BES224257

Connected BIM for Structures

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Learning Objectives

- Learn how to position the products in the AEC Collection with each BIM project lifecycle phase
- Discover efficient workflows from design to analysis to fabrication
- Learn how to choose the right tool for the integration of design and data between each engineering BIM phase
- Discover how BIM 360 Design and Document Management can help the digitization process

Description

In this new digital era, "the Era of Connection," building professionals are facing a lot of challenges to digitize their processes for designing and delivering buildings. In this class, you'll get a full overview on how the products of the Architecture, Engineering & Construction Collection can be used in the most efficient and integrated way for structural engineers to meet this urge for full-process digitization. You will learn which workflows can be set up with Revit software, Advance Steel software, Robot Structural Analysis software, Dynamo, BIM 360 Design software, and BIM 360 Docs software to streamline the process from design to fabrication for steel and concrete structures. You will also learn about how the products within the AEC Collection are mapped with BIM project lifecycle phases and industry persona.

Speakers

Dieter Vermeulen

Working as a Technical Specialist AEC for the Northern European region at Autodesk, I’m specialized in the products of the Computational Design and Engineering portfolio. Within that domain I support the authorized Autodesk channel partners and our customers with innovative workflows and solution strategies. I evangelize the power of computational design with Dynamo in the building and infrastructure industry. This results in workflows covering the process from design, analysis, construction to fabrication for structural steel and reinforced concrete structures in building and infrastructure projects.

Tomasz Fudala

Tomasz Fudala is the Technical Marketing Manager for Structure at Autodesk. He has over 14 years of experience in the software industry and a comprehensive background and vast knowledge of structural solutions in the Autodesk portfolio.

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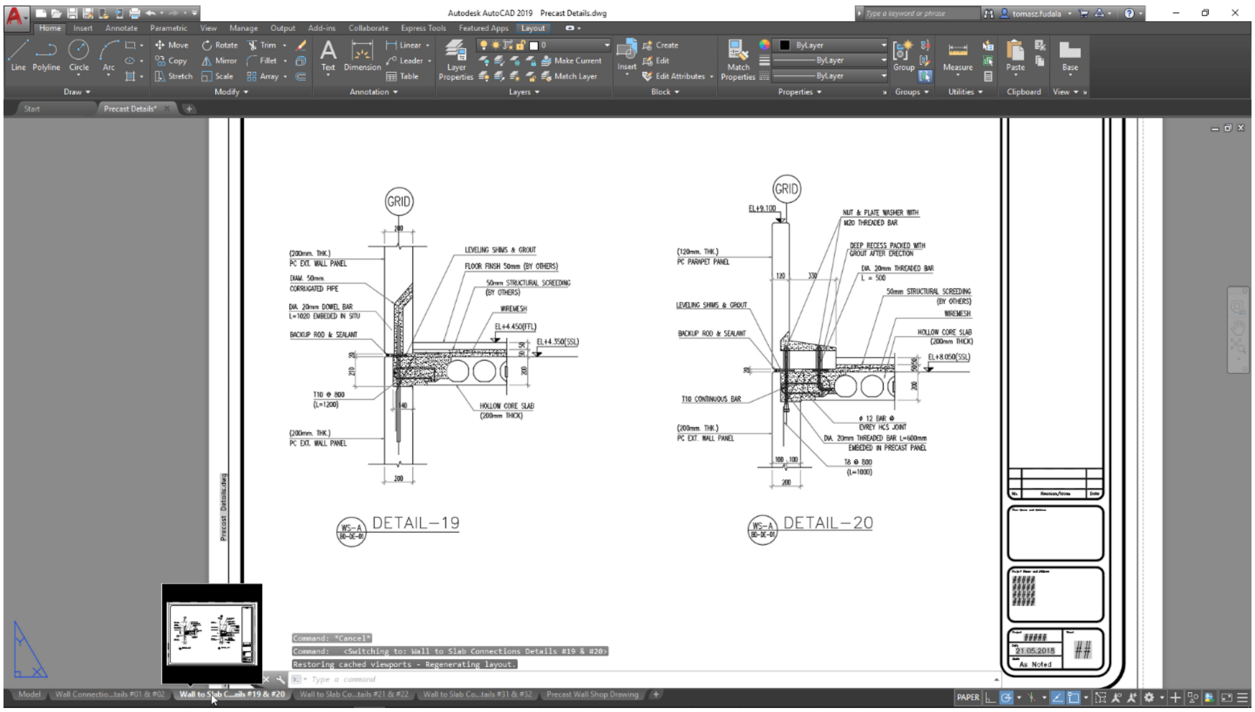
Connected BIM for Concrete Structures

Communication of designs using BIM 360 Docs

AEC Collection customers can use a combination of AutoCAD and Revit-based deliverables with BIM 360 Docs to deliver accurate documentation for all project members.
In this workflow example, a structural precast detailer has an existing library of AutoCAD details that he would like to leverage on a project that requires Revit.



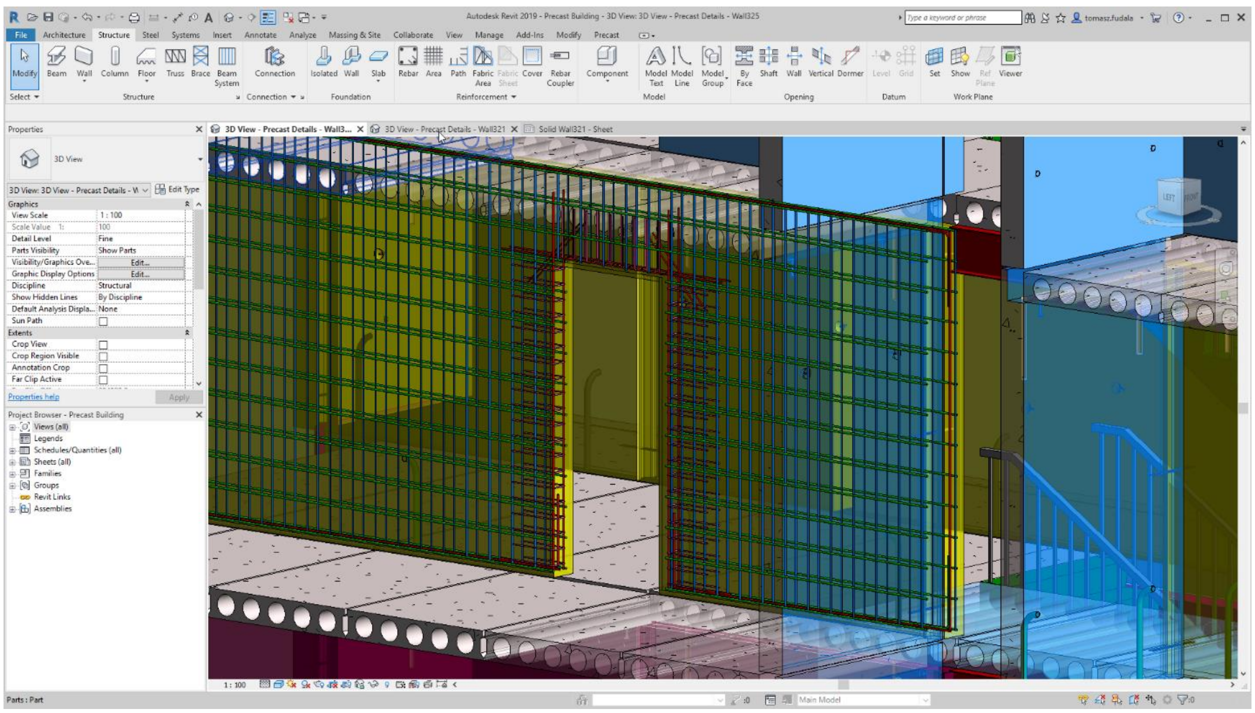
Using BIM 360 Docs, he can collaborate with Revit users on the required precast designs and communicate all necessary precast connections in the DWG file format.

Creation of LOD 400 models

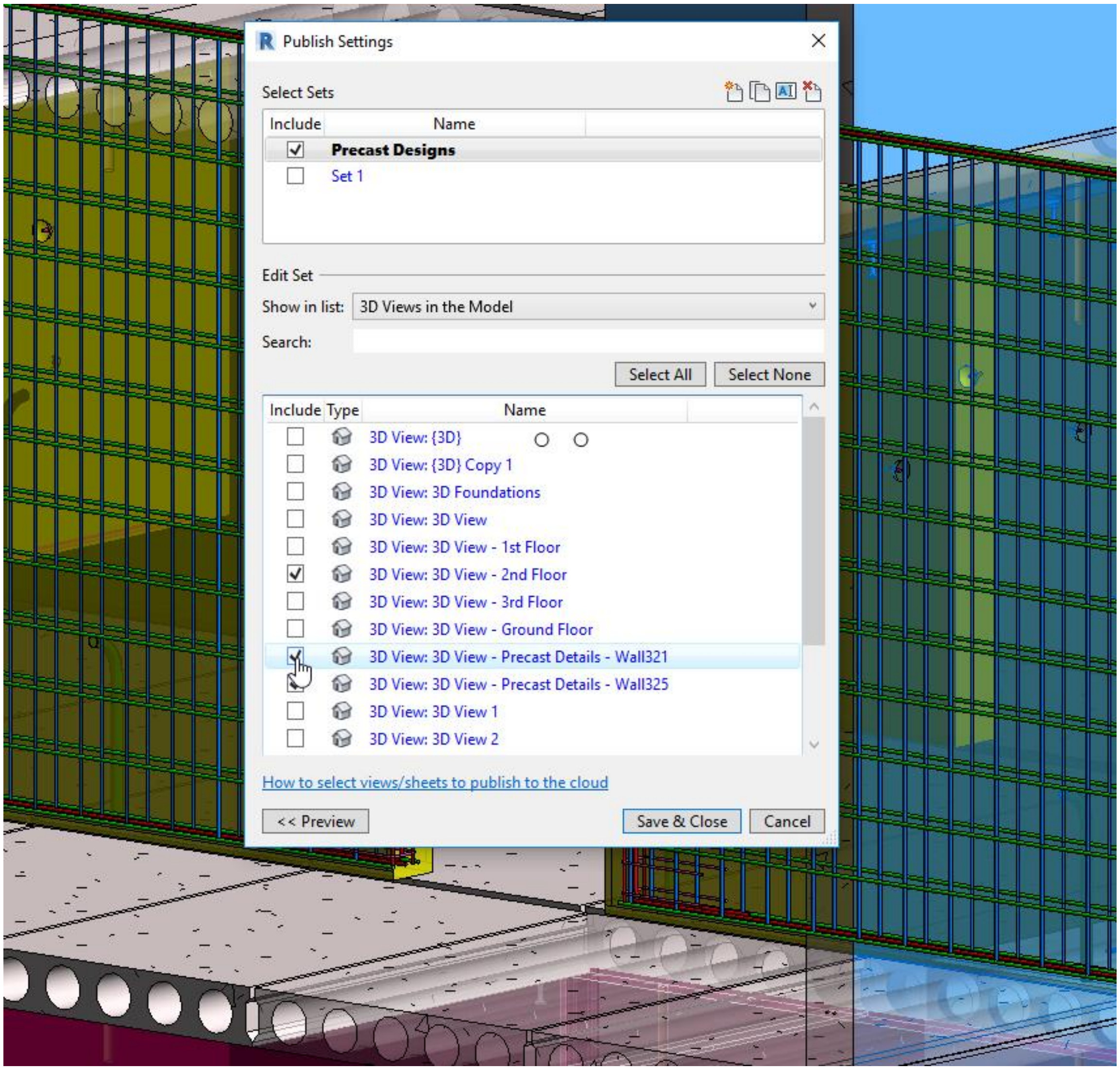
The AutoCAD designs can be leveraged by Revit users when modelling LOD 400 in the BIM environment. These details can be attached to the final documentation too.

Revit is a BIM-centric solution for the reinforced concrete industry to connect concrete design and detailing to fabrication. It provides tools for detailers for modeling 3D concrete reinforcements, creation of shop drawings, and bending schedules in the advanced BIM environment.

The Structural Precast for Revit extension provides Revit users access to powerful tools for automatic rule-based segmentation of precast structures, automatic reinforcement, shop drawings and CAM files.



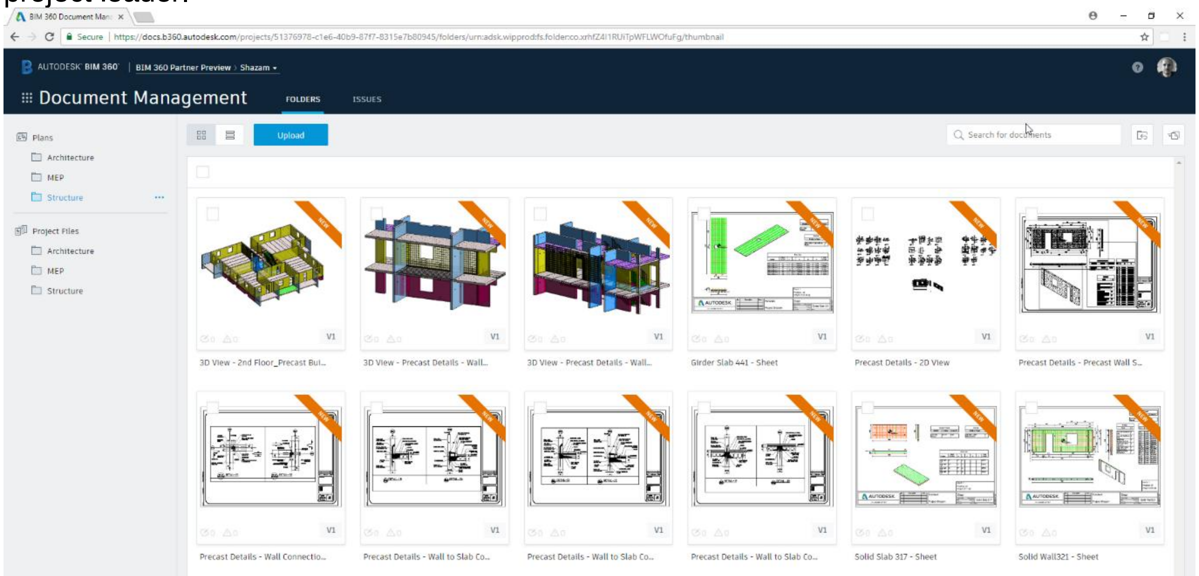
The structural detailer can use the Publish Settings tool in Revit to select views and sheets of the model and publish them to the cloud.



Once all 3D precast designs and drawings are created, the structural detailer can share them with the project leader via BIM 360 Docs.
BIM 360 Docs integrates the entire project workflow from design to construction across one common data platform.

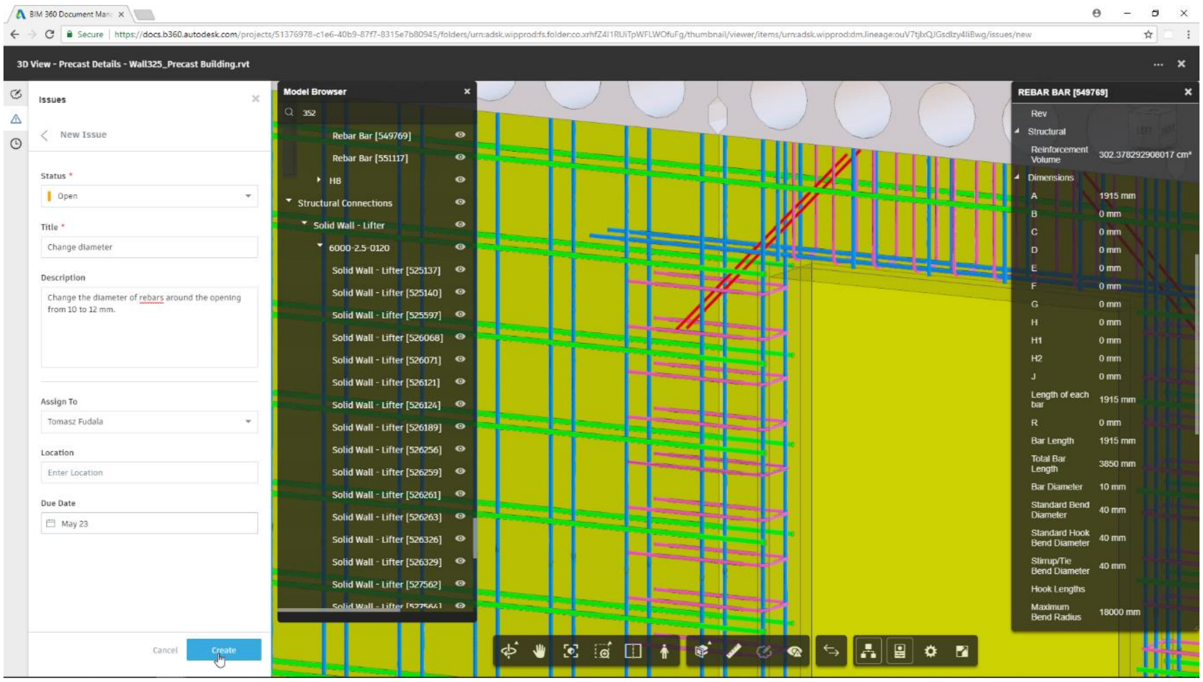
Reviewing process and feedback

Once all published views and sheets have been extracted, they are ready to be reviewed by the project leader.

