

Collaborating Across Disciplines with Revit Architecture, MEP, and Structure

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AB104-3

Are you ready to take the next step and use building information modeling to share data across the entire design team? The need for sharing data across design disciplines has become increasingly critical. In this class, we'll look at how the Revit platform facilitates collaboration and coordination among architects and engineers. You'll learn how to link project files between Revit Architecture, Revit Structure, and Revit MEP, coordinate work between disciplines, identify and correct interferences, and use Revit's revision tracking to keep track of changes.

About the Speaker:

David has more than 25 years of hands-on experience with AutoCAD® as a user, developer, author, and consultant. He is an independent CAD consultant, a contributing editor to *Desktop Engineering* magazine, the former publisher and editor-in-chief of *CADCAMNet* and *Engineering Automation Report*, the former senior editor of *CADalyst* magazine, and the author of more than a dozen books about AutoCAD. A licensed architect, David was also one of the earliest AutoCAD third-party software developers, creating numerous AutoCAD add-on programs. As an industry consultant, David has worked with many companies including Autodesk. He teaches college-level AutoCAD courses and is always a popular presenter at both Autodesk University and AUGI® CAD Camps.

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Introduction

As more people adopt Building Information Modeling (BIM), the need for sharing data and information among disciplines has become increasingly critical. The Revit platform facilitates collaboration and coordination among members of an extended design team by providing tools enabling better understanding of designs and methods to enhance communication between design team members. Through the use of these tools, architects and engineers using Revit Architecture, Revit Structure, and Revit MEP can coordinate work between disciplines, identify and correct interferences, and use Revit's revision tracking to keep track of changes.

In most building projects, a team of architects, engineers, and others collaborate on the overall building design. For example, a mechanical engineer uses an architect's building model as the starting point in the design of the HVAC system. Proper coordination and monitoring helps ensure that the mechanical model is synchronized with the changes that the architect makes to the building model. Effective change monitoring can reduce errors and expensive rework during construction.

This class will look at the tools in all three versions of Revit that enable architects, engineers, and other team members to collaborate together. Key to making this work are Revit's file linking tools. While file linking can be used to link a number of different types of files into a Revit project—for example, you can link details created using AutoCAD into a Revit project so that they can be tracked and managed as part of a complete set of construction documents—this class focuses on linking various Revit files.

An important aspect to consider when linking those files is how they relate to each other within three-dimensional space. One way to ensure that the architect's model and the structural engineer's model actually fit together is to share the same coordinate system. Although we can also share this information between Revit and AutoCAD, this class will focus just on sharing positions between Revit project files.

Once we have linked project files together, we need to be able to manage those links. For example, if the architect's model changes, the structural engineer needs to be able to reload the architect's model so that he can see those changes.

The engineer also needs to be able to understand how he can change the appearance of the architect's model within the context of his structural model, and vice versa. So we will look at how you can control the visibility of objects within linked files separately from those in the Revit project that is hosting those links.

A key aspect of collaborating within Revit is the ability to monitor changes that occur within these linked files. So we will look at how this monitoring function actually works.

When changes do occur—for example, if the structural engineer changes the size of columns and beams—the architect needs not only to be alerted to those changes, but also to be able to appropriately respond to those changes. So we will look at Revit's project coordination tools designed specifically for this purpose.

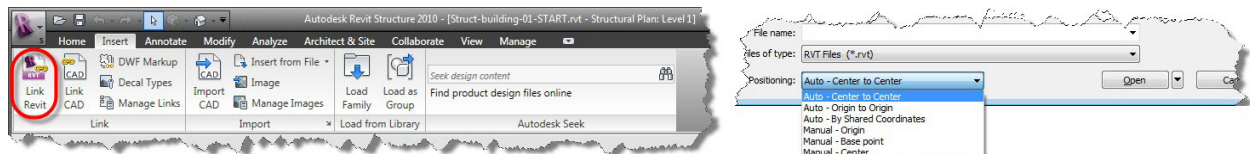
We will also look at tools built into Revit that enable us to see if there are any conflicts between components. For example, is there really enough room to run the HVAC system within the space between the architect's ceiling and the structural engineer's beams.

And finally, when changes need to be made within the drawings, how can we track those revisions?

File Linking

The first step in sharing information and collaborating between disciplines is to link the Revit files together. For example, a structural engineer can link in an architectural model and use it as a base for creating and analyzing a structural model. The structural engineer can share his model with the MEP engineer, so that the engineer can create an MEP model on the same design. The architect can then link both the structural and MEP model back into the original architectural model.

You link Revit project files using the File Linking tool. This is similar to creating an external reference in AutoCAD. When linking, select Auto – By Shared Coordinates to specify the positioning of the linked model in the host project.



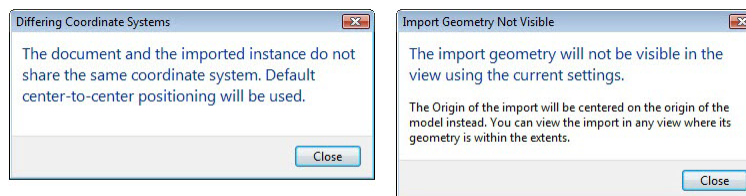
When you link one Revit project file into another, its path is saved in the host Revit project file. After linking, if the linked project file changes, you can reload it in the host project file to view the updated linked project file. If the path of the linked project file changes, you can update its path in the host project file using the Manage Links dialog.

Note: You can select a linked project file and bind it into the host. Binding converts the linked file to a group within the host file. You can then edit the group or ungroup objects. You can also convert a model group into a link, which saves the group as an external file. To bind a linked project, select the link and then click the Bind Link tool in the Modify RVT Links contextual ribbon.

