Journal of Applied Science, Engineering, Technology and Management
Vol. 04, Issue 1, June 2026 pp. 25-30

Enhancing Construction Efficiency of Educational Building Through BIM Based Clash Detection

Laksmi P.S
Department of Civil Engineering
Federal Institute of Science and Technology
Angamaly, Kerala, India
lakshmi36ps@gmail.com

Mohammed Rizwan
Department of Civil Engineering
Federal Institute of Science and Technology
Angamaly, Kerala, India
mrizwan1601@gmail.com

Mehreen Rafeeq
Department of Civil Engineering
Federal Institute of Science and Technology
Angamaly, Kerala, India
mehreenrafeeq53@gmail.com

Nirmal Thomas
Department of Civil Engineering
Federal Institute of Science and Technology
Angamaly, Kerala, India
lamrindude@gmail.com

Asha Joseph
Department of Civil Engineering
Federal Institute of Science and Technology
Angamaly, Kerala, India
ashameledath@fisat.ac.in

Abstract*—The construction of educational facilities involves complex interactions between architectural, structural, and MEP systems, often resulting in design conflicts when conventional practices are followed. Building Information Modelling (BIM) provides an integrated digital framework that enhances coordination and enables early detection of such conflicts. This study investigates the application of BIM-based clash detection to improve the efficiency and reliability of construction processes in educational buildings. A comprehensive BIM model is developed using Autodesk Revit, incorporating architectural, structural, and MEP components. The discipline-specific models are federated within Navisworks Manage to perform systematic clash detection. Identified conflicts are categorized into hard clashes, soft (clearance) clashes, and workflow clashes. The detected issues are analyzed, and appropriate design modifications are implemented to achieve coordination among all systems. The implementation of BIM-based clash detection significantly reduces design inconsistencies, minimizes rework, and enhances interdisciplinary coordination. The findings demonstrate improved constructability, optimized project scheduling, and better resource utilization. This study establishes BIM as an effective tool for proactive conflict resolution, contributing to improved project performance and quality in the construction of educational infrastructure.

***Keywords*—BIM, Clash Detection Navisworks, Revit, Coordination**

I. INTRODUCTION

The construction industry is undergoing a significant transformation with the adoption of digital technologies aimed at improving efficiency, coordination, and accuracy. Among these, Building Information Modelling (BIM) has emerged as a powerful approach that enables the creation of an integrated digital representation of a building, supporting collaboration among stakeholders throughout the project lifecycle [10], [5]. This approach is particularly beneficial for educational institutions, which involve multiple functional spaces and complex service systems requiring precise coordination.

The significance of BIM lies in its ability to integrate architectural, structural, and MEP systems within a unified platform. Unlike conventional methods, where different disciplines work independently, BIM enhances visualization, improves communication, and enables early identification of design inconsistencies. Previous studies have shown that BIM improves design efficiency and supports better decision-making, thereby reducing errors and enhancing project outcomes [9], [12].

Clash detection is one of the most important applications of BIM, allowing conflicts between building components to be identified before construction begins. Early identification of clashes minimizes rework, reduces project delays, and improves construction quality. Research indicates that BIM-based clash detection significantly enhances coordination and reduces overall project cost [12], [19]. The process typically involves integrating discipline-specific models and analyzing them using coordination software such as Navisworks, where automated tools are used to detect and manage conflicts [13].

Clashes identified in BIM are generally classified into three types: hard clashes, soft clashes, and workflow clashes. Hard clashes occur when physical elements intersect, such as a pipe passing through a beam. Soft clashes arise due to insufficient clearance between components, while workflow clashes are related to scheduling and sequencing conflicts during construction [16]. Recent advancements have incorporated artificial intelligence and machine learning

eISSN 2584-0371

Received for review: 11-05-2026
Accepted for publication: 25-05-2026
Published: 30-05-2026

techniques to improve the efficiency and accuracy of clash detection processes, enabling better prediction and automated coordination [13], [15].