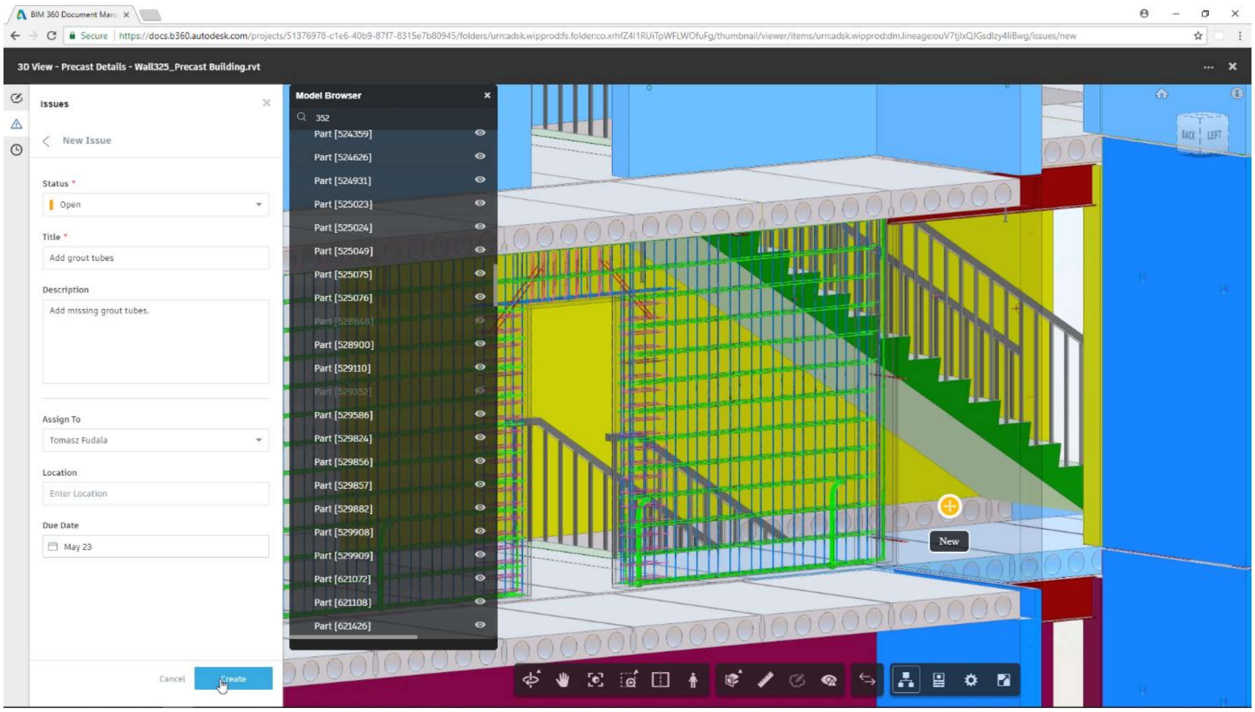


To ensure that any errors found in the review process are addressed, a trackable issue, complete with a detailed description of the problem and a recommended completion date, can be assigned to a specific project member - in this case to the structural detailer. Let's have a look at a few example issues.

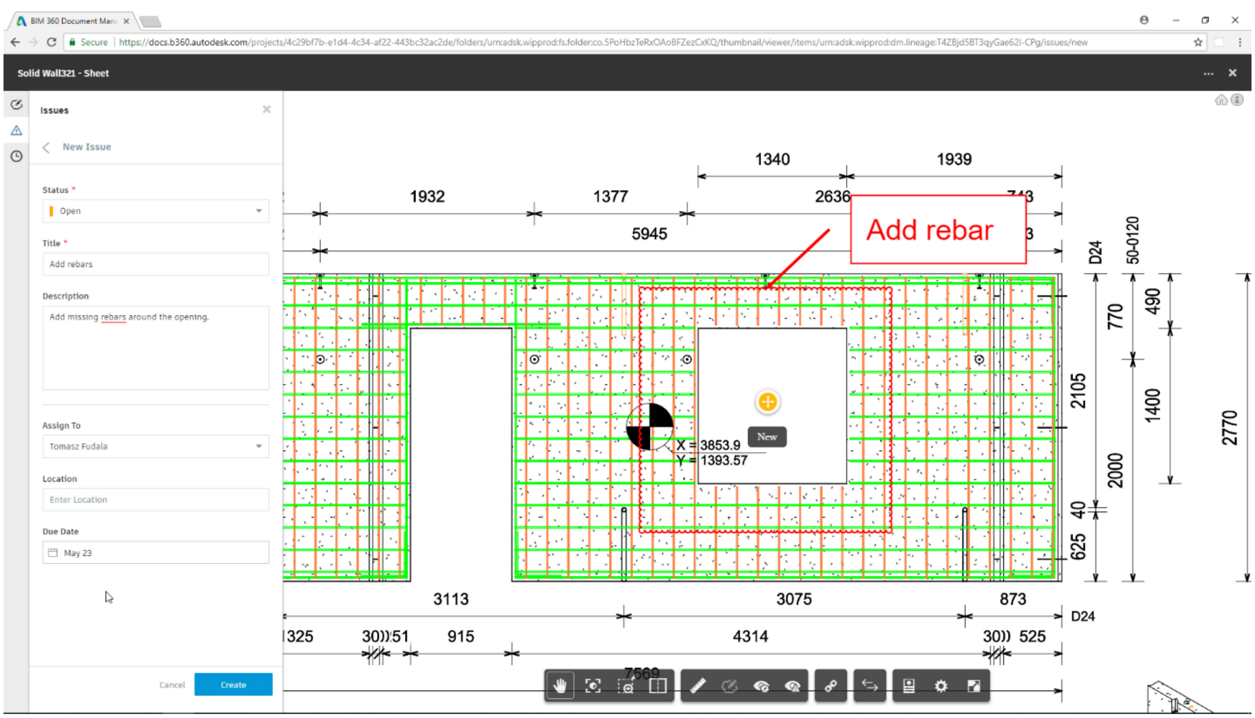
In this first case reinforcements around the door opening need to have a greater diameter.



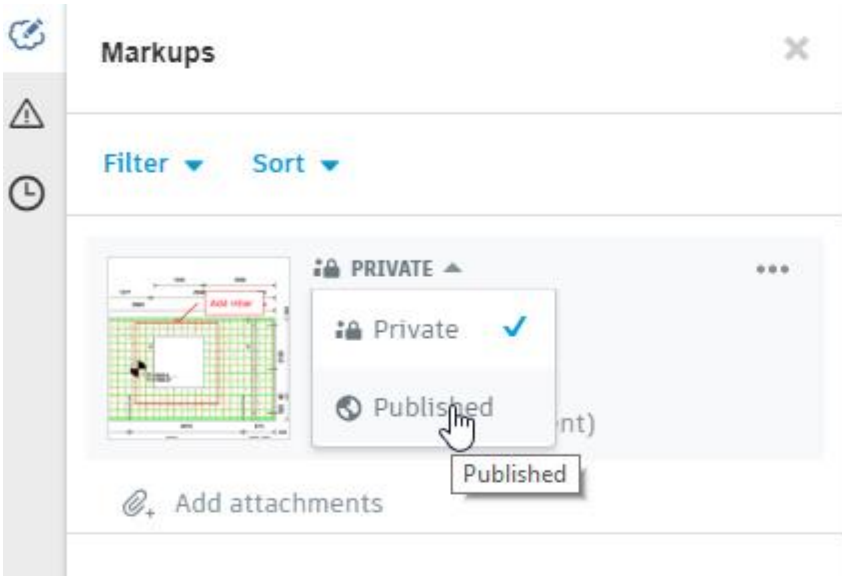
The second issue points out that there are missing grout tubes in the precast wall.



The third issue identifies missing reinforcements around the opening.

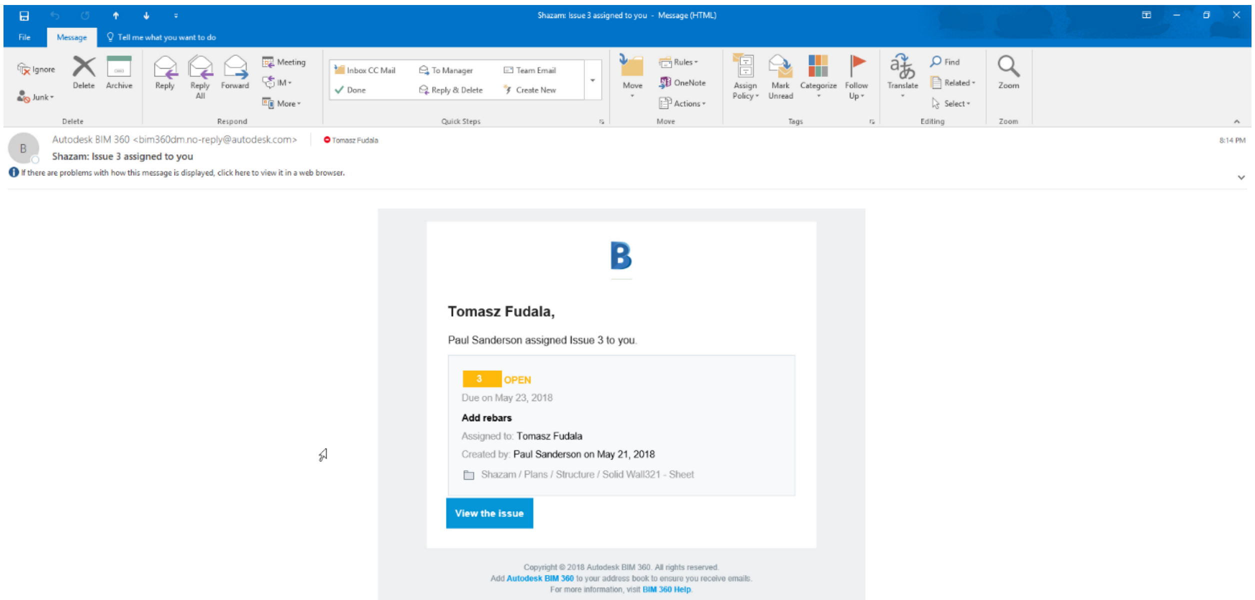


BIM 360 Docs can also create markups. When a user adds a markup, it is added to the document's markup history. It can be tracked by the revision history as the team responds and adds additional markups.
By default, markups are private, but they can be set to Publish via the markups panel and seen by all project members.

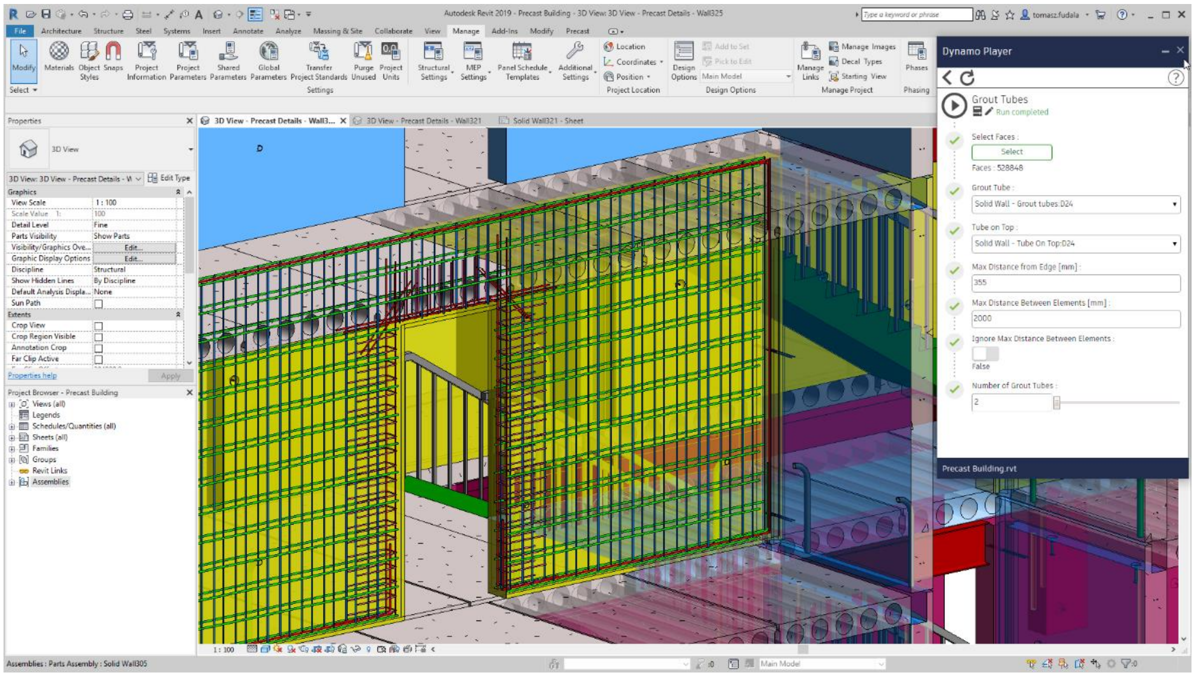


Making updates based on the feedback

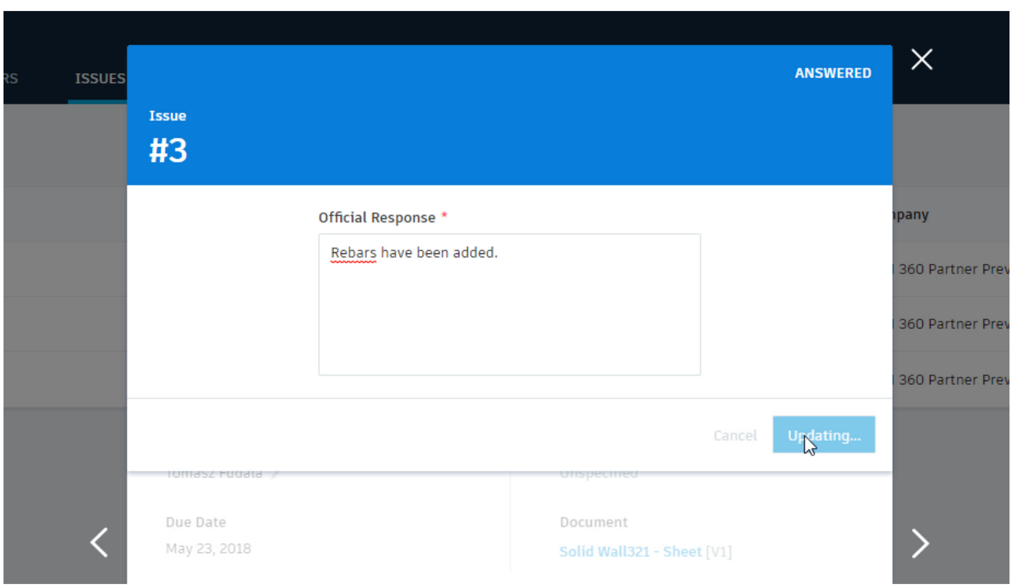
In our example scenario a precast detailer received an email notification with a link to the issue that was assigned to him.



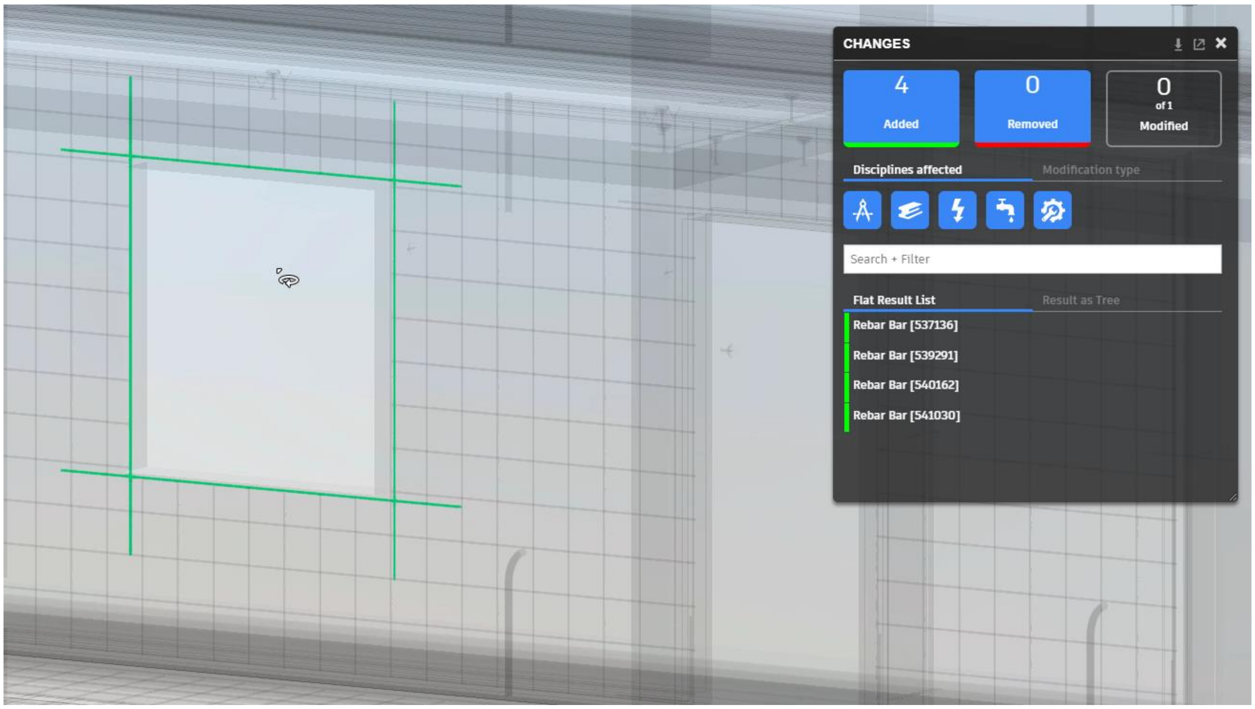
The received link instantly brings him to his BIM 360 Docs project and to the right view. The viewer is automatically zoomed into the issue push pin. He can get a very quick understanding of all issues that should be addressed. Fixing issues with Dynamo and Revit is very useful. In this case the structural detailer is using Dynamo Player within Revit to automate the process of adding tubes to the precast walls.



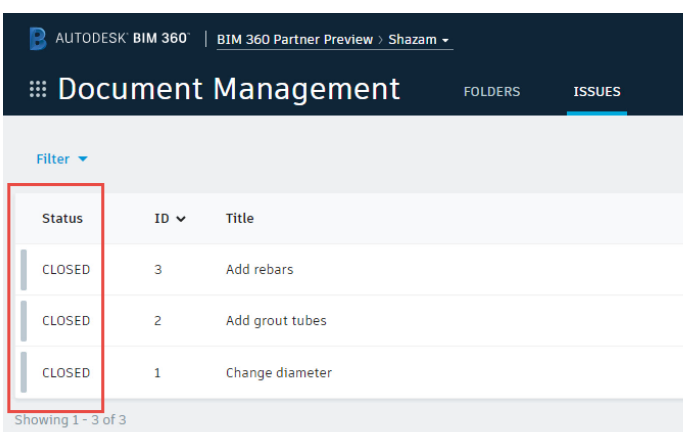
Once the updates/changes are completed in Revit, the structural detailer can respond to the project leader, using that same tracking tool that keeps an up-to-date record of the issue's progress.



Confirmation of the issue's resolution can be done by using BIM 360 Docs “Compare” feature, that visually highlights exactly what has been modified.
BIM 360 Docs has integrated change visualization that lets users compare the changes between two selected versions of the project.



