



CLASH DETECTION ANALYSIS OF RSIA BUILDING CONSTRUCTION USING AUTODESK REVIT AND NAVISWORKS

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ABSTRACT

Clashes between objects in construction projects often lead to delays, increased costs, and rework due to a lack of coordination between disciplines and the limitations of traditional clash detection technologies. This study evaluates the effectiveness of implementing clash detection based on Building Information Modeling (BIM) using Autodesk Revit and Navisworks in reducing rework, additional costs, and project duration. The research adopts a quantitative method using secondary data, including 3D models, time schedules, and Unit Price Analysis. The analysis identified a total of 964 clashes, consisting of 274 structure and mechanical-plumbing (MP) clashes, 603 architectural and MP clashes, and 87 structure and architectural clashes. The implementation of clash detection resulted in a rework reduction of 0.34% and a total cost saving of 4.63%, which includes savings in structural work (0.08%), architectural work (7.76%), and MP work (0.06%). Avoided rework includes the demolition of 4.93 m³ of concrete, 70.81 m² of walls, 1051.11 m² of ducting relay layout, and 1.05 m of pipe relocation. Additionally, the potential time saving is estimated at 41.7 days or 7.79% of the total project duration.

Keywords: Autodesk Naviswork, Autodesk Revit, Building Information Modelling, Clash Detection

1. INTRODUCTION

Clashes between construction elements such as structural, architectural, and MEP (mechanical, electrical, and plumbing) systems are among the major challenges in construction projects. These clashes often result in project delays, increased costs, and reduced construction quality. They are primarily caused by a lack of coordination among different disciplines, which tend to work separately using their own sets of drawings and specifications. The continued use of traditional 2D-based planning methods further increases the risk of clashes during the integration of design components in the field [1], [2]. The more complex a building's design, the greater the likelihood of clashes—especially in modern buildings with dense and intricate MEP systems that must be accommodated in limited spaces. Design changes during construction, without proper coordination, can also lead to new undetected clashes [2].

In projects that do not implement advanced clash detection technologies, clash identification is typically performed manually using 2D drawings, which is time-consuming

and prone to errors [3]. Undetected or unresolved clashes can have serious consequences, including rework, redesign, material waste, and safety risks on-site due to deviations between design and actual construction conditions [3]. This issue was evident in the case study of the RSIA hospital construction project, where several clashes between architectural, structural, and MEP components were only discovered during the construction phase. As a result, redesigns and rework were required, leading to inefficiencies in both time and cost. These problems highlight the importance of utilizing Building Information Modeling (BIM) with integrated Clash Detection features to proactively identify and resolve clashes during the design phase.

The implementation of Clash Detection using BIM has been proven to improve project efficiency by significantly reducing design clashes, minimizing rework, and accelerating project completion [4]. This technological approach aligns with lean construction principles, such as waste minimization and value maximization, which were applied by the project contractor, PT. Hutama Karya. Several studies have shown that BIM implementation can reduce project costs by up to 10% and shorten project durations by up to 7% [2]. Furthermore, BIM enhances coordination and communication across project teams, ultimately improving overall project performance [1], [3].

This study aims to explore the extent of rework and additional costs that arise from undetected clashes during the planning stage, as well as to evaluate how the implementation of Clash Detection contributes to cost and time savings in construction projects.

2. THEORY AND METHODS

2.1 Theory

Building Information Modeling (BIM) 3D is a digital process utilized in the planning, design, construction, and management of buildings and infrastructure. By creating a comprehensive digital representation of a building's physical and functional characteristics, BIM enables collaboration among stakeholders such as architects, engineers, and contractors within a single integrated model. This approach enhances project efficiency and reduces design errors [2]. BIM 3D comprises several key aspects, including 3D modeling with detailed geometric and material data, collaborative coordination supported by interoperability across disciplines, and centralized information management throughout the building's lifecycle.

One of BIM's most powerful features is clash detection, which identifies potential conflicts between architectural, structural, and MEP components early in the design phase. These clashes are classified as hard (physical overlap), soft (violation of clearance zones), and workflow (scheduling issues) [5], [6]. The use of tools such as Autodesk Revit and Navisworks facilitates detection and resolution of these issues before construction, leading to improved design quality, cost savings, and time efficiency [2], [7].

