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A Story-Time Fairy Tale: Case Studies on Designing Theme Parks with BIM

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Learning Objectives

- Understand what challenges come with adopting BIM for unconventional projects
- Learn how to use multiple BIM platforms to synergistically overcome performance issues
- Learn how to capitalize on BIM for large unconventional projects
- Learn what best practices exist for managing complex geometry

Description

BIM (Building Information Modeling) is great for large commercial projects with conventional geometry, but what about modeling an architectural Mayan ruins site that's been excavated, or modeling themed columns with adjacent rockwork, or pulling quantities for a mountain? These are some of the challenges we faced when considering Revit software for our theme park projects. Come and listen as we share the good, the bad, and the ugly of our lessons learned when taking on these unconventional projects, and how we overcame the problems. This is the story of a firm's quest to design a Mayan theme park in Revit, and how that firm used Revit to set in motion best practices for all its subsequent theme park projects.

Speaker

Bill Allen is CEO, and President of EvolveLAB, Disrupt Repeat, and On Point Scans. These firms synergistically help Architects, Engineers, and Contractors optimize the built environment. He has over 14 years of experience managing technology for buildings in the AEC industry for cutting edge firms. Bill has experience lecturing on staff as a College Instructor for the University of Nebraska Omaha and regularly speaks at such conferences as Autodesk University, the Central States BIM Workshop, as well as is a keynote speaker for firms implementing change. Bill served on the BIM Board of Omaha, Central States Revit Workshop Board, and the board of the Rocky Mountain Building Information Society.

Precursor – The Introduction

It was a sunny day in Boulder Colorado. I had just started my own BIM Consulting practice 6 months prior, and I was invited into to talk to DTJ Design in Boulder, Colorado, an integrated Architectural and Landscape Design firm known for having incredible creativity and progressive project types.

I was sitting in a conference room at a table with a group of project managers, architects, and designers listening to them tell me that they wanted to move from 2D AutoCAD to Building Information Modeling. They recognized many of their competitors had already made the switch to Revit, and they wanted to know if it made sense for their practice to do so too.

I remember being very confident and was thinking of course. I would help them build out their template, Revit families, and schedules as I had done many times before for other clients. Then one of the project managers told me we have a desire to move to Revit, but we'd like to try the software on a pilot project first. Of course, I thought. We had done this many times before. Leverage your super users, pilot a project, and then implement the process for the rest of the firm.

Then they pulled out multiple hard copy sets and began to show me their project portfolio of buildings shaped like cupcakes, mid-evil castles, and water slides coming in and out of caves made to look like the amazon jungle. "These are the type of projects we work on. Do you think you are capable of modeling these projects with Revit?" Inside I became nervous, unsure, and self-doubting. I was unsure of my ability to deliver what the project manager was asking, but before I could stop the words coming out of my mouth, I said of course!

Next, he began to show me the project they were getting ready to start. A Mayan themed water park. Columns sculpted to look like deities, cabanas with straw roofs, and signage made to look like snakes. "This is the pilot project we would like you to help us with." As I thumbed through the sketches, I became even more unsure of my ability to deliver this project in Revit. If I said I couldn't do it, what did that mean for my consultancy? Had a found a client with a project too complex for my computational design and BIM consulting company? I reluctantly said "Yes! Let's do it. It sounds like a fun challenge!"

Chapter 1 – The Mayan Theme Park

Chongqing was a theme park with a unique set of challenges, including 420 acres of theme park attractions

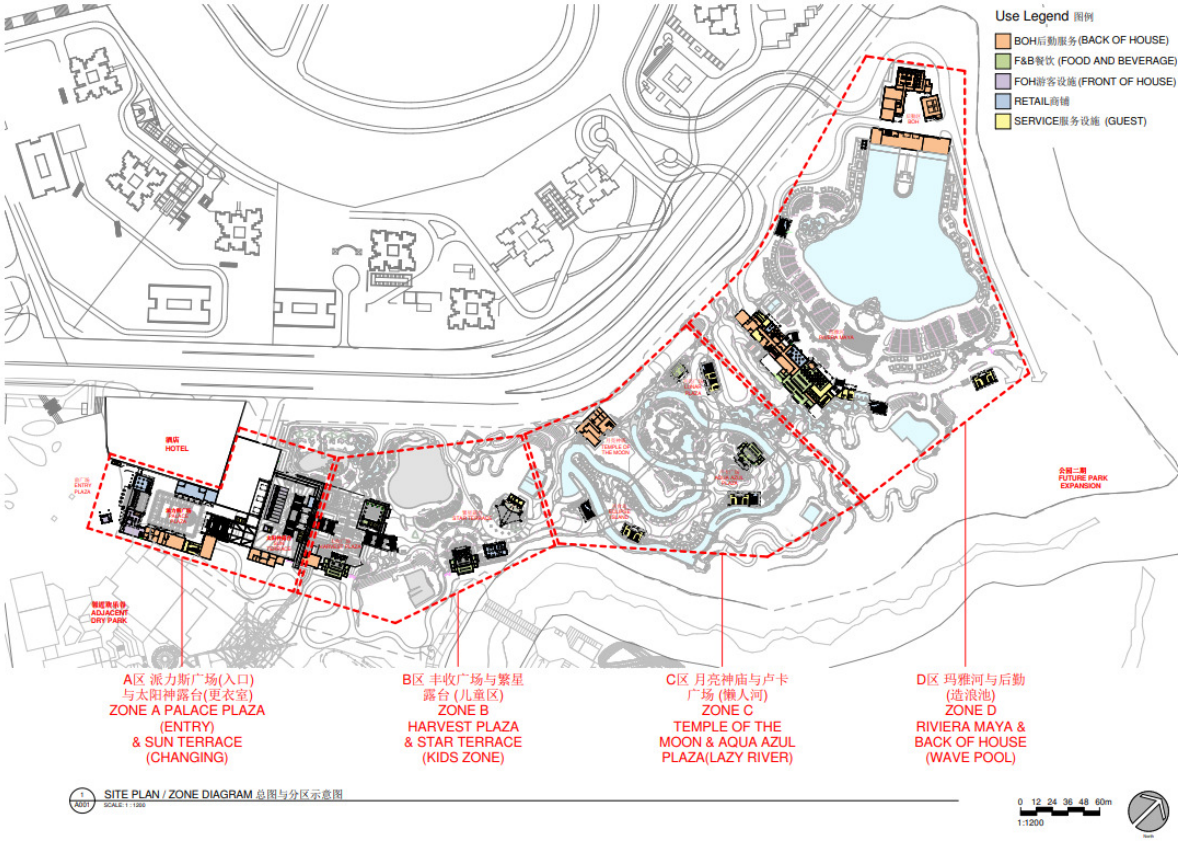
160 meters of fall from one end of the park to the other side

and the 3rd largest wave pool in the world.

Did I mention the team had never delivered a project like this in Revit before?

Project Organization

Something that is unique about theme park design vs. many other project types is that they are very landscape heavy with multiple large and small structures spread throughout a very large site.



With this unique type of site design, we broke up the structures within their own respective models and linked them into a master site file utilizing shared coordinates.

Project Exports

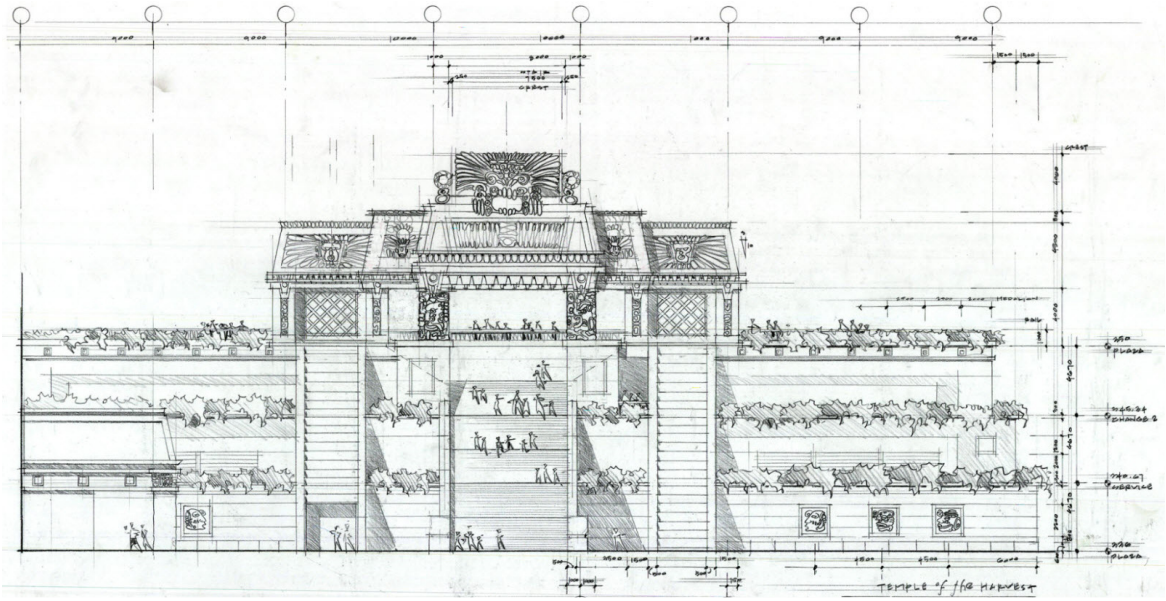
Given the large integration with landscape, we had to maintain ongoing exports to AutoCAD as that was the program the landscape designers used. The posed a large challenge as the landscape design team was used to architecture working in AutoCAD and utilizing live backgrounds. We set up export views in the site file with view templates assigned and exported all the backgrounds from that file almost daily.

**Note that there are more efficient tools to automate cad exports such as Clarity, but the client had not invested in this software yet.*

Given the large amount of grade drop that this project had from one end of the site to the other, this posed another challenge for view ranges. We used a series of plan regions and linked views to try to cut the building in its respective place.

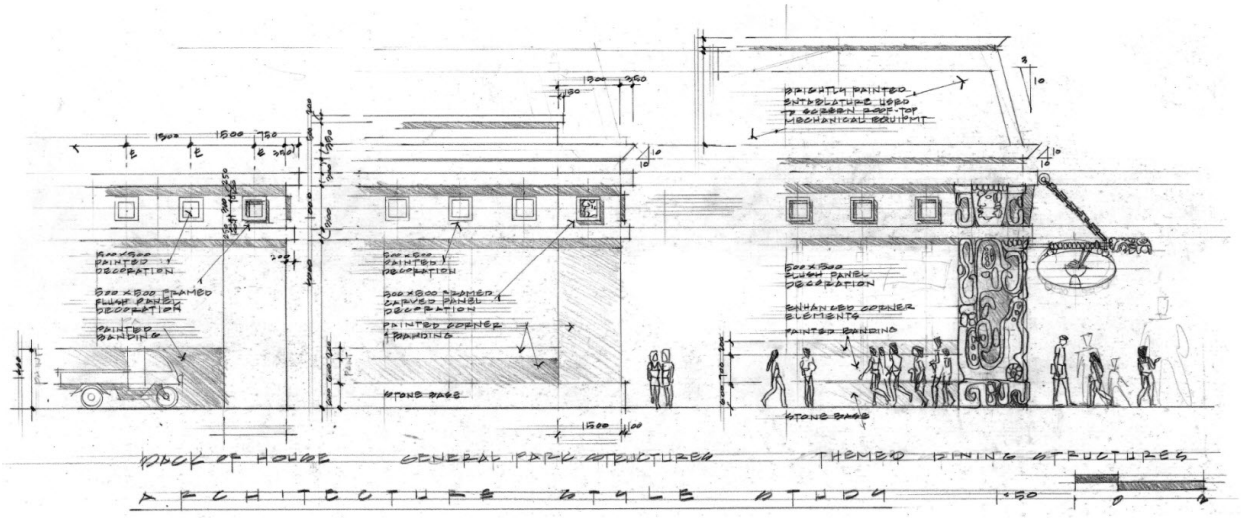
Sketch to BIM

DTJ Design has some of the most talented designers in the world. Their sketching ability is unlike anything I have ever seen, especially in the AEC space. Sketching in lieu of modeling in SketchUp, FormIt, or Rhino became invaluable in communicating design intent from the principal designer. "The computer just doesn't give us the freedom or efficiency a pencil does", he said. Scalable sketches became the vehicle for feeding myself and the rest of the team information about the project. We would receive scalable sketches from the designer that looked like this…

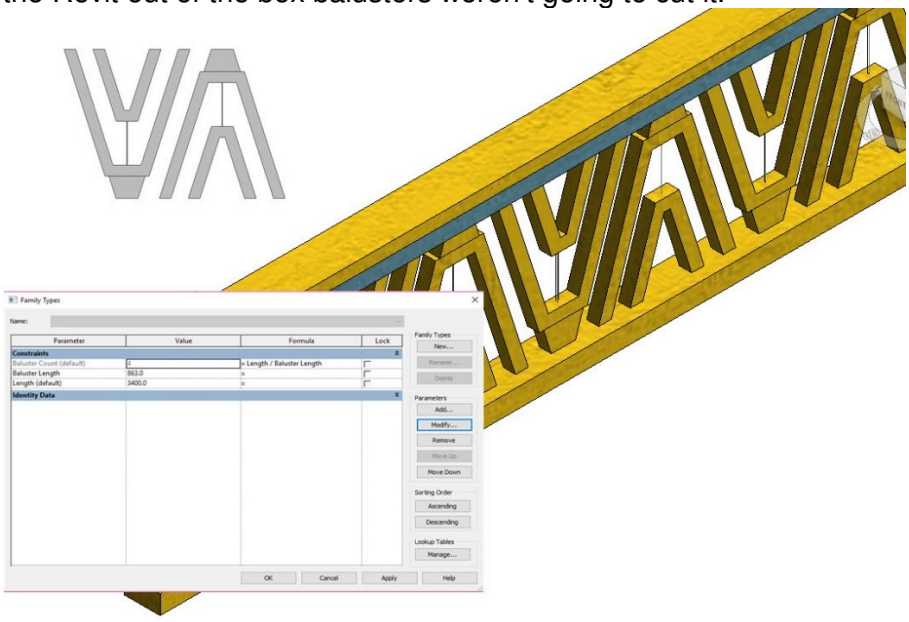


It was the team's job to take these sketches and turn them into this.

