

Design Automation for Structural Engineers

Tomasz Fudala, MSc in Structural Engineering

Technical Marketing Manager at Autodesk | @TomekF



About the speaker

Tomasz Fudala

He has over 17 years of experience in the software industry and a comprehensive background and vast knowledge of structural solutions in the Autodesk portfolio. He achieved a Master of Science degree in Structural Engineering from the Cracow University of Technology, Poland.

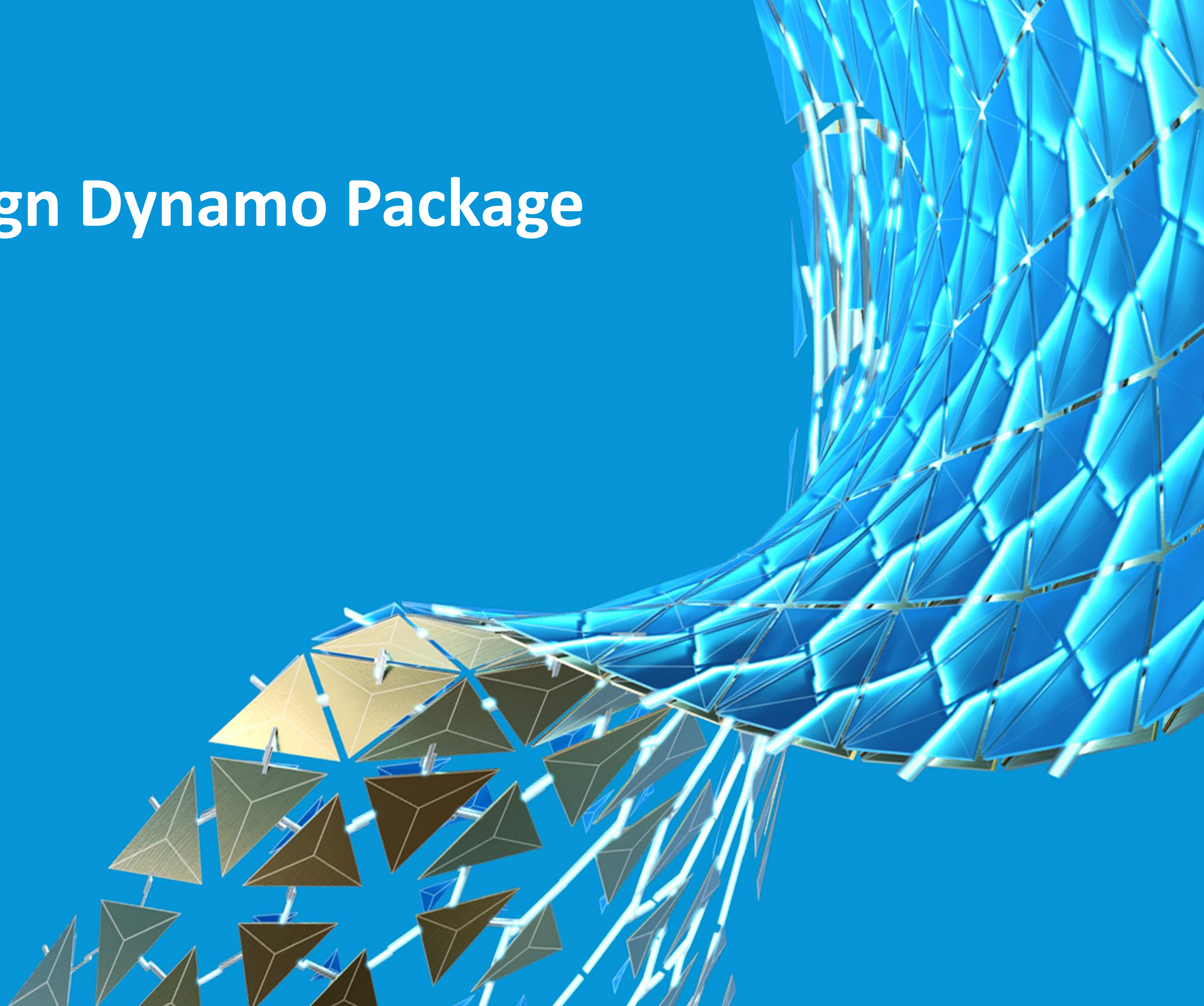
Agenda

Design Automation for Structural Engineering

- Structural Design Dynamo Package
- Structural Analysis for Dynamo Package
- Autodesk Analytical Model Dynamo Package
- Autodesk Steel Connections Dynamo Package



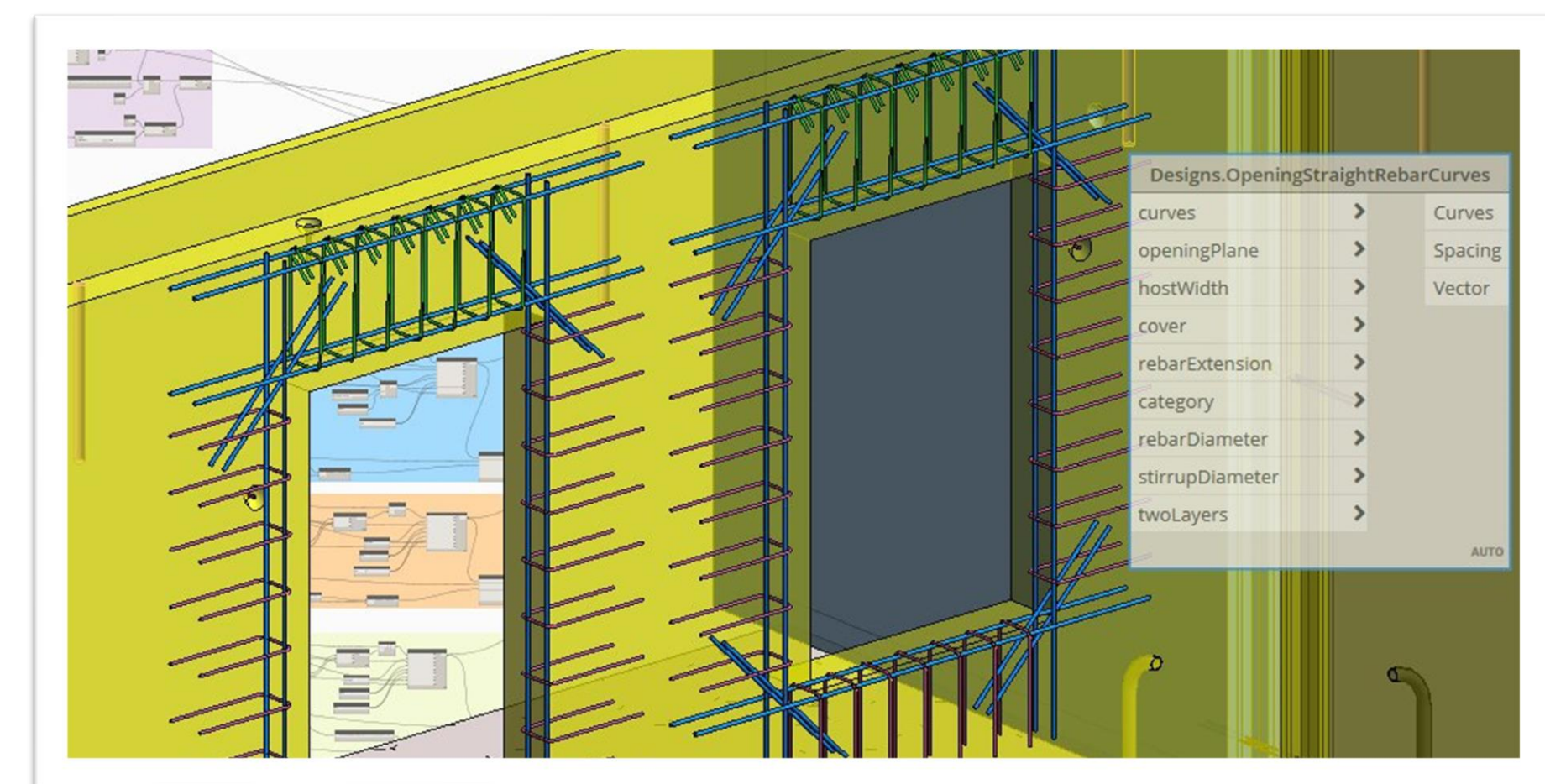
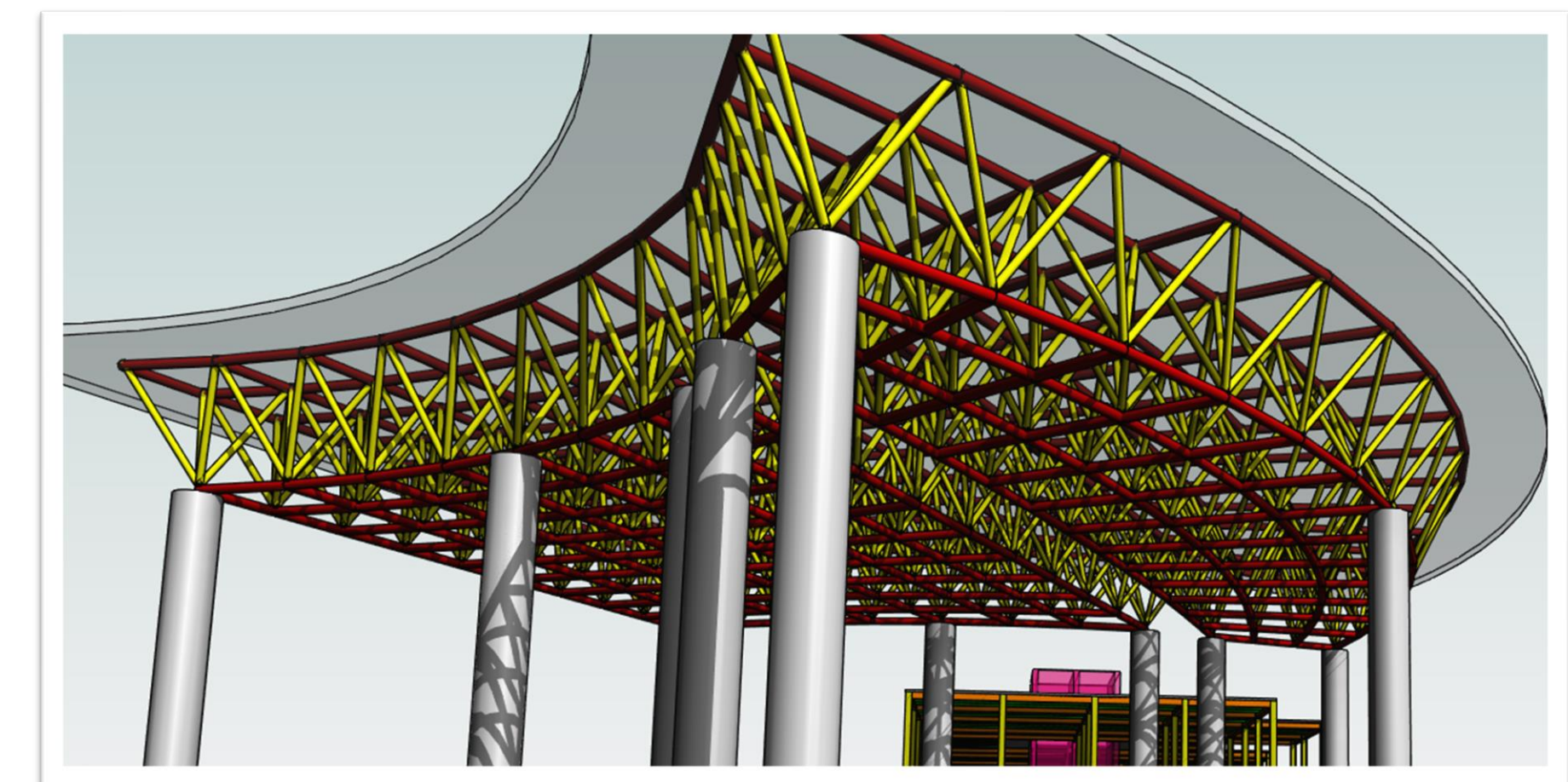
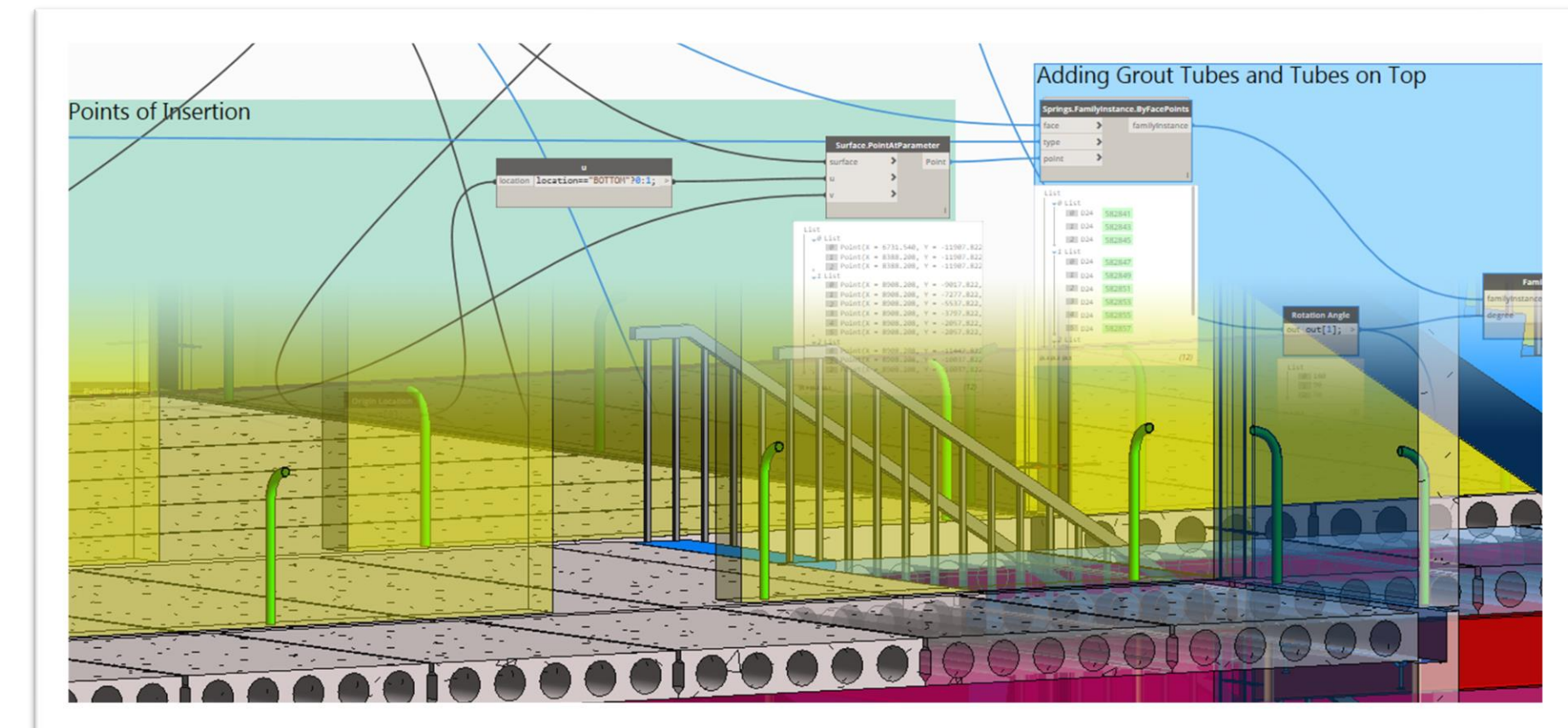
Structural Design Dynamo Package



Overview

Structural Design Dynamo Package

- Supports various structural workflows in Dynamo and Revit
- Nodes are shared with example scripts to automate workflows
- Cross-industry nodes
- Compatible with Dynamo 2.6
- 70 nodes and the number is growing...



Selection

Structural Design Dynamo Package

- **Selection Nodes**
 - 6 nodes to enhance default Dynamo selection of Revit model elements
 - Filter selection by categories
 - Different types of selection
 - Pick Element,
 - Pick Elements by Rectangle
 - Pick Faces

| Selection.ActiveSelectionOfCategory | | |
|-------------------------------------|---|----------|
| category | > | Elements |
| refresh | > | |
| AUTO | | |

| Selection.PickElements | | |
|------------------------|---|----------|
| statusPrompt | > | Elements |
| refresh | > | |
| AUTO | | |

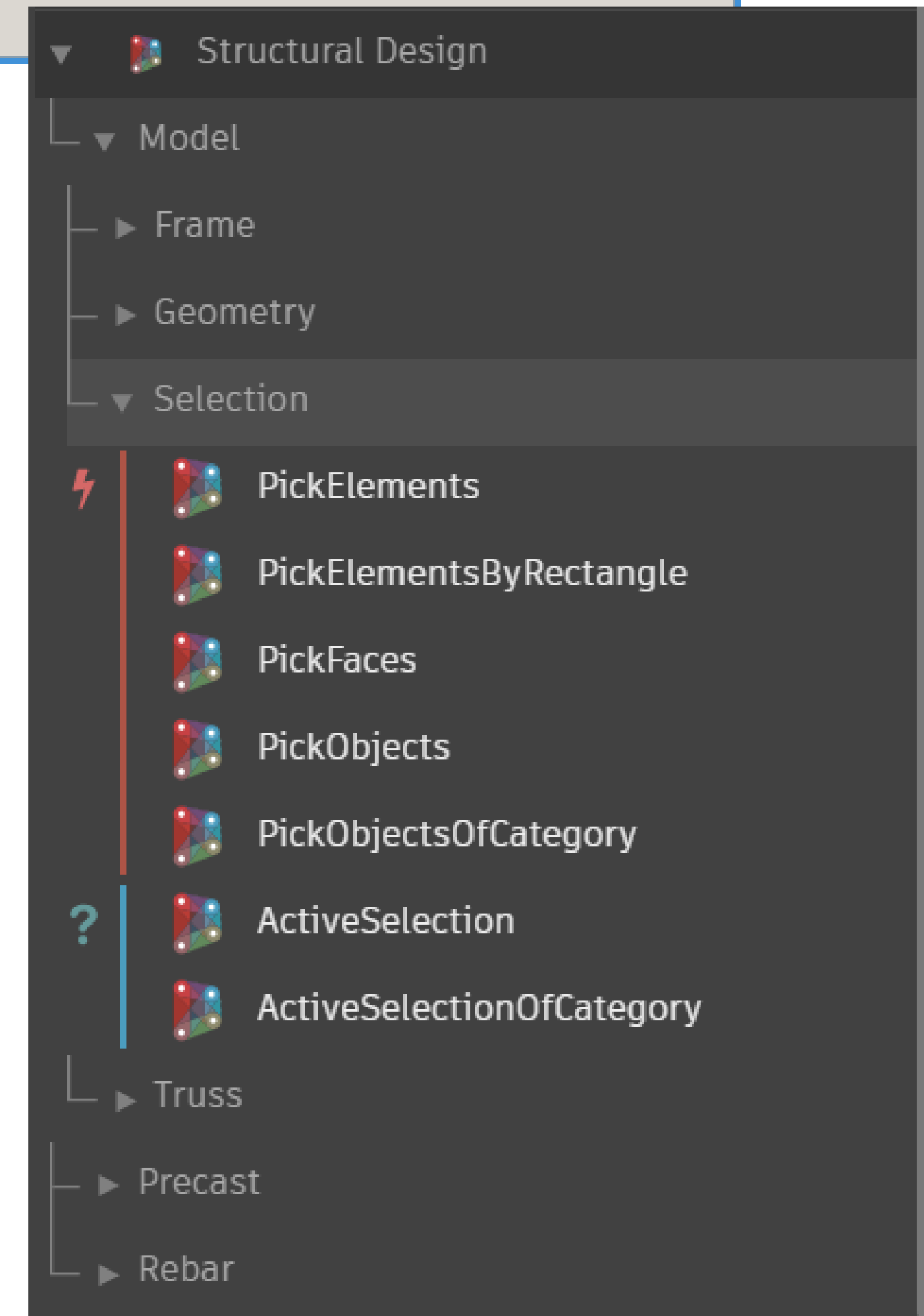
| Selection.PickElementsByRectangle | | |
|-----------------------------------|---|-----------|
| refresh | > | Element[] |
| AUTO | | |

| Selection.PickFaces | | |
|---------------------|---|-------|
| statusPrompt | > | Faces |
| refresh | > | |
| AUTO | | |

| Selection.PickObjects | | |
|-----------------------|---|----------|
| objectType | > | Elements |
| statusPrompt | > | |
| refresh | > | |
| AUTO | | |

| Selection.ActiveSelection | | |
|---------------------------|---|----------|
| refresh | > | Elements |
| AUTO | | |

| Selection.PickObjectsOfCategory | | |
|---------------------------------|---|----------|
| category | > | Elements |
| objectType | > | |
| statusPrompt | > | |
| preselection | > | |
| refresh | > | |
| ★ | | |

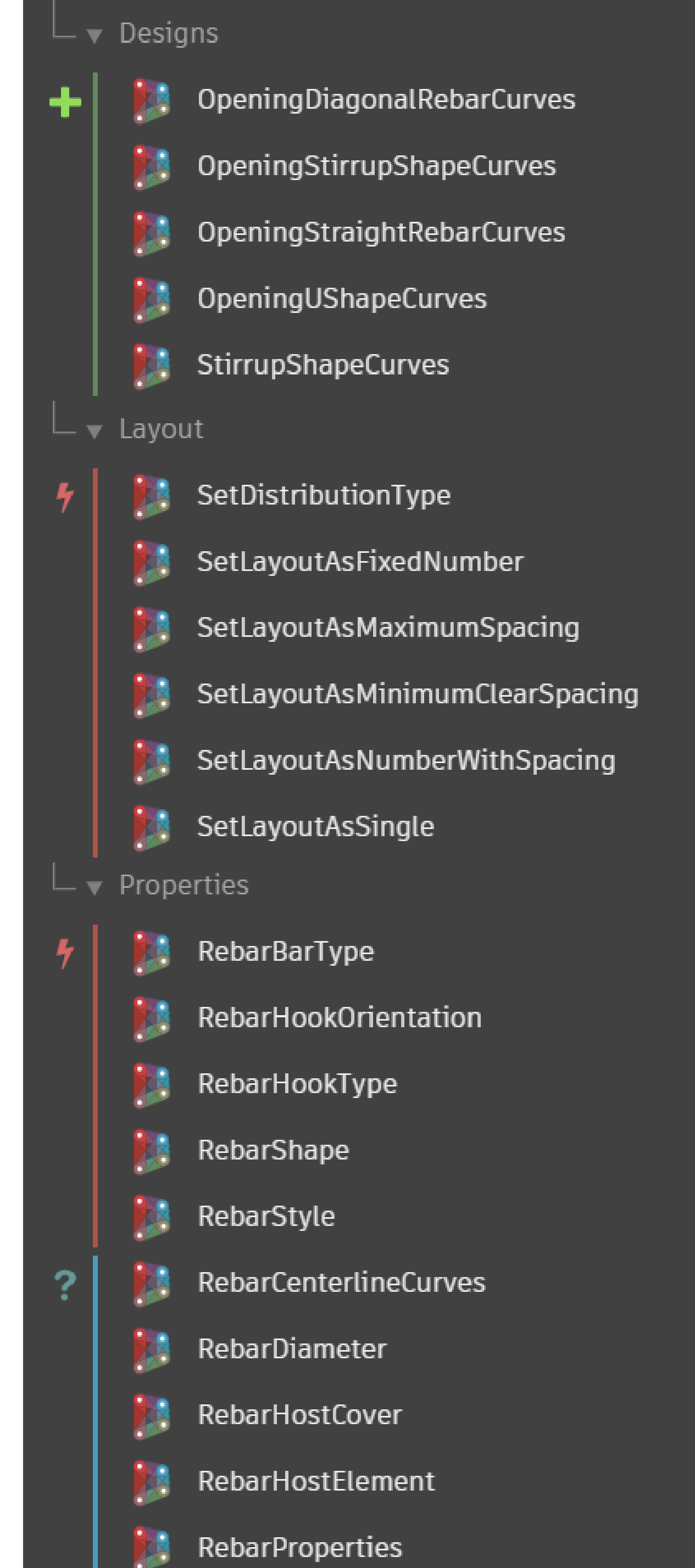
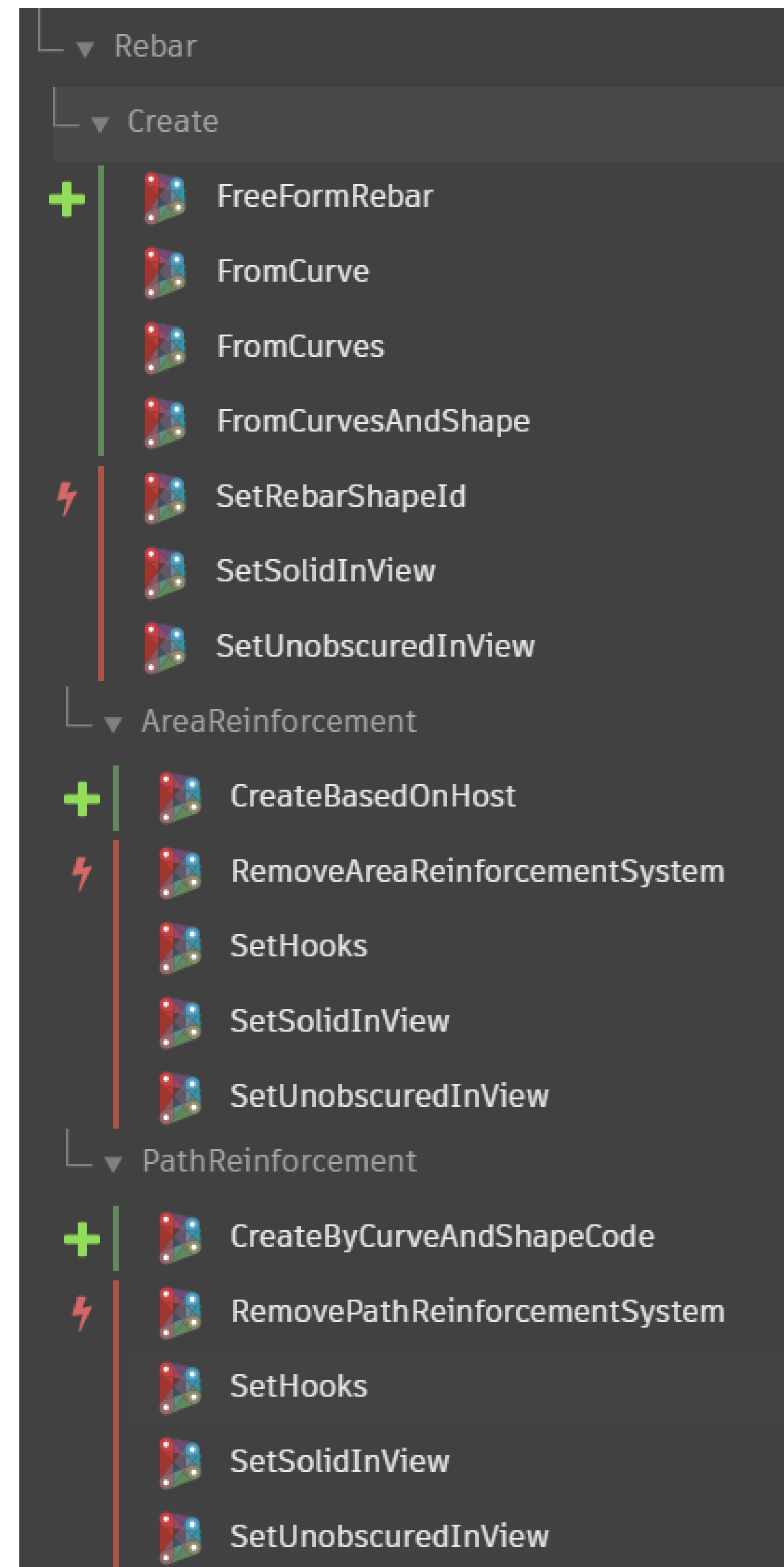
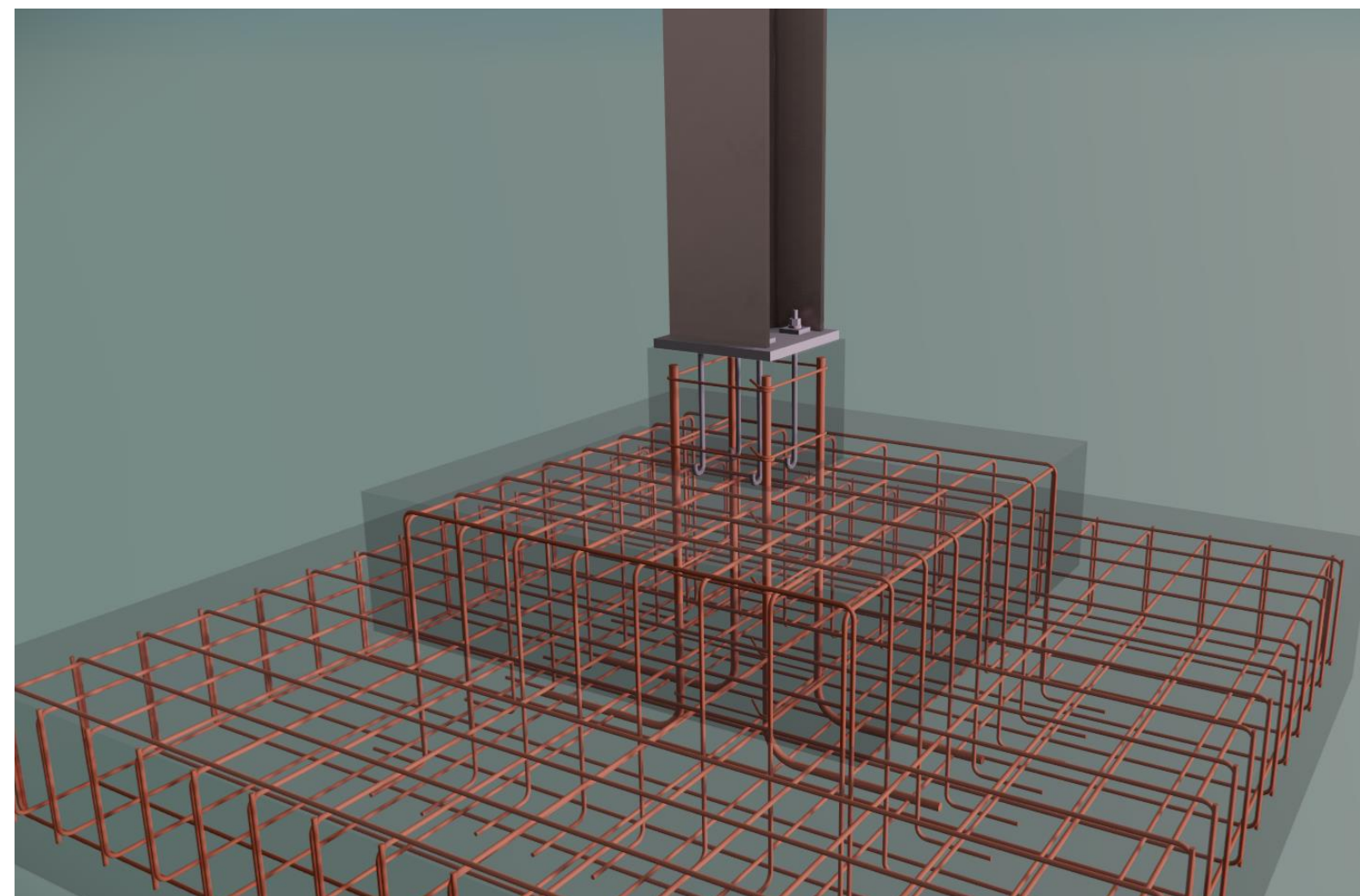


