APPLICATION OF BUILDING INFORMATION MODELING (BIM) FOR CONFLICT MITIGATION IN THE DESIGN PHASE OF CONSTRUCTION PROJECTS

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Abstract: This paper analyzes the application of Building Information Modeling (BIM) in the design phase to minimize conflicts among architectural, structural, MEP, and infrastructure disciplines. Based on a synthesis of theory and practice, the study identifies four key aspects of BIM: multidisciplinary modeling and coordination, conflict detection, management and resolution within a common data environment, and evaluation of implementation effectiveness. The findings demonstrate that BIM significantly reduces the number of conflicts, shortens revision cycles, ensures better control over coordination schedules, enhances the quality of design documentation, and maintains data consistency. Furthermore, resolving conflicts early in the design stage contributes to investment cost control, minimizes unforeseen changes, and increases the reliability of cost estimates.

Keywords: Building Information Modeling (BIM); Design process; Design conflicts; Multidisciplinary coordination; Common Data Environment (CDE).

Tóm tắt: Bài báo này phân tích việc ứng dụng Mô hình Thông tin Công trình (BIM) trong giai đoạn thiết kế nhằm giảm thiểu xung đột giữa các bộ môn kiến trúc, kết cấu, MEP và hạ tầng. Dựa trên sự tổng hợp giữa lý thuyết và thực tiễn, nghiên cứu xác định bốn khía cạnh chính của BIM: mô hình hóa và phối hợp đa ngành; phát hiện xung đột; quản lý và xử lý xung đột trong môi trường dữ liệu chung; và đánh giá hiệu quả triển khai. Kết quả cho thấy BIM giúp giảm đáng kể số lượng xung đột, rút ngắn chu kỳ điều chỉnh, kiểm soát tốt hơn tiến độ phối hợp, nâng cao chất lượng hồ sơ thiết kế và đảm bảo tính nhất quán của dữ liệu. Bên cạnh đó, việc giải quyết xung đột ngay từ giai đoạn thiết kế góp phần kiểm soát chi phí đầu tư, hạn chế các thay đổi phát sinh và tăng độ tin cậy của dự toán chi phí.

Từ khóa: Mô hình thông tin công trình (BIM); Quy trình thiết kế; Xung đột thiết kế; Phối hợp đa ngành; Môi trường dữ liệu chung (CDE).

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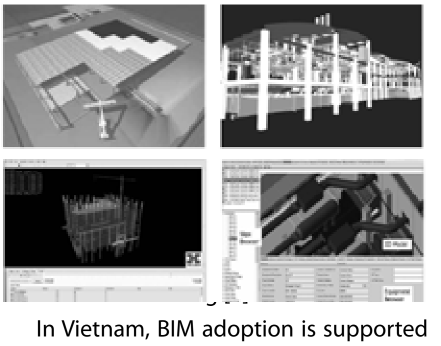
1. INTRODUCTION

In construction design, conflicts among architectural, structural, MEP, and infrastructure disciplines are a major cause of cost overruns and schedule delays. Evidence shows that resolving clashes during construction is significantly more expensive than addressing them during the design stage [1], highlighting the need for effective coordination and data management platforms [3; 10]. Building Information Modeling (BIM) provides a key solution by enabling a digital representation of buildings that integrates both geometric and non-geometric information. This supports early conflict detection, improves multidisciplinary coordination, and enhances the quality of design documentation [12; 13].



In Vietnam, BIM adoption is supported by regulations such as Circular 10/2021/TT-BXD and TCVN 14177-1:2024, aligned with ISO 19650, demonstrating strong commitment to modern construction

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management [2; 4; 5; 7; 8; 9].

2. FRAMEWORK OF BIM IN DESIGN CONFLICT MANAGEMENT

2.1. Design conflicts in construction projects

2.1.1. Geometric conflicts

Geometric conflicts occur when building elements physically overlap in 3D space, often involving clashes between MEP systems and structural components. They are the most common issue in poorly coordinated projects. Main causes include isolated discipline modeling, lack of early clash detection, inconsistent LOD, and absence of a collaborative platform, all of which hinder accurate model integration [11].

