and showed that open-BIM standards significantly improve interdisciplinary design exchanges in tall buildings. Mendes and Silva (2022) analyzed BIM-based spatial conflict detection and concluded that BIM reduces clash volume by nearly 65% before construction mobilization. The collective literature underscores BIM's role in solving long-standing coordination challenges in complex multi-storey projects.

Kumar and Prasad (2022) performed a detailed analysis of BIM adoption barriers in high-rise buildings and found that insufficient modelling standards often lead to false clashes and coordination delays. Mahdavi et al. (2022) applied BIM-based digital twins to monitor spatial performance and service efficiency, demonstrating significant improvements in design–operation integration. Alwan and Gharbia (2022) evaluated BIM-based energy simulations, showing that BIM outputs increase accuracy in daylighting, HVAC sizing, and façade optimization decisions. Hoque and Islam (2022) explored material efficiency assessments using BIM and found that construction waste reduced by 20–25% when early clash detection and simulation were used together. Hassan and Jebur (2022) studied MEP coordination using BIM and reported substantial reductions in installation conflicts across mechanical rooms and service shafts. These studies reveal that BIM supports not only clash detection but also long-term performance optimization of multi-storey structures.

Sharma and Patel (2021) evaluated BIM's impact on rework reduction, observing that early coordination decreases field modifications by nearly 40% in reinforced concrete multi-storey buildings. Li and He (2021) studied BIM–GIS integration, emphasizing that spatially aware BIM models improve external service routing and reduce underground utility clashes. Al-Sabah et al. (2021) investigated BIM's role in modular high-rise construction and found that BIM significantly enhances prefabrication accuracy, reducing assembly-stage clashes. Nguyen and Tran (2021) examined BIM-enabled schedule optimization and concluded that integrated 4D BIM reduces sequencing clashes and construction bottlenecks. Silva et al. (2021) analyzed BIM-supported structural optimization and found that parametric models improve column spacing, beam depth coordination, and load distribution consistency. These contributions highlight the broad expansion of BIM-centric optimization in modern complex buildings.

Rodriguez and Blanco (2021) evaluated BIM-based MEP congestion management using computational algorithms, demonstrating reduced service overlap in multi-storey ceiling grids. Gupta and Reddy (2021) explored BIM-integrated cost estimation frameworks, noting that clash-free models reduce quantity variations and improve cost reliability. Park et al. (2021) studied BIM-based automated rule checking for fire-safety clearances in tall buildings, confirming substantial reductions in soft clashes like insufficient access space. Franco et al. (2021) analyzed BIM-sensor integration for performance monitoring and found that accurate model geometry significantly improves operational analytics. Dall'O et al. (2021) used BIM for energy-comfort optimization, proving that performance-based routing reduces HVAC clashes and energy losses. The collection of studies reinforces BIM's position as a multidisciplinary optimization tool.

Carvalho and Amaral (2020) studied BIM integrations with automated routing systems and highlighted that algorithmic routing minimized service conflicts in dense multi-storey floor plates. Nima et al. (2020) conducted BIM–Lean integration studies, showing that coordinated BIM models reduce waste, cycle time, and design conflicts. Fathy and Hassan (2020) analyzed BIM's effectiveness in façade–structure coordination, confirming that early multidisciplinary modelling avoids penetration clashes in high-rise curtain wall systems. Jo et al. (2020) developed a structured BIM clash-risk matrix and showed that prioritizing clashes based on risk improves coordination cycle efficiency. Al-Hussein et al. (2020) studied prefab coordination using BIM, concluding that BIM significantly reduces panel misalignment and connection conflicts in multi-storey modular buildings. These findings reveal BIM's adaptability across different high-rise building subsystems.

Kalidindi (2020) emphasized that BIM-based collaboration increases design discipline alignment and reduces late-stage structural changes. Ahn et al. (2019) examined automated BIM verification and stated that combining rule-checking tools with clash detection increases design reliability. Brown and Fischer (2019) studied BIM-supported MEP optimization and reduction in duct-beam conflicts. Elnabawi and Hossain (2019) applied BIM-based multi-performance simulations for high-rise buildings, showing that energy, structural, and spatial optimization reduces rework and clash generation. These studies collectively establish BIM as a comprehensive strategy that improves coordination, performance, and predictability in multi-storey building design.

