Module 14

Tools for Energy Efficiency

Digitalisation in Construction

24 partners

12 countries

Date of Event

*Author/ **Institute***

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Tools for Energy Efficiency | Summary

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To equip the learner with the basic knowledge and skills required to understand and know how BIM and other digital tools can improve the energy performance of buildings

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Tools for Energy Efficiency | Objectives

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1. List and outline how the use of digital tools can improve the energy efficiency of buildings.
2. Outline how a BIM model can be used to perform an energy analysis
3. Outline how to develop a Building Energy Model (BEM)
4. Demonstrate how to develop a Building Energy Model (BEM) using a case study
5. Outline how using a BEM affects the design and operation of nZEB buildings.
6. Outline the process of delivering a BEM to an energy simulation tool.

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Topic 1 – Energy Efficiency Tools

Topic 2 – Energy simulation tools

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1. Energy Efficiency Tools

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Summary NZEB

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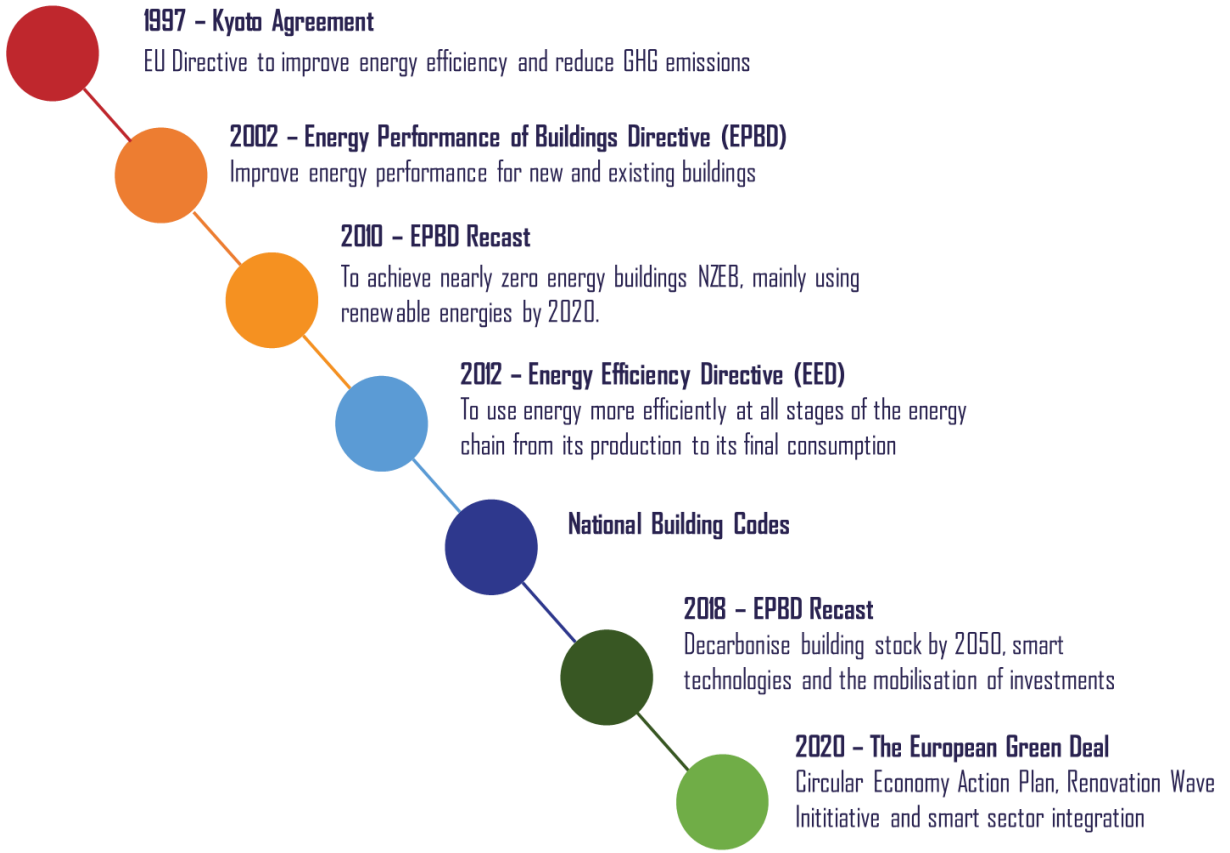
In Europe

- The construction of quality efficient buildings is important and is the responsibility of all involved.
- NZEB policies and Green directives have set out an action plan for the construction industry.
- “Construction of energy efficient, healthy, sustainable buildings”

- **Energy Performance of Buildings Directive**
- **Energy Efficiency Directive**
- **The European Green Deal**

EU POLICIES & LEGISLATION



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Summary of NZEB

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Nearly Zero Energy Buildings means a building that has a very high energy performance, Annex 1 of the Directive, and in which "the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby".

- A building which produces more or less the same amount of energy per year as it uses.
- The building can generate this renewable energy on site or feed back to the electricity grid.

Source: BIMzeED project

Why go NZEB?

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“To construct quality, healthy, energy efficient buildings”

Occupants –

- By improving energy savings, comfort levels, indoor air quality (IAQ), healthy living, reduce fuel poverty

Building Owners –

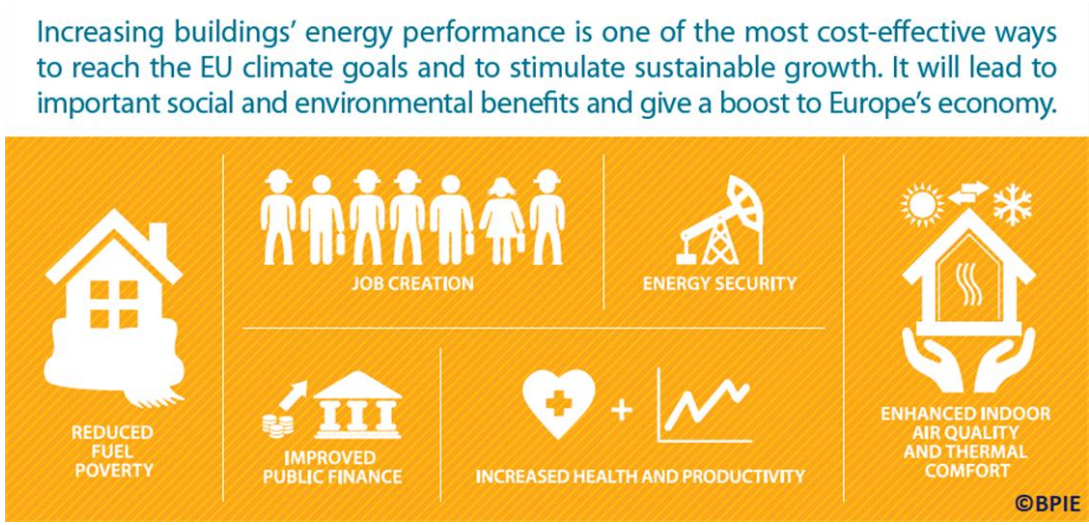
- By improving building value, quality dwellings, lower maintenance, improve image,

Contractors –

- By streamlining work schedules, improve costs, improve image, trained workforce, job creation

Also it is Law!

Energy savings
Comfort
IAQ



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Key principles of energy usage and waste

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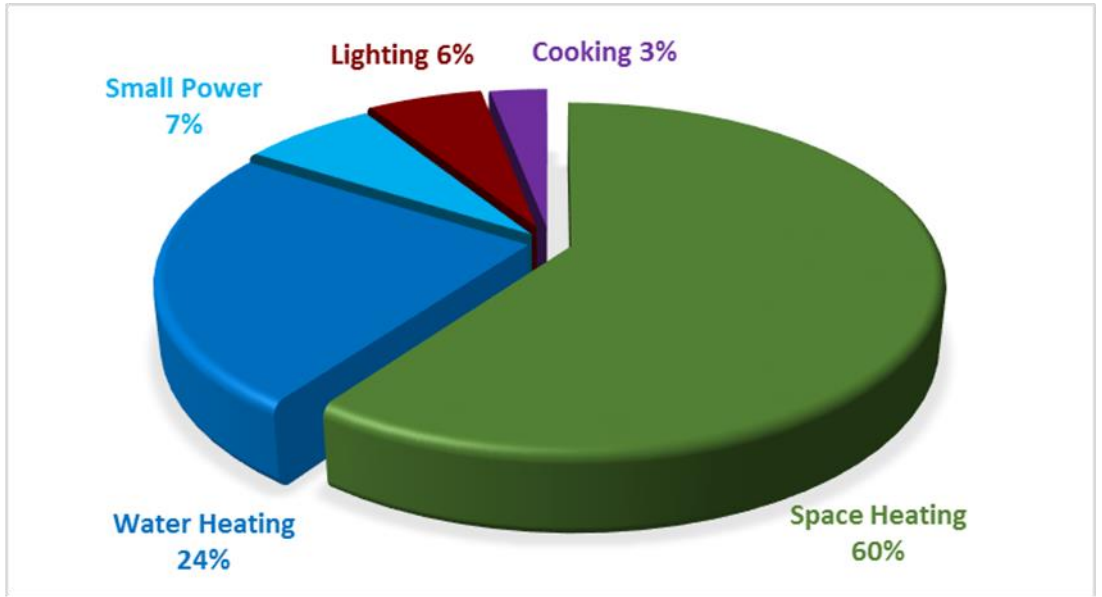
Building Envelope

The building envelope separates the outdoor environment from the conditions inside the building. It consists of walls, doors, windows, floors and roof.

The envelope controls the flow of heat energy, air movement, moisture penetration, and solar heat, to maintain the indoor conditions within a range that is convenient to the occupants' comfort, health, safety and purse!

To maintain required conditions inside the building space, the building systems must overcome the energy loads that are imposed by the climatic conditions outside the building and also, energy loads that are imposed by factors inside the building itself.



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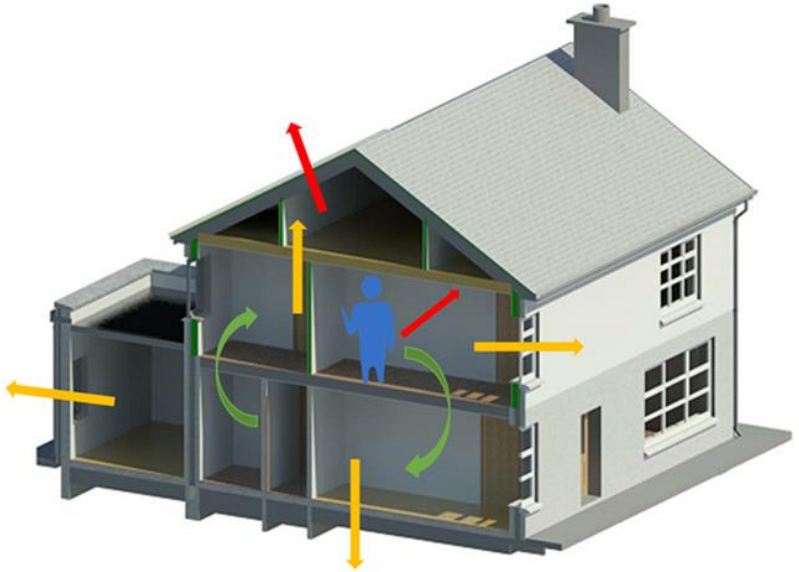
Heat Losses and Gains

The transmission of heat energy through the solid elements of the building envelope is caused by the difference between the indoor and outdoor temperatures. The materials used in the building envelope have a significant impact on the amount of energy required to maintain a suitable environment within the building space. Building walls composed primarily of glass and steel are a major source of heat loss in the winter and heat gains in the summer.

Heat is transmitted through the building envelope in three ways:

1. Conduction is the heat flow through a solid material from the warmer to the cooler side of the envelope, through walls, roof/ceiling and floor slabs.
2. Convection is the heat transfer caused by the motion of heated air from a warmer to a cooler surface, thorough openings and cracks around windows and doors.
3. Radiation is the transfer of heat by electromagnetic waves from a warmer to a cooler surface. Solar radiation depends on: its location, time of year, time of day, the building's orientation



✓ Conduction

✓ Convection

✓ Radiation

Source: BIMzeED project

Key principles of energy usage and waste

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Heat losses and gains

Materials of different properties have different thermal conductivities of energy, and are compared on the basis of U-values and R-values. The thermal transmittance (U-value) identifies the ability of a material to conduct thermal energy. The thermal resistance coefficient (R-value) is the corresponding rate of thermal resistance of the material.

Thermal Coefficients

- Thermal Conductivity Coefficient λ [W/(mK)] represents the properties of the material to conduct heat.
- Thermal Resistance Coefficient R = d/λ [m2xK/W] ; d= thickness of material; represents the properties of a building element to resist conductive transfer of heat per unit of exposed area.
- Heat Transfer Coefficient U = 1/R [W/m^2K] represents the rate of transfer of heat through one square metre of a structure divided by the difference in temperature across the structure.
- Materials with better insulation properties have higher R-values
- Calculation of R for combination of materials : Rtotal = ΣRi

Source: BIMzeED project

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Energy Efficiency Tools

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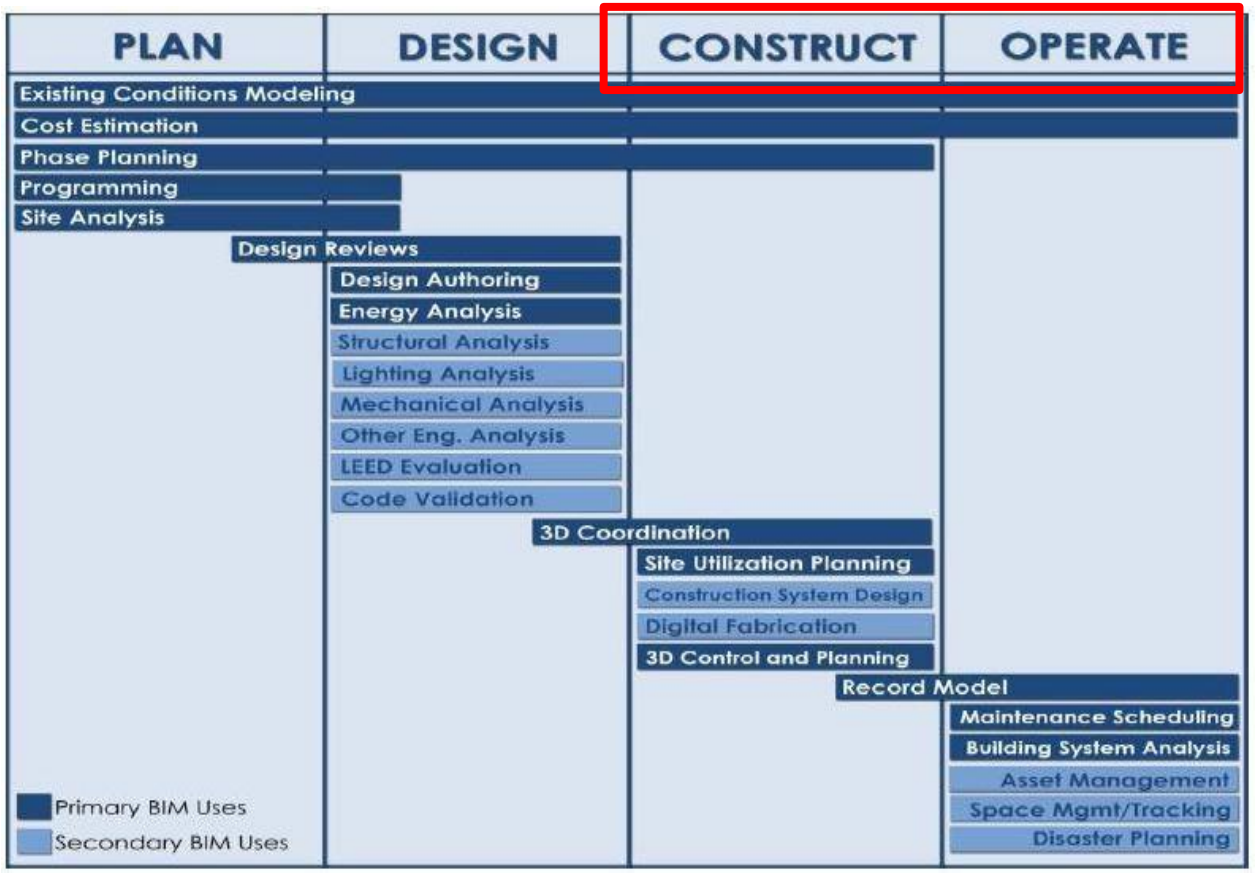
BIM can control quality and better design and construction of NZEB buildings

- Project Management and Coordination
- Sequencing and Scheduling
- Cost Estimation
- Time Management

BIM allows for better collaboration by all Teams

- Roles and Responsibilities
- Information Transfer



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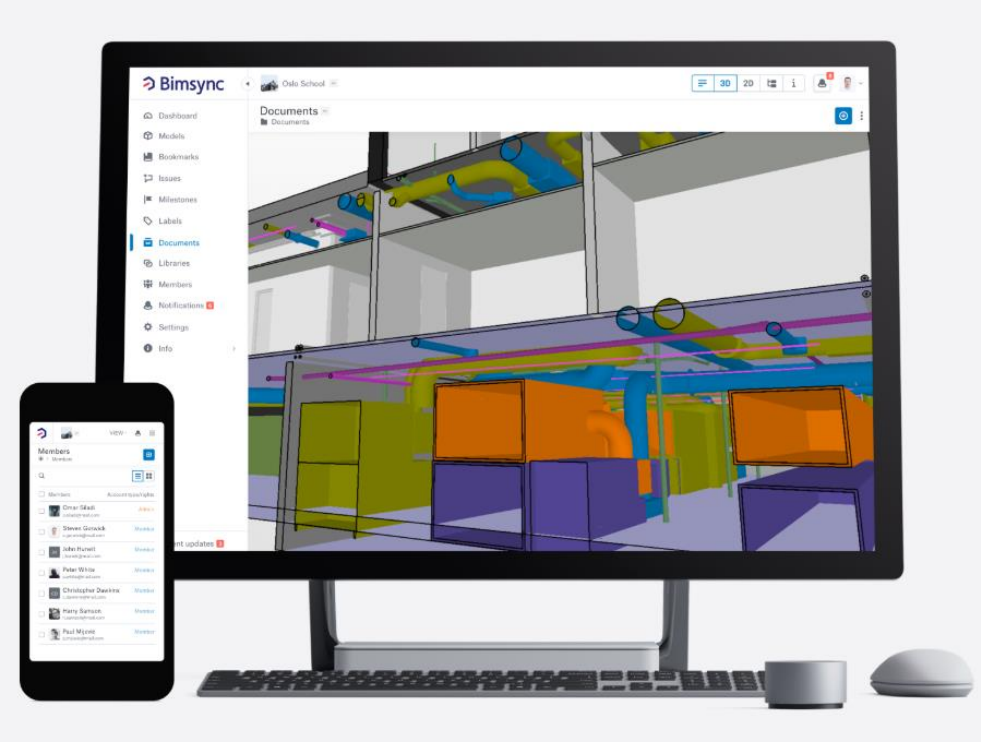

