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Research Article

Application of Building Information Modeling (BIM) for Clash Detection and Mitigation of Building System Conflicts in Construction Projects

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Abstract

In the building construction process coordination among various systems such as structural architectural and mechanical electrical and plumbing (MEP) systems often results in component clashes that can lead to project delays and increased costs. The use of Building Information Modeling (BIM) technology in design and model review processes has proven effective in reducing the risk of such issues. This research aims to study the application of BIM technology for detecting and reducing system clashes within building models by utilizing BIM software capable of accurately analyzing and identifying clashes such as Autodesk Navisworks and Solibri Model Checker. The methodology involves collecting sample BIM model data detecting clashes among systems and analyzing the outcomes of using BIM technology to minimize these conflicts.

The results show that BIM has high potential in accurately detecting system clashes and supports designers in refining the model during the pre-construction phase. This leads to a reduction in errors lowers the cost of rework on-site and improves the overall construction process efficiency. Therefore, the application of BIM technology represents an effective approach that should be widely promoted in the modern construction industry to enhance project quality and precision.

Key Words: Building Information Modeling (Bim), Clash Detection, System Coordination, Autodesk Navisworks, Solibri Model Checker, Construction Process

Introduction

In today's construction industry, which is characterized by high complexity and demands for precision, coordination among various building systems such as structural, architectural, and MEP (Mechanical, Electrical, and Plumbing) systems is a critical factor determining project success. Effective coordination directly impacts the quality, efficiency, and cost-effectiveness of a project. Poor planning, inconsistent designs, or inefficient collaboration often lead to clashes between building components, such as pipes intersecting beams or electrical conduits overlapping drainage systems. These clashes can disrupt on-site operations, cause project delays, increase costs, and compromise the building's long-term safety.

Traditionally, clash detection and prevention relied heavily on two-dimensional (2D) reviews and the experience of engineers and designers. However, this approach was limited in accuracy and was time-consuming. Today, Building Information Modeling (BIM) has emerged as a transformative technology, revolutionizing the way buildings are designed and managed. BIM is not merely a 3D model of a building; it encompasses detailed information about materials, quantities, and construction sequencing. This enables accurate simulations and analysis before actual construction begins.

Over the past decade, Building Information Modeling (BIM) technology has been widely developed and adopted within the construction industry. Its key features include the creation of 3D models integrated with in-depth data such as material specifications, quantities, schedules, and construction sequences. BIM allows for early detection and analysis of potential issues during the design phase, significantly reducing the likelihood of errors during construction. Furthermore, BIM can be integrated with specialized software tools such as Autodesk Navisworks and Solibri Model Checker to perform clash detection efficiently. These tools can clearly and accurately highlight points of conflict between different systems, enabling designers to resolve issues during the pre-construction phase. This proactive approach minimizes rework costs, reduces on-site disruptions, and enhances overall project planning accuracy.

Given the recurring problems in construction processes and the potential of BIM technology to address them effectively, this study focuses on the application of BIM for clash detection and reduction in building construction processes. The objective is to evaluate the efficiency of BIM tools in minimizing design errors and enhancing project management capabilities, ensuring smoother, faster, and more accurate project execution.

Figure 1: Illustrate examples of locations where clashes were identified through clash detection processes utilizing BIM

Therefore, the study of applying BIM technology for clash detection and reduction in building construction processes is highly important, especially in an era where the construction industry is moving toward digital technologies to enhance efficiency, accuracy, and minimize waste at every stage of construction. This research aims to present approaches and outcomes of using BIM technology to identify clashes between different systems, with the goal of raising the standards of planning and project management quality in the construction industry for the future.

Methodology

The application of Building Information Modeling (BIM) technology in combination with clash detection software such as Autodesk Navisworks or Solibri Model Checker to study the process of detecting and reducing clashes in building models. The study will involve experiments using sample building models and will analyze the results both quantitatively and qualitatively to provide recommendations for the effective application of BIM in actual construction projects, with detailed descriptions of each step.

No.	Step	Description
1	Prepare BIM Models	Import files from Revit/IFC for each system
2	Combine Models in Navisworks	Create a combined model (NWF or NWD)
3	Set Clash Detection Parameters	Define conditions, resolution, and scope
4	Analyze Clash Results	Review clash locations and types
5	Generate Reports	Summarize clash locations, issues, and recommendations
6	Present Research Results	Use 3D visuals and reports to demonstrate improvements

Table 1: Steps for Using Autodesk Navisworks in Clash Detection

Table 1 describes the step-by-step process of using Autodesk Navisworks for Clash Detection, with clear details for each stage to help users understand and follow the workflow systematically. It begins with preparing BIM model files for each system, such as architectural, structural, and MEP systems, which need to be imported in appropriate formats (e.g., Revit or IFC) to be ready for coordination processes.