You can also insert 2D elements or drafting views created in one Revit project into another project using the Insert from File tool in the Import panel of the Insert ribbon. You can also insert schedules created in one Revit project into another. The inserted schedule retains the formatting of the original Revit project.

Dealing with Positioning Issues

In some situations, you may have to deal with discrepancies in the positioning of the geometry in the linked project relative to the host project. For example, if the architect has begun her design of the project using Revit Architecture and the structural engineer has also begun his design using Revit Structure, when the structural engineer links in the Revit Architecture model, it may not share the same coordinate system as his model. In that case, Revit will display an alert informing you that the current project and the imported instance do not share the same coordinate system and that Revit will default to center-to-center positioning.



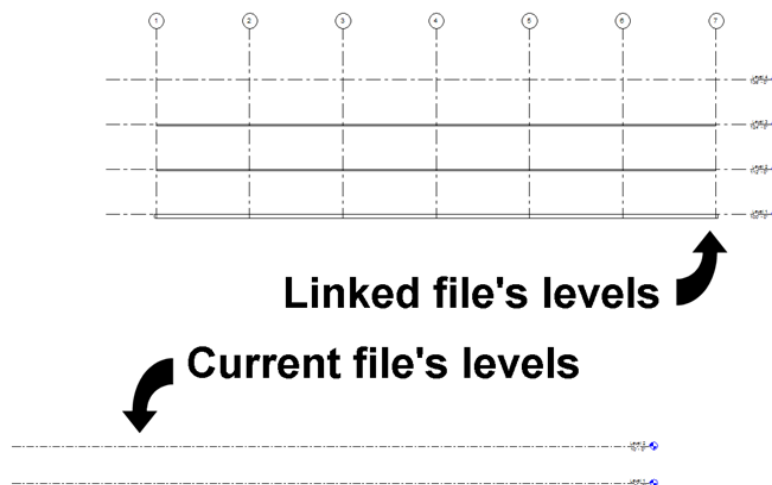
Revit may also display an alert letting you know that Revit is unable to get the center of the imported geometry in the current view to place the import. As a result, the imported file will not be centered on the current view. If you see either or both of these alert dialogs, simply click Close to clear them and continue. You will need to deal with these positioning issues once the linked file has been imported into the host.

Each Revit project has an internal coordinate system for all of the elements that comprise the model. Those coordinates are known only to that project. This is acceptable if you are working on a standalone model whose position is not relevant to any other model or to a site. However, if you want the position of the model to be known to other linked models, you need to share the coordinates.

Shared coordinates are used for remembering the mutual positions of multiple interlinked files. Those interlinked files can all be Revit RVT files, or a combination of RVT, DWG, and DXF files.

Although the default Revit template places the first level at an elevation of 0'-0", some designers like to begin modeling their buildings with the first level placed at an elevation of 100'-0", or they may have moved the levels to their actual elevation above sea level. The alert dialog described above will display any time the levels in the project being linked in do not match those of the project it is being linked into. If you see this message, it simply means that after linking you will need to adjust the levels of one project file to match those of the other.

For example, the linked model may be positioned at a different elevation (and perhaps in a different location) relative to the current project.



In that case, after linking the files, you can switch to an elevation view, zoom so that you can see the entire model, and then simply move the two models into the proper alignment. It really doesn't matter which model geometry you move, although generally it is easier to move the linked geometry so that it matches the host model. After correcting the discrepancy in elevation, you may also need to move the linked file in a plan view as well.

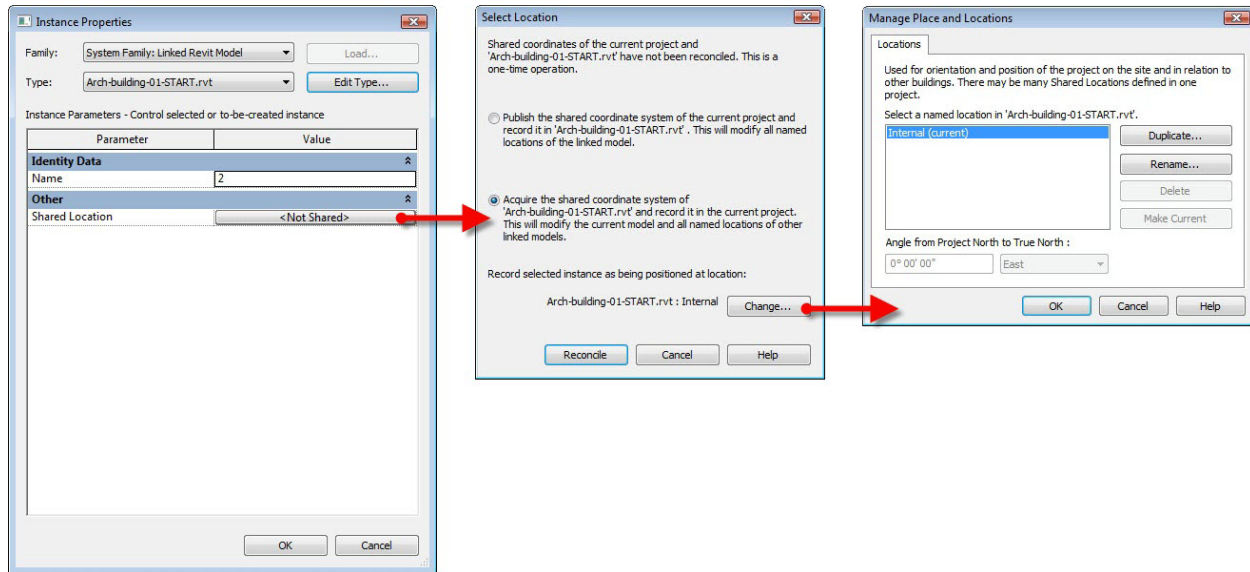
Shared Positioning

Although in our example, we've moved the architect's model so that it is in the proper position in relation to the structural model, if we were to stop here, the architect would end up having to do the same thing when she subsequently links the structural model into her architectural model. And that's fine. But Revit's shared positioning tools can eliminate the need to do this.

