When designing a structural engineering project, how often do you quantify every sheet of welded wire fabric, every bar of reinforcing, or every steel connection right down to the number of bolts? It is possible to do all of this with Autodesk Revit Structure software, but should you? With the recent introduction of new Revit Structure tools, such as the Parts and Assemblies and Structural Fabric Area tools, the enhancements to the Reinforcement tools, and the introduction of AutoCAD® Structural Detailing, many structural engineers and designers are wondering when and where it is appropriate to model this much detail in their Revit Structure projects. Because these tools seem to be geared towards detailing and fabrication, the design engineers might not see a use for them, if only because they are not responsible for creating shop drawings. In this class, we will review these tools and show when and how to use them, whether it be for design, detailing and fabrication, right through to construction.

Learning Objectives
At the end of this class, you will be able to:

- Use the Parts and Assemblies, Structural Fabric Area, and Reinforcement tools within Revit Structure
- Determine when and where to use this level of detail in your structural model
- Work with AutoCAD Structural Detailing in conjunction with Revit Structure for detailing
- Use detailed structural models during the construction administration phase of a project

About the Speaker
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Introduction

In the latest versions of Revit Structure, many new features have been added, and enhancements have been made to several existing ones. With these additions and improvements comes uncertainty as to when or if they should be used for a particular stage in the building process. This is because the BIM industry seems to be evolving Building Information Modeling into a process that encompasses the entire lifespan of a building, from design to fabrication to construction, and finally facilities management. So it becomes difficult to know when it is appropriate to use these features that are geared towards one stage in the building process or another.

This class will explore several of these tools within Revit Structure by first reviewing how to use them, then by examining the advantages and disadvantages of their use during the different stages of the building process.

Overview of Revit Structure Features

This section will review several Revit Structure tools and features. The basic procedures for properly applying these tools, configuring parameters, and visualizing the resulting modeled elements will be discussed.

Structural Fabric Area

Revit Structure 2013 introduced a new feature called Structural Fabric Area. Its purpose is to place modeled sheets of welded wire meshes in floors, walls, and foundation slabs. The tool is located on the Reinforcement panel within the Structure tab:

Use of the tool is relatively straightforward. After initiating the command, Revit asks for the selection of a floor or wall in which to act as a host for the Structural Fabric Area. When an element is selected, a sketch mode is activated. A boundary sketch is created to define the extent of the Structural Fabric Area. The Major Direction of this area is shown with a parallel line symbol, which determines the rotation of the fabric sheets. This Major Direction can also be changed by drawing a sketch line.
The checkmark edge controls that appear allow control of starting and ending edges of the fabric sheet layout. At least two neighboring controls must be selected to complete the sketch. Fabric sheets will automatically adjust to the sketch boundary and any openings in the floor or wall hosts.

The instance parameters allow for selection of standard Fabric sheet sizes, Location within floor, Lap splice Position, Major and Minor Lap Splice Length, and Additional Cover Offset.

When the sketch is completed, a Structural Fabric Area System Family is created. The Type parameters of these Structural Fabric Area Families are minimal. Because of this, the Instance Parameters control individual instances of the Fabric Areas, meaning that multiple instances of one Area family can have different Fabric Sheet sizes, Lap Splice Positions, etc. Also, Fabric Sheets, and the Fabric Wire within them, are system families. Lastly, each Fabric Sheet within a Structural Fabric Area has the ability to be tagged individually and scheduled.
Reinforcing Enhancements
The Reinforcement tools Area and Path have been a part of Revit Structure for several versions, but enhancements have been made to these tools in the 2013 version. The main enhancement is that when applying these tools to a wall, floor, or foundation slab, the actual reinforcement is now a modeled element. In the previous versions, the only way to see these elements after they are applied is by adding a section callout and viewing the rebar in the resulting section view. Also, view controls for Rebar allow for better visualization of these elements in 3D views.

