



# Create Structural Shop Drawings and Fabrication Models Using Autodesk Revit

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New tools in Revit software have enhanced the ability of structural engineers and detailers to create shop drawings and fabrication models for structural components. This class will demonstrate the Building Information Modeling (BIM) workflow from structural models to fabrication to construction, all within Autodesk, Inc., software. We will learn how to take a structural engineer's Revit software model and turn it into a fabrication model and create shops drawings for rebar, steel framing and miscellaneous metals, and precast concrete. We will demonstrate new rebar modeling and annotation tools within Revit software, such as partitions and automatic bar-mark numbering, and we'll learn how to create rebar shop drawings and concrete lift drawings. We'll take steel framing from Revit software to Advance Steel software to detail the structural steel and miscellaneous metals and to create steel shop drawings. We will also show how to use parts, assemblies, and new structural framing and modeling tools to create precast concrete models and shops drawings.

## Learning Objectives

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

- Discover the new tools and features for rebar modeling and annotation within Revit software to create rebar shop drawings
- Learn how to take steel framing from a Revit software model to Advance Steel software for steel detailing and then take it back to Revit software
- Learn how to use parts, assemblies, and new structural framing and modeling tools to create precast concrete shops drawings and model
- Discover how to use a Revit software model to create concrete lift drawings that enhance coordination and increase field labor productivity

## About the Speaker

Dan McCloskey received his bachelor's degree in civil engineering from the University of Illinois at Champaign-Urbana. After spending 2 years in Tampa, Florida, designing bridges for URS Corporation, Dan attended Purdue University, where he focused his research on seismic design in steel-framed buildings and he obtained a master's degree in structural engineering. Dan then moved to Denver, Colorado, where he worked as a structural design engineer and then structural project engineer for S.A. Miro, Inc. During his 5 years with Miro, Dan became an in-house expert in Revit Structure software, and he moved into the role of Building Information Modeling (BIM) manager. In 2011 Dan co-founded MB BIM Solutions as a BIM-focused consultancy that provides construction-level modeling of structural systems and components for its clients. Dan is active in the Denver-area BIM community with Rocky Mountain Building Information Society, has taught several classes at Autodesk University, is a Revit Beta contributor, and is also a Revit Gunslinger participant.

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## Introduction

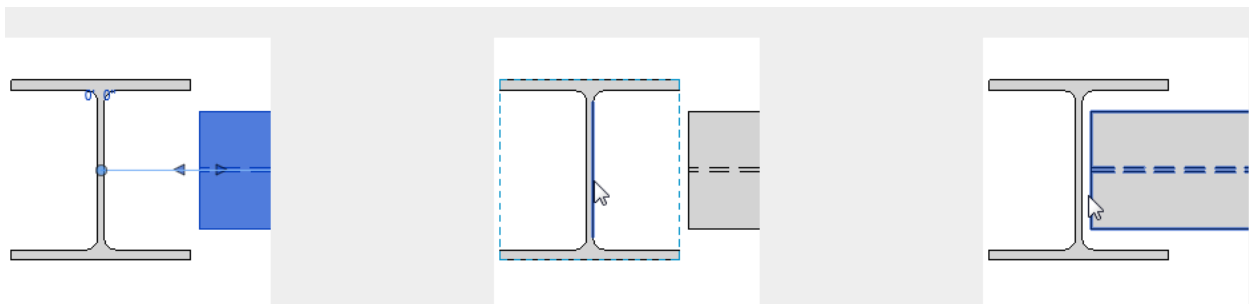
Due to new tools available to design teams and contractors, faster construction schedules, and the increased in integrated project delivery through the use of BIM, the 'who', 'how', and 'when' of shop drawings and fabrication models is changing. It is now possible to leverage a structural engineer's design model to create shops drawings and fabrication models for rebar, precast, structural steel and miscellaneous metals, and to create concrete lift drawings.

The 'who' is starting to change from fabricators and subcontractors to structural engineers, and BIM consultants. The 'how' is changing from 2D CAD for rebar, concrete lift drawings, and precast concrete, and from Tekla and SDS/2 for steel. Revit (and Advance Steel) can now be used to do this on a true BIM platform, with the advantage being to re-use the information and knowledge in a design Revit model further downstream into fabrication and construction. The 'when' is being change from a linear design-bid-build structure to a collaborative structure in which shop drawings and piece drawings are being produced in the late stages of the design process. This new approach enables schedule and constructability efficiencies by engaging the fabrication and construction team's knowledge and preferences before design is complete.

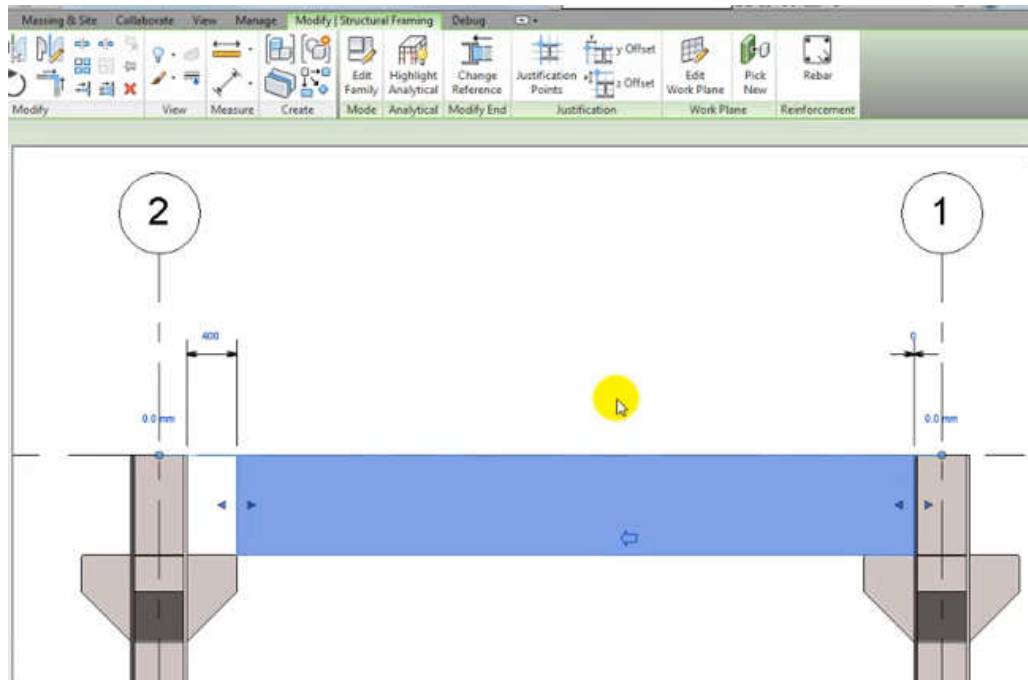
## Overview of Revit Tools for Shops Drawings

Though the tools for each structural component are somewhat different, there are a few tools that are important to understand and use correctly to create a fabrication model rather than a design model:

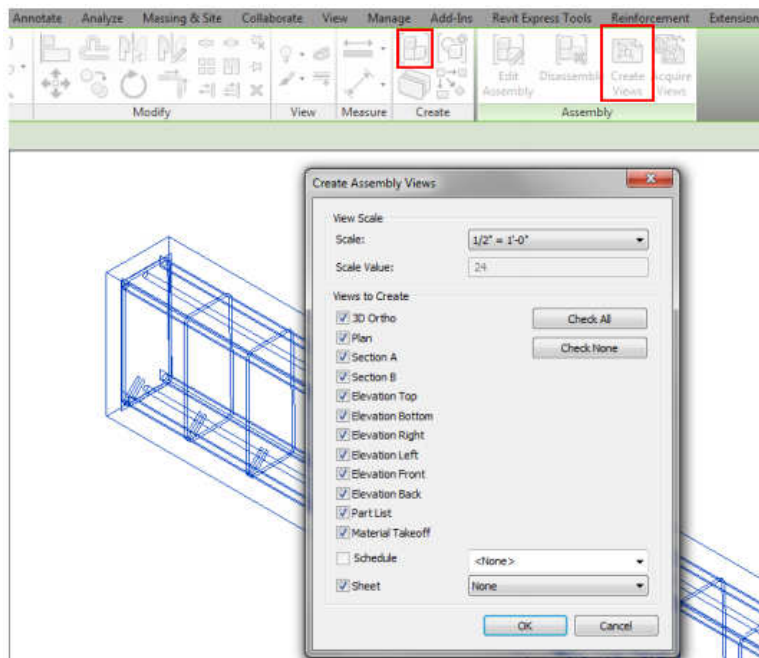
- Model the building as it will actually be built!
  - Split CIP columns and walls floor-to-floor, or in 2-story lifts if that is likely to be used by the construction team.
  - Split steel columns at actual splice lengths, rather than a single column for several stories.
  - Split walls horizontally (using the split tool), and then disallow the join to represent the true pour sequence.
  - Model the framing with geometric accuracy – learn to use the new structural framing enhancements in Revit 2015.



## Create Structural Shops Drawings and Fabrication Models Using Autodesk Revit



- Assemblies tool – similar to a model group in which a group of model elements are grouped together and can be re-used.
  - Assemblies have the benefit of being able to automatically create views, sheets, and schedules that recognize the components of that assembly.



- Parts tool – divide CIP concrete elements (or precast walls panels) into parts that represent the actual pour or piece. The part can then be manipulated (reinforced, added parameters, etc.) separately from its ‘original’ entire component.
  - Also use this to separate out the concrete portion of a wall component that has several layers.
- Add-ins made specifically for creating shops drawings:
  - CTC’s Fab Sheets – for CIP concrete, assign pours to groups of concrete elements and automatically create views and sheets for each pour.
  - SofiSTIK’s reinforcement add-in – speed up the annotation of rebar shops.

## **Rebar Modeling and Shop Drawings in Revit**

### **Why (and When) to Model Rebar:**

Modeling rebar for an entire building is very time intensive and takes considerable effort. Modeling rebar for the sole purpose of meeting an arbitrary BIM LOD (level of detail) requirement is not recommended, unless that rebar model is going to be pushed downstream into fabrication/construction and used to save schedule or money.

#### **Why/When to Model Rebar:**

- Shop drawing production
  - Why = construction schedule and material tonnage (\$\$) savings
- Constructability, congestion, and coordination studies
  - Why = better constructability, reduced congestion issues, enhanced coordination

#### **Why/When NOT to Model Rebar:**

- Because you can
  - Why not = you’ll blow your budget
- To draw details for construction documents
  - Why not = you’ll end up chasing around bar in other unrelated views, modifications are more of a pain, and you can draw details faster using detail components

### **General Considerations for Starting the Model:**

One of the first things to consider, in the case of a structural engineer acting as EOR for a project and simultaneously creating a rebar model and shop drawings, is whether to combine the rebar and design models, or create two separate models. We prefer to have two separate models, which are obviously then linked and copy/monitored. Here are the pros and cons of the separate model approach:

#### **Pros:**

- Design modeling vs. construction modeling – different needs and LOD
- File size – these models can get very big, and tougher to work with for the design team
- Possibility of design team inadvertently messing up rebar

### Cons:

- Duplication of work, possibility of design model not matching rebar model
- Some data and details will need to be generated twice

It may be make sense to combine the design and rebar model for some firms or for specific projects. In this case, using worksets is a good way to separate the rebar from the rest of the model.

Before starting on a rebar model, we recommend meeting with the fabricator, installer, and GC (or concrete sub) to kick off the project and determine pour breaks, bar lengths, installation preferences, BOM data preferences, etc..

### A Good Rebar Template Goes a Long Way:

Producing your first rebar model and shops drawings in Revit will take some patience, foresight, and good planning. A good rebar template will go a long way to make the next job much faster (and more profitable!). To save you some of the headache on your first job, here is what we include in our rebar template:

- Custom parameters that are used in conjunction with filters to help control visibilities of views and to schedule data:
  - Pour – we previously assigned this to both rebar and CIP elements to control what is shown in schedules and views. We still use this to assign to CIP elements to filter out elements that have not yet been poured. For example, setting up a filter with Pour > CP4 (column pour 4) and turning it off will allow us to turn off columns that will not have been poured yet when showing views of CP4 pours.
  - **NEW IN REVIT 2015** – the 'partition' parameter that is used for rebar assignments and automatic bar marking. This is essentially the 'pour' that the rebar belongs to, and can be used for scheduling (BOM's, bend schedules), bar tagging, and view filters. It also recognizes any two identical bars within a partition and assigns the same bar mark. This tool is a huge addition!

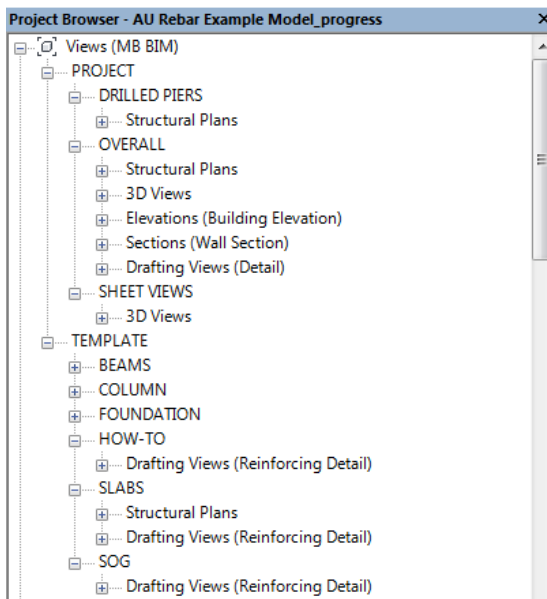
Partition	Rebar Numbers		Fabric Numbers		Remove Gaps
	Start	In Use	Start	In Use	
P1	1	01-02			<input type="checkbox"/>
P2	1	01-02			<input type="checkbox"/>
P3	1	01-02			<input type="checkbox"/>

- Accessory – this is used for formsavers, threaded ends, dowels, or any other atypical data that you want to add to a bar that can show up in a tag and a schedule.

- 'Top/Bottom' – though area reinforcement for walls and columns automatically assigns this and you can easily turn on/off top or bottom bars, there are inevitably going to be cases where you've added custom rebar sets to the bottom or top of the slab. This allows you to turn all of these on/off in a top or bottom slab plan view.
- 'User Bar Quantity' and 'User Bar Spacing' – we like to use the Revit rebar sets data as much as possible. For example, this works well for a beam top or bottom set of longitudinal bars and stirrups or ties. However, for something like the total number of column verticals or the face reinforcement of a beam, we like to be able to tag the number of bars and/or their spacing.
- 'Comments' – this parameter automatically exists for rebar, and we add this to the end of our tags to enter text like 'PROJECT 1'-10''.

