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Building Information Modeling and Clash Detection for Multi-Story Building Design Using Revit, Navisworks, Twinmotion (A Case Study: Bontang City Environmental Laboratory Building Planning)

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Abstract: The transformation of digital technology within the Architecture, Engineering, and Construction (AEC) industry has led to increasingly integrated and efficient design workflows. This study explores the application of Building Information Modeling (BIM) using three key software platforms—Autodesk Revit, Navisworks, and Twinmotion—in the design process of a multi-story public building. Using a case study of the Bontang City Environmental Laboratory, the research applies a qualitative approach with an integrative literature synthesis to analyze how BIM tools can enhance accuracy, efficiency, and artistic value in architectural planning. Revit is used for detailed parametric modeling, Navisworks for early-stage clash detection, and Twinmotion for immersive design visualization. The results show that the integrated use of these three platforms can significantly reduce design conflicts, improve communication among stakeholders, and accelerate decision-making in pre-construction phases. This study contributes a conceptual framework for BIM implementation in public building projects, especially in developing country contexts, while providing a practical reference for professionals in the AEC industry.

Keywords: Architecture; BIM Revit; Clash Detection; Construction; Engineering; Navisworks; Public Building Design; Twinmotion

1. Introduction

The advancement of digital technology has transformed the landscape of the Architecture, Engineering, and Construction (AEC) industry globally. Digital technology has enabled AEC professionals to create accurate and detailed digital models of buildings and other constructions, allowing them to analyze, simulate, and visualize building designs before construction commences (Eastman et al., 2011). The implementation of Building Information Modeling (BIM) has emerged as a key innovation in recent decades, owing to its ability to integrate various aspects of design and construction into a unified information system. BIM not only serves as a three-dimensional visualization tool but also as a digital database that enables interdisciplinary collaboration in planning and executing construction projects (Numan et al., 2024). In Indonesia, the adoption of BIM technology is further encouraged through government policies aimed at enhancing efficiency and accuracy in building planning, particularly for high-rise building projects (Sari et al., 2024). BIM, through software such as Revit, Navisworks, and Twinmotion, has demonstrated significant

IJTEC
ISSN : XXXX XXXX

contributions in designing visual simulations of buildings, detecting clashes, and reducing design errors from the early stages (Joseph et al., 2020).

Despite this, the practical implementation of BIM in the field still faces several obstacles. Many construction practitioners still rely on conventional planning methods based on two-dimensional drawings, which often lead to miscommunication and project delays (Khasbage, 2022). Additionally, there is a gap between the potential of BIM technology and its actual implementation, particularly in the context of multidisciplinary coordination and digital data management efficiency (Shah & Shrestha, 2023). The lack of interoperability between BIM software also hinders the effectiveness of its use in collaborative design and construction processes (Golabchi & Kamat, 2013). This indicates the importance of in-depth studies on the integration and optimization of Revit, Navisworks, and Twinmotion within an efficient and artistic framework for high-rise building projects.

As a conceptual approach, this research is based on the theoretical framework of BIM development, which emphasizes three main aspects: architectural and structural modeling through Revit, spatial conflict detection using Navisworks, and immersive animation-based visualization through Twinmotion. The integration of these three aspects enables more comprehensive and real-time design information processing, which is highly relevant in the planning of environmental laboratory buildings in Bontang as a case study (Christiandava et al., 2023). In this context, BIM is not only a visualization tool but also an analytical and predictive medium for supporting data-driven design decision-making (V. Mittal et al., 2001).

This research aims to answer the primary question: How to optimize the use of Revit, Navisworks, and Twinmotion as accurate, efficient, and artistic BIM software in high-rise building planning? To address this, this research employs a qualitative approach based on case studies and meta-synthesis of literature to analyze the potential and challenges of integrating these three software in the real-world context of construction projects. The main focus is directed towards the effectiveness of digital collaboration among AEC professionals and validation of modeling through conflict detection and dynamic visual simulation that comprehensively illustrates the construction process (Khattra et al., 2022).

The scientific contribution of this article lies in the presentation of an integrative conceptual model that combines the main functions of BIM in a unified workflow, particularly for high-rise buildings in tropical regions such as Bontang City. This article offers a new perspective on how BIM can be optimized not only from a technical standpoint but also from an artistic and efficiency perspective in building design visualization, and contributes a replicable implementation model for similar projects at national and international levels (Al-Taie et al., 2016; Khaddaj & Srour, 2016).

2. Materials and Methods

2.1. Research Location

This study was conducted in Awang Long Street, North Bontang, Bontang City, East Kalimantan, Indeonesia.