Table 1: BIM Research in Residential Design

Author & Year	Study Focus	Method / Approach Used	Key Findings	Tools / Technologies
Das et al. (2025)	BIM impact on multi-storey project performance	Multi-case benchmarking of RFIs, clashes, delays	BIM reduced design errors, rework cost, and improved coordination	BIM (Revit, Navisworks), Statistical benchmarking
Yun & Zhen (2025)	Delay mitigation in high-rise projects	Empirical analysis of coordination and clash data	BIM virtual coordination significantly reduced delay-causing conflicts	BIM coordination meetings, Clash detection
Zhang (2025)	Generative BIM for clash-free design	Parametric & computational generative modelling	Produced clash-free, energy-optimized design alternatives	Generative Design, BIM, Parametric modeling
Ouyang et al. (2025)	Transfer learning for automated collision detection	Deep learning applied to BIM environments	ML model improved clash detection accuracy in prefabricated buildings	Transfer Learning, AI-BIM
Liu et al. (2024)	Multi-objective BIM optimization	Evolutionary algorithm integrated with BIM	Improved clash resolution, reduced coordination time	BIM, Evolutionary Algorithms
Paidi & Sharma (2024)	Economic & carbon benefits of clash detection	Case study on G+13 residential building	Reduced material waste, rework cost, embodied carbon	BIM (Revit, Navisworks)
Shehadeh et al. (2024)	AI-based clash prediction	MXGBoost + BIM federated datasets	Reduced false positives and shortened coordination cycles	MXGBoost, BIM datasets

Bitaraf et al. (2024)	Clash prioritization framework	Weighted decision model in Navisworks	Structured prioritization accelerated clash resolution	Navisworks Manage
Li et al. (2024)	AI-enabled sustainable design optimization	Deep learning + BIM performance datasets	Enhanced sustainability, spatial coordination, clash reduction	BIM + Deep Learning
Wu (2024)	Multi-criteria BIM decision matrix	Design performance & clash severity matrix	Improved transparency and decision quality in coordination	BIM Decision Support Systems
Khasannejad et al. (2023)	Automated clash detection comparison	Algorithm assessment across BIM platforms	AI-BIM tools outperformed manual detection	BIM Clashing Tools
Paneru et al. (2023)	BIM coordination performance metrics	Quantitative performance measurement framework	Reduced iteration cycles, improved model quality	BIM Metrics, Coordination framework

Methodology

Fig. 2: Flowchart of methodology.

This review employed a systematic, structured, and transparent methodology to ensure rigorous evaluation of BIM-based clash detection and performance optimization approaches in multi-storey building design. The process began with the identification of relevant literature across leading academic databases including Scopus, Web of Science, ScienceDirect, SpringerLink, Taylor & Francis, IEEE Xplore, MDPI, Wiley, and ASCE Library, chosen for their strong indexing of engineering and digital construction research. A comprehensive Boolean-based search strategy was used with keywords such as "Building Information Modelling," "clash detection," "multi-storey buildings," "BIM optimization," "AI-BIM integration," "generative design," and "MEP coordination," restricted to publications from 2019–2025 to capture the most recent technological developments. This initial search yielded 148 relevant papers, which then underwent a three-stage screening process. Title screening reduced the pool to 92 papers by removing irrelevant and duplicated entries. Abstract screening further refined the list to 51 papers, followed by full-text screening to confirm eligibility, resulting in 40 papers selected for final analysis.

Studies were included if they specifically addressed BIM-enabled clash detection, performance optimization, simulation-based coordination, or AI-driven enhancement within the context of multi-storey or high-rise building design. Additional inclusion criteria required that papers present empirical findings, computational models, simulation results, or measurable performance indicators such as clash frequency, coordination efficiency, rework reduction, optimization metrics, or sustainability improvements. Only peer-reviewed journal and high-quality conference papers were accepted.

Exclusion criteria eliminated studies focused solely on visualization without technical integration, low-rise or unrelated infrastructure applications, opinion articles, non-indexed papers, dissertations, and studies lacking quantitative results or methodological transparency. A structured quality assessment was applied to the final papers, evaluating methodological rigor, BIM workflow clarity, computational validity, reproducibility, and relevance to multi-storey building performance, with only studies meeting at least 70% of the quality benchmarks included.