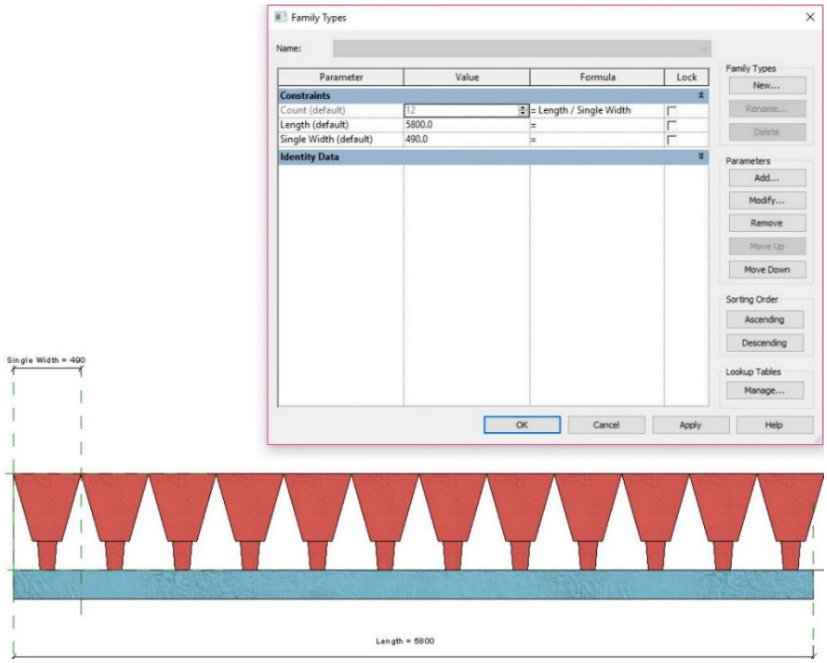
The sketches really went into detail even to include the roof slope ratios giving us some really accurate ways to interpret the sketches that were being fed to us.



Another major task of mine was to create componentized families that could be used throughout the project from one file to the next. I built out parametric line based families for the railings as the Revit out of the box balusters weren't going to cut it.

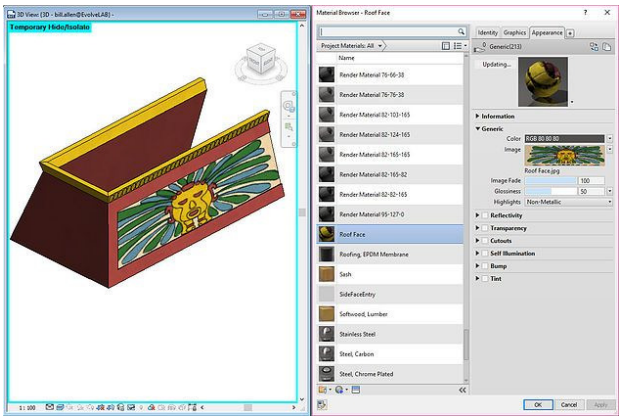


I did the same for much of the decorative elements that would be used throughout the buildings.



Less is More….. (Efficient)

Given the quick turn around and this being the architects first project in Revit, we took a leaner approach to this specific project. We decided to photoshop the sketches from the designer, and import these images as materials that could then be “painted” to the surface of the geometry. The materials were scaled up so that they represented a 1:1 ratio on the surface to mitigate any kind of unwanted repeatability.

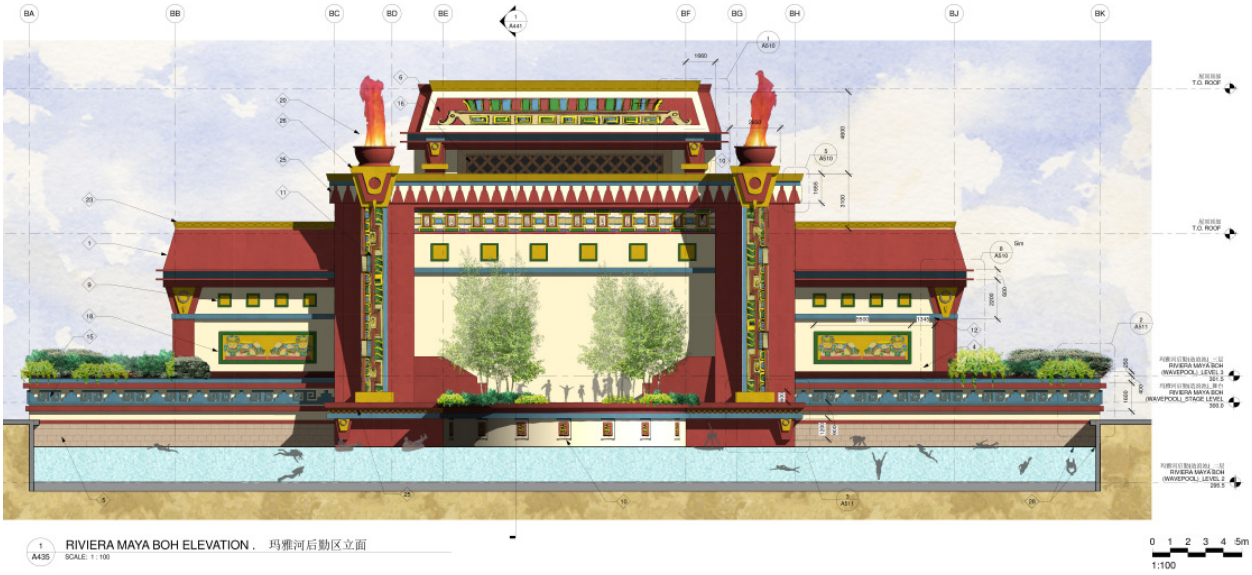


Note one of the reasons we used materials in lieu of revit decals was that decals will give you a phantom box around the image if the surface you are applying the decal is not square/rectangular. Given the vast amount of irregular shapes we were applying the graphics to, painting was the better option.

Elevations

The elevation quality for this project was extremely impressive. We not only showed the project in color with shadows on, but we also needed to represent rockwork, trees, shrubs, waterfalls, and architectural information beyond. Please note this was before the Revit “depth cueing” feature.

In short it required an intense amount of photoshop. We didn’t have time to wait to be done modeling to hand it off to the photoshop artist, so we exported “rough” elevations for them that would be put on a separate layer and they would begin photoshopping while we continued modeling. As new updates came in, they would replace the old building layer with the new one.

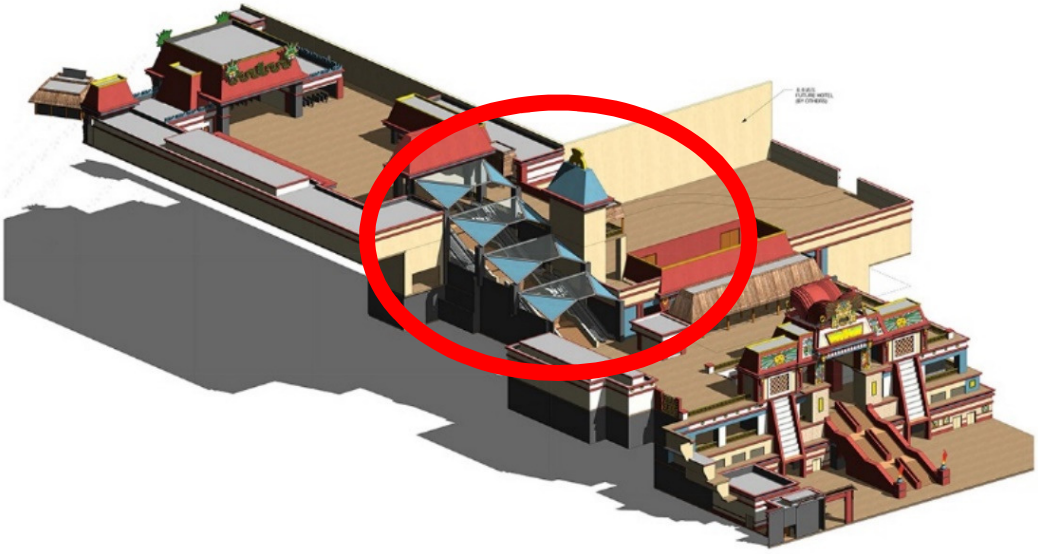


Isometrics

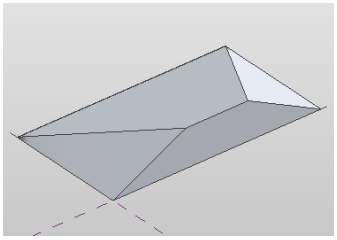
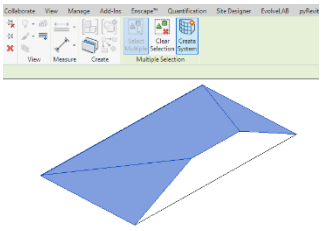
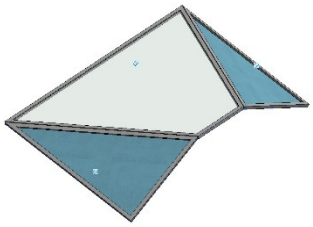
We also decided to include isometrics of the project to help inform the architect of record as well as the contractor how the theming components wrapped around edges and surfaces. We didn't' want it to look like a Hollywood set where only the front of the building had these theming components.

Canopy Structures

Another challenging structure we had to model were the escalator roofs. This was actually one of the lesser challenging tasks I had as I was use to designing complicated canopies for vehicular canopies at hospitals.

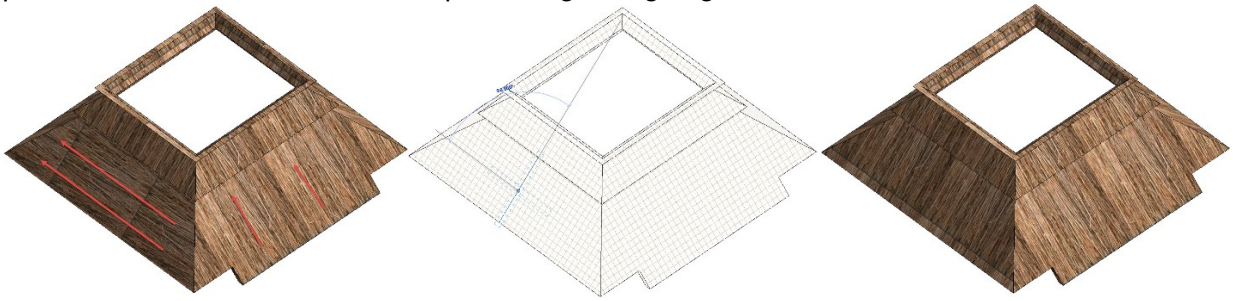


The process is to create a conceptual mass and host a curtainwall system to it in a Revit project.

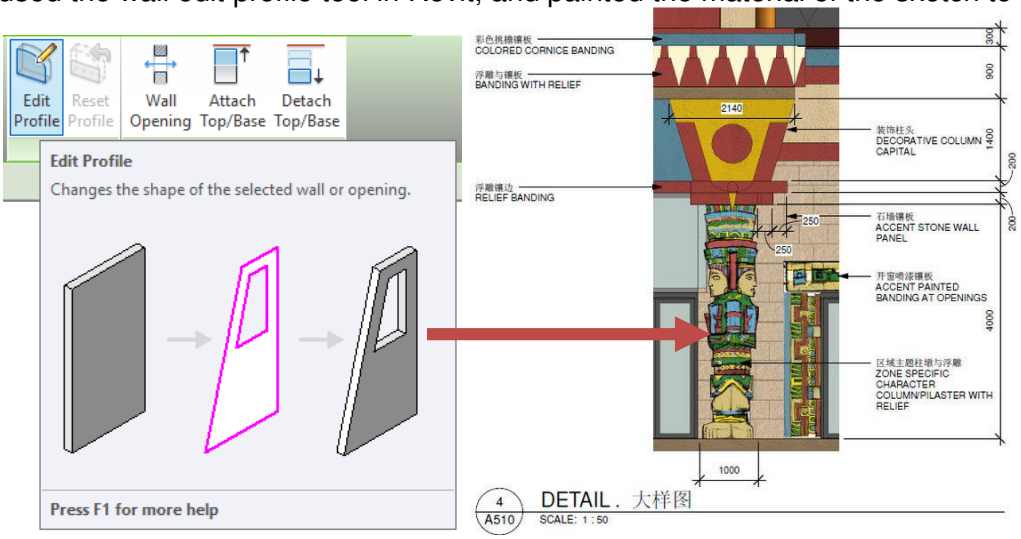
Shade structures

Rather than modeling the roof thatch which would have been very processor heavy, we modeled the general shape, and then applied the material of the thatch to the shape. We also applied a hatch pattern to the material so when it wasn't set to realistic, we would have a grid pattern to rotate to make sure the patterning was going the correct direction.



