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# Implementation of 4D Buiding Information Modelling in The Steel Structure Workflow of The Paraqouai Sao Paulo Building Lospalos Using Navisworks Manage

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**Abstract**

Steel structure construction necessitates high precision in planning and execution to ensure structural stability and operational efficiency. The Paraqouai Sao Paulo building project in Lospalos presents complex geometry and tight scheduling constraints, necessitating advanced construction management techniques. This paper demonstrates the application of 4D Building Information Modeling (BIM) using Navisworks Manage to optimize the steel structure workflow. The study integrates 3D models developed in Revit with construction schedules from Microsoft Project to create a dynamic 4D simulation that adheres to Level of Development (LOD) 350 standards. The methodology focuses on visualizing the erection sequence, identifying temporal clashes, and optimizing logistics planning for crane operations. The results indicate that 4D BIM significantly enhances constructability by detecting potential spatial conflicts prior to on-site work and improving communication among stakeholders. The simulation facilitated an optimized erection sequence, reducing the estimated project duration by 15.5% (from 90 days to 76 days). This study concludes that implementing Navisworks Manage is a strategic approach for managing complex steel structures in remote areas like Lospalos, ensuring timely and cost-effective project delivery.

**Keywords:** 4D BIM, Navisworks Manage, Steel Structure, Construction Simulation, Paraqouai Sao Paulo.

**Abstrak**

Konstruksi struktur baja memerlukan ketelitian tinggi dalam perencanaan dan pelaksanaan untuk memastikan stabilitas struktural dan efisiensi operasional. Proyek bangunan Paraqouai Sao Paulo di Lospalos menghadirkan geometri yang kompleks dan kendala penjadwalan yang ketat, sehingga memerlukan teknik manajemen konstruksi tingkat lanjut. Makalah ini mendemonstrasikan penerapan Pemodelan Informasi Bangunan (BIM) 4D menggunakan Navisworks Manage untuk mengoptimalkan alur kerja struktur baja. Studi ini mengintegrasikan model 3D yang dikembangkan di Revit dengan jadwal konstruksi dari Microsoft Project untuk menciptakan simulasi 4D dinamis yang sesuai dengan standar Level of Development (LOD) 350. Metodologi ini berfokus pada visualisasi urutan pemasangan, identifikasi bentrokan temporal, dan optimalisasi perencanaan logistik untuk operasi derek. Hasil menunjukkan bahwa BIM 4D secara signifikan meningkatkan kemampuan konstruksi dengan mendeteksi potensi konflik spasial sebelum pekerjaan di lokasi dan meningkatkan komunikasi antar pemangku kepentingan. Simulasi ini memfasilitasi urutan pemasangan yang dioptimalkan, mengurangi perkiraan durasi proyek sebesar 15,5% (dari 90 hari menjadi 76 hari). Studi ini menyimpulkan bahwa implementasi Navisworks Manage merupakan pendekatan strategis untuk mengelola struktur baja kompleks di daerah terpencil seperti Lospalos, memastikan penyelesaian proyek tepat waktu dan hemat biaya.

**Kata kunci:** 4D BIM, Navisworks Manage, Struktur Baja, Simulasi Konstruksi, Paraqouai Sao Paulo

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## INTRODUCTION

The introduction of digital technologies is now causing a major upheaval in the building industry. From 3D modeling, Building Information Modeling (BIM) has expanded to incorporate 4D (time), 5D (cost),

