AUTODESK UNIVERSITY

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BIM-Centered Workflows for Structural Analysis

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Learning Objectives

- Learn about the value of new workflows for structural analysis available in Revit 2023.
- Learn how to use the new Revit analytical modeling tools.
- Learn how to automate structural analytical modeling workflows in Revit.
- Learn about the library-based steel connection design automation available in Revit 2023.

Description

In this class, you'll learn about a completely new approach to structural analytical modeling introduced in Revit 2023 software. This approach offers structural engineers more flexibility and control over their analytical modeling, particularly for complex structures, and therefore enables fully bidirectional workflows between Revit and analysis software. Moreover, you'll learn how the new library-based steel connection design automation introduced in Revit 2023 enables you to design steel structures more quickly and accurately, using predefined and easily customized rules maximizing results of structural analysis.

Speaker(s)

Tomasz is the Technical Marketing Manager for Structure at Autodesk. He has almost 20 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. He is very passionate about computational design and generative design. He is a BIM enthusiast and a Revit API & Dynamo coder. Find him on Twitter @TomekF

Catalin is a former Autodesk customer, currently at Autodesk, working in constructions field since 2000, going through several branches of the industry, from junior unskilled worker to formwork specialist, storekeeper, project coordinator, project manager, CAD designer, structural designer. He is specialized in structural modeling and detailing. Joined Autodesk since 2014 as Quality Analyst. Currently, Product Owner for one of the teams that develops Revit and Advance Steel structural features. Since 2020, focused on connecting structural engineers to BIM environment, using Revit as coordination tools between physical model and structural analysis solutions.

Introduction

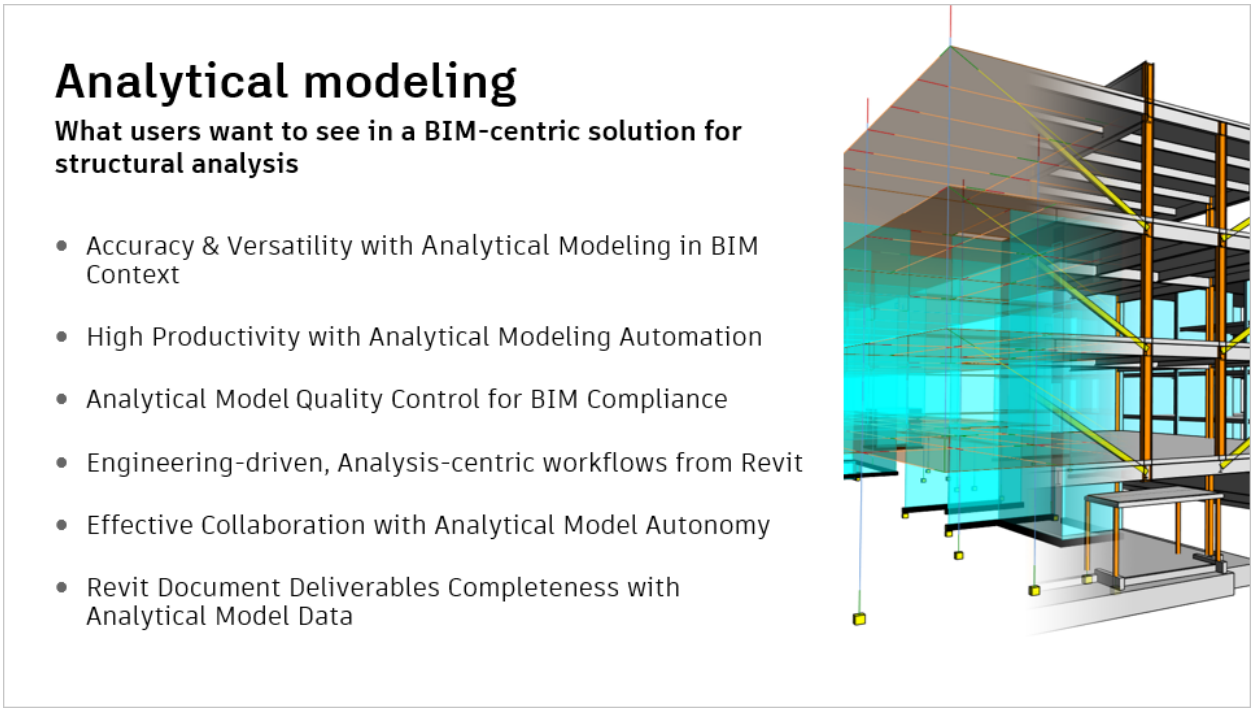
As the industry moves from CAD to BIM, structural professionals have an opportunity to capitalize on more effective project delivery workflows, increase their productivity, and reduce rework, waste, and cost. We at Autodesk are prioritizing workflows and capabilities that will help prepare structural professionals both for the challenges of today and the buildings of tomorrow. With that in mind, we are pleased to give you an introduction to our new BIM-centered workflows for Structural Analysis.

Analytical Model

What users want to see in a BIM-centric solution for structural analysis

As more and more structural engineers connect to and embrace building information modeling (BIM) workflows, there is increasing demand for analytical collaboration in BIM.

For many years now, Autodesk Revit has offered features for structural analytical modeling, but structural engineers often struggled to use them effectively. They have been looking for features that would give them more flexibility and control over their analytical models, especially while modeling non-standard and complex structures.



