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# Creating Parametric Families in Autodesk Revit Architecture





## Parametric Families – Conceptual Overview

Families are the heart of the internal data structure of Autodesk Revit. Every object, whether it is a geometric component, an annotation component, a View or any other component in Revit, is part of a Family. Families come in three “flavors”:

- System Families are managed by Revit, and cannot be created or deleted. They typically are not shared between Projects. Views, dimensions, text, etc. all belong to System families, as do geometric objects such as ducts and pipes (anything that would be assembled on the job site).
- Component Families (the focus of this class) can be created and customized, and can be stored in an external library, to be loaded into your Revit project on an “as needed” basis. Examples of Component Families are equipment, fixtures, devices and fittings, as well as custom annotation tags and callouts. When considering geometry, Component Families are objects that might be ordered out of a catalog and installed or placed on the job site.
- In-Place Families represent “one-off” items; custom geometry that is not meant to be re-used or shared between projects.

One of the strengths of component families is that they can be controlled by parameters, which allow for a great deal of flexibility. For example a table family can be created to have several sizes, all based on parameters that can be set by the user, allowing for a single family definition to accommodate several different kinds of tables. Parameters can control more than just sizes and distances, however. They can control materials, visibility states and non-graphical information (such as catalog number, voltage, cost, etc.).

Revit Component Families are a unique file type, with an extension of RFA. To create a family, you begin a new file by selecting File->New->Family from the Revit pull-down menus. After selecting the appropriate family template, you’ll be placed in the Revit Family Editor. The Family Editor looks just like the normal Revit interface, except that it has a different set of ribbons that include all of the tools that you will need to create your family.

## Component Family Creation Process

While each family will vary in complexity and features, the basic process to create a component family will be the same:

1. Select the family template. This is the most important part of creating a family. The template will determine not only the category (and therefore the available default parameters) of the family, but also how it will behave and interact with other Revit components.
2. Plan the major parameters. Parameters are what control any variable values (sizes, materials, informational elements, etc. of the family). In addition to deciding what the parameters need to be, you will also need to consider whether they will need to be used in schedules or tags, and whether they will be type or instance parameters.
3. Create and constrain model geometry. This will entail laying out critical reference planes and constraining geometry with parameters. We will look at this more closely in the “Modeling Tools and Methods” and “Parameters and Constraints” sections of this paper.
4. Assign Object Subcategories if necessary. This will allow you to have independent control of the component in visibility graphics overrides, object styles and material assignments. If necessary, you can create new subcategories within your Revit Family.

5. Set visibility rules. Some geometry may not be appropriate in all views or detail levels. Using the visibility tools in Revit families, you can control when each component will be visible.
6. Create Family Types. Many component families contain multiple type definitions. An example of family types is found with Door families. The door size is defined by type definitions. Family types make it easy to change multiple parameters simply by selecting an overall type definition.

## Family Templates

As stated previously, the most important step in creating a component family is to choose the family template. The template will determine not only which object category the component will be a part of, but also how the family will act when it comes in contact with other components. In some cases you will also need to determine whether a family will be hosted or not, and if so, what type of object will serve as the host. For example, if you are creating a toilet fixture, you can choose from the generic (non-hosted) Plumbing Fixture.rft template or the Plumbing Fixture wall based.rft template. If your fixture is a wall-mounted toilet, then you would choose the wall-based template, meaning that the family can only be placed on a wall. Another example of hosted families can be found with light fixtures. A ceiling-hosted light fixture can only be inserted on a ceiling object. Hosted components will be attached to their hosts, “following” them wherever the host may go.

You should consider carefully which template to use. Once you’ve chosen the template and begun your family, you cannot change it. There are templates provided for virtually every object type, and in some cases multiple templates are provided for a single object type to accommodate a variety of behaviors (see Figure 1).

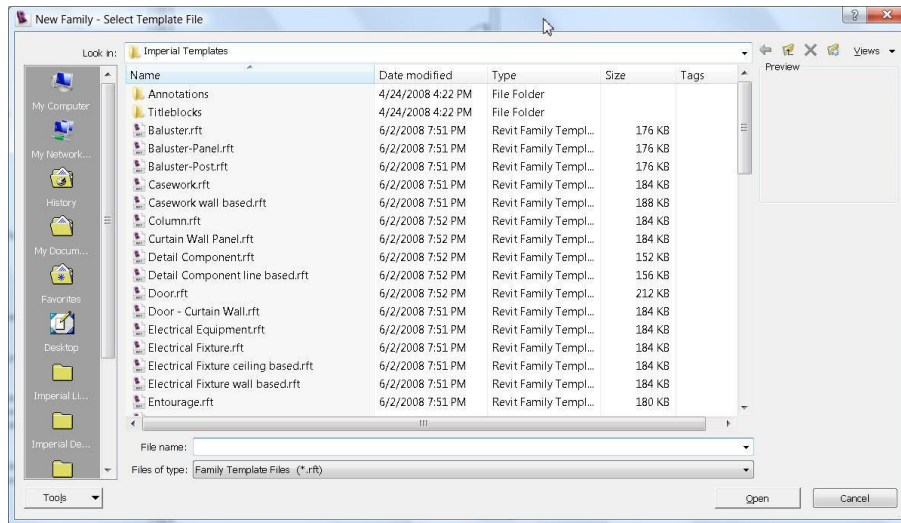


Figure 1: There are several templates provided that will determine not only what the object category will be, but also how the family will behave when placed in a family. Note that there are six family templates provided for lights alone.