Several studies have contributed to the advancement of BIM-based construction practices. Wang and Fang [7] developed automated BIM reconstruction techniques for MEP systems, while Zeng et al. [8] explored AI-based methods for identifying design inconsistencies. Lystbæk [9] emphasized machine learning-driven BIM workflows for improving coordination efficiency, and Zhang and Zhang [10] highlighted the role of generative AI in detecting design conflicts. Jadhav et al. [11] demonstrated the application of BIM in educational construction, while Li et al. [6] and Chahrour et al. [12] showed that early clash detection improves accuracy and reduces rework. Savitri et al. [19] further confirmed the effectiveness of BIM-based tools in minimizing construction conflicts.

Based on these insights, the present study focuses on the planning and development of a three-storeyed (G+3) educational building using BIM. The objective is to develop integrated architectural, structural, and MEP models, identify clashes using Navisworks through BIM-based clash detection techniques, and resolve these conflicts at the design stage. This approach aims to improve coordination among disciplines, reduce construction errors, and enhance overall project efficiency.

II. METHODOLOGY

A. Study Area and Site Details

The study was conducted for a proposed educational building located in Kolazhy, Thrissur district, Kerala. The site lies in an urban fringe region under a Grama Panchayat jurisdiction. The geographical coordinates of the site are approximately 10°34′25″N latitude and 76.22°12’25”E longitude. The soil condition of the site is predominantly lateritic with a sandy clay layer, providing good drainage characteristics and moderate permeability. The safe bearing capacity (SBC) of the soil ranges between 150–200 kN/m², making it suitable for conventional RCC construction. The total plot area is approximately 11,135 m², providing sufficient space for building layout, circulation, and future expansion.

B. Building Description (NBC & KPBR Compliance)

The project consists of a G+3 storeyed educational building designed in accordance with the provisions of the National Building Code of India and Kerala Panchayat Building Rules. The structure is an RCC framed system ensuring strength and stability. The total built-up area ranges from 2800 m² to 3600 m², with each floor having a built-up area of approximately 753.40 m² and a floor area of 666.95 m². The Floor Space Index (FSI) is about 0.39.The design incorporates standard provisions for ventilation, lighting, fire safety, sanitation, and circulation.

C. BIM-Based Methodological Framework

The study adopts a Building Information Modeling (BIM)-based approach to achieve integrated design, coordination, and efficient project execution. Initially, data collection and project definition were carried out by gathering site details, functional requirements, and relevant codes and standards. Based on this, discipline-specific BIM models, including architectural, structural, and MEP models, were developed using Autodesk Revit. The architectural model serves as the base model, upon which structural and MEP components are integrated to form a comprehensive digital representation of the building.

The individual discipline models were then coordinated and validated to ensure consistency and eliminate discrepancies between systems. Subsequently, the models were exported to Autodesk Navisworks to create a federated model for integrated analysis.

Clash detection was performed to identify and analyze conflicts between architectural, structural, and MEP elements. BIM-based clash detection techniques significantly enhance the identification and prioritization of design conflicts during the planning stage [13]. The detected clashes were reviewed, categorized, and resolved through necessary modifications in the respective discipline models. Finally, the coordinated model was evaluated to assess improvements in design accuracy, reduction in rework, and enhancement in overall construction efficiency [7]

D. Architectural BIM Modelling

Architectural modelling was carried out using the Autodesk Revit platform to develop a precise and coordinated digital representation of the proposed G+3 educational building. The modelling process began with the creation of a project file, where levels were defined according to the elevations of each floor to ensure proper vertical alignment and consistency throughout the model.