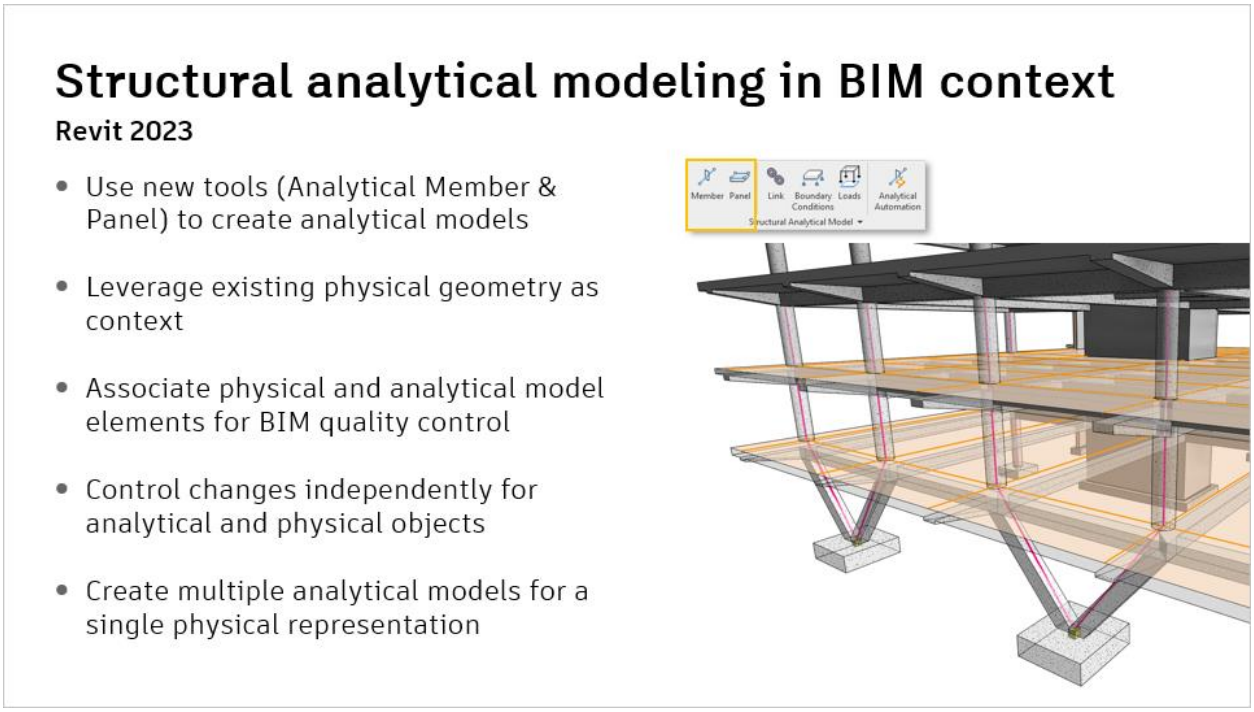
For example, engineers might want to adjust the position of a physical model easily—without changing the geometry and positioning of the associated analytical model.

We know that engineers are looking to increase their analytical modeling productivity while ensuring that their physical and analytical models are well coordinated throughout the design process.

Structural analytical modeling in physical BIM model context

To that end, Revit 2023 introduces a completely new approach to structural analytical modeling.

We have totally reimagined the structural analytical modeling workflow with the goal of helping engineers use Revit to coordinate across structural physical and analytical models and drive BIM-centric analysis workflows from there.



As before, you can leverage existing physical geometry in 2D and 3D views as context for the analytical model. The analytical model remains associated to the physical geometry but is now independent, providing you with the benefits of speed and accuracy in model creation while protecting the analytical model from unexpected changes.

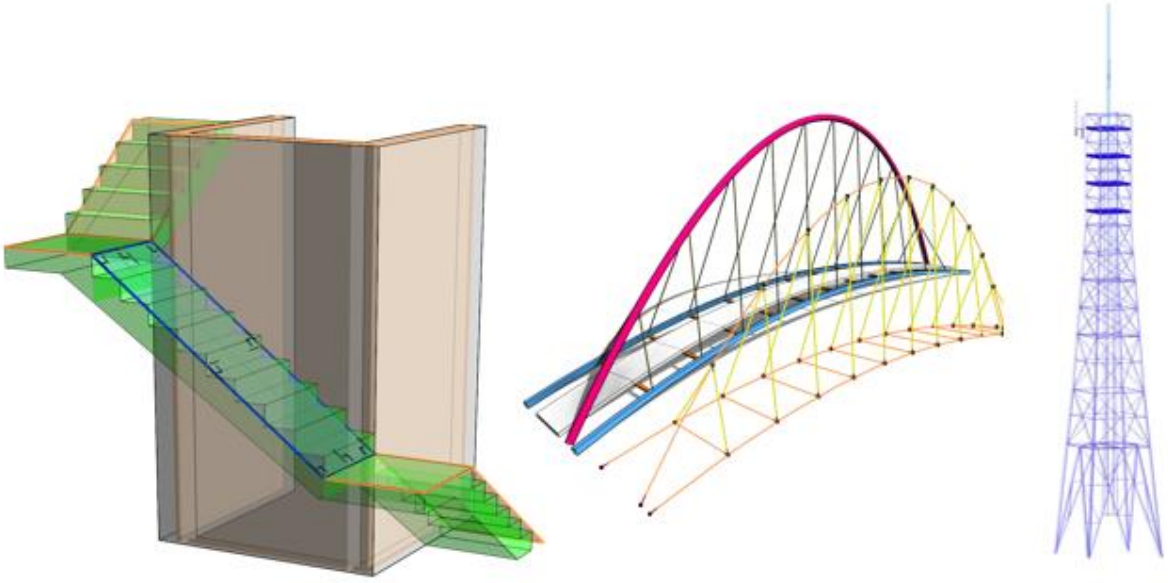
Structural engineers can now create a model with analytical members and panels in the context of the physical model and then decide what the physical-analytical relation should be as they go, element by element.

The analytical elements are now fully parametric and associated with grids and levels, enabling you to control analytical model positioning using these datums and others.
When modeling analytical elements, you can now assign their Structural Role, Type and (profile) Shape, define their Cross-Section Rotation, and specify how these elements should be analyzed.

To keep track of the relationships between physical and analytical model elements, you can easily associate them to each other. Once this is done, associated elements are highlighted upon selection.

Modeling versatility for diverse project types

This new approach to structural analytical modeling enables you to create representations for any type of structure—buildings, frames, pavilions, bridges, stairs and more. You can create consistent analytical models that align with your preferred engineering approach.