Concrete Detailing

Structural Design Dynamo Package

- **Rebar Nodes**

- 53 nodes to automate rebar detailing
- Area & Path reinforcement
- Fabric Sheet reinforcement
- Typical Rebar Designs
- Rebar Visibility Control



Concrete Detailing

Structural Design Dynamo Package

NEW

- NEW Nodes

| Properties.SetHookRotationAngle | | |
|---------------------------------|---|-------|
| rebar | > | Rebar |
| hookRotationAngle | > | |
| rebarEnd | > | |
| | | AUTO |

| Properties.GetHookRotationAngle | | |
|---------------------------------|---|-------|
| rebar | > | Angle |
| rebarEnd | > | |
| | | AUTO |

| Properties.SetEndTreatment | | |
|----------------------------|---|-------|
| rebar | > | Rebar |
| endTreatmentType | > | |
| rebarEnd | > | |
| | | AUTO |

| Properties.EnableHookLengthOverride | | |
|-------------------------------------|---|-------|
| rebar | > | Rebar |
| enable | > | |
| | | AUTO |

| Properties.IsHookLengthOverrideEnabled | | |
|--|---|---------|
| rebar | > | Enabled |
| | | AUTO |

| RebarEndTreatmentType | |
|-----------------------|-----------------------|
| Threaded | RebarEndTreatmentType |

| FabricSheetType | |
|-----------------|-----------------|
| A142 | FabricSheetType |

| FabricLocation | |
|------------------|----------------|
| BottomOrInternal | FabricLocation |

| FabricLapSplicePosition | |
|-------------------------|-------------------------|
| Aligned | FabricLapSplicePosition |

| FabricSheet.SetSolidInView | | |
|----------------------------|---|-------------|
| fabricSheet | > | FabricSheet |
| view | > | |
| solid | > | |
| | | AUTO |

| FabricSheet.SetUnobscuredInView | | |
|---------------------------------|---|-------------|
| fabricSheet | > | FabricSheet |
| view | > | |
| unobscured | > | |
| | | AUTO |

| FabricArea.Create | | |
|-----------------------|---|------------|
| hostElement | > | FabricArea |
| majorDirection | > | |
| fabricSheetType | > | |
| location | > | |
| lapSplicePosition | > | |
| additionalCoverOffset | > | |
| | | AUTO |

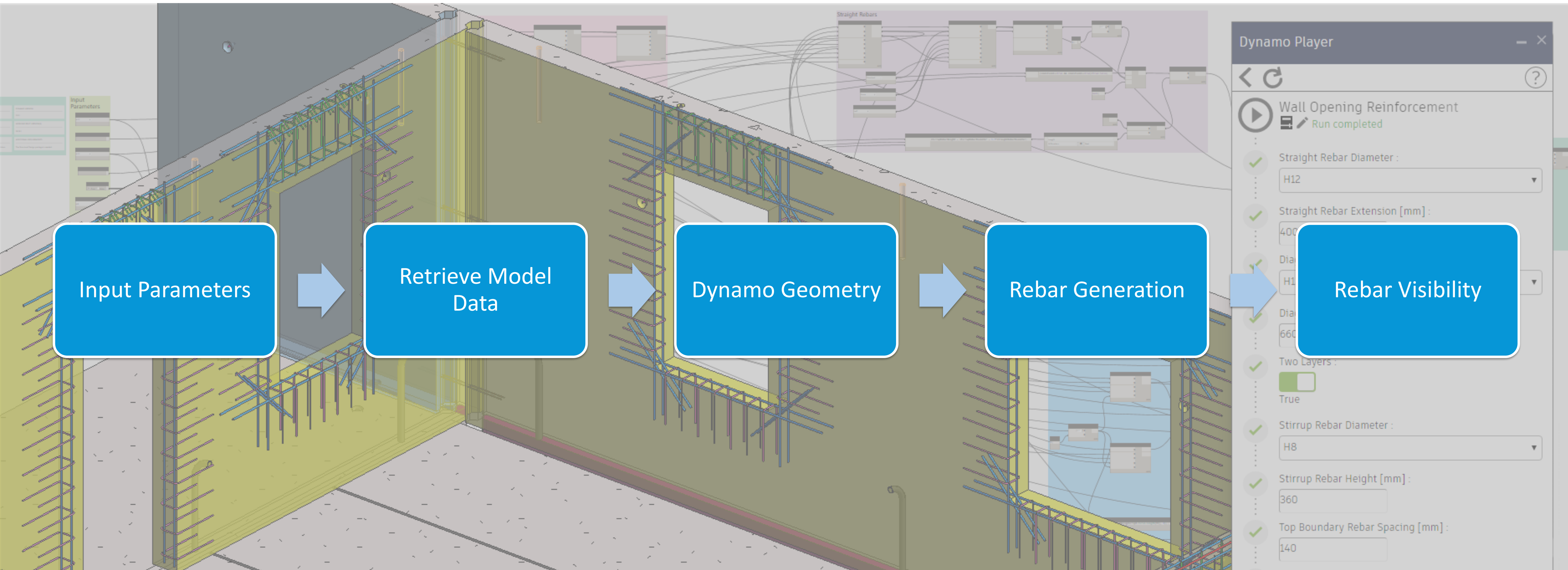
| FabricArea.RemoveFabricReinforcementSystem | | |
|--|---|--------------|
| fabricArea | > | FabricSheets |
| | | AUTO |

| FabricArea.SetSolidInView | | |
|---------------------------|---|------------|
| fabricArea | > | FabricArea |
| view | > | |
| solid | > | |
| | | AUTO |

| FabricArea.SetUnobscuredInView | | |
|--------------------------------|---|------------|
| fabricArea | > | FabricArea |
| view | > | |
| unobscured | > | |
| | | AUTO |

Concrete Detailing: Process

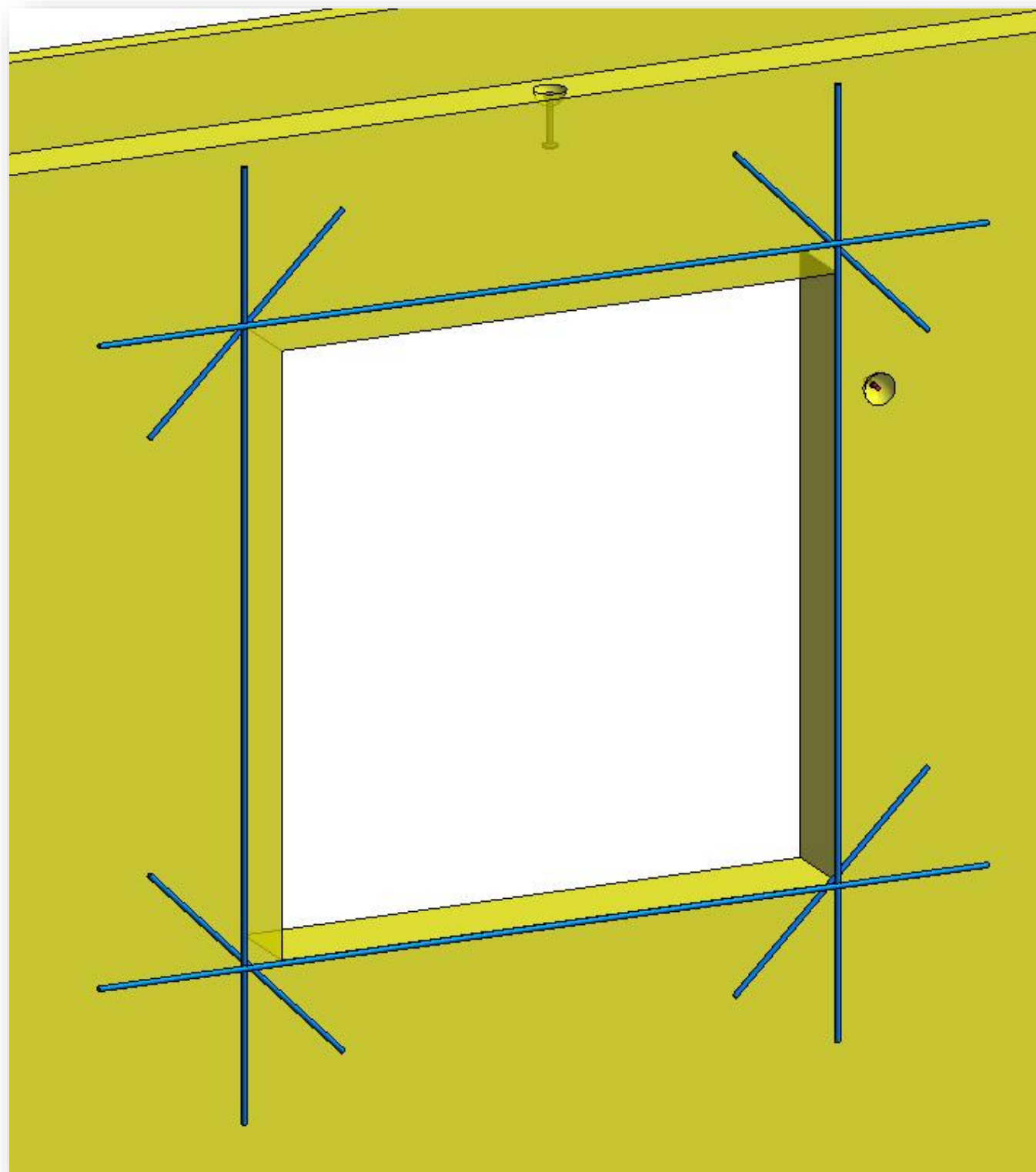
Structural Design Dynamo Package



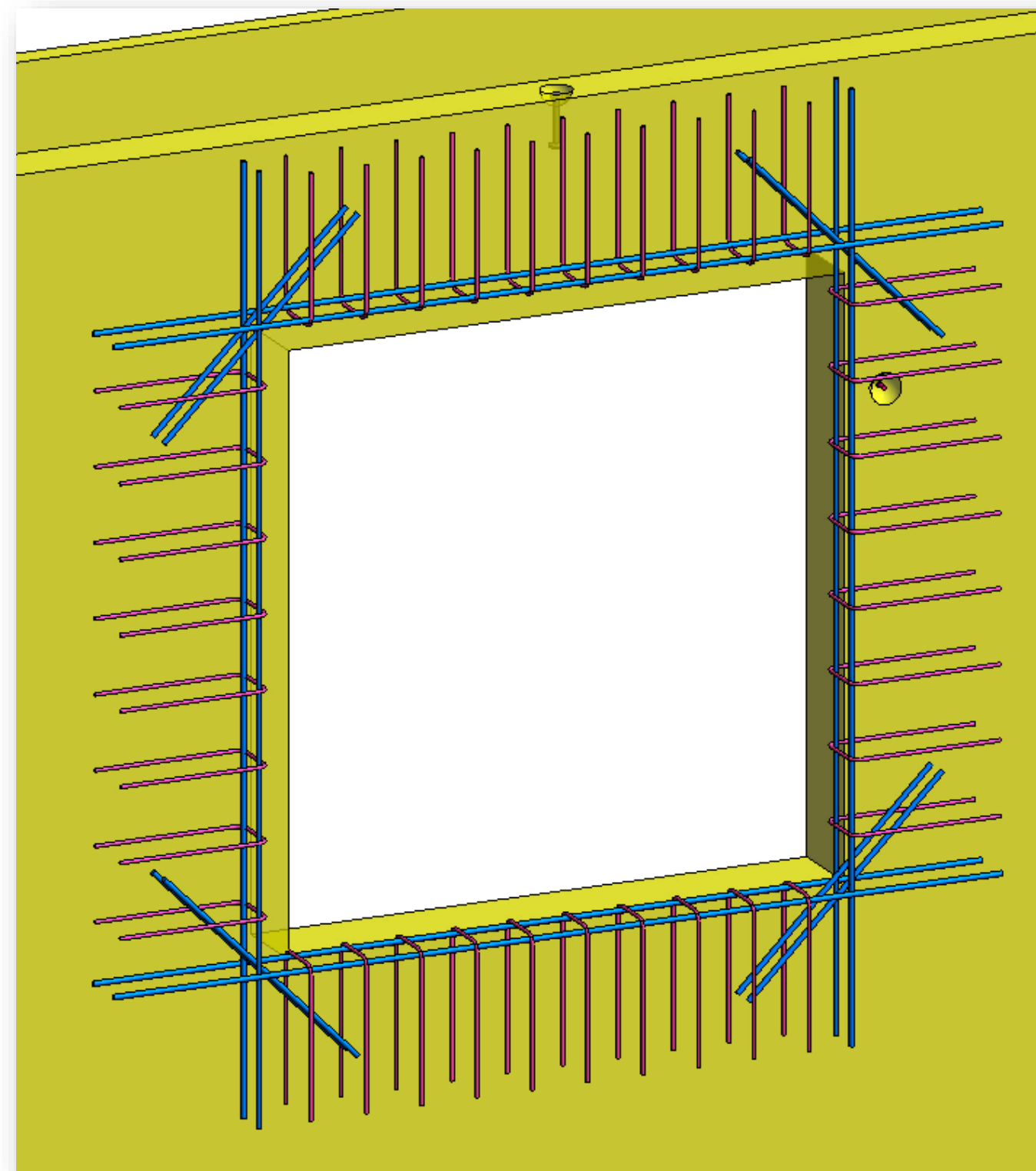
Concrete Detailing

Structural Design Dynamo Package

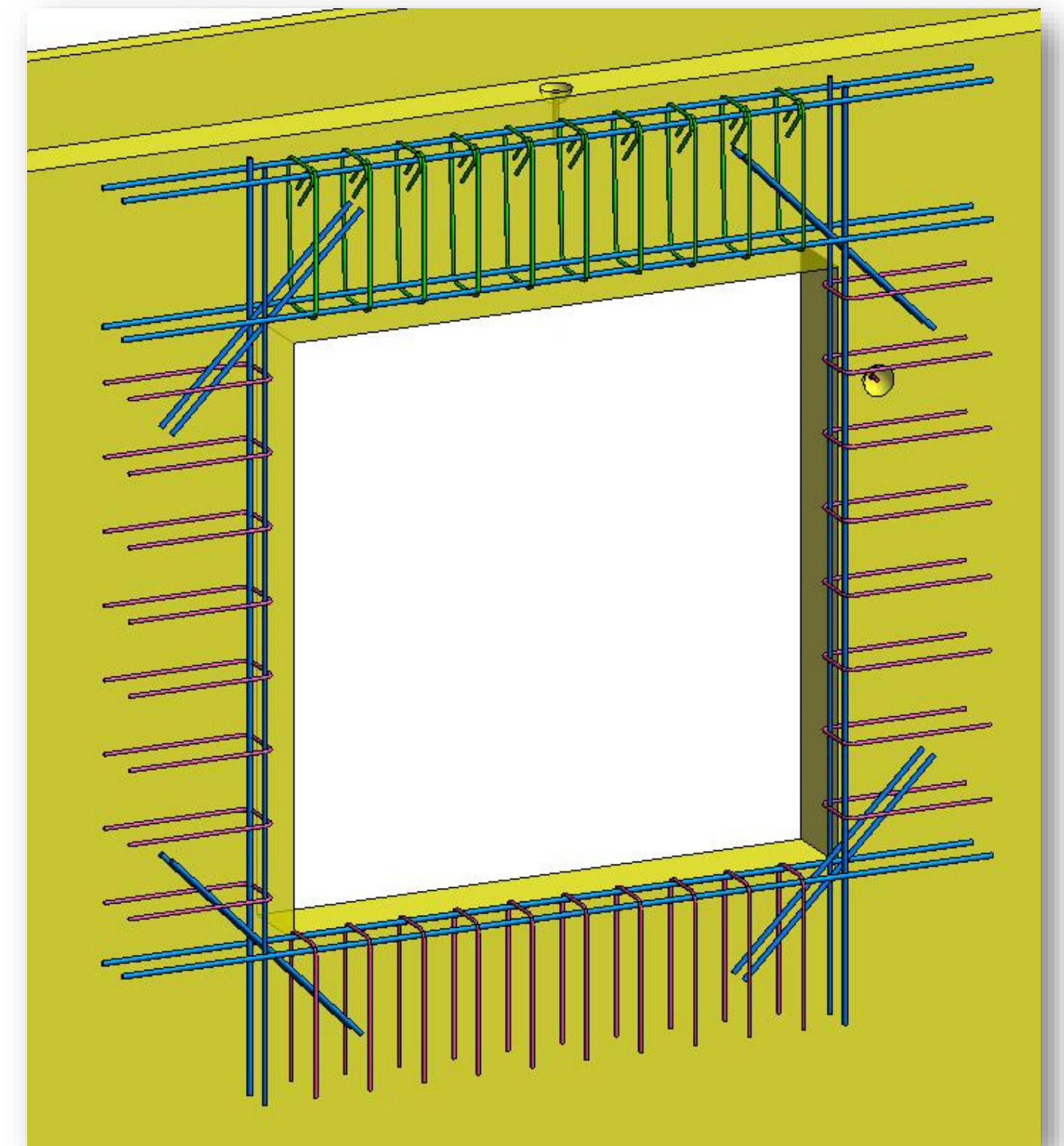
- Automated process of reinforcement detailing around wall openings



