# AB2374 - Is Beauty Only Skin Deep? Computational Approach to Design of Parametric Exteriors in Autodesk® Revit®


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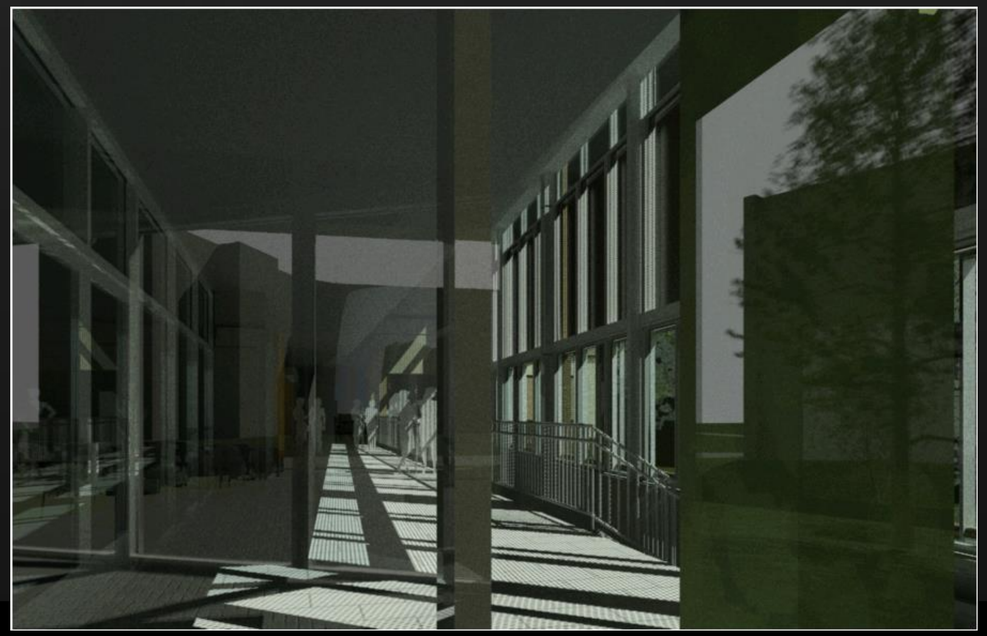
# Learning Objectives – Case Studies

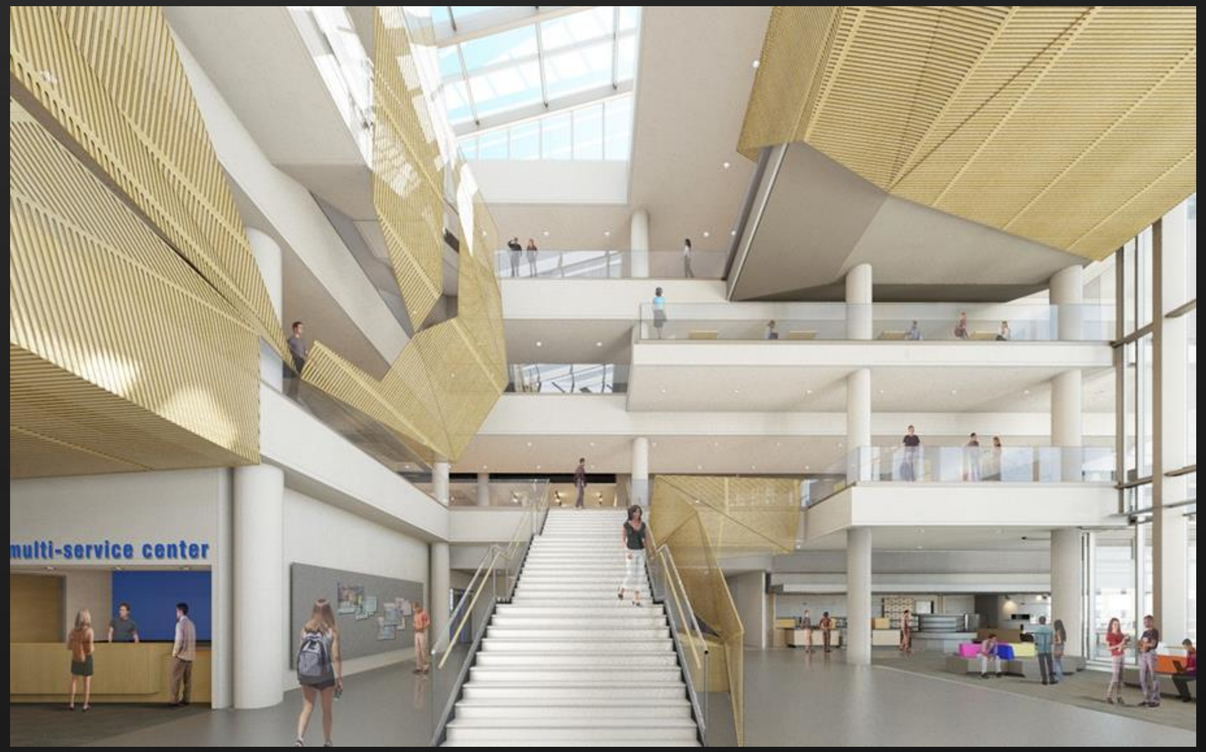
At the end of this class, you will be able to:

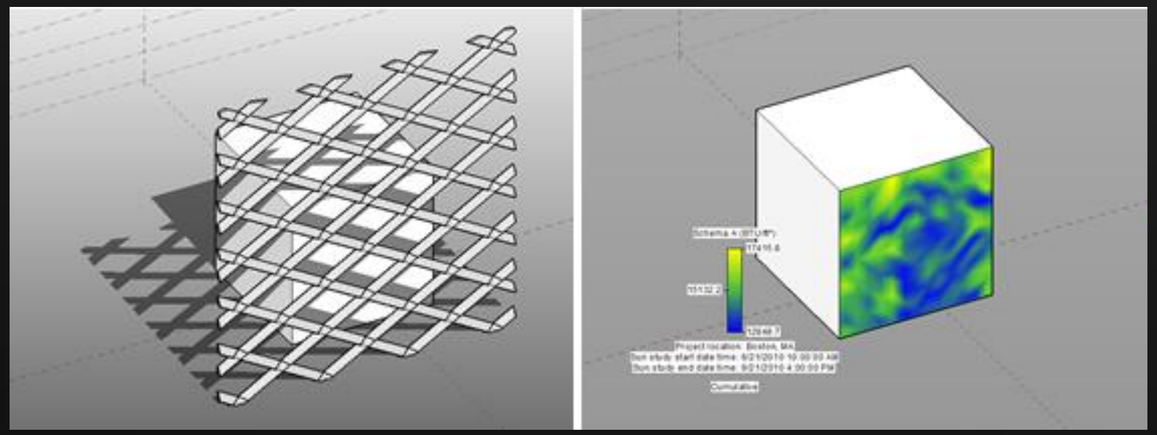
- Apply your knowledge of shared parameters to streamline design and documentation process.
- Create patterns and panels based on true hexagon with infinite variations of design
- Use material parameters for visual studies
- Understand  advantages and shortcomings of different approaches to modeling of complex structures: from traditional modeling techniques to various scripting and latest Revit tools
- Use adaptive components to help you build and refine your design
- Understand how to build families for rapid design iteration and solar radiation analysis in Vasari

# Case studies



# Case studies

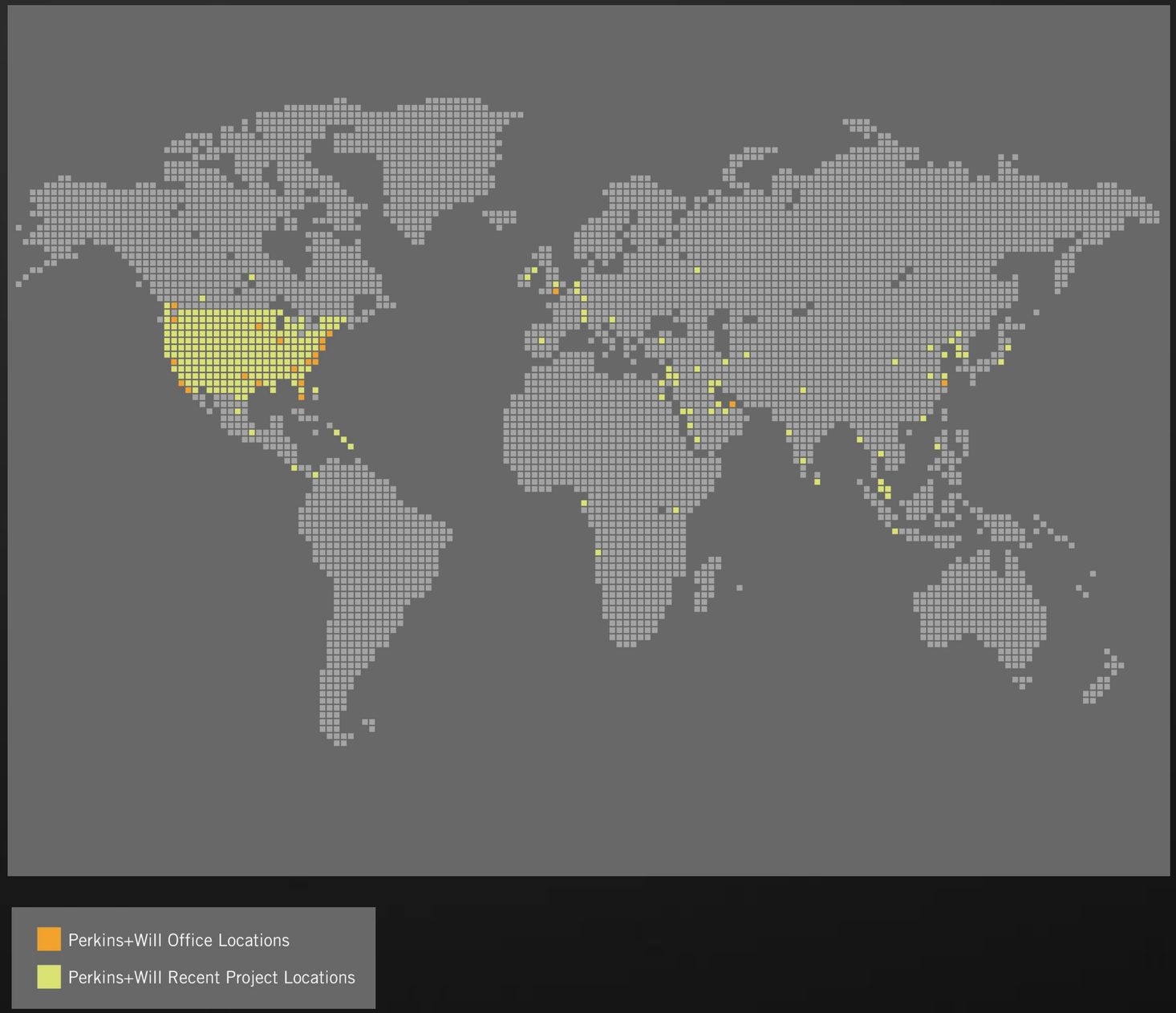


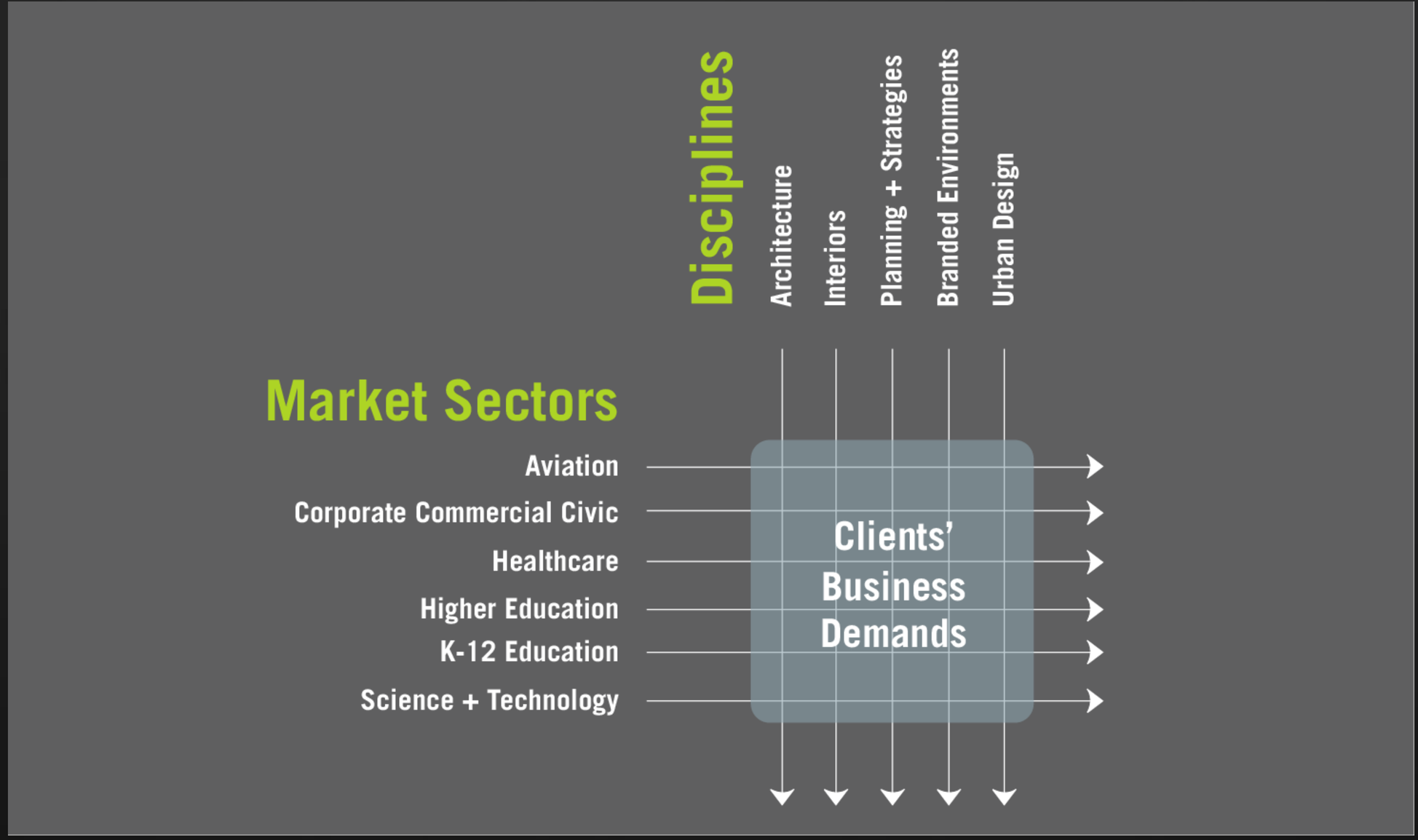



# Team

# Office Locations

**23 offices worldwide:**
Atlanta, Boston, Charlotte, Chicago, Dallas, Dubai, Hartford, Houston, London, Los Angeles, Miami, Minneapolis, New York, Orlando, Philadelphia, Research Triangle Park, San Diego, San Francisco, Seattle, Shanghai, Toronto, Vancouver, Washington DC, Sao Paulo.






Perkins+Will brings design expertise to six Market Sectors with professionals in five disciplines

# Market Sectors

**AVIATION + TRANSIT**

**COMMERCIAL + CORPORATE + CIVIC**

**HEALTHCARE**

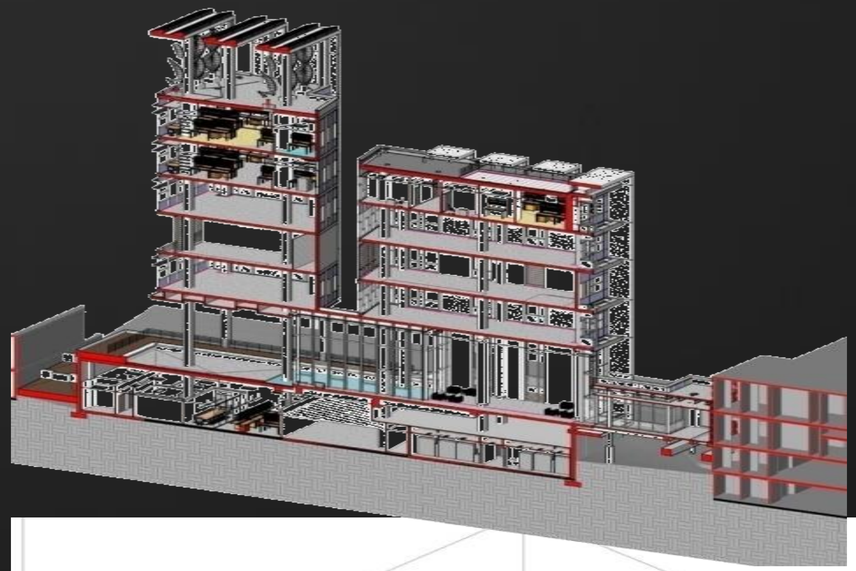
**HIGHER EDUCATION**

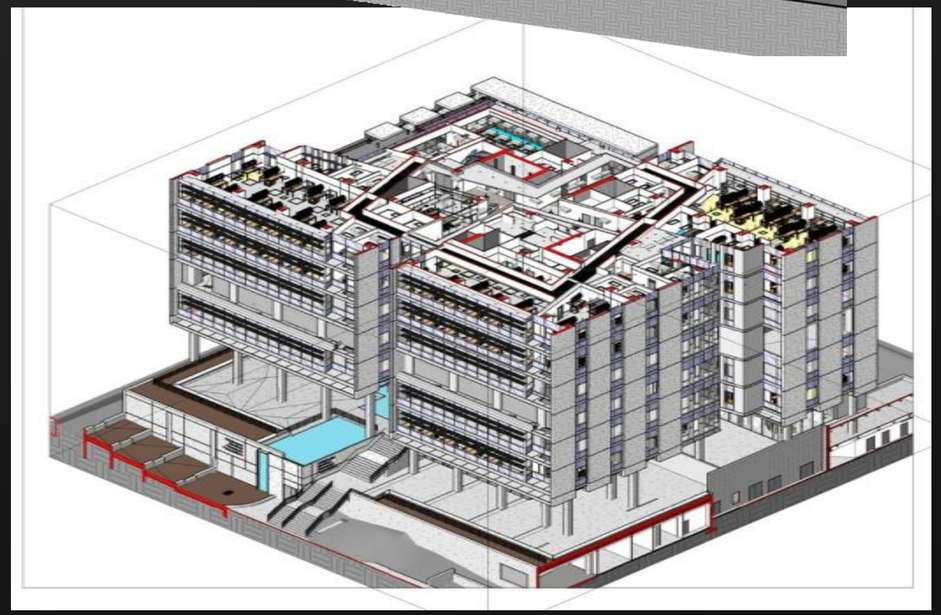
**K – 12 EDUCATION**

**SCIENCE + TECHNOLOGY**

# P+W BIM Implementation

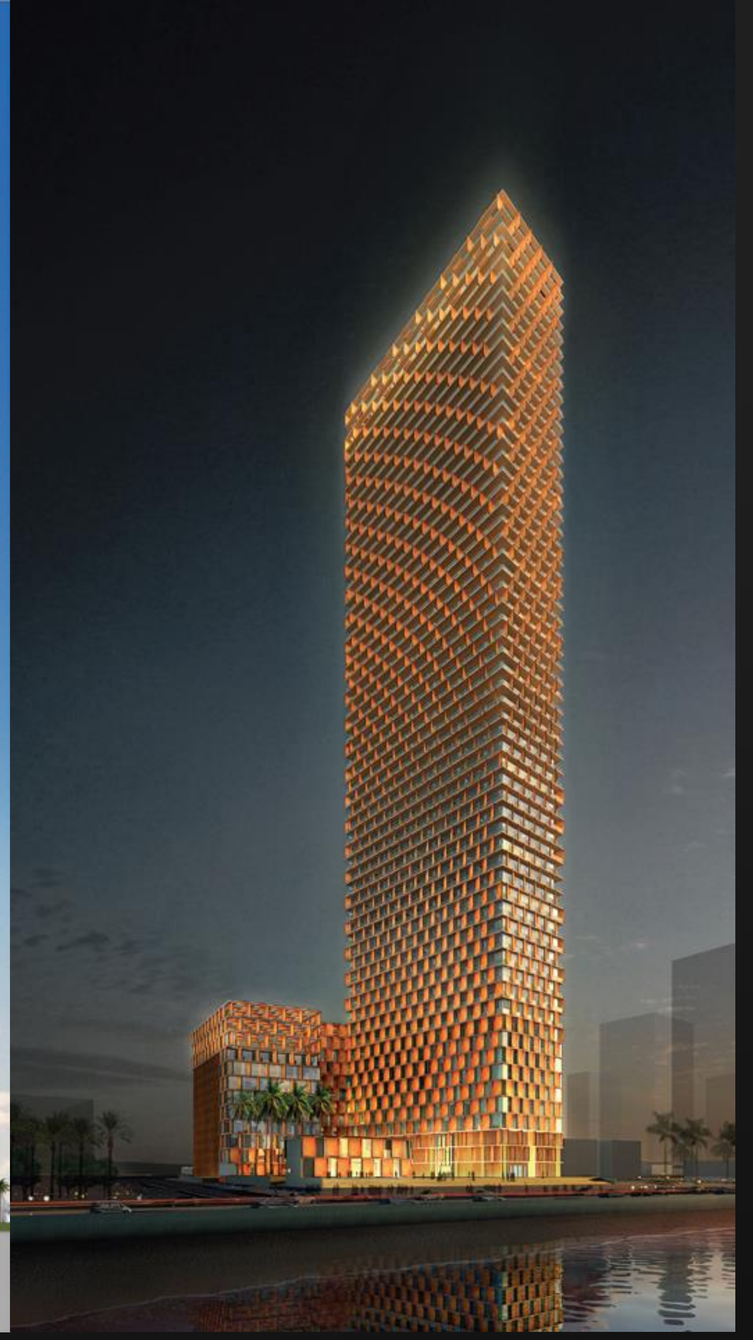
- Began in 2004
- Revit Architecture is our Core BIM Application.
- Team of Design Applications Professionals supporting projects internally.
- 850+ Staff trained in-house
- Over 250 projects are completed or underway



