IRJIF. I.F. : 3.821

North Asian International Research Journal of Sciences, Engineering & I.T.

ISSN: 2454-7514 Vol. 11, Issue-4, April-2025

Index Copernicus Value: 52.88 Indian Citation Index Thomson Reuters ID: S-8304-2016

A Peer Reviewed Refereed International Journal

DOI: doiglobal.org/doilink/10.2025/6802518813c2d

INTEGRATED PROJECT MANAGEMENT USING REVIT AND NAVISWORKS

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ABSTRACT:

Integrated project management using Revit and Navisworks streamlines the design, planning, and execution phases of construction projects. Revit enables Building Information Modeling (BIM), offering detailed 3D models with embedded data. Navisworks complements this by providing powerful tools for clash detection, project simulation, and coordination. Together, they facilitate real-time collaboration among architects, engineers, and contractors. This integration reduces errors, improves decision-making, and enhances project timelines. Clash detection helps identify and resolve design conflicts before construction begins. 4D simulations in Navisworks allow better visualization of construction sequencing. Integrated workflows improve communication across disciplines. Project managers can monitor progress with greater accuracy. Overall, this synergy leads to more efficient, cost-effective, and successful project delivery.

***KEYWORDS** —BIM, Planning, 2D & 3D modelling, 4D & 5D Visual Simulation, Clash Detection*

I. INTRODUCTION

Integrated project management using Revit and Navisworks represents a modern approach to handling complex construction projects. Revit, a BIM software, allows professionals to create detailed, data-rich 3D models of buildings. Navisworks enhances these models by enabling coordination, clash detection, and time-based simulations. Navisworks complements this by offering powerful tools for clash detection, 4D construction simulation, and model aggregation, enabling real-time collaboration among multidisciplinary teams. The integration of these tools fosters a seamless workflow from design to execution. It enables early detection of design conflicts, efficient scheduling, and better visualization of project phases. This proactive approach significantly reduces costly rework and delays during construction.When used together, these tools bridge gaps between design, engineering, and construction teams. They support a collaborative workflow that reduces rework and improves efficiency. Additionally, project managers benefit from improved coordination, accurate progress tracking, and enhanced decision-making. The ability to visualize the construction timeline and detect clashes before they occur on-site promotes a more controlled and cost-effective project environment. This integration ensures that all stakeholders work from a single source of truth. Real-time updates and issue tracking streamline decision-making. Project timelines and costs become easier to manage and forecast. As a result, project outcomes are more predictable and successful. This approach is transforming the architecture, engineering, and construction (AEC) industry.By combining the modeling capabilities of Revit with the coordination and project review strengths of Navisworks, project teams can achieve better planning, minimized rework, enhanced communication, and improved decision-making throughout the project lifecycle. This integrated approach not only reduces project risks and costs but also drives efficiency from design through construction.

II. GENERATION OF BIM MODELS (2D & 3D MODELS)

2D and 3D modeling are fundamental components of Building Information Modeling (BIM), transforming how construction and infrastructure projects are designed and executed. In traditional 2D modeling, drawings such as plans, sections, and elevations are used to represent building elements. These are typically created using CAD software and provide basic geometric and spatial information. With the evolution to 3D modeling in BIM, designers can now create intelligent, data-rich representations of buildings. Unlike 2D drawings, 3D models offer a realistic visual of the entire structure, including depth, height, and material properties. This enhances visualization, communication, and understanding among stakeholders.3D BIM models allow for better spatial coordination, clash detection, and quantity takeoffs. They integrate various building systems—architectural, structural, mechanical, electrical, and plumbing—into a single digital environment. This reduces errors, improves collaboration, and streamlines project execution.Together, 2D and 3D modeling in BIM support a comprehensive approach to building design and construction. While 2D is still used for documentation, 3D models form the backbone of modern project workflows, enhancing accuracy, efficiency, and decision-making.

III. 2D MODELLING

2D modeling in AutoCAD is the process of creating flat representations of objects, structures, or layouts using two dimensions—length and width. It is widely used in architectural, engineering, and construction industries for drafting plans, elevations, sections, and detailed views.

AutoCAD is one of the most widely used computer-aided design (CAD) software for creating precise 2D drawings and technical documentation. The 2D modelling process in AutoCAD involves several key steps:

1. **Setting Up the Drawing Environment**
   - Define the drawing units (millimetres, inches, etc.).
   - Set limits and scales according to the project requirements.

- Choose the appropriate template or create a new one.

2. **Creating Layers**
   - Organize different elements (walls, furniture, electrical, etc.) on separate layers.
   - Assign colors, line types, and line weights to improve drawing clarity and print control.
3. **Using Drawing Tools**
   - Use basic drawing commands such as:
   - LINE, CIRCLE, ARC, RECTANGLE, POLYLINE, etc.
   - Combine and modify shapes to form complex geometry.
4. **Applying Modify Commands**
   - Modify existing geometry using commands like:
   - MOVE, COPY, ROTATE, SCALE, TRIM, EXTEND, OFFSET, MIRROR, and FILLET.