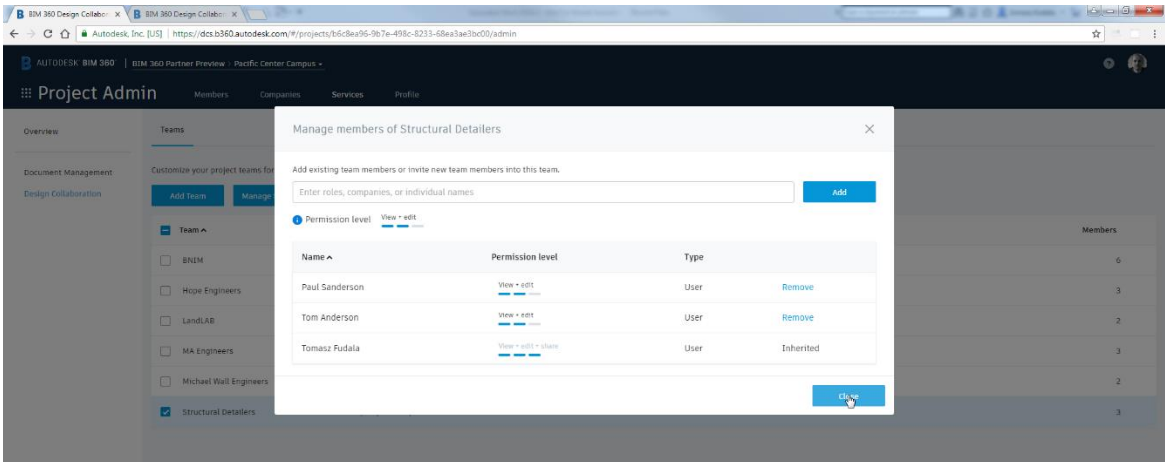
The summary provides a quick accounting of the changes contained within the new version of the project. The number of changes within the list may vary when filters and search criteria are applied.
BIM 360 Docs users see color-coding that shows how information has changed. The Added, Removed, and Modified buttons act as a toggle to hide or show the results from the list.
At this point, the issues can be closed and the issues history is kept in the BIM 360 Docs environment where everyone on the project team can see who was involved in its resolution.



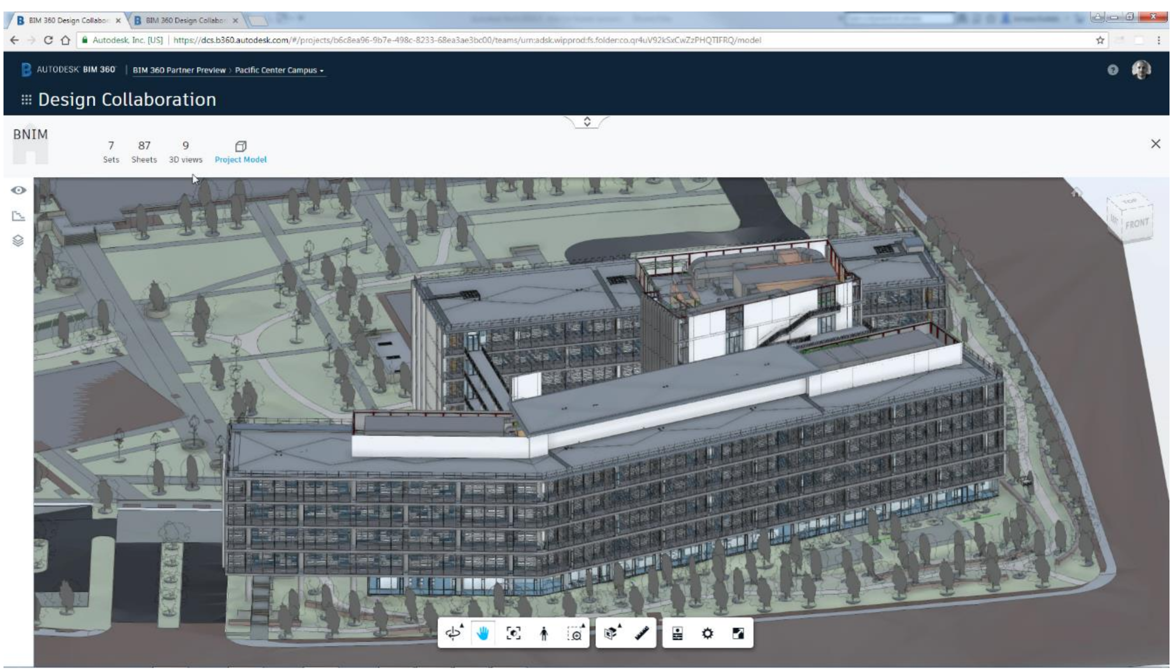
Collaboration with multi-disciplinary teams

Setting up a project in the BIM 360 environment

Autodesk BIM 360 Design lets project teams collaborate on shared Revit models. It helps project teams reduce errors & omissions and enables faster project delivery.
One of the components of BIM 360 Design is Revit Cloud Work-sharing. Folder-level access control within the Document Management module allows teams to quickly define and control who can access individual pieces of data coming in from Revit Cloud Work-sharing.

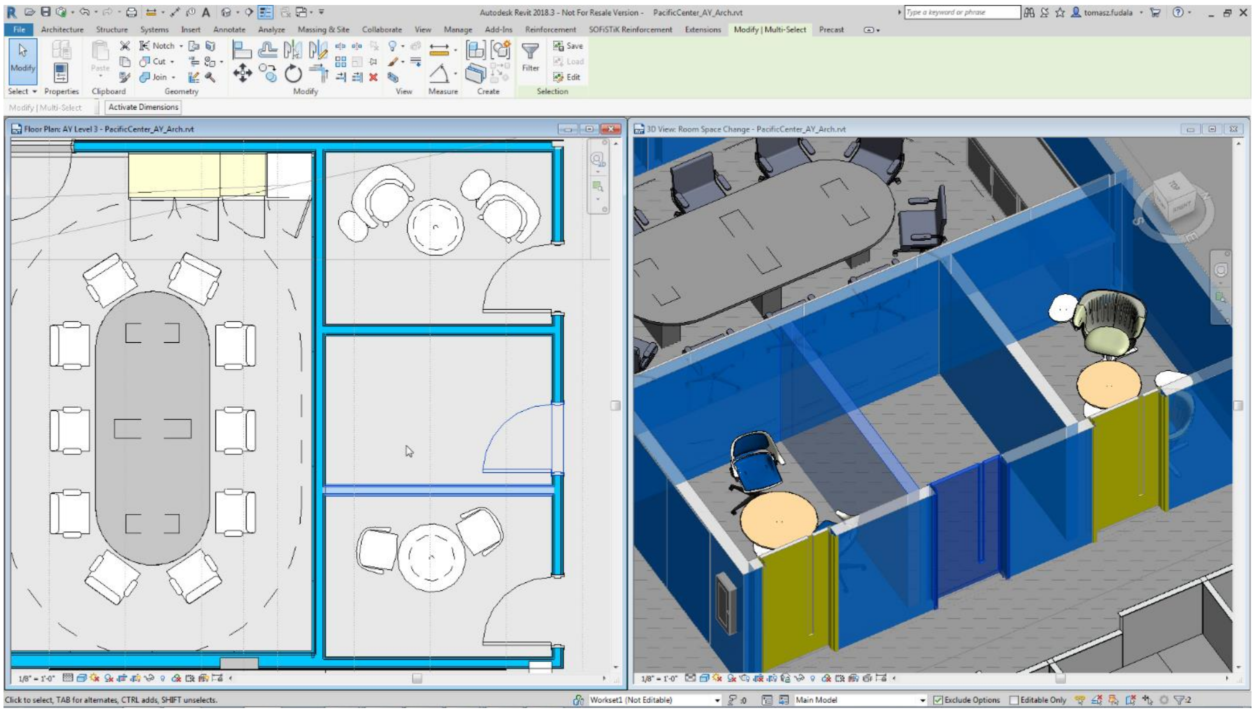


In this example workflow, the architect starts collaboration with the structural team setting up a cloud work-sharing project.



Making a change by an architect in the Revit model

There are many situations where architects and engineers need to make changes to the current project. In this case the architect needs to change a door location and move a few walls to enlarge the room space.



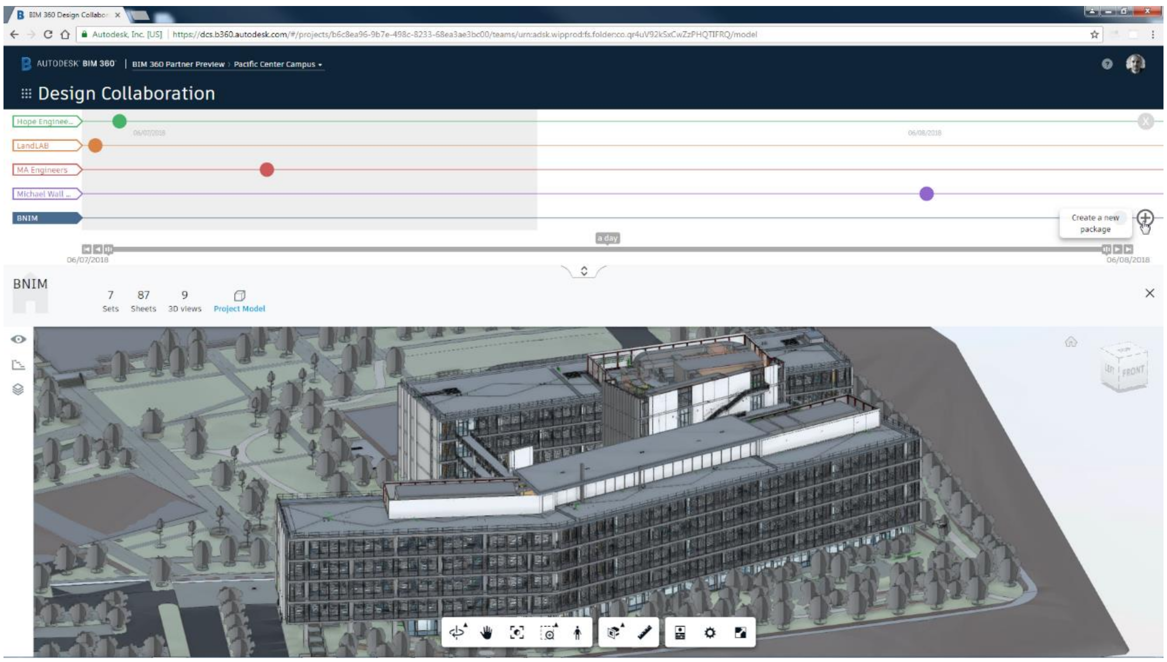
The architect working in Revit can use the Publish Settings tool to select views and sheets of the model that should be published to the cloud.

Once these changes are made by the architect, the model is synchronized with central and then published to the BIM 360 environment.

Communication of changes via packages

The Design Collaboration Module of BIM 360 Design can help an individual team collaborate efficiently with multiple firms. The Team Space provides an up-to-date viewing experience of the current state of the model. The individual team works in its own space, with complete control of how other project teams see the state of their work.

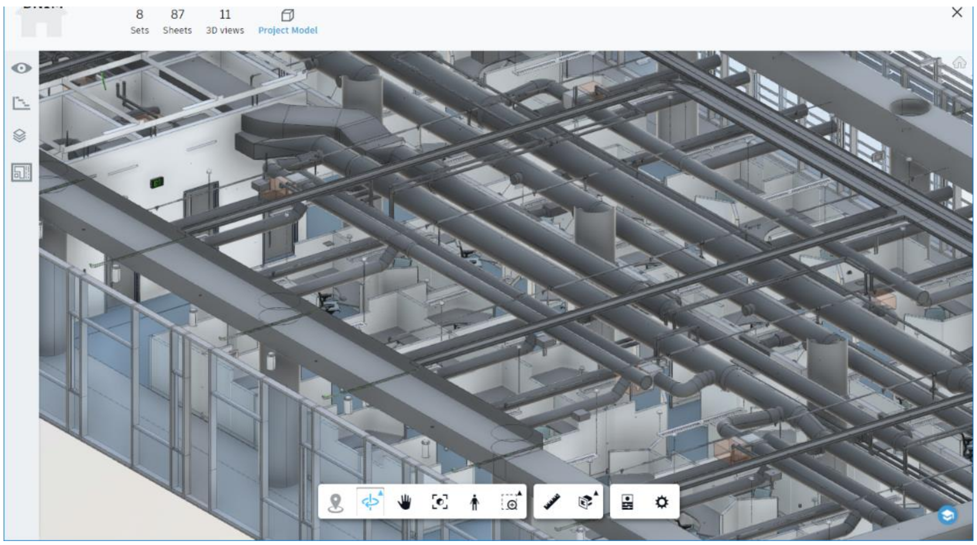
A great tool in the Design Collaboration module is the visual timeline. This is a visual representation of the exchange of data, showing packages that collaborating teams have shared and consumed throughout the lifecycle of the project.



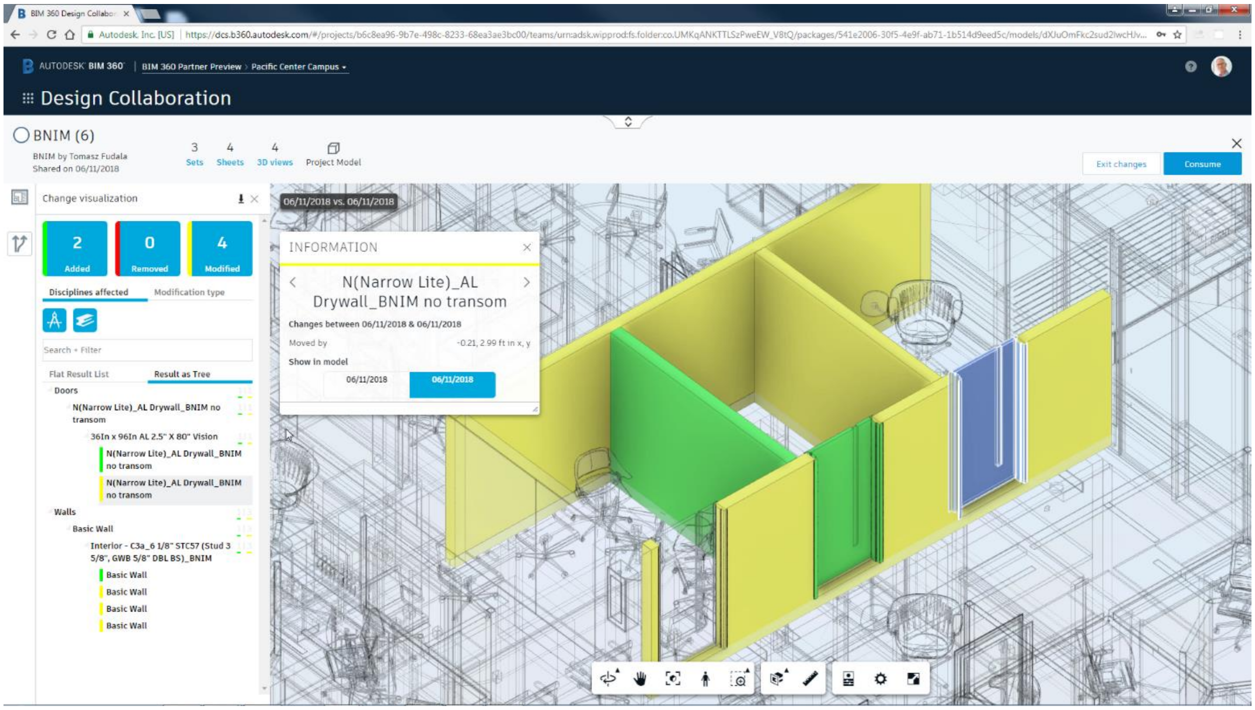
A package is a container that allows the architect to bundle her team's Revit models and sets to share with other teams.

Change review and package consumption

Now let's switch to the structural engineer's perspective.
Like the architect, the structural engineer can explore all views he decided to publish to the cloud in his Team Space. This aggregated viewer can also display all models the structural engineer owns as well as all models consumed into his team environment.



The structural engineer has already consumed the previous package that was shared with him by the architectural team – and now on the timeline a new package shows up with the recent changes made by the architect.
Previously in this situation the structural engineer would review revision clouds in project sheets. BIM 360 Design integrates change visualization into this overall experience. The structural engineer can compare the changes between a given package and the previous package from the same team.



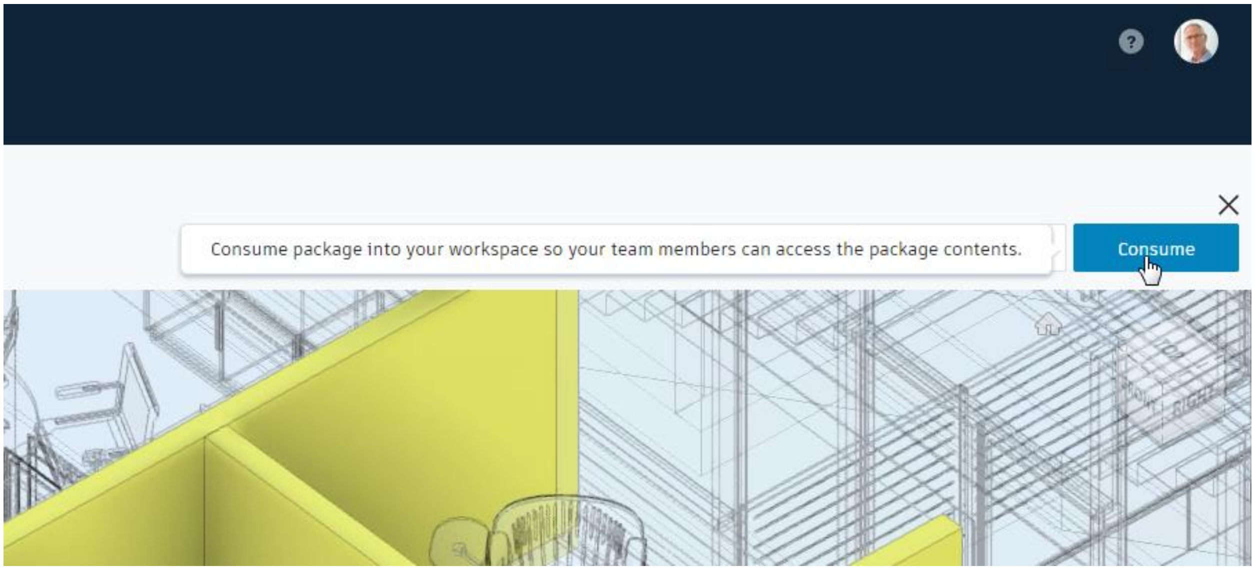
BIM 360 Design users get visual color-coding that shows how information changed. The Added, Removed, and Modified buttons act as toggle to hide or show the results from the list.

The summary provides a quick accounting of the changes contained within the new revision. The number of changes within the list may vary when filters and search criteria are applied.