and even 6D (sustainability) dimensions (Eastman et al., 2011). Planning is difficult in the context of steel structures because of the intricacy of linkages and the crucial importance of erection sequences. Construction delays and safety risks result from traditional 2D scheduling tools' frequent inability to convey the geographical restrictions related to time (Sacks et al., 2005). A steel structure intended to function as a community facility is the Paraqouai Sao Paulo project in Lospalos. Because of Lospalos' distinct geography and the building's particular architectural style, the steel frame involves long-span trusses and intricate connection details. Managing these elements requires a robust tool to visualize the construction process before actual work begins on site. Building Information Modeling (BIM) software, with its ability to create 3D models and simulate the construction process, has proven to be an invaluable tool for projects like the Paraqouai Sao Paulo project. By using BIM, the project team can identify and address potential clashes or conflicts in the design early on, reducing the likelihood of costly rework during construction. This technology allows for a more efficient and streamlined construction process, ultimately leading to a successful and safe completion of the community facility in Lospalos. Additionally, BIM software facilitates better coordination among different trades and disciplines involved in the project, ensuring that all aspects of the design fit together seamlessly. This level of collaboration helps to improve communication and decision-making throughout the construction process. Ultimately, the use of BIM on the Paraqouai Sao Paulo project will not only result in a high-quality facility for the community in Lospalos, but also save time and money for all stakeholders involved. The location of project as figure below.



**Figure 1** Project Loaction Sao Paulo Lospalos, Republik Demokratik Timor-Leste

**Problem Statement**

Coordinating the installation of steel components within a constrained site area is the main challenge in the Paraqouai Sao Paulo project. Large steel sections must be transported and positioned logistically with exact timing to prevent collisions with temporary structures and equipment. Additionally, traditional planning techniques' lack of real-time visualization raises the possibility of construction errors, which are expensive to fix in steelworks (Putra & Choanji, 2016). In addition to streamlining the Paraquai Sao Paulo project's steel element coordination process, the implementation of a digital construction management system would offer real-time visualization for improved planning and execution. Stakeholders would be able to monitor development, spot possible conflicts, and make the required corrections before expensive mistakes happen thanks to this technology. By applying this creative strategy, the project team can enhance efficiency, reduce construction delays, and ultimately deliver a successful and cost-effective outcome for the community in Lospalos.

**Objectives**

This study aims to apply 4D BIM technology using Navisworks Manage to the steel structure workflow of the Paraqouai Sao Paulo building. The specific objectives are to: (1) Develop a 4D simulation linking the 3D BIM model with the construction schedule, (2) Identify potential clashes and workflow bottlenecks, and (3) Propose an optimized erection sequence to enhance efficiency and safety. By

achieving these objectives, the project team can ensure that the construction process runs smoothly and without major interruptions. The use of 4D BIM technology will allow for a more detailed and comprehensive understanding of the project, leading to better decision-making and problem-solving throughout the construction phase. Ultimately, the successful implementation of this strategy will result in a high-quality steel structure for the Paraqouai Sao Paulo building, benefiting the community of Lospalos. To enhance efficiency and safety during the erection process, the project team should first prioritize proper training and communication among all workers involved. This will ensure that everyone is on the same page and working towards the same goals. Additionally, using prefabricated components and implementing a just-in-time delivery system can help streamline the erection process and reduce the risk of delays. By carefully planning and coordinating each step of the erection sequence, the team can minimize potential safety hazards and maximize productivity. Ultimately, these measures will contribute to the successful completion of the Paraqouai Sao Paulo building, providing a safe and high-quality structure for the community of Lospalos.

## METHODOLOGY

The research methodology follows a systematic workflow divided into three main stages: 3D Modeling, Scheduling, and 4D Simulation. In the 3D Modeling stage, the team will create detailed digital representations of the building components to ensure accurate planning and execution. The Scheduling stage will involve creating a precise timeline for each step of the construction process, taking into account the just-in-time delivery system for optimal efficiency. Finally, the 4D Simulation stage will allow the team to visualize the erection sequence in a dynamic and interactive manner, identifying any potential conflicts or issues before they arise on-site. This comprehensive methodology will ensure smooth progress and successful completion of the Paraqouai Sao Paulo building, meeting the highest standards of safety and quality.

