Geometry Tools: Auto Warping

Programmed Result of Tool:

This tool will take a grouping of Spot Elevations that a user has placed on a given work plane and create a loop by which the elements within that loop will be warped. The endpoints of each warpable element within the loop are then determined and the warp is calculated, displaying the warp to the user.

To facilitate warping of embeds, CIP, and erection material, two new parameters will need to be utilized: IS_WARPABLE_SHAPE and AUTOWARP_DISPLACEMENT (see the section below titled "Direct Shape Creation and Displacements" for more details). Upon running Auto Warping, any Specialty Equipment or Generic Model elements that have IS_WARPABLE_SHAPE toggled on will have a direct shape (belonging to the Entourage category) created for them. This direct shape is representative of where that element would be positioned in the warped state. Additionally, an AUTO_WARP_DISPLACEMENT value will be written to all top level Specialty Equipment and Generic Model families. This value represents the offset that the element would need from its current position to be placed properly in the warped state. This parameter could be used within host families to automate the movement of embeds (ex. spandrel plates that would be used to connect to a warped double tee). For more details, see the section below titled "Adding Offset Parameter to Families".

Steps to Perform Tool Operation:

The tool takes pre-placed spot elevation families for use as the basis for creating the warp.

1. User must place the SPOT_ELEVATION family at each "corner" or at each change in slope to create the warping loops. See the section below titled "Spot Elevation Placement" for more details.
2. The user must toggle on AUTO_WARPING_CREATE_DIRECT_SHAPES in the Project Information if they would like direct shapes to get created. If the user does not wish to have direct shapes created, then this parameter should be toggled off, and the user should skip step 3 below.
3. The user toggles on IS_WARPABLE_SHAPE for any Specialty Equipment or Generic Model elements that they want direct shapes to be made for. This can either be built into the families or set at the project level.
4. Run the Auto-Warping tool and choose if you want it to process the whole model, active view, or selected spot elevations.
5. All warpable Structural Framing elements and elements that have IS_WARPABLE_SHAPE checked and are contained within the warping loop(s) will be processed.

Result: For warpable Structural Framing elements, the appropriate warp and offset values will be written to the following parameters if they exist for that family: Manual_Mark_End_Offset, Manual_Opp_End_Offset, Manual_Mark_End_Warp_Angle, Manual_Opp_End_Warp_Angle, Vertical_Offset_MarkEnd, and/or Vertical_Offset_OppEnd. For Specialty Equipment and Generic Model elements that had IS_WARPABLE_SHAPE checked, a direct shape will be created for them and a value will be assigned to the AUTO_WARP_DISPLACEMENT parameter.

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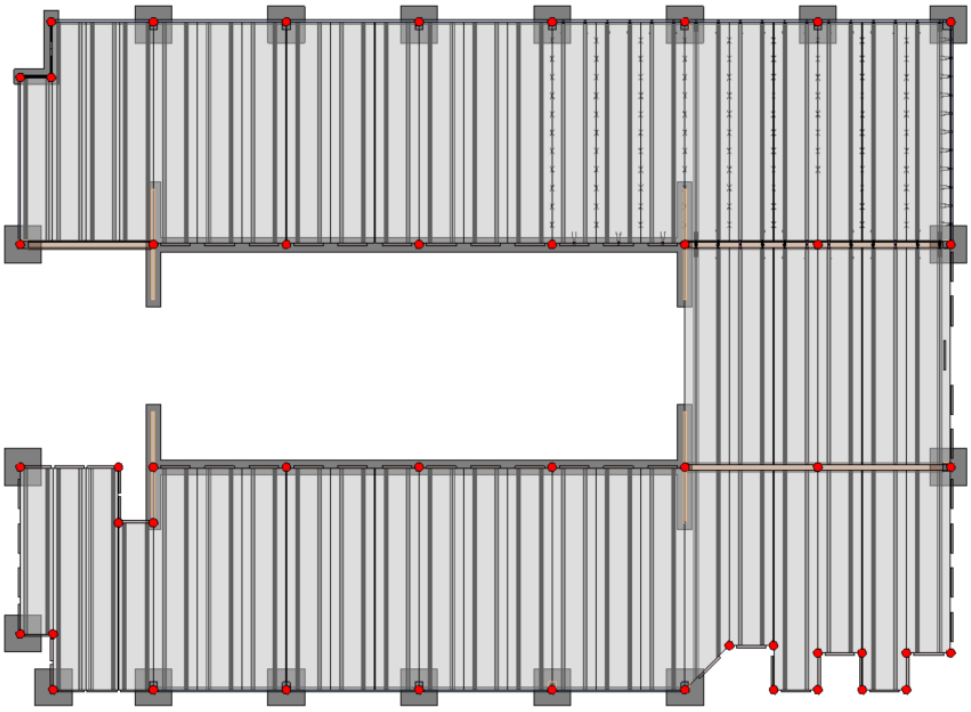
Spot Elevation Placement:

