CLASH DETECTION IN CONSTRUCTION PROJECT BY BIM

Mr. Akash Mahendra Ingle[1, a *], Dr. Amitkumar B. Ranit[2, b] and Prof. Rahul R. Wankhade[3, c]

[1] Construction Engineering and Management, Prof. Ram Meghe College of Engineering and Management, India

[2] Associate Professor, Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Management, India

[3] Assistant Professor, Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Management, India

Abstract. In this article, we learn about the Architecture, Engineering and Construction (AEC) industry and how Building Information Modeling (BIM) has fundamentally changed their way of doing things. Clash detection is a key feature of BIM, which will identify and resolve conflicts between different building elements during design phase, reducing expensive on-site alterations and construction delays. The effectiveness of clash detection in BIM frameworks is investigated, more specifically, the effectiveness of clash detection in design coordination. A comparative analysis of BIM enabled clash detection with traditional methods is performed to determine the time and cost efficiencies. Using case studies and simulations this research explores ways to reduce the clashes in BIM and enhance the efficiency, cost saving and quality of the project. Results reveal that clash detection in BIM not only speeds up project timelines but also ensures cost savings and therefore the valuable role of BIM as a proactive suppressing methodology of construction project conflicts. The paper concludes with further integration clash detection (CLD) techniques in the AEC industry towards further integrated resource allocation.

Keywords: Clash Detection, Coordination, Building Information Modeling (BIM), Revit, Navisworks, AEC industry, Time, Collaboration, MEP,

1. INTRODUCTION

In the Architecture, Engineering, and Construction (AEC) industry, successful project planning and execution of resources as well as timely delivery are critical to the success of the project. Despite complex coordination among a variety of disciplines, conflicts and clashes, such as spatial, structural, and systems related conflicts, frequently occur during project execution. This has a potential for costly rework, schedule delays and inefficient use of resources such that: Clash detection has become an invaluable process to address these challenges early in the project lifecycle with the advent of Building Information Modelling (BIM).

BIM clashes detection is a process of using digital models to detect and solve out conflicts between various project elements without constructing. The ability of this technique to detect both "Hard" clashes, e.g. physical intersections of structural components, and "Soft" clashes, i.e. spatial conflicts that could inhibit functionality provides the functional conflict matrix routability assessment with much higher accuracy and completeness. Clash detection proactively contributes to improved decision making, reduced construction waste, and higher efficiency by identifying clashes.

Rationale of the Study

The value of this research is related to the ability of improving the efficiency and coordination in construction projects in the industry of Architectural, Engineering, and Construction (AEC) using Building Information Modeling (BIM) based Clash detection.

i. **Addressing Core Challenges:**
However, this study directly attacks the key pain points in Construction Management, such as architectural, structural, and MEP Systems conflicts. The research quantifies and categorizes these clashes; it identifies what nature, frequency and severity of conflicts it is, to help bypass more proactive and precise coordination.

ii. **Advancing BIM Integration:**
The presented research shows the potential of BIM tools such as Revit and Navisworks to revolutionise project planning. It shows how early identification and resolution of clashes in both hard and soft formats can reduce costly rework, delay projects and eliminate the need to integrate multi-disciplinary models.

iii. **Improving Project Outcomes:**
The research provides evidence across case studies and quantifiable metrics of the potential for construction rework reduction by up to 40%, associated time saving (up to 30 days) and cost (estimated savings of ₹12–15 lakh). These findings emphasize the penetration of BIM based clash detection to succeed in defining the timely delivery of cost effective and high-quality projects.

iv. **Promoting Collaboration:**
The advantage of implementing BIM based clash detection on enhanced co-ordination within the inter-disciplinary team becomes a key result. It identifies the use of structured work flows, regular model reviews and collaborative resolutions to help promote communication between teams, improve integration and reduce design irregularities.

v. **Sustainability and Resource Optimization:**
This research also pertains to sustainable construction by identifying conflicts during the design phase. In sign of the global efforts of greener, more responsible construction methodologies, the reduction of material waste and efficient use of resources is key.

vi. **Practical Recommendations:**
The study not only describes challenges and benefits of BIM-based clash detection but also proposes a framework for BIM based clash detection, followed by a reference for practitioners, project managers and decision makers in the AEC field.

This research covers the gap between theoretical BIM utilization and its application which proves the value of clash detection as a cornerstone of contemporary efficient and sustainable construction management.

2. AIM AND OBJECTIVES

The aim of this research is to conduct a comprehensive investigation into the effectiveness of Building Information Modeling (BIM)-based clash detection in addressing critical challenges within construction projects.

The study is focused on understanding how BIM-based clash detection can identify conflicts, reduce construction delays, and minimize costs, thus contributing to more efficient project delivery and successful outcomes. This aim encompasses several key aspects that are essential to the modernization and optimization of construction management.

Objectives

i. Investigating the Effectiveness of BIM-based Clash Detection in Identifying Conflicts
ii. Study the intensity of Clashes
iii. Study the impact of implementation of BIM based Clash detection technique
iv. Providing Insights into How BIM-Based Clash Detection Enhances Project Outcomes
v. Offering Recommendations for Improving BIM-based Clash Detection Implementation

3. LITERATURE

[1] By providing a 4D model, BIM dramatically enhances construction management by streamlining visualization, scheduling, and coordination between architects, engineers and contractors. The clash detection capability of BIM helps to identify the design conflicts before construction begins avoiding costly on-site errors. It helps with precise material procurement, minimizing waste and makes optimal equipment use to save on equipment rental costs. [2] Furthermore, BIM helps improve build quality by identifying potential problems early and also provides access to the project during its lifecycle wherever it may be. BIM as an overall construction processes streamlines construction process, minimizes human error and optimal schedules for the best project delivery.
[4] This research emphasizes the importance of early collaboration and automated BIM processes for achieving clash-free designs through 3D coordination. However, it finds that current design practices still rely heavily on clash detection, with various root causes contributing to persistent clashes. Key issues include isolated working environments, insufficient BIM-specific training among design professionals, and limitations within cloud-based *Common Data Environments* (CDEs), which often foster "digital information silos." To address these issues, the study proposes an Open Work in Progress (OWIP) framework to promote transparency and real-time collaboration. The findings highlight the need for a more integrated CDE approach and suggest a shift in training for future AEC professionals to support collaborative, clash-avoidant design practices.

4. METHODOLOGY

This chapter discusses the methodology applied to carry out the study.

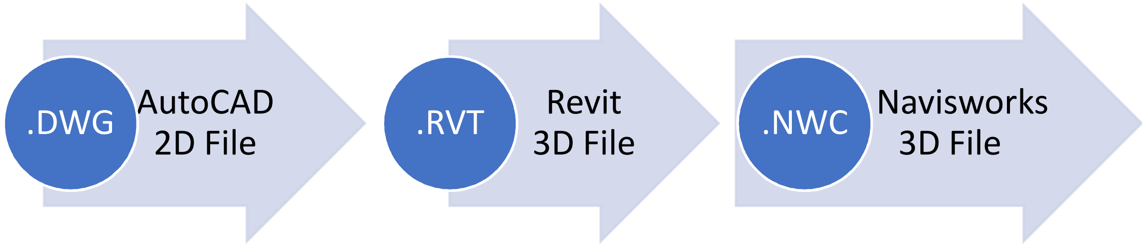


Fig. 4.1 - File updating sequence

i. Data Collection of AutoCAD Drawings.