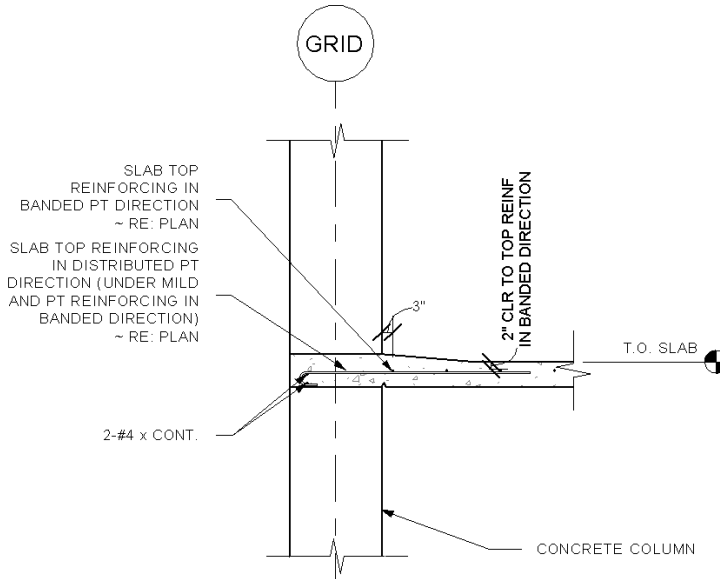
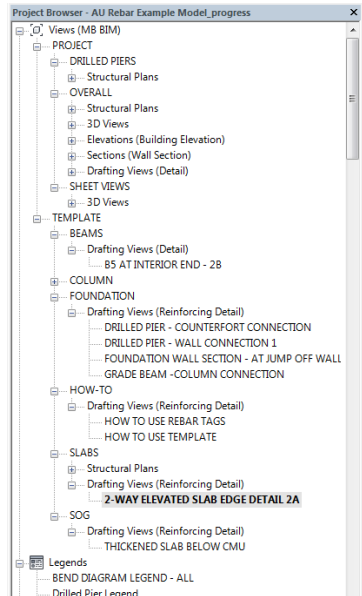
Identity Data	
Comments	
Mark	
Pour	
User Bar Quantity	
User Bar Spacing	
Accessory	
Top/Bottom	

- Logical view and sheet organization:
  - We like to organize the views and sheets different for rebar than what would be in a design model. We organize by element type (columns, slabs, beams, etc.), and then have view subcategories under each of those.

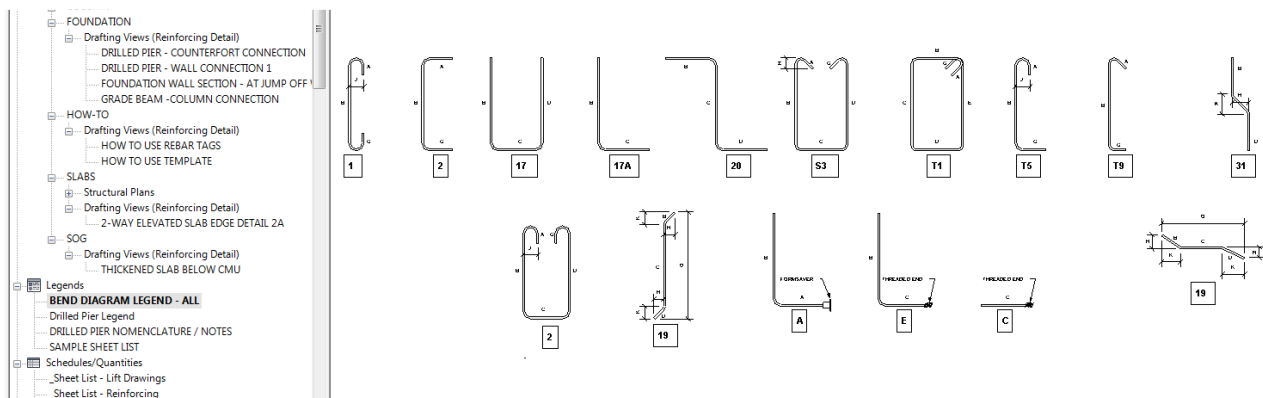


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- 2D typical details for typical conditions:

- No need for these to be live details, and they can be used over and over from project to project.



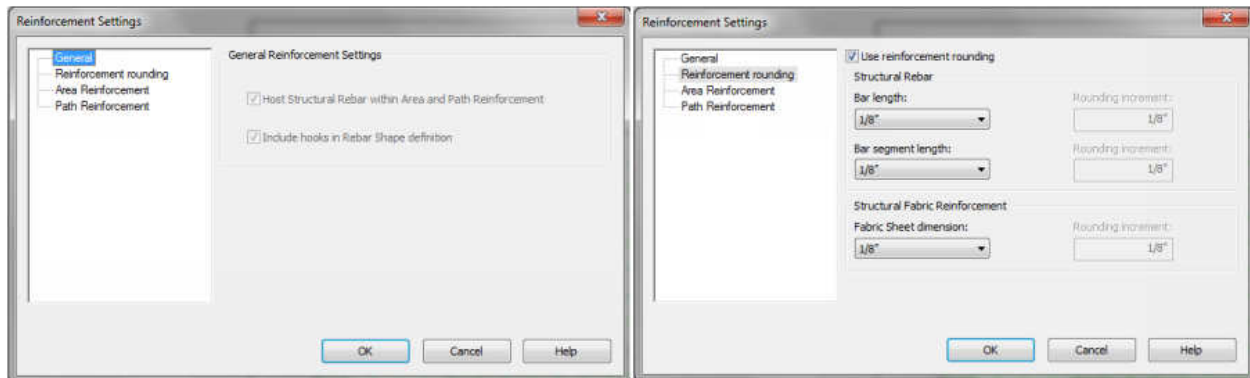
- View templates to ensure consistency and efficient view set-up.
- Bend schedule and BOM's (bill of materials):
  - Set up one bend schedule and one BOM, using a filter to reference the prefix of the partition to only include bar in a particular pour (partition). Then duplicate this numerous times to have a bend schedule for each pour (each one will be used on a single sheet, and BOM's will be sent to the fabricator for each pour).
- Rebar bend types in the form of a legend view that can be placed on multiple sheets.
  - Note – with the ability to now include an image with a family, you can create a schedule that has the different rebar shapes used in a particular pour, and place that schedule (with the image of the bend type) on each sheet!



## Global Rebar Settings Set-up:

Under 'Structure – Reinforcement (drop-down)', there are global rebar settings that should be addressed at the beginning of a rebar job:

- Rebar Cover Settings – set up standards for each type of element on the job, using the structural general notes as a starting point.
  - Then, assign each element to have the proper settings by selecting the elements (or all columns in an entire job, for instance), and applying the proper setting.
- Reinforcement Settings – 'Area Reinforcement' and 'Path Reinforcement' deal with the abbreviations used in the automatic rebar tags.
  - Reinforcement Rounding – this was new in Revit 2014, and is a great feature. Sometimes Revit will want to round a bar length or bar segment lengths to the 256<sup>th</sup> of an inch, but this option assures that bars will round to a value that fabricators actually use, such as 1/4".
  - General – make sure you have 'Host Structural Rebar within Area and Path Reinforcement' checked to use these tools to create actual rebar elements.



## Rebar Modeling Techniques:

There are various ways to model rebar in Revit. Each of these has a time and a place, and you will most likely use each of these to model when modeling a project that has various CIP concrete components (walls, slabs, beams, foundation elements, and columns).

### *Area and Path Reinforcement:*

This is the clear winner to place the majority of the bar in walls and slabs. Area reinforcement populates a slab or wall with rebar, top and bottom, each way. Path reinforcement specified a 'path' in a wall or slab represented by a line, for which rebar is laid out at a specified spacing along that path. Some notes on each of these:

- Make sure that you have set the slabs and walls as 'structural' to enable this tool.
- Properly set your cover settings for the element before placing rebar.
- For both of these, changes can be made to the entire set, its geometry, and any openings and the area or path will recognize these until the set is removed.
- Area Reinforcement:
  - This recognizes openings for floor penetrations, doors, etc..
  - TIP – Revit does not currently have a method to automatically set splice lengths and add splice lengths to bars. Instead, you can offset the edge of the area reinforcement by a



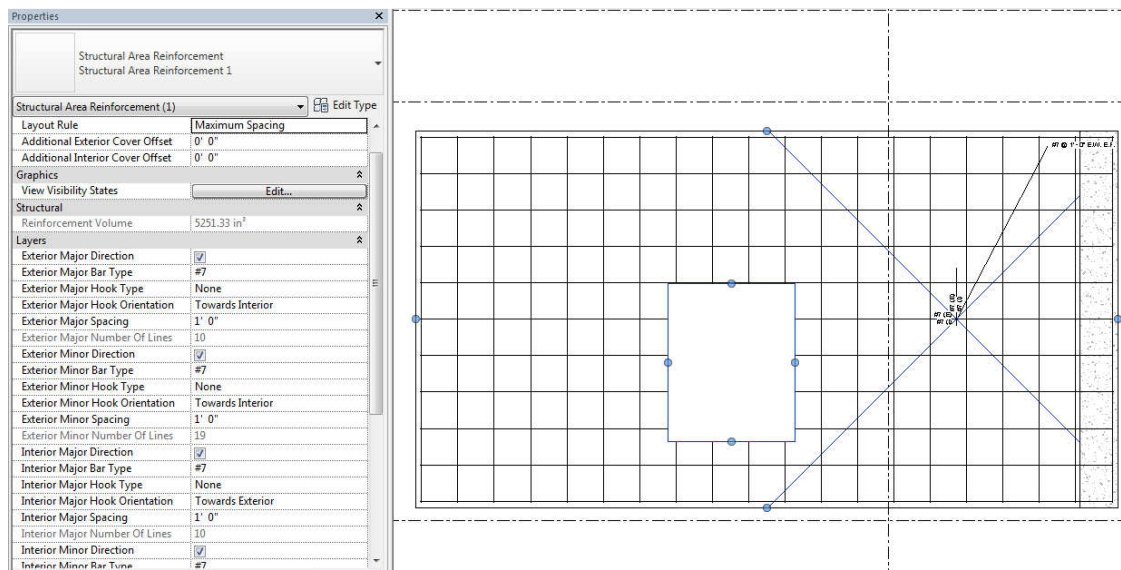
splice length to achieve bar splices (so that there are multiple area reinforcements on a slab that overlap.

- Path Reinforcement:
  - This is great for hairpins or 'candy-cane' bars at the edge of a slab, or confinement reinforcement at the edge of a wall.

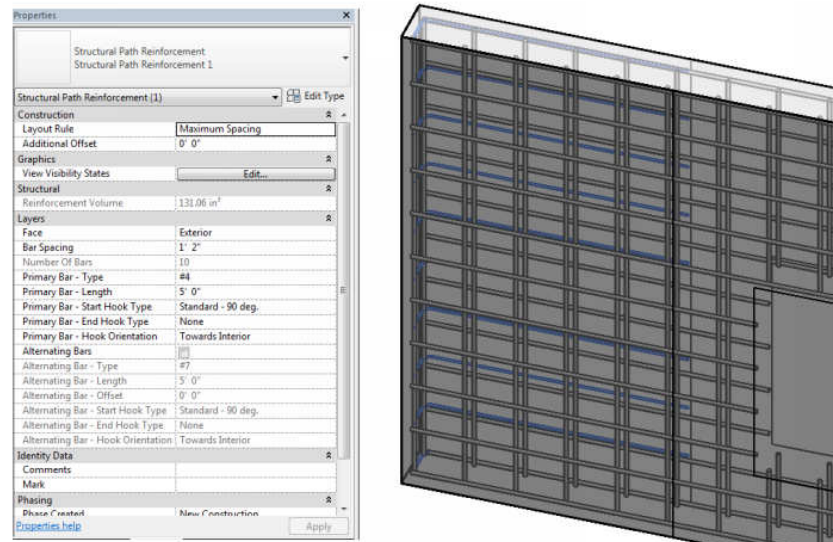
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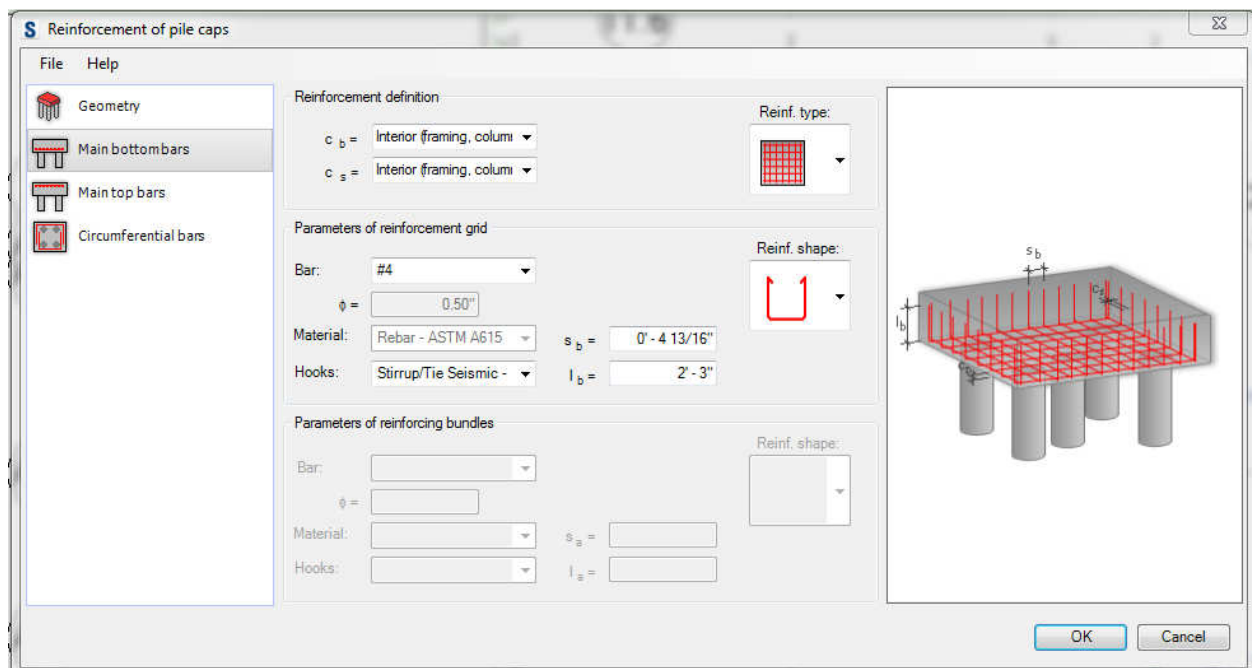
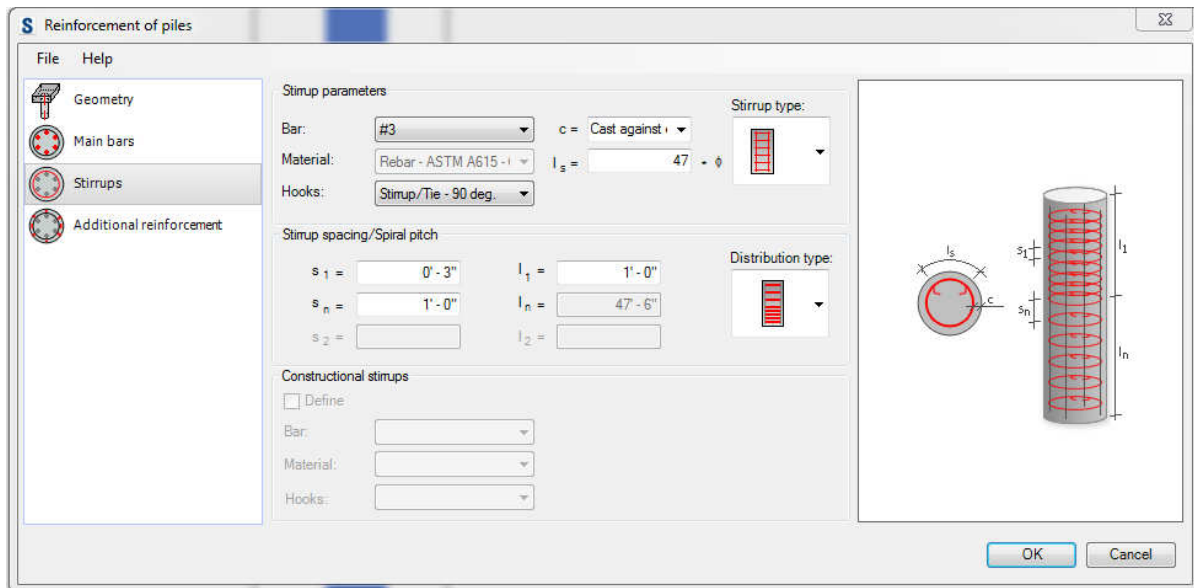
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### ***Autodesk Revit Extensions:***

