AUTODESK. UNIVERSITY

Automate Structural Analytical Modeling Workflows in Revit

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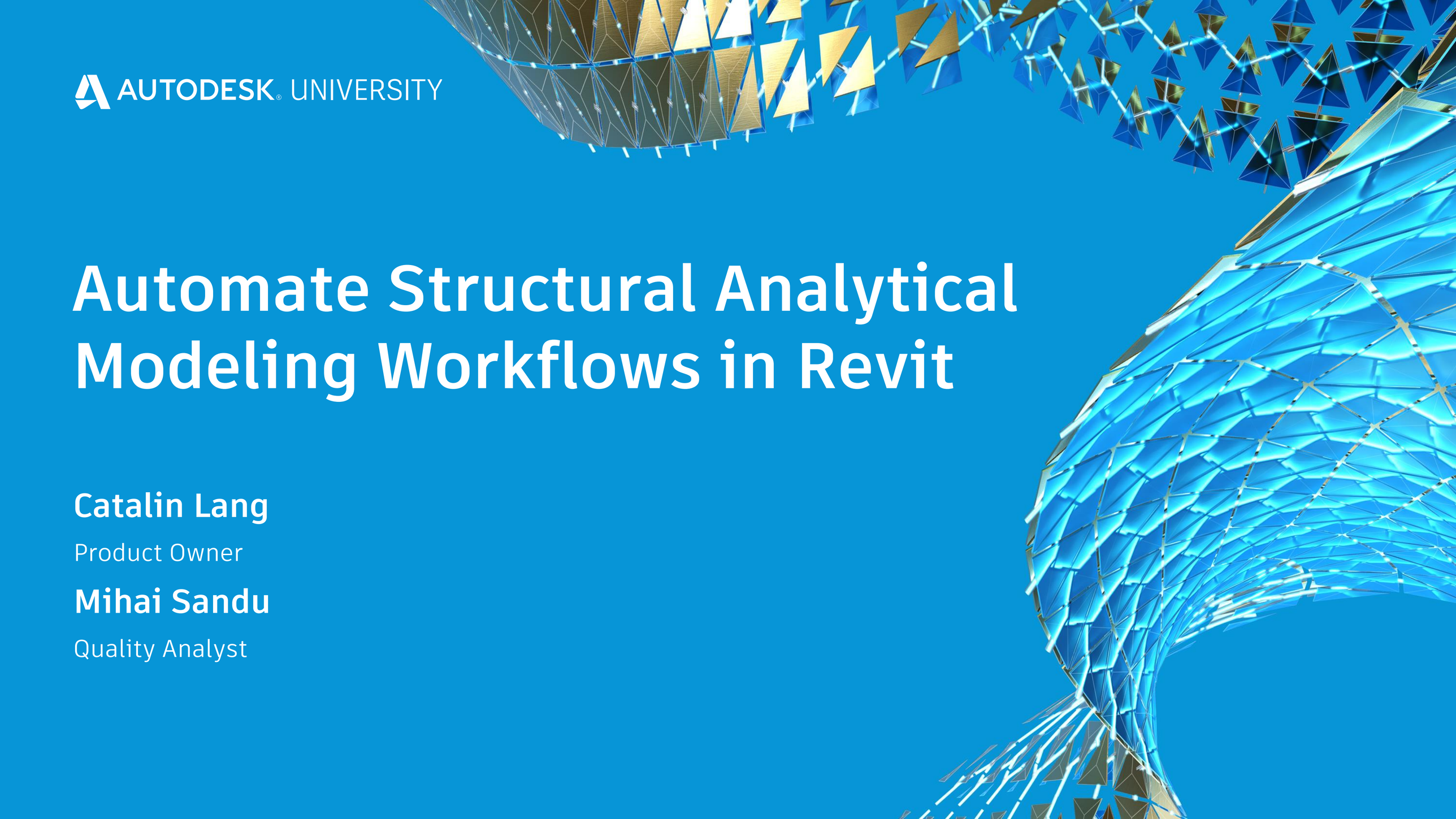


About the speaker

Catalin Lang

Former Autodesk customer, currently Autodesk employee, working in constructions field for over 19 years, going through several branches of the industry, from junior unskilled worker to formwork specialist, storekeeper, project coordinator, project manager, CAD designer, structural designer. Joined Autodesk since 2014 as Quality Analyst. Currently, Product Owner for one of the teams that develops Revit and Advance Steel structural features.

He is specialized in structural modeling and detailing.

About the speaker

Mihai Sandu

Mihai has been working in the construction industry for over 13 years, going through several branches of the industry, from working in the production of aluminum windows, construction cost estimations, junior project planner, construction work supervision and quality assurance engineer in the software industry. Joined Autodesk in 2013, through the acquisition of Graitec, he is currently working as a Sr.QA Analyst for one of the teams that develops Revit and Advance Steel features. He is specialized in structural modeling and detailing.

Automate Structural Analytical Modeling Workflows in Revit

Description

Creating the analytical representation of the structural model in the Revit environment can be seen as the easy part.

The ability to constantly check your assumptions while dealing with the analytical representation and ensuring connectivity during the process can be tedious and time consuming.

In this class, you'll learn how to have an analytical model that constantly reflects the structural model and how to automate the process.

Class Summary

Learning Objectives

- **Check the analytical model assumptions**
  - Exercise 1: Identify Physical-Analytical Relation
- **Maintain analytical model connectivity**
  - Exercise 2.1: Identify Analytical Model Connectivity Issues
  - Exercise 2.2: Manually Analytical Model Adjustment
- **Keep analytical model updated**
  - Exercise 3: Auto-detect Adjustments
- **Dynamo in physical-analytical relationship**
  - Exercise 4.1: Check the Differences Between Physical and Analytical Representation for Linear Elements
  - Exercise 4.2: Maintain analytical model connectivity using Dynamo

Tips before we start

USED SOFTWARE:

Revit 2021.1.1, build 21.1.10.26 20200909_1515(x64)

CLASS HANDOUT

- Exercise models
- Video\Steps
- Links to other resources

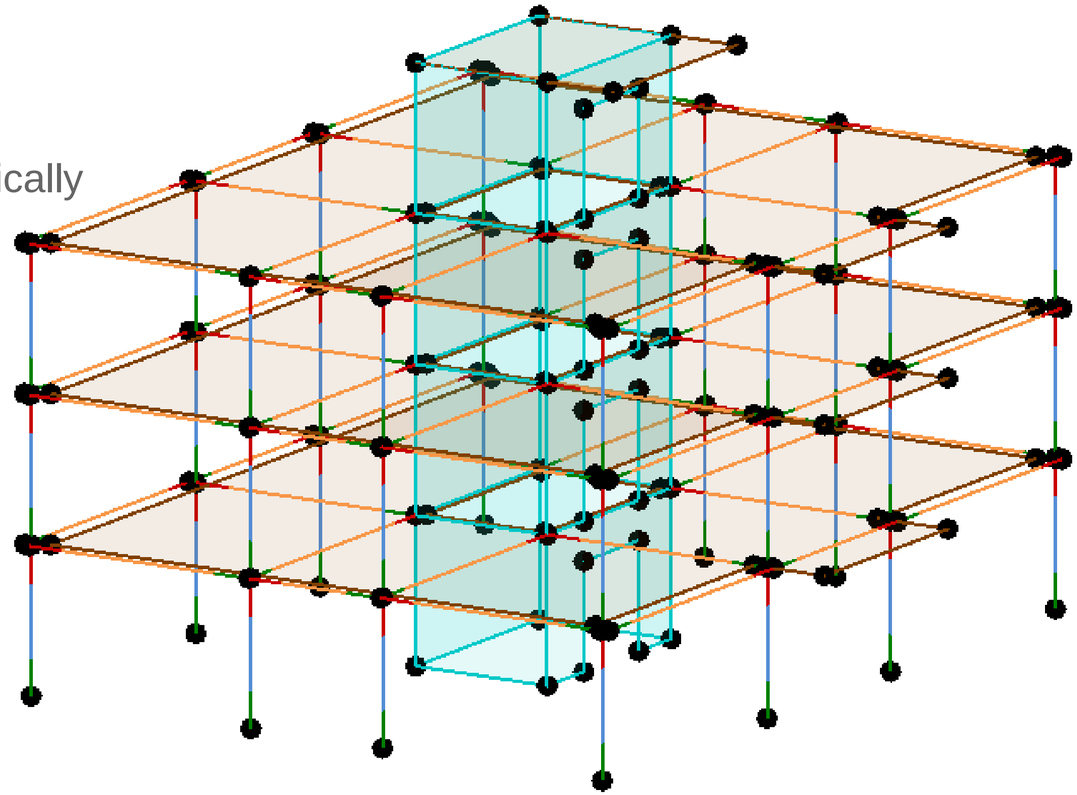
Revit Analytical Model

OVERVIEW

Analytical representation of a structural elements in Revit

- The analytical model is a simplified 3D representation of the structural physical model. It consists of those structural components, geometry, material properties and loads, that together form an engineering system.

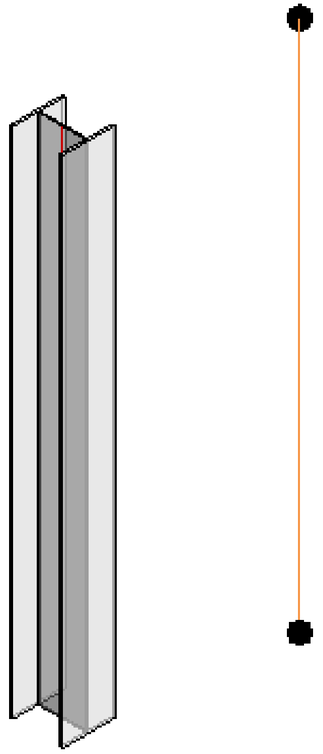
- In Revit software, the analytical model can be created automatically as the physical model is built.



Analytical representation of a structural elements in Revit

Analytical Elements Creation

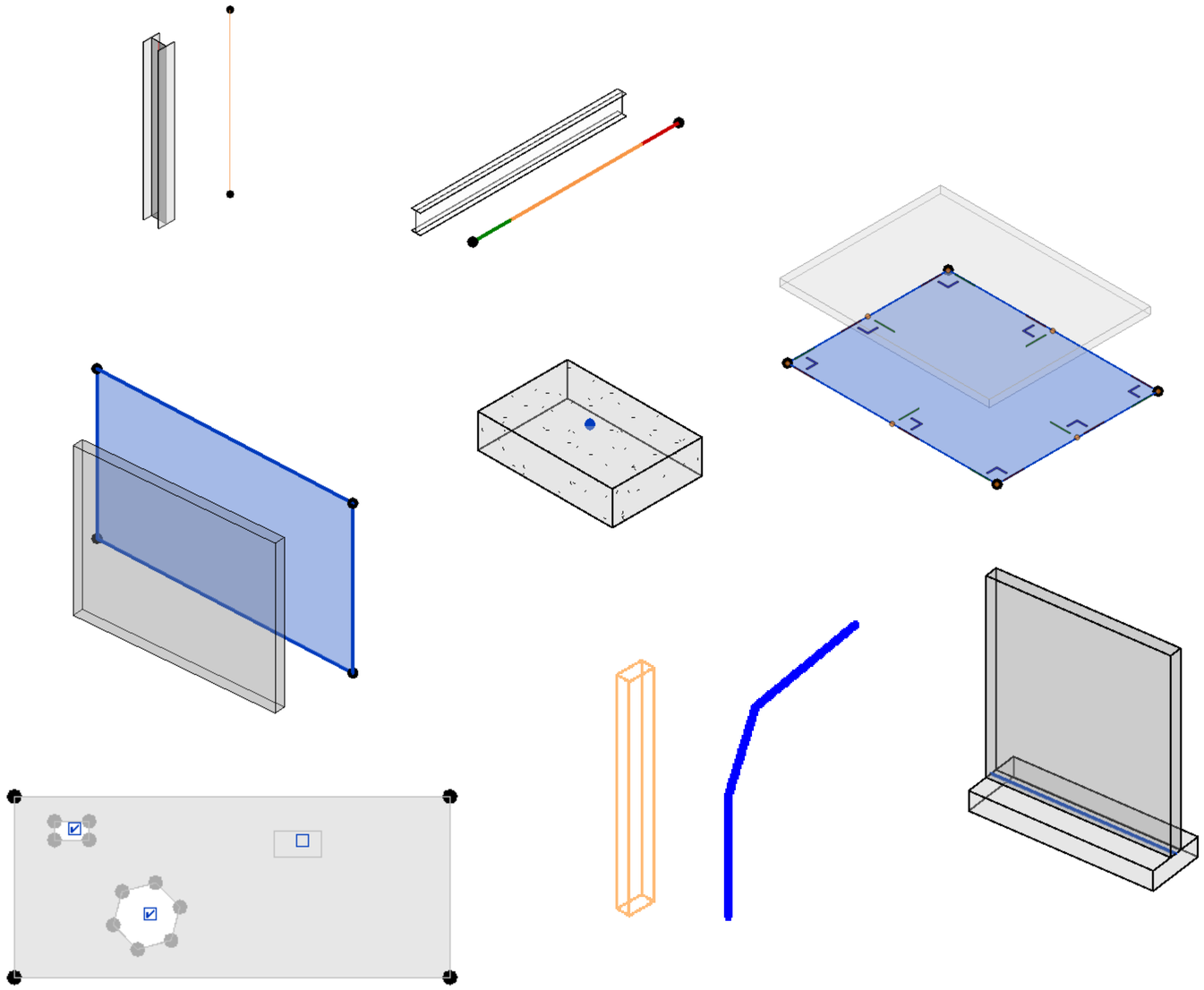
- **In Revit software, the analytical model can be created automatically as the physical model is built.**
- **Analytical Elements are derived from the correspondent physical object.**
- **There’s a 1:1 relationship between the physical element and its analytical representation.**
- **Analytical Elements are in a continuous relation with the correspondent physical objects**
  - Cannot be created without the correspondent physical objects
  - Cannot exist without the correspondent physical objects



Analytical representation of a structural elements in Revit

Revit Analytical Elements

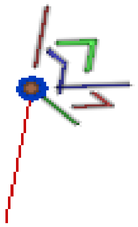
- **Analytical Column**
- **Analytical Beam**
- **Analytical Brace**
- **Analytical Floors**
- **Analytical Walls**
- **Analytical Isolated Foundation**
- **Analytical Wall Foundation**
- **Analytical Foundation Slab**
- **Analytical Line within In-Place Family**
- **Analytical Surface Opening**

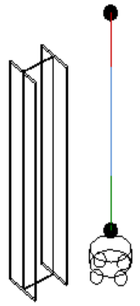


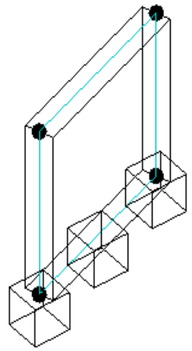
Analytical representation of a structural elements in Revit

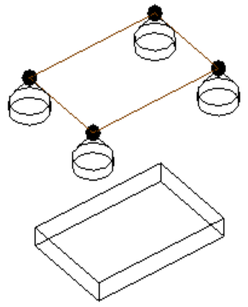
Revit Analytical Elements

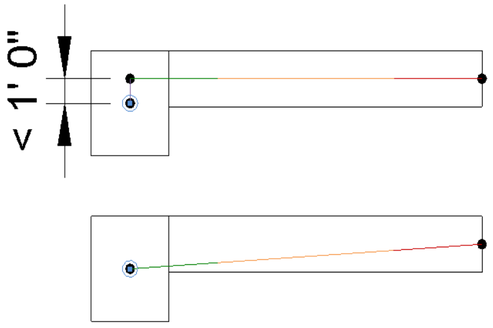
- **Node**
- **Boundary Conditions**
- **Analytical (Rigid) Link**









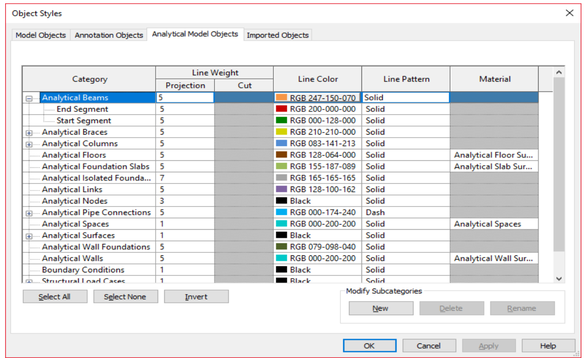


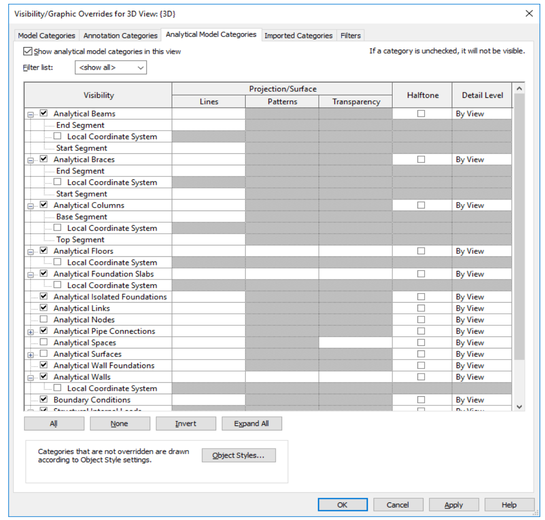
Analytical representation of a structural elements in Revit

Analytical Elements Visibility

- **Analytical element can be enabled/disabled by checking Enable Analytical instance parameter from the Properties Palette.**

- **Analytical element visibility can be controlled from:**
  - **View Control Bar - Show Analytical Model.**
  - **Object Styles in Analytical Model Objects tab.**
  - **Visibility/Graphics Overrides in Analytical Model Categories tab.**

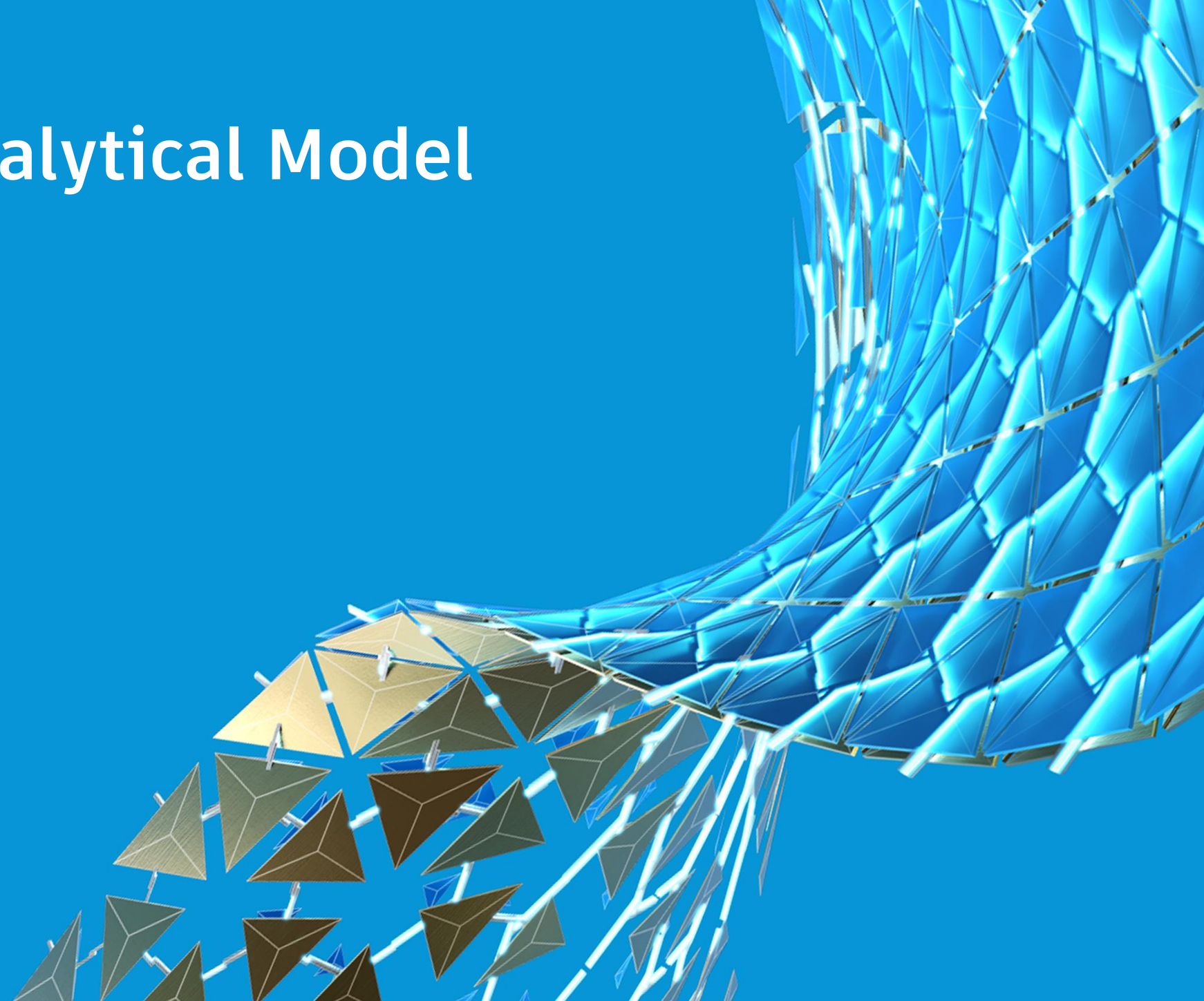


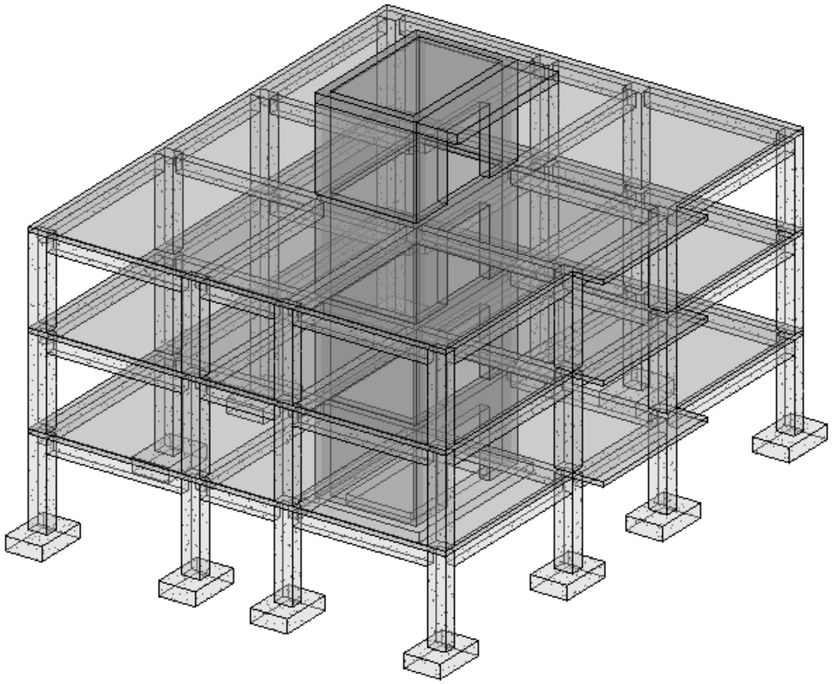


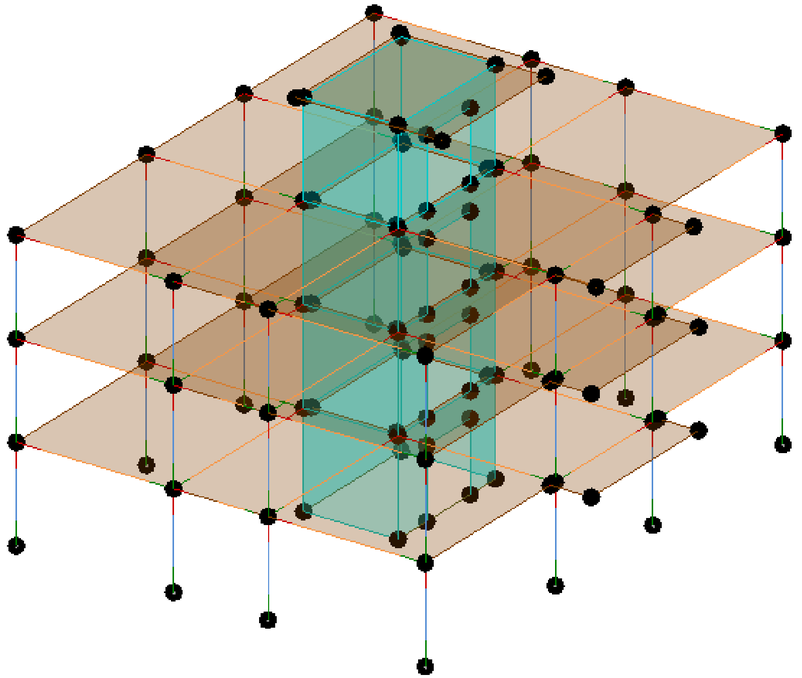
Useful Links

- **Dealing with the Structural Analytical Representation in Revit - BES322440-L**
- **Revit Help**