2.1.2. Spatial conflicts

Spatial conflicts arise when systems fail to meet installation, operation, or maintenance requirements, such as insufficient clearances, limited access, or safety violations. Identifying them requires evaluating operational spaces within the model [6]. They are mainly caused by missing clearance standards and lack of maintenance checks during design.

2.1.3. Information conflicts

Information conflicts arise from inconsistencies in attribute data for the same object, such as differences in dimensions, materials, or codes across documents. They are not visible in drawings and often appear during cost estimation or procurement [13].

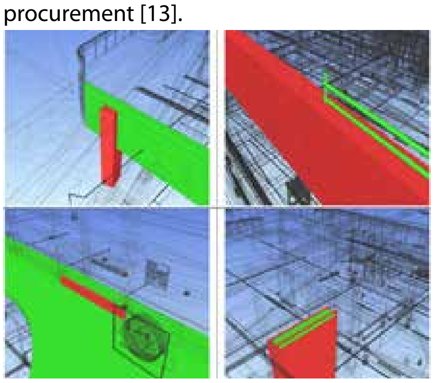

Figure 2. Visualization of Clash Detection in a BIM Model [12]

Their causes include lack of standardization, inconsistent naming, unstructured data, and weak exchange controls.

2.1.4. Design schedule conflicts

Design schedule conflicts arise when model development and document issuance timelines are misaligned across disciplines, causing teams to work with outdated versions. These conflicts are mainly due to missing version control and the absence of a well-defined Common Data Environment (CDE) with clear roles, release schedules, and exchange protocols. Although standards such as ISO 19650 (2018) provide guidance, inconsistent implementation often leads to discrepancies between model versions and documentation.

2.2. Framework for BIM application in clash detection

2.2.1. Three-layer architecture

The Data and Standardization Layer requires structured data aligned with ISO 19650, IFC, and COBie, with consistent attributes, identifiers, and naming conventions. TCVN 14177:2024 ensures interoperability and traceability [4; 5; 8]. Within the CDE Process Layer, coordination follows defined states and plans, establishing roles, timelines, and controls to manage conflicts from detection to resolution.

2.2.2. Mapping conflict types to BIM mechanisms

Geometric conflicts are detected through comparisons, tolerance thresholds, and clash matrices, with iterative resolution in the CDE ensuring synchronized models [11]. Spatial conflicts are addressed by modeling clearances and using 4D simulations to optimize layouts and accessibility. Information conflicts are managed via standardized data structures and naming conventions. Design schedule conflicts are controlled through model release planning, version control, and approval workflows to prevent outdated data use.

2.2.3. Model quality rules and implementation conditions

Level of Information Need (LOIN) ensures models contain appropriate information for each stage, enabling reliable clash detection and consistent comparison across disciplines [6]. Rule-based checking applies standardized rules for clashes, clearances, data consistency, and sequencing, improving consistency and reusability. A responsibility matrix assigns roles for issue identification, resolution, and approval, enhancing traceability, accountability, and efficiency in the coordination process.

2.2.4. Information flow within the CDE

Issue Identification: Issues are generated from automated checks and tagged with object references, locations, priority levels, and resolution deadlines. Coordination and Resolution: Relevant disciplines update their models according to identified issues and upload revised versions to the CDE for re-evaluation. Publication and Archiving: Once acceptance criteria are met, models are formally published and stored in a controlled environment to support subsequent project phases.

3. RESEARCH METHOD

This study is based on a systematic review of domestic and international literature on the application of BIM for controlling design conflicts. Selected sources include studies with empirical evidence or strong theoretical frameworks, covering both global and Vietnamese contexts. The analysis uses thematic classification, grouping studies into key domains: BIM concepts, conflict types, detection tools, and coordination processes. Findings are compared to identify common trends, differences, and research gaps.