Complementary to BIM, lean construction is a project management philosophy rooted in the Toyota Production System that emphasizes value creation and waste elimination. Introduced by Koskela [8], lean construction seeks to improve workflow reliability, reduce variability, and optimize resource usage. Core principles include identifying value from the customer's perspective, ensuring continuous process flow, eliminating non-value-adding activities, implementing pull-based systems, and pursuing continuous improvement (Kaizen). Practical tools supporting lean construction include the Last Planner System (LPS), Value Stream Mapping (VSM), Just-In-Time (JIT), 5S methodology, and Integrated Project Delivery (IPD), all aimed at enhancing collaboration, reducing delays, and maximizing customer satisfaction [9].

Another critical application of BIM is quantity takeoff, which allows for the extraction of material quantities directly from the 3D model. Compared to traditional manual methods, BIM-

based quantity takeoff is significantly more accurate and efficient, capable of reducing time requirements by up to 80% and improving estimation accuracy by up to 3% [10], [11]. BIM models update quantities automatically when design changes occur, ensuring that cost and scheduling decisions are based on the most current data [1], [12].

To manage project timelines, a well-structured time schedule outlines each construction activity along with its start date, duration, and end date, allowing for better project control [13]. Cost estimation is supported by unit price analysis, which calculates the cost of labor, materials, and equipment. This method forms the basis of cost planning and is crucial for determining project budgets [14]. The total unit price incorporates both direct and indirect costs, including overhead and profit margins.

Furthermore, in analyzing work duration, especially for rework scenarios, it is essential to consider the volume of work and labor productivity. The duration is calculated using productivity coefficients sourced from relevant local unit price analysis data, ensuring results align with actual site conditions [15]. The formula used for duration estimation accounts for volume, work coefficient, and the number of workers, allowing for accurate planning of additional work caused by design clashes and rework.

2.2 Methods

This study uses a quantitative approach through secondary data on the RSIA construction project. BIM 3D models were created using Autodesk Revit, followed by clash detection analysis using Navisworks to identify design conflicts. After correcting the model, material volumes were recalculated through quantity takeoff. Time and cost impacts of rework were analyzed using AHSP coefficients and calculated with Microsoft Excel. The results were compared to assess the effectiveness of clash detection on project efficiency.

3. RESULTS AND DISCUSSION

The 3D models for Structural, Architectural, and Mechanical-Plumbing (MP) elements were developed using Autodesk Revit 2024, as shown in Figures 1 to 3. In this study, the structural modeling analyzed includes columns, beams, and floor slabs. For the architectural elements, the analysis focused on doors, windows, and railings. Meanwhile, the MP modeling covered ductwork and piping systems. Although the research utilized secondary data in the form of existing 2D drawings and project specifications from the RSIA construction project, all 3D BIM models were created from scratch by the research team based on these references to ensure accuracy and consistency in geometric detail and level of development (LOD).



Figure 1. Structural Model



Figure 2. Architectural Model



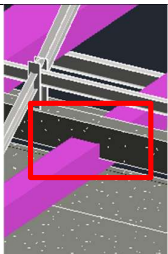
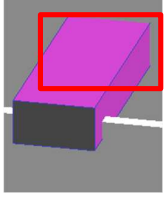
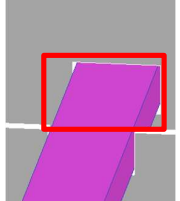
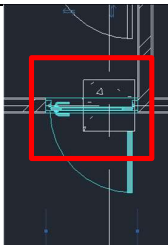
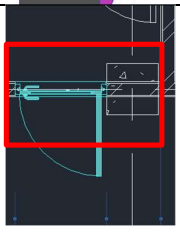
Figure 3. Mechanical Plumbing Model

Clash detection analysis was carried out on three combinations of elements: structure vs MP, architecture vs MP, and structure vs architecture. This process used Autodesk Navisworks

to identify clashes between elements, which were then corrected using Autodesk Revit. An example of the identified clashes is shown in Table 1.

As a result, a total of 964 clashes were detected, consisting of 274 clashes between structure and MP, 603 clashes between architecture and MP, and 87 clashes between structure and architecture. After corrections were made, all clashes were successfully eliminated through iterative re-modeling.