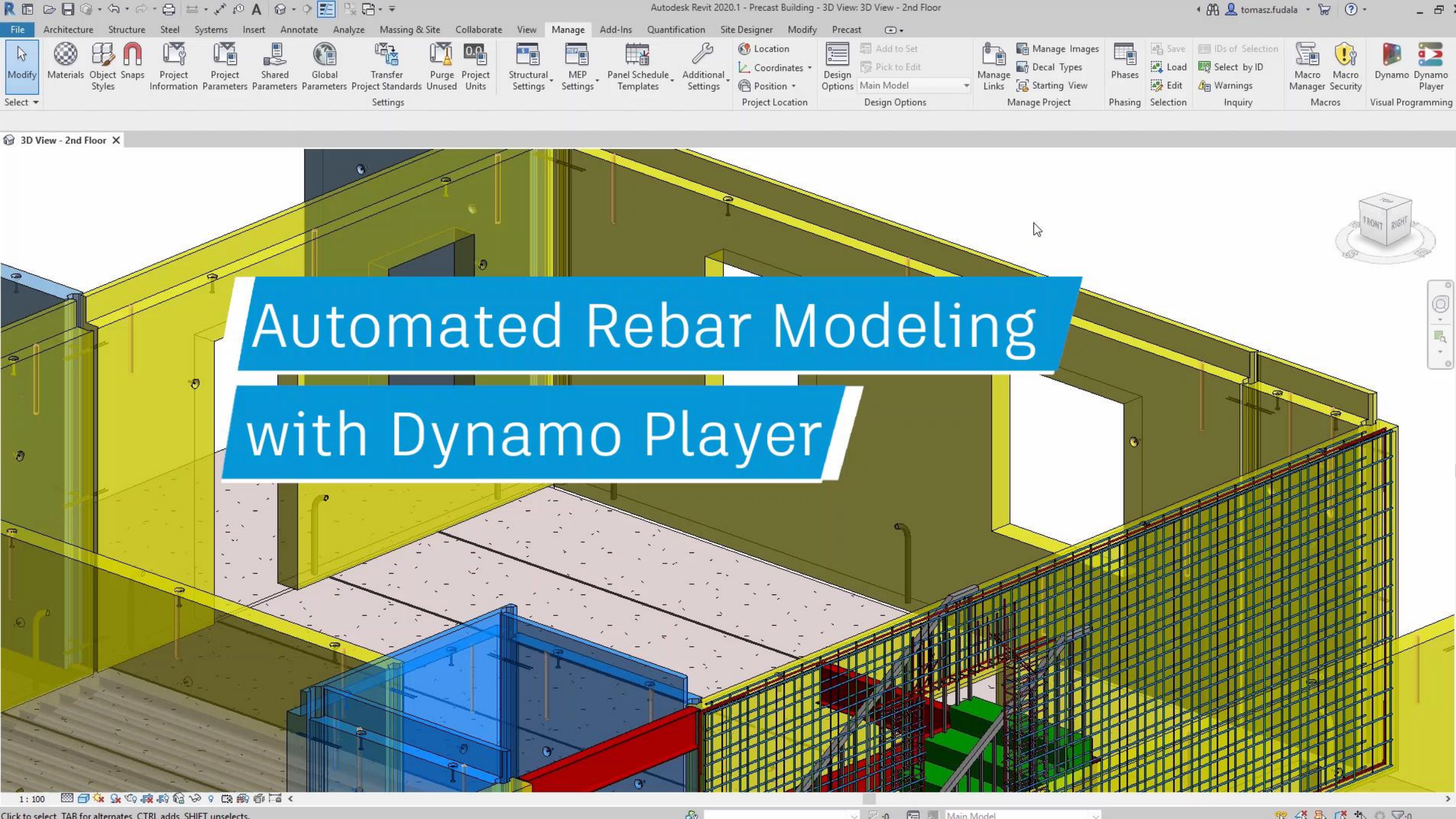
One Layer



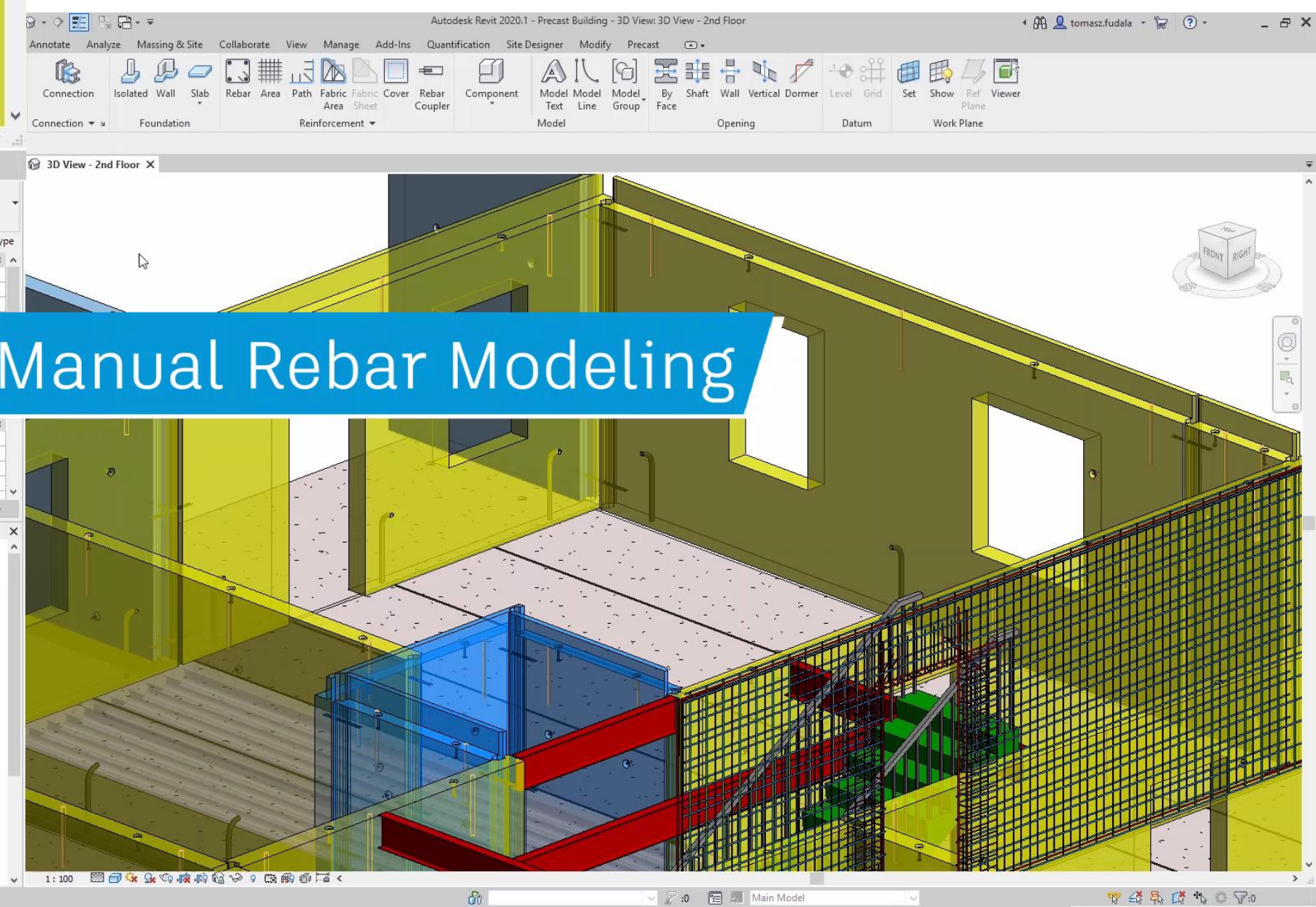
Two Layers &
Top Stirrups with U-shape



Two Layers &
Top Stirrups are Closed



TIMESAVER

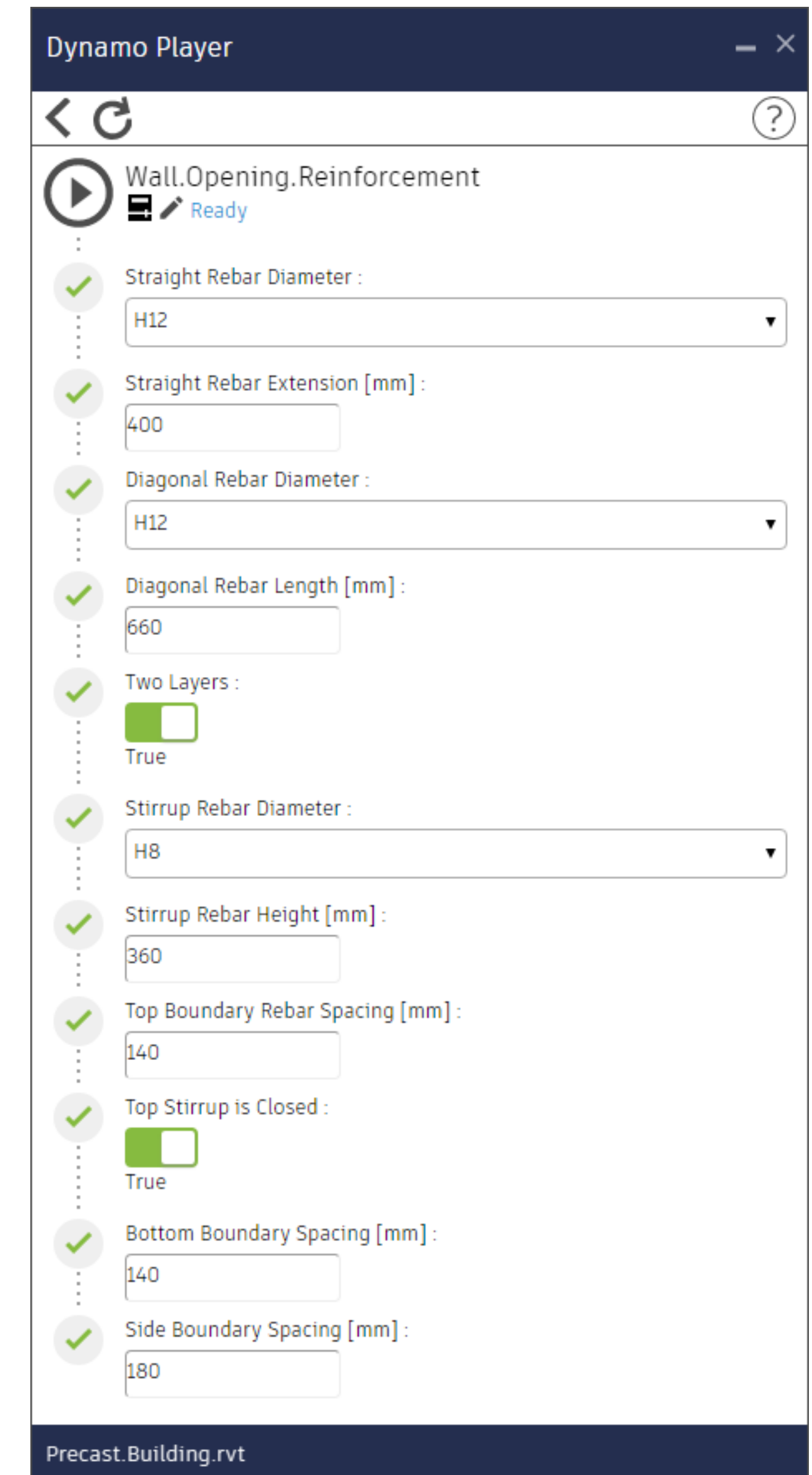
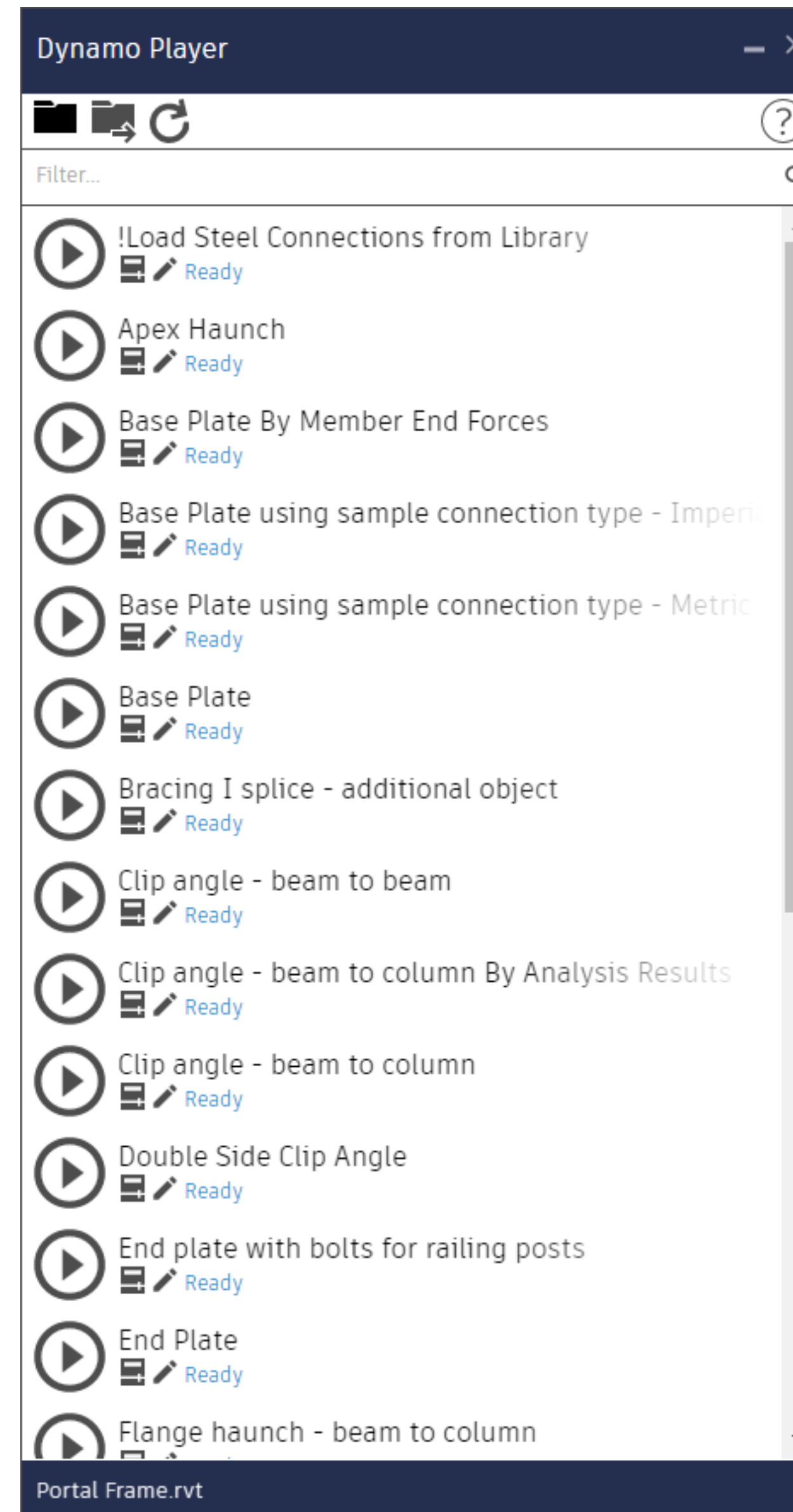


AUTOMATED VS MANUAL

Dynamo Player

Simple way to execute Dynamo scripts in Revit

- **Default directory for scripts**
- **Filtering visible scripts**
- **Viewing the status of current scripts**
- **Launching a script**
- **Providing input for scripts in Dynamo Player**
- **Editing a script in Dynamo**

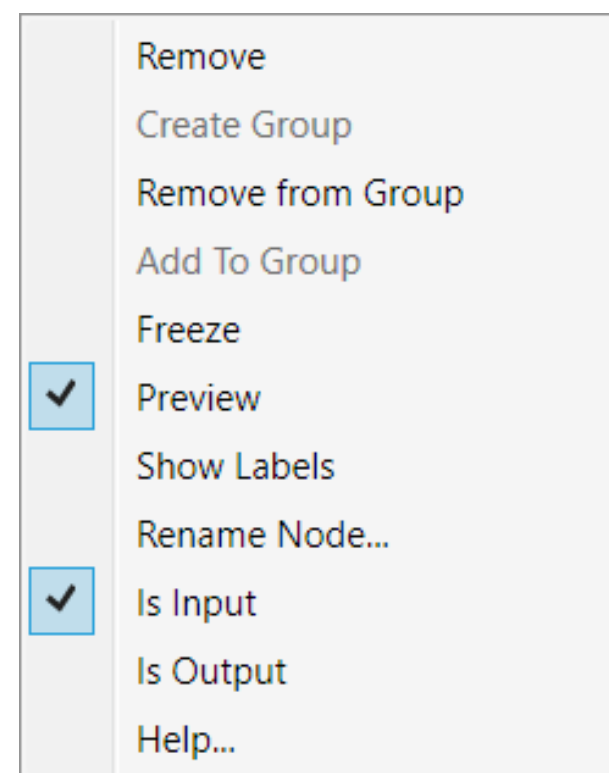


Dynamo Player

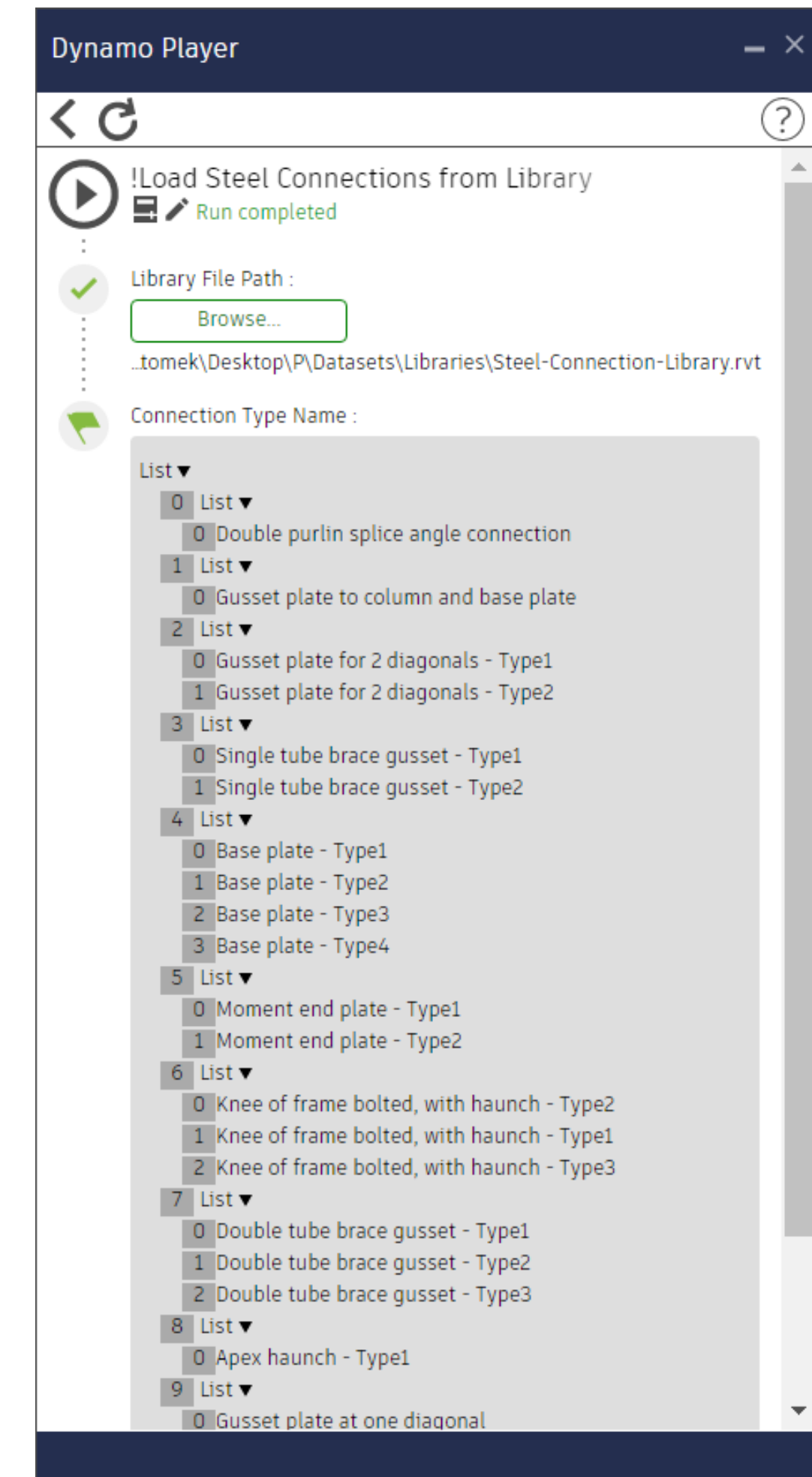
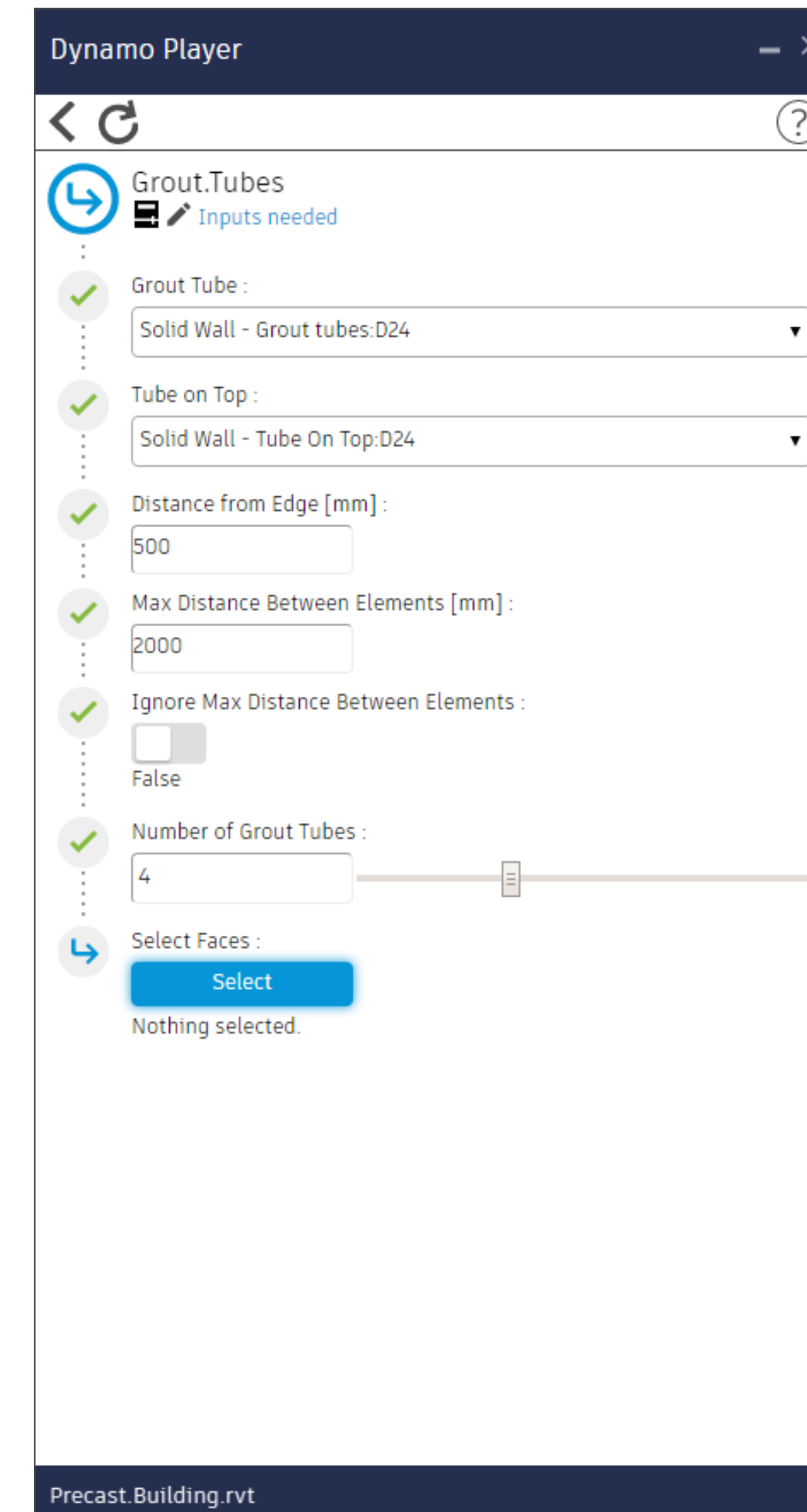
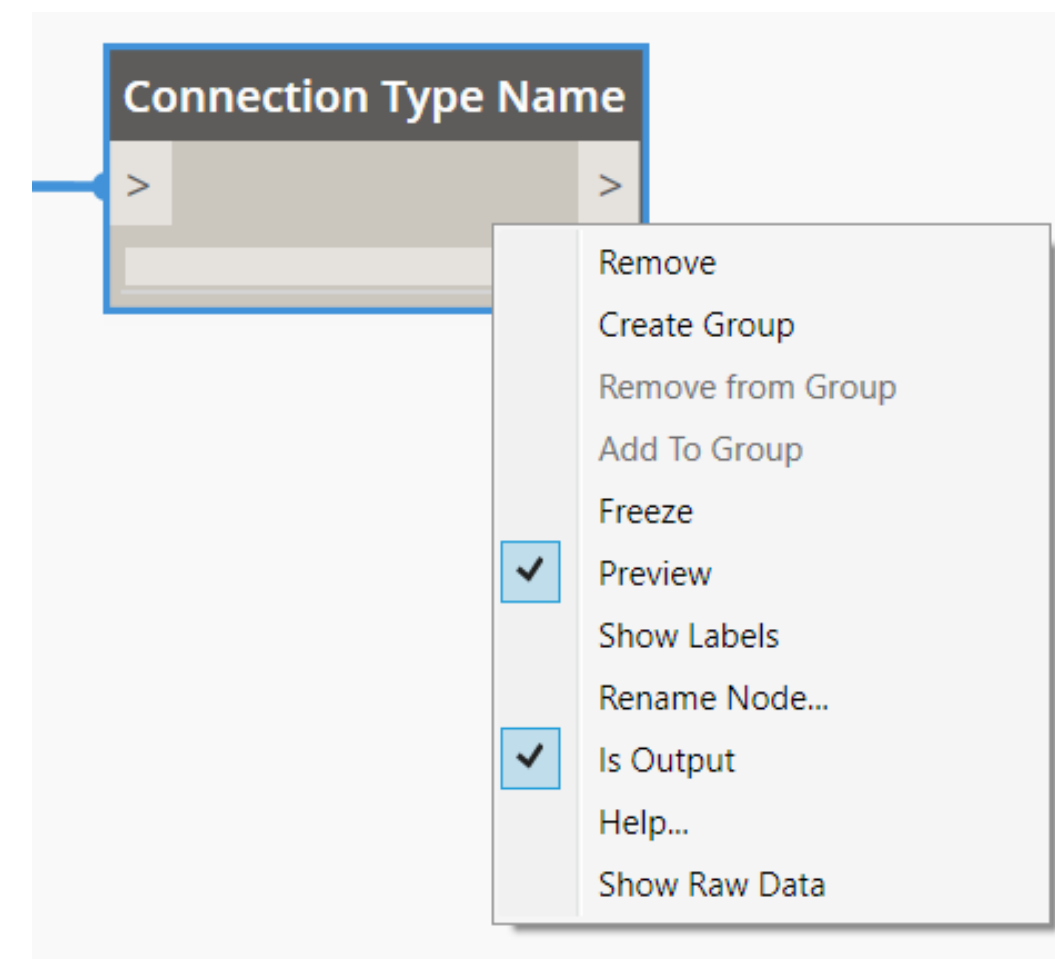
Inputs & Outputs

- **Supported input types**

- Select Model Element
- Select Model Elements
- Categories
- Element Types
- File Path
- Directory Path
- String
- Levels
- Boolean
- Number



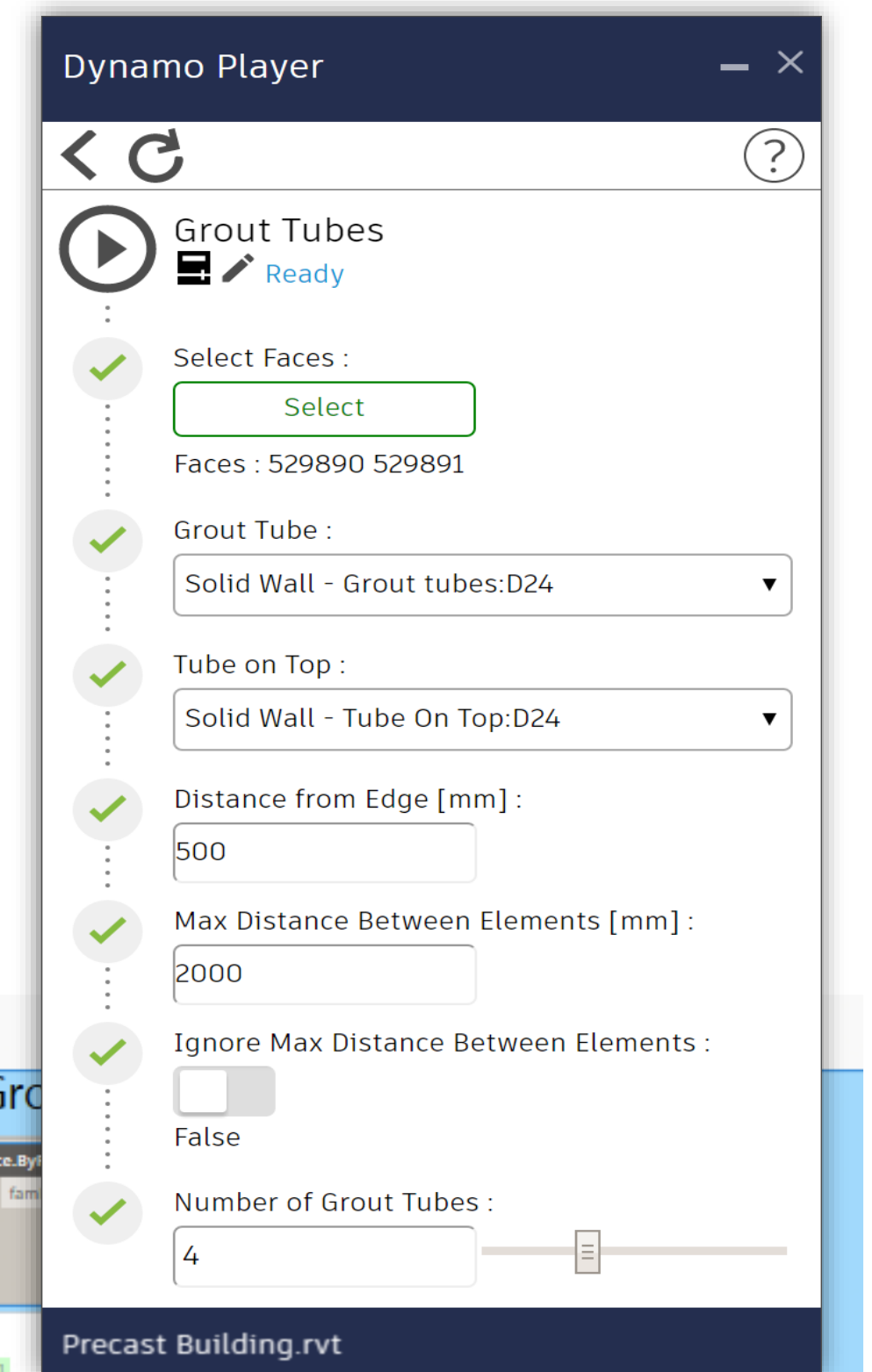
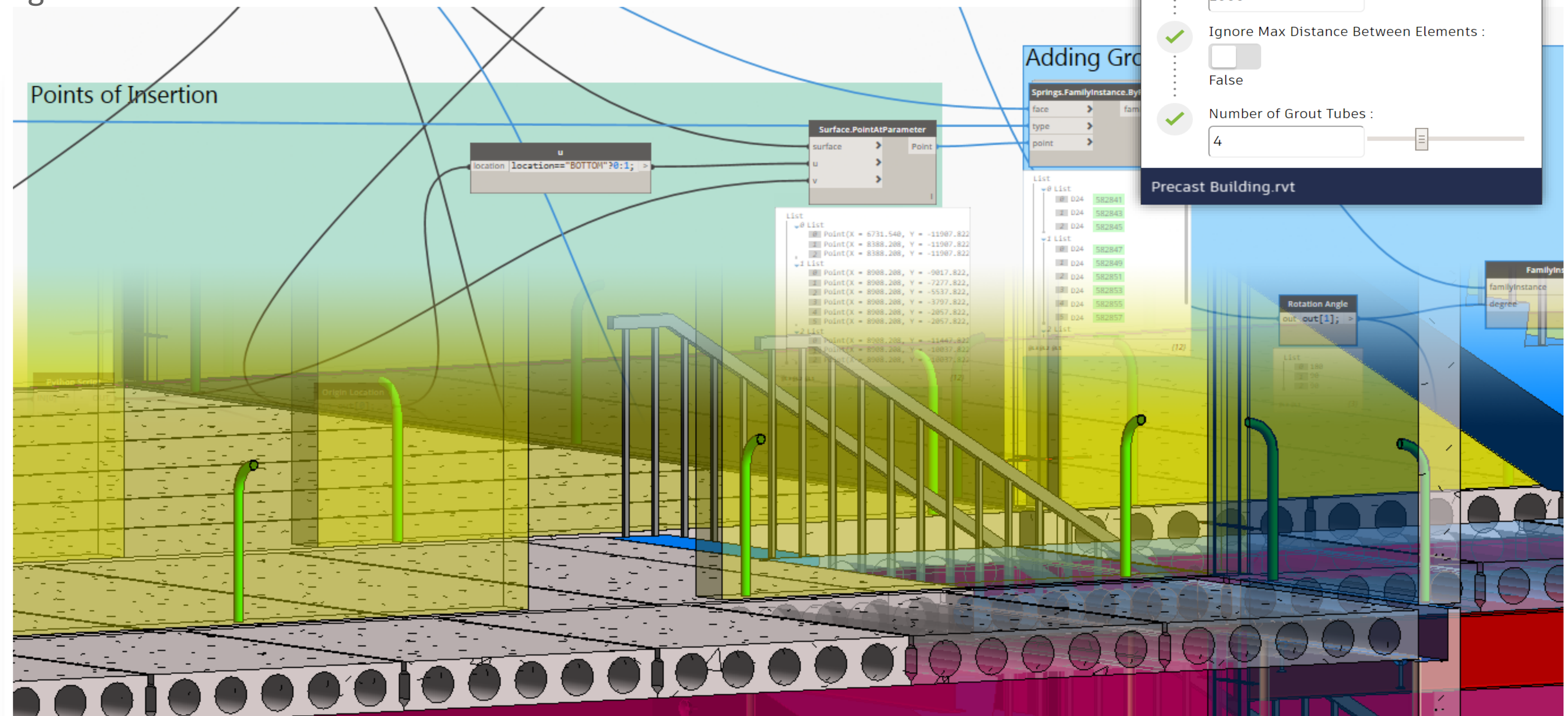
- Number Slider
- Integer Slider
- Views
- Number From Feet and Inches
- **Outputs**
 - Watch nodes

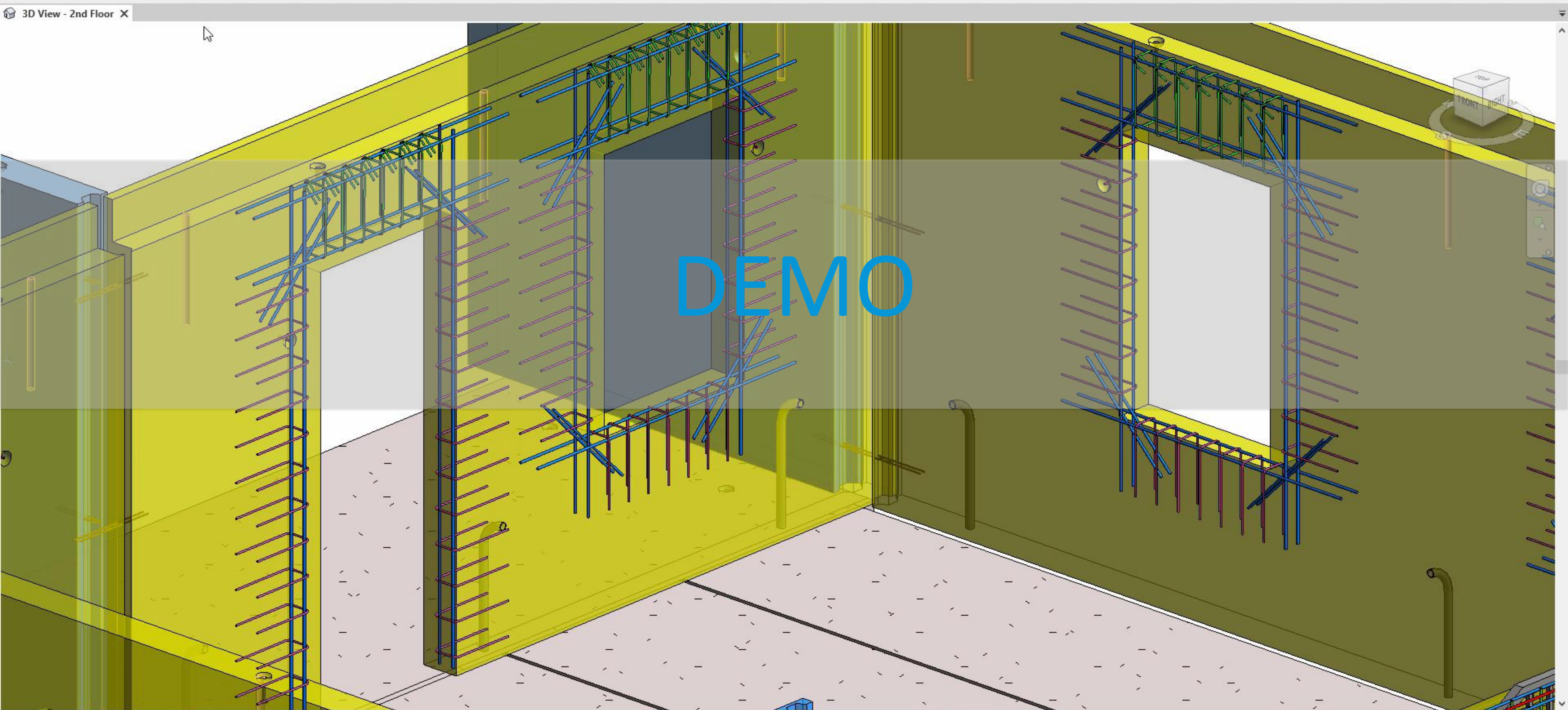


Precast Concrete Detailing

Structural Design Dynamo Package

- **Grout Tubes Automation**
 - Get point parameters based on specified division
 - Calculate grout tube rotation angle