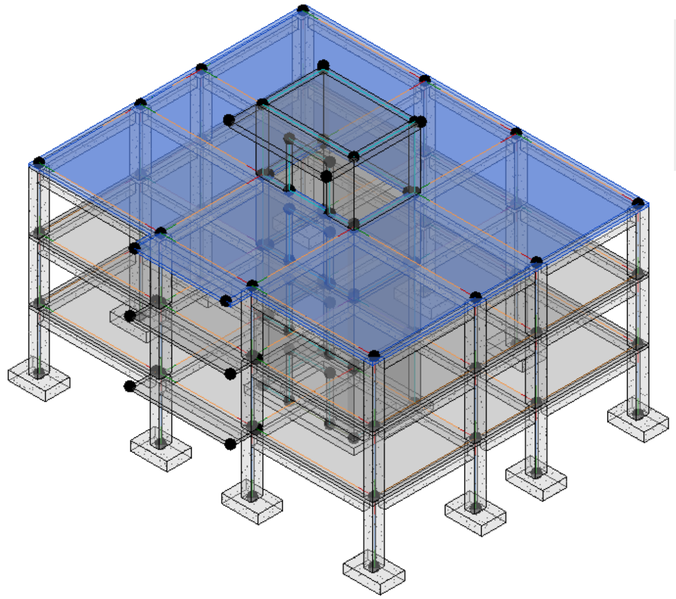
Check the Analytical Model Assumptions







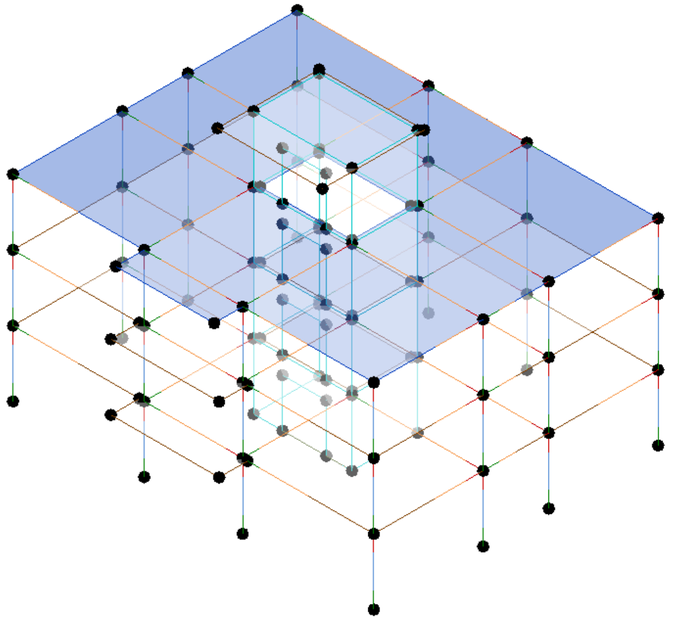
Identify the Counterpart



Highlight the Analytical Model

You can highlight the analytical model while working on structural elements in an analytical view. This is useful when both the physical model and analytical model are visible.

1. Select a structural element.
2. Click Modify <Element> tab > Analytical panel (Highlight Analytical). The analytical model will highlight.
3. Similarly, you can highlight the physical model when adjusting analytical models.

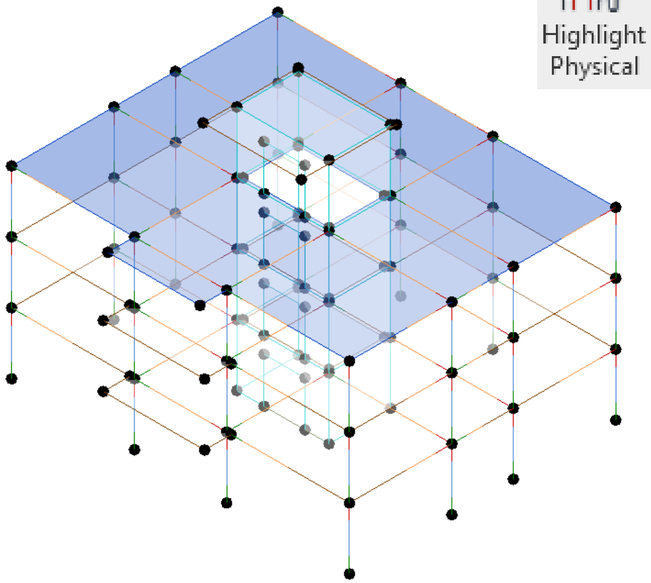


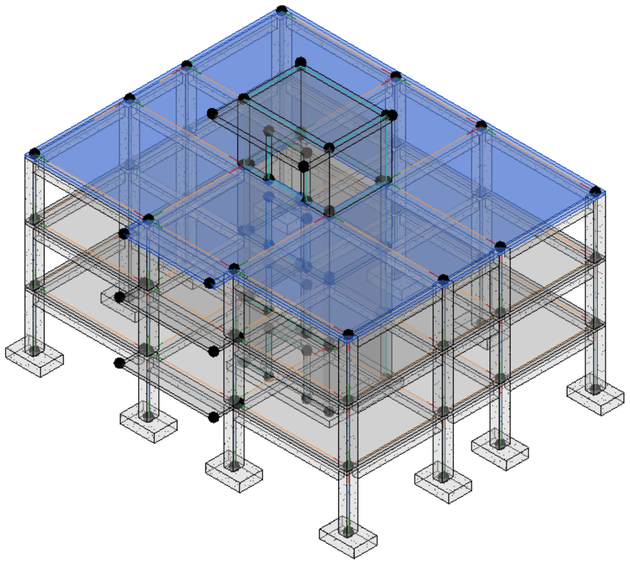
Identify the Counterpart

Highlight the Physical Model

Similarly, you can highlight the physical model when adjusting analytical models.

1. Select an analytical model element.
2. Click Modify <Element> tab > Analytical Model Tools panel (Highlight Physical). The physical model will highlight.





Analytical Alignment

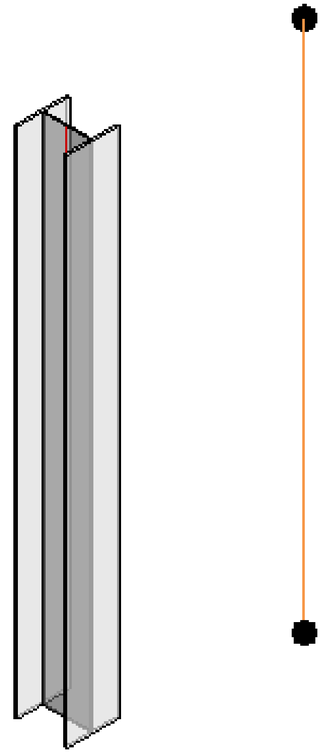
Analytical alignment encompasses a number of different options available in placing the analytical model in relationship to itself and other analytical elements.

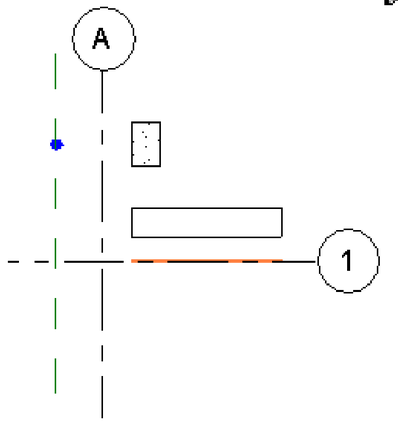
There are three methods of analytical alignment

1. Auto-detection.
2. Projection
3. Manual Adjustment

Analytical alignment is determined by structural element instance properties.

The Analytical Model Element alignment can be restored to its original position.

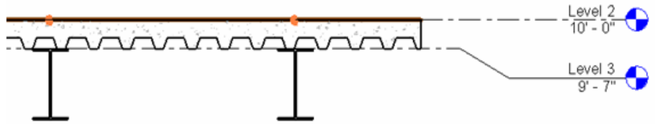




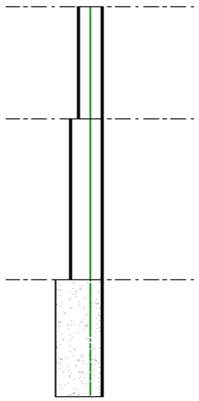
Analytical Auto-Detect

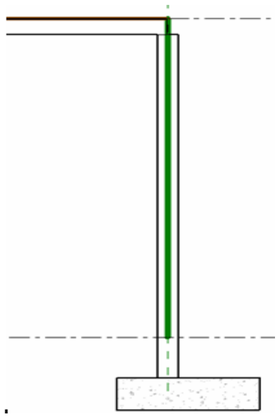
Analytical Alignment	
Top Alignment Method	Auto-Detect
Top y Projection	Location Line

Automatic adjustment is performed on a structural element, in relation to a neighboring structural element.



Revit can automatically adjust the analytical model for beams, braces, structural columns, structural walls, structural floors, and foundation slabs so that they align more accurately. This behavior is based on the instance parameters of the elements and tolerance settings.





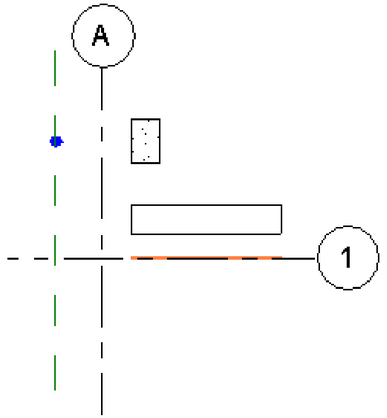
For auto-detection to take place, the analytical Adjustment Methods instance properties must be set to Auto-Detect for an element and its individual ends. This is the default justification method for all analytical structural elements. Automatic adjustment is then performed, as long as the Analytical Model of the adjacent element is within tolerance.

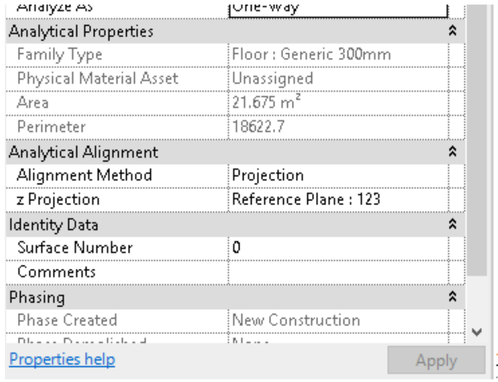
Analytical Projection Alignment

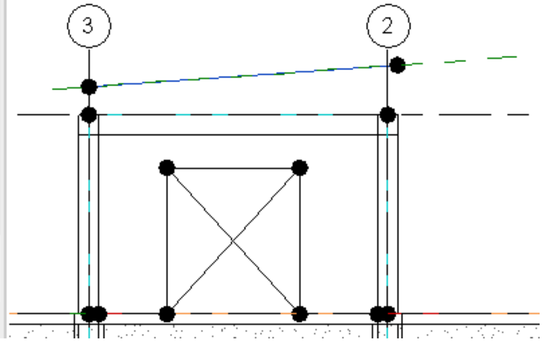
The guidelines for analytical projection are based on the presence of additional elements in relation to the element, the element itself (whether it is a beam, column, floor, or wall), the order of creation, and specified projection properties.

Projection references for linear elements are defined as horizontal and vertical in relation to the local beam coordinate system. Horizontal plane (y-direction) projection references include grids, sides and center of a beam. Vertical plane (z-direction) projection references include levels, top of beam, middle of beam and bottom of beam.

Named reference planes are included in the horizontal and vertical projections where appropriate.

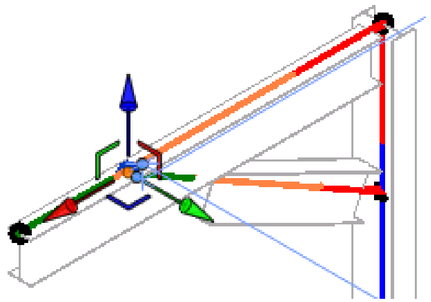




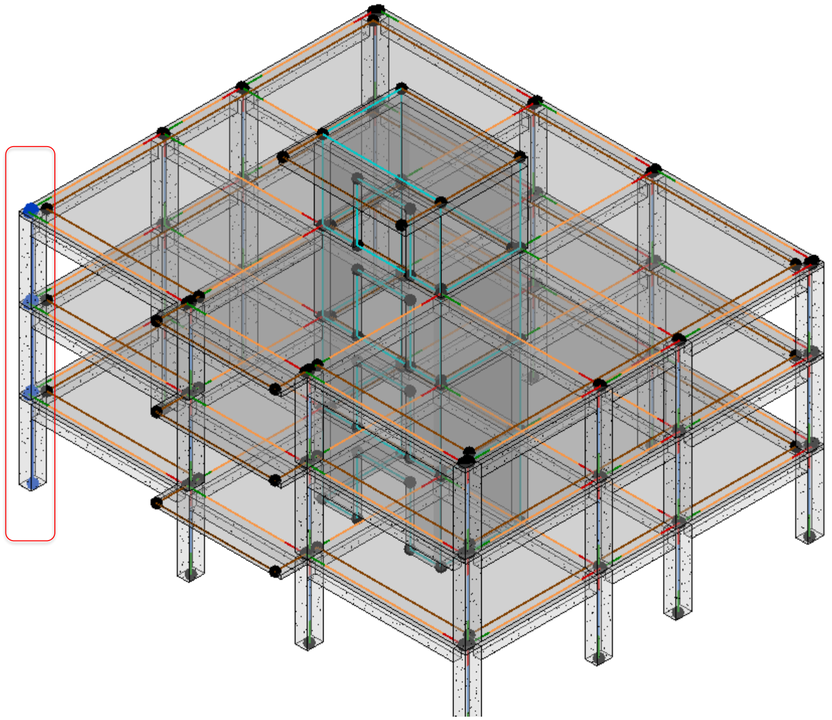


Manual Adjustment

Some structural configurations are not suitable for direct integration with analysis and design software. Adaptive adjustment is required before a structural model is input into the analysis and design software. For this reason, the geometry of the structural member analytical model may also be adjusted in relation to those elements to which it joins.



Analytical Alignment	
Top Alignment Method	<Manually Adjusted>
Top y Projection	Location Line
Top z Projection	Location Line
Top Extension Method	<Manually Adjusted>
Top x Projection	Top Level Reference
Base Alignment Method	<Manually Adjusted>
Base y Projection	Location Line
Base z Projection	Location Line
Base Extension Method	<Manually Adjusted>
Base x Projection	



Exercise 1 | Identify Physical-Analytical Relation

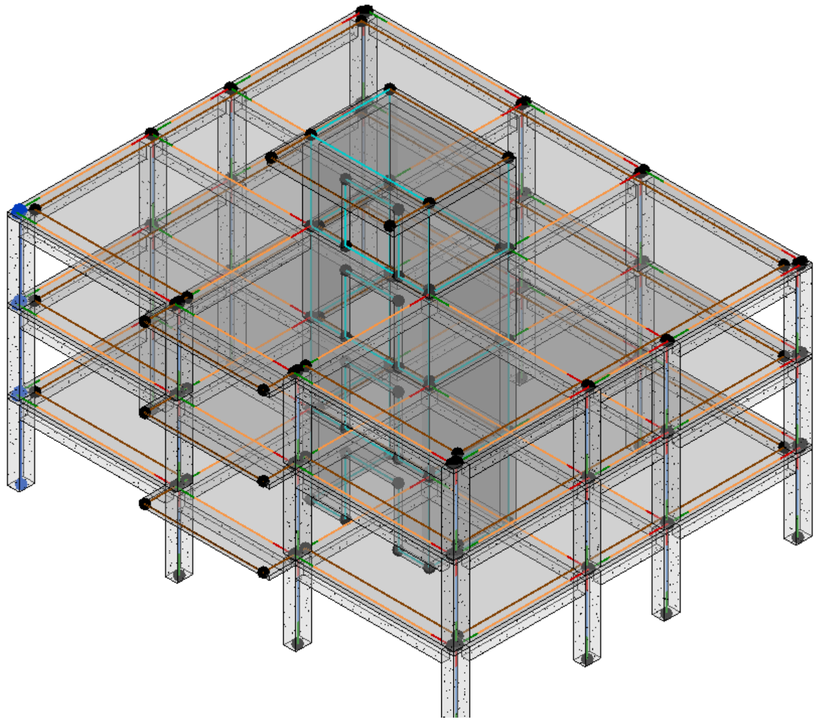
In this exercise, we'll see how we can identify the physical/analytical counterpart for model's elements.

Also, we'll do a quick overview of analytical elements alignment settings and we'll learn how to restore the analytical representation to its default position.

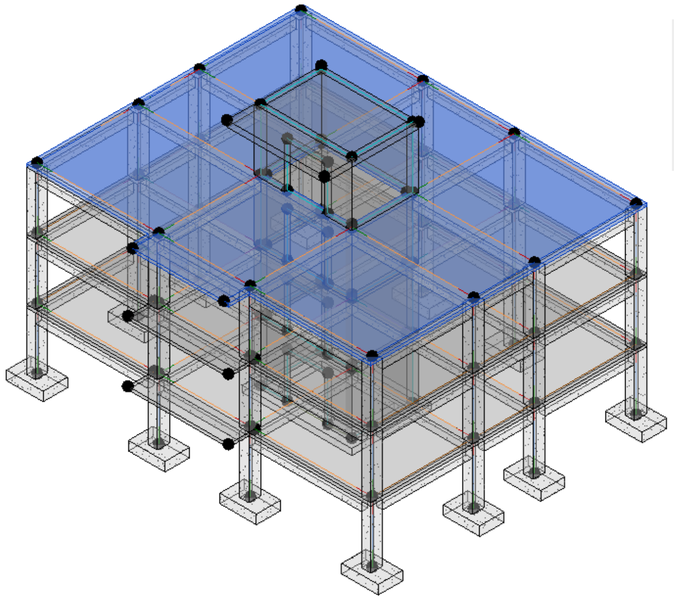
Exercise 1 | Identify Physical-Analytical Relation

Environment

1. Open Model_001_StartPoint.rvt
2. Open Analytical Model 3D view
3. Enable Analytical Model Visibility



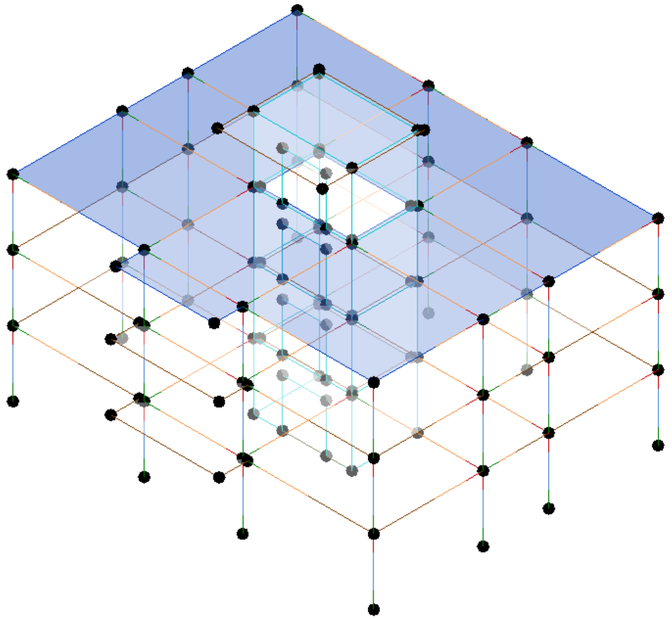
Exercise 1 | Identify Physical-Analytical Relation



Highlight Analytical Counterpart

4. Select the floor on the top floor
5. From Modify Floors tab > Analytical panel > Highlight Analytical.

The analytical floor will highlight.