- The Auto Warping tool works by checking for SPOT_ELEVATIONS that are hosted to levels or reference planes.
- The Offset parameter for each SPOT_ELEVATION must be adjusted to define the warp.
- SPOT_ELEVATIONS must be placed at each corner of the structure and at each change in slope along an edge in order to define the warping loops. See the image below for an example. In this scenario, a SPOT_ELEVATION would need to be placed at each of the red dots for Auto Warping to process it appropriately.
- If the slope along any warping edge changes then a new warping loop must be defined with additional SPOT_ELEVATIONS.
- For each work plane/reference plane in the project, all spot elevations on that level are processed and checked if a warping edge loop can be created from those spot elevations.
- User placed SPOT_ELEVATIONS will define “warping loops”. Each individual warping loop must be linear in order to be successfully warped. If a loop is found to be non-linear along the length and width of the double tees within the loop, then that loop will be rejected and will not be warped.
- When placing SPOT_ELEVATIONS, here are a few things to keep in mind:
    - Make sure the SPOT_ELEVATIONS are hosted to levels or reference planes and are not hosted to a face.
    - The SPOT_ELEVATIONS you place must be able to create a closed warping loop, so difficulties may arise with more abstract placements of SPOT_ELEVATIONS.
    - The algorithm works best if the points are placed adjacent to the edges of a piece.
    - Make sure appropriate SPOT_ELEVATIONS are colinear or aligned to one another.
- Multiple warping loops can be created per reference level/work plane if the warping shape(s) can be detected.
- Smaller loops are prioritized over larger loops.