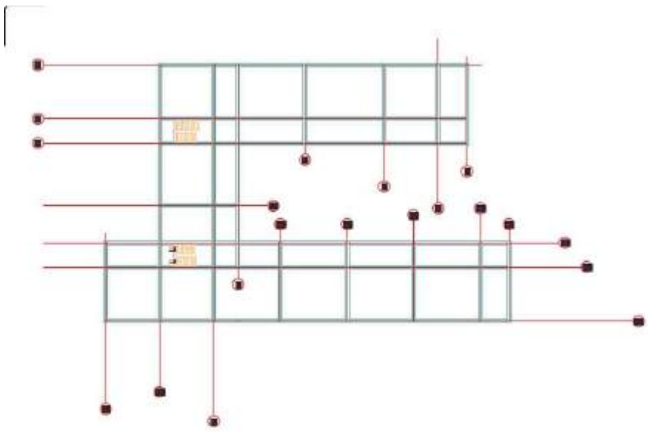
- **5. Adding Annotations**
   - Add dimensions using DIM tools.
   - Insert text with TEXT or MTEXT.
   - Use leaders and hatches for clarity and detail.
- **6. Blocks and Reusability**
   - Create and insert blocks for repeated elements (e.g., doors, windows, fixtures).
   - Use attributes if data needs to be linked with objects.

7. Finalizing the Drawing

- Use LAYOUT tabs to prepare sheets for plotting. Add title blocks, viewports, and scales. Ensure layers and linetypes are correctly displayed for plotting.

8. Plotting/Exporting

- Use the PLOT command to print or export the drawing as a PDF. Ensure all settings (scale, paper size, plot style) are correctly applied.



2D MODELLING PLAN

IV . 3D MODELLING

Revit is a Building Information Modeling (BIM) software that allows users to design buildings and structures in a fully coordinated 3D environment. Unlike traditional CAD tools, Revit generates intelligent models that store both geometric and parametric data. The 3D modelling process in Revit typically follows these steps:

1. Project Setup

- Start a new project using a predefined or custom template.
- Set up project units, levels, and grids to define building height and layout.

2. Creating the Building Structure

- Use Walls, Floors, Roofs, Columns, and Beams to construct the building shell.
- These elements are placed using tools from the Architecture and Structure tabs.
- Elements are automatically generated in 3D and can be modified in both 2D (plan, section) and 3D views.

3. Adding Components

- Insert elements such as doors, windows, furniture, and fixtures from the Revit Family library.
- Customize or create new families for specific design needs.

4. Creating Views

- Generate floor plans, 3D views, sections, and elevations automatically from the model.
- Each view is a representation of the same central model, ensuring consistency.

5. Applying Materials and Rendering

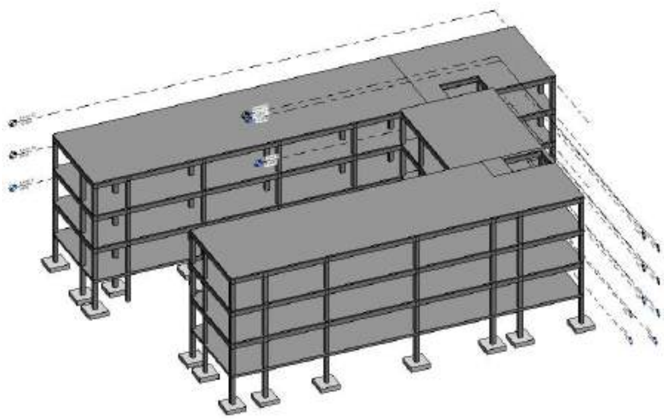
- Assign materials to elements for realistic visuals.
- Use built-in rendering tools to produce photorealistic images for presentation.

6. Documentation and Annotation

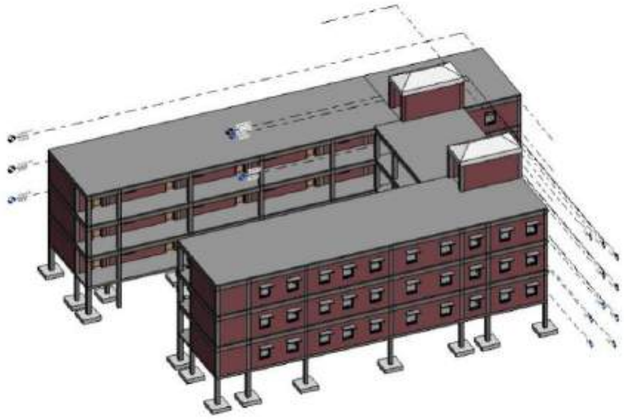
- Add dimensions, tags, schedules, and annotations.
- Revit auto-generates material takeoffs, quantity schedules, and other data-rich documentation.