There will be times when you can’t find an appropriate template or when one of the provided templates doesn’t quite fit the bill. For example, you may be creating a mechanical equipment family to be hosted in a linked model. You can only host to faces in a linked model, not walls or ceilings. If there is not a face-based template for the specific family type that you’re trying to create you can use a Generic Model template instead (in this case the Generic Model face based.rft template). As soon as you are in the Family Editor, select Settings->Family Category and Parameters and set the family the correct category (see Figure 2).

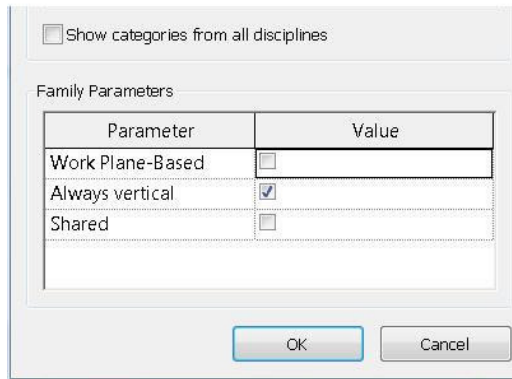


Figure 2: When using a Generic Model family template, it is important to set the Family Category and Parameters.

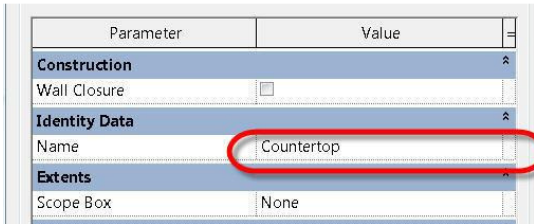
## Modeling Tools

Revit modeling tools can be divided into two main groups: “Helpers” and “Methods”.

A Helper is geometry that in and of itself does not make up the model in the family, but instead can be used to generate the actual model geometry. Typical helpers in Revit Families are:

- Reference Planes – These can be used to constrain Revit Geometry (we’ll explore this in just a bit). Reference Planes can also be used as Work Planes.
- Work Planes – Every component of 3D geometry in a Revit Family is based to some extent on a 2D sketch. The Work Plane is the actual plane that the sketch is created on. Work Planes can be generated from existing faces on 3D geometry, lines that were already drawn using another plane, or from Reference Planes.

Note: In order for a Reference Plane to be used as a Work Plane, you should name it in its element properties, then use the “Name” option from the Work Plane dialog box to select it. (See Figure 3).



Parameter	Value
<b>Construction</b>	
Wall Closure	<input type="checkbox"/>
<b>Identity Data</b>	
Name	Countertop
<b>Extents</b>	
Scope Box	None

Figure 3. When using Reference Planes as Work Planes, you should name them first, to allow them to be selected by name.

A “Method” is a technique used to create model geometry. In Revit there are only five Methods used, and the resulting geometry is either a solid or a void (a void will remove geometry from an existing solid). The five methods used will be the same, whether you are modeling a solid or a void, and whether you are creating an In-Place Family or a Component Family:

- Extrusion – Comprised of a 2D Sketch Profile that is extruded in the Z axis of the Work Plane that the sketch was created in.
- Blend – Consists of a 2D Sketch Profile for the bottom of the shape and a 2D Sketch Profile for the top. The actual 3D shape is extrapolated from the bottom shape, the top shape, and the blend depth.
- Revolve – Created from a 2D Sketch Profile that is revolved around an axis. The revolved shape can be revolved through a complete circle or any fraction of a circle.
- Sweep – Created from a 2D Sketch Profile that is driven along a 2D Sketch Path. Note that the sketch path must exist in a single plane.
- Swept Blend – Created from two 2D Sketch Profiles, one at each end of a 2D Sketch Path. The resulting shape will be interpolated along the path between the two profiles. Like the Sweep Path, the Sketch Path must exist in a single plane.

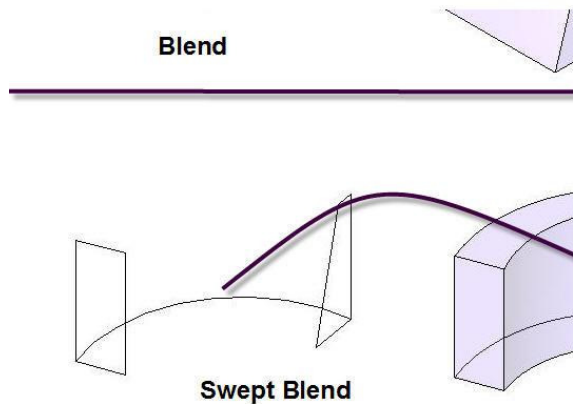


Figure 4. The five methods for creating solid or void geometry in Revit.

## Parameters and Constraints

Parameters are at the heart of a successful Revit Family. While you don't have to make a family parametric, doing so will allow for a single family to be flexible enough to address issues that otherwise may take multiple families to handle. For example, by creating a parameter to control the height of a wall-mounted toilet, you can accommodate both an ADA-compliant toilet's dimensions with those of a standard toilet with a single family definition. In addition to controlling the dimensions of an object, parameters can control visibility and materials, as well as a host of other types of data, including user-defined text properties for scheduling and annotation.

Parameters are typically created in the Family Types Editor (see Figure 5). The Family Types Editor actually has three purposes:

1. Create, manage and modify parameters.
2. Create, manage and modify family types (more on this later)
3. Flex the family (test parameter values against the model geometry).