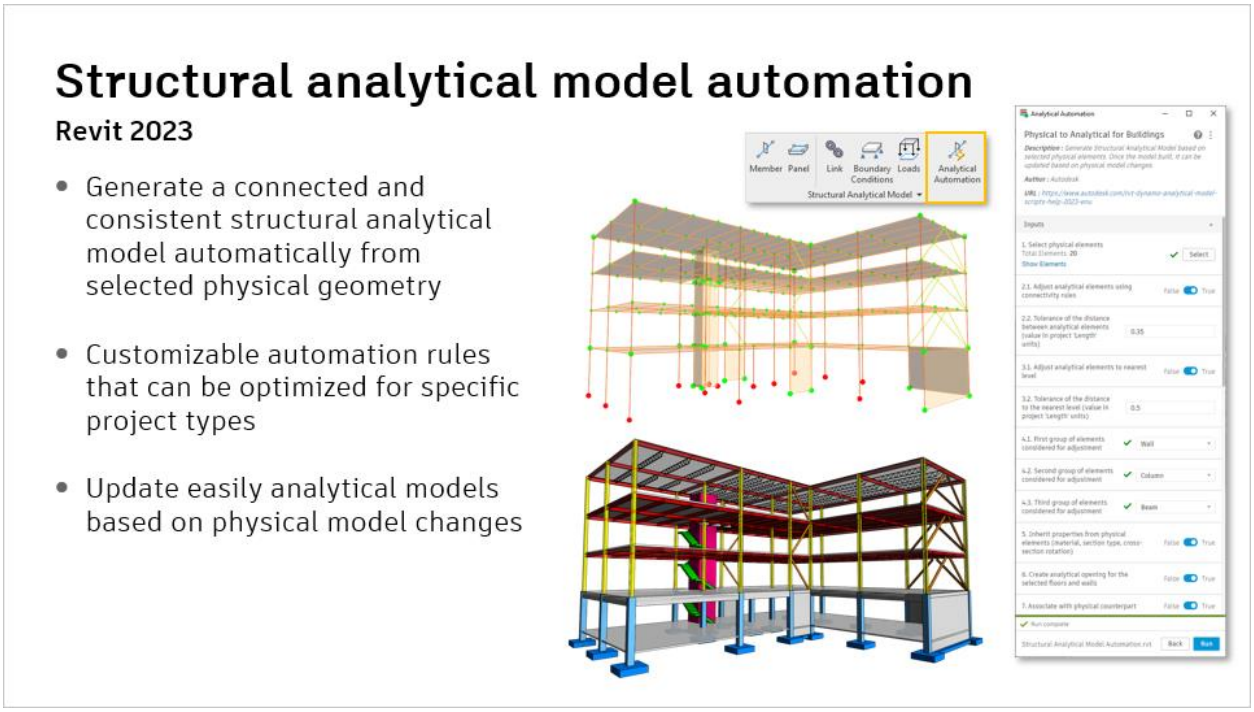


With the modeling autonomy enabled by Member and Panel objects, the analytical model can represent not just structural elements, but also generic objects, roofing structures, stairs, compound geometries, etc.

Accuracy and speed of analytical modeling automation

Revit 2023 also introduces new, rules based Structural Analytical Model Automation. The new solution ensures that automatically created model should always be consistent and connected, eliminating the need for tedious corrections and rework.
This tool enables you to generate a structural analytical model automatically from selected physical geometry, and it offers many options for customization. This tool also ensures that the automatically created model remains consistent and connected, eliminating the need for tedious corrections.

This feature offers many options for customization, including analytical adjustments prioritization per structural category and connectivity tolerances.



You can designate a first, second, and third priority element hierarchy. This is useful, for example, when prioritizing column locations over beam locations. First priority elements are the main elements, meaning that second and third priority elements will snap to them. Likewise, third priority elements will snap to first and second priority elements.

You may specify a tolerance for the distance between analytical elements.
This feature also allows you to create associations between newly created analytical elements and physical counterparts.

You can also choose to have analytical elements inherit their properties from associated physical elements, such as material, section type, and cross-section rotation.

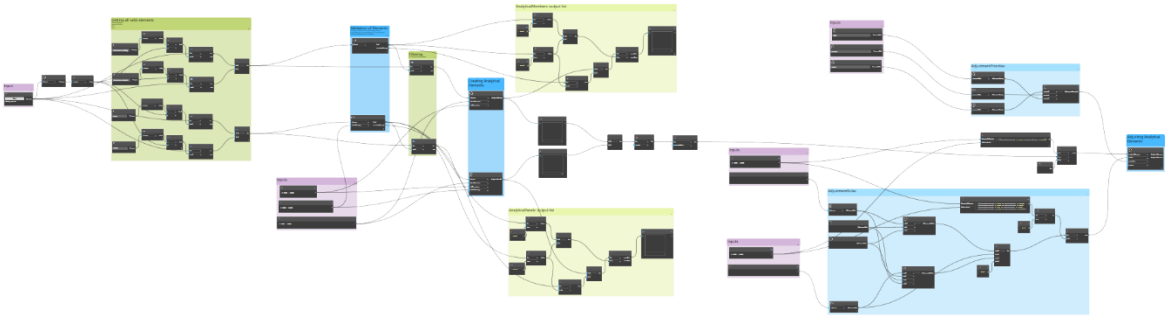
You can specify whether analytical openings should be created for selected floors and walls.

Finally, once the analytical model has been generated, it can be updated easily based on physical model changes.

Customizable automation rules

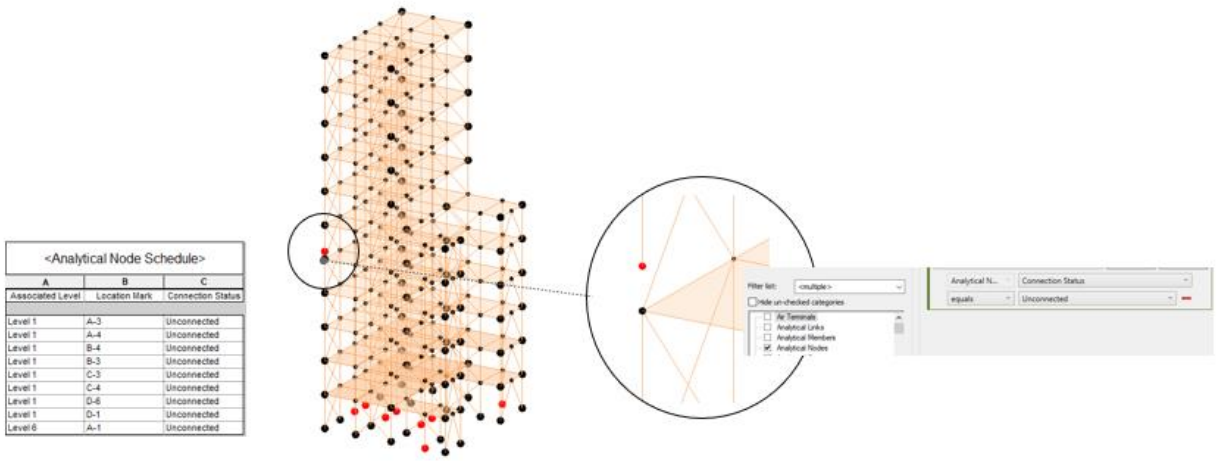
The automation logic can be customized to specific project types, whether those are buildings, pre-engineered metal building, roofing structures, bridges, etc.

Optionally, those who are skilled to use computational automation techniques can open up the automation logic and edit it in the convenient visual scripting environment of Dynamo.