Repeat the steps for other elements.

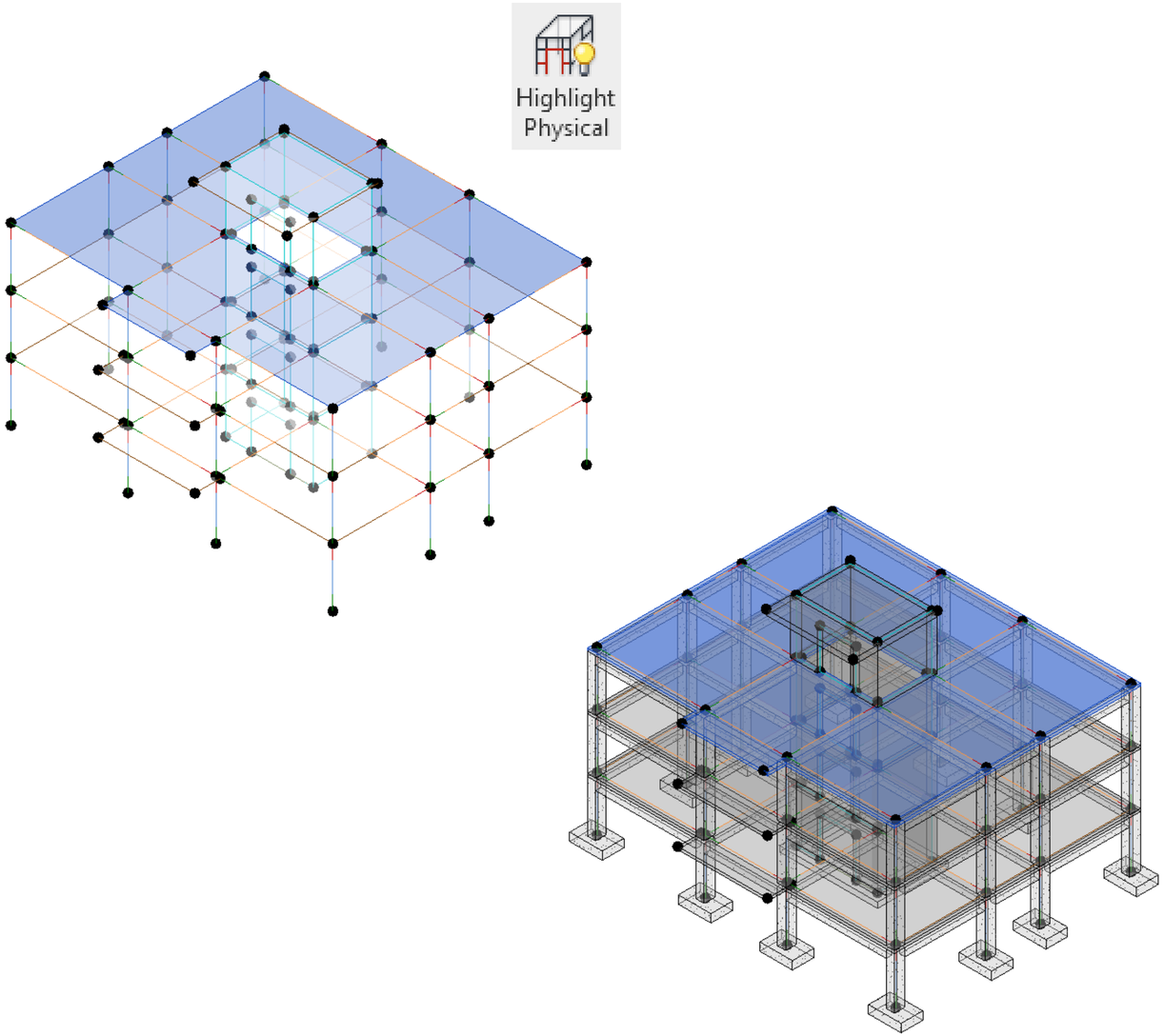
Exercise 1 | Identify Physical-Analytical Relation

Highlight Physical Counterpart

6. Select the analytical floor on the top floor
7. From Modify Analytical Floors tab > Physical panel > Highlight Physical.

The physical floor will highlight.

Repeat the steps for other elements.



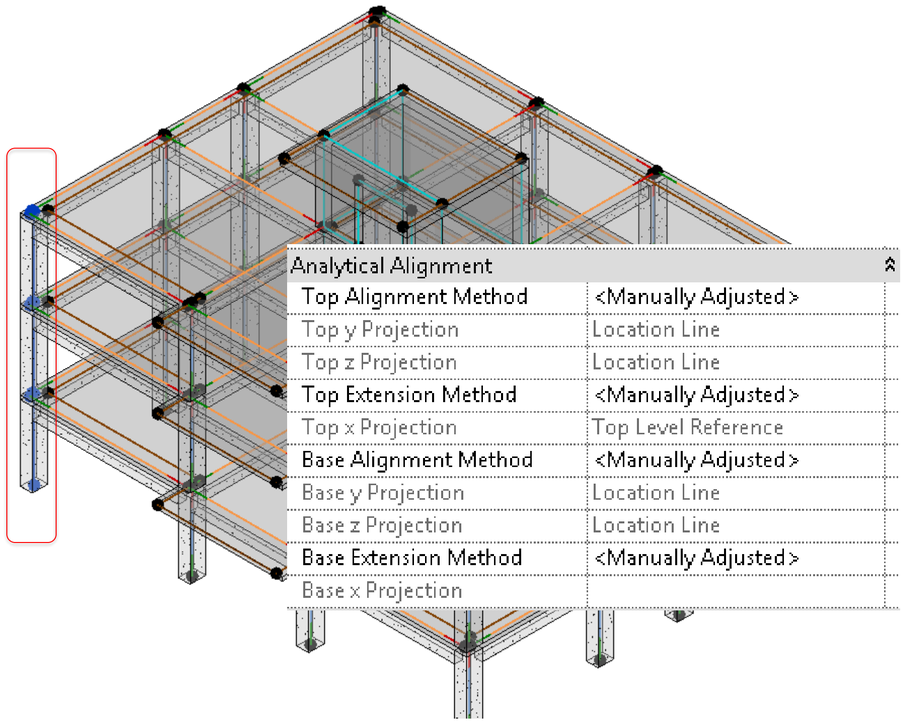
Exercise 1 | Identify Physical-Analytical Relation

Identify Analytical Adjustment Settings

8. Select all the South-West corner analytical columns

(You can select all the South-West corner elements and use Filters to isolate the analytical columns)

9. In Properties palette, the Analytical Columns alignment method is set to manual.



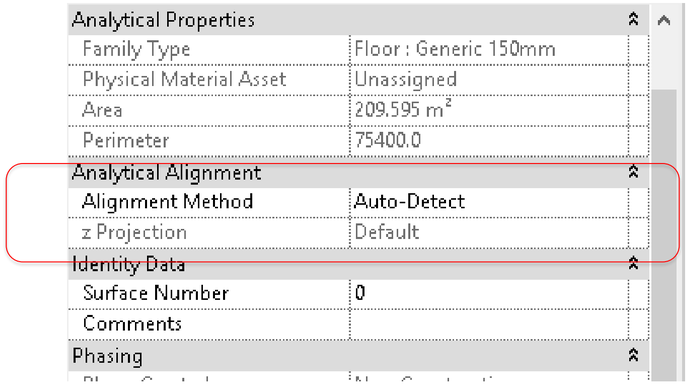
Exercise 1 | Identify Physical-Analytical Relation

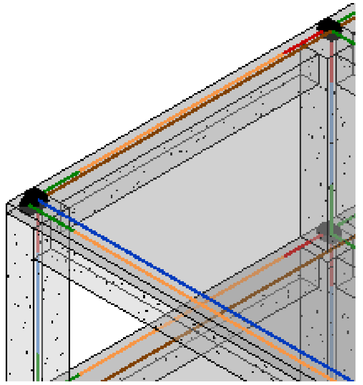
Reset the Analytical Model

10. Go to Analyze tab > Analytical Model Tools panel > Reset.
11. Select the floor from the top-level floor.

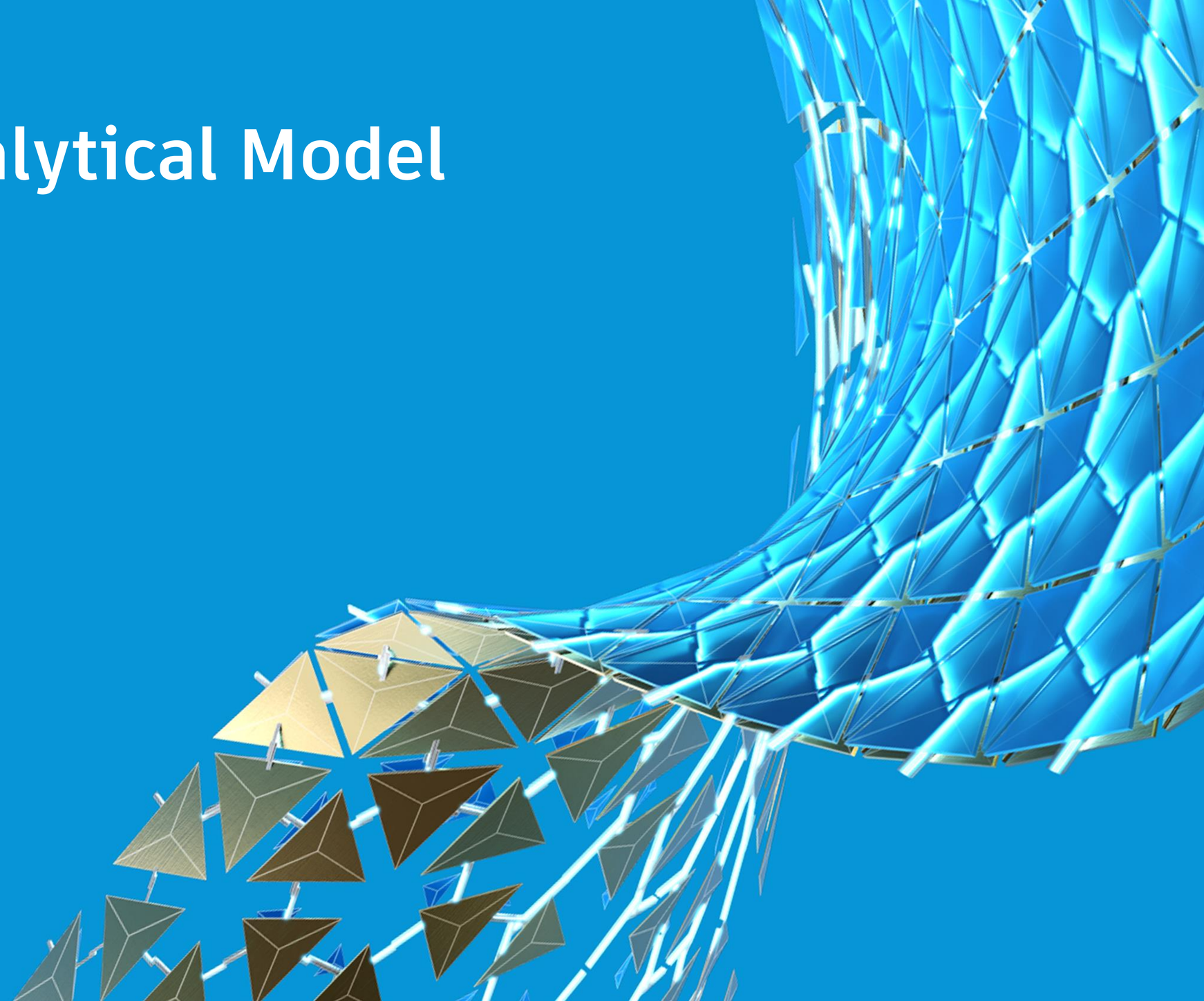
The selected structural element analytical model is back to its original shape or location, relative to its corresponding physical model.

The Analytical Alignment parameter is back to Auto-Detect



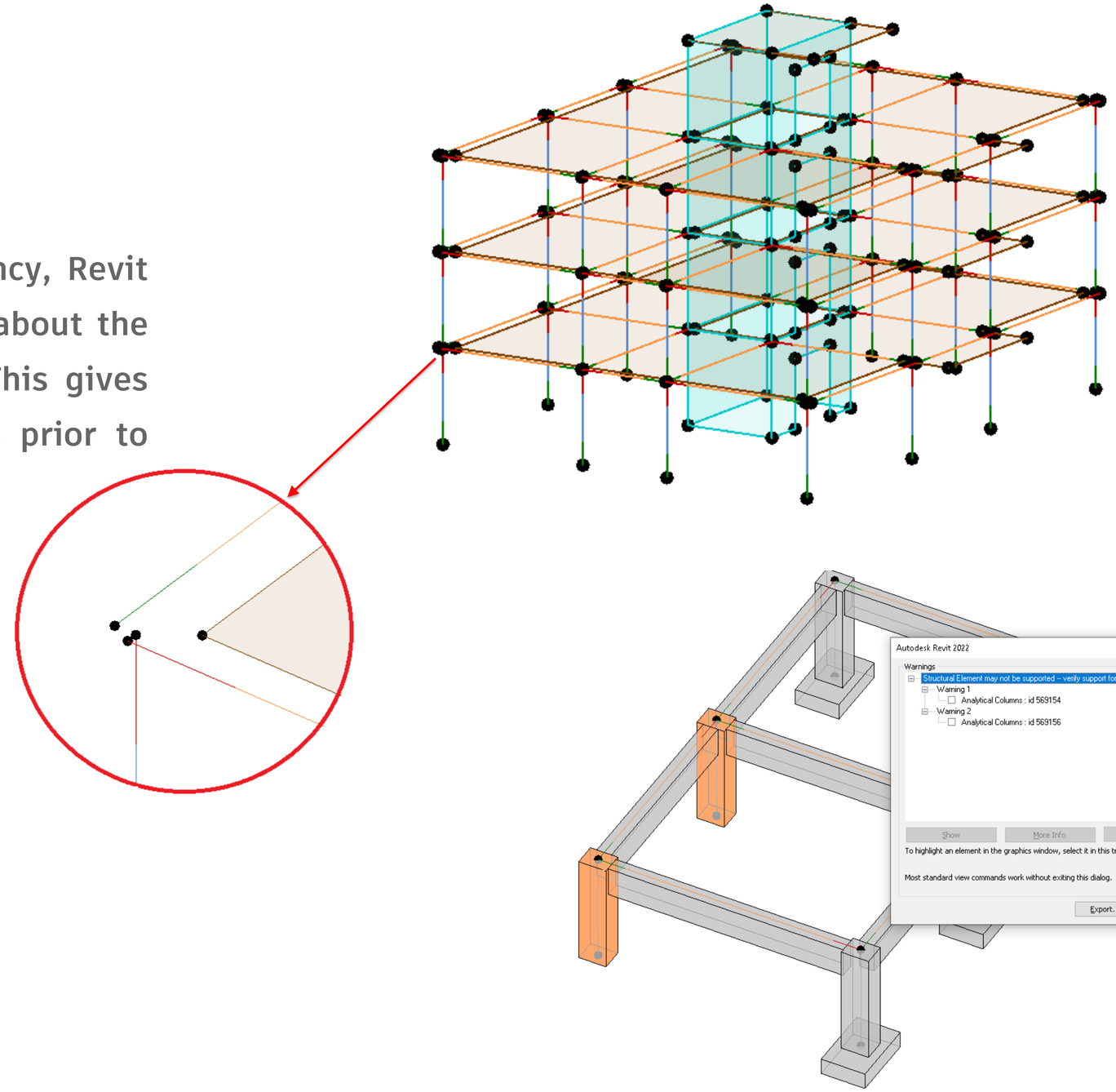


Maintain Analytical Model Connectivity



Analytical Model Check Tools

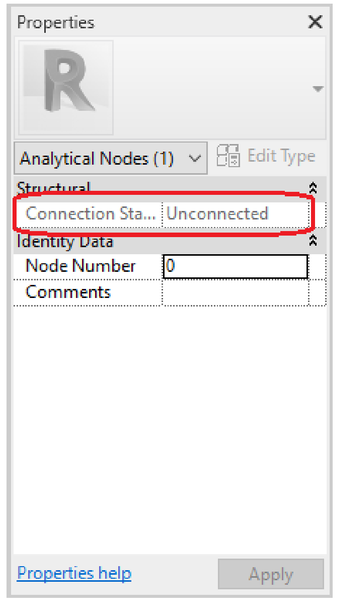
To investigate the analytical model consistency, Revit provides tools in the early stages of design about the connectivity and stability of the structure. This gives engineers greater insight into their designs prior to submitting them for complete analysis.

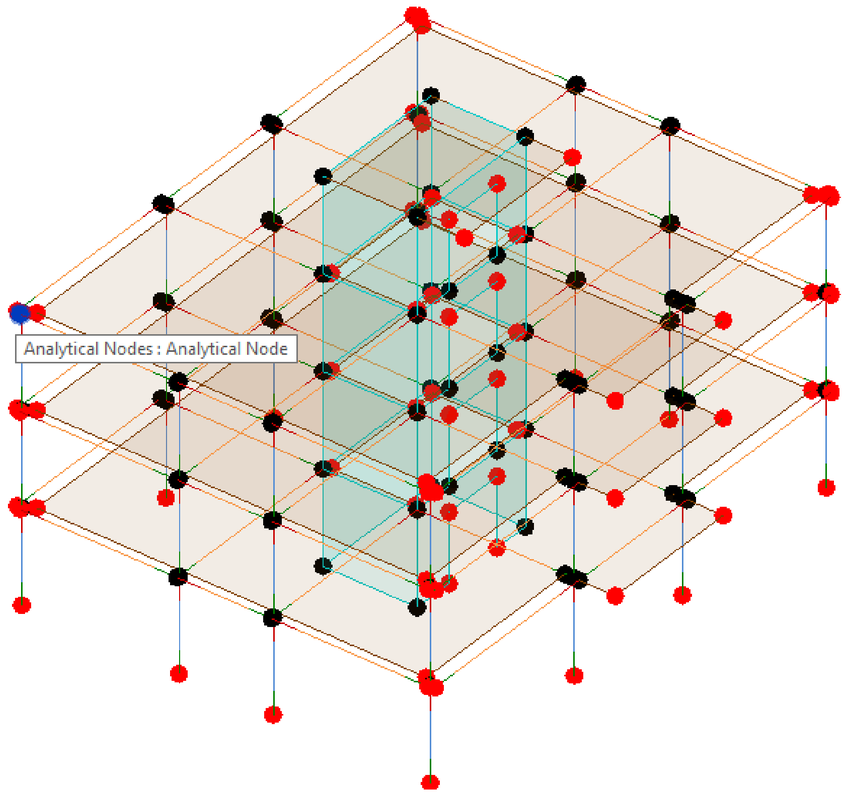


Connectivity Check Tools

Analytical Node – Connection Status parameter

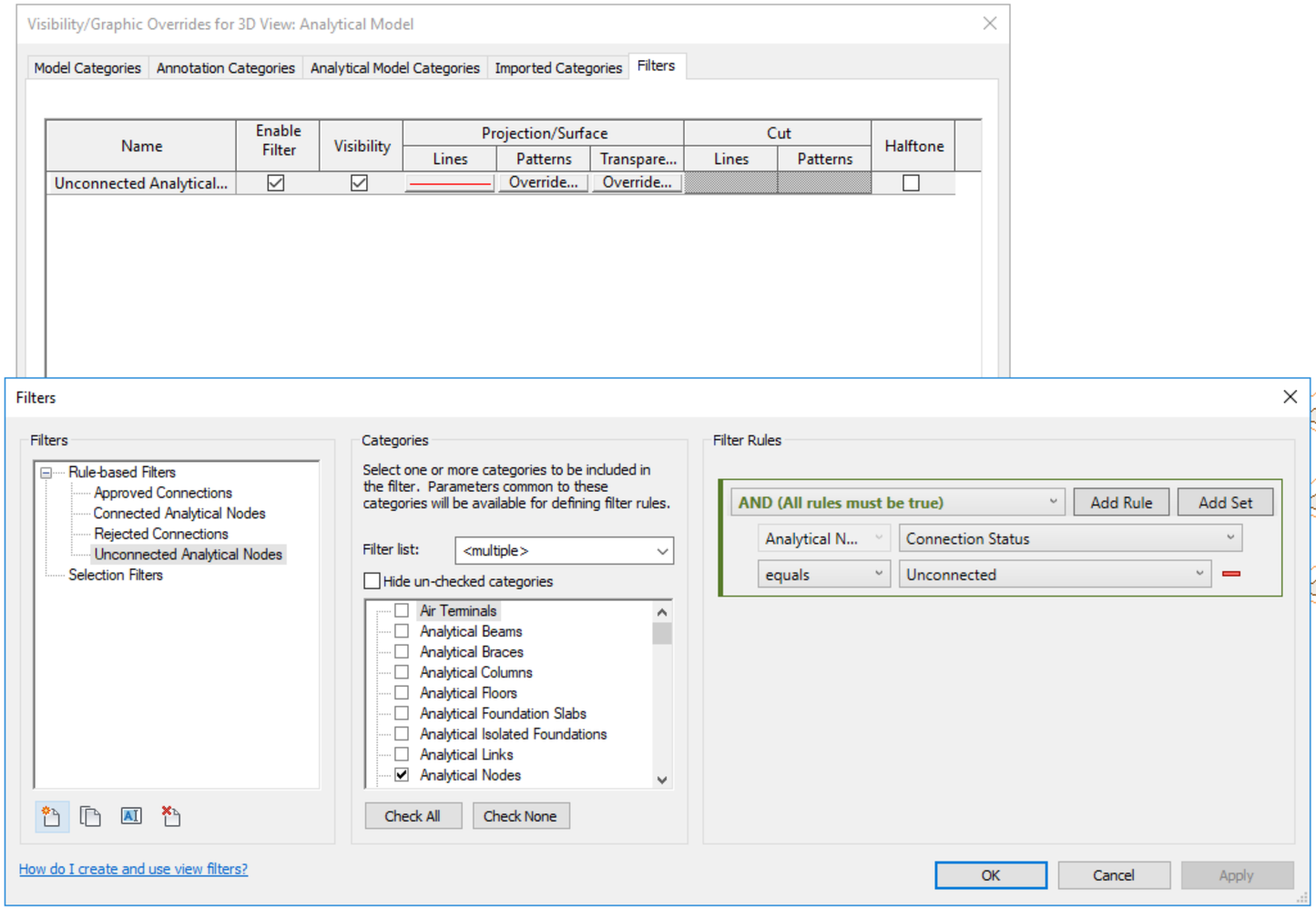
- **A read-only parameter that displays the connection status of an analytical node.**
  - Connected - Auto-detect (when connected automatically)
  - Connected - Linear (when connected to a column or beam)
  - Connected - Surface (when connected to a slab)
  - Unconnected.