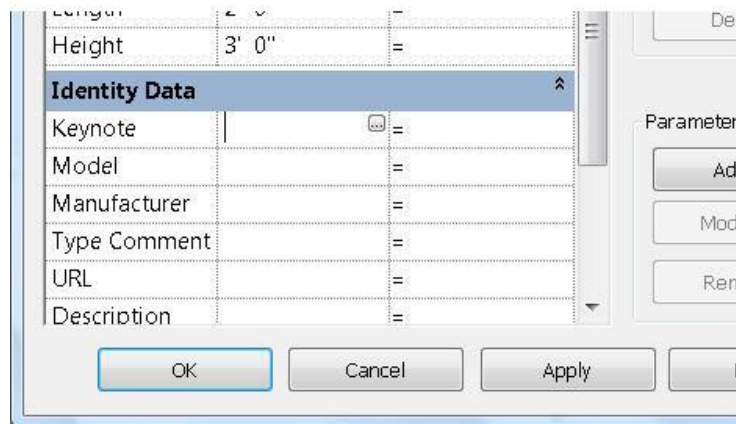


Figure 5. The Family Types Editor.

**Note:** You can also create a parameter “on the fly” by modifying a dimension and choosing to add a new parameter from the “Label” box on the options toolbar. This will create the parameter and link it to the selected dimension at the same time.

When creating a parameter, there are several items that you need to consider carefully:

- Will the parameter need to be reported in a schedule or will it need to be part of an intelligent annotation tag? If so, it will need to be a shared parameter. Shared parameters are stored in an external text file so that they can be accessible to multiple projects (you can edit the shared parameter file from within the Revit Family Editor).
- What type of parameter is it? Length parameters are applied to dimensions. Material parameters can control the material assigned to a piece of model geometry. Yes/No parameters will provide a checkbox (“on/off”) type of parameter, etc. The parameter type is crucial to the behavior of the parameter.
- The parameter discipline will control what types of units are available for the parameter. In the case of an architectural application, virtually all of your parameters could very well be of the “Common” discipline (comprising of units for length, volume, area, etc.), however if you are an MEP engineer, you will need to choose HVAC, Electric, Plumbing, etc. to gain access to unit types for airflow, velocity, friction, voltage, etc.
- Will the parameter be type-based or instance-based? In other words, will the parameter actually define a new type within the family or will it be able to be edited on an element-by-element basis?



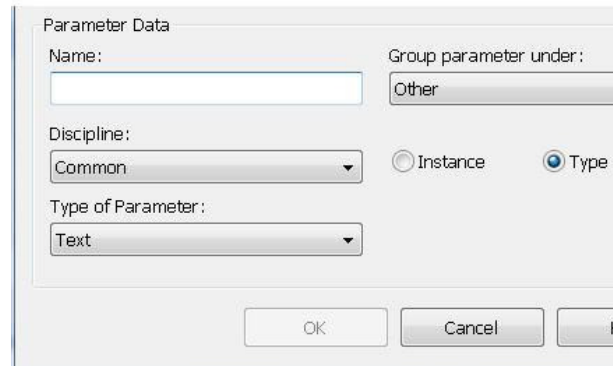


Figure 6. Consider carefully the properties of the parameters that you create.

## Guidelines for Geometric Parameters and Constraints

When using parameters and constraints to control physical geometry, there are some simple but definite do's and don't's:

- When applying a dimension parameter always dimension to reference planes. Never, under any circumstances, should you dimension to an actual piece of geometry or a sketch line if you are going to use a parameter to control the dimension. Doing so will result in a “Constraints not satisfied” error message. After assigning parameter dimensions to your reference planes, you can constrain (lock) the sketch geometry to the reference planes. The dimension parameter will actually control the position of the reference planes, which will in turn control the position of the model geometry.
- When using an equality constraint to make geometry symmetrical about a center line while allowing it to grow or shrink about the centerline with an overall parametric constraint, create the reference planes with the desired symmetry before applying the equality constraint. This will remove any possible ambiguities from the equality constraint and will ensure proper behavior when the family is flexed later on. (See Figure 7).

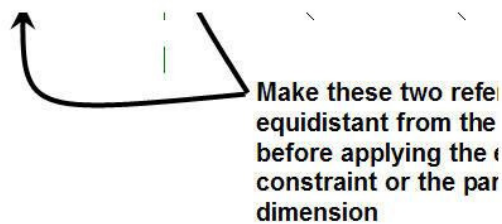


Figure 7. Controlling equality constraint behavior.

- Flex the family often. Each time you apply a new geometric constraint you should test it by flexing the family. It is much easier to fix a problem with conflicting constraints if you know within one or two parameters where the problem may lie. If you wait until you have created and applied four or five parameters before you flex the family and then you have an error, you have a lot more possible conflicts to investigate.

## 3D Model Component Creation Process

A common mistake that users make when creating families is to begin modeling 3D geometry before the “up front” work is done. In the case of a parametric family especially, the actual modeling of extrusions, revolves, blends and sweeps is a small part of the overall process. First, take care to plan, define and test the parameters that you are going to use to control the geometry. Only after you have confirmed that all of the underlying rules and constraints are working and properly configured should you actually create the model geometry.

Combining the modeling tools provided by Revit and the parametric tools and constraints, a typical process for modeling a 3D family object will include the following steps:

1. Define all Reference Planes needed to define the geometry in three dimensions. Provide names for any that may need to be used as Work Planes in the future.
2. Constrain the Reference Planes with dimensions and parameters.
3. Flex the Family to test the behavior of the Reference Planes against the parameters and constraints.
4. Begin the creation of the Solid or Void geometry using either an extrusion, revolve, blend, sweep or swept blend.
5. Check and set the Work Plane for the sketch geometry. It is important to do this first, if for no other reason than to ensure that you’re drawing the sketch where you think you are (see Figure 8). Note that you can also set the current Work Plane at any time by selecting the Work Plane

tool on the “Create” ribbon, and you can display the current Work Plane using the Work Plane Display toggle on the ribbon as well (see Figure 8).