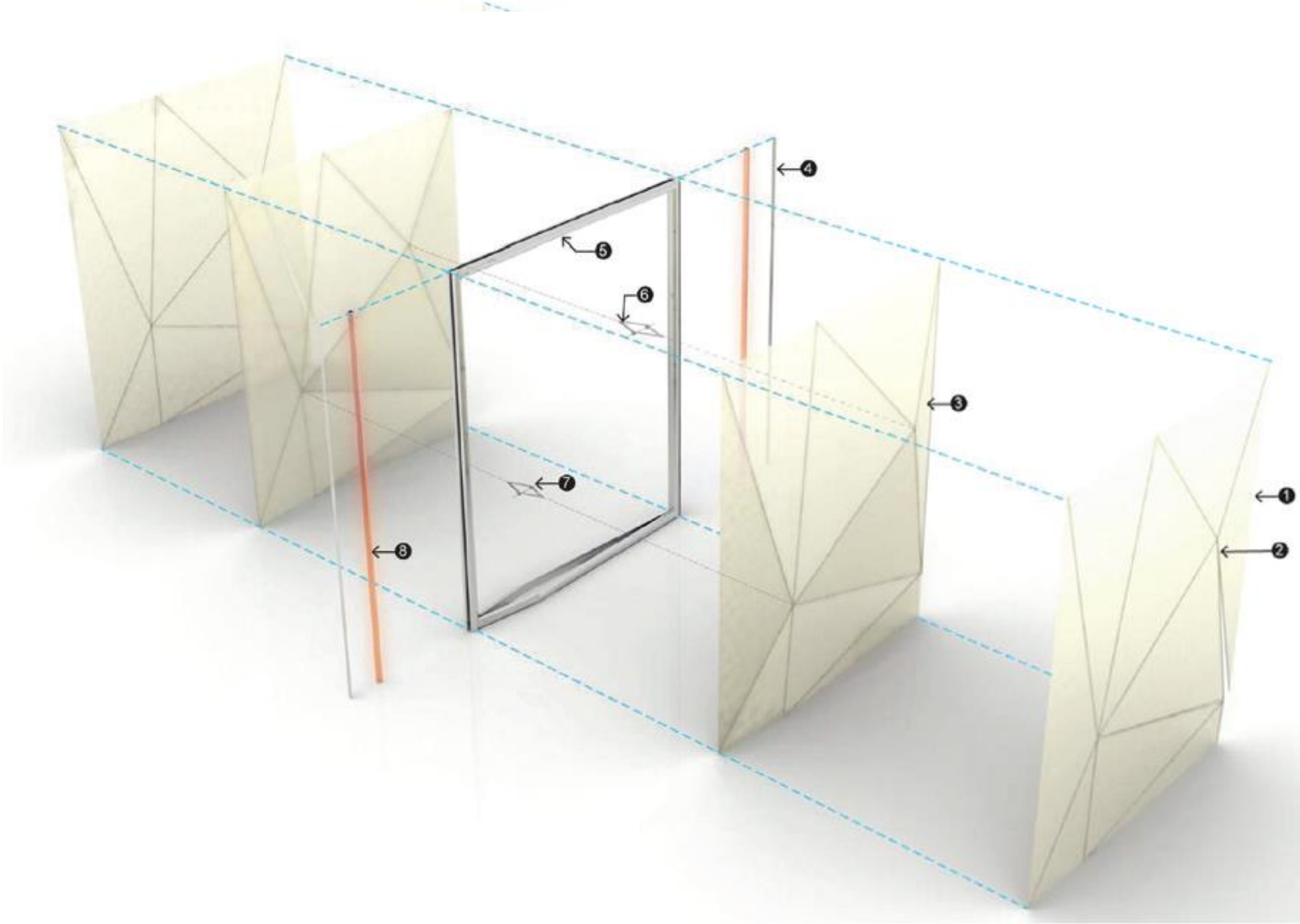


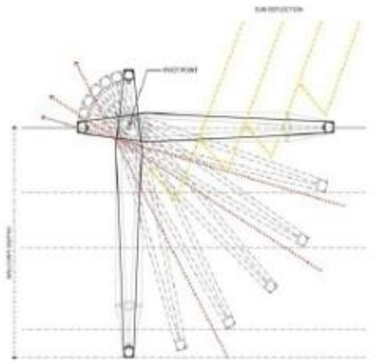
# Smooth Sailing

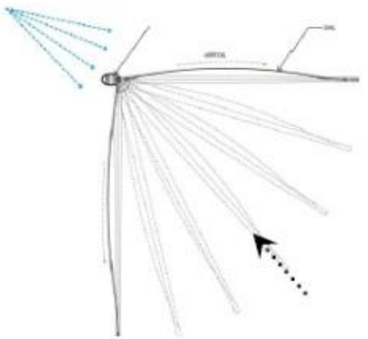
# KEMPINSKI HOTEL AND RESIDENCES JEDDAH,  KSA

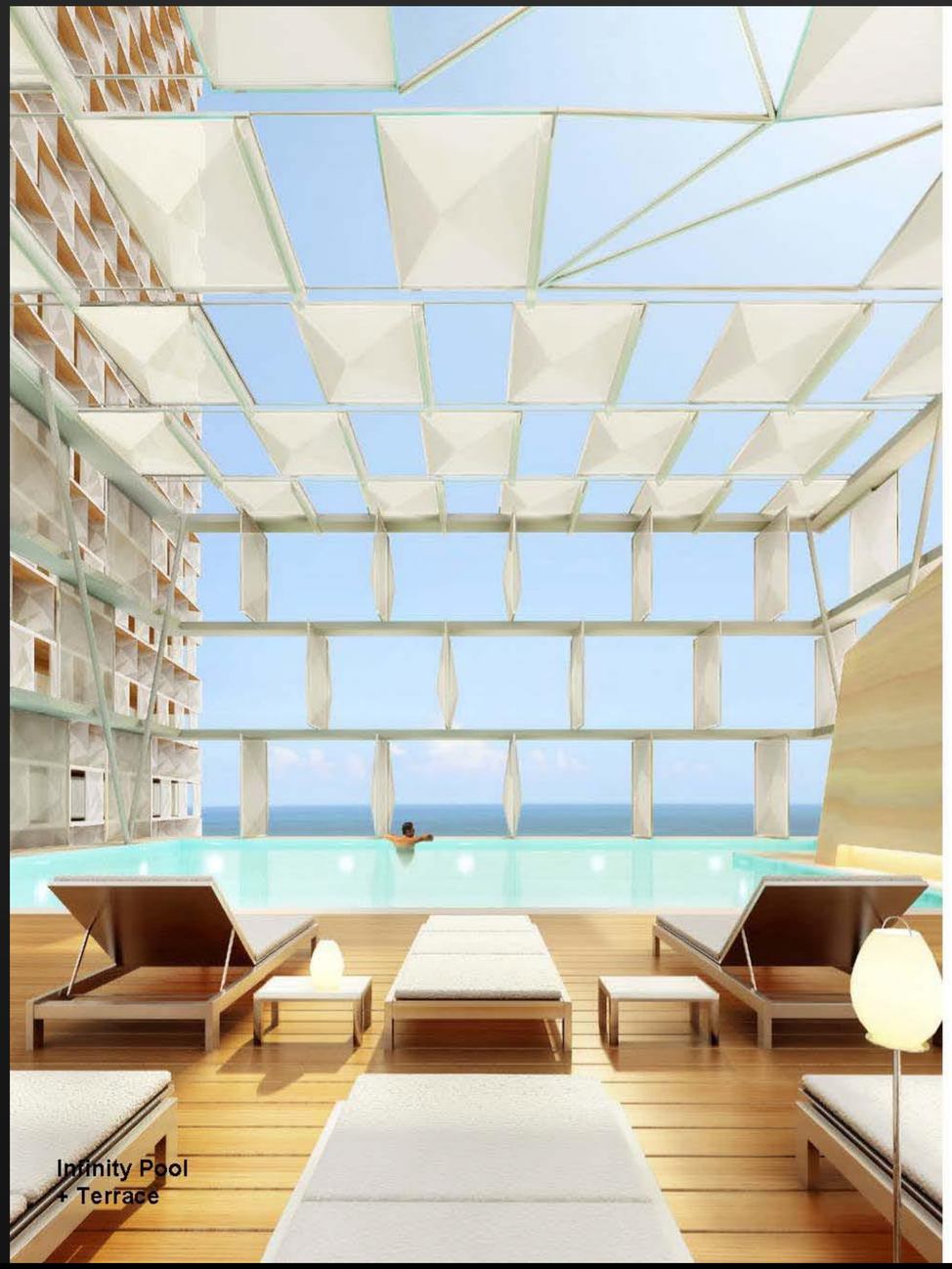


# Kempinski Sails

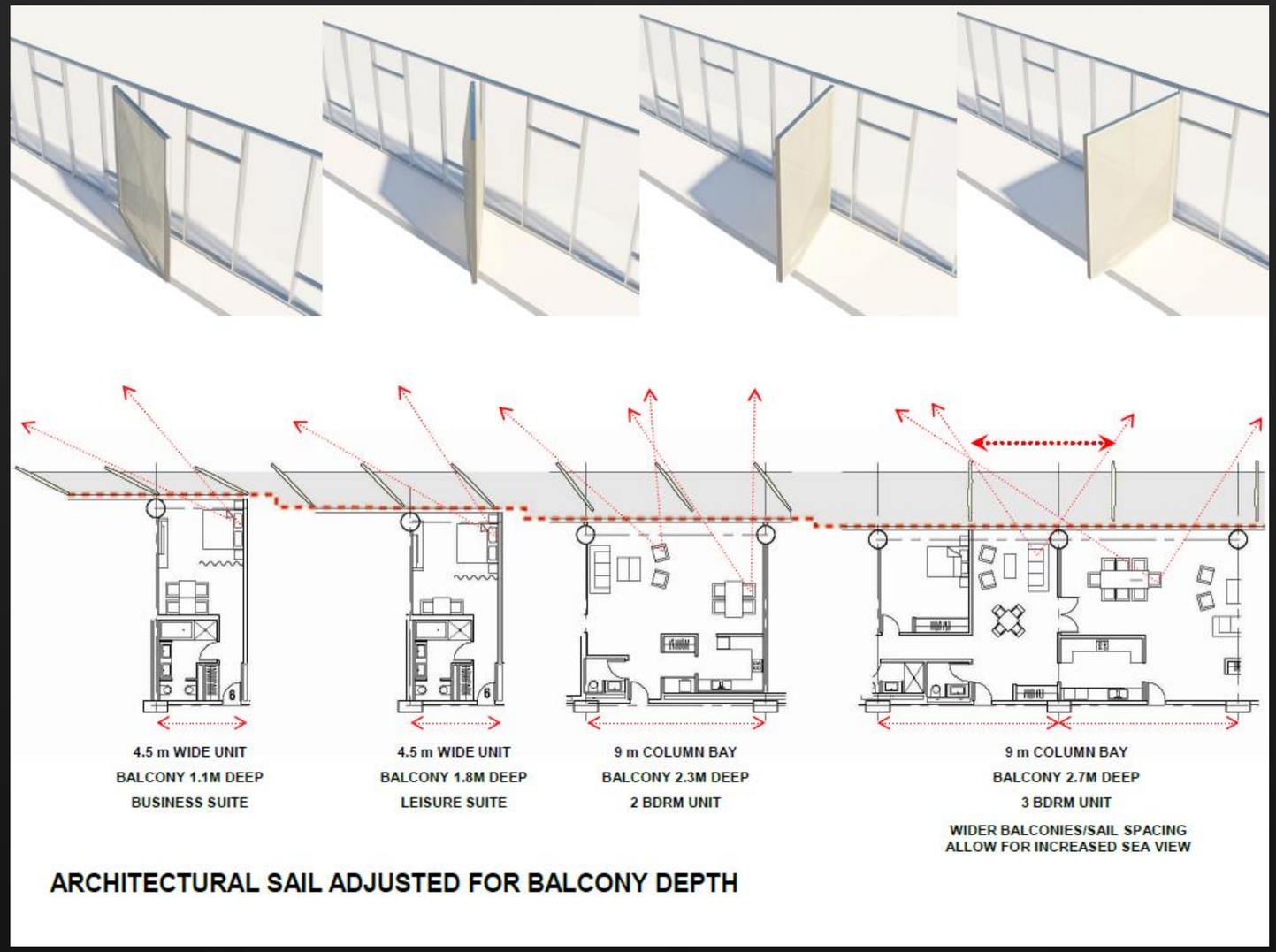




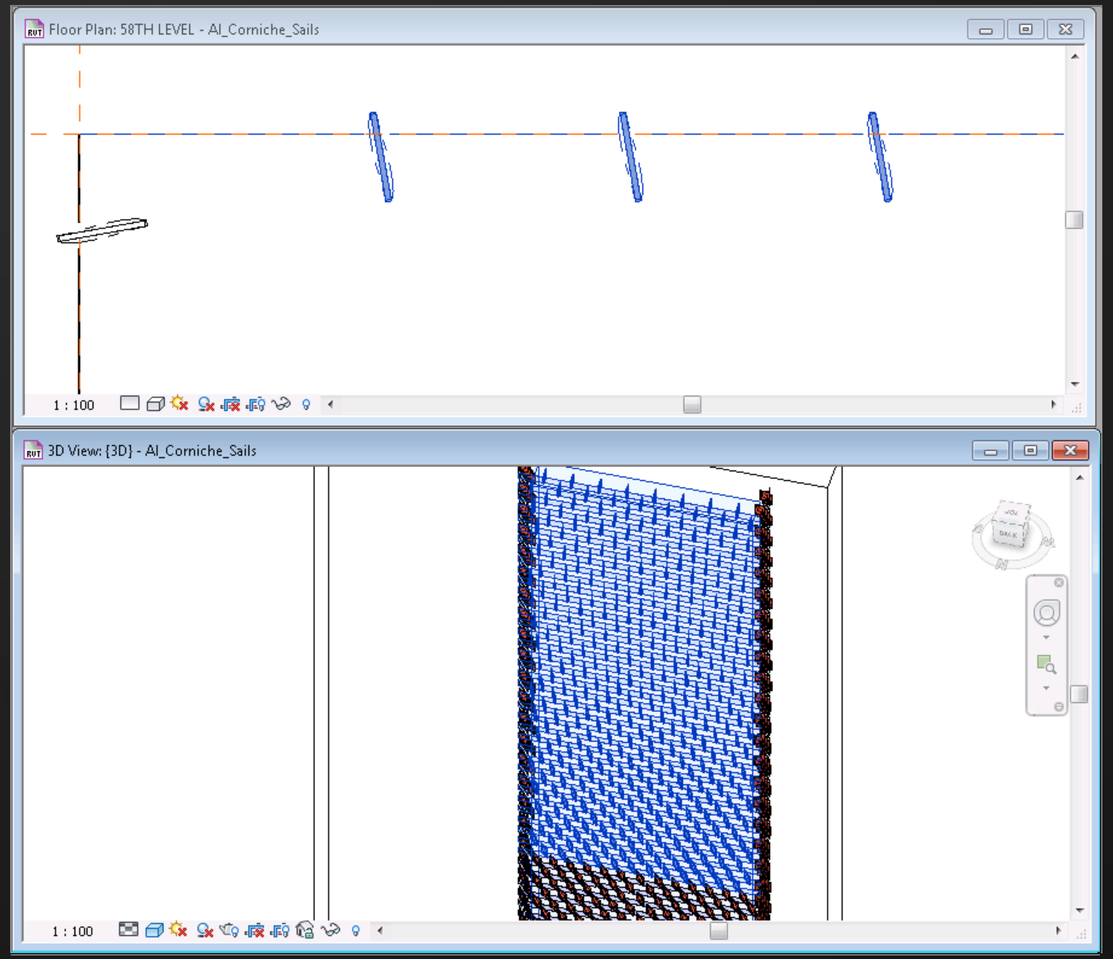



# Kempinski Sails



# Kempinski Sails

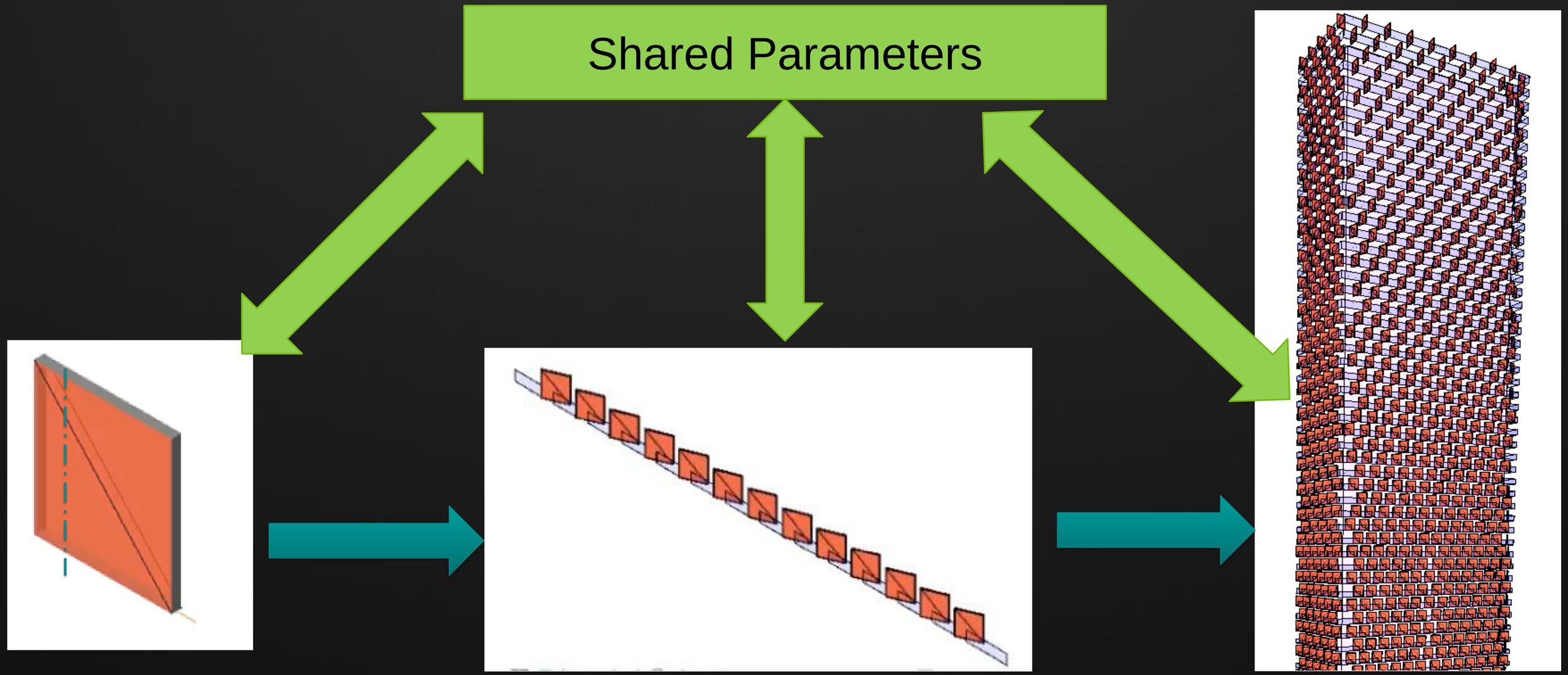
- Each sail is attached at a pivot point. Pivot points are co-linear.
- Zone 1- 6 each have fixed angle and spacing
- Zone 7- angle and spacing increments on each floor.
- Checkerboard effect
- Sail dimensions may change overall and between floors
- Overall floor count may change