7. Export and Publishing

- Export models to formats like DWG, IFC, or Navisworks NWC.
- Publish drawings and sheets for construction documentation.



3D FRAME MODEL



3D BUILDING

V. ESTIMATION & COSTING

Estimation and Costing is a crucial part of civil engineering, construction, and project management. It involves predicting the quantity of materials, labour, time, and overall cost needed for a project. The main goal is to prepare a budget and ensure efficient resource management. It helps in planning, decision-making, and tendering processes. Estimation ensures that a project is economically feasible and can be completed within the allocated resources. There are different types of estimates like preliminary, detailed, plinth area, and cube rate estimates. Accuracy in estimation helps avoid cost overruns and delays. Costing involves determining the unit cost of items and services. It includes direct costs (materials, labour) and indirect costs (overheads, equipment).Standard methods such as DPR (Detailed Project Report) and BOQ (Bill of Quantities) are used. Rates for materials and labour are taken from standard schedules or market analysis. Estimation also accounts for wastage, transportation, and contingencies. It is essential for contractors, engineers, and clients alike. Tools like Excel, AutoCAD, and estimation software improve efficiency. A well-prepared estimate aids in bidding for projects and managing finances. It serves as a baseline for cost control and project monitoring. Costing is also vital in valuation, billing, and auditing.

Here the sample Calculation part for understanding:

Column:

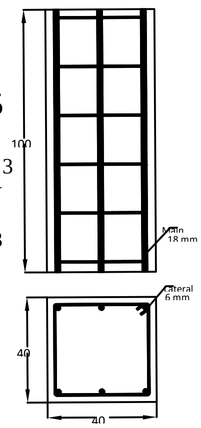
$0.4 \text{ X } 0.4 \text{ X } 3 = 0.48 \text{ m}^3$

M_{30} (1: 0.75 : 1.5)

Sum of ratio = 1 + 0.75 + 1.5 = 3.25

Wet volume = 0.48 m^3

Dry volume = 0.48 x 1.54 =0.739 m^3



1) Cement = 0.739 / 3.25 =0.277 m^3

$1 \text{ m}^3 = 1440$ kg

0.277 m^3 = ?

0.277 x 1440 = 326.88 kg = 327 kg

1 bag = 50 kg

x = 327 kg

x = 327 / 50 = 6.54 bags = 7 bags
1 bag = 400/-
Cost = 7 x 400 =2800/-

2) Sand = (0.739 X 0.75) / 3.25 = 0.17 m^3
1 m^3 = 1750 kg
0.17 m^3= ?
0.17 x 1750 = 297.5 = 300 kg

1000 kg = 600/-
300 kg = ?
Cost = (300 x 600) / 1000 = 180/-

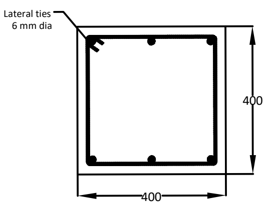
3) Ballast = (0.739 x 1.5) / 3.25 = 0.341 m^3
1 m^3 = 1450 kg

0.341 m^3 = ?
1450 x 0.341 = 494.45 kg = 500 kg
1000 kg = 800/-
Cost = (500 x 800) / 1000 = 400/-

Gross area (A_g)= 1600 cm^3 = 160 x 10^3 mm^3
Area of steel(A_{sc})= 12.8 x 10^2 mm^2
Assume 18 mm Φ bars
number of bars = 1280 / ((π/4) x 18^2) = 5.1 Nos. = 6 Nos.
A_{sc}, provided = 6 x ((π /4) x 18^2) = 1526 mm^2
Main Reinforcement = A_{sc} = 1526 mm^2

Shear reinforcement:
A_{sv}= 443.37 mm^2
Number of lateral ties = 443.37 / ((π/4) x 6^2) = 15.68 = 16 Nos.
A_{sv} ,provided = 16 x((π/4) x 6^2) = 452.38 mm^2
Unit weight of steel = $Φ^2$ / 162.2 = 18^2 /162.2 = 1.99 kg /m
1000 kg = 50000/-
1kg = ?
? = 50000 / 1000 = 50/-
Therefore , 1.99 x 50 = 99.5/-
Lateral ties spacing = 3000 x (((π/4) x 6^2) / 452.38) = 187.5 mm = 180 mm C/C

Lateral ties:



a = 400 – 50 = 350 mm
b = 400 – 50 = 350 mm
length = 2(a+b) + 2 x 12 x 6
= 2(350 +350) + 2 x 12 x 6
= 1544 mm = 1.54 m