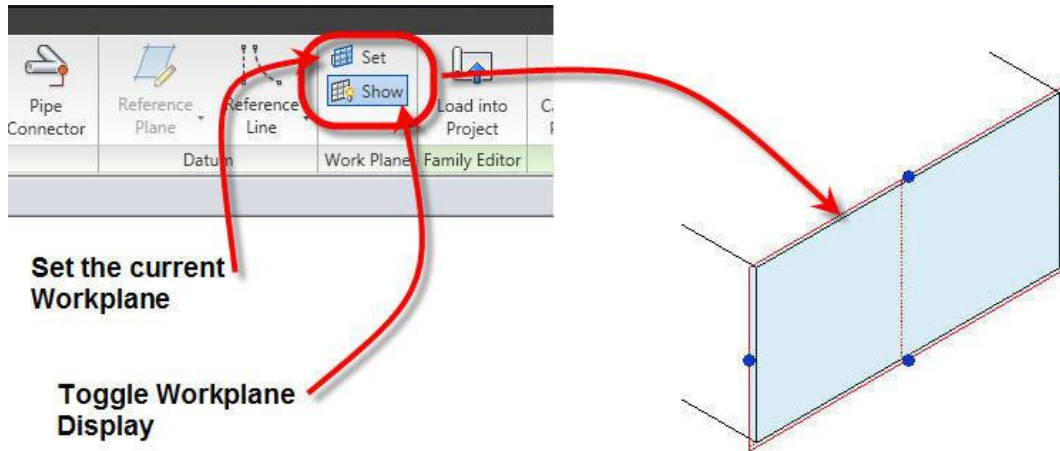


Figure 8. Setting the current Work Plane and toggling display.

6. Create the sketch geometry. Lock the geometry to your reference planes.
7. Set the object’s properties. To do this, do not select the method Properties tool on the ribbon. Technically the object doesn’t exist yet, so selecting the Element Properties tool while in sketch mode will take you to the properties of whatever sketch linework you have selected. Instead, select the method-specific Properties button on the ribbon. Specific properties that you are interested in include the depth (in the case of an extrusion or blend), the material of the object, visibility and sub-category (if necessary). You can also set the properties after the object has been created and you have exited sketch mode. It is also important to note that you can link properties to parameters. For example, if you have created a Yes/No parameter, that parameter can be used to control the Visibility property of the object (see Figure 9).

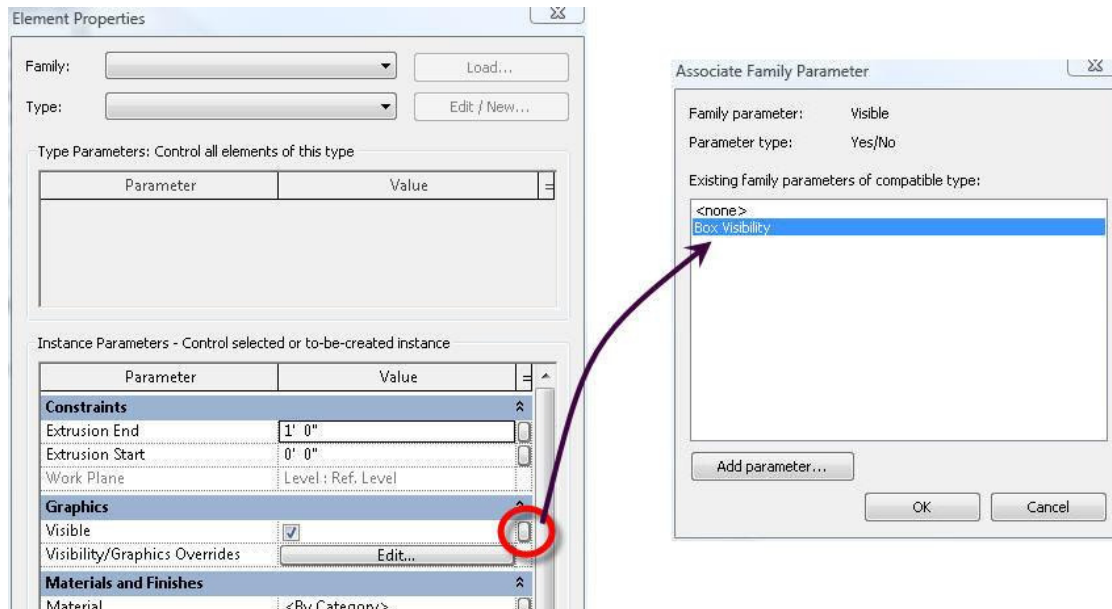


Figure 9. Object properties in families can be linked to parameters of the appropriate type.

8. Finish the Sketch, which will complete the object and apply the 3D properties to the 2D Sketch geometry.
9. Flex the Family, testing both the dimensional constraints and parameters again as well as any parameters that you linked to object properties. If there are any errors, you can either edit the sketch or modify any parameter-based properties to resolve the issue before going on to the next geometric component.

