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BIM Workflows for the Structural Engineer: Design to Fabrication

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Learning Objectives

- Learn how to transfer model information between design and analysis applications.
- Develop model standards and workflow protocols that facilitate transferring model information.
- Learn how to employ BIM 360 capabilities to manage and share models and drawings.
- Learn how to create processes in BIM 360 to review models and drawings for quality control.

Description

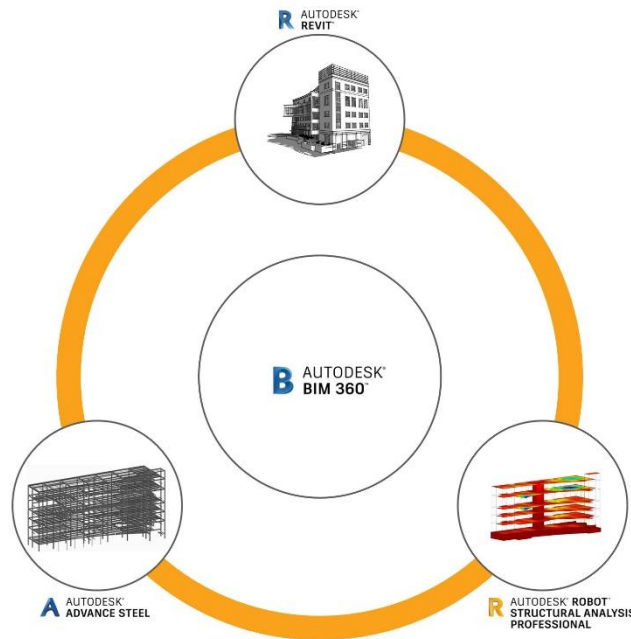
Structural engineers manage design changes and updates on a daily basis. Coordinating models and drawings while maintaining quality is always a challenge—not to mention working remotely or from home. The DRY (Don't Repeat Yourself) principle is an effective approach to managing change during design and construction processes. Linking Revit models with structural analysis tools is one of the biggest benefits and challenges structural engineering teams still encounter. In this class, we will look at best practices for keeping structural models and workflows DRY, including linking models between Revit, Robot Structural Analysis software, and Advance Steel software; managing, coordinating, and sharing models using BIM 360 software; and reviewing construction and fabrication drawings for quality control with BIM 360. Incorporating some of these approaches into your workflows will help you keep up with the pace of change.

Speaker

Brian is a Technical Specialist for Autodesk. He is an expert in structural modeling and design using Revit and Robot Structural Analysis. Brian is a licensed structural engineer with over 15 years of building design and consulting experience. During that time he worked as a Project Manager, and Principal on a variety of structures. He earned a B.S. in Civil Engineering from the University of Texas at Austin.

Linking Structural Models

Managing changes in the design process is one of the challenges structural engineers face daily. The links between Autodesk Revit, Robot Structural Analysis (RSA), and Advance Steel enable engineers to not duplicate modeling efforts for drawings, analysis, and fabrication detailing. With this in mind, we will explore connected workflows between Revit, Robot Structural Analysis Professional and Advance Steel with BIM 360 as a hub for coordination.



I will be using BIM 360 Design for Revit and BIM 360 Docs for these examples. A subscription to BIM 360 is not needed for the links between the applications. Sign up for a trial of BIM 360 if you want to follow along. See Figure 1 for the folder structure used in the exercise.

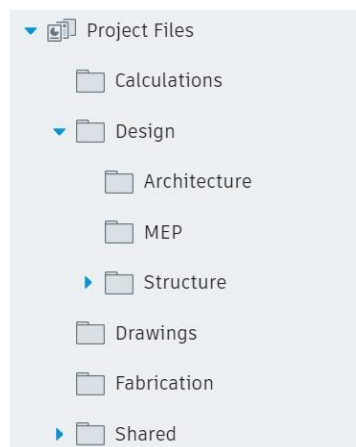


FIGURE 1: FOLDER STRUCTURE IN BIM 360

Download the Addins

Some of these connected workflows require addins. The exchange workflow between Revit and Robot Structural Analysis does not require any addins if both applications are installed on the same computer. The Structural Analysis Toolkit is needed to view analysis results in Revit. Download the appropriate addin for the other workflows. The exercises use the 2021 releases.

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- Robot Structural Analysis Link for Revit 2021*
- Advance Steel Extension for Revit 2019–2021 [Hotfix 1]
- Revit 2018 Steel Connections

*Only need if Robot Structural Analysis Professional is not installed alongside Revit.

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- Structural Analysis Toolkit 2018–2020*
- Robot-AdvanceSteel Link 2018–2021
- Advance Steel 2018 Extension

*Functionality ships with Revit 2021

The linking interfaces will appear on the ribbons and menus of the applications upon installation of the respective add-ins.