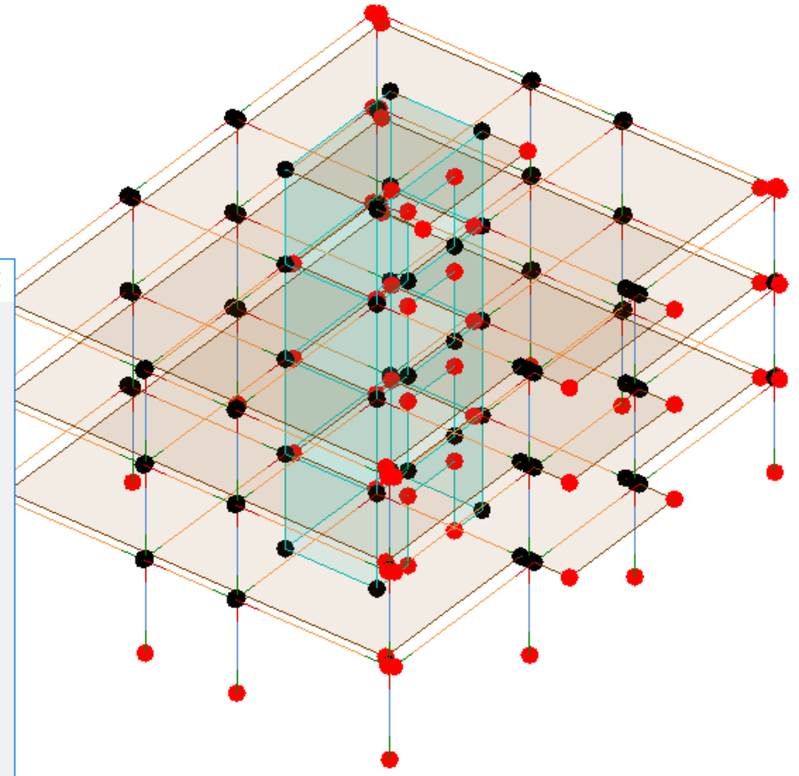




Connectivity Check Tools

Analytical Node – Connection Status parameter

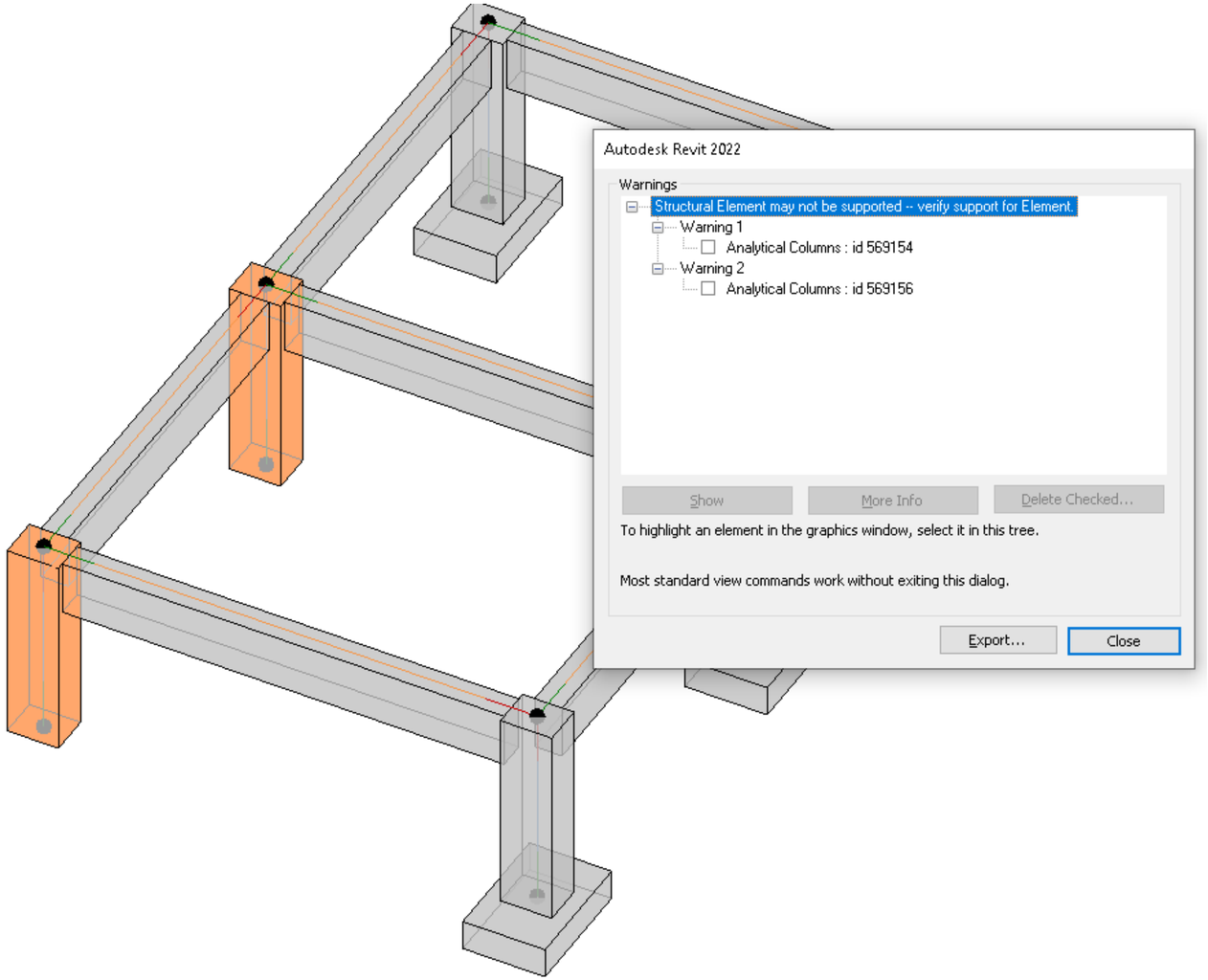




Connectivity Check Tools

Member Supports

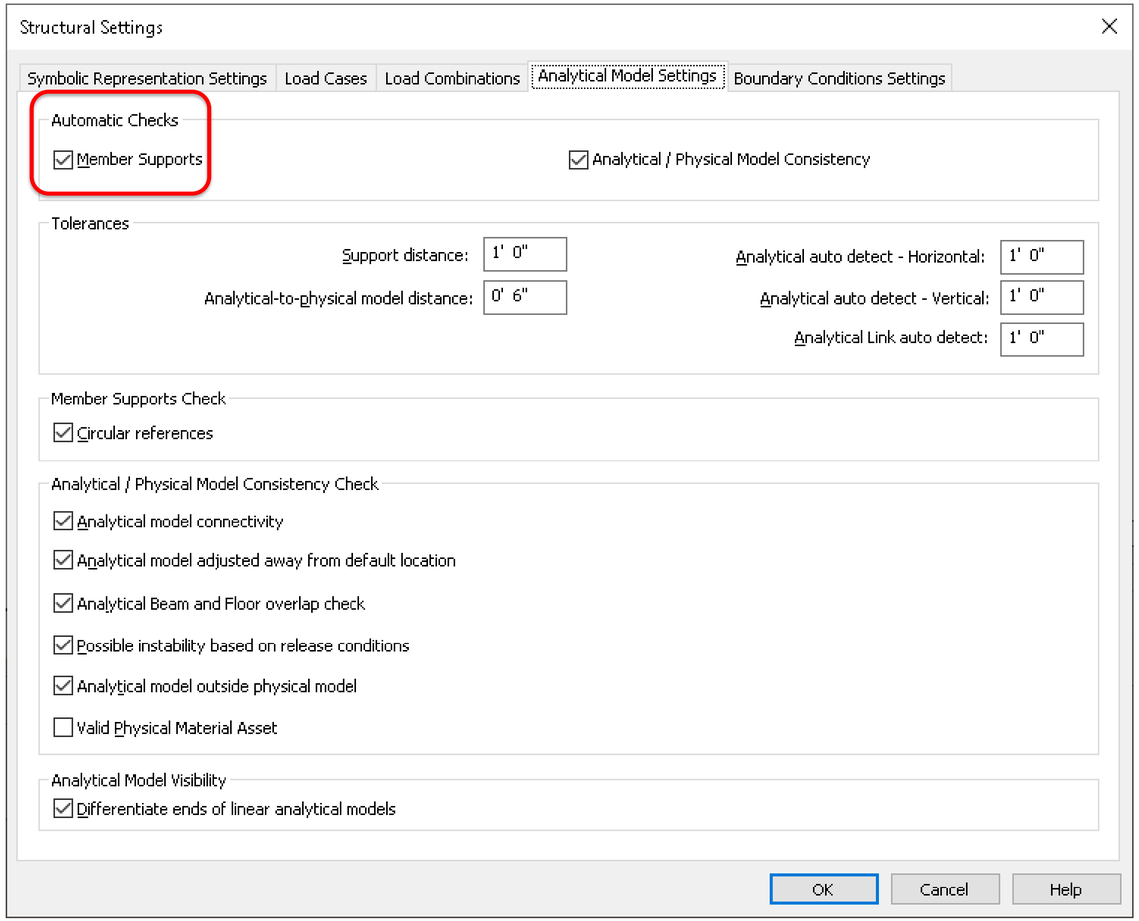
- Identifies unsupported elements

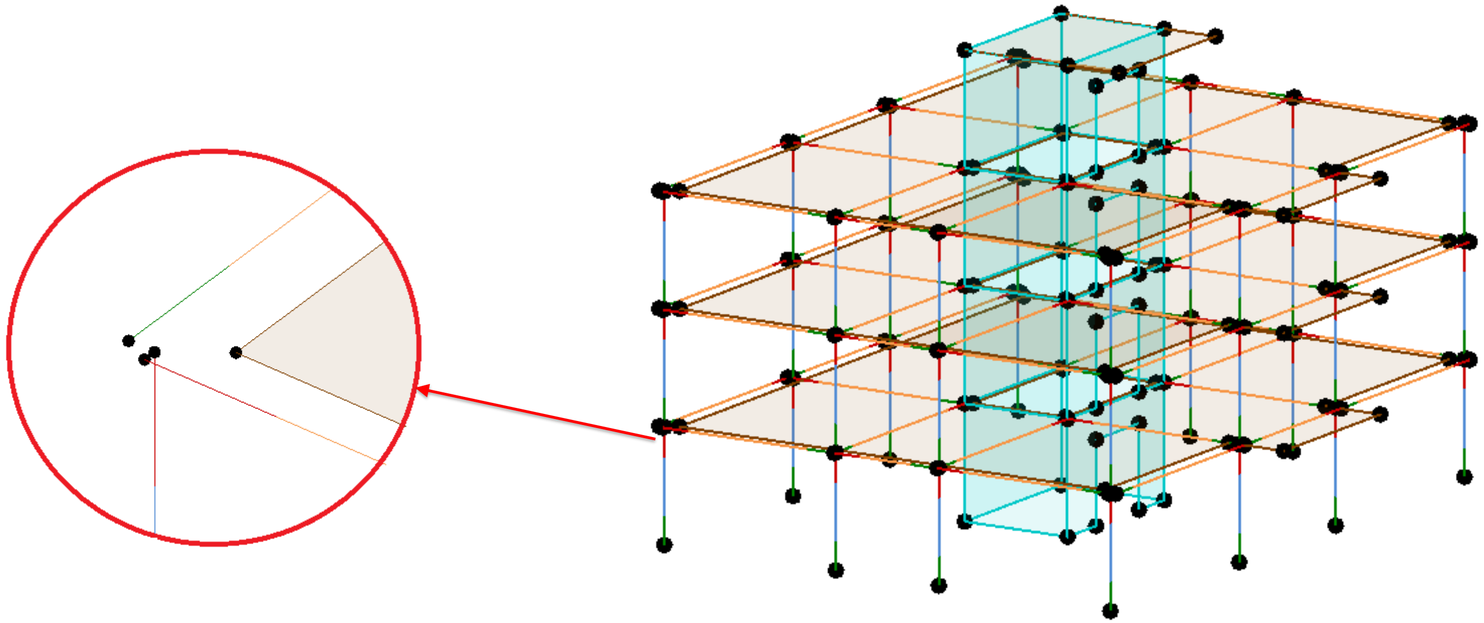


Connectivity Check Tools

Member Supports

It is not recommended to enable these setting in the early stages of a project. The number of elements unsupported during model creation is significant.





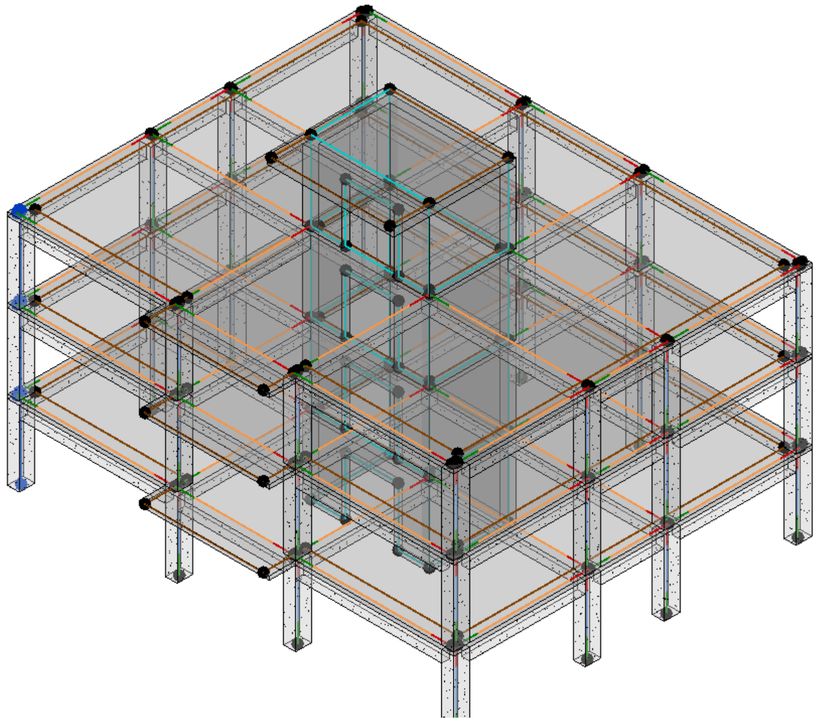
Exercise 2.1 | Identify Analytical Model Connectivity Issues

In this exercise, we'll learn how to identify analytical representation connectivity issues in our projects.

Exercise 2.1 | Identify Analytical Model Connectivity Issues

Environment

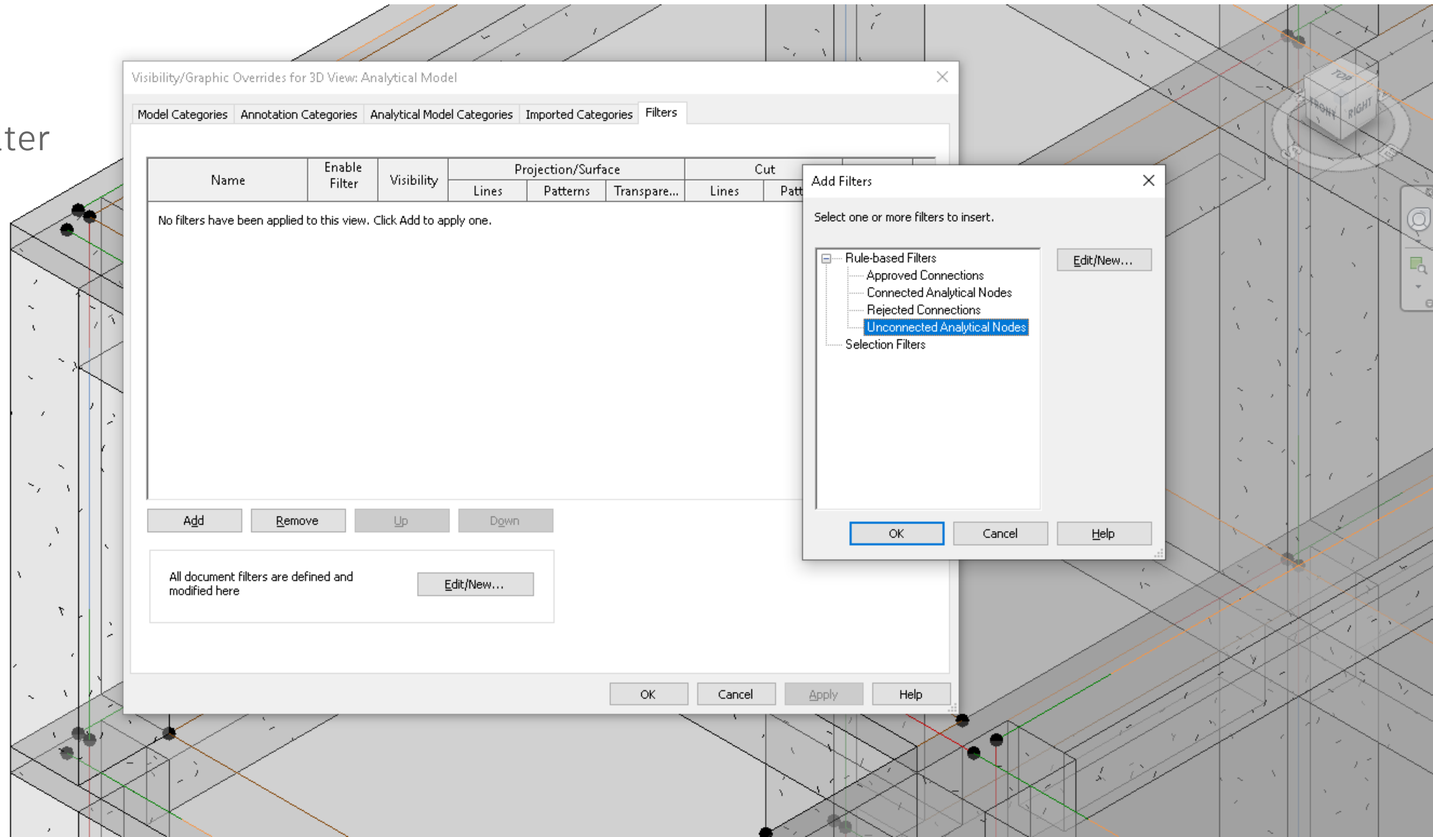
1. Open Model_001_StartPoint.rvt
2. Open Analytical Model 3D view
3. Enable Analytical Model Visibility



Exercise 2.1 | Identify Analytical Model Connectivity Issues

Identify Unconnected Nodes

1. Open Visibility/Graphics Overrides dialog
2. Go to Filters tab
3. Click Add button
4. Select the Unconnected Analytical Nodes predefined filter
5. OK

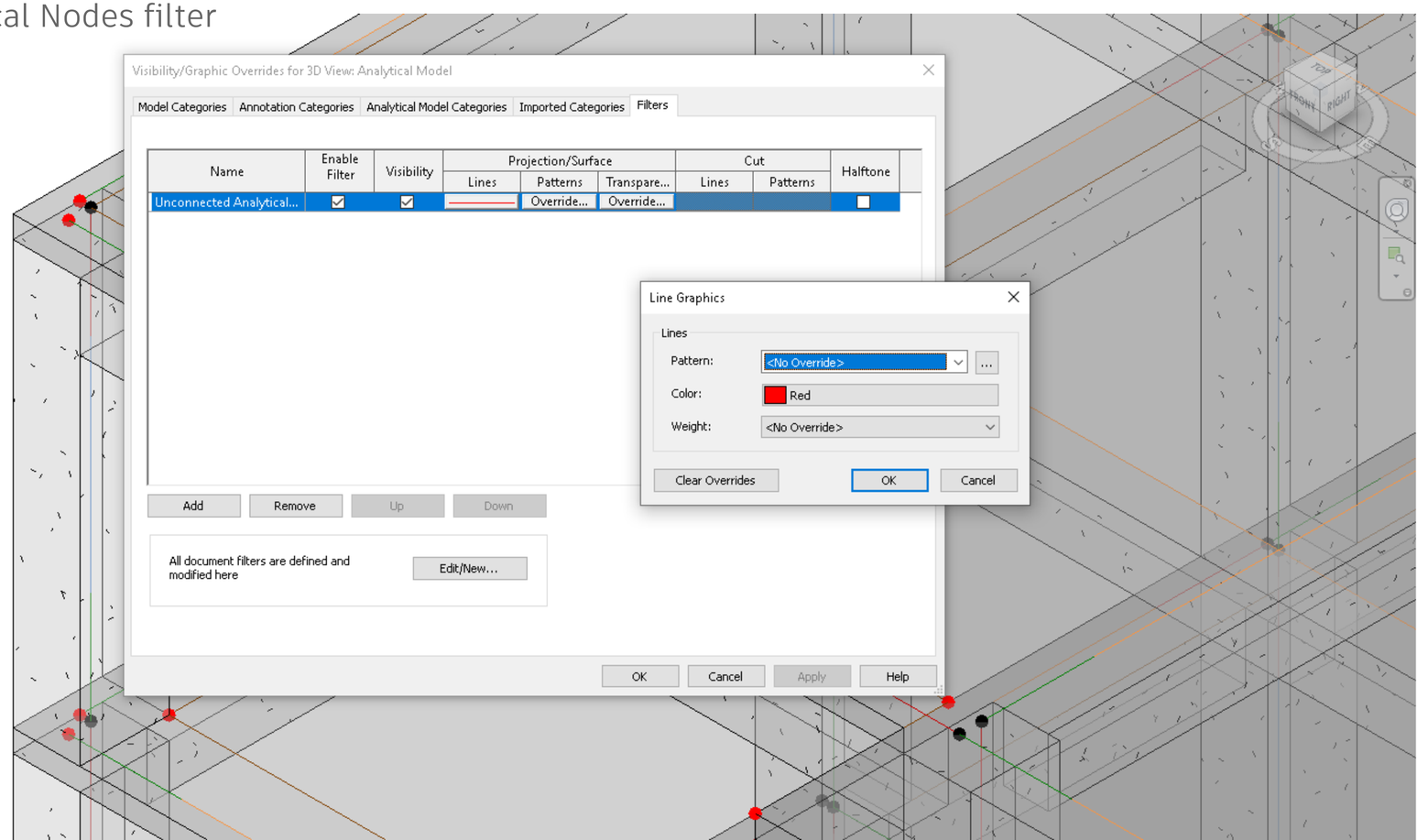


Exercise 2.1 | Identify Analytical Model Connectivity Issues

Identify Unconnected Nodes

9. Set the Lines color for the Unconnected Analytical Nodes filter to Red
10. Apply changes

All the unconnected notes are displayed in red.