In this particular research, 2D drawings from AutoCAD were obtained from verified, legal sources, ensuring the integrity and accuracy of the data. The focus of the data collection was on two essential components of the construction project:

- Architectural layouts.
- Structural layouts.

ii. Developing 3D Model: Architectural, Structural & MEP BIM Model

The (fig 4.2, 4.3 & 4.4) accompanying this explanation likely illustrate the results of the architectural, structural and MEP modeling performed in Revit, providing visual context for how the 2D plans have been transformed into a detailed 3D representation. This 3D model is essential for the subsequent stages of the project, where it will be used to detect clashes between architectural, structural, and other design elements, ensuring project efficiency and minimizing costly modifications during construction.

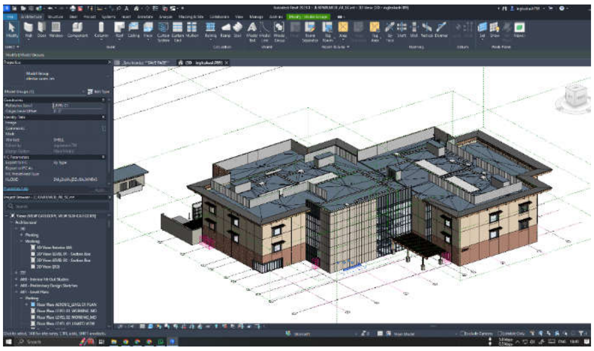


Fig 4.2: - AutoCAD 2D layout to Architectural 3D plan

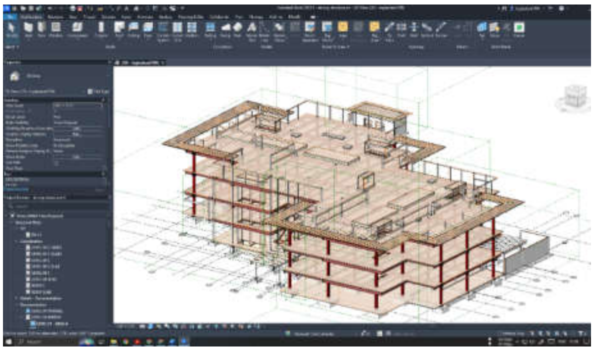


Fig 4.3: - AutoCAD 2D layout to Structural 3D plan

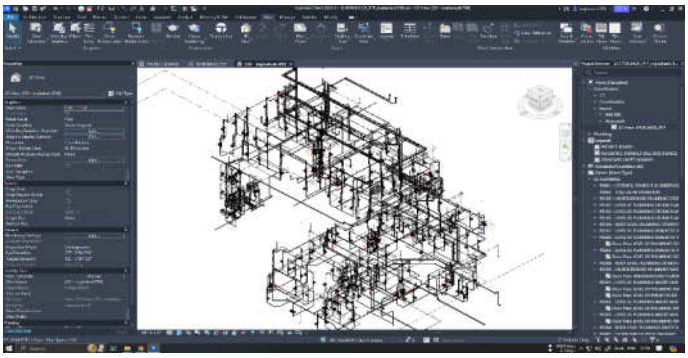


Fig 4.4: - MEP Revit 3D plan

iii. Internal Coordination & Coordinated Model

Internal coordination plays a critical role in addressing clashes identified during the modeling phase. The process of **Internal coordination** ensures that any conflicts or overlaps between the architectural, structural, and MEP (Mechanical, Electrical, and Plumbing) models are thoroughly analyzed, communicated, and resolved efficiently across all departments involved in the project. [3]

iv. Clash Detection Using Navisworks

Autodesk Navisworks used for identifying and resolving potential conflicts between different design disciplines. (Fig. 4.5) Navisworks is widely used for **clash detection** because of its ability to integrate multiple 3D models and run detailed analyses to uncover clashes between elements, such as architectural, structural, and MEP systems.[6]

Fig 4.5: - 3D model in Navisworks

4.1 RESOLUTION PROCESS

4.1.1. Categorization and Prioritization of Clash

Categorize the Clashes: Arrange the clashes in a manner such that severe (critical clashes) group of clashes can be differentiated from the moderate (design adjustments required) and the minor (aesthetic or tolerable) clashes.

- **Severe (**Critical Clashes**):** These disputes affect the integrity of structures, safety, or accessibility. Examples: Overlaps with critical escape routes or Such elements that interfere with load bearing structures.
- **Moderate (**Design Adjustments Needed**):** However, these clashes need to be addressed but do not immediately threaten the viability of the project. Examples: Partitions or finishes that are only slightly overlapping or They cause conflict with the secondary design elements.
- **Minor (**Aesthetic or Tolerable**):** The clashes are petty and don't have much weight in the scales of things; they need not be settled right away. Examples: Aesthetic misalignments or Similar structures; Small overlaps in decorative elements.

4.1.2. Clash Analysis

i. Find out the cause of each clash in Navisworks and review the clash.

ii. Find out what is causing the clashes (for example, duct through a beam and wall cutting a pipe).

iii. Record every clash and detailed observation of each clash by element ID, location, and system involved.

4.1.3. Resolution Strategies

i. Collaborative Coordination: Speak to architects, structural engineers and MEP specialists in order to formulate a new design. Do this via Navisworks tools such as viewpoints, markup to highlight areas of the clash.
ii. Modify Models: If agreed upon solutions, modify versions of the corresponding models (architecture, structure or MEP) in their respective authoring software (e.g. Revit, AutoCAD, etc).
iii. Check Updated Models: Perform the clash detection tests again to see that the issues in the Navisworks models have been resolved, and then update the models in Navisworks.

4.1.4. Documenting the Process

i. Clash Resolution Report: Write a complete report of the initial occurrence of the clash, how both parties were solved and what came out of it. You can use visuals such as before-and-after snapshots in Navisworks.
ii. Decision Log: At the coordination meeting, document the decisions made, and provide rationale.

5. RESULT AND DISCUSSION

Using **Building Information Modeling (BIM)** techniques, conflict detection in this project found **2,714 clashes** in many disciplines, including **Structural, Architectural, and MEP (Mechanical, Electrical, and Plumbing)** systems. Based on how well the corresponding systems coordinated, these conflicts were categorized into four main groups:

i. Architect vs Architect (478 clashes)
ii. Architect vs Structure (479 clashes)
iii. Architect vs MEP (391 clashes)
iv. Structure vs MEP (1,399 clashes)

Table 1: - Tests Conducted

Test Run	Architect	Structure	MEP	Clashs-10mm Tolerance
Test - 1	A vs A	-	-	478
Test - 2	Architect	Structure	-	479
Test - 3	Architect	-	MEP	391
Test - 4	-	Structure	MEP	1399

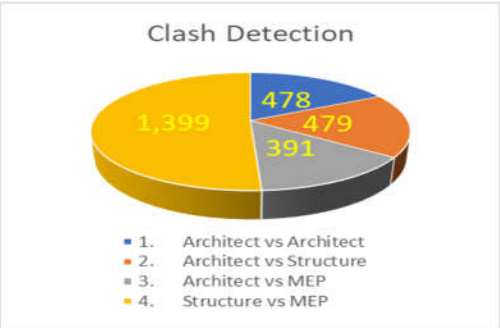


Fig 5.1: - Hard Clash (10mm Tolerance)