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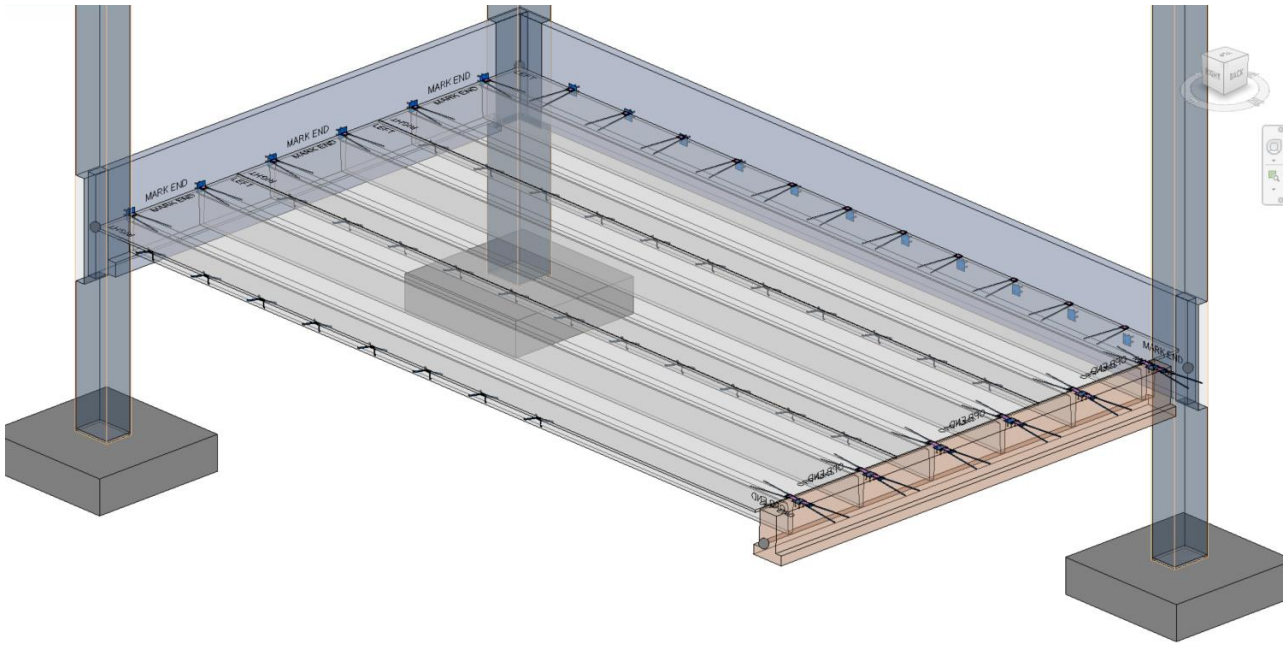
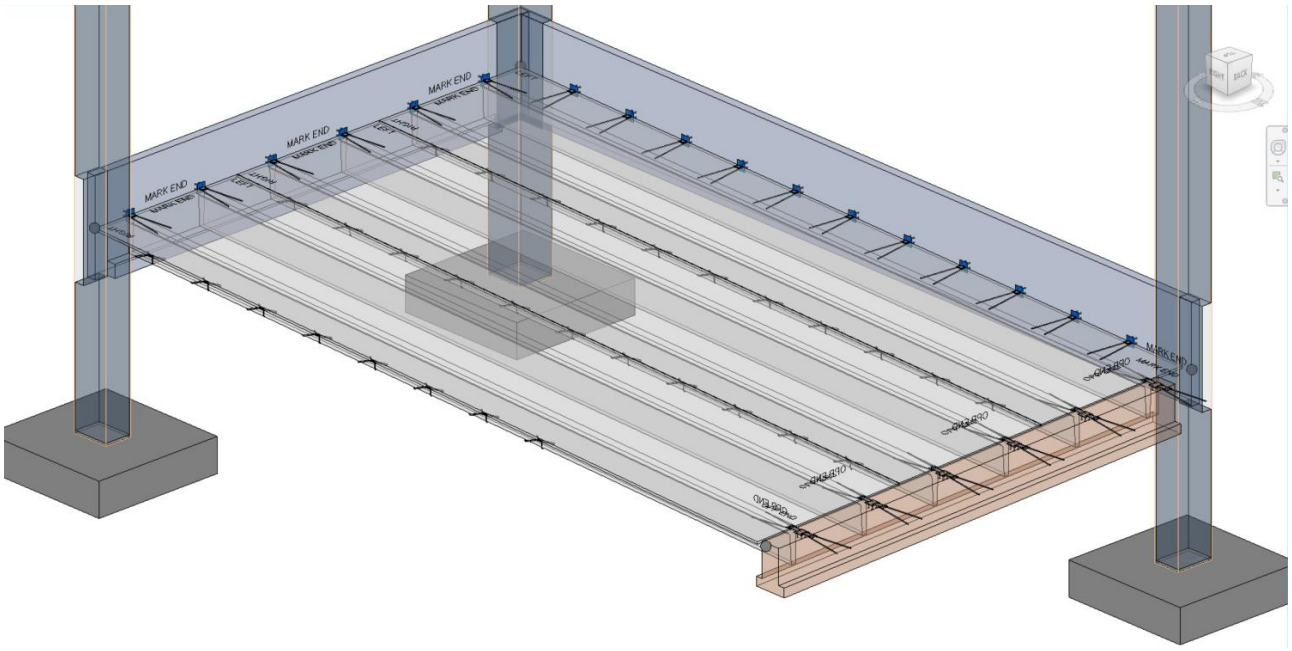
Visibility of Warped and Flat Elements:

- First, Project Shared Parameters must be run on the project to add the WARPED_ELEMENTS and ENTOURAGE filters to the project.
- The visibility of warped Structural Framing elements and direct shapes can then be turned on and off with the Warped toggle.
- The visibility of flat Structural Framing elements and elements eligible for direct shape creation that have IS_WARPABLE_SHAPE checked can be controlled with the Flat toggle.