Next, all models are combined in Navisworks to create a single, integrated model (NWF or NWD), consolidating information from all systems into one file. This enables users to see the overall picture and check coordination efficiently. In the following step, users need to set clash detection parameters by defining conditions such as the scope of inspection, detection resolution, and rules for identifying conflicts. This is a critical step that directly affects the accuracy of the results.

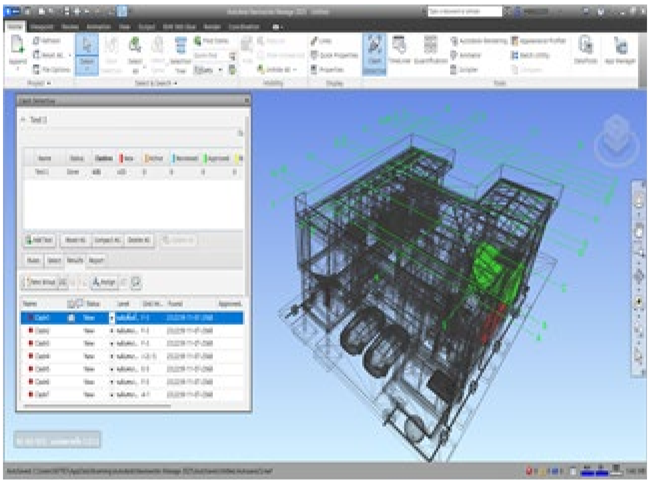

Figure 2: The Use of Autodesk Navisworks for Clash Detection and the Results Obtained

No.	Step	Description
1	Open Solibri	Launch and set up the software
2	Import Model	Load IFC files from BIM tools
3	Classification	Group elements for checking
4	Select Ruleset	Choose clash detection rules
5	Run Checking	Perform clash detection
6	Issue Detection	View detected clashes with details
7	3D Review	Inspect clashes in 3D
8	Issue Management	Add notes, set status, share via BCF
9	Report Generation	Export results in PDF, Excel, or HTML
10	Iteration	Revise and recheck until clashes are resolved

Table 2: Steps for Using Solibri Model Checker in Clash Detection

Table 2 shows the step-by-step process for using Solibri Model Checker to perform clash detection in a concise manner, starting from launching the program, importing IFC files, grouping model elements, selecting clash detection rules, running the check, reviewing clash details, inspecting in 3D, managing issues, generating reports, and iterating revisions and checks until all clashes are resolved.

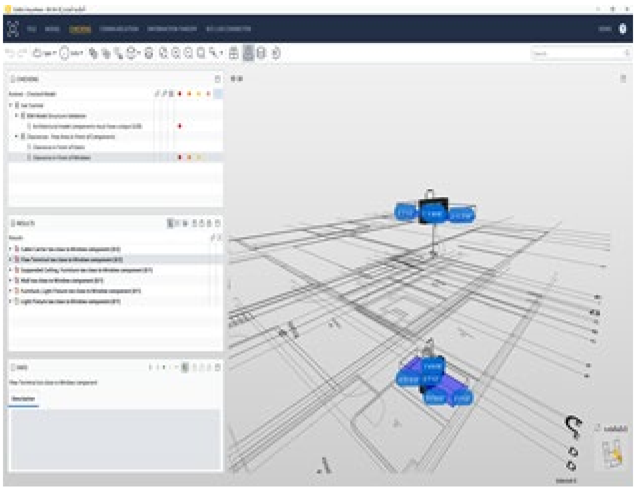

Figure 3: The Use of Solibri Model Checker for Clash Detection and the Results Obtained