EAST KALIMANTAN MAP

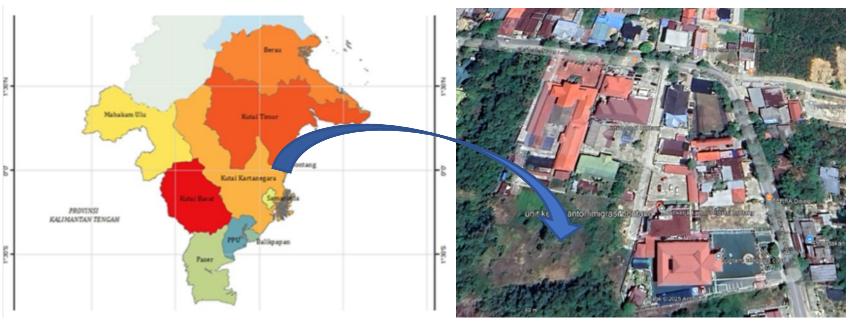

Figure 1. Location Map

IJTEC
ISSN : XXXX XXXX

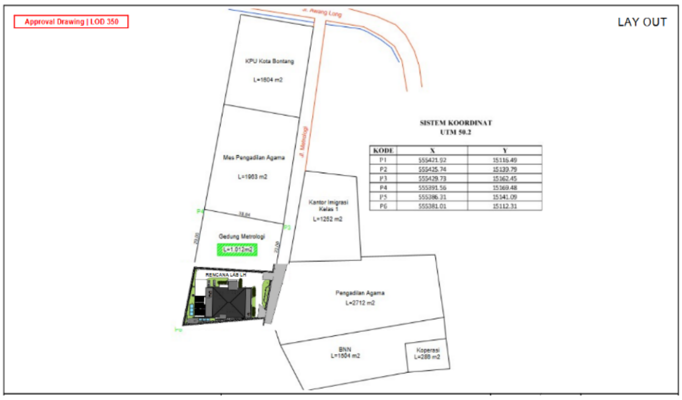

Figure 2. Layout Project

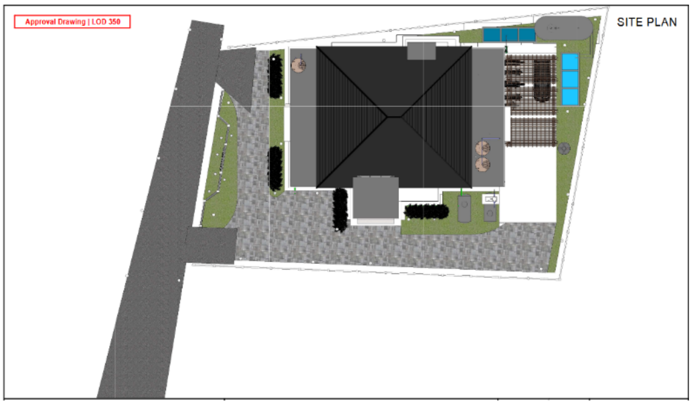

Figure 3. Site Plan Project

2.2. Data Sources

Secondary data were obtained from planning of the Environmental Laboratory Building in Bontang City.

2.3. Research Method

This study employs a qualitative approach with a literature-based case study strategy, focusing on an integrative analysis of Building Information Modeling (BIM) implementation through Revit, Navisworks, and Twinmotion software in high-rise building planning. This strategy is chosen because case studies enable researchers to explore phenomena in-depth and contextually based on a specific unit of analysis, namely the planning of the Environmental Laboratory Building in Bontang City. A literature-based approach is selected because all data are obtained from relevant scientific sources without involving direct interaction with field participants (Hoon, 2013).

This study utilizes secondary data sourced from scientific publications, building planning reports, and prior research findings relevant to the topic. The literature review encompasses nationally and internationally reputable open-access journals, with a particular focus on studies examining the application of Building Information Modeling (BIM) in architectural design, structural clash detection, and architectural visualization. All literature is accessed through online databases such as the Directory of Open Access Journals (DOAJ), PubMed Central, and university repository portals. No primary data, including interviews, direct observations, or field surveys, are employed, as this research focuses on a synthetic literature review (Afshari et al., 2023).

2.4. Building Information Modeling (BIM) Policy in Indonesia

Regulations related to the implementation of BIM in the construction sector in Indonesia include:

IJTEC
ISSN : XXXX XXXX

a. Minister of Public Works and Housing Regulation No. 22/PRT/M/2018 on Guidelines for State Building Construction, which states that BIM must be used for non-simple state buildings with an area of over 2000 m2 and more than 2 floors (Perundang-undangan, 2018). Therefore, the output of the design must be the result of a design that uses BIM for all documents, including architectural drawings, structural drawings, landscape plans, utilities, quantity details, and cost estimates (Fazeli et al., 2021).
b. Government Regulation No. 16 of 2021, which implements Law No. 28 of 2002 on Building Construction. The appendix to the document explains the use of BIM, specifically in the section on Procedures and Methods for Implementing Building Construction (Government of Indonesia, 2021).

2.5. BIM Model Integration

The integration of BIM models in this study is carried out using Revit software (Navisworks, 2024). According to Autodesk (2024), Revit can be used to create accurate and detailed digital models of buildings. In this study, Revit is used to create a BIM model of the Environmental Laboratory Building Planning of Bontang City. The BIM Revit is expected to integrate architectural, structural, and MEP (Mechanical, Electrical, and Plumbing) modeling, particularly plumbing modeling. Revit can also integrate with Robotic Structure before modeling the structure.

2.6. Clash Detection

Clash detection in this study is carried out using Navisworks software (Navisworks, 2024). According to Navisworks (2024), Navisworks can be used to detect clashes between building components.

2.7. Visualization, Rendering, and Animation

For visualization, rendering, and animation in this study, Twinmotion software is used to obtain a more realistic and artistic result (Twinmotion, 2024).