It doesn't matter whether you acquire the shared coordinates from the linked file or publish them from the host file. But you should derive shared coordinates from only one file. That one file defines the coordinates for all other files that compose the project. Acquire coordinates from one file and then publish those coordinates to the other files.

To acquire or publish coordinates through linked instance properties, select the linked model in the host project and open its Instance Properties dialog. In the Instance Properties dialog, notice the button in the value box next to the Shared Location parameter. It says Not Shared, which indicates that there is no coordinate sharing between the linked instance and the host model.

Click the Not Shared button. Revit displays the Select Location dialog. Because this is the first time that you are setting up shared coordinates between the host and the linked model, you need to reconcile the coordinates in favor of either the host or the linked model. You need to reconcile the coordinates only once.



Select either Publish or Acquire. If you select Publish, you publish the coordinates of the host model to the linked model. The linked model coordinates change to those of the host model. If you select Acquire, you acquire the coordinates from the linked model to the host model.

Since the method you choose can affect other team members, you should all agree which coordinate system will be used. For example, in a situation where you will be dealing with models created in Revit Architecture, Revit Structure, and Revit MEP, you might agree to use the coordinate system established by the architect. In that case, the structural engineer will select Acquire to match the coordinate system in his Revit Structure model to the coordinate system in the architect's Revit Architecture model. The MEP engineer would also acquire the coordinate system from the Revit Architecture model when he links that model into his Revit MEP project.

Regardless of the method you choose, the linked model's position in the host model is saved to a location named in the linked model file. If desired, you can change the name of the location by clicking Change and selecting a name from the Manage Place and Locations dialog.

Click Reconcile to confirm the changes, and then click OK to close the linked model properties.

Note that you cannot acquire coordinates or publish coordinates from a project that has multiple locations using the Acquire Coordinates or Publish Coordinates commands. You can do this, however, through the properties of the linked model. Also note that you don't have to use shared coordinates when collaborating using linked files. Doing so simply eliminates the need for each of the other disciplines to move the linked file into the proper position.

Managing Links

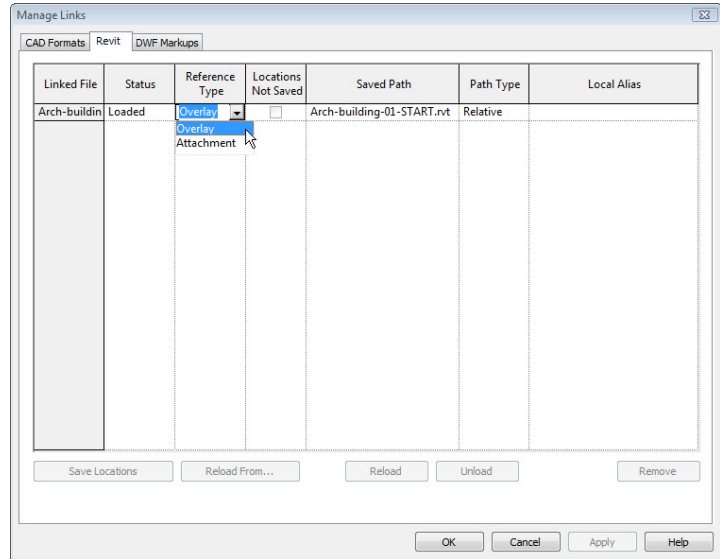
In addition to the proper position of the linked project, the team members should also be aware of how Revit deals with any project files that were themselves linked to the project files that they link to their models.

Revit deals with linked files similar to the way AutoCAD deals with external references. There are two different ways in which one file can be linked to another: Overlay and Attachment. You

can control the method used to link files from within the Manage Links dialog. To display this dialog box, in the Manage Project panel of the Manage ribbon, click Manage Links.

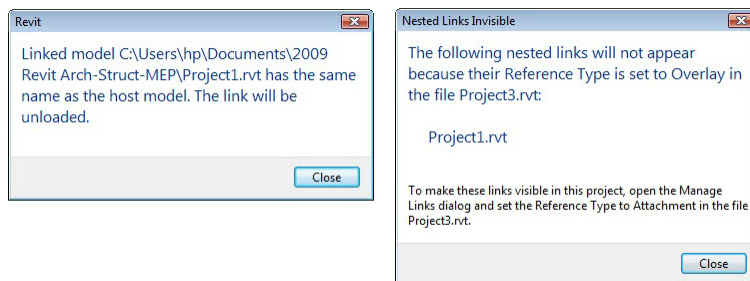
The Manage Links dialog lets you control any files linked to the current Revit project. Notice that the dialog box has three tabs: CAD Formats, Revit, and DWF Markups. Linked Revit files appear on the Revit tab.

Revit files can be linked using either the Overlay or Attachment method. Overlay is the default method. When a file is linked using the Overlay method, the linked file appears in the file it is linked into, but the link will not follow the host if the host becomes linked into another file. Using this method, if the architect subsequently links the structural model into her architectural project file, she will not create a circular reference back to her architectural file that had already been linked into the structural file. When a file is linked using the Attachment method, if the host file is subsequently linked into another file, all attached links are also included.



If the architectural model had been linked to the structural model using the Attachment method, and then the architect subsequently linked the structural model into her architectural model, Revit would display an alert telling her that the file being linked contains a linked file that has the same name as the host model. In that case, Revit automatically unloads the attached link to avoid creating a circular reference.

If the model being linked has other files linked to it using the Overlay method, Revit may display an alert telling you that those linked files will not be visible in the current project.