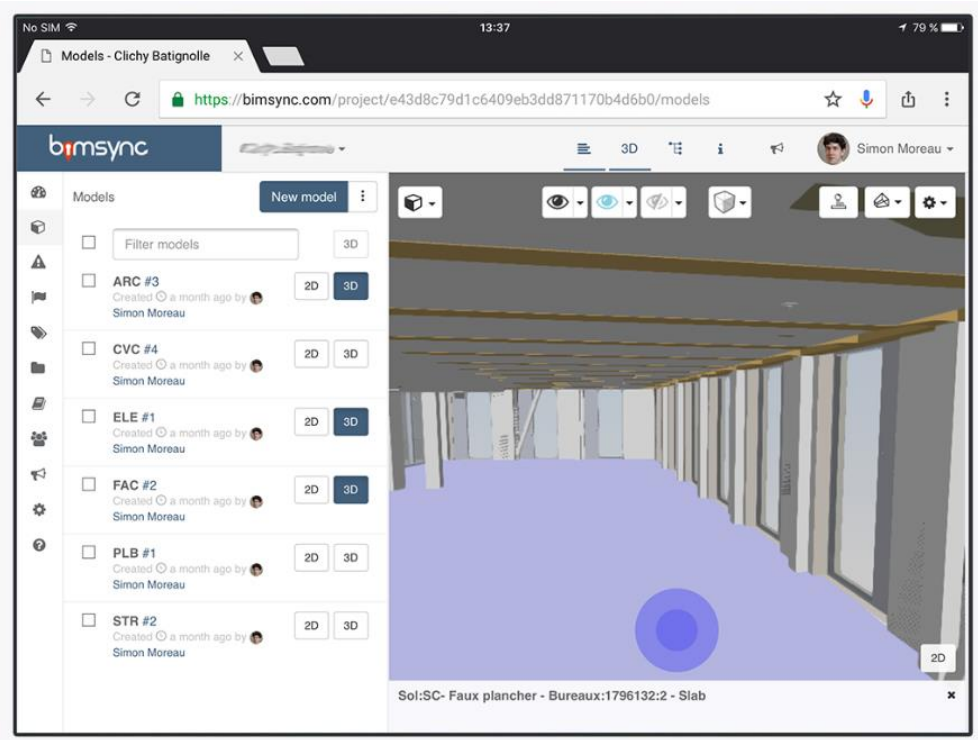

[Free Trial: https://bimsync.com/](https://bimsync.com/)

Source: BIMzeED project

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VISUALIZATION PLATFORMS - Issue Management - BIMTrack

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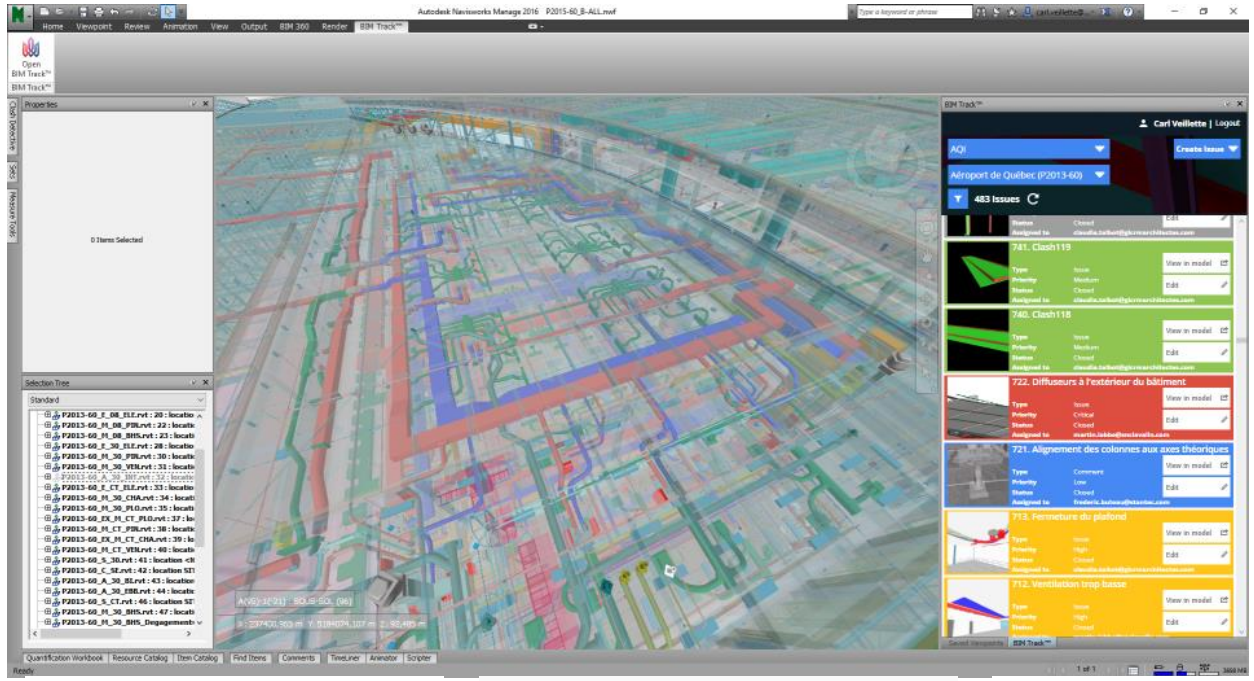

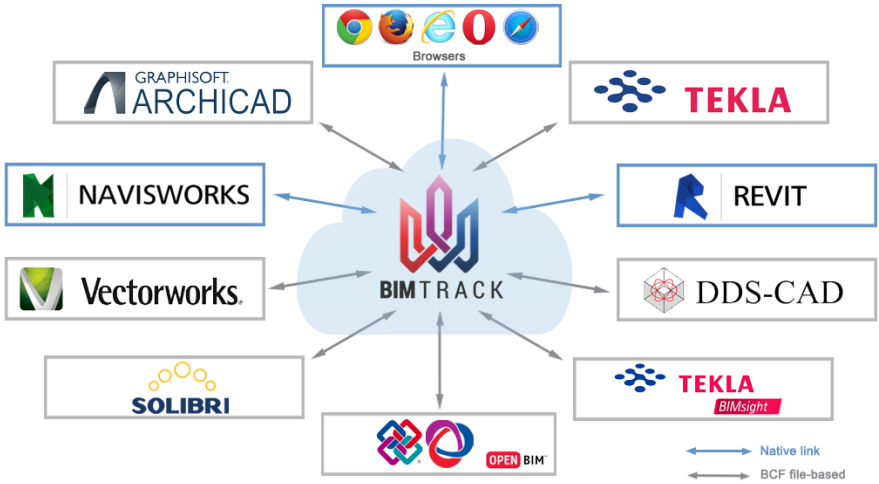

Simplifies communication by connecting platforms via the cloud.

Resolve the issues that matter most in your everyday BIM software.

Analytics give you the information you need to make the right decisions.

BIM Track provides total accountability and transparency.

Source: BIMzeED project

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Review the BIM-Viewer

There are several free BIM Viewers available in the market:

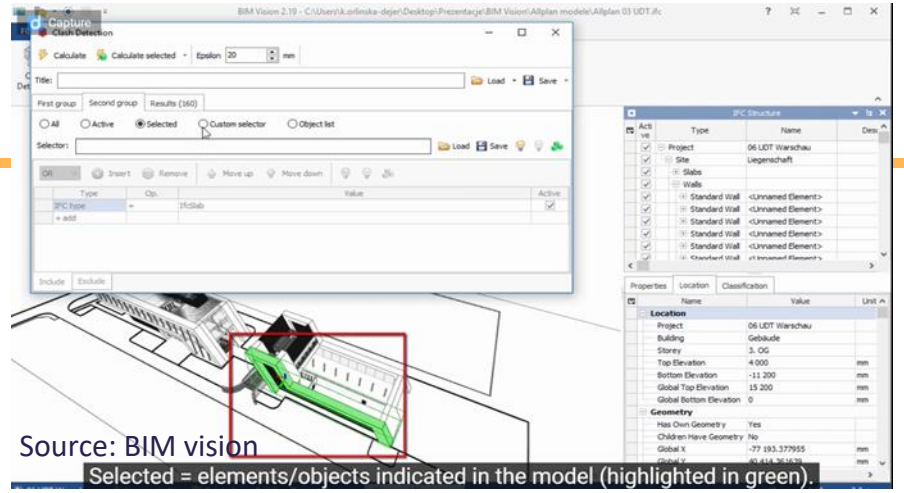
https://**bimvision**.eu/en/

https://www.**dalux**.com/daluxbimviewer/

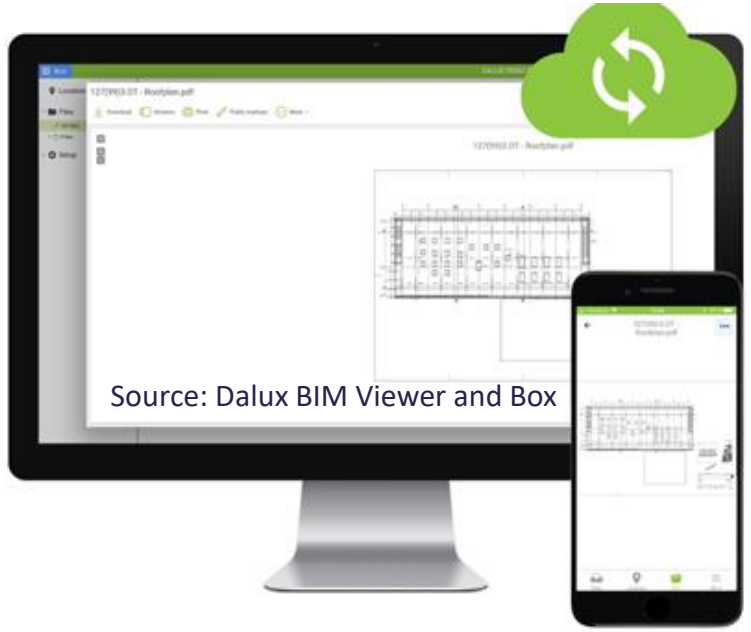
https://teklastructures.support.tekla.com/2019/en/rel_2019_Tekla_BIMsight_and_Web_Viewer_replaced_by_**Trimble_Connect**_for_Desktop

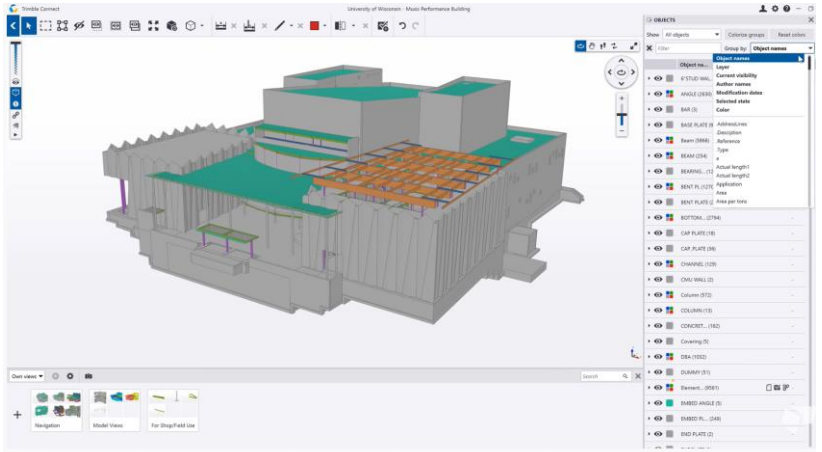
https://solution.**solibri**.com/application/#!ProductsView

We will look at Navisworks Manage



Source: BIM vision


Source: Dalux BIM Viewer and Box


Trimble Connect for Windows Feature Overview

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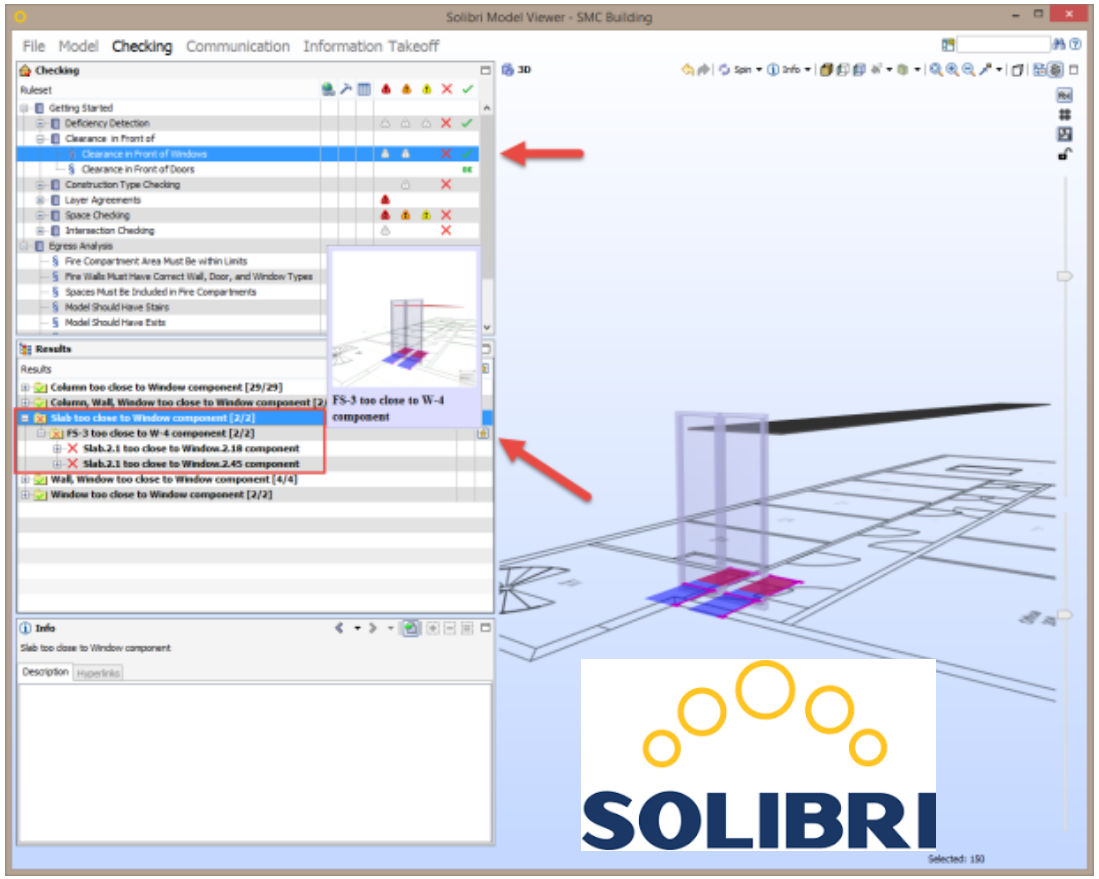

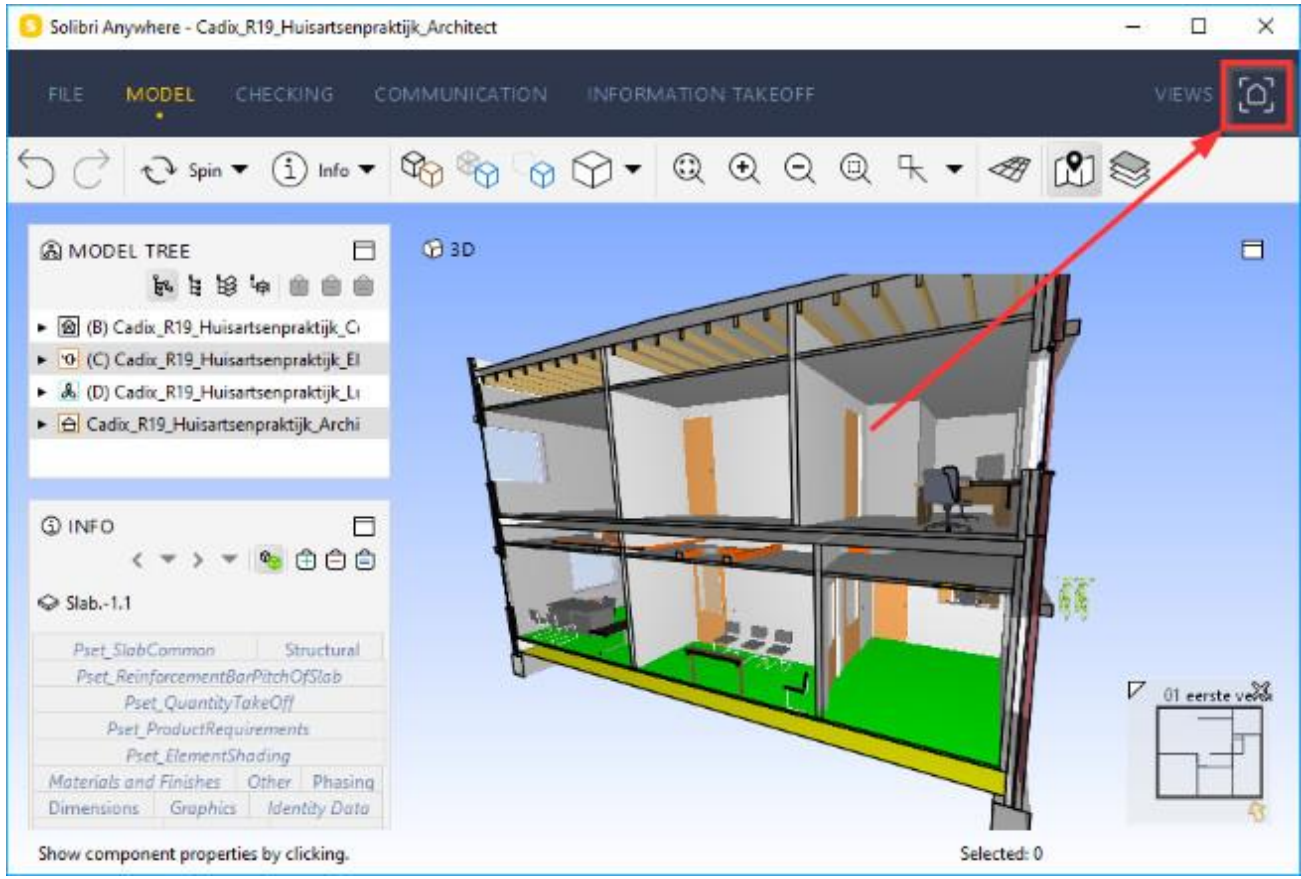

https://www.solibri.com/solibri-anywhere

Source: BIMzeED project

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VISUALIZATION PLATFORMS - BIMVision