## Parameters for ZONES

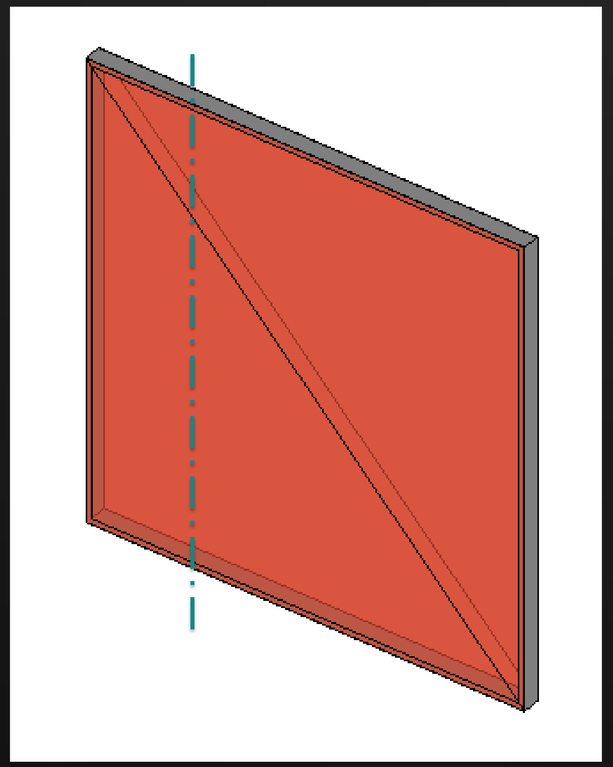
| Sails Array angles-ALL | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | TA1 | A2 | TA2 | A3 | TA3 | A4 | TA4 | A5 | TA5 | A6 | TA6 | TAVar |
| 0.00° | 4 | 10.00° | 8 | 22.50° | 17 | 32.50° | 23 | 35.00° | 26 | 38.00° | 29 | 66 |

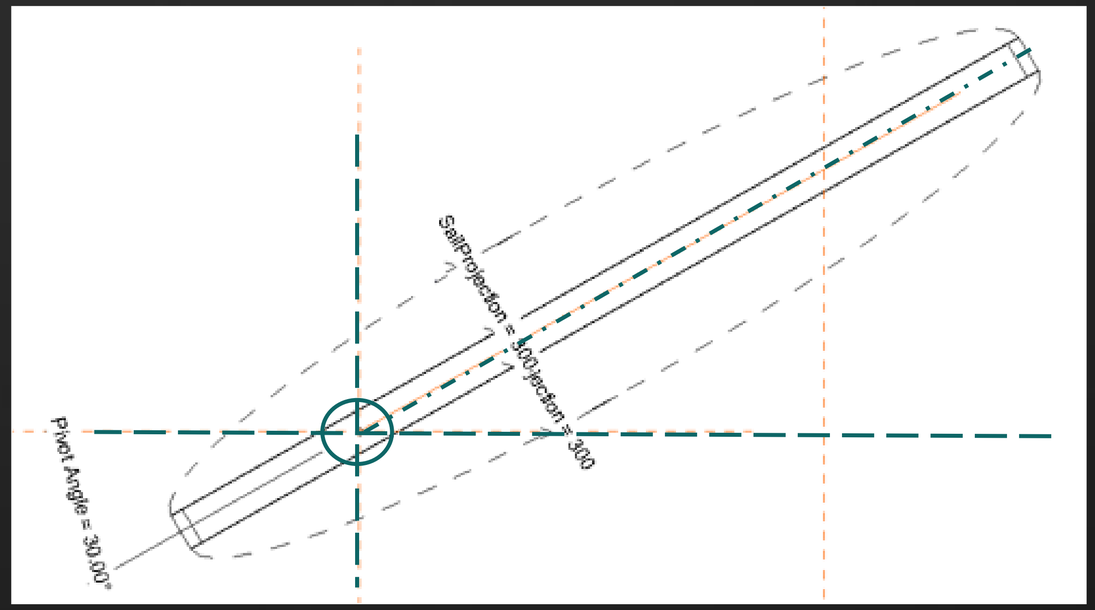
# Kempinski Sails: Shared Parameters



# Kempinski Sails

## All parameters are shared



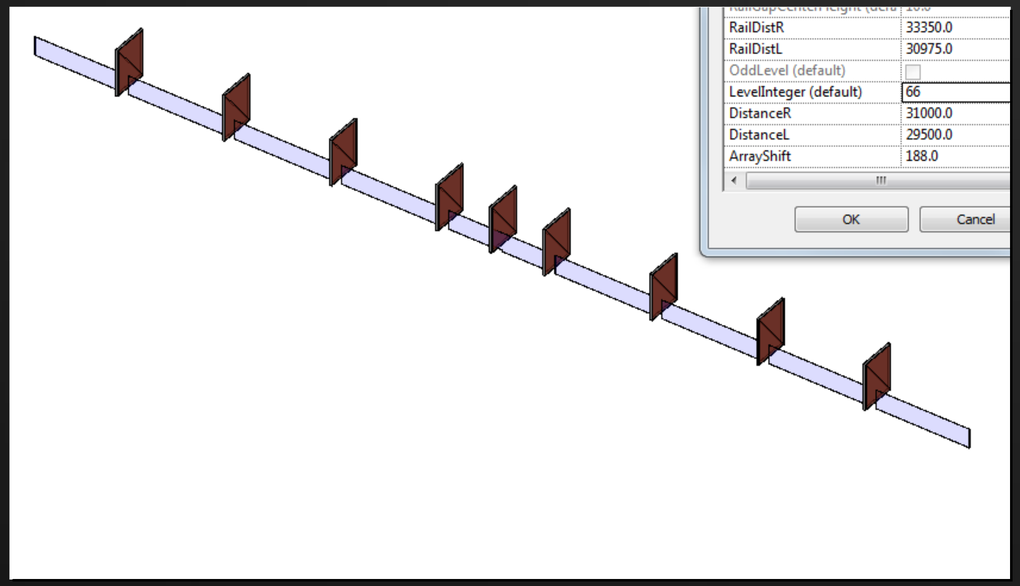



| Parameter | Value | Formula | Lock |
|---|---|---|---|
| **Constraints** | | | |
| Level (default) | 0 | = | ☑ |
| **Dimensions** | | | |
| Width2 | 800.0 | = | ☑ |
| Width1 (default) | 3000.0 | = | ☑ |
| Thickness | 150.0 | = | ☑ |
| SailProjection | 300.0 | = | ☐ |
| SailHeight | 4000.0 | = | ☐ |
| Pivot Angle (default) | 30.000° | = | ☑ |

# Sail Array Families

One parameter rules them all

66

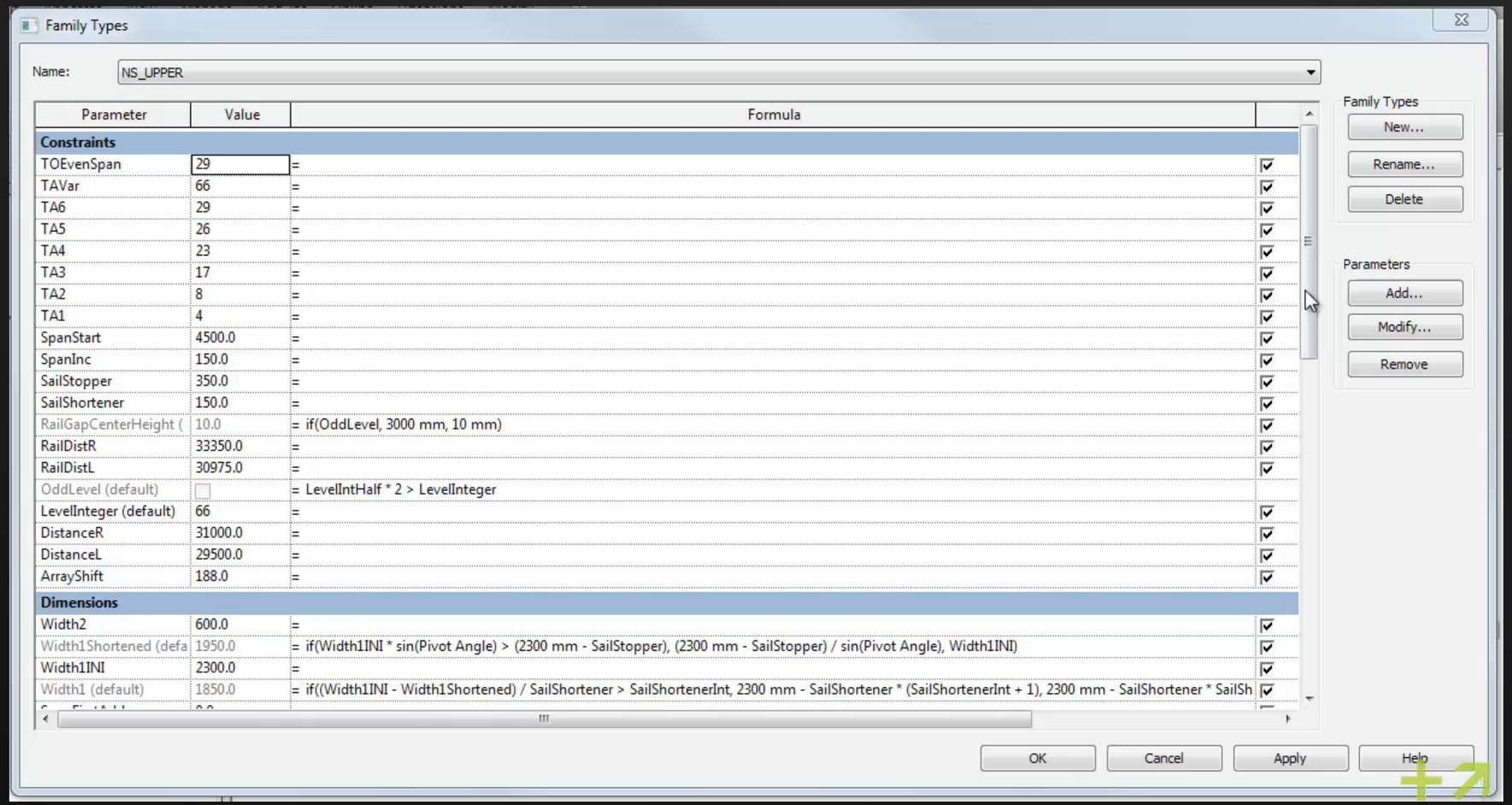


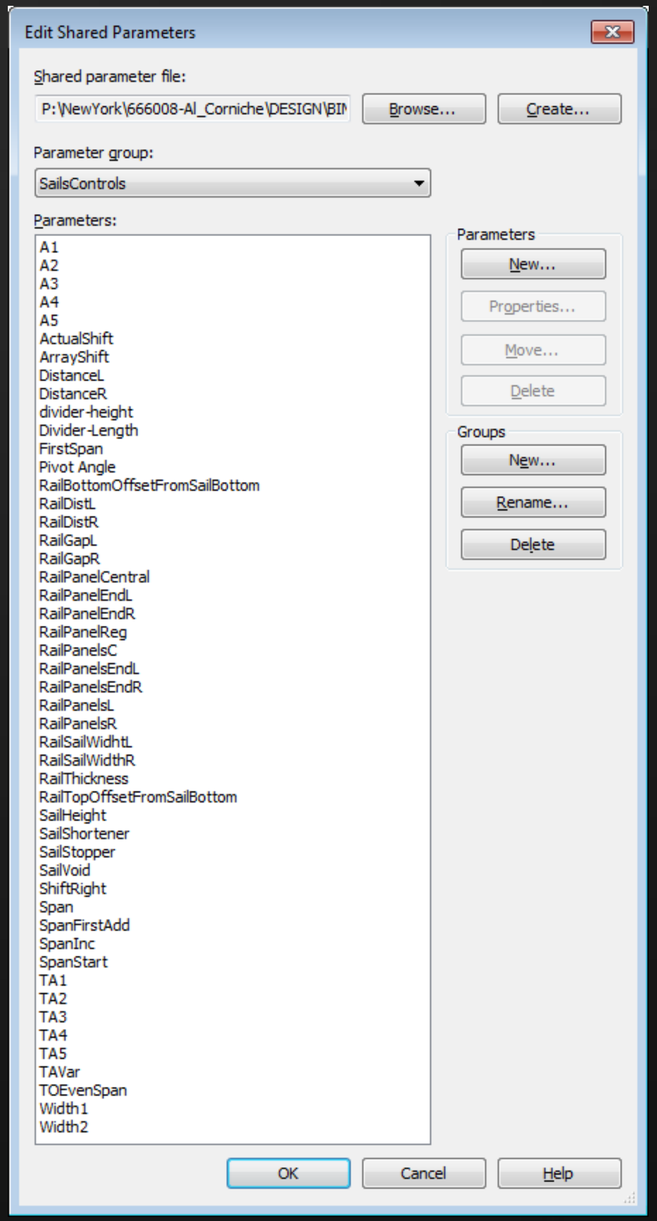

| Sail Panels Schedule | |
|---|---|
| Levels | LevelInteger |
| 1ST LEVEL | 1 |
| 2ND LEVEL | 2 |
| 3RD LEVEL | 3 |
| 4TH LEVEL | 4 |
| 5TH LEVEL | 5 |
| 6TH LEVEL | 6 |
| 7TH LEVEL | 7 |
| 8TH LEVEL | 8 |
| 9TH LEVEL | 9 |

- Two families (long façade and short façade)
- Place on the first level, then paste aligned to other levels
- Level integer is an instance parameter. Easy to assign using schedule
- Everything else is calculated

# Sail Array Families

## 54 shared parameters used in 34 formulas

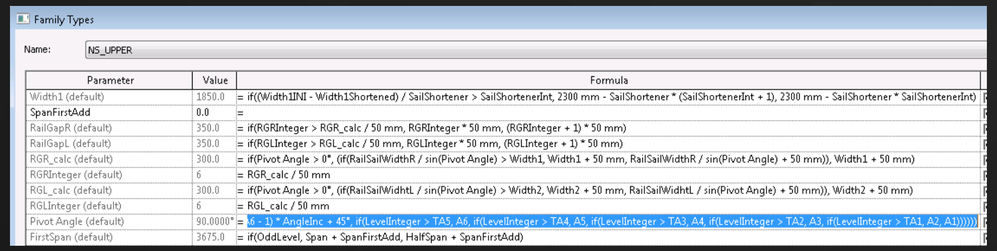


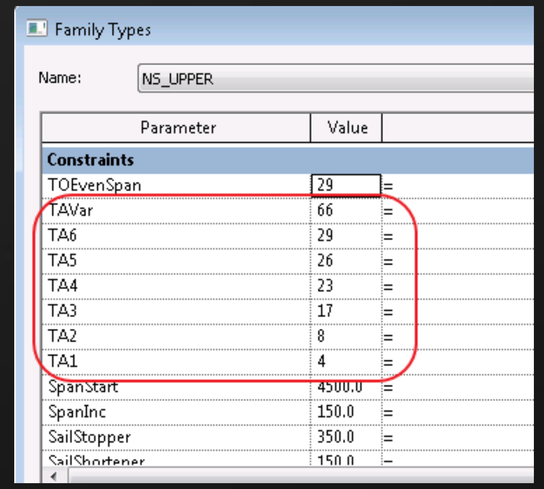
# Sail Array Families

## Controlling pivot angle: shared parameter calculated in SailArray passed to Sail

| Sails Array angles-ALL | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | TA1 | A2 | TA2 | A3 | TA3 | A4 | TA4 | A5 | TA5 | A6 | TA6 | TAVar |
| 0.00° | 4 | 10.00° | 8 | 22.50° | 17 | 32.50° | 23 | 35.00° | 26 | 38.00° | 29 | 66 |




AngleInc=(90°-A6)/(TAVar-TA6)




# IF(condition, true, false)

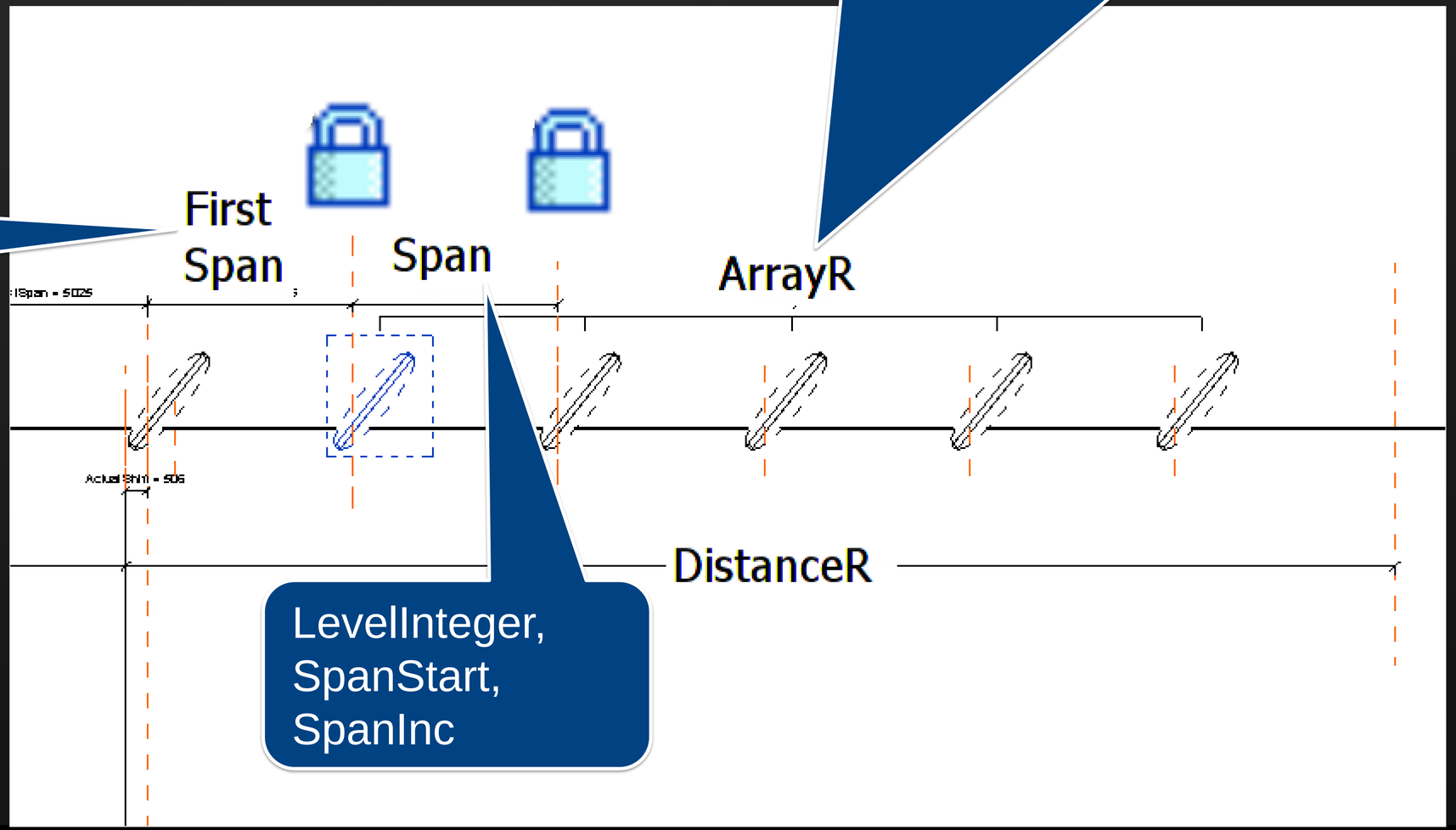
PivotAngle=IF(LevelInteger > TA6, (LevelInteger - TA6 - 1) * AngleInc + A6,
IF(LevelInteger > TA5, A6,
IF(LevelInteger > TA4, A5,
IF(LevelInteger > TA3, A4,
IF(LevelInteger > TA2, A3,
IF(LevelInteger > TA1, A2, A1))))))