Design with Revit

Start the modeling process from Revit or RSA. Some engineers prefer to start with the analysis model while others prefer to lay out the structure first in Revit. We will start with Revit for these examples.

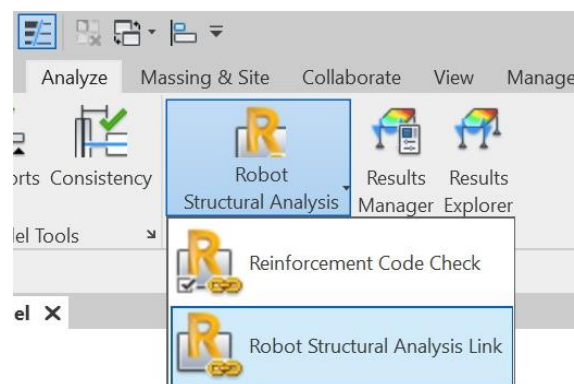


FIGURE 2: ROBOT STRUCTURAL ANALYSIS LINK IN REVIT

Direct Transfer

1. Open Connected Frame.rvt in Revit 2021.
2. Start a new Building Design project in RSA 2021.
3. Select Robot Structural Analysis Link from the Analyze ribbon in Revit.
4. Select Send model.
5. Select Direct Integration if you have RSA installed and open on your computer. Select Send to the intermediate file (.smxx) if you do not have RSA installed on your computer.
6. Select OK to start the data transfer.

The Direct Transfer option will immediately start transferring information into the open analysis model in RSA. Have both applications open side-by-side to see the transfer occur in real-time in RSA.

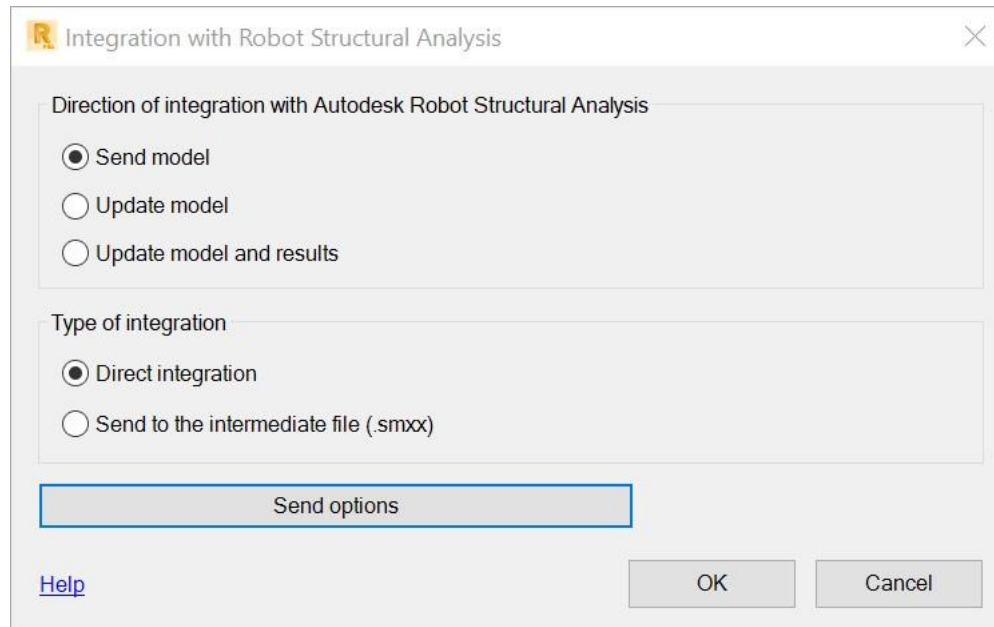


FIGURE 3: INTEGRATION DIALOG IN REVIT

7. In RSA, select Add-Ins > Integration > Autodesk Revit Structure in the menu bar.
8. Select Update model.
9. Select Update from the intermediate file (.smxx).
10. Select OK to start the data transfer.
11. Browse to and select the exchange file.
12. Select Open.