## Detail Component and Annotation Families

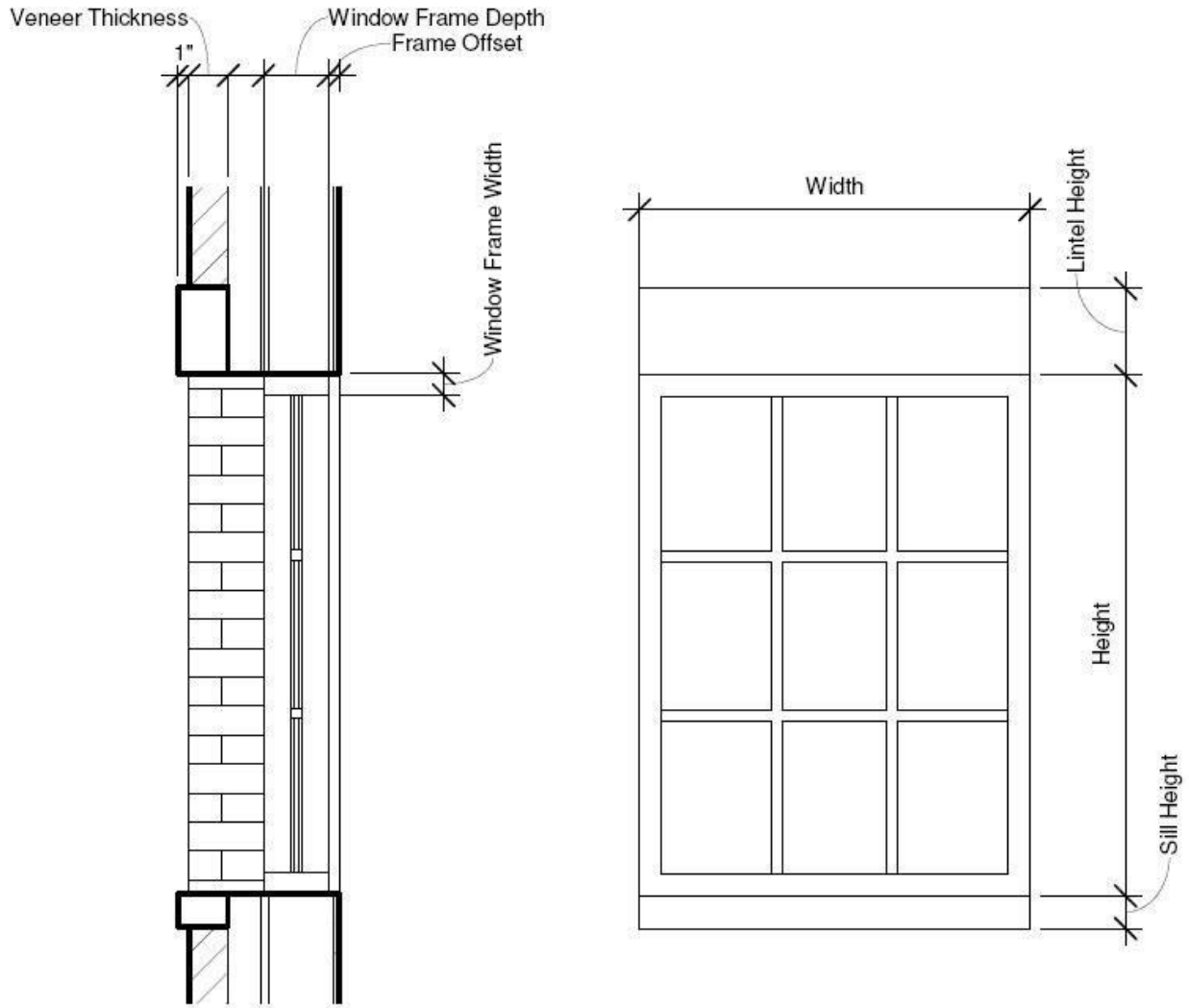
The focus of this document is 3D Model Component Families, however there are other kinds of families in Revit as well, in particular Detail Component and Annotation Families. These are typically very easy to create; if you can successfully create a 3D Model Component Family, then you will have no trouble creating detail components and annotation.

- Detail Component Family creation has a similar overall process to the 3D Model Component Family Creation process outlined on pages 1 and 2. Instead of creating Solids or Voids, however, you will be working with lines, filled regions and masking regions. These can also be parametric if necessary, to control variations in geometry, and the rules for assigning dimensional parameters are the same as in 3D Model Component Families. If you are creating a Detail Component that has an extremely large number of types, you can associate it with a catalog file. This is nothing more than a text file that is formatted to list the parameters and types to allow the user to only load specific types of the family into their project rather than several types at once. An example of a detail component with a catalog can be found in the structural metal framing families that are provided with the default content libraries that ship with Revit. For information on how to format a family catalog, you should refer to the Revit Help Utility.
- Annotation Families are usually even easier still. They typically contain minimal 2D geometry, maybe some text, and most likely a label. The label will link to a parameter of the object type that the annotation tag is meant to be associated with.

## Tutorial

The following tutorial will walk you through the process of creating a parametric window family using the techniques and processes discussed in the previous page. You will create a family for a fixed glass window with muntins, a lintel and a sill. First you will create the physical geometry, providing parametric dimensions to allow for different window sizes, then you will add material parameters and fine tune the display characteristics for different levels of detail. Finally, you will create the various window types and test them in a Revit Architecture project.

# Window Family Tutorial



## Introduction

Using the graphics in the image above, you will create a parametric window following the procedures and methods described in the first part of this document.

