



All in the Family: Creating Parametric Parts in Autodesk® Revit® Architecture

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AB204-3 Once you have become comfortable working with Revit Architecture tools, and you understand the general concepts behind model-based design, you'll need to begin developing your own library of custom parametric components. This class will give you a solid background in the critical tools and rules of parametric part design. We'll focus mainly on parametric 3D model families; however, we'll also explore 2D detail and annotation families as well.

About the Speaker:

Having been a registered architect with over 20 years of experience in Autodesk architectural applications, Matt has worked with AutoCAD Architecture since its initial release and Autodesk Revit Architecture since its purchase by Autodesk. Matt is an Autodesk Certified Instructor at an Autodesk Authorized Training Center. In addition to assisting customers in implementing Autodesk Architectural Desktop and Autodesk Revit platform products, he has also consulted with Autodesk development staff in product design and usability for AutoCAD Architecture. He co-authored *Autodesk Architectural Desktop 2007 – An Advanced Implementation Guide (Second Edition)* and has consistently been a highly rated instructor at Autodesk University since he began presenting in 2000.

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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 walls and floors (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).

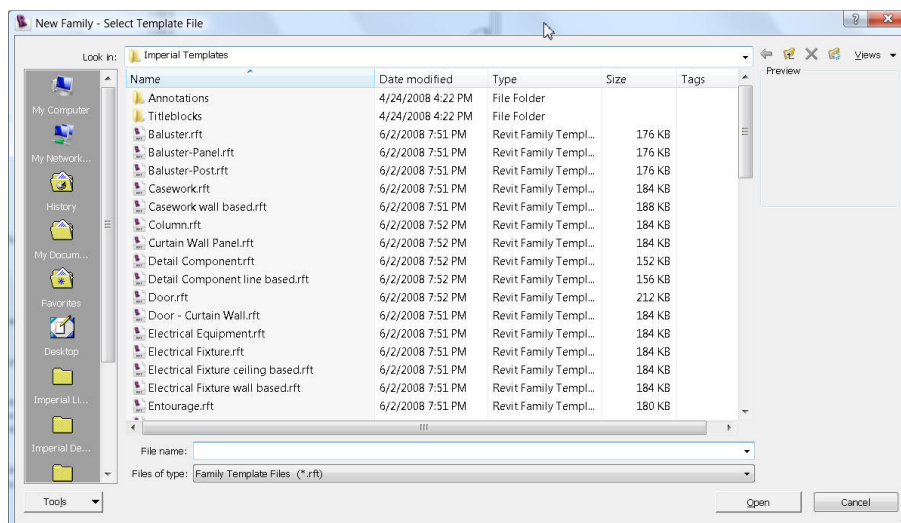


Figure 1: There are several templates provided that will determine not only what the object category will be, but also how the family will behave when placed in a family. Note that there are six family templates provided for lights alone.

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).

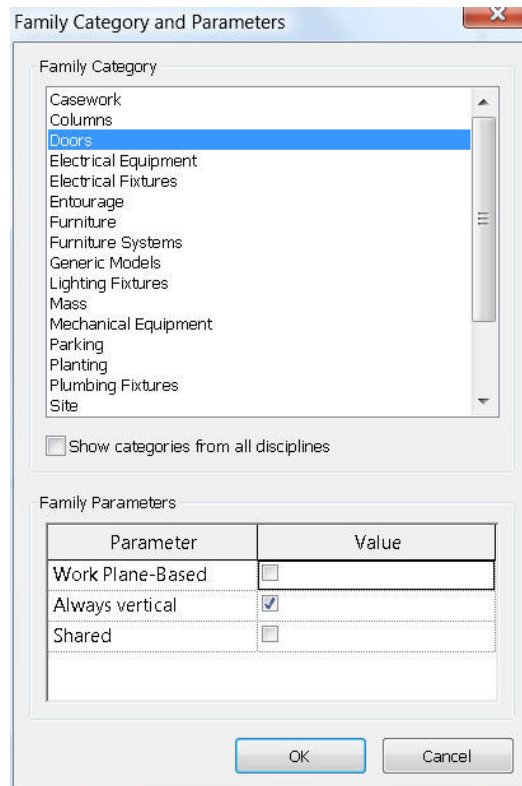


Figure 2: When using a Generic Model family template, it is important to set the Family Category and Parameters.

