Session 3

Power Points & Power Plays:
Using Adaptive Component points to drive your Revit families

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Class Description

Say goodbye to the old static and non-interactive families that we are used to in Revit and say hello to the new dynamic adaptive components. The adaptive component is the newest type of family to hit the Revit scene. Available since Revit 2011, and updated in each successive Revit version, the adaptive component family has the ability to use “smart points” that could be manipulated and dragged to change parameters or other associations.

The developers created the adaptive component to be smart enough to be nested into other families and to “adapt” as the host family parameters change. Because of the adaptive component’s smart nature its applications are endless. This course will teach attendees how create adaptive components to be intelligent enough so that they could be interacted with by the user or by other families.

This session will take advantage of the divide command and repeater element new in Revit 2013. This course will also cover how to use points to drive rotation parameters by hosting points on circles. This method is called “Ride the Rail Method”

This handout also covers two alternative rotation methods in the “post lab” section that are based on the theory of the ride the rail method. It will not be covered in the lab but it could be practiced after the class is over at home or in the office. The post labs cover two alternative rotation methods that could be applied in the “classic” family editor.
Power Points & Power Plays: Using Adaptive Components Points to Drive Your Revit Families
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About the Speaker:

Marcello is the BIM Director at John A. Martin & Associates Structural Engineers in Los Angeles, CA. He has been using Autodesk products for over 15 years including AutoCAD, 3ds Max, and Revit Structure. He is a member of the ASCE-SEI BIM committee and continually speaks at structural professional conferences across the country. Marcello teaches classes regularly at Autodesk University and the Revit Technology Conference that focus on free form modelling in Revit and alpha/beta tests the yearly releases of Revit Structure. He has worked on many projects that have incorporated complex geometry including the Walt Disney Concert Hall in Los Angeles, CA, the Stata Centre at MIT, and the Tom Bradley International Terminal Expansion at LAX. Marcello received B.S. and M.S. degrees in Civil Engineering. He is also a licensed Civil and Structural Engineer.
Lab Outline

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Introduction

The adaptive component is the newest type of family to hit the Revit scene. Available since Revit 2011, the adaptive component family was mainly intended to be used in curtain wall panels or some other repetitive application. The developers created the adaptive component to be smart enough to be nested into other families and to “adapt” as the host family parameters change. Because of the adaptive component’s smart nature, its applications are endless.

This lab will teach attendees several key aspects, including how to nest the adaptive component family into other families and how to change the host family’s parameter values by simply grabbing and dragging points or by pressing the arrow keys.

Say goodbye to old methods of changing family parameter values by manual entry or using the limiting “shape handles”.

The adaptive component is created in the mass family editor environment and uses a generic family as its basis.
Lab Exercise 1 (Dropped Ceiling)

Figure 1 (Dropped Ceiling Isometric View, Courtesy of P+R Architects, Long Beach)

Figure 2 (Dropped Ceiling RCP View, Courtesy of P+R Architects, Long Beach)
Figure 1B (Final Dropped Ceiling Component Created in Revit)

Divide and Repeat Command

The Divide Command

Divide Path allows the user to simply select and divide lines, arcs, circles, partial ellipses, ellipses, splines, Hermite curves, and edges of forms, in the mass (or adaptive component) environment into any desired number of segments as shown in Figure 3. Dividing an element is nothing new; users have always had the ability to divide a surface into a “grid” since the new massing tools were introduced in Revit 2010. See Figure 4.

Figure 3 (The divided path)
What is new is that the Divide Path command allows you to divide line elements instead of only dividing surface elements; this is the same concept, just expanded on. The divided surface elements and the divided path elements have the same properties, including number of divisions, node visibilities, intersections, and the ability to host other elements at their nodes.

Creating a Divided Path

Creating a divided path is extremely easy! Create any line in the mass family environment, adaptive component environment, or in-place mass environment. Select the “curve” and click on the “Divide Path” command as shown in Figure 5.
A new element will be created called the “divided path” that “hosts” divided nodes along its length. It is important not to get the divided nodes confused with the reference points.

This new divided path element is completely separate from the curve that was used to create the divided path. This is the same concept as the divided surface element being independent of the mass surface that was used to create it.