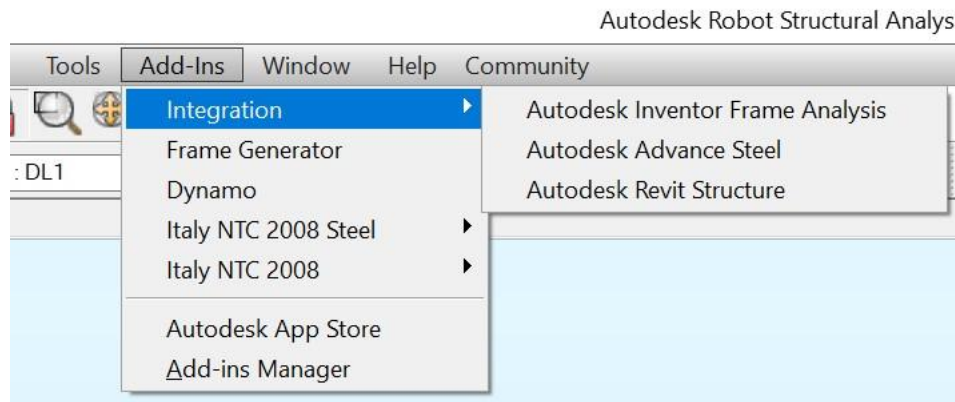


FIGURE 4: INTEGRATION ADDINS IN RSA PRO

A prompt to view the transfer report appears when any of the transfer processes is complete. Any warnings or errors will show up here for troubleshooting. Dismiss the dialog.

Transfer Updates

After optimizations are complete, transfer the updates back to Revit. The transfer processes are reversed. In the case of sending the RSA updates back to Revit, the option to Send model and results will synchronize the structural elements (adding, deleting, and modifying) and transfer all the results, such as:

- Internal axial and shear forces and moments
 - Displacements and deflections
 - End reactions
1. Change the layout to Loads from the Layout Navigator listbox.
 2. Select LL1 in the Load Types dialog.
 3. Open Load Definition from the right-hand toolbar.
 4. Select the Bar tab.
 5. Select Uniform load.
 6. Change the Z value to -0.50.
 7. Press Add.
 8. Select the beam in the model canvas.
 9. Close the dialog.
 10. Change the layout to Geometry from the Layout Navigator listbox.
 11. Select the beam in the model canvas.
 12. Change the Section to a W 8x28 from the Property Palette.
 13. Press the Calculate button on the main toolbar to analyze the structure.
 14. Save the RSA model to the Calculations folder in the BIM 360 “drive.”
 15. Select Add-Ins > Integration > Autodesk Revit Structure from the menu.
 16. Send Model *and results*.
 17. Press okay to update the Revit model, leaving the defaults in the results manager dialog that opens.

View the analysis results in Revit using the Results Manager and Results Explorer from the Analyze ribbon.

1. In Revit, open the Analytical Model view.
2. Change the view orientation to Front using the View Cube.
3. Select Results Explorer in the Analyze ribbon.
4. Select Load Case: LL1 and Moments.
5. Click Apply to view the live load moments.
6. Click Synchronize with Central from the Collaborate ribbon if using BIM 360 Design. Save otherwise.