### 3D Detailed Modeling Preparation

1. The initial phase involved creating a comprehensive 3D digital prototype of the Paraqouai Sao Paulo building using Autodesk Revit 2023. To ensure the model's suitability for construction simulation, the modeling process adhered to the Level of Development (LOD) 350 standard, which implies that the model contains specific quantities, sizes, shapes, locations, and assembly details necessary for fabrication and erection. The process involved: The structural steel elements of the Paraqouai Sao Paulo building were modeled using Autodesk Revit 2025.**Structural Axis and Grids:** Establishing precise coordinate systems aligned with the topographical data of the Lospalos site to ensure accurate positioning.
2. **Element Definition:** All structural steel components were modeled parametrically, including Columns (WF sections), Main Beams, Secondary Beams, Roof Trusses, Purlins, and lateral Bracing systems.
3. **Connection Details:** Steel connections (eg, base plates, moment connections, gusset plates) were modeled in detail. This is crucial for 4D simulation as connections often dictate the sequence of assembly (eg, bolts cannot be installed if the beam is not yet positioned).
4. **Data Standardization:** To facilitate seamless data exchange with Navisworks, a specific naming convention (naming rule) was applied to all elements (eg, "COL_L1_A1" for Level 1 Column at Grid A1). This nomenclature served as the key identifier for linking with the construction schedule. , as figure below.

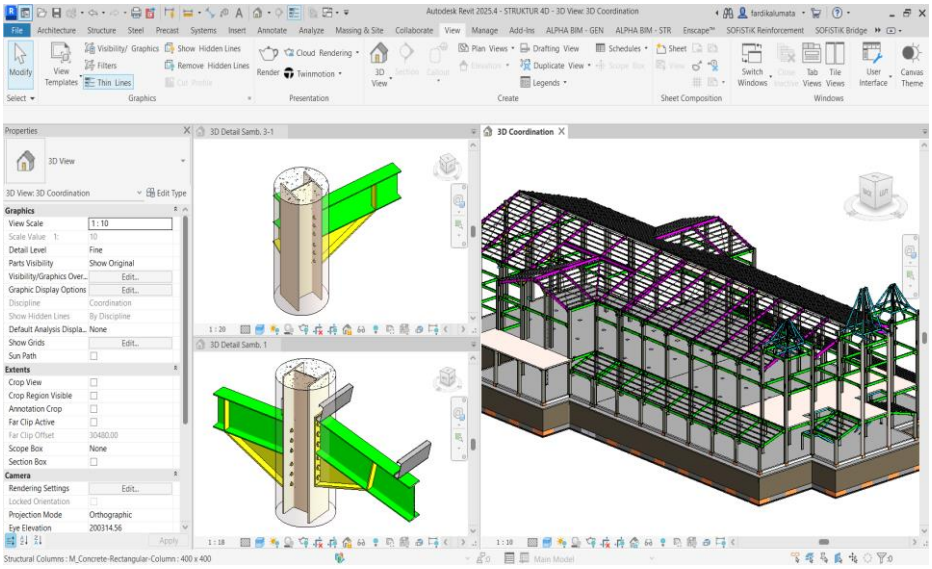


Figure 2. 3D structural modeling

**Construction Scheduling**

Following the model creation, the project timeline was developed using Microsoft Project 2019. The Work Breakdown Structure (WBS) was defined based on the physical breakdown of the steel structure to align with the 3D model hierarchy. The scheduling process includes:

1. **Task Breakdown:** The erection process was decomposed into discrete tasks related to the BIM assemblies, such as "Erection of Columns Zone A," "Installation of Roof Trusses Zone B," and "Tightening of Bracing Systems."
2. **Duration Estimation:** Duration for each task was calculated based on crew productivity rates, specific equipment availability (Crane capacity), and the specific volume of steel elements in the corresponding BIM zone.
3. **Dependency Definition:** Logical relationships (Finish-to-Start, Start-to-Start) were established to reflect technical constraints. For example, "Roof Truss Installation" was linked with a "Finish-to-Start" dependency to "Column Erection," ensuring structural stability logic was maintained in the schedule.