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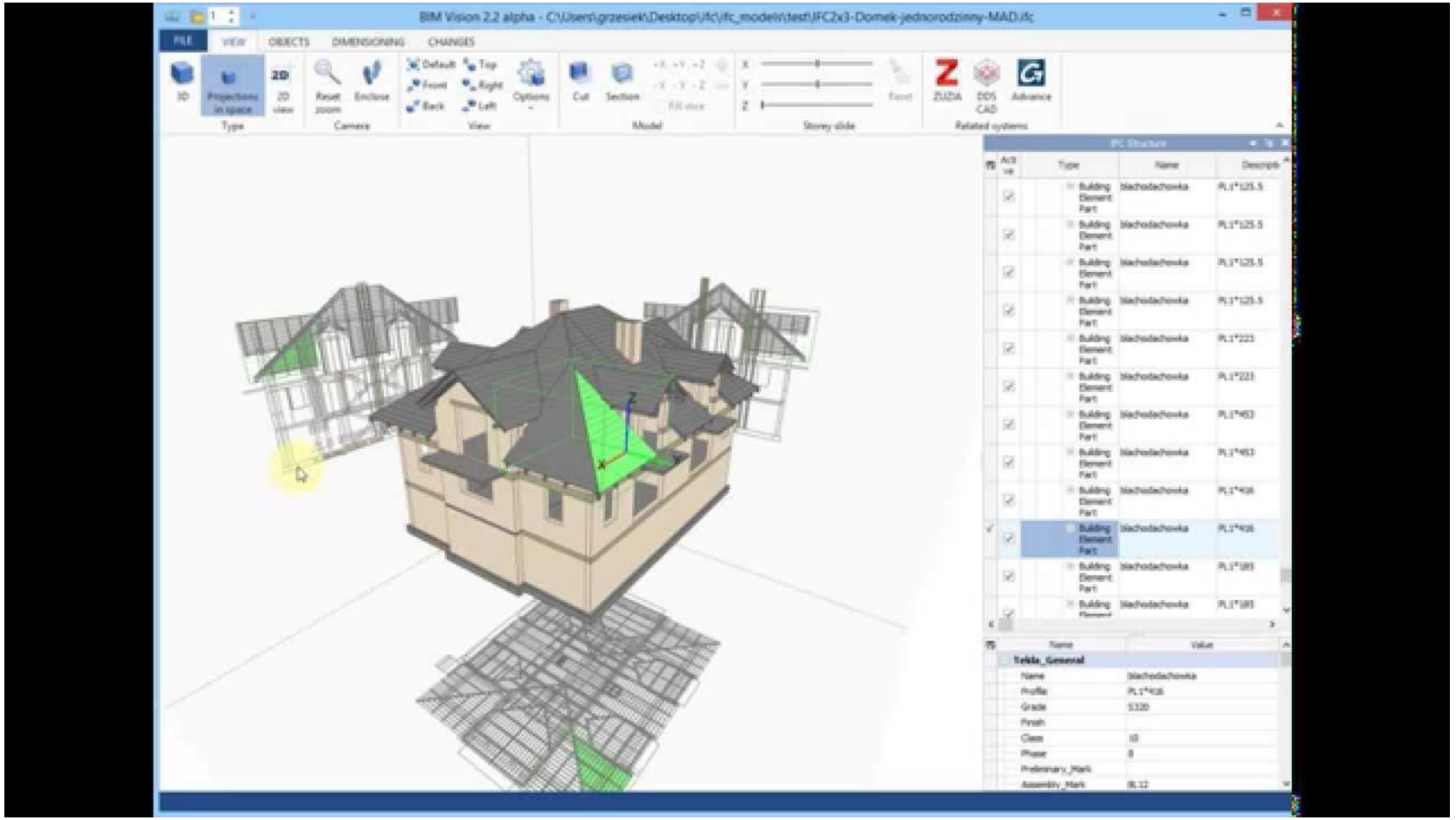

BIMVision

Read more and download: **https://bimvision.eu/**

Source: BIMzeED project

CDE - Trimble Connect/ Aconnex/ ThinkProject/ Dalux

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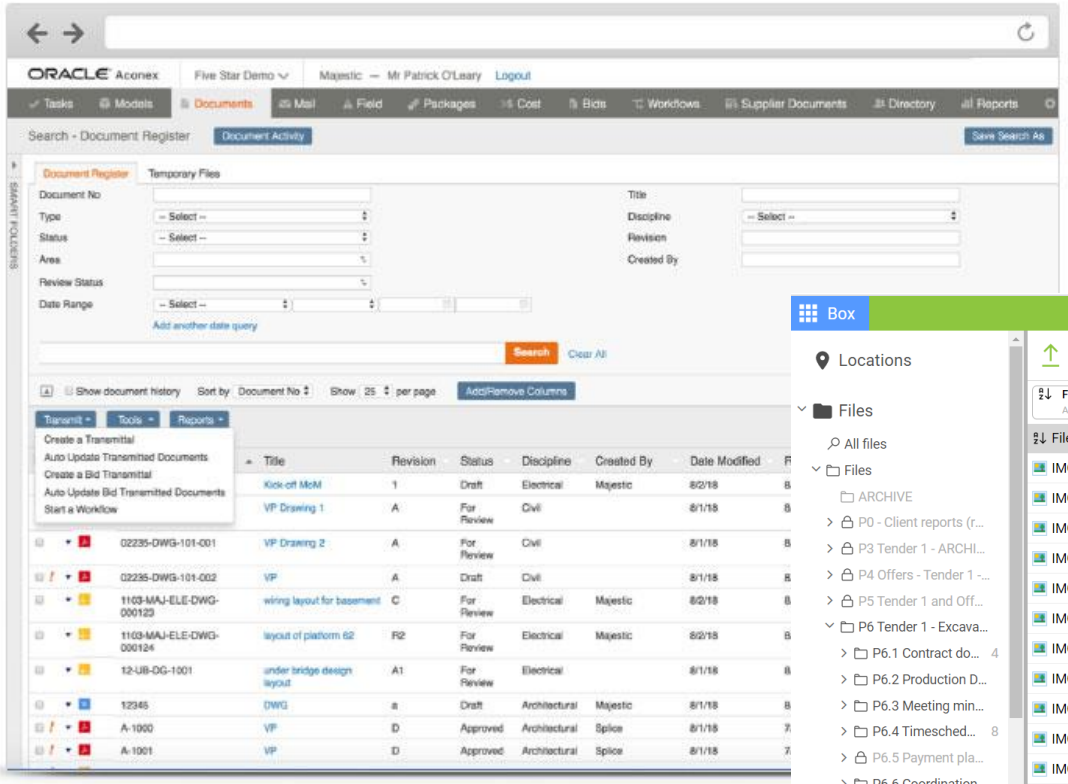
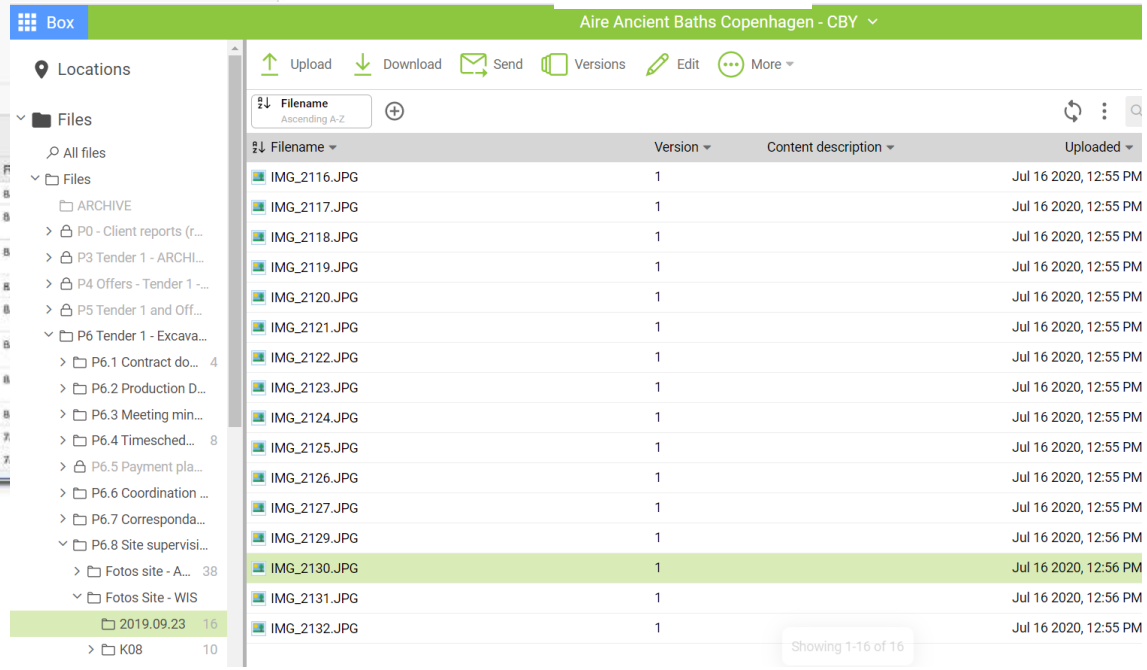
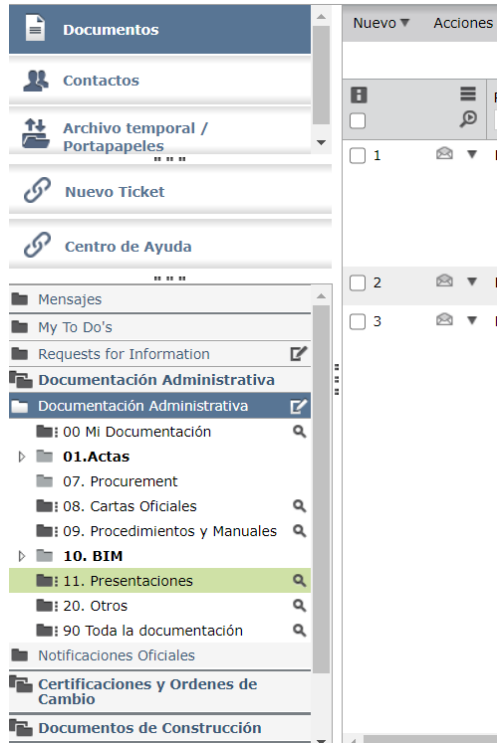


DALUX



thinkproject!



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CDE - Autodesk B360

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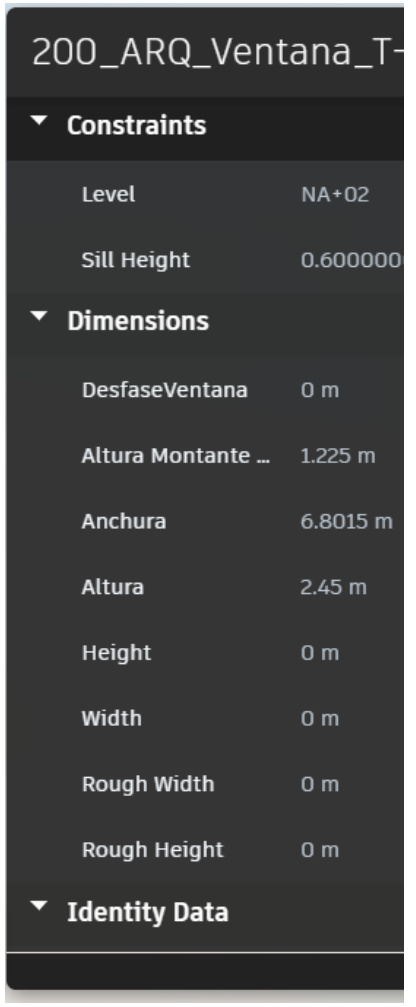

https://www.autodesk.com/bim-360/

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VISUALIZATION PLATFORMS - Autodesk Navisworks

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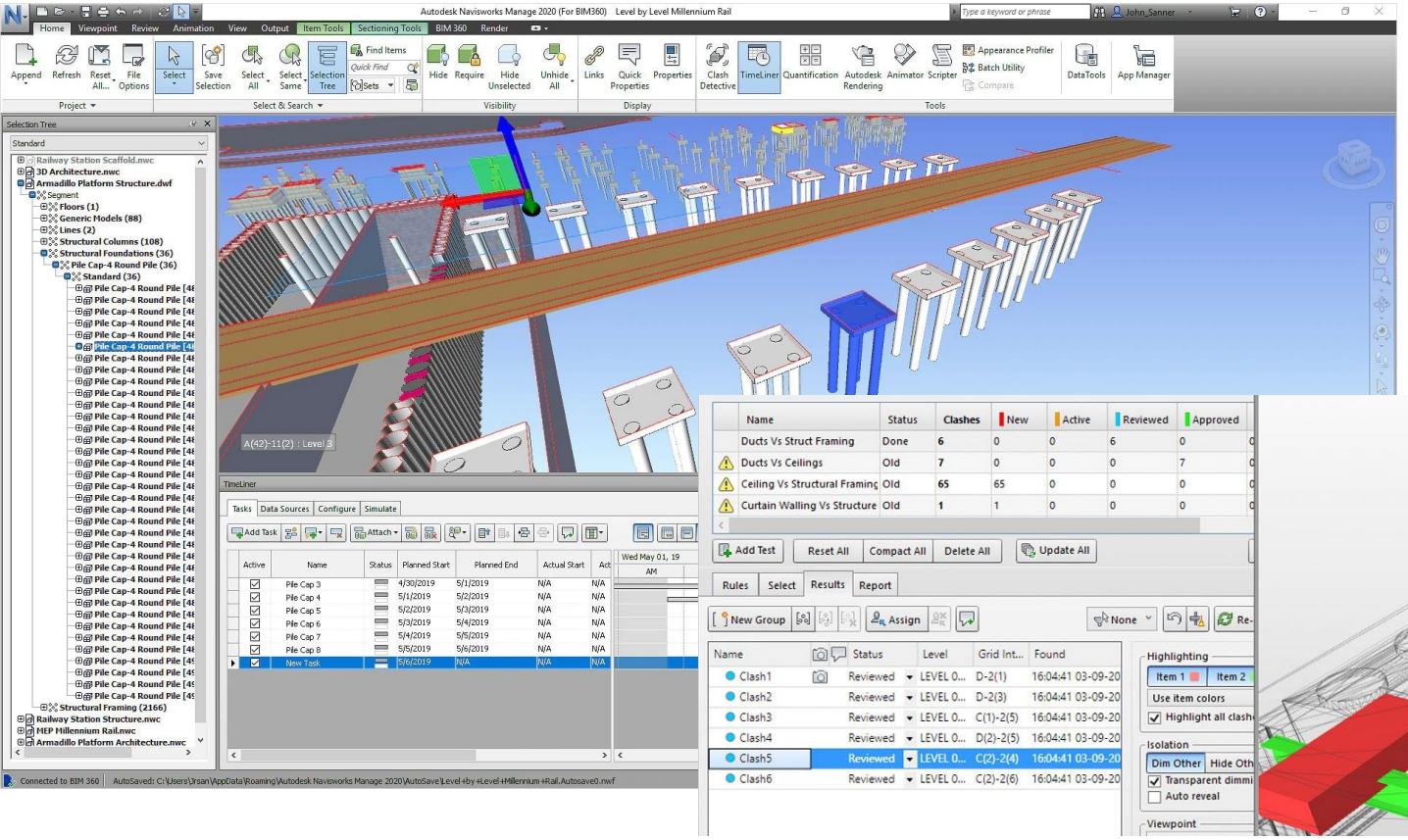
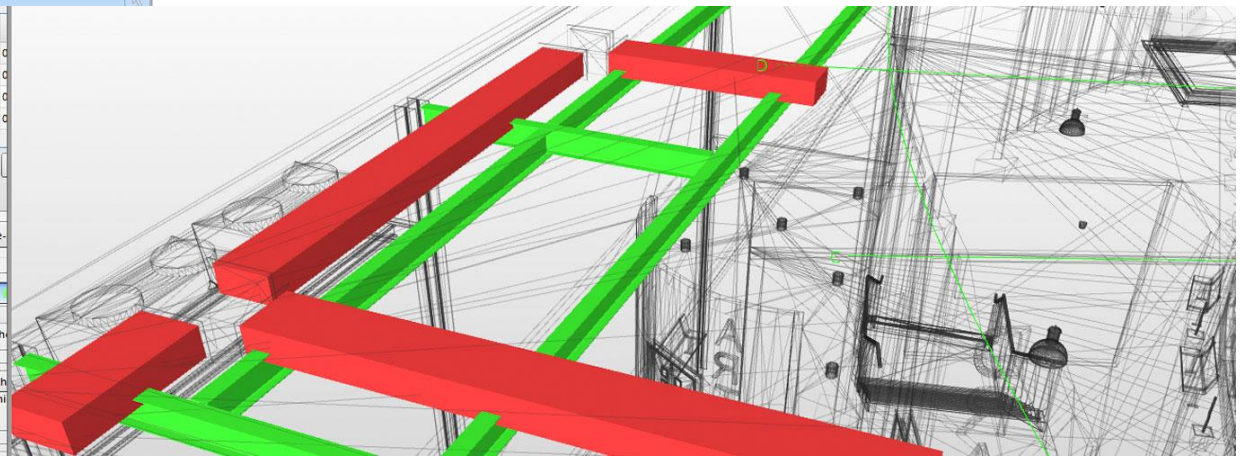
AUTODESK
NAVISWORKS





Digitalisation in Construction:
Tools for Energy Efficiency

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Access and Navigate Data

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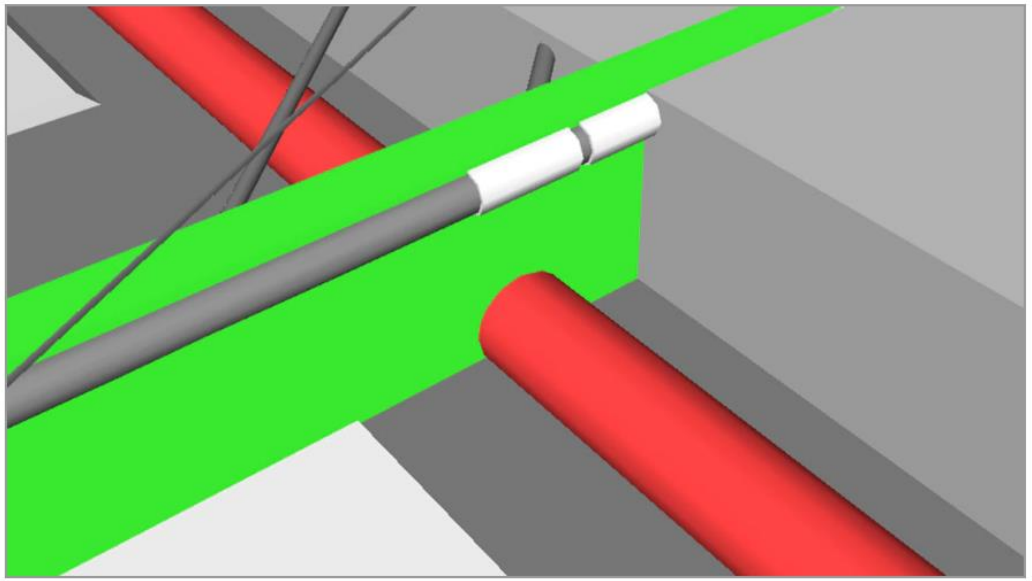
What is Navisworks?

Use Navisworks® project review software to improve BIM (Building Information Modelling) coordination.

1. Combine design and construction data into a single model.
2. Identify and resolve clash and interference problems before construction.
3. Aggregate data from multiple trades to better control outcomes.



Combine data from multiple sources to prevent problems.

Source: BIMzeED project

BIM System Requirements

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Before downloading the applications check that the system requirements.

See the following sections for hardware and software requirements:

Single Installation Requirements
Microsoft® Windows® 10 (64-bit) on the Semi Annual Channel servicing option.
Intel® Pentium® 4 or AMD Athlon™ 3.0 GHz (or higher) with SSE2 technology
2 GB RAM (minimum)
15 GB free disk space for installation
Direct3D 9® and OpenGL® capable graphics card with Shader Model 2 (minimum)
1,280 x 800 VGA display with true color (1,920 x 1,080 monitor and 32-bit video display adapter recommended)
Microsoft Mouse-compliant pointing device
Microsoft® Internet Explorer® 8.0 or later

Source: BIMzeED project

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Navisworks Download

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Video lessons related to NavisWorks were developed using the BIM tool **NavisWorks Manage**

Students can download a free Navisworks Manage student account.

You can use the following link for download 2021:
Navisworks_Manage_2021_dlm.sfx.exe
https://www.autodesk.com/education/free-software/navisworks-manage

Install

Run the downloaded executable to unpack the Manage installer to a location of your choice and to begin the installation process. Note that administration rights are needed to install this product.

Learn more

A Readme, Installation Guide, and other important documentation are accessible from within the installer. Navisworks Manage includes a comprehensive help system.

Navisworks Video lessons

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ALL THE BIM RELATED EXCERCISES CAN ALSO BE PERFORMED IN OTHER BIM TOOLS

- Revit https://www.autodesk.eu/free-trials or
- Allplan https://www.allplan.com/en/products/allplan-architecture/
- 3D Rhinocerous ETC ETC

It's all about the principles, and the principles remain unchanged regardless of the tools used.