Visibility Control

Another issue that you may need to deal with involves controlling the visibility of objects in your model. When you have one or more models linked into a project, visibility control becomes a bit more complicated. You can't simply go to the Visibility/Graphics dialog and turn off a category. Doing so would turn off all of the objects in that category within all of the linked models as well as within your current model.

Instead, Revit provides a way to control the visibility of objects within each linked Revit model separate from those of the current host project. To do so, you must first change the control on the Revit Links tab of the Visibility/Graphics dialog by clicking the By Host View button. This

displays a RVT Link Display Settings dialog. It is in this dialog that you will be able to control the display of objects in the linked file separate from those in the host project file.

When you have linked one or more Revit project files into the current project, the Visibility/Graphics dialog contains an additional tab labeled Revit Links. When you select this tab, you see each RVT file linked to the current project. The Display Settings for each is initially set to By Host View, which means that the changes you make to the display of objects in the current project also affect those of the linked project.



If you click the By Host View button, however, Revit displays the RVT Link Display Settings dialog. This lets you control the visibility graphics for the linked file. To control its settings separately from the current project file, you need to make two changes. First, on the Basics tab, change the setting from By Host View to Custom.

Then, select the Model Categories tab and from the Model Categories drop-down, select <Custom>. Now any changes you make within this dialog box will only affect the linked file. Notice that you can control this setting separately for the Model Categories, Annotation Categories, and any categories imported into the linked file.

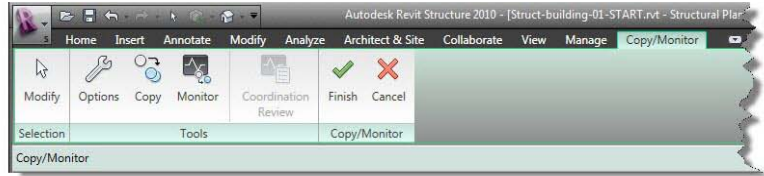
The following describes the settings available on the Basics tab:

- **By Host View.** When you select this option, you cannot override any visibility settings for the linked model, because the host view governs its appearance. When the primary linked model is set to By Host View, each copy or instance of the linked model can still be overridden on an individual basis by checking the box for Override display settings for this instance. This option appears on the Basics tab when a copy or instance of a primary linked model is selected in the Visibility/Graphics dialog.
- **By Linked View.** When you select this option, you can choose which project view should display for the linked model by choosing from a drop-down list. The views in the list depend on the view for which you are currently applying visibility and graphics settings.
- **Custom.** When you select this option, you can select override settings on all available tabs.

Note that filters do not apply to elements that are part of linked models.

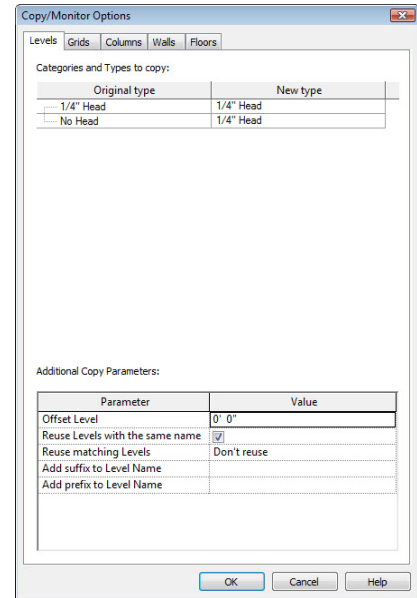
Monitoring Changes

After linking Revit projects, you need to set up the collaboration mechanism. For example, the structural engineer needs to know any time the architect makes changes to her model that may affect his structural model, and vice versa.



The tool in Revit used to set up this collaboration is called Copy/Monitor. To copy and monitor objects contained in a linked file, you activate the tool by choosing Copy/Monitor > Select Link in the Coordinate panel of the Collaborate ribbon and then selecting the linked file. Revit immediately displays the Copy/Monitor contextual ribbon. You can then use the tools on the ribbon to select the objects you want to monitor in the linked file.

The first thing you may want to do is to click the Options tool. This opens the Copy/Monitor Options dialog. Elements available for monitoring are separated into five categories: Levels, Grids, Columns, Walls, and Floors. On each tab, the Original Type column identifies the type for the Revit Architecture file and the New Type for the corresponding element available in the template selected. Each tab provides various parameters that can be set for that specific element. You can also exclude element types that you do not want to copy.



For example, if the levels already exist within the host model, you won't need to copy them from the linked model. You would only need to monitor them. But if the levels don't yet exist, then you would want to copy them into the host model and then also monitor the levels in the linked file so that if the architect changes the levels, the structural engineer will know about those changes.

You can also add a suffix or prefix to level names and grid names so that if you do copy them you can more easily determine which ones are in the host model and which are coming from the linked model.

The structural engineer also has the option of splitting columns by levels. Architectural columns typically extend through multiple levels of a model. For example, the architectural columns may span from Level 1 to Level 10. But this may present a problem when the structural analytical model is generated. Therefore, the structural engineer will want to split the columns at each level.

After setting the Copy/Monitor options, you're ready to click the Copy tool and select the objects you want to copy. As you select the objects you want to copy and monitor, Revit displays a copy/monitor icon adjacent to those objects, so that you can see which objects are being monitored.



When you select objects to copy and monitor, you can select the Multiple check box on the Options bar so that you can select multiple objects at one time. Then click on each object you want to copy. To select multiple objects, hold down the Ctrl key while making selections. You can use the Filter tool to de-select anything that you don't want to monitor. When you are finished making selections, click the Finish button on the Options bar.

You may need to repeat this process in multiple views. For example, you will probably need to repeat these steps for each level in the project to copy any structural walls and columns on that level, and also display a building elevation view to copy the levels and floors. You can continue to add objects that you wish to monitor by using the tools in the Copy/Monitor contextual ribbon.