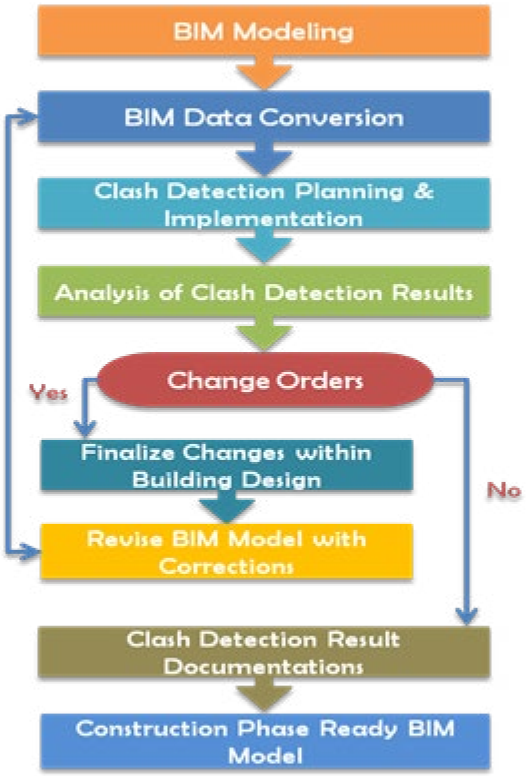

Figure 4: Steps for Performing Clash Detection of Building Components

Conclusion

Clash detection using both Autodesk Navisworks and Solibri Model Checker produces detailed and clear information about the location and nature of clashes between various building elements in the BIM model. This is a critical step in supporting coordination among design teams, contractors, and engineering consultants to prevent issues that might arise on-site. The results of clash detection include the total number of clashes identified in the model, helping teams systematically assess the scope of issues, understand the overall complexity to be managed, and prioritize solutions appropriately. The software can also categorize and summarize the number of clashes by system type, such as structural, architectural, electrical, plumbing, or mechanical systems, and indicate the percentage of clashes resolved versus remaining for example, showing 80% Resolved /20% Remaining as a metric to track coordination progress among teams.

For clash locations, the software provides precise coordinates or areas within the 3D model where clashes occur. Users can rotate views, zoom in and out, and explore the surrounding context in detail, allowing them to analyze exactly where issues are located such as in lobbies, equipment rooms, parking areas, or vertical risers between floors enabling targeted planning for corrections and minimizing design discrepancies.

The software also clearly classifies types of clashes, such as structural versus MEP systems, clashes within MEP systems themselves (e.g., HVAC ducts versus plumbing pipes), or clashes between architectural elements and structural components. This clear classification helps assign responsibility for resolving issues to the appropriate teams, ensuring that managing cross-disciplinary complexities is systematic and reducing conflict between trades.

Related elements are identified in detail, such as major beams conflicting with drainage pipes or low-voltage electrical conduits intersecting HVAC ducts, so that designers and contractors immediately understand which components are involved and which system models need adjustment or which team is responsible. Progress can also be tracked by team or system, for example, showing that the MEP team has resolved 75% of its identified clashes.

For severity or priority, the software typically ranks clashes as High, Medium, or Low, helping teams plan staged resolutions. High-priority clashes that might prevent construction progress are flagged for urgent correction, with the ability to summarize resolution percentages by priority for example, High Priority Resolved 90%, Medium Priority Resolved 70%. Recommendations for resolution derived from the clash detection process can include technical details such as adjusting pipe routes, relocating openings, resizing or rerouting electrical conduits. These recommendations can be documented in reports or directly within the model as notes or BCF (BIM Collaboration Format) entries, helping design teams and coordinators work precisely, reduce repetitive corrections, and maintain quality control throughout the design process.

Finally, the software generates clash detection summary reports in standard formats such as PDF, Excel, or BCF. These reports include detailed tables of all clashes with their resolution status as percentages (e.g., Resolved 85%, Open 15%), 3D images illustrating issues, descriptions of locations and involved elements, and status tags (Open, Solved). Such reports serve as clear, transparent documentation for meetings, coordination, and project management, enabling teams to systematically track progress, measure results, and maintain accountability. This ultimately improves design quality, reduces errors and rework, lowers construction-phase risks, and leads to a more efficient, cost-effective, and sustainable construction process overall.

Advantages and Limitations

Autodesk Navisworks offers several advantages for performing clash detection because it can easily integrate models from multiple disciplines, such as architecture, structure, and MEP (Mechanical, Electrical, and Plumbing), into a single 3D environment. This integration allows users to clearly visualize the overall project. The Clash Detective tool enables systematic and efficient detection of clashes between different elements. The software can accurately identify the locations of clashes and display them clearly within the 3D model, making it easier to analyze and resolve issues during the design phase. This reduces the risk of errors during actual construction, lowers the cost of rework on-site, and improves coordination among the various design teams. Additionally, Navisworks can generate clash reports in different formats, which are valuable for communication and tracking the progress of issue resolution.