Frame Design

Structural Design Dynamo Package

- **Frame Design Automation**
 - 10 nodes to automate frame design

| Frame.ByWidthHeightAngles | | |
|---------------------------|---|---------|
| insertionPoint | > | 2DFrame |
| vector | > | Columns |
| width | > | Beams |
| height | > | |
| angle | > | |
| AUTO | | |

| Frame.ByWidthHeights | | |
|----------------------|---|---------|
| insertionPoint | > | 2DFrame |
| vector | > | Columns |
| width | > | Beams |
| height1 | > | |
| height2 | > | |
| AUTO | | |

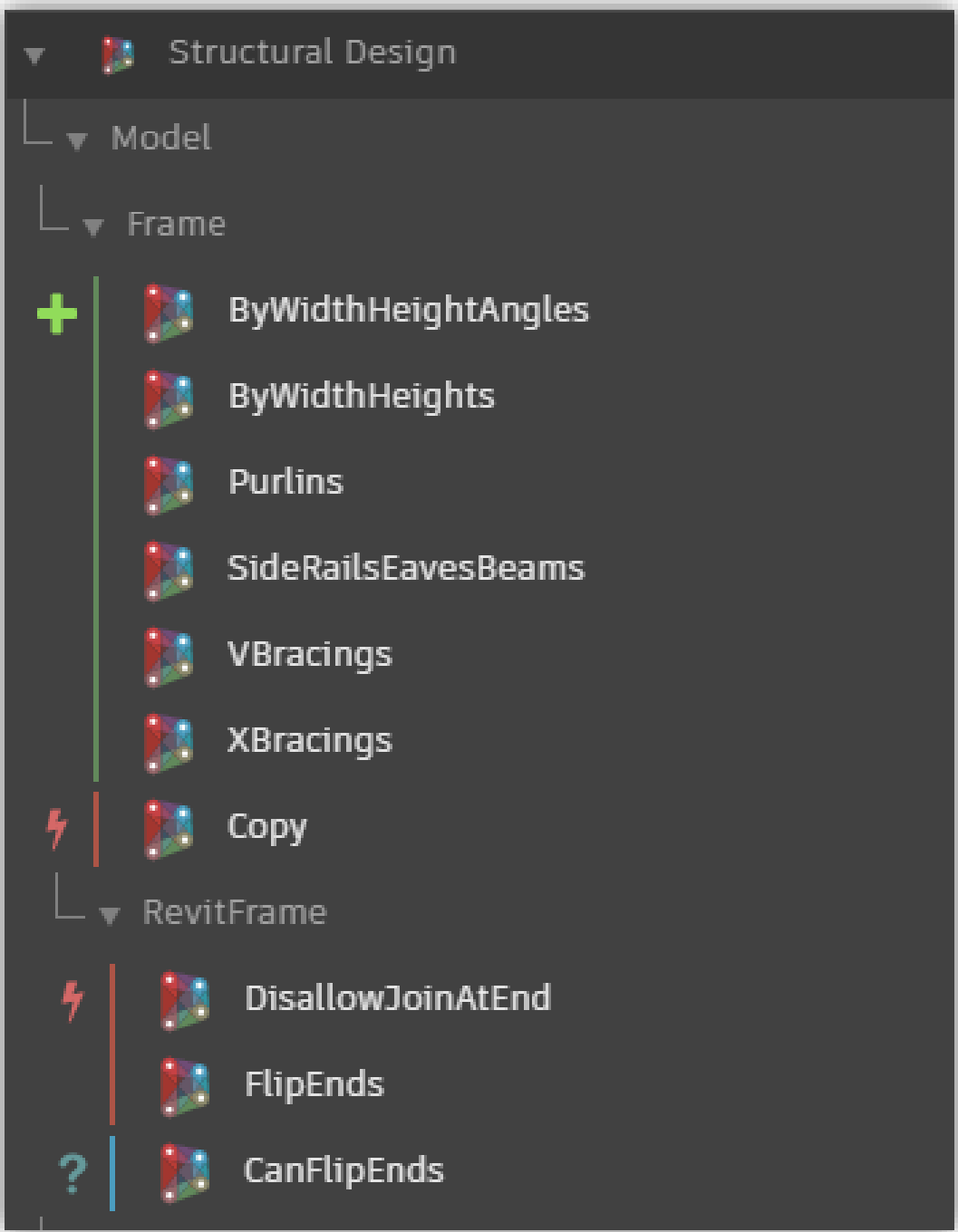
| Frame.SideRailsEavesBeams | | |
|---------------------------|---|--------|
| columns | > | Beams |
| heights | > | Points |
| AUTO | | |

| Frame.Purlins | | |
|---------------|---|---------|
| rafters | > | Purlins |
| number | > | Points |
| dp1 | > | |
| dp2 | > | |
| AUTO | | |

| Frame.Copy | | |
|-----------------|---|----------|
| frame2DGeometry | > | 2DFrames |
| equalSpacing | > | Columns |
| numberOfTimes | > | Beams |
| spacing | > | |
| varyingSpacing | > | |
| flip | > | |
| AUTO | | |

| Frame.XBracings | | |
|-----------------|---|-----------|
| points | > | XBracings |
| zones | > | |
| AUTO | | |

| Frame.VBracings | | |
|-----------------|---|-----------|
| points | > | VBracings |
| zones | > | |
| AUTO | | |



| RevitFrame.DisallowJoinAtEnd | | |
|------------------------------|---|-------------------|
| structuralFraming | > | StructuralFraming |
| end | > | |
| allow | > | |
| AUTO | | |

| RevitFrame.FlipEnds | | |
|---------------------|---|-------------------|
| structuralFraming | > | StructuralFraming |
| AUTO | | |

| RevitFrame.CanFlipEnds | | |
|------------------------|---|---------|
| structuralFraming | > | Boolean |
| AUTO | | |

Frame Design

Structural Design Dynamo Package

| Frame.ByWidthHeights | | |
|----------------------|---|---------|
| insertionPoint | > | 2DFrame |
| vector | > | Columns |
| width | > | Beams |
| height1 | > | |
| height2 | > | |
| AUTO | | |

| Frame.Copy | | |
|-----------------|---|----------|
| frame2DGeometry | > | 2DFrames |
| equalSpacing | > | Columns |
| numberOfTimes | > | Beams |
| spacing | > | |
| varyingSpacing | > | |
| flip | > | |
| AUTO | | |

| Frame.SideRailsEavesBeams | | |
|---------------------------|---|--------|
| columns | > | Beams |
| heights | > | Points |
| AUTO | | |

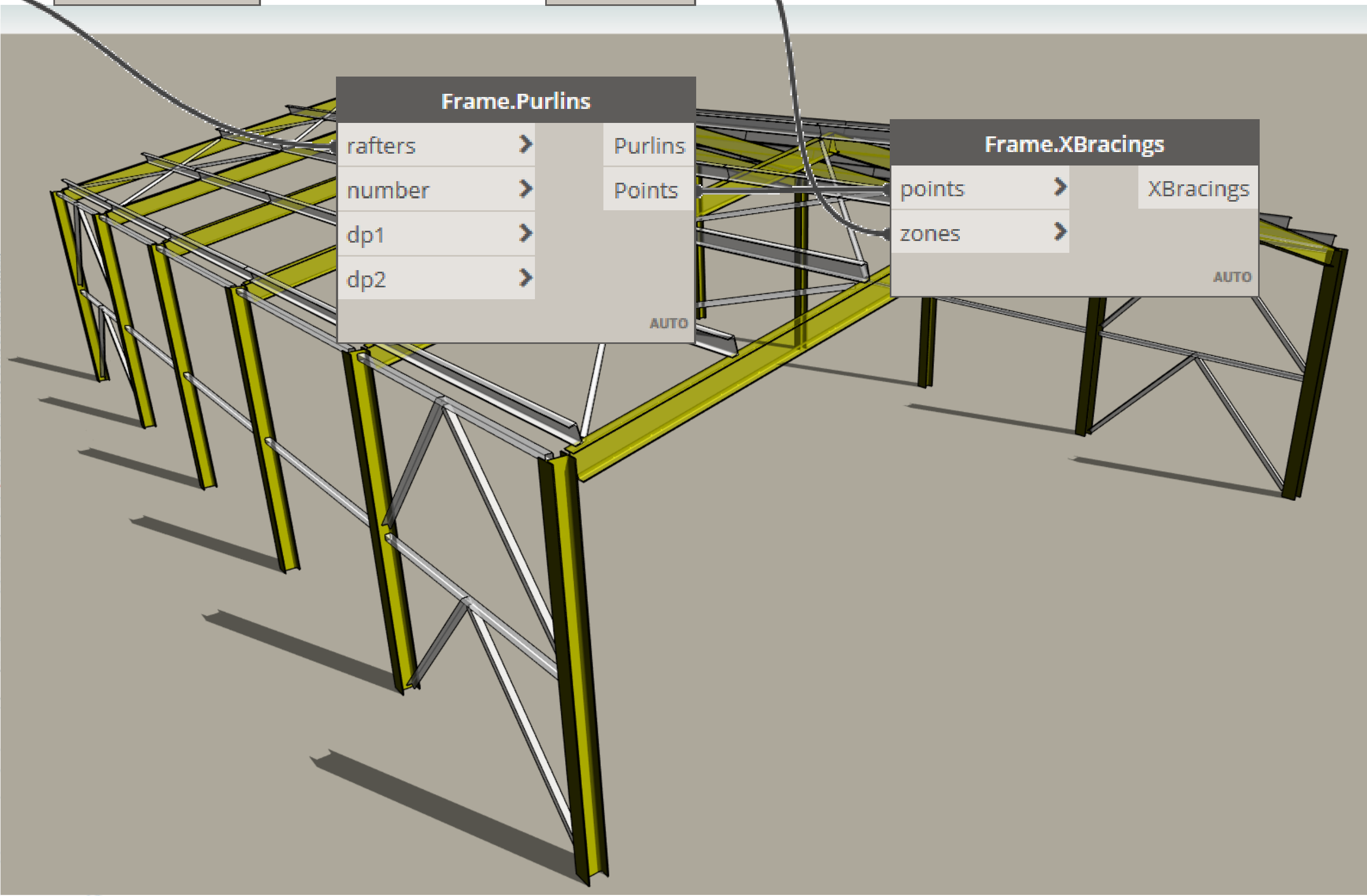
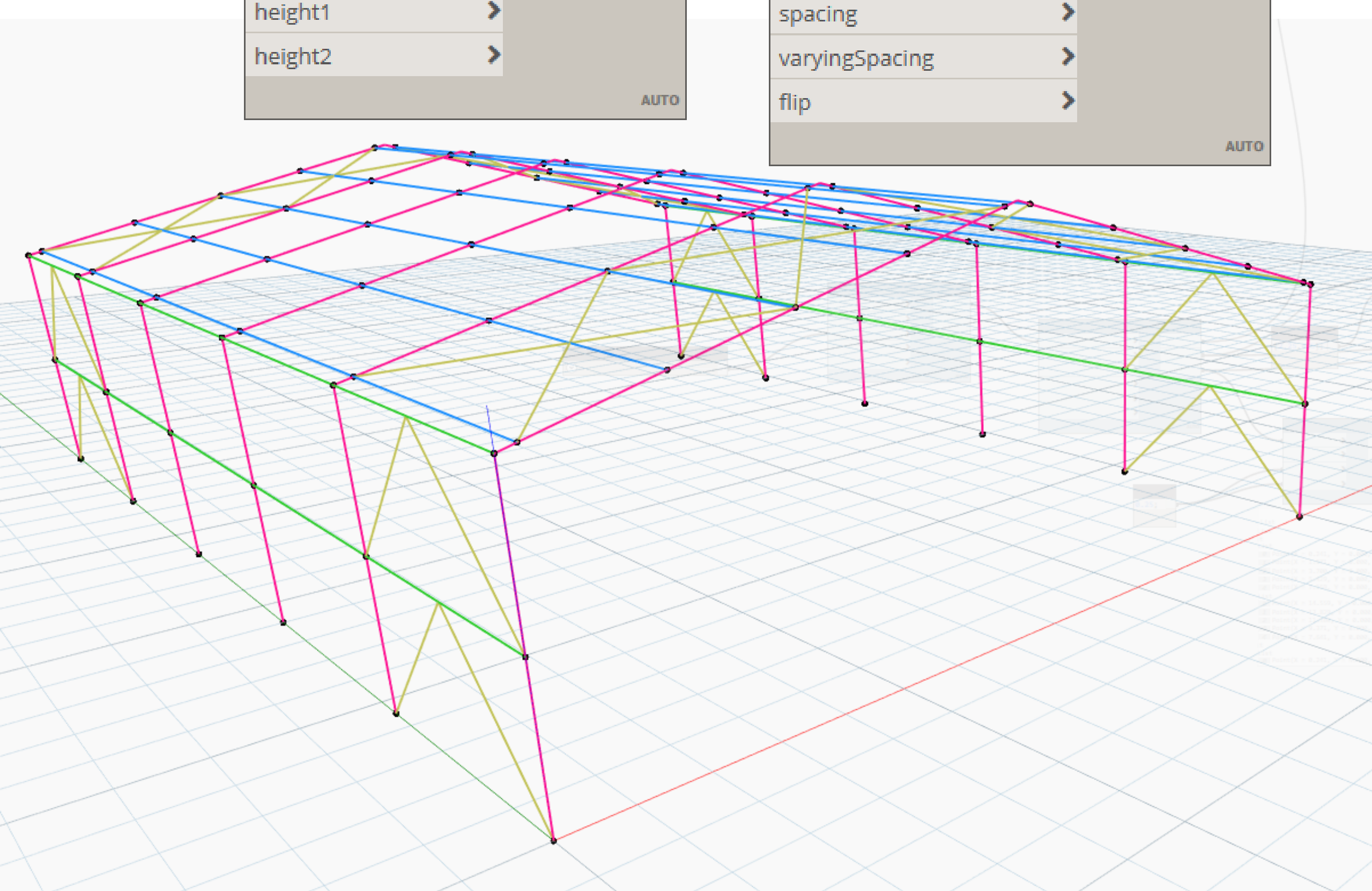
| Frame.VBracings | | |
|-----------------|---|-----------|
| points | > | VBracings |
| zones | > | |
| AUTO | | |

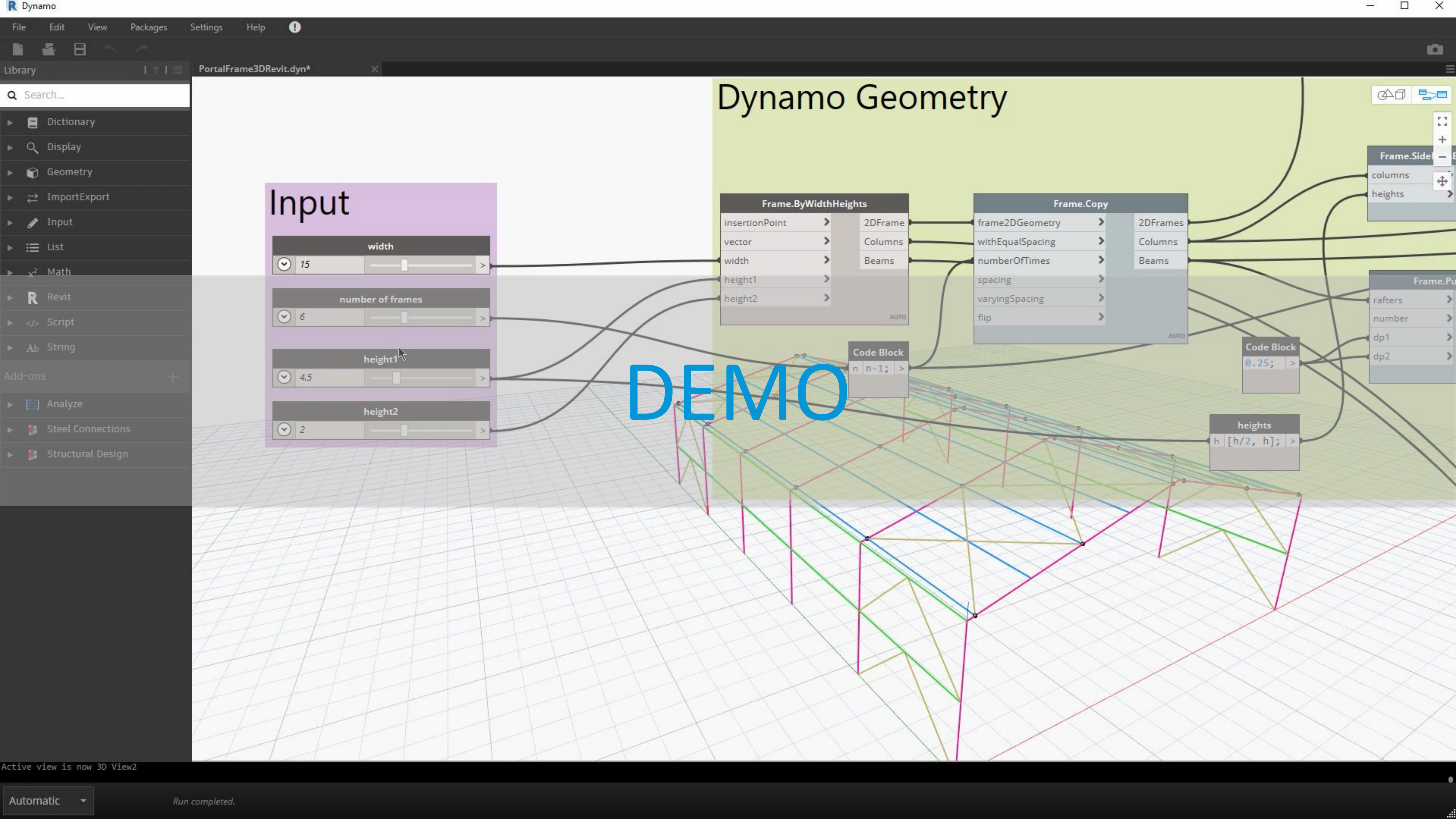
| Heights | | |
|-------------|---|--|
| [2.25, 45]; | > | |

| Zones | | |
|---------|---|--|
| [1, 5]; | > | |

| Frame.Purlins | | |
|---------------|---|---------|
| rafters | > | Purlins |
| number | > | Points |
| dp1 | > | |
| dp2 | > | |
| AUTO | | |

| Frame.XBracings | | |
|-----------------|---|-----------|
| points | > | XBracings |
| zones | > | |
| AUTO | | |



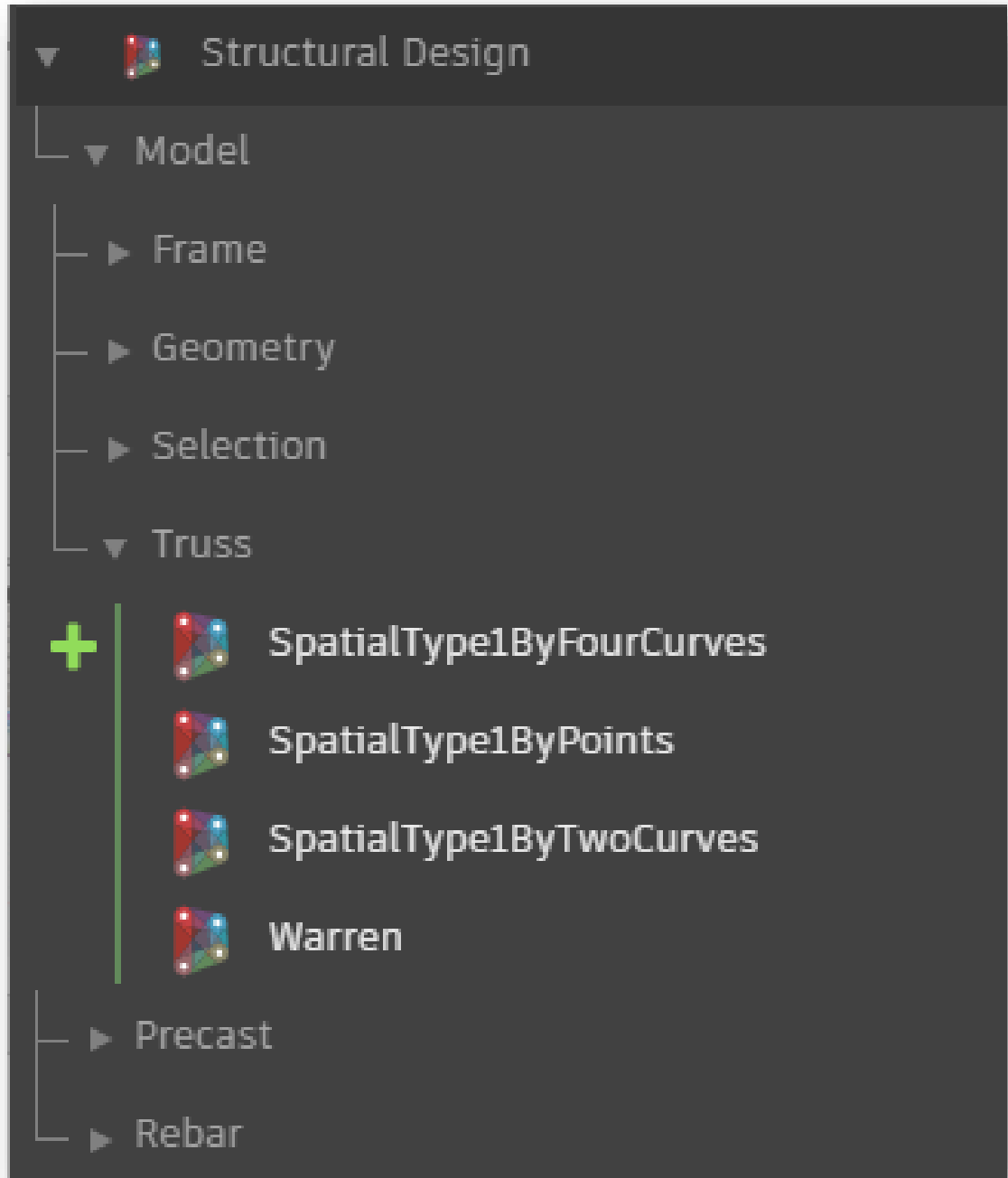


Truss Design

Structural Design Dynamo Package

- **Truss Design Automation**
 - 4 nodes to automate frame design
- **Warren truss**
- **Special truss**
 - By boundary points
 - By two curves
 - By four curves
- **Easy of usage**

| Truss.Warren | | |
|-----------------------|---|------------------|
| insertionPoint | ➤ | Chords |
| vector | ➤ | BottomChordNodes |
| length | ➤ | UpperChordNodes |
| startHeight | ➤ | Diagonals |
| endHeight | ➤ | Posts |
| division | ➤ | |
| posts | ➤ | |
| firstDiagonalUp | ➤ | |
| removeTrianglesAtEnds | ➤ | |
| d1 | ➤ | |
| d2 | ➤ | |
| AUTO | | |



| Truss.SpatialType1ByPoints | | |
|----------------------------|---|---------------|
| contourPoints | ➤ | TopNodes |
| divisionA | ➤ | BottomNodes |
| divisionB | ➤ | TopMembers |
| depth | ➤ | BottomMembers |
| | | Diagonals |
| AUTO | | |

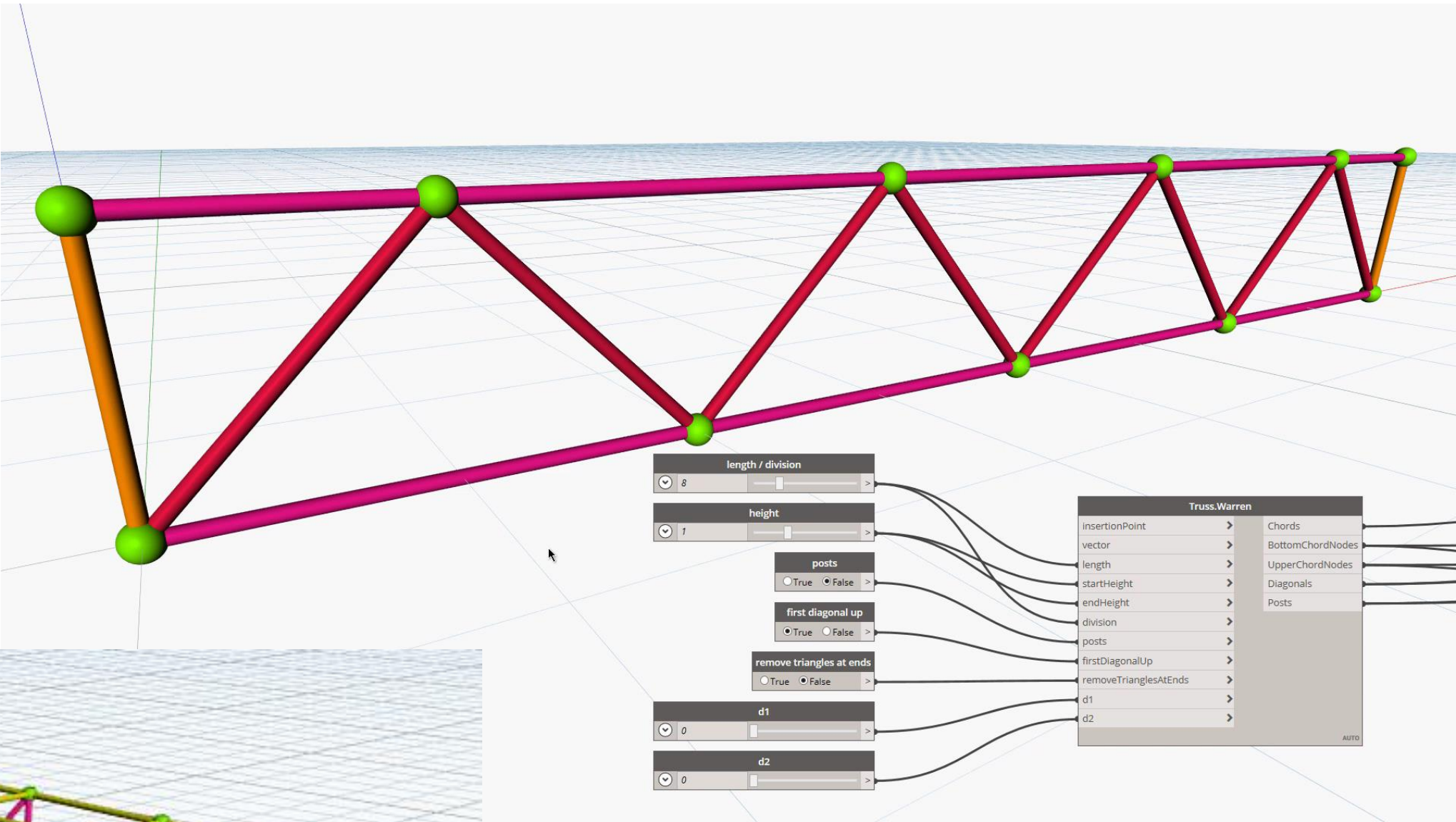
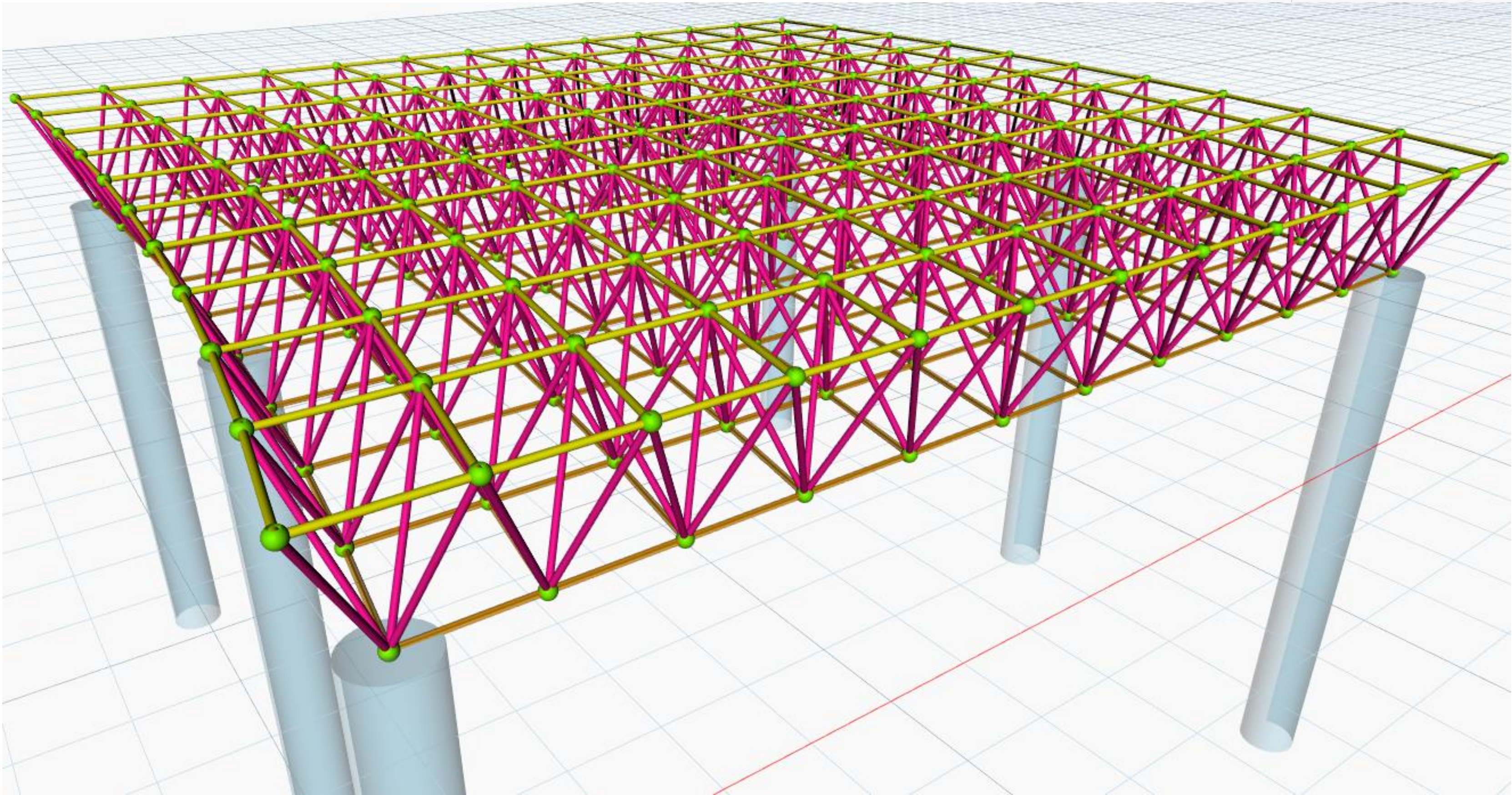
| Truss.SpatialType1ByFourCurves | | |
|--------------------------------|---|---------------|
| contourCurves | ➤ | TopNodes |
| divisionA | ➤ | BottomNodes |
| divisionB | ➤ | TopMembers |
| depth | ➤ | BottomMembers |
| | | Diagonals |
| AUTO | | |

| Truss.SpatialType1ByTwoCurves | | |
|-------------------------------|---|---------------|
| contourCurves | ➤ | TopNodes |
| divisionA | ➤ | BottomNodes |
| divisionB | ➤ | TopMembers |
| depth | ➤ | BottomMembers |
| | | Diagonals |
| AUTO | | |