Area Reinforcement
The procedure for placement of Area Reinforcement remains the same as previous versions. The tool is located on the Reinforcement panel within the Structure tab:

After initiating the command, Revit asks for the selection of a floor or wall in which to act as a host for the Area Reinforcement. When an element is selected, a sketch mode is activated. A boundary sketch is created to define the extent of the Structural Area Reinforcement. Just as with the Structural Fabric Area, the Major Direction of this area is shown with a parallel line symbol, which allows for the selection of different Bar Types in Major and Minor directions. This Major Direction can also be changed by drawing a sketch line.
The Instance Parameters allow for Top Major and Minor Bar properties and Bottom Major and Minor Bar Properties, which include Bar Type, Hook Type and Orientation, and Spacing. The placement and spacing of these bars is also controlled by a Layout Rule parameter which allows the spacing of the bars to be placed by Maximum Spacing or by a Fixed Number. Selection of either one of these parameters will exclude the Spacing or the Number Of Lines parameter depending on which Layout Rule is selected.
When the sketch is completed, a Structural Area Reinforcement System Family is created. The Type parameters of these Structural Area Reinforcement Families are minimal. Because of this, the Instance Parameters control individual instances of the Reinforcement Areas, meaning that multiple instances of one Area family can have different Bar Types, Spacing, etc. Also, Rebar Bar and Rebar Hook within them are system families. Lastly, each Rebar Bar within a Structural Reinforcement Area has the ability to be tagged individually and the Area itself can be tagged.
Path Reinforcement

The procedure for placement of Area Reinforcement remains the same as previous versions. The tool is located on the Reinforcement panel within the Structure tab:

After initiating the command, Revit asks for the selection of a floor or wall in which to act as a host for the Path Reinforcement. When an element is selected, a sketch mode is activated. This sketch mode requires an open sketch (not a continuous loop) that defines a path along which the reinforcement will be placed. A Flip control also appears to allow for proper orientation of the Reinforcement along the path.
The Instance Parameters allow for Bar Spacing, Type, Length, and Hooks. These parameters can also be applied to Alternating Bars along a Path, meaning that every other bar can have its own set of properties. The Face parameter determines which face of the host element the Path is oriented to, either Top or Bottom. The placement and spacing of these bars is also controlled by a Layout Rule parameter which allows the spacing of the bars to be placed by Maximum Spacing or by a Fixed Number. Selection of either one of these parameters will exclude the Bar Spacing or the Number Of Bars parameter depending on which Layout Rule is selected.

When the sketch is completed, a Structural Path Reinforcement System Family is created. The Type parameters of these Structural Path Reinforcement Families are minimal. Because of this, the Instance Parameters control individual instances of the Reinforcement Paths, meaning that multiple instances of one Path family can have different Bar Types, Spacing, etc. Also, Rebar Bar and Rebar Hook within them are system families. Lastly, each Rebar Bar within a Structural Reinforcement Path has the ability to be tagged individually and the Path itself can be tagged.
As stated above, the main difference between the 2013 version of Area and Path Reinforcement and past versions is the fact that these elements are now actually modeled. And the View Visibility States parameter has been added to these elements to help users better visualize the reinforcement in 3D views as well as other view directions.
The Parts command in Revit allows for various elements to be divided into individual subcomponents. Parts were introduced in the 2012 version of Revit. There were certain limitations to the command, mainly of which that only host elements such as Walls and Floors were the only elements that could have their respective Layers subdivided into parts. In the 2013 version, more flexibility has been added to the command along with the ability to create parts from other types of elements including certain Component families, such as structural columns.

The tool is located on the Create panel within the Modify tab:

To divide an element into Parts, either select the command first, then the element to be divided, or vice versa. When an element is divided into Parts, the Parts still maintain a relationship with the larger whole element. And added flexibility has been added in the latest Revit version to allow those Parts to be divided into even smaller parts.

For example, a Wall element with several layers can have those layers divided into separate parts. These parts will then have their own individual properties such as Area, Height, and Material. And then the individual parts can be scheduled accordingly.
A special View property called Parts Visibility allows different visibility selections of elements divided into parts. The settings, Show Parts, Show Original, and Show Both, allow for only the Parts of elements to be visible, only the original elements in their entirety to be visible, or both the Parts and the entire elements to be visible, respectively.

Another property of a part is the ability to show Shape Handles on the part. This allows for easy manipulation of the size and thickness of the individual parts.
More flexibility to the Parts tools in the latest Revit version allows for those individual parts to be subdivided into smaller parts. To do this, select a part, and in the Parts contextual tab, select Divide Parts:

When this is invoked, there are two options for dividing the Part. One way is to draw a sketch. The sketch does not require a closed loop, but only needs to intersect the boundaries of the part. The other option is Intersecting Named References. This refers to Datum elements such as Levels, Grids, and Reference Planes that have been given a name.
These Divisions made to a Part can have gaps placed between them using the Divider gap property. Also, a special Profile family, Division Profiles, can be applied to these gaps to allow for custom shapes of these gaps.

A wall with its divided brick Part layer has a 1” Divider Gap applied to the division. The Divisions properties allow for a shape profile to be used to create custom gaps.
Parts that have been Divided can be merged back into their original element as long as they consist of the same material. This is accomplished by selecting the Parts to be merged and selecting the Merge Parts tool from the Parts contextual tab.