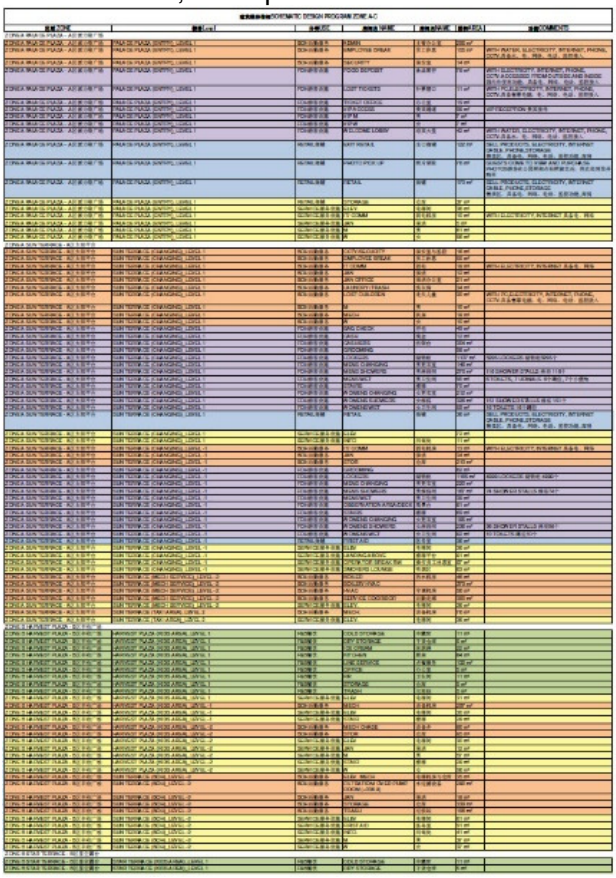
Detailing

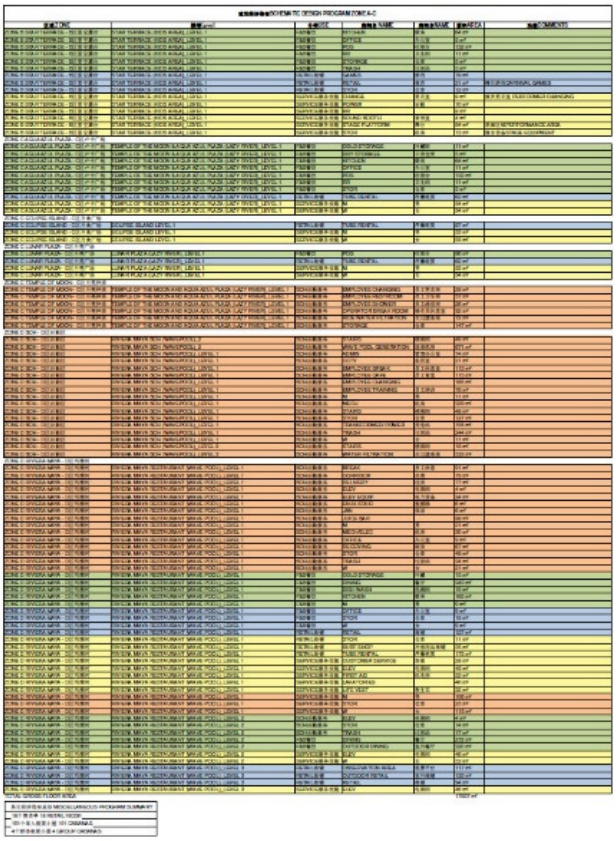
Even though we were delivering a schematic design package, we had a very high level of detailing that occurred for the theming elements on the project which included dimensions, descriptions, and Chinese translations. To accomplish some of these complex shapes, we simply used the wall edit profile tool in Revit, and painted the material of the sketch to the front.



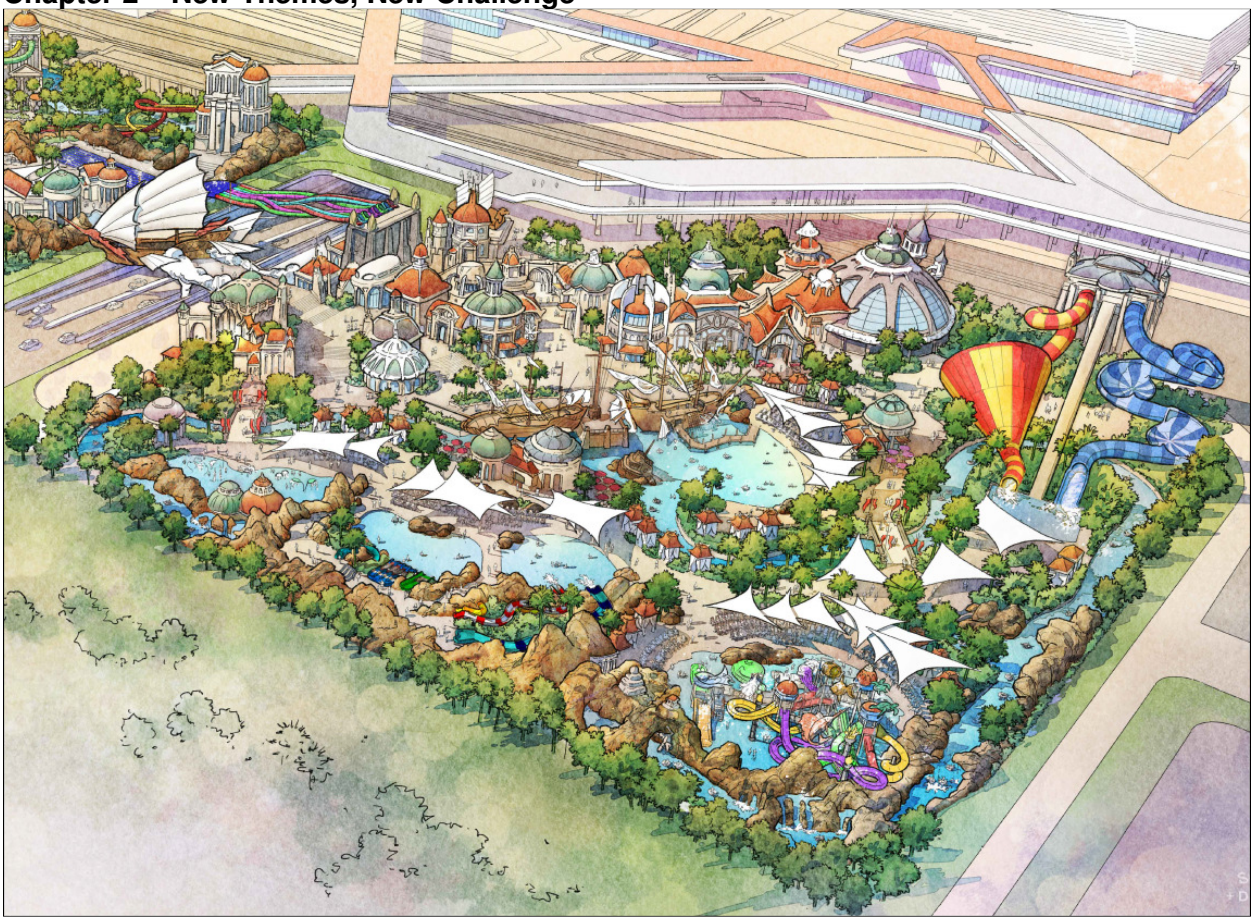
Data Capture

The great promise of BIM is the data. We really wanted to leverage the capturing of data for the project as the previous process typically provided data via excel, which would have a direct disconnect from the drawings. Leveraging Revit we were able to get locker counts, plumbing fixture counts, and special data.





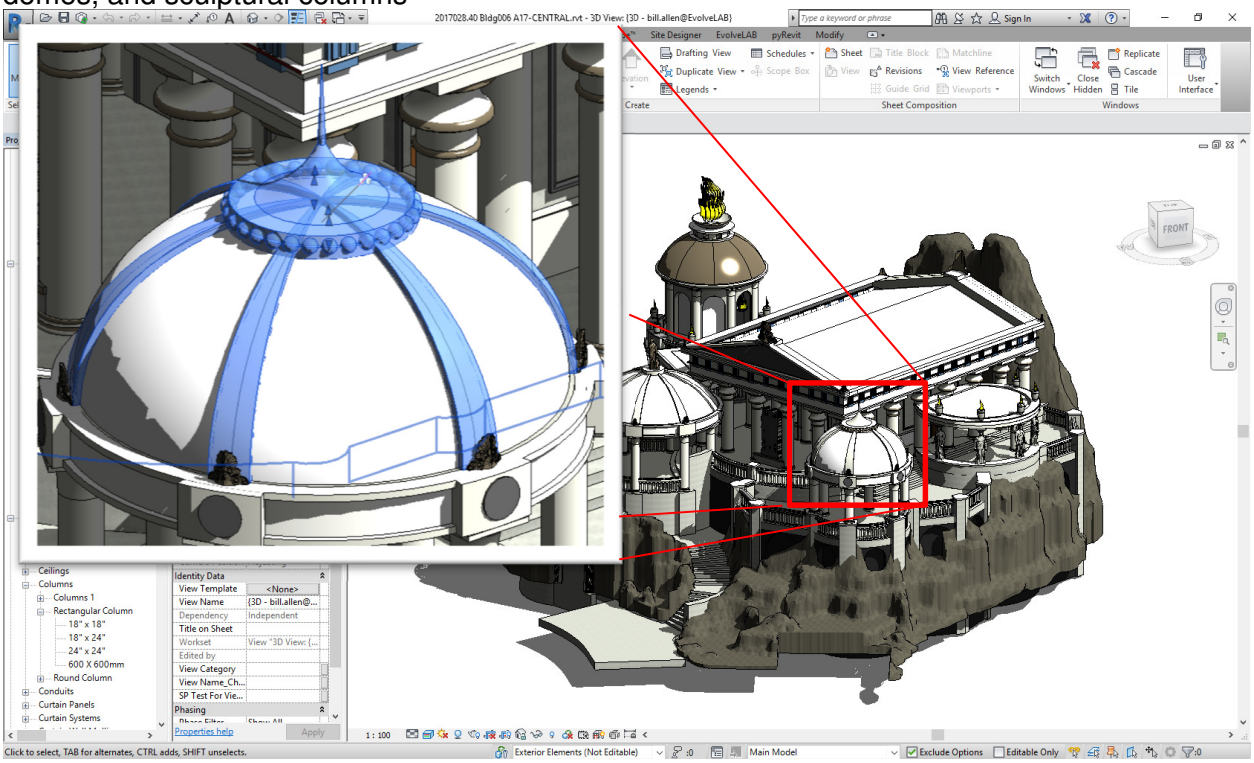
Chapter 2 – New Themes, New Challenge



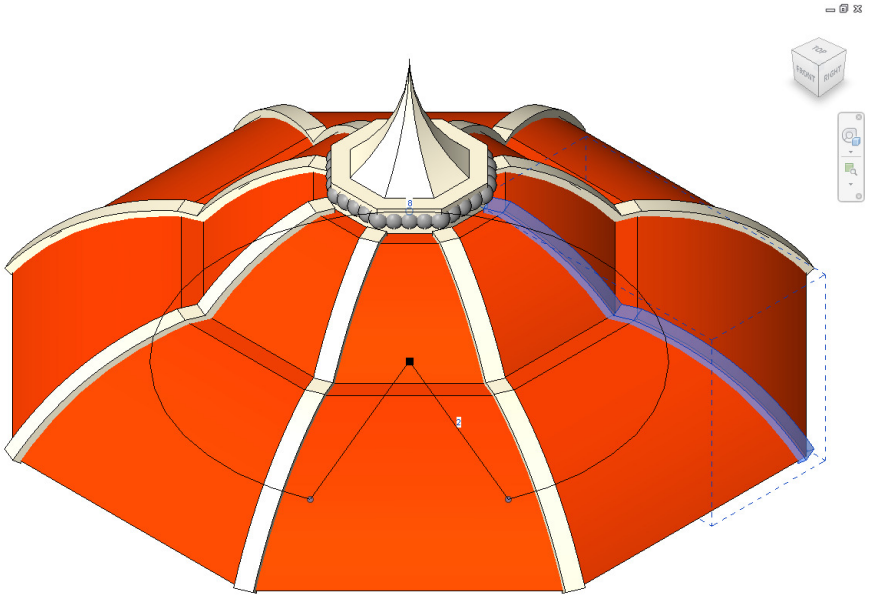
- THE LOST CIVILIZATION
- LAND OF LEGENDS
- SECRET WHARF

Modeling Ancient Architecture

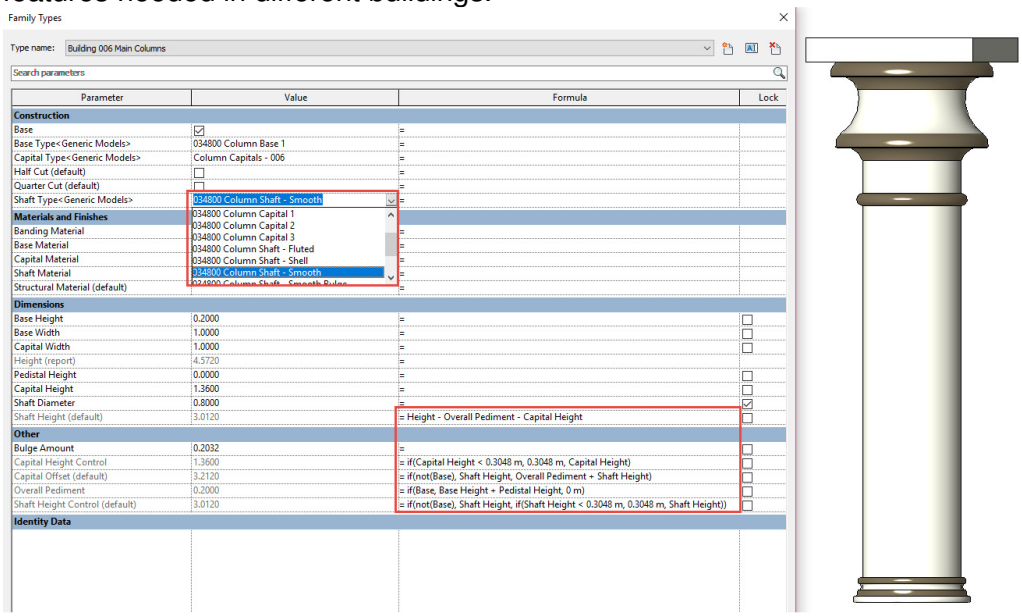
The land of legends had this classical Greek architecture with decorative Fascia's, detailed domes, and sculptural columns



We used a series of sweeps and arrays in Revit to accomplish modeling of the domes.

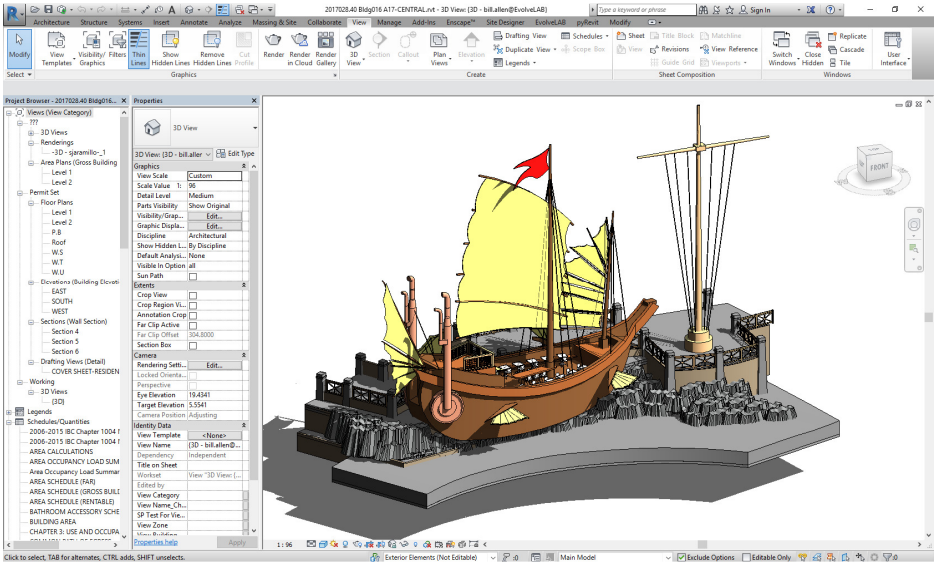


We built parametric columns that were formulaically driven with type drop downs for different features needed in different buildings.