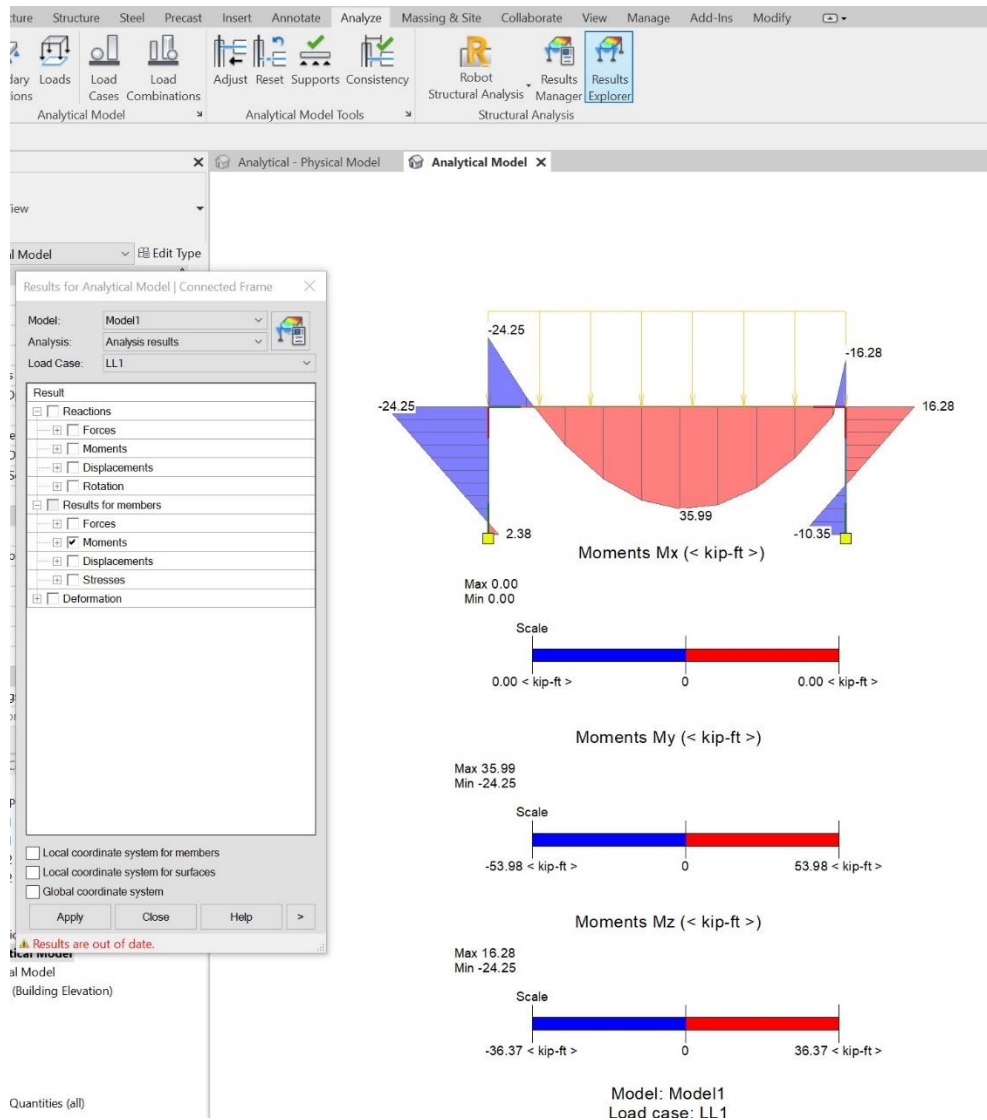


FIGURE 5: RESULTS EXPLORER IN REVIT

Design with Advance Steel

Companies that design industrial structures typically have other AutoCAD-based software like Plant 3D and have structures that are primarily structural steel. For these companies, a design workflow in Advance Steel may be preferable. The intermediate file workflow for Advance Steel and Robot Structural Analysis is similar to that of Revit to Advance Steel workflow described below. Analysis results from RSA may be transferred to Advance Steel for the Joint Design functions in certain connection types.

Fabrication Advance Steel

Upon completion of the design model, engineers may wish offer steel detailing services during the construction phase. The Revit model is then transferred to Advance Steel to model connections and miscellaneous steel, number the parts, and create shop and erection drawings.

Model a Steel Connection

1. Select the Connection Settings (small arrow) from the Steel ribbon in Revit.
2. Select the Platform beams Connection Group.
3. Select Clip angle from Available Connections.
4. Press Add to populate the Loaded Connections.
5. Press OK.
6. Select the Connection from the Steel ribbon in Revit.
7. Select Clip angle from the Type Selector.
8. Select a column and a beam (CTRL+Click) and press Enter or Space.
9. Optionally, Rename... to Clip angle W12x W-B.
10. Press Edit... to Modify Parameters.
11. Open the Preview window and change to the 3D view. Zoom in.
12. Select the Clip weld tab in the Clip angle dialog.
13. Change Welded at to main.
14. Press OK twice to complete the connection command.
15. Synchronize with Central or Save the Revit model.

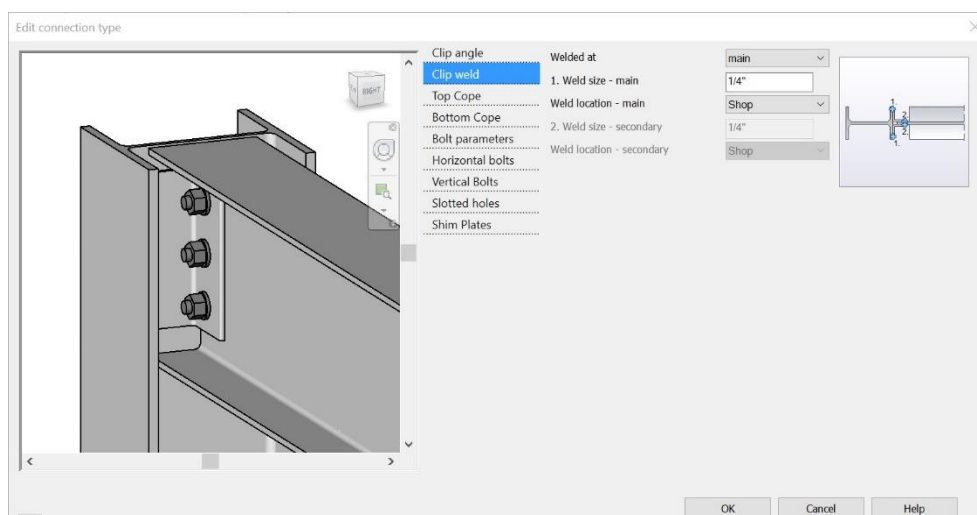


FIGURE 6: EDIT CONNECTION TYPE IN REVIT

Export to Advance Steel (.smlx)

The Advance Steel Extension in Revit (and RSA) sends and updates the Revit (and RSA) model to and from Advance Steel. The exchange file format is similar to that of the Revit-RSA exchange file. The process is very similar as well.