When two or more part divisions are selected, the Merge Parts tool can be used to consolidate the parts into one part.

Lastly, these parts can be scheduled, in a similar way that Material Takeoff schedules are created, but with more flexibility and conciseness. And there is also the ability to Exclude Parts from both the Model and the Parts schedules, and they are easily restored if needed again.

Assemblies
Assemblies allow for several elements to be grouped together as a single entity. This helps with the organization, scheduling, and documentation of related elements.
For example, a Concrete Beam can have various individual elements associated with it, such as reinforcing bars and ties. All these elements can be put together in an Assembly as a single entity. And instances of these assemblies can be placed throughout a model.

The easiest way to create an assembly is to first select all elements needed for the assembly, and then initiate the Assembly tool. The tool is located on the Create panel within the Modify tab:

![Assemblies Tool](image)

When an assembly is created, it is listed as a type in the Type Selector and a new Assemblies header appears in the Project Browser.
Assemblies also act similarly to Groups in the sense that if there are multiple instances of an assembly throughout a model, and changes are made to that assembly, those changes will also be propagated throughout the model. Furthermore, when creating Assemblies that consist of the exact same elements of existing Assemblies, Revit will recognize them as a duplicate type and automatically classify them as that type.

Finally, Assemblies have the unique ability to have a series of views automatically created that relate just to them. These views will only include the Assembly and its elements, and these views will appear under the Assembly type within the Assemblies header in the Project Browser.

To create these views, simply select an Assembly and chose Create Views from the Assemblies contextual tab. A Create Assembly Views dialog box appears with a list of Views to Create that can be selected.
These views take on the look and utility of fabrication or shop drawings.

**Steel Detailing with the AutoCAD Structural Detailing Extension**

AutoCAD Structural Detailing (ASD) is a vertical AutoCAD product included with the Autodesk Building Design Suites. It is a program designed for the creation of steel and concrete reinforcing fabrication drawings and shop drawings. When AutoCAD Structural Detailing and Revit Structure are installed on the same computer, an Autodesk Revit Extension is automatically added to Revit. The tool is located on the Autodesk Revit Extensions panel within the Extensions tab:

![AutoCAD Structural Detailing Extension](image)

When Assembly views are created, they appear under the Assembly in the Project Browser.

This extension can be used to create a link between the two programs. For instance, a Revit Structure model containing steel framing can have those elements linked into AutoCAD Structural Detailing by using the Steel Detailing Link tool. A dialog box appears with the selection to Send model to AutoCAD Structural Detailing.
When the link is made, AutoCAD Structural Detailing automatically opens, and a representation of the steel elements in the Revit model is created in a drawing file. These steel elements are represented by an AutoCAD Profile which is a 3D type of element.
These profiles can be used to add additional steel detailing, such as Beam to Column Flange connections.

The multitude of tools and macros in ASD provide more robust detailing options than what is available in the base Revit Structure program.

**Use of Revit Features in the Building Process**

Determining when to use the Revit features highlighted in the section above can be based on a project’s stage in the building process. Those stages are Design, Fabrication, and Construction. This section will weigh the advantages and disadvantages of each feature’s use during these different stages. It will also be noted that not all stages of the building process will require the use of all of these features.

**Structural Fabric Area**

**Design**

There are various drawbacks to using Revit Structure’s Structural Fabric Area tool during the design stage of the Building process. First of all, the modeled Fabric Sheets contained within the Fabric Areas are modeled at their exact size. Due to the small section area of the individual wires in a sheet of fabric, it is very difficult to see them in a section view:
Welded Wire Fabric’s inclusion in the design stage is usually noted with general notes, typical details, and sections. When it is depicted in drawings, welded wire fabric is usually denoted symbolically with a series of dashed lines and X’s.

A typical detail created with Revit Detail Components showing a symbolic representation of welded wire fabric.

This is usually enough information to provide for the construction documentation, so adding this modeled element is probably not necessary during this stage of the building process.

**Fabrication**

A fabricator can probably get the most use out of the Structural Fabric Area feature. It will allow for the exact placement of fabric sheets throughout a project, taking into consideration all shapes, sizes, and openings of floors and walls. All necessary parameters are included to properly lap and splice the sheets. Then this data can be used to schedule and quantify the amount and size of fabric sheets needed for a project.