Bar Bending Schedule:

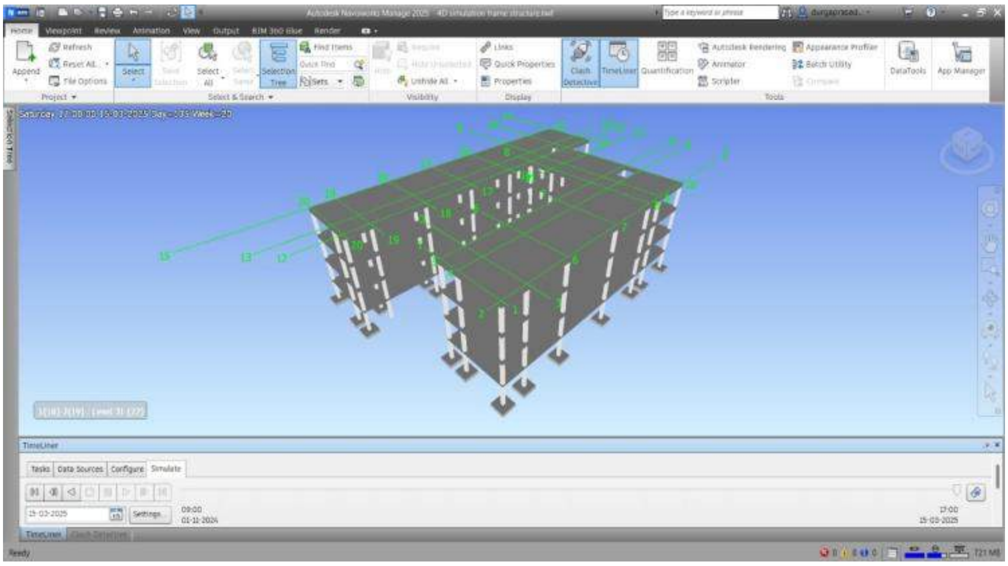
S.NO	Description of item	Shape of bar	Nos	Length (m)	Total Length (m)	Weight (kg)
1	Main Reinforcement of 18mm diameter (Φ^2/162.2)= (18^2/162.2)=1.99 kg/m		6	3	18	35.82 kg
2	Lateral ties of 6mm diameter (6^2/162.2)= 0.22 kg/m		16	1.54	24.7	5.534 kg
					Total =	41.2kg

Total Cost = 35.82 + 5.434 = 41.2 kg = 42 kg
42 x 50 = 2100/-
Total cost of the column = 2800 + 180 + 400 + 2100
= 5480/- = 5500/-
Columns Cost = 5500 x 50 = 2,75,000/-
Total Cost of column at Ground floor = 2,75,000/-

As similar as Column calculation make the calculation of footing, beams, slabs and brick work Calculations.

VI. 4D SIMULATION

The 4D simulation process in Navisworks is a powerful tool used in construction project planning and management. It integrates 3D models with construction schedules (time = 4th dimension), enabling users to simulate the construction sequence over time. Here's a step-by-step breakdown of how the 4D simulation process works in Autodesk Navisworks Manage:



1. Prepare Your Files

- 3D Model: Typically from Revit, AutoCAD, or other modelling tools.
- Schedule: Usually created in Microsoft Project, Primavera P6, or even Excel or make time line in Navisworks in time liner sheet.

2. Import the Files into Navisworks

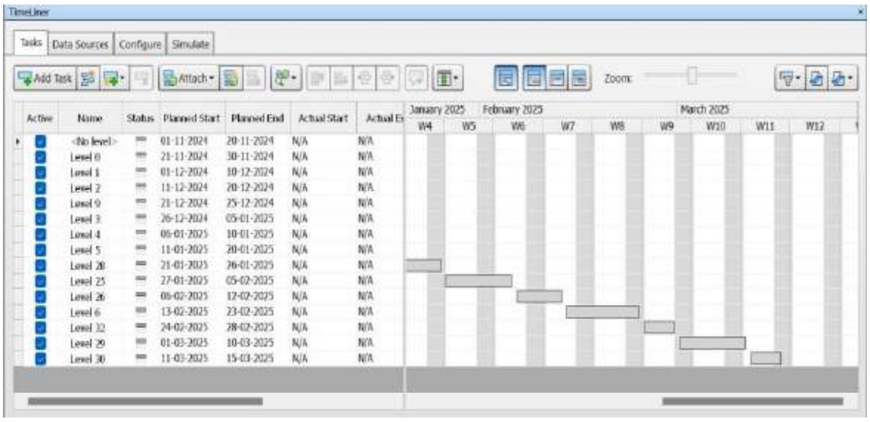
- Open Navisworks and import your 3D model (usually in NWD/NWC/NWF format).
- Use the Timeliner tool to import the schedule.