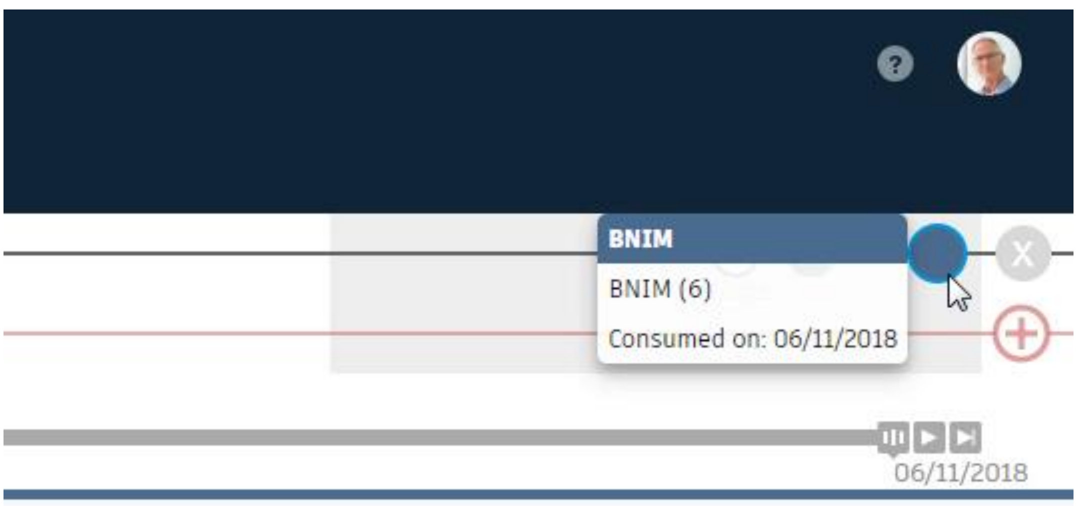
This gives the structural engineer a quick insight into the number and type of changes made by the architect.

Once all changes have been reviewed, the structural engineer may decide to consume this package since there are some architectural changes that affect the structural designs.

By consuming a package, the structural engineer brings the architect's package into his environment-- not to own it or take responsibility for it-- but to see it combined with his work and with all other teams' work.



On the timeline, the package is now filled to indicate that the structural engineer just consumed it.

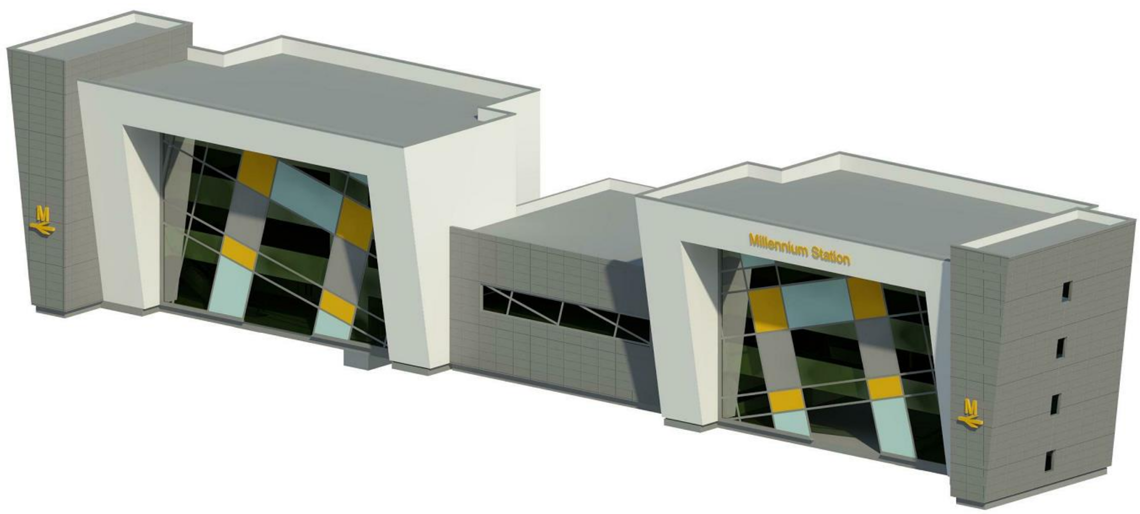


If Revit users linked into the other team's consumed online models, those Revit links are automatically updated in the team's authoring environment. Now with the automatically updated linked architectural model, the structural engineer can update the structural model to have it aligned with the architectural design changes. Used together, Revit, BIM 360 Docs, Revit Cloud Worksharing and Design Collaboration together provide greater data management and improved design productivity and efficiency through multidiscipline team collaboration.

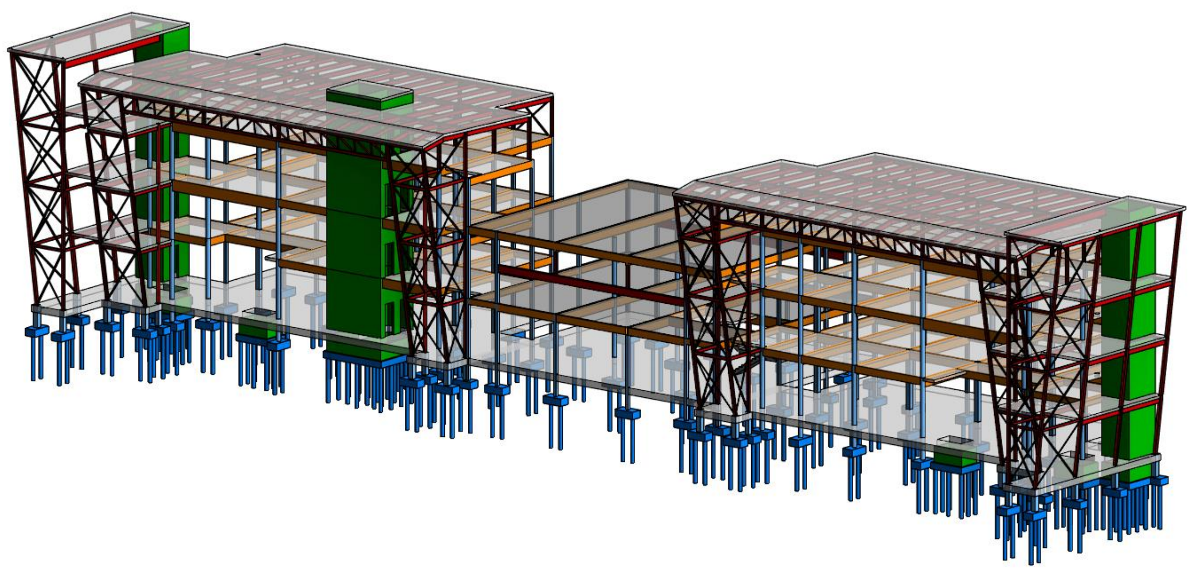
Integration of BIM and analysis - Making informed design decisions

Structural model creation in Revit and sharing data via BIM 360 Docs

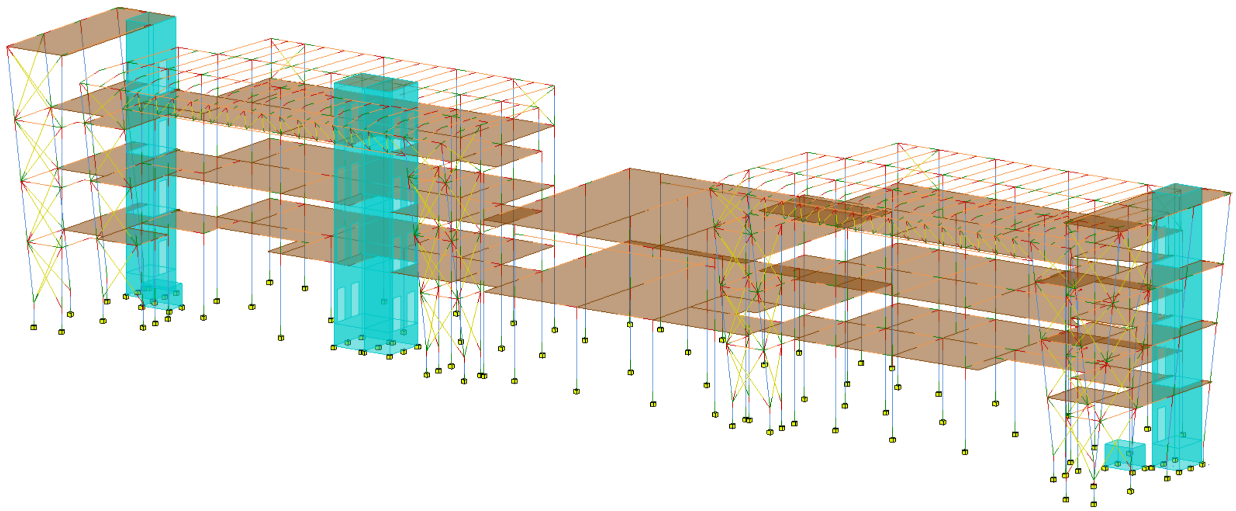
Traditional structural engineering workflows involve a variety of challenges. Structural engineers typically start the design process by getting familiar with the architect's design by interpreting architectural drawings or general 3D conceptions.



From those drawings, most structural engineering offices will create at least two different visions of the project by creating a design of the physical models for documentation and creating various analytical models for analysis. These analytical models must be consistently coordinated with respect to general framing layout, material and section properties, and loading.

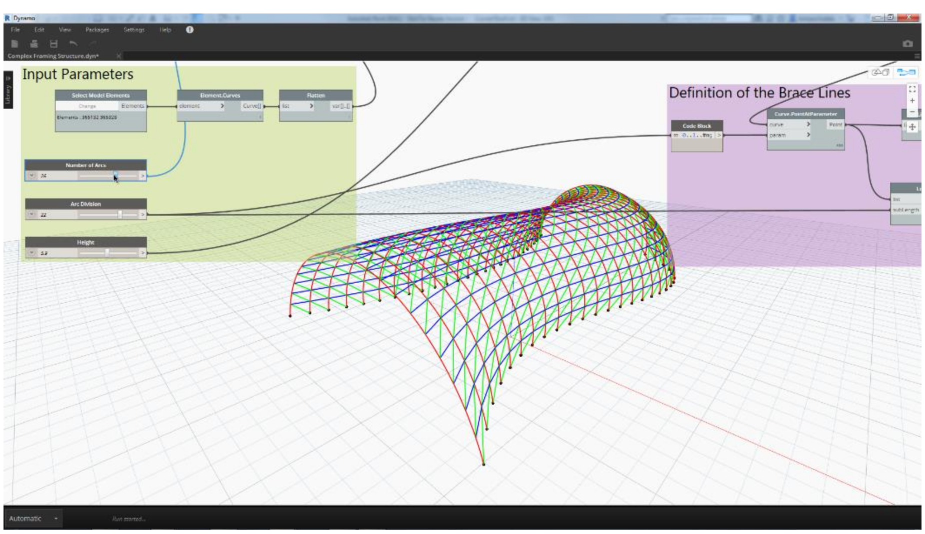


In Revit software, the physical model and the associated analytical model (which contains the boundary conditions and load definitions used for analysis) are created concurrently.



This modelling process can be done using traditional native Revit tools, or it can be exported by using Dynamo. The visual programming interface of Dynamo for Revit provides structural engineers with the tools to build complex steel structural models with minimal energy and make their own structural design tools. Dynamo allows structural designers and engineers to design organic and optimized steel structures faster than with traditional modeling tools by using computational methods.

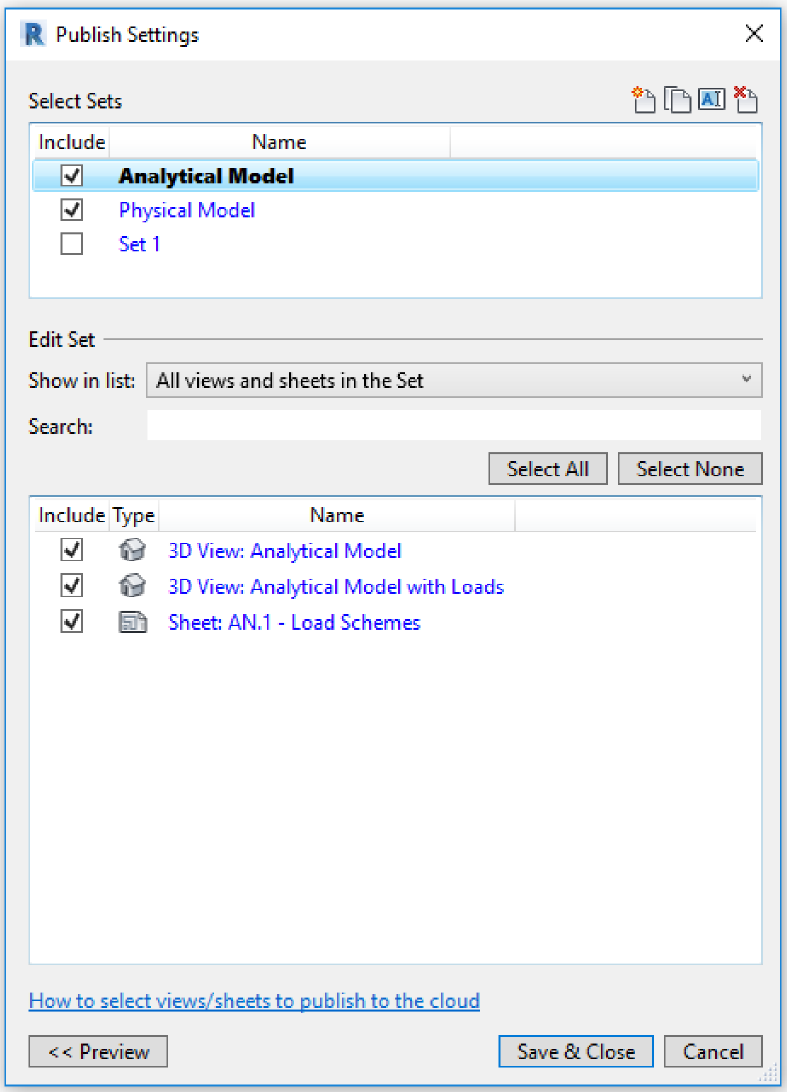
They can access and edit building parameters more effectively than traditional hard coded tools allow. They can iterate and evaluate multiple building design options with ease, and build structures based on natural and mathematical principles.



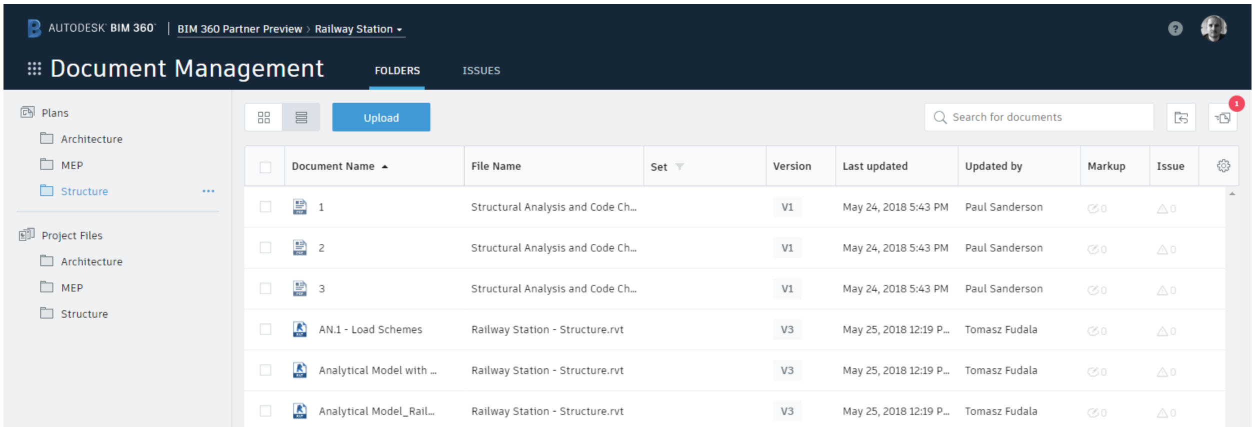
If the structural designer/engineer creates both the physical and the analytical model in Revit, the same data does not need to be entered in several different software applications multiple times for different purposes.

Rather than working in siloed systems structural designers, engineers and detailers can use BIM 360 Docs. BIM 360 Docs integrates the entire project workflow from design to construction across one common data platform.

Structural designers can use the Publish Settings tool in Revit to select views and sheets of the model to publish them to the cloud.

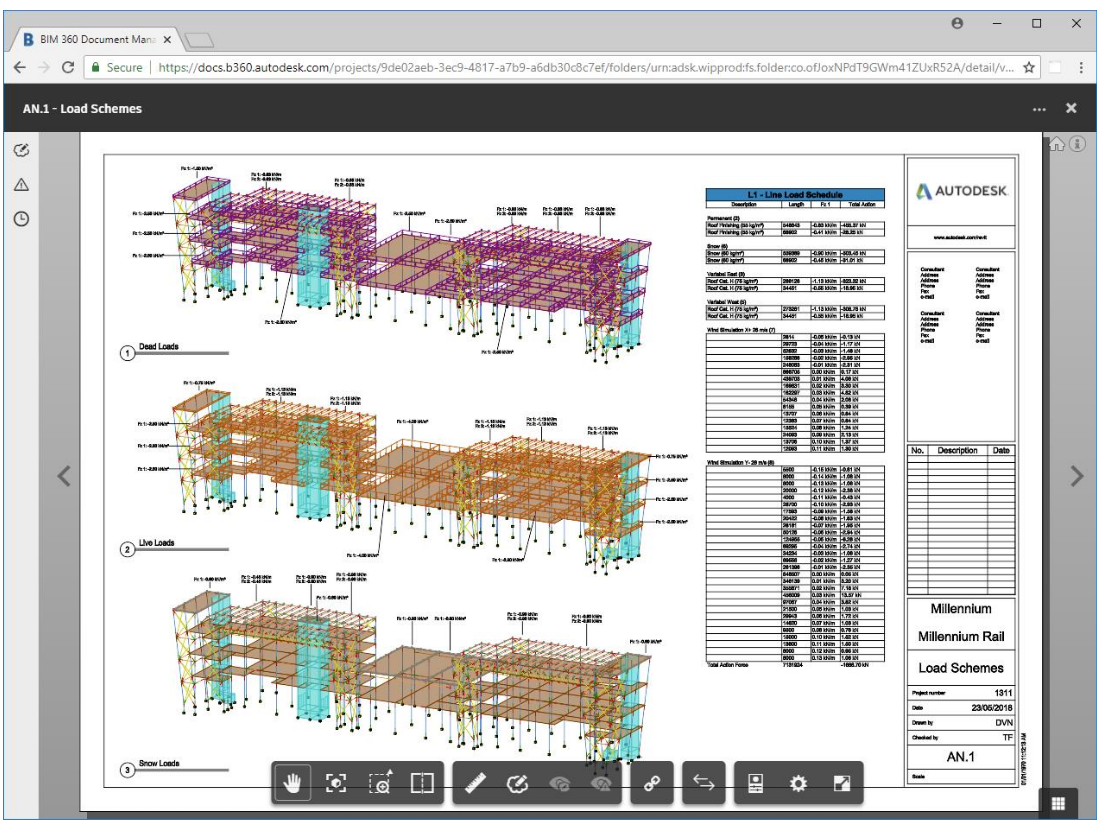


These selected views and sheets are automatically extracted in the BIM 360 Docs environment to give extended teams easy and instant access to the project information via web or mobile.