4. RESULTS AND DISCUSSION

4.1. Clash Detection

4.1.1. Establishment of clash detection matrix

Disciplines are paired for checking under specific scenarios, such as architecture–structure, structure–MEP, or MEP–infrastructure. Within each matrix, engineers define tolerance thresholds, such as minimum clearances between mechanical systems and structural elements.

Figure 3. Clash detection process

This enables the software not only to detect direct clashes but also to identify violations of protective zones. The clash matrix functions as a predefined "conflict map." When properly configured, it helps avoid false positives and ensures that critical conflicts are not overlooked. In practice, this step determines the reliability of the entire detection process, as all subsequent results depend on the quality of the initial setup.

4.1.2. Execution of detection tools

Specialized software such as Navisworks, Revit, or Tekla is used to scan the entire federated model. The results are visualized in a 3D environment, indicating the coordinates, involved elements, and types of conflicts. International applications have demonstrated the effectiveness of these tools in systematically classifying and managing issues. For example, in infrastructure projects in Europe, periodic clash detection has reduced nearly half of geometric conflicts before the release of construction documents. A key advantage of these tools is their ability to visualize conflicts directly within the 3D model. By observing clashes in a spatial context, stakeholders can quickly understand the nature of the problem and propose appropriate solutions. This significantly reduces coordination time and minimizes misunderstandings among disciplines.

4.1.3. Reporting and analysis of results

Detected clashes are compiled into issue lists, where each conflict is associated with model elements and assigned a status. Reports can be filtered by discipline, priority level, or design stage. This approach ensures transparency and supports iterative review cycles. Practical experience in Indonesia shows that BIM-based detection enables early identification of MEP conflicts and reduces the extent of revisions required in construction documentation.

These reports function as lifecycle management tools for conflicts. Through systematic tracking, design teams can identify not only the location of conflicts but also the responsible parties and required deadlines for resolution. As a result, coordination processes become more transparent, and the risk of unresolved conflicts persisting into the construction phase is significantly reduced.

4.2. Conflict Management and Resolution in BIM

4.2.1. Conflict management and resolution in BIM

If clash detection only identifies conflicts within the model, then conflict management and resolution represent the stage that transforms detected data into concrete actions. This is the most challenging phase, as it directly involves responsibility allocation, coordination of model revisions, and validation of results. In practice, many projects may detect hundreds of clashes; however, without an effective management mechanism, most of these issues remain unresolved and extend into the construction phase, leading to significant additional costs. Therefore, organizing a structured process for conflict management and resolution within a Common Data Environment (CDE) is critical to the effectiveness of BIM implementation.

4.2.2. Conflict recording and classification

Detected clashes are recorded in the CDE as a structured issue list. Each issue is assigned a unique identifier, coordinates, links to model elements, visual evidence, descriptions of violated rules, related disciplines, responsible parties, and deadlines. These issues are managed through defined states such as work-in-progress, shared, published, and archived, enabling full traceability of each issue's lifecycle. Conflicts are generally classified into three categories: geometric, spatial, and informational. Their severity is assessed based on criteria such as safety requirements, schedule impact, and cost implications. The system also allows filtering by zone, floor, or technical system, and grouping similar clashes to reduce redundancy.

4.2.3. Responsibility assignment and coordination

Following classification, each conflict is assigned to a specific individual or discipline team responsible for resolution. Assignment details include the responsible party, scope of work, deadline, and tracking status. Managing this process within the CDE ensures that all changes are fully traceable. More importantly, it establishes a continuous control mechanism in which each issue has clear ownership and its progress can be monitored in real time. As a result, coordination meetings can focus on solutions rather than responsibility identification, thereby improving efficiency and reducing resolution time.

4.2.4. Proposal and approval of resolution measures

Based on assigned responsibilities, design teams develop resolution proposals directly within the BIM model. These solutions typically involve modifying component dimensions, rerouting MEP systems, or reorganizing installation spaces to ensure constructability. Proposed solutions are not only represented geometrically but also include attribute data reflecting their impacts on schedule, cost, and technical requirements. Within the CDE, updated models are issued as controlled information packages with version tracking and recorded authorship.