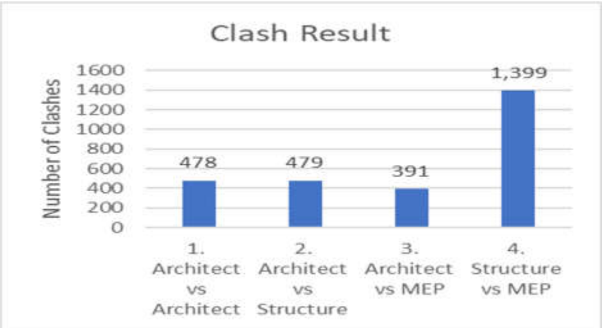


Fig 5.2: - Hard Clash (10mm Tolerance)

The results from the thesis on clash detection through Building Information Modelling (BIM) discusses the distribution of hard clashes (up to 10mm of tolerance) between different models, particularly structural, architectural and MEP (Mechanical, Electrical, Plumbing) models. Here's a breakdown of the findings:

1. **Total Clashes Identified:** Within the BIM models, we detect total of 2,714 clashes. The number referred to above is the sum of all hard that was found across multiple tests, showing just how prevalent coordination and design change will be required.
2. **Test with Minimum Clashes:** In Test-3 between the Architectural and MEP models, the fewest clashes, 391, were observed. Therefore, due to the Wall Based System the MEP systems are closely linked to the architectural model, thus, this lower number of clashes. Thus, this system permits more integrated design of MEP elements within the architectural design, and thus a reduced chance of clashes in the structural model.
3. **Test with Maximum Clashes:** Test - 4 that was between Structural and MEP models was found to be the largest contributor, in the number of clashes, to 1,399 clashes. The high count indicates considerable interference of structural elements and MEP components. This could be because of physical space constraints and the complexity of MEP services to integrate from structural framework.

5.1. Architect vs architect (478 clashes)

In this category it's about **internal clashes between architectural elements**. The architectural designs include multiple complex arrangements of walls, doors, windows, facades and other components that render them functional and aesthetic. This category (the 478 clashes) show inconsistencies and conflicts within the architectural model itself.

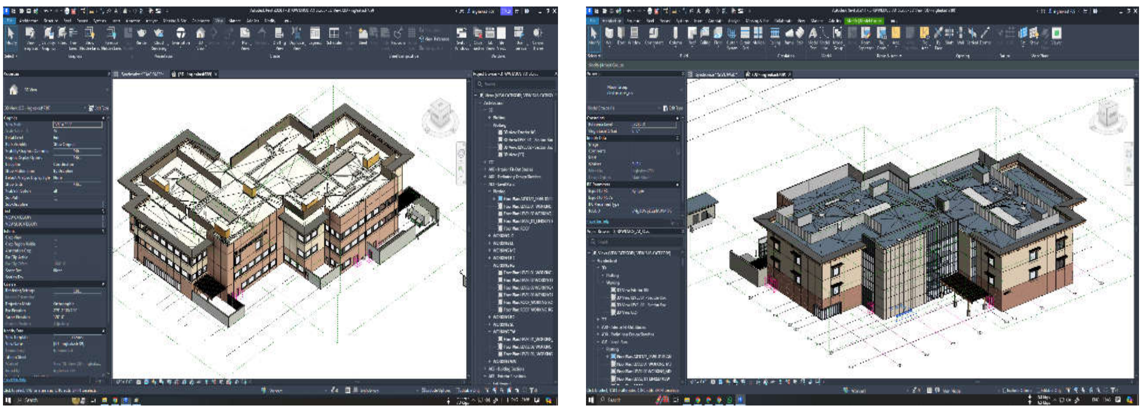


Figure 5.3: - Revit Architecture 3D Plans

5.1.1 Detailed Example of Clashes in different Architectural elements.

In the **Architectural vs Architectural** clash detection, conflicts are primarily because of architectural design conflicts where architectural elements such as walls, doors, windows, floors, and ceilings overlap or misalign. These clashes can be very serious though, because of how severe it affects on the building's overall design and functionability and integrity. Detailed examples of **Severe, Moderate and Minor clashes** are included in the following, and Table 5.1 classifies clashes by their categorization.

Table 5.1: Summary Metrics Architectural vs Architectural

Category	**Number of Clashes**	**Percentage**	**Priority**
Severe	80	16.7%	High (Resolve First)
Moderate	300	62.8%	Medium
Minor	98	20.5%	Low
Total	**478**	**100%**	**-**

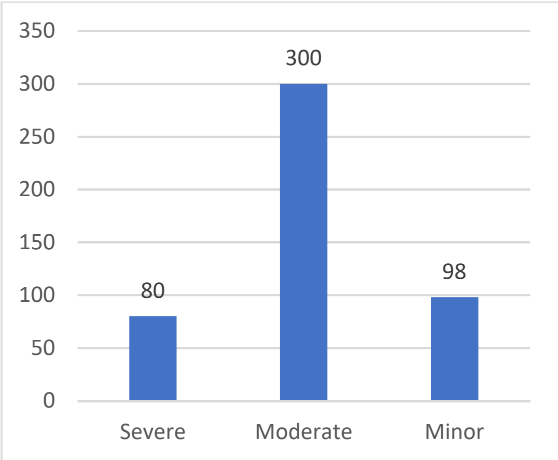


Figure 5.4: Number of Clashes

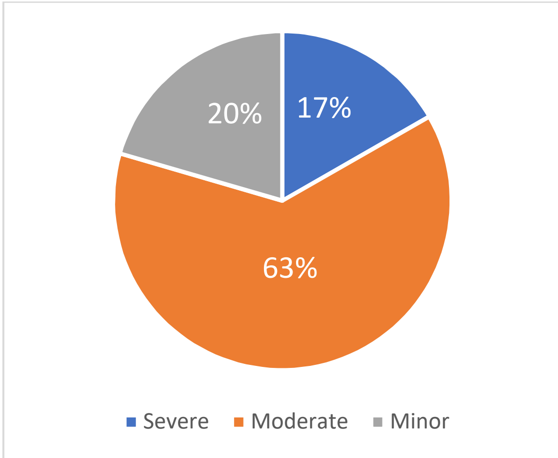


Figure 5.5: Percentage

A. Severe Clash (Critical Impact)

Severe Clash Example: Element ID: 397

i. **Elements: Roof vs Load-bearing Wall in this,** roof element and wall element create clash, interfering with each other's placement in the design.

ii. **Issue:** As a result of this clash, this undermines the building's structural integrity. Misalignment can make load-bearing walls unsafe conditions. This is why load bearing walls are so important. It forces a wall system to be reconfigure, and can affect the architectural layout of the building.

iii. **Resolution Suggestion:** Two or one are repositioned to ensure they are properly aligned and load bearing.