Though the development of this does not seem to be the way forward in Revit (check that this still exists in Revit 2015), these tools are often a good starting point for laying out rebar for elements such as columns, drilled piers, and pier caps that have a specific geometric arrangement. For example, here are items that inputs that Revit Extensions use to quickly lay out rebar for a couple of elements:

- Columns:
  - Number and arrangement of vertical bars, dowels, tie size and spacing (top, bottom, and middle, etc.).
- Drilled Piers:
  - Vertical bars (size, layout pattern, cover, etc.)
  - Stirrups (bar size, shape, spacing sets, cover, etc.)
- Pier Caps:
  - Main top and bottom bars (size, spacing, shapes, cover)
  - Stirrups (bar size, shape, spacing, cover, etc.)



Though these extensions work, more often than not they require some manipulation and massaging after the bar has been generated. However, this is a great way to add bar for multiple elements quickly, and to add specify several 'sets' of bar in one element in one shot.

### ***Manually Adding Rebar 'Sets':***

This is the 'original' method of modeling rebar in Revit, and still the most customizable. It is as easy as selecting an element, specifying the workplane for the bar, selecting a bar shape and size, and adding either a 'set' (with a specified number of bars or spacing), or a single bar.

- **New in Revit 2015 R2** – you now have the ability to place a bar in an element in a view such as a plan, without having to modify the view range to encompass the whole beam. This is done by selecting the elements and placing bar 'by far cover' and 'by near cover'.
  - **Previously you would have to modify your view depth or cut a section to place this bar.**
- Bar recognizes cover settings of host element and stays within the cover.
- Bar recognizes the existence of other bar sets and will snap to the correct location within them (i.e. longitudinal beam bars stay within the ties).
- You can drag the blue arrows to adjust the extent of the set, to enable manipulation for things like splicing.
- **New in Revit 2015** – you can hide the first and last bar of a set by selecting it and clicking the checkbox.
  - This is on a per-view basis.

### ***Creating and Copying Assemblies of Identical Elements:***

After creating the reinforcement for an element (most useful for repeating elements like a beam, column, or pier cap), you can then create an 'assembly'. That assembly is similar to a model group, but has the following advantages and disadvantages:

- Lighter model weight than a group – it doesn't slow your model down like groups.
- From a workflow standpoint, this has replace model groups for us for copying rebar cages of identical elements around a project.
  - It is also useful for similar elements to copy and similar assembly, disassemble it, and then modify it.
- Big disadvantage – if you edit an assembly and want to push that edit through to all other instances of an assembly, it will instead create a new assembly for this instance.
  - Downside of this is you then have to change the other instances to this one, and that will mess with your view/sheet creation.
- When you copy this around your project, you'll usually get an error saying it made a new assembly type. This is because Revit is trying to recognize that for a pier cap for example, it has a different type of grade beam joining on one side of another instance, even if you want these two pier caps assemblies to be identical.

### **Rebar Annotation Tools Within Revit:**

Modeling rebar in Revit is actually the 'fun' part, and probably only takes about half of the total time involved in modeling bar and creating shop drawings. Improvements have been made to help create rebar shops more efficiently in Revit.

### ***Using Assemblies to Automatically Create Sheets, Schedules, and Views:***

After creating an assembly, you have the option to automatically create views (ortho, plans, details, elevations), schedules, and sheets from that assembly.

- Ability to automatically create views, sheets, and schedules from that assembly.
  - These views and schedules go to a different place in the browser than your typical ones, but starting in Revit 2014, you got the ability to drop assembly views on other sheets, and vice-versa.
  - Wouldn't automated dimensioning of these views be great? It isn't there yet.

- You can assign different parameter data to elements other instances of the assembly, so you can use the same assembly for another instance that is in a different pour.
- Disadvantage – your assembly views will only show elements (even grids) that are part of that assembly. This somewhat makes sense, but often your views will have to look different than you are used to seeing.
- We typically don't use the schedules out of assemblies that are created. We typically create one bend schedule and BOM for a pour (partition), and then duplicate those and change our filter for each subsequent pour.

### ***Tagging Rebar in Revit:***

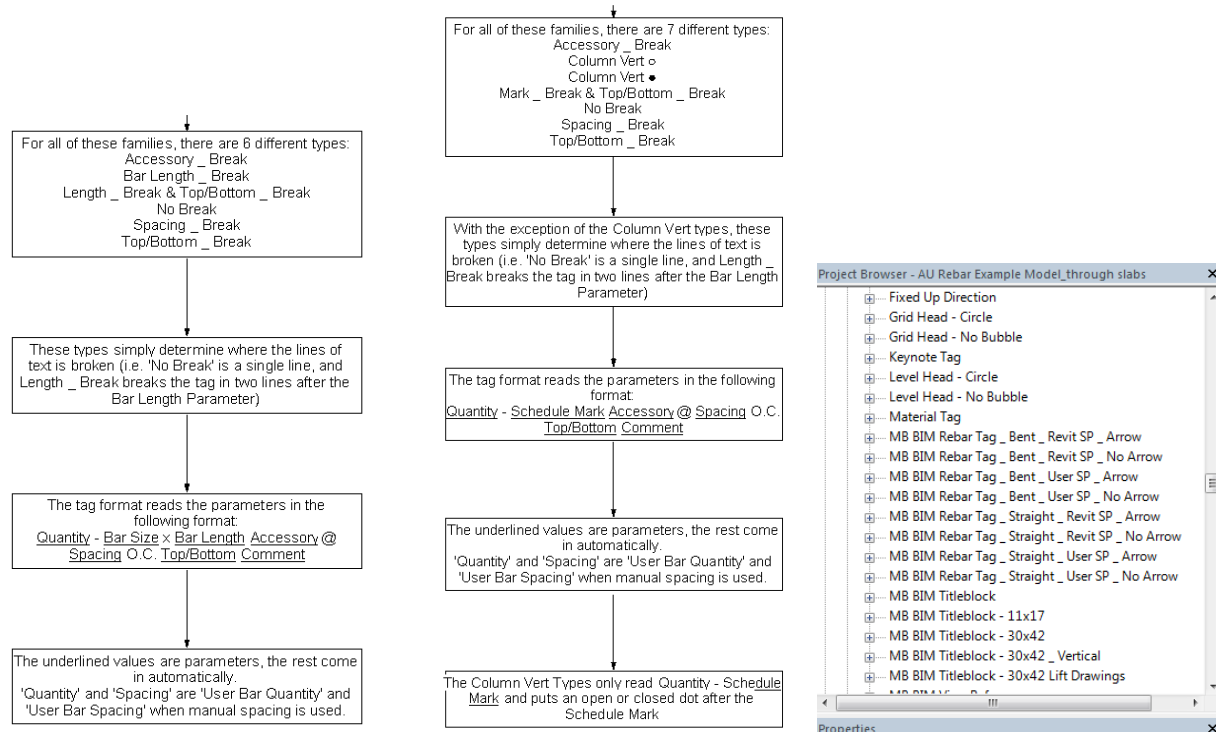
**New in Revit 2015** – Multi-Rebar Annotation. This is essentially a dimension string that can read a rebar tag within it. You have the ability to add any of your own custom tags to this tool and also to show it in a variety of ways to meet your standards (such as dimension leaders at every bar, just the end, etc.).

Because we want very little text in our rebar views and instead want the rebar data itself to be referenced, we have created a series of rebar tags that reference all data associated with rebar. Because we often want these parameters to show in different numbers of lines within the tag, we have created several types within each tag to allow this flexibility. It creates a large number of tags that can be used and can look overwhelming at first, so in a drafting view in our rebar template we have created a flow chart that shows our team how to use the rebar tag. Though it looks complex, there are really only a few choices, and it becomes very easy to remember once you have used it a few times. The choices are:

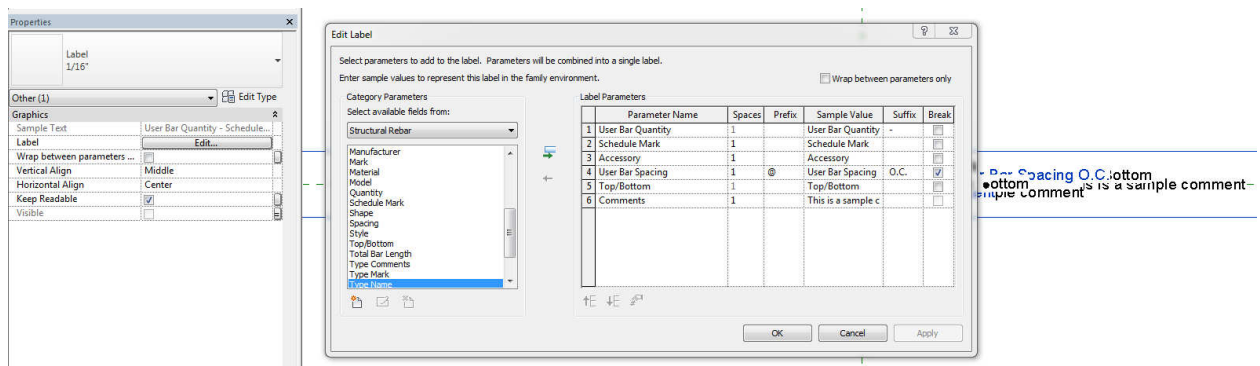
- Straight bar vs. bent bar (bent bar tags the bar mark, and straight bar tags the length)
- Revit spacing vs. manual spacing (as described above)
- Arrow vs. no arrow
- Then, the type just determines where the lines of text are broken within the tag

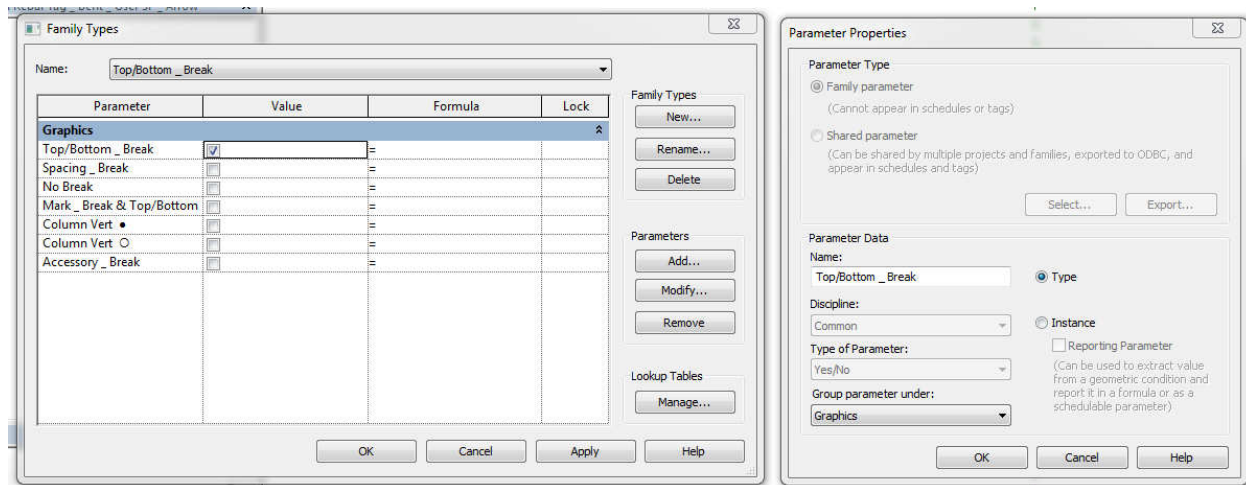
There are also types for column vertical which put open or close dots in the tag to represent vertical bars already poured vs. those that are new for the pour being detailed.