3. Link Schedule to Model Elements

- In Timeliner, go to the Tasks tab where your schedule appears.
- In the "Links" tab, associate each task with the model elements it represents.
- This can be done manually or via rules/search sets for faster mapping.

4. Set Task Types

- Define each task as:
- Construction
- Demolition
- Temporary (e.g., scaffolding)
- This tells Navisworks how to display objects over time.



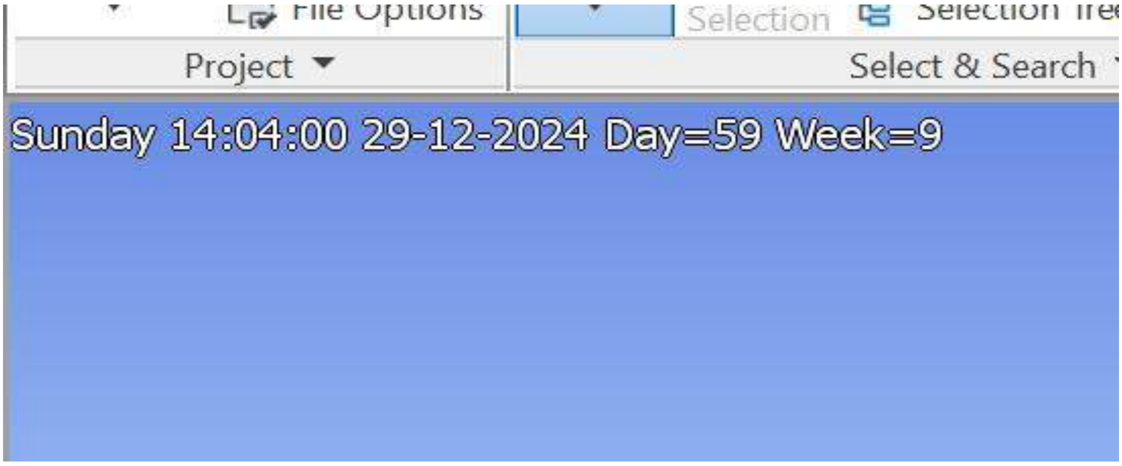
TIME LINE

5. Simulate the Sequence

- Go to the Simulate tab and play the simulation.
- You'll see construction progress over time as defined in the schedule.

6. Export the Simulation

- You can record the 4D simulation and export it as a video file (AVI).
- Useful for presentations, client meetings, and team coordination.

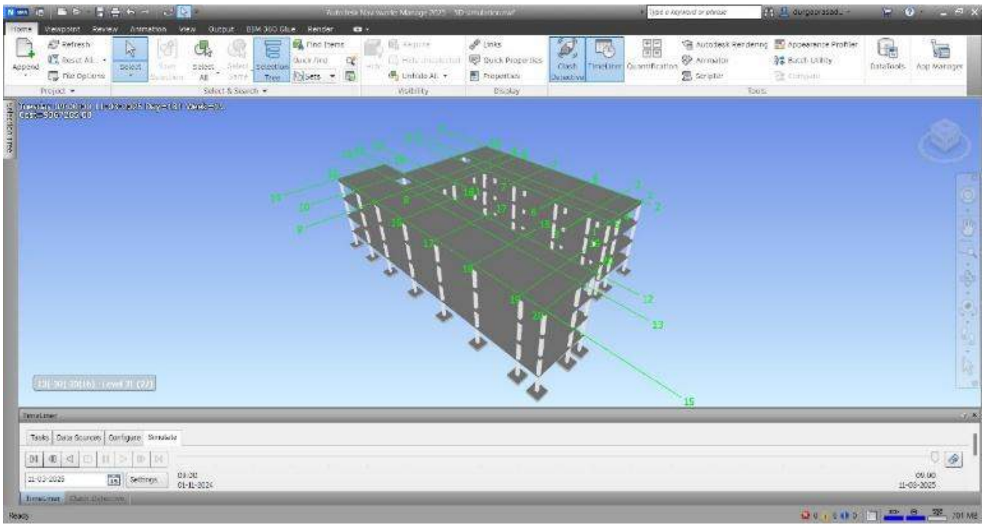


4D Simulation = 3D modelling + Time line

VII . 5D SIMULATION

5D simulation in Navisworks is a powerful technique used in Building Information Modeling (BIM) to integrate the 3D model (geometry), 4D (time/scheduling), and 5D (cost). This allows stakeholders to visualize how a project will evolve over time and how costs will accumulate.