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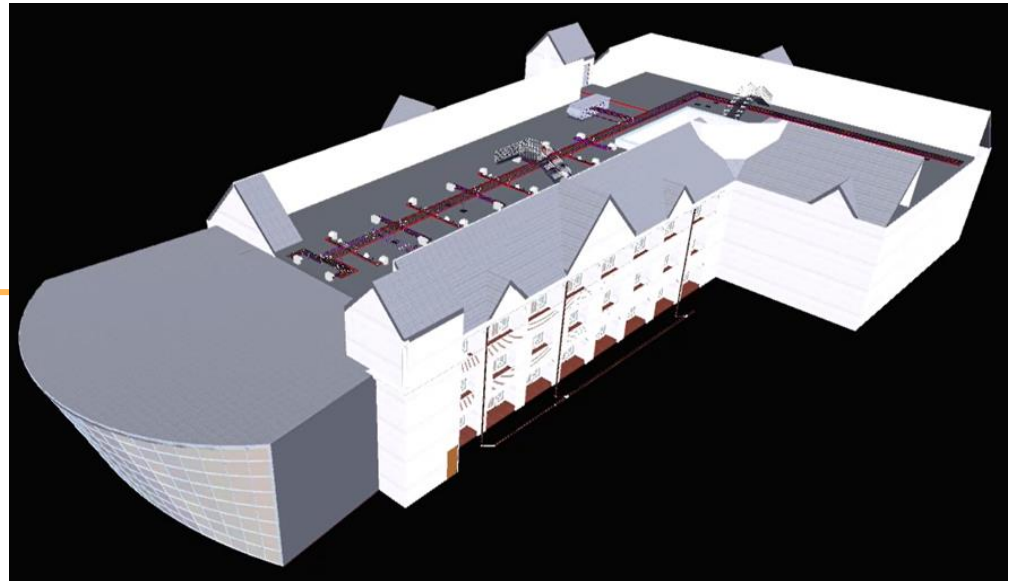
Navisworks Exercises

NAVISWORKS



VISUALIZATION PLATFORMS - Navisworks

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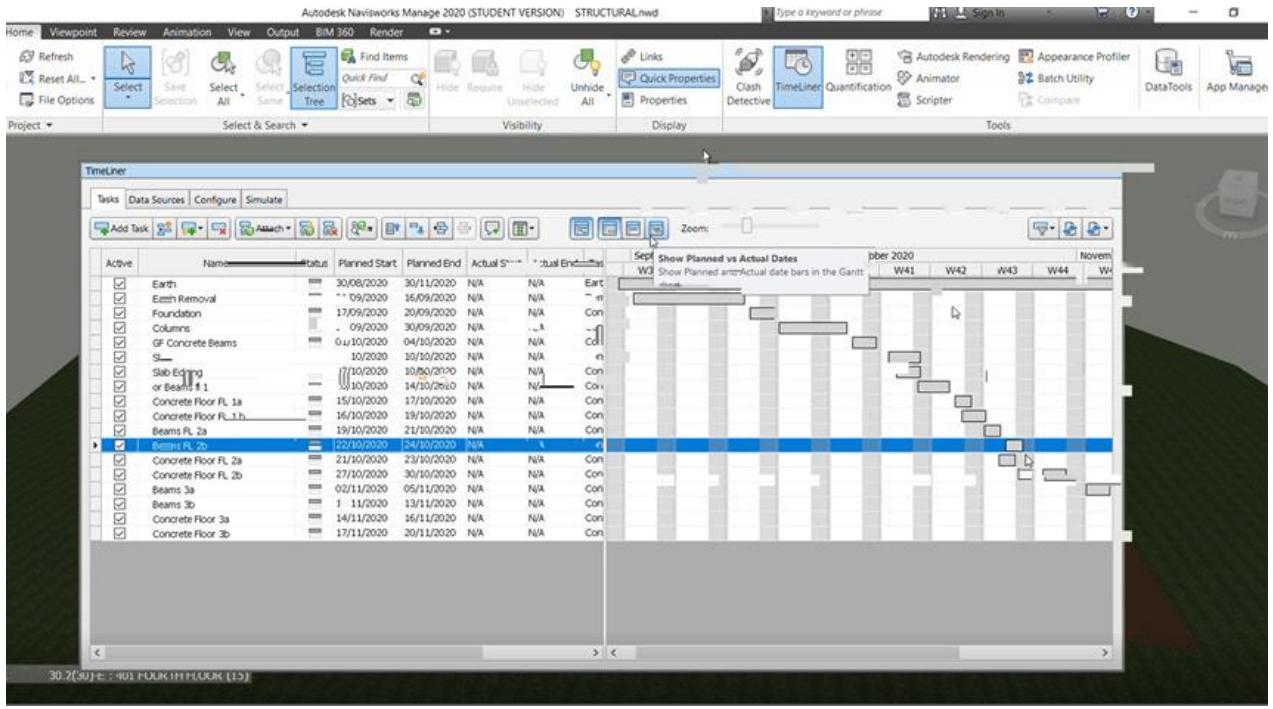
- **THEORY BEHIND THE TASK**
- 1- User Interface (Selection Tree, Properties, Sets, Find Items, Saved Viewpoints)
- 2- Units of Navisworks File
- 3- Types of Navisworks Files
- **NWF: Navisworks File**
- **NWD: Navisworks Document**
- **NWC: Navisworks Caché**
- 4- Gridlines
- 5- Navigation
- 6- Viewpoints
- 7- Comments



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VISUALIZATION PLATFORM - Navisworks

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Open Screencast from Autodesk to record your screen and carry out the following steps:

1. Open a Navisworks file
2. Organize your User Interface as you desire to show Selection Tree, Properties, Saved Viewpoints.
3. Append all the files of the folder provided.
4. Show Gridlines.
5. Navigate through the Project and save relevant Viewpoints. Include Sections of the Model.
6. Organize the views in Navisworks folders.
7. Show Properties of a particular Element.

Source: BIMzeED project

VISUALIZATION PLATFORMS – Navisworks-User Interface

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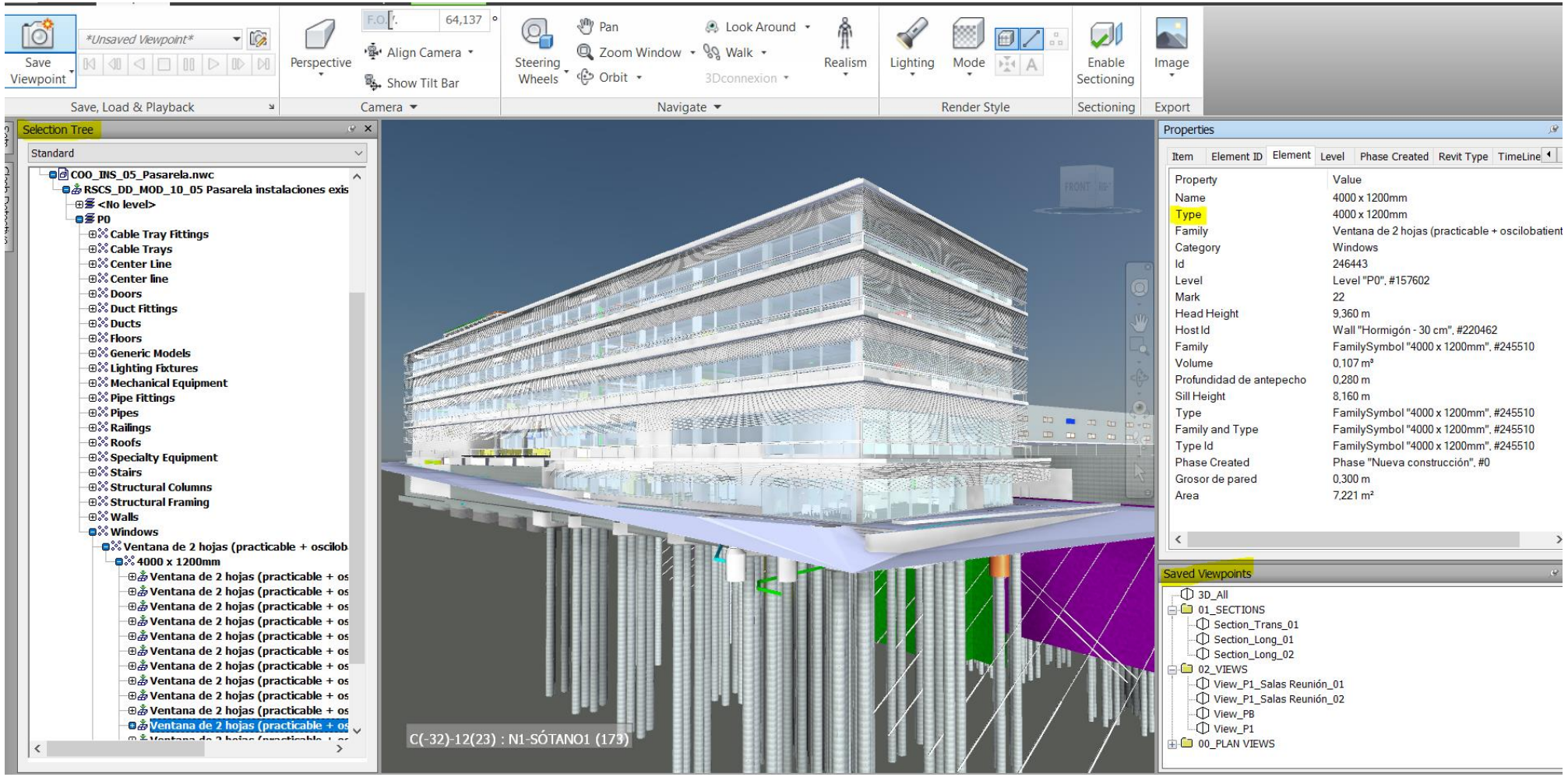

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VISUALIZATION PLATFORMS – Navisworks-Units

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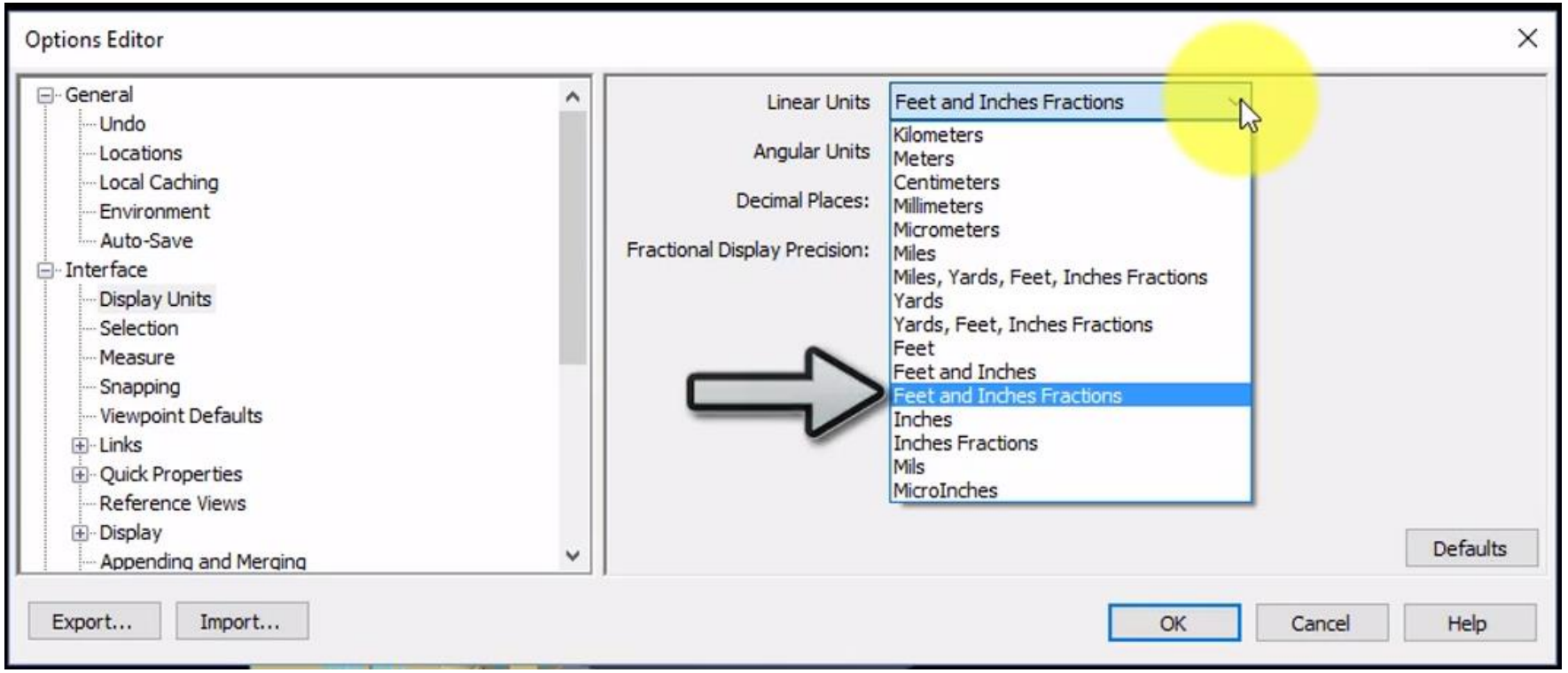

Source: BIMzeED project

VISUALIZATION PLATFORMS – Navisworks - Gridlines

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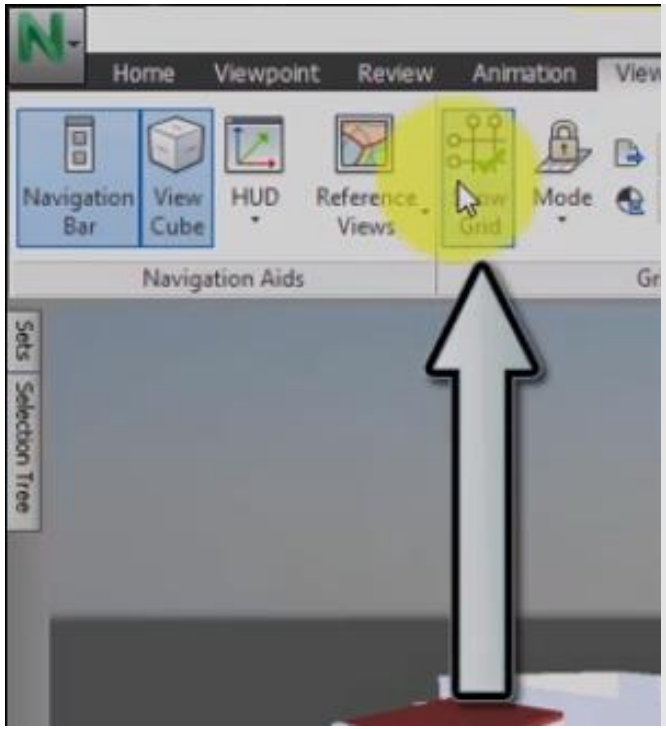

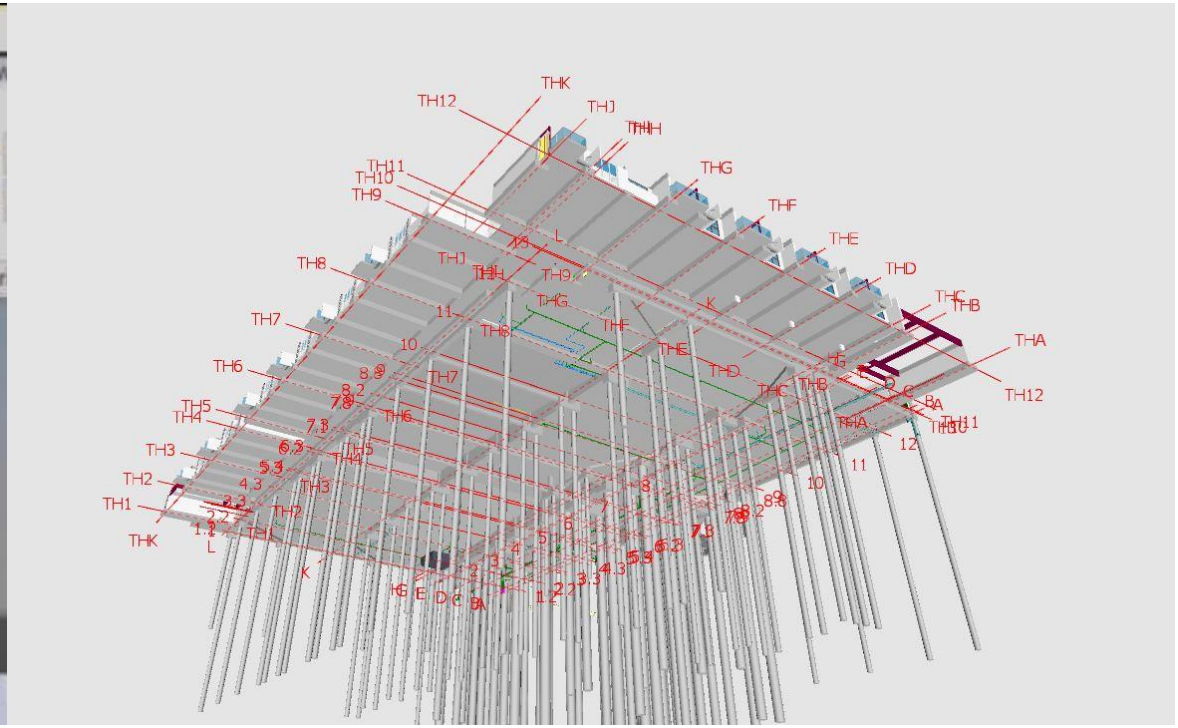

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CONSTRUCTION BLUEPRINT

VISUALIZATION PLATFORMS – Navisworks -Navigation

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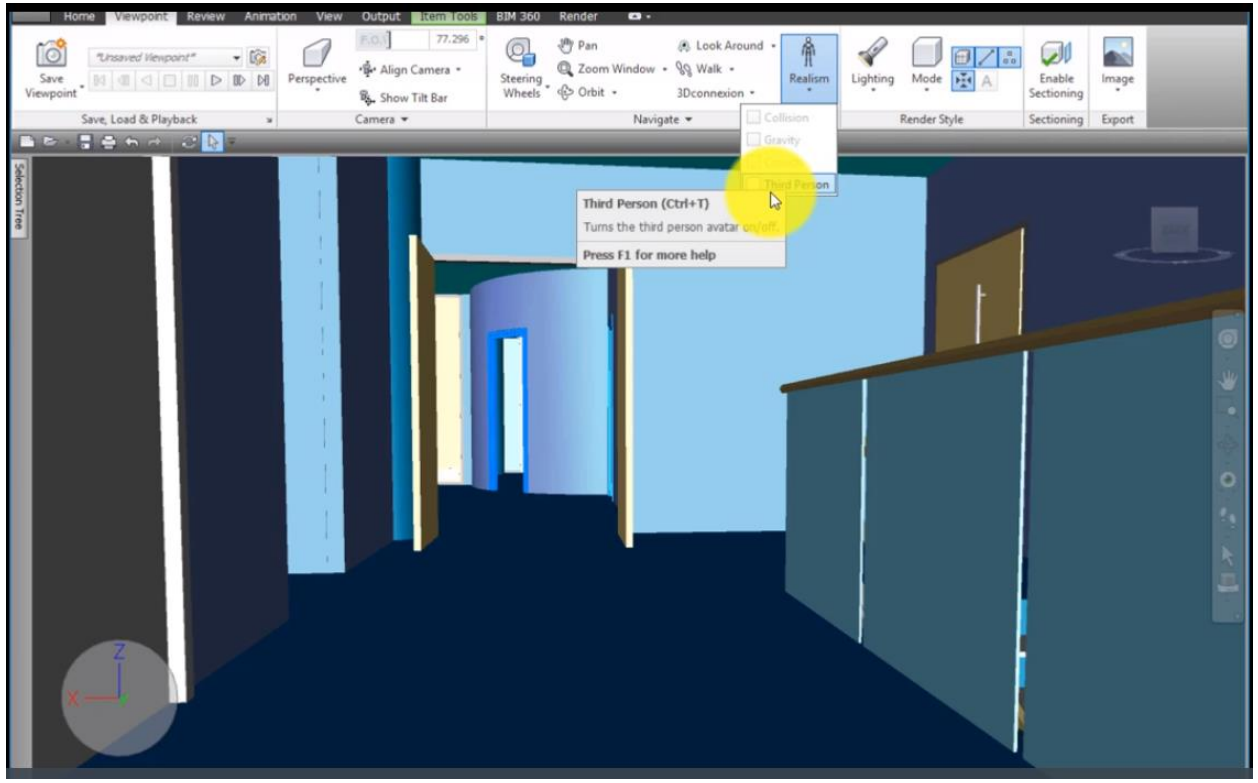