2.8. Flowchart of Study Implementation

The stages of the study implementation are outlined in the diagram below :

Figure 4. Flowchart of Study Implementation

3. Results

3.1. Modeling Steps

The following are the steps taken to create a 3D model of the Environmental Laboratory Building in Bontang City using Autodesk Revit 2024 software.

3.1.1. Preparation

The initial step in modeling begins with preparation and creating a new work sheet in Autodesk Revit 2024. Select "New Project", then choose a template. The template used in this study is the US Metric template, specifically the "Construction-default metric" template (Autodesk, 2024).

3.1.2. Grid and Level Creation

Grids are used as a coordinate reference for modeling. The coordinate lines on the grid consist of X and Y lines. Grids are used to facilitate the placement of building structure components and as a reference point for reinforcement. Grids are created by selecting the "Grid" option on the Structure tab (Autodesk, 2024). The resulting grid is shown in Figure 5.

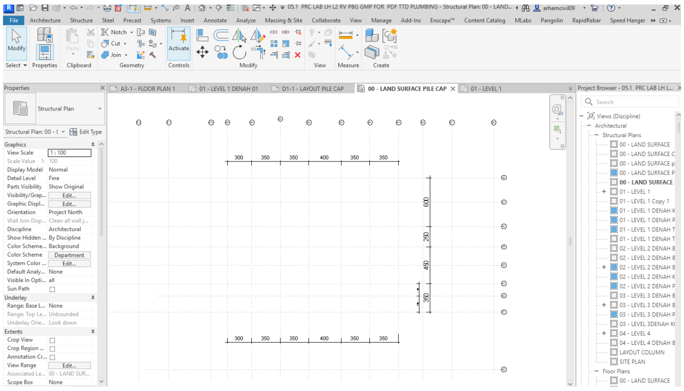

Figure 5. Grid Plan of Bontang City Environmental Laboratory Building

In Autodesk Revit 2024, levels denote the Z-coordinate or elevation of building floors. The creation of levels is predicated on the average ground surface elevation for each working floor of the Bontang City Environmental Laboratory Building. Prior to level creation, the view is adjusted to the East elevation view to orient the work sheet along the Z-axis (Autodesk, 2024). The resultant levels are depicted in Figure 6.

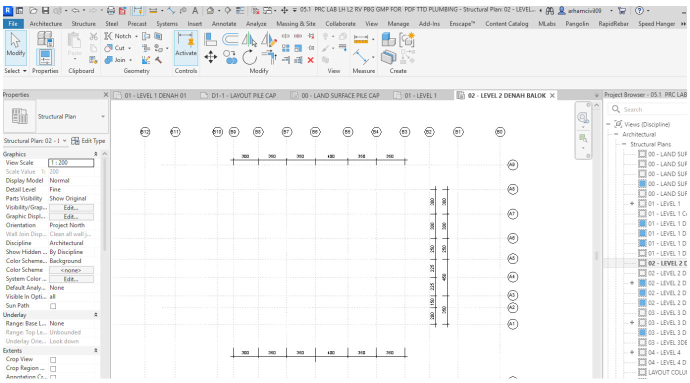

Figure 6. Second Floor Plan Grid

3.1.3. Foundation Modeling

The foundation used in the construction of the Bontang City Environmental Laboratory Building is a pile foundation. The steps for modeling the pile foundation involve selecting the "Structural Foundation: Isolated" option on the Structure tab. The available foundation components will appear in the software, and

IJTEC
ISSN : XXXX XXXX

the foundation is selected based on the number of pile caps used. Before modeling the reinforcement, the rebar cover is set by selecting the "Cover" option on the Structure tab. A Rebar Cover Settings dialog box will appear, containing a list of concrete cover thicknesses. After setting the rebar cover, the reinforcement can be modeled into the foundation structure. Reinforcement modeling can be performed in two ways: using the "Sketch Rebar" or "Host Rebar" options (Autodesk, 2024). Figure 7. (Pile Cap Layout) and Figure 8. (Pile Cap Modeling) display examples of the results of the foundation reinforcement modeling.