Table 1. Clash Identification Example

Details	Identification	Resolve
STR vs MP Clash between ducting (ID:1205559) and beam (ID:1321231)		
ARS vs MP Clash between ducting (ID:1210088) and wall (ID:1016255)		
STR vs ARS Clash between door (ID: 970282) and column (ID: 1116470)		

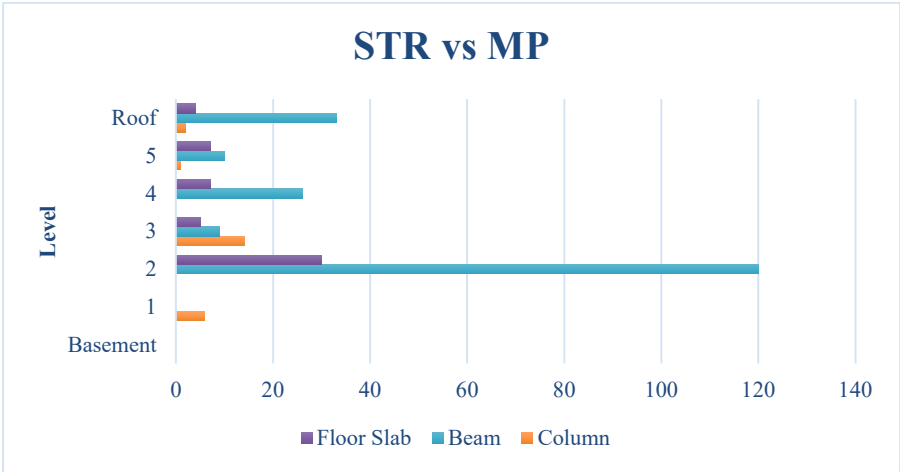


Figure 4. Clash Grouping Diagram between Structural and MP Elements on Each Floor

Clashes between structure and MP, as seen in Figure 4, occurred in beams (198 cases), floor slabs (53 cases), and columns (23 cases), mainly caused by design discrepancies such as the absence of shafts and design errors like element overlaps.

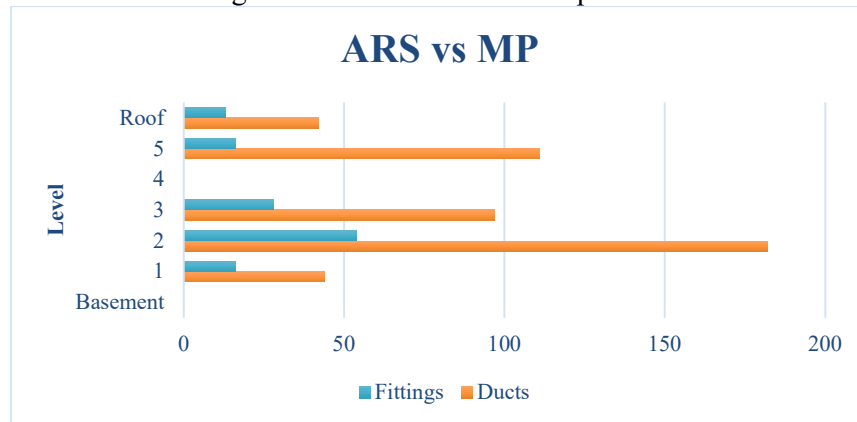


Figure 5 Clash Grouping Diagram between Architectural and MP Elements on Each Floor

Meanwhile, all clashes between architecture and MP, as shown in Figure 5, were caused by missing wall openings for duct and pipe installations (603 cases).

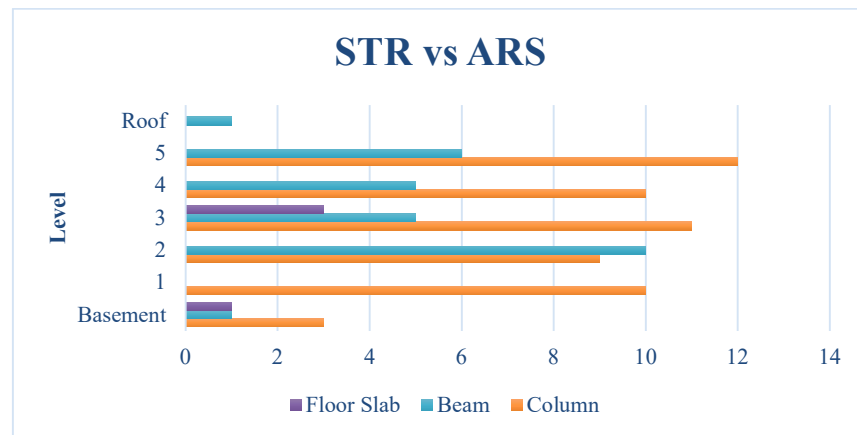


Figure 6. Clash Grouping Diagram between Structural and Architectural Elements on Each Floor

Clashes between structure and architecture, as seen in Figure 6, were dominated by collisions involving doors (36 cases), windows (12 cases), and railings (39 cases) with structural elements, commonly due to layout errors.