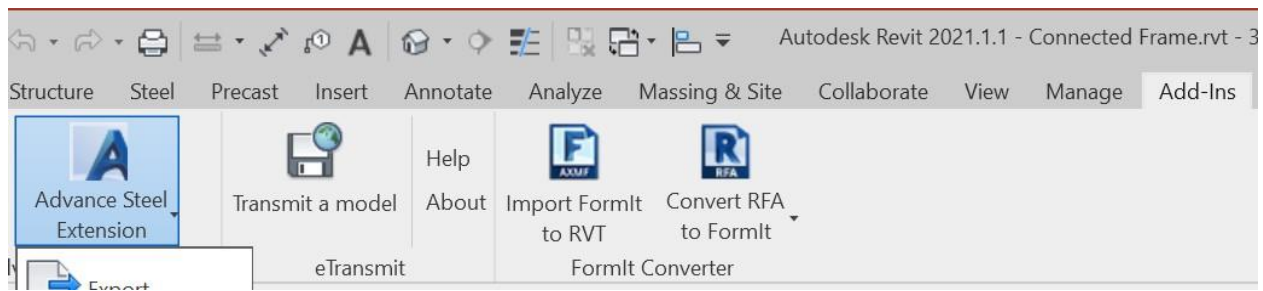


FIGURE 7: ADVANCE STEEL EXTENSION IN REVIT

1. Select the Advance Steel Extension > Export from the Add-Ins ribbon in Revit.
2. Select Advance export.
3. Select OK to start the data transfer.
4. Input the file name and location.
5. Select Save.
6. Create a new project in Advance Steel.
7. Select Import & Export > Revit > Import in the menu bar in Advance Steel.
8. Browse to and select the exchange file.
9. Select Open.
10. Use the mapping dialog to match any section or material, if needed.
11. Zoom extents.
12. Save the Advance Steel model to the Fabrication folder in the BIM 360 “drive.”

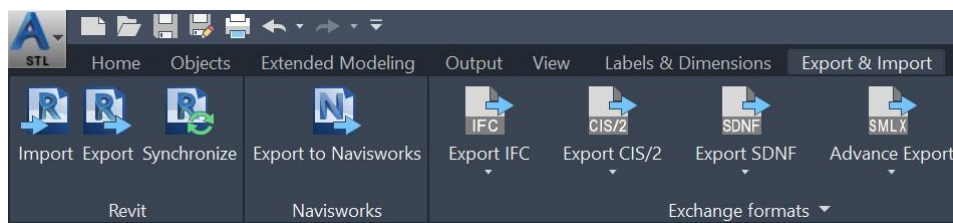


FIGURE 8: IMPORT & EXPORT COMMANDS IN ADVANCE STEEL

Transfer Updates

Make adjustments to any connections made in Revit, and add new connections.

1. Right-click one of the bolts of the clip angle connection in Advance Steel.
2. Select Advance Joint Properties.
3. Change the Clip weld Weld at parameter to none.
4. Open the Connection Vault from the Home ribbon.
5. Select Plates at beam > Base plate.
6. Select the bottom of the column, and press Enter or Space.

7. Select No to also picking a Concrete element.
8. Select the Properties > Joint Design tab.
9. Press Check to run the code check calculations.
10. Click Report... to view the calculations in your browser.
11. In the browser, save or print-to-PDF the results to the Calculations folder in the BIM 360 “drive.”
12. Close the Base plate dialog, and Zoom extents in Advance Steel.
13. Save.
14. Select Revit > Export from the Export & Import ribbon.
15. Save the file to the Fabrication folder in the BIM 360 “drive.”

Use the Synchronize(ation) command to update the models on the round-trip instead of Export or Import. The Synchronize dialog enables you to:

1. Open the Physical Model view in Revit.
2. Select Advance Steel Extension > Synchronization from the Add-Ins ribbon.
3. Load the file from the Fabrication folder in the BIM 360 “drive.”
4. Double-click the blue Connection text under Model object to zoom to the updated clip angle.
5. Select all the Status check boxes.
6. Press Apply All Actions to update the Revit model.
7. Synchronize with Central or Save the Revit model.