Flat State After Running Auto Warping:



Warped State After Running Auto Warping:



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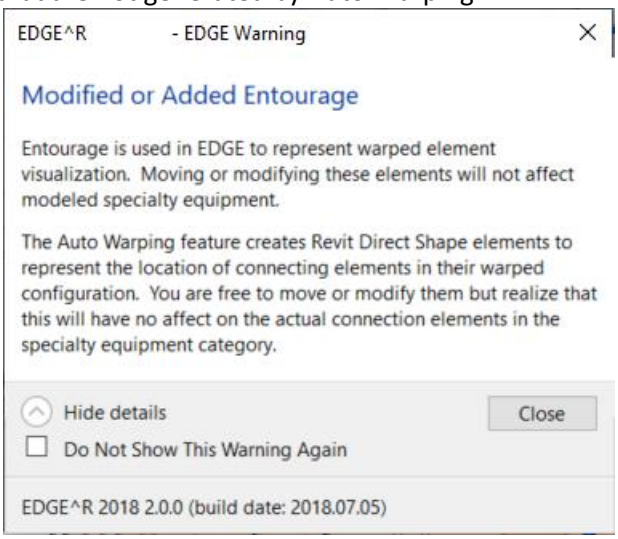
Direct Shape Creation and Displacements:

- AUTO_WARPING_CREATE_DIRECT_SHAPES in the Project Information must be toggled on for any direct shapes to be created when Auto Warping is run. If it is toggled off then no direct shapes will be created when Auto Warping is run; however, AUTO_WARP_DISPLACEMENT values will still be assigned to relevant elements.
- Since direct shapes have actual geometry, as the quantity of direct shapes in the model increases model performance will be impacted.
- Direct Shapes are not processed or taken into consideration for Mark Verification, Assembly Creation, BOM Product Hosting, or Construction Product Hosting.
- Only Specialty Equipment or Generic Model elements that have a MANUFACTURE_COMPONENT that contains EMBED, ERECTION, or CIP are eligible to have direct shapes created for them.
- If an EMBED, CIP, or ERECTION element has a shared family nested into it that has a MANUFACTURE_COMPONENT that contains RAW CONSUMABLE, then the raw consumable families will be combined with their host to create a single solid for the direct shape.
- The following elements will be excluded entirely from the Auto Warping process and direct shapes will not be created for them regardless of if they have IS_WARPABLE_SHAPE checked or not. They also will not get a value assigned for AUTO_WARP_DISPLACEMENT.
    - If the element's MANUFACTURE_COMPONENT contains: REBAR, CGRID, SPIRAL REINFORCING, SHEARGRID, STRAND, REBAR ASSEMBLY, LIFTING, MESH, VOID, WOOD NAILER, SHEAR GRID, WWF, INSULATION, GROUT
    - If the element's Family Name contains: LIFT, SPOT_ELEVATION, CENTROID, CONNECTOR_COMPONENT, PILASTER, CORNICE, SOLID_ZONE_RECTANGULAR, SOLID_ZONE_TAPERED, BRICK, PERLITE
- All top level Specialty Equipment or Generic Model families (excluding those called out directly about) will get a value assigned for AUTO_WARP_DISPLACEMENT regardless of if it has IS_WARPABLE_SHAPE toggled on or not.
- If a top level family has IS_WARPABLE_SHAPE toggled on, then that will be transferred down to all eligible nested families that do not have the IS_WARPABLE_SHAPE parameter built into the family itself when Auto Warping is run.
- If an element that belongs to the Entourage category is modified in any way (moved, deleted, added, etc.), then the warning below will be displayed. This applies to all Entourage category elements; even those that are not generated by Auto Warping.