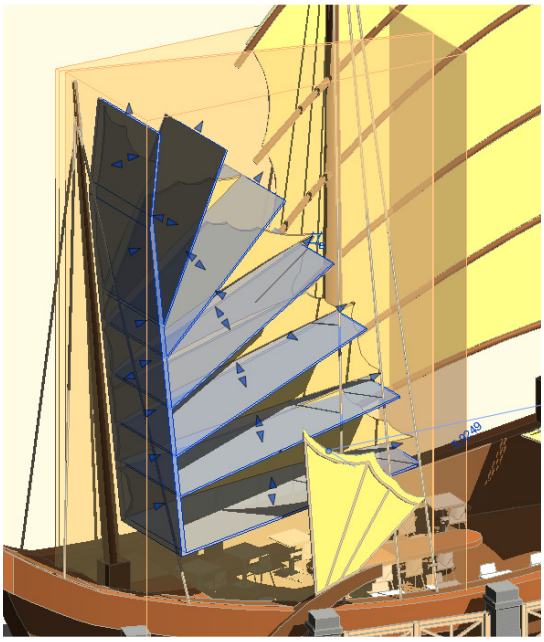


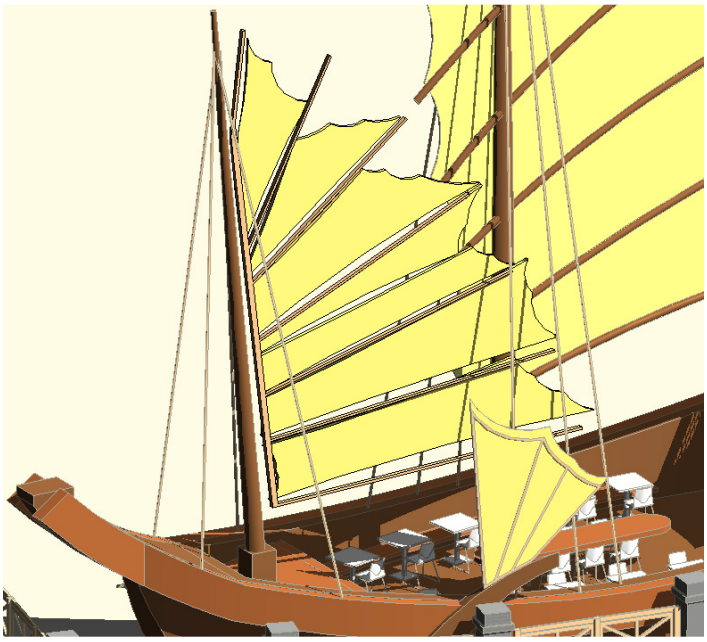
Modeling Uncategorical Information

A common theme (no pun intended) when modeling theme parks is the shear amount of geometry that doesn't fit into a Revit category. "Generic Model" and "Specialty Equipment" are some of the most common and usually the most abused. Further, there is a lot of information that is NOT repeatable. When was the last time you need to model an ancient explorer's ship multiple times throughout a project? With these types of geometry, it's best to "model in-place" this content

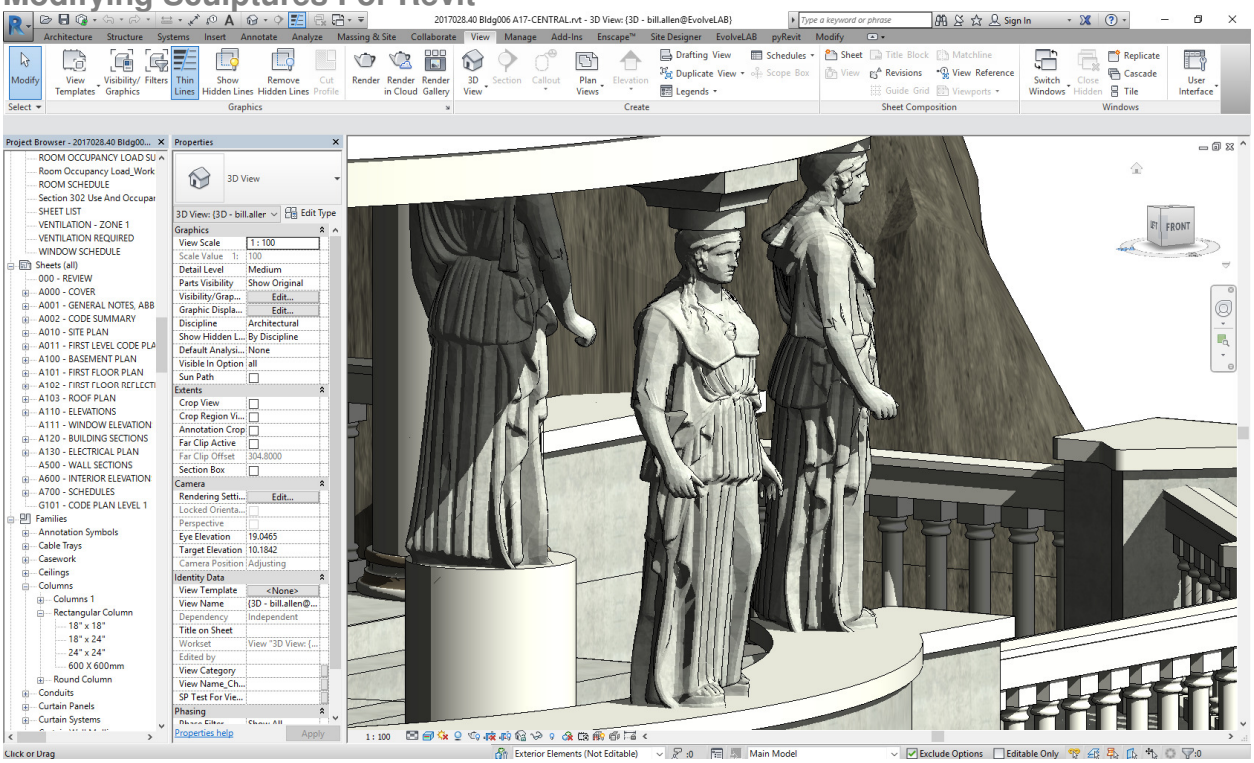


Further the “Void” tool in Revit is completely underutilized. We used the out of the box modeling tools to model the sails on the sail boat simply by creating an extrusion voided out.



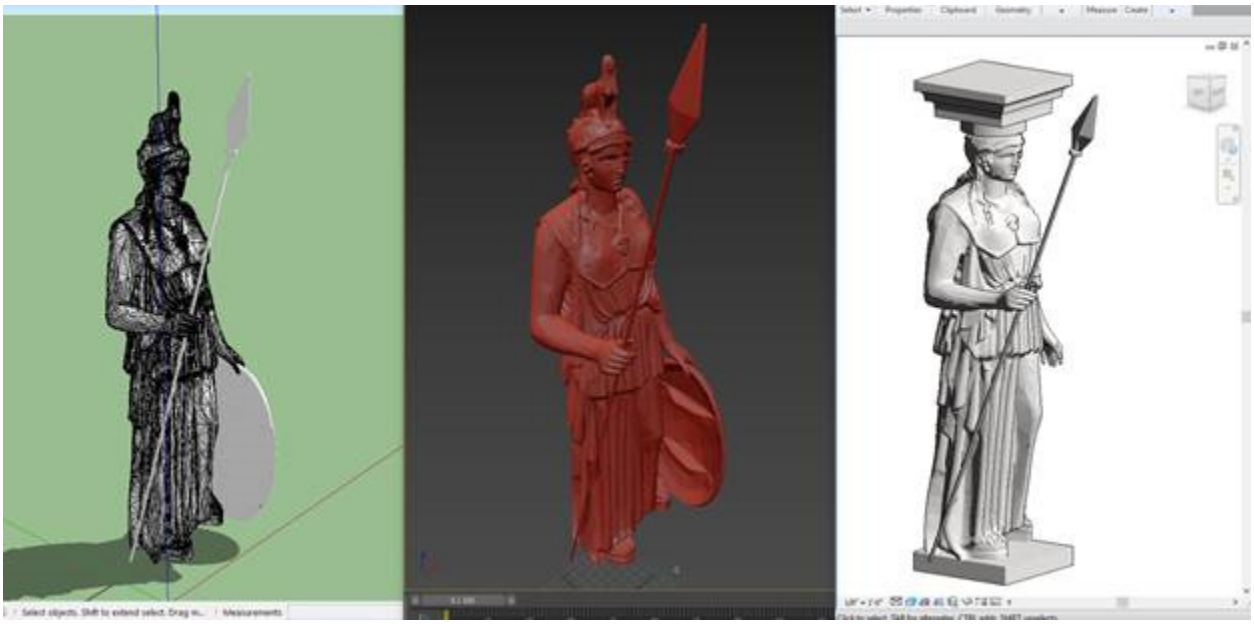


Modifying Sculptures For Revit



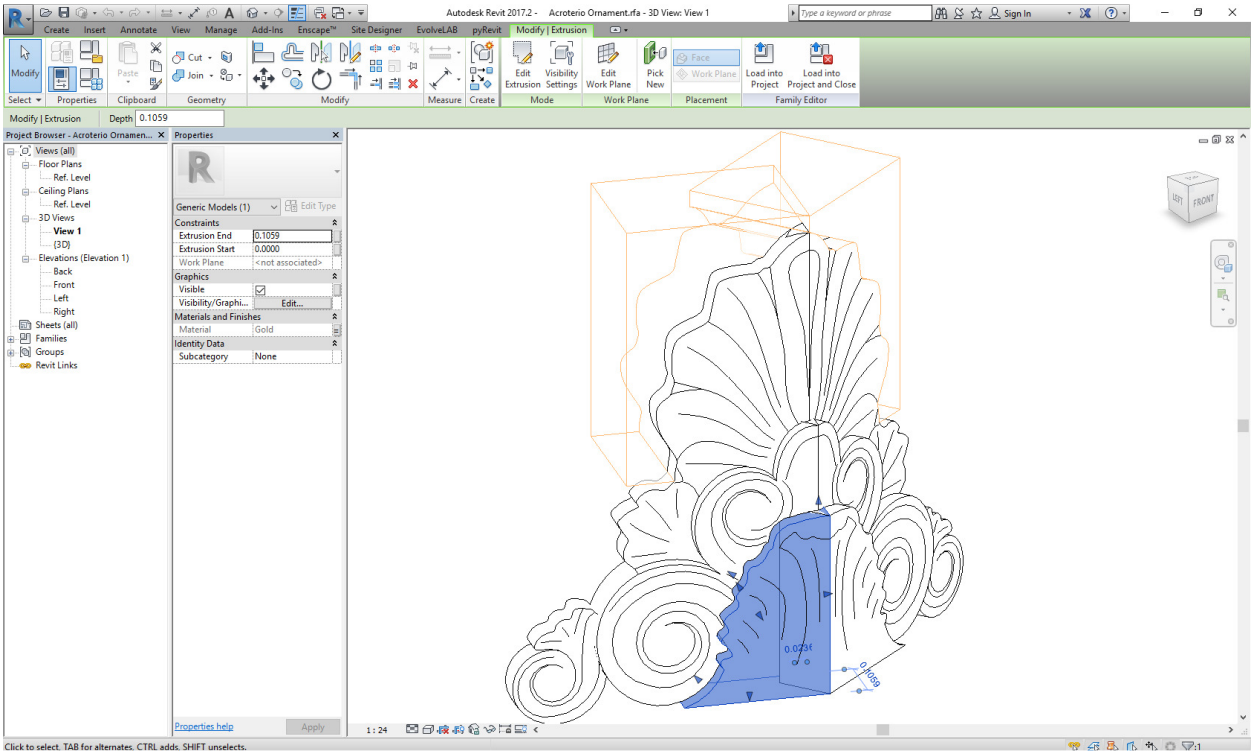
In this example we pulled this character from the SketchUp Warehouse to give us a good starting point.

1. Import mesh into 3dsMax
2. Select the object
3. On the palette on the right got to “Modify” tab
4. Looking at the modifier stack, if the object isn’t’ an editable mesh → go to the “Modifier List” pulldown → Select “Edit Mesh”
5. In the tools below the modifier stack, in the “Selection” group, pick the “Edge” Icon to select edge sub objects
6. Select the edges
7. In the tools below the modifier stack, scroll down to the bottom group “Surface Properties → Select “Invisible”
8. Because Revit prefers to select objects using edges (rather than faces), a few edges still need to be visible. Newer versions of Revit allow you to select by face, but it can still be an issue if you don’t have a couple of edges to select.
9. Select a few edges on the bottom of the object → Select “Visible”
10. Turn off the “edge” sub-object select in the “Select” group
11. With the object selected click on the 3DS Max Icon in the upper left → “Export” → “Export Selected”
12. Pick a location and file name
13. Change “Save as type:” → “ AutoCAD (*.dxf)
14. Slick “Save”
15. In the “Export ot AutoCAD file” dialog change “Export Version” to AutoCAD 2007 DXF or AutoCAD 2004 DXF”. The other settings don’t matter in this instance, but exporting as 2004 or 2007 does matter.
16. Click “Ok”
17. Open the exported DXF file in AutoCAD
18. If it worked, only the edges that you left visible will be visible.
19. Click on the “Layer Properties” button
20. Click on the “New Layer” button
21. Give the layer an appropriate name for the object. This will allow you to assign materials and change the line weights for the mesh in Revit
22. Change the layer’s color to white
23. Select the Object → using the layer pull down, change the object layer to the new layer
24. Verify that under the properties group on the Ribbon, the object color, line weight, and linotype are all set to “By Layer”
25. Save (either as a DXF or DWG)
26. In Revit → create a new family or in your project under the “Architecture” tab → “Component” button → “Model in-Place”. The type of family should match what the object is. Generic Models or Masses are typically good choices
27. In the family → “Insert” tab → “Link CAD” or “Import CAD” (Link CAD will only be available in “Model In-Place” families.
28. Select your DXF or DWG file and place it (don’t forget to check the “Import Units” and the “Positioning”)
29. The mesh object will come in as an outline with only the edges you left visible still there.