**4D Integration using Navisworks Manage**

The core of this study involved the integration of the 3D model and the schedule using Autodesk Navisworks Manage 2024. This process transformed the static geometry into a dynamic 4D model. The implementation followed a specific step-by-step procedure within the software environment:

**Step 1: Data Integration and Preparation**

The 3D model (NWC or NWD format) was appended into the Navisworks Manage session. To ensure clean data mapping, the "Selection Tree" in the "Select" tab was utilized to organize the model elements into a hierarchical structure matching the WBS (eg, grouping all Level 1 Columns under a folder named "Zone 1 Columns")

**Step 2: Timeliner Configuration**

The "Timeliner" module was activated from the ribbon menu. A new Timeliner configuration was created. In the "Data Sources" tab, the external project schedule (Microsoft Project file) was linked using the

"Add" button. Navisworks automatically synchronizes the task list, including Start Dates, Finish Dates, and Task Names.

**Step 3: Mapping Tasks to Model Elements (Linking)**

This is the most critical step for an accurate simulation. The study utilized the "Rules" tab within Timislinker to establish an automated link between the schedule and the 3D model.

1. **Rule Definition:** A mapping rule was created stating: *If "Task Name" in the Schedule CONTAINS the text "COL_L1," then SELECT the corresponding items in the "Selection Tree."*
2. **Alternative Manual Linking:** For specific complex assemblies (such as roof trusses), the manual "Attach" button was used. The specific task was highlighted in the "Tasks" tab, and the corresponding 3D geometry was selected in the scene to establish a direct link.

**Step 4: Configuring Simulation Settings**

In the "Simulate" tab of Timeliner, the playback speed was set to a reasonable rate for review (eg, 1:10 ratio). The "Playback" start and end dates were aligned with the project contract period. The "Zoom to Fit" option was enabled so that the view would automatically focus on the specific element being erected during the animation.

**Step 5: Review and Validation**

The 4D simulation was replayed multiple times. The team verified that every task corresponded to the erection of the intended steel element and that the chronological order respected the technical dependencies. Once validated, the simulation was exported as a video file (AVI/WMV format) to communicate the sequence to the on-site construction team

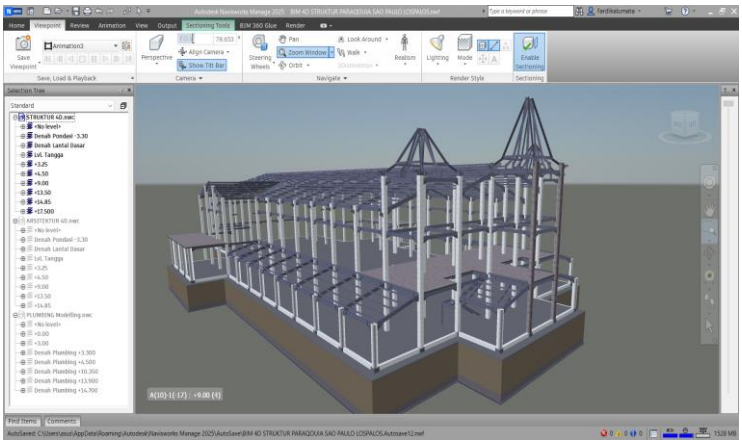


Figure 3. Integrated Modeling Structure

**RESULTS AND DISCUSSION**

The Paraqouai Sao Paulo project's use of 4D BIM produced important insights into the steel structure erection's constructability, safety, and scheduling effectiveness. The findings are divided into three primary categories: Erection Sequence Visualization, Spatio-Temporal Clash Analysis, and Project Duration Optimization. These findings demonstrate how crucial it is to use 4D BIM technology when organizing and carrying out intricate construction projects. Construction activities were better coordinated thanks to the erection sequence visualization, which decreased the possibility of conflicts and delays. Potential conflicts were found and resolved with the aid of spatiotemporal clash analysis before they affected the project schedule. Overall, the Paraqouai Sao Paulo construction site has seen increased productivity and efficiency as a result of the optimization of project duration through the use of 4D BIM.

**Visualization of Erection Sequence**

The 4D simulation provided a comprehensive visual representation of the steel assembly process, which served as a critical tool for validating structural stability during construction. Unlike 2D Gantt charts, the simulation allowed the project team to visualize the "growing" structure over time.