Based on the finalized floor plans, architectural elements such as walls, floors, doors, and windows were modeled with accurate dimensions and spatial positioning. The functional layout of each floor was incorporated into the model. The ground floor consists of 4 classrooms, 3 laboratories, and an administrative office along with separate toilet facilities. The first floor includes 4 classrooms, 3 laboratories, and a staff room. The second floor accommodates 5 classrooms, a staff room, and a meeting hall. The third floor comprises 3 classrooms, 2 laboratories, a library, and a meeting hall. Staircases were provided to ensure efficient vertical circulation, and a central corridor/verandah was maintained across all floors for smooth horizontal movement. Openings and circulation spaces were designed considering functional requirements and user comfort. Material properties were assigned to various building components to enhance model detailing and visualization. The complete set of 2D drawings was thus transformed into a comprehensive 3D architectural model. This architectural model given in Fig. 1 serves as the foundational reference for subsequent structural and MEP modelling, enabling effective interdisciplinary coordination and minimizing potential design conflicts during later stages of the project.

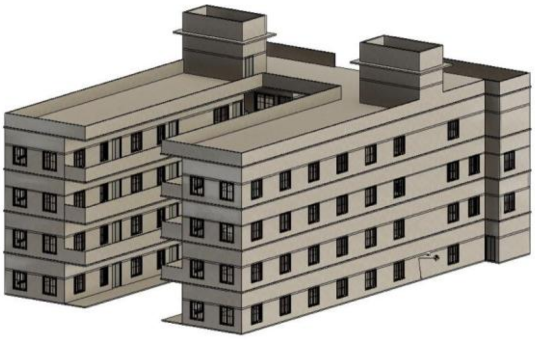


Fig 1 : Architectural model of educational building

E. Structural BIM Modelling

Structural modelling was carried out using Autodesk Revit by developing a 3D representation of the load-bearing framework of the proposed G+3 educational building. The structural model was created in alignment with the architectural model using a predefined grid system to ensure proper coordination and element positioning. The building is designed as an RCC framed structure comprising columns, beams, and slabs. Two types of columns, sized 220 × 450 mm and 220 × 300 mm, were modeled based on structural requirements. Columns were extended from the base level to the top floor, forming the primary vertical load-resisting system. Beams were provided to connect columns and support slab loads, following the grid layout. Floor slabs were modeled at each level corresponding to the architectural layout, maintaining uniformity across all floors. The structural arrangement was kept consistent for ease of construction and efficient load transfer. The completed 3D structural model as given in Fig. 2 was then prepared for integration with architectural and MEP models, facilitating effective coordination and clash detection.

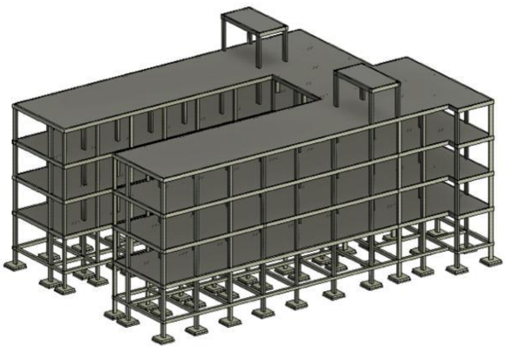


Fig 2: Structural model of educational building

F. MEP BIM Modelling

MEP (Mechanical, Electrical, and Plumbing) modelling was carried out using Autodesk Revit by developing separate discipline models and integrating them within the BIM environment. Each system was modeled independently to ensure better control, accuracy, and coordination. The electrical model included the layout of lighting fixtures and power distribution components, arranged to ensure adequate illumination and efficient usage of electrical supply. The plumbing model represented water supply and drainage networks, where pipelines were routed to connect sanitary fixtures while maintaining appropriate slopes for gravity flow. The mechanical model incorporated HVAC elements such as ducts and associated equipment, positioned to facilitate proper air distribution and indoor comfort.

All components were placed according to floor levels and aligned with the architectural and structural models to maintain consistency. The integrated MEP model given in Fig. 3was then prepared for coordination and clash detection, enabling identification of potential conflicts and ensuring efficient service layout within the building.