- Walk Mode (Shift)
- Fly Mode
- Realism
- Collision
- Gravity
- Crouch
- Third Person

Source: BIMzeED project

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VISUALIZATION PLATFORMS – Navisworks - Viewpoints

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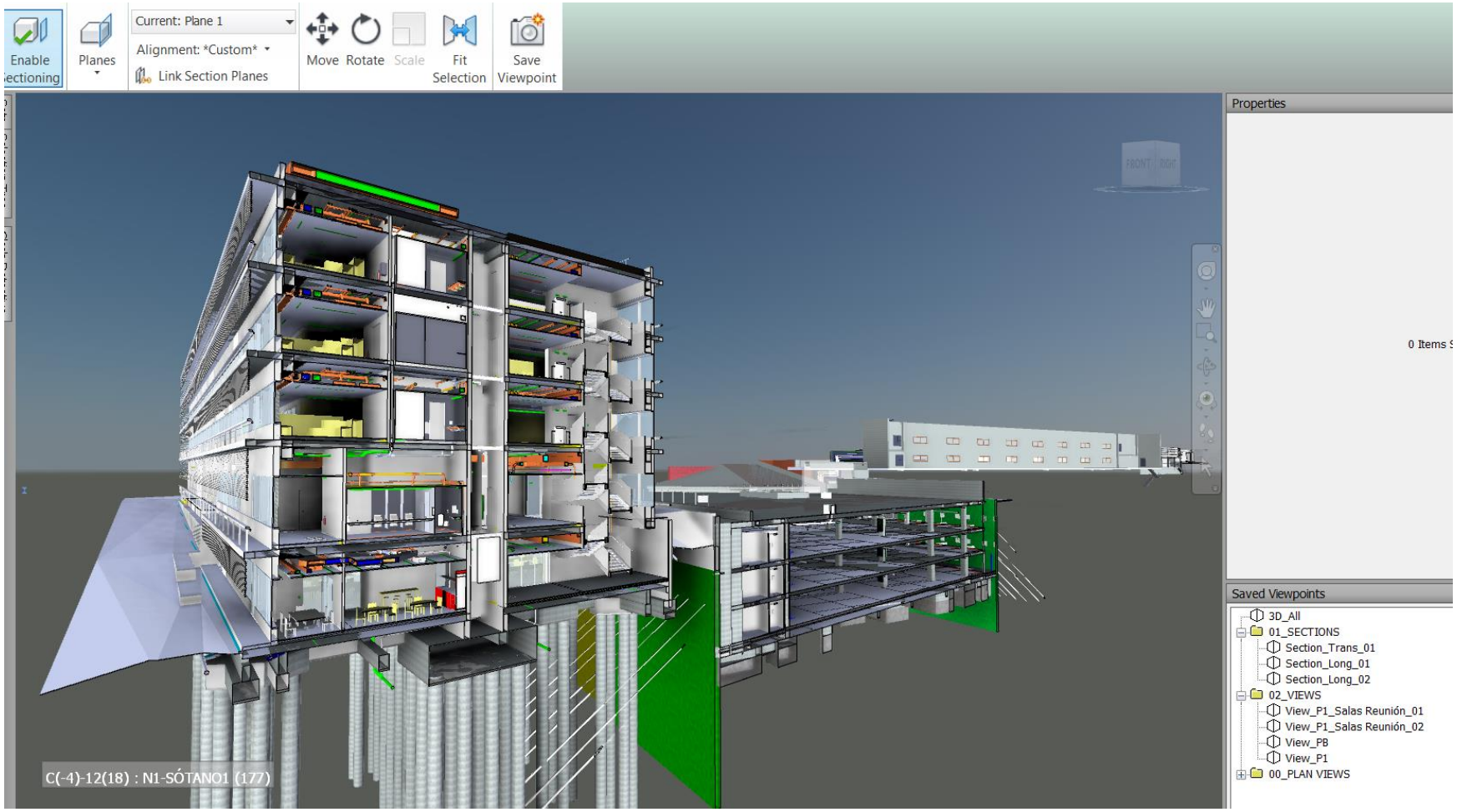

Source: BIMzeED project

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VISUALIZATION PLATFORMS – Navisworks -Comments

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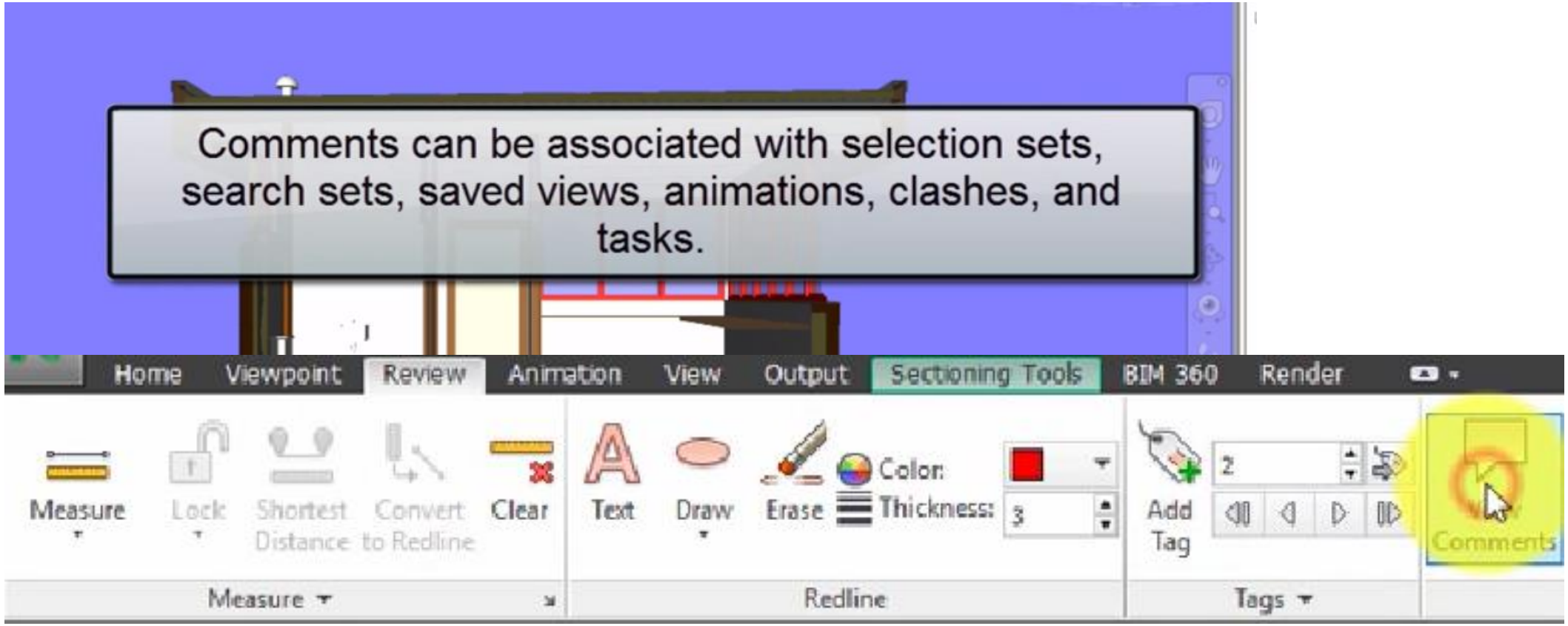


Source: BIMzeED project

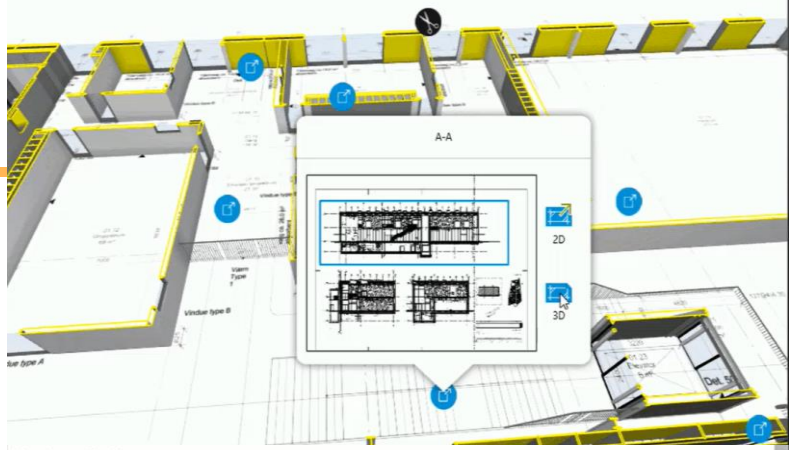
Review the BIM-Viewer

What is a BIM-Viewer?

An App/Tool that allows the easy sharing of drawings, IFC and BIM models.

This is to help workers to:-

- Visualise the building by viewing, [location of columns]
- Compare sheets to see changes in real-time [reviews and log activity]
- Confirm what information is needed, [floor finishes, size of window opening].
- Report a problem in the viewer, [marking and highlighting service clashes]
- Check the delivery of materials on site, [time of arrival and quantity of concrete],



Source: Dalux BIM Viewer and Box

Source: BIMzeED project

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Access and Navigate Data

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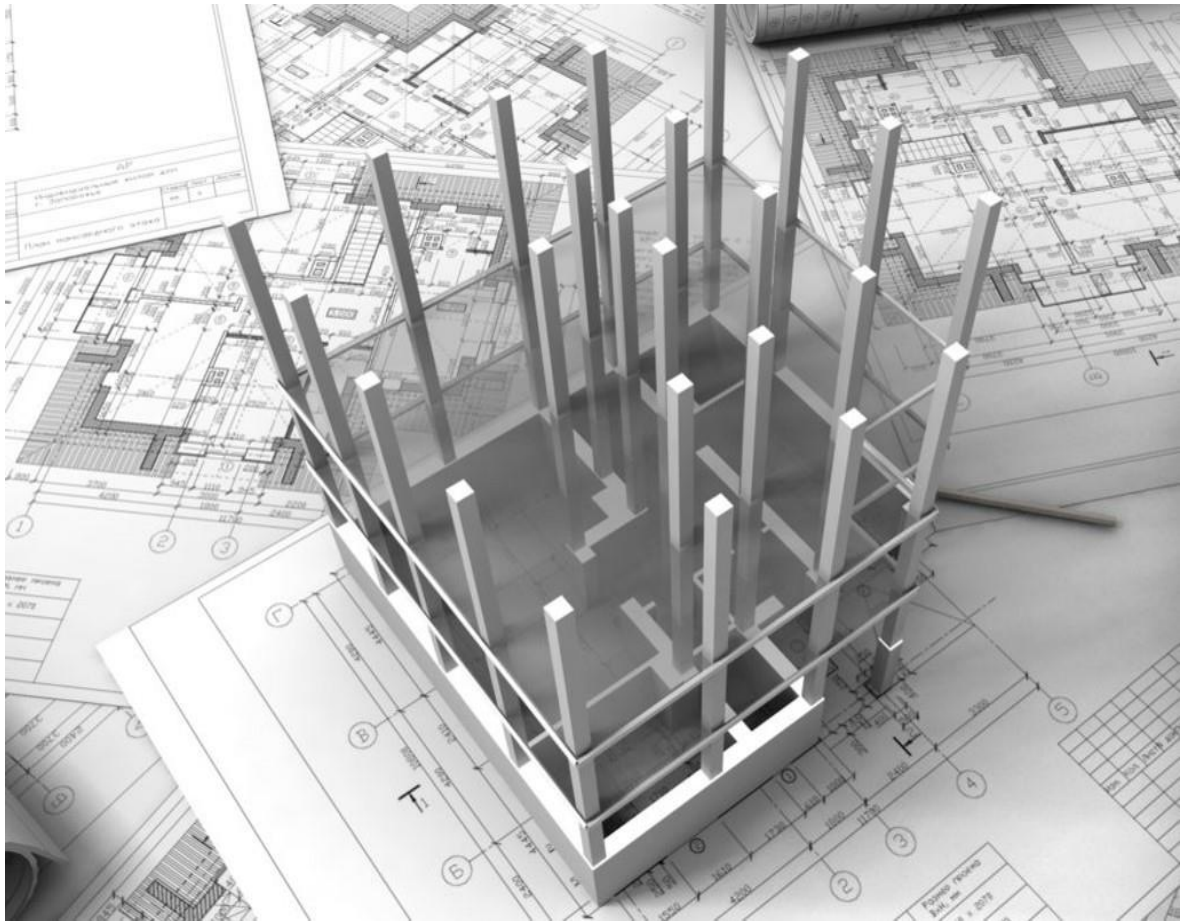
Work within a cloud-based Common Data Environment (CDE) for the purposes of construction site and office activity.

- **Connect to Navisworks Manage**

Understand the benefits of BIM and Navisworks

- **Access and follow the BIM Navisworks**

Manage and export/import suitable data and information from Revit/AllPlan to Navisworks model for the purposes of construction site and office activity.



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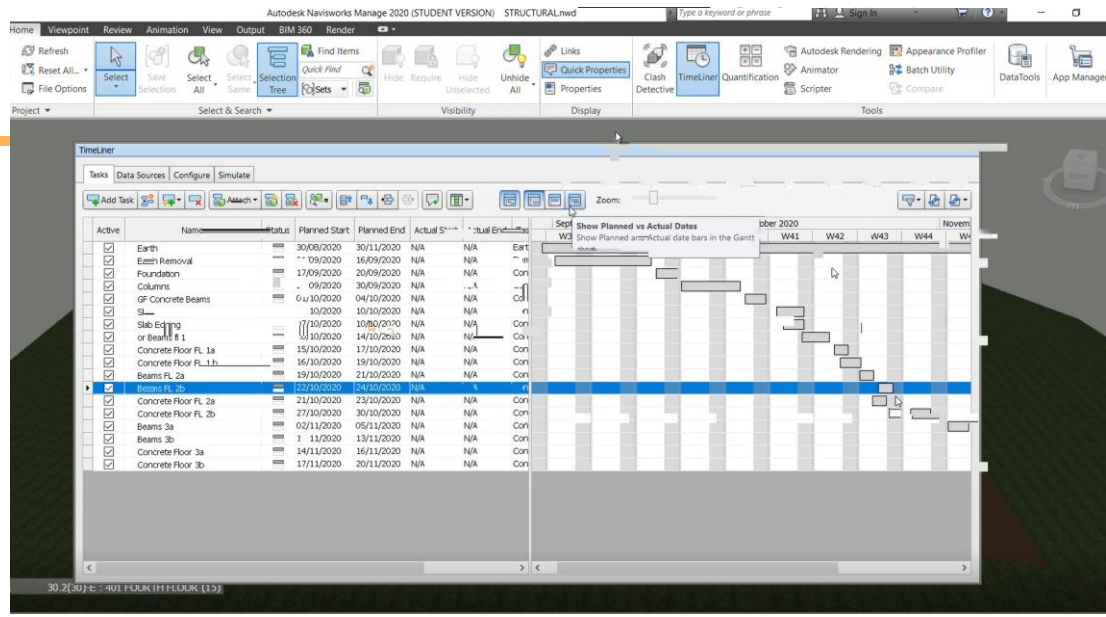
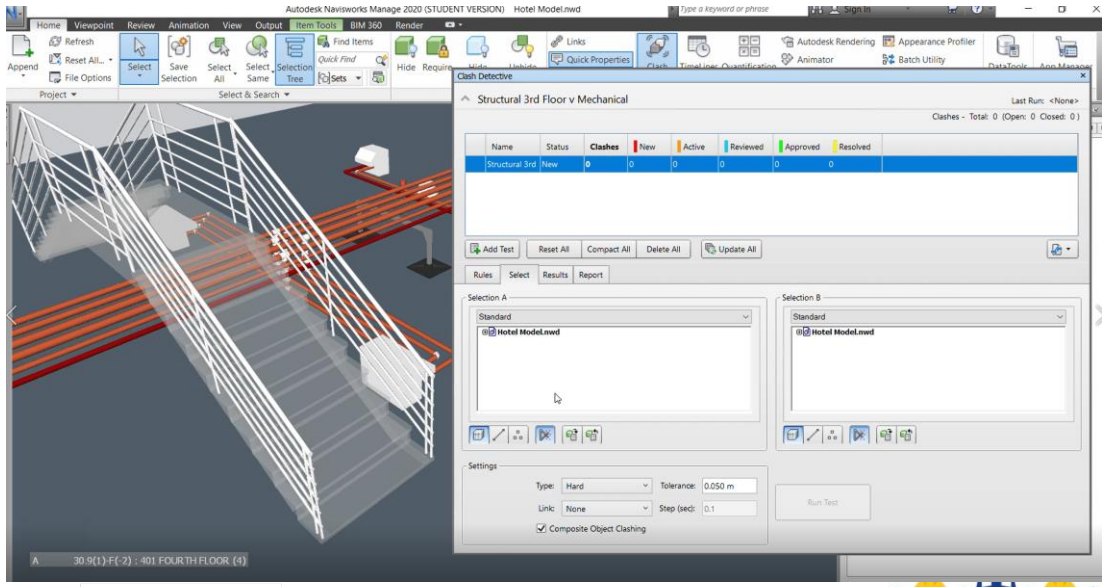
Access and Navigate Data

Navisworks on Site

- In general, the construction-phase of the BIM model provides information used for:
- coordination amongst trades,
- clash detection,
- quantification
- installation and maintenance procedures.

- Navisworks will demonstrate how BIM can help to achieve NZEB and quality works on site using a number of video lessons and tutorials.





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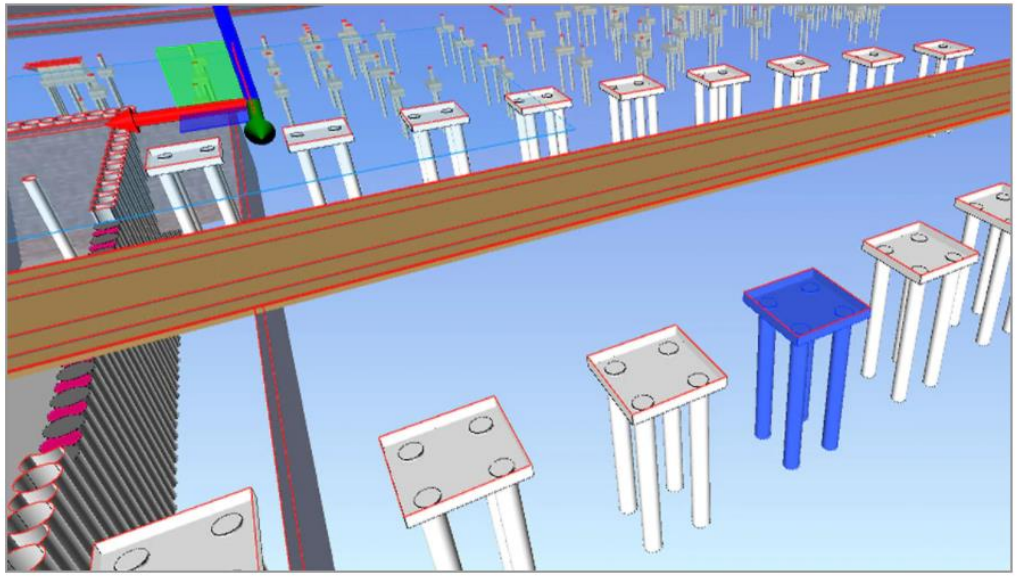
Navisworks on Site

Control schedules and costs using 4D and 5D simulation

- Animate and interact with model objects for simulation.
- Create schedules directly from project models.
- Import schedules and cost items from external project management applications.