When you have finished selecting the objects you want to copy and monitor, you must exit the Copy/Monitor mode by clicking the Finish button in the Copy/Monitor contextual ribbon. If you click Cancel, the objects you selected will not be monitored.

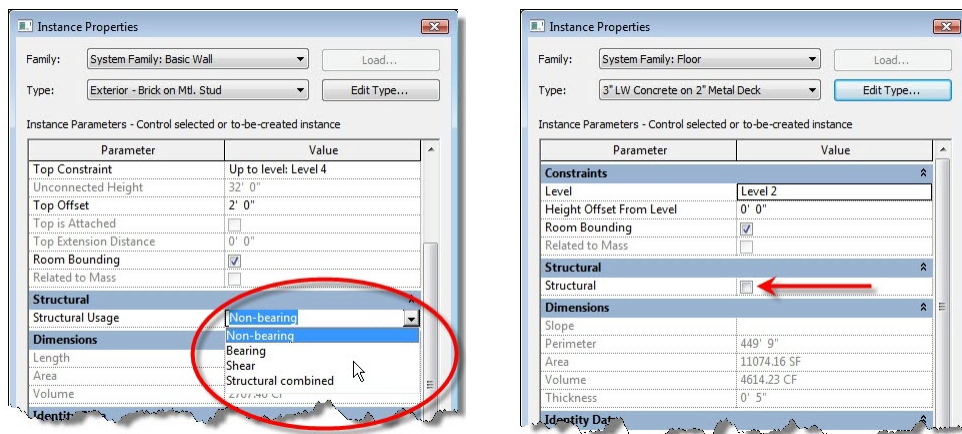
The Copy/Monitor tool can only be used on those categories that would actually impact the work of the other design team members. Specifically, Copy/Monitor only works with grids, levels, columns, walls, floors, and openings, and in the case of Revit MEP, rooms.

Note that the more objects you monitor, the slower the performance may become and the more complicated it can be to track changes. You should only monitor key objects.

Structural Usage

Walls created in Revit Architecture present a bit of a special case. By default, most walls defined in Revit Architecture are not structural walls and therefore cannot be copied and monitored when linked into a host file. Only structural walls can be copied and monitored in Revit Structure.

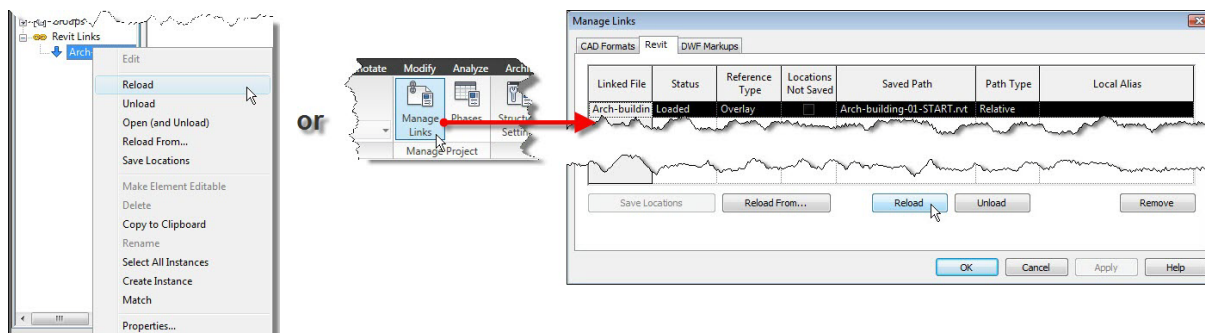
In order for walls to be copied and monitored in Revit Structure, they must first be defined in Revit Architecture as structural walls: either Bearing, Shear, or Structural Combined.



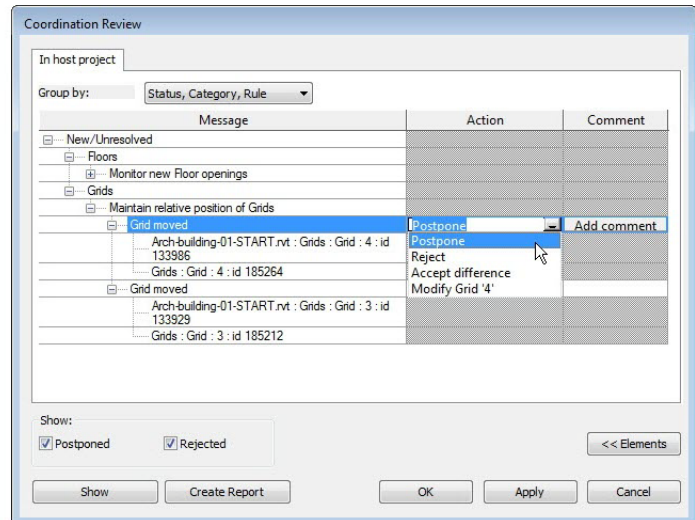
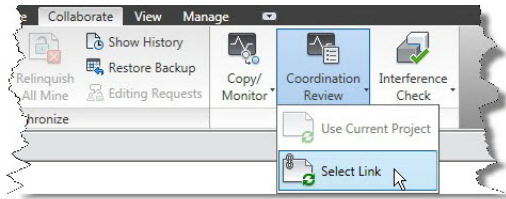
Floors can be copied from Revit Architecture to Revit Structure, but may need to be changed to structural floors. To do this, select the floor in Revit Structure, display its element properties, and select the Structural check box.

Project Coordination

With the project linked and monitored, you can continue to work as usual. If you receive an updated file from you project team members, Revit will automatically update links to that file the next time you load the host project. If you receive the updated file while you're working within the host file, you can reload the link by using the Manage Links tool (or by right-clicking on the linked file under Revit Links in the Project Browser).