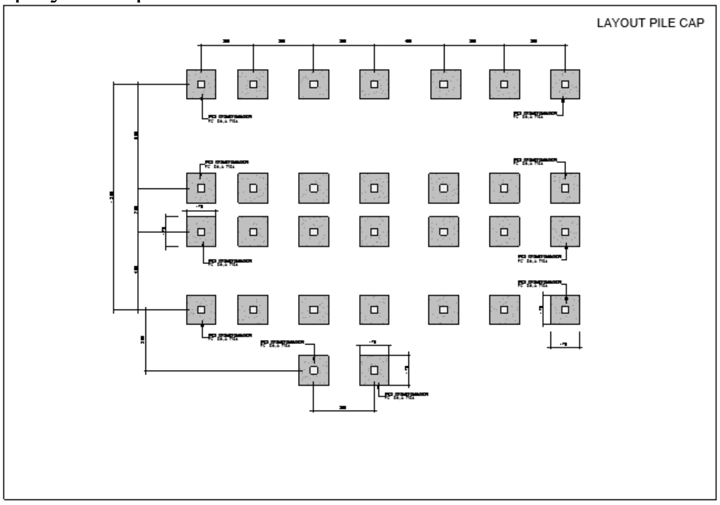

Figure 7. Pile Cap (PC) Layout

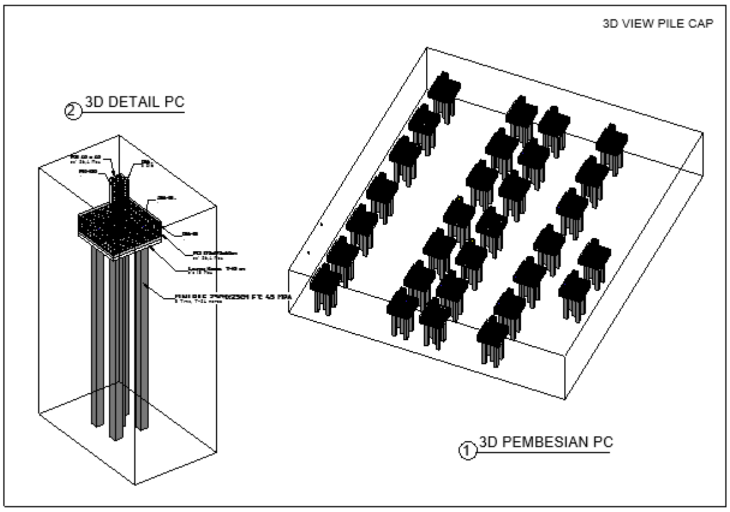

Figure 8. Pile Cap (PC) Modeling

3.1.4. Column Modeling

The steps for modeling columns of the Bontang City Environmental Laboratory Building involve creating a family for each column type per floor by opening the column family in US Metric, selecting the structural columns section, and choosing the concrete option. Next, select the corresponding column type; in this modeling, the M_Concrete_Rectangular_Column type is used. Adjust the column dimensions and materials, and define the column name according to the column parameters per floor by editing the type family in the properties box. After creating all column types, the column family can be loaded into the project by selecting the load family option. Once the column structure modeling is complete, the reinforcement detailing is modeled. The steps for modeling column reinforcement detailing include preparing a column section view by selecting the section option on the view tab, then selecting a column and drawing a line along the column. Select the column structure and set the rebar cover by choosing the cover option on the structure tab. Next, reinforcement can be modeled on the family by selecting the

IJTEC
ISSN : XXXX XXXX

corresponding rebar type (Autodesk, 2024).. Examples of the results of the column reinforcement modeling are presented in Figure 9., Figure 10., and Figure 11.

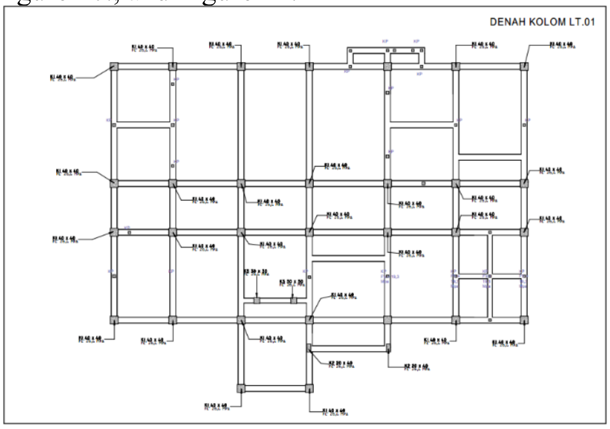

Figure 9. Column Layout of Floor 01

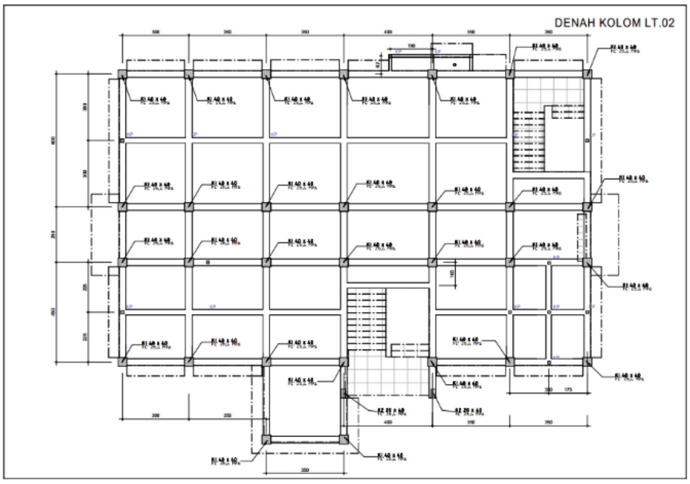

Figure 10. Column Layout of Floor 02

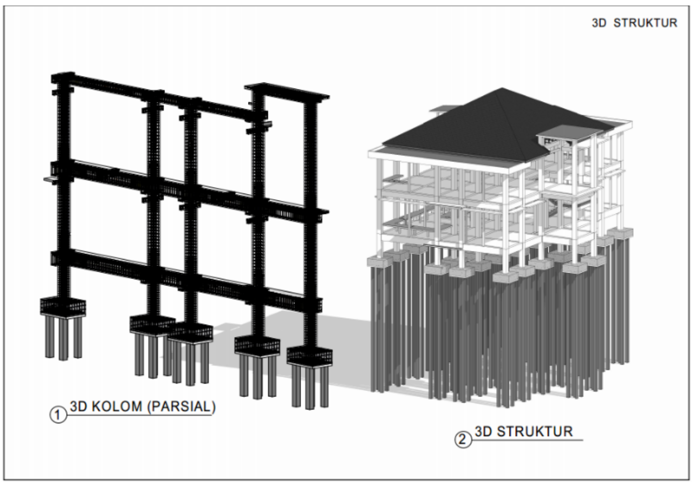

Figure 11. 3D Column & 3D Structure

3.1.5. Beam Modeling

Beam modeling using Autodesk Revit 2024 software is done by creating a family for each beam type per floor. It starts by selecting the beam option on the structure tab and then loading the family. Next,