								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash397	New	-0.019	J-6 : LEVEL 01	Hard	2024/10/21 08:49	x:30.270, y:39.243, z:74.445	*Element ID:* 11604500	ROOF	Default Roof	Solid	*Element ID:* 11626368	ROOF	Default Wall	Solid

Figure 5.6: Severe Clash Element ID: 397

B. Moderate Clash (Design Adjustments Needed)

Moderate Clash Example: Element ID: 5

i. **Elements:** Gypsum Wall Board clashes with Roof

ii. **Issue:** The Gypsum Wall Board placement or design might need to be adjusted, but it doesn't affect the overall structural integrity of the building. It could cause delays in construction due to the need for minor redesigns of the openings or wall placements.

iii. **Resolution Suggestion:** Adjust the wall or opening location slightly to ensure proper clearance for doors or windows.

								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash5	New	-0.375	D-8 : LEVEL 01	Hard	2024/10/21 08:49	x:11.646, y:4.704, z:74.568	*Element ID:* 11625863	ROOF	09 - Gypsum Wall Board	Solid	*Element ID:* 11610840	ROOF	Default Roof	Solid

Figure 5.7: Moderate Clash Element ID: 5

C. Minor Clash (Aesthetic or Tolerable)

Minor Clash Example: Element ID: 9

i. **Element: Decorative Roof Beam vs Wood Glu,** A Decorative Roof Beam Feature Aesthetic look to the elevation of structure seems intersected with its connecting element i.e. Wood Glu Lam

ii. **Issue:** Affects aesthetics but does not affect the functionality or safety of the building. It's a minor issue that can be easily resolved or no need to be resolved

iii. **Resolution Suggestion:** Adjust the connecting element or leave it as it can be easily adjusted on site at time of construction

								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash9	New	-0.356	I-9 : LEVEL 01	Hard	2024/10/21 08:49	x:-3.200, y:32.258, z:75.523	*Element ID:* 11036234	ROOF	Roof Beam	Solid	*Element ID:* 11036124	ROOF	Wood - Glu Lam	Solid

Figure 5.8: Minor Clash Element ID no 9

5.2. STRUCTURE VS. ARCHITECT (479 CLASHES)

Conflicts between structural and architectural elements fall under this category. These disputes occur when structural components like beams, columns, and load-bearing walls clash with architectural features like windows, walls, and room arrangements. There were 479 confrontations found in this category overall.

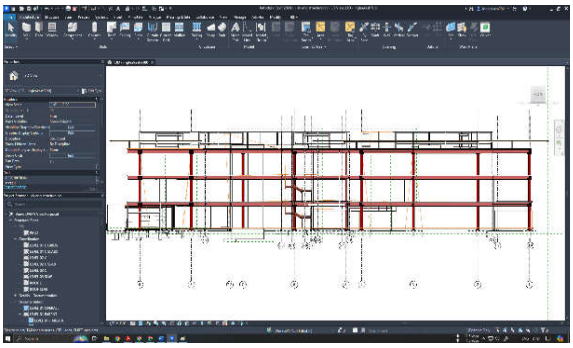


Figure 5.9: - Revit Structure 3D Plan

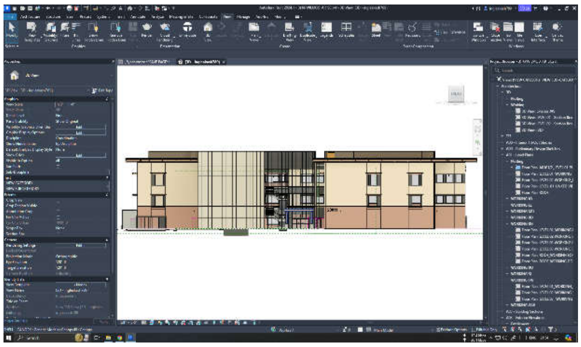


Figure 5.10: - Revit Architecture 3D Plan

5.2.1 Detailed Example of Clashes in Architectural vs Structural Elements

When structural components (such as columns, beams, slabs, foundations, etc.) and architectural features (such as walls, doors, windows, floors, and ceilings) misalign or collide, conflicts arise. This is known as architectural vs. structural collision detection. These conflicts are crucial as they may compromise the building's structural soundness, usability, and safety. The influence these conflicts have on the whole design and construction process determines how serious they are. Examples of severe, moderate, and minor confrontations are shown below and Table 5.2 classifies clashes by their categorization.

Table 5.2: Summary Metrics Architectural vs Architectural

Category	Number of Clashes	Percentage	Priority
Severe	120	25.1%	High (Resolve First)
Moderate	280	58.5%	Medium
Minor	79	16.5%	Low
Total	**479**	**100%**	**-**

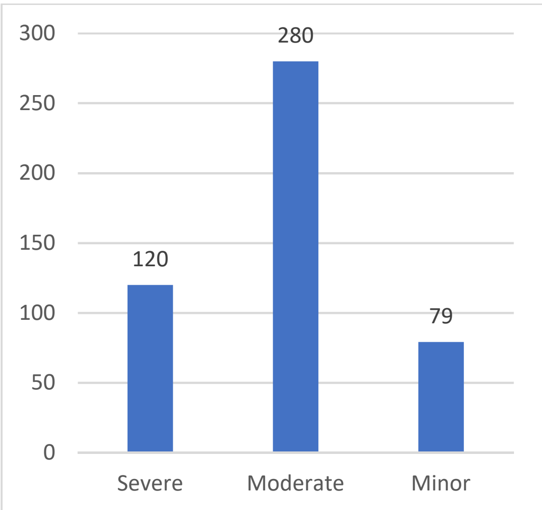


Figure 5.11: Number of Clashes

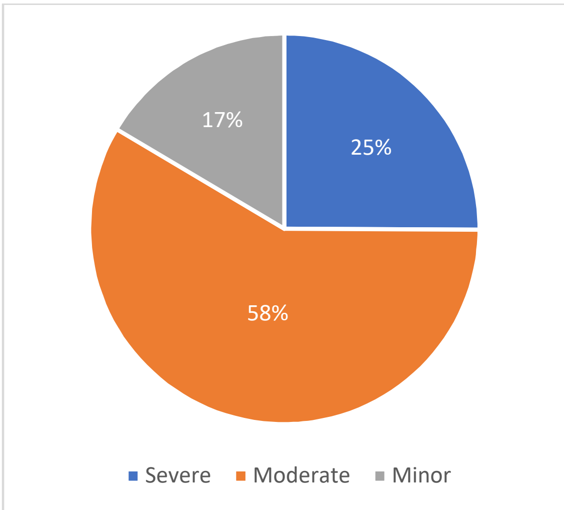


Figure 5.12: Percentage

A. Severe Clash (Critical Impact)

Severe Clash Example: Element ID: 982

i. **Element: Column vs Wall (Load-Bearing)** A structural column interferes with a load-bearing wall, causing misalignment between the two systems.

ii. **Issue:** Disrupts the building's load-bearing capacity. Can cause significant delays in the project as both the column and wall layout need major redesigns to maintain structural stability.

iii. **Resolution:** Reposition the column or move the load-bearing wall to ensure proper alignment and structural integrity.