If a monitored object has been changed and requires attention, Revit displays a dialog box informing you that an instance of a linked RVT file needs Coordination Review. This lets you know that you will need to perform a coordination review to address the changes.



To perform a Coordination Review, in the Coordinate panel of the Collaborate ribbon, choose Coordination Review > Select Link, and then click on the linked model. As soon as you select the link, Revit displays the Coordination Review dialog. This dialog box displays a list of all of the changes that require some type of action. The messages in this dialog box identify elements that were deleted, moved, or changed in some way in the linked file. In this case, the structural engineer should address each message individually and take some form of action to resolve the conflict. Whatever action you take changes the element in the current project, not in the linked project. Actions include:

- **Postpone/Do Nothing:** Take no action on the element. This changes the message status so that it can be filtered out or considered later.
- **Reject:** Makes no change in the host file. The change made in the linked file appearing in the host file is incorrect and a change must be made to the associated monitored element. You will need to communicate this information back to the other project team member to resolve the problem.
- **Accept Difference:** Accepts the change made to the element and updates the relationship. For example, if a pair of grids were 25'-0" apart and one was moved to 30'-0", accepting the difference would change the relationship to 30'-0".
- **Modify/Rename/Move:** The name of this command changes based on the action required. If the name of the monitored element has changed, the command reads Rename and choosing this option renames the element. If a column or level is moved, the command reads Move and choosing this option moves the element to match the change made in the linked file. If a grid is changed or moved, the command reads Modify and choosing this option modifies the grid. This is the option you will choose if you agree to the change in the linked file.

For each change, you can decide if you accept or reject the change. Or, if you don't want to deal with the change until later, you can choose to Postpone any action.

If you aren't sure what or where the changed objects are, you can click the Show button to have Revit switch to a view in which you can see the object so you can properly identify the change that has been made.

You should work your way through the list, selecting the appropriate command next to each warning. If desired, you can click Add Comment to enter comments on your action. Enter comments into the Edit Comments window and then click OK. In this way, you can communicate the reasons for your decisions to other team members.

Once you have dealt with all of the items in the Coordination Review dialog, the list should be clear and your project is coordinated.

Of course, as your project proceeds, you will probably receive further updates from the other members of your design team. When you update the links, Revit may warn you again that coordination review is required. So you may need to repeat this process a number of times as the project is developed.

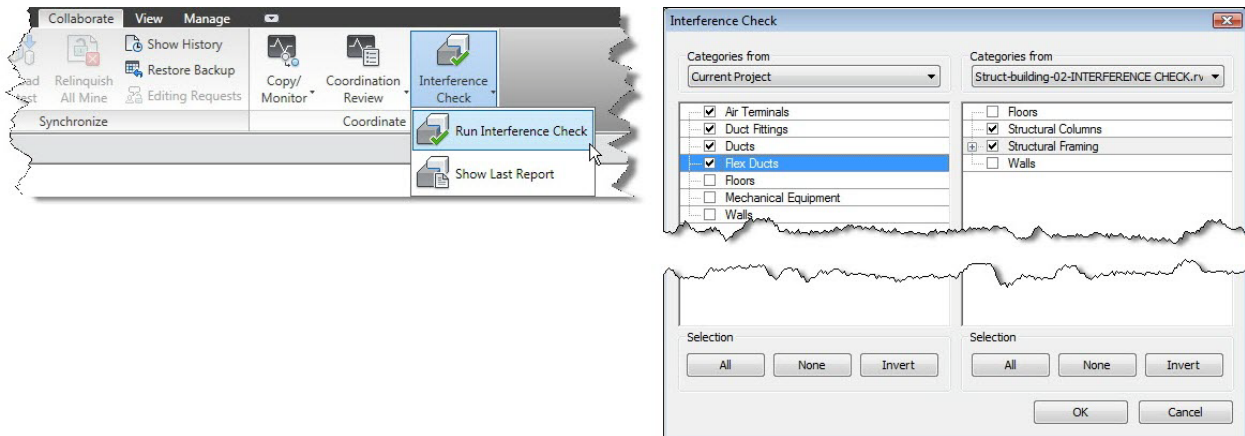
If you select postpone or reject, you can always return to the Coordination Review to re-evaluate those issues.

Note that Revit will only alert you to changes made to elements that you are already monitoring. If new elements that need to be monitored have been added to a linked file, those elements will not be monitored unless you use the Copy/Monitor tool to add them. So it is important that team members continue to communicate with each other throughout the course of the project.

Interference Check

In addition to the coordination tools, Revit also includes tools to help you identify and correct interference conditions, such as when a structural beam interferes with an HVAC duct.