Overall, out of the 964 clashes, 656 (68.1%) were caused by design discrepancies between disciplines, while 308 (31.9%) resulted from design errors. The identification and correction of these clashes demonstrate that the implementation of BIM with clash detection can improve cross-disciplinary coordination and reduce the risk of rework in construction project execution.

The quantity take-off analysis was conducted to identify changes in material volumes and project costs before and after the model corrections based on clash detection. The results indicate that design corrections led to material savings and a reduction in rework costs.

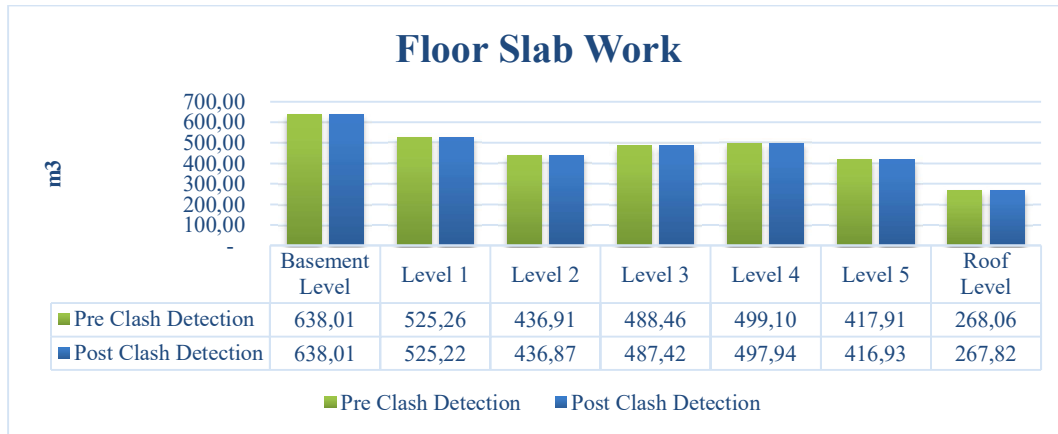


Figure 7. Comparison of Floor Slab Work Volumes

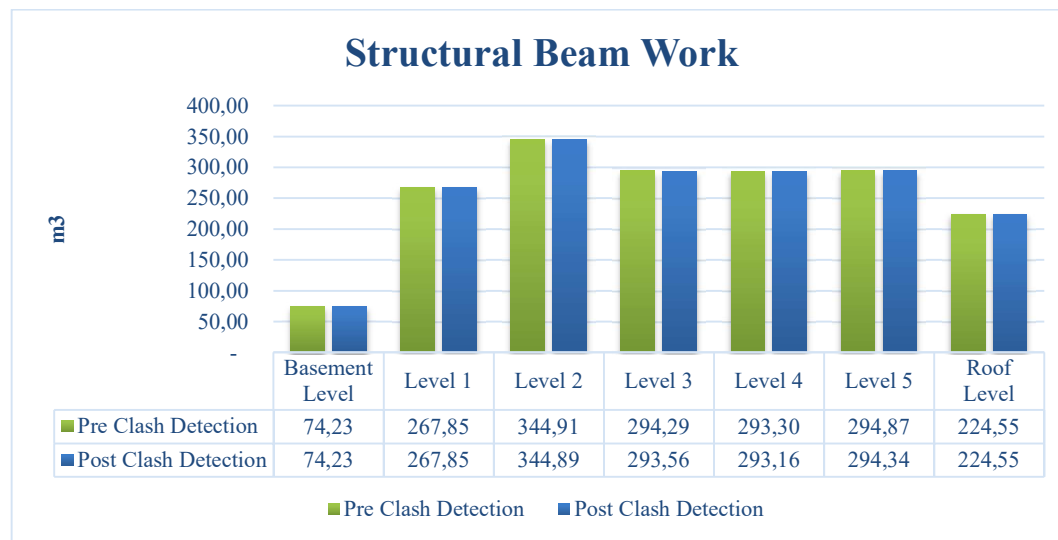


Figure 8. Comparison of Beam Work Volumes

For structural elements, as shown in Figures 7–8, there was a reduction in concrete volume by 5.03 m³, resulting in a cost saving of 0.08%.