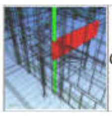
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash982	Active	-0.139	C-6 : LEVEL 01	Hard	2024/10/21 09:04	x:30.838, y:-1.045, z:64.008	*Element* ID: 11126065	LEVEL 01	Default Wall	Solid	*Element* ID: 1693779	LEVEL 01	Steel ASTM A500, Grade B, Rectangular and Square	Solid

Figure 5.13: Severe Clash Element ID: 982

B. Moderate Clash (Design Adjustments Needed)

Moderate Clash Example: Element ID: 470

i. **Element: Gypsum Wall vs Structural Element (Ridge Beam)** A vertical wall is positioned where a ridge beam is located, interfering with the structural component.

ii. **Issue:** Affects the space and load distribution but does not immediately compromise the structural safety of the building. Requires minor adjustment of the wall or beam to clear the area for both systems to function properly.

iii. **Resolution:** Move the wall slightly or adjust the ridge beam design to accommodate the wall placement.

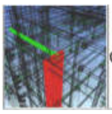
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash470	Active	-0.228	C-7 : LEVEL 01	Hard	2024/10/21 09:04	x:21.831, y:-0.238, z:73.789	*Element* ID: 11911212	LEVEL 01	09 - Gypsum Wall Board	Solid	*Element* ID: 1101002	LEVEL 01	Steel ASTM A992	Solid

Figure 5.14: Moderate Clash Element ID: 470

C. Minor Clash (Aesthetic or Tolerable)

Minor Clash Example: Element ID: 135

i. **Element: Column vs Floor Level,** A Column does not align perfectly with the floor level, creating a slight misalignment.

ii. **Impact:** Can be resolved by minor adjustments to the **Floor Level** cornering positioning.

iii. **Resolution:** no need to do any specific changes this can be easily solved on site

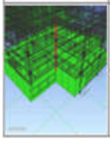
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash135	Active	-0.457	B-2 : LEVEL 01	Hard	2024/10/21 09:04	x:59.782, y:-5.994, z:60.960	*Element ID:* 634969	LEVEL 01	Steel ASTM A500, Grade C, Rectangular and Square	Solid	*Element ID:* 2028468	LEVEL 01	Analytical Panels	Solid

Figure 5.15: Minor Clash Element ID: 135

5.3. ARCHITECT VS MEP (391 CLASHES)

There have been 391 disputes found in the Architect vs. MEP category, which addresses conflicts between architectural features and MEP systems. These conflicts usually arise when walls, ceilings, or other architectural elements are intruded upon by MEP systems, such as HVAC systems, ducts, pipes, and electrical conduits.

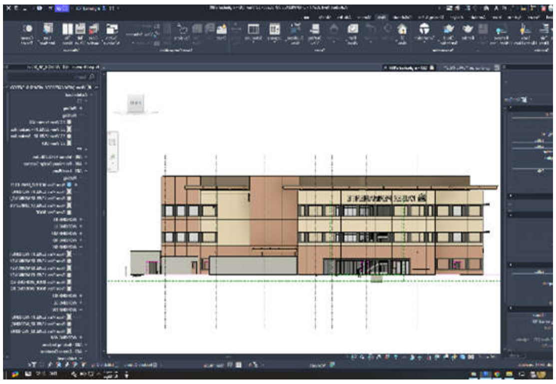


Figure 5.16: - Revit Architecture 3D Plan

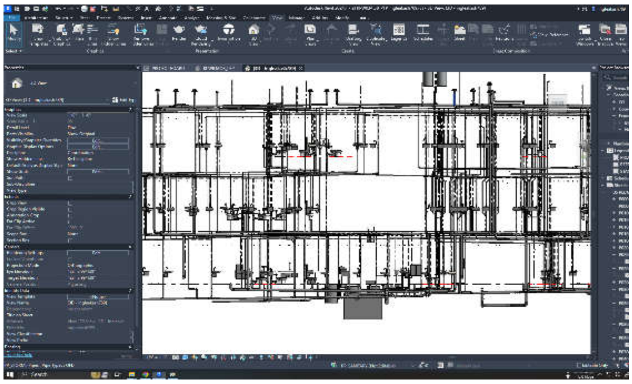


Figure 5.17: - Revit MEP 3D Plan

5.3.1 Detailed Example of Clashes in Architectural vs MEP (Mechanical, Electrical, Plumbing)

When MEP systems like HVAC ducts, electrical conduits, plumbing pipes, or fire protection systems cross or misalign with building elements like walls, doors, ceilings, or floors, conflicts occur. This is known as **architectural vs. MEP clash detection**. These conflicts may affect the building's usability, effectiveness, and aesthetic appeal; in certain cases, they could even risk safety. Examples of **severe, moderate, and minor conflicts** between architectural and MEP aspects are provided below. and Table 5.3 classifies clashes by their categorization.

Table 5.3: Summary Metrics Architectural vs Architectural

Category	Number of Clashes	Percentage	Priority
Severe	90	23%	High (Resolve First)
Moderate	240	61%	Medium
Minor	61	16%	Low
Total	**391**	**100%**	**-**

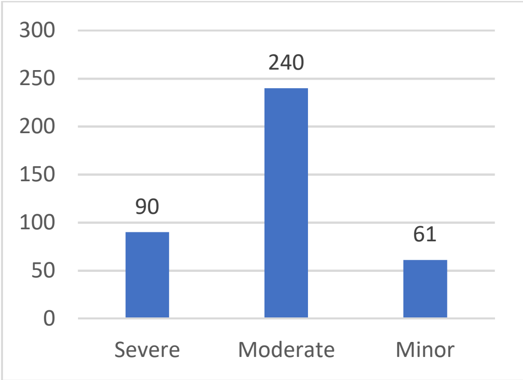


Figure 5.18.: Number of Clashes

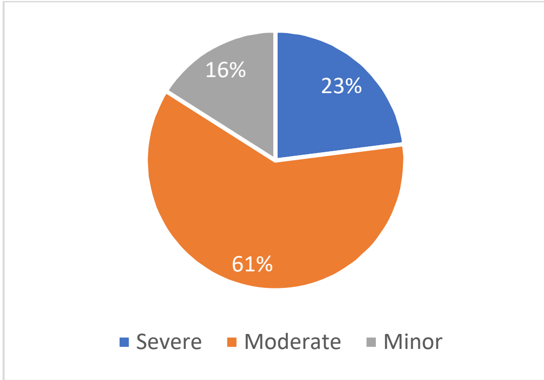


Figure 5.19: Percentage

A. Severe Clash (Critical Impact)

Severe Clash Example: Element ID: 73

i. **Element: Exterior Wall vs Plumbing Element,** the placement interferes with specific standardized plumbing element, causing a misalignment between the plumbing system and Architectural elements.

ii. **Issue:** Affects the building's **Waterflow system** and the **structural integrity** of the load-bearing wall. Plumbing element may need to be rearranged in another place, and the wall's position could require adjustment.

iii. **Resolution:** Adjust the Plumbing element position or move the wall to ensure that both systems can coexist without compromising the building's safety or functionality.