# Sail Array Family

Controlling Sail arrays number and locations

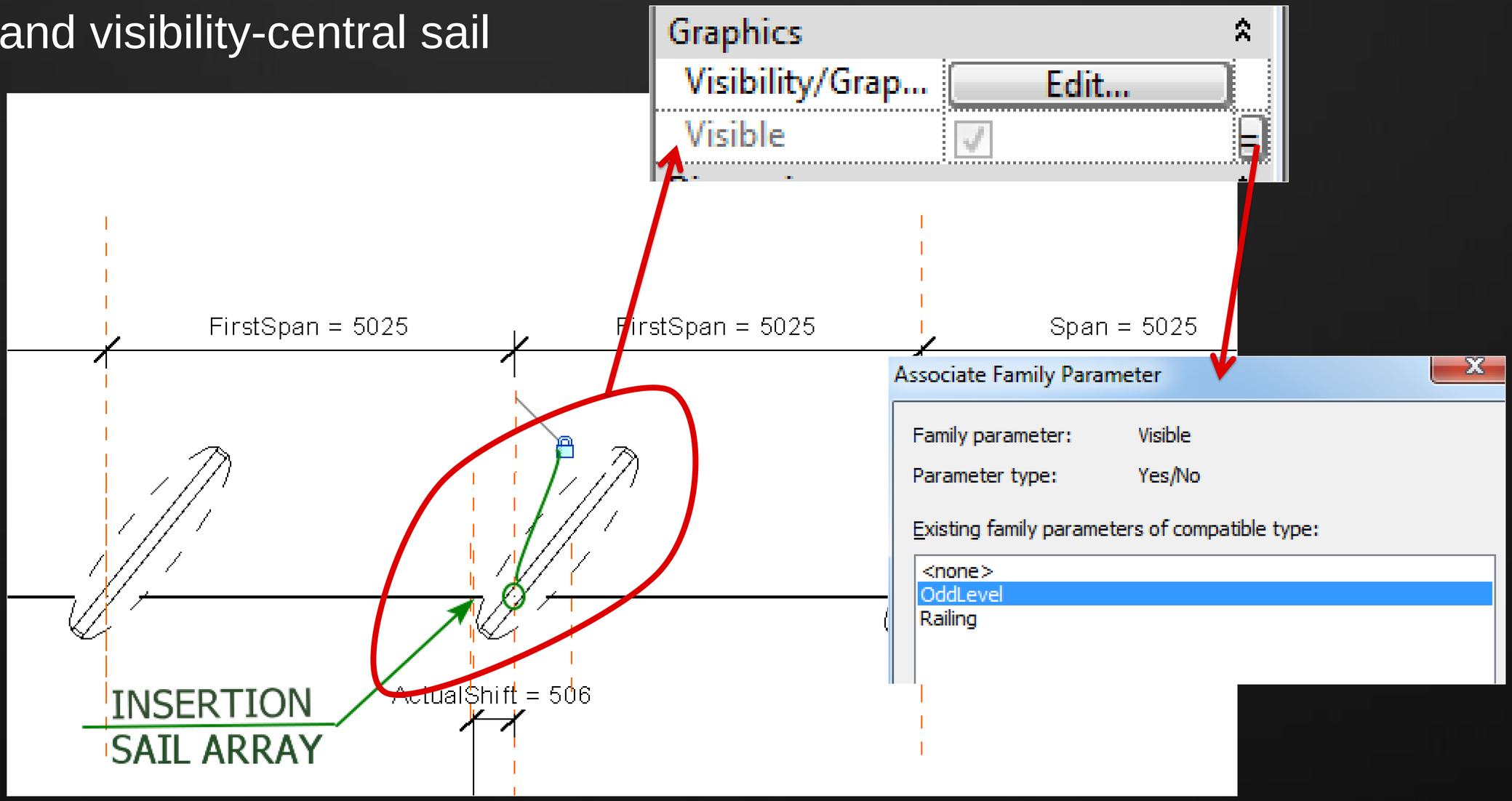
ROUNDDOWN
(DistanceR - FirstSpan - ActualShift – Width1 * cos(Pivot Angle)) / Span

IF(OddLevel, Span, Span/2)

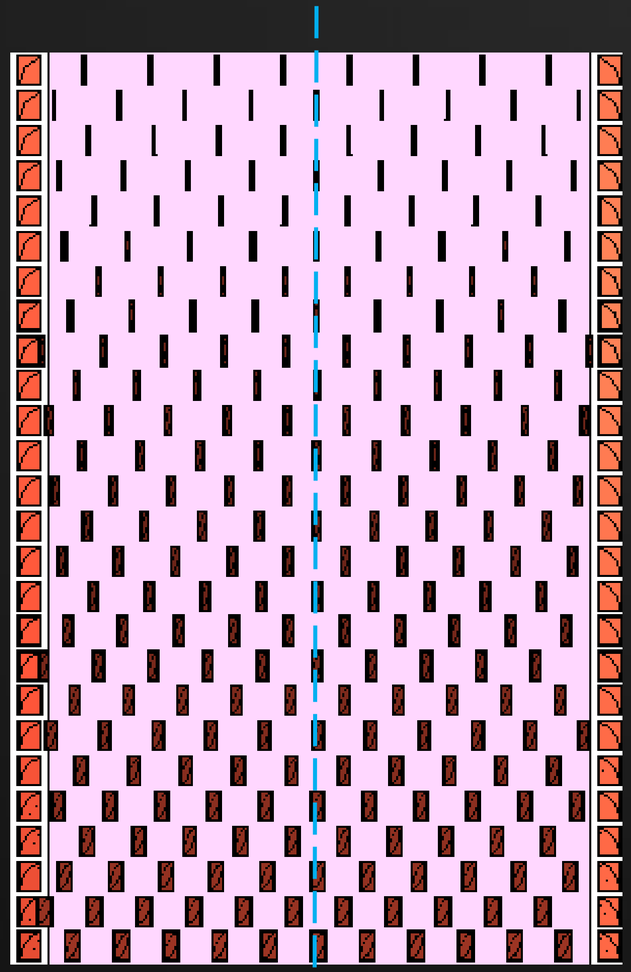


# Sail Array Family

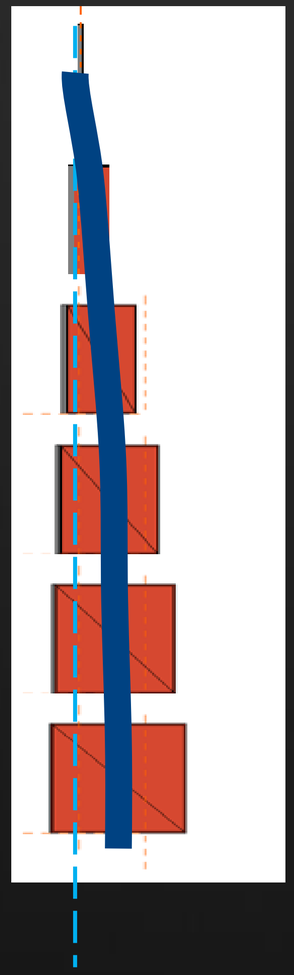
## Location and visibility-central sail



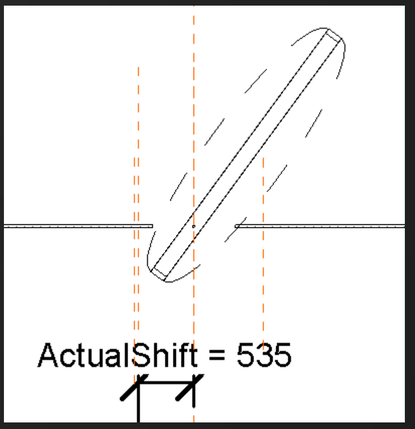
# Sail Array Families

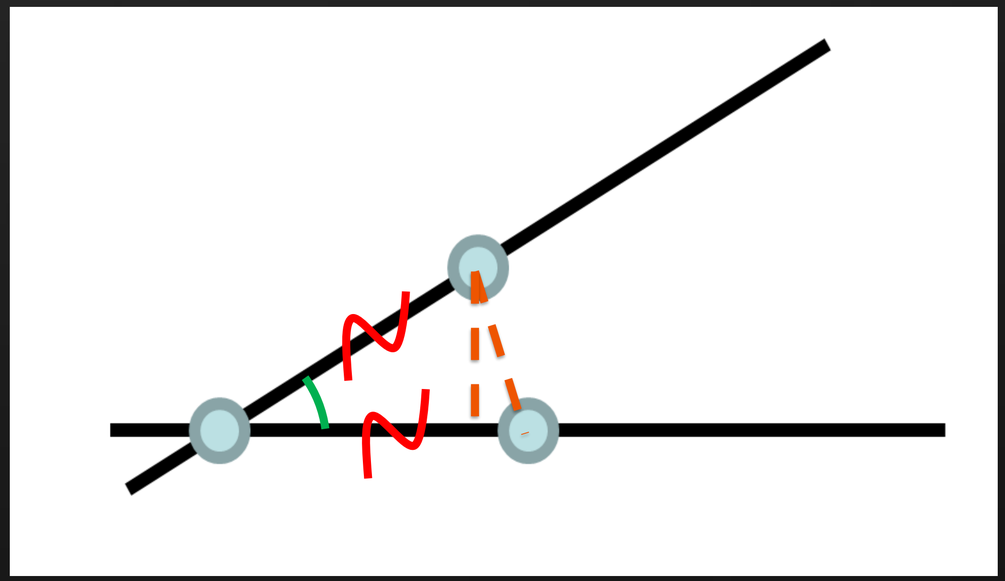


Elevation



## Do not slouch!



ActualShift = (Width1 - (Width1 + Width2) / 2) –(Width1 - (Width1 + Width2) / 2)*cos(Pivot Angle)

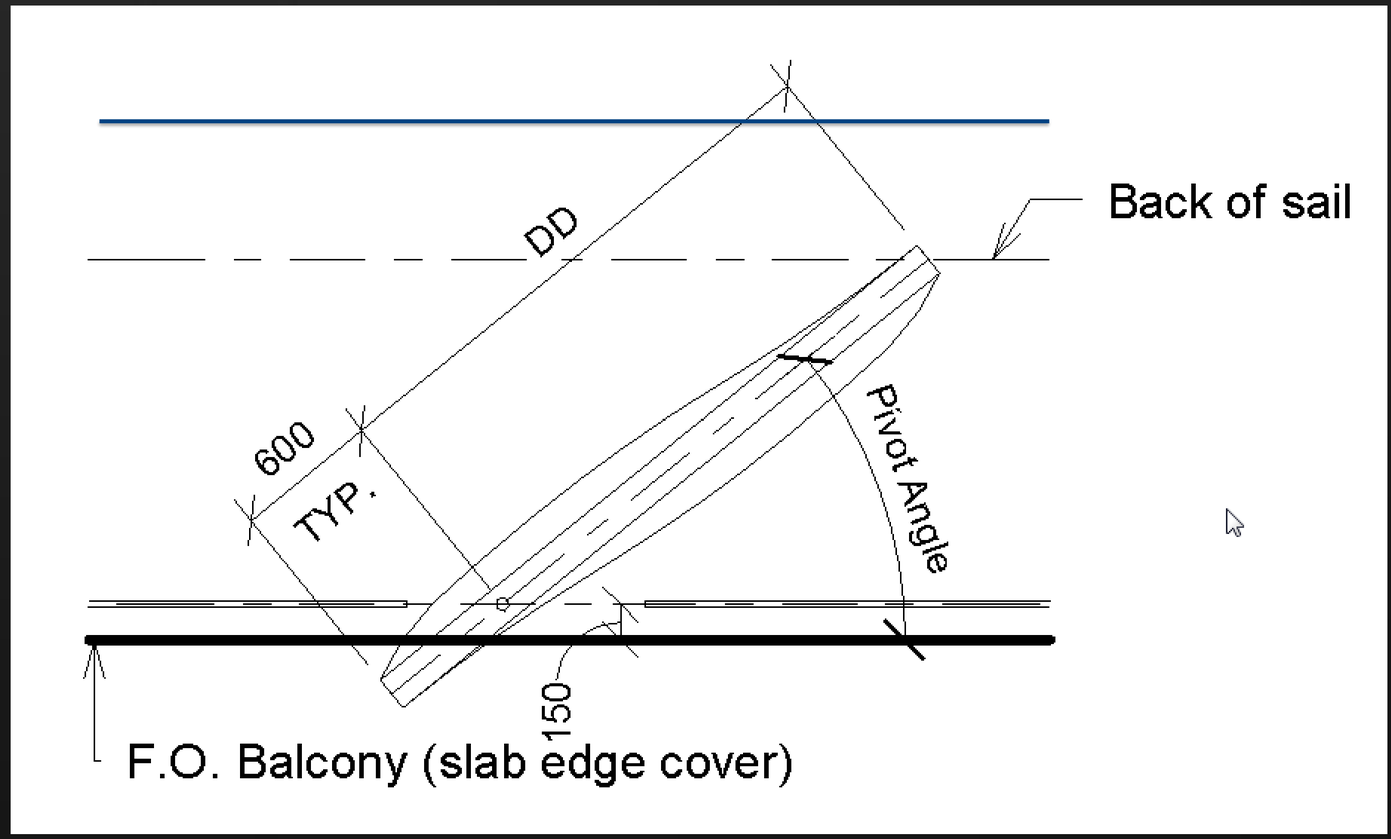
# Sail Array Family

## Interact with facade

Need minimum access between back of sail and back of balcony.