Truss Design

Structural Design Dynamo Package

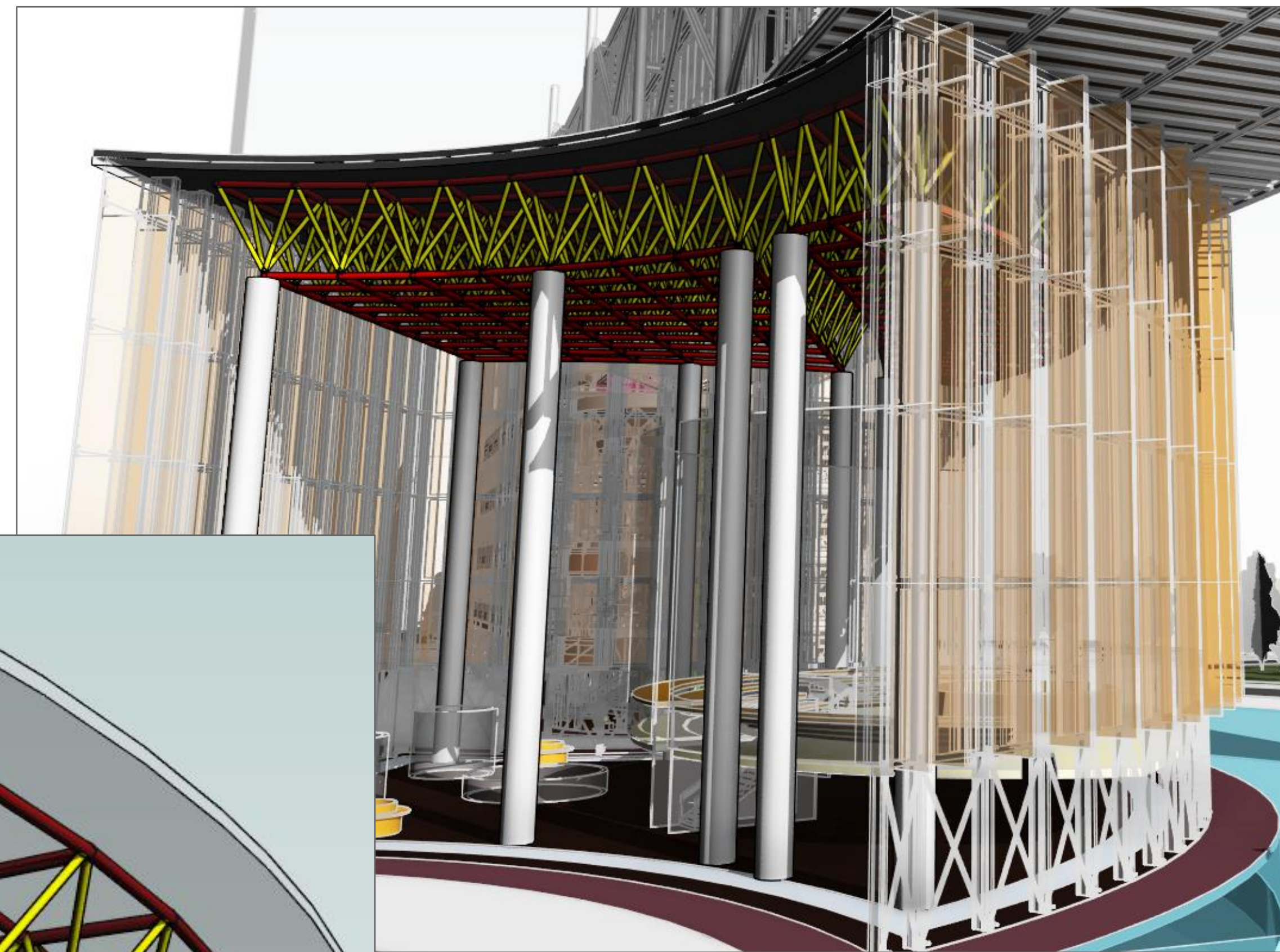
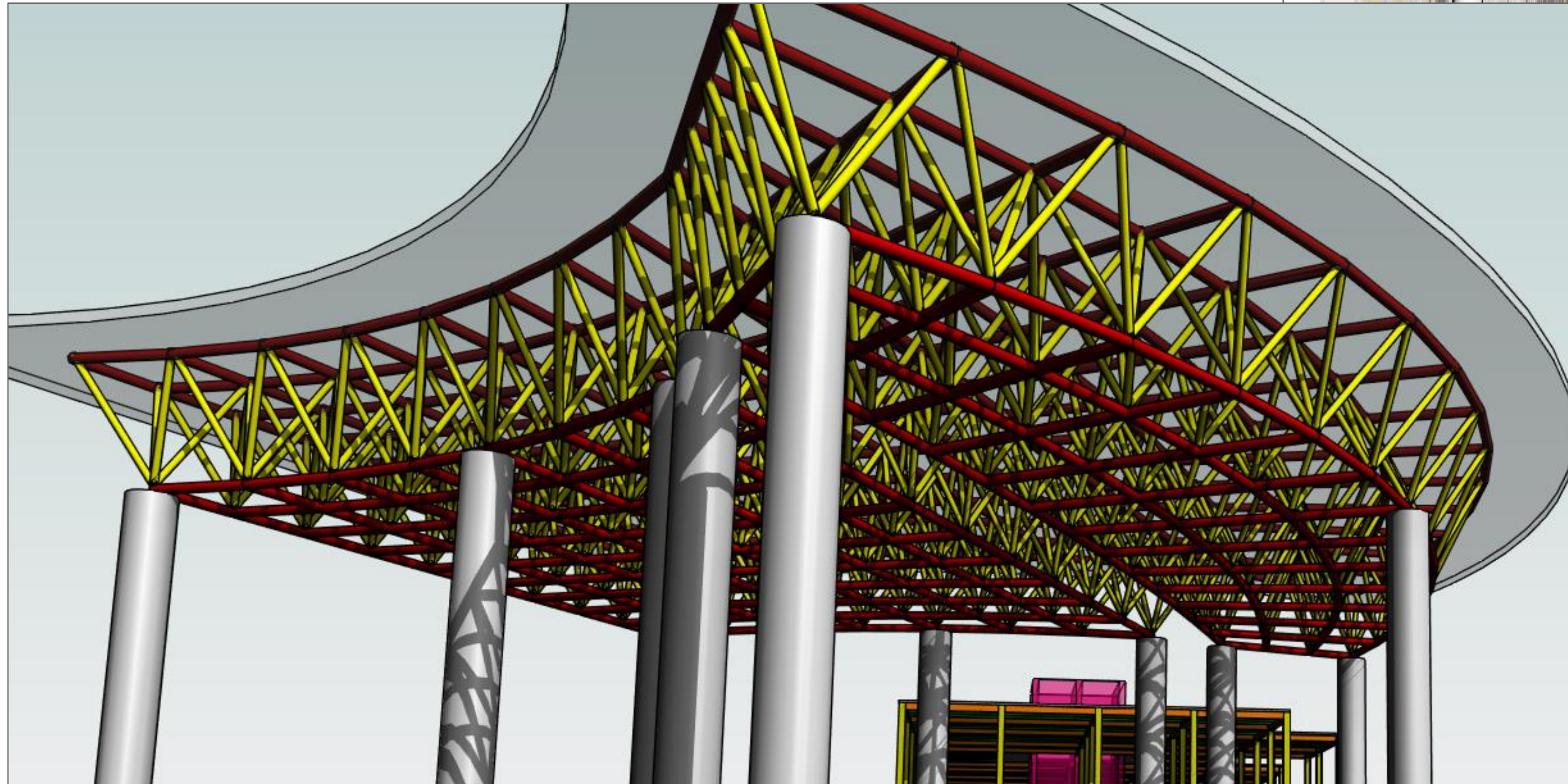
- Examples

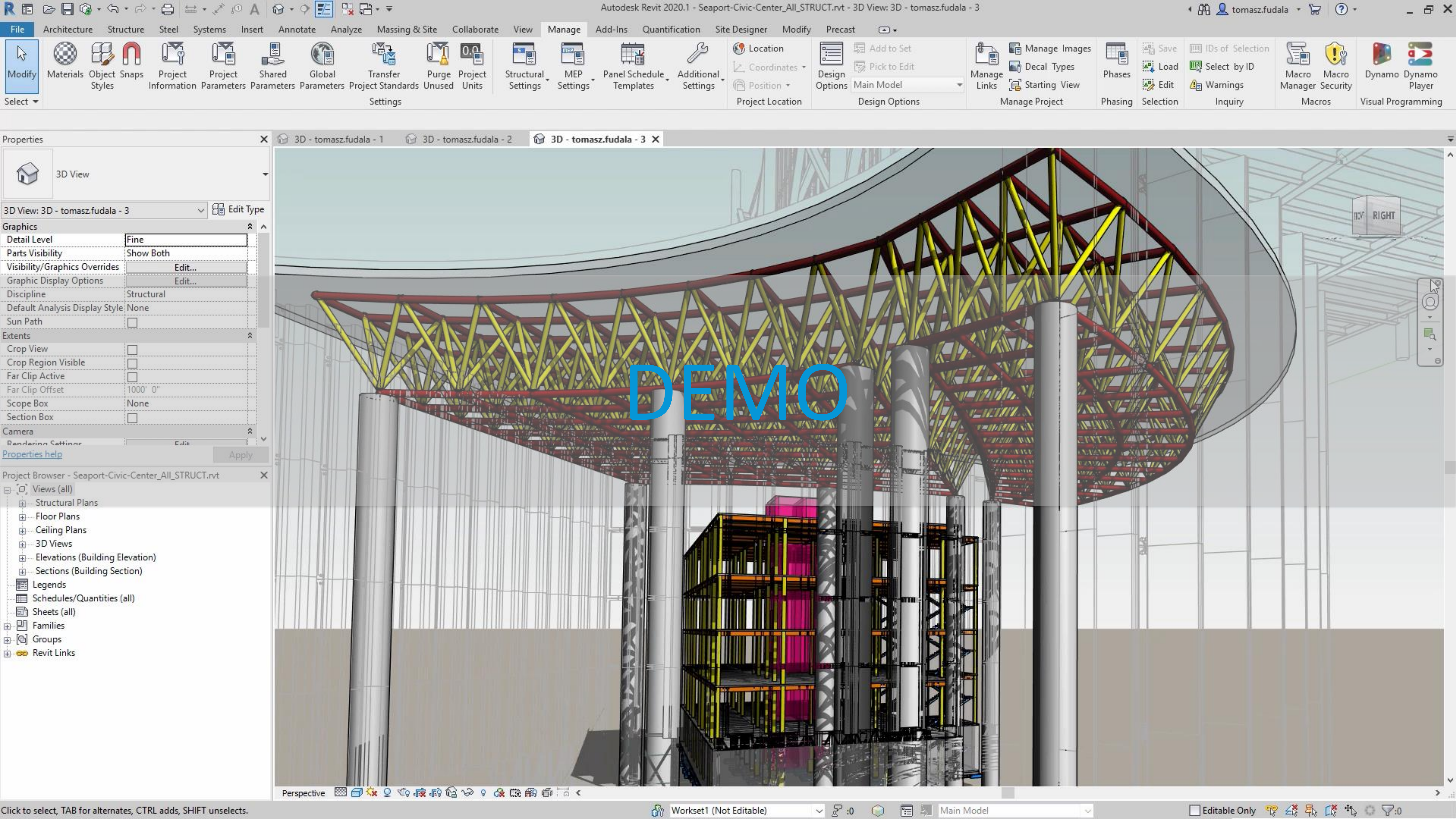


Truss Design

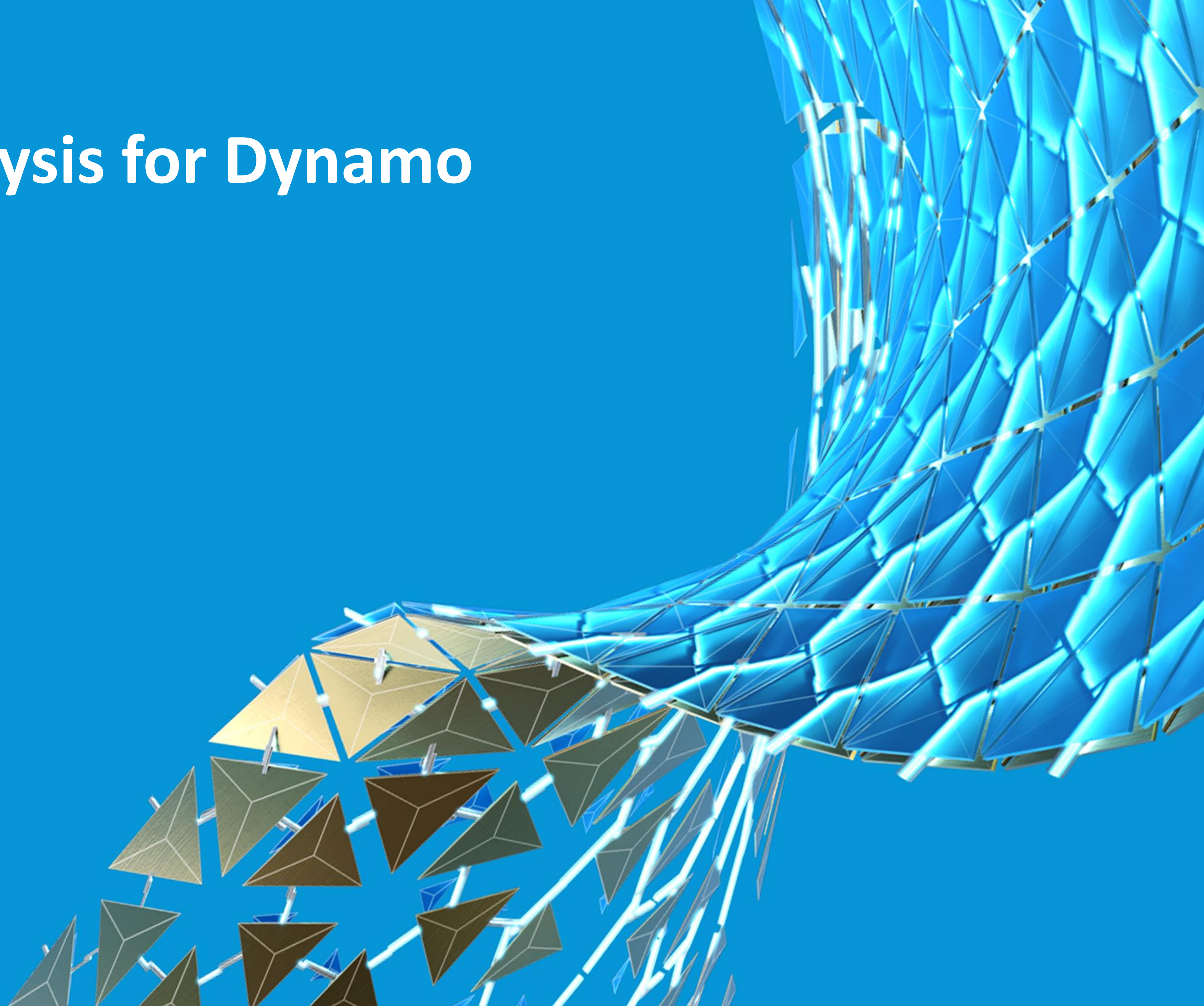
Structural Design Dynamo Package

- Examples





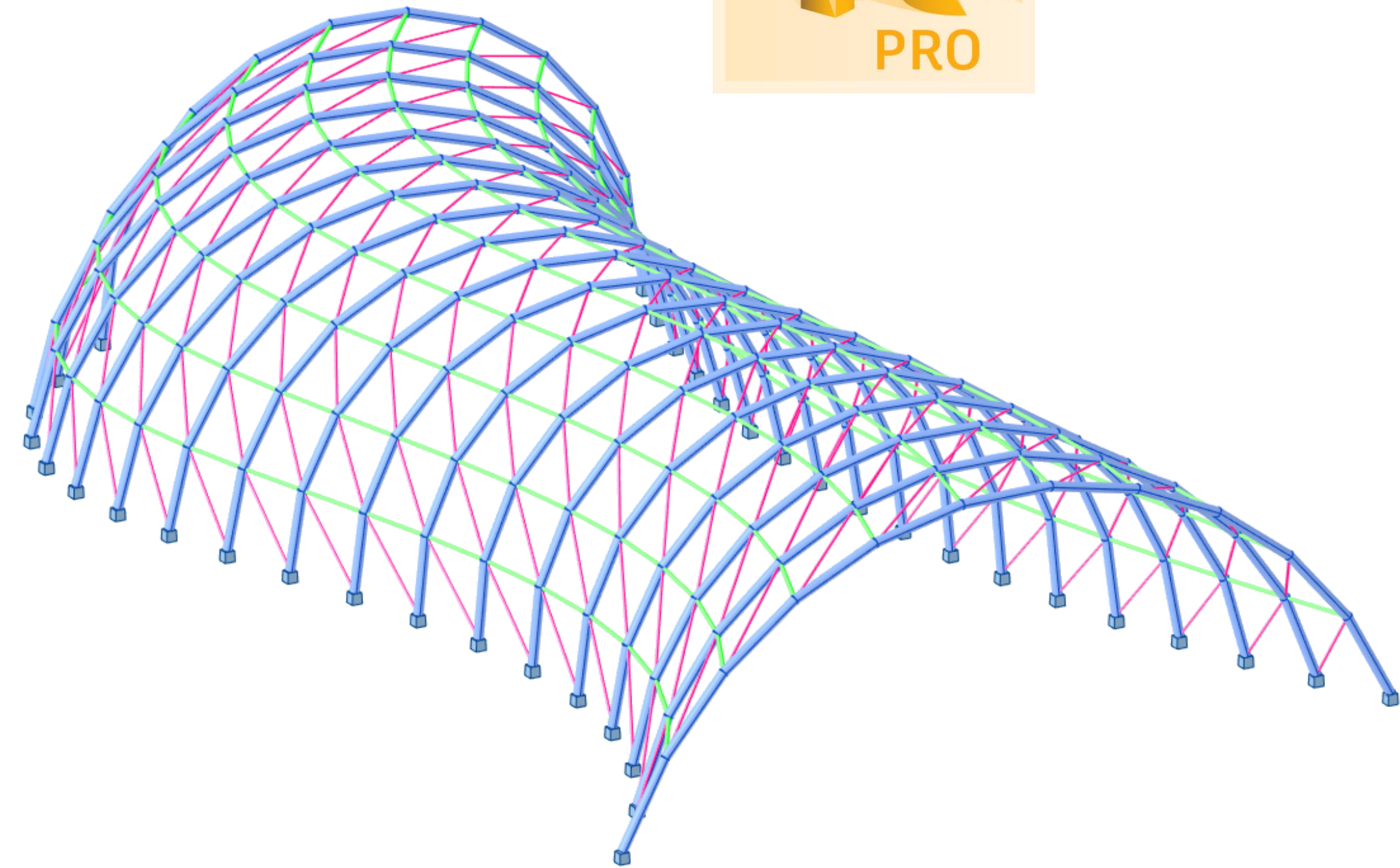
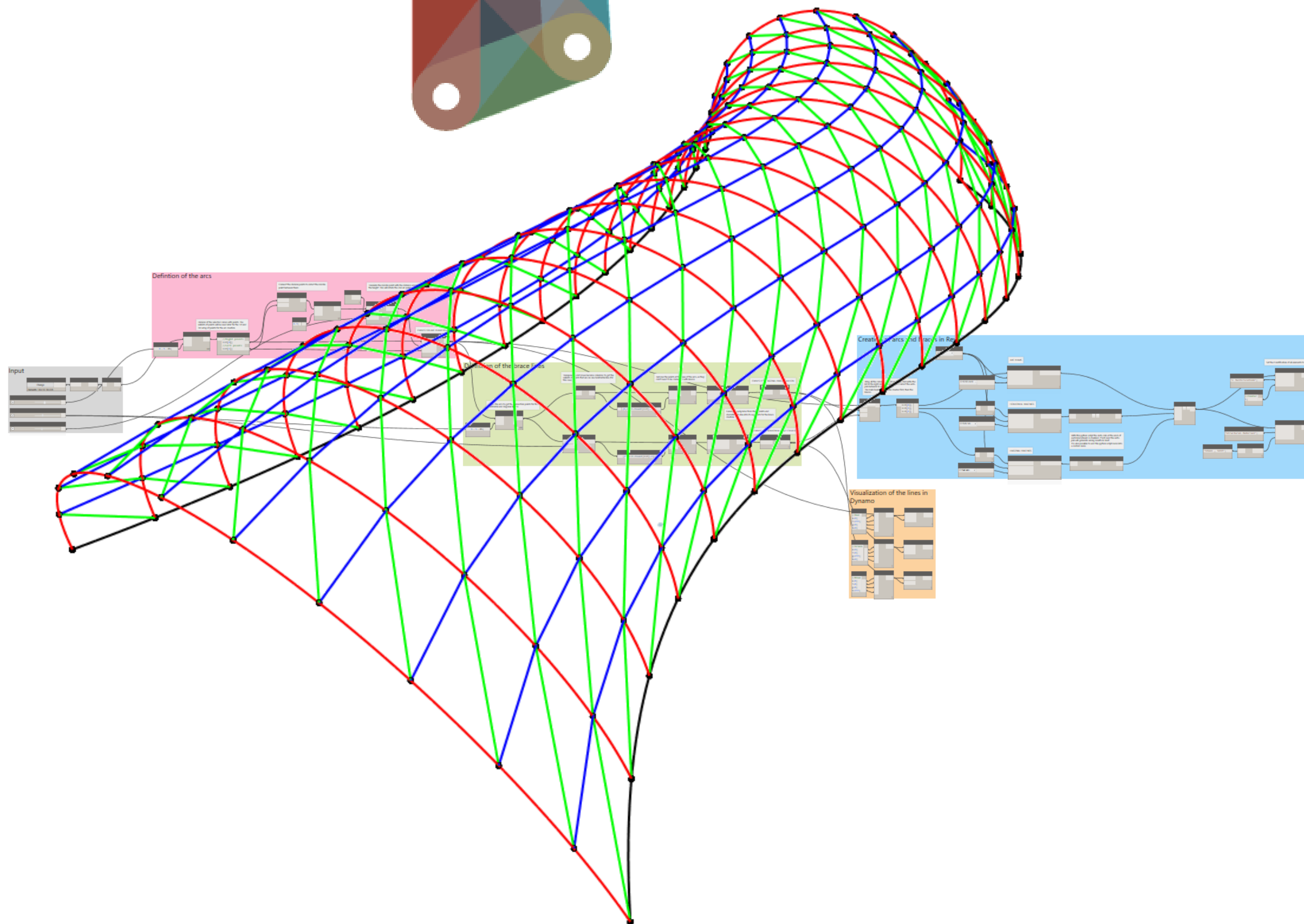
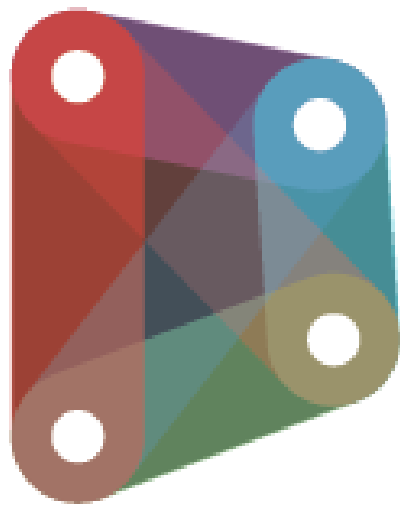
Structural Analysis for Dynamo Package





Automate Structural Analysis

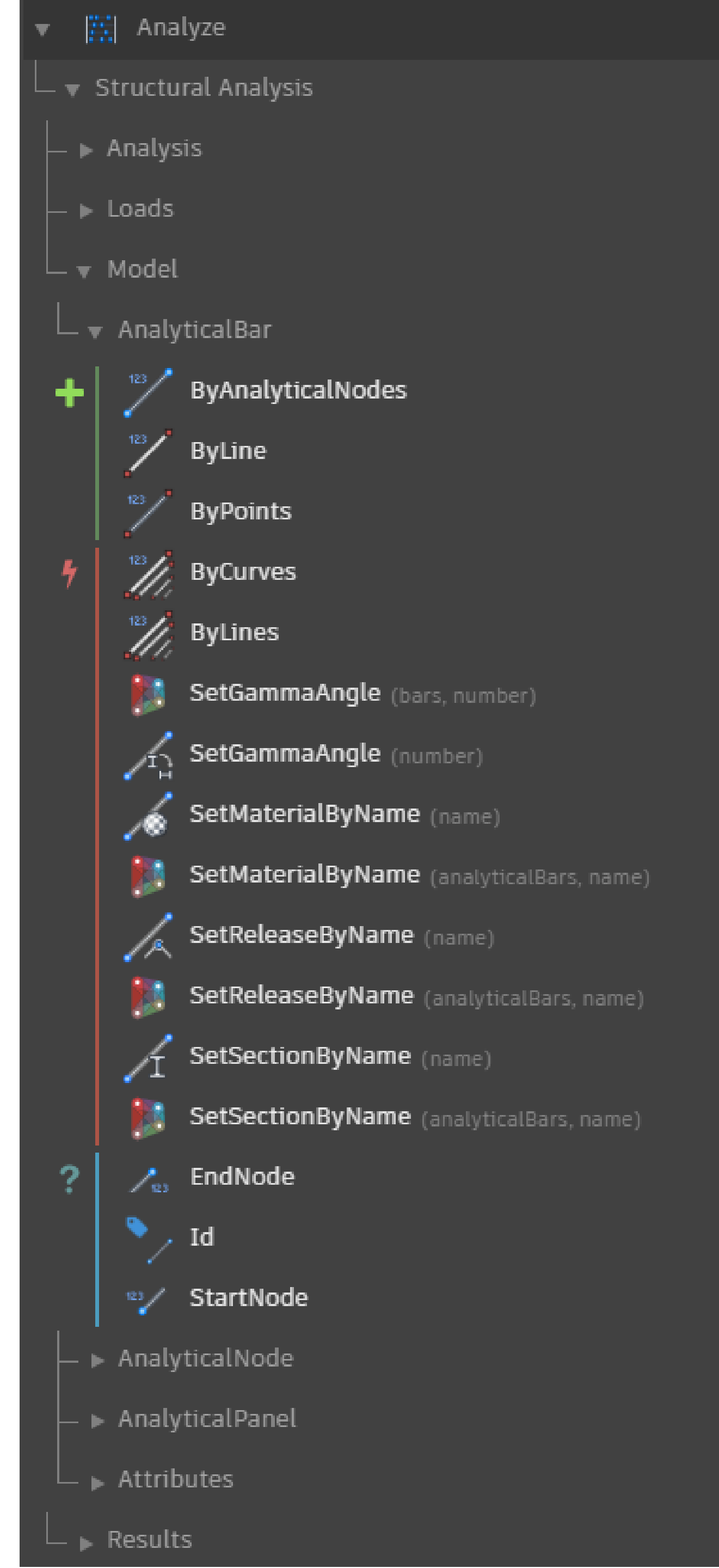
Structural Analysis for Dynamo Package, Robot Structural Analysis Professional