![A simple schedule that can quantify Fabric Reinforcement totals in a project.](image)

**Construction**

The use of the Structural Fabric Area feature during the construction stage is probably best utilized to plan different phases of construction. For example, when a concrete floor is poured, it may not be poured all at once. The floor element in Revit can be divided into parts depicting these different pours, and these Parts can be assigned a phase, along with the welded fabric sheets within them. This allows the contractor to properly plan this element’s construction, which utilizes Revit’s inherent 4D capabilities. The process of utilizing Parts and phasing will be outlined in a later section.
Reinforcing

*Design*

Using the modeled Reinforcement features within Revit Structure during the design stage of the building process can be useful in several instances. By adding these modeled elements to the concrete beam, columns, and floors, most of the work to add this geometry to sections and details will be complete.

Another use would be the ability to quickly quantify the amount of rebar in a project for early cost estimating. This can be accomplished by creating Structural Rebar schedules.

<table>
<thead>
<tr>
<th>Rebar Schedule</th>
<th>Type</th>
<th>Bar Length</th>
<th>Total Bar Length</th>
<th>Quantity</th>
<th>Reinforcement Volume</th>
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<tr>
<td>#4</td>
<td>29’-6”</td>
<td>442’-6”</td>
<td>15</td>
<td></td>
<td>1042.62 in³</td>
</tr>
<tr>
<td>#4</td>
<td>9’-6”</td>
<td>57’-0”</td>
<td>6</td>
<td></td>
<td>134.30 in³</td>
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<td>#4</td>
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<td>57’-0”</td>
<td>6</td>
<td></td>
<td>134.30 in³</td>
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<tr>
<td>#4</td>
<td>29’-6”</td>
<td>265’-6”</td>
<td>9</td>
<td></td>
<td>625.57 in³</td>
</tr>
<tr>
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<td></td>
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<tr>
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<td>265’-6”</td>
<td>6</td>
<td></td>
<td>625.57 in³</td>
</tr>
<tr>
<td>#4</td>
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<td>1</td>
<td></td>
<td>81.29 in³</td>
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<tr>
<td>#4</td>
<td>14’-6”</td>
<td>159’-6”</td>
<td>11</td>
<td></td>
<td>375.81 in³</td>
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<tr>
<td>#4</td>
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<td>345’-0”</td>
<td>10</td>
<td></td>
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</tbody>
</table>

Also, by utilizing the Reinforcement tools, the structural design stage can benefit by modeling rebar in tight and complex areas of a project to check for proper space allocations and concrete cover, along with avoiding interferences and collisions.
The main drawback to this is, of course, the time spent adding these reinforcement elements. Even though the tools have been improved to add better manipulation and visualization, it is still a time intensive endeavor. Several methods could be employed to alleviate this process, including the use of assemblies and some of the Revit Extensions devoted to Reinforcement Modeling. Reinforcing in complex areas of the project can avoid interferences during the construction stage of the building process.

(Left) The Revit Reinforcement Extension.
(Below) The Beam Reinforcement Extension tool
Another consideration should be the ratio of the amount of effort to benefiting results. For example, if the amount of time it takes to add reinforcement is great and the resulting benefit is only the automatic placement of that geometry in a section or detail, then perhaps a 2D typical detail or section using less time to create would suffice.

Plus, another thing to think about is the size and complexity of a Revit model file after all concrete elements have had reinforcement placed within them. It could slow down the use of the file in Revit and make use of it unwieldy.

**Fabrication**
The benefits of using the Reinforcement tools during the fabrication stage of the building process can be numerous. As mentioned above, accurate placement, planning, and scheduling can be achieved by adding these elements to the Revit Model. Additionally, through the use of the AutoCAD Structural Detailing Revit Extension, reinforcement and formwork drawings can be generated by linking the Revit model.

**Construction**
Some of the uses of the Reinforcement tools in Revit can also assist with the construction stage of the building process. These uses include modeling rebar to check for interferences and collisions in highly congested and complex areas of concrete in the project.

Another use as stated above would be the 4D element of a project which is the planning of different phases of the project. This involves modeling various areas of a project with rebar and applying a Revit Phase to these elements to better plan for the construction process and the
scheduling of delivery to the job site of concrete reinforcing when needed for those phases of construction. This process might also involve the Parts tool in Revit and will be outlined in the next section.

Parts

Design
There are various uses the design stage of the building process could take advantage of by utilizing the Parts feature in Revit. One of the major advantages is the ability to divide certain Revit Structure components into Parts for added flexibility and manipulation. These components include families from the Structural Framing and Structural Column categories. Being able to apply the Show Shape Handles property within these components after they have been divided into parts allows them to be easily manipulated to conform to specific design intent.