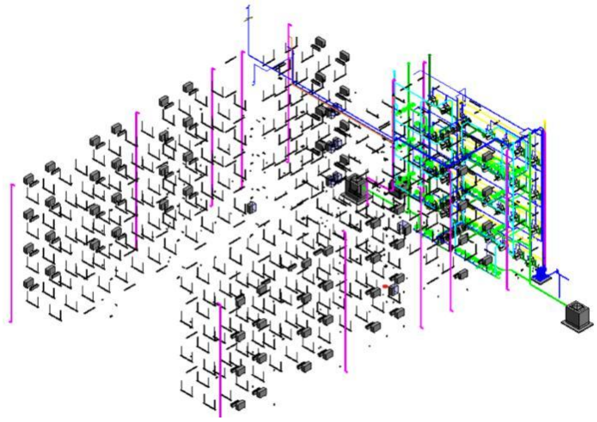


Fig3: MEP model of educational building

III. DETECTION OF CLASHES

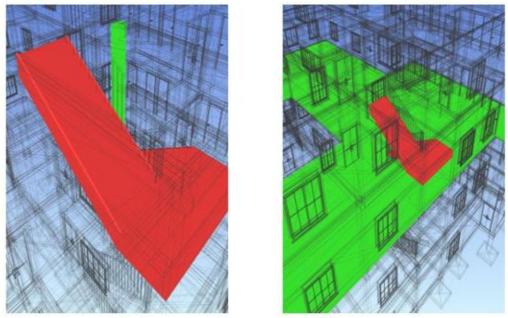
Clash detection was performed using Autodesk Navisworks to identify and resolve conflicts between architectural, structural, and MEP systems. The discipline models developed in Revit were exported in NWC format and integrated within Navisworks to create a federated model for coordination. Clash tests were conducted between different model combinations, including architectural vs structural, structural vs MEP, and architectural vs MEP. The software automatically identified intersections and interferences between building components, enabling efficient detection of potential conflicts at the design stage. The identified clashes were analyzed and categorized based on their nature. Certain intersections, such as service penetrations through slabs or walls, were considered intentional and marked as approved. Conflicts arising due to improper alignment or routing of elements were reviewed and resolved by modifying the respective discipline models. This process ensured proper coordination among all building systems, minimized design inconsistencies, and reduced the likelihood of errors during construction. The use of Navisworks significantly improved the efficiency of clash identification and supported informed decision-making during the design phase.

A. Architectural Vs Structural Clash

Clash detection between architectural and structural models identified intersections where architectural elements such as walls overlap with structural components including beams, columns, and slabs. These clashes generally occur due to misalignment between the two disciplines during the design stage. Clash tests were conducted level-wise in Autodesk Navisworks to ensure accurate coordination. The results indicated that Test 1 identified 57 clashes (all approved), Test 2 identified 194 clashes (182 approved, 10 reviewed, and 2 new), Test 3 identified 166 clashes (157 approved and 9 reviewed), Test 4 identified 163 clashes (156 approved and 7 reviewed), Test 5 identified 60 clashes (31 approved and 29 new), and Test 6 identified 2 clashes (1 approved and 1 new).

A majority of the detected clashes were found at locations where architectural walls were supported by structural members such as beams or slabs. These intersections represent intended design conditions and were verified against the design intent. Such cases were classified as approved clashes, as they do not create any construction conflict. Other clashes occurred due to improper alignment or positioning of architectural elements with respect to structural components.

These conflicts were analyzed in detail, and necessary modifications were carried out in the respective models, including adjusting wall positions, aligning elements with structural grids, and providing required clearances (Fig. 4 a). The clash detection process ensured proper coordination between architectural and structural systems, reducing design inconsistencies and minimizing potential issues during construction.