**SailStopper**

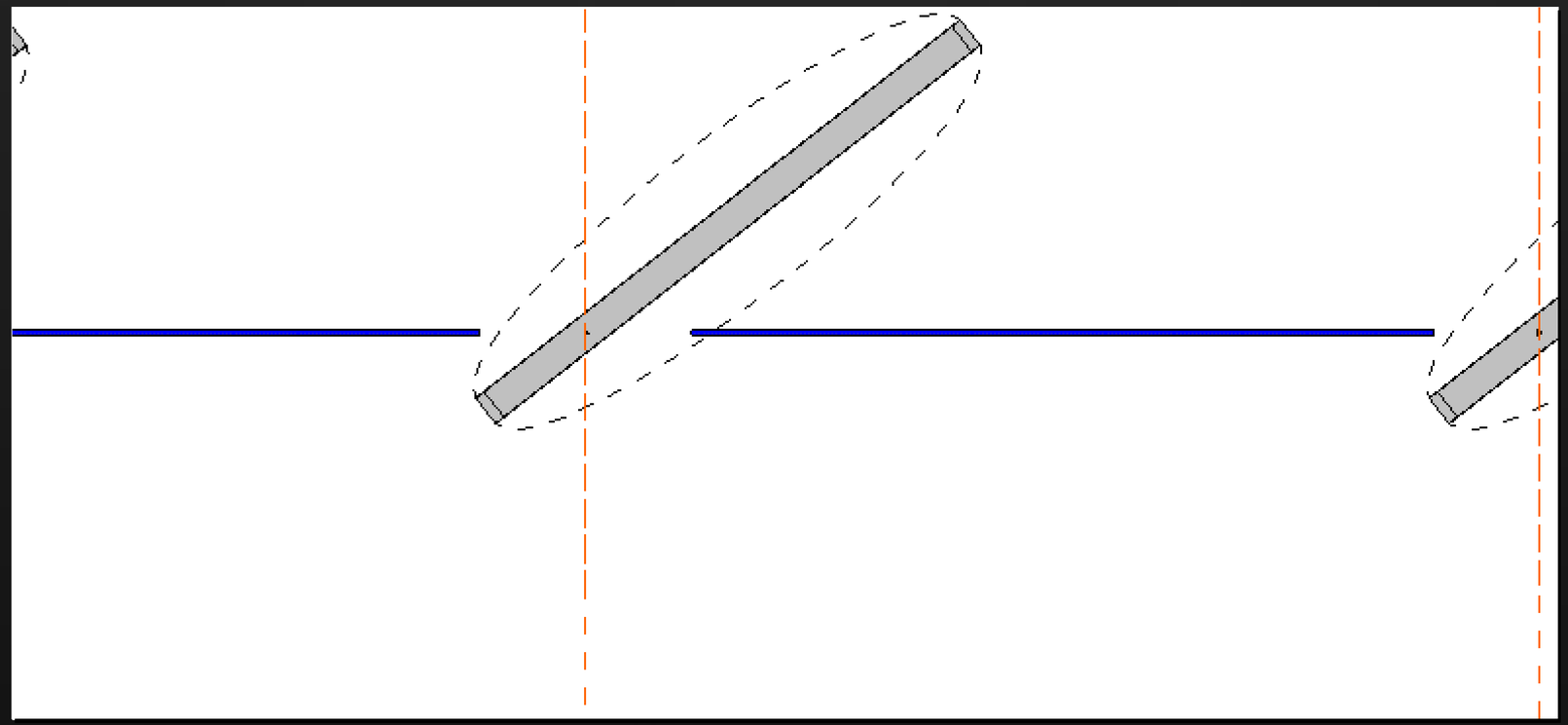
**SailShortener**



# Sail Array Family

Railing is cooperating with Sail

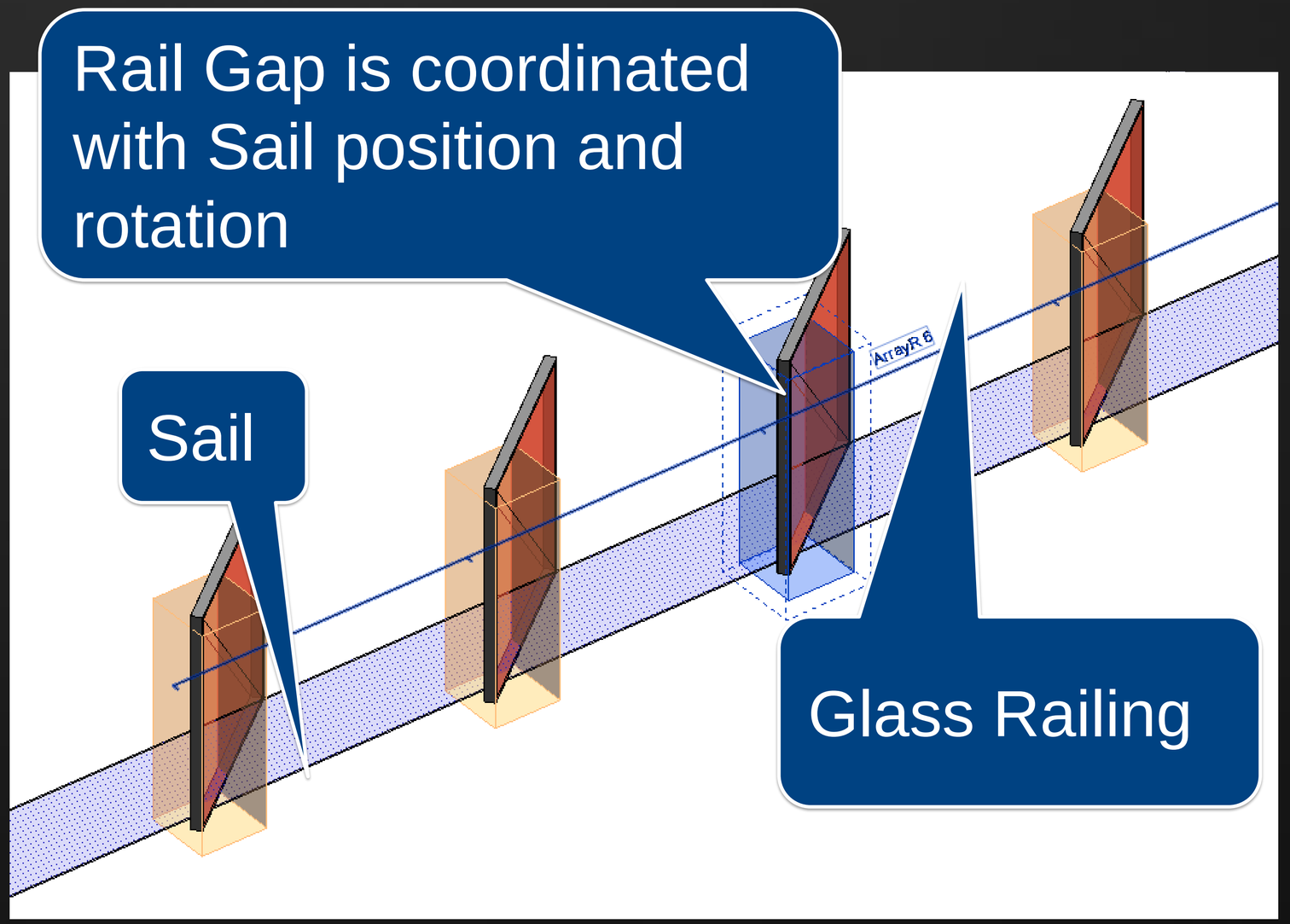
Examples: Levels 3,5,9,27



# Sail Array Family

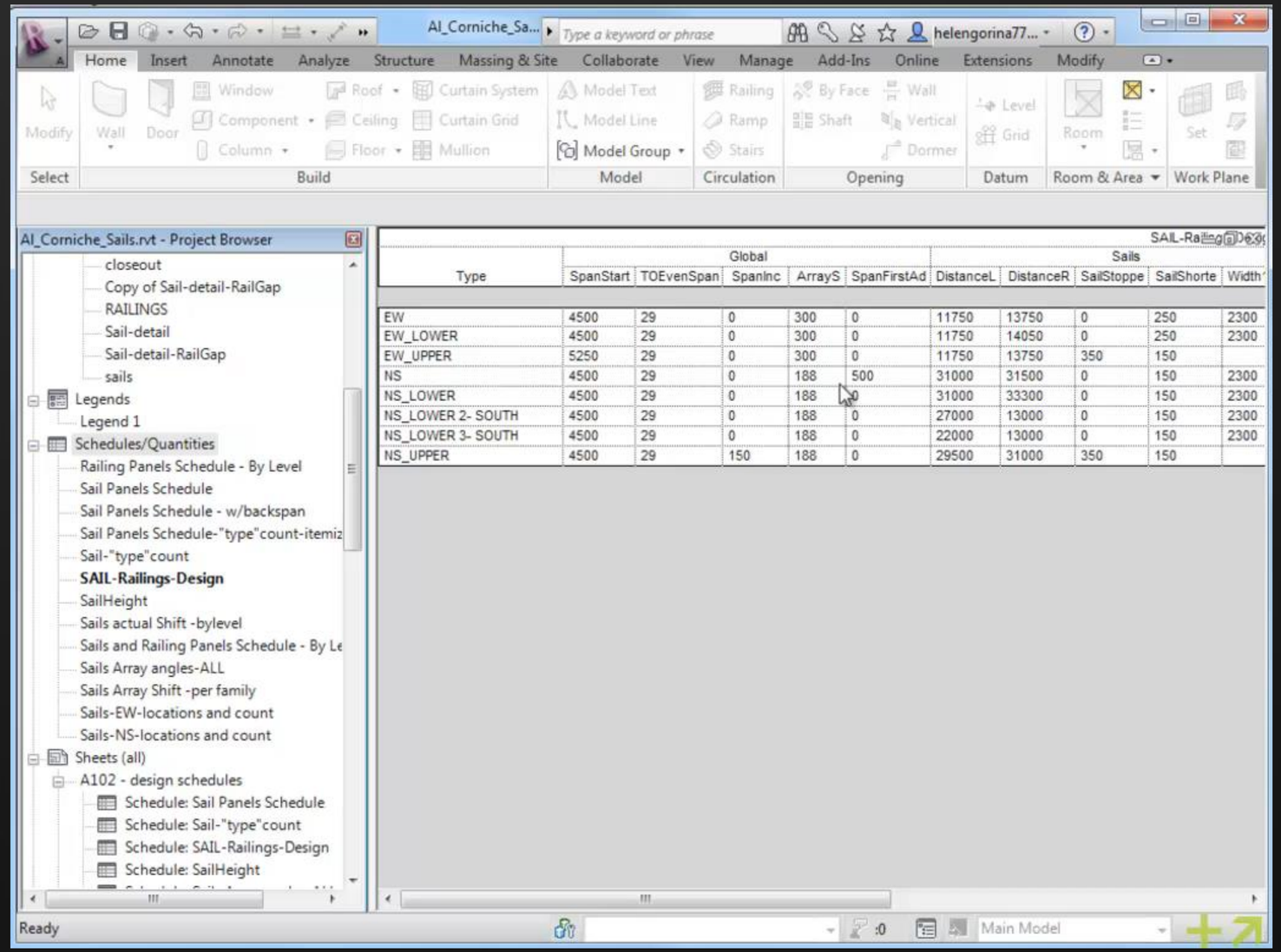
Railing is cooperating with Sail

- Overall length is calculated based on DistanceL and DistanceR
- Gaps are controlled using parametric arrayed voids.
- Gap width is calculated based on sail rotation and width.
- Sail and gap position and sail rotation is calculated based on LevelInteger



# Kempinski Sails

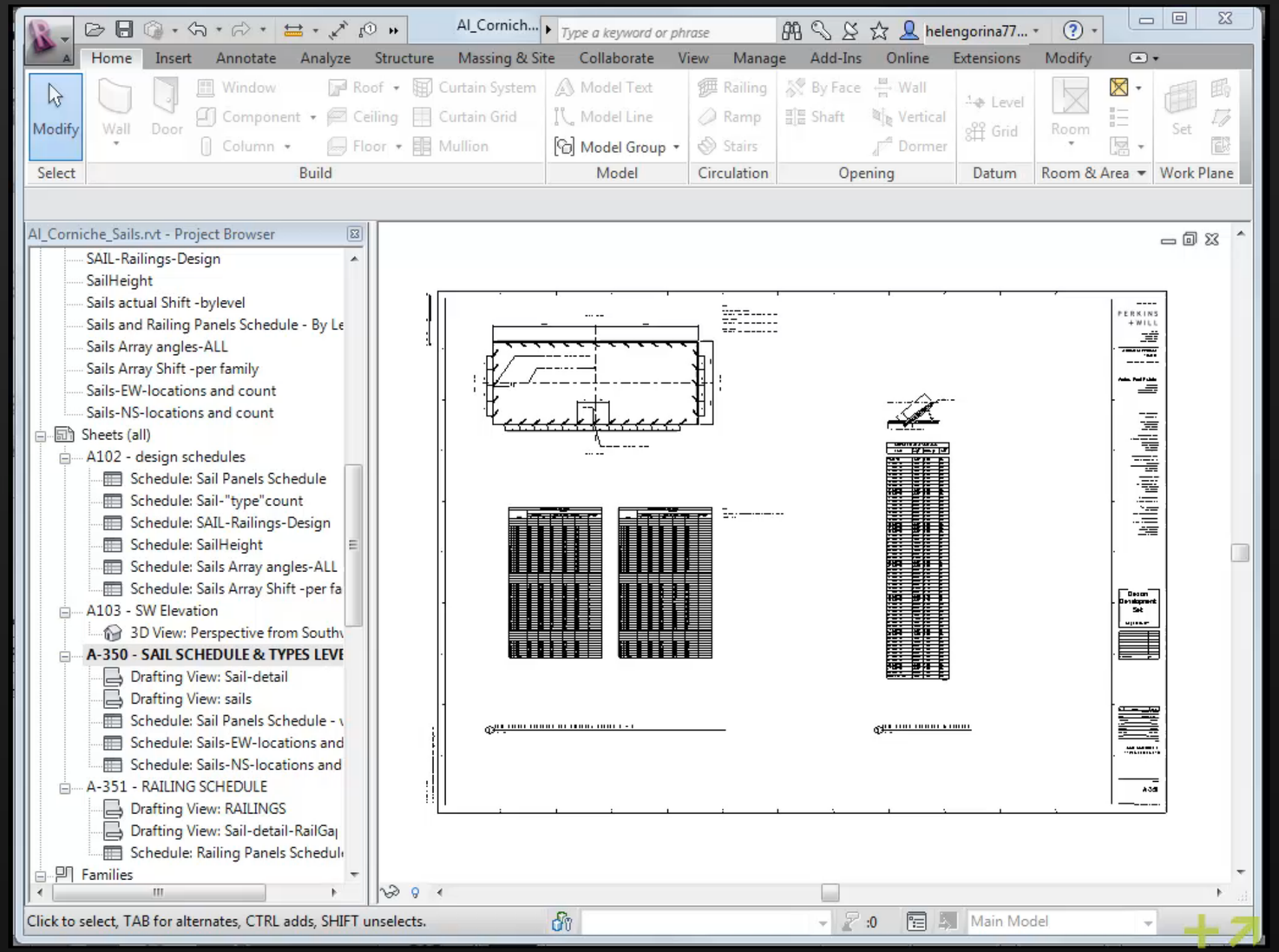
- Parameter management and rapid design iterations