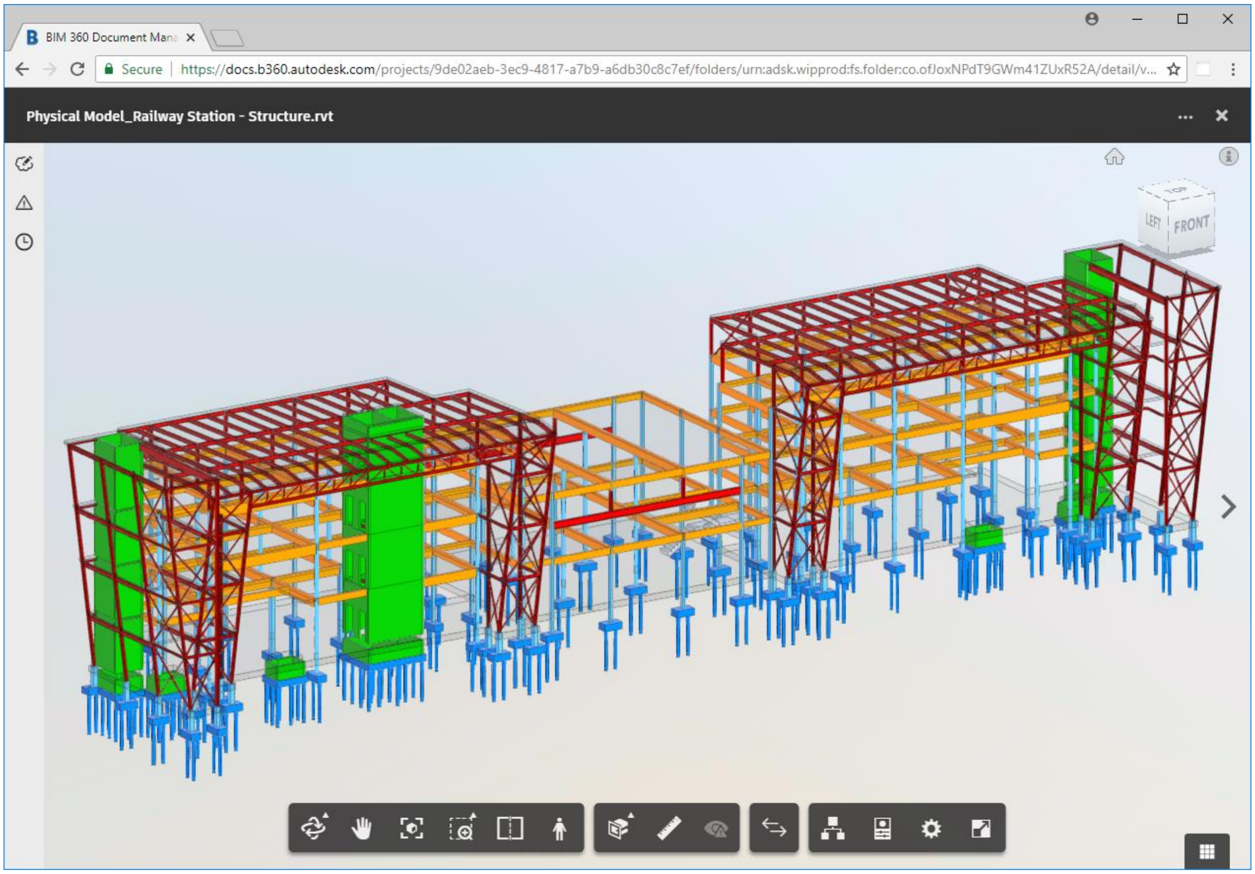


Model review and running the structural analysis & code checking

Then the extended team of structural engineers can easily review what has been done in Revit and the current state of the structural project.

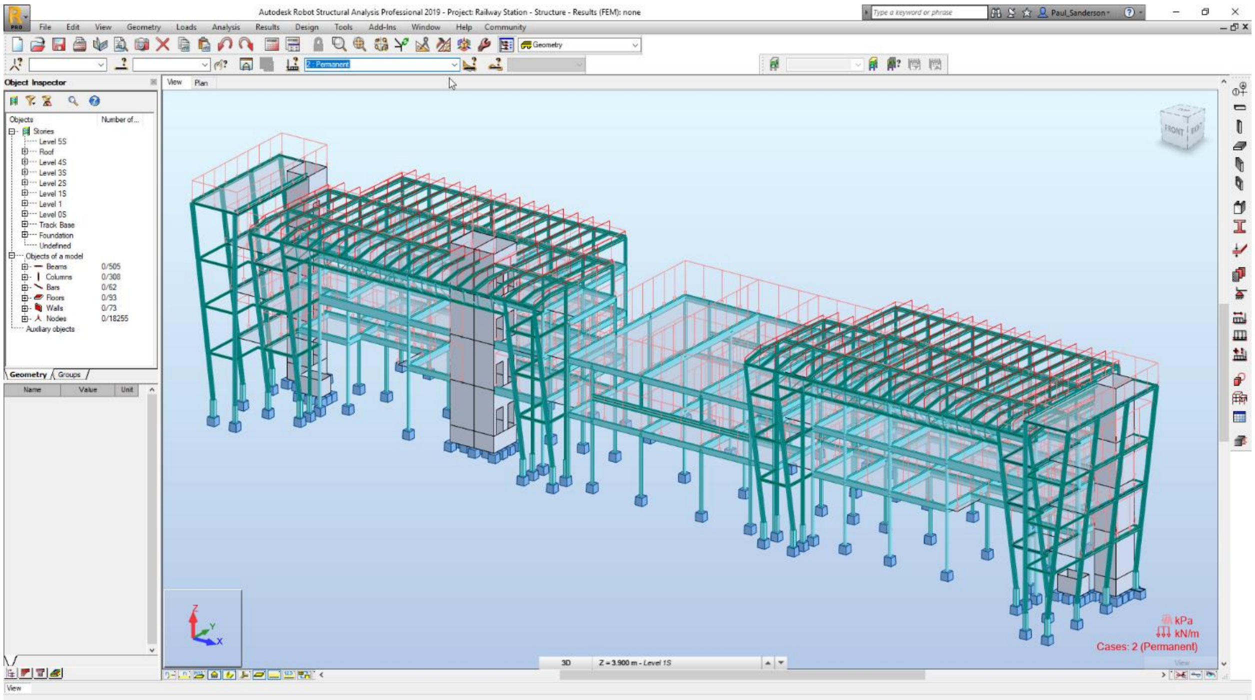


When project teams have the right information at the right time, work happens faster. BIM 360 Docs lets them publish, manage, review and approve all drawings, documents and models — anytime, anywhere.

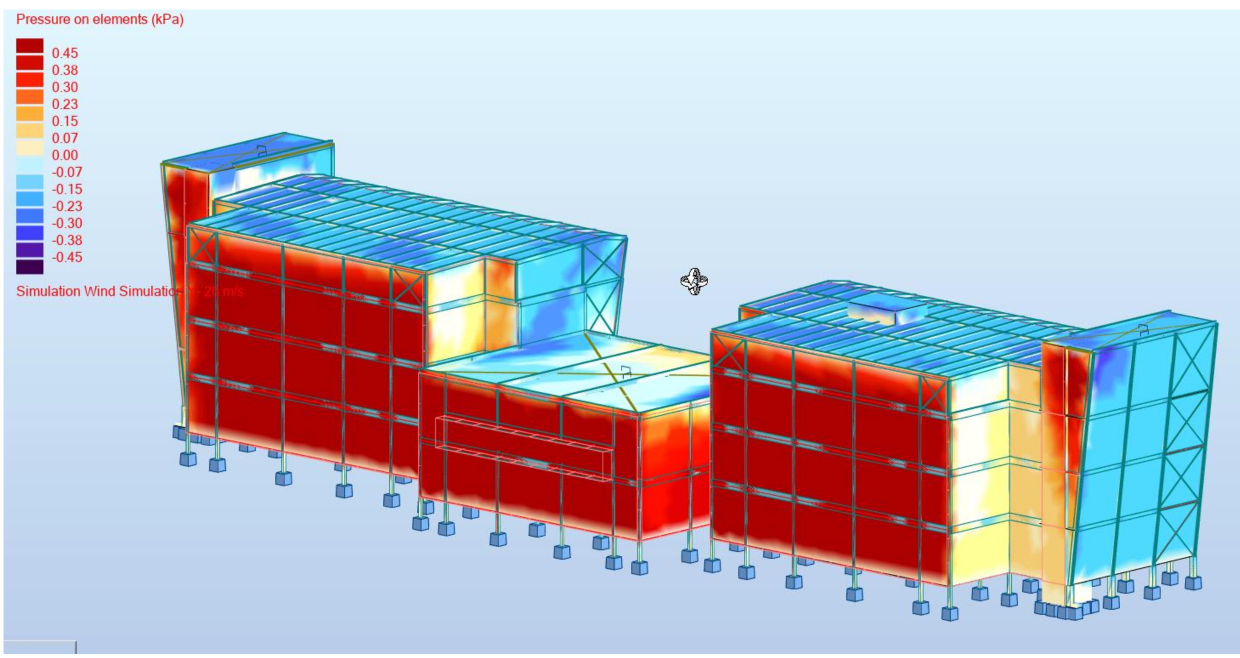


With access to the project data, a structural engineer continues the design process by performing structural analysis and running code-checking optimization.

The Revit analytical model can be sent to Robot Structural Analysis Professional with all the information needed for structural analysis, including boundary conditions and loads.

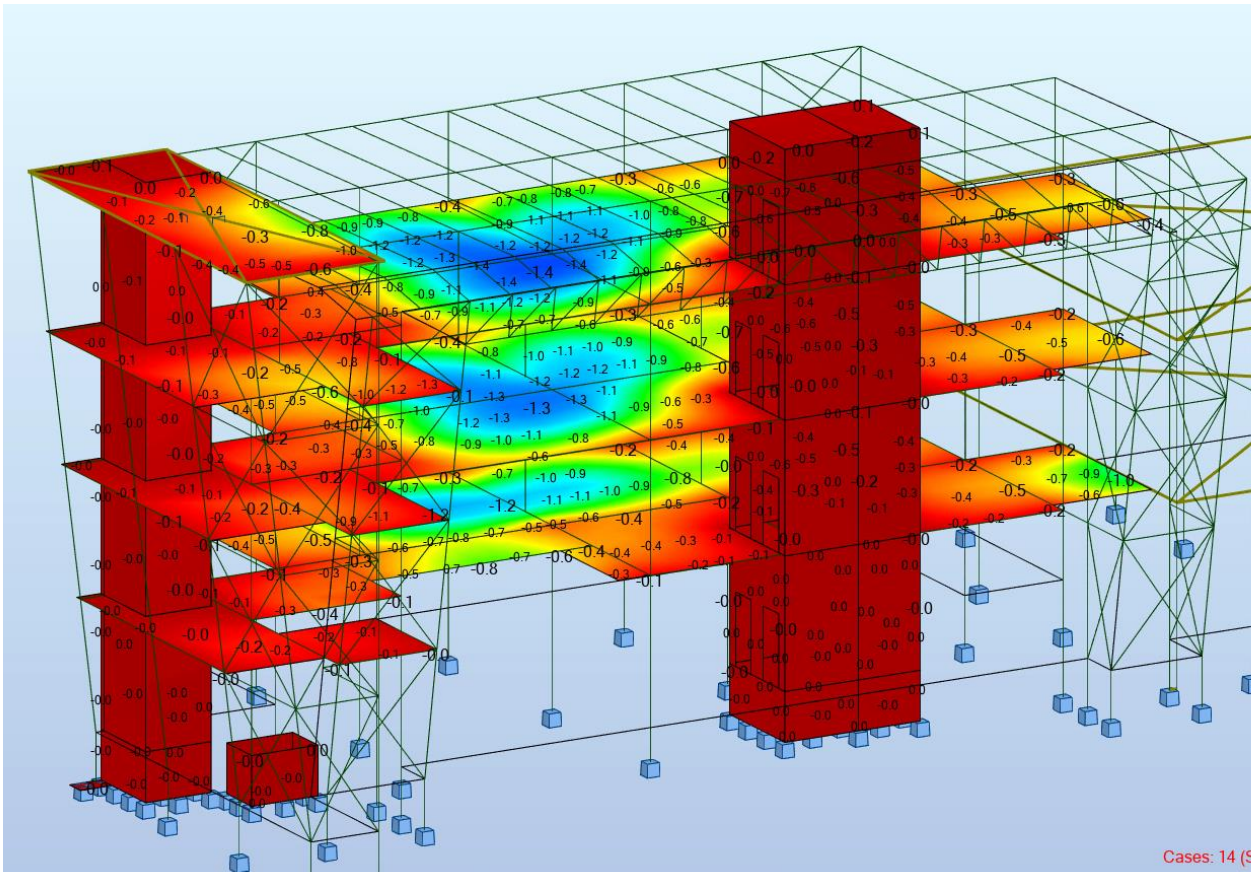


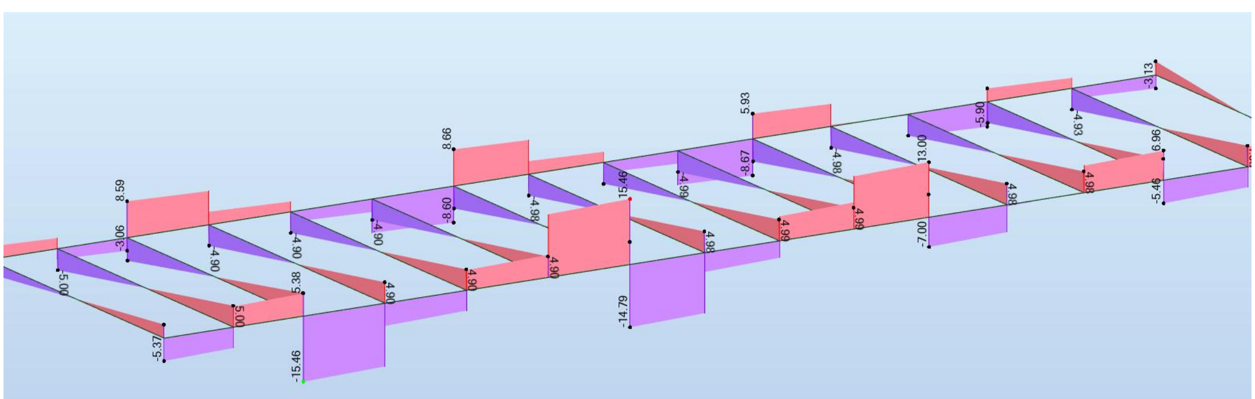
Once the analysis has finished, the engineer can easily explore all results and start the design of structural elements.



Robot Structural Analysis Professional is a powerful tool not only for calculations, but also for visually exploring results.

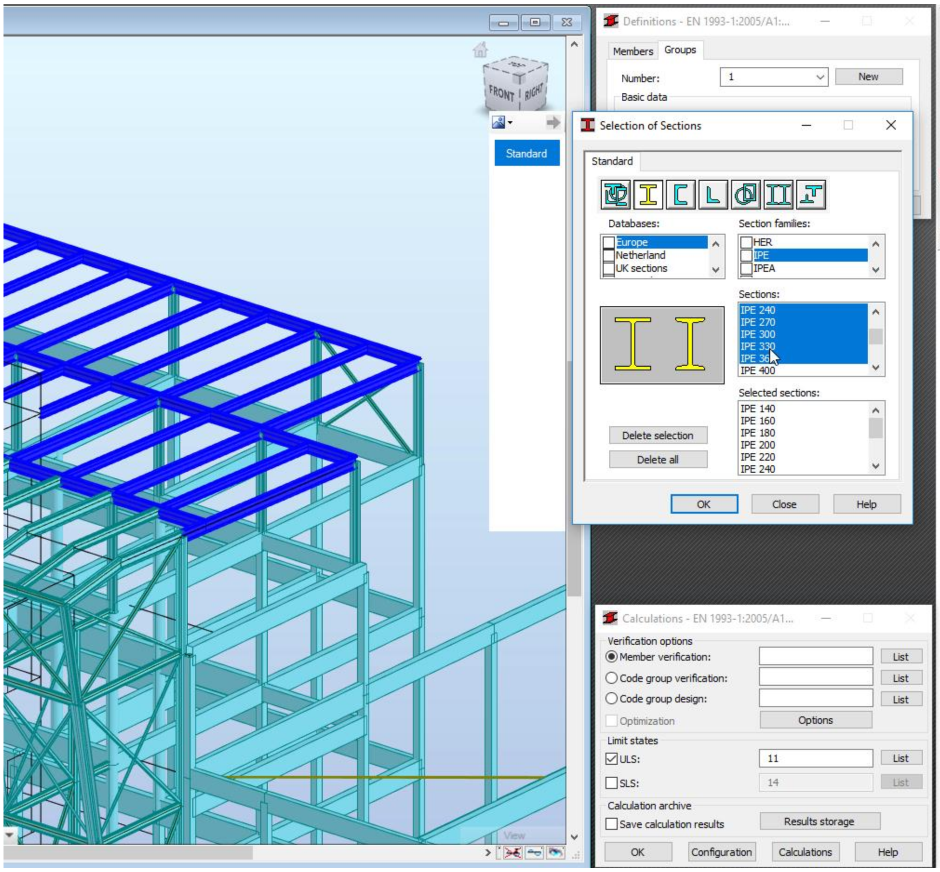
With multiple ways of presenting analytical results and the ability to easily access them, structural engineers can very quickly prepare the final structural documentation for review by project stakeholders.