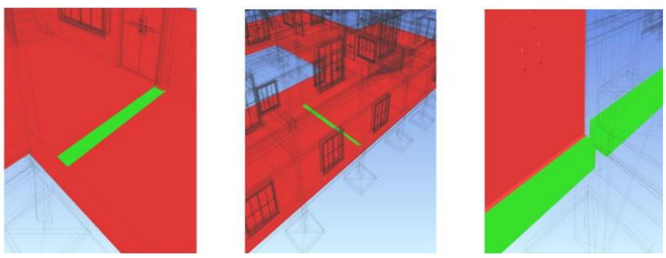


(b)

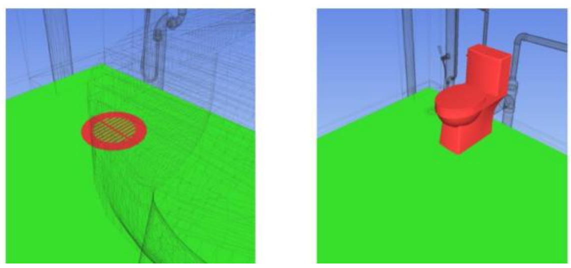
Fig4: Architectural Vs Structural (a) approved and (b) resolved clashes

B. Structural Vs MEP Clash

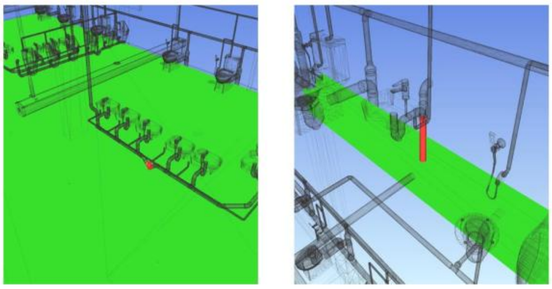
Clash detection between structural and MEP models identified intersections where building services such as plumbing pipelines and fixtures interfere with structural elements including slabs, beams, and columns. These clashes typically occur when MEP services pass through structural zones without proper coordination. Clash tests conducted in Autodesk Navisworks showed that Test 1 identified 50 clashes (49 approved), Test 2 identified 66 clashes (57 approved and 9 reviewed), Test 3 identified 51 clashes (44 approved and 7 reviewed), and Test 4 identified 1 clash (approved). Several clashes were observed at locations where plumbing fixtures and drainage pipes pass through structural slabs. These intersections are necessary for service connections and are commonly expected in building construction. Such cases were reviewed against the design intent and classified as approved clashes, requiring no modification (Fig 5a). Other clashes occurred due to improper routing of pipelines through beams or slabs. These conflicts were analyzed to determine their cause and location, and were resolved by adjusting pipe routing, modifying elevation levels, or providing adequate clearances. This ensured proper coordination between structural and MEP systems and prevented potential construction issues.



(a)



(a)

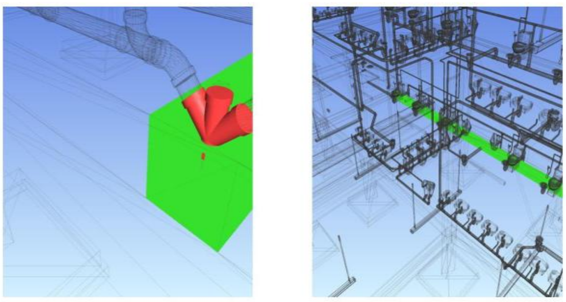


(b)

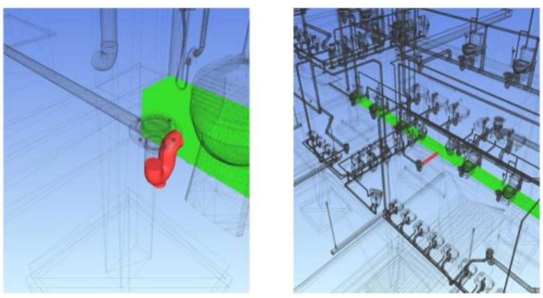
Fig 5: Structural Vs MEP (a) approved and (b) resolved clashes