The simulation was divided into four distinct erection phases:

1. **Substructure and Anchor Bolts:**
   The animation confirmed that all anchor bolts were positioned correctly relative to the column bases before the arrival of the steel elements.
2. **Column Erection:** The visualization highlighted that the initial plan to erect all columns in Zone A before moving to Zone B was the most logical approach to ensure the immediate fixing of bracings.
3. **Roof Truss Installation:** For the Paraqouai Sao Paulo building, which features long-span roof trusses, the 4D model is essential to verify the sequence of hoisting. The simulation demonstrated that the roof trusses could only be erected after the purlins of the lower levels were fully installed to provide lateral support.
4. **Bracing and Connections:** The simulation emphasizes the critical path of installing K-bracing immediately after column erection. This visualization proved vital for the safety briefing, as it demonstrated exactly when the structure became self-supporting, reducing the need for temporary propping.

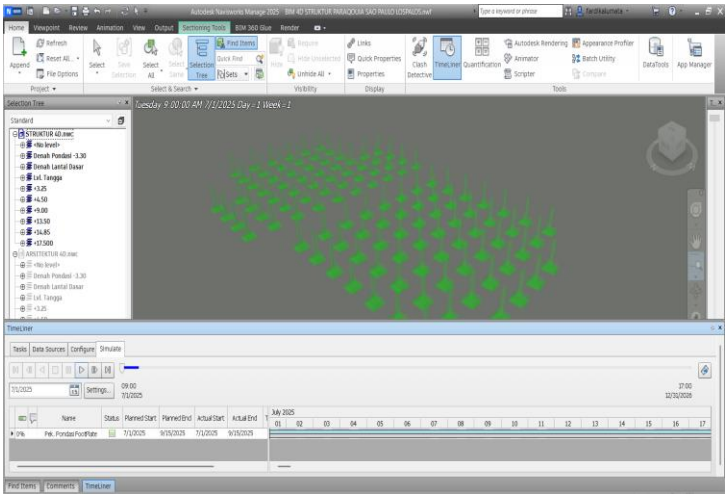


Figure 4. Structure Simulation – 1

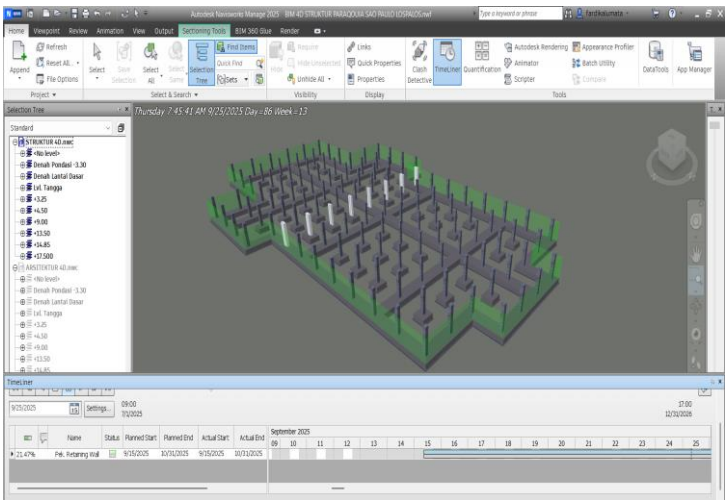


Figure 5. Structure Simulation – 2

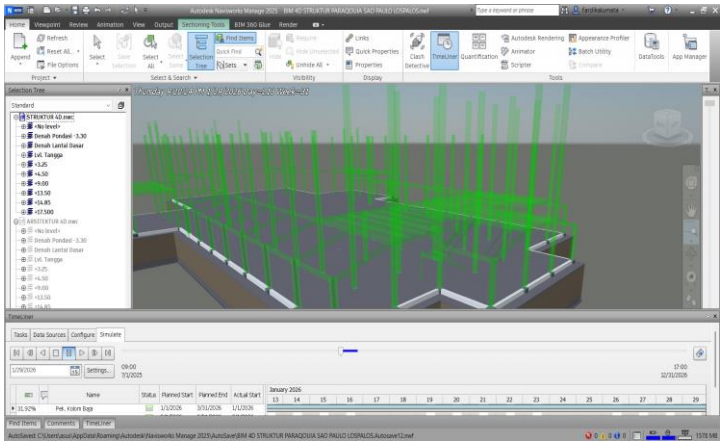


Figure 6. Structure Simulation – 3

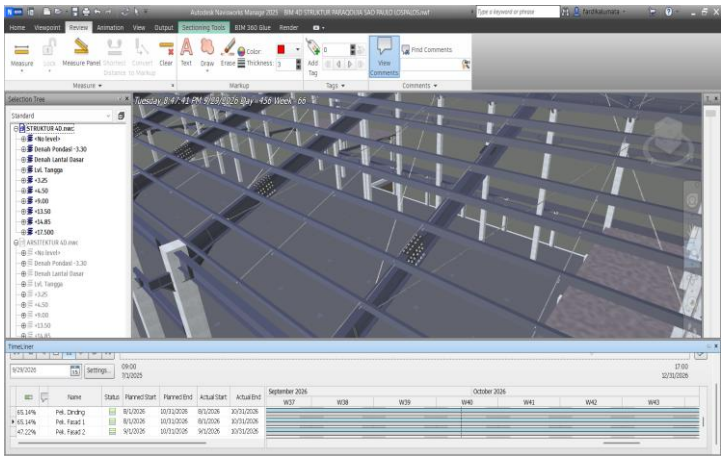


Figure 7. Structure Simulation - 4

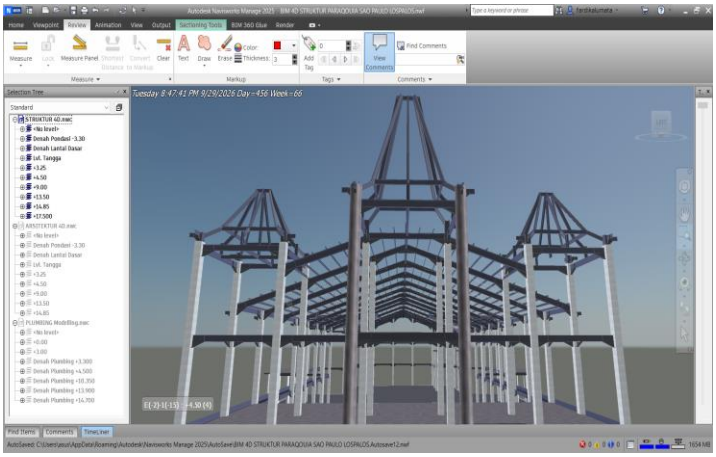


Figure 8 Structure Simulation - 5

**Clash Detection and Temporal Analysis**

One of the most powerful features of Navisworks Manage is its ability to perform "Temporal Clash Detection" where conflicts are identified not just by spatial coordinates, but by the time at which elements occupy the same space. The study conducted a comprehensive clash detection analysis by