Construction
As discussed above, the ability to divide some Revit elements into Parts can assist the construction stage of the building process by leveraging the programs inherent 4D capabilities, namely by applying Revit Phases to elements. A good example of this is the pouring of a concrete floor system. When a floor is created in Revit, usually the entire border of the floor is outlined in a sketch mode, with no regard as to how that floor will be divided into different pours. With the capabilities of the Parts tools, a floor can be divided into Parts representing the different pours it will take to create that floor, while still being able to maintain the integrity of the floor element as a whole. And each pour can be assigned a different Revit phase, including any reinforcement that has to be placed in those parts of the floor.
Pour 1: A slab is divided into Parts that represent its different Phases of construction. This view shows only the part of the slab created during the first Pour.

Pour 2: This view shows the previous Phase, Pour 1, as halftone, and the part of the slab created during the second Pour.

Pour 3: This view shows the previous Phases, Pour 1 and Pour 2, as halftone, and the part of the slab created during the third Pour.

Pour 4: Finally, this view shows the previous Phases, Pour 1, Pour 2, and Pour 3, as halftone, and the part of the slab created during the last Pour.
This ability allows, once again, for proper planning and scheduling of all elements and resources needed to complete those phases of the construction of these elements.

Assemblies

Design
The design stage of the building process can take advantage of the Assemblies feature in Revit in many ways. The main advantage is the organization achieved by including many related elements into easily managed single entities. In the Reinforcement section above, the topic of adding reinforcing during the design stage brought up the fact this is a very labor intensive task. With the use of Assemblies, many elements, such as concrete beams and columns, might have similar or exact configurations, including size, length or height, and the amount and type of reinforcement. By using Assemblies, these common elements can have several instances placed within a project, saving time by adding the reinforcement to only one instance. And the greatest benefit is that if the configuration needs to change, the change is propagated to all instances of that Assembly.
Fabrication
Assemblies have an inherent capability that is useful to the Fabrication stage of the building process which is the ability to automatically generate Assembly Views. While these views are probably not as detailed as needed to create the actual fabrication or shop drawings, these views can be embellished with added detail, or they can act as a good starting point for the continuation of that process in other programs such as AutoCAD.

The highlighted column Assembly from the Revit Structure model. By creating an assembly, all column elements, including rebar and corbels, act as one single entity.
Steel Detailing with the AutoCAD Structural Detailing Extension

Design
The use of the AutoCAD Structural Detailing Extension for the linking of a Revit model into ASD can assist the design stage by being able to use the robust set of tools and macros to design and detail complex steel connections. And the tool should probably be viewed in this way, which is to only use it for some of the more difficult connections that need to be included in the design drawings. The reason for this is Revit Structure already has some abilities to detail and model more common steel connections with the Structural Connections category of families and another Revit Extension called Steel Connections.

The advantage that the ASD extension offers is a much more robust set of tools that offer more options for creating and designing very complex connections and configurations. The only drawback is that the elements created in ASD cannot easily make the roundtrip back into Revit as seamlessly as the Revit model can link with ASD. Because of this, the shop drawing generation capabilities in ASD have to be leveraged to document these complex connections, and the resulting AutoCAD files can then be imported or linked into Revit Structure within a Drafting view. But all-in-all the same result is achieved, which is the modeling of these connections, which creates the detailing and documentation views necessary to convey the design intent to the steel fabricators.

Fabrication
AutoCAD Structural Detailing was designed mainly for the fabrication stage of the building process, so it goes without saying that this is an enormously useful tool for that purpose. But this program does not need Revit in order to generate a working model of a project. The program has tools to independently create all the necessary elements of a project to create a 3D model, and then it uses this model to automatically generate the necessary shop drawings. That being said, a fabricator that uses the ASD program would greatly benefit if given access to a project’s Revit Structure model. This is because Revit’s ASD extension could be used to link the model into ASD, which would provide a greater level of accuracy to the alternative of having to recreate the ASD model from the construction documents.

Conclusion
The addition and enhancements of these Revit Structure features reflects the BIM industry’s move toward a process that includes all stages of a building’s lifecycle. Most of the program’s modeling tools are geared for the design stage. But the resulting structural model can have uses beyond that stage, from what some have termed “Adaptive Reuse” for the fabrication and detailing stage, to “Construction Modeling” for the construction stage. Consequently, a conclusion can be made as to which tools and features are appropriate for the differing requirements of each stage in the building process, and hopefully the findings in this class can assist the participants in each of those stages in making those decisions.