## Create Structural Shops Drawings and Fabrication Models Using Autodesk Revit



Our tags are just composed of multiple labels sitting on top of each other. Our tags have six parameters that are being referenced with the tag, and how the different types simply define where the tag has line breaks. Then, type parameters (and corresponding types) were set up as simple 'yes/no' type parameters that simply turn on the correct label for the tag type. This seems like a lot of parameters, but we use the 'Accessory' and 'Comments' parameters to give us the ability to add some text or data after the bar mark, and at the end of the tag. An example of this would be grade beam dowels that are bent bars (bent into the SOG). Here, the tag would call out the bar as '12 – 3T201 SOG DOWELS @ 12" O.C. PROJECT 8'. 'SOG DOWELS' would be the data entered into the 'Accessory', and 'PROJECT 8' would be entered into the comments. We have found that with these two parameters, we very rarely need text, and can have tags take care of it all.

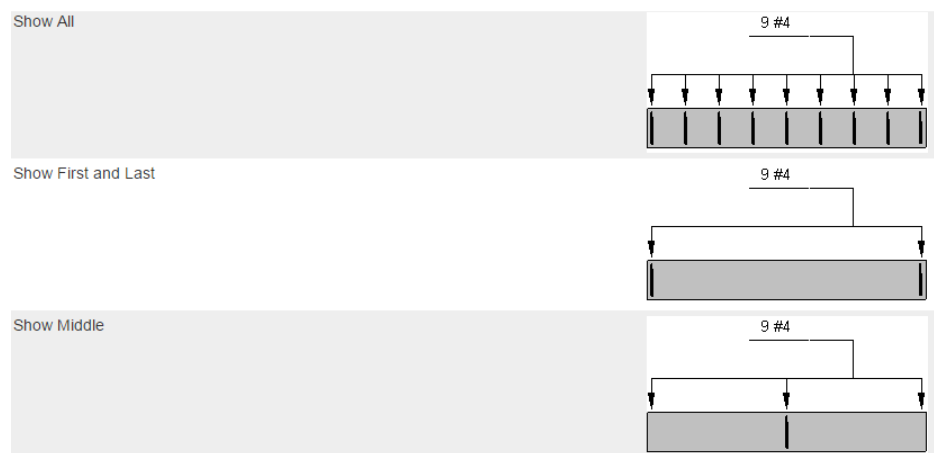




### ***Creating Rebar Views:***

Though you have the ability to automatically create views from assemblies, for the reasons described above we rarely use this right now and just use a series of view templates to apply to different types of views for different elements (i.e. slab plan vs. grade beam plan). We include pour and partition parameters within our filters for our view templates so that we can easily turn on or off relevant pours.

**New in Revit 2015** – as mentioned earlier, there is now a tool for rebar sets that allows you to show all bar, first and last, and only the middle bar. This is a huge time-saver for us – we used to accomplish this by creating a 'hide in view' yes/no parameter!



### ***Creating Rebar Bend Schedules and BOM's (Bill of Materials):***

Creating a bend schedule and BOM for each pour (partition) is easy, and then can then be duplicated to all subsequent pours. Create a schedule with the structural rebar category, then add all bar segment dimensions, shape, type (bar size), bar number, partition, and pour. You can sort set up a filter to only show bars with the 'partition' that you are working in, and also filter out all straight bar (shape 00), as that

is typically not shown in a bend schedule. Sort by type and then by bar number and do not itemize every instance, and then filter out any straight bar and any bar from other pours. Finally, hide bar fields that do not apply.

Duplicate the bend schedule to create the Bill of Material (BOM) each pour (partition). This is the data that is submitted to the fabricator, and included the straight bar, all bar segment lengths, and bar quantities. It might be useful in the schedule to add (and hide) the reinforcement weight. This is a calculated parameter that is just  $\text{Reinforcement Volume} / 1 \text{ CF} * 490 / 2000$  (in tons).

<Rebar Schedule - WORKING>										
A	B	C	D	E	F	G	H	I	J	K
Type	Shape	Schedule Mark	Reinforced Element	Pour	A	B	C	D	E	F
#3	T3	4T100	DRILLED PIER	DP1	0' - 0"	0' - 0"	0' - 0"	0' - 0"	0' - 0"	0' - 0"
#4	T2	4T200	PIER CAP	GB1	0' - 4 1/2"	4' - 0"	4' - 0"	4' - 0"	4' - 0"	0' - 0"
#4	T9	4T201	PIER CAP	GB1	0' - 4 1/2"	4' - 0"	0' - 0"	0' - 0"	0' - 0"	0' - 0"
#6	S3	6T200	PIER CAP	GB1	0' - 8"	1' - 11 1/4"	3' - 11"	1' - 11 1/4"	0' - 0"	0' - 0"
#6	T9	6T201	PIER CAP	GB1	0' - 8"	3' - 11"	0' - 0"	0' - 0"	0' - 0"	0' - 0"

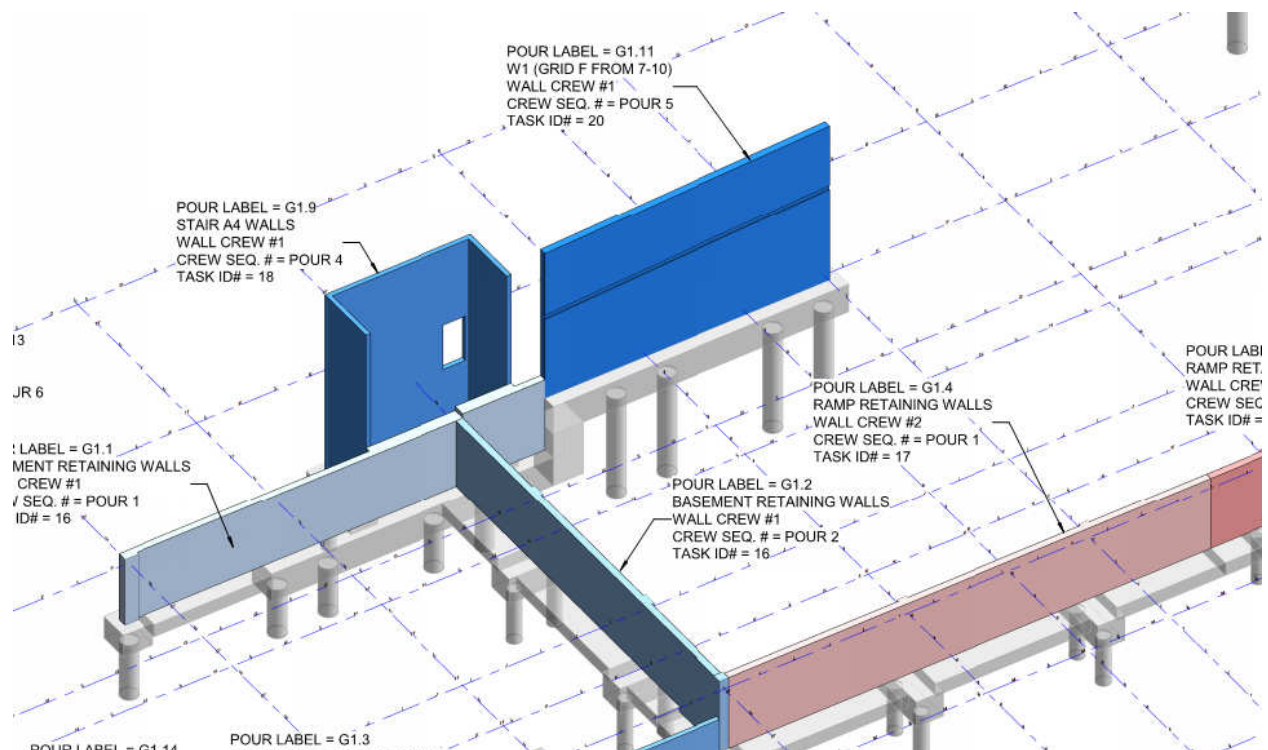
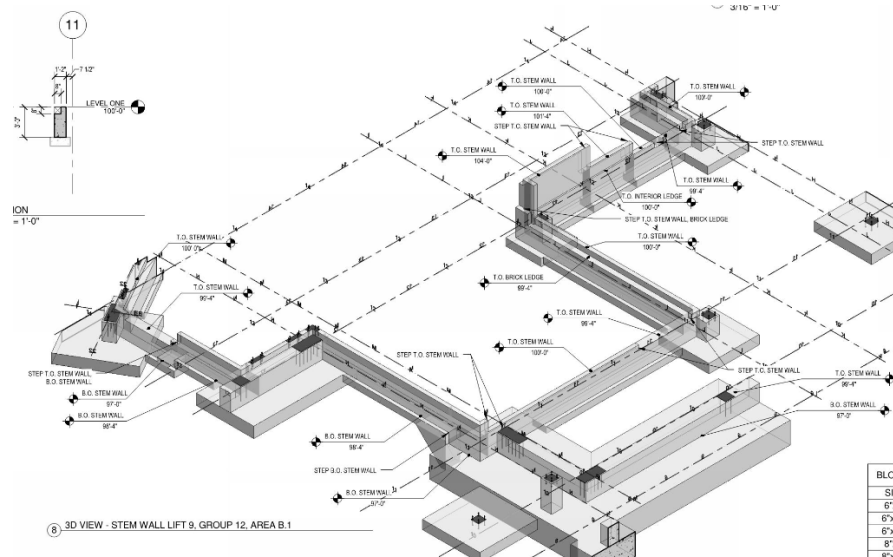
## Creating Cast-in-Place Concrete Lift Drawings in Revit

Several larger GC's that self-perform their CIP concrete work has begun to use a model to create concrete lift drawings, and in the last couple of years we have done this more and more for our GC and concrete subcontractor clients. These are the benefits that we are seeing:

- Enhance productivity from field crews:
  - Much is a result of enhanced coordination (below), but it is also the result of having clear, concise drawings with dimensions laid out in a manner consistent with how tape is laid out in the field.
  - Isometrics of each pour that allow for field labor visualization of complicated pour geometry, and QC that all embedded items are included.
- Sharing of the model, pours, and drawings (often to DWG) to the formwork team and rebar detailing team. This ensures everyone is using the same information.
- Enhanced coordination:
  - By included all cast-in elements as well as void forms, wall pours are figured out well ahead of time and contain all elements and data in one place.
  - Field crews do not have to look through design drawings and steel shops drawings. Concrete lift drawings from the model contain everything shown in the drawings from all disciplines, as well as embeds.
- Quantity management (embeds, CIP pour volumes), schedule visualization and crew visualizations.



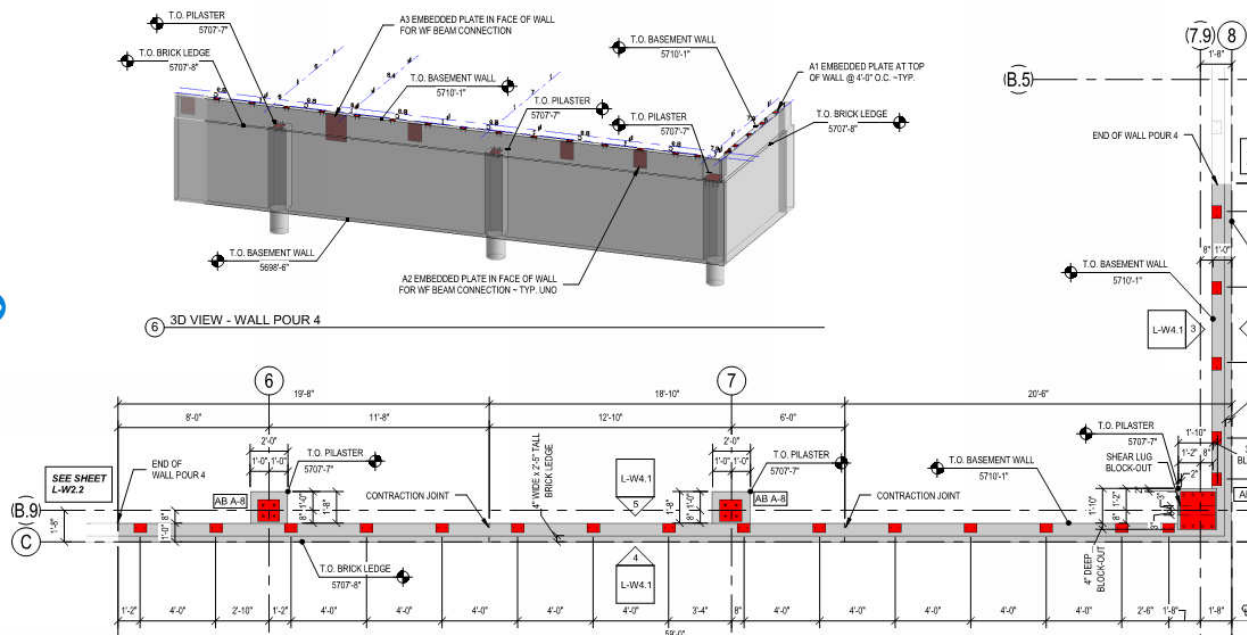
## Create Structural Shops Drawings and Fabrication Models Using Autodesk Revit



### Modeling CIP Concrete and Components within CIP for Lift Drawings:

Modeling rebar cast-in-place and its embedded components in Revit for the purpose of creating concrete lift drawings (line drawings) is a bit different than how you would model the same elements for design documents. Items that are included in a concrete lift drawings model but not a design model are as follows, and typically incorporated from shop drawings or models from other trades:

- Walls split up at correct pour breaks
- Anchor bolts
- Embeds
  - Elevators
  - Steel framing
  - Curtainwall
  - Precast
- Void forms
- MEP penetrations
- Future items to include, from feedback from our clients:
  - Point layout (Autodesk Point Creator) – export directly to the gun in the field.
  - Formwork



### Creating and Annotating Lift Drawings Sheets within Revit for Lift Drawings:

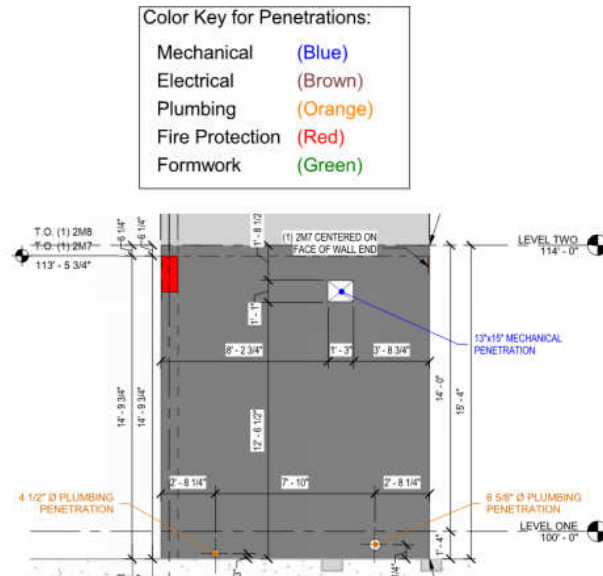
Annotate your lift drawings in a way that increases field productivity as described above, keeping the drawings easy to read and understand. Include all information (such as embed piece marks) that keeps field crews from having to look to another source for the information.