IJTEC
ISSN : XXXX XXXX

navigate to the US Metric template directory, then structural framing, and direct to the concrete directory to open M_Concrete_Rectangular_Beam. Edit the family parameters such as size and material data for each beam in the family types menu in the properties section. Beams are placed on the grid according to the shop drawing by drawing a line from the column axis to the next column. After modeling the beam structure, the next step is to model the reinforcement detailing. The steps for modeling beam reinforcement detailing include preparing a beam section view by selecting the section option on the view tab. Click on the beam structure and set the rebar cover by selecting the cover option on the structure tab. Next, reinforcement can be modeled on the family by selecting the corresponding rebar type (Autodesk, 2024). Figure 12. displays the results of the beam modeling and reinforcement that have been created.

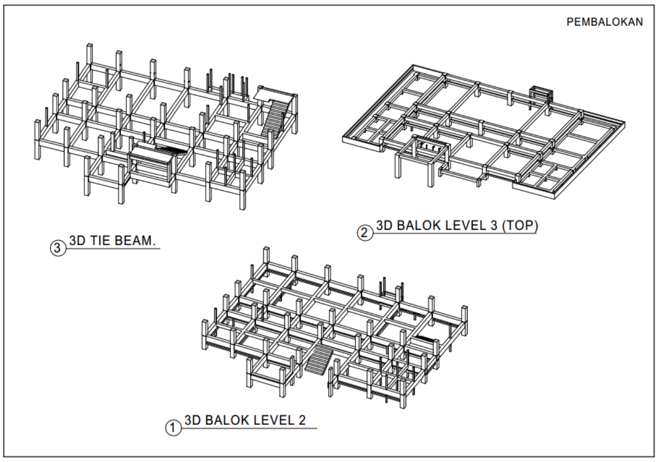

Figure 12. 3D Beam Modeling

4.1.6. Slab/Floor Modeling

The steps for modeling slabs/floors using Autodesk Revit software begin by selecting the slab family for the floor slab on the 1st floor and choosing floor slab for the beams on the 2nd floor to the roof floor. Define the slab family according to the needs of each floor. In this example, a slab with a thickness of 120 mm is used, and since it is not available in the Revit family, adjustments need to be made. This is done by selecting the generic 120mm slab/floor type and then choosing edit type (Autodesk, 2024). The results of the slab modeling are displayed in Figure 13.

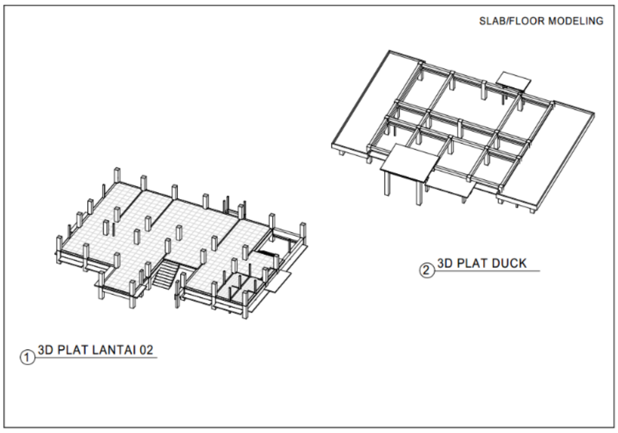

Figure 13. 3D Slab/Floor Modeling

3.1.7. Stair Modeling

The initial step in stair modeling is to prepare a slab between two floors as a host that connects the stairs. Modeling is performed using the stairs menu on the architecture tab or by accessing the stair libraries through the insert menu and selecting load family. In this modeling, concrete stairs with a straight type are selected. Drawings and placement of stairs are done according to needs and location. Justification is performed by adjusting the width and length of the stairs if the drawing is not accurate. After modeling the stair structure, the next step is to model the stair reinforcement. Stair reinforcement modeling in Autodesk Revit 2019 begins with creating a section line on the stairs using the section: building section on the view tab. The rebar menu is used to model the stair reinforcement (Autodesk, 2024). Figure 14. displays the results of the stair modeling that has been created.