Physical & analytical model connectivity and association inspection

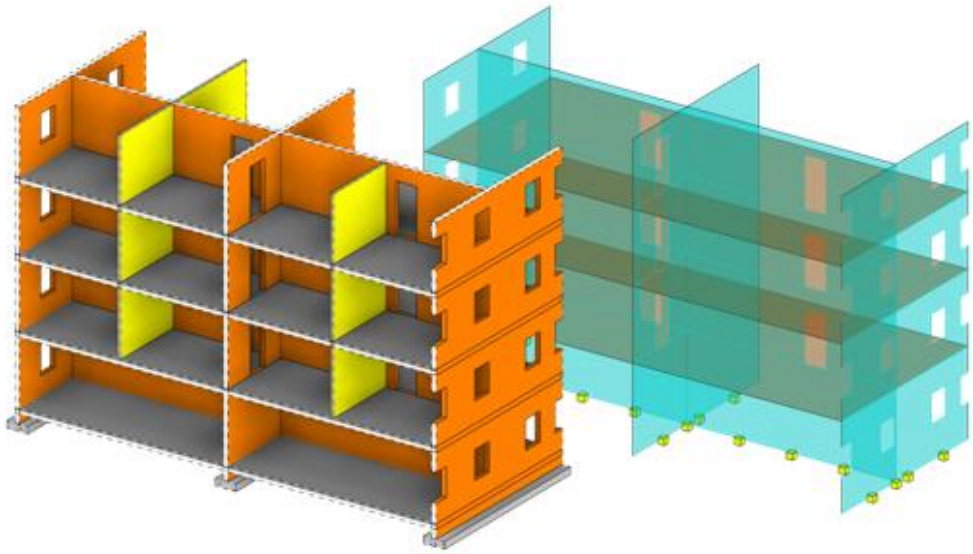
The recognition of analytical nodes status has been significantly improved in Revit 2023 and helps better determine analytical model quality.



<Analytical Node Schedule>

A	B	C
Associated Level	Location Mark	Connection Status
Level 1	A-3	Unconnected
Level 1	A-4	Unconnected
Level 1	B-4	Unconnected
Level 1	B-3	Unconnected
Level 1	C-3	Unconnected
Level 1	C-4	Unconnected
Level 1	D-6	Unconnected
Level 1	D-1	Unconnected
Level 6	A-1	Unconnected

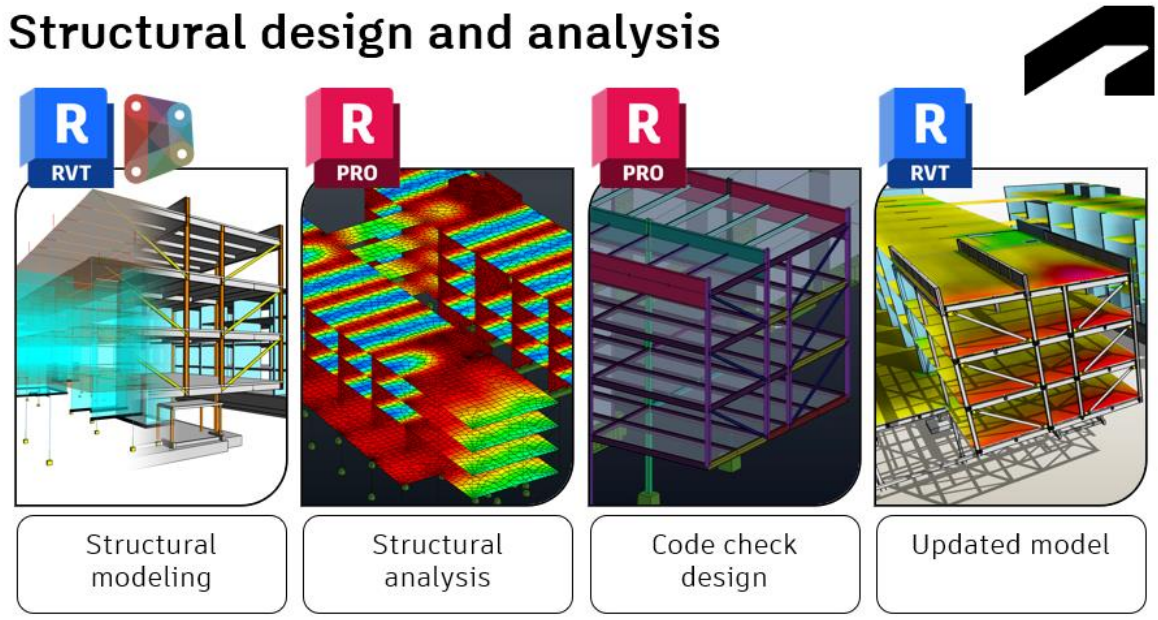
As far as the BIM model quality is considered, we can now control how analytical objects are associated to physical counterparts if needed. This helps track whether (for example) load-bearing and other model elements are respectively represented or not by analytical objects.



Bidirectional interoperability with analysis software

Now, with the unleashed versatility for analytical model geometry in Revit, true bidirectional workflows with analysis software are enabled, as Revit eliminates its own modeling limitations and can capture geometrical edits made in other tools.

The link between Revit 2023 and Robot Structural Analysis Professional 2023 software has been updated to reflect these changes that have been made to analytical modeling in Revit.



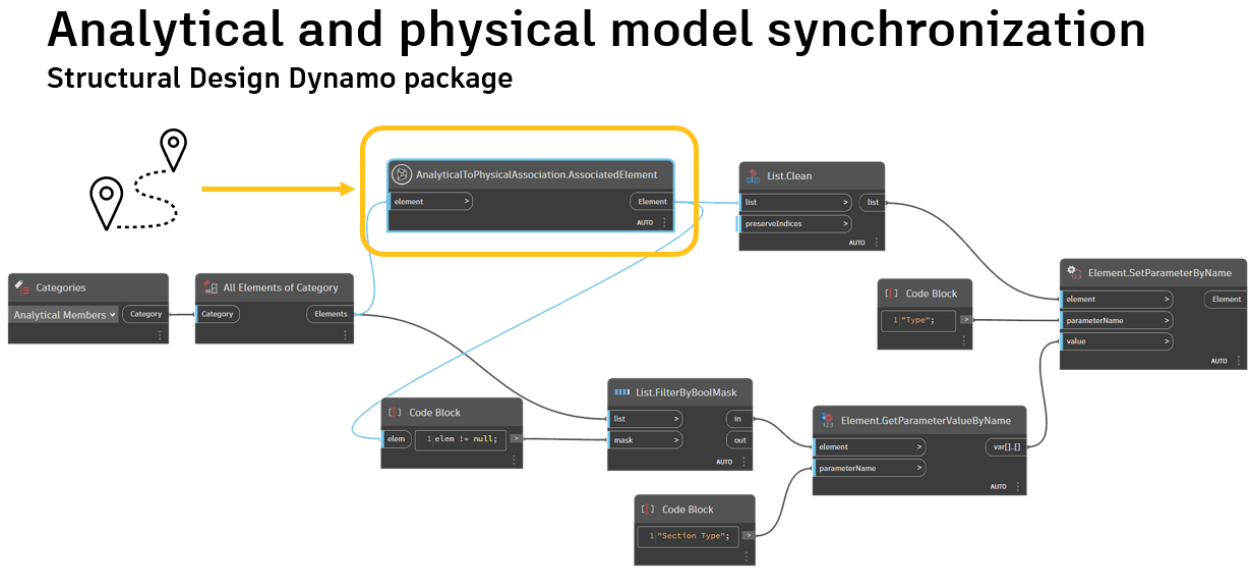
Structural engineers typically start the design process by interpreting architectural drawings, creating design documentation, and creating various analytical models. In this workflow, the structural model is created in Revit and then sent to Robot Structural Analysis software, where the structural analysis is performed. As you all know, elements of a building structure must be designed to ensure that they can resist applied loads and internal forces exerted in specific conditions. Having internal forces in Robot, you run code checking of the structure to verify and design steel, concrete, and timber elements based on a wide variety of national and international codes.