- Use assemblies or CTC Fab Sheets to create views and sheets quickly
- Data to add to CIP elements and elements embedded in CIP:
  - Pour
  - Crew

- Schedule dates
- Dimension strings – think about how they lay out the tape in the field
- Clearly annotate spot elevations for all changes in geometry.
- MEP penetrations – use different colors for the different trades
- Void dimensions and lengths – easy use of blockouts (include a schedule of these)
- Cover sheet with crew info, pour sequence in colors, etc.

EMBEDS - POUR 4	
TYPE	COUNT
A1	20
A2	3
A3	1
AB Templ A-8	2
AB Templ D-8Rev	1

BLOCK-OUTS - POUR 4	
SIZE	LENGTH
3"x30"	2'-2"
4"x29"	78'-0"
4"x30"	1'-10"



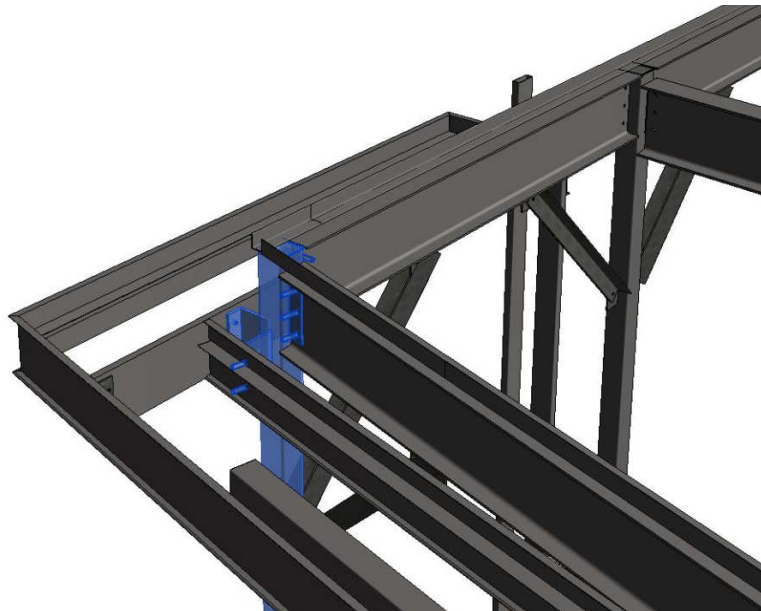
## Structural Steel Shop Drawings in Revit and Advance Steel

In our market, there has been a push recently for EOR's to offer steel shop drawing services. This is partly a result of shortened construction schedules, and the desire to start creating steel shops drawings earlier in the design phase. It also has come from the desire to lose the data and knowledge drop-off that comes with the EOR creating a steel model from their design documents and then the fabricator scrapping that and starting over with a fabrication model to be used for shop drawings. This streamlined workflow has allowed for better coordination carrying through from design into fabrication (and then construction).

We have created steel and miscellaneous metals shops drawings for several jobs now, and have used both Revit and Advance Steel to produce these models and drawings. Revit is by no means a steel detailing software platform, and using it to do so is getting outside of the intent of the tool. However, it is practical to use it as an introduction to steel detailing for design teams on small, simple projects.

- Revit Advantages:
  - Seamless integration with design, and linking with other models
  - Low learning curve, staff doesn't have to pick up another piece of software
  - Cost of licenses
  - Ease of use with standard, typical framing elements, and small projects (smaller amounts of data management).

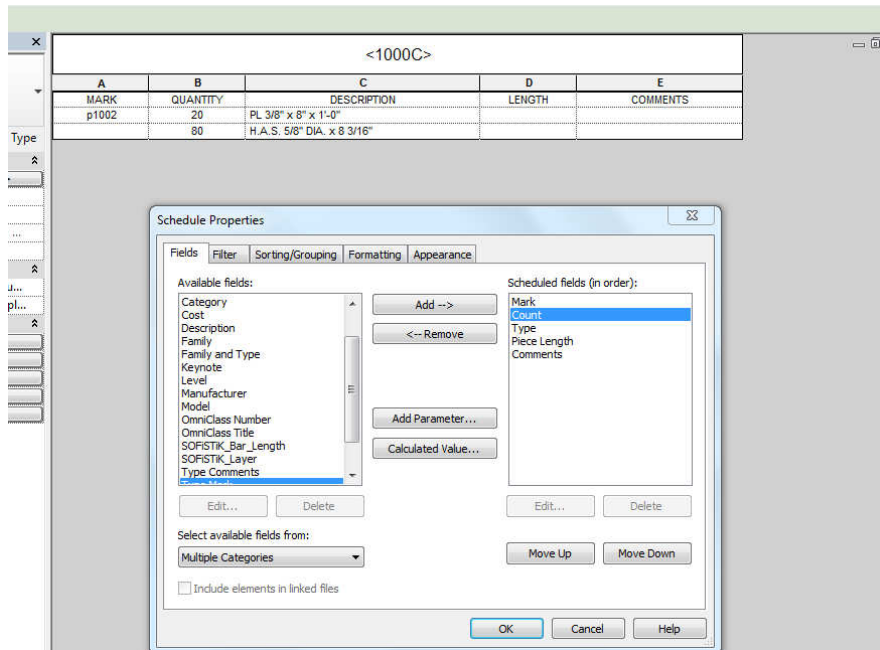
- Revit Disadvantages:
  - Lack of automation of piece drawings – no ability to automate dimensioning, piece marking, any other tools typical found in steel detailing software.
  - Inability to produce CNC output – this is HUGE and limits this to projects with smaller, less sophisticated fabricators
  - Need to create families and connection elements manually with more complex families, while in steel detailing software this can be done out of the box
  - Difficulty to create complex framing and highly detailed elements such as stairs



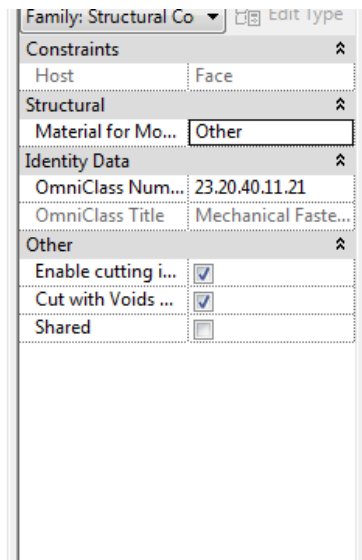
### Creating Structural Steel Shop Drawings in Revit

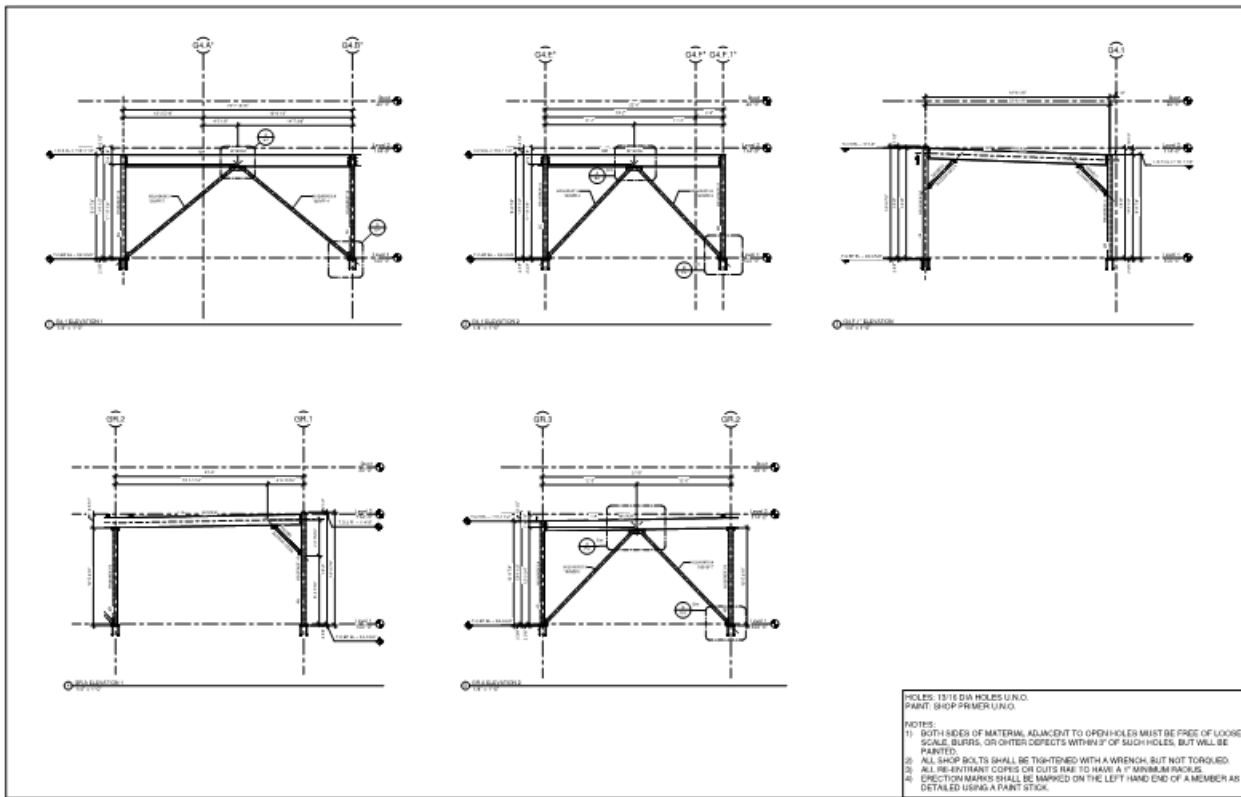
When creating steel shop drawings in Revit, the most important thing to remember is that precision is absolutely critical to the success of your project. Since Revit is more of a design tool, it has a tendency to 'correct' framing as it sees fit – which may or may not be what you are looking for.

We utilize assemblies for creation of all main parts and single parts. The assembly views are used to create the main part and single part views. The standard 'Parts List' assembly view can be modified to create the standard schedules that appear on shop drawings. One drawback is the lack of the ability to schedule the 'Length' property of an instance of a Revit element. This property should appear in the main part schedules that get dropped on the detail sheets. We suggest introducing a new shared parameter called 'Piece Length', set it to be an instance, reporting parameter and set it equal to the length of the member in each family. Finally, we recommend utilizing the 'Mark' property (in lieu of 'Type Mark') of each instance to create the Parts List for each main part.



For standard shear tabs or any element with a bolt, we use plate elements with a void extrusion cut through the plate. With properly set family parameters for the plate, the bolts will cut through the connecting element. This technique also ensures that bolt holes line up between main parts.





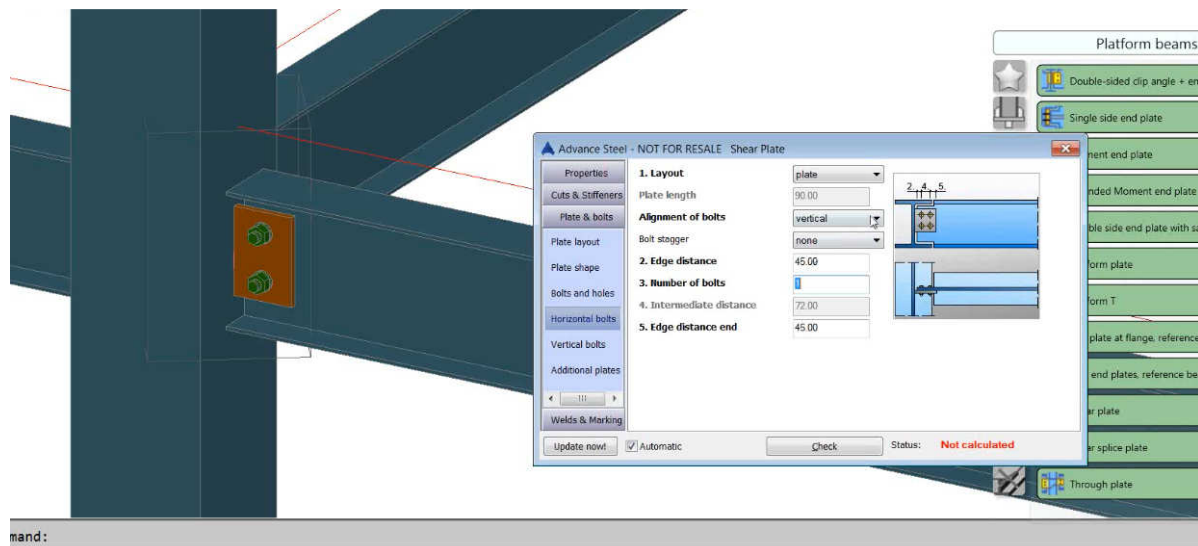
## Round-Tripping a Steel Model From Revit to Advance Steel and Back

Specifics of using Advance Steel are not described in this class, but with think it will be useful to show you an overview of the functionality of Advance Steel. There is plenty of literature and marketing material out there to show you it's functionality, but instead of describing how steel detailing software works in this handout, we'll just discuss round-tripping from Revit to Advance Steel.

We see the ability to seamlessly link between Revit and Advance Steel as extremely promising, and think that this has the ability to change the typical workflow so that structural EOR's are able to effectively offer steel detailing as an added service. With the fairly recent acquisition of Advance Steel by Autodesk, the import/export capabilities are workable but with limitations, such as getting all of the bolts and connection elements to come back into Revit (which is the main 'want'). We think that when this is working well and EOR's have familiarity with Advance Steel, they will be able to send models to Advance Steel during design phases, automatically add LOD 350 connection elements within Advance Steel, and then bring that back into Revit to help enhance coordination and allow live details to be drawn for atypical connections.