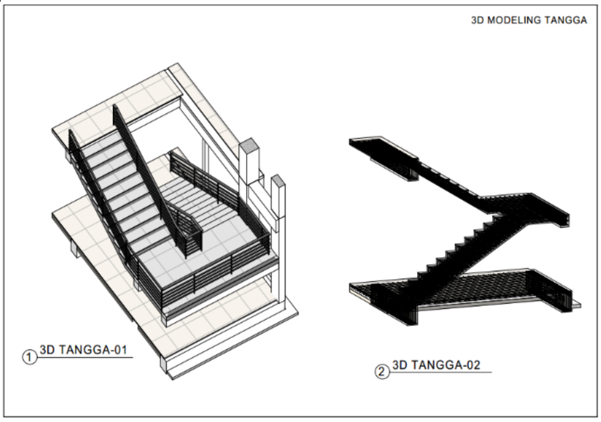

Figure 14. Stairs Modeling

3.1.8. Roof Modeling

The first step in roof modeling for this building project is to create a steel column family using C75.75 Light Gauge Steel (C 75mm x 0.75mm) and R35.45 Light Gauge Steel purlins. The steel profiles are modeled in the drawing area through a 3D view. Roof modeling continues with modeling the steel beam profiles on the attic floor to create the roof trusses. Connections between steel profiles are modeled using the connection option in the structure menu. Then, to create the roof covering, the roof menu on the architecture tab is used. The material and thickness of the roof dimensions are modified through the properties window by selecting edit type. Following the installation of the roof trusses and light gauge steel purlins, the Surya Roof metal roof with sand coating is then installed and secured with metal roof nails (Autodesk, 2024). The results of the ROOF modeling are displayed in Figure 15.

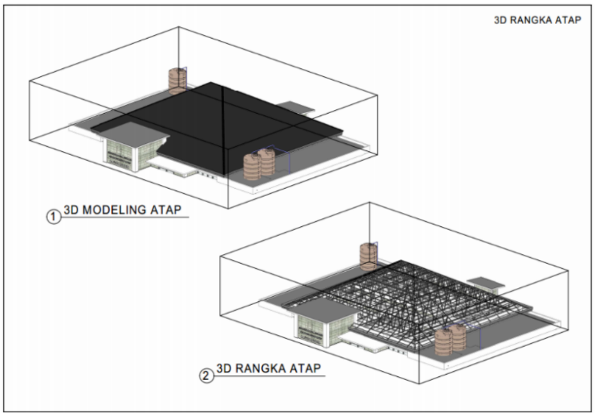

Figure 15. Roof Modeling

3.1.9. Wall Modeling

Architectural wall modeling in Autodesk Revit 2024 begins with selecting the wall: architectural option on the architecture tab. The wall is defined according to specifications by selecting edit type, which displays the type properties box containing the wall's parameters. The wall family is then placed on the grid, which has been adjusted to fit the room size on each floor according to the existing floor plan. Additionally, the wall layout position must be adjusted on the location line (Autodesk, 2024).

IJTEC
ISSN : XXXX XXXX

3.1.10. Door and Window Modeling

The initial step in creating doors or windows is to model the door or window family in Autodesk Revit 2024 software. Family modeling is done using available templates. Next, select the metric door or window template type from the library. The next step is to adjust the dimensions of the door or window. After all window parameters have been adjusted according to the type and modeling needs, load the family into the project and close to input the family. Place the door or window family in the appropriate position within the project. Alternatively, a curtain wall family can be used for custom doors and windows. The initial step in curtain wall modeling is to create a family. Creating a curtain wall family involves selecting wall architectural on the architecture tab. Choose the storefront option as the curtain wall family, model the door or window frame according to needs, then select the glass area where the door or window opening will be created, and finally, place the custom door or window in the existing door and window frame (Autodesk, 2024).

3.2. 3D Modeling Results by BIM Revit

The following is a 3D view of the building modeling using Autodesk Revit 2024 software, as shown in Figure 16., Figure 17., and Figure 18.

Figure 16. 3D Visual Number 1

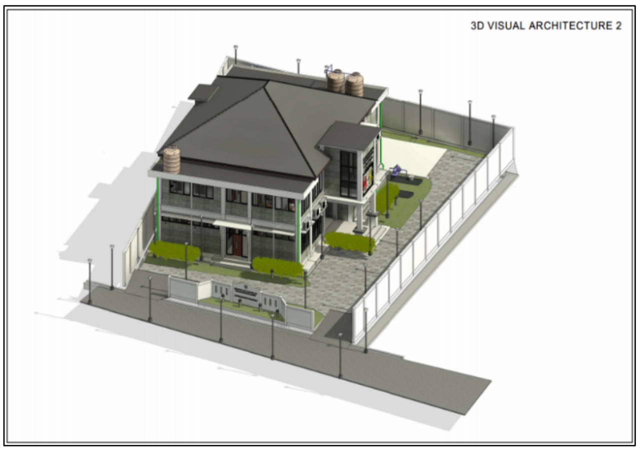

Figure 17. 3D Visual Number 2

IJTEC
ISSN : XXXX XXXX

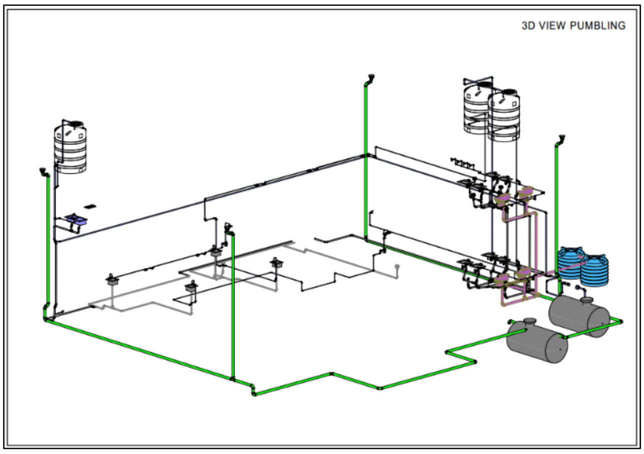

Figure 18. 3D Plumbing

3.3. Clash Detection Results by BIM Naviswork

The detailed steps for detecting clash detection between components in a building using Navisworks:

3.3.1. Importing Models

a. Import 3D models from various disciplines (architecture, structure, MEP, etc.) into Navisworks, (Autodesk, 2024)
b. Ensure that the models are in a format compatible with Navisworks, such as NWD, NWF, or other formats like Autodesk Revit, AutoCAD, etc, (Autodesk, 2024)

3.3.2. Merging Models

a. Merge the imported models into a single Navisworks project (Navisworks, 2024).
b. Ensure that all models are properly set up and accessible within the Navisworks project (Autodesk, 2024).

3.3.3. Setting Up Clash Detection

a. Open the "Clash Detection" tab in Navisworks (Naviswork, 2024).
b. Choose the type of clash to detect, such as:
c. Hard clash: clash between elements with the same geometry (Naviswork, 2024).
d. Clearance clash: clash between elements with an inappropriate distance ((Naviswork, 2024)..
e. Standard clash: clash between elements with specific standards (Naviswork, 2024).
f. Set up clash detection parameters, such as distance tolerance, element types to detect, etc (Naviswork, 2024).

3.3.4. Running Clash Detection

a. Run the clash detection analysis by clicking the "Run Clash Detection" button (Naviswork, 2024).
b. Navisworks will analyze the merged models and detect clashes between elements (Naviswork, 2024).

3.3.5. Analyzing Results

a. After the analysis is complete, Navisworks will display the clash detection results in a clash report (Naviswork, 2024).
b. The clash report will show information about the detected clashes (Naviswork, 2024)., such as:
c. Clash location
d. Clash type
e. Involved elements
f. Other details

g. You can analyze the clash detection results to determine the priority of clashes that need to be fixed (Naviswork, 2024).

3.3.6. Sending Results

a. Send the clash detection results to the project team for correction (Naviswork, 2024).
b. Navisworks allows you to send the results in various formats, such as PDF, XML, or other formats (Naviswork, 2024).

3.3.7. Updating Models

a. After clashes are fixed, update the 3D model and re-run the clash detection analysis to ensure that the clashes have been resolved (Naviswork, 2024).

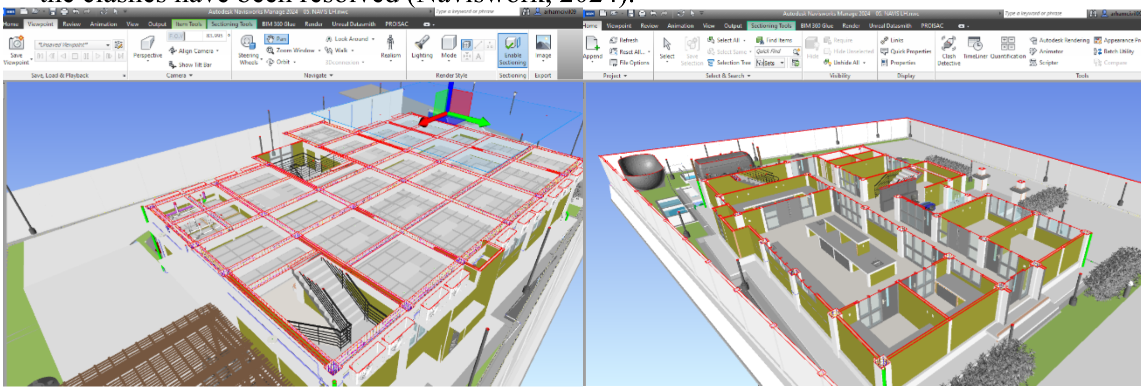

Figure 19. Clash Detection by Naviswork

3.4. Mechanism of Animation and Rendering in Twinmotion with Revit Design Integration

The detailed steps to create animation and rendering in Twinmotion with Revit design integration, such as:

3.4.1. Setting up the Scene:

a. Import Revit model into Twinmotion using the "Import" feature (Twinmotion, 2024).
b. Adjust material and texture of objects to create a realistic appearance (Epic Games, 2024).
c. Add lighting to create the desired lighting effect (Autodesk, 2020).
d. Set up the camera to determine the angle and position (Twinmotion, 2024).

3.4.2. Creating a Timeline:

a. Create a new timeline by determining the animation duration (Twinmotion, 2024).
b. Add keyframes to control camera and object movement (Chaos Group, 2024).
c. Adjust the time interval between keyframes to control animation speed (Epic Games, 2024).

3.4.3. Setting up Keyframes:

a. Set up keyframes to control camera and object movement by determining:
b. Position: Set the position of the camera and object in 3D space (Autodesk, 2024).
c. Rotation: Set the rotation of the camera and object to create movement effects (Twinmotion, 2024).
d. Scale: Set the scale of the camera and object to create size change effects (Chaos Group, 2024).

3.4.4. Setting up the Camera:

a. Set up the camera to follow object movement or to create specific camera effects (Twinmotion, 2024).