Once you have completed the structural analysis and design in Robot, this information can be sent to Revit to update the model and documentation.

The new analytical model remains associated to the physical geometry but is now fully independent, having its own set of properties such as section type, material etc. Therefore, when you update the Revit model after the code design process in Robot (bringing information about updated cross sections), you will notice that the physical section types (in the Revit model) are not automatically updated. Only the analytical model section type properties are updated.

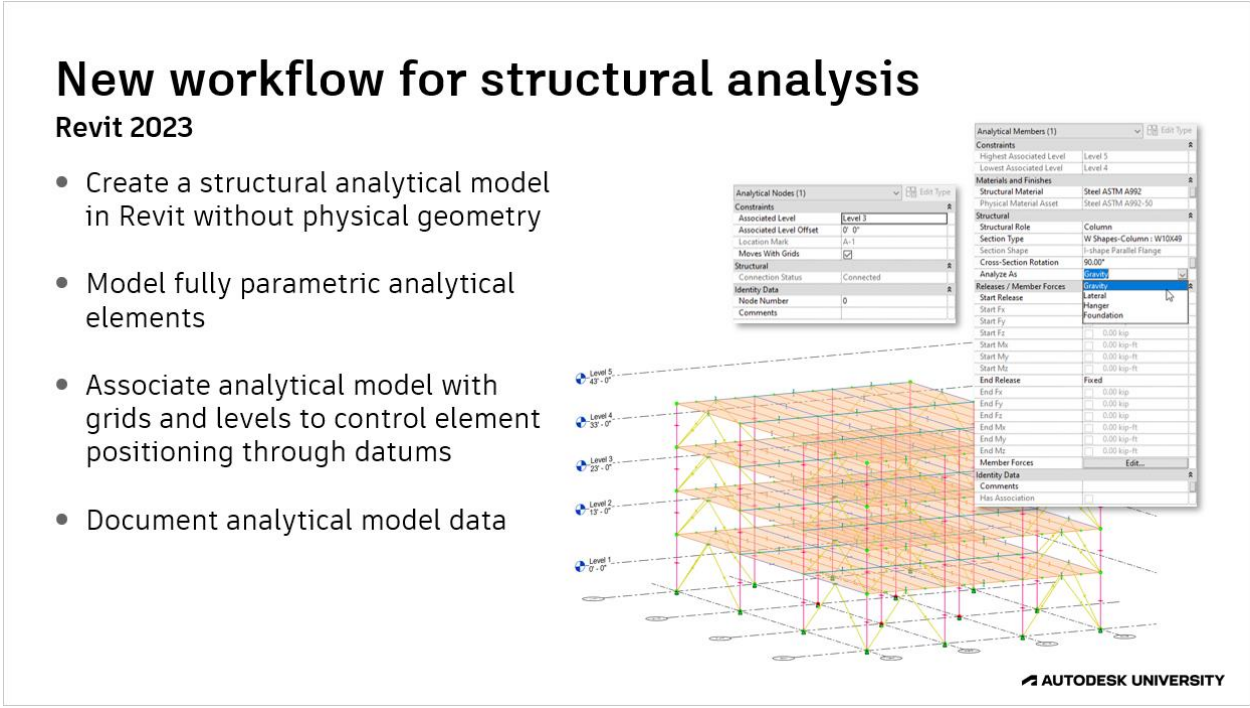
We are aware of this temporary gap in the round-trip workflow, and I would like to propose you a nice workaround how to overcome this issue.

This Dynamo script can help you propagate/synchronize cross-section information between the analytical and physical models automatically.



New workflow for structural analysis: Analysis-first Modeling

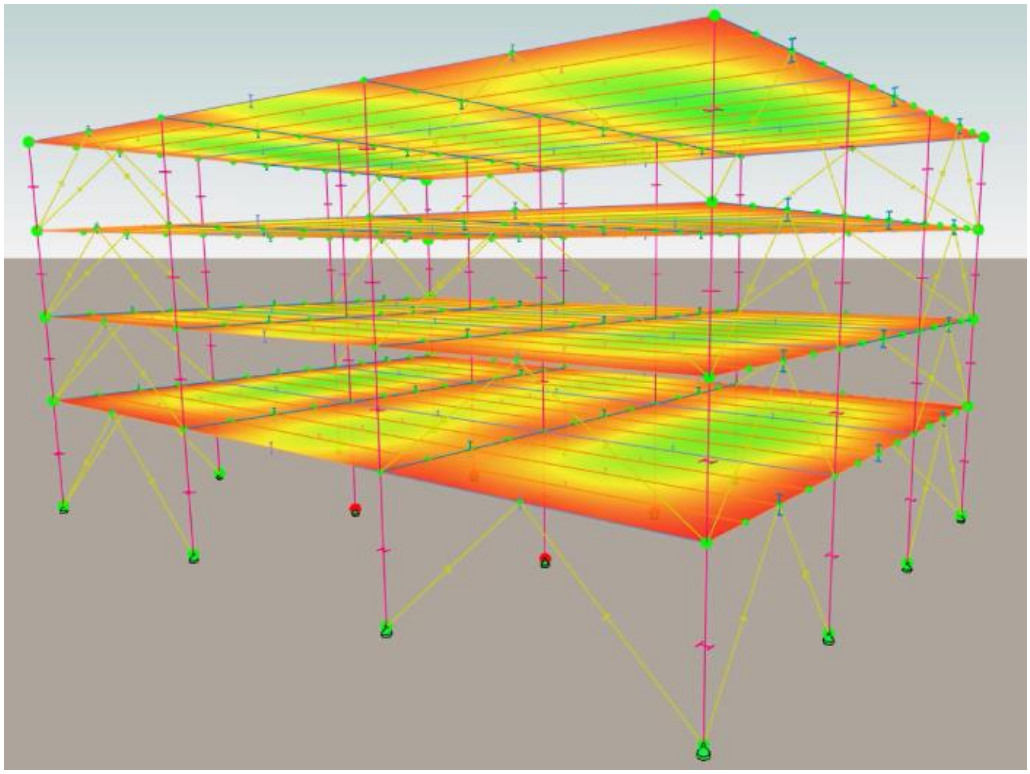
Probably the most revolutionary capability when it comes to the BIM-Centered Workflows for Structural Analysis is the fact that now we can start modeling with analytical intent. As the analytical model is now completely autonomous, it allows you to initiate structural analysis workflows from Revit without any physical geometry. Instead, you can start a new model from scratch and focus exclusively on structural analysis aspects.