C. Architectural Vs MEP Clash

Clash detection between architectural and MEP models revealed intersections where service elements such as pipes and ducts interfere with architectural components including walls, floors, and beams. These clashes generally occur when MEP services are routed without adequate consideration of architectural layout. Clash tests conducted in Autodesk Navisworks indicated that Test 1 identified 67 clashes (33 approved and 34 reviewed), Test 2 identified 67 clashes (31 approved and 36 reviewed), Test 3 identified 75 clashes (28 approved and 47 reviewed), Test 4 identified 1 clash (approved), Test 5 identified no clashes, and Test 6 identified 2 clashes (1 approved and 1 new). Some clashes were found where pipes or ducts pass through walls or floor openings. These are necessary for routing building services such as plumbing and ventilation, and were verified against the design intent. Such cases were marked as approved clashes (Fig. 6 a).



(a)



(b)

Fig 6: Architectural vs MEP (a) approved and (b) resolved clashes

Other conflicts occurred due to improper coordination, where MEP pipelines intersected architectural elements like beams or slabs without sufficient clearance. These clashes were analyzed and resolved by modifying pipe routing or elevation to avoid interference. Proper coordination between architectural and MEP models ensured efficient service integration and minimized construction difficulties.

IV. RESOLUTION OF CLASHES

Clash resolution was performed using Autodesk Navisworks as part of an integrated BIM workflow. After executing clash detection, each identified conflict was examined based on its location, severity, and design intent. Clashes were categorized into acceptable (intentional) and conflicting (unintentional) cases. Approved clashes, such as required service penetrations or structural support conditions, were retained, while conflicting instances were resolved through coordinated modifications in the respective discipline models using Revit. The process followed an iterative approach, where models were updated and revalidated until satisfactory coordination was achieved.

A. Architectural Vs Structural Clash Resolution

Conflicts between architectural and structural components were primarily associated with the interaction of walls and structural members such as beams, slabs, and columns. In cases where walls were intentionally supported by beams or slabs, the intersections were verified against the design intent and retained without modification. Unintended conflicts were resolved by improving alignment between architectural and structural systems. This included repositioning walls to coincide with structural grid lines, refining layout dimensions, and ensuring that openings and partitions did not interfere with load-bearing elements. Where necessary, clearances were introduced to maintain constructability and avoid stress concentrations. These adjustments ensured that the architectural layout remained functionally efficient while being structurally compatible (Fig. 4b).

B. Structural Vs MEP Clash Resolution

Clashes between structural and MEP systems mainly resulted from service elements intersecting structural components without adequate planning. While certain interactions, such as pipes passing through slabs for drainage, were essential and accepted, other instances required corrective action to prevent structural interference. Resolution was achieved by optimizing the routing and elevation of MEP services. Pipes and ducts were redirected along alternative paths or shifted vertically to bypass beams and slabs. In situations where services needed to pass through structural elements, provisions such as sleeves or openings were incorporated at appropriate locations. Care was taken to ensure that these modifications did not compromise structural performance (Fig. 5b). This approach enabled efficient integration of services within the structural framework.

C. Architectural Vs MEP Clash Resolution

Conflicts between architectural and MEP systems were observed where service components intersected walls, floors, or other architectural features. Necessary penetrations required for routing utilities were retained after validation, as they are inherent to building service integration. Non-compliant clashes were resolved by refining the layout of MEP systems in relation to architectural elements. Adjustments were made to the routing paths and elevation levels of pipes and ducts to avoid interference. In addition, coordinated openings were introduced in walls and slabs to accommodate service lines without disrupting architectural functionality. These changes ensured that service installation could be carried out efficiently without affecting spatial planning.

The resolution process involved continuous coordination between disciplines, with updates made in the BIM models and verified through repeated clash detection cycles (Fig. 6b). This iterative refinement improved model accuracy, ensured consistency across systems, and minimized the likelihood of construction-stage conflicts. The adopted clash resolution strategy enhanced design coordination, reduced the need for rework, and contributed to a more efficient and constructible building model.