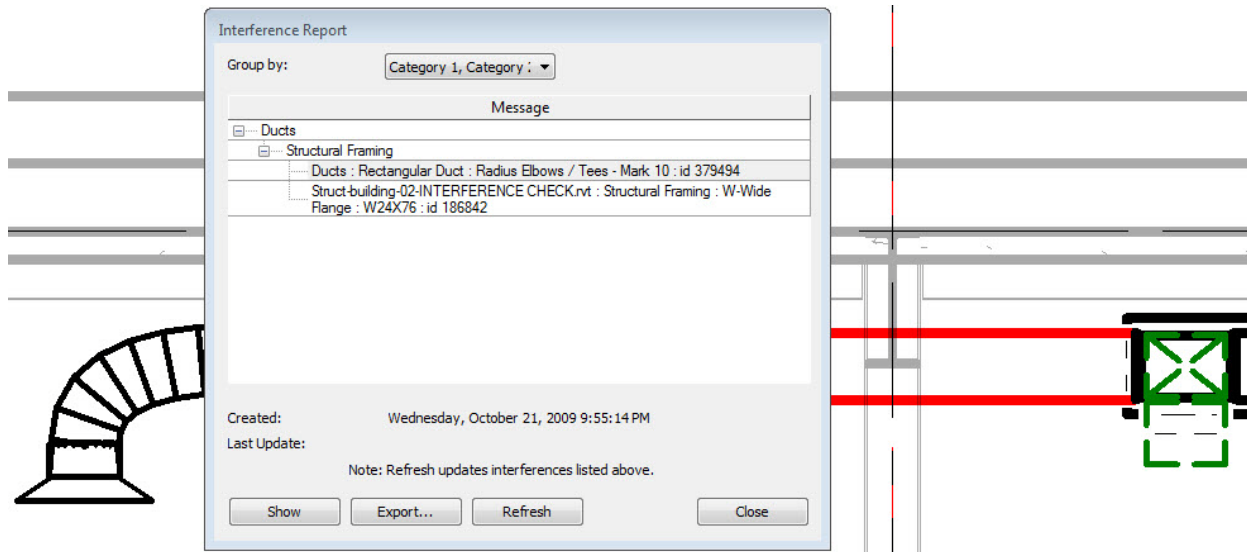
You can run an interference check at any time. To do so, in the Coordinate panel on the Collaborate ribbon, choose Interference Check > Run Interference Check. Revit displays the Interference Check dialog. You can check for interference conditions between objects within the current project and between objects in a linked project. You cannot run a check between two different linked files, however.



The Interference Check dialog has two columns. Initially, both of these columns list objects in the current project. To compare one or more types of objects in the current project to another set of objects in a linked project (such as checking to see if any beams interfere with ductwork in a linked MEP model), select Current Project in one column and the linked project in the other. Then select the objects in the current project (such as the structural framing) and the object in

the linked project (such as the ducts, duct fittings, and mechanical equipment) and then click OK.

Revit immediately runs the interference check and then displays a report showing all instances of interferences between the selected objects. You can expand each instance to see the report in more detail. As was true for the coordination report, if you aren't sure what or where the interfering objects are, you can click the Show button to have Revit switch to a view in which you can see the objects. You can also export the interference report to an HTML file.



Once you have identified an interference condition, it is up to you to use the various tools in Revit to correct the problem and resolve the interference. Once you have made the necessary corrections, click the Refresh button to update the report. When the interference has been resolved, it is removed from the report. When the list is empty, all of the interference conditions have been resolved. That is, there are no longer any interferences between the set of component types that were compared. You may still need to run other interference checks between other categories of objects to make sure no other collisions exist.

Revit will not automatically solve interference conditions, but the interference check tool goes a long way toward helping find and deal with interference conditions during the design of the building. Used efficiently, there is no longer any reason to remain unaware of conflicts until during construction, when solving them is likely to result in a costly change order.

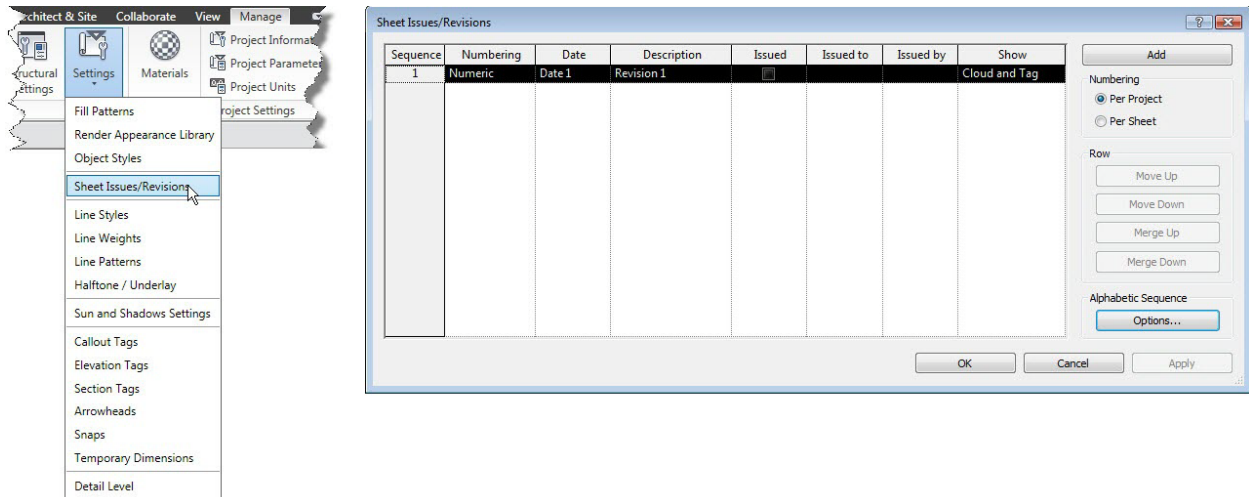
Revision Tracking

All three flavors of Revit also provide tools that enable you to track revisions you make to your project. You can create a sequence of revisions and you can draw revision clouds around elements in your project that have changed. You can use revision tags to annotate the revision clouds, and then display the revisions in schedules that appear in the title block of each project sheet.

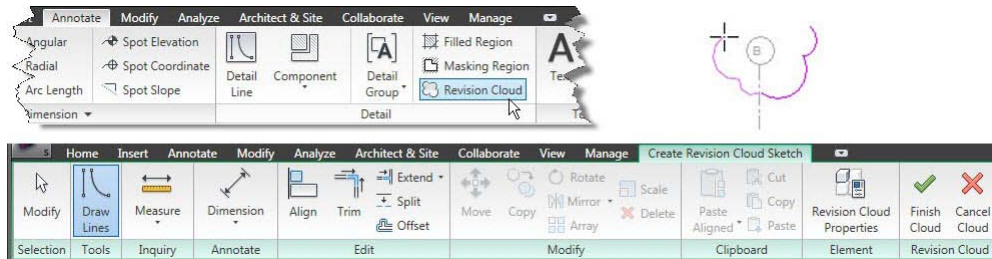
The first step in using revision tracking is to set up the revision table. Revit provides tools for this. In the Project Settings panel of the Manage ribbon, choose Settings > Sheet Issues/Revisions. Then, in the Revisions dialog, select the method you want to use to track revisions.