# Kempinski Sails

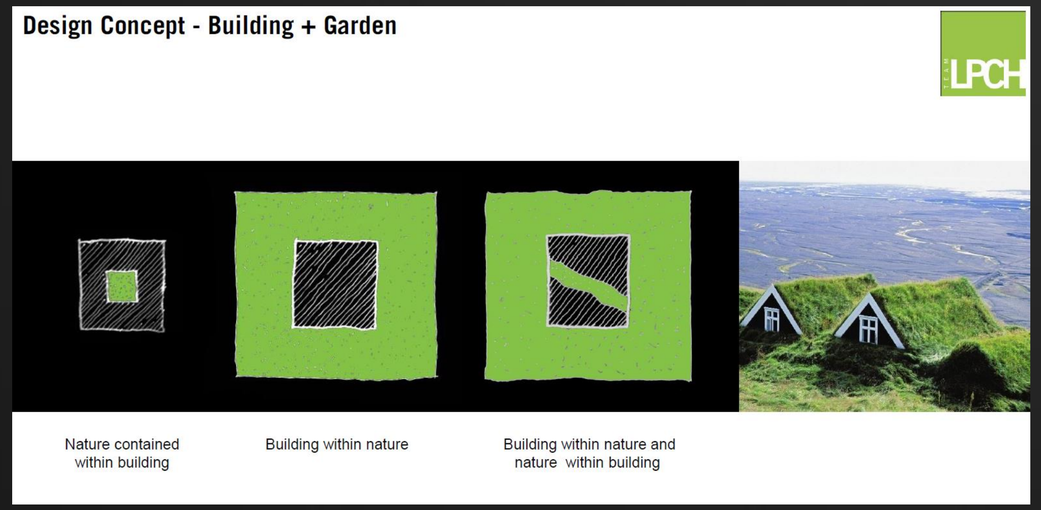
## Documentation

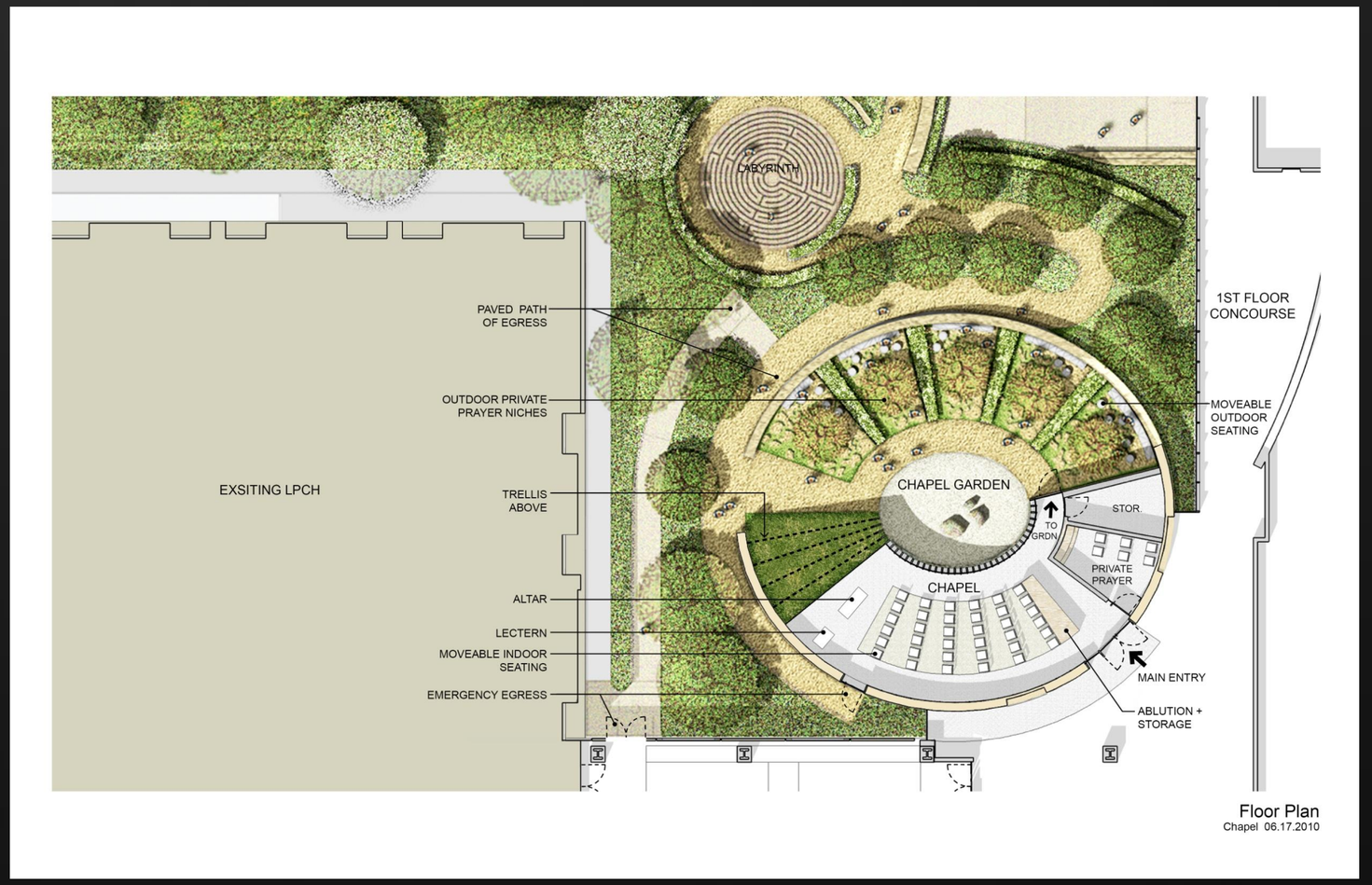
## Huge time saver



# Meditation Space

# Concept

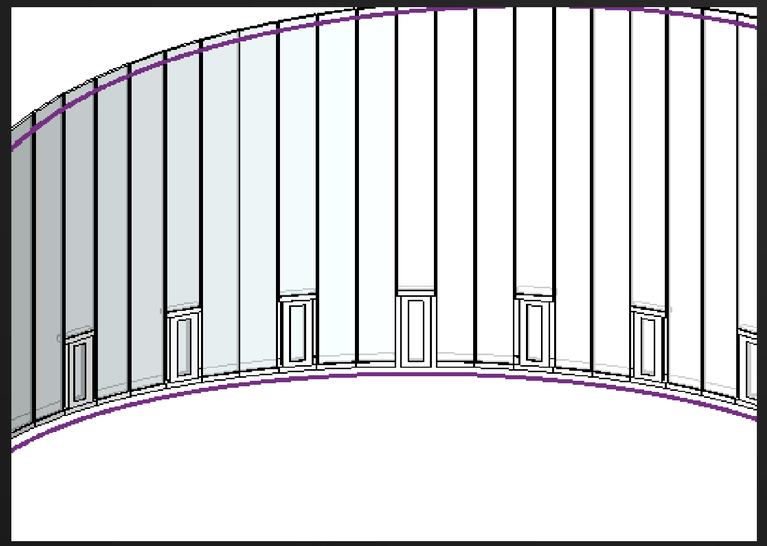


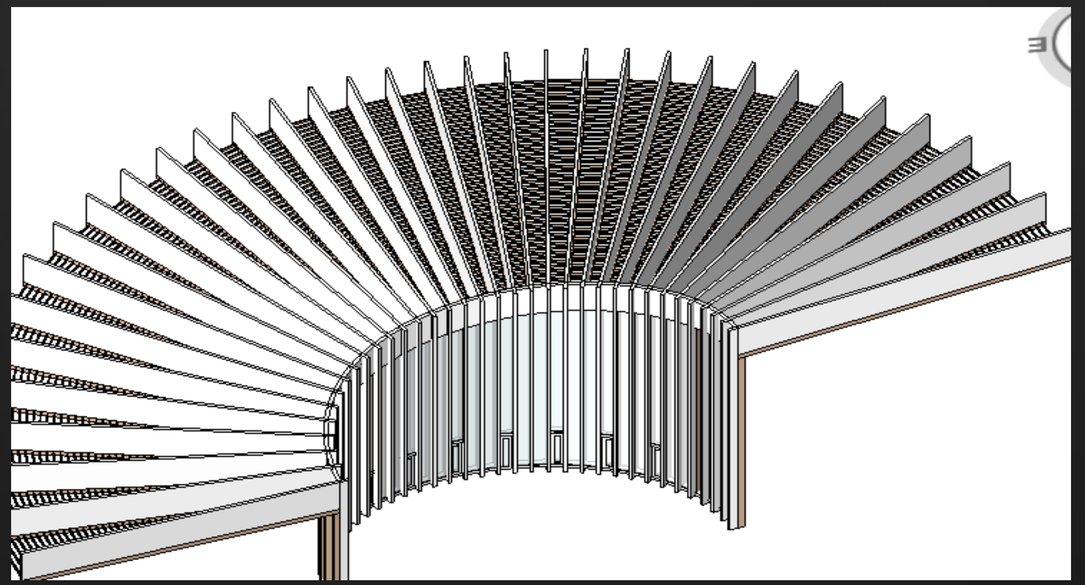
# Chapel / Meditation Space

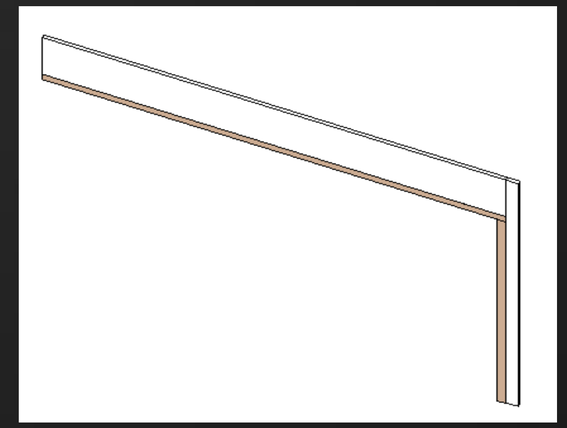
EXTERIOR VIEW – **LOOKING SOUTH-EAST**

# Round 1: Revit 2010, early development

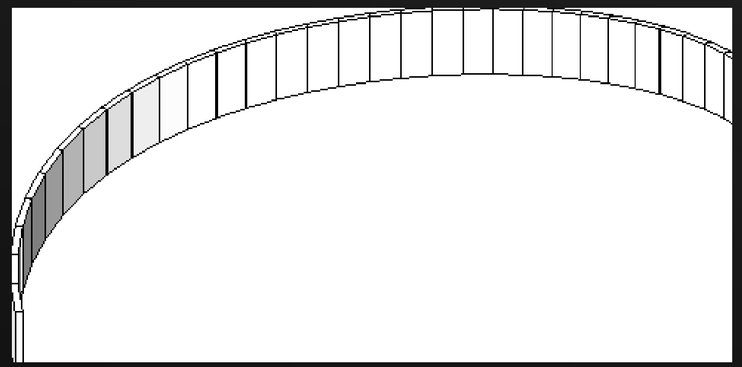


Curtain System

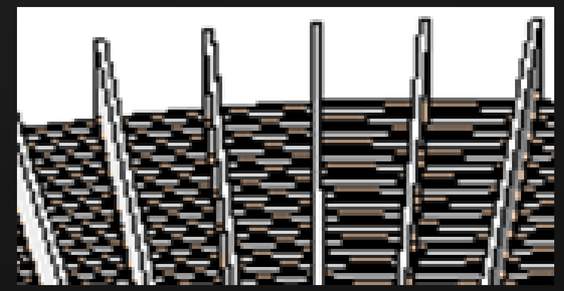




Generic Model

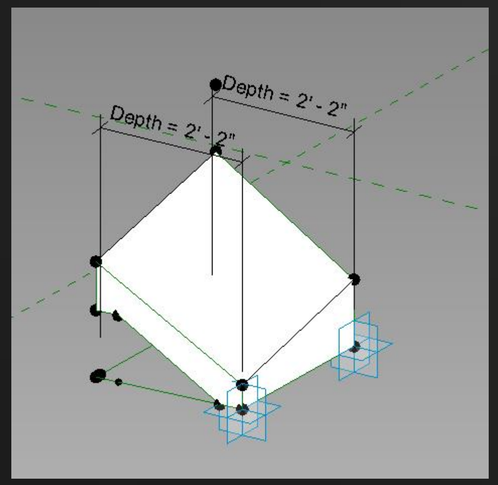


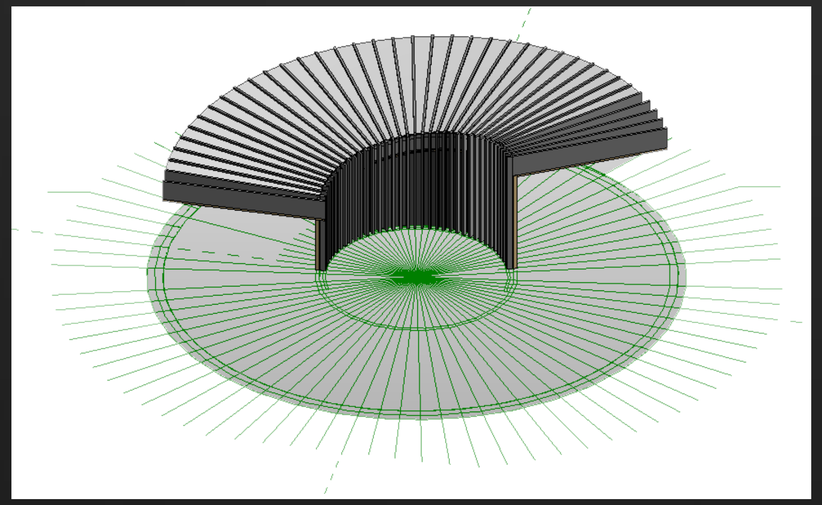
Curtain System

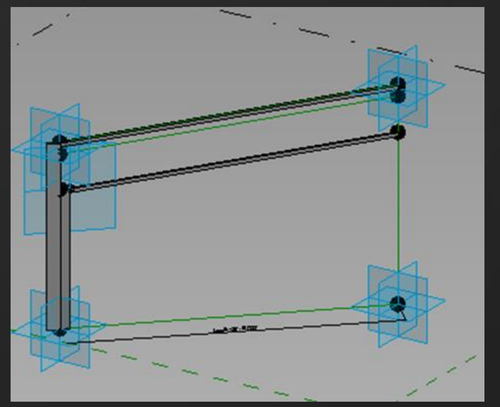


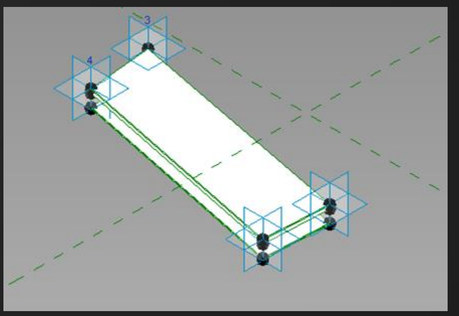
Curtain Systems

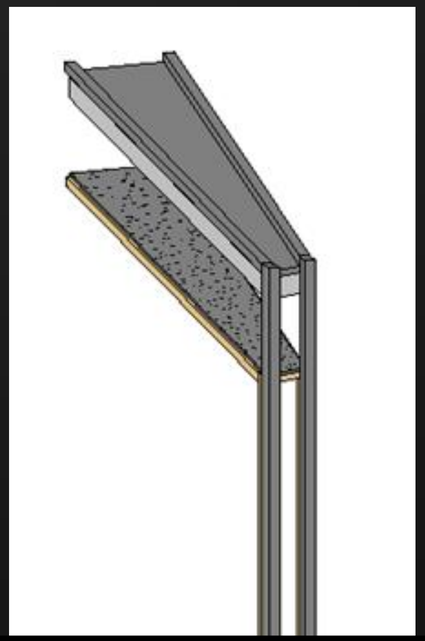
# Round 2: Revit 2011 and 2012 , DD

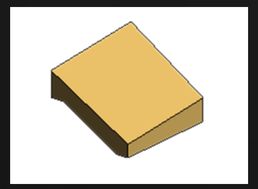


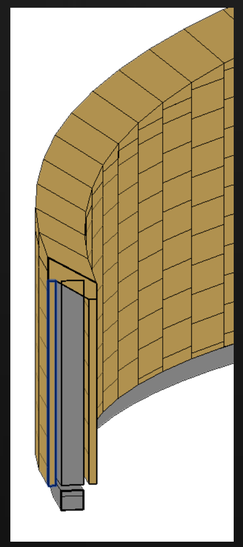



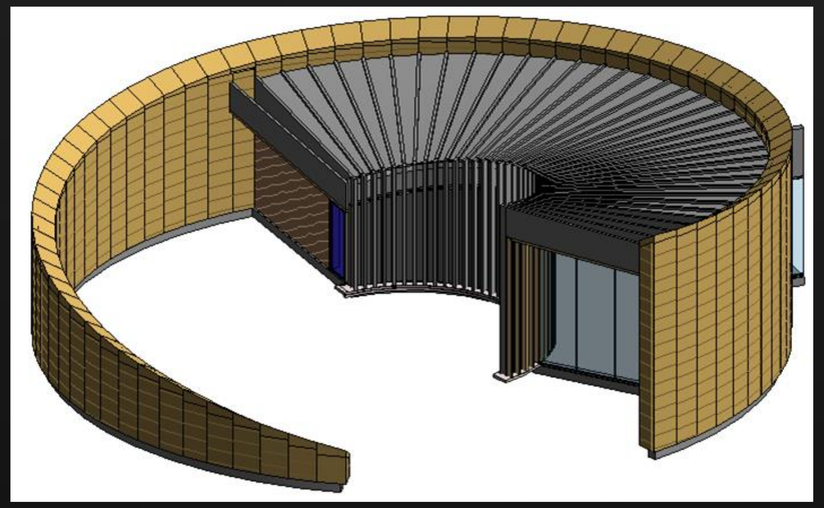


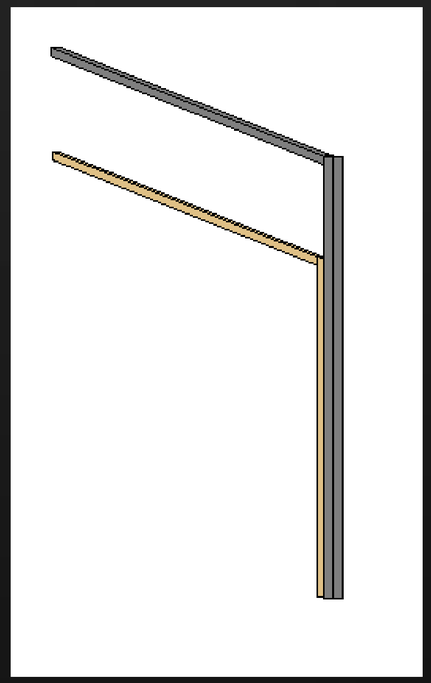






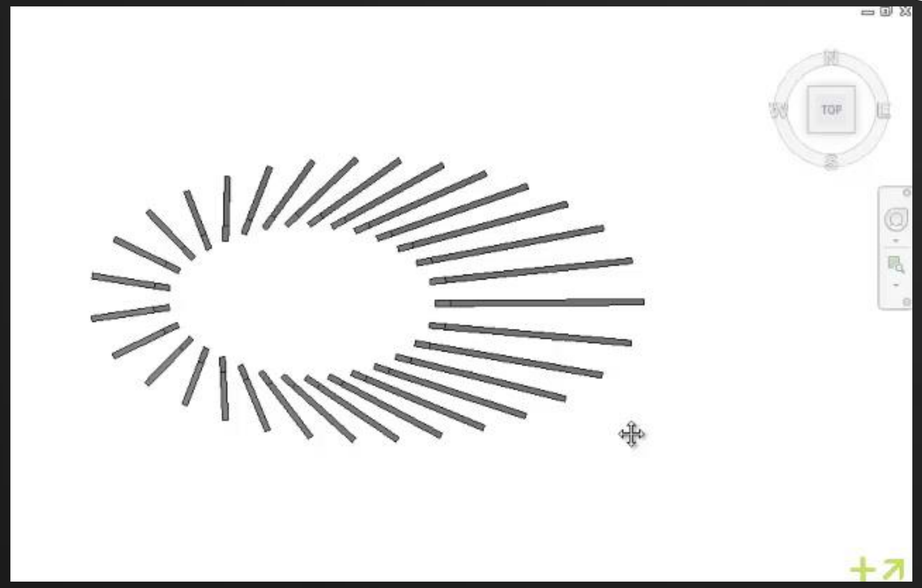






Assembly of Roof – metal, concrete, air space, wood ceiling

# Round 3: Design Changes



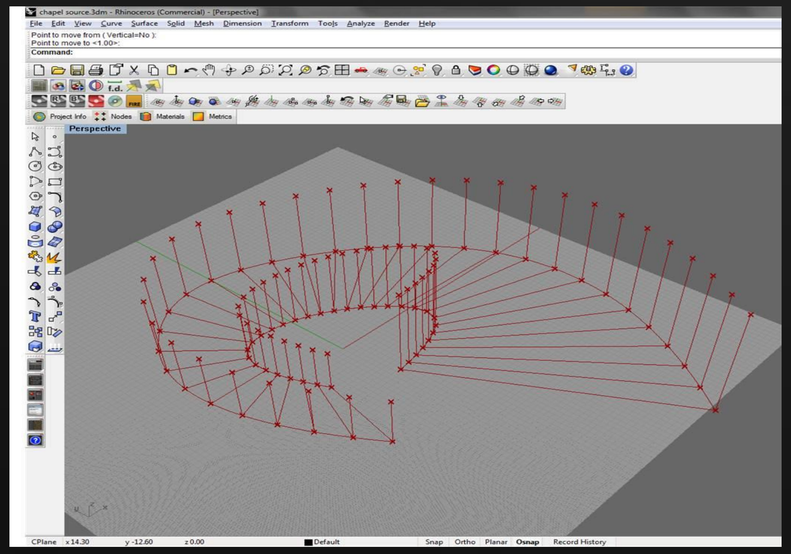

Challenge: circle, ellipse , shifted ellipses…

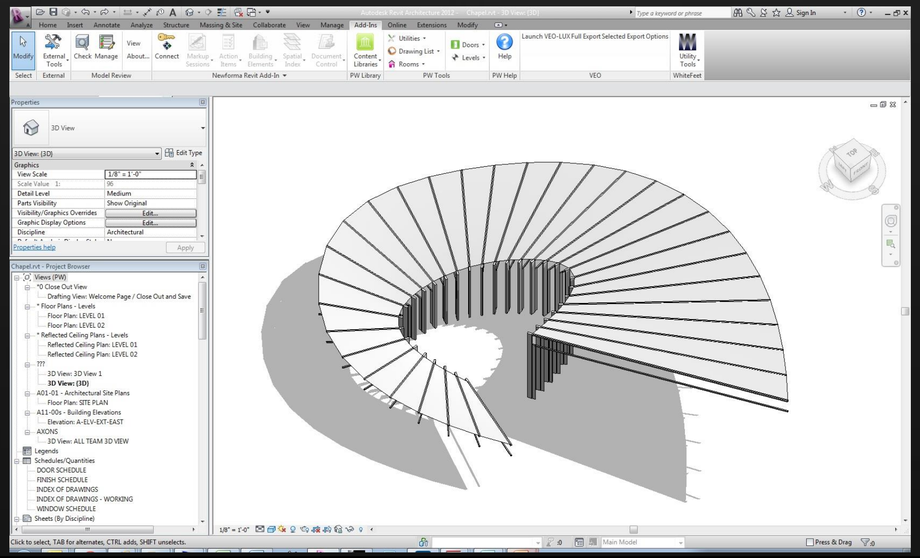
Solution: Script in Grasshopper, bring to Revit as adaptive component using Hummingbird and ModelBuilder of WhiteFeet tools.

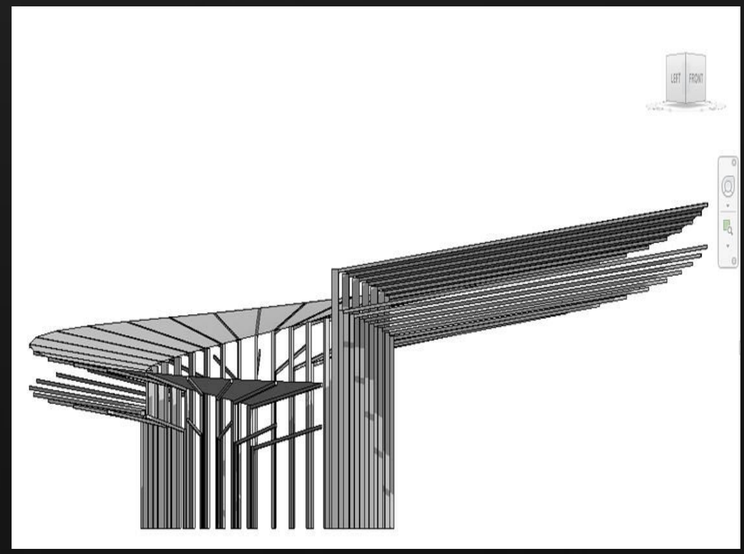
http://ghhummingbird.wordpress.com/

http://www.grasshopper3d.com/group/hummingbird

**Authors: Mario Guttman and Tim Meador, Perkins+Will**



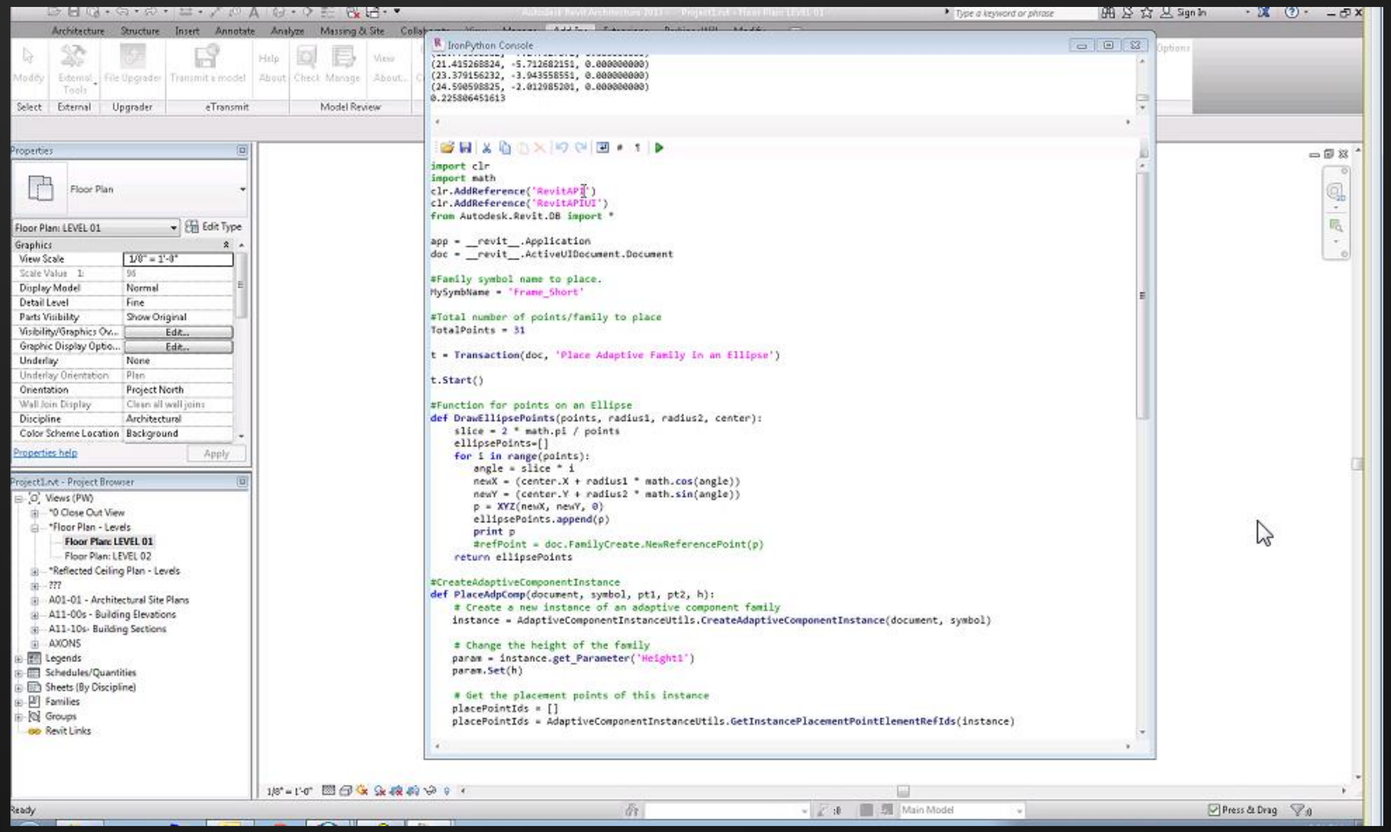



# Round 3: Another Approach

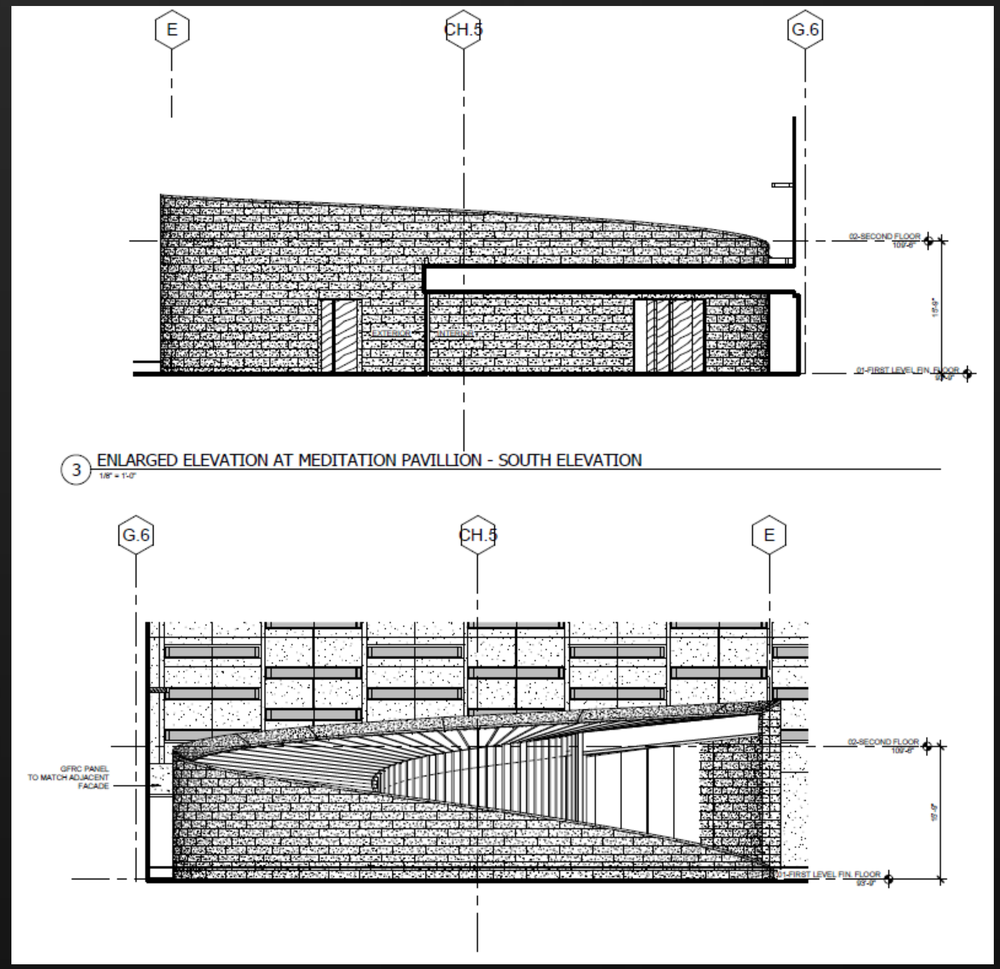
Script with Revit Python Shell

Rapid iterations, one software environment

More info: **CP3837-L** - Scripting with RevitPythonShell in Autodesk® Vasari. Class Speaker: Iffat Mai, Perkins+Will