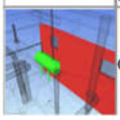
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash73	Active	-0.157	J-9 : LEVEL 01	Hard	2024/10/21 09:13	x:-1.029, y:73.072, z:62.029	*Element ID:* 11648637	LEVEL 01	07 - Finishes - Exterior - Plaster and Lathe	Solid	*Element ID:* 1773843	PFP Level 01	120 Gallon	Solid

Figure 5.20: Severe Clash Element ID: 73

B. Moderate Clash (Design Adjustments Needed)

Moderate Clash Example: Element ID: 309-310

i. **Element: Plumbing Pipes vs Interior Wall**, Plumbing pipes run along the interior walls and intersect with architectural features such as windows, doors, or built-in cabinets. **sudden change in the size of pipeline cause clash with wall**

ii. **Issue:** This can result in minor space adjustments but does not compromise the building's overall function. The plumbing system might need to be slightly rerouted or the wall design altered.

iii. **Resolution:** Shift the plumbing pipes slightly to avoid obstructions or adjust the interior wall design to accommodate the pipes.

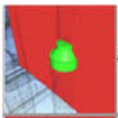
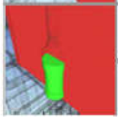
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash309	Active	-0.059	C-7 : LEVEL 01	Hard	2024/10/21 09:13	x:14.193, y:-0.406, z:65.652	*Element ID:* 11514909	LEVEL 02	09 - Metal - Stud Layer	Solid	*Element ID:* 1871439	PFP Level 02	Standard	Solid
	Clash310	Active	-0.059	C-7 : LEVEL 01	Hard	2024/10/21 09:13	x:14.261, y:-0.406, z:70.071	*Element ID:* 11514914	LEVEL 03	09 - Metal - Stud Layer	Solid	*Element ID:* 1876187	LEVEL 03	Standard	Solid

Figure 5.21: Moderate Clash Element ID: 309-310

C. Minor Clash (Aesthetic or Tolerable)

Minor Clash Example: Element ID: 432-433

i. **Element: Plumbing Pipes vs Non-Structural Partition Walls,** Plumbing pipes run along non-structural partition walls, causing slight alignment issues with the wall design.

ii. **Issue:** The clash does not affect the structural integrity of the building or the plumbing system's functionality. This clash can be resolved with minor design adjustments to the plumbing layout or partition wall alignment.

iii. **Resolution:** Adjust the plumbing routing or partition wall layout to resolve the clash.

								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash432	Active	-0.045	C-7 : LEVEL 01	Hard	2024/10/21 09:13	x:13.770, y:-0.427, z:61.648	*Element ID:* 11089473	LEVEL 01	09 - Gypsum Wall Board	Solid	*Element ID:* 1806450	PFP Level 01	Copper	Solid
	Clash433	Active	-0.045	C-7 : LEVEL 01	Hard	2024/10/21 09:13	x:13.770, y:-0.427, z:70.487	*Element ID:* 11112594	LEVEL 03	09 - Gypsum Wall Board	Solid	*Element ID:* 1805544	LEVEL 03	Copper	Solid

Figure 5.22: Minor Clash Element ID: 432-433

5.4. STRUCTURE VS MEP (1,399 CLASHES)

The largest number of conflicts—1,399—occurred between MEP systems and structural elements. While MEP systems must be flexible and adaptable, structural systems like beams, columns, and slabs are usually fixed. When merging the two systems, these competing requirements frequently cause conflicts.

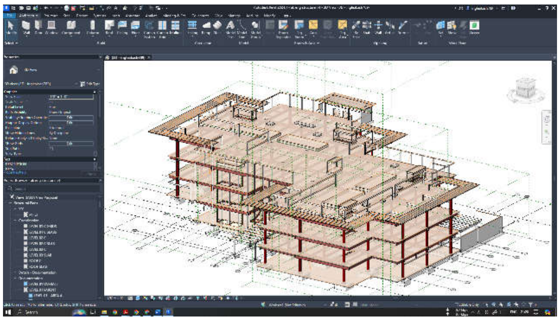


Figure 5.23: - Revit Structure 3D Plan

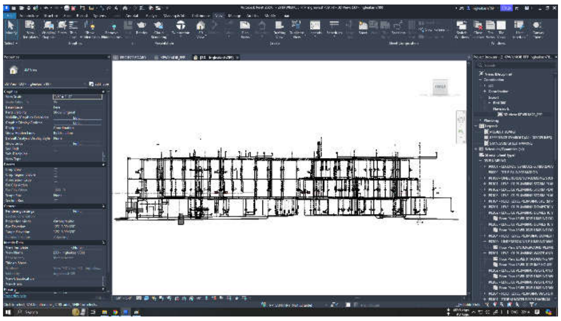


Figure 5.24: - Revit MEP 3D Plan

5.4.1 Detailed Example of Clashes in Structural vs MEP (Mechanical, Electrical, Plumbing)

Conflicts between structural components like beams, columns, slabs, or foundations and MEP systems like HVAC ducts, plumbing pipes, electrical conduits, or fire protection systems arise during **structural vs. MEP clash**

detection. These conflicts can compromise the building's efficiency, utility, and structural soundness, and their resolution frequently calls for close teamwork. Examples of **minor, moderate, and severe conflicts** between structural and MEP aspects are shown below. Additionally, table no. contains a summary of the categorized data and Table 5.4 classifies clashes by their categorization.

Table 5.4: Summary Metrics Architectural vs Architectural

Category	Number of Clashes	Percentage	Priority
Severe	320	22.9%	High (Resolve First)
Moderate	820	58.6%	Medium
Minor	259	18.5%	Low
Total	**1399**	**100%**	**-**

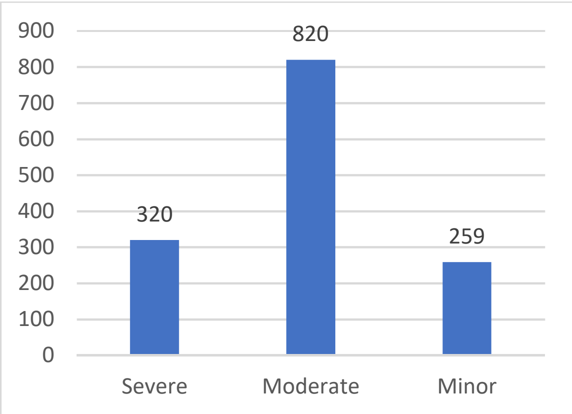


Figure 5.25.: Number of Clashes

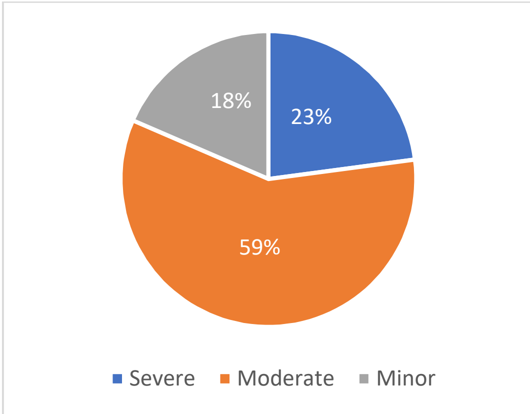


Figure 5.26.: Percentage

A. Severe Clash (Critical Impact)

Severe Clash Example: Element ID: 2678

i. **Element: Beam vs Plumbing Pipes (Vertical Routing),** Plumbing pipes for vertical distribution (e.g., wastewater, vent stacks) clash with a structural beam in the ceiling or floor slab.

ii. **Issue:** The clash blocks the planned routing of the plumbing system and may force a redesign of the floor or ceiling slab. It could also interfere with load distribution, requiring structural modifications.

iii. **Resolution:** Adjust the beam placement or reroute the plumbing pipes to avoid structural interference while maintaining the flow of services.