If you select By Project, all revisions are numbered according to the sequence of revisions in the Revisions dialog. If you select By Sheet, revision clouds are numbered relative to the sequence of other clouds on a given sheet.

Within this dialog, you also specify the release date of the revision and provide a description as well as control other aspects of each revision. In general, revision descriptions should be comprehensive, yet as concise as possible. Be sure to leave the Issued check box cleared at this time. When Issued is selected, the revision is locked and issued to the field.



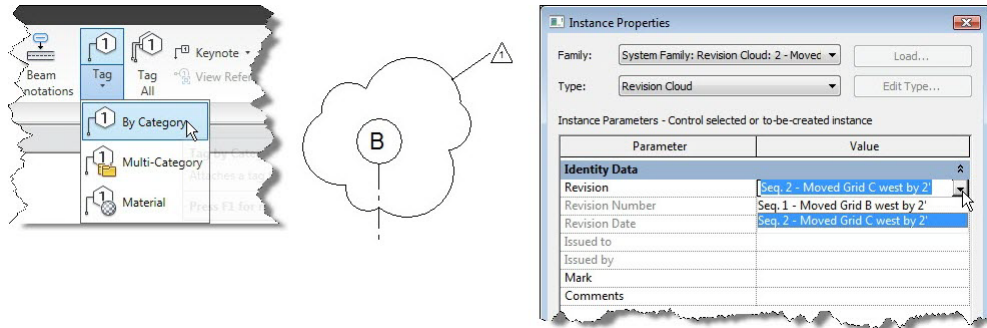
Next, you need to indicate the changes within the drawings that are part of the revision. You do this using the Revision Cloud tool. This tool is located in the Detail panel of the Annotate ribbon. Generally, you will add revision clouds while working in a sheet view, but you should add the revision to the specific view within that sheet, so you will need to select the view and activate it by right-clicking on the view and choosing Activate View.



When you select the Revision Cloud tool, Revit displays the Create Revision Cloud Sketch contextual ribbon. You can use the tools on this ribbon to create the revision cloud. Start adding cloud segments, working your way around the area of the drawing that needs to be revised, in a clockwise direction (so that the cloud bulges outward). Continue adding segments until the cloud surrounds the area that you changed. Then, in the ribbon, click Finish Cloud.

Remember that the appearance of the revision cloud is controlled using the Visibility/Graphics settings, just like any other object in Revit.

To add additional revision clouds that relate to the same revision, simply draw another revision cloud. To add a revision cloud that identifies a different revision, you must first add the new revision to the Revisions dialog. To do this, open the Revisions dialog again, click the New button to add a new row to the revision table, and then specify the pertinent information for the new revision.

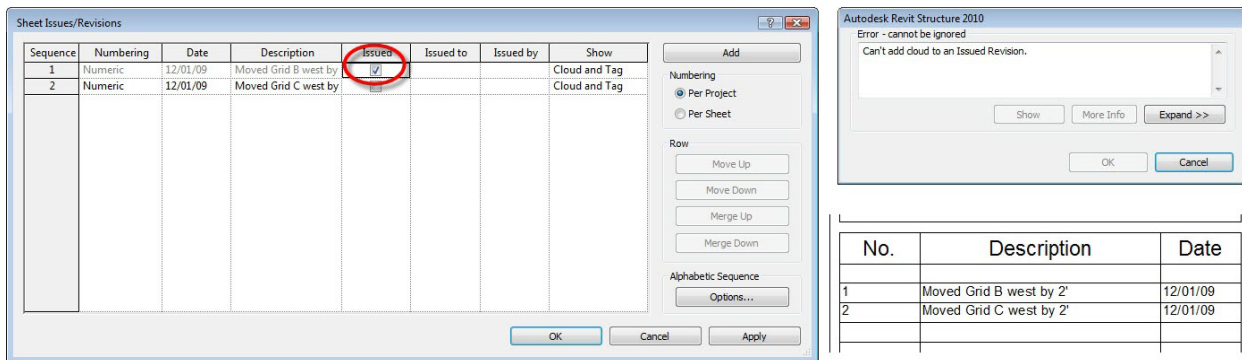


Note that when you add your next revision cloud, it will automatically be assigned to the new revision you added. But you can change this by selecting the revision cloud and opening its Instance Properties dialog. You can then select the revision number from the drop-down under the Identity Data.

When you're ready to tag the revision cloud, in the Tag panel of the Annotate ribbon, choose Tag > Tag by Category, and then simply click to select the revision cloud. Revit automatically tags the cloud using the revision number assigned to it. If you change the revision number assigned to the revision cloud (by changing the revision cloud's element properties), the number in the tag automatically updates.

Remember that the numbering method used is based on the selection you made (by sheet or by project) when you first set up the revision table.

You can continue to modify a revision until you release that revision. Once the revision has been issued, you can no longer make any modifications to that revision. You cannot add revision clouds to the revision, you cannot edit the sketch of the revision cloud, and you cannot use the Instance Properties dialog to change a revision cloud if its revision has already been issued.



As you add revisions to the Revisions dialog, Revit automatically adds them to the revision schedule that appears in the title block of each project sheet.

Conclusion

Revit provides all the tools you need to collaborate across disciplines, linking data created by architects, engineers, and other consultants. Revit by itself won't prevent conflicts from occurring, but it helps facilitate improved communication between project team members. You can use the tools in Revit to ensure that your designs are accurate, coordinated and complete.