Here's a step-by-step outline of the 5D simulation process in Autodesk Navisworks:



1. Import the 3D Model

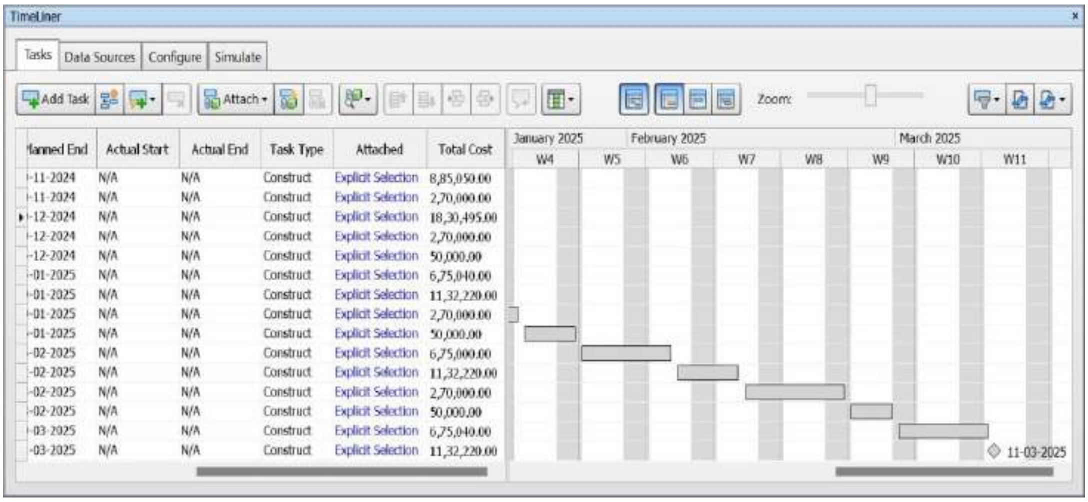
- Load your BIM model into Navisworks Manage.
- Compatible formats: .nwc, .nwd, .nwf (exported from Revit, AutoCAD, etc.)

2. Link the Project Schedule (4D)

- Go to the Timeliner tool.
- Import a project schedule:
- Supported formats: Primavera P6, MS Project, or even Excel.
- Assign model elements to tasks in the schedule.

3. Add Cost Data (5D)

- Timeliner also supports cost data.
- Each task can be assigned Planned Cost, Actual Cost, Resource Usage, etc.
- Cost data can be imported via.
- Excel spreadsheet with costs linked to schedule items.
- Custom plugin/API integration from ERP systems (like SAP).



TIME LINE + COST

4. Link Model Elements to Tasks and Costs

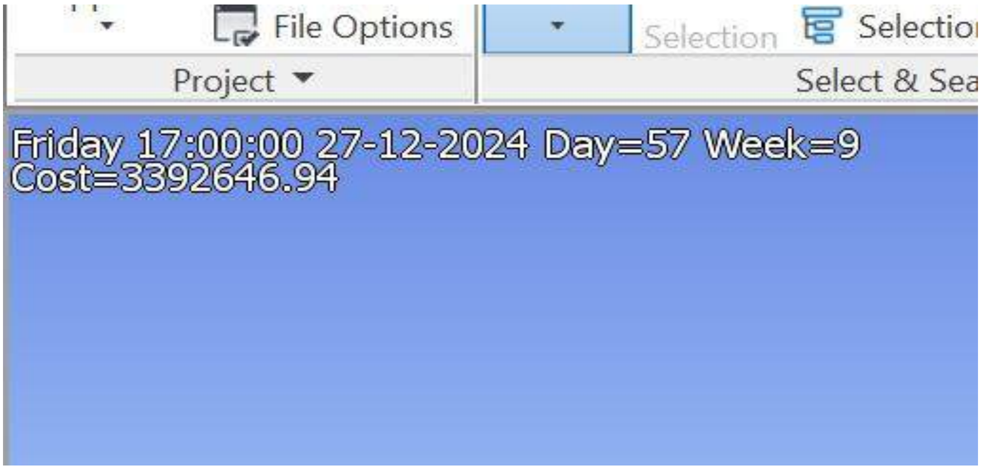
- In the Timeliner> Tasks tab, assign model geometry to each task.
- This links physical elements (e.g., slabs, walls) to construction activities and their costs.

5. Run 5D Simulation

- Use the Simulate tab to run the simulation.
- Visualize how elements are built over time and how costs are incurred.
- You can toggle views to show
- Task progression (4D)
- Cost accumulation (5D)
- Critical paths or delays

6. Analyze& Export

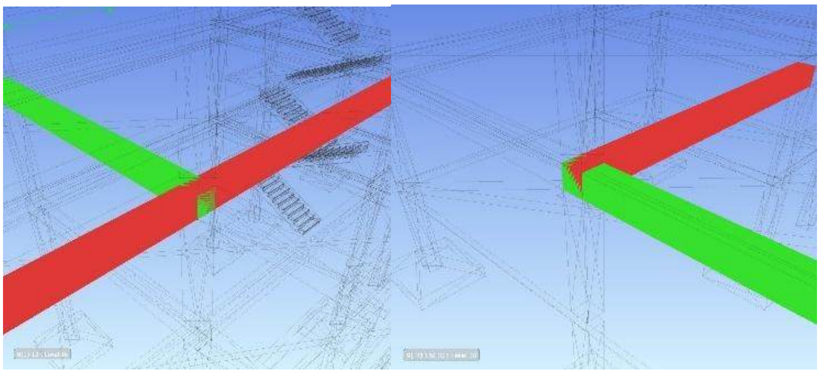
- Export the simulation as a video for presentation.
- Export cost and time reports.
- Useful for stakeholders, site managers, and clients to understand progress and budget forecasts.