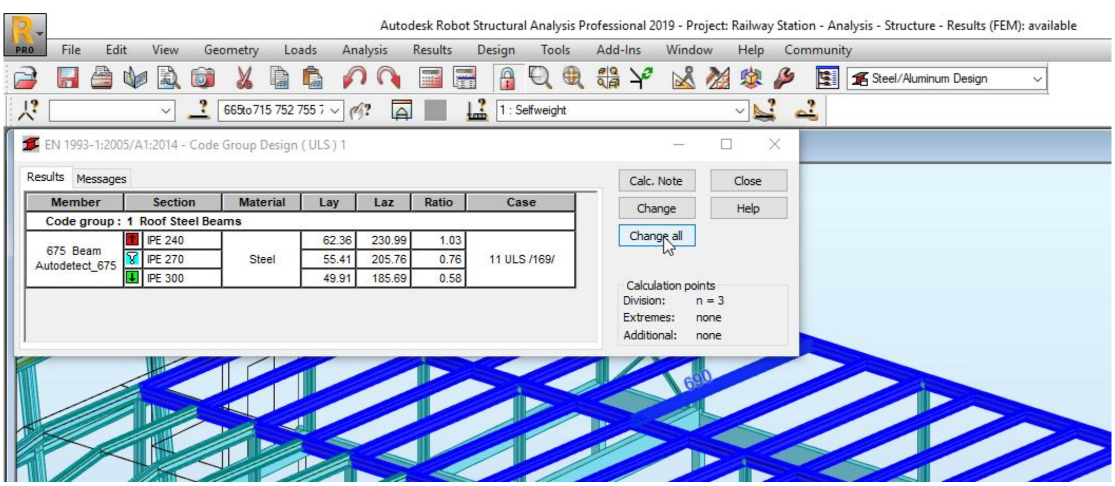


Using Robot Structural Analysis Professional, the engineer can run code checking to verify and design steel members based on a wide variety of national and international codes.

The first step in designing structural steel is to organize the bar elements (beams, columns, braces, etc.) into member groups. Each member in a group will be assigned the same section by the design process.



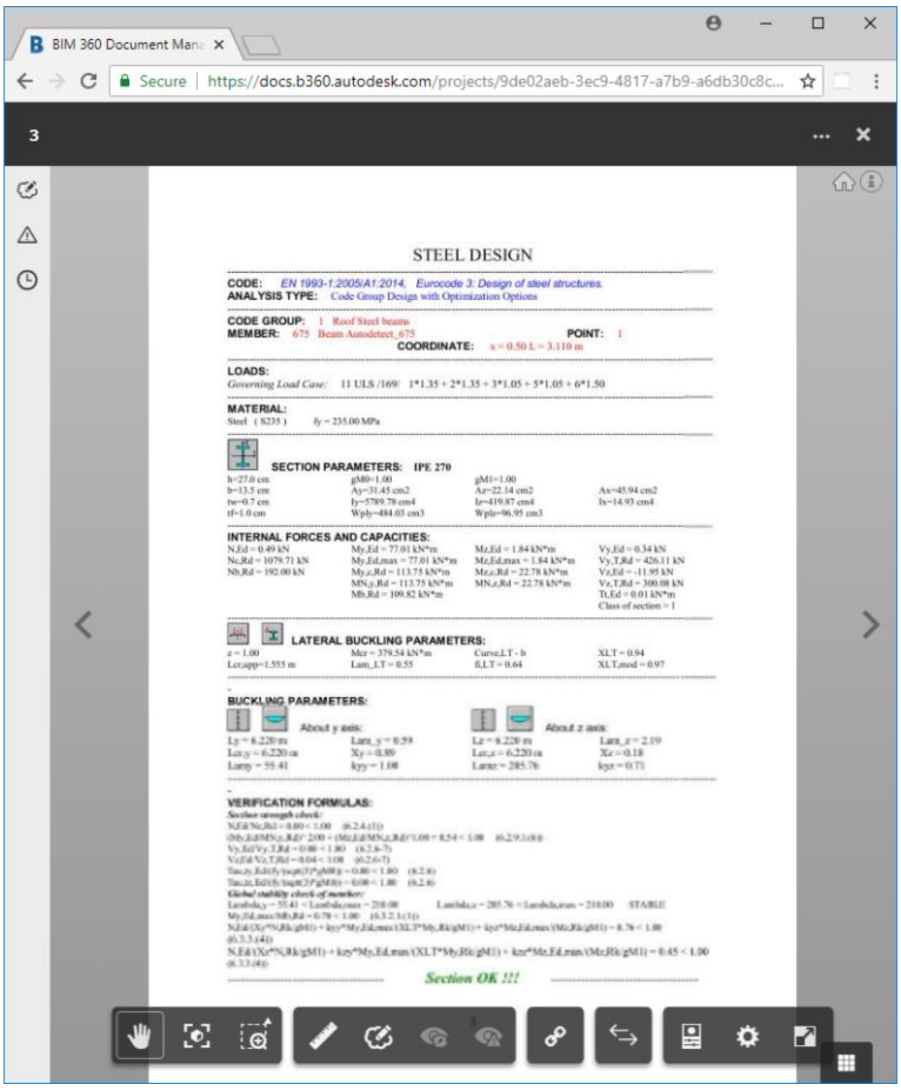
Once the design group is optimized a simple Change All button allows all new sections to be applied to the model.

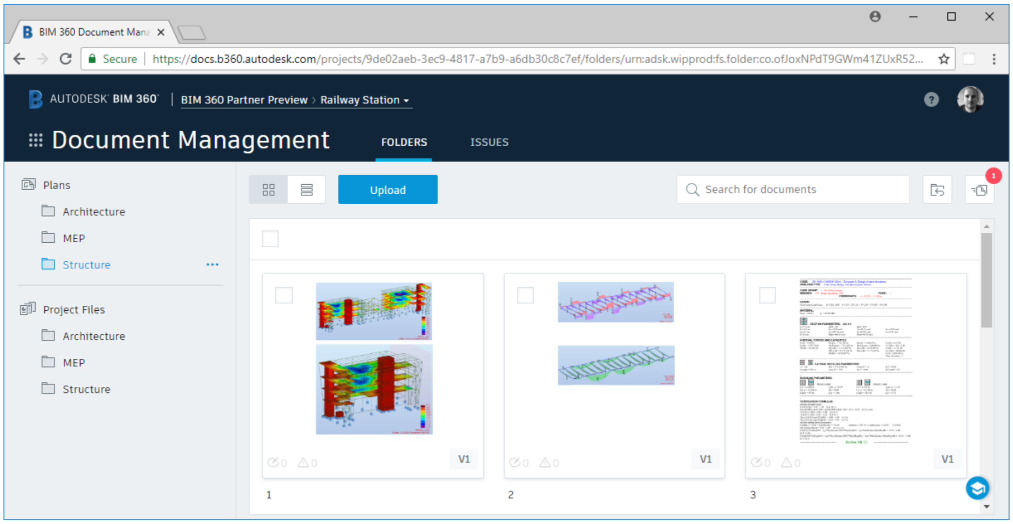


Update of the model and communication of final designs

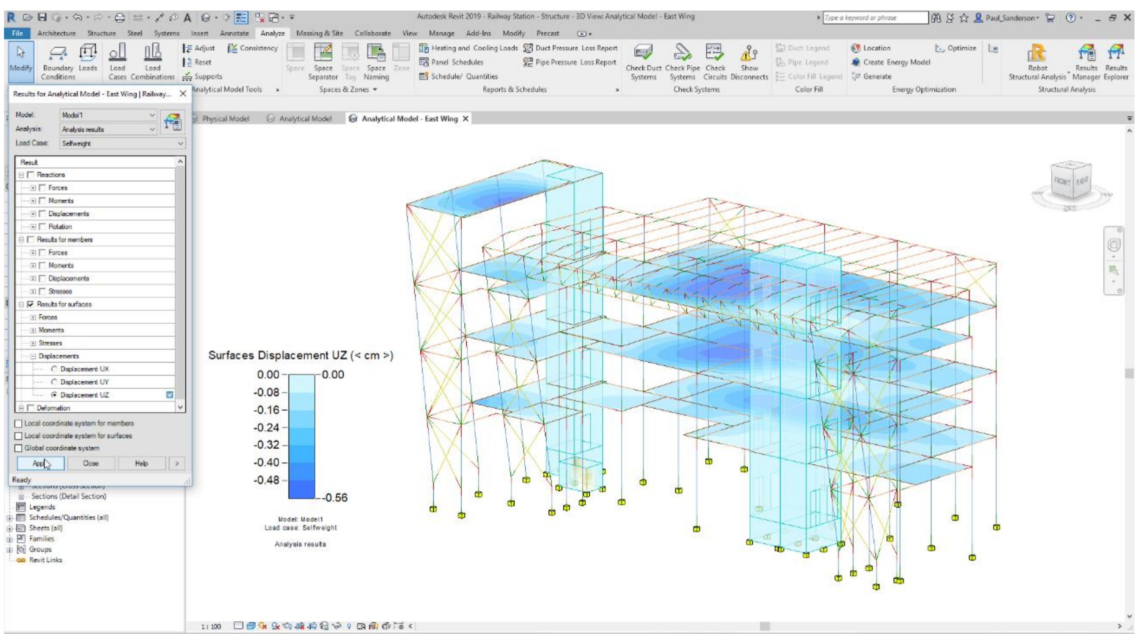
When design changes and analysis have been completed by the engineer, the information can be brought back into BIM 360 Docs to allow the designer to review the design changes (the updated physical model /steel sections profiles).

Also, here structural engineers can upload their structural analysis and code-checking documentation in the PDF file format.





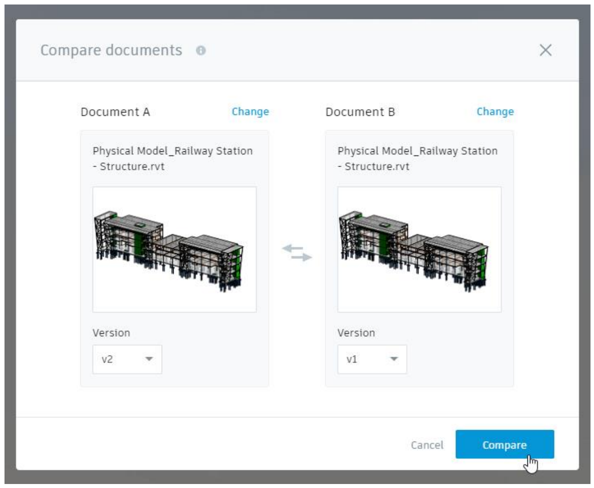
Results can be easily stored and explored in the Revit environment, enabling users to explore and document results and make effective design decisions. Structural Results Storage and Results Exploration tools delivered by the Structural Analysis Toolkit enable users to explore and document results. They can use this information to understand the structure's behavior, view consolidated and detailed results, update documentation, and make further effective design decisions.



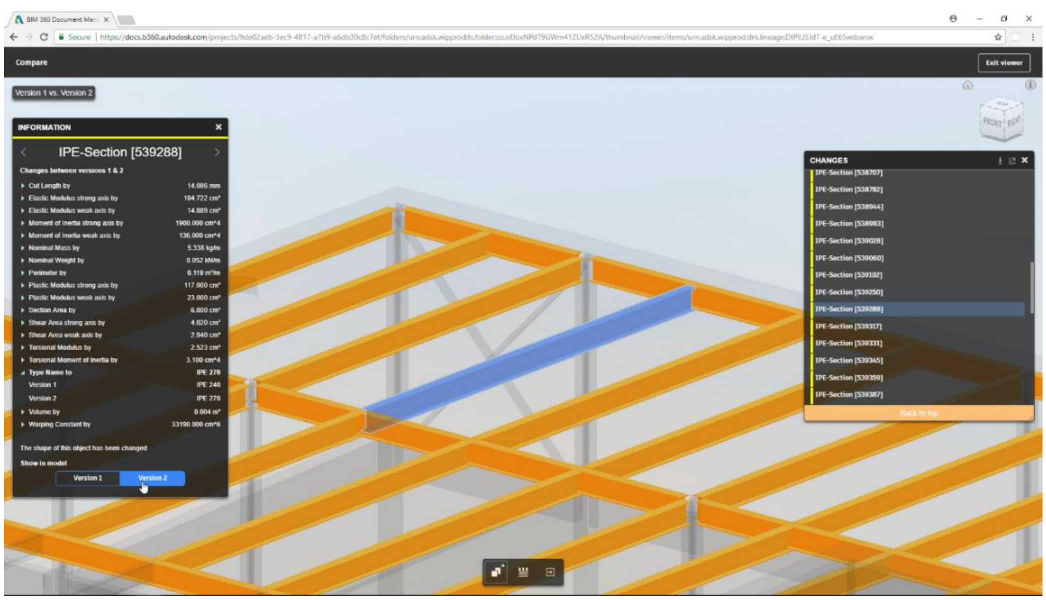
Once the Revit model has been updated after the analysis and code-checking process the structural engineer can upload a new version of the Revit project to BIM 360 Docs.

Comparison of changes in the structural model

Then the structural designer can access the updated optimized model by the structural engineer via BIM 360 Docs.
Using the Compare tool, the structural designer can get insight into what has been changed in the model.



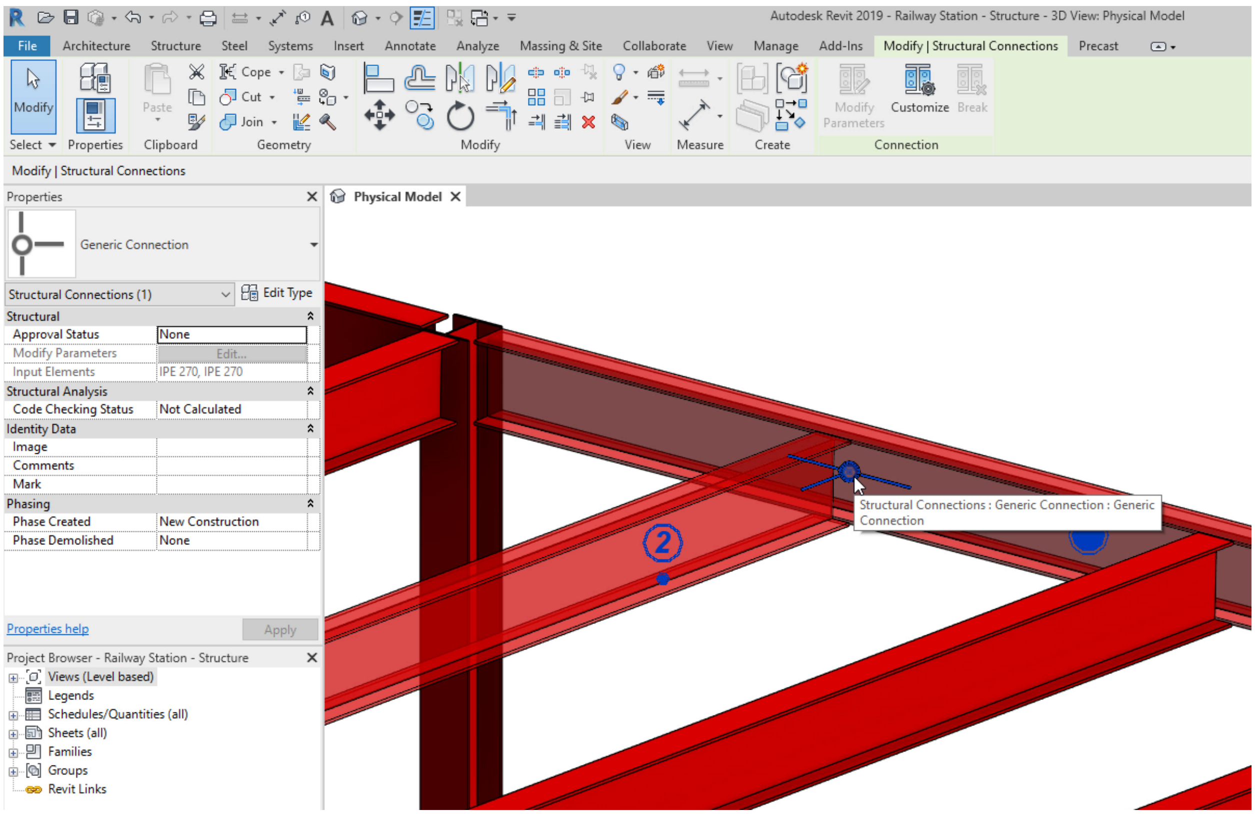
BIM 360 Docs has integrated change visualization that lets users compare the changes between two selected versions of the project.



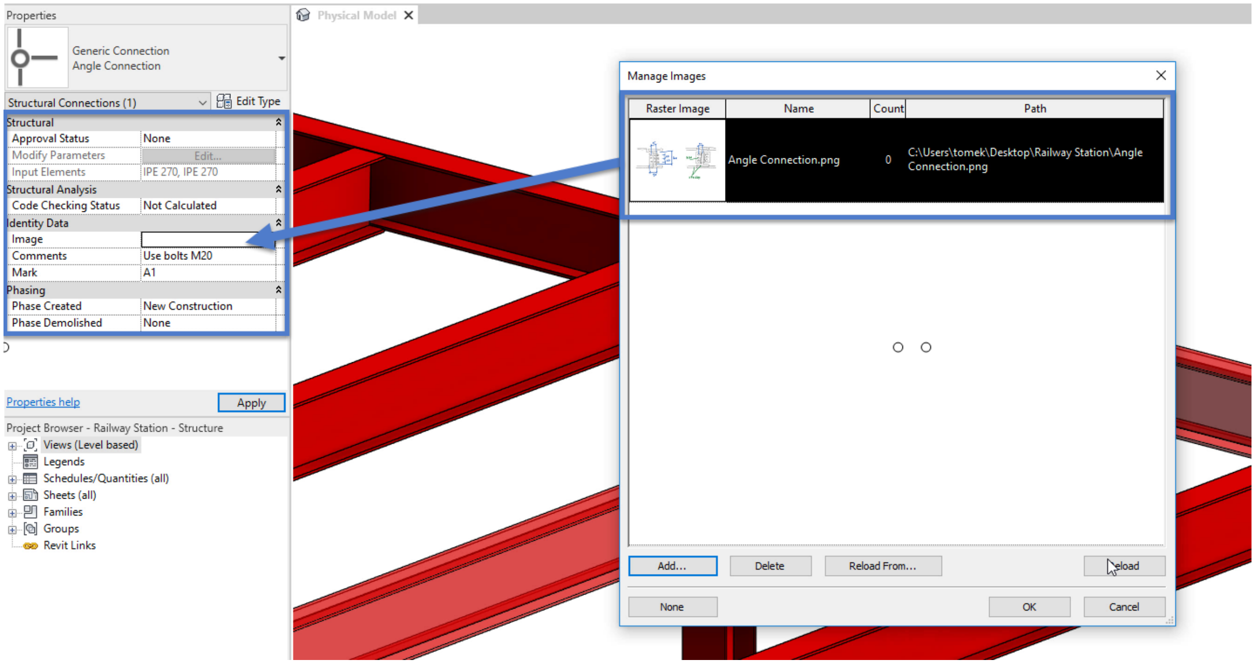
This summary provides a quick overview of changes made by the structural engineer during the code-checking process.
With BIM 360 Docs, structural teams can manage 2D plans, 3D BIM models, and any other project documents.