**Repeat Command**

A repeater is a separate element that is simply a collection of adaptive components that is repeated along a divided path or divided surface. Previously, if the user wanted to create repeating components they would have to copy them manually... not anymore! The repeat command takes the busy work out of copying multiple components.

To create a repeater or to use the repeat command, the user must have a minimum of one divided path or divided surface and one adaptive component with at least one placement point.

First, create a divided curve or curves as shown in Figure 6. Create an adaptive component that is made up of a simple cylinder to represent a column. This adaptive component contains only one placement point. Place or host the adaptive components placement point on the divided path’s node as shown in Figure 6. Select the adaptive component and select the repeat command shown in Figure 7.
Figure 6 (Placing a Component on a Divided Path)

Figure 7 (Repeater Pattern with 1 Component on a Divided Path with Varying Nodes)
Other Possible Combinations to Create a Repeater

Figure 8 shows all possible repeaters that are results from the combination of a simple, single line, 2 placement point adaptive component and divided elements.

![Figure 8 (Repeater Patterns Resulting from 2 Placement Point Adaptive Components)]

Lab Exercise 1

Build Support Geometry for Complex Divided Paths

The complex divided paths in this example are paths that curve in multiple directions. The following steps will show how to create these paths by finding the intersection of solids created from extrusions, using the
boundary lines of the ceiling in plan, shown in Figure 9 and the boundary lines of the ceiling in elevation, shown in Figure 10. This illustrates the divided path line of the near side ‘wave’ in Figure 11. This exercise will use "sacrificial" solids instead of using surfaces, because in Revit if two solids are joined together, then the resulting intersection of those solids creates a new “form edge"; surfaces do not give those results. It is this new form edge that will be used to the divided path. The final divided paths are shown in Figure 12.
1. Open the Supporting File called “EX_1_reflected plan repeater rtc_start.rfa” and go to 3-D view as shown in the Figure Below
2. Click on the nearside surface/face and extrude the face until a solid is created as shown in the Figure below.

![Figure 13](image.png)

Figure 13 (Divided Path Line/Edge of ceiling, nearside, as intersection of surfaces)

3. Join the two solids together and select the new form edge and click on the divide path command as shown in the Figure below.

![Figure 13](image.png)
4. Hide the near side solids and follow steps 2 and 3 to create the far side divided path.

5. Change the number of segments to 58 for both paths as shown in the Figure below. The reason for 58 points is because there will be 58 components evenly spaced along these paths. Also in order for the repeater command to work correctly in this example, each path has to have an equal amount of points.

Create Simple Adaptive Component

Let’s create a simple two placement point adaptive component to apply to the divided path. It is best to create a “line” or simple adaptive component to test. Then apply a solid element to the line. This is recommended because it is easy to troubleshoot any issues that may arise when using the repeater command.

1. To start a new adaptive component go to Revit>New>Family>Generic Model Adaptive.rft
1. Go to plan reference level and draw 2 reference points anywhere and draw a reference spline thru those points. This will act as the path line for the ceiling components.

2. Change 2 points to adaptive component points
   a. Select points Click "make adaptive"
   b. This changes the points from reference points to adaptive placement points. Notice the points are now labelled 1,2
   c. These will act at the “placement points” when inserting this family into the divided path.
3. Save the adaptive component file.
Create Repeater

Let’s now load that simple 2 placement point adaptive component into the divided path and create a repeater.

1. Load Adaptive Component into the project.
   a. Open family with divided paths
   b. Load family into divided path family

2. Place the adaptive component such that point 1 on the near side divided path and point 2 on far side divided path point

3. Place another adaptive component adjacent to the previous placed one.

4. Click on both adaptive components and click the repeater command.

5. WOW! Behold the Repeater!
Create Complex Adaptive Component

Now that the repeater is working correctly let’s create an adaptive component that is representative of the dropped ceiling. It is very important that the following steps are followed when creating the cross sections of the components. If done incorrectly, the components, when repeated, will not function properly.

1. Make a cross section of the pipe.

2. Open or change back to the 3d view of the two point adaptive component.

3. Set the work plane to the point 1 reference plane that is perpendicular to the line and add a circle to point 1 that has a 125mm or 5” radius. Change the circle to a reference line.