5D Simulation = 4D Simulation + Cost

VIII . CLASH DETECTION

Clash detection is a critical process in Building Information Modeling (BIM) used to identify and resolve design conflicts before construction begins. Autodesk Navisworks is a powerful tool widely used in the architecture, engineering, and construction (AEC) industry to perform clash detection efficiently. It enables project teams to integrate 3D models from various disciplines—such as architectural, structural, and MEP (mechanical, electrical, and plumbing)—into a single environment, allowing for comprehensive analysis.The clash detection process in Navisworks not only highlights conflicts but also facilitates collaboration by allowing users to group clashes, assign responsibilities, and track their resolution through reports and visualizations. This makes Navisworks an essential tool for ensuring model accuracy, enhancing communication among stakeholders, and ultimately delivering a more constructible and efficient design.



1. Prepare Models

- Import all relevant discipline models (e.g., architectural, structural, MEP) into Navisworks.
- Use NWC, DWG, IFC, RVT, etc. files.
- Ensure models are properly aligned and coordinated (same origin, units, and orientation).

2. Open Navisworks Manage

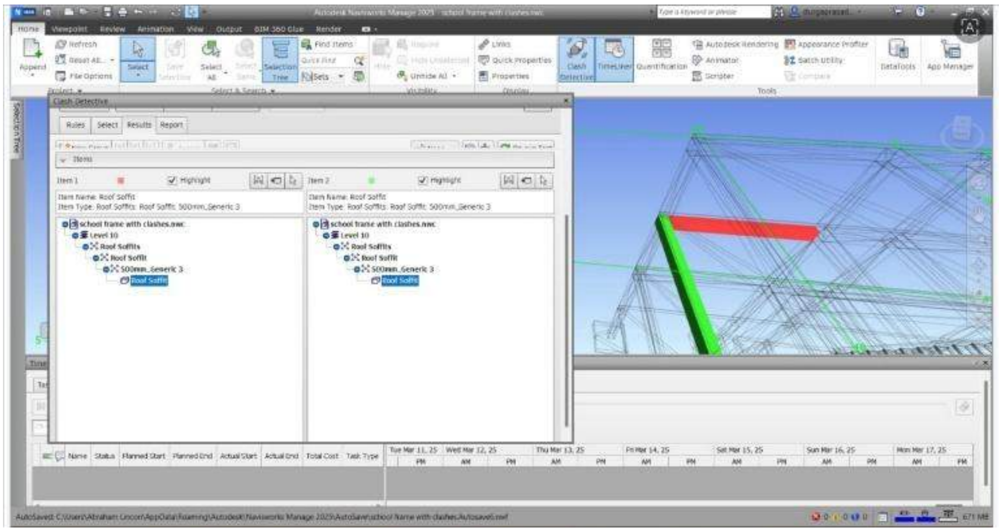
- Use Navisworks Manage (not just Navisworks Freedom or Simulate) for clash detection features

3. Append All Models

- Use the "Append" option (File > Append) to load all discipline models into one federated model.
- Visually inspect to confirm correct placement and alignment.

4. Set Up Clash Test (Clash Detective Tool)

- Open the Clash Detective (Home tab > Tools panel > Clash Detective).
- Click "Add Test".
- Define the two sets of objects to test:
- Selection A (e.g., Columns)
- Selection B (e.g., beams)
- You can use selection sets or search sets for more dynamic control.



5. Configure Clash Test Settings

Choose clash type:

- Hard (physical overlaps)
- Clearance (minimum space violations)
- Duplicate (identical elements in same space
- Set tolerance if needed (e.g., 25mm clearance between elements).

6. Run Clash Test

- Click Run Test.
- Navisworks will analyze and list all clashes found between Set A and Set B.

7. Review and Manage Clashes

Use the Results tab to:

- View clashes
- Sort/group/filter by status, grid location, type, etc.
- Mark clashes as:New, Active, Reviewed, Approved, Resolved.

8. Export Reports

Export clash reports as:

- HTML, XML, CSV

- Viewpoint reports (.nwd/.nwf)
- Useful for meetings or sending to stakeholders.