Connect design to fabrication for steel structures

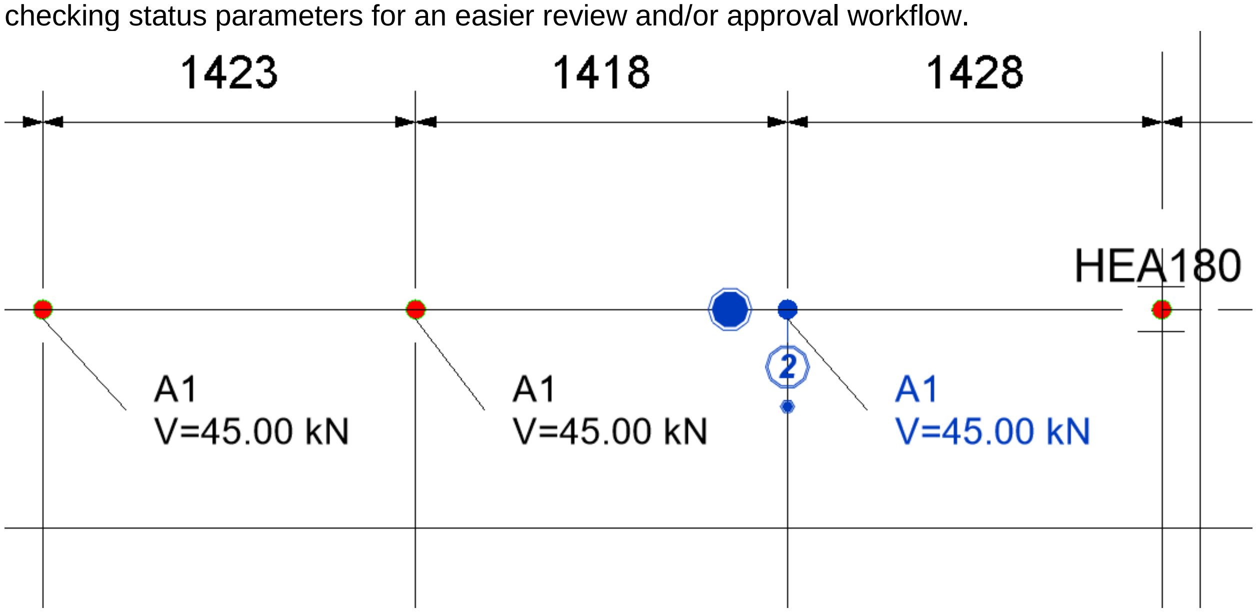
During the project process from design to detailing, there are many discussions between the engineer, detailer, and fabricator about how to connect the multi-material framing elements like beams, columns, and bracings. In this case in Revit, a structural connection object can be placed to supply information about the desired connection and define the relations between the elements.



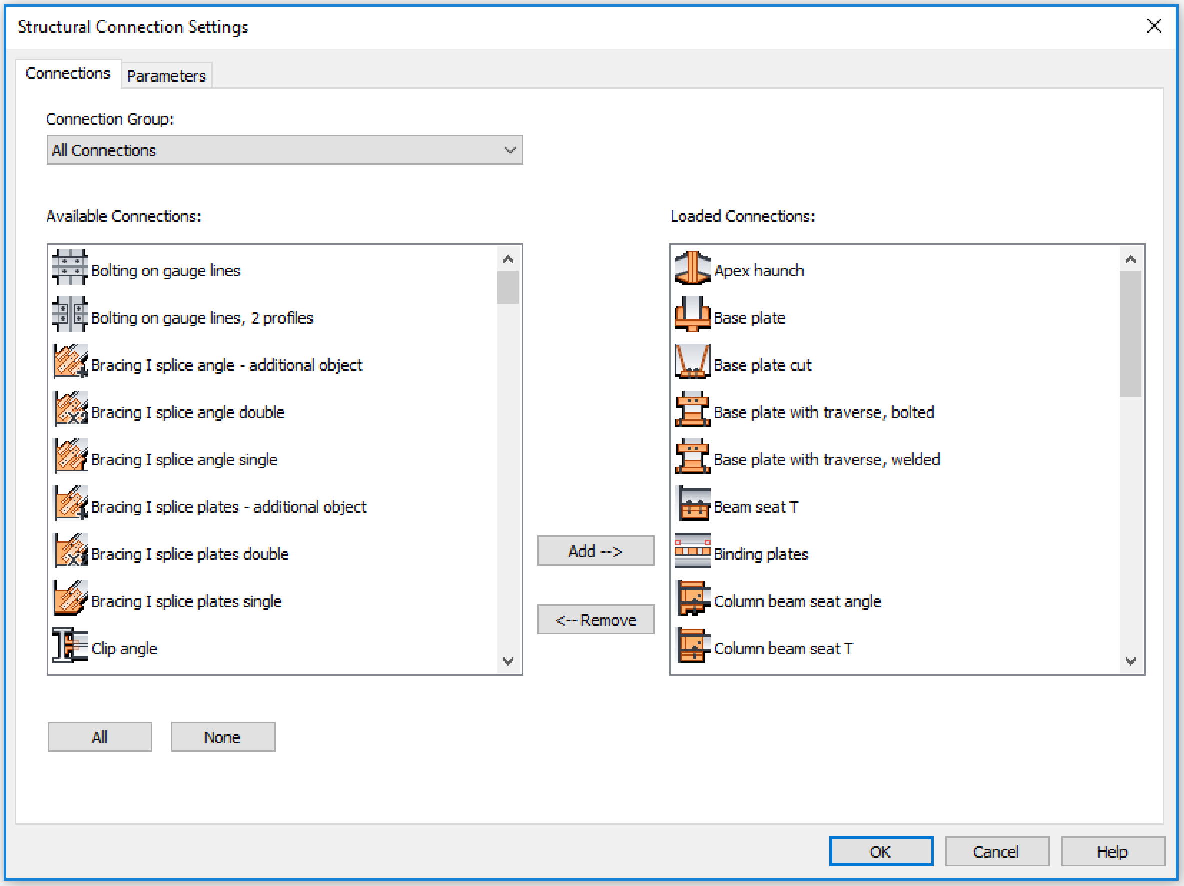
Beneath several parameters for schedules and tags, it also enables you to store pictures and link to further documentation about the connection, like connection requirements or design reports.

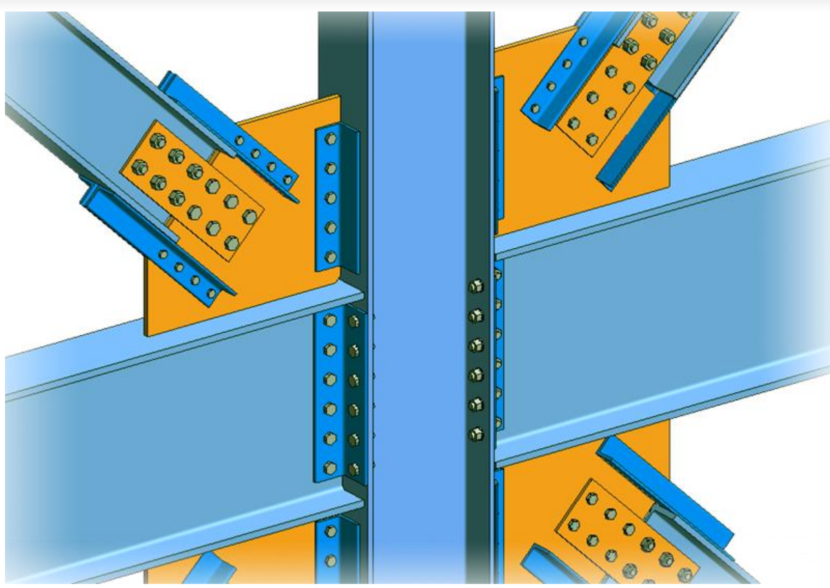


The symbolic connectors can be shown in drawings with color-based approval and/or code checking status parameters for an easier review and/or approval workflow.



If required, the connection between framing steel elements can be extended with detailed steel connections. Revit 2019 now provides higher levels of detail for modeling steel connections. The connections are comprised of new object types within Revit including bolts, shear studs, anchors, welds and plate work, and new cut and penetration object types. Users can also build custom connection details, in addition to using over 130 out-of-the-box parametric steel components.


Structural Connection Settings
Connections
Parameters
Connection Group:
All Connections
Available Connections:
Bolting on gauge lines
Bolting on gauge lines, 2 profiles
Bracing I splice angle - additional object
Bracing I splice angle double
Bracing I splice angle single
Bracing I splice plates - additional object
Bracing I splice plates double
Bracing I splice plates single
Clip angle
Add -->
<-- Remove
Loaded Connections:
Apex haunch
Base plate
Base plate cut
Base plate with traverse, bolted
Base plate with traverse, welded
Beam seat T
Binding plates
Column beam seat angle
Column beam seat T
All
None
OK
Cancel
Help



Also interesting is the ability to perform connection design.
There is built-in connection design in Revit for standard connections (in the previous workflow I described how to get the internal forces needed for the code-checking), and integrations with third party connection design solutions, like IDEA Statica.

Bolt Checking

Conditions

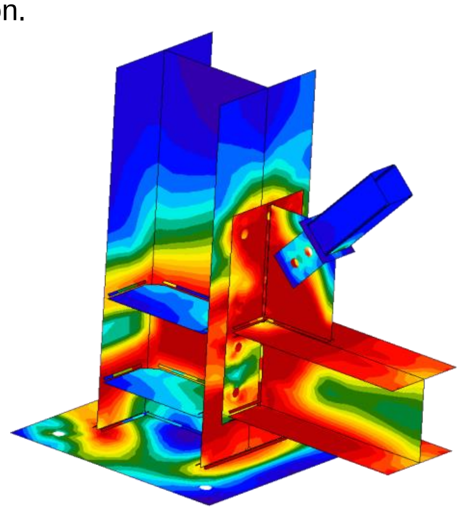
Bolts center distance ≤ Secondary beam width
100mm ≤ 100mm
OK

Bolts on connecting object: [J3]
Minimum Bolt Edge Distance [J3.4]
Minimum Bolt Edge Distance ≤ Bolt Edge Distance
25mm ≤ 35mm
OK
Maximum Bolt Edge Distance [J3.5]
Bolt Edge Distance ≤ min (6 inch or 150 mm, 12*min(connected objects thicknesses))
50mm ≤ 150mm
OK
Minimum Bolt Spacing [J3.3]
3*d (round up to 1/8 inch or 5 mm) ≤ Bolt Spacing
60mm ≤ 60mm
OK
Maximum Bolt Spacing [J3.5]
Bolt Spacing ≤ min(12 inch or 305 mm, 24*min(connected objects thicknesses))
60mm ≤ 228mm
OK

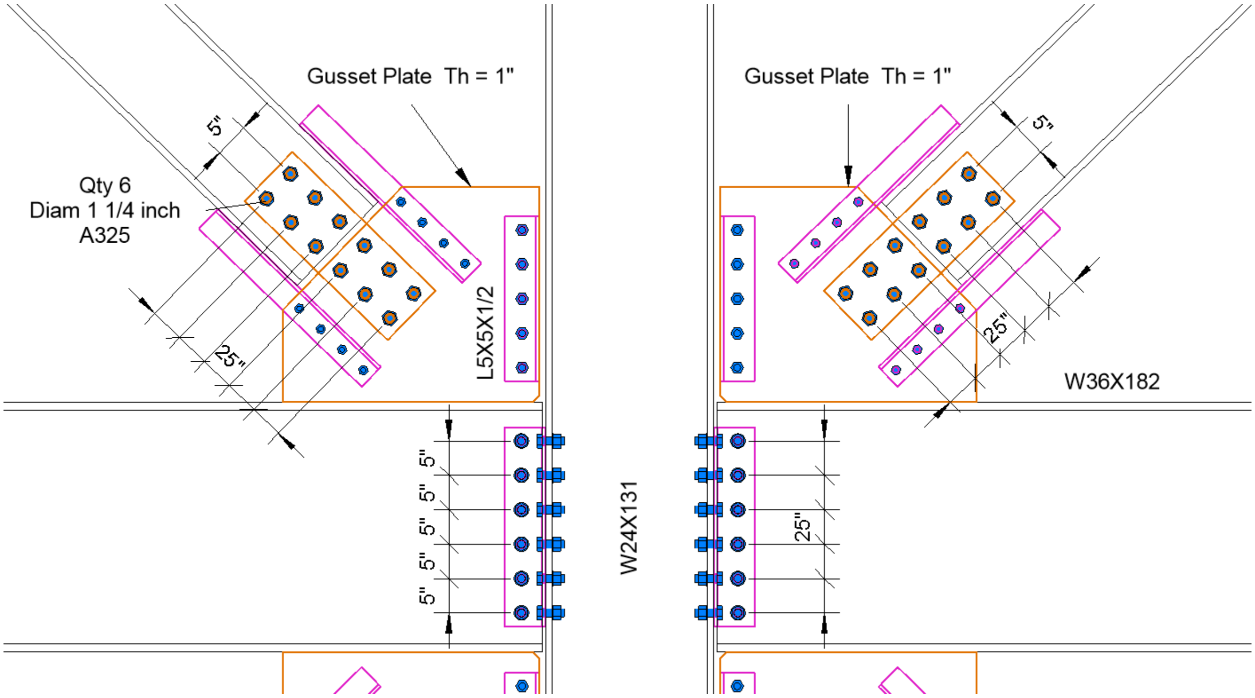
Bolt Strength Verification

Vu ≤ nObj*Phi*n*rnv
97.2kN ≤ 1*0.75*6*106.03kN
97.2kN ≤ 477.13kN
20.37 %
OK

By connecting Revit steel connections to Statica, engineers can analyze and design the non-typical steel connections in the same BIM environment where they produce their design documents. The connection forces are also extracted from Revit's analytical model database, which stores all forces collected by structural analysis solutions. This makes Revit a single source of truth for structural engineers to perform both the frame and connection design, as well as produce their documentation.



With detailed steel design capabilities in Revit, structural engineers can create new types of engineering documentation, perform BIM-based connection design, and produce more accurate bills of material (BOMs).



This streamlines the work processes by enabling better collaboration between structural engineers, connection engineers, detailers, and fabricators in different locations. An effective bidding process is critical to the success of the structural business. Fabricators can benefit by receiving accurate quantities for bidding purposes through Revit design models. They can also eliminate waste in the shop and field by using the BIM environment to better coordinate their connection design to optimize for fabrication. Take a look below at the comparison of material take offs from Revit and Advance Steel.

Material Take Off from **Revit**:

<Structural Framing Schedule - Cut Lenght>

A	B	C	D	E	F	G	H	I
Mark	Type	Structural Material	Cut Length	Count	Weight o Piece	Total Weight	Surface of Piece	Total Surface
1000	UB305x165x40	Metal - Steel 43-275	4747	5	191.32 kgf	956.60 kgf	5.96 m²	29.79 m²
1001	UB203x102x23	Metal - Steel 43-275	2794	4	64.54 kgf	258.17 kgf	2.24 m²	8.97 m²
1002	UB305x165x40	Metal - Steel 43-275	2777	4	111.91 kgf	447.65 kgf	3.49 m²	13.94 m²
1003	UB203x102x23	Metal - Steel 43-275	2994	3	69.16 kgf	207.48 kgf	2.40 m²	7.21 m²
1004	UB203x102x23	Metal - Steel 43-275	2094	3	48.37 kgf	145.11 kgf	1.68 m²	5.04 m²
1005	CHS114.3x5	Metal - Steel 43-275	3020	2	40.77 kgf	81.54 kgf	1.08 m²	2.17 m²
1006	L100x100x10	Metal - Steel 43-275	4850	2	72.75 kgf	145.50 kgf	1.94 m²	3.88 m²
1007	UB305x165x40	Metal - Steel 43-275	4427	2	178.41 kgf	356.82 kgf	5.56 m²	11.11 m²
1008	UB305x165x40	Metal - Steel 43-275	4444	1	179.09 kgf	179.09 kgf	5.58 m²	5.58 m²
						2777.97 kgf		87.70 m²

Material Take Off from **Advance Steel**:

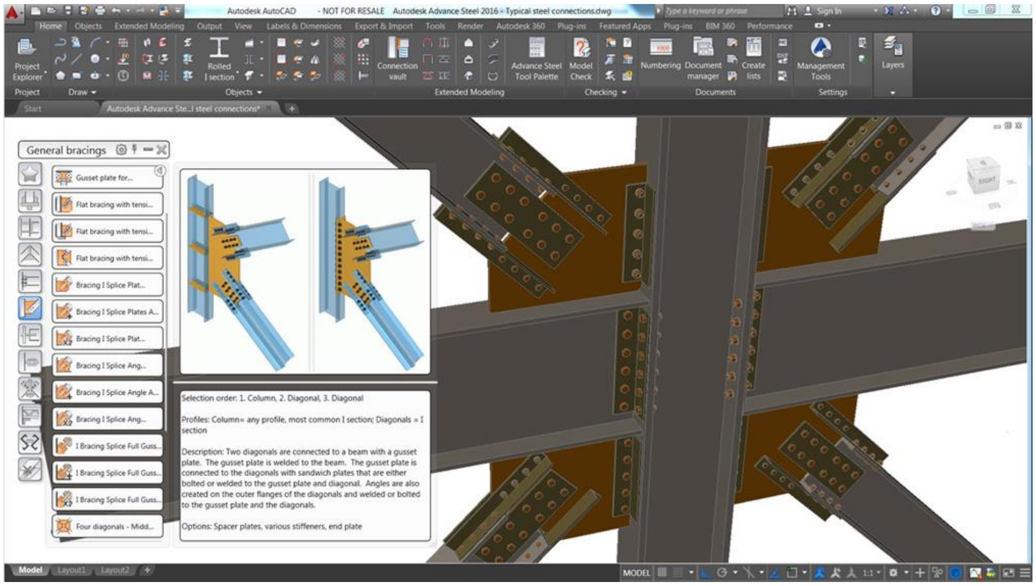
Company *MATERIAL LIST*

Date: 01-Apr-2018
Project:
Author:

Mark	Size	Quantity	Grade	Length (mm)	Width (mm)	Weight each (kg)	Total Weight (kg)	Surface Area (m^2/part)	Total Surface (m^2)	Description
	Straight Beams									
1000	UB305x165x40	5	S235	4,747.00		191.20	955.90	5.96	29.79	
1001	UB203x102x23	4	S235	2,794.00		64.50	257.90	2.24	8.97	
1002	UB305x165x40	4	S235	2,777.00		111.80	447.30	3.49	13.94	
1003	UB203x102x23	3	S235	2,994.00		69.10	207.30	2.40	7.21	
1004	UB203x102x23	3	S235	2,094.00		48.30	145.00	1.68	5.04	
1005	CHS114.3x5	2	S235	3,020.00		40.70	81.40	1.08	2.17	
1006	RSA100x100x10	2	S235	4,850.00		73.10	146.20	1.94	3.88	
1007	UB305x165x40	2	S235	4,427.00		178.30	356.60	5.56	11.11	
1008	UB305x165x40	1	S235	4,444.00		179.00	179.00	5.58	5.58	
		26					2,776.60		87.69	
		26					2,776.60		87.69	

The BIM-centric solution allows users to design and detail with clash prevention in mind to reduce clashes both in the preconstruction and site execution project phases.
Detailers can benefit by better coordinating with engineers and contractors and managing the design changes. They can also extend their BIM-based services into preconstruction and reuse BIM-based model information directly from engineers to eliminate rework.