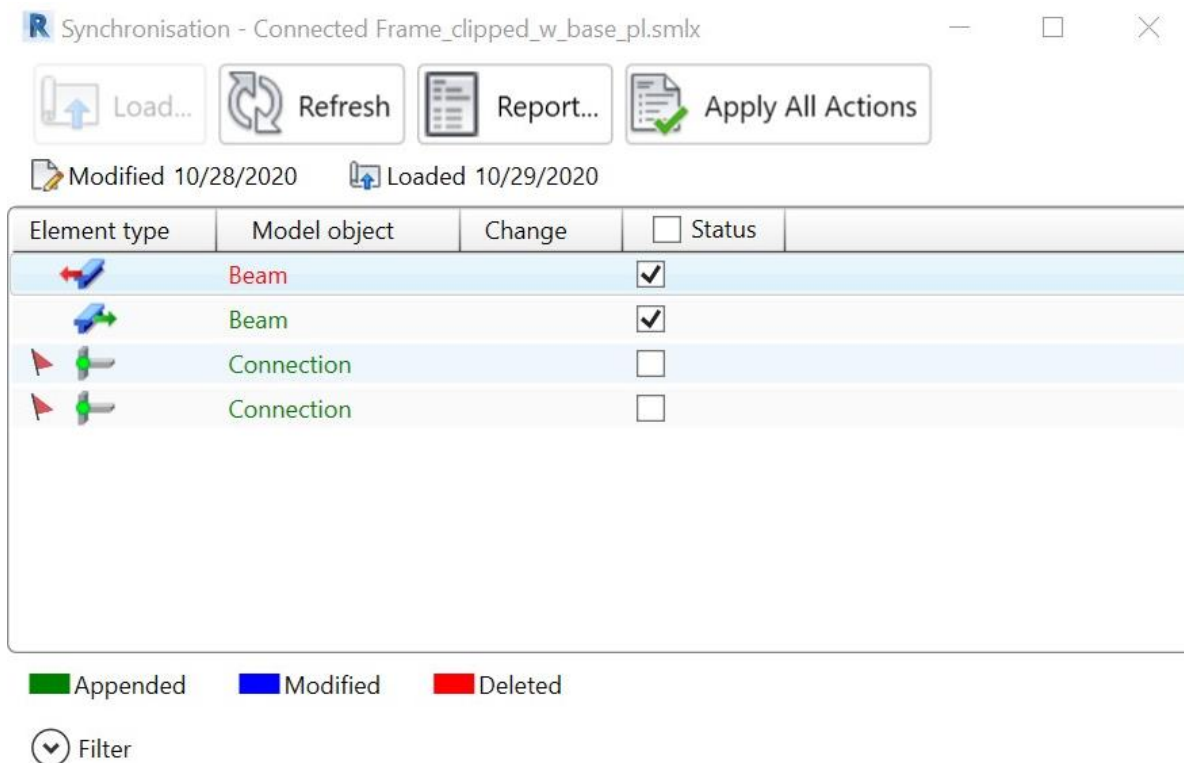


FIGURE 9: SYNCHRONIZATION DIALOG FOR ADVANCE STEEL

Mapping Sections and Materials

A dialog will appear when the exchange process cannot determine the section or material to use in the receiving application. Select the appropriate section or material from the dialog to create a mapping between the two applications for that particular item. See the Content Libraries section for more information.

Pre-transfer Activities

Review the Analytical Model elements in Revit or the System Lines in Advance Steel prior to sending them to RSA. In particular look for members that are not connected to other members. The analysis in RSA may not complete due to gaps between elements. Updates from RSA are generally coherent if you are able to run the analysis without issue. See the Model Hygiene section for more information.

Post-transfer Activities

Review the model in the receiving application to confirm all the elements were transferred as expected. After transfers to RSA, engineers will want to review the model and perform any additional modifications to prepare for analysis such as:

- Edit end releases of members, if they were not modified in Revit.
- Add load cases, loads, and load combinations, if they were not applied in Revit.
- Edit any advanced member properties, such as tension-only behavior.
- Edit mesh settings for panel elements.
- Edit design parameters/criteria for steel and concrete elements.

Most of these activities are only available in RSA.

Upon completion of the analysis model preparations, analyze the structure, and optimize the members.