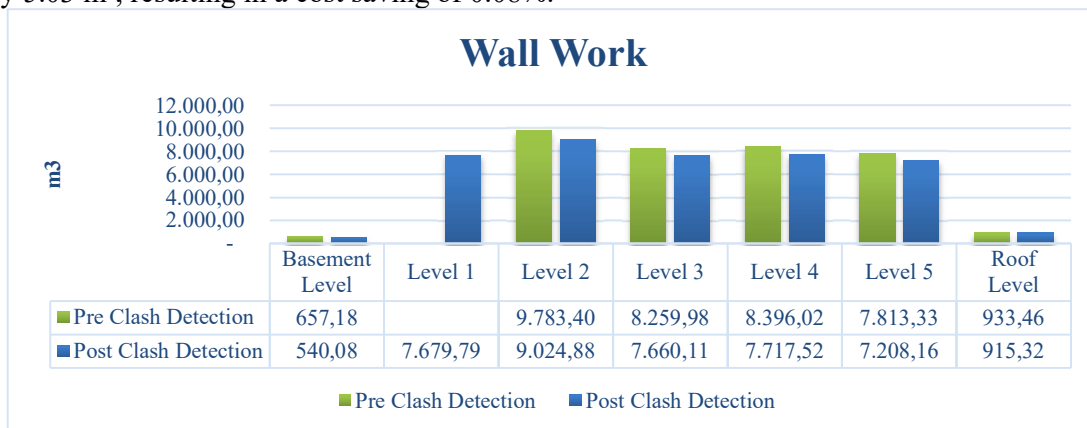


Figure 9. Comparison of Wall Work Volumes

For architectural elements, as shown in Figure 9, model corrections reduced wall area by 3,357.47 m², with cost savings reaching 7.76%.

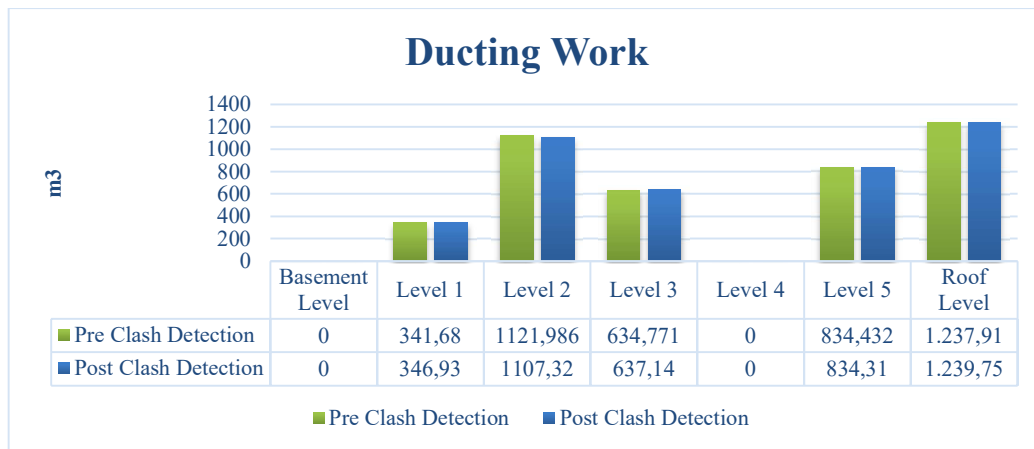


Figure 10. Comparison of Ducting Work Volumes

Meanwhile, mechanical and plumbing (MP) elements, as shown in Figure 10, experienced a reduction in ducting volume by 5.32 m³, with a potential saving of 0.06%.

In addition to material volume reductions, the model correction also eliminated rework that was previously required. The avoided rework volumes include 4.93 m³ of concrete demolition, 70.81 m² of wall demolition, 1,051.11 m² of ducting relayout, and 1.84 m of pipe relayout. Overall, the implementation of clash detection resulted in a total potential cost saving of 4.63% of the overall project cost. A further comparison is presented in the graph shown in Figure 11.