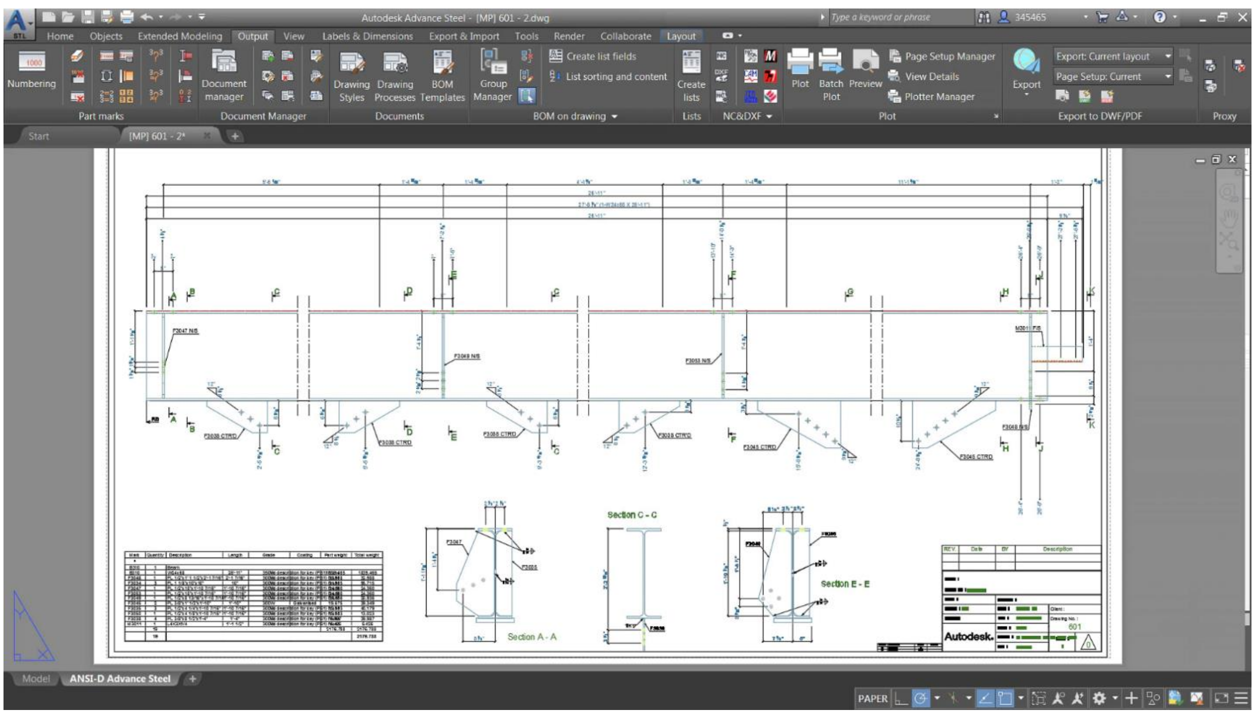
The link between Revit and Advance Steel software helps make the design to fabrication workflow smoother by facilitating the coordination of design models with detailed models. The bidirectional interoperability between the two products helps reduce the time needed to create and update design models and helps to avoid potential errors resulting from manual coordination between conceptual design and documentation for steel detailing and fabrication.



Advance Steel software provides structural steel detailers, fabricators and engineers, with easy-to-use, comprehensive tools based on the familiar AutoCAD platform. These powerful 3D modeling tools support a BIM process to help accelerate more accurate detailing of structural elements, steel connections, and plates.

Advance Steel helps save valuable design and modeling time with its robust library of parametric steel connections that are ready to use right out of the box. Because the connections are parametric, changes to any structural member's size will automatically adjust the connection's size as well. In addition to the intelligent structural objects, and parametric steel connections, you can help save valuable modeling time by using powerful wizards to more quickly generate straight and spiral stairs, straight and curved railings, and cage ladders and bring it back to Revit if needed.

Assemblies are automatically created in Advance Steel based on the field/bolt assignments in Revit's steel connections.



Once your design is completed, Advance Steel offers a wide range of automated functions to create all the fabrication and general arrangement drawings.
Users can also create bill of materials using predefined and custom formats.
The software also automatically generates CNC (Computer Numeric Control) files (DSTV format) for workshop machines, such as welding robots, allowing the direct data transfer from the 3D model to fabrication.
Advance Steel is intuitive enough to inform the user in real time if documents such as drawings, bill-of-materials and CNC data require an update. Advance Steel offers the possibility to update the drawings with an integrated revision control including automatic revision clouds.

Structural Optimization of Constructions

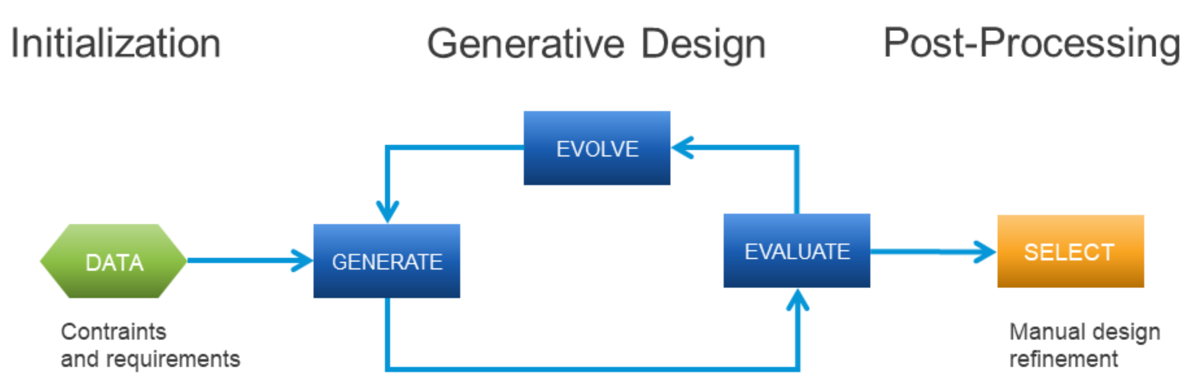
Outcome based BIM technology helps generate a virtually infinite number of design alternatives. Start with your desired outcome, then explore a near infinite range of possibilities and produce optimal designs in a fraction of the time - the power of the cloud helps make this a reality today. Designers and engineers can generate multiple options, ideas and scenarios more rapidly than ever before - exploring forms, simulating performance, and impressing clients with cinematic quality renders and optimal designs.

Computational Design for BIM is an intelligent model-based process that provides a framework for negotiating and influencing the interrelation of internal and external building parameters.

In relation to design, computation involves the processing of information and interactions between elements which constitute an environment. Computational Design provides a framework for negotiating and influencing the interrelation of both internal and external properties, with the capacity to generate complex order, form, and structure. By combining the principles of computational design with Building Information Modeling, a fundamentally new method of building design is made possible.

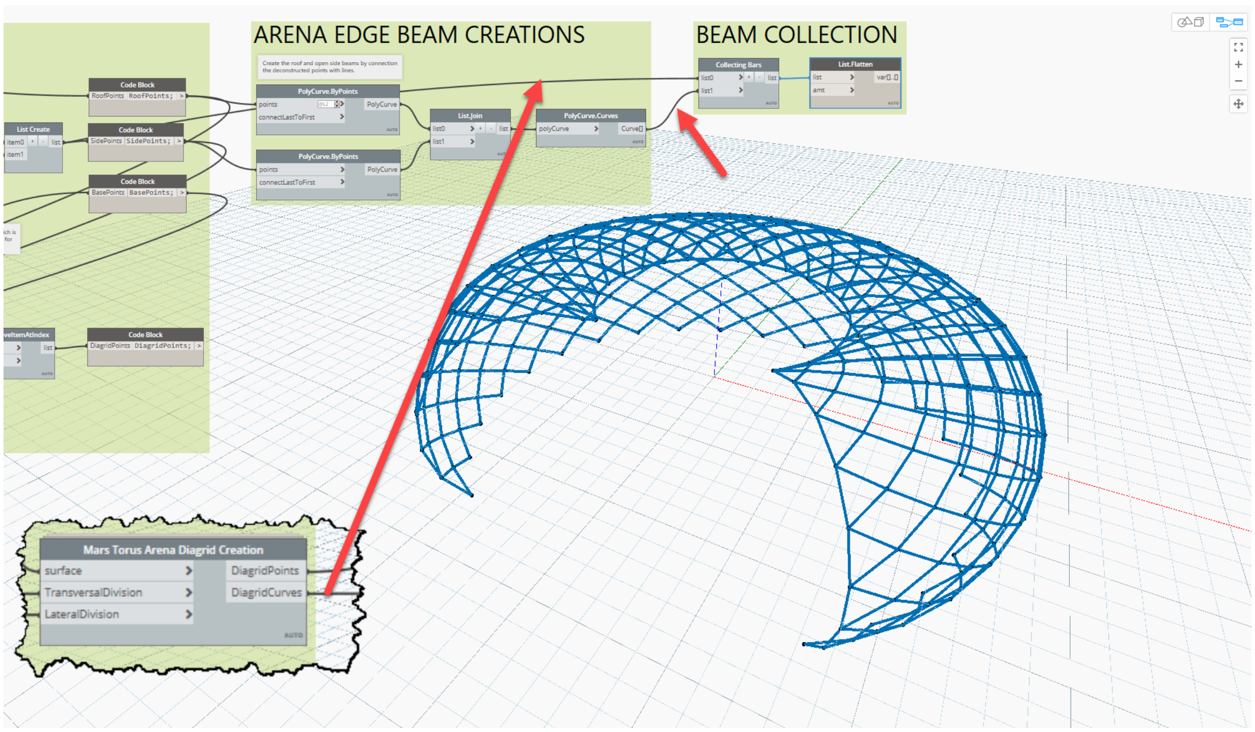
In practice, this is made possible by means of Dynamo. (www.dynamobim.org)

In this workflow a structural problem is initialized and analyzed by means of a computational model. Several options are generated, evaluated and then evolved to better designs.



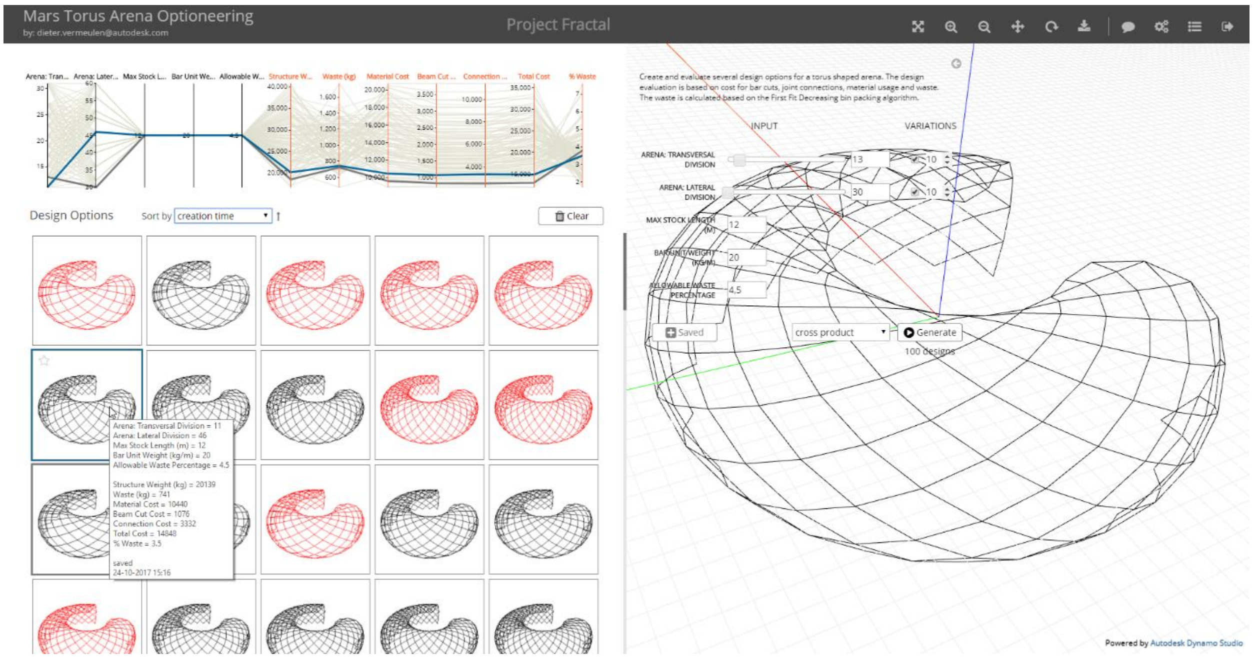
Computational Model

First, a computational model is setup by means of nodes and custom nodes. This will create the framework for the geometry that needs to be evaluated.



Option Generation

Generating options in a “brute-force” method can be done with the beta project “Project Fractal”. This online service allows a user to explore the parametric design space of models created in Dynamo Studio with the automatic generation of a wide sampling of options.



More information about this beta project can be found here: https://home.fractal.live/

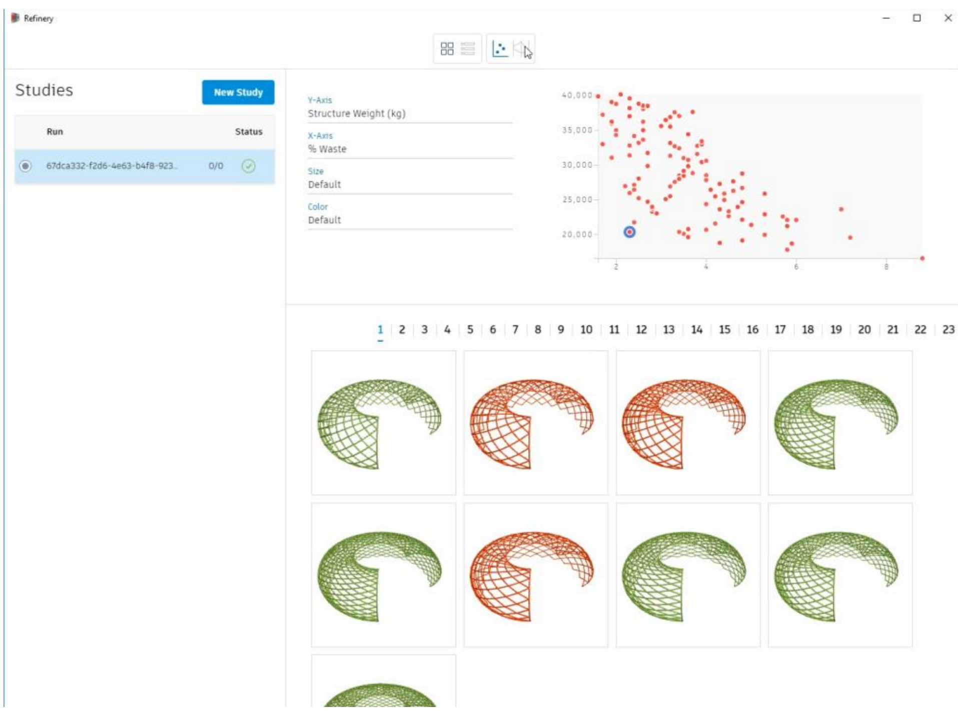
Important notes about Project Fractal:

- It is not a commercial service or product
- Only for testing purposes / feedback gathering
- Connects with Dynamo Studio
- Design Exploration software that supports optioneering workflows
- Request access through this link: https://home.fractal.live/

Optimization with Refinery

Project Refinery allows users to perform design exploration including optioneering and optimization workflows on Dynamo projects.

Refinery uses the NSGA-II optimization algorithm (a type of genetic algorithm), which is a meta-heuristic optimization algorithm for multi-objective optimization. Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection. A genetic algorithm is a population-based optimization. Population-based approaches maintain and improve multiple candidate solutions, often using population characteristics to guide the search. Each round of the optimization processed in the genetic algorithm is called a generation. So, when you set the generation value to 40, the process of selection, cross over, and mutation happens 40 times for each population of 40 designs. You can read more here. The seed simply says where the algorithm should start. If you keep the seed at "64" and then do another run with the same inputs you should get the same answer.



Important notes about Project Refinery:

- Connects with Dynamo 2.0
- Design Exploration software
- Optioneering and Optimization workflows
- Advanced results display
- Syncing selected option back to Dynamo
- Request access through this link: https://beta.autodesk.com/key/refinery

More information

More information on how to set up this workflow including the datasets, can be found from two other classes Dieter Vermeulen teached in the past:

ES119852 - Dynam(o)ite Your Steel Design @ AU Las Vegas 2017
In this class you could learn about how to involve computational design and optimization techniques in your structural steel constructions. The example of the "famous" Mars Torus Arena was used.
Class Recording:
http://au.autodesk.com/au-online/classes-on-demand/class-catalog/classes/year-2017/dynamo-studio/es119852#chapter=0

Presentation:
https://www.dropbox.com/s/c5jq01n94tyr3jq/ES119852%20-%20Dynam%28o%29ite%20Your%20Steel%20Design.pptx?dl=0

Datasets:
https://www.dropbox.com/s/v33pvb27dhnm0lj/ES119852%20-%20Dynam%28o%29ite%20Your%20Steel%20Design%20-%20datasets.zip?dl=0

Optimization of Structural Designs with Dynamo @ AU London 2018
In this hands-on session, you could learn how to create your own Dynamo script for structural optimization with Optimo, Fractal and Refinery.

Presentation:
https://www.dropbox.com/s/5jv73w47jgx6u87/Optimisation%20of%20Structural%20Designs%20with%20Dynamo.pptx?dl=0

Datasets:
https://www.dropbox.com/s/20l81yuw5hrguw9/Mars%20Torus%20Arena%20Datasets.zip?dl=0