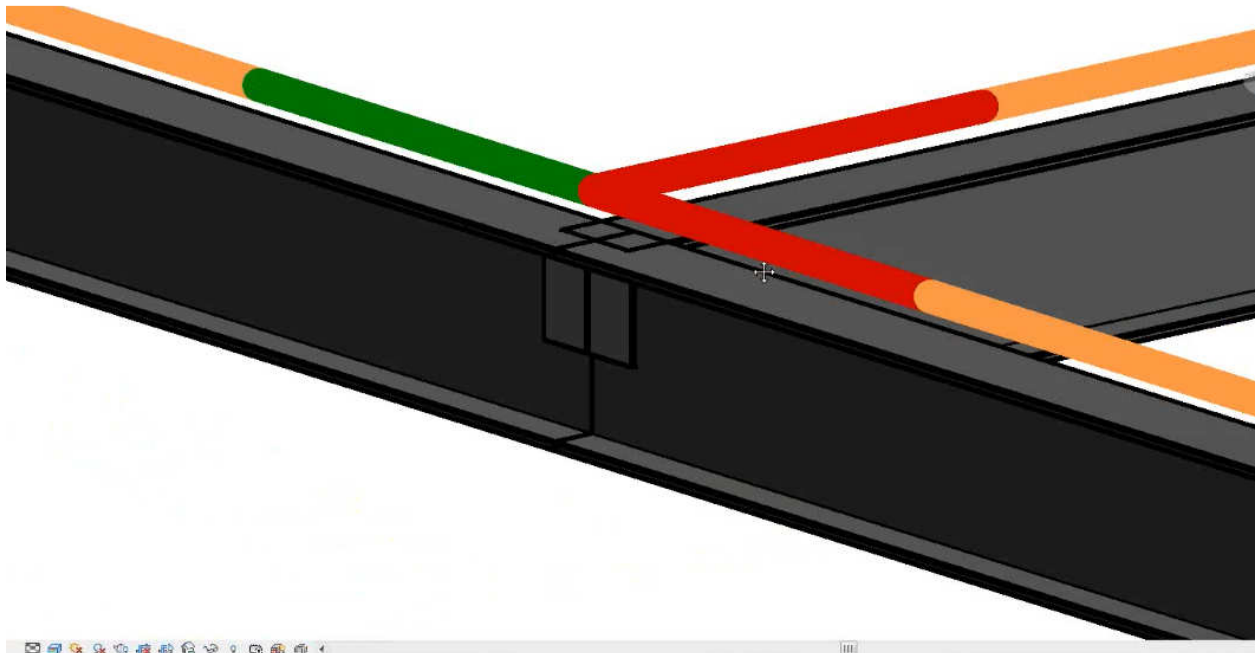
Advance Steel is great for automating many of the tasks that must be done manually in Revit such as automated creation of drawings, automatic piece numbering, and connection detailing. Advance Steel has many 'canned' connection details that have many input options that allow you to create customized connections and then automatically apply them to similar conditions throughout your model.





The automatic drawing creation and piece drawing tools within Advance Steel give you a great starting point to creating your erection drawings, details, and piece drawings. It is important to note that these tools simply create a starting point to your erection plans, details, and main part drawings – there is some editing that will inevitably need to be done to make your drawings look like they should.

As you can see in the screenshot below, the connection plates will come back into Revit, but the copes and other cuts applied in Advance Steel and bolts do NOT come over back into Revit after re-importing the model. From a coordination standpoint, this is acceptable because the overall geometry is captured in the Revit model.



## **Precast Concrete Fabrication Modeling and Shop Drawings in Revit**

### **Why to Create a Precast Fabrication-Level Models and Shops in Revit**

The vertically integrated nature of the precast concrete industry presents many opportunities to leverage data created and managed in a BIM. This vertical integration is different than the typical delivery methods of other structural systems (such as concrete and steel). Additionally, because there are many facets to a precaster's total product (design, fabrication, delivery, erection, etc), there is substantial benefit to the re-use of data and information throughout all phases of the project (rather than re-creating data and information at each step).

For example, a model created during the conceptual design and estimating phases can be used to quickly compute the volume of material and number of pieces on a project, leading to better understanding of costs. This can happen long before production and erection are imminent. During the design phases of a project, the precaster's model can be used as a coordination tool, supplying a better service to the client that could be achieved through typical 2d drawings creation. During production, shipping, and erection, the model can be populated with data to accurately plan and sequence these phases. All of these activities can be done within the same model that was started early in the project.

Precasters creating Revit models of their product during the design phase, rather than the design teams, has advantages for both the precasters and the design team. Obviously this is not possible on all types of project delivery approaches, but should be practiced when possible. Having the precaster model the profiles of spandrels, layout of structural precast framing, and size of members results in a more cost-efficient design, better coordinated design drawings, and allows for best estimating and scheduling data to be captured and optimized early in the process.

The adoption of BIM by a precaster is a method of improving the overall level of service to a client. This improvement comes in the form of enhanced coordination that is possible through the use of the model, and also by allowing the precaster to deliver their product more accurately, more efficiently, and faster. The use of a BIM can permeate all phases of a precast project, offering an excellent return on investment.

### **How is Modeling Precast Concrete for Use in Shop Drawings Different than Modeling Other Structural Systems?**

The discussion above about the vertically integrated nature of precast concrete also presents many challenges from a modeling standpoint. Since the data created in the model has many potential uses beyond the layout/design phases of a project, optimizing the use of the model and balancing the effort required to get the most out of the model is a constant struggle.

For example, consider the need (from a piece tracking perspective) to 'lock' unique elements into unique geometry to ensure that two different elements are not inadvertently given the same piece tracking data. Maybe you have a 10' wide double tee that in one instance is 10' long, but in another instance is 20' long. Does the difference in length warrant a new type when modeling in Revit? In this application, the piece



tracking parameter would likely be a type parameter in Revit. If this implementation is used, you would be left with countless types of standard double tees, making navigating the project browser very challenging! This also adds an unnecessary level of complexity to the modeling exercise.

On the other hand, if every 10' wide double tee is the same type regardless of the length, your production tracking data would likely be in the form of an instance parameter. This comes at the expense of possibly having two double tees that are exactly the same in every way but that have different production tracking data.

In our opinion, the latter option noted above makes for a much more usable precast concrete model. It should be noted that in this implementation, there is a need to manually search out instances of the same type that may be exactly the same in an effort to optimize production. However, these instances will likely be easy to spot – for example double tees on floors that stack are likely to be exactly the same as the floor above or below.

### **Custom Parameters and Schedules – What Might Be Useful:**

Everyone knows that Revit is very good at computing, counting, and representing data in schedules. These are some suggestions of some custom parameters that can be added to precast elements to automate tasks and some suggestions on ways to represent and extract data with schedules.

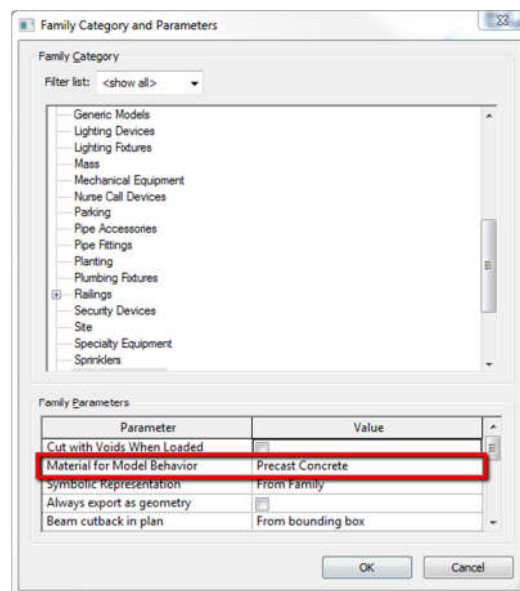
This is a short list of potential parameters and schedules that a precaster may find useful. Of course, every precaster's shop is different, so the things that one precaster finds useful may not fit well with the needs of another. Nonetheless, the overall idea is that the implementation of this kind of functionality into a good template is critical to the success of the modeling effort.

- A material take-off schedule showing the volume of concrete can be used to aid in the generation of a project cost estimate or bid early in a project. Additionally, this material take-off can be used to help plan for the material required during production.
- A count of the number of pieces and the type of piece can be used to plan production and operation of production beds. The piece count can also be used to facilitate production, delivery, and erection scheduling. During erection, the piece count can aid in determining the number of cranes, crane locations, and total erection duration.
- Counting of the number of connector plates needed to be installed in the cast-in-place concrete can ensure that the proper material is at the site when it is needed by the general contractor or concrete sub-contractor.
- A custom parameter that computes that weight and length of a member can be used to check the maximum dimensions of a member and the maximum weight that can be lifted in a specific crane orientation.
- A custom parameter that stores the design type of a framing element can make the connection between structural calculations and what is represented on the precast shop drawings clear to a reviewer.
- Piece marking parameters can be used to track a piece all the way from design to production to delivery and finally to erection. This information can be input into a precast concrete manufacturer's scheduling system.
- Proper marking can also identify pieces that are duplicates of each other but have different scheduling properties (for example – a beam that is exactly the same between two floors, but will obviously be erected at different times).

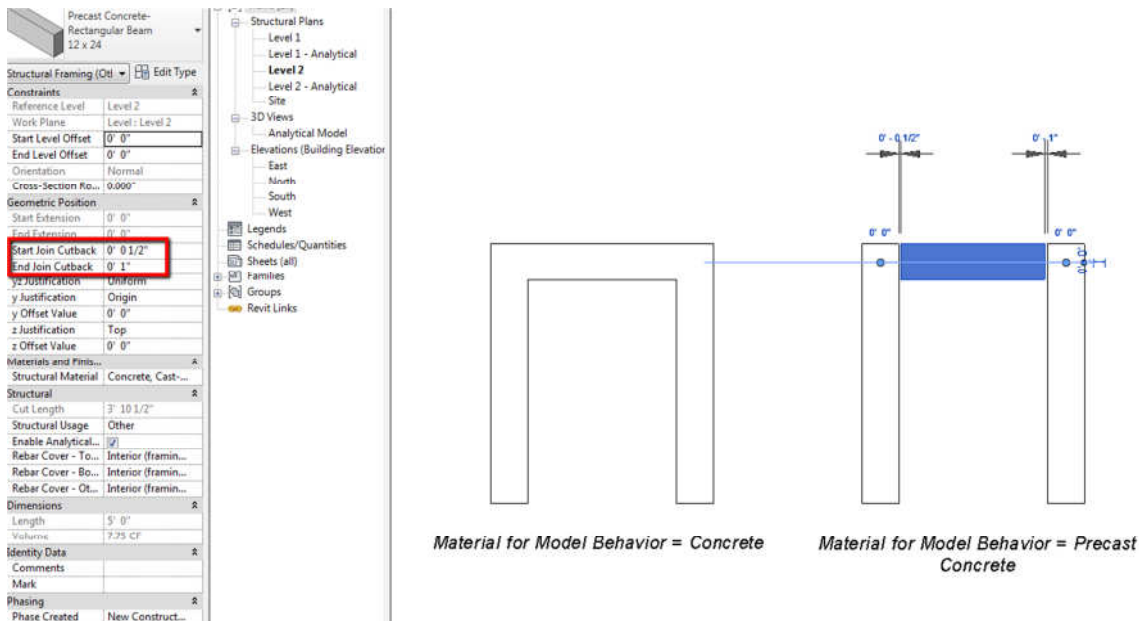
- Special components or components with a long lead time can be flagged to aid in material procurement and delivery.

### Concepts for all Precast Concrete Elements:

Revit needs to be told when a concrete element should be monolithic (a cast-in-place element) and when it should be discrete (a precast element). To let Revit know that precast beams and columns should not join and merge with another concrete elements, every precast concrete 'Structural Column' and 'Structural Framing' family must be edited so its 'Material for Model Behavior' (in 'Family Category and Parameters') is set to 'Precast Concrete'. Note that this step is necessary regardless of the material property you have assigned to the element ('Cast in place concrete', 'Precast concrete', etc).



When this parameter is properly set, two new instance properties appear for each 'Structural Framing' element: 'Start Join Cutback' and 'End Join Cutback'. These parameters dictate the distance between the framing element and the other elements that the instance is attached to. Setting this parameter properly in a Structural Column element does not add any new parameters.



Precast slabs (plank) are typically modeled as 'Structural Framing' elements (instead of as 'Floor' elements), so this should be properly set for those families as well.

Note that since structural walls are made from a system family, you do not have the ability to change this property for any precast walls. We will discuss how to achieve the proper behavior in the following sections.

In the examples that we discuss in this handout, we are also assuming that all of the framing families (walls, columns, beams, double tees, etc) have several custom parameters implemented to enhance their functionality. These include piece length, piece width, piece weight, and a piece mark. The piece mark is different than the standard out-of-the box Revit parameter 'Type Mark'. As discussed above, it is our opinion that the piece mark is best left as an instance parameter. We do not use the 'Type Mark' parameter in the examples below.

## Family Library – Precast Walls:

Since walls are system families, there is very little flexibility in the ways that they can be modeled. We typically check the 'Structural' Instance parameter of each wall so they appear properly in structural views and so an analytical model of the wall is created. We also change the material property for the wall type to be precast concrete.

We recommend populating your template with common wall thicknesses so they are ready to use when needed.