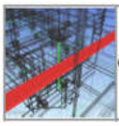
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash2678	Active	-0.016	I-4 : LEVEL 01	Hard	2024/10/21 10:12	x:38.502, y:25.875, z:69.657	*Element ID:* 1096489	LEVEL 03	Steel ASTM A992	Solid	*Element ID:* 1270738	LEVEL 03	Copper	Solid

Figure 5.27: Severe Clashes Element ID: 2678

B. Moderate Clash (Design Adjustments Needed)

Moderate Clash Example: Element ID: 1312

i. **Element: Slab vs Plumbing System** The placement of an plumbing system (e.g., Fire safety water Sprinklers) clashes with the structural slab's reinforcement or thickness, causing interference in their routing.

ii. **Issue:** A minor issue that impacts space allocation but does not compromise structural stability. Plumbing system adjustments or slab modifications may be necessary, but it does not result in critical failure.

iii. **Resolution:** Reroute the Plumbing system slightly or adjust the slab's thickness or reinforcement to ensure proper installation of both systems.

								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash1312	Active	-0.070	F-2 : LEVEL 01	Hard	2024/10/21 10:12	x:57.613, y:11.672, z:74.219	*Element ID:* 638136	ROOF	Concrete - Cast-in-Place Concrete	Solid	*Element ID:* 1229013	<No level>	4" OFD	Solid

Figure 5.28: Moderate Clash Element ID: 1312

C. Minor Clash (Aesthetic or Tolerable)

Minor Clash Example: Element ID: 289

i. **Element: Plumbing Fixtures vs Structural Elements**, Plumbing fixtures such as faucets or showerheads clash with structural elements like load-bearing walls or partitions.

ii. **Issue:** This is typically an **aesthetic or spatial issue**, as the plumbing fixture placement is affected but does not compromise the **functionality** of the plumbing system or **structural stability**. The fixture or wall placement can be adjusted with minor changes.

iii. **Resolution:** Move the plumbing fixture slightly or adjust the wall layout to clear the path.

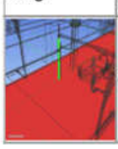
								Item 1				Item 2			
Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash289	Active	-0.159	G-9 : LEVEL 01	Hard	2024/10/21 10:12	x:0.052, y:16.433, z:60.833	*Element ID:* 641035	LEVEL 01	Concrete - Cast-in-Place Concrete	Solid	*Element ID:* 1784121	ROOF	Polyvinyl Chloride - Rigid	Solid

Figure 5.29: Minor Clash Element ID: 289

5.5 DISCUSSION REPORT: QUANTIFYING THE IMPACT OF CLASH DETECTION USING BIM

A thorough collision detection test using Building Information Modeling (BIM) found 2,714 clashes in four major disciplines: architect vs. architect, architect vs. structure, architect vs. MEP, and structure vs. MEP. Based on their impact, these conflicts were divided into three categories: severe, moderate, and minor. This conversation focuses on how resolving these conflicts enhanced the project by decreasing rework, improving collaboration, and cutting down on delays and cost overruns. Below table 5.5 shows summarized clash detection result category wise

Table 5.5: Summary of Clash Detection Results

Category	Severe Clashes	Moderate Clashes	Minor Clashes	Total Clashes 2,714
Architect vs Architect	80 (16.7%)	300 (62.8%)	98 (20.5%)	478
Architect vs Structure	120 (25.1%)	280 (58.5%)	79 (16.5%)	479
Architect vs MEP	90 (23%)	240 (61%)	61 (16%)	391
Structure vs MEP	320 (22.9%)	820 (58.6%)	259 (18.5%)	1,399

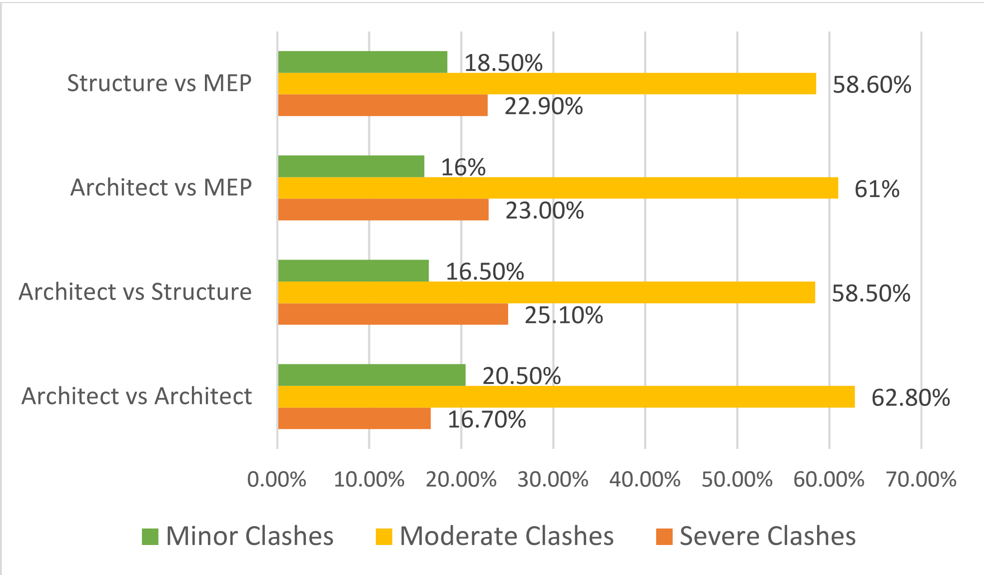


Figure 5.30: - Clash Detection Results

5.5.1 Quantifying the Impact of Clash Resolution

a. Reduced Rework During Building Construction: Rework during construction was reduced by addressing severe and moderate conflicts during the design phase, which resulted in significant labor, material, and time savings.

i. **Examples:** Architect vs. Structure: Expensive structural alterations were avoided by resolving 120 serious conflicts between columns and load-bearing walls. o Structure vs. MEP: By resolving beam and plumbing interference (320 serious clashes), structural installations were maintained.

ii. **Impact:** Construction rework is estimated to be reduced by 30–40% when compared to projects that do not employ BIM-based collision detection. There were few on-site corrections made for small conflicts (such as decorative beam overlaps).

b. Enhanced Coordination Between Disciplines: A clash detection process created better communication between, and better coordination among, the disciplines, thereby enabling smoother workflows and tighter integration of the architectural and structural and MEP systems.

i. **Examples:** Architect vs. MEP: 240 moderate HVAC duct conflicts with ceilings were settled cooperatively, guaranteeing acceptable system routing. Architect vs. Architect: 300 minor conflicts or misaligned apertures were fixed to bring architectural designs into alignment with other elements.

ii. **Impact:** Regular BIM model reviews and teamwork have resulted in a 50% approximate reduction in the time needed to resolve highlighted disputes. Better integration of MEP systems with architectural and structural components, which lessens design irregularities in the future.

c. Minimized Delays and Cost Overruns: Potential delays and cost overruns were reduced by the early detection and settlement of conflicts. Addressing major clashes saved disruptions that would have required extensive modification during construction.

i. **Examples:** Structure vs. MEP: In order to preserve structural integrity and prevent schedule disruptions, plumbing pipes that collided with structural beams (320 serious clashes) were rerouted.

ii. **Impact:** By avoiding delays caused by structural and system conflicts, an estimated 25 to 30 construction days were saved. Reduced material waste and early resolution of important conflicts resulted in Approx cost savings of ₹12–15 lakh.