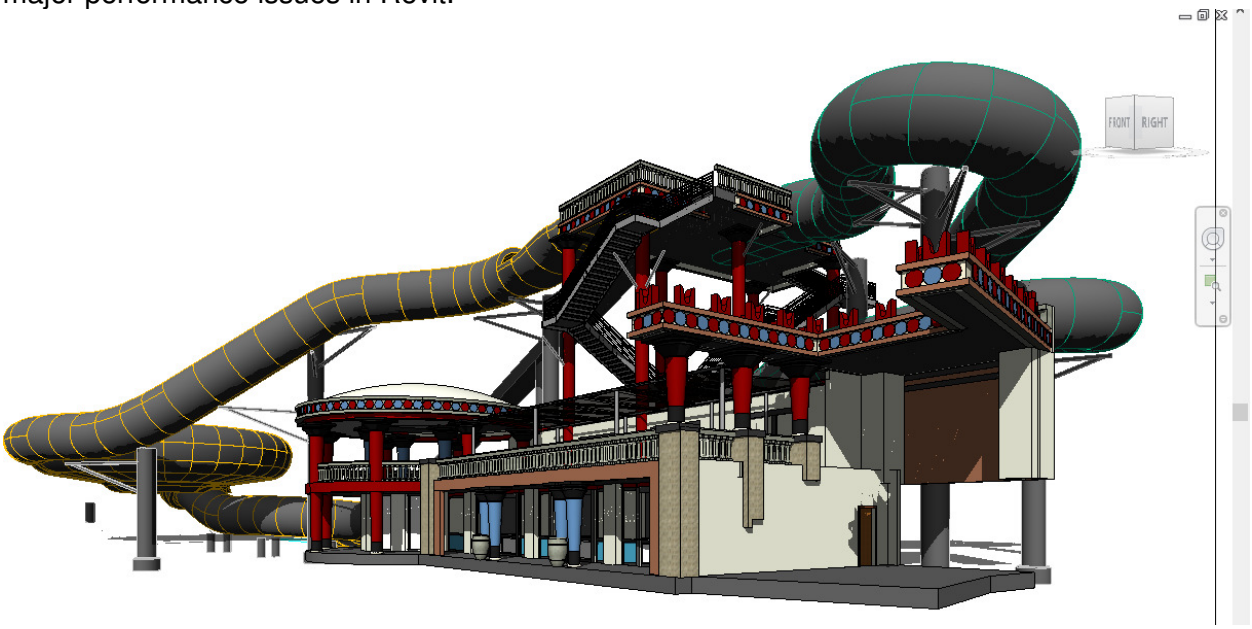
Decorative Details

Many of the decorative elements were a combination of voids, extrusions, and model lines built into families that didn't necessarily need to be parametric, so we kept these leaner.



Converting CAD Files to Revit

Another challenge when working on theme park projects is the shear amount of detail from the ride consultant files. Ride consultants will model every nut and bolt is SketchUp which causes major performance issues in Revit.



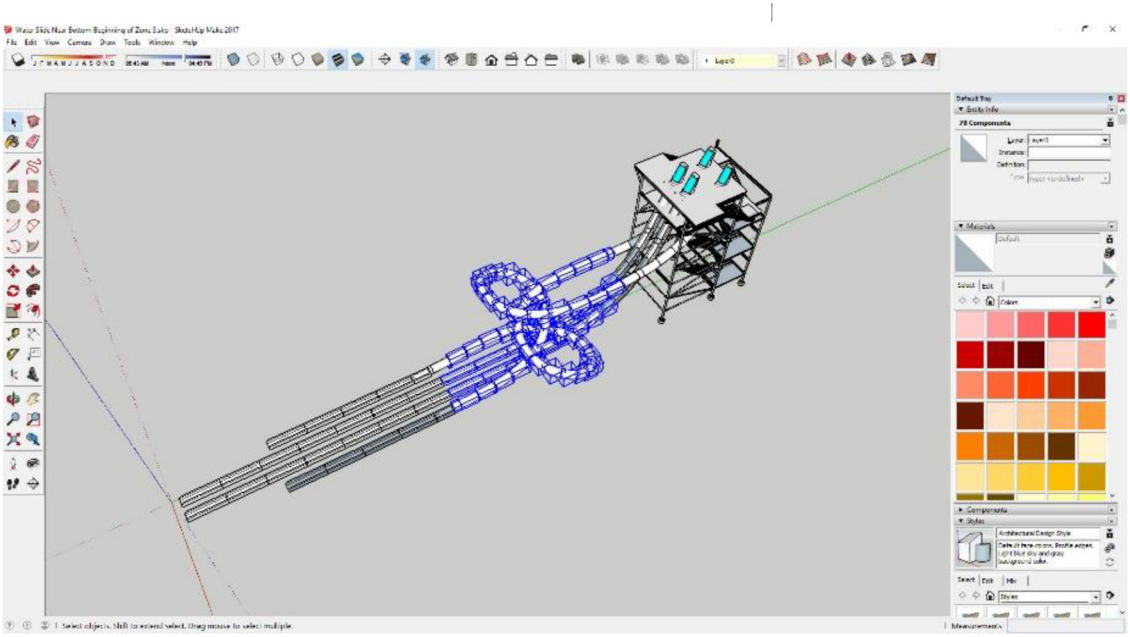
Conversion of DWG or DXF files to something suitable for Revit is a lengthy process, but necessary for eliminating extraneous edges for complex triangulated forms. The process described here is focused around five main concepts:

1. Split geometry into layers based on the materials to be assigned;
2. Make edges invisible for the mesh geometry in 3ds Max;
3. Export the geometry in layers from 3ds Max to the 2007 DXF format and import it into AutoCAD;
4. Set all geometry to the correct layer, and set all geometry to use white lines in AutoCAD;
5. Import the geometry into a Revit family and use Object Styles to set the materials for each Imported Category subcategory made automatically for the layers.

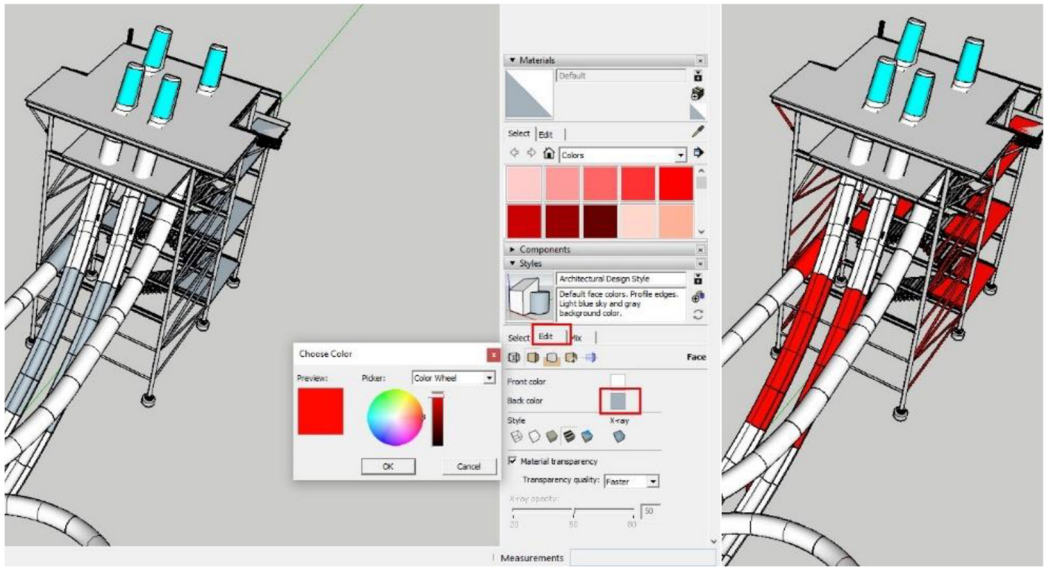
Starting with SketchUp

It's not necessary to begin with SketchUp, but SketchUp is easy to work with for organizing the geometry into layers.

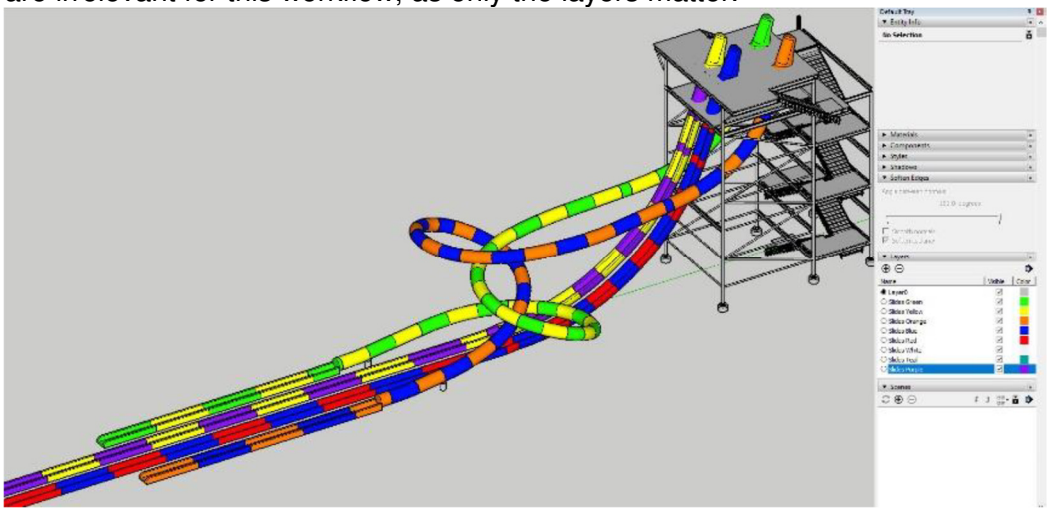
1. When beginning with SketchUp, all geometry faces must belong to a layer that corresponds the material it will receive in Revit. It is easiest to first explode groups of components in SketchUp if they exist, so they can be reduced to basic geometry. If geometry is not exploded, 3ds Max will treat the component's layer as the layer for all subcomponents. Also, geometry may need to be detached from other geometry in 3ds Max if exploding components has not been done beforehand.



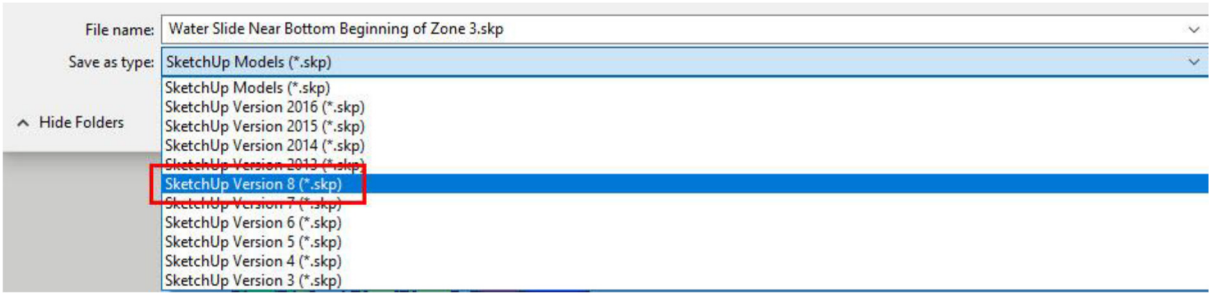
2. Also, it is a best practice, but not always necessary to ensure all faces are oriented outward for solids. Changing the face Back Face color to red will assist in determining which faces need flipped with the Reverse Faces tool. 3ds Max may have a hard time displaying the geometry if its faces are reversed.



3. Assign all geometry faces to their appropriate layer based on the material they should receive in Revit. Setting the UI to display geometry by layer will help with showing which faces have been assigned to a layer. Materials painted in SketchUp are irrelevant for this workflow, as only the layers matter.



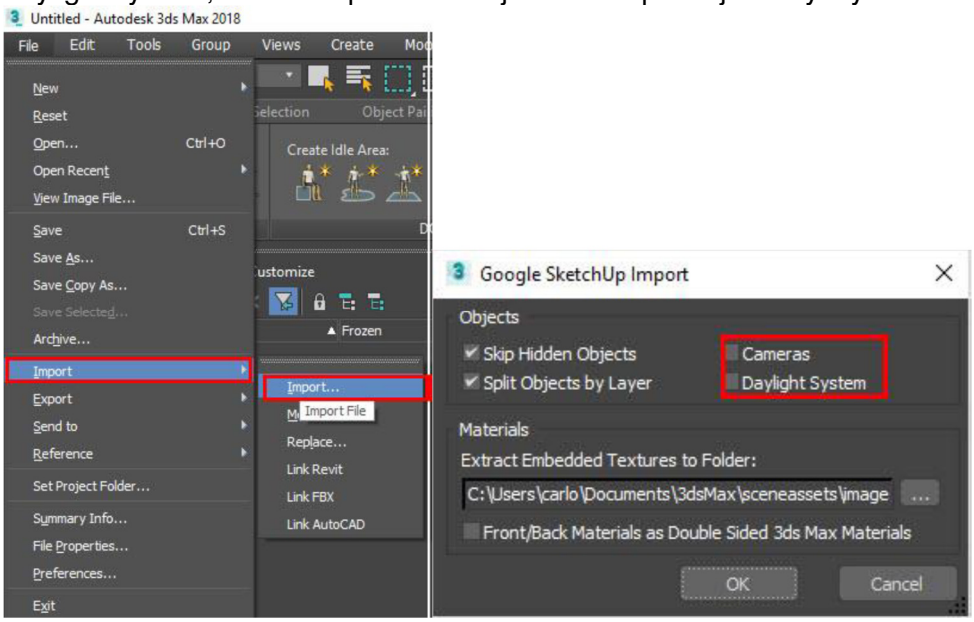
4. Once the geometry has been assigned to the correct layers, save the SketchUp file as a SketchUp Version 8 file. Do not save to any format newer since 3ds Max cannot import newer formats.