4.2.5. Monitoring and rechecking

After approval, updated models must be rechecked through the clash detection process to confirm that conflicts have been fully resolved and no secondary issues have emerged. This entire process is documented within the CDE, including revision history, responsible parties, and issue status, in accordance with ISO 19650. Rechecking serves not only as validation but also as part of a continuous control loop. Each modification is systematically reassessed, enabling early detection of secondary clashes arising from design changes. This transforms conflict management into a closed-loop process, where all issues are recorded, addressed, and verified before closure.

4.3. Effectiveness of BIM Application in Conflict Management

The implementation of BIM in the design phase delivers multiple integrated benefits, reflected in its ability to reduce conflicts, control coordination schedules, improve documentation quality, and optimize costs. These benefits are not isolated; rather, they are interconnected within a closed-loop process in which data is systematically managed, verified, and issued in a controlled manner through the BIM environment.

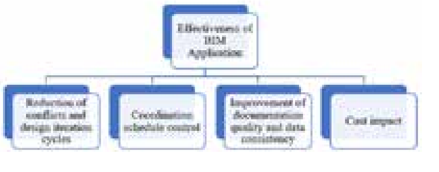

Figure 4. Overview of the effectiveness of BIM application in the design phase

4.3.1. Reduction of conflicts and design iteration cycles

BIM's primary benefit is reducing conflicts from early multidisciplinary modeling. Architectural, structural, MEP, and infrastructure teams work within a unified framework, where consistent LOD minimizes discrepancies and prevents misaligned standards. During coordination, models are integrated and checked through clash detection. Tools such as Navisworks or Solibri identify geometric, spatial, and data conflicts, classifying them for prioritization. The CDE acts as the central platform, tracking issues with clear responsibilities, deadlines, and version control. This structured process reduces design iterations and minimizes conflicting model versions across disciplines.

4.3.2. Coordination schedule control

Schedule control in BIM is achieved by assigning each conflict a unique ID, status, and deadline within the CDE. Status tracking, version logs, and defined responsibilities enable real-time monitoring, while only approved models are issued as the design basis, ensuring traceability and reducing overlaps. Coordination runs continuously across BIM environments. Models developed with consistent LOD are checked for clashes, generating prioritized issues. These are managed in the CDE through assignment, deadlines, and tracking, followed by iterative rechecking, helping shorten resolution time and stabilize design schedules.

4.3.3. Improvement of documentation quality and data consistency

A key benefit of BIM in the design phase is improved documentation quality and data consistency. Standardized LOD-based modeling embeds attributes from the outset, reducing incomplete or inconsistent data common in 2D workflows. Federated models enable early detection of geometric and data discrepancies during coordination. Consistency is reinforced through CDE management, where each update includes version control, authorship, and timestamps. Standards such as IFC and COBie ensure interoperability across platforms, resulting in complete, reliable documentation ready for construction and operation stages.

4.3.4. Cost impact

The cost impact of BIM follows a clear chain across three environments. In multidisciplinary modeling, consistent attributes and LOD reduce errors at the source. In coordination, clash detection eliminates conflicts early, minimizing on-site rework. Within the CDE, version control prevents errors from outdated models. When integrated with 4D and 5D BIM, models link to schedule and cost data, enabling early evaluation of design options. Key benefits include reduced rework, controlled variation rates, and improved cost estimation accuracy through standardized quantity extraction.

5. CONCLUSION

This study examines the theoretical foundation and application of BIM in detecting and managing design-stage conflicts. BIM provides an integrated environment for multidisciplinary coordination and centralized data management, enabling early conflict detection, fewer design iterations, controlled schedules, improved data consistency, and reduced costs.

In Vietnam, BIM adoption is supported by an emerging legal framework and initial project implementation. However, further efforts are needed in data standardization, human resource development, and coordination processes. Overall, BIM is a feasible and essential solution to enhance documentation quality, reduce risks, optimize costs, and support sustainable lifecycle management of built assets. Future research could build on this study by examining specific case studies in greater depth.

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