4. Repeat the previous step for point 2.

5. Select both circles and select create form
6. Select both adaptive points and change the node orientation to “orthogonal to family”. This is done to keep the cross sections from rotating and the family from “twisting” relative to the divided path nodes.

Update Repeater with Completed Component

Load the completed adaptive component into the family with the divided path and update the repeater!
Modify the Divided Path Geometry

One major advantage of the repeater is, the fact that it’s based on the adaptive component; any changes to the base geometry will change the repeater accordingly. Suppose, the far side divided path needed to be changed to “straight”. Follow the steps below to see results.

1. Unhide the solids and delete the points as shown to “straighten” the far side divided path as shown.

2. The following modifications are shown below.

![Diagram showing modifications to the divided path geometry](image-url)
Lab Exercise 2 – Create Roof Framing

Now that you have the basics down for the adaptive components and you know how to make a repeater that extends from one divided path to another divided path, let’s now examine how to apply an adaptive component on a divided surface to create a quick roof framing mesh. We will also cover how to and use the shape handle point to change geometry.

Create the Divided Surface

1. Create the guide surface
   
   a. Revit>Open> EX_2_ROOF_GEOMETRY_FAMILY_START.rfa
   
   b. Notice that the adaptive component family only contains splines and reference points that define these splines as well as four columns to support the roof framing.
2. Click on four splines and click “create form, the resulting surface is created.
3. Select all the 32 points and click “make adaptive”. These points will later be used to change the geometry via mouse drag!

4. Select the newly created surface and click “divide surface” and change the u and v divide amount to 12.

5. In order to place the adaptive component onto the divided surface, we must turn on the nodes on the surface by selecting the surface and clicking on the “surface representation” button. Click on the “node” button. This will display the surface nodes. These divided surface nodes are the same nodes used in the divided path element.
Create a 13 point adaptive component (pipe beams)

Just like in the previous exercise, it is very important that the ensuing steps are followed when creating the cross sections of the components. If done incorrectly, the components, when repeated, will not function properly.

1. To start a new adaptive component go to Revit>New>Family>Generic Model Adaptive.rft

2. Go to plan reference level and draw 13 reference points in a single line and draw a reference spline thru those points. This will act as the path line for the beam components.
3. Change all 13 points to adaptive component points
   a. Select points Click “make adaptive”
   b. This changes the points from reference points to adaptive placement points.
   c. These will act at the “placement points” when inserting this family into the divided path.

4. Set the work plane to the point 1 reference plane that is perpendicular to the line and add a circle to point 1 that has a 125mm or 5" radius. Change the circle to a reference line.

5. Repeat the previous step for point 13.

6. Select both circles and select create form

7. Select both adaptive points and change the node orientation to “orthogonal to family”. This is done to keep the cross sections from rotating and the family from “twisting” relative to the divided path nodes.

8. Save the adaptive component
Create Repeater on Divided Surface

Let us now load and place the 13 point adaptive component on a divided surface and use the repeater command to populate all the beam locations.

1. Open and load the 13 point family into the roof family

2. Place the all 13 points of the adaptive pipe component on the divided surface in the U direction as shown.

3. Repeat for the V direction as shown.

4. Click on both adaptive components and click the repeater command.

5. WOW! Behold the Repeater on a divided surface!
Flexing the shape handle points with mouse drag in the project environment

Now that we have seen how to create a repeater on a divided surface, let's modify the geometry of the roof component by loading it into a project environment. Instead of deleting or moving nodes within the family itself to modify the geometry, as we did in the previous exercise, let's take advantage of the smart nature of the adaptive component and do it differently for this exercise.