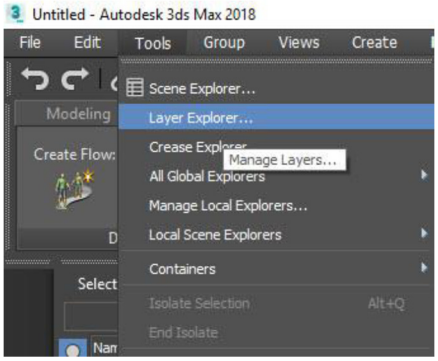
Using 3ds Max

3ds Max is critical in removing the edges of the geometry. It is also useful for organizing the geometry into layers if it wasn't already done in SketchUp.

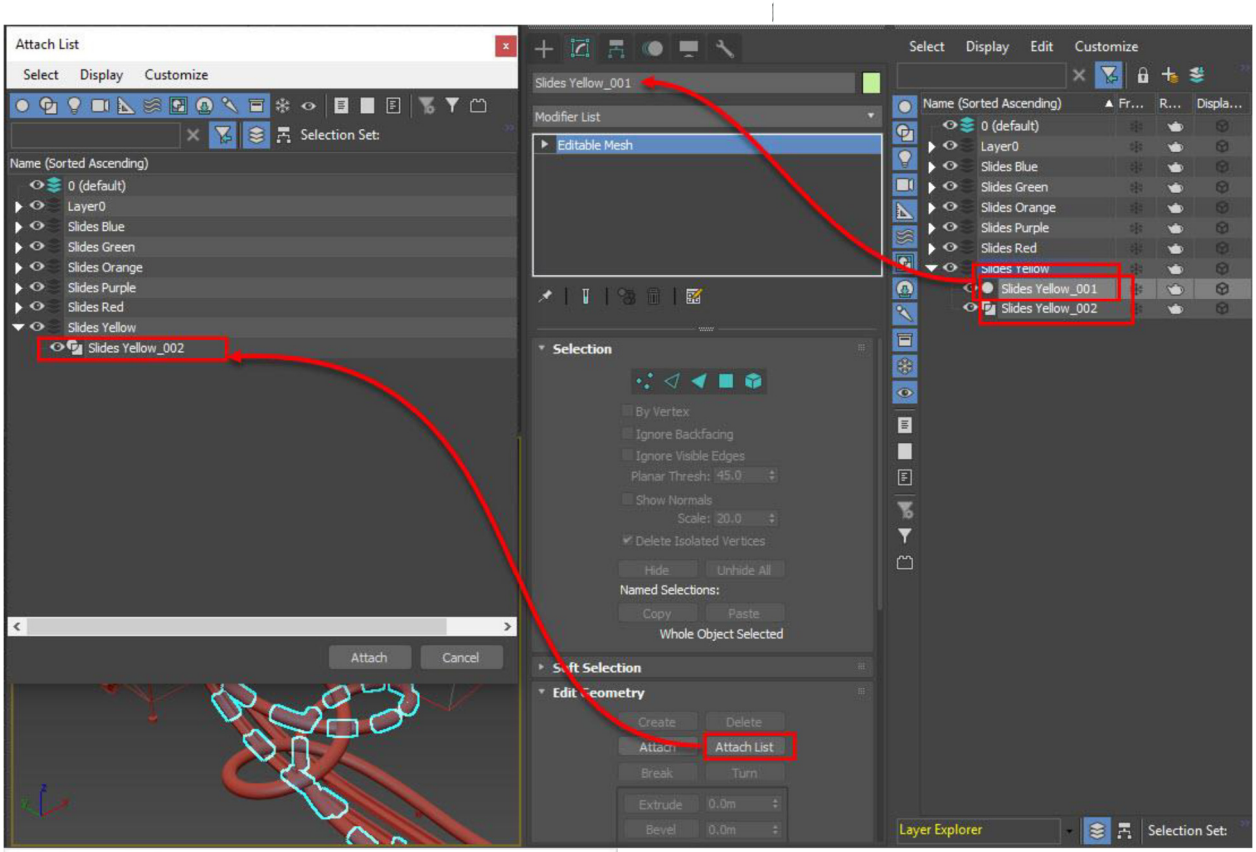
1. In 3ds Max, import the Sketchup file. During import, do not import the cameras or daylight system, but do skip hidden objects and split objects by layer.

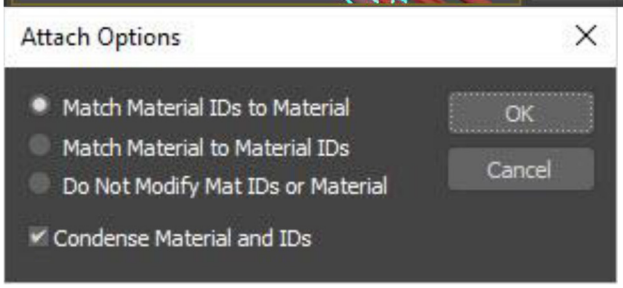


2. Use the Layer Explorer to verify all layers came through in the import.

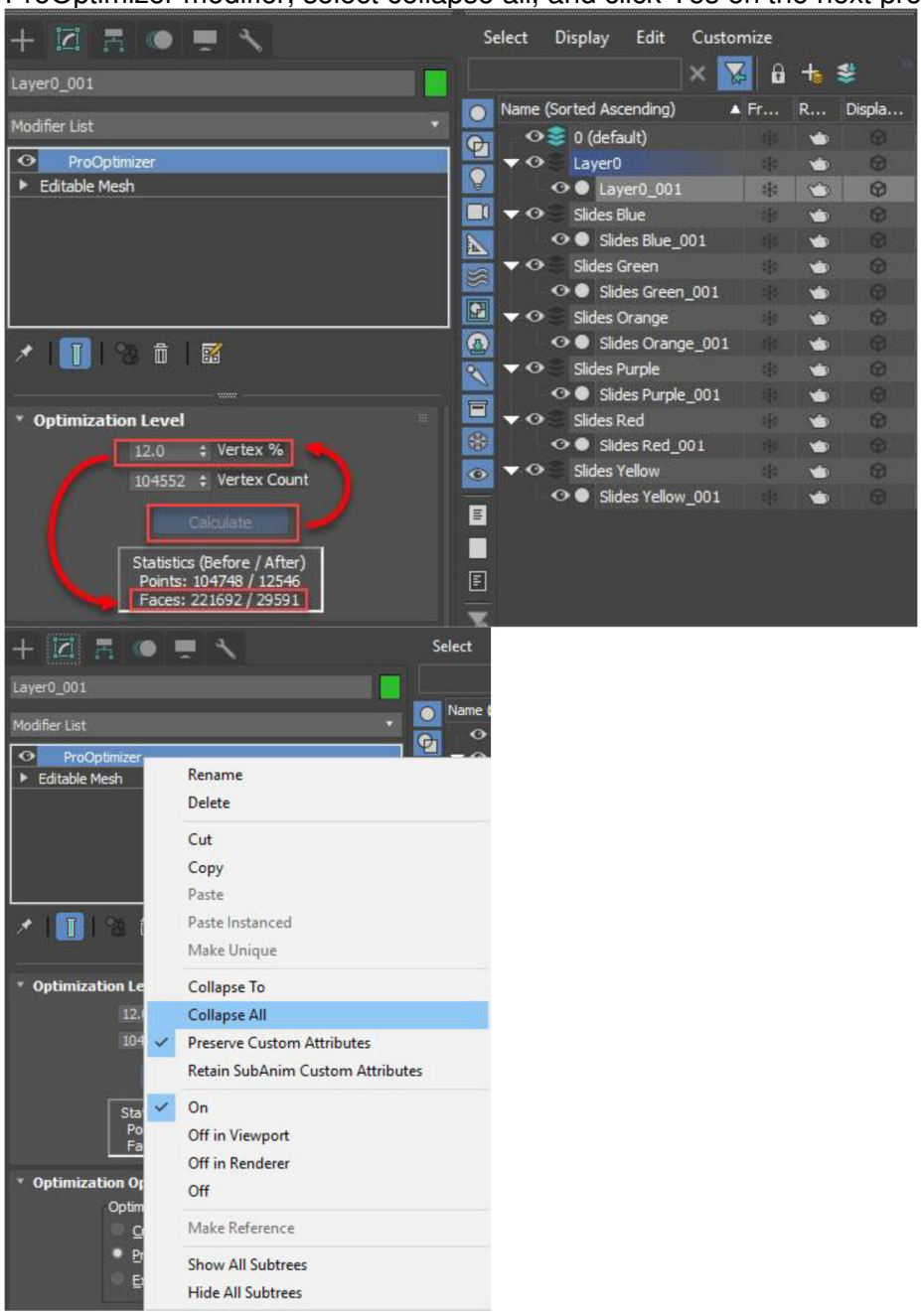


3. If more than one object is under a layer, select one of the objects. In the modify tab scroll down to the Edit Geometry section and click Attach List. This will allow you to select any object to attach to the active object and thus reduce the number of operations that will need to be performed on the geometry. Do this instead of grouping objects since groups will not work for controlling layer materials later. When attaching, use the Do Not Modify Mat IDs or Material option since neither matter and will only take more time.

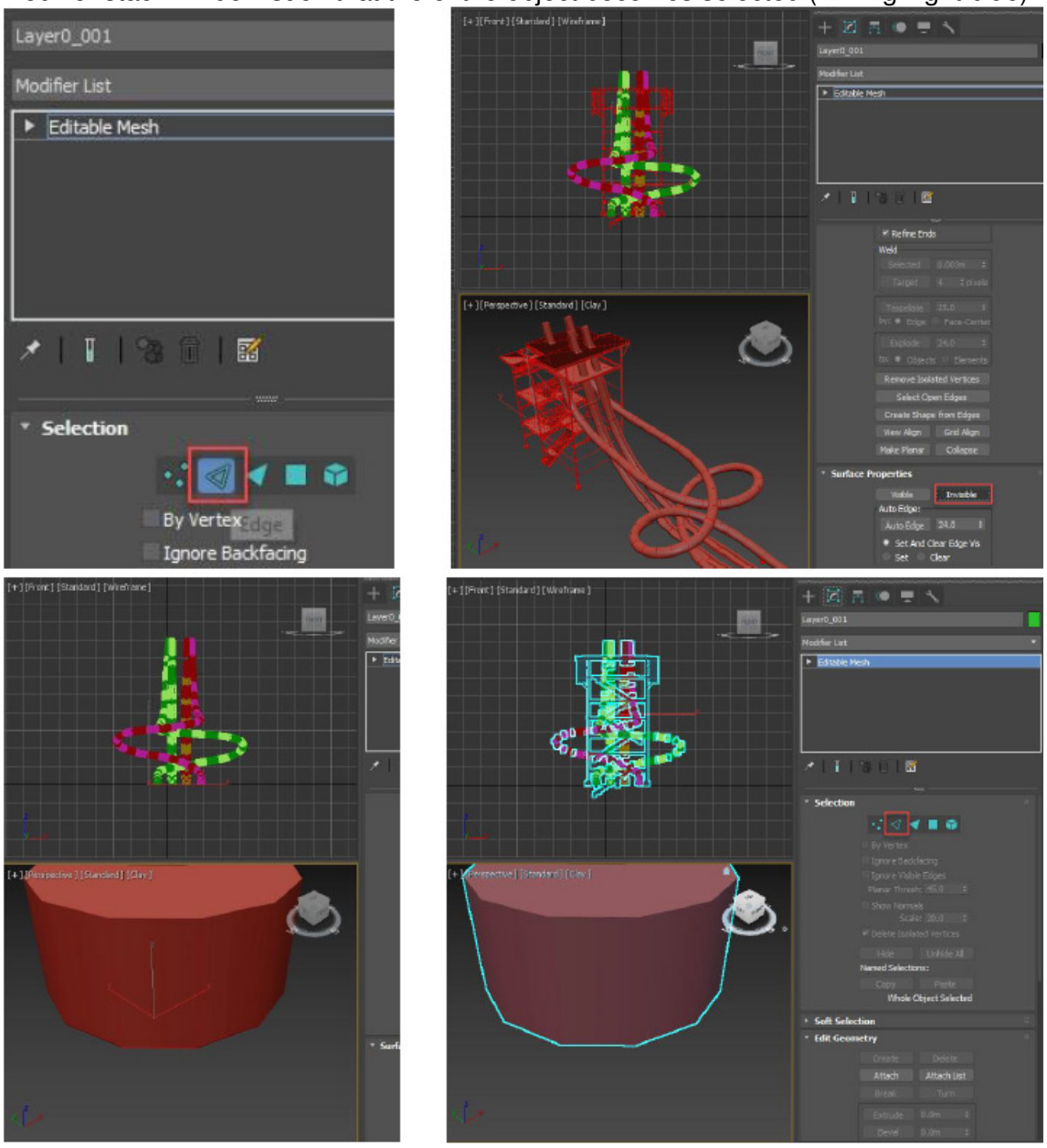

Attach List
Select
Display
Customize
Selection Set:
Name (Sorted Ascending)
0 (default)
Layer0
Slides Blue
Slides Green
Slides Orange
Slides Purple
Slides Red
Slides Yellow
Slides Yellow_002
Attach
Cancel
Slides Yellow_001
Modifier List
Editable Mesh
Selection
By Vertex
Ignore Backfacing
Ignore Visible Edges
Planar Thresh: 45.0
Show Normals
Scale: 20.0
Delete Isolated Vertices
Hide
Unhide All
Named Selections:
Copy
Paste
Whole Object Selected
Edit Geometry
Create
Delete
Attach
Attach List
Break
Turn
Extrude
0.0m
Bevel
0.0m
Select
Display
Edit
Customize
Name (Sorted Ascending)
0 (default)
Layer0
Slides Blue
Slides Green
Slides Orange
Slides Purple
Slides Red
Slides Yellow
Slides Yellow_001
Slides Yellow_002
Layer Explorer
Selection Set:


Attach Options
Match Material IDs to Material
Match Material to Material IDs
Do Not Modify Mat IDs or Material
Condense Material and IDs
OK
Cancel

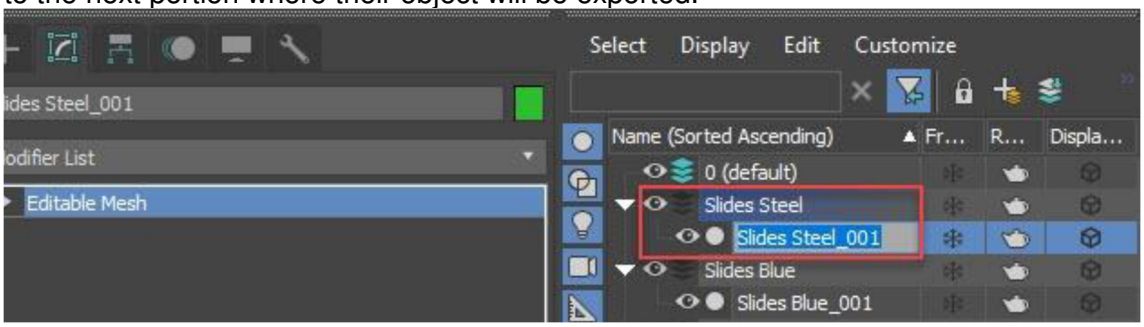
4. If any object fails to attach, most likely it can be deleted, which also includes spline objects. Once the layers have one object under them, use a ProOptimizer modifier to calculate the number of faces, and reduce the vertex count. The number of faces must be under 32,000 for the object being exported. Once done, right-click on the ProOptimizer modifier, select collapse all, and click Yes on the next prompt.