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).

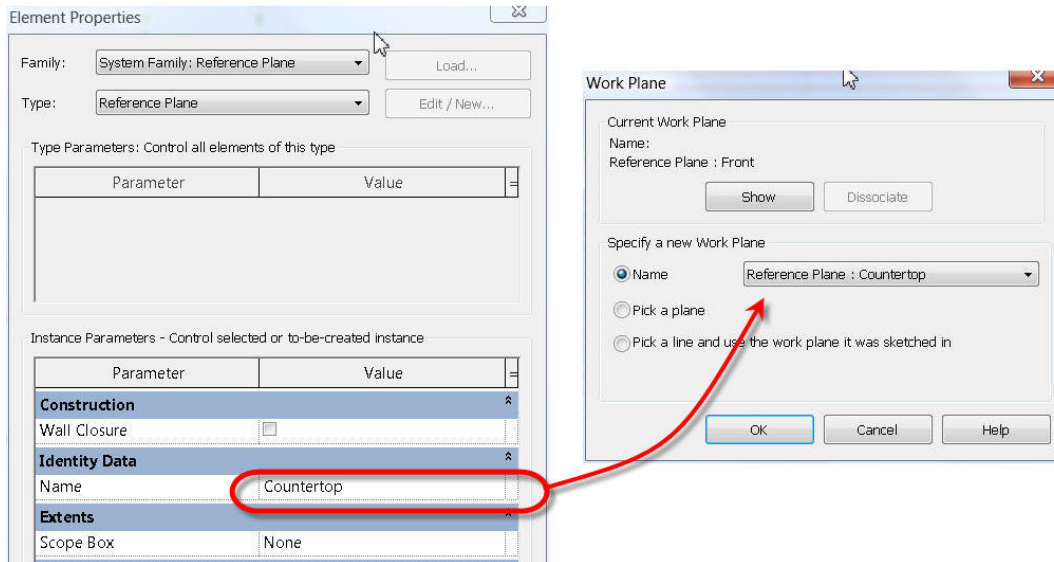


Figure 3. When using Reference Planes as Work Planes, you should name them first, to allow them to be selected by name.

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.