Automate Structural Analysis

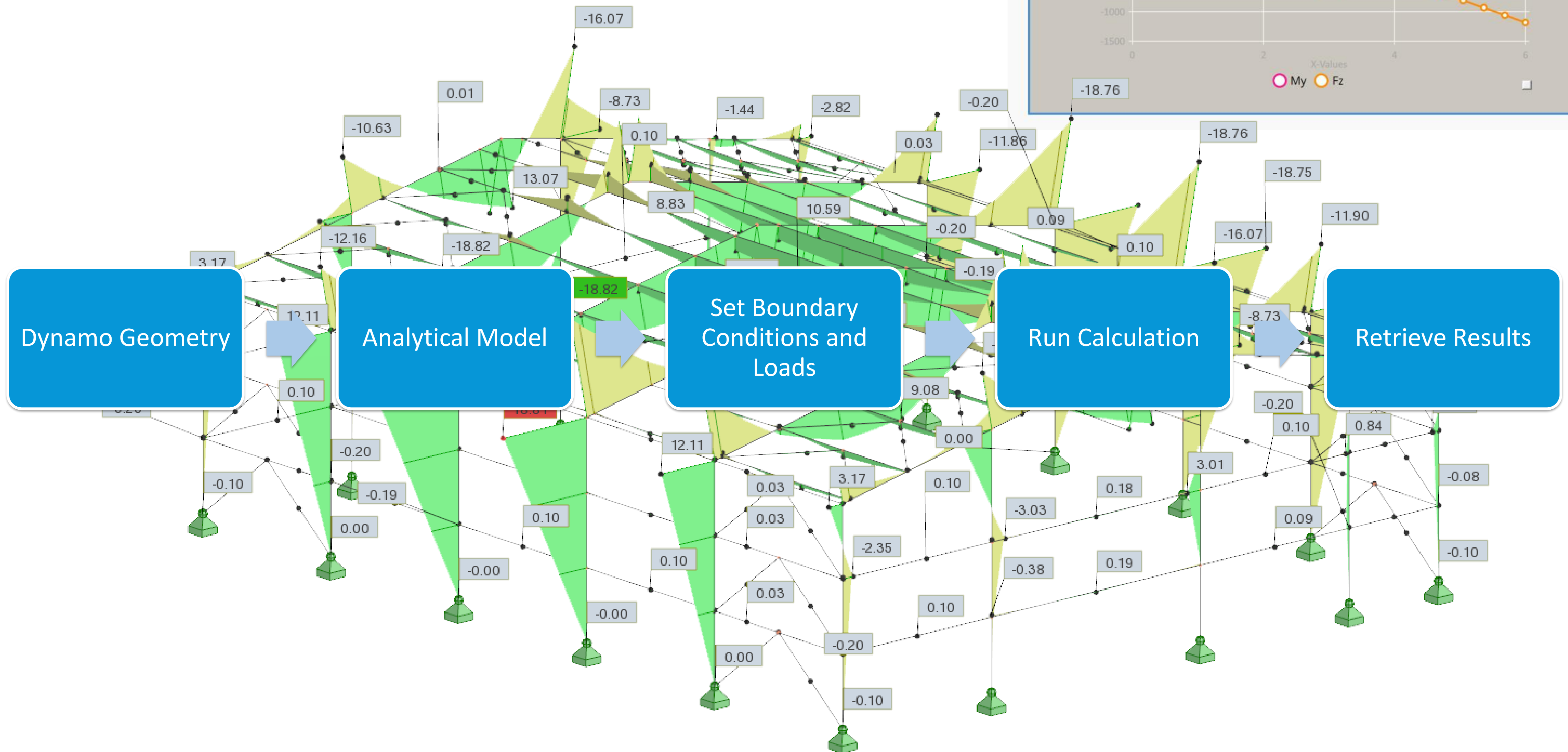
Structural Analysis for Dynamo Package, Robot Structural Analysis Professional

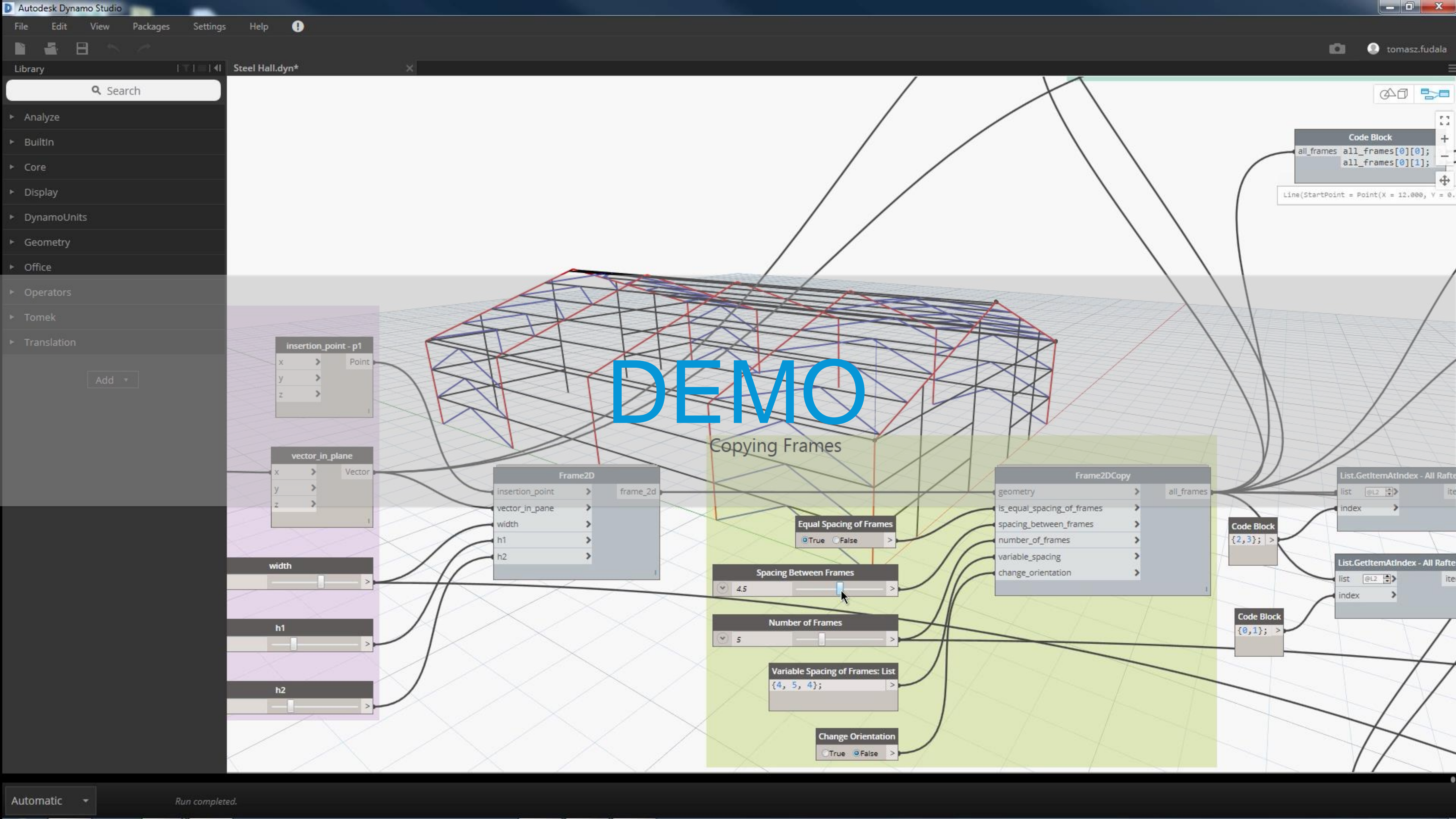
- **Create Analytical Model in Robot**
 - Analytical Nodes, Lines, Surfaces
- **Set Attributes: Section Shapes, Gamma Angles, Materials**
- **Definition of Boundary Conditions**
 - Supports, Releases
- **Definition of Loads**
 - Load cases
 - Applying: nodal, linear and surface loads
- **Running Calculation from Dynamo**
- **Getting results of the analysis from RSA in Dynamo**



Automate Structural Analysis

Structural Analysis for Dynamo Package, Robot Structural Analysis Professional



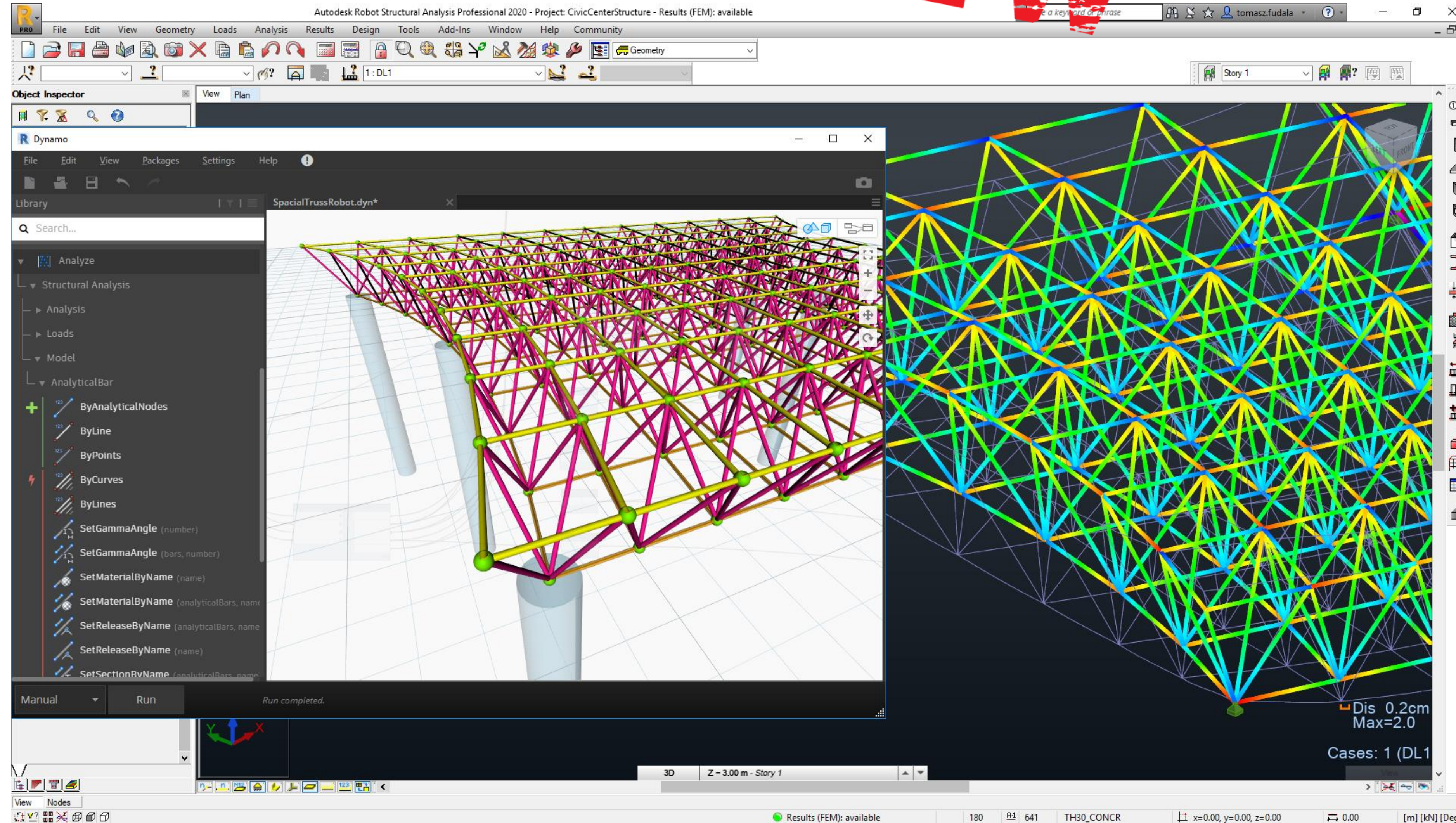


Automate Structural Analysis

Structural Analysis for Dynamo Package, Robot Structural Analysis Professional

NEW

- **Dynamo in Robot**



Automate Structural Analysis

Structural Analysis for Dynamo Package, Robot Structural Analysis Professional

- **Join beta**
 - https://feedback.autodesk.com/key/RSA_Feedback



Autodesk Robot Structural Analysis Feedback Community

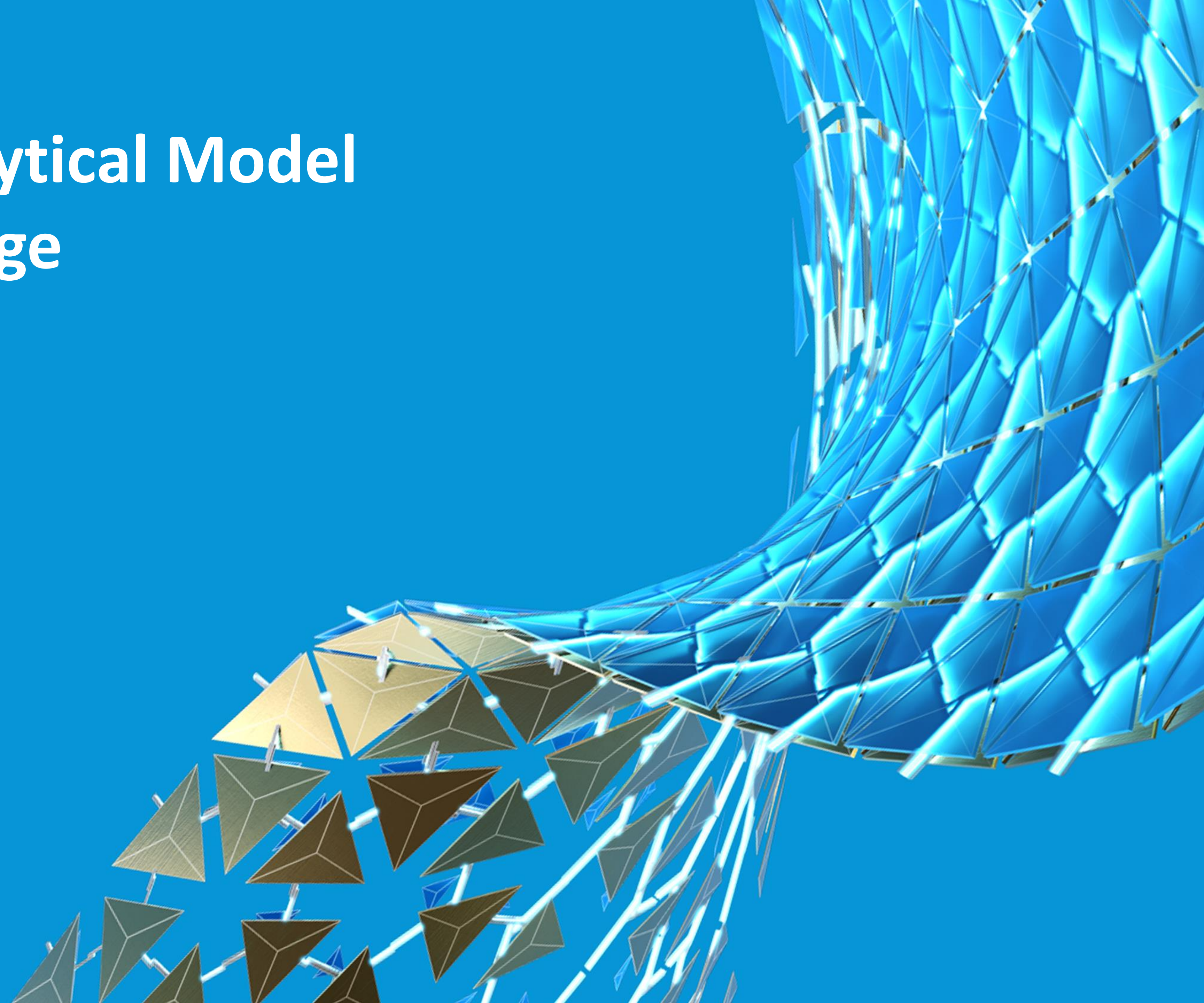
Thank you for participating in Autodesk Robot Structural Analysis Preview program.

As you download and test this version, we are kindly asking you to provide your feedback and assist us with further testing. Your suggestions will help us to fine-tune Robot Structural Analysis release next year. Please complete a short survey to give us your feedback on new features.

Robot Structural Analysis Team

[Log in or Create Account.](#)

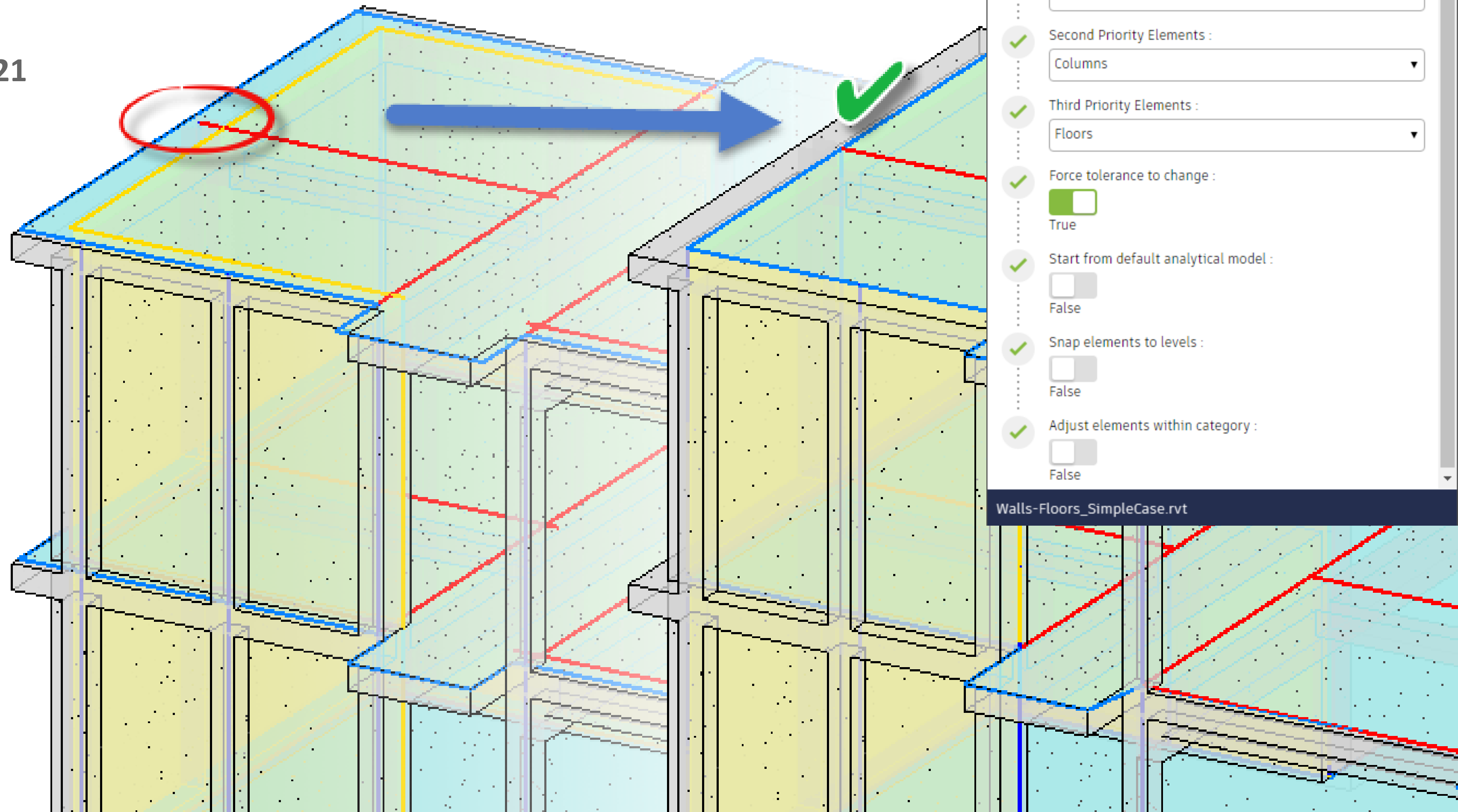
Autodesk Analytical Model Dynamo Package

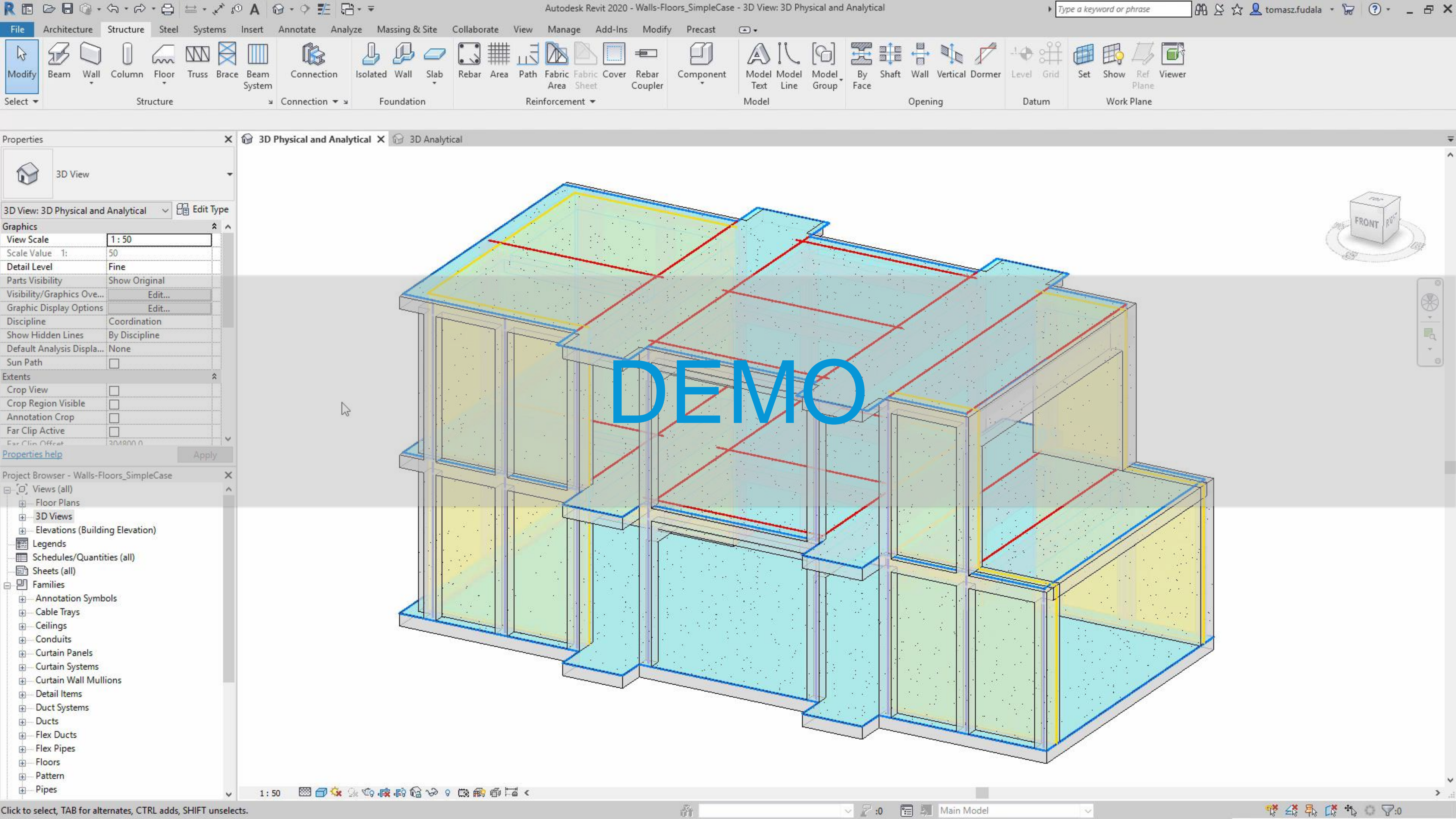


Automation of Analytical Model Adjustment

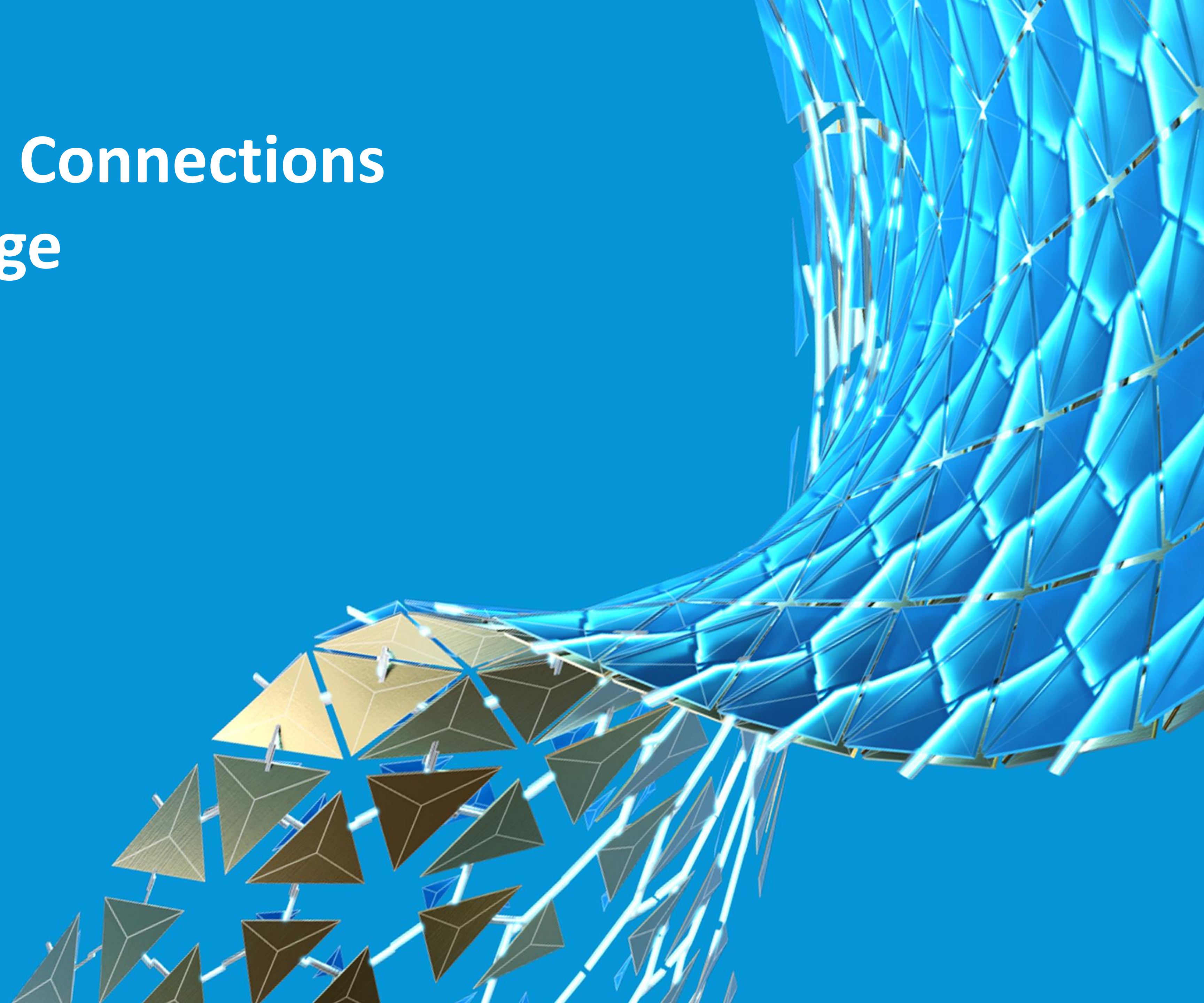
Autodesk Analytical Model 2021 Dynamo Package, Autodesk Revit 2021

- Adjust Elements Between Categories
- Adjust Elements Within Categories
- Works with Dynamo 2.6 and Revit 2021