## Family Library – Columns:

There are several precast column families that come with Revit out-of-the-box. There are standard columns, columns with pockets to accept framing elements, and columns with corbels. We prefer the

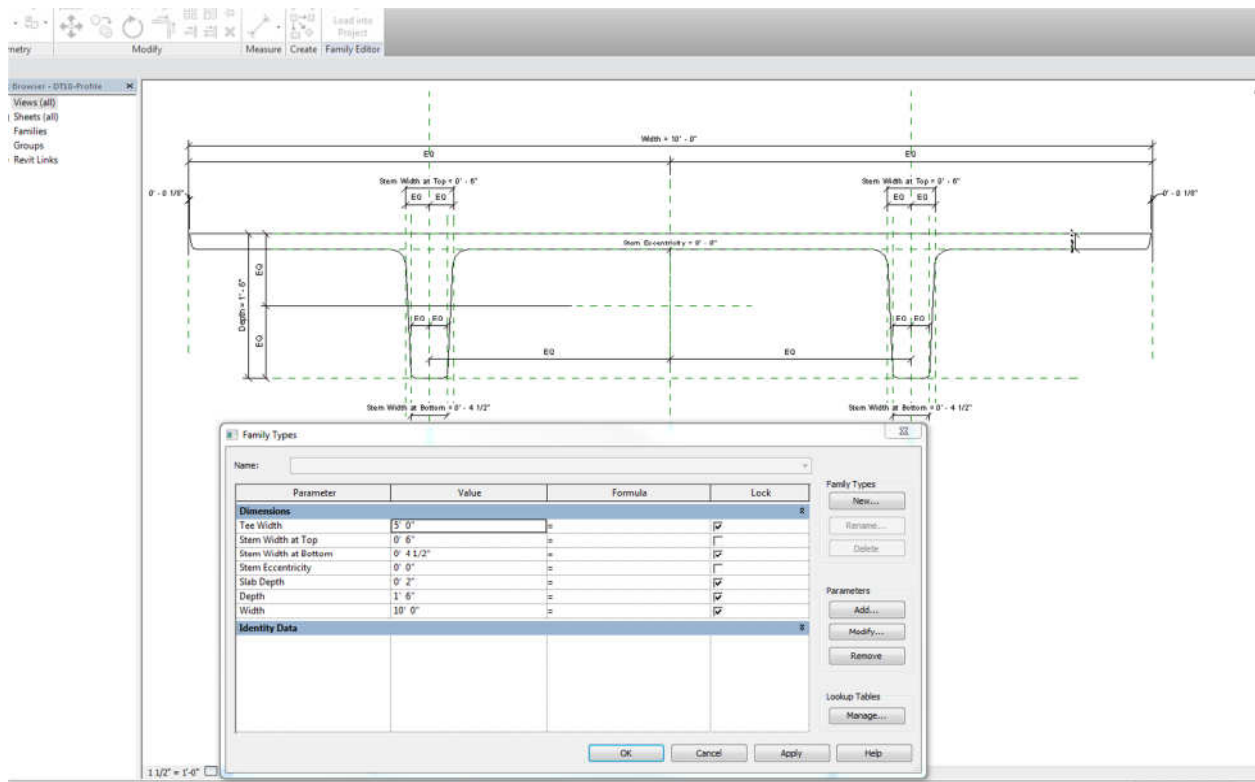
standard columns (no voids or corbels) for the increased flexibility that comes with using separate column and corbel elements.

The difference between the standard Revit out-of-the-box precast concrete column and concrete column families is the precast family has the ability to input a chamfer and has parameters to compute the weight of rebar and tie rods.

### **Family Library – Framing Members (Double Tees in This Example):**

Every precaster has their own custom form shapes that are unique to their production plant. Each of these cross sectional shapes can be turned into a Revit profile family and then loaded into a structural framing family to drive the geometry of the 'Structural Framing' family. Since there are so many potential framing shapes (widths and depths of beams and double tees for example), the best way to fully develop your framing shapes library is to utilize profiles loaded into structural framing families.

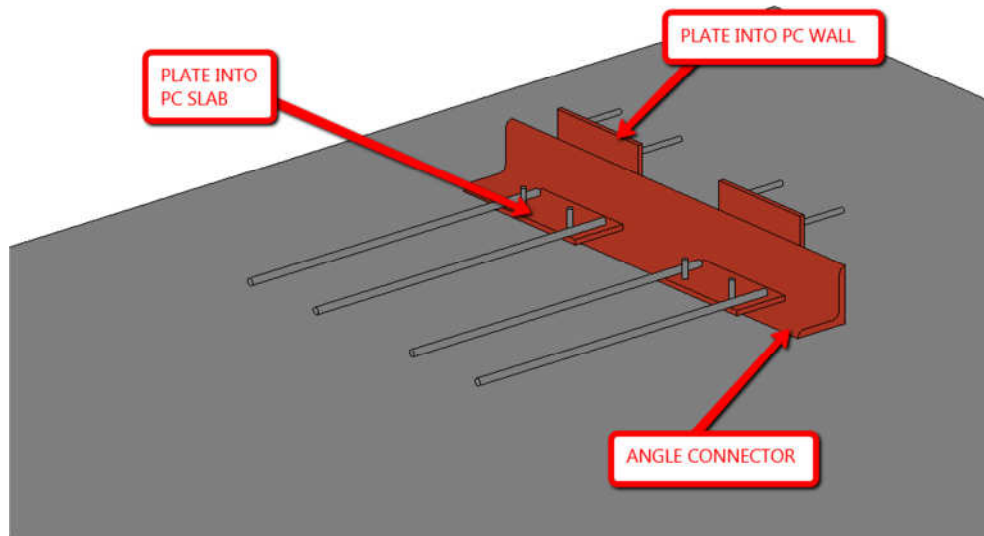
The use of profiles also allows the user a good means to 'lock down' the geometry of a form (or certain portions of the geometry of the form) – not allowing the other users to change the geometry (inadvertently or otherwise), resulting in quality control issues. By using profiles, you also maintain the flexibility to restore the parameters at a later date if the form flexibility is desired. For example, in the double tee profile family, we define the geometry of the profile using parameters (such as stem width, tee width, slab thickness, stem spacing etc). When this family is loaded into a Structural Framing family, the double tee family should only have parameters that are 'allowed' to change (such as tee width and slab thickness). The values of these parameters are linked to the parameters in the profile family so the geometry of the profile can be driven inside of the double tee Structural Framing family. The other parameters (stem width, stem spacing, etc) cannot change (unless production bed geometry changes), and as such do not exist in the double tee Structural Framing family.



## Family Library – Steel Connection Plates:

Since steel plates cut into standard shapes are used in many different connections by a typical precaster, it is best to start by creating separate families for each most basic plate element. The more complex, built up shapes are created by putting several of these small standard components together. This will also facilitate counting of plates for accurate quantity take-offs.

See the example below – the connection piece is a slab to wall connection detail. It is composed of an embed plate with studs that is cast into a precast wall, an embed plate with studs and rebar that is cast into the precast slab, and an angle that is used to connect the two pieces. We will create the connection from these three separate pieces.



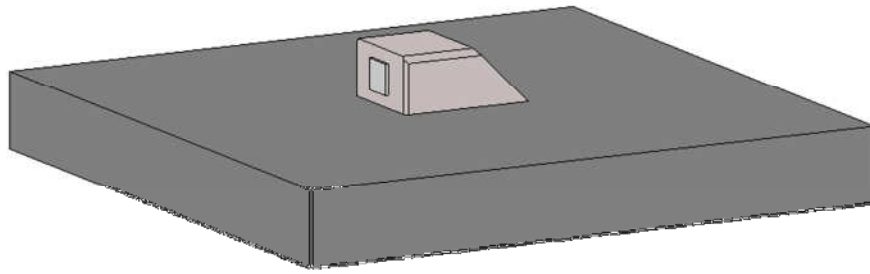
Create each of these plates from the 'Generic Model face based' Revit family template. Each piece within this family is simply an extrusion oriented to its appropriate location relative to the other extrusions. As you are building these families, it is a good idea to locate the 'Center (Left/Right)' and 'Center (Front/Back)' reference planes where they will be most useful from an alignment standpoint when the family is loaded into a project. Another important consideration is to leave the top of the extrusion at the top of the face of the host (as though the plate is cast into the host). As you use these elements, you will find that this handles 95% of the conditions that you will come across, and make for easy use.

After each of the three components is created and saved, they are all loaded into a new face-based family and assembled appropriately. Again, be sure to position the elements appropriately relative to the reference planes and host face (depending on how you anticipate using the family).

You may be asking why we chose to use a generic model in lieu of a structural connection, which intuitively seems to fit better. We use generic models because of the greater ability to modify the graphics of the generic models. One downside to doing this is that in order to schedule / count your generic models in a project, you must use 'Material Takeoffs' in lieu of 'Schedule/Quantities'.

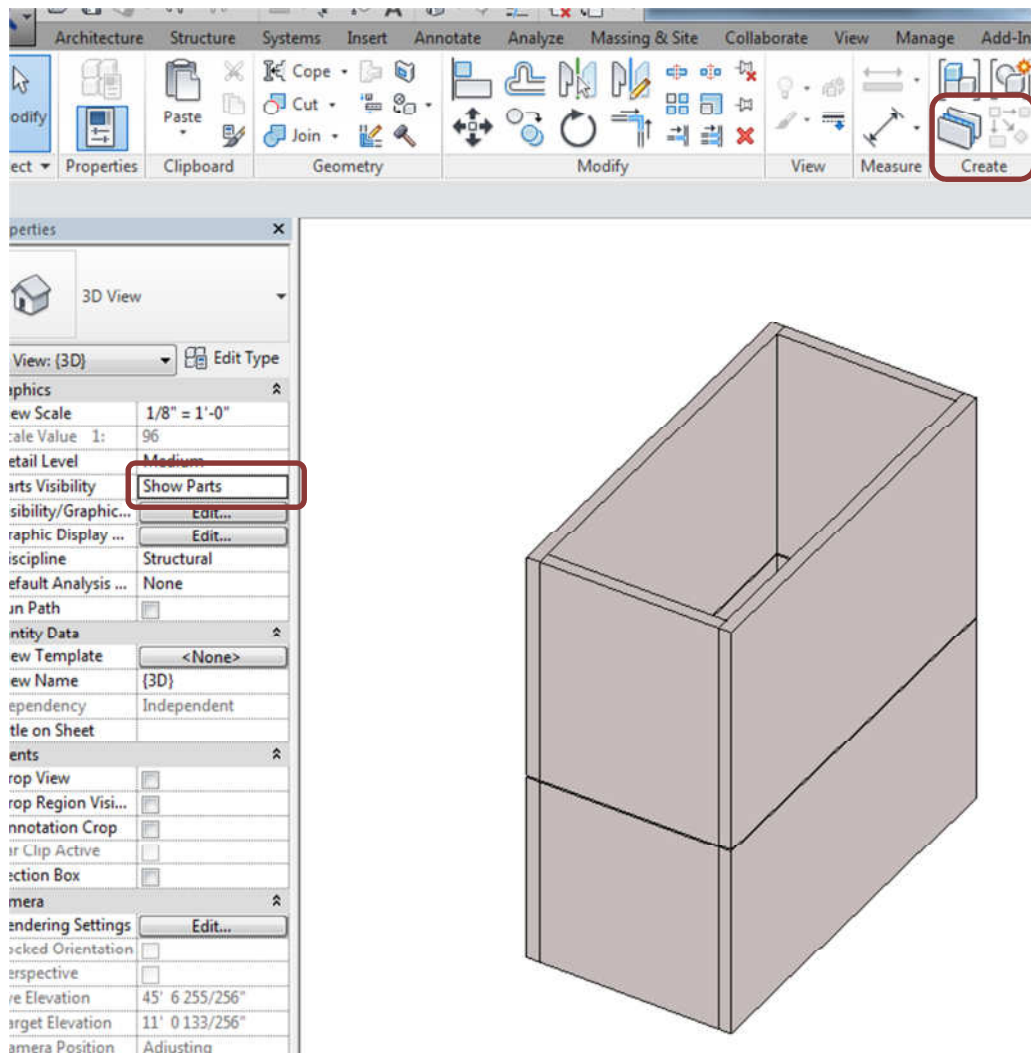
### **Family Library – Concrete Connections (Corbels):**

A concrete corbel is very much like the steel connection plates created above in the sense that it is created from a face-based generic model and is built up from an extrusion (or a set of extrusions). There is an important difference in the way that this family is built differently from the steel connection plates families. Since the corbel will be fastened to the face of its host, we build the corbel on the face (rather than being embedded into the host).



### Utilizing Parts to Segment Precast Concrete Walls

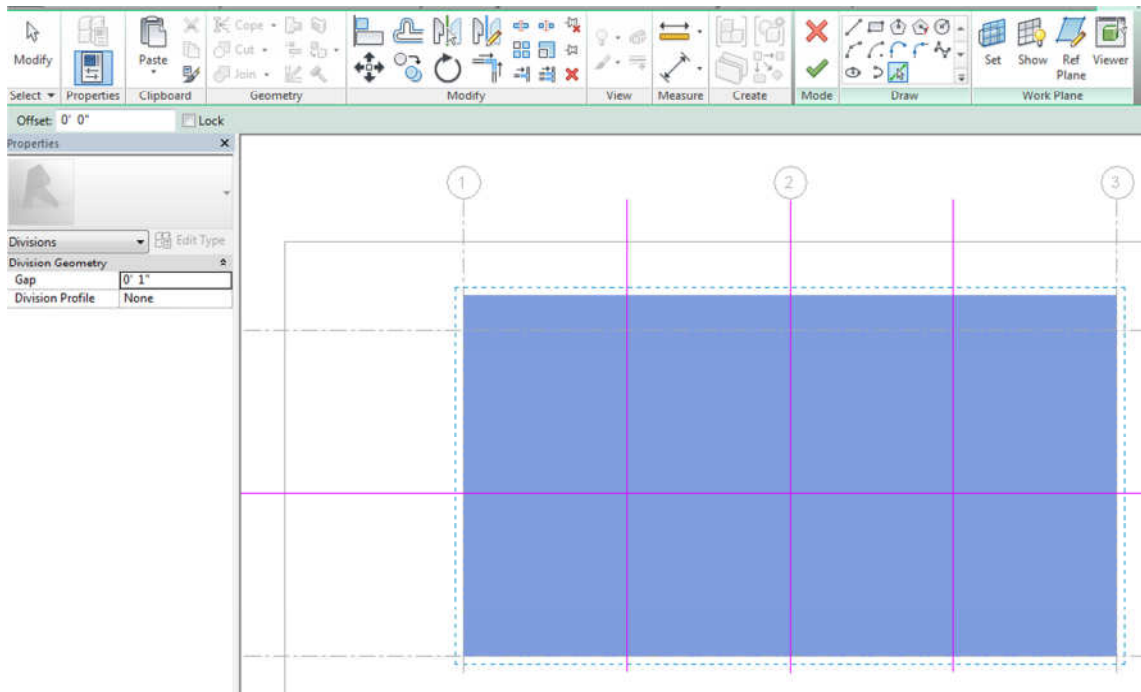
Parts allow portions of large elements (walls, floors, etc) to be scheduled, tagged, filtered, and exported separately from the original object. This implementation is perfect for panelized precast walls. For example, when working with a long wall, it is more efficient to create a single wall element and break it into parts to panelize the wall than to create a series of individual wall panel elements. In that implementation, it is difficult to separate the wall elements and to prevent them from joining to the other wall elements. Also, if/when changes are made in the panelization, you are forced to change many elements to reflect the revision. If Revit's parts functionality is used, a single wall (the 'whole') is created and the separate panels (the 'parts') are managed within that single wall. This is also an effective tool for modeling concrete cores (stair/elevator) that should be broken into planar walls, as we will demonstrate below.