running the simulation on a daily basis. The analysis revealed two critical categories of conflicts that were invisible in the traditional planning phase:

- **Type A: Equipment-Structure Clash (Static vs. Dynamic):**
  The simulation identified a critical safety hazard on Day 18. As per the schedule, a Mobile Crane (Telescopic Boom) was scheduled to lift the Level 2 roof trusses. However, the simulation showed that at the required lifting radius (15m), the crane's outriggers and rear superstructure would physically intersect with Column C1 of the adjacent wing which had been erected on Day 5 (See Fig. 1).
    - *Impact:* If undetected, this would have prevented the crane from extending its outriggers fully, creating a risk of tipping (overturning) during the lift.
    - *Resolution:* The team used the simulation to visualize alternative crane positioning. The crane was shifted 3 meters to the south, and a new access ramp was virtually created in the model to ensure the crane could reach the lifting point without colliding with existing structures.
- **Type B: Temporary Works vs. Temporary Works Permanent Works:**
  The initial schedule allowed for the installation of scaffolding for the roof purlins while the steel erectors were still working on the lower levels. The 4D simulation revealed a "Time-Spaceoverlap," meaning the scaffolding installation crew would be working directly underneath the area where the steel beams were being lifted (Drop Zone).
    - *Impact:* High risk of falling objects striking workers below.
    - *Resolution:* The schedule was adjusted to enforce a temporal separation. The steel erection in the upper level was delayed by two days to allow the scaffolding team to finish and vacate the area, strictly adhering to safety protocols (Tagout/ Touchout ).