3.4.5. Setting up Lighting:

a. Set up lighting to create the desired lighting effect (Autodesk, 2024).

3.4.6. Adding Effects:

a. Add effects such as motion blur and depth of field to create a more realistic animation (Epic Games, 2024).

3.4.7. Setting up Rendering:

a. Set up rendering settings to create animation with the desired quality (Twinmotion, 2024).

3.4.8. Running the Animation:

a. Run the animation by clicking the "Render" button in Twinmotion (Twinmotion, 2024).

3.4.9. Generating Output:

a. After the animation is complete, Twinmotion will generate output in the form of a video that can be used for presentations, visualizations, or other purposes (Twinmotion, 2024).

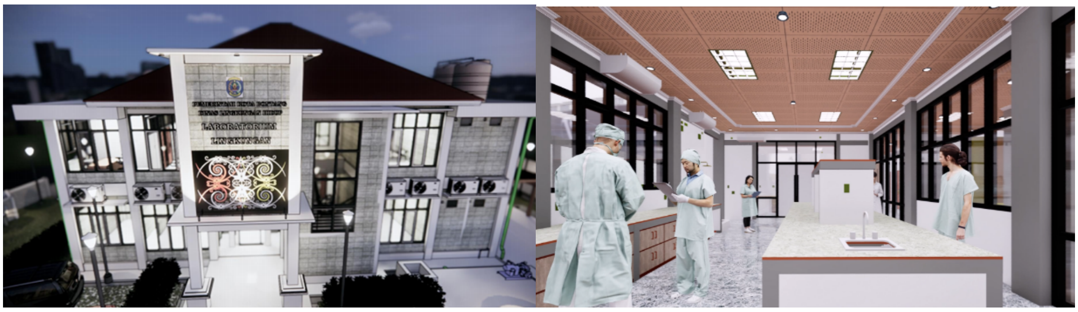

Figure 20. 3D View Rendered

4. Discussion

The primary findings of this study affirm that the integration of Building Information Modeling (BIM) through Revit, Navisworks, and Twinmotion significantly contributes to enhancing design accuracy, conflict detection efficiency, and visualization quality of high-rise building projects. These results align with the main objective of the research, which is to explore how these three software tools can be utilized more accurately, efficiently, and artistically in the building planning process. The main themes identified—encompassing quantification accuracy, multi-disciplinary design integration, dynamic visualization, and cost and time efficiency—support the research question posed, namely the need for optimizing BIM implementation in complex building projects.

Within the theoretical framework of BIM development, the results of this study reinforce the understanding that Revit serves as a parametric modeling platform that not only produces architectural, structural, and MEP designs but also enables accurate estimation of work volumes (Alshabab et al., 2020). Navisworks functions in detecting clashes or collisions between various building systems spatially, supporting design decisions before construction begins (Abdalhameed & Nalmi, 2023). Meanwhile, Twinmotion, as a visual animation platform, offers visualization capabilities that enhance design communication across teams and stakeholders (R. Mittal & Solano, 2023).

Compared to previous studies, the results of this research are consistent with the findings of Christiandava et al. (2023), which demonstrate that the integration of Revit and Navisworks can produce accurate 3D construction schedules while supporting automated cost estimation (Christiandava et al., 2023). However, this study also expands the scope by adding the role of Twinmotion in creating immersive simulations, which is not commonly found in many prior studies. This finding adds an artistic dimension and strong visual communication to modern BIM practices. On the other hand, a study by Neves et al. (2021) highlights the limitations of interoperability in model exchange between software, a challenge also acknowledged in the results of this study (Neves et al., 2021).

The scientific contribution of this article lies in presenting a meta-conceptual synthesis that integrates three BIM software tools within a unified framework to support holistic high-rise building planning. This

IJTEC
ISSN : XXXX XXXX

study reinforces the literature stating that BIM is not merely a visualization tool but a project information management system that supports collaboration, efficiency, and design accuracy (Hadi et al., 2021). By incorporating visual, technical, and quantitative aspects, this study provides a foundation for a BIM implementation model that is more adaptive to project complexity in the digital era.

5. Conclusions

The results of this study indicate that the implementation of Building Information Modeling (BIM) through the integration of Revit, Navisworks, and Twinmotion software in high-rise building planning significantly contributes to enhanced efficiency, accuracy, and design visualization quality. Revit enables the creation of accurate parametric models and supports automatic quantity estimation, while Navisworks plays a crucial role in detecting spatial clashes between building elements before construction commences. Meanwhile, Twinmotion serves as a dynamic visualization tool capable of presenting realistic simulations, thereby strengthening cross-team communication in the planning process. These findings directly address the research question regarding the optimization of BIM tools for more accurate, efficient, and artistic applications in the context of high-rise building projects.

The conceptual contribution of this article lies in developing an integrative understanding of the use of three BIM platforms within a unified framework. This model not only strengthens technical aspects such as quantity calculations and clash detection but also expands the scope of BIM applications to the realm of visual communication and architectural design simulation. In the realm of practice, this article presents a strategic reference for planners, consultants, and construction service providers in implementing BIM more comprehensively and collaboratively in medium to large-scale projects, particularly in developing areas that require high efficiency in planning and development processes.

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