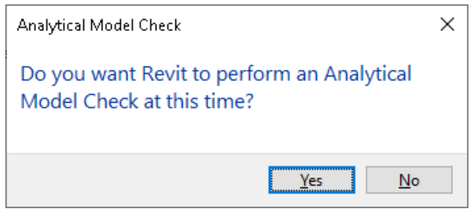


Exercise 2.1 | Identify Analytical Model Connectivity Issues

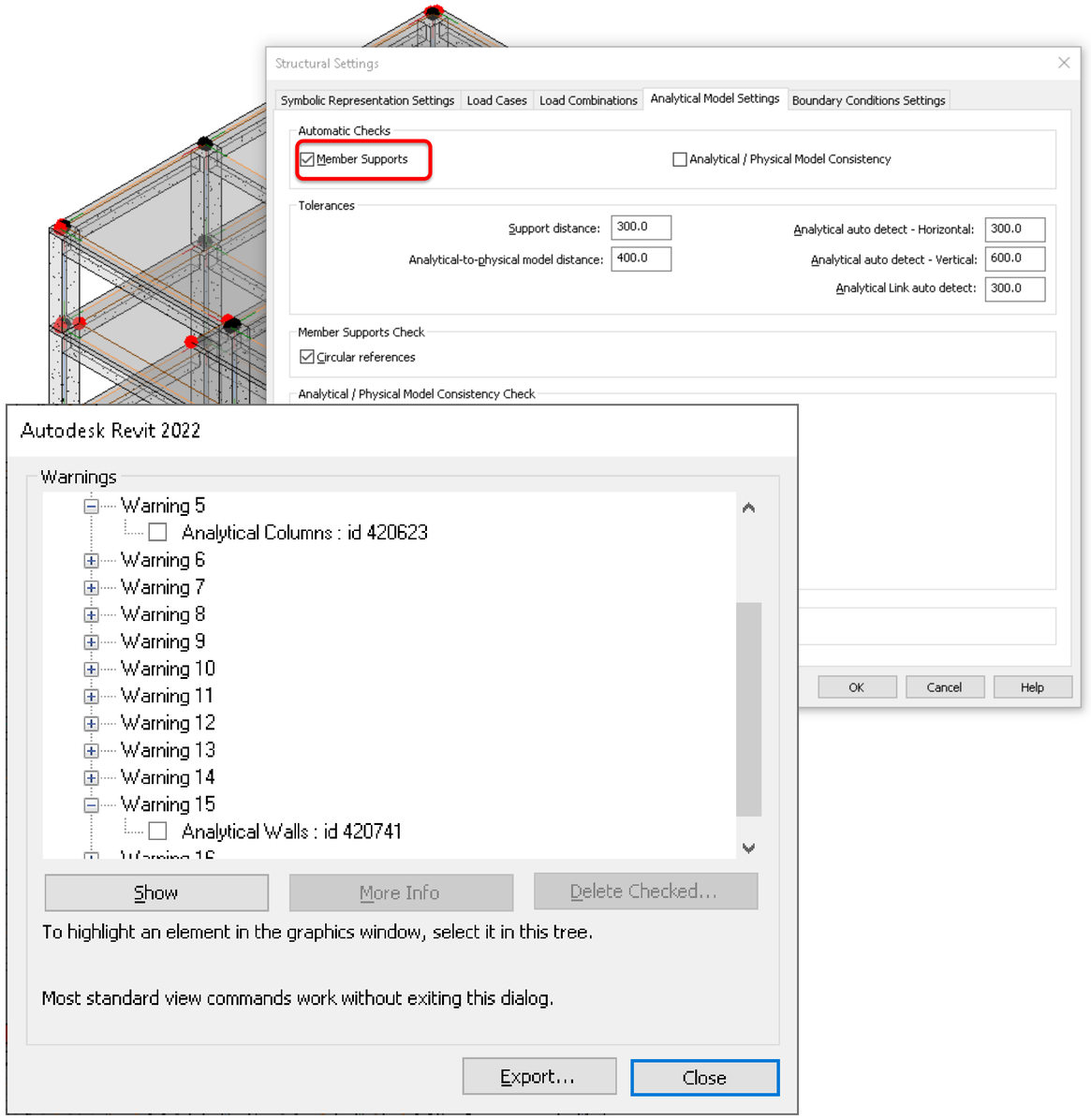
Identify Unsupported Elements

11. Go to Manage tab > Settings panel > open Structural Settings dialog
12. Go to Analytical Model Settings tab > Automatic Checks area > Check Member Supports option
13. OK

A warning message will ask you to perform an analytical check for the entire model



14. Yes
15. Warnings are issued for all the walls and columns on the first level



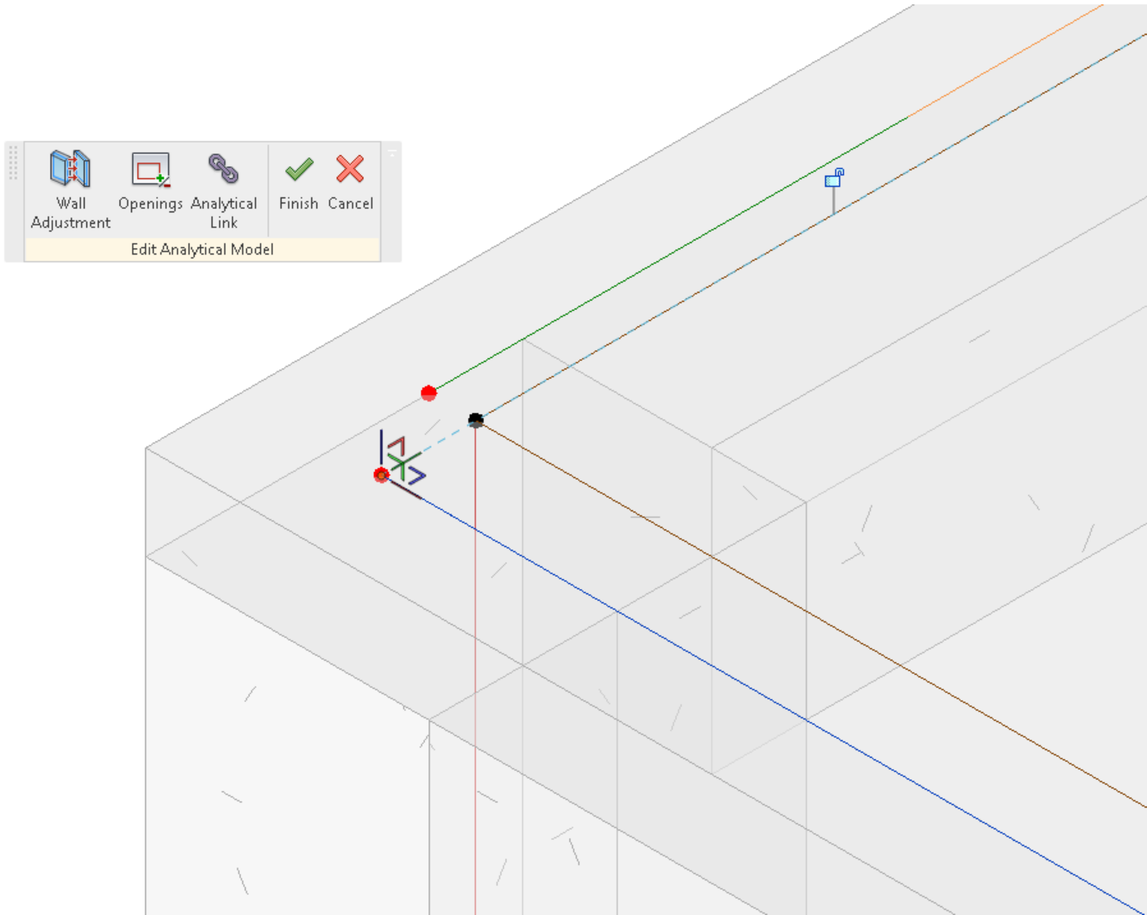
Analytical Model Adjustment Tools

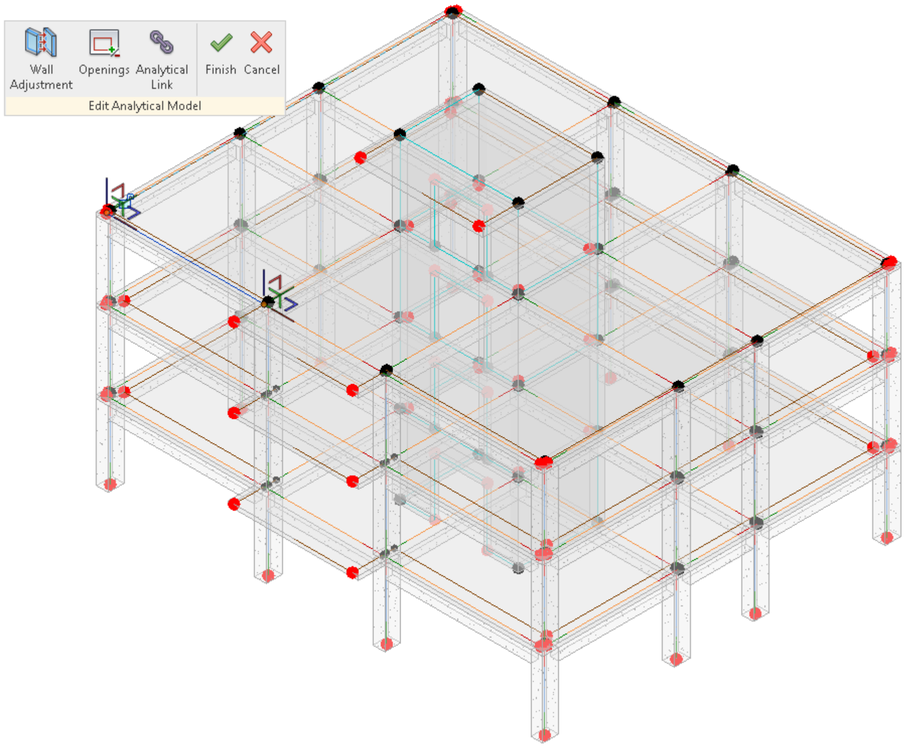
Some structural configurations are not suitable for direct integration with analysis and design software. Adaptive adjustment is required before a structural model is input into the analysis and design software.

- **Manual Adjustment**
- Projection Adjustment
- Auto-detect Adjustment

Analytical Model Manual Adjustment

1. Click Analyze tab > Analytical Model Tools panel > Analytical Adjust to manually adjust the analytical model.
2. In the drawing area, move and adjust analytical nodes and edges by snapping them onto analytical model geometry, nodes, grids and reference planes.
3. Click Analyze tab > Edit Analytical Model panel > Finish to exit the analytical edit mode and save changes to the analytical model or Cancel to exit without saving.





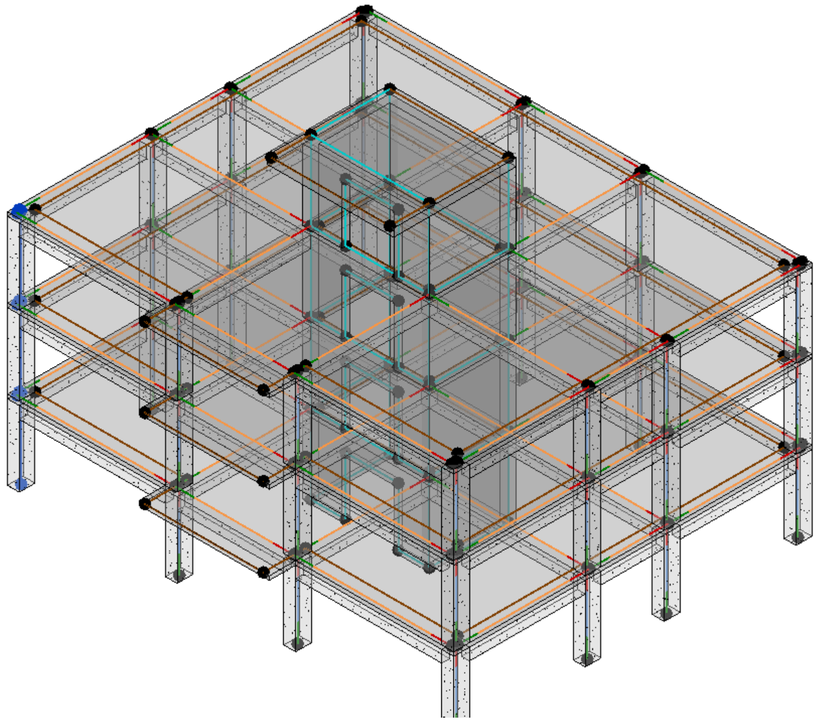
Exercise 2.2 | Manually Analytical Model Adjustment

In this exercise, we'll learn how to manually adjust the analytical representation when elements are unconnected.

Exercise 2.2 | Manually Analytical Model Adjustment

Environment

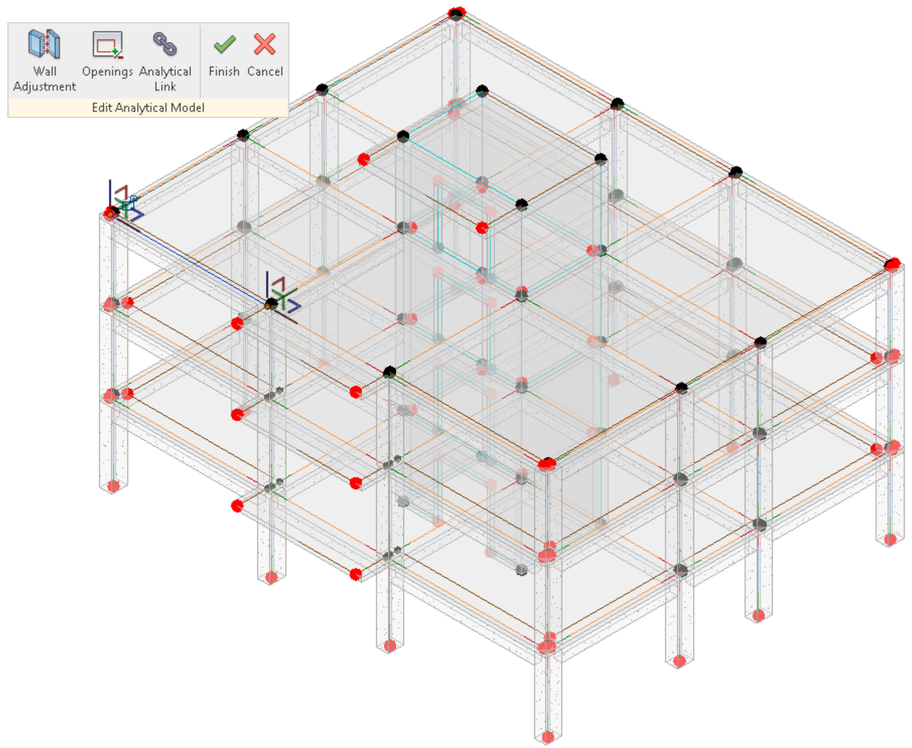
1. Open Model_001_StartPoint.rvt
2. Open Analytical Model 3D view
3. Enable Analytical Model Visibility



Exercise 2.2 | Manually Analytical Model Adjustment

Open Analytical Adjust Edit Mode

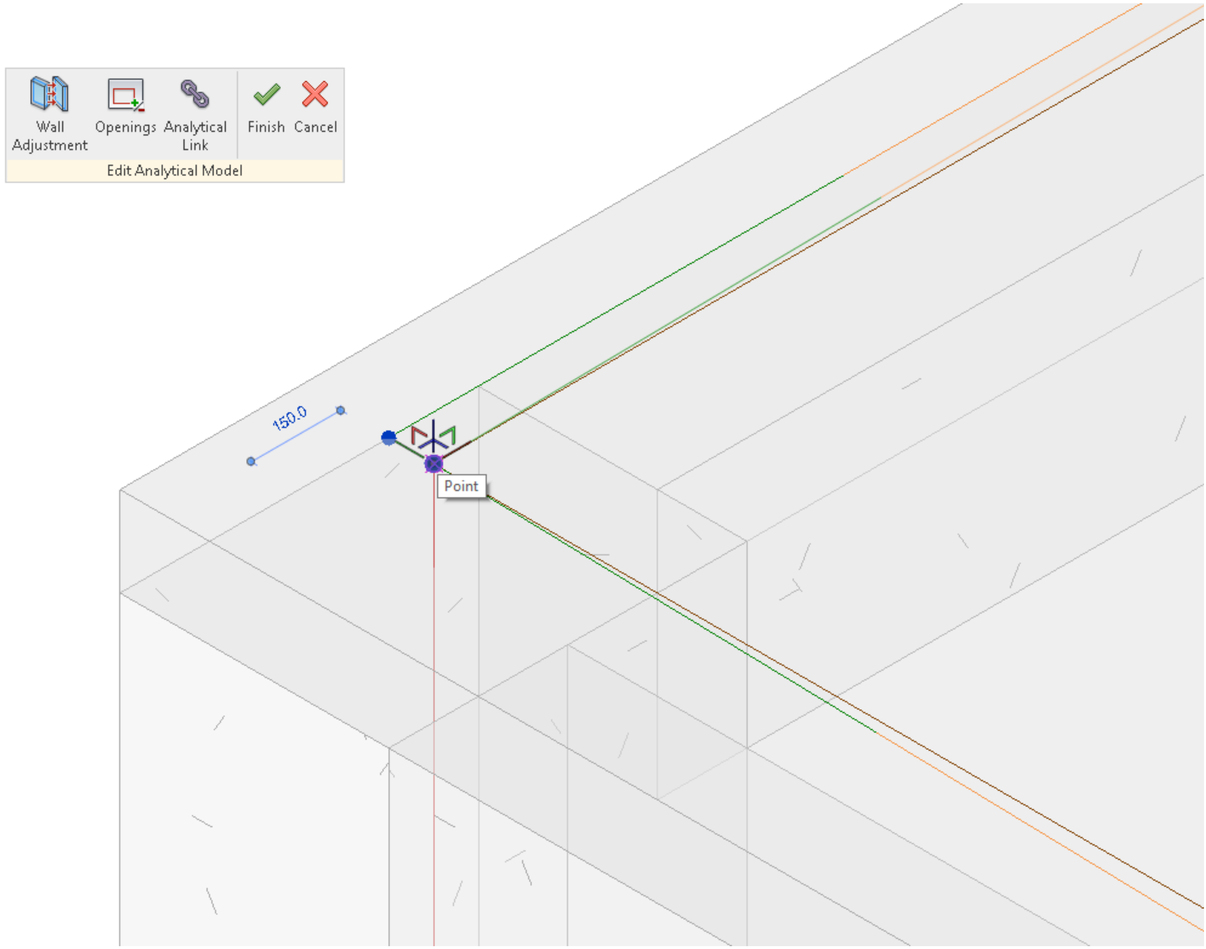
4. Click Analyze tab > Analytical Model Tools panel > Analytical Adjust to manually adjust the analytical model.



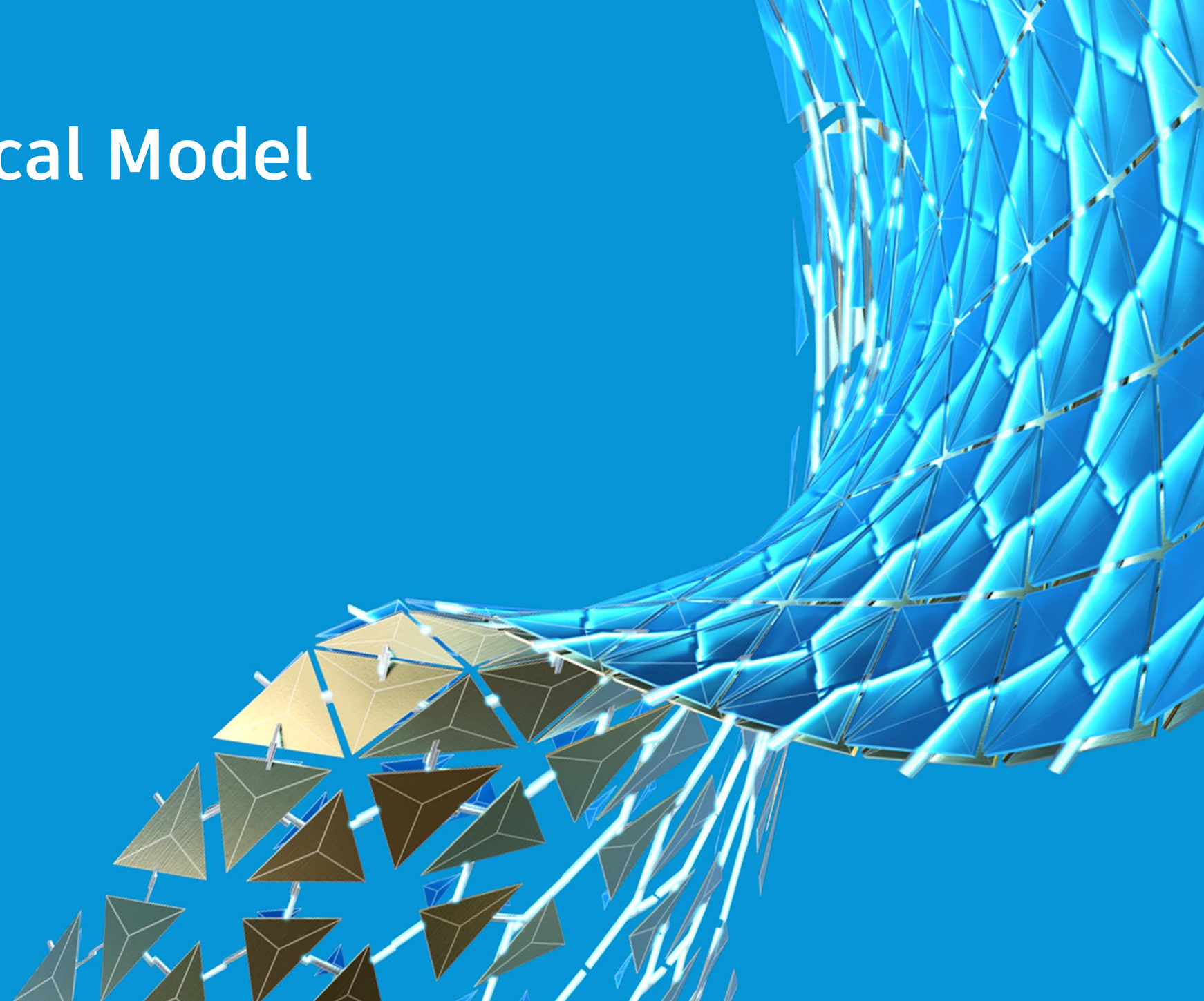
Exercise 2.2 | Manually Analytical Model Adjustment

Manually Adjust the Analytical Elements

5. In the drawing area, move and adjust analytical nodes and edges by snapping them onto analytical model geometry, nodes, grids and reference planes.
6. Click Analyze tab > Edit Analytical Model panel > Finish to exit the analytical edit mode and save changes to the analytical model or Cancel to exit without saving.