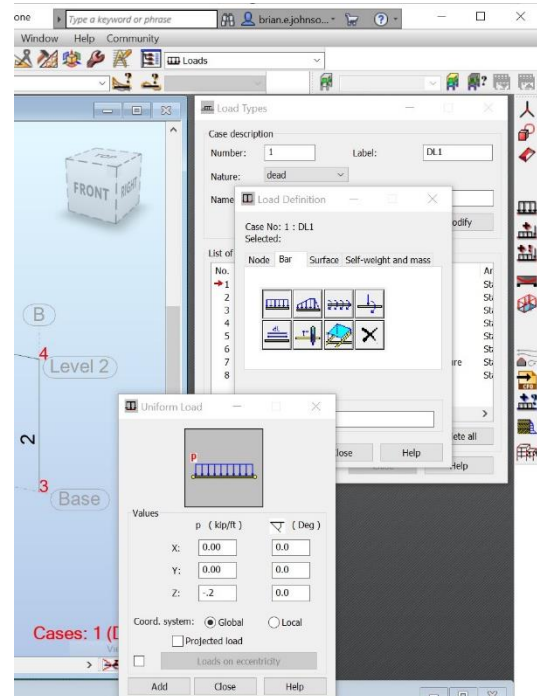


FIGURE 10: ADD UNIFORM LOAD IN RSA

Model Standards and Protocols

Successful transfers depend on good model hygiene, content libraries, and standard operating procedures. Adopting these workflows requires planning and some experimentation to get an intuition for the transfer processes and what works for your company and staff.

Model Hygiene

Structural analysis models typically require precision in modeling. For example, it may appear as though a column is connected to a beam at a common node; however, there may actually be two nodes very close together. Analyses usually fail due to instabilities when there are duplicate node conditions. This type of condition is easy to create in Revit if model elements are not connected well.

A few tips for maintaining a good analytical model in Revit:

- Inspect both 3D and 2D views of just the analytical elements.
- Compare the analytical elements to the “physical” elements in a 3D, Wireframe model.
- Adjust the analytical model elements using the tools in the Analyze ribbon and properties palette.
- Disable the analytical model for non-structural elements such as veneer walls or slabs-on-grade.
- Check and resolve any warnings related to the analytical model elements.

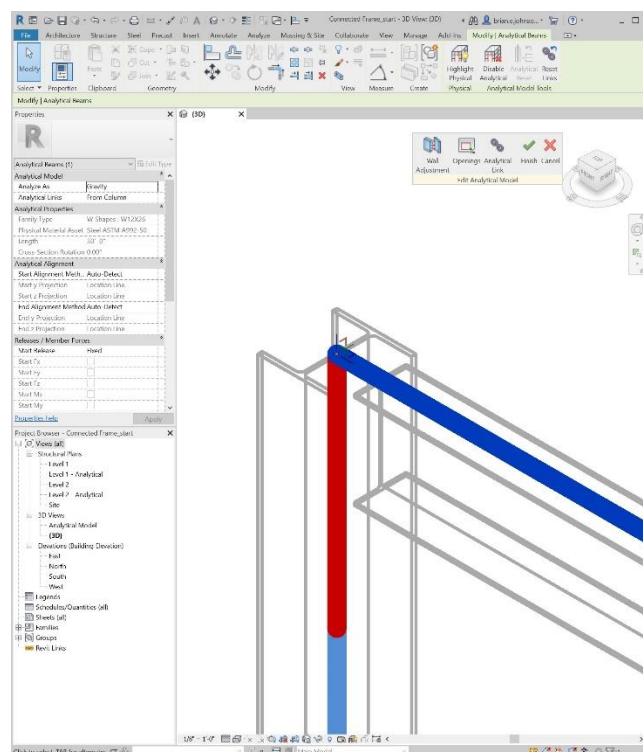


FIGURE 11: ANALYTICAL MODEL ADJUSTMENT IN REVIT

Content Libraries

Most of the standard sections and materials shipped out-of-the-box will transfer without issue between any of the three applications. However, many firms will customize the shipped content to suit their standards and create additional content. Plan for the transfer processes when developing content.

When synchronizing sections and materials between applications, the Revit Type is used to find a matching section or material in RSA or Advance Steel. The transfer procedures include some pattern matching with regular expressions to reconcile differences such as “W 8x10” and “W8X10”; however, other transfers such as HSS4x4x1/2 to HSS4x4x0.500 may not.

Consider the following:

- Align Revit family Types with RSA and Advance Steel section names.
- Align Revit material Types with RSA and Advance Steel material names.
- Load Case and Load Combination names in Revit and RSA.
- Create custom content in Revit, RSA, and/or Advance Steel PRIOR to transfers.
- Experiment with transfers of compound and built-up shapes between applications, such as plate girders, cover plated beams, and 3-ply wood beams.

If a section or material cannot be found during the transfer process, one of the following with occur:

- A new Revit family and type will be generated from a RSA to Revit transfer if that section Type is not loaded into Revit.
- A new material will be created automatically in either Revit or RSA with the same material properties (e.g. $f'c = 3,000$ psi in both)
- A mapping dialog will appear to select the appropriate section or material to match in the receiving application.