Start modeling with analytical geometry first and simply add physical geometry when needed for the construction documentation and detailing phases. This workflow is especially well suited and applicable to projects where engineering requirements dictate the design.

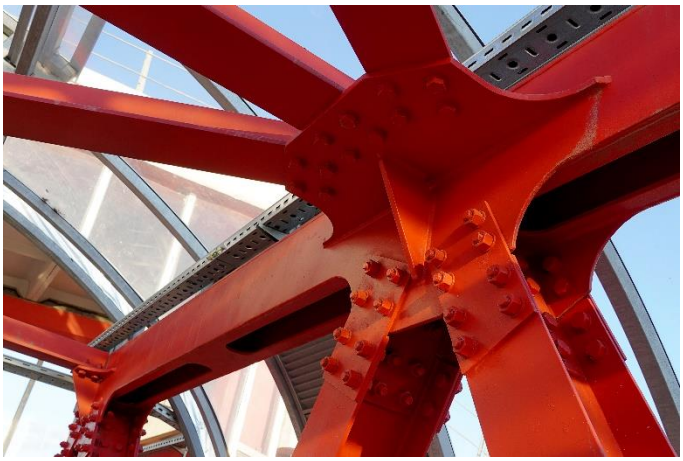
In Revit, analytical elements are fully parametric and associated with grids and levels, enabling you to control analytical model positioning using these datums and others.

You can also Control Analytical Layouts Through Global Parameters, Combine Analytical Objects with Groups, Define Analytical Objects Dependencies Through Parameters (Constraints, Shared Parameters, Global Parameters, etc.)



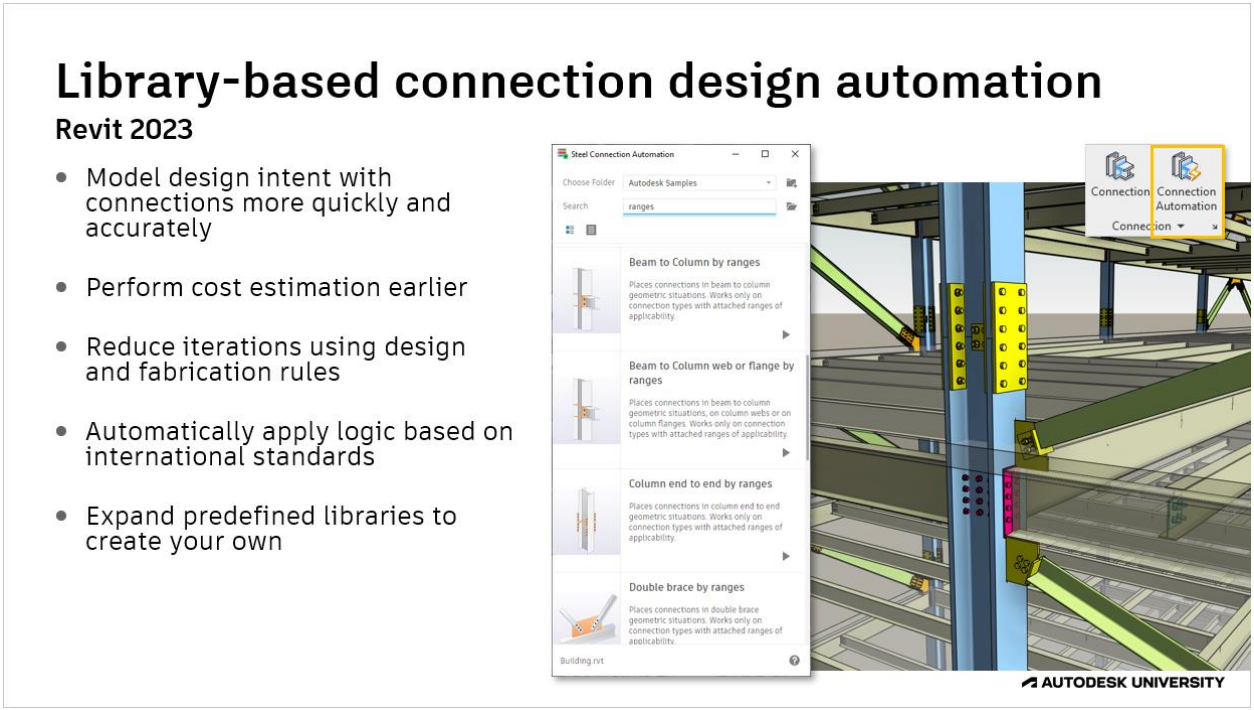
Library-based Steel Connection Design Automation

Finding the optimal sizes for the structural elements is not trivial, and it is so time consuming to come up with good steel connections for every new design.



Imagine the tools that were out there about a decade ago: disconnected across design and modelling phases, worksharing was in its early days, and there was no proper BIM solution that could have embedded all the details that engineers must handle in their minds.

Now, with Revit 2023, you have access to new library-based steel connection design automation features.