# Results

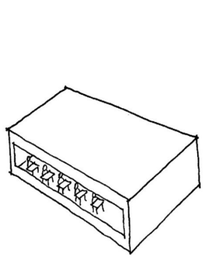


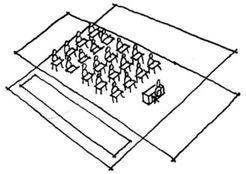
# Shade in the Desert

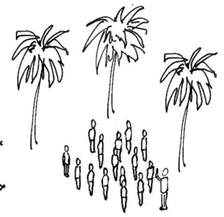
# Kuwait University

- 2012 WAN AWARDS Education Sector
- Strong identity for the school, extend learning beyond the classroom

# A1: DESIGN A SCHOOL AS LEARNING LABORATORY







RENDERING OF PARAPET GUARD WALL

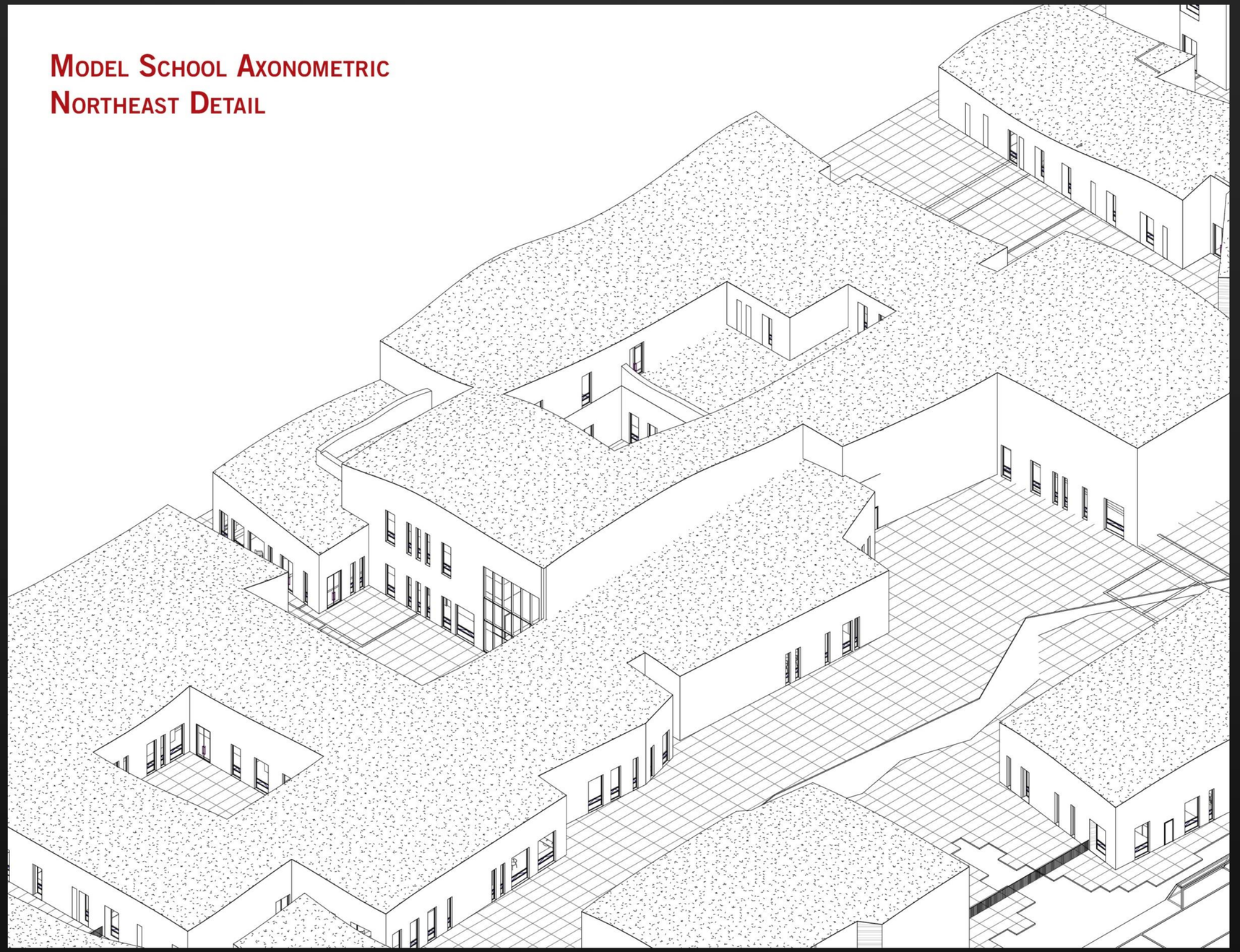
# SITE PLAN + ACTIVATED ROOFSCAPE PROGRAMMING DIAGRAM

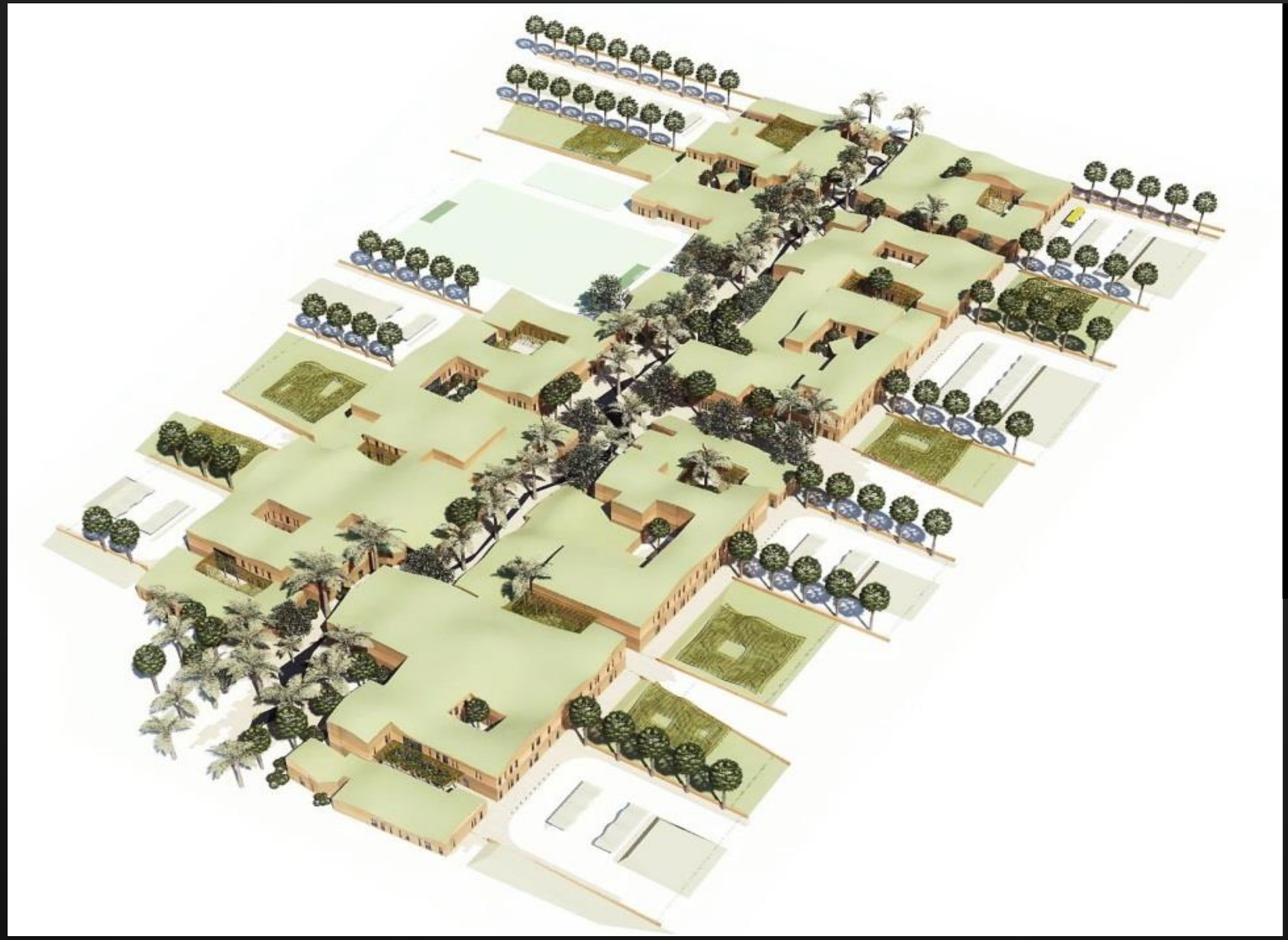
1 BUTTERFLY GARDEN
2 VEGETABLE GARDEN
3 WEATHER STATION
4 OUTDOOR CLASSROOM
5 FLOWER GARDEN
6 PHILOSOPHERS GARDEN
7 READING TERRACE
8 POULTRY SHED
9 GOAT MEADOW
10 APIARY
11 OBSERVATORY
12 ORNITHOLOGY LAB
13 BIOLOGY LAB
14 ZOOLOGY LAB
15 CHEMISTRY LAB
16 ACADEMIC GARDEN
17 KITE MEADOW

## TEACHING SCHOOL MASSING DIAGRAM


31,000 sm Green Roof // 14,300 sm Outdoor Play Area

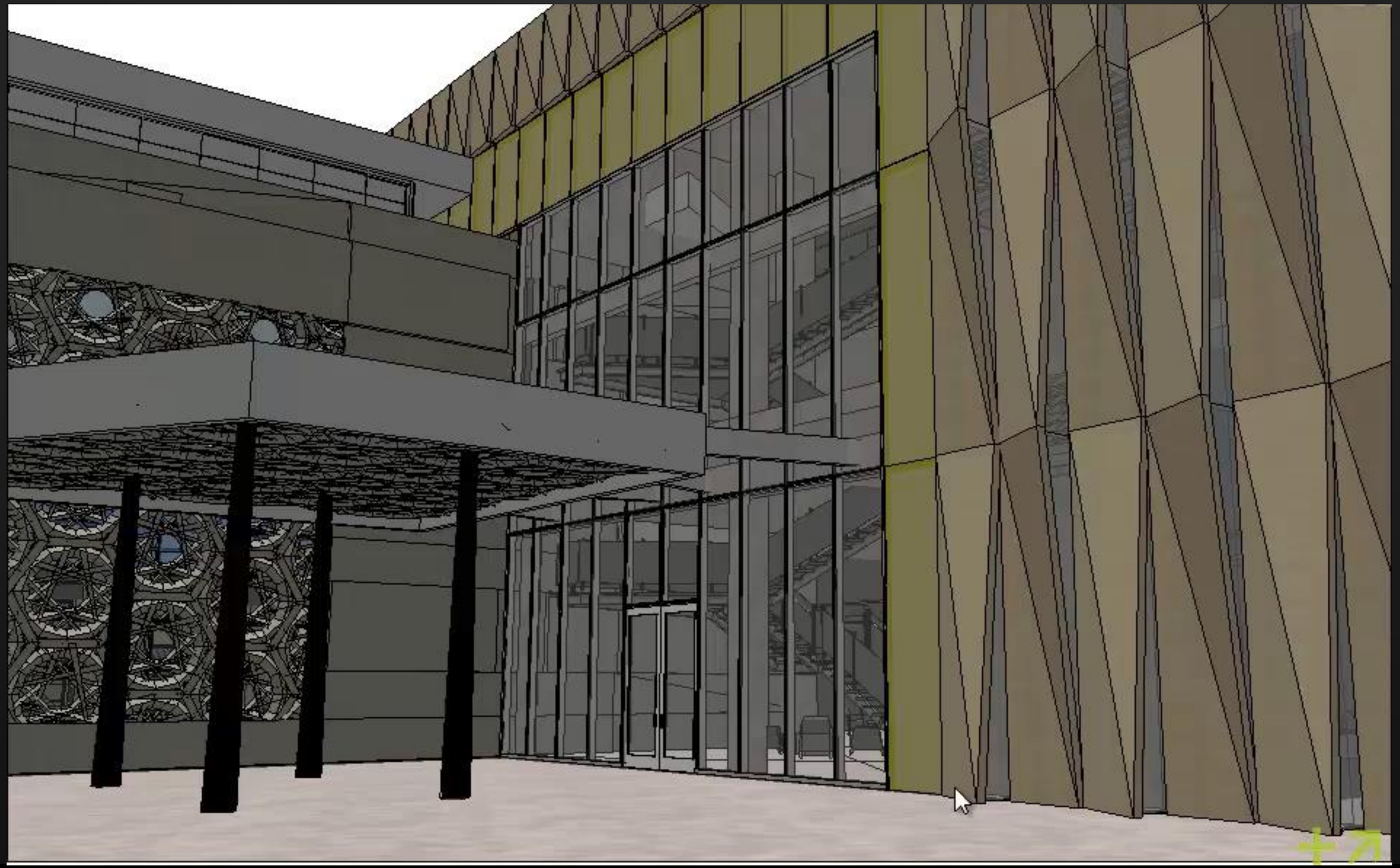
# Model School Axonometric
# Northeast Detail

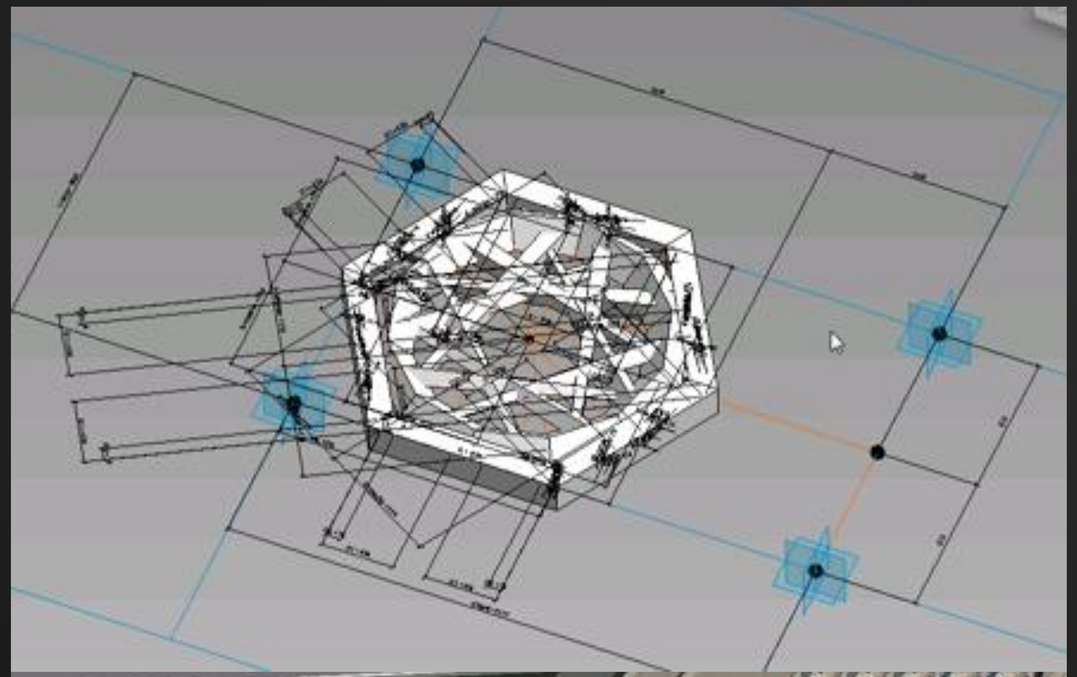


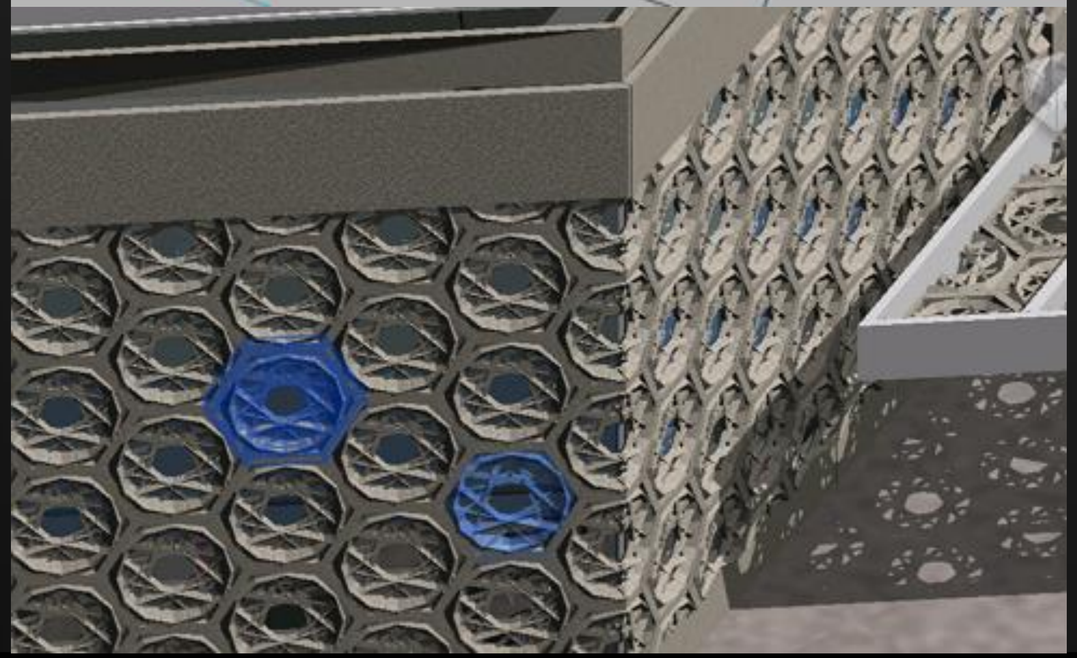


- Modeled in Rhino
- Interior wall attached to the Roof form → Revit model size swelled to 2GB.
- Temporary solution: Stop attaching the walls till the last minute
- Autodesk released a SP