## Start the Family

The first and most important step in creating any Family is to choose the proper template. Revit Architecture ships with a variety of templates for the various classes of objects. Take time to carefully consider which template is correct; once you have chosen the template there is no going back. If you decide later that you need a different template, you have to start over with your Family. For your Window it's pretty simple; you need to use a Window template. There are three templates for Window Families – Window.rft, Window with Trim.rft and Window-Curtainwall.rft. Your Window will not have trim and will need to be hosted by a Basic or Stacked wall, so you need to use the Window.rft template:

1. From the Recent Files window under Families, choose New.
2. In the file dialog box, choose the Window.rft file as the template and click Open.

Your screen should look like Figure 10, with a sample wall host and an opening with preliminary parametric dimensions.

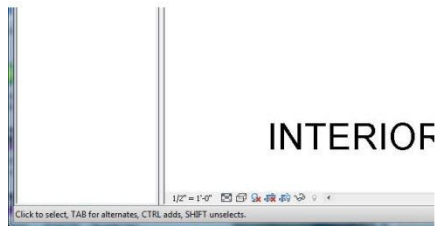


Figure 10. The Window.rft template.

## Create the Model Geometry

The model geometry will be created in five stages:

- The Window opening. There is already an opening in the template, however it will need to be deleted and recreated, for reasons that will explained a bit later in this document.
- The Window Sill and Lintel.
- The Window Frame.
- The Window Muntins.
- The Glass.

### Modeling the Window Opening

Before beginning work, you should make the wall a bit more representative of the type of wall that this Window Family is intended to be hosted by, and remove the existing opening.

1. Pick the Wall, then select Element Properties from the Ribbon. In the Element Properties dialog, click the Edit Type button.

- In the Type Properties dialog, click Edit next to “Structure”.
- In the Edit Assembly dialog, change the Thickness of the single material in the wall to 1'-2" as shown in Figure 11, then click OK until you exit all dialogs.

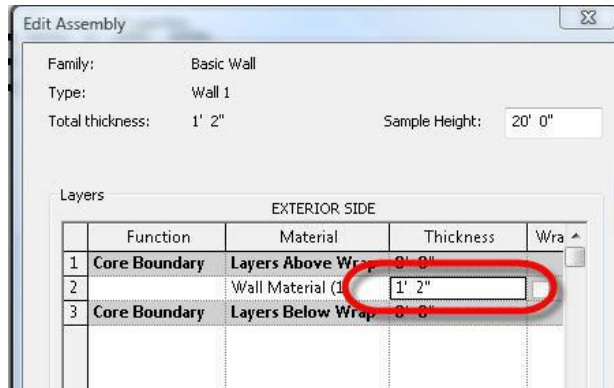


Figure 11. Changing the thickness of the example host Wall.

- Select the opening (it is represented by a line on the interior side of the wall) and delete it.

Note: Openings (not voids) have limitations that make them unusable for this family. First, you can only have one opening per family, and openings cannot exist in same wall host as voids. Since you need an opening for the window as well as an opening to host the Lintel and Sill, the opening will need be created by a void instead.

Normally you would first create all of the Reference Planes that are needed to define the void for the window opening, and then assign them dimensions and parameters. In this template, however, the reference planes defining the opening width and height are already in place and already have parameters assigned to them. For the opening, then, you can immediately begin modeling.

- Navigate to the Ref Level Floorplan View if you're not already there. From the Create ribbon, click the Void tool, then click Extrusion (see Figure 12).

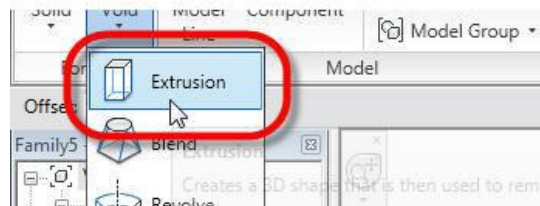


Figure 12. Beginning the opening void.

- Use the Rectangle tool to create the rectangle shown in Figure 13. Make sure and click all four locks to constrain the rectangle to the sides of the wall and the two reference planes.

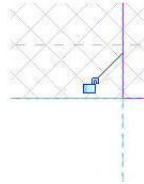


Figure 13. Creating the void rectangle.

7. Click Extrusion Properties from the Ribbon. In the Instance Properties dialog, note first that the Work Plane is set to “Reference Plane: Sill”. This is the bottom of the window opening.
8. Click the small button to the left of the value for “Extrusion End” as shown in Figure 14. This will allow you to link the value to a Parameter.

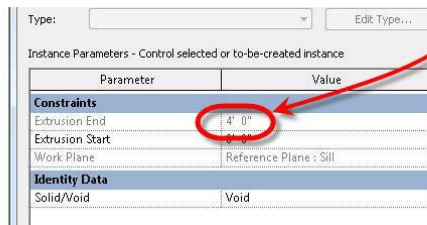


Figure 14. Establishing the height of the opening.

9. Select the “Height” parameter as shown in Figure 14 and click OK. Note the value for “Extrusion End” is now greyed out and set to 4’-0”. It will now be driven by the “Height” parameter of the window.
10. Click OK to exit the dialog.
11. Click Finish Extrusion from the Ribbon to finish defining the opening void.

Now that the void has been created, you can cut the wall with it to recreate the opening for the window.

12. From the Modify ribbon, click the Cut tool (see Figure 15). Pick the void (shown in orange in your graphics window), then click the wall.



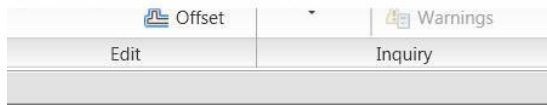


Figure 15. The Cut Geometry tool.