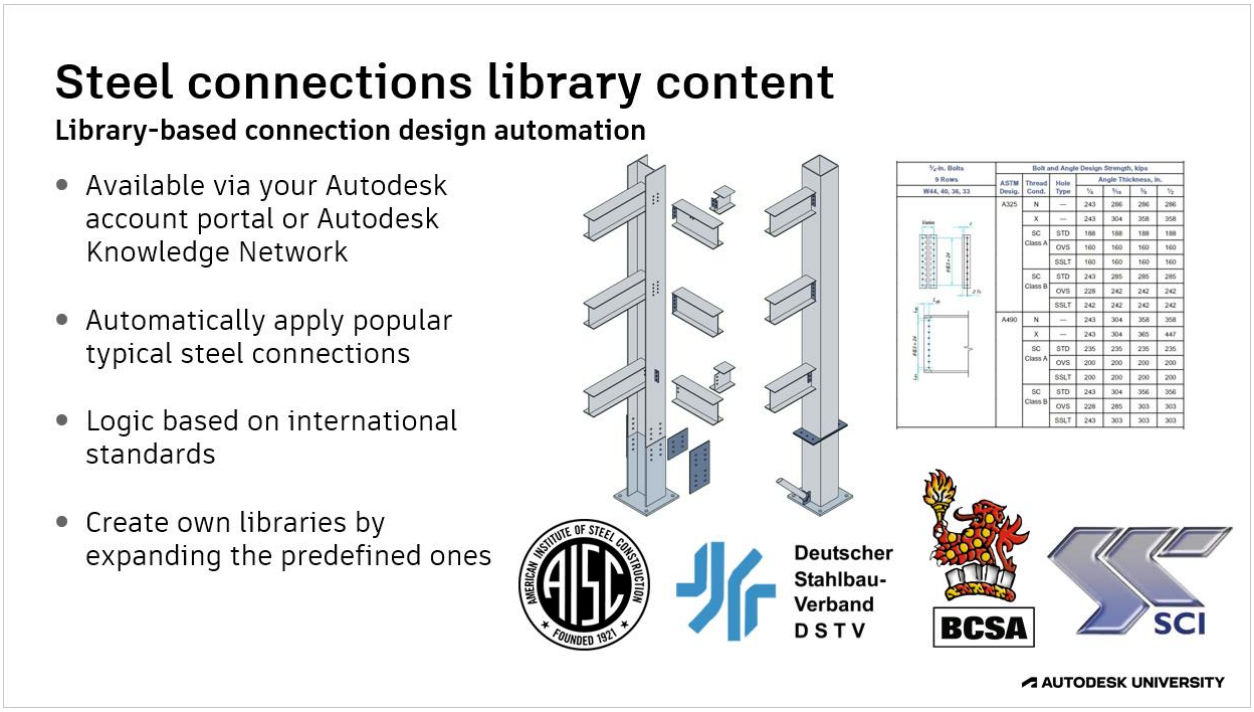


These tools will help structural engineers working with typical steel buildings work faster and more precisely, enabling them to spend their time on more valuable tasks.

Structural engineers and fabricators can blend their own specific rules into libraries of connections, which will serve as the single source of information for all new projects.

Steel connections library content

With Revit 2023, you will find sample libraries of steel connection types, configured according to commonly used engineering standards. These have embedded associations between the connections proposed by the tables from the standards, the steel profiles to which they fit, and the ranges of compatible member end forces. Single- or double-angles, shear end plates, seated connections, column splices, base plates, fin plates and many more typical connections like these are included in various Revit 2023 content packs and available via your Autodesk account portal or the Autodesk Knowledge Network.



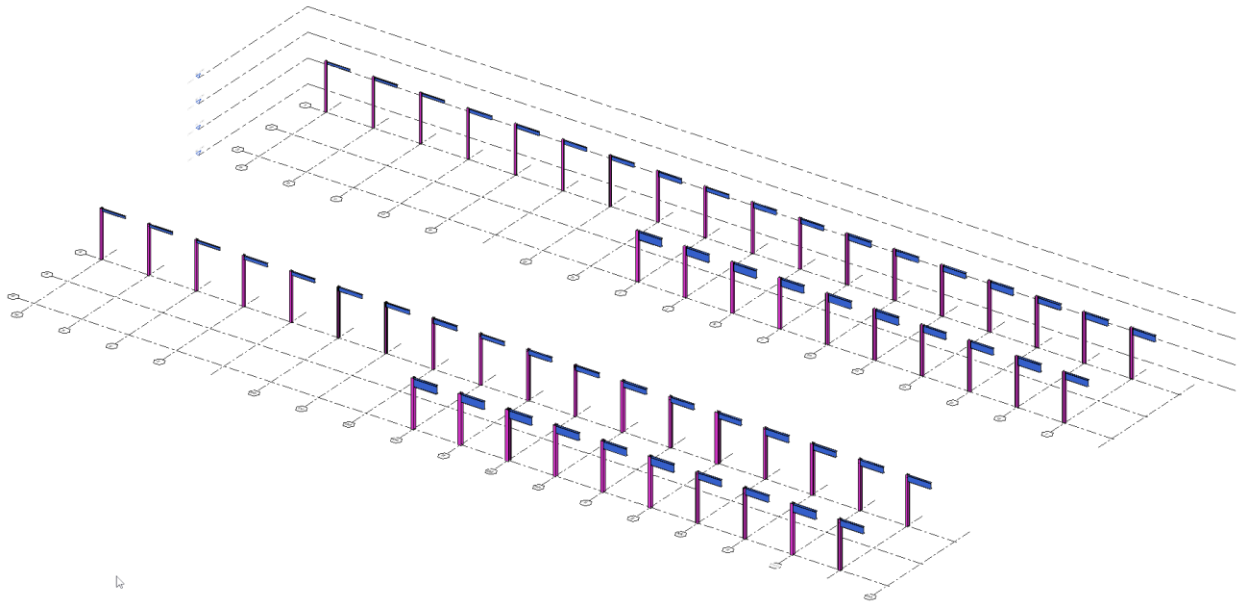
At this moment you can find:

- the AISC Steel Construction Manual 15th Edition and 14th Edition,
- the BCSA and SCI publication P358 – “Joints in Steel Construction – Simple Joints to Eurocode 3” – 2014 Edition (also known as the Green Book),
- and the German DSTV – “Standardized Joints in Steel Structures to DIN EN 1993-1-8” (“Typisierte Anschlüsse im Stahlhochbau nach DIN EN 1993-1-8”) – 2013 Edition.

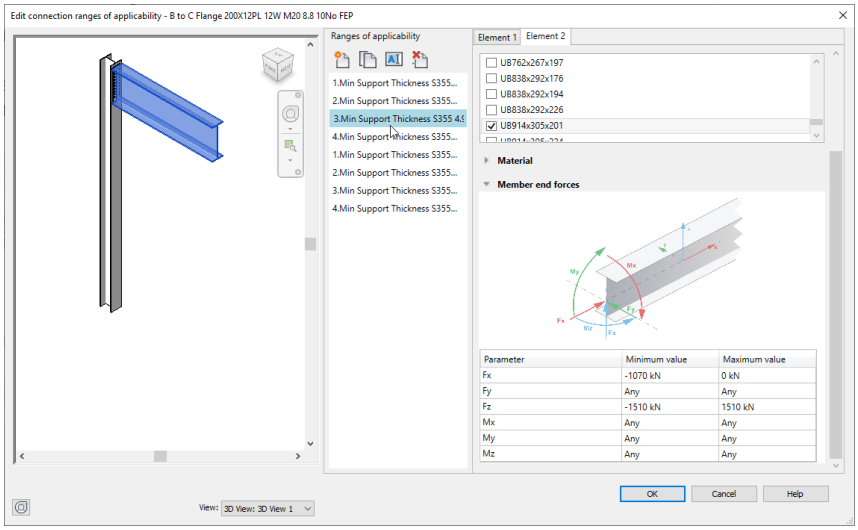
Customization of steel connection libraries

No worries if you don’t see libraries that would be valid in your country.