# KU – Faculty Club Hexagonal Pattern

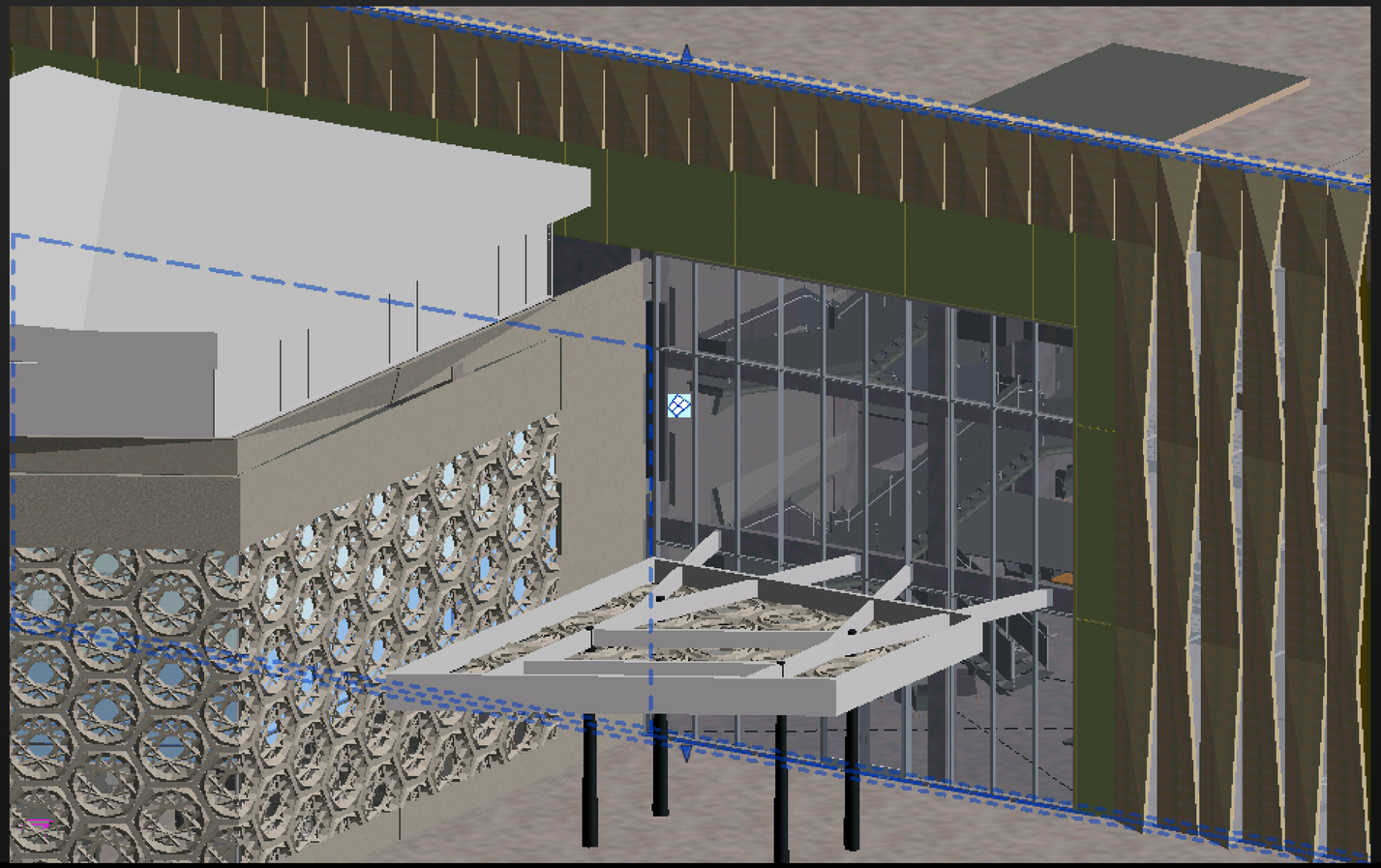


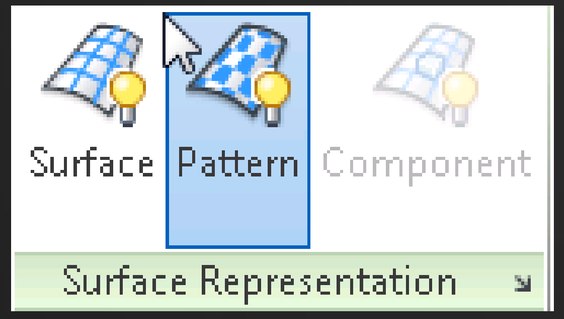


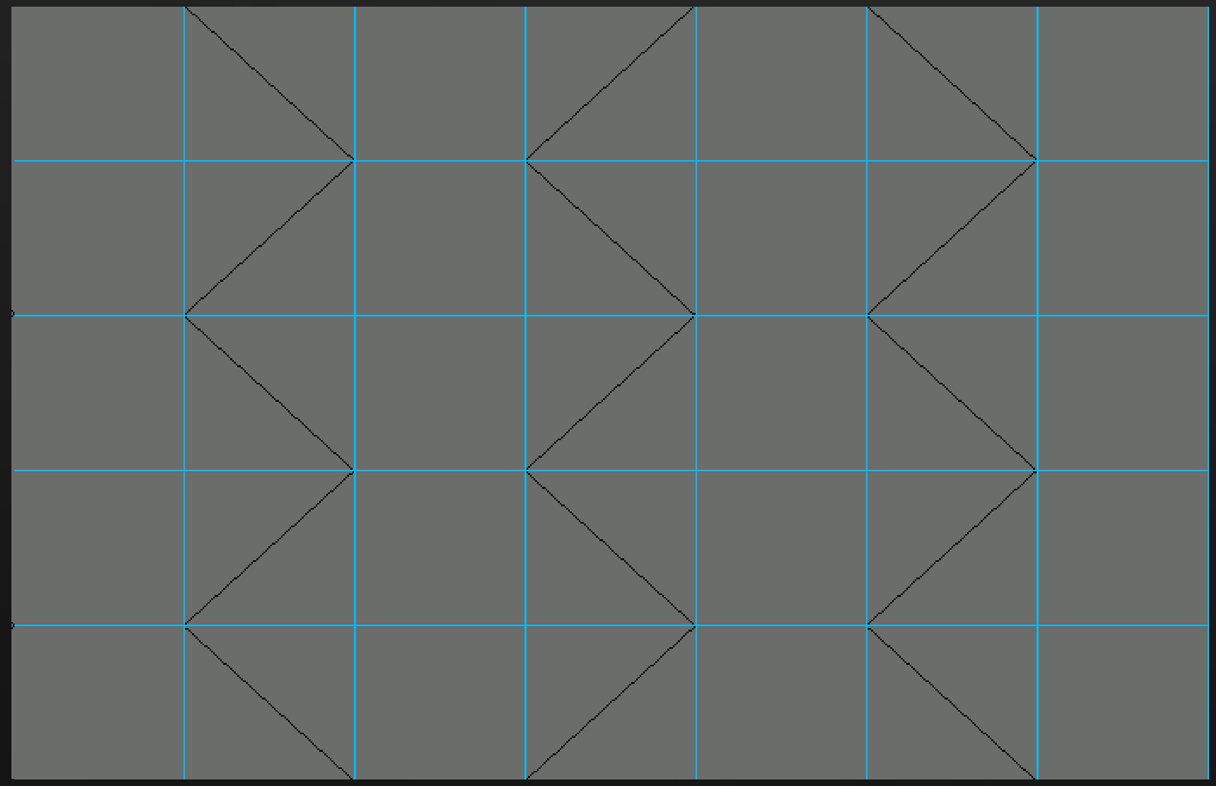


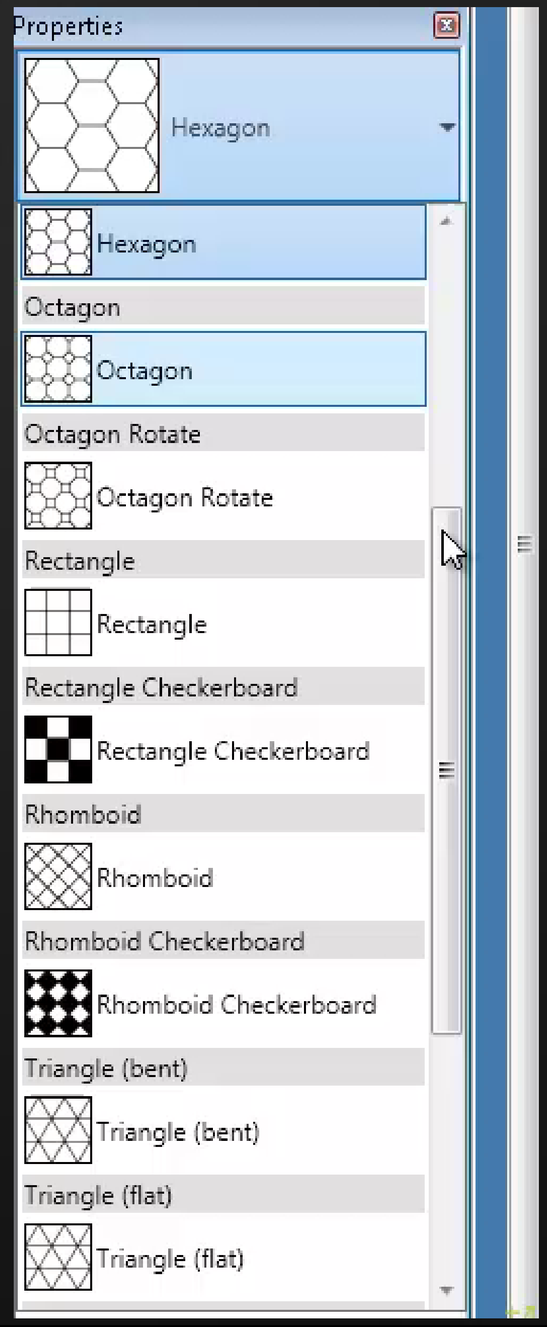
Infinite variety of visually distinctive types:

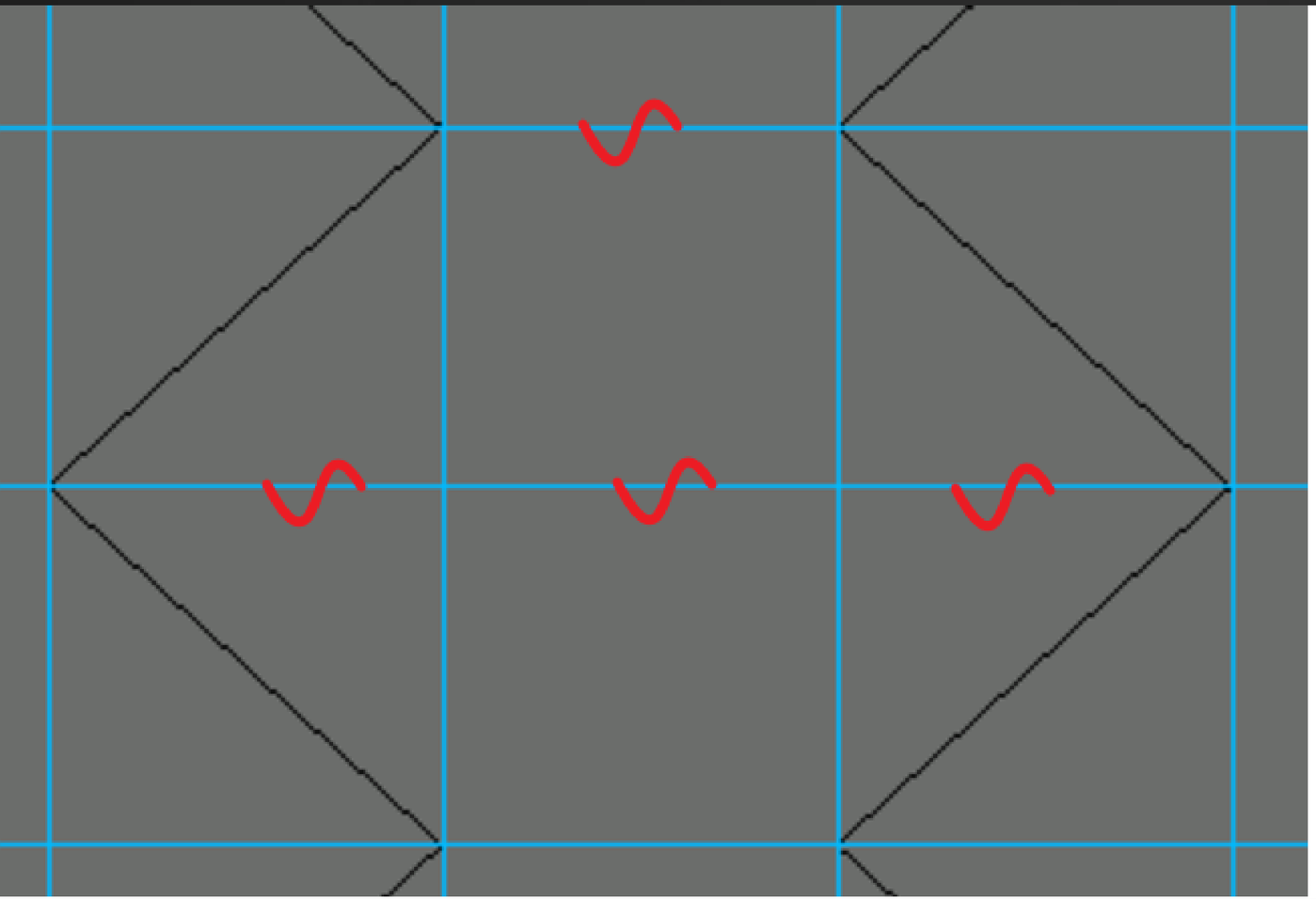
- Dimensional parameters
- Visibility parameters
- Material parameters

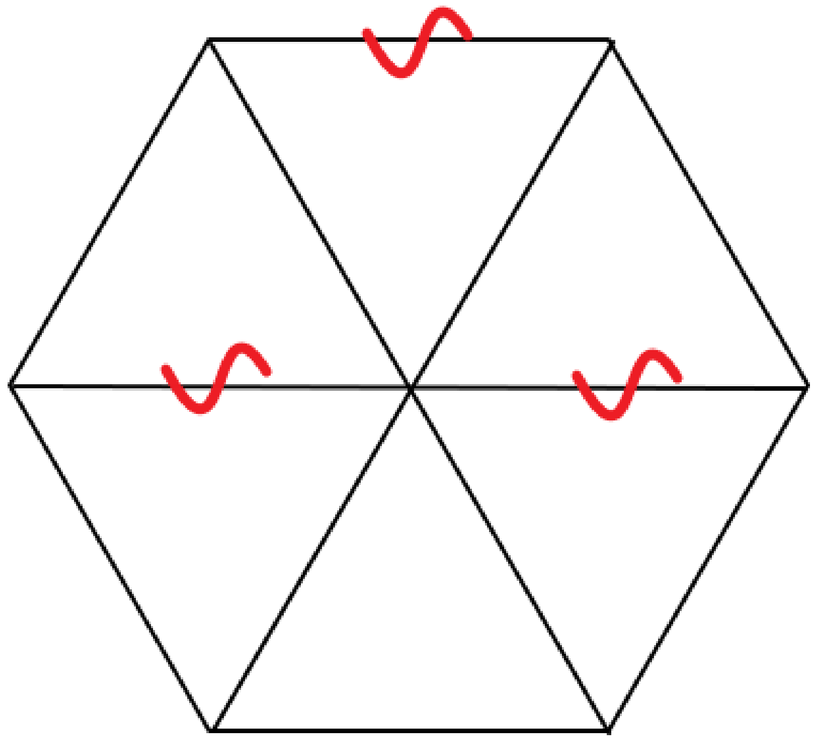


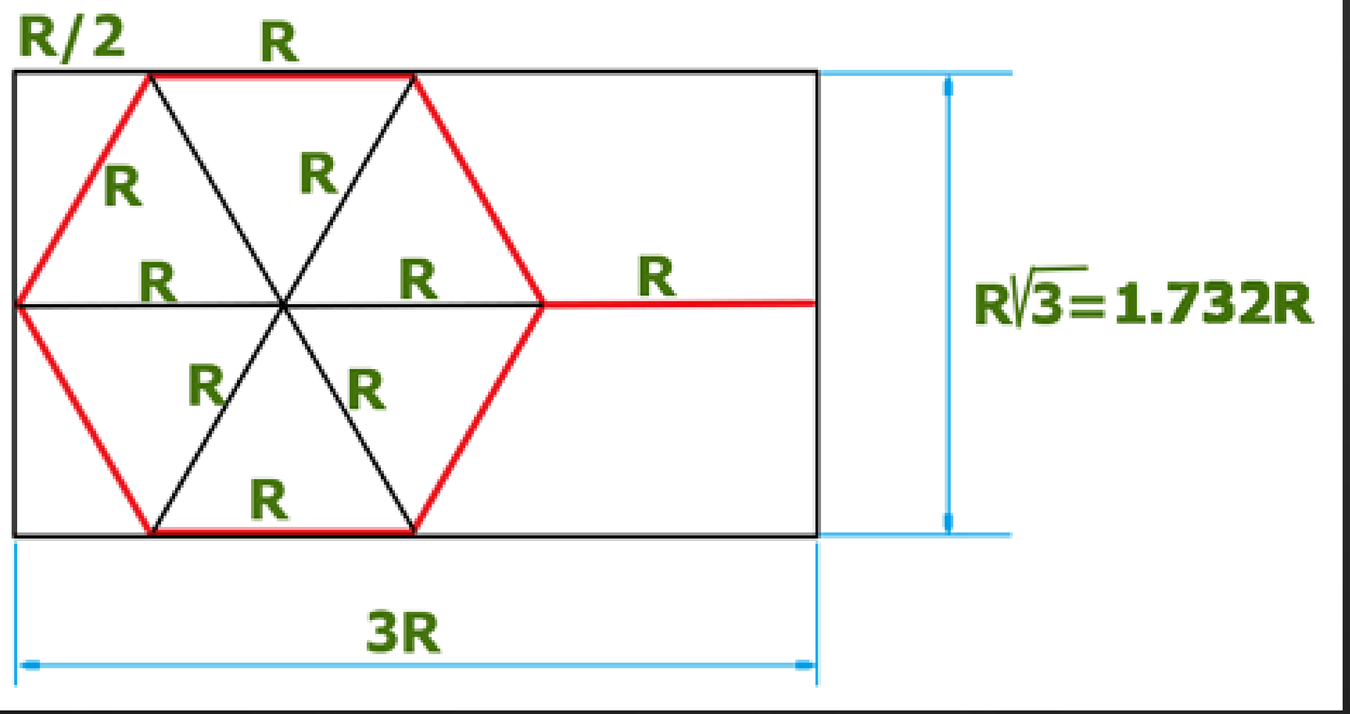


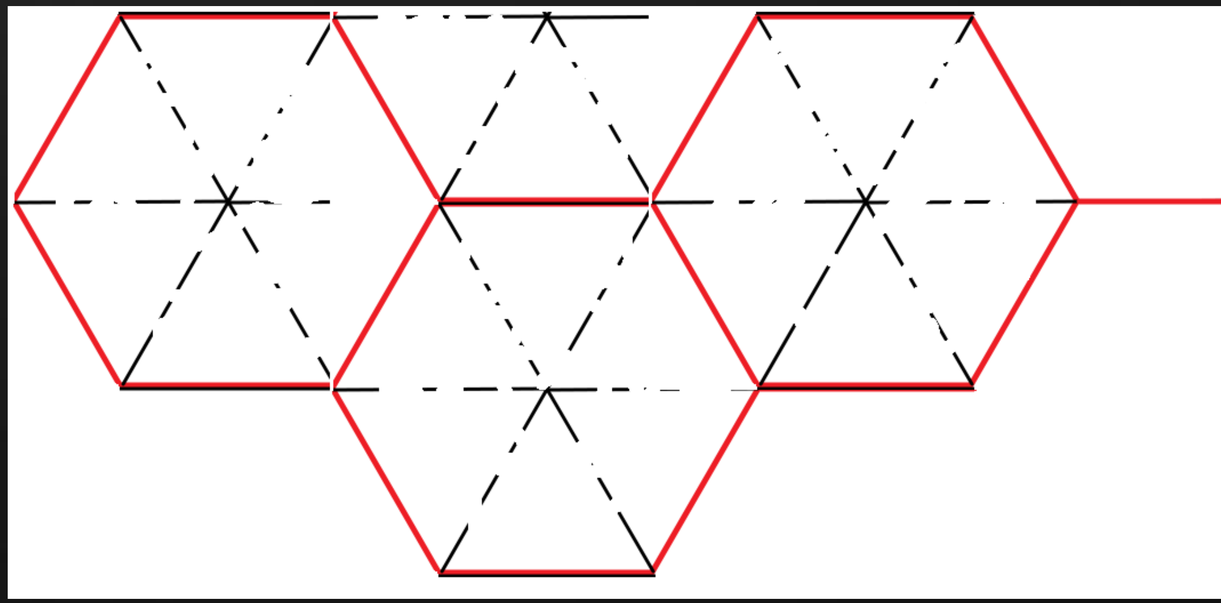