1. Load the adaptive roof surface family into the project environment and place it on level 1.

2. Experiment changing the geometry by simple mouse drag.
a. Carefully select one of the shape handle nodes and move it up in elevation. See how the repeater framing, and the divided surface all automatically update.

b. These nodes could also be “re-hosted” to other project elements.

c. In this exercise, build a column approximately at the centre of the roof and that starts at level 1 and is just tall enough to reach above the roof framing.

d. Next carefully select one of the shape handle nodes in roughly the same location and click “re-host”

e. Drag the node to the top of the column.

f. Adjust the height of the column.

g. See how the roof framing automatically updates with the new hosted column top?!
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Lab Exercise 1 – Ride the Rail Method

History

As shown above in the rotation rig, the Ride the Rail method does not use the angular dimension to control the angle of the hosting reference line. It uses the power of the reference point to “ride” the “rail” of the circle or curve to control the angle.
Example and Description

I built this construction lift family to help understand how a virtual lift would “fit” inside of a particular building. This lift was built per manufacture specifications. When I originally built this family, I did not invent the “Ride the Rail” method yet so all 18 or so rotation rigs are built off of the traditional rotation method. I thought it would be good to change the “base” rotation rig into a Ride the Rail rig. This is what exercise 1 will cover.
Creating the Base Rotation Rig within the lift family

1. Open the file “EX_1_LIFT_BOTTOM_START.RFA"

2. Isolate the Reference line in top down view as shown

3. Set the work plane of the isolated reference line

4. Create a reference circle at the end of the isolated ref line

5. Place two points anywhere on the circle
6. Change the measurement type to “angle” in the properties for both points.

7. Set the following parameters to the first point “RIDE THE RAIL.”

8. Set the following parameters to the first point “RIDE THE RAIL PLUS 180.”

9. Select both points and click “spline thru points” and change new line to “reference line” (this is the new hosting reference line).

10. Congratulations! The Ride the Rail rotation rig is complete.

Note: even though this method was applied to a complex family it could be used to rotation anything within the adaptive component/mass editor family environment.
11. Set the Horizontal work plane of the new reference line.

12. Place the nested lift family “TOP.RFA” as work plane based at the middle of the reference line.

13. Map the nested lift family parameters to the host family as shown above.
14. Flex and enjoy. Take this family with you and practice! What other rotation angles could be applied to this Ride the Rail rig?
Post Lab Exercise 1 Open Reference Circle Method

History

I realized that the whole concept of ride the rail method was based not on the point but the reference plane of the point. I then made the
connection…open up the circle and host the reference line on the reference plane at the end of the open reference circle.

From this, I created the “Open Reference Circle” rotation method as shown in the rotation rig above and notice that it uses the arc angle of the open circle to control the angle NOT the angle parameter.

OPEN REFERENCE CIRCLE METHOD "ORC"
Example and Description

Below is a step by step process on how to create the Open Reference Circle rig to control rotation for a door family in Revit. Above is the example Door family at different angles that are hosted on a wall element in the project environment that is using the Open Reference Circle rotation rig.
Creating the Rotation Rig within the door family
1. First start a new door family from the default family template in Revit. Go to the reference plan view.
2. Create a reference circle whose centre is set away from the centre of rotation.
3. Turn on the centre of the circle mark. Developers please turn it on by default.

4. Align and lock the centre of the circle mark to the horizontal reference plane.
5. Align and lock the centre of the circle mark to the vertical reference plane.
Note that in the step above the circle centre was placed away from the centre of rotation so that it would be easy to confirm that it was aligned in the correct location.

6. Split the circle with the split tool
7. Delete the portion of the circle to create
8. Align and lock the tail end of the open circle to the horizontal axis.

9. Select the open circle.

   Note that when the open circle/arc is selected a interesting element pops up that is not available anywhere else in Revit.....the **arc degree dimension**! It is this phenomenon that I took advantage of in order for the Open Reference Circle method to work.

   Select the arc angle dimension and make it permanent

   Please note that the arc angle is **NOT** the arc length
As shown above, do not get the arc angle and arc length confused. They are two completely different dimensions. The difference is that the arc angle is able to be converted to a parameter that is CHANGEABLE. In contrast to the arch length, the arch length is a reporting parameter only, meaning it is only able to “show” the length value and not able to be changed.
10. Create two angle parameters

11. Create an angle parameter called “INPUT_ANGLE”. This will be used as the input angle, what is traditionally used to define how “open” a door is. I like to use the arc angle to control the back side of the angle instead of the front because it is easier to work with.