TimeLiner 4D simulation tool streamlines BIM coordination.

Source: BIMzeED project

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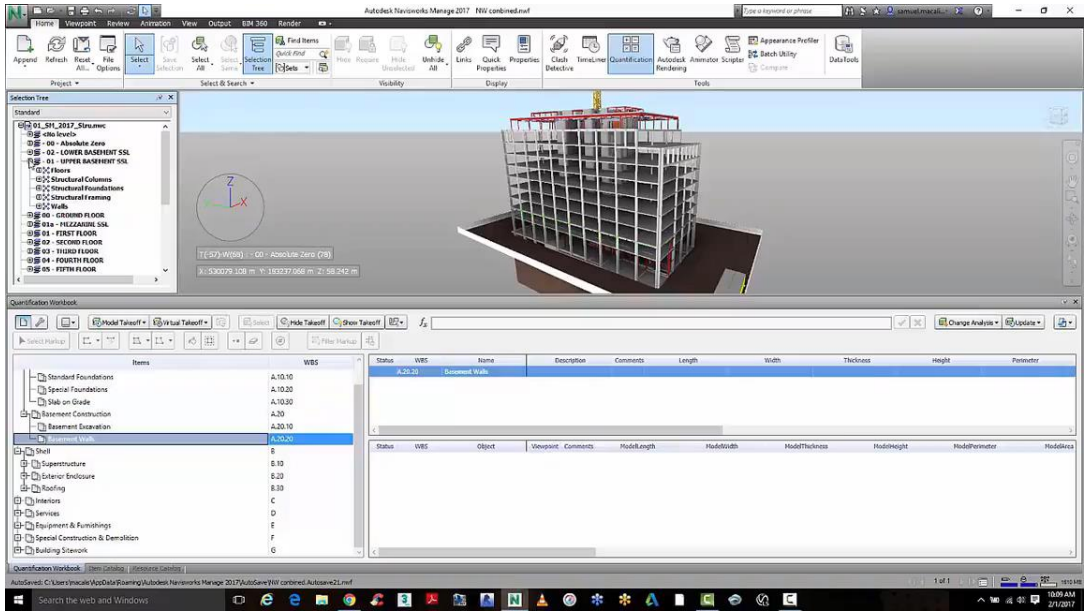
Navisworks on Site

Capture material quantities from 2D or 3D designs

- Measure lines, areas, and counts from 2D sheets or 3D models.
- Create synchronized project views that combine Revit and AutoCAD files, including geometry, images, and data.
- Export take off data to Excel for analysis



Analyse the whole project during preconstruction

Source: BIMzeED project

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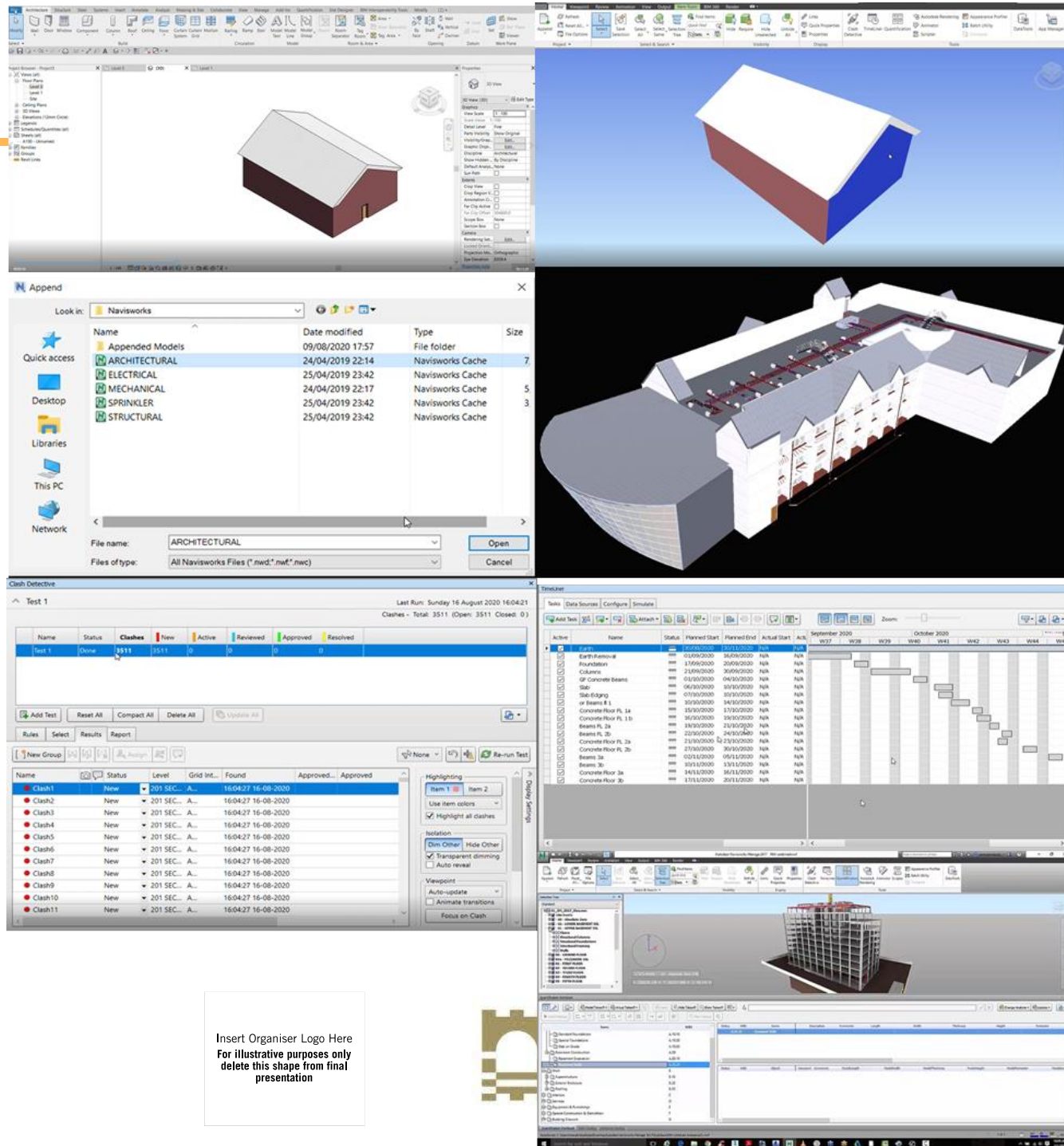
Practice Navisworks

Practice on Navisworks Manage using the videos provided for reference.

Part 1a Refresh house
Part 1b Navisworks and Revit
Part 2 Federated Model (6.51min)
Part 3 Viewpoint (9.06min)
Part 4 Item Selection (4.26min)
Part 5 Clash Detection (16.18)
Part 6 Timeliner (15.14)
Part 7 Quantifications (13.27)

Navisworks Manage



Source: BIMzeED project

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Navisworks Video Review

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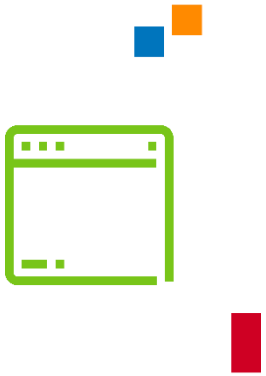
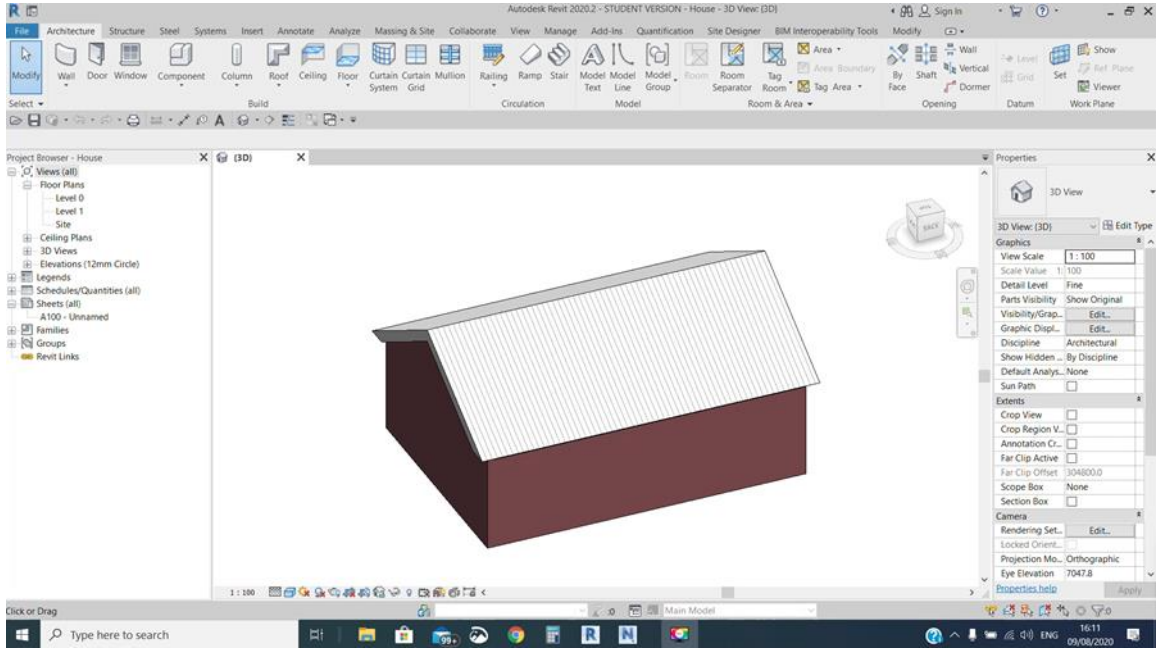
- Video Part 1a: Navisworks Refresher
- Explains the benefits of linking Revit Model to Navisworks model



Videos



Duration 1.58m

Source: BIMzeED project

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Navisworks Video Review

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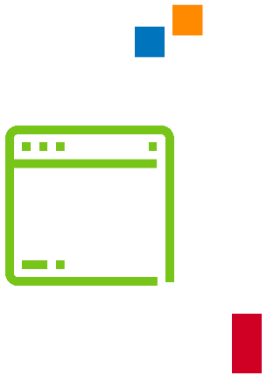
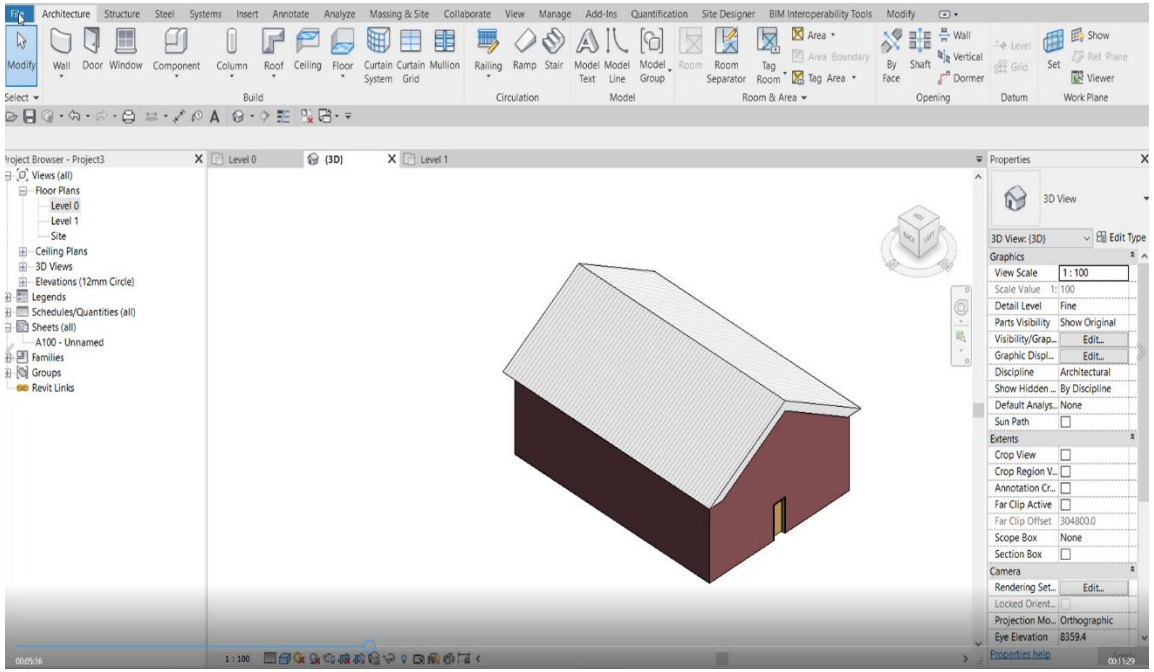
- Video Part 1b Navisworks and Revit
- Learn how Revit and Navisworks are connected



Videos



Duration 16.45m

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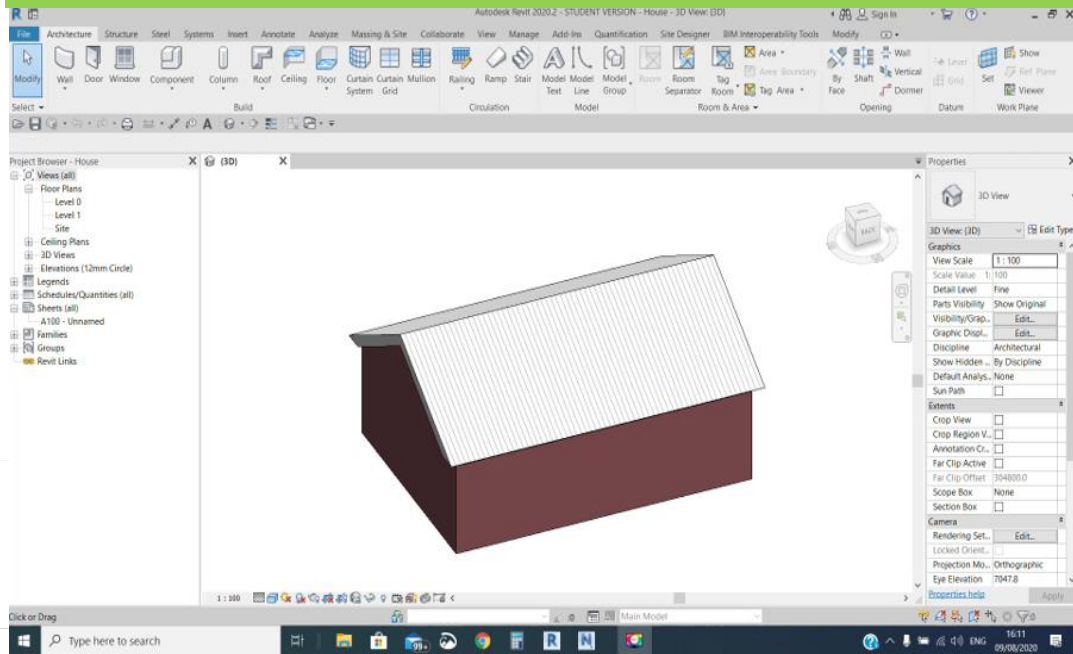
Part 1a: Navisworks Refresher

Learning Outcome: Benefit of linking Revit/AllPlan Model to Navisworks Model

Navisworks will update automatically if linked to REVIT/AllPlan Model.
Save changes
Refresh and open Navisworks model

Activity

Tutorial



Source: BIMzeED project

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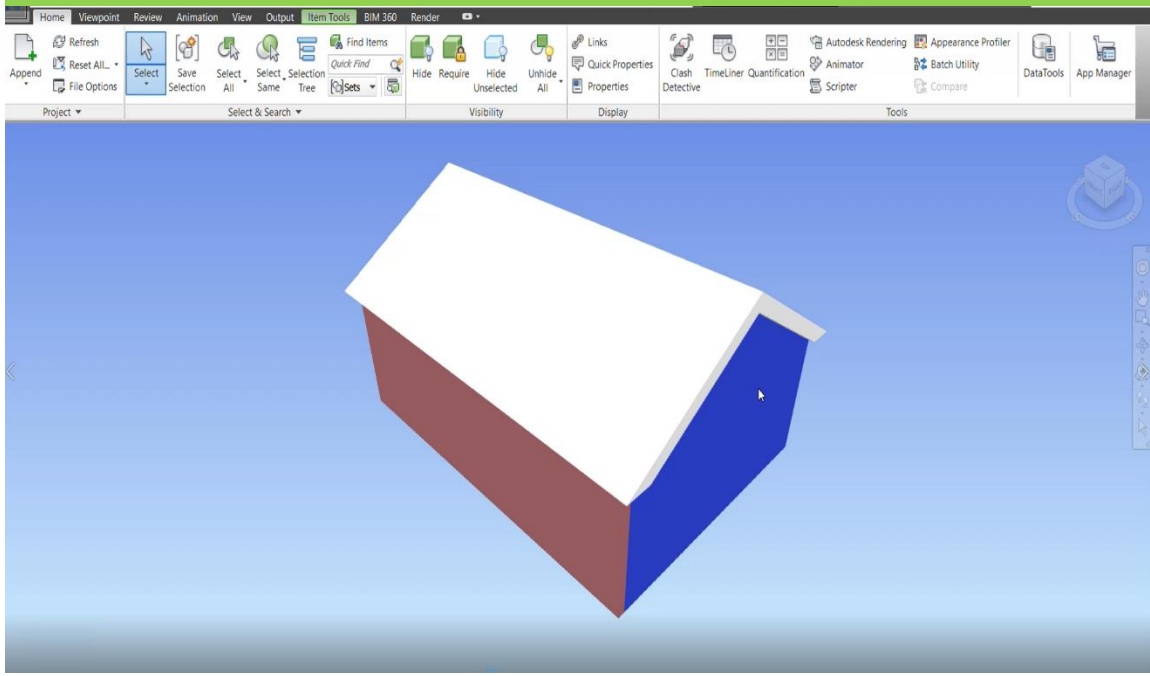
Part 1b: Navisworks and Revit
Learning Outcome: Learn how Revit and Navisworks are. connected

Import/Export data and information from Revit/AllPlan model to Navisworks
Differences in Navisworks, freedom, simulate and manage Review Revit
External tools – export and add-ins
Save NWC files in a safe location
Generate Plans and external tools