Keep Analytical Model Updated

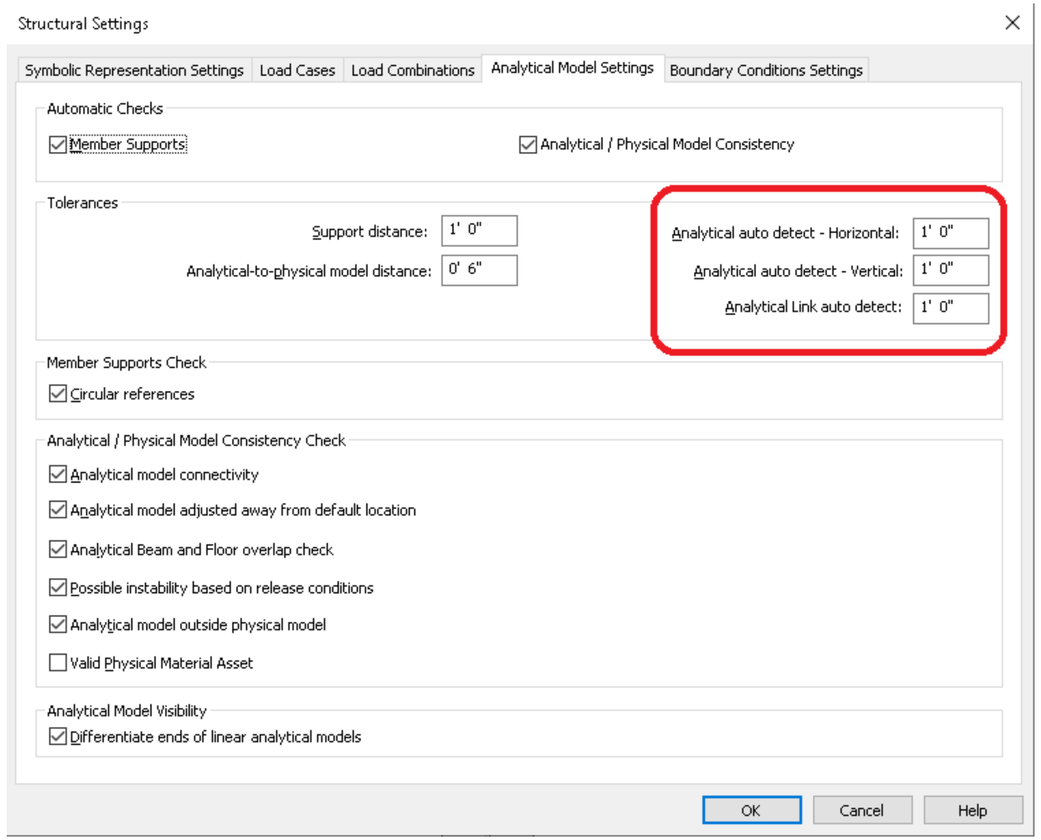


Auto-detect Adjustments

Automatic adjustment is performed on a structural element, in relation to a neighboring structural element.

Revit can automatically adjust the analytical model for beams, braces, structural columns, structural walls, structural floors, and foundation slabs so that they align more accurately. This behavior is based on the instance parameters of the elements and tolerance settings.

For auto-detection to take place, the analytical Adjustment Methods instance properties must be set to Auto-Detect for an element and its individual ends. This is the default justification method for all analytical structural elements. Automatic adjustment is then performed, as long as the Analytical Model of the adjacent element is within tolerance.

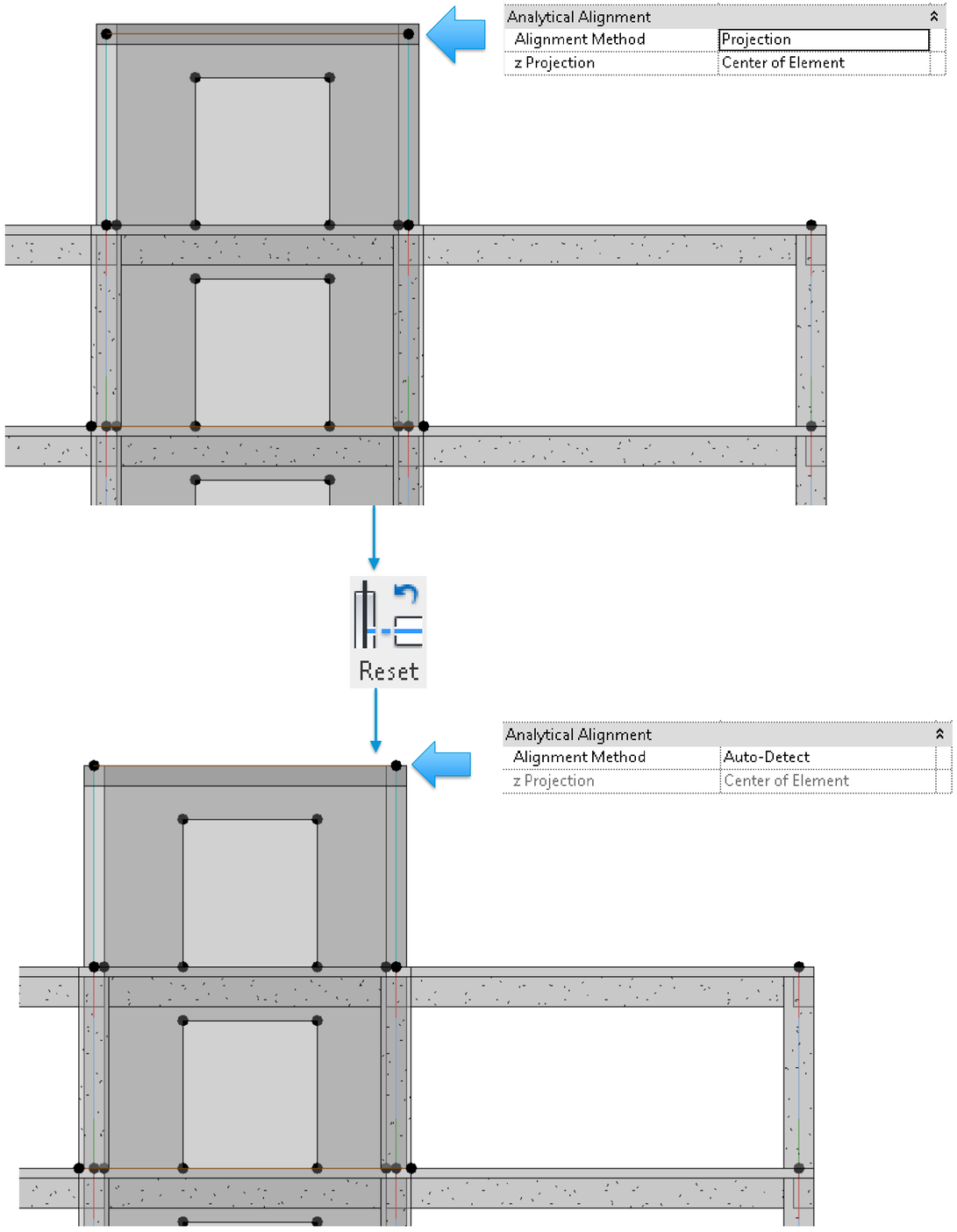


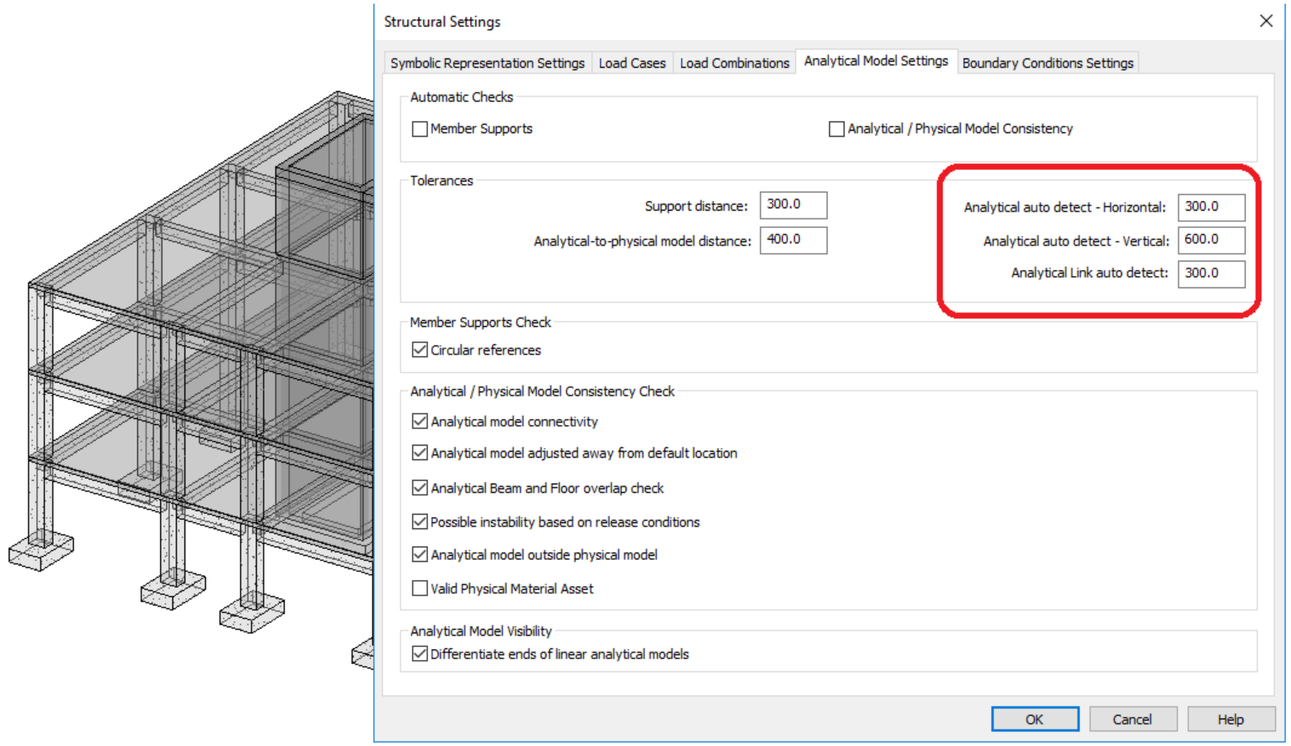
Reset the Analytical Model

The Analytical Nodes position can be restored to their original position

1. Click Analyze tab > Analytical Model Tools panel > Reset.

2. Select the element to reset the selected structural element analytical model back to its original shape or location, relative to its corresponding physical model.
3. Optionally, If you are currently editing the analytical model, select the element and click Modify | <Element> tab > Analytical Model Tools panel > Reset.





Exercise 3 | Auto-detect Adjustments

In this exercise, we'll learn how to get benefit of auto-detect adjustment tool while managing the physical-analytical relationship .

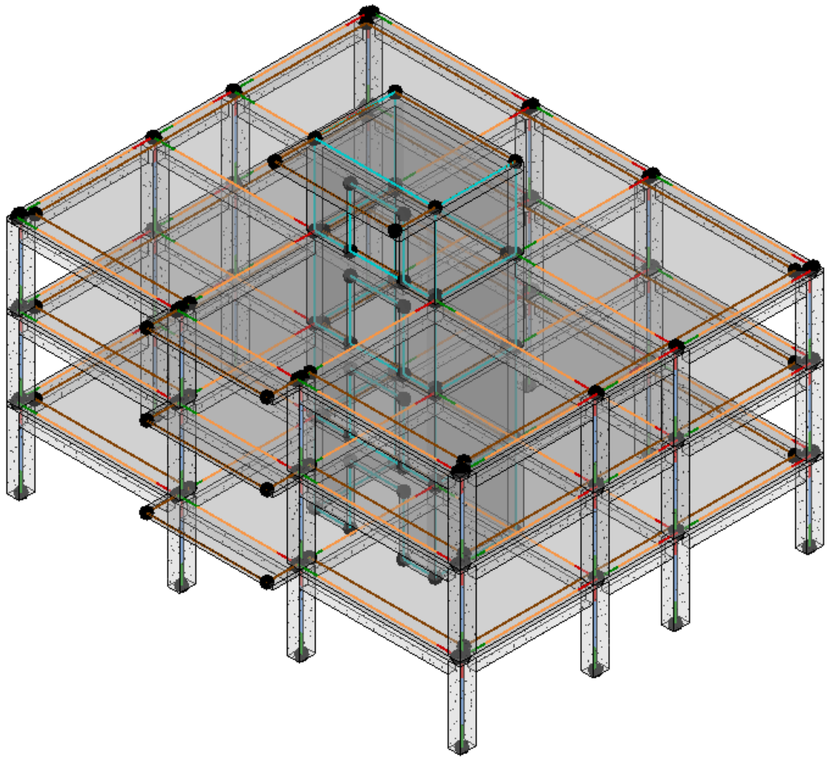
Exercise 3 | Auto-detect Adjustments

Environment

1. Open Model_001_StartPoint.rvt
2. Open Analytical Model 3D view
3. Enable Analytical Model Visibility

Most of the analytical beam, columns and floors are not connected.

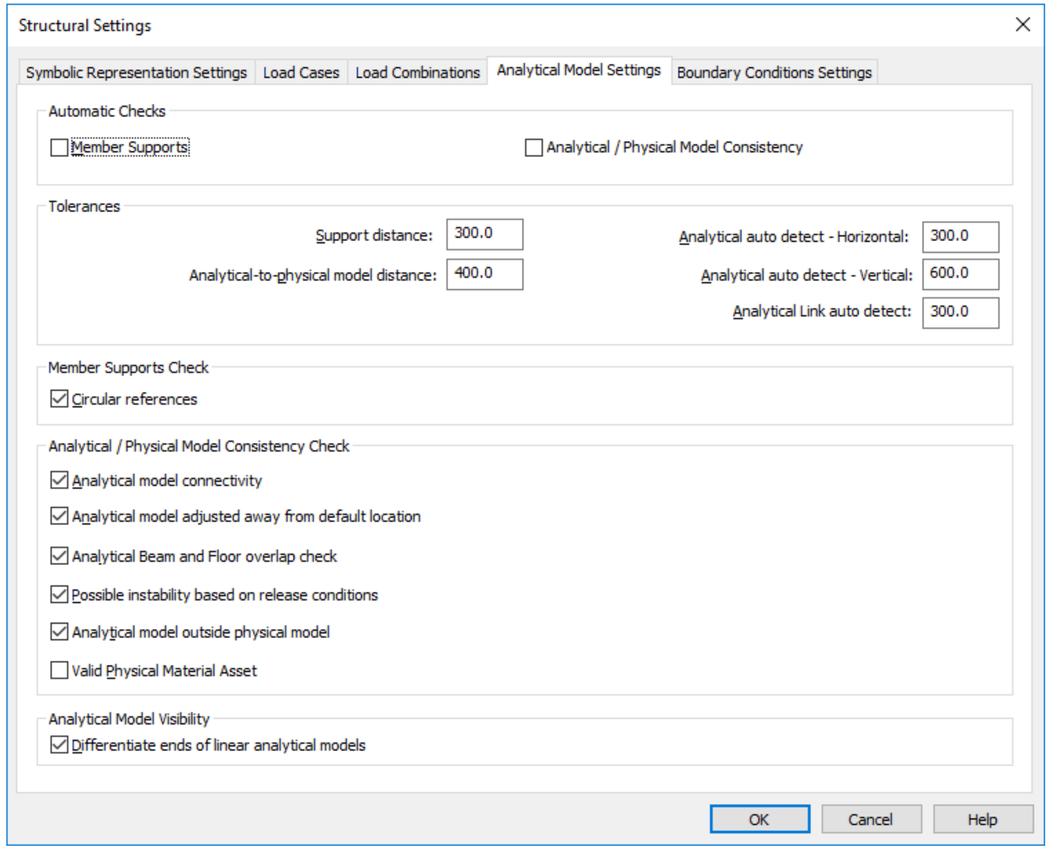
The goal of this exercise is to connect them using auto-detect adjustment tool.



Exercise 3 | Auto-detect Adjustments

Check the Member Supports

4. Go to Manage tab > Setting panel > Structural Settings dialog
5. Analytical Model Setting tab
6. Make sure that in Tolerances area the Analytical auto detect – Horizontal is set to 300mm



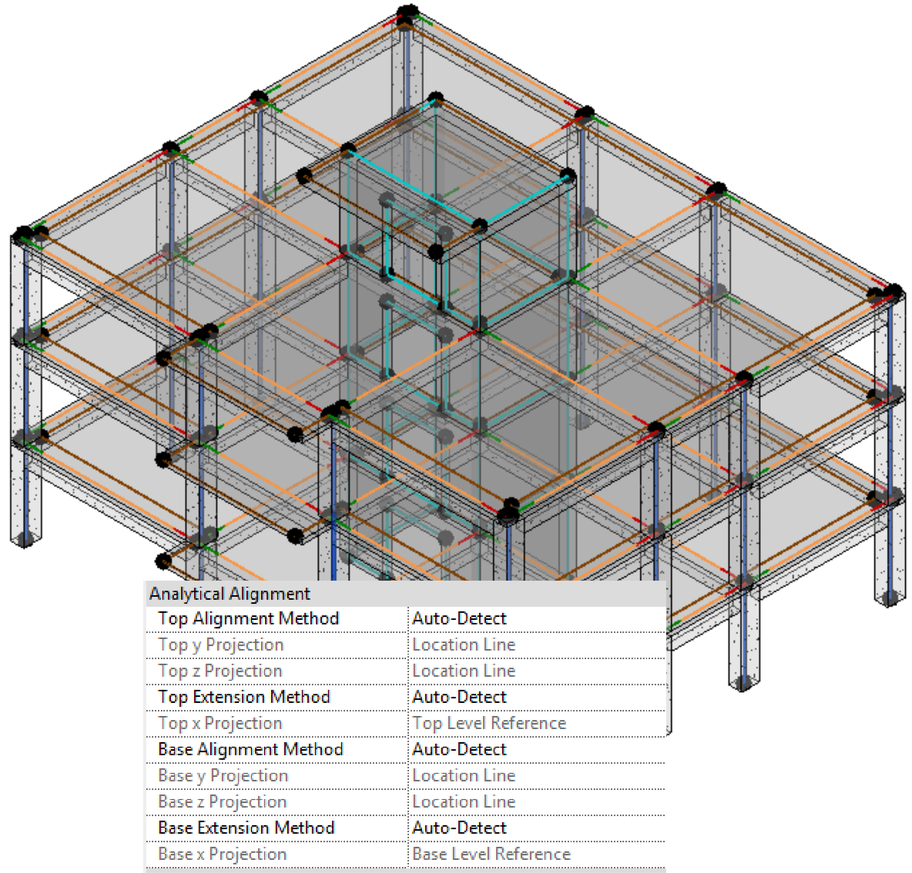
Exercise 3 | Auto-detect Adjustments

Analytical Columns Alignment Method

7. Go to Analyze tab > Analytical Model Tools panel > Adjust

Revit will enter in Analytical Adjust mode

8. Select all the Analytical Columns
9. Go to Properties palette > Analytical Alignment parameters group >
   - Switch the Top/Base Alignment Method to Auto-Detect
   - Switch the Top/Base Extension Method to Auto-Detect
10. Apply the changes
11. The analytical columns position are now controlled by the auto-adjust tool