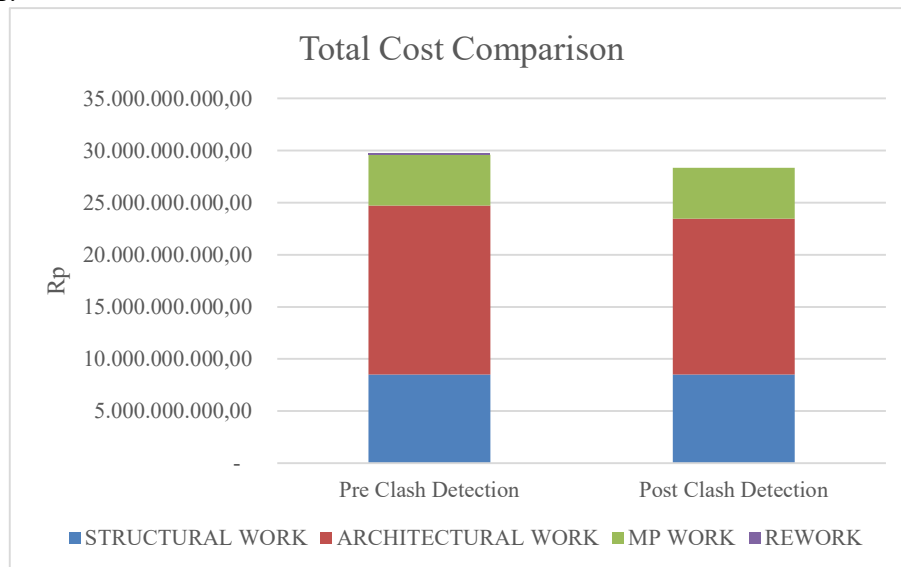


Figure 11. Total Cost Comparison

The quantity take-off analysis revealed that additional work due to rework includes demolition of concrete beams and slabs totaling 4.93 m³, demolition of walls covering 70.81 m², ducting layout changes of 1,051.11 m², and piping layout changes totaling 1.85 m. Based on the volume and productivity of each task, the rework is estimated to extend the project duration by 41.7 days. When compared to the actual total project duration of 536 days, clash

detection analysis has the potential to reduce the project time by up to 7.79%. Detailed durations for each rework task are presented in Table 2, while a visual representation of the rework duration is shown in Figure 12.

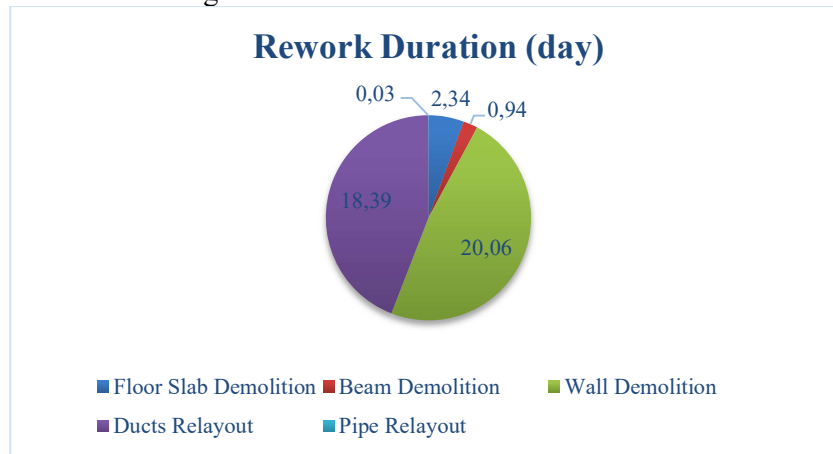


Figure 12. Rework Duration

Table 2. Rework Duration Recapitulation

Description		Volume	Unit	Productivity (unit/day)	Day
Structural Rework	Floor Slab Demolition	3.51	m^3	1.50	2.34
	Beam Demolition	1.416	m^3	1.50	0.94
Architectural Rework	Wall Demolition	70.81	m^2	3.53	20.06
MP Rework	Ducts Relayout	1051.108	m^2	57.14	18.39
	Pipes Relayout	1.8481	m	66.67	0.03
Total					41.77

4. CONCLUSIONS

Clash detection using Building Information Modelling (BIM) with Autodesk Navisworks can significantly reduce the potential for rework, directly impacting the reduction of additional project costs. The clash detection analysis identified 274 clashes between structural and MP elements, 603 between architectural and MP elements, and 87 between structural and architectural elements. These clashes indicated a potential cost saving of 0.36% of the total project budget (BOQ).