12. Create another angle parameter called “ANGLE_180_FIX” it is the true arc angle.

13. Give it a formula = 180 - INPUT_ANGLE

14. Assign the “ANGLE_180_FIX” parameter to the arc angle parameter
15. Make the radius of the open circle a permanent dimension. This is done to further constrain the open circle. It is also very critical that it is done at this step and not any other time.

16. Set the work plane to the end of the open circle, this is done so that the reference line that will host the door geometry is placed at the correct plane.
17. Draw a reference line on the set work plane from the open circle end to the centre of rotation of the open circle.

18. Congratulations! The Open Reference Circle rotation rig is now complete.
19. Set the reference plane of the host reference line to receive the door geometry, create the door geometry on the hosting reference line. How to create the door geometry will not be covered in this posting however, it is very simple to perform.

Note: The door family was covered here however; this method is applicable to host any geometry, in any family, in any environment.
Post Lab Exercise 2 Revolve Method

History

The Open Reference Circle method as shown in the previous exercise will not work when the value of the arc angle is zero because it is not allowed to have a zero length. However, if the length were to never change then the problem would be solved.

It was this fundamental concept that had me realize that the Revolve element (which is one of the four forms that could be created in the classic family editor) could have a constant angle value and have its start and end angles move together. This would allow the arc angle to never be zero. As shown above the end of the revolve element could be defined as a work plane similar to the point on Ride the Rail method and the reference plane on the Open Reference Circle method.
From this, I created the “Revolve” rotation method as shown in the rotation rig above and notice that it uses the preset revolve form parameters of the start and end angles to control the angle NOT the angle parameter. Basically it is the Open Reference Circle method with the revolve element swapped out for the reference arc. This way, the revolve element could be a constant arc length/angle and the end angle is “chasing” its start angle. This is not possible with the reference arc element in the Open Reference Circle method and that is why a revolve element is used because it is not plagued with the limitation of having the arc angle value break when it has a zero value.
Example and Description

Above is the example Door family at different angles that are hosted on a wall element in the project environment that is using the Open Reference Circle rotation rig. Any angle is now possible. Below is a step by step process on how to create the Revolve rig to control a door family in Revit.
1. First start a new door family from the default family template in Revit. Go to the reference plan view.
2. Set the reference plane to exterior. This will host the revolve profile.
3. Create a rectangular profile where the top of the profile is at the floor line.

4. Select the revolve axis line as the vertical reference plane that intersects the centre of rotation. Click ok when done and the revolve element will be created.

5. Click on the revolve element and make it “not” visible. This will make the revolve element not visible in the project environment.

Note: this element could be left as “visible” and be changed to look like a door handle instead of how the revolve element looks in this example.
6. Create two angle parameters
7. Create an angle parameter called “INPUT” This will be used as the input angle, what is traditionally used to define how “open” a door is. I like to use the end angle to control the back side of the angle instead of the front because it is easier to work with
8. Create another angle parameter called “START” and give it the formula as shown above
9. Create another angle parameter called “END” and give it the formula as shown above.
10. Assign the “START” and “END” parameter to the start and end preset parameters of the revolve element respectfully.
11. Go to the top down 3d view and set the work plane to the end of the revolve element, this is done so that the reference line that will host the door geometry is placed at the correct plane.
12. Create a reference line by picking the face of the end of the revolve element.

13. Congratulations! The Revolve rotation rig is now complete.
14. Set the reference plane of the host reference line to receive the door geometry, create the door geometry on the hosting reference line.

15. The door geometry will not be covered in this posting however; it is very simple to perform.

16. MAKE IT A DOOR KNOB

Note: The door family was covered here however; this method is applicable to host any geometry, in any classic family editor.
Final words

This lab was intended to show what potential the adaptive component has to the attendees and not cover every type of possible application. Now that Revit allows repeaters and smart points that could be hosted the possibilities are endless to what this could be used for. It’s time to get creative! Good luck.

These post labs were intended to offer “alternatives” to traditional rotation rig modelling methods in Revit and provide the general theory behind these new methods by applying these new methods on sample families. However, the theory is what is important and you may need a different application of these new methods at the work place since every project and family is unique. I encourage everyone to practice these new methods, understand the underlying theories, decide if they are a viable alternative for your situation and apply them accordingly.