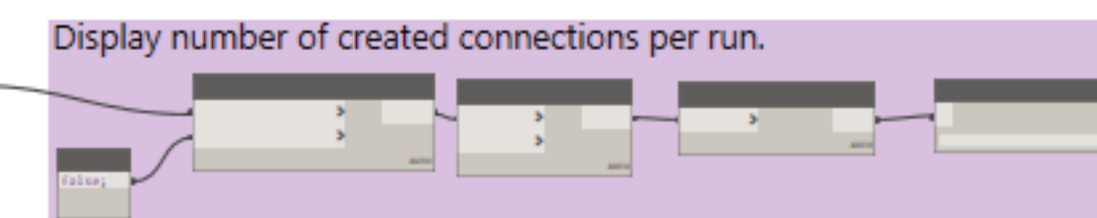
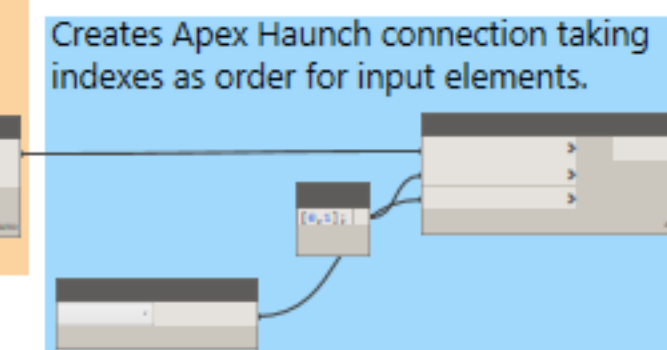
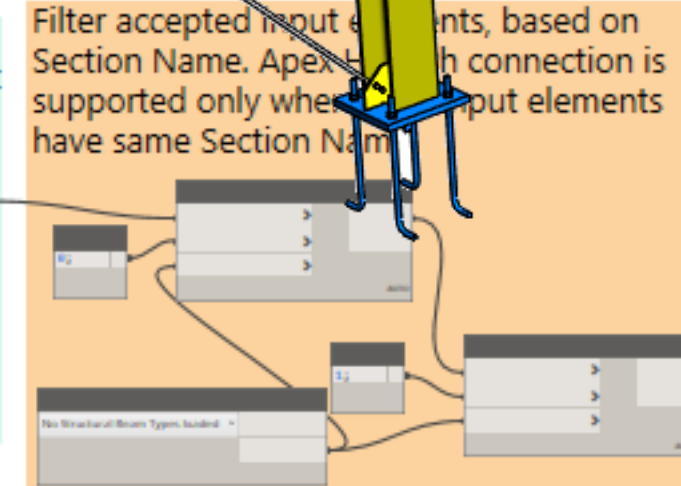
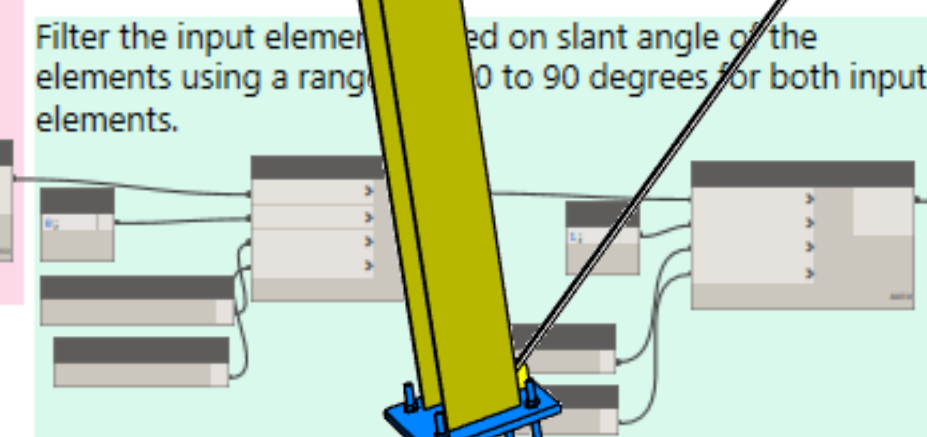
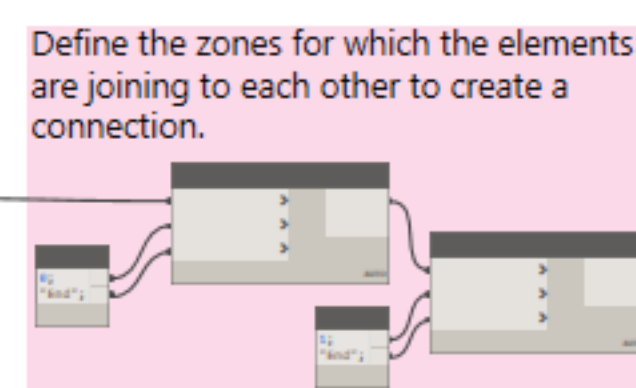
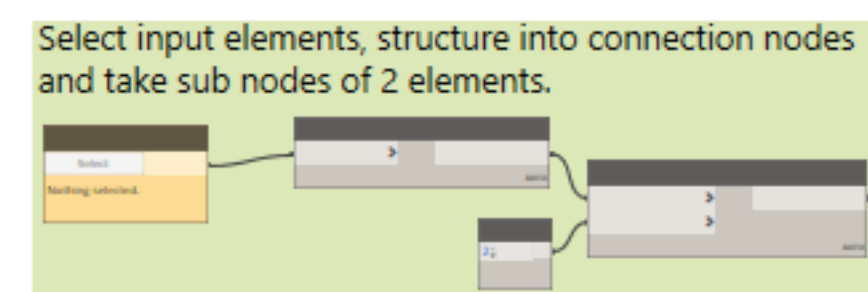
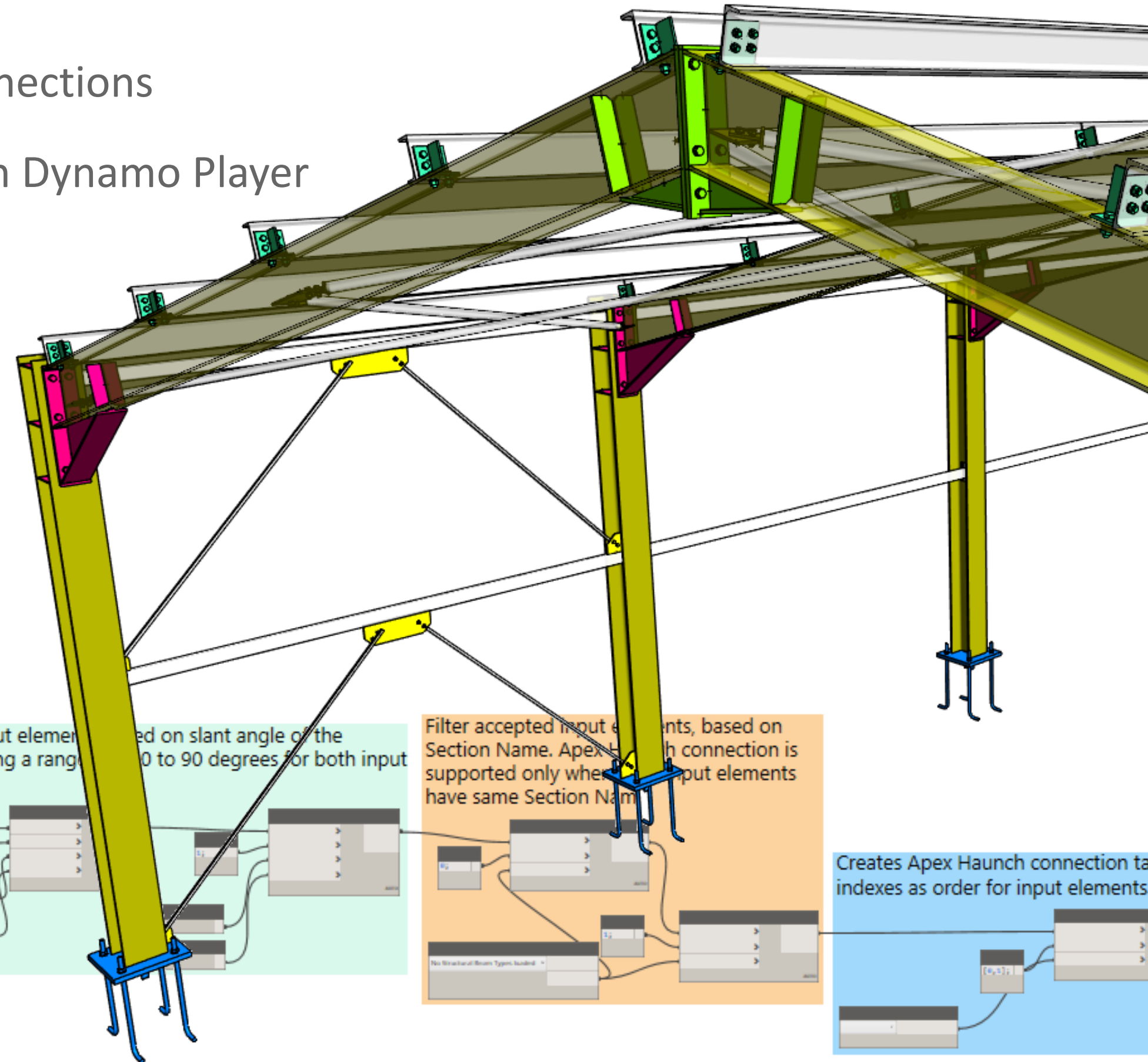
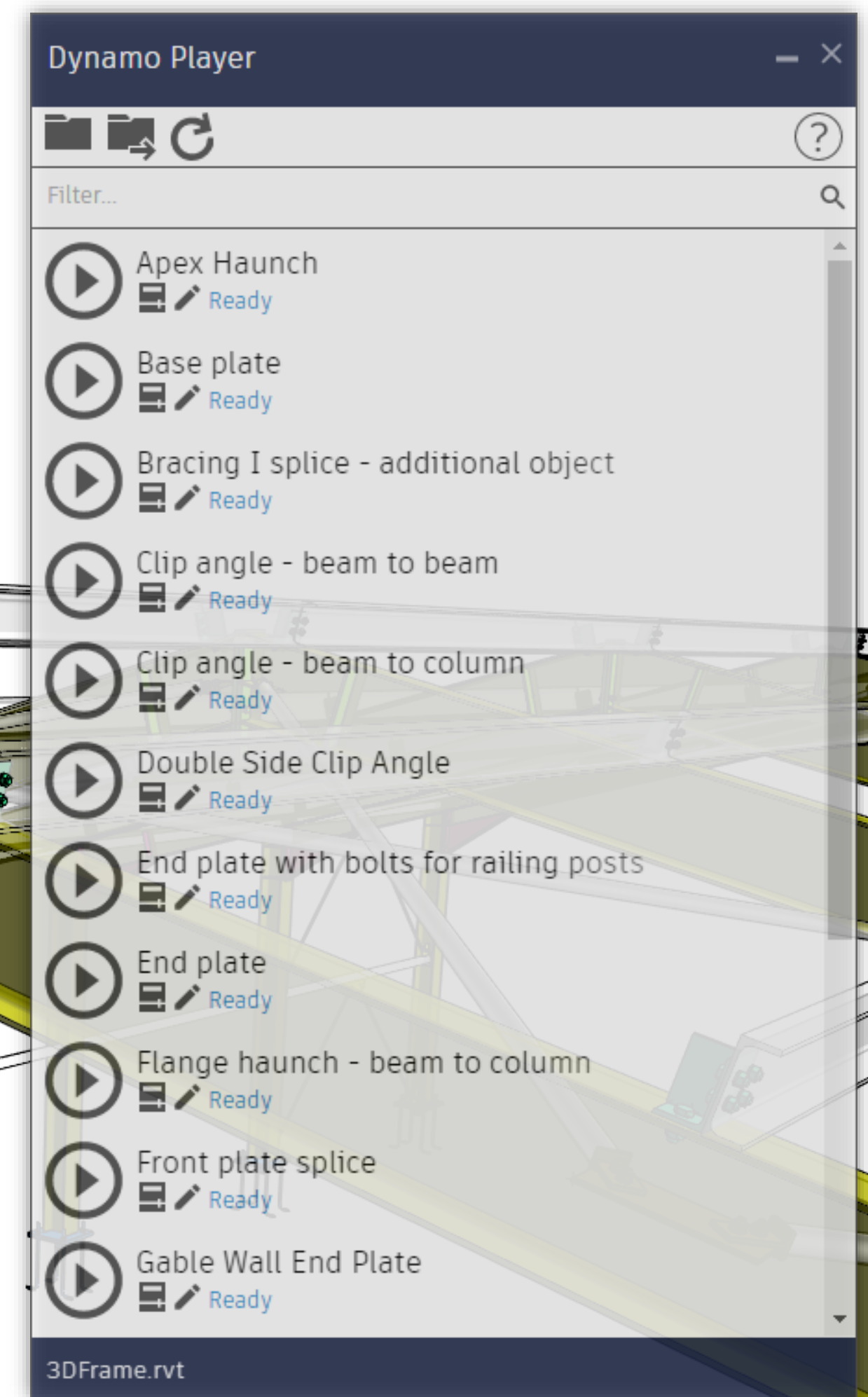
Autodesk Steel Connections Dynamo Package

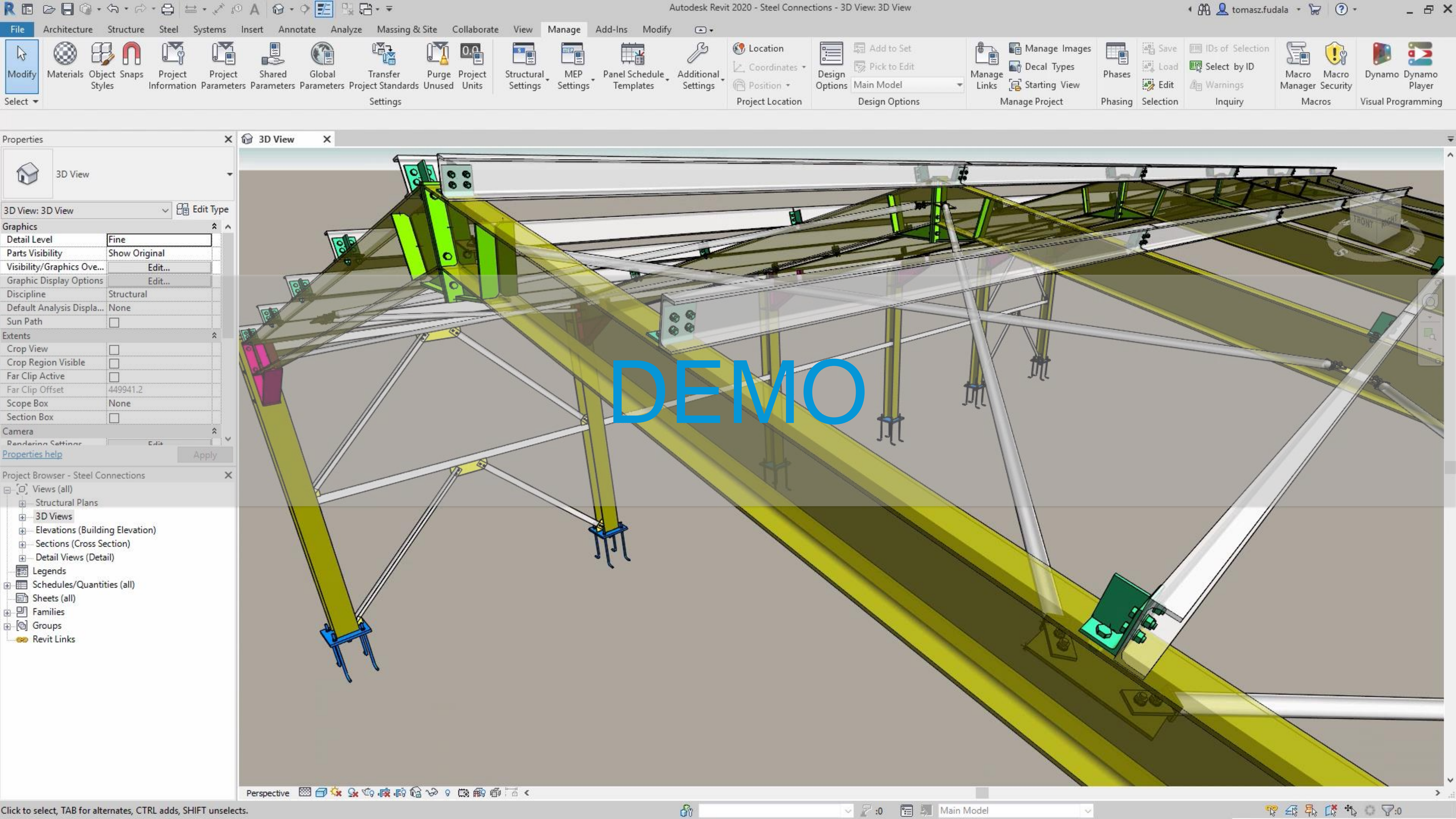


Automation of Steel Connections

Autodesk Steel Connections Dynamo Package, Autodesk Revit 2020

- **Steel Connections for Dynamo**
 - New Dynamo nodes to model steel connections
 - Out-of-the box scripts ready to be run in Dynamo Player

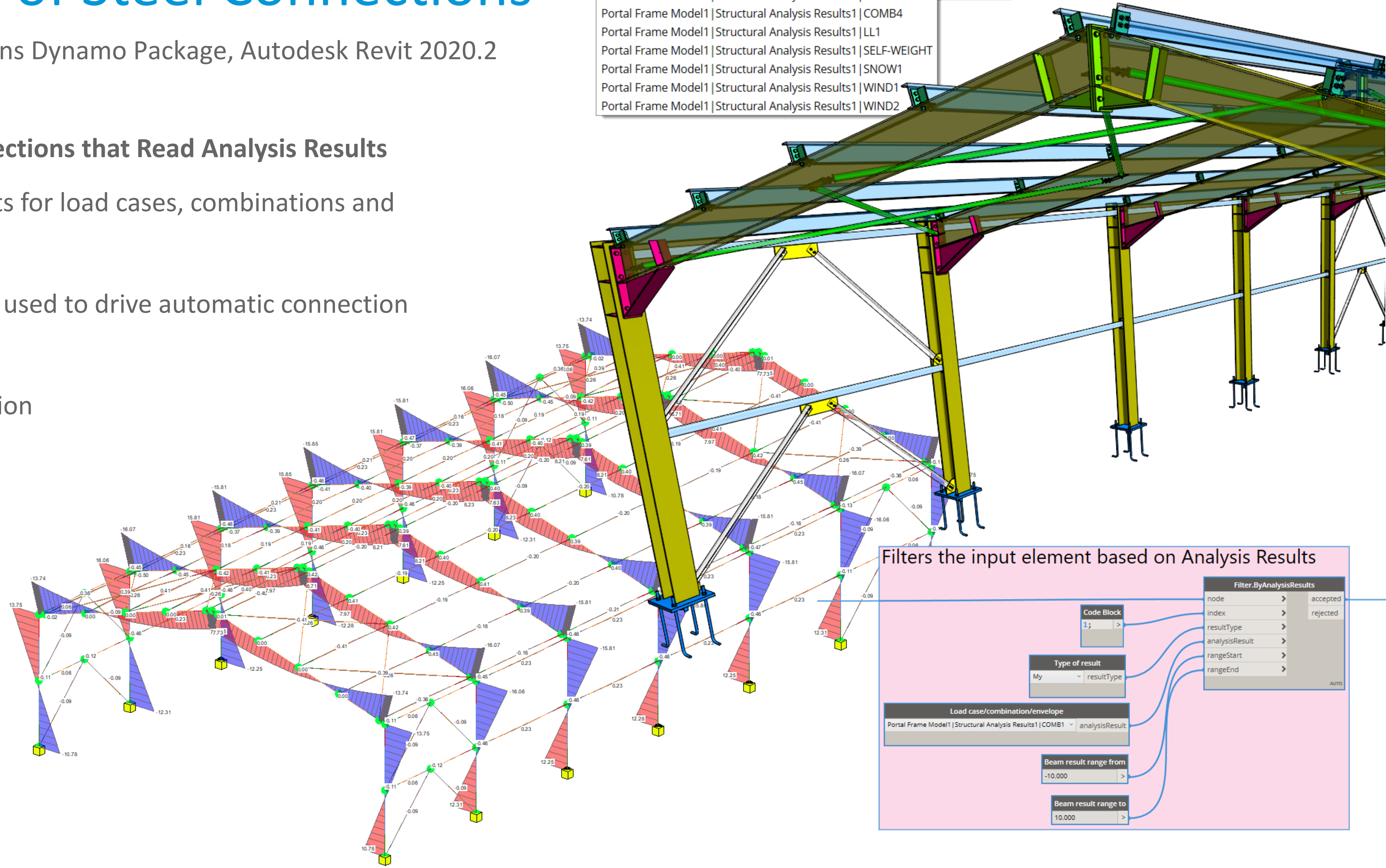




Automation of Steel Connections

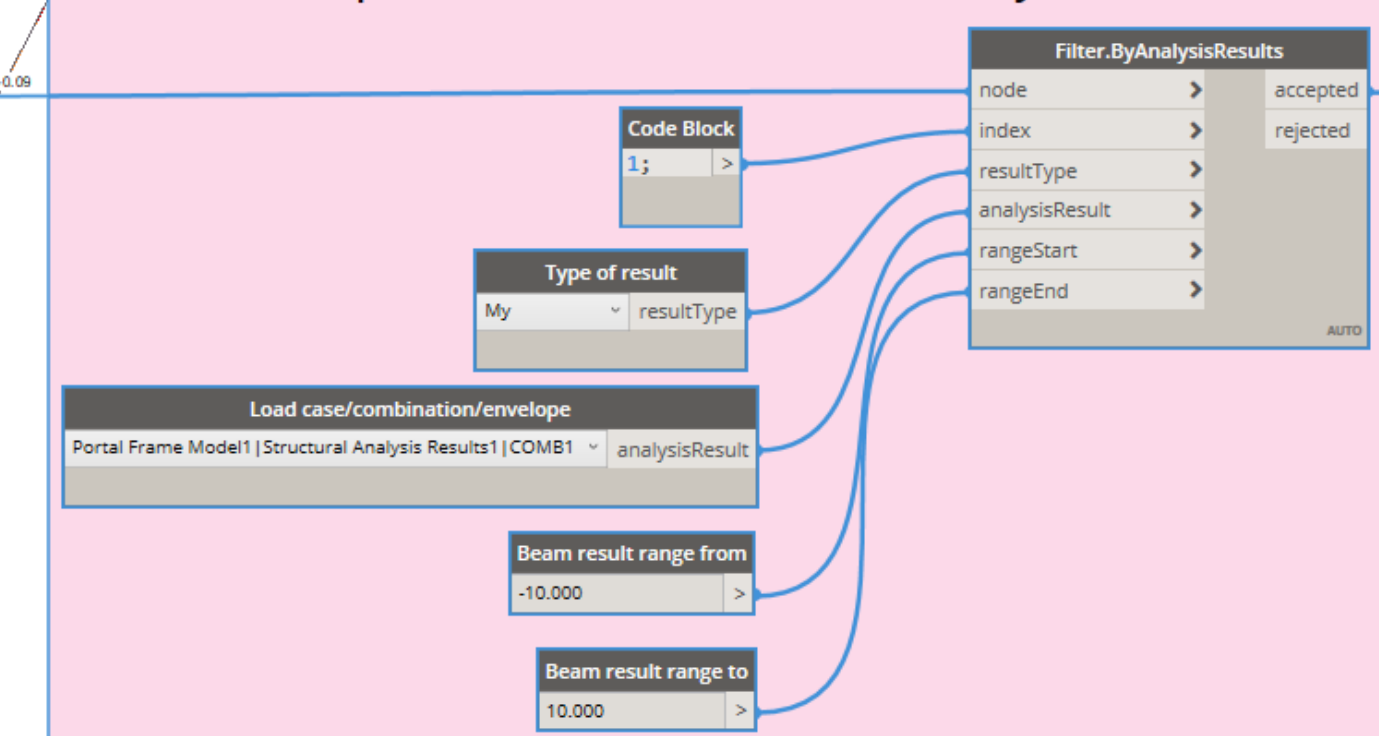
Autodesk Steel Connections Dynamo Package, Autodesk Revit 2020.2

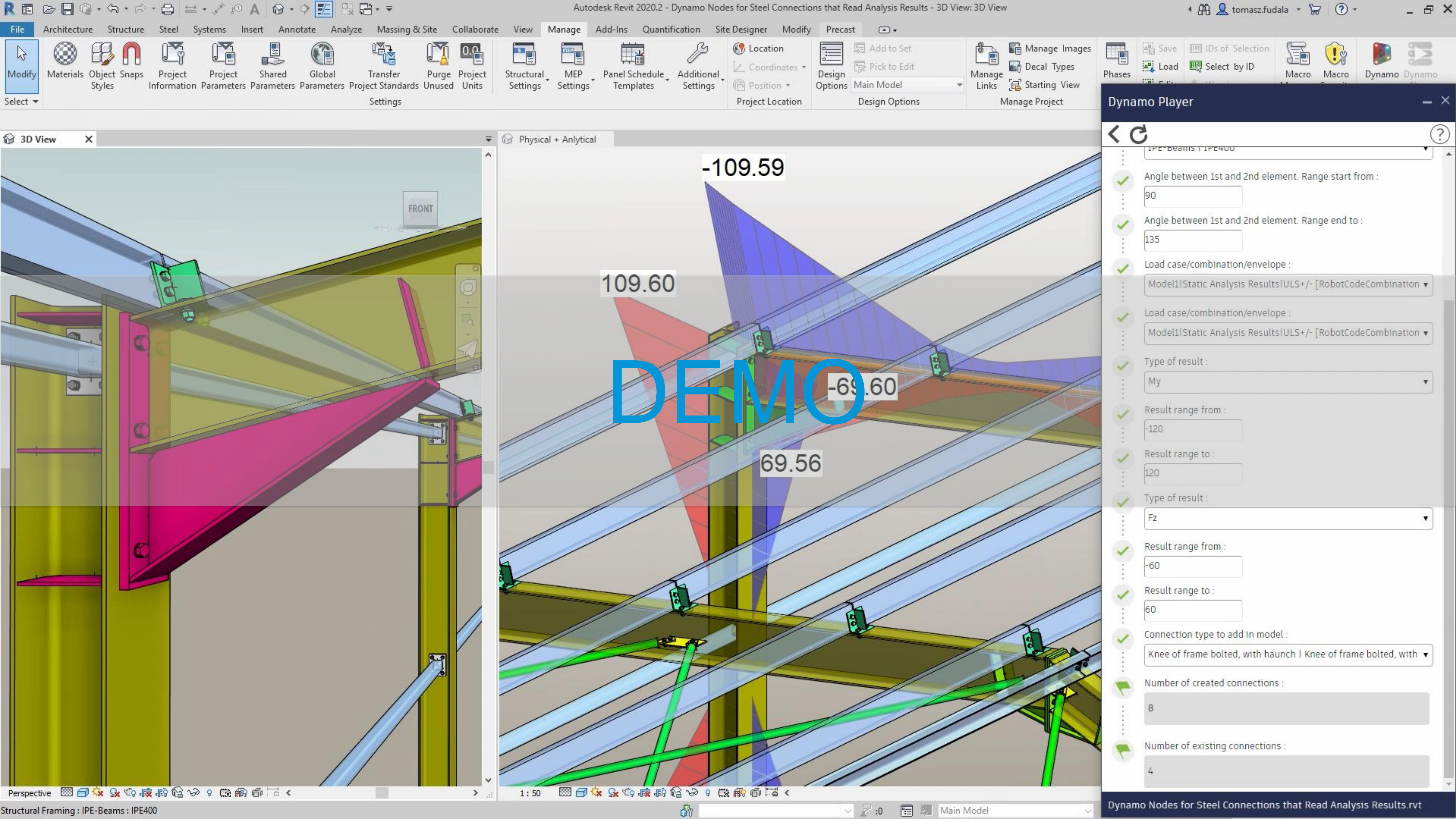
- **Nodes for Steel Connections that Read Analysis Results**
 - Read analysis results for load cases, combinations and envelopes
 - Analysis results are used to drive automatic connection placement
 - Faster design iteration



| Load case/combination/envelope | |
|--|----------------|
| Portal Frame Model1 Structural Analysis Results1 COMB1 | analysisResult |
| Portal Frame Model1 Structural Analysis Results1 COMB1 | |
| Portal Frame Model1 Structural Analysis Results1 COMB2 | |
| Portal Frame Model1 Structural Analysis Results1 COMB3 | |
| Portal Frame Model1 Structural Analysis Results1 COMB4 | |
| Portal Frame Model1 Structural Analysis Results1 LL1 | |
| Portal Frame Model1 Structural Analysis Results1 SELF-WEIGHT | |
| Portal Frame Model1 Structural Analysis Results1 SNOW1 | |
| Portal Frame Model1 Structural Analysis Results1 WIND1 | |
| Portal Frame Model1 Structural Analysis Results1 WIND2 | |