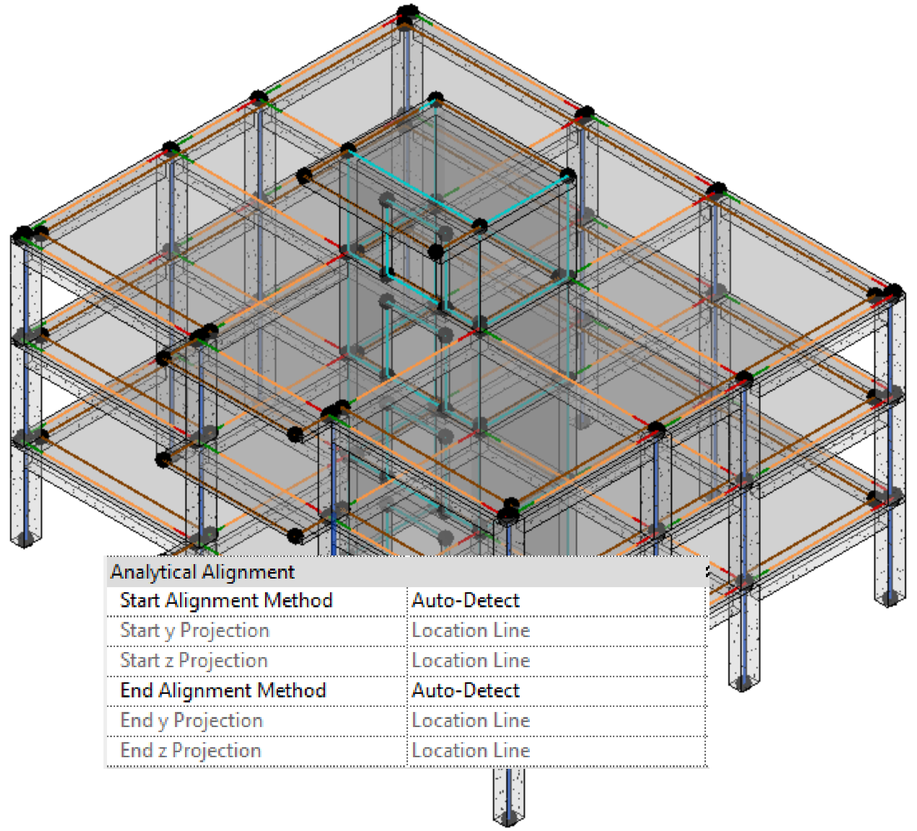
Analytical Alignment	
Top Alignment Method	Auto-Detect
Top y Projection	Location Line
Top z Projection	Location Line
Top Extension Method	Auto-Detect
Top x Projection	Top Level Reference
Base Alignment Method	Auto-Detect
Base y Projection	Location Line
Base z Projection	Location Line
Base Extension Method	Auto-Detect
Base x Projection	Base Level Reference

Exercise 3 | Auto-detect Adjustments

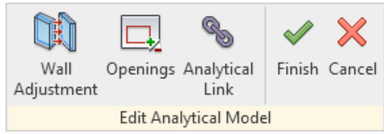
Analytical Beams Alignment Method

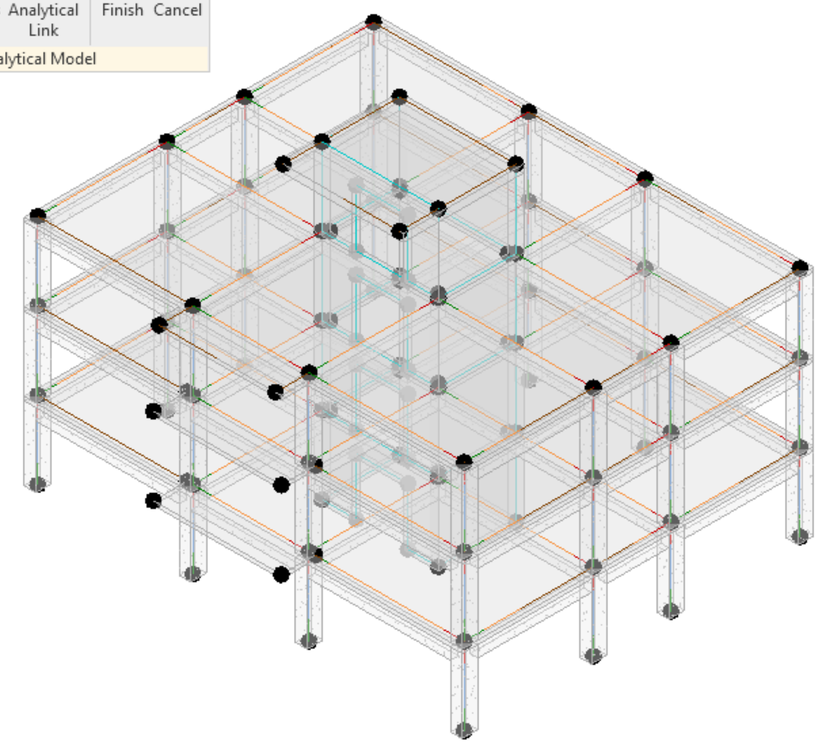
12. Select all the Analytical beams
13. Go to Properties palette > Analytical Alignment parameters group > Switch the Start/End Alignment Method to Auto-Detect
14. Apply the changes

The analytical beams position are now controlled by the auto-adjust tool. The Auto-Detect tool identifies that an analytical column is less than 300mm away from the analytical beams. It adjusts the analytical beam position, so they join the analytical columns.



Exercise 3 | Auto-detect Adjustments





Reset Analytical Floor Position

15. Select all the Analytical floors
16. Go to to Analyze tab > Analytical Model Tools panel > Reset Analytical Model
17. Select the top analytical floor

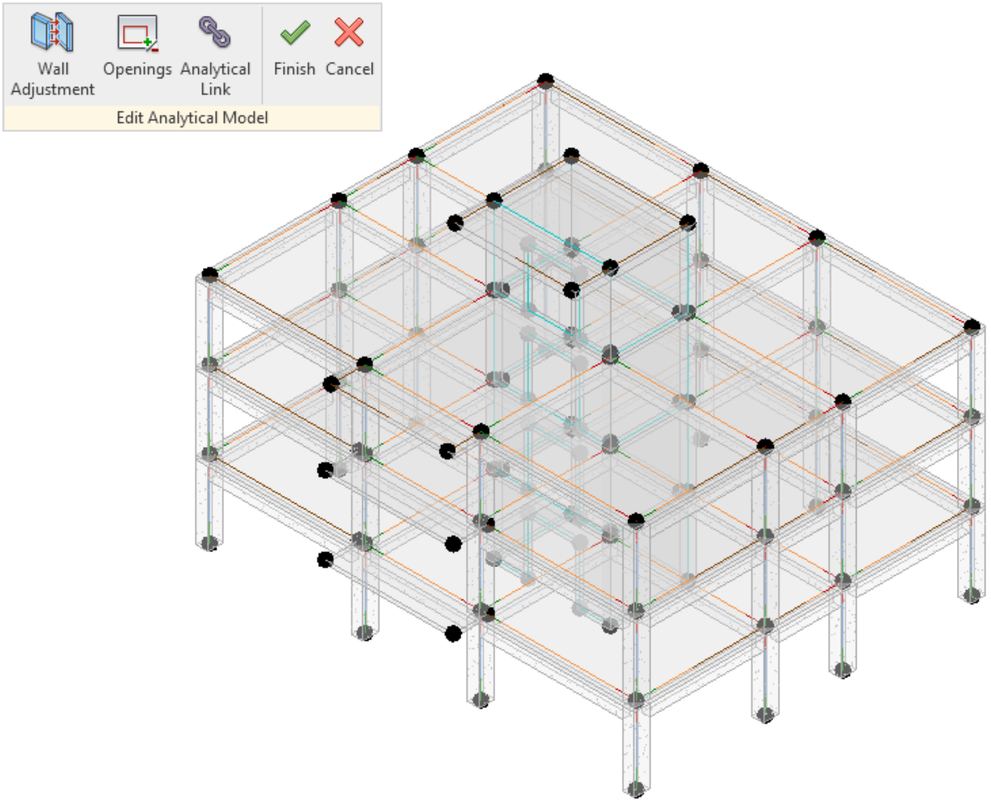
The analytical floor position is now based on the analytical beams placed on its contour.

18. Repeat the operation for all the analytical floors

Exercise 3 | Auto-detect Adjustments

19. Finish the analytical editing.

The auto-detect tools adjusted the analytical representation position and now controls the physical-analytical relationship.

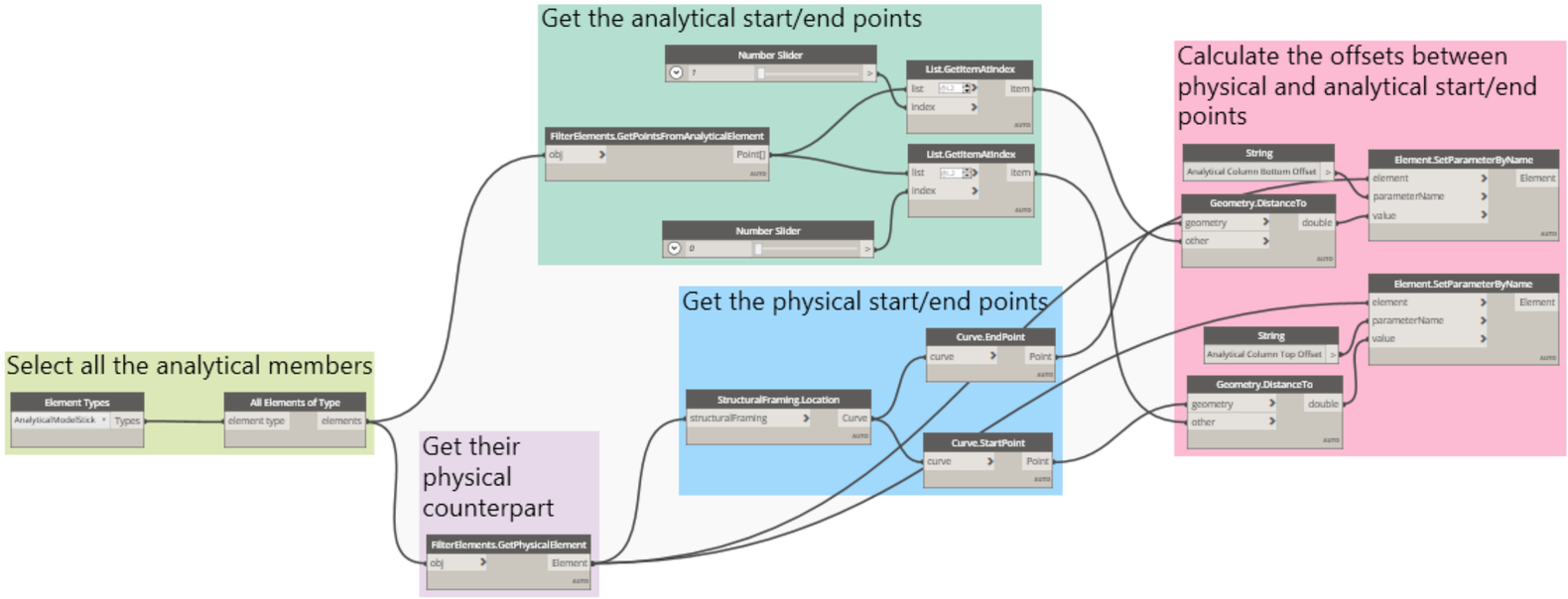


Dynamo in Physical-Analytical Relationship

Dynamo in Physical-Analytical Relationship

- Check the analytical model assumptions using Dynamo

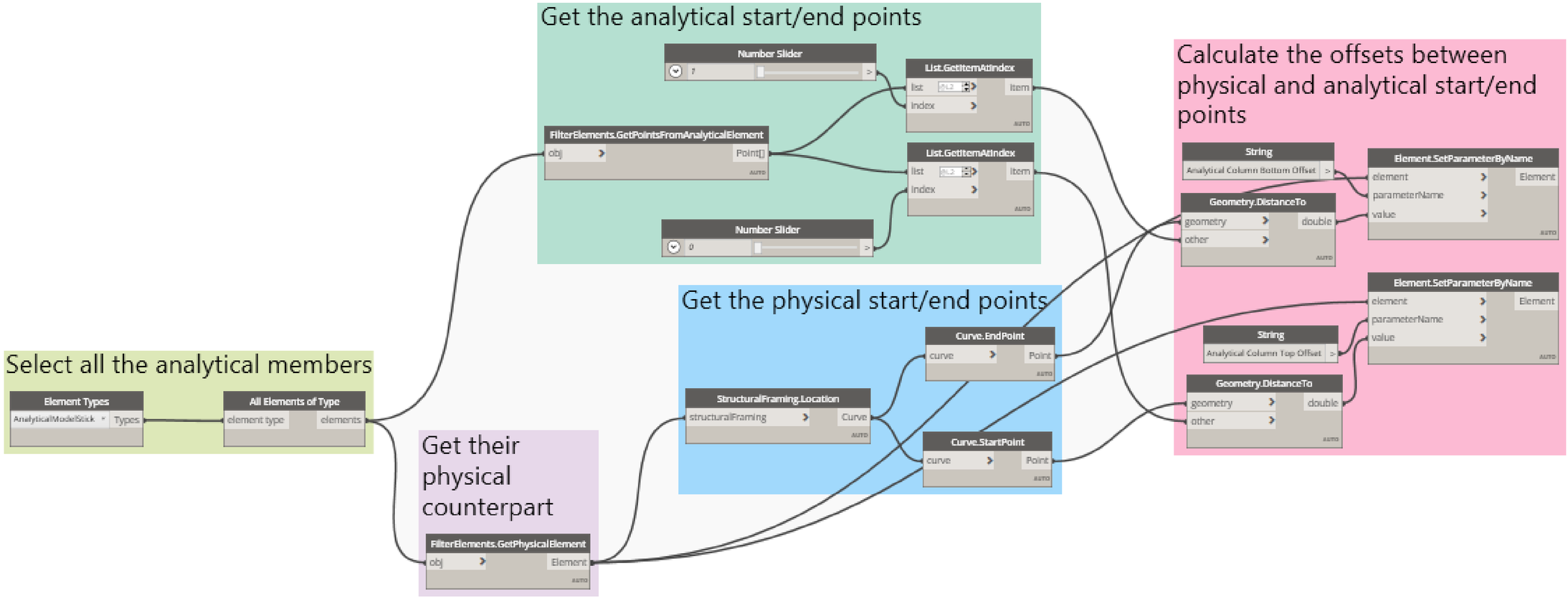
- Maintain analytical model connectivity using Dynamo



Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

In this exercise, we'll learn how to easily identify the differences between the position of the physical elements and their analytical counterparts .

Dynamo Package used: Physical-Analytical Offset


Select all the analytical members
Element Types
AnalyticalModelStick
Types
All Elements of Type
element type
elements
Get the analytical start/end points
Number Slider
7
List.GetItemAtIndex
list
index
item
FilterElements.GetPointsFromAnalyticalElement
obj
Point[]
List.GetItemAtIndex
list
index
item
Number Slider
0
Get the physical start/end points
Curve.EndPoint
curve
Point
StructuralFraming.Location
structuralFraming
Curve
Curve.StartPoint
curve
Point
Get their physical counterpart
FilterElements.GetPhysicalElement
obj
Element
Calculate the offsets between physical and analytical start/end points
String
Analytical Column Bottom Offset
Geometry.DistanceTo
geometry
other
double
Element.SetParameterByName
element
parameterName
value
Element
String
Analytical Column Top Offset
Geometry.DistanceTo
geometry
other
double
Element.SetParameterByName
element
parameterName
value
Element

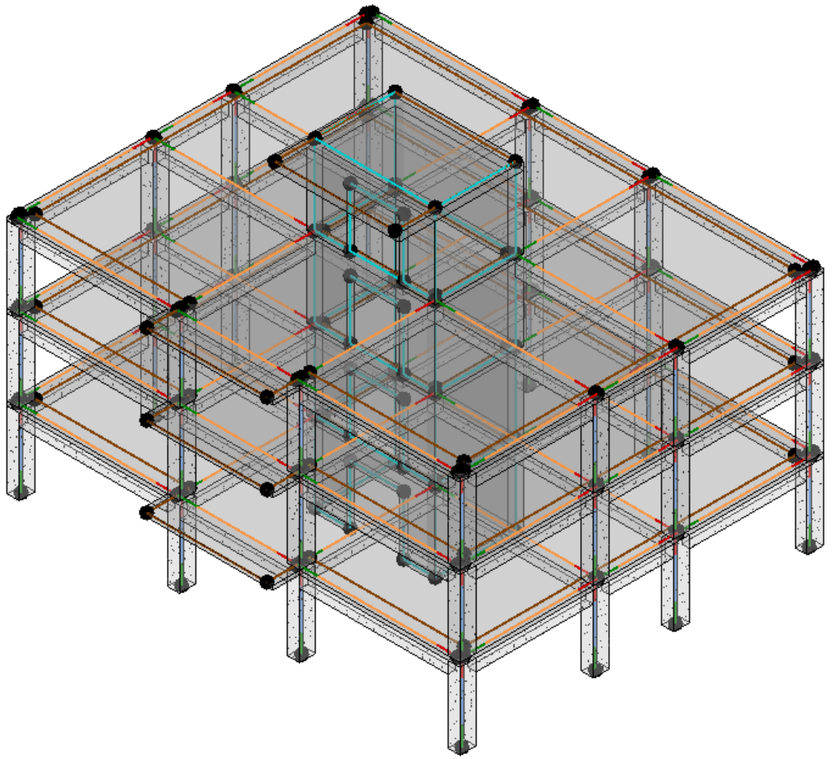
Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

Environment

1. Open Model_001_StartPoint.rvt
2. Open Analytical Model 3D view
3. Enable Analytical Model Visibility

Most of the analytical beam, columns and floors are not connected.

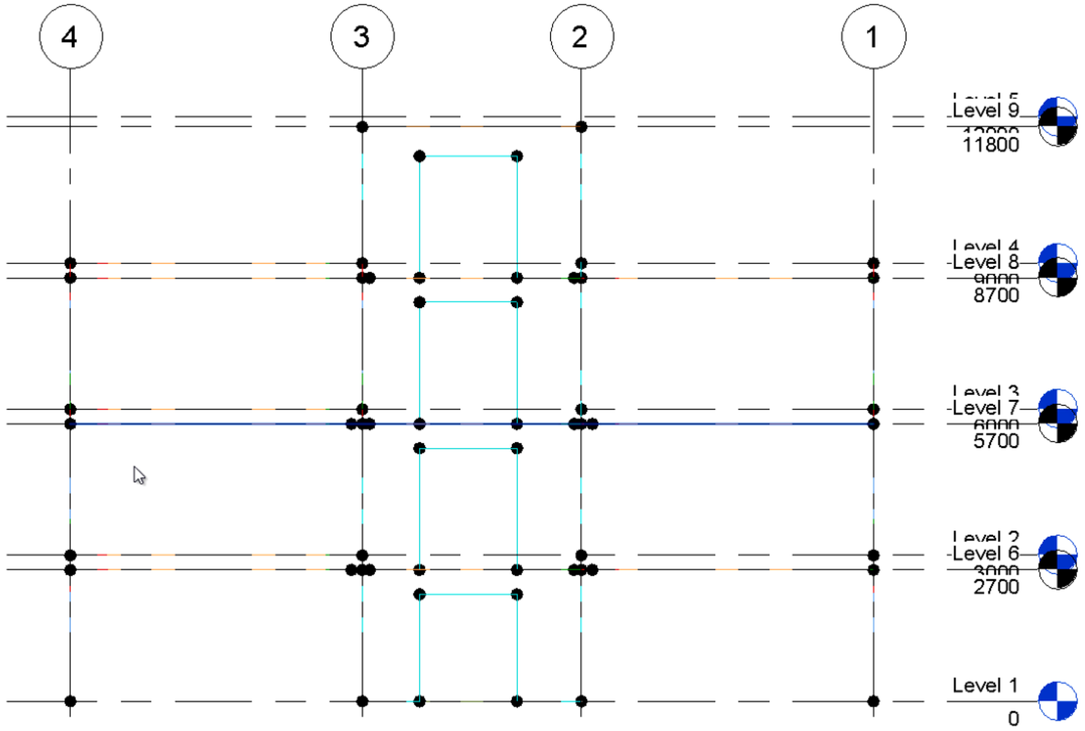
The goal of this exercise is to identify the offsets between linear physical elements and their analytical counterparts.



Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

Analytical Projection

4. For each Level create a copy 300mm bellow it
5. Adjust the Analytical Floors position using Projection settings on dedicated analytical levels
   - Select each analytical floor
   - Go to properties palette > Analytical Alignment group of parameters
   - Change Alignment method to Projection
   - Select the correspondent analytical level for each analytical floor

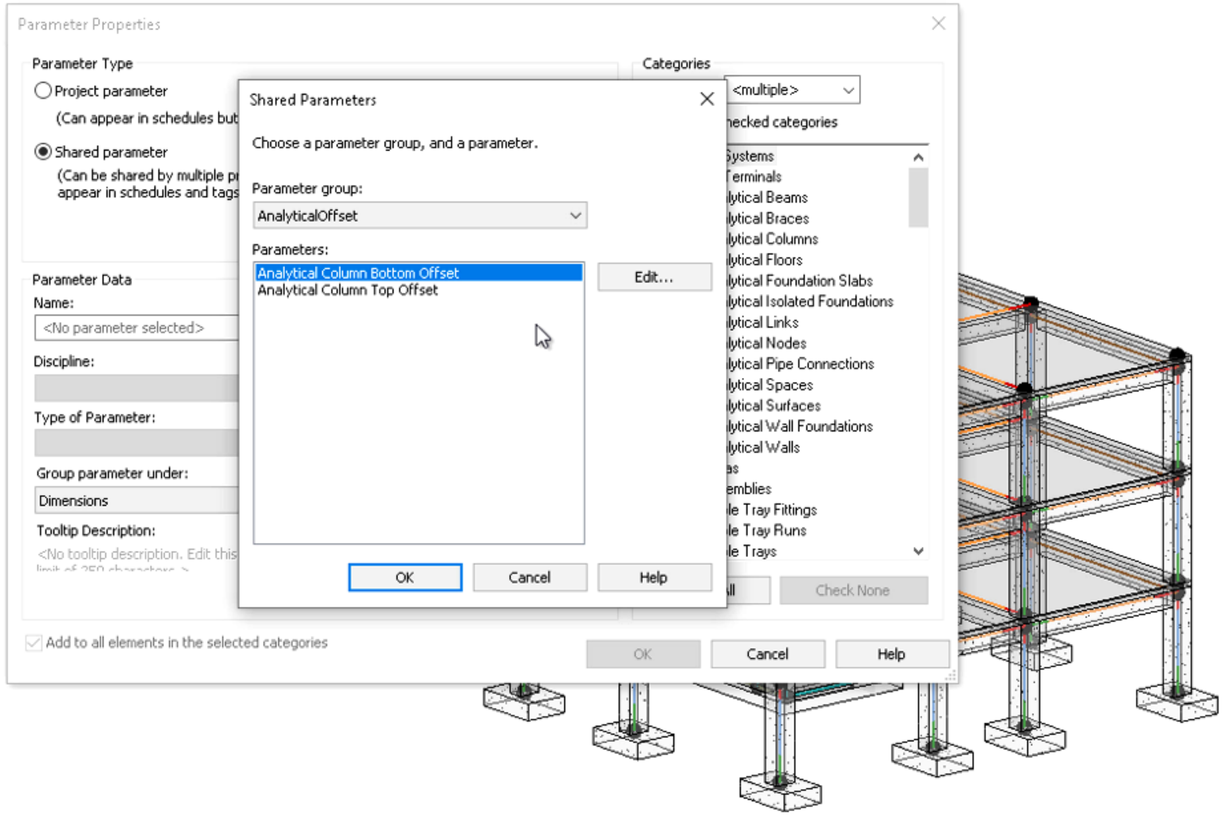


Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

Define the support parameters for the offset information

6. Setup specific parameters to mark the offset between the physical elements and their analytical counterparts.

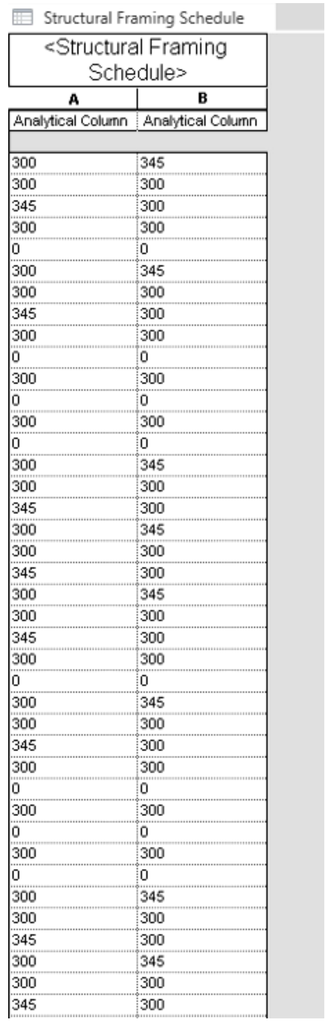
- Go To Manage tab > Settings panel > Shared Parameters
- Create two shared parameters of type length – Analytical Column Bottom Offset and Analytical Column Top Offset
- Go to Manage tab > Setting panel > Project Parameters
- Click on Add button to add a new project parameter
- Choose Shared Parameter option > Select Analytical Column Bottom Offset
- Group parameter under Analytical Alignment group of parameters
- Check Instance option (we need this parameter to be instance based one)
- Check Analytical Beam and Analytical Column categories



Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

Create support for offset observation

7. Go to View tab > Create panel > create Schedule/Quantities
8. Select Analytical Beam category
9. OK
10. Add Analytical Column Bottom Offset and Analytical Column Top Offset parameters for this schedule
11. OK



Structural Framing Schedule

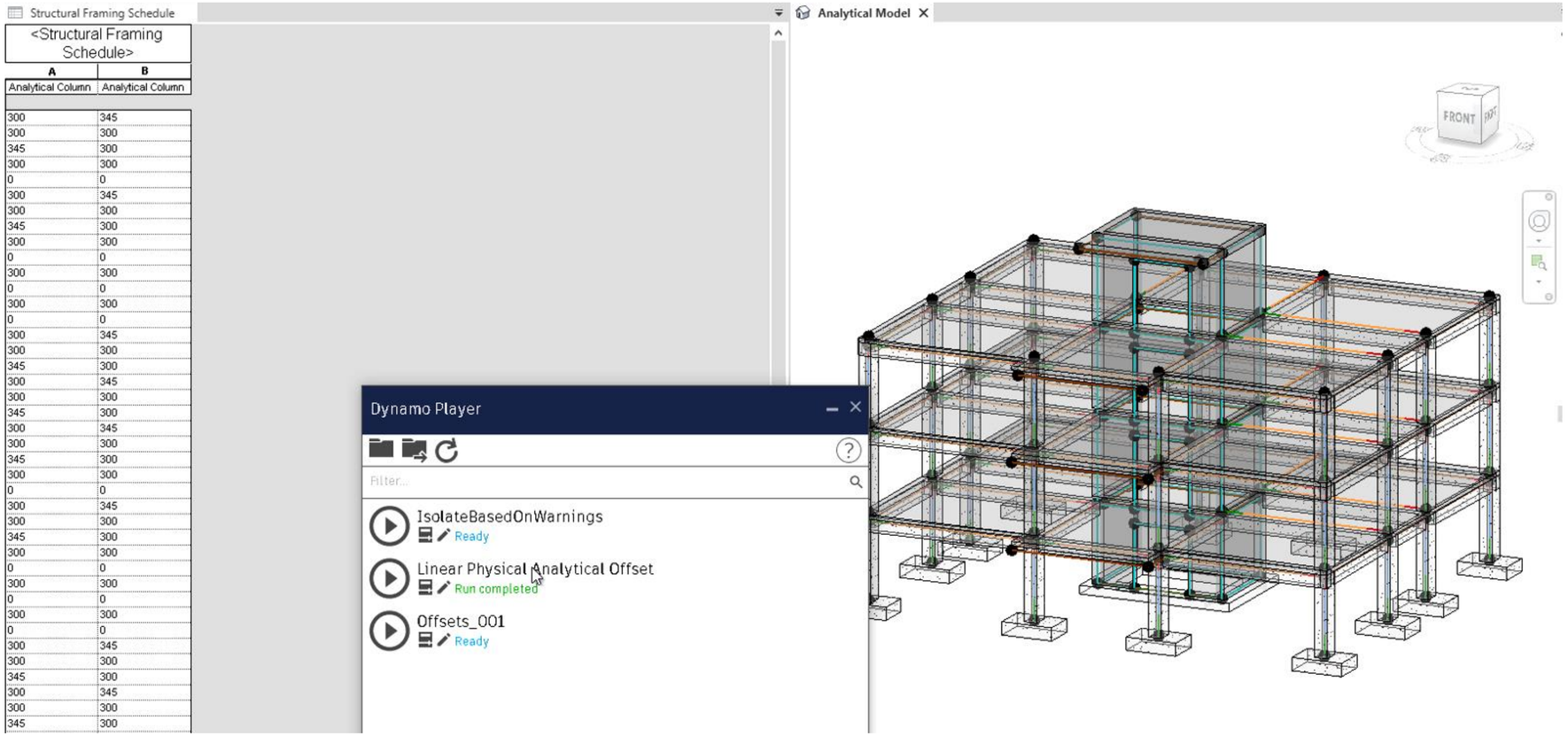
<Structural Framing Schedule>

A	B
Analytical Column	Analytical Column
300	345
300	300
345	300
300	300
0	0
300	345
300	300
345	300
300	300
0	0
300	300
0	0
300	300
0	0
300	345
300	300
345	300
300	345
300	300
345	300
300	345
300	300
345	300
300	300
0	0
300	345
300	300
345	300
300	300
0	0
300	300
0	0
300	300
0	0
300	345
300	300
345	300
300	345
300	300
345	300

Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

Calculate physical-analytical offset

12. Run Linear Physical Analytical Offset Dynamo script



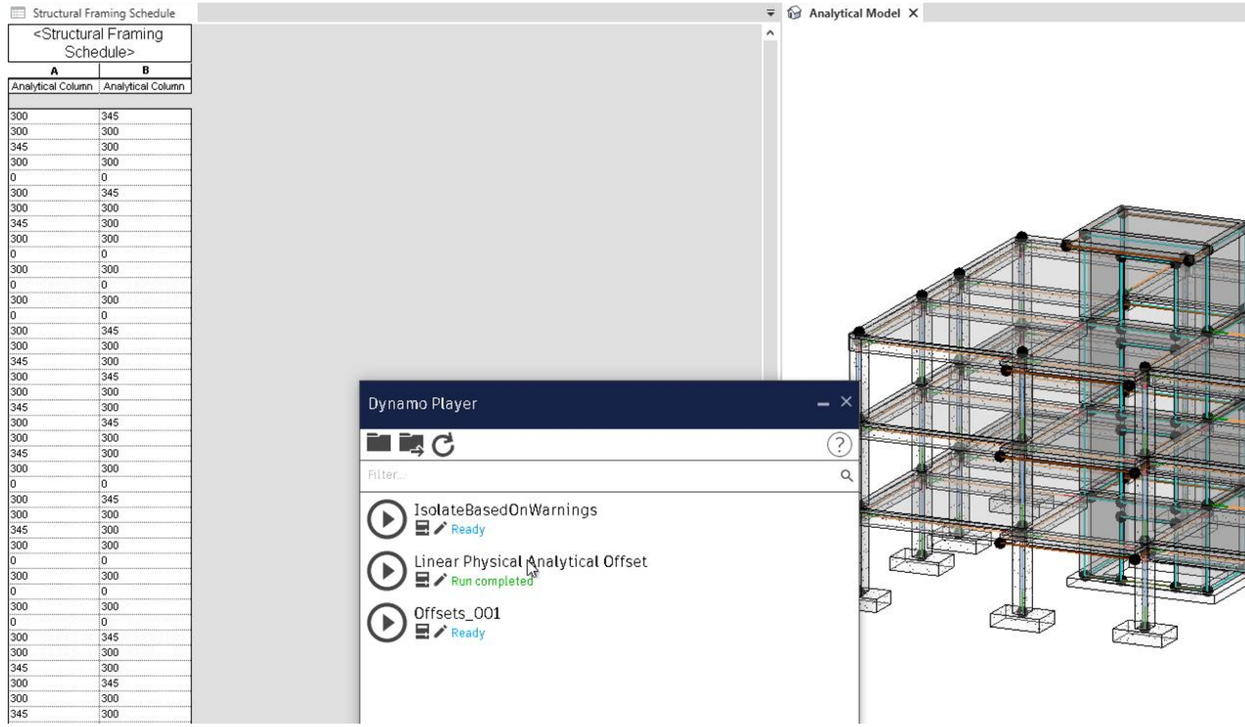
Exercise 4.1 | Check the Differences Between Physical and Analytical Representation for Linear Elements

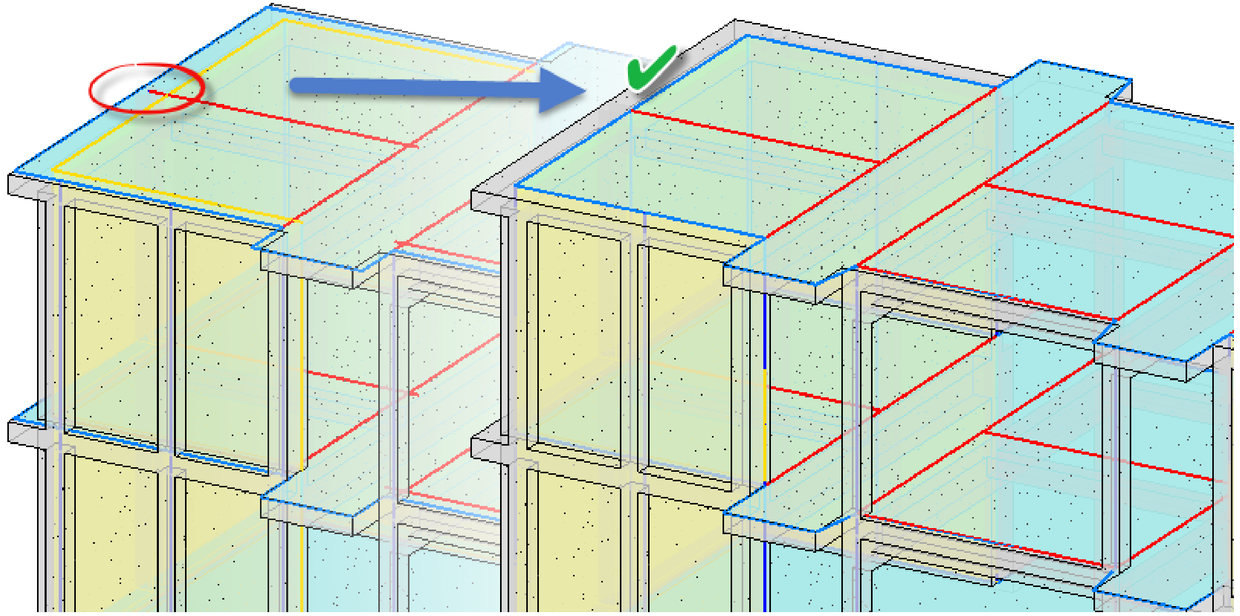
Analyze the results

The script calculates the offset between physical and analytical representation for linear elements for each end.

In this regard, a tolerance can be set in the form of a schedule filter. This will allow a quick filter of the cases that exceed an acceptable value.

The script run on-demand. The parameters are not updated automatically.





Exercise 4.2 | Maintain analytical model connectivity using Dynamo

In this exercise, we'll learn how to adjust the analytical model using Dynamo with parameterization, definition of logical assumptions, priorities and customizable scripting.

Dynamo Package used: Analytical Modeling 2021 Dynamo Package

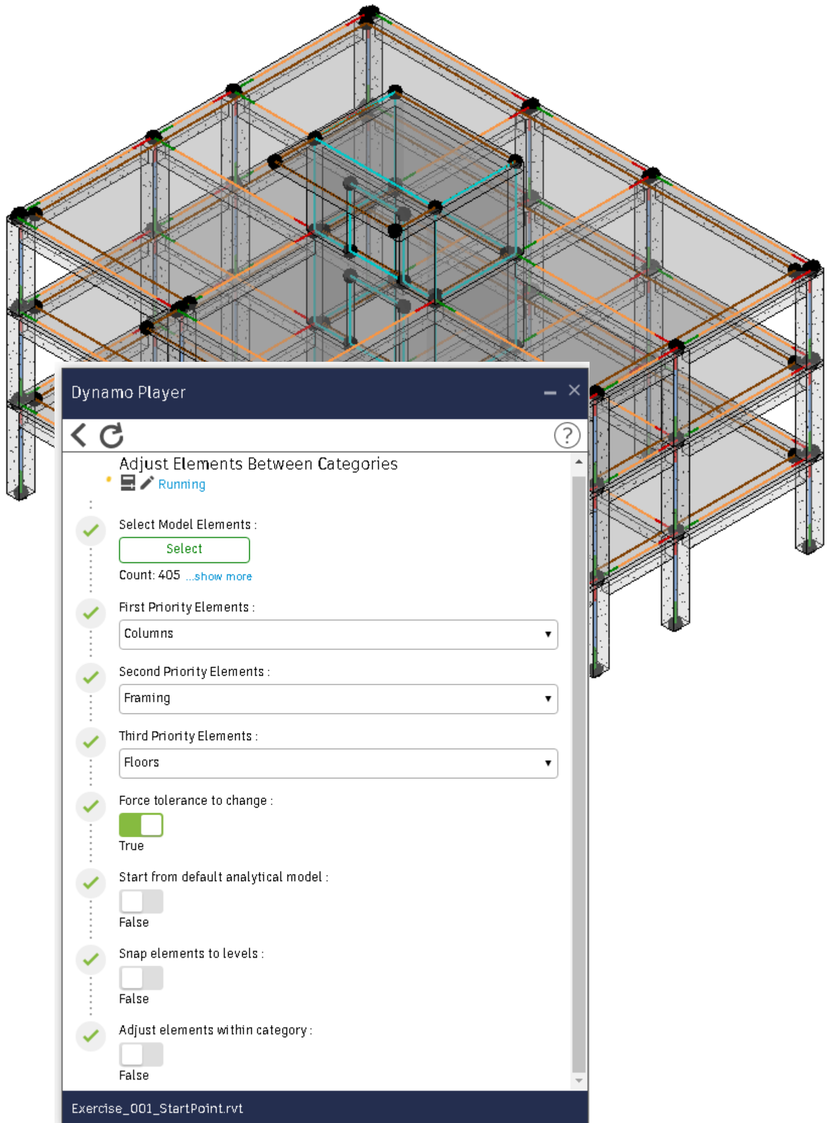
Exercise 4.2 | Maintain analytical model connectivity using Dynamo

Environment

1. Open Model_001_StartPoint.rvt
2. Open Analytical Model 3D view
3. Enable Analytical Model Visibility
4. Open Dynamo Player
5. Load Adjust Elements Between Categories Dynamo script

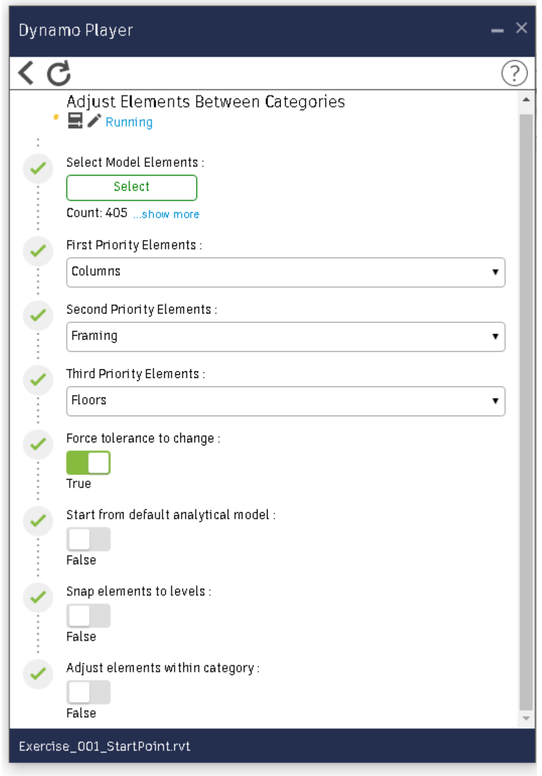
Most of the analytical beam, columns and floors are not connected.

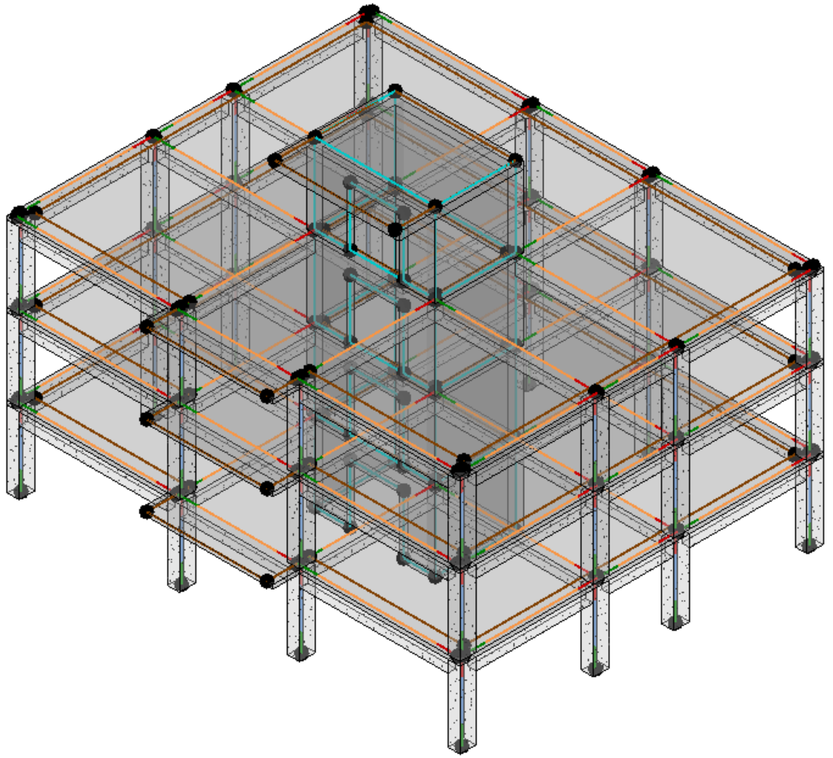
The goal of this exercise is to adjust the analytical model using Dynamo.



Exercise 4.2 | Maintain analytical model connectivity using Dynamo

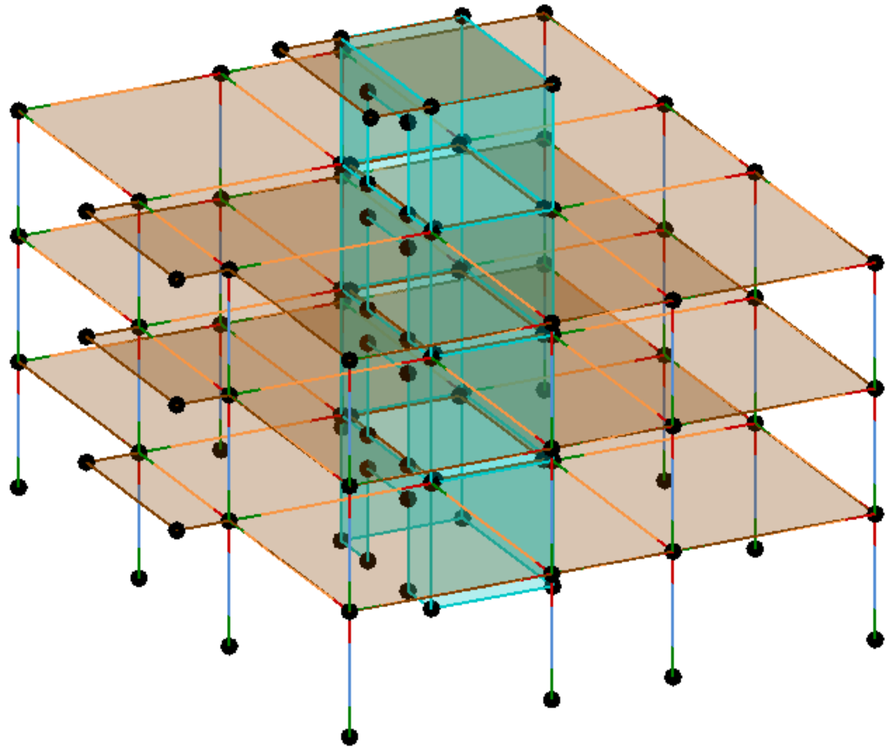
Setup script's parameters based on the project needs





Exercise 4.2 | Maintain analytical model connectivity using Dynamo

Adjust the analytical model using Dynamo with parameterization

The analytical elements of type column, beam and floors were analyzed, and their position was adjusted within the defined tolerance, in the order specified in the script settings – the beams are adjusted based on the column position and the floors based on the beam position.

For all the analytical elements, the analytical alignment method for each end/edge is now Manually Adjusted.