However, Navisworks also has some limitations. Its clash detection capabilities are primarily based on geometric analysis (hard clashes) and may not fully account for complex engineering conditions or design intent. Handling soft clashes or ensuring sufficient clearance for maintenance often relies on the user's own judgment. Moreover, mastering the software to use its full capabilities requires time and expertise. Users need a good understanding of preparing models from other software, ensuring accuracy and correct alignment; if the original models contain errors, the clash detection results may be unreliable. In addition, the full-featured Navisworks Manage version, which includes the Clash Detective tool, comes with significant licensing costs, which can be a barrier for some projects or companies with limited budgets. In summary, using Autodesk Navisworks for clash detection is a powerful tool that greatly enhances design quality and project coordination in construction. However, it requires good data preparation, technical understanding, and appropriate investment to maximize its benefits.

Solibri Model Checker is a highly effective software for performing clash detection because it is designed for detailed BIM model quality analysis. The program can read IFC files directly, supporting robust Open BIM collaboration across various software platforms, which significantly reduces compatibility issues among different disciplines. Clash detection in Solibri is not limited to simple geometric analysis (hard clashes); it also supports complex, rule-based checking such as ensuring maintenance clearances (soft clashes) or verifying compliance with project-specific standards and requirements in a flexible manner. The software can generate detailed, easy-to-read clash reports complete with images and explanations, enabling design teams and project managers to clearly understand and address the issues. Additionally, Solibri offers other model-checking functions such as component quality verification, quantity takeoff, and data validation, which are highly valuable for overall quality control in construction projects.

However, Solibri Model Checker also has some limitations. The software's interface and underlying concepts can be complex for new users, requiring significant time and training to master. Creating and customizing checking rules demands a solid understanding of technical requirements and design standards; otherwise, the results may not align with project needs. Moreover, although Solibri handles IFC files well, working with models exported incorrectly from other software can lead to data loss or inaccuracies. Furthermore, the full-featured versions of Solibri, such as Solibri Office or Enterprise, come with high licensing costs, which can be a barrier for organizations or projects with limited budgets.

In summary, Solibri Model Checker is a powerful and highly suitable tool for professional-level clash detection and BIM model quality assurance, as it enables in-depth analysis and customizable rule-based checking. However, it requires solid technical knowledge, careful preparation, and appropriate investment to use its full capabilities effectively.

Recommendations

Although this study of clash detection in BIM is not merely about software techniques, it is a process that involves multiple stakeholders working together systematically with clear roles and responsibilities. By developing effective coordination approaches and using BIM tools appropriately, errors can be reduced, project quality improved, and costs controlled more efficiently. However, there are still several directions for future research and development, including.

- Define a clear workflow Plan the clash detection process systematically from preparing BIM files, combining models, and setting up rulesets to reporting results—to ensure all parties understand and follow the same procedures.
- Establish standardized settings and rulesets for the project Develop rulesets and checking criteria tailored to the project type to ensure accurate results and reduce misinterpretation among team members.
- Train and upskill personnel Provide training for designers, engineers, and coordinators to use Navisworks and Solibri correctly, ensuring high-quality clash detection and reducing errors from improper software use.
- Integrate clash detection results into the design and revision process. Use clash detection outcomes to coordinate and systematically revise BIM models, performing iterative checks until all clashes are resolved.
- Incorporate clash detection throughout all project phases Plan to perform clash detection continuously, not just once, by checking during Concept, Design Development, and pre-construction phases to prevent issues early.
- Promote the use of reports and BCF for communication. Use PDF, Excel, or BCF reports as central communication tools among team members to clearly share clash information, resolution status, and ensure transparent, verifiable coordination.

However, clash detection in building components is a critical step that helps enhance the quality of design and construction in a systematic way. It is a process that enables teams to identify and resolve conflicts between different systems early in the design stage, reducing errors, minimizing rework, and effectively controlling construction costs. Using tools such as Autodesk Navisworks and Solibri Model Checker, combined with well-planned workflows and good coordination between teams, fosters mutual understanding and allows issues to be resolved quickly and accurately. Therefore, clash detection is not merely a software-based technique but a collaborative process that requires teamwork, clear roles and responsibilities, and effective communication to ensure the project is completed smoothly, with high quality, and meets the needs of all stakeholders involved.

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