Filters the input element based on Analysis Results

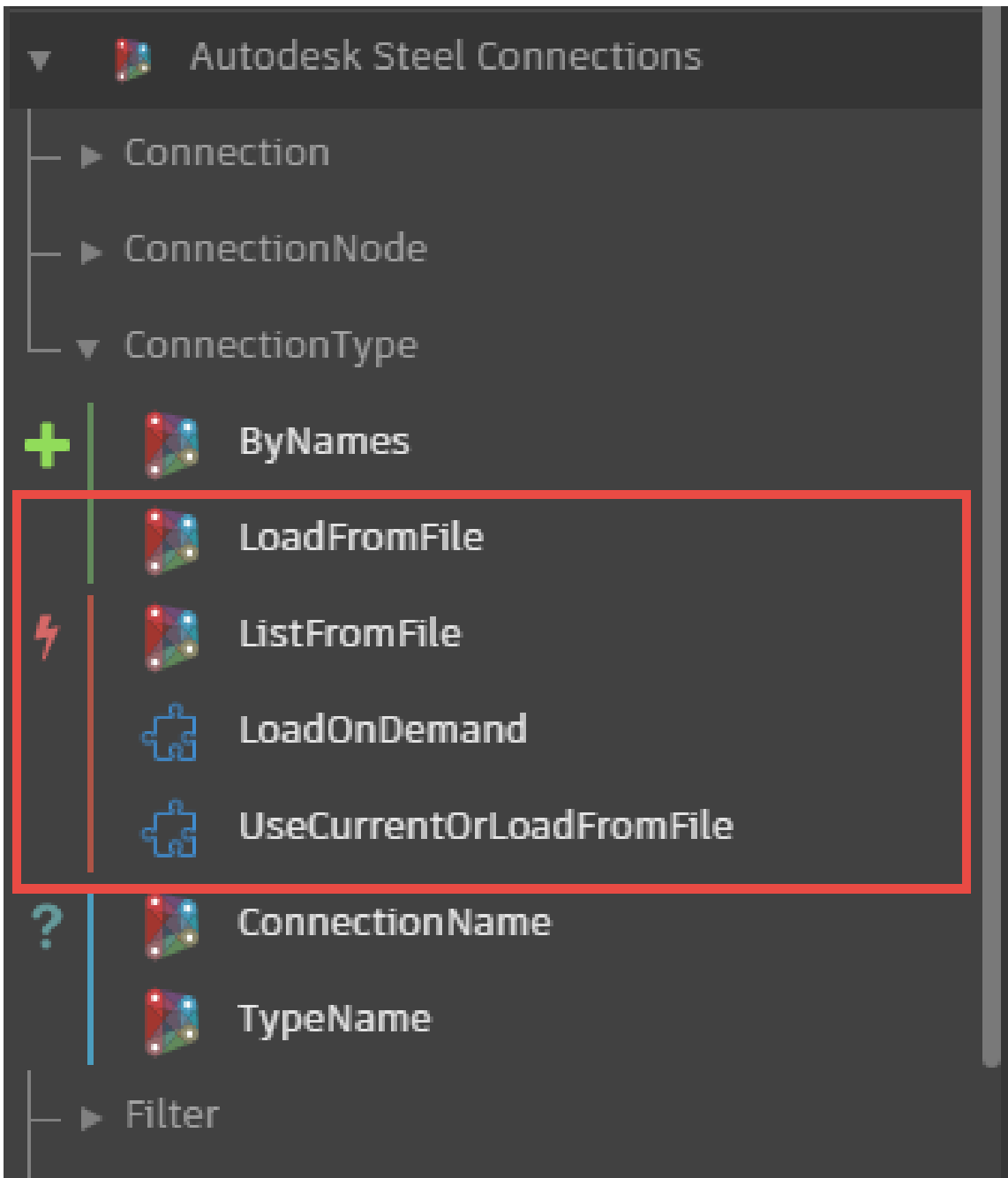
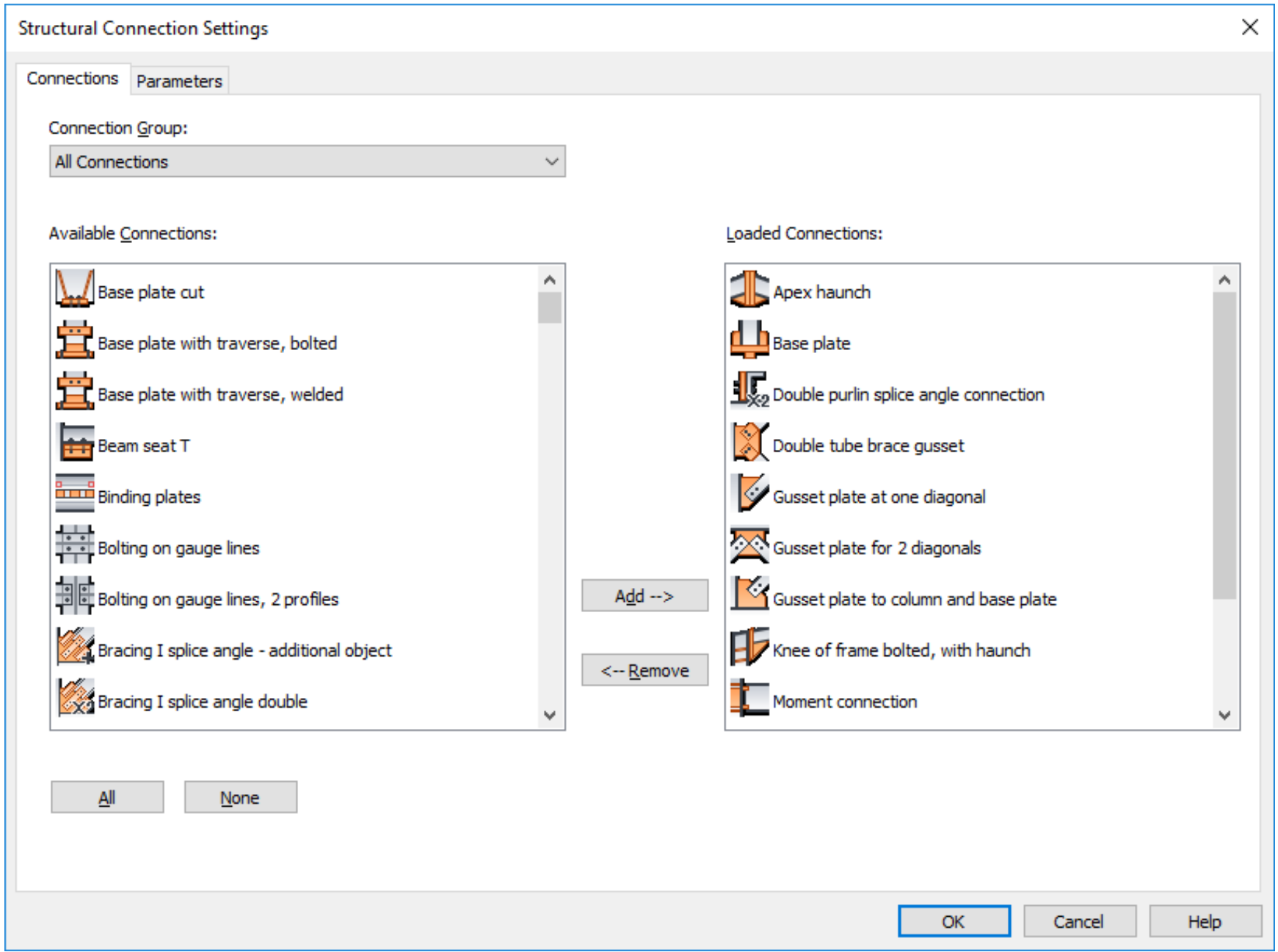
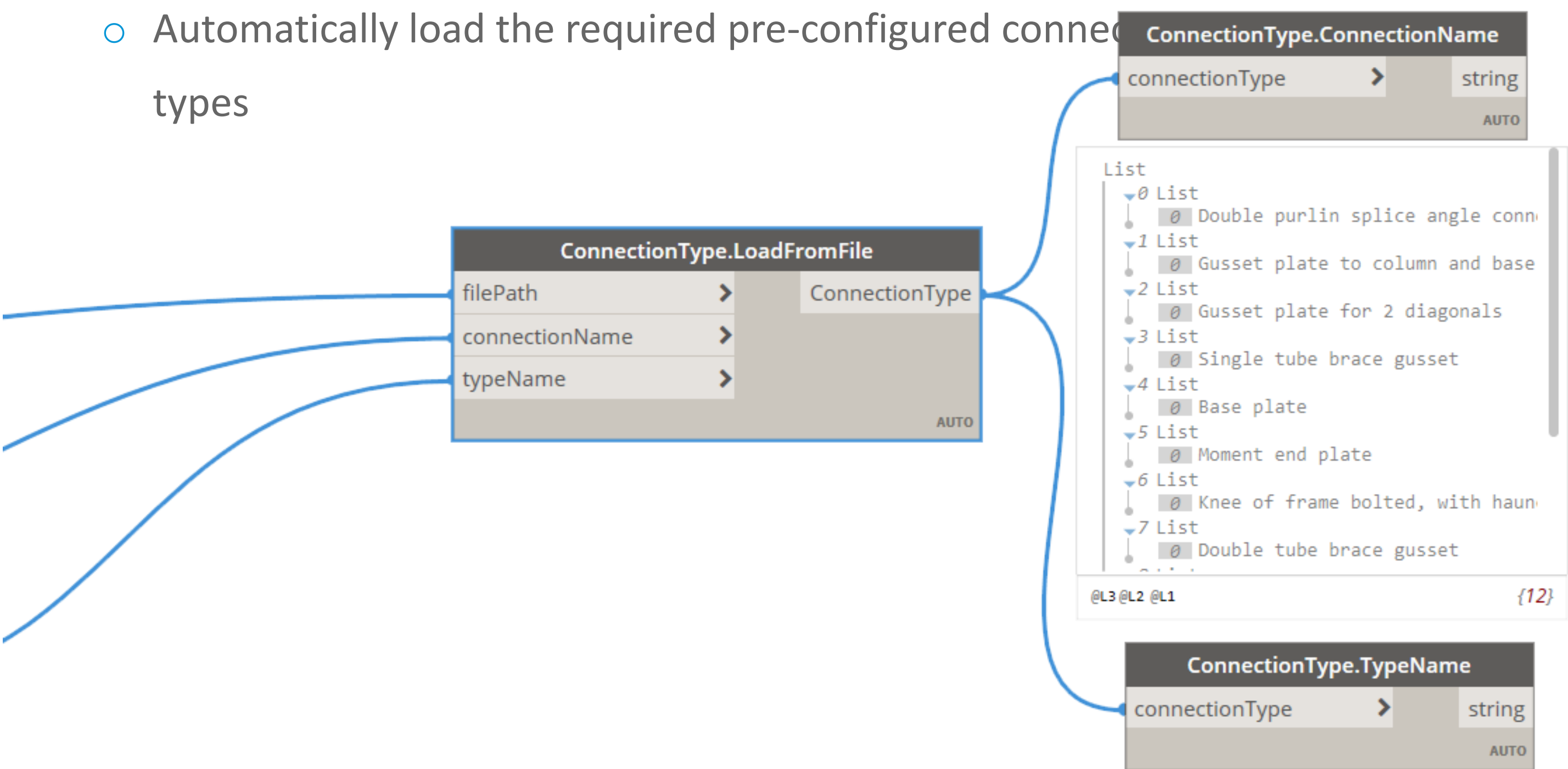


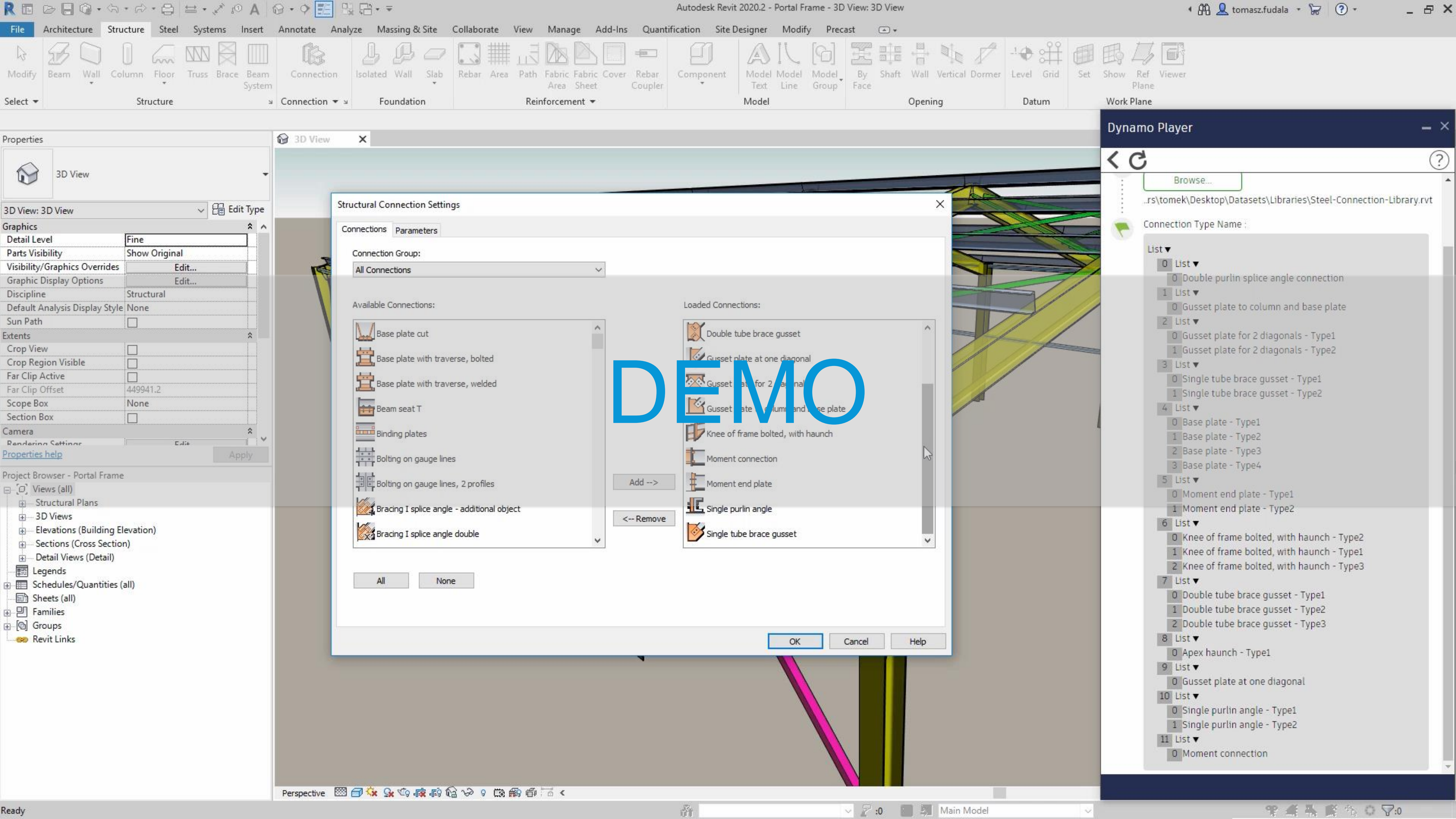


Automation of Steel Connections

Autodesk Steel Connections Dynamo Package, Autodesk Revit 2020.2

- **Nodes that Load Steel Connections from Libraries**
 - Save libraries of connections as Revit project files
 - New nodes for rule-based loading of connections from libraries
 - Automatically load the required pre-configured connection types



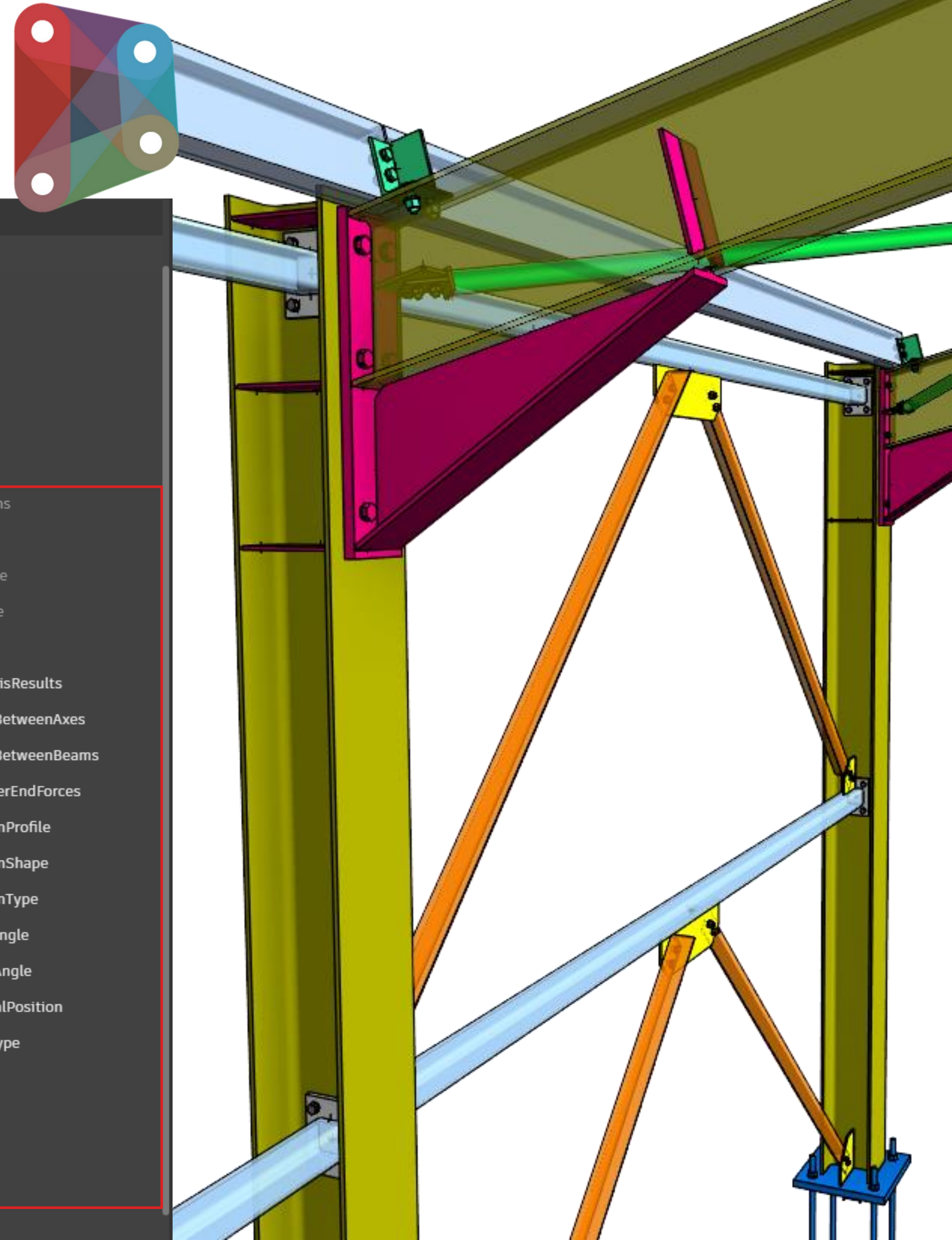
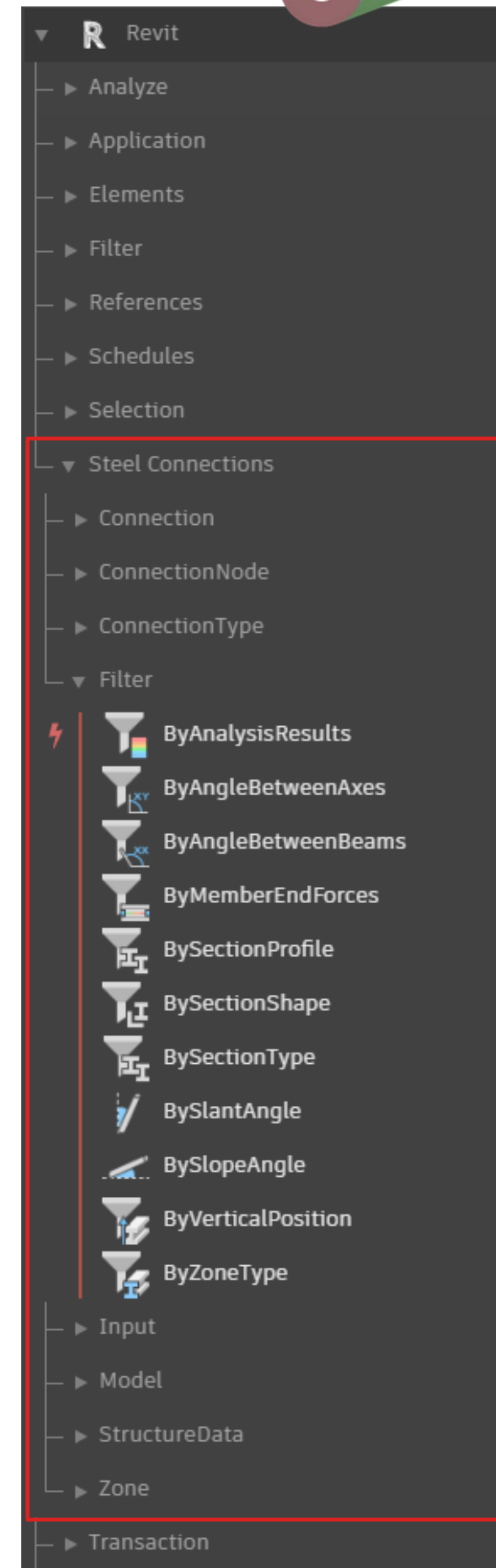


Automation of Steel Connections

Autodesk Revit 2021

- **Integrated Steel Connection Automation Nodes in Dynamo for Revit 2021**

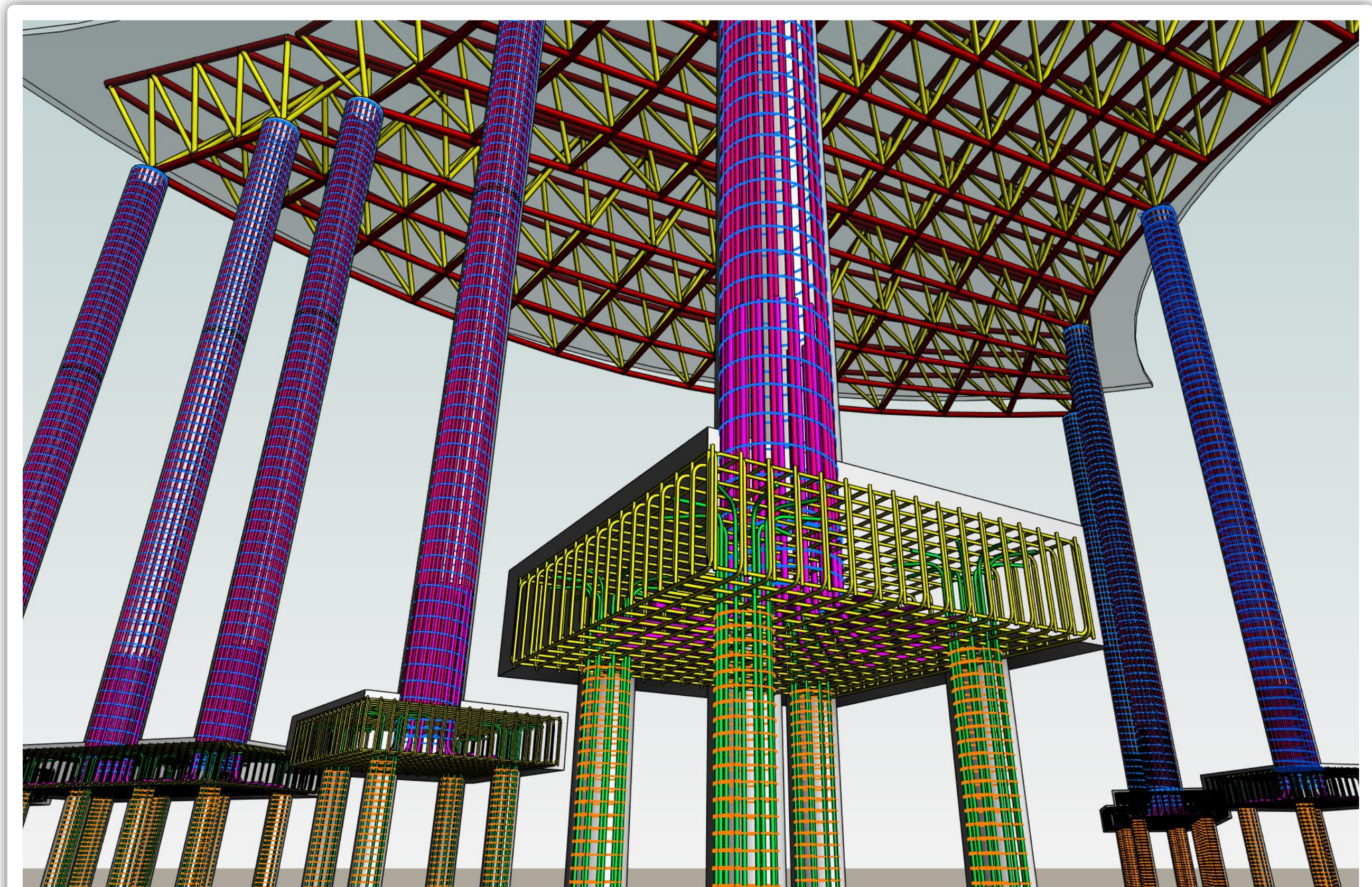
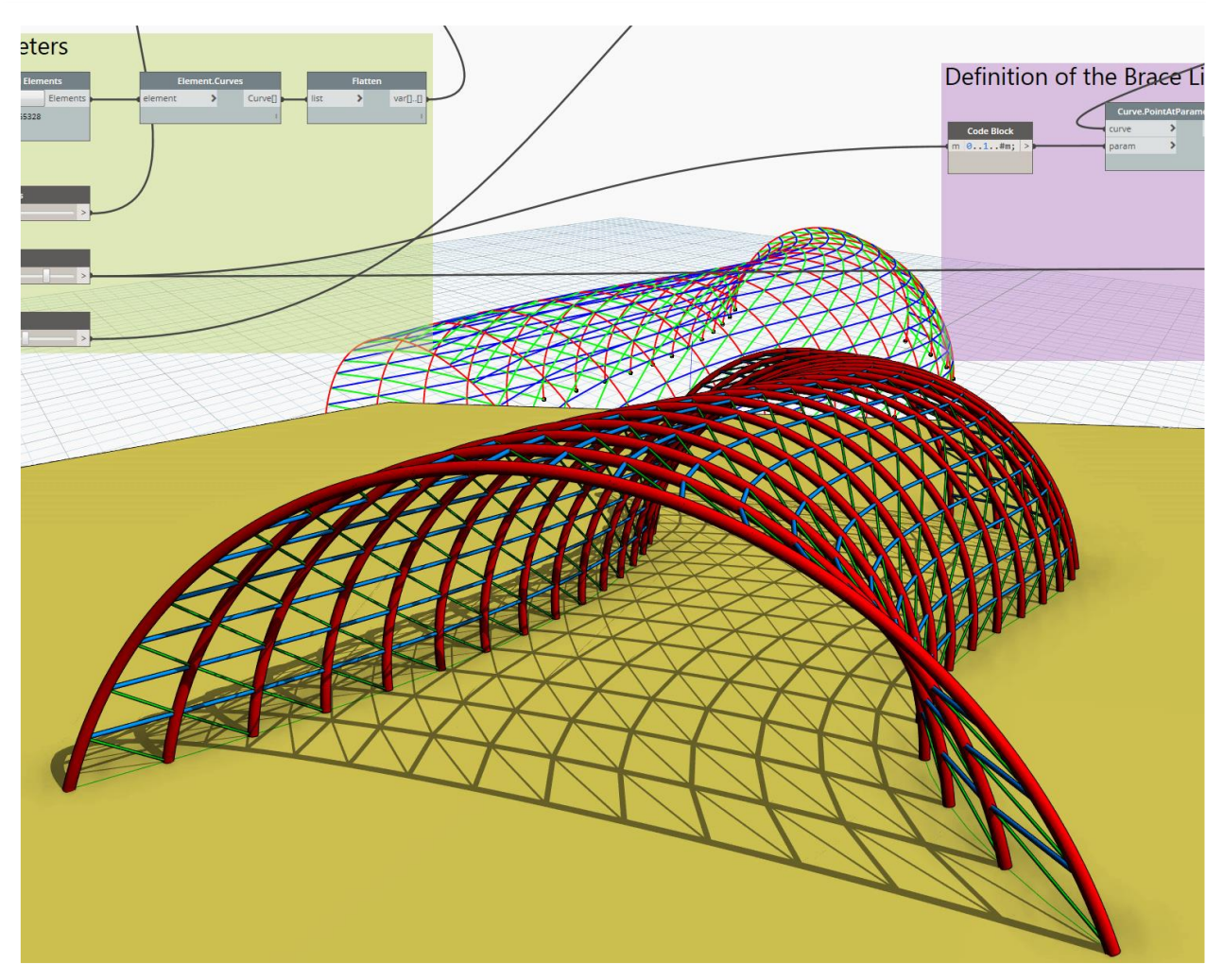
- Nodes available in Dynamo for Revit
- Thumbnail pictures for all nodes
- Sample scripts available



Conclusions

Automation of Structural Design with Dynamo

- Making your own design tools is easy
- Build optimized structures with minimal energy
- Work faster with complex structures
- Automated processes save tones of manual and tedious work, save a lot of time
- Dynamo opens a world of possibilities for all structural personas





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