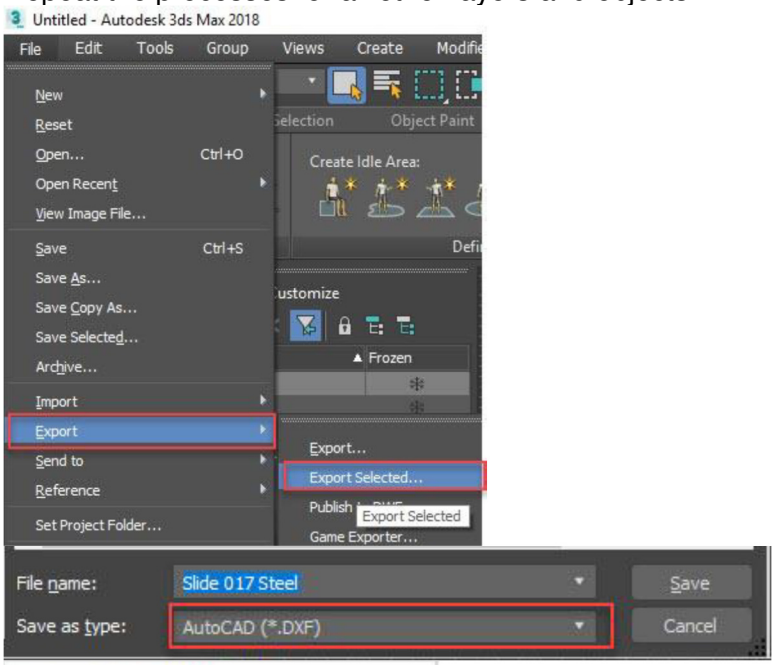
5. Next, activate edge selection. Use CTRL+A to select all edges. Scroll down to the Surface Properties section and set all edges to Invisible. Then, select just 3 edges and set them to Visible. Deactivate the select edges tool and select the Editable Mesh in the modifier stack window such that the entire object becomes selected (will highlight blue).

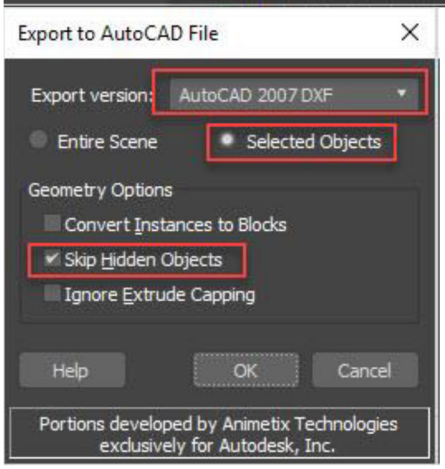


6. If some of the layers are not properly named, right click on them and rename them prior to the next portion where their object will be exported.



7. Next, export just the selected object geometry and save it to the 2007 DXF format. Repeat the processes for all other layers and objects.

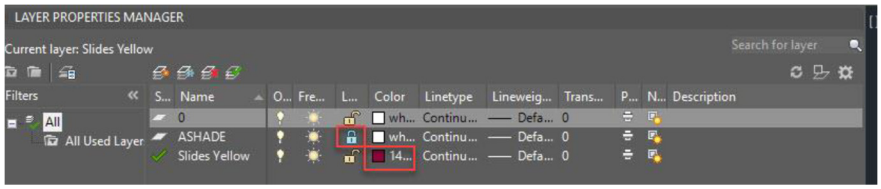




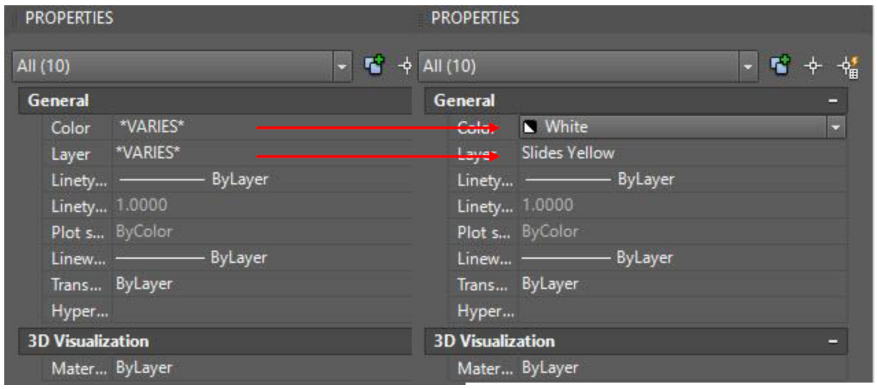
Using AutoCAD to Set Layer Properties

AutoCAD must be used to set all layers to a White color, and all objects to their appropriate layer and using a White color. The layer's color does not necessarily make all object edges white, and therefore must be done in the object's properties and the Layer Properties Manager. You will know the previous steps in 3ds Max worked if the 2007 DXF format file only shows the edges set to visible when the AutoCAD window is set to display wireframe.

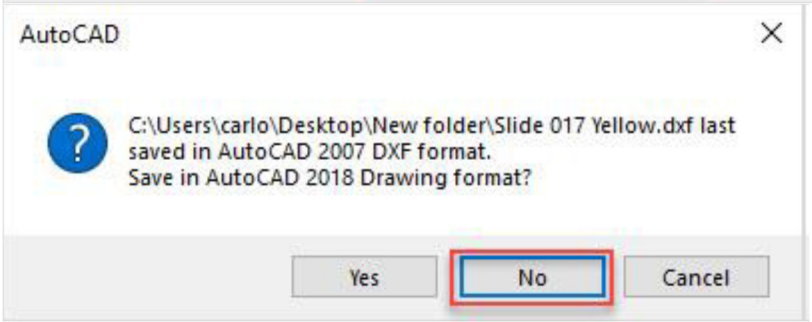
1. Open the DXFs in AutoCAD, unlock their ASHADE layer, and set the layer colors to White.



2. Also, use CTRL+A to select all objects in the view and change the appropriate layer, and set their color to White.

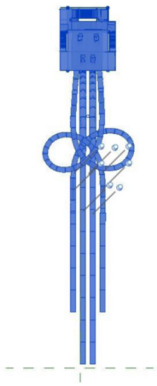


3. Save the DXF to the 2007 DXF format and click No when closing the file. Repeat the process for each DXF file saved for the layers.

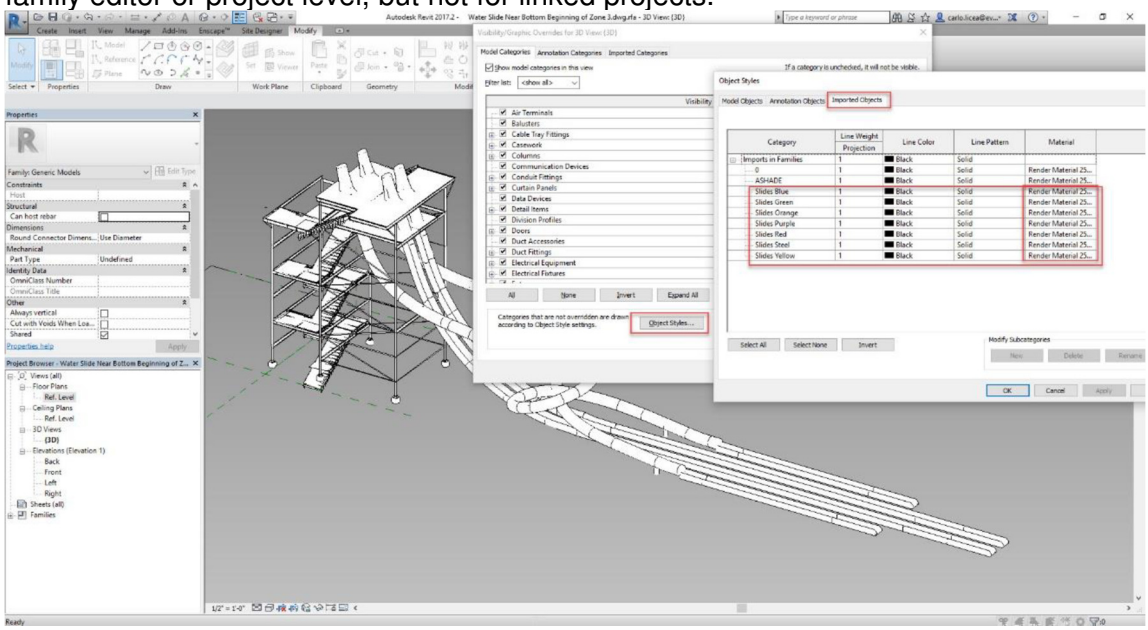


Creating the Revit Family

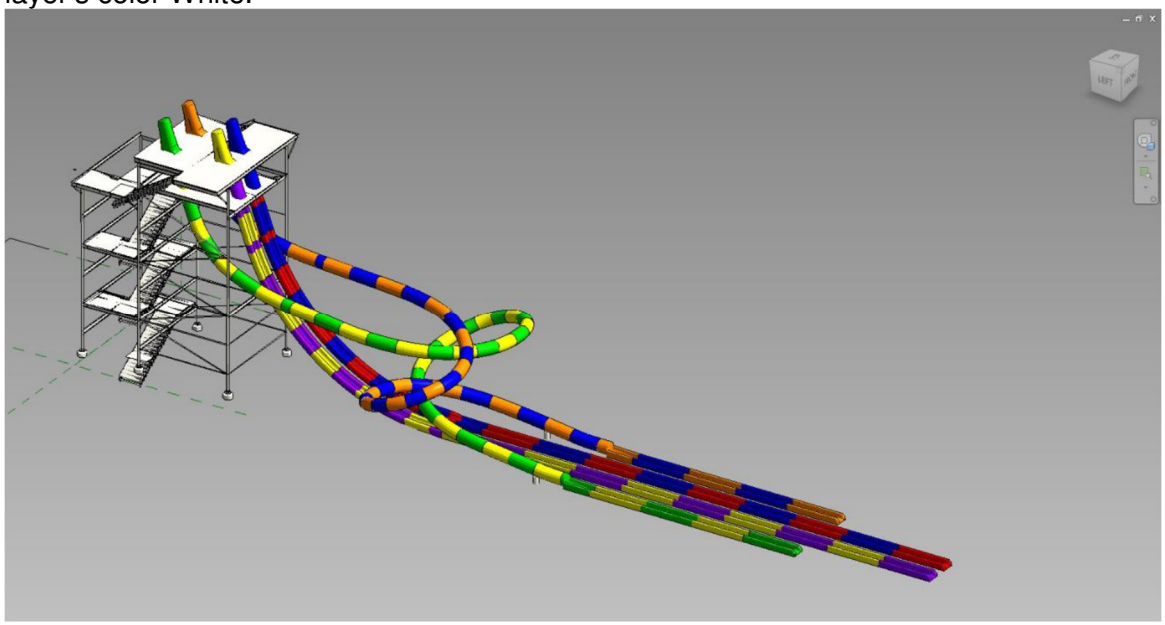
1. In Revit, start a new Generic Model family and import each DXF file. Since each object layer that was exported as a separate DXF will have a known origin, they should import oriented relative to the other DXF files. With all imports selected, unpin them and move them to a reference location near the origin point of the family file



2. Imported objects in Revit can only receive materials by Object Style overrides, and one is generated for each layer of the CAD file imported. From the Object Style overrides in the project and family editor environments, materials can be assigned, but only at the family editor or project level, but not for linked projects.



3. This long process of converting CAD geometry to DXF and into a Revit family will allow the geometry to be used in Revit without edges for every face and allow application of materials. If the process was done correctly, a family's geometry will color based on the material assigned to its Object Style subcategory. If it doesn't receive a material, then most likely something was missed in the AutoCAD steps, such as forgetting to make a layer's color White.



Chapter 3 – Moving Mountains

This next exercise was one we were recently contracted to do. We were responsible for again, not only for project set up and organization, but also for modeling the largest mountain and it's architecture on the site.