V. CONCLUSIONS

The study illustrates the application of Building Information Modeling (BIM) for improving design coordination in a G+3 educational building. The integration of architectural, structural, and MEP models developed using Autodesk Revit enabled the creation of a unified digital model, supporting accurate visualization and effective interaction between disciplines. Clash detection carried out in Autodesk Navisworks facilitated the identification of conflicts among building systems at the design stage. Intersections between elements were analyzed based on their nature, distinguishing between intentional conditions and actual conflicts. Necessary interactions, such as structural supports and service penetrations, were validated and retained, while incompatible overlaps were addressed through appropriate modifications. The resolution process involved adjustments in element positioning, alignment with structural layouts, and refinement of service routing to eliminate interference. Iterative coordination ensured consistency across models and improved the reliability of the final design. The implementation of BIM-based clash detection enhanced design accuracy, reduced the likelihood of construction errors, and supported efficient coordination among disciplines. The approach demonstrates its effectiveness in producing a well-integrated and constructible building model during the design phase.

REFERENCES

[1] A. A. Firoozi et al., "Innovations in Energy-Efficient Construction: Pioneering Sustainable Building Practices," Cleaner Engineering and Technology, 2025.

[2] S. A. Khan et al., "Evaluating Sustainable Building Strategies: Life Cycle Comparison of Demountable and Conventional Structures," Cleaner Environmental Systems, 2025.

[3] C. Bouillon et al., "Multi-LOD Generative Approach for Multi-Objective Sustainability Optimization," Automation in Construction, 2025.

[4] A. M. Khan et al., "Optimizing Sustainable Alternatives in Value Engineering Decision-Making through BIM-Integrated Plugin Automation," Ain Shams Engineering Journal, 2025.

[5] B. Manzoor et al., "Green Buildings and Digital Technologies: A Pathway to Sustainable Development," Green Technologies and Sustainability, 2025.

[6] H. Li et al., "Tracking the Built Status of MEP Works Using the Value of a Scan-vs-BIM System," 2025.

[7] W. Wang and Y. Fang, "Automatic BIM Reconstruction for Existing Building MEP Systems from Drawing Recognition," Buildings, MDPI, 2025.

[8] S. Zeng et al., "Research on Human–Machine Collaborative Innovation in Design Education Inspired by GANs," Design and Artificial Intelligence, 2025.

[9] M. S. Lystbæk, "Machine Learning-Driven Processes in Architectural Building Design," Automation in Construction, 2025.

[10] H. Zhang and R. Zhang, "Generative Artificial Intelligence in Built Environment Design and Planning: A State-of-the-Art Review," Progress in Engineering Science, 2025.

[11] J. Jadhav et al., "Integrating Knowledge of Project-Based Education with BIM," 2025.

[12] R. Chahrour et al., "Cost Savings through BIM-Based Clash Detection and Resolution in Construction Projects," 2024.

[13] A. Shehadeh et al., "Enhanced Clash Detection in BIM Using Modified Extreme Gradient Boosting (MXGBoost)," Results in Engineering, Elsevier, 2024.

[14] I. Bitaraf et al., "Prioritization Framework for Clash Detection Using Best–Worst Method," 2024.

[15] S. D. Datta et al., "Artificial Intelligence and Machine Learning Applications in the Project Lifecycle of the Construction Industry," Heliyon, 2024.

[16] M. S. Lystbæk et al., "BIM and Machine Learning Integration in Design Coordination," 2024.

[17] P. Schönfelder et al., "Enriching BIM Models with Fire Safety Equipment Using Deep Learning," Automation in Construction, Elsevier, 2024.

[18] Pestana et al., "A BIM-Based Framework for Quantifying Energy and Efficiency in Building Life Cycle Assessments," 2023.

[19] D. M. Savitri, Juliastuti, and Pramudya, "Clash Detection Analysis with BIM-Based Software on Mid-Rise Building Construction Projects," IOP Conf. Series: Earth and Environmental Science, 2020.