Activity

Tutorial



Source: BIMzeED project

Navisworks Video Review

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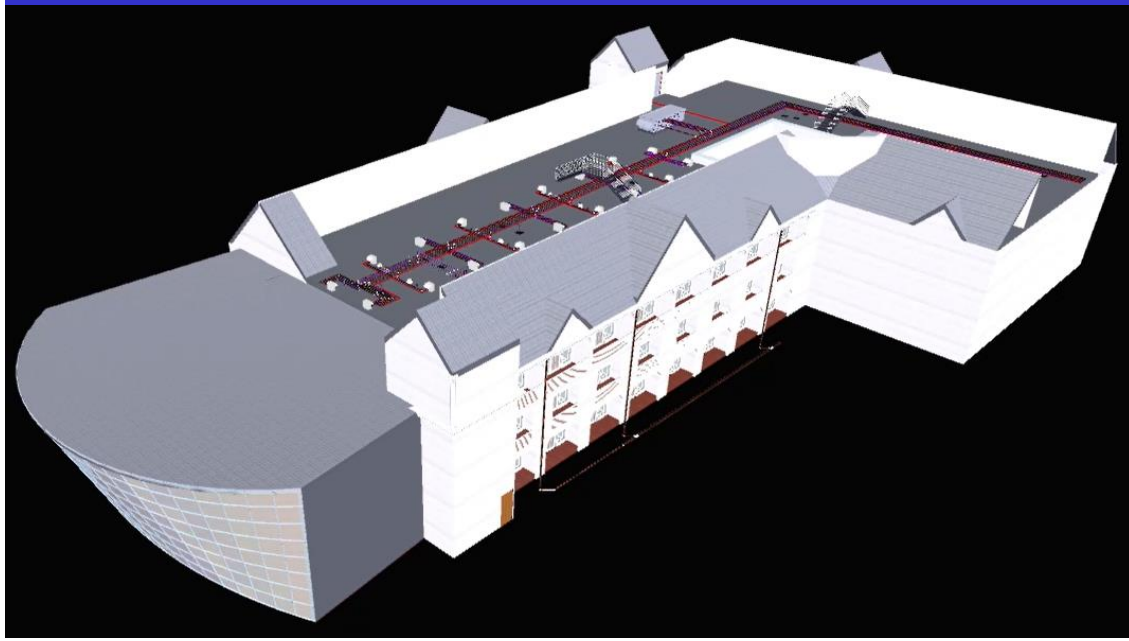
Part 2: Federated Model and Navigate
Learning Outcome: Learn how to create a Federated Model

Activity

Open Navisworks Manage.
A number of tools will be presented:
Append – select a number of NWC files
Viewports – navigate around the building
Walk – in/out motion and rotation of building
Gravity – walk through the building

Tutorial



Source: BIMzeED project

Navisworks Video Review

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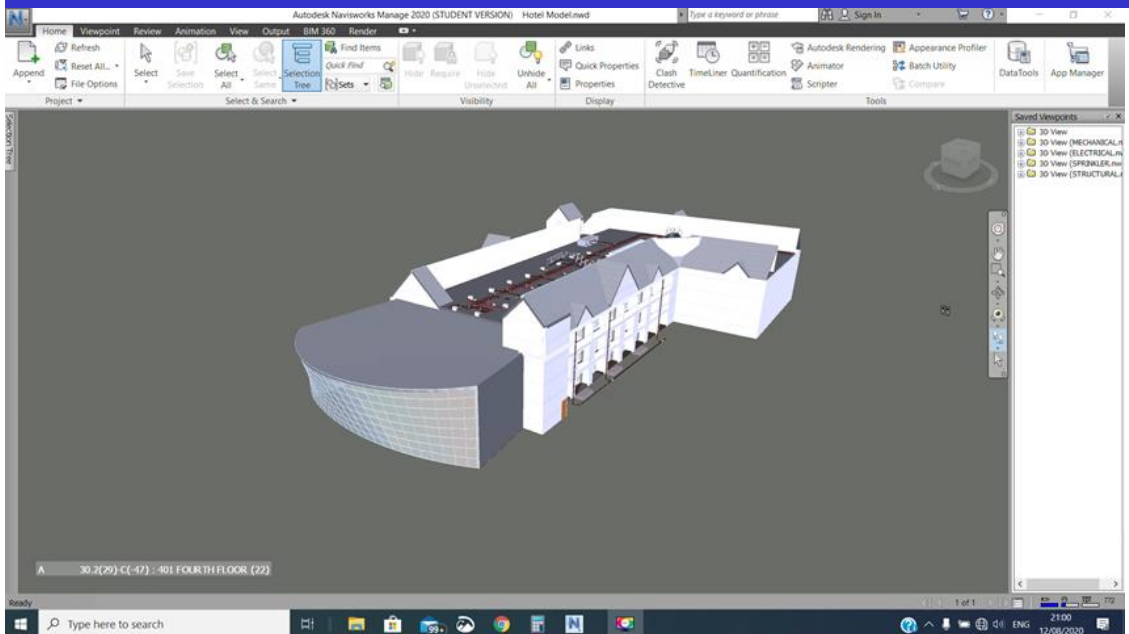
Part 3: Viewpoint and Revit
Learning Outcome: Learn about the functions ‘Viewpoint’ and ‘Review’

A number of Tools will be presented:

- Viewpoint – snapshot of a view which can be marked up.
- Review – comment on the mark up
- Measure – use temporary measurements and convert
- Draw – highlight parts of the drawing
- Text – annotate the view
- Sectioning – create a section
- Fit Selection – moving the cutting plane
- Add tag – tag and comment on an element

Activity

Tutorial



Source: BIMzeED project

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Navisworks Video - Lessons

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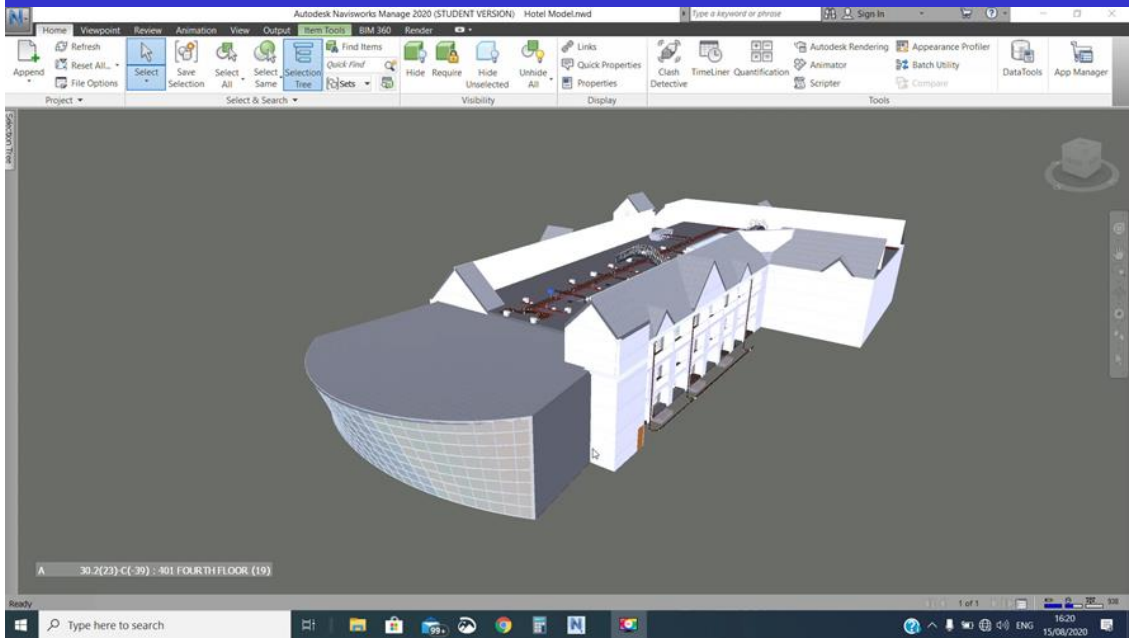
Part 4: Item Selection
Learning Outcome: How to locate and select elements.

Learn how to select element properties using:

- Properties tree
- Selection tree.

Activity

Tutorial



Source: BIMzeED project

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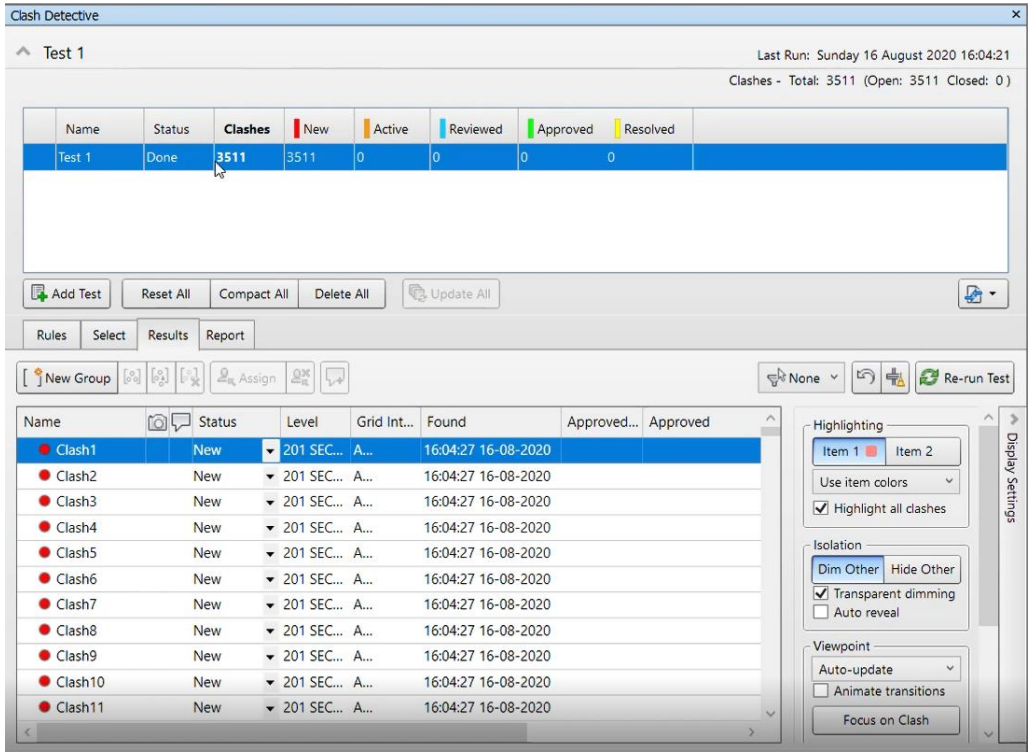
Clash Detection

- Knowing what is possible with this software helps to inform site workers of the potential of such tools in avoiding problems on site. Engagement between site workers and Navisworks experts is the key to using the tool successfully.
- Clash detection should mainly be completed during the design phase. However it can be very useful in checking the set up of works or with renovation works as information missed at design stage can be sent directly to the rest of team highlighting any issues , clashes or comments.
- Ideally , clash detections are run before a project starts on site, otherwise much of the cost/time saving potential will have been missed.



Source: BIMzeED project

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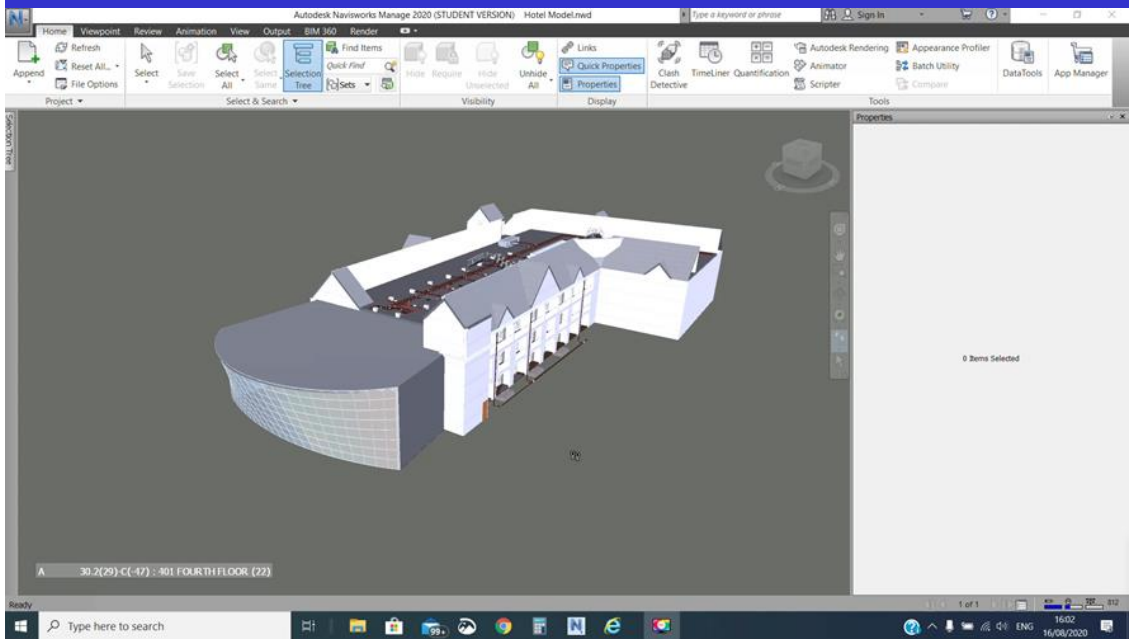
Part 5: Clash Detection
Learning Outcome : How to use clash detection**.**

Select Clash Detection and Add Test.
Tolerance – review of tolerances
Surface Clashes
Self-Intersect clashes
New Group function
Resolved – active, reviewed, approved
Clash Report and snaps

Activity

Tutorial



Source: BIMzeED project

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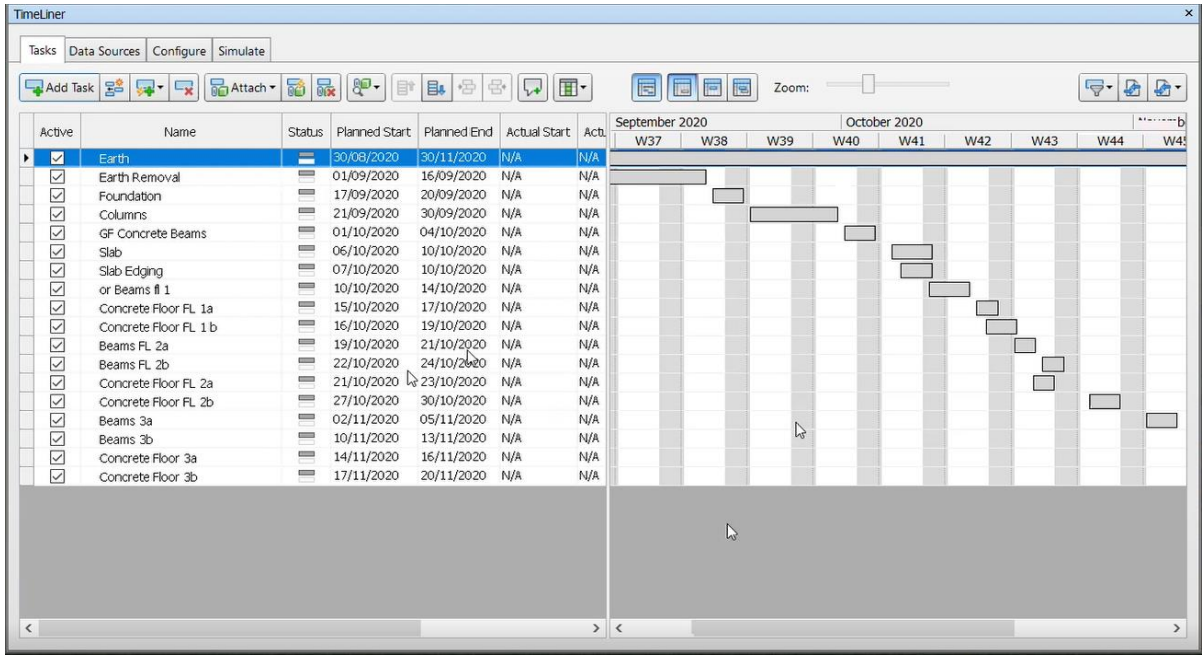
Cost and Time Management

Timeliner

- BIM tools are not just for design or graphical purposes, but can assist with management sequencing.

Timeliner is available on Manage and Simulate

- It is an ideal tool for project managers or the main contractor.
- It enables time and cost planning management by setting out timeframes, tasks and costs associated to these tasks.
- It is ideal for site supervisors to check for any gaps or deviations from the planned schedules or budgets and how many workers are needed to get the job completed on time and in budget.



Source: BIMzeED project

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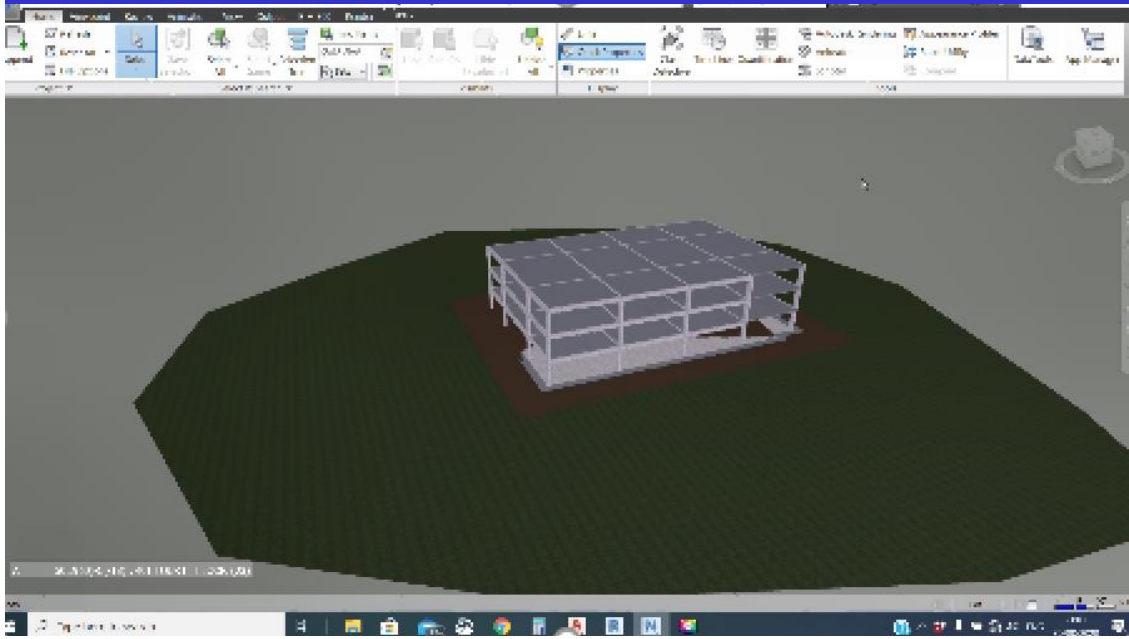
Part 6: NavisWorks Timeliner
Learning Outcome: How to create a timeline simulation

Used for construction sequencing
Classify types of works– Construct, Demolish, Temporary,
Appearance definition
Planning – planned and actual
Create a Set
Task sequencing
Simulate

Activity

Tutorial



Source: BIMzeED project

Navisworks Video - Review

Quantifications

This is one of the core functional features of Navisworks, creating a highly accurate quantity takeoff linked to the model. It allows you to see items that have been accounted for—and those that have not—and make sure you produce accurate material estimates and quantities. This is important as it allows for the extraction of key information from the model and project, to assess materials costs, quantities and order items when required.