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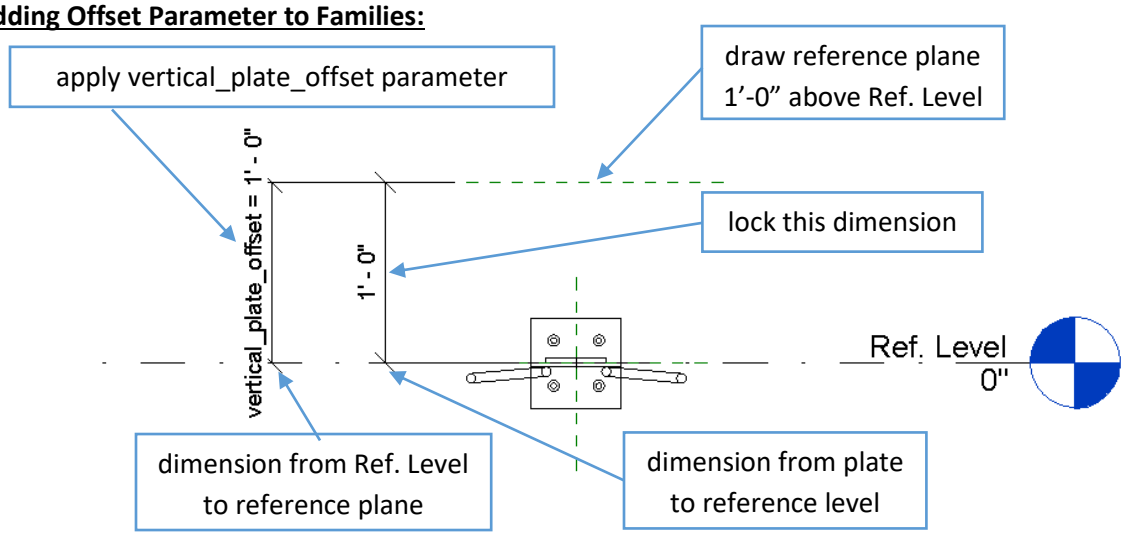
Adding Offset Parameter to Families:



Instructions:

1. Open the family
2. Create the parameters needed below
3. In your project browser click on "Elevation Right"
4. Draw a Reference Plane (in the create tab) the maximum amount of displacement the plate would ever need to be above the Ref. Level (1'-0" in this example)
5. Dimension from the plate to the reference plane and lock the dimension (1'-0")
6. Dimension from the Ref. Level to the reference plane and apply the vertical_plate_offset parameter

Parameters Needed:

1. Parameter Name: vertical_plate_offset
   Parameter Type: Family parameter (helper parameter)
   Discipline: Common
   Type of Parameter: Length
   Group Parameter Under: Other
   Instance

2. Parameter Name: AUTO_WARP_DISPLACEMENT
   Parameter Type: Shared parameter (This is an EDGE parameter. You will not need to create it from scratch.)
   Discipline: Common
   Type of Parameter: Length
   Group Parameter Under: Other
   Instance

*After you create these parameters you will need to add a formula to the helper parameter. In the Formula field for vertical_plate_offset, type the following: AUTO_WARP_DISPLACEMENT + 1'

Other		
finish_check (default)	0	=if(FINISH_GALVANIZED, 1, (if(FINISH
vertical_plate_offset (default)	1' 0"	=AUTO_WARP_DISPLACEMENT + 1'

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Known Limitations:

- All elements that are to be processed by Auto Warping must be plan based. Meaning that the families must be built such that when they are placed in the model, you must be in a plan view to place them in the appropriate orientation. Vertically placed elements are not supported for Auto Warping and results may not be accurate for such elements.
- The user must run Project Shared Parameters on the project prior to running Auto Warping for the first time for all features to function properly.
- Model In-Place shapes are not eligible for Auto Warping. Direct shapes will not be created for them regardless of if they have IS_WARPABLE_SHAPE checked or not.
- As the model gets larger and more complex, Auto Warping will require more time to process the model.
- If an element has had “Flip Work Plane” performed, then the Auto Warping results for that element may not be accurate.
- A warping loop within another warping loop is not supported by Auto Warping. The transaction will be cancelled after warning the user of this error. The user would need to place more SPOT_ELEVATIONS, thereby creating several smaller warping loops which would allow Auto Warping to run successfully on the model.
- If a loop is found to be non-linear along the length and width of the double tees within the loop, then that particular loop will be rejected and will not be warped.
- Auto Warping only warps structural framing elements with the following CONSTRUCTION_PRODUCT values: DOUBLE TEE, TGIRGER, LGIRDER, RBEAM, HOLLOW CORE, or FLAT SLAB.