You can take the libraries shipped by Autodesk and duplicate or edit existing connection types to expand and customize your own.



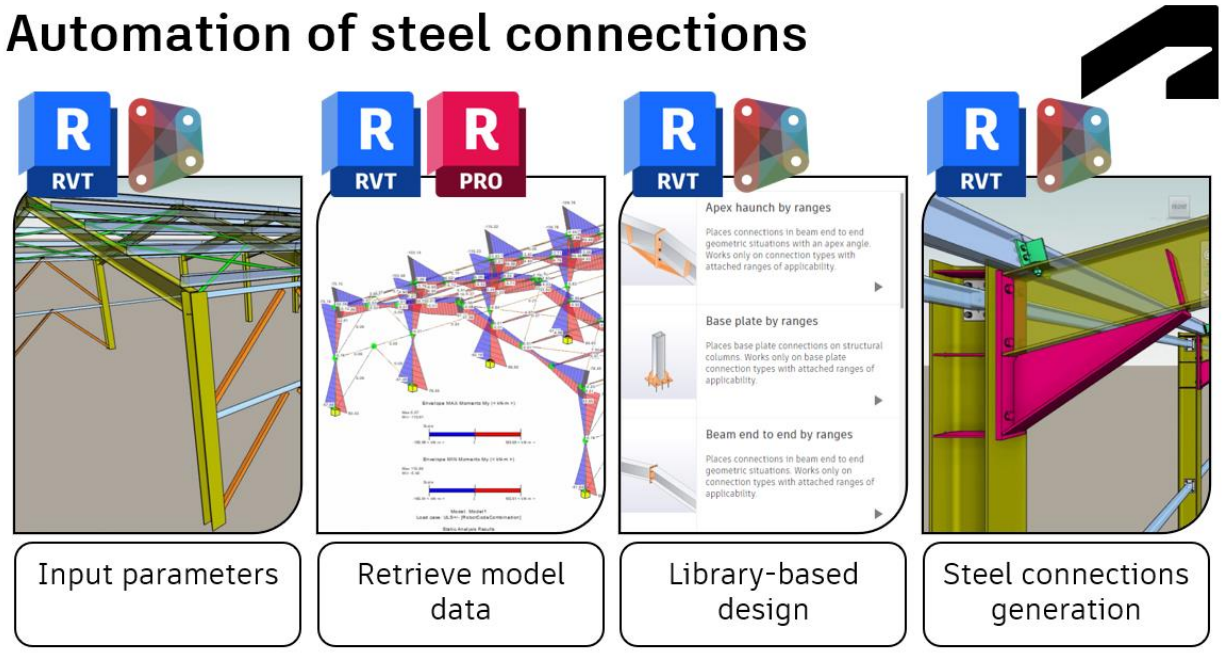
The “Associate Connections with Profile Sizes” is meant to be a universal tool for all engineers to express the rules they need to respect for each steel connection type.



Once saved in libraries, they can be reused across projects, saving countless hours, and offering you the confidence that fabricators will have less RFIs addressed towards you.

Automation of steel connections – workflow

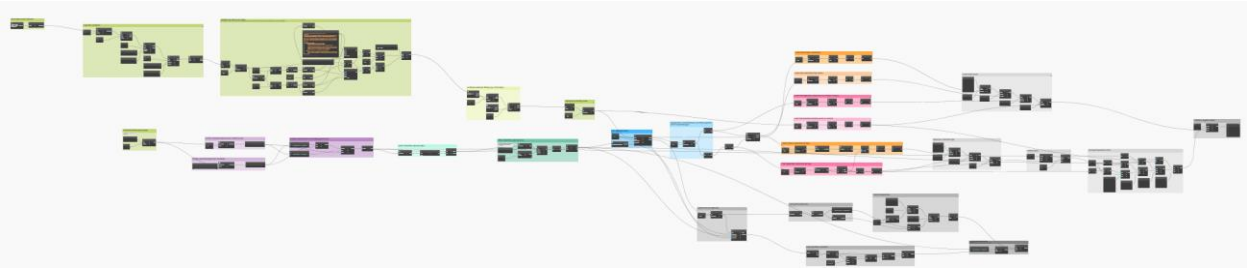
Imagine how easy it is to create the design intent model with steel connections, when you can place off-the-shelf connections in the model automatically.



Once libraries have been defined, the next steps of Connection Automation enable a simple, connected workflow: start from your new Revit design intent model, transfer it to Autodesk Robot Structural Analysis Professional or another analysis software that can exchange analysis results with Revit to perform the structural analysis, and then bring it back to Revit, where our out-of-the-box rules read the results, look into your preferred libraries, and match the intersections of steel elements with compatible configurations of connections—automatically modelling the steel connection types.

Rules

To facilitate easy rules management, we created dedicated rules for each of the typical kinds of connections found in our sample libraries.



This reduces the risk of accidentally placing end plates with 4 rows of bolts instead of 5, for example, as our automation mechanism checks the actual shear force from the indicated load combination against the limits defined for each connection type and will automatically place one capable of resisting that force. You can also reduce the risk of other troublesome scenarios, with potential large wastes of material, like using connections designed for beams made of S275 on a model made of S355 elements, as the ranges of applicability can compare the steel grades as well.

Performance

Just in case you may think performance would become an issue when dealing with so many connections, it's worth saying that in Revit 2023, the overall performance of navigation in all views has been improved, with benchmark tests reporting an average improvement of 35% for more than 100 affected test cases. Moreover, the Analytical Model in Revit is now created on demand when needed, which means creating and editing detailed models with steel connections is up to 50% faster.

Constructability and costs

Since connections can now be placed much faster, highly detailed design models with connections can be created quicker too. This empowers engineers to create estimates faster and more accurately before submitting their designs for tender, increasing their competitiveness. This gives you more time to iterate on the design itself by reducing the tedious work of modeling connections.

Constructability can be assessed earlier as well. Once connections are modeled, one can easily do a clash check using Autodesk BIM Collaborate. This helps ensure that the design progresses is headed in the right direction from the start, potentially saving significant rework over a traditional workflow.

Summary

You have read about several new features introduced in Revit 2023 that support BIM-Centered Workflows for Structural Analysis. We have explored new Revit analytical model capabilities and library-based steel connection design automation.
These Autodesk BIM tools and workflows are all part of our broader portfolio for structures.

As you have seen and heard, Autodesk is continually making investments in structural analysis workflows. These tools are designed to work together in a BIM process to give you a more seamless, connected workflow as your structural project moves from one phase to the next.