It is important to note that when a part is created, it does not destroy the original. The parts are independent but remain linked to the original elements. To facilitate the use and manipulation of the parts and the original, it is helpful to create separate working views of levels/elevations that show either the parts or the original elements.

Before you divide an element, think about how an element will be divided (grids, levels, reference planes, or sketch dimensions). It is helpful to set up and name your reference planes prior to creating parts so they can be easily referenced and modified later as needed. In the example below, we will break up a wall with reference lines, grids, and levels.



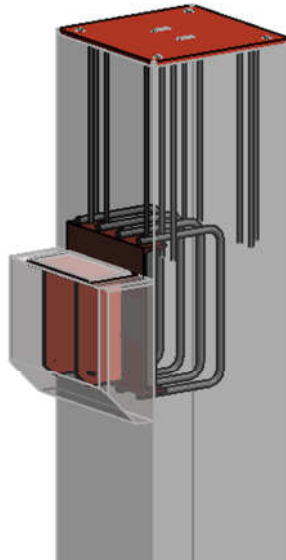


### Utilizing Assemblies to Streamline Creation of Composite Precast Elements:

Assemblies allow one or more elements to be aggregated into a single model element, allowing the built-up element to be edited, scheduled, tagged, documented, filtered etc as a single element. When creating assemblies, if you create an assembly that is exactly like another previously created assembly, Revit will recognize that you are duplicating a previously created assembly and alert you to this.

So, how are assemblies different from groups? The primary difference is that assemblies do not enforce uniformity of geometry, whereas groups do. So, if you have an assembly whose geometry inadvertently becomes slightly different from the assembly that it was copied from, a new assembly is created, in lieu of maintaining the previously generated elements exactly as they existed in the original assembly. It is very important to understand that this is true for properties that control geometry, but not true for other parameters (such as piece tracking parameters).

In the example below, we have a precast column with 4 pieces that need to be assembled together – the column itself, the cap plate of the column, the embed plate to attach the steel corbel, the steel corbel plate, and the concrete portion of the corbel. When you select all of these elements, the 'Create Assembly' button becomes active from the toolbar. When it is selected, you can create all of the views and schedules that are needed to fully document the assembly. After an assembly is created, it can be copied around your project and re-used in several different places.

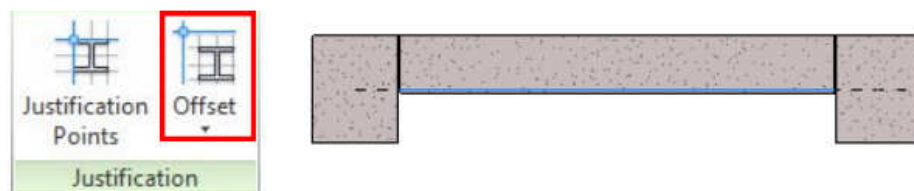


For precast concrete manufacturers, the use of assemblies is greatly enhanced by the fact only geometrical information must match for two assemblies to be the same. Other parameters (such as piece tracking parameters) are not required to be exactly the same, allowing the number of assembly types to be substantially limited, enhancing usability.

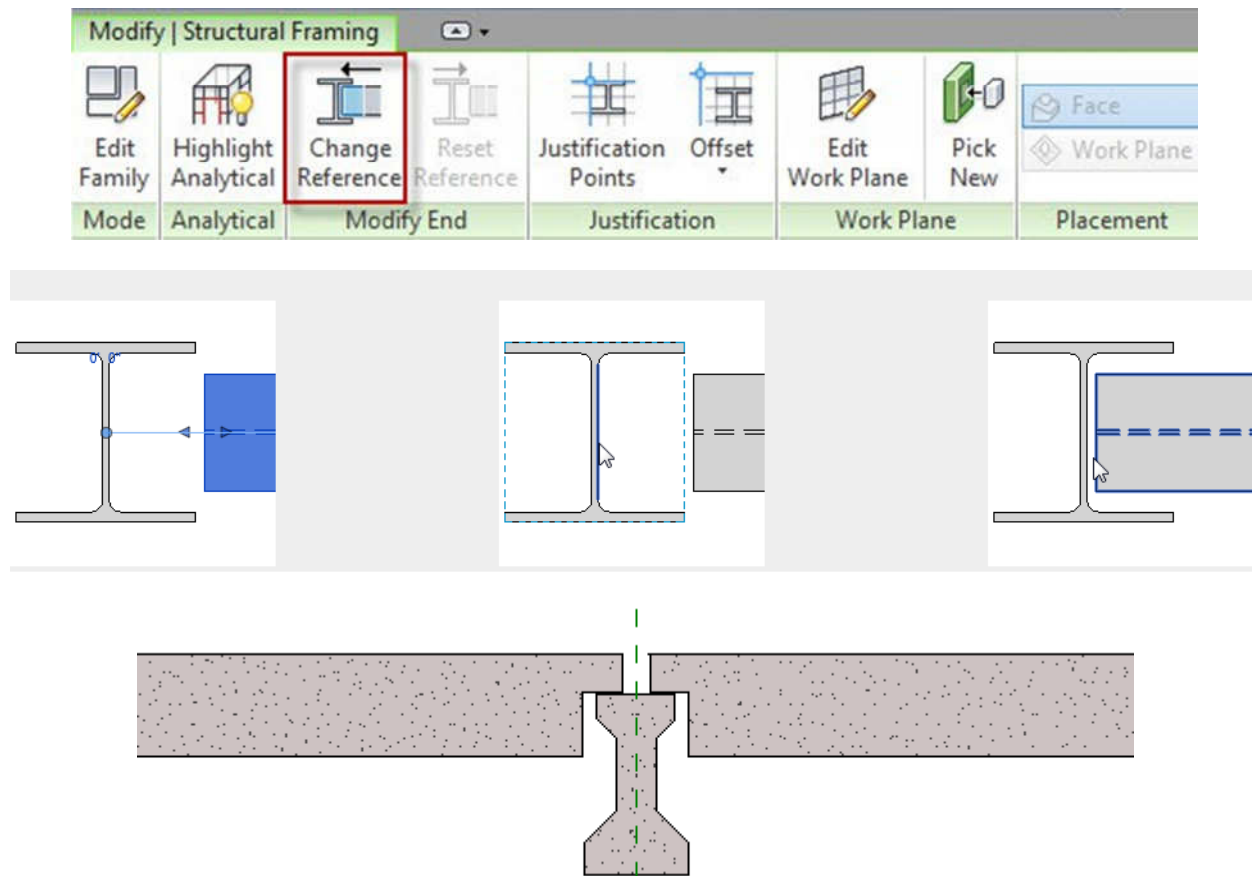
### Structural Framing Enhancements for Precast:

There are a couple of tools **new in Revit 2015** to help with modeling precast framing.

First, there is a new tool to offset the physical geometry of a framing member. Instead of using the offset tool, you can now leave the location line of the member alone (and not mess with analytical settings and deal with Revit trying to snap to centers), and just offset the physical geometry.



Also new in Revit 2015 is the change reference tool, which helps with many typical precast framing conditions, such as a DT sitting on an IT Beam ledge. With this tool, you can now specify where you would like the beam's end reference to acknowledge, such as the face of the ledge of an IT Beam (or the web of a beam in steel construction). This also allows you to still maintain your proper specified cutback distances at the end of the framing.



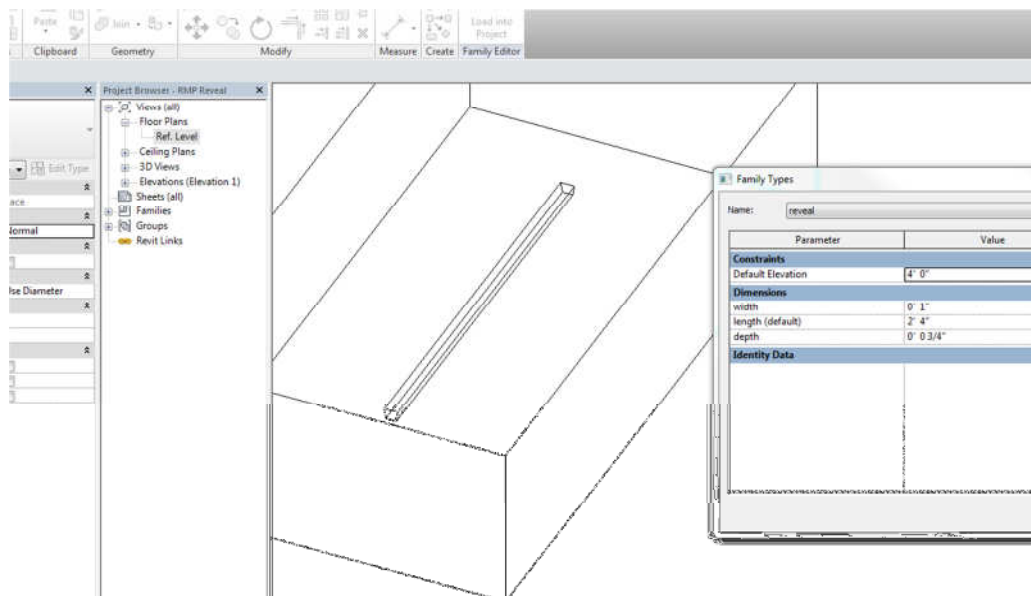
### One-Off Custom Elements:

A big selling point to using precast on any project is the flexibility of the shapes that can be created, especially for architecturally exposed elements. When creating new families of any kind, there is often a desire to make the family as robust as possible and as re-usable as possible. For some shapes, however, the time and effort required to properly create and parameterize complex forms does not justify the likelihood that the family would be re-used. See below for an example of a column family that would be very difficult to define using parameters and extrusions. In cases like these, we typically start a new family with a template and create the form with extrusions, sweeps, voids, etc that are NOT driven by parameters. Yes, these families are 'dumb' and must be re-created for different conditions if they exist, but the time required to create a smart, 'superfamily' is difficult to justify for a family that is unlikely to be re-used. This is very similar to a choice that a precaster may be faced with when fabricating a custom form for this type of element. Does the ability to re-use the form justify the increased cost and effort to create a custom, flexible form or is it better to simply make a one-time, throw away form?



### Reveals in Beams and Columns:

Reveals in Revit are easy to insert into any wall element using Revit's reveal tool. But in precast structures, reveals in beams and columns are very common. Unfortunately, defining where reveals should be located along the length of a beam or column can be very difficult to describe using parameters (see previous section on one-off items). An effective tool to incorporate reveals is a reveal custom family. The family is simply a generic model (face based) with a single void whose geometry is driven by three parameters: width, depth, and length. When inserted into a project, the reveal can be placed on any surface to 'cut' a reveal out of the surface.

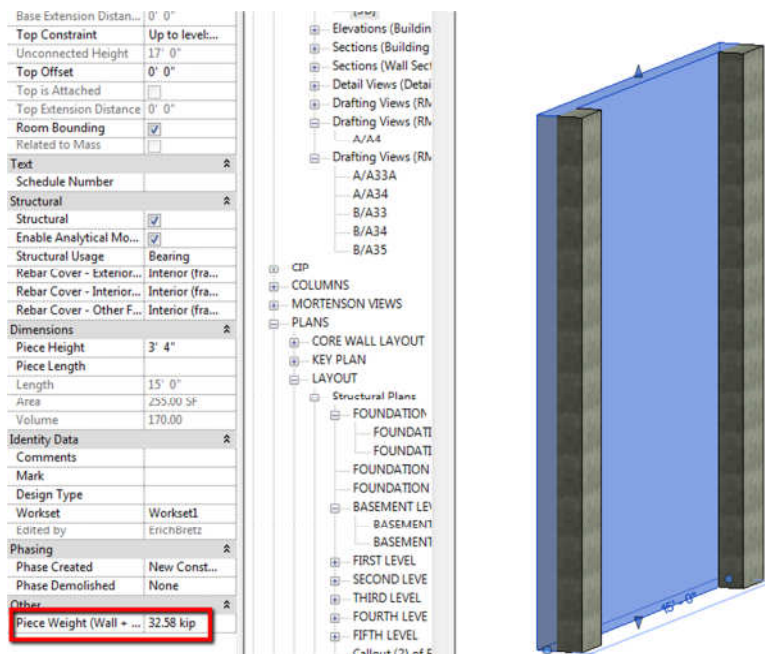


## Daps in Beams and Double Tees:

The dap at the end of a beam or double tees is another item that is difficult to describe parametrically. It is clear right off the bat that a dap is best formed from a void – but is this void best incorporated into the framing family or as a standalone element? Our preference has been to model daps as standalone elements, giving you the flexibility to place and move them quickly within the model. The big advantage here is that a new type is not needed for every instance of a framing element when the dap changes. The creation of a dap family is very similar to the creation of a reveal family. It is easiest to start with a generic model template and insert a single void. The geometry of the void may be driven with parameters if desired. It is important to check the ‘Cuts with Voids When Loaded’ box so the void can properly cut the desired beam geometry.

## Using a Spreadsheet Link to Perform Calculations Outside of Revit:

By now, you probably realize that manipulation of the data in Revit is absolutely critical to the success of your project. It is also true that in precast concrete construction, there are some instances where the shapes that are needed do not fit adequately within the categories that Revit provides. One such example is a precast concrete core wall with pilasters at each end. In Revit, this is likely to be composed of a wall element and two column elements. In reality, this is a single solid piece of precast concrete. However, we need to be able to read the piece weight for the core and pilasters as one element.



There are many spreadsheet links created by third party vendors. For these examples, we will use the CAD Technology Center's 'Revit Express Tools'.

Another example of how we use a spreadsheet link to extract data, we will start with a very simple example where we need to be able to tag the 'Cut Length' data for a 'Structural Framing' element. This parameter is not tag-able in Revit as it comes out-of-the-box. To make it tag-able, we introduce a custom shared parameter (called 'Piece Length'). We will then export the 'Cut Length' data to a spreadsheet, and

then manually assign the data to this new parameter so that it is exactly the same as the 'Cut Length' data. The spreadsheet link essentially acts as a means to 'expose' the data that cannot be turned into a shared parameter and allows you to assign data to other parameters within the family. Note that this could be easily accomplished for a structural framing family using a shared, reporting parameter. However, this does not work for walls because they are system families and custom parameters cannot be added. In that case, using the spreadsheet link is the only option to extract the needed data.