13. Navigate to the View 1 3D View and flex the family again by changing the “Width” and “Height” parameters. Once finished, return the window opening to its original size.
14. Save the file to Window-Fixed with Sill and Lintel.rfa.

### Modeling the Window Sill and Lintel

To create the Sill and Lintel, you first need to create another void in the wall to accommodate them, then create the actual geometry that will represent them. Both the void and the solid geometry can be created from extrusions. Before creating them you should set up the reference planes and parametric dimensions that control them.

1. Navigate to the Ref. Level Floorplan view.
2. From the Create ribbon, click the Reference Plane tool. Draw a Reference Plane from left to right between the wall centerline and the exterior face of the wall. This will be the Work Plane for the extrusions that will form the Sill and the Lintel.

Note: Reference planes have a positive and a negative side, with the positive side being the left side of the Reference Plane. By drawing it left to right, you ensure that the positive side of the Reference Plane is toward the exterior of the wall. This will mean that when you create the extrusions using it as a Work Plane, a positive extrusion depth will cause them to extrude in the correct direction.

3. Click the Modify tool or press <ESCAPE> to stop the Reference Plane tool.

While it is not absolutely necessary to name a Reference Plane that you plan on using as a Work Plane, it’s a good habit to get into, as it makes it easier to select it as the Work Plane when the time comes.

4. Select the Reference Plane you just drew, then click Element Properties from the ribbon. In the Element Properties dialog, enter “Back of Sill and Lintel” in the space next to “Name” and click OK.

The lintel and sill depth will need to be controlled by a parameter to accommodate different conditions. To do this, you will add a dimension and then attach the dimension to a parameter which you will create.

5. From the Detail ribbon panel, click the Aligned dimension tool and place the dimension shown in Figure 16, then click Modify from the ribbon.

Note: Make sure you dimension from the Reference Plane you just created, not the wall centerline Reference Plane, to the face of the wall.



Figure 16. Creating the parametric dimension for the Lintel and Sill depth.

6. Select the dimension you just placed, then from the Options bar, click Add Parameter from the drop down list next to “Label” (see Figure 17.)
7. In the Parameter Properties dialog, leave the Parameter Type set to “Family parameter” (we will look at Family vs. Shared parameters a bit later). Enter “Veneer Thickness” for the Parameter Name, group the parameter under “Dimensions” and click Instance. Make sure your settings match Figure 17 and click OK.

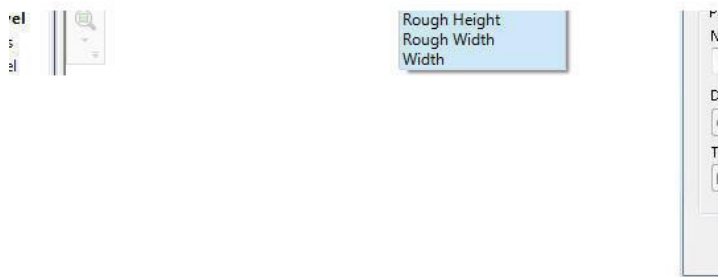


Figure 17. Establishing the “Veneer Thickness” parameter.

8. Flex the Family. To do this, click Types from the Create ribbon. In the Family Types dialog enter a value of 0'-3 5/8" for the Sill and Lintel Depth and click Apply. The Reference Plane that you just dimensioned should move to reflect the new value. Click OK to exit the dialog.
9. Navigate to the Exterior Elevation View
10. Draw the Reference Planes shown in Figure 18.

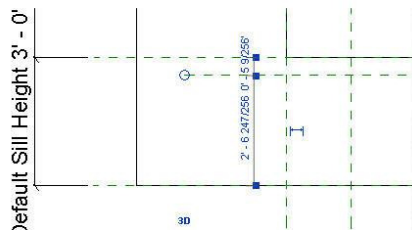


Figure 18. Creating the Reference Planes for the top and bottoms of the sill and lintel.

11. Create the aligned dimensions shown in Figure 19. Again, make sure that you dimension to the Reference Planes and not actual geometry.

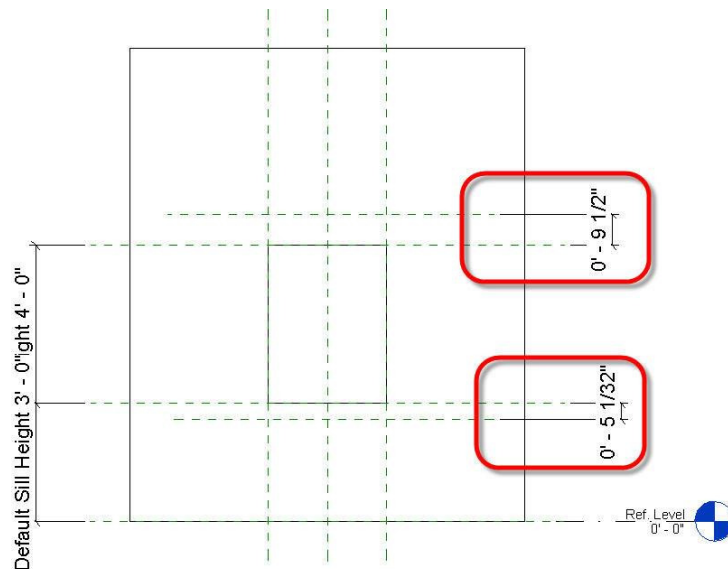


Figure 19. Dimensioning the sill and lintel Reference Planes.

12. Using the same procedure in Steps 6 and 7, assign new parameters “Lintel Height” and “Sill Height” to the top and bottom dimensions respectively.
13. Flex the Family using the Types tool again, this time, assigning a value of 4” to the Sill Height and a value of 8” to the Lintel Height.
14. From the Create ribbon, Click the Void tool, then click Extrusion.
15. Again, from the Create ribbon, click the Set Work Plane tool (see Figure 20). In the Work Plane dialog, choose “Reference Plane: Back of Sill and Lintel” from the drop down list next to “Name” as shown in Figure 20 and click OK.



Figure 20. Setting the Work Plane.

Note: The Set Work Plane tool is only located on the Create ribbon. Since you will frequently have to use this tool when you are on another ribbon, you may want to consider moving it and the Show Work Plane tool to the Quick Access Toolbar to make it easier to get to.

16. From the Create Void Extrusion ribbon, click on the Rectangle tool and create the rectangles shown in Figure 21, making sure to lock all lines to the appropriate Reference Planes so that they will move any time the window width, window height, sill height or lintel height changes.

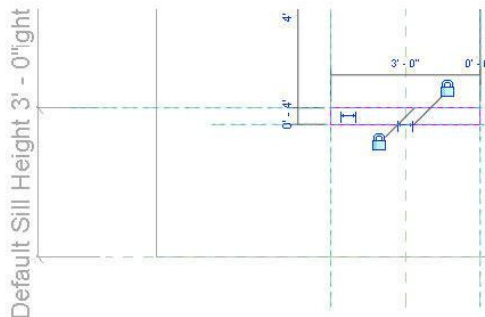


Figure 21. Creating the void sketch.

17. Click Extrusion Properties from the ribbon, then click the small button to the far right of the value for Extrusion End. In the Associate Family Parameter dialog, select the “Veneer Thickness”

parameter and click OK. The Extrusion End property should now be tied to that parameter and should currently show a value of 0'-3 5/8". Click OK to exit the dialog.

18. Click Finish Extrusion from the ribbon.
19. Navigate to the View 1 3D View and spin the view so that you are looking at the exterior side of the wall and you can see the void represented by orange linework (it is not cutting the wall yet).
20. From the Modify ribbon, click the Cut tool, then select the Wall followed by the void. The void for the lintel and sill should now appear in the wall as shown in Figure 22.

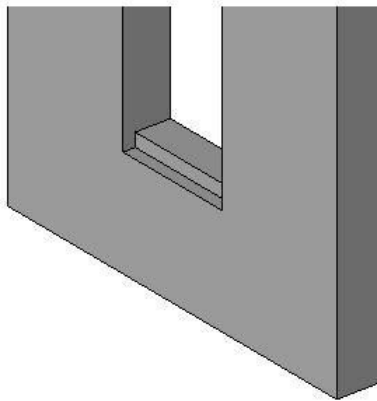


Figure 22. The finished lintel and sill voids.

21. Flex the Family again, making sure to check all parameters that will affect the size of the sill and lintel, either directly or indirectly (this would include the “Width” and “Height” parameters).
22. Save the Family.

Finally, you will model the sill and lintel. You will find that creating a Section view will assist in creating the geometry. You need to create the view before creating the geometry.

23. Navigate to the Ref. Level Floorplan view.
24. Use the Section tool on the View ribbon to create the Section shown in Figure 23. It is important to put the section in the location and orientations shown in the figure for a later step in this tutorial.

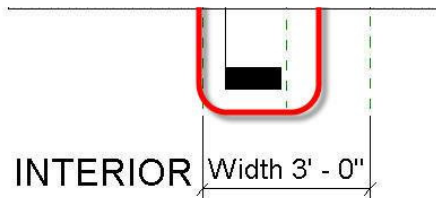


Figure 23. Create a Section view.

25. Navigate to the Exterior Elevation view.
26. From the Create ribbon, click the Solid tool, then click Extrusion.
27. Using the same procedure as that shown in Step 15, make sure your Work Plane is still set to “Back of Sill and Lintel”.
28. Using the same procedure you used to create the void sketch, create the sketch for the sill and lintel, again locking your lines to the appropriate Reference Planes as shown in Figure 21.
29. Click Extrusion Properties from the ribbon. In the Element Properties dialog, set the value for “Extrusion End” to 0’-5” to establish an initial value for now, then click OK.
30. Click Finish Extrusion from the ribbon.

To control the depth of the sill and lintel, you will create a new parameter and use a formula based on the existing “Veneer Thickness” parameter.

31. Click the Types tool from the Create ribbon. In the Family Types dialog box, click Add. Provide a name of “Lintel and Sill Thickness”, group the parameter under Other, make it Instance-based and make it a Length parameter as shown in Figure 24.

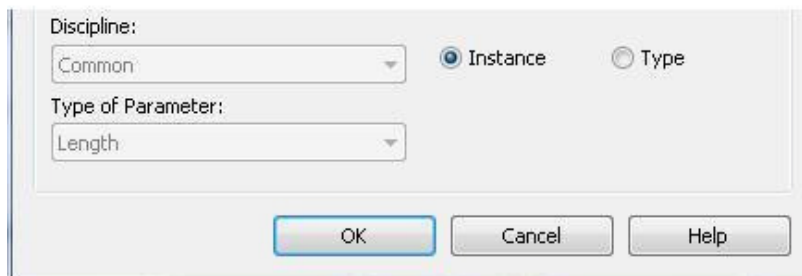


Figure 24. Creating the “Lintel and Sill Thickness” parameter.