The analysis results demonstrate that the implementation of clash detection in the RSIA construction project leads to both cost and time savings. The structural work achieved a cost saving of 0.08%, architectural work 7.76%, and MP work 0.06%. Rework that was successfully avoided includes 4.93 m^3 of concrete demolition, 70.81 m^2 of wall demolition, 1,051.11 m^2 of ducting relayout, and 1.84 m of pipe relayout. In total, the project experienced a cost saving of 4.63%. Meanwhile, the potential time saving resulting from the analysis is 41.7 days, equivalent to a 7.79% reduction from the project's actual time schedule.

REFERENCES

- [1] S. & L. Eastman, Teicholz, *A Guide to Building Information Modeling for Owners, Managers, Architects, Engineers, Contractors, and Fabricators*, vol. 53, no. 9. 2008.
- [2] S. Azhar, “Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry,” *Leadersh. Manag. Eng.*, vol. 11, no. 3, pp. 241–252, 2011, doi: 10.1061/(ASCE)LM.1943-5630.0000127.
- [3] B. Hardin and D. McCool, *BIM and Construction Management: Proven Tools, Methods, and Workflows*, vol. 11.
- [4] W. K. Murphy and S. Ismailiyah Al Athas, “Penggunaan Clash Detection Untuk Efisiensi Biaya Dan Waktu Pada Perencanaan Bangunan Industrial Berbasis IPD,” *Sustain. Archit.*, vol. 7, pp. 69–77, 2020.
- [5] J.-H. Seo, B.-R. Lee, J.-H. Kim, and J.-J. Kim, “Collaborative Process to Facilitate BIM-based Clash Detection Tasks for Enhancing Constructability,” *J. Korea Inst. Build. Constr.*, vol. 12, no. 3, pp. 299–314, 2012, doi: 10.5345/jkibc.2012.12.3.299.
- [6] D. M. Savitri, Juliastuti, and A. A. Pramudya, “Clash detection analysis with BIM-based software on midrise building construction project,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 426, no. 1, 2020, doi: 10.1088/1755-1315/426/1/012002.
- [7] M. R. Elyano and Yuliastuti, “Analysis of clash detection and quantity take-off using BIM for warehouse construction,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 794, no. 1, 2021, doi: 10.1088/1755-1315/794/1/012012.
- [8] L. Koskela, *Application of the new production philosophy to construction*. Stanford University, 1992. [Online]. Available: <http://cife.stanford.edu/sites/default/files/TR072.pdf>
- [9] I. Nahmens and L. H. Ikuma, “Effects of Lean Construction on Sustainability of Modular Homebuilding,” *J. Archit. Eng.*, vol. 18, no. 2, pp. 155–163, 2012, doi: 10.1061/(asce)ae.1943-5568.0000054.
- [10] A. Monteiro and J. Poças Martins, “A survey on modeling guidelines for quantity takeoff-oriented BIM-based design,” *Autom. Constr.*, vol. 35, no. November 2013, pp. 238–253, 2013, doi: 10.1016/j.autcon.2013.05.005.
- [11] D. Olsen and J. M. Taylor, “Quantity Take-Off Using Building Information Modeling (BIM), and Its Limiting Factors,” *Procedia Eng.*, vol. 196, no. June, pp. 1098–1105, 2017, doi: 10.1016/j.proeng.2017.08.067.
- [12] T. V. N. Ngo, “Implementation of Building Information Model (BIM) in terms of quantity takeoff (QTO) and estimation at construction consultant company in Vietnam,” *Int. Master Sci. Constr. Real Estate Manag. Jt. Study Program. Metrop. UAS HTW Berlin*, 2018, [Online]. Available: <https://urn.fi/URN:NBN:fi:amk-2018102216150>
- [13] Mahyuddin et al., *Manajemen Proyek Konstruksi*, no. September. Yayasan Kita Menulis, 2022.
- [14] PUPR, “Permen PUPR No. 1 Tahun 2022 Tentang Penyusunan Perkiraan Biaya Pekerjaan Konstruksi Bidang Pekerjaan Umum dan Perumahan Rakyat,” 2022.
- [15] W. Mandela and C. I. Sitepu, “ANALISIS WAKTU DAN BIAYA BERDASARKAN PRODUKTIVITAS TENAGA KERJA PADA PROYEK PEMBANGUNAN GEDUNG KIR KOTA SORONG,” *J. Tek. Sipil*, vol. 9, no. 2, pp. 30–35, 2023, [Online]. Available: <https://jurnal.poltekstpaul.ac.id/index.php/jkar/article/download/468/526/>