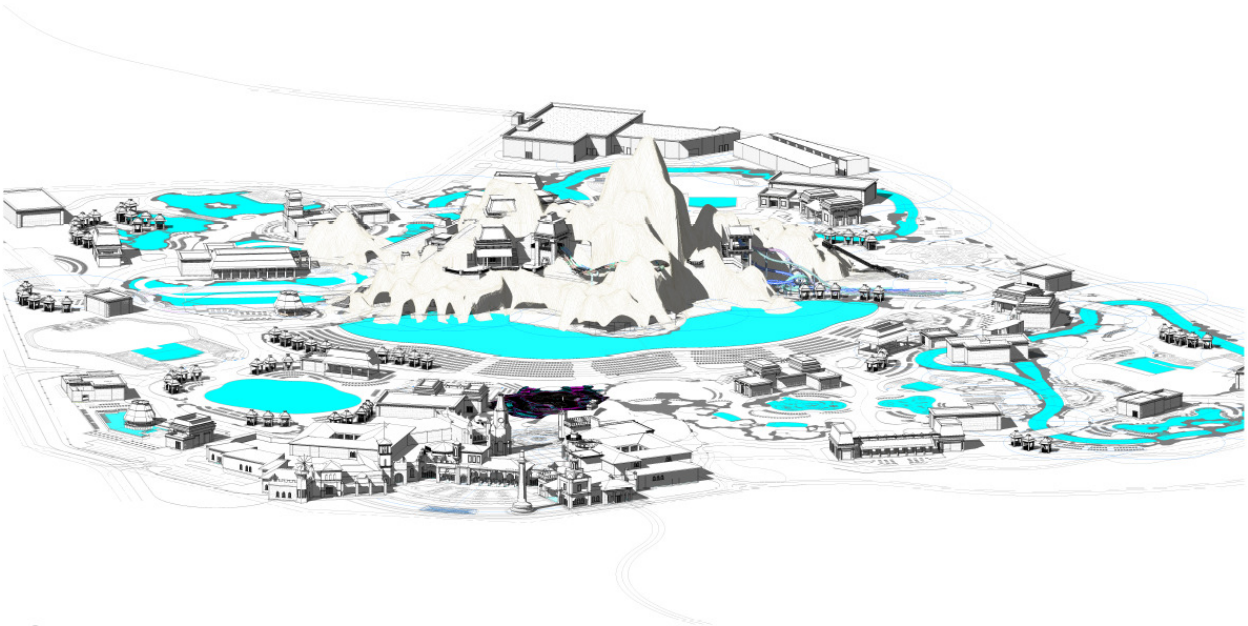
Project Organization

The project consisted of a massive site with multiple functions important to the guest experience. For this project we decided to link and document all the buildings in the site file. We ultimately treated the site as one master project and documented the project in the site file. This was a mistake. It caused a series of performance issues, and ultimately led to some corruption with linked views. A big lesson learned is to always document your buildings in their respective files.

Modeling a Mountain

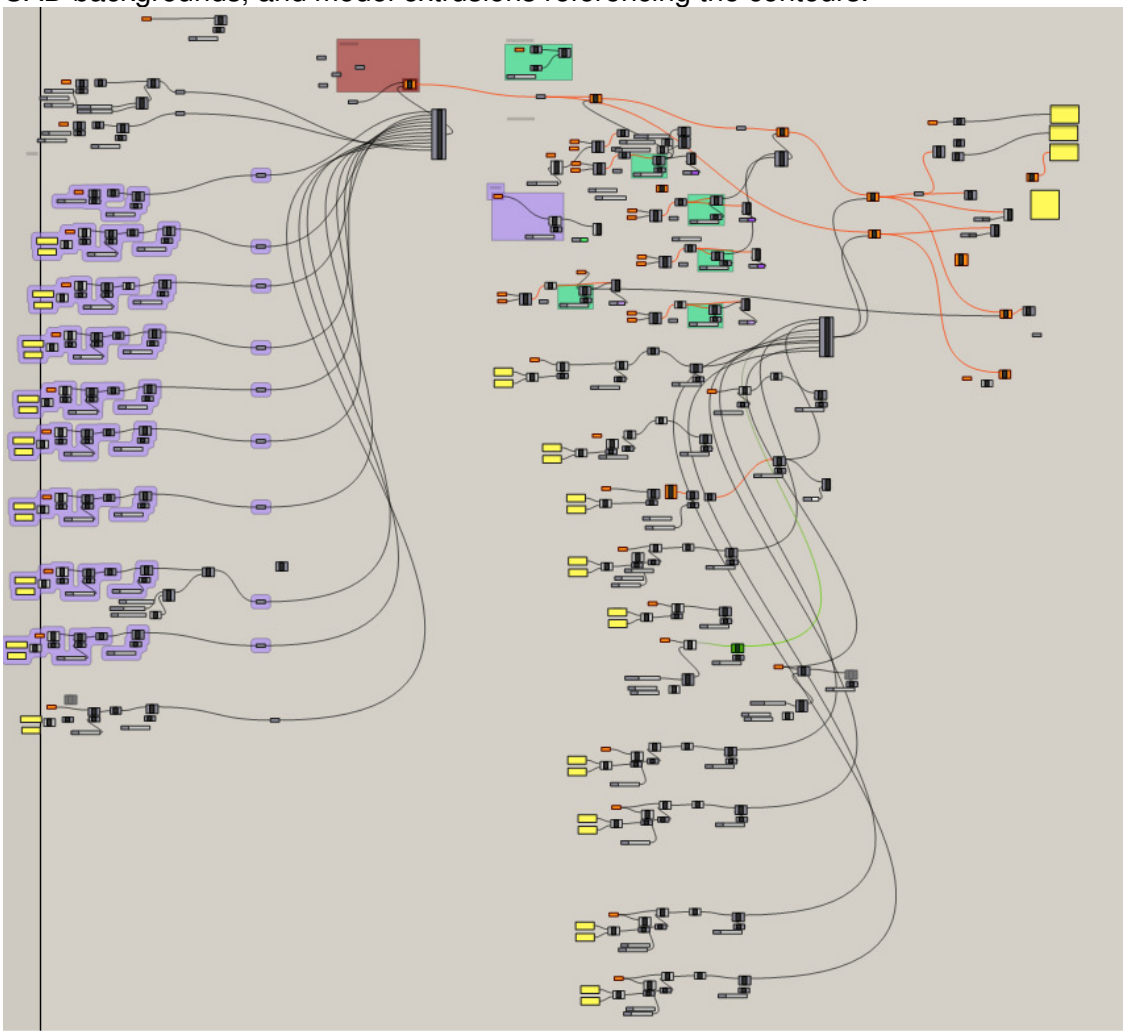
DTJ deliverables to BIM team for mountain design evolution:

A. Locate major elements and components
B. Conflict resolution / clash detection of rides with aquatic vault and other BOH programmatic elements (1M clear between ride & vault)
C. Paths and points of access, including required rise/run and queues

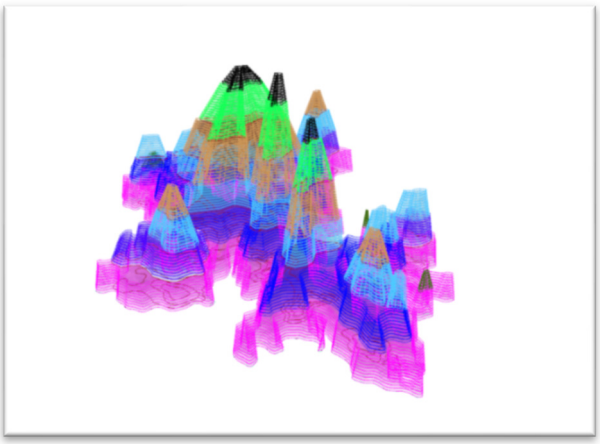


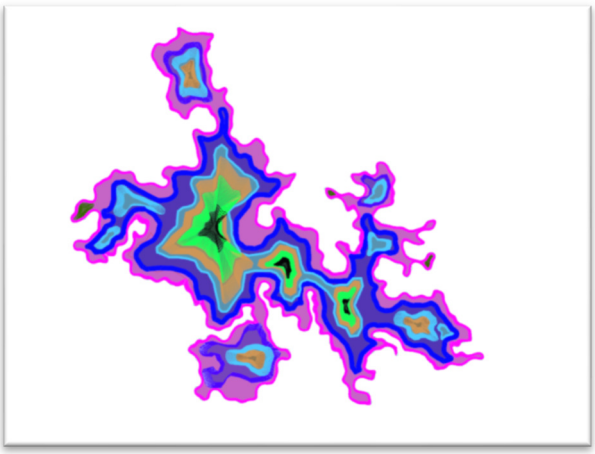
SITE AXONOMETRIC 场地轴测图

For this specific task, we were fed a series of AutoCAD backgrounds that we anticipated might be changing. Given the dynamic backgrounds, we decided to use grasshopper to reference the CAD backgrounds, and model extrusions referencing the contours.

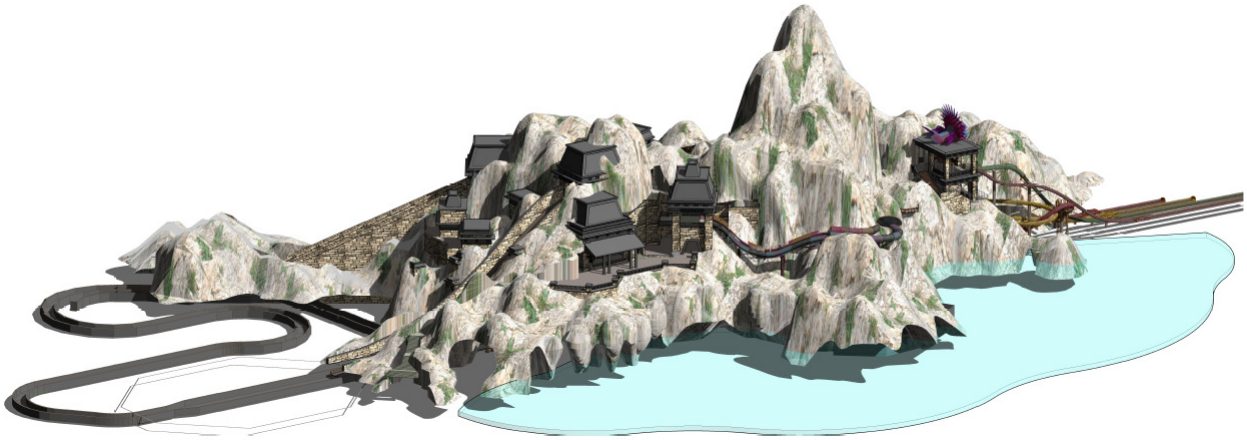


We used different colors to represent different tiers of elevation and contours we were referencing. It was a great way to graphically see different elevations. It also looked like a Gnarly bacteria in petri dish when looking in plan.



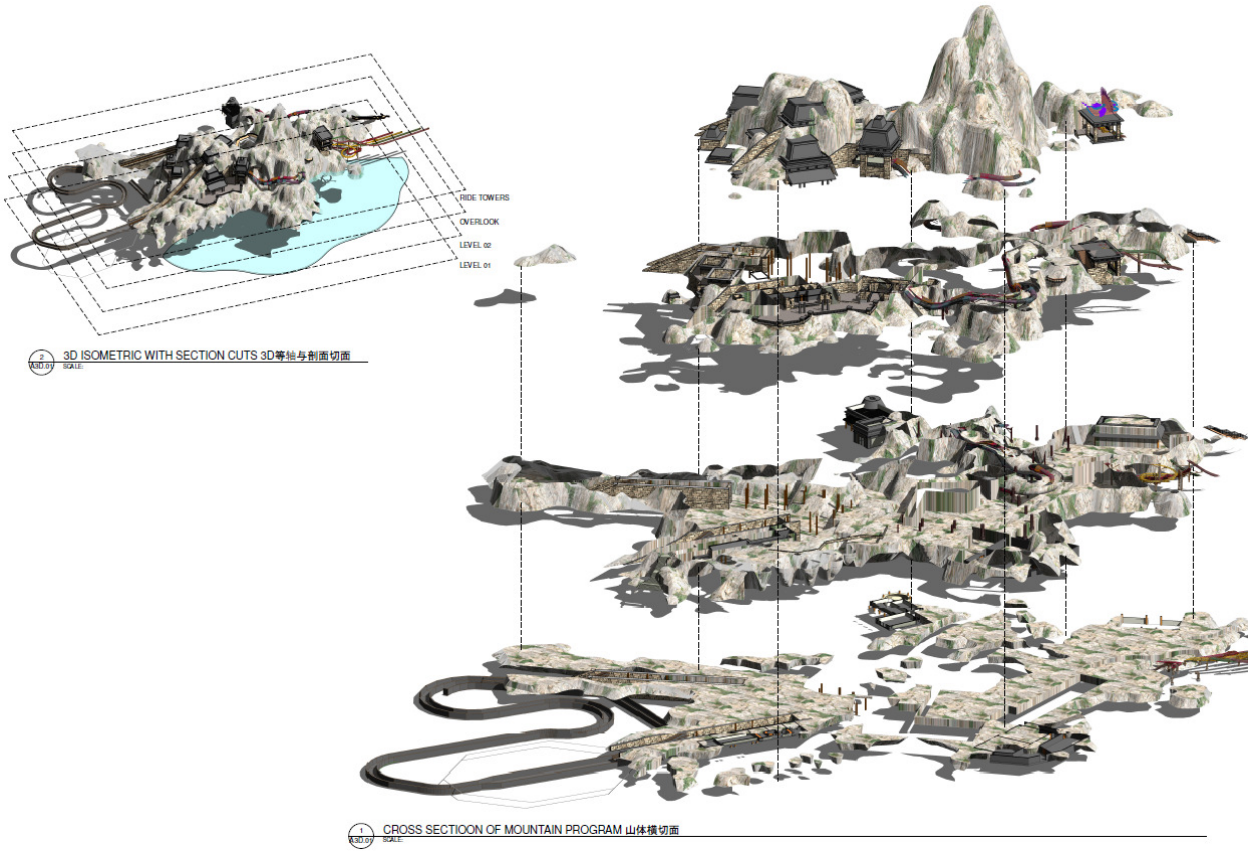


We applied a bitmap material to the 3D mountain to illustrate moss, rocks, etc. to help add another detail of realism to the mountain.



The mountain had a series of penetrations for rides, waterfall features, and caves. We had to coordinate egress, ride clearances, and mechanical rooms inside of the massive mountain file. We additionally modeled food and beverage buildings, ride towers, pathways, and caves to help us coordinate various complex 3d elements.

What really helped us communicate function of the mountain was bringing it into Revit, and creating a series of section boxes, and diagrammatically laying these out for our documentation set.



Conclusion

Overall, there were quite a few lessons learned through out these projects.

1. Find ways to model elements “light weight” and keep the files lean
2. Document buildings in their respective files/zones. Not in the site file. Caveat would be elements that need to exist in a master file such as programmatic information or an overall site plan.
3. Use multiple software platforms synergistically to remove complex vertices
4. Leverage the right tool for the right job to accomplish specific tasks, such as parametric model, 3D coordination, and BIM Documentation