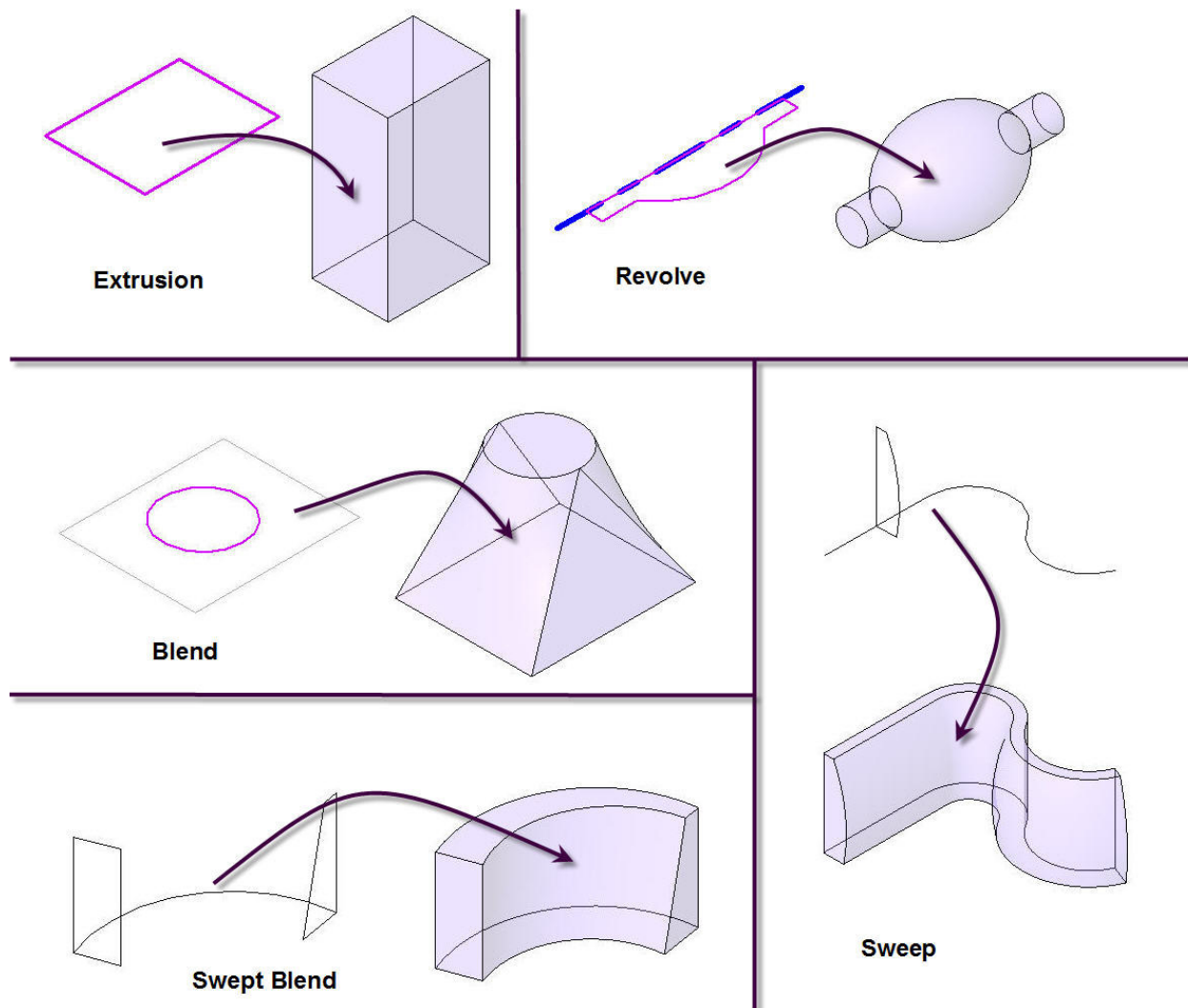


Figure 4. The five methods for creating solid or void geometry in Revit.

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).