Protocols

Each firm is unique and has different workflows based on their staffing, preferences, and standards. These transfer processes are different. Consideration should be made for who performs certain tasks and in what application a task is performed. Some questions to ask:

- Who adjusts the analytical model in Revit—the designer or the engineer?
- Are loads applied in Revit or in RSA?
- Are some connections modeled in Revit or Advance Steel? Who models them?

My suggestions are as follows:

- Model grids, levels, framing and foundations in Revit.
- Model & update Boundary Conditions, Loads, and End Releases in RSA.
- Model connections in Revit if needed for clash coordination during design.

- Model remaining connections in Advance Steel.
- Update Revit with optimized members from RSA
- Update design changes from the Architect or Owner in Revit.

There are more options and parameters available in RSA than in Revit for boundary conditions, loads, and end releases, thus the recommendation to perform those tasks in Robot. Similarly, there are additional tools in Advance Steel to bulk create connections that are not in Revit.

Lastly, braces are the most difficult elements to transfer between the applications due to the challenge reconciling the physical model Work Point locations versus optimal analytical model node locations. Consider disabling the analytical model for braces in Revit and modeling them directly in Robot. Furthermore, exclude them from the transfers using Selection Sets in Revit and Groups in RSA.

Check out the [White Paper](#) available on the Autodesk Knowledge Network for additional suggestions, such as how to work with Worksets, Design Options, and Phases.

Manage and Share Models on BIM 360

BIM 360 Design is ideal for worksharing Revit models among the internal structural team as well as collaborating with the models from Architects and MEP engineers. BIM 360 is also ideal for managing and sharing RSA models, analysis results reports, exchange files, and Advance Steel models, drawings, and other deliverables.

BIM 360 Design

When worksharing Revit models in any context, be aware of what is updated while the engineer is working on the RSA model. Avoid making changes to the framing and foundations which would put the Revit model out of sync with the RSA model. Limit activities in Revit to annotations, setting up sheets, creating rendered view, etc. Similarly, avoid working on the RSA model while the Revit framing and foundations are adjusted for other design updates.

RSA models, the exchange files, and the Advance steel model and files should be added and edited via the Autodesk Desktop Connector. Uploading them to BIM 360 via the browser is also fine, but tends to take you out of process.

BIM 360 Docs

Consider the following when benefits of using BIM 360 for these files:

- **File Locking:** Lock the RSA and Advance Steel models in BIM 360 to prevent others from working on them at the same time and incurring a race condition for overwriting one and others' work. Unlock the files when you are done.
- **File Versions:** Compare different versions side-by-side. At any point you can regress back to a particular version if need be.
- **Share:** Share documents with others quickly and easily.
- **Model Coordination:** With a subscription to BIM 360 Coordinate, you can detect clashes fabricators, contractors, and other members of the design team.

Model and Drawing Reviews in BIM 360

Use BIM 360 Markups, Issues, and Review workflows for internal design reviews, calculation checks, peer reviews, shop drawing submittal review, or sharing design calculations with a municipality.

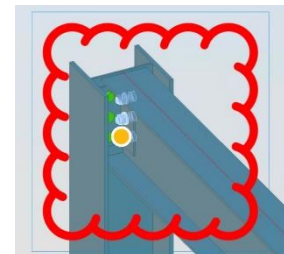
Issues and markups capture the problem to solve or decision to make right in the 3D view or Sheet. You can assign an Issue to someone to complete, assign a due date for completion, input other data like Location or Root Cause for filters and analytics.

Create an Markup

1. Open the Revit or Advance Steel model in BIM 360 Docs.
2. Select the Physical Model 3D view (Revit) or the 3D View (Advance Steel).
3. Zoom in on the Clip angle connection.
4. Select Markups from the left side toolbar.
5. Use the Cloud markup tool from the right side toolbar to place a cloud around the connection.
6. Change the visibility state from Private (people icon) to Public (world icon) from the top center toolbar.
7. Save Markup.
8. Zoom out and orbit around.
9. Select the new Markup in the side bar to zoom back to the markup.

Create an Issue

1. Select Issues from the left side toolbar.
2. Press Create Issue from the bottom of the side bar.
3. Click on the Clip angle connection.
4. Set Details to:
 - a. Type: Design
 - b. Assigned to: <Select User, Role or Company>
 - c. Due Date: <Choose date>
 - d. Root Cause: Design Coordination
 - e. Description: Due to changes from the Architect, we need to change this connection.
5. Press Create.
6. Zoom out and orbit around.
7. Select the new Issue in the side bar to zoom back to the Issue with the view it was created in.
8. Click ISSUES in the main navigation bar to see a list of Issues.



BIM 360 Reviews enable formal QA/QC processes for document review & release. Approved documents can be copied to another folder like “Approved for Release” while rejected items are held back for additional refinement. Reference the BIM 360 help documentation for more details.