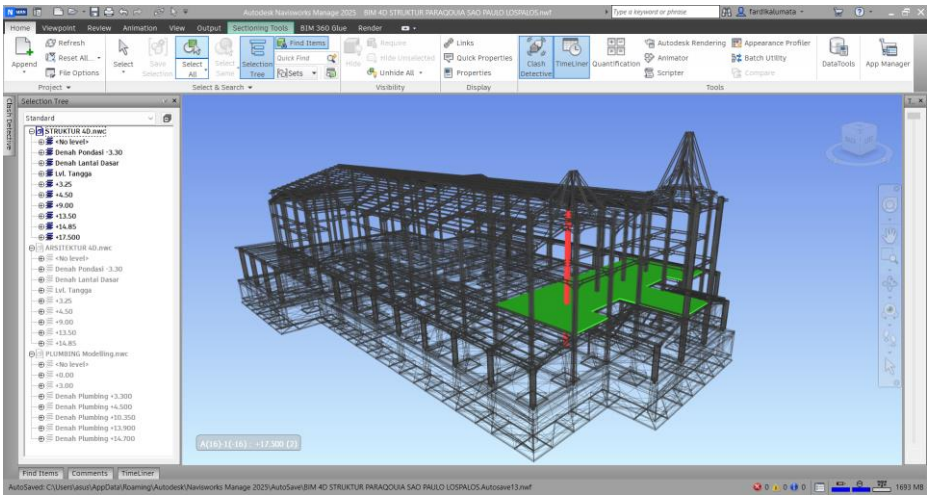


Figure 9. Clash Detection Between Slab 2th Floor With Composite Column

This spatial-temporal clash, shown would have necessitated a costly rework on-site.

Table 1. Comparison of Initial Duration vs. Optimized Duration.

| Activity Description | Initial Plan (Days) | Optimized Plan (Days) | Efficiency Gain (%) |
|---|---|---|---|
| Column Erection | 30 | 25 | 16.6 % |
| Main Beam Installation | 25 | 21 | 16.0 % |
| Roof Truss Assembly | 35 | 30 | 14.28 % |
| Total Project Duration | 90 | 76 | 15.55 % |

### Optimization of Workflow and Project Duration

The iterative process of identifying clashes and visualizing the sequence allowed the project team to optimize the construction workflow significantly. The optimization was not merely a one-time fix but an iterative cycle of: *Simulate -> Identify Conflict -> Adjust -> Re-Simulate* .

Based on the analysis in 3.2, the following optimizations were implemented:

1. **Zoning Reconfiguration:** The building was divided into three independent erection zones (Zone West, Center, East) instead of a linear flow. This allowed two crane teams to work simultaneously in different zones without interference, leveraging the spatial freedom identified in the model.
2. **Material Logistics Optimization:** The simulation revealed that material laydown areas were placed too far from the crane radius, causing delays in moving materials. The model was used to reposition laydown areas within the 10m effective working radius of the crane, reducing pick-and-place cycle times by approximately 10%.

As a result of these interventions, the total steel erection duration was significantly reduced. The initial estimated duration was 90 days. After the 4D optimization, the duration was reduced to 14 days. This represents a **15.55 % efficiency gain** , primarily achieved by eliminating downtime due to equipment repositioning and enabling parallel workstreams.

## CONCLUSION

The implementation of 4D BIM using Navisworks Manage has proven to be an effective strategy for managing the steel structure workflow of the Paraqouai Sao Paulo building. The integration of the 3D model with the construction schedule provided a powerful tool for visualization and planning. The study successfully identified potential temporal clashes that could have caused significant delays and safety issues. By optimizing the erection sequence, the project duration was reduced by 15.55 %. This research underscores the importance of adopting digital technologies in the construction industry, particularly for complex projects in developing regions like Lospalos.

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