9. Resolve Clashes and Iterate

- Share clashes with respective teams.
- Teams revise models in their native software (Revit, AutoCAD, etc.).
- Import updated models back into Navisworks and rerun clash tests.

10. Finalize and Approve

- Once all clashes are resolved or accepted, mark the test as complete.
- Document resolutions for future reference.

IX . RE-ESTIMATION AFTER FINDING THE CLASHES IN BUILDING

BUILDING WITH CLASHES

Beams :
Quantity = 0.08 m^3
M_{30} (1: 0.75 : 1.5)
Sum of ratio = 1 + 0.75 + 1.5 = 3.25
Wet volume = 0.08 m^3
Dry volume = 0.08 x 1.54 = 0.1232 m^3

1) Cement = 0.1232 / 3.25 = 0.038 m^3
1 m^3 = 1440 kg
0.038 m^3 = ?
0.038 x 1440 = 54.72 kg

1 bag = 50 kg
x = 54.72 kg
x = 54.72 / 50 = 2 bags

1 bag = 400/-
Total Cost of Cement = 2 x 400 = 800/-

2) Sand = (0.1232 x 0.75) / 3.25 = 0.028 m^3
1 m^3 = 1750 kg
0.028 m^3= ?
0.028 x 1750 = 49 kg
1000 kg = 600/-
49 kg= ?
Cost =(49 x 600) / 1000 = 30/-

Total cost of sand = 30/-

3) Ballast = (0.1232 x 1.5) / 3.25 = 0.057 m^3
1 m^3 = 1450 kg
0.057 m^3 = ?

1450 x 0.057 = 83 kg

1000 kg = 800/-
Cost = (83 x 800) / 1000 = 68/-
total cost = 68 + 150 + 30 + 800 = 1048 /-
total = 1048 x 15 = 15720 /-

The quantity is increasing due to the increase in conflicts (Clashes), so we need to re-evaluate and test by comparing the building with conflicts (Clashes) and the building without conflicts.

X . COMPARISON OF COST OF WITH & WITHOUT CLASHES OF BUILDING

When comparing the cost of building with and without clashes, the difference can be significant. In a construction project with clashes—such as overlapping structural elements, conflicting mechanical systems, or misaligned components—there are often delays, material wastage, and additional labor costs due to the need for rework and on-site adjustments.
These clashes may not only increase the direct cost of construction but also extend the project timeline, leading to further financial losses. On the other hand, a clash-free project, often achieved through proper planning and the use of tools like Building Information Modeling (BIM), enables smoother execution.
It minimizes rework, reduces waste, and ensures efficient coordination among different disciplines, ultimately leading to lower overall costs. Therefore, resolving clashes in the design phase rather than during construction can result in substantial cost savings and a more streamlined building process.
On the other hand, when clash detection is implemented early, often through Building Information Modeling (BIM), many of these issues are resolved in the planning phase. This proactive approach reduces unexpected costs, shortens project timelines, and enhances coordination among stakeholders. Therefore, the cost of building with proper clash management is generally much lower than proceeding without it, offering both financial and operational benefits throughout the construction lifecycle.

Building with Clashes Calculation

LEVEL	ITEMS	COST
NO LEVEL	Foundation	885050
LEVEL 0	Column	270000
LEVEL 1	Basement	1830495
LEVEL 2	Column	270000
LEVEL 9	Stairs	50000
LEVEL 3	Beams	690760
LEVEL 4	Slab	1132220
LEVEL 5	Column	270000
LEVEL 28	Stairs	59000

LEVEL 25	Beams	690760
LEVEL 26	Slab	1132220
LEVEL 6	Column	270000
LEVEL 32	Stairs	50000
LEVEL 29	Beams	690760
LEVEL 30	Slab	1132220
	Total Brick work	2250330
		11673815

By comparing the costs of two materials, we can determine the cost difference. Similarly, when we compare costs using Navisworks, we can easily understand the efficiency of our building design and ensure safer construction practices.

XI. CONCLUSION

The integration of Revit and Navisworks offers a powerful solution for enhancing project management in the Architecture, Engineering, and Construction (AEC) industry. By combining Revit's robust Building Information Modeling (BIM) capabilities with Navisworks' advanced coordination, clash detection, and project review tools, stakeholders can achieve greater efficiency, collaboration, and accuracy throughout the project lifecycle.

This integrated approach streamlines workflows by enabling real-time updates, reducing design conflicts, and improving communication across disciplines. It also facilitates better planning and decision-making through detailed 3D visualization and simulation. As a result, project teams can identify and resolve issues early, minimize costly delays, and ensure that projects are delivered on time and within budget.

In conclusion, the synergy between Revit and Navisworks not only elevates the quality of project delivery but also sets a strong foundation for a more collaborative, data-driven, and future-ready construction process.

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