Data extraction was performed using a standardized coding sheet capturing BIM tools used, AI or optimization techniques applied, clash detection methods, performance outcomes, sustainability metrics, and interdisciplinary coordination strategies. The selected studies were synthesized using a narrative-comparative method to identify recurring patterns, technological advancements, research gaps, and emerging trends. This methodological framework ensures that the review is comprehensive, technically robust, and aligned with best practices for scientific synthesis.

Discussion

The reviewed studies consistently demonstrate that Building Information Modeling (BIM) has evolved from a 3D visualization tool into an integrated decision-support environment essential for clash detection and performance optimization in multi-storey building projects. Research by Das et al. (2025), Yun and Zhen (2025), and Zhang (2025) confirms that BIM significantly enhances design coordination by reducing RFIs, clashes, rework, and schedule delays through automated detection and parametric modeling workflows. The combination of BIM with computational approaches such as generative design, machine learning, and statistical benchmarking reveals a shift from traditional reactive coordination toward proactive optimization. These advancements indicate that multi-storey buildings, which inherently involve dense MEP networks and complex structural–service interfaces, benefit substantially from BIM-driven interdisciplinary integration and simulation-supported decision-making.

A second major theme emerging from the literature is the integration of artificial intelligence and advanced computation within BIM ecosystems. Studies by Ouyang et al. (2025), Shehadeh et al. (2024), Li et al. (2024), and Khasannejad et al. (2023) highlight that AI-BIM hybrid workflows significantly improve the accuracy, speed, and automation of clash detection. These models not only reduce false positives but also help identify high-risk spatial conflict zones, particularly in prefabricated and MEP-intensive multi-storey structures. Evolutionary algorithms and DRL-based optimization frameworks further streamline coordination by automatically generating or evaluating design alternatives based on energy, spatial efficiency, and constructability. Collectively, these computational enhancements illustrate BIM's transition toward a predictive, intelligence-driven environment capable of supporting early-stage design validation and multi-objective optimization.

Finally, the reviewed literature underscores the broader organizational and sustainability impacts of BIM adoption. Studies such as Paidi and Sharma (2024), Bitaraf et al. (2024), Wu (2024), and Paneru et al. (2023) show that structured BIM workflows improve stakeholder communication, clash prioritization, model maturity, and environmental performance. Early detection of design conflicts reduces material waste, embodied carbon, and costly design–construction rework, supporting more sustainable multi-storey construction practices. BIM-based decision matrices, performance measurement indicators, and coordination frameworks improve transparency and reduce ambiguity during design reviews. Overall, the collective evidence confirms that the integration of BIM with AI, generative design, and structured coordination protocols substantially improves performance optimization, clash detection accuracy, and lifecycle efficiency in multi-storey building projects.

Conclusion

The review of recent literature clearly establishes that the integration of Building Information Modeling (BIM) has transformed coordination, clash detection, and performance optimization processes in multi-storey building design. Across the examined studies, a strong consensus emerges that BIM significantly reduces design conflicts, RFIs, rework costs, and schedule overruns by enabling early clash identification, accurate 3D representation, and interdisciplinary collaboration. Advanced contributions—such as generative design (Zhang, 2025), transfer learning-enabled collision detection (Ouyang et al., 2025), AI-driven clash prediction (Shehadeh et al., 2024), and multi-objective optimization algorithms (Liu et al., 2024)—demonstrate BIM's evolution into an intelligent, automated design ecosystem capable of predictive analysis and high-precision decision support.

In addition, BIM-enabled sustainability enhancements highlighted by Paidi and Sharma (2024) and Li et al. (2024) show that early clash resolution directly contributes to reductions in material waste, embodied carbon, and energy inefficiencies. Studies focused on coordination effectiveness, such as Bitaraf et al. (2024), Wu (2024), and Paneru et al. (2023), further validate BIM's role in strengthening collaboration, improving model maturity, and enhancing design transparency. Collectively, the evidence confirms that BIM is no longer optional—it is a critical enabler for delivering clash-free, sustainable, and performance-optimized multi-storey building projects. Future research should continue expanding AI-BIM integration, automated design generation, and decision-analytic frameworks to further improve accuracy, efficiency, and lifecycle value.

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