Glossary before you start:-

Quantification Workbook

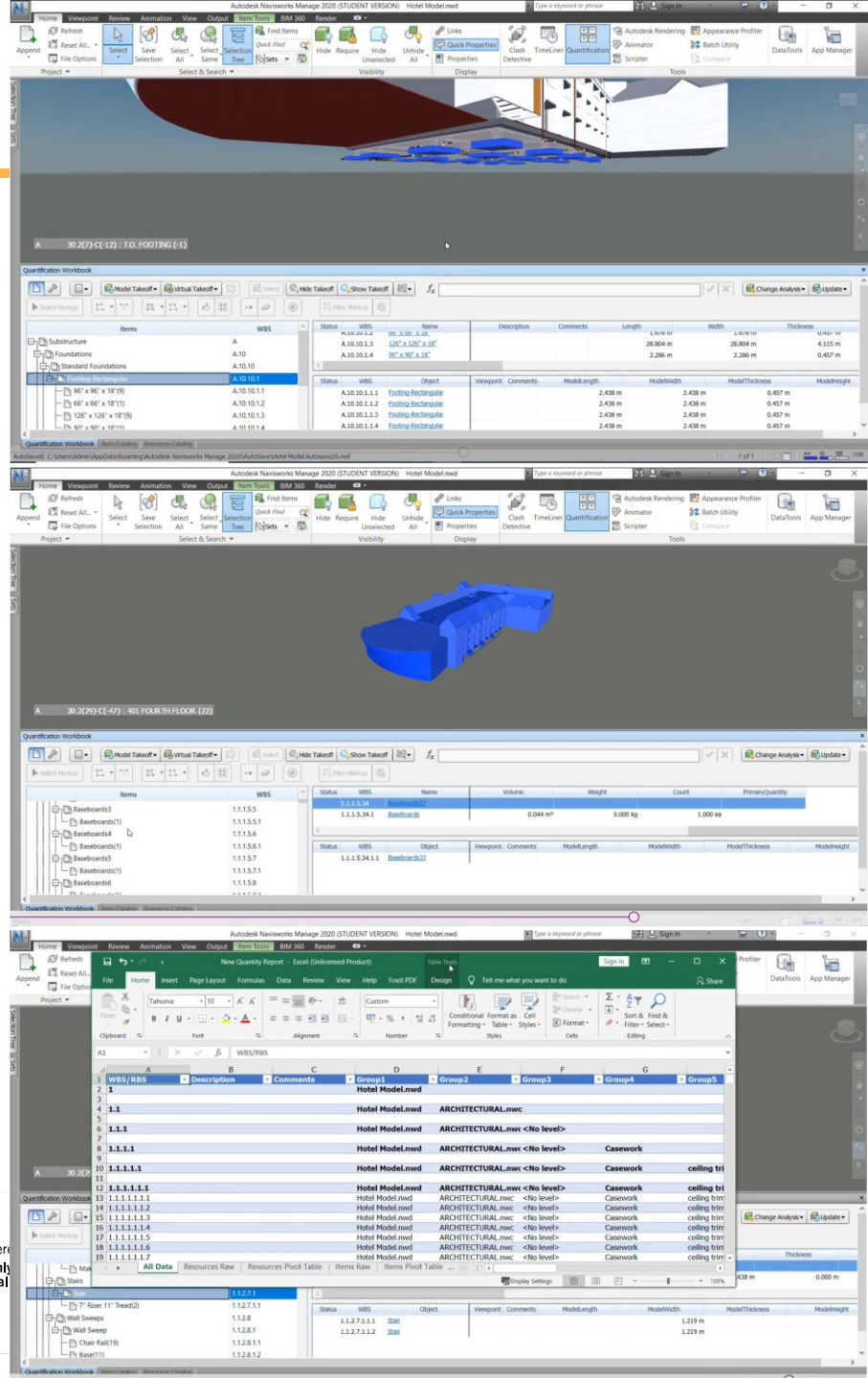
The main workspace that contains the object data for the takeoffs you create in a project.

Item Catalog

The organisational database for your takeoff project, defining takeoff groups and disciplines.

Resource Catalog

The resources needed for successful completion of a project, related by function and type including materials, equipment or tools.



Source: BIMzeED project

Navisworks Video - Lessons

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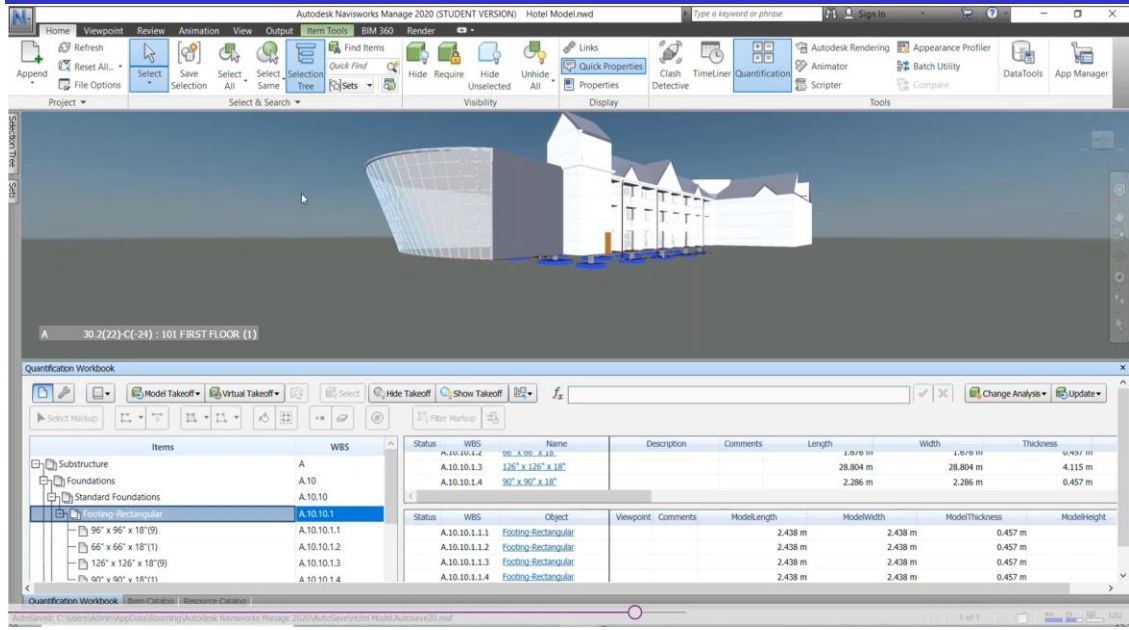
Part 7 Quantifications

- **Learning Outcome:** how to use the quantification tool in Navisworks and
- Used to export an excel quantities file from Navisworks.
- Set up a Project - Qualification Workbook
- Item and Resource Catalogs -
  - Catalogs and COBie
  - Uniformat
  - Folders
- Model takeoff - Export Quantities to Excel

Activity

Tutorial



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2. Energy Simulation Tools

BIM to BEM

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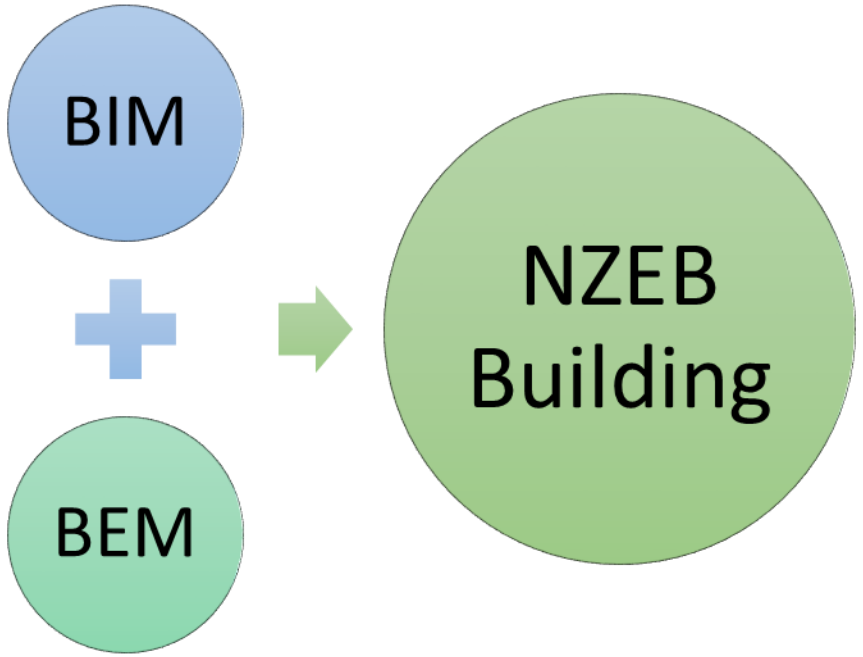
The implementation of BIM for energy efficiency will provide energy savings through the combination of:

- accurate energy monitoring
- real-time data analysis, behavior modelling and real-time decisions
- identification of consumption patterns.
- enhanced supervision of energy flows and use in buildings
- new partnerships between energy managers, energy distributors, energy equipment suppliers, and technology (including smart software tools)

All this will inform the optimal management of the evolution of energy use in buildings, and result in a quantifiable energy consumption reduction.

The application of NZEB in BIM projects is done through the connection between BIM and BEM (Building Energy Modelling) software.



So with NZEB & BIM together, the European construction industry have the opportunity to:

1. Reduce energy demand
2. Reduce carbon emissions
3. Improve process efficiency

Source: BIMzeED project

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BIM to BEM

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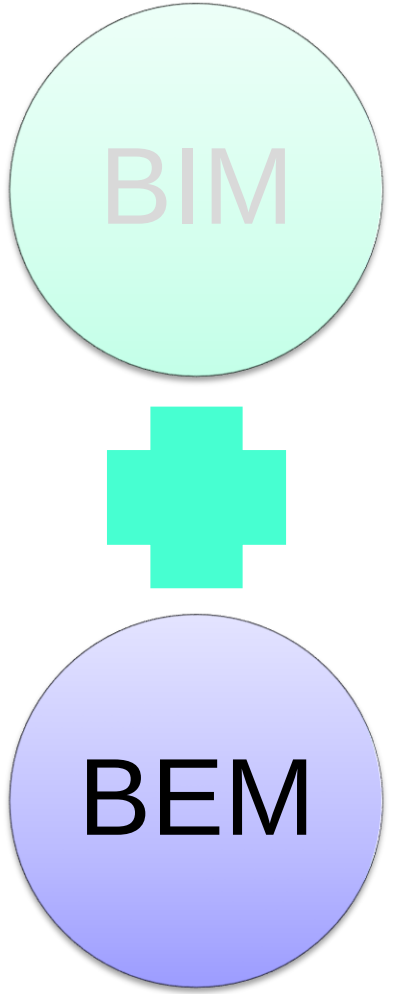
BEM Benefits:

- Versatile, multi-purpose tool that is used in new building and retrofit design
- Provide code compliance and green certification
- Qualification for tax credits and utility incentives
- Real-time building control.

BEM is also used in large-scale analyses to develop building energy-efficiency codes and inform policy decisions.



Source: BIMzeED project

BIM to BEM

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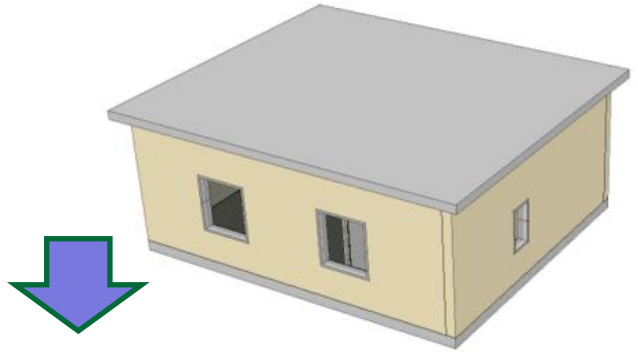
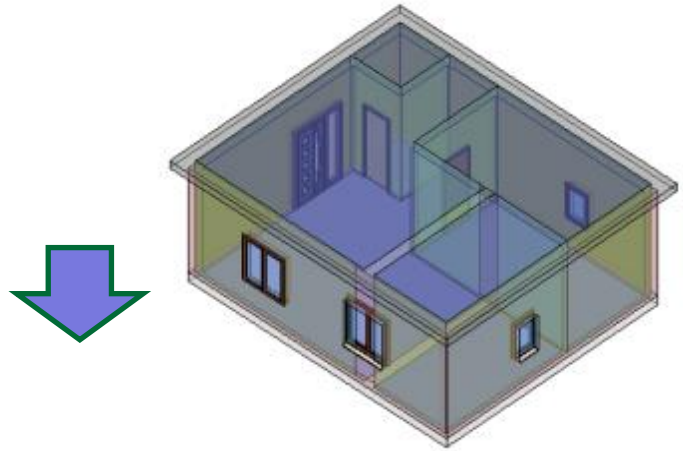
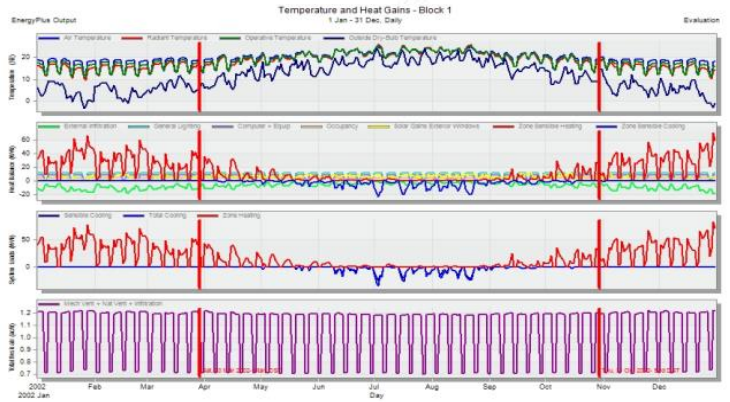
Generic BIM to BEM project workflow

Depending on the BEM (Building Energy Modelling) tool that we will use, the workflow may vary. Some common steps to enable interaction between BIM and BEM tools are:

1. Set the site location
2. Define building form and levels
3. Create building envelope based on energy necessities
4. Export BIM model
5. Import the BIM into BEM tools
6. Fix or adjust the imported model
7. Run energy simulation
8. Extract and output results







Source: BIMEET EU PROJECT. D3.1

BIM to BEM

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INPUTS

It's important to check that all the required inputs to support energy simulations are set in the BIM Models and successfully transferred while importing to BEM tools.

Inputs related with:

- Building program
- Building form
- Building envelope
- Equipment

Building Program	Building Form	Building Envelope	Equipment
Location	Floor Area and Zoning	Exterior Walls	Lighting and Plug Loads
Ventilation Requirements	Number of Floors	Roof	HVAC System Types
Occupancy and Occupancy Schedules	Aspect Ratio	Floor	Economizers
Space Environmental Conditions	Window Fraction	Window Specifications	Water Heating Equipment
Service Hot Water Demand	Window Locations	Interior Partitions	Component Efficiency
Operating Schedule	Shading	Internal Mass	Control Setting
	Floor Height	Infiltration	Refrigeration
	Orientation		

Source: BIMEET EU PROJECT. D3.1 – Table 3 – Inputs required for energy simulation

Source: BIMzeED project

BIM to BEM

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OUTPUTS

If all the inputs are correctly set and transferred, we will be able to analyse the results:

- Thermal needs
- Delivered energy
- Primary energy
- Emissions

Thermal Needs	Delivered Energy	Primary Energy	Emissions
Heating Load	Heating	considering source factor of energy carriers Electricity, NG, Fuel Oil, and etc.	CO_2, NO_x, SO_x, and etc.
Cooling Load	Cooling		
	Internal and External Lighting		
	Internal and External Equipment		
	Fan and Pump		

Source: BIMEET EU PROJECT. D3.1 – Table 4 – Results from energy simulation

BIM to BEM

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BIM & BEM integration workflow

R16 – provide guidance for using building and equipment
R21 - perform energy audit and assessment of building with BIM-based approach
R23 - provide consultancy on energy efficiency and indoor climate targets
R24 - engage with clients on the BIM requirements implied by EE regulations compliance
R25 - develop models and simulations to simulate energy performance of a project: optimize architectural design, calculate energy consumptions, life cycle costs, carbon footprint
R26 - simulate the effects of the design development: thermal bridges, illuminance, etc.
R34 - manage and repair conflicts
R35 - educate FM and users how building is operated

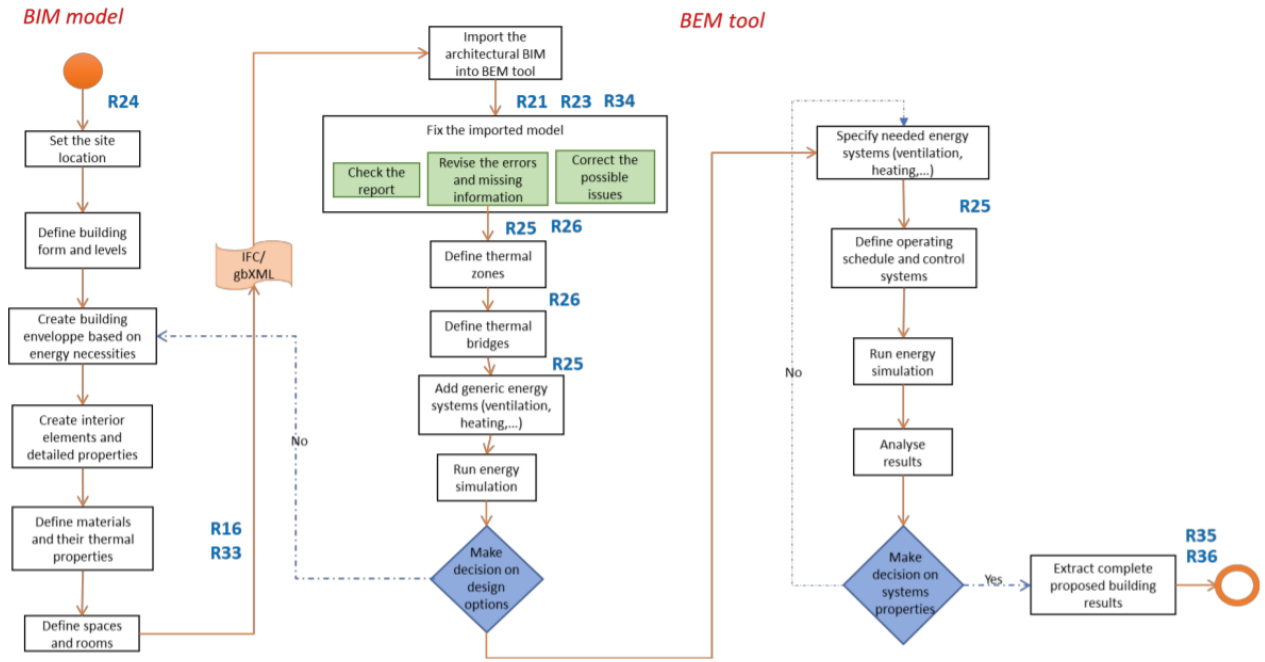

Figure 40 example of BIM to BEM workflow with some identified responsibilities. Software used here are Revit and Pléiades

Source: BIMEET EU PROJECT. D3.1 – Figure 40

BIM to BEM

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BIM & BEM integration challenges

It is therefore important to ensure some tools or strategies should enable integration between BEM and BIM to finally achieve quality NZEB Buildings.

- Define the process through project standards and workflow criteria
  We need to create BIM Models which are helpful for many BIM uses to ensure that they will be usable to analyse and create the appropriate BIM standards in order to assure the achievement of the project goals.
- Specialized software and training for different agents
  Often it can be complicated to use these type of tools and requires experts in the management of these tools.
- Collaboration
  As much as we apply good processes and have the best trained team, we need to collaborate and share information. We need to define mechanisms that allow us to share information, as efficiently as possible, in order to optimize information transfers in the context of a project.

Source: BIMzeED project

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Energy design modelling: characteristics

- Control of the data provided by other tools – control of the different models:

- **Architectural model** – definition of spaces and enclosures; compartmentalisation elements; characteristics of materials.

- **Structural model** – definition of materials; definition of sections for the determination of thermal inertia and possible thermal bridges.

- **Installations model** – definition of different systems; definition of the equipment involved in the conditioning of spaces, indicating characteristics and performance.

Source: SIBIM project

TUS
Technological University of the Shannon:
Midlands Midwest
Ollscoil Teicneolaíochta na Sionainne:
Lár Tíre Iarthar Láir

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Energy design modelling : tools

CYPETHERM

- Independent tool based on an openBIM workflow.
- It allows the analysis of models made by other programmes.

Green Building Studio

Autodesk web service that allows the energy performance and carbon footprint of a building to be assessed from the design phase and integrated into the Revit workflow.

EcoDesigner

- Plugin for Archicad, developed by Graphicsoft.
- Software that provides accurate data for each design so that the designer can opt for the most efficient solution when designing their building.

The Revit, ArchiCad and Openbuildings modellers include thermal analysis tools.

Source: SIBIM Project

Assessment

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Thank You

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