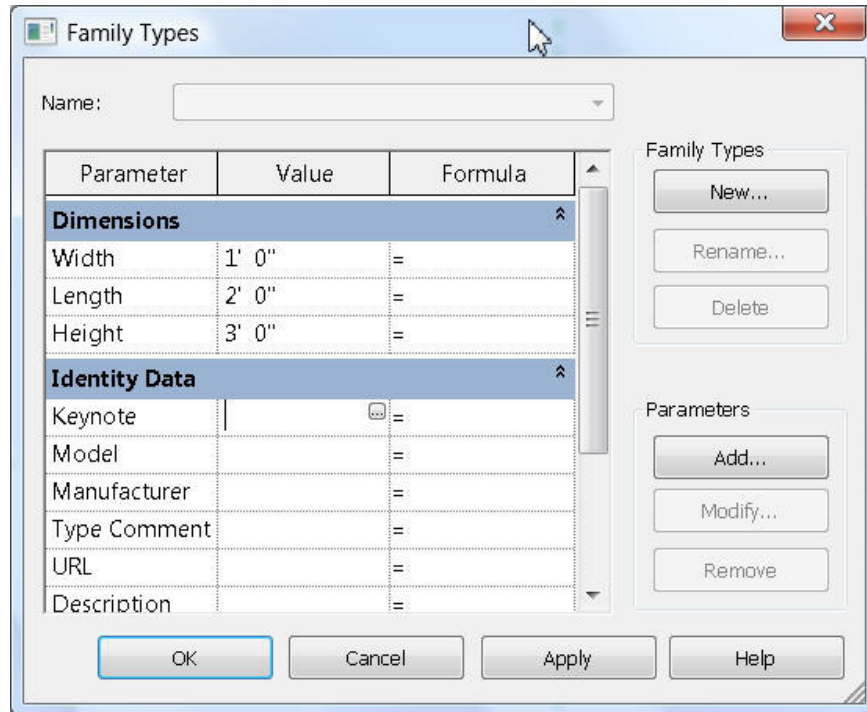


Figure 5. The Family Types Editor.

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?

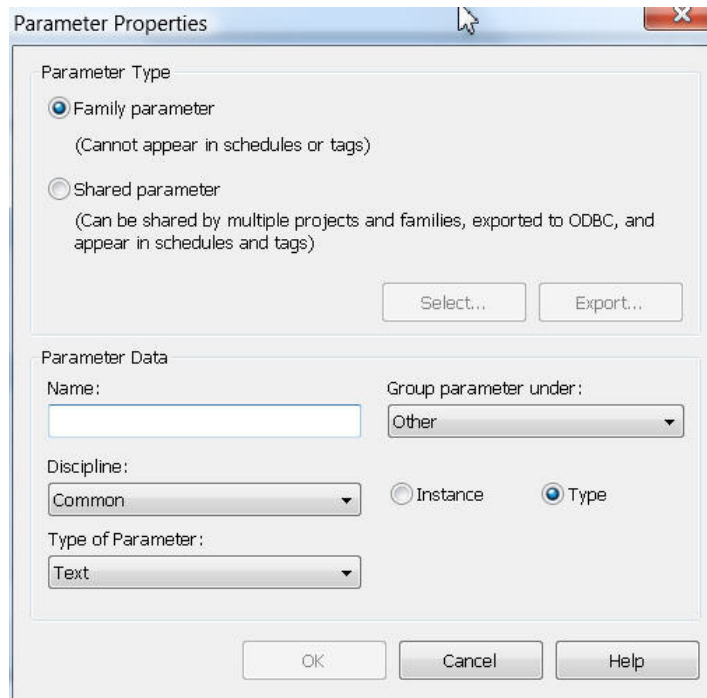


Figure 6. Consider carefully the properties of the parameters that you create.

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).

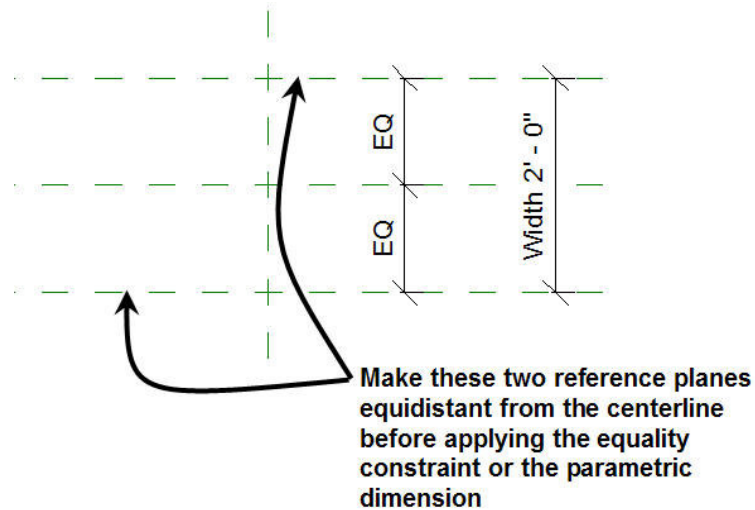


Figure 7. Controlling equality constraint behavior.