5.5.2 Improvements to Project Outcomes

Table 5.6: Improvement in Different Aspects

Aspect	Improvement
Rework Reduction	By addressing severe and moderate disputes during the design phase, rework can be roughly reduced by 30 to 40%.
Enhanced Coordination	enhanced interdisciplinary collaboration, a 50% roughly reduction in resolution time, and seamless design integration.
Delays Avoided	saved roughly 25–30 construction days by avoiding schedule delay.
Cost Savings	prevented cost overruns and saved ₹12–15 lakh roughly on time, labor, and materials.
Improved Design Quality	All identified conflicts (2,714) have been resolved, improving design usability, aesthetics, and adherence to safety standards.

6. CONCLUSION

Research on clash detection in construction project using Building Information Modeling (BIM) stresses the importance of how it contributes to construction practice. It has worked very well at filling the gap between design and execution by creating detailed 3D models, and incorporating integration of tools like Autodesk Revit and Navisworks in this process. These virtual models represent the whole project as complete and comprehensive representation of interrelated architectural, structural and MEP systems, and used to anticipate and eliminate future clashes in design phase. With this proactive approach, any problems like misaligned ducts, structural beams that messed up with the ducting and building components that stepped over ducting are anticipated and corrected before start of construction to expedite the project readiness for on-site implementation.

6.1. Challenges within traditional construction techniques.

The current traditional construction process is typically hindered by a lack of effective interdisciplinary coordination between the architectural, structural and MEP systems. These challenges result in: **Design-Execution Gap**, **Manual Clash Detection**, **On-Site Adjustments**, **Resource Mismanagement**, **Poor Coordination**, **Higher Costs and Delays and Limited Adaptability**

6.2. Research Contributions and Solutions

In order to find and classify 2,714 conflicts across the architectural, structural, and MEP disciplines, this study used BIM-based collision detection. The results showed that a:

i. **BIM's Importance in Clash Identification:** Uses intricate 3D models to close the gap between design and implementation, provides thorough system representation by integrating programs like Autodesk Revit and Navisworks, Foresees and resolves design conflicts prior to the start of construction.

ii. **BIM's Principal Contributions:** Recognizes and reduces risks such as design compromises, delays, and budget overruns, increases efficiency by minimizing on-site modifications and redesigns.

iii. **Efficiency and Sustainability:** Promotes environmentally friendly building methods and waste reduction, Improves communication and cooperation amongst project participants.

iv. **Strategic Benefits:** Guarantees the timely, economical, and superior completion of projects, makes "what-if" scenario planning possible for more flexibility, enhances teamwork by producing designs that are technically sound, visually pleasing, and devoid of conflicts.

v. **BIM as a Tool for Strategy:** Goes beyond settling disputes to become necessary for contemporary building, Encourages sustainable practices, efficiency, and risk mitigation.

vi. **Benefits of Categorization:** Prioritized Resolution: Allocating resources to resolve severe clashes first ensures that critical project milestones remain unaffected, Enhanced Decision-Making: Stakeholders can focus on high-impact issues while tracking minor ones for later stages. Optimized Workflow Categorization streamlines coordination efforts, reducing confusion and redundant efforts across teams, Improved Cost Management: Identifying the severity of clashes allows for better budgeting and allocation of contingency funds.

6.3. Future Directions for Research

Even if BIM-based conflict detection greatly enhances building procedures, more study might concentrate on:

i. **Integration with Emerging Technologies:** To improve real-time decision-making and predictive analytics, investigate combining BIM with AI, ML, and IoT. Use augmented reality (AR) and virtual reality (VR) to discover conflicts and conduct immersive design assessments.

ii. **Automation in Clash Detection:** Create automated systems that can identify and resolve clashes in real time while the design process is underway. Use generative design methods to proactively avoid conflicts.

iii. **Standardization Across Platforms:** To enhance interoperability among BIM systems, like as Revit, Navisworks, and others, establish universal data exchange standards.

iv. **Training and Skill Development:** To enhance clash detection procedures and increase BIM utilization, provide specific training programs for professionals.

v. **International Case Studies and Benchmarks:** Gather and examine international case studies to compare best practices and pinpoint areas where BIM implementation needs to be improved.

REFERENCES

[1] Abubakkar Sidiq A, D. P. T. (2018). Study on implementation of Clash Detection tool in housing project using BIM.

[2] A. M. Radke, T. W., M. M. Tseng. (2009). An Automated Approach for Identification and Resolution of Spatial Clashes in Building Design.

[3] Akponeware, A., & Adamu, Z. (2017). Clash Detection or Clash Avoidance? An Investigation into Coordination Problems in 3D BIM. Buildings, 7, 75-103. https://doi.org/10.3390/buildings7030075

[4] Farnsworth, C., Beveridge, S., Miller, K., & Christofferson, J. (2014). Application, Advantages, and Methods Associated with Using BIM in Commercial Construction. International Journal of Construction Education and Research, 11, 1-19. https://doi.org/10.1080/15578771.2013.865683

[5] Global, J. H. M. G. L. L. M. (2011). Beyond the Limits: Using Autodesk® Revit® and Navisworks® Manage for Design Collaboration on Large-Scale Projects [Conference Paper]. *Autodesk University*.

[6] Juszczyk, M., Wieczorek, D., Pacyno, H., & Dzienniak, A. (2023). *Clash Detection Based on IFC/BIM Models – Case Studies Process Parameterization*. https://doi.org/10.5592/CO/SENET.2022.8

[7] Kassem, M., Brogden, T., & Dawood, N. (2012). BIM and 4D planning: a holistic study of the barriers and drivers to widespread adoption. *Journal of Construction Engineering and Project Management*, *2*. https://doi.org/10.6106/JCEPM.2012.2.4.001

[8] Khanzode, A., Fischer, M., & Reed, D. (2008). Benefits and lessons learned of implementing Building Virtual Design and Construction (VDC) technologies for coordination of Mechanical, Electrical, and Plumbing (MEP) systems on a large Healthcare project. Journal of Information Technology in Construction, 13.

[9] Leite, F., Akinci, B., & Garrett, J. (2009). *Identification of Data Items Needed for Automatic Clash Detection in MEP Design Coordination*. https://doi.org/10.1061/41020(339)43

[10] Riley, D., Varadan, P., James, J., & Thomas, H. (2005). Benefit-Cost Metrics for Design Coordination of Mechanical, Electrical, and Plumbing Systems in Multistory Buildings. *Journal of Construction Engineering and Management-asce - J CONSTR ENG MANAGE-ASCE*, *131*.

[11] Sood, R., & Laishram, B. (2024). Challenges in Implementation of 7D-BIM for Infrastructure Asset Management: A Systematic Review. *Construction Economics and Building*, *24*. https://doi.org/10.5130/AJCEB.v24i3.8738