- 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).

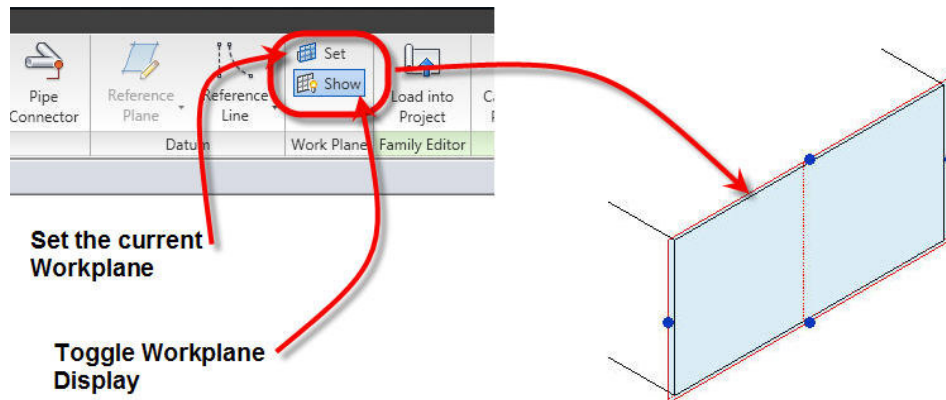


Figure 8. Setting the current Work Plane and toggling display.

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).

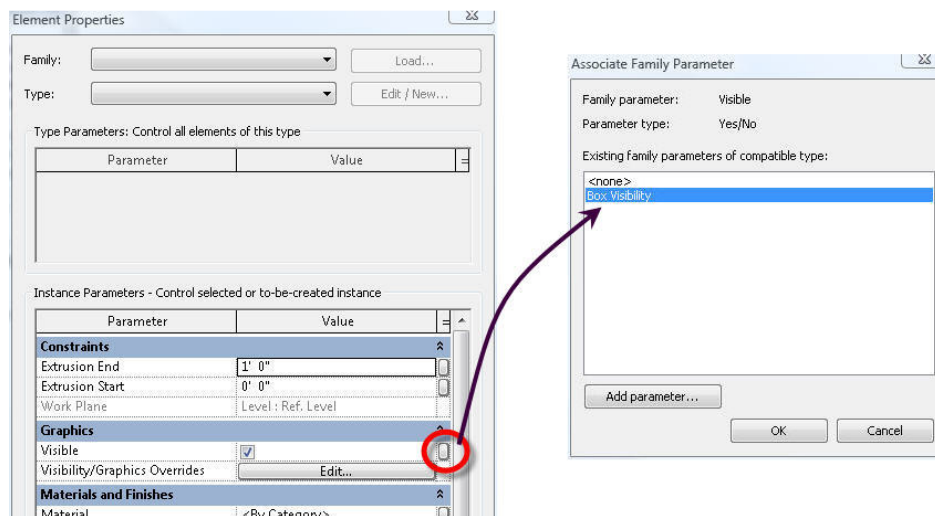


Figure 9. Object properties in families can be linked to parameters of the appropriate type.

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.

Summary

Hopefully this short document and the accompanying 90 minute class provided some insight into the Family Creation process in Revit Architecture. The concepts explained here will apply to Revit MEP and Revit Structure as well. Additionally, you should be armed now with some critical do's and don't's for assigning parameters to geometry.

Remember the Family Creation Process outlined on pages 3 and 4, the Model Geometry creation process outlined on pages 10-12, and the rules for assigning dimensional constraints and parameters explained on pages 8-10. Most importantly, remember to flex the family often to test your work.

There will be an accompanying step-by-step tutorial that will walk you through creating a parametric window family posted to AU Online as supplemental documentation for this class.

If you have never created a Family before, expect to struggle a bit with your first few attempts, but stick with it. The process and nuances will eventually become more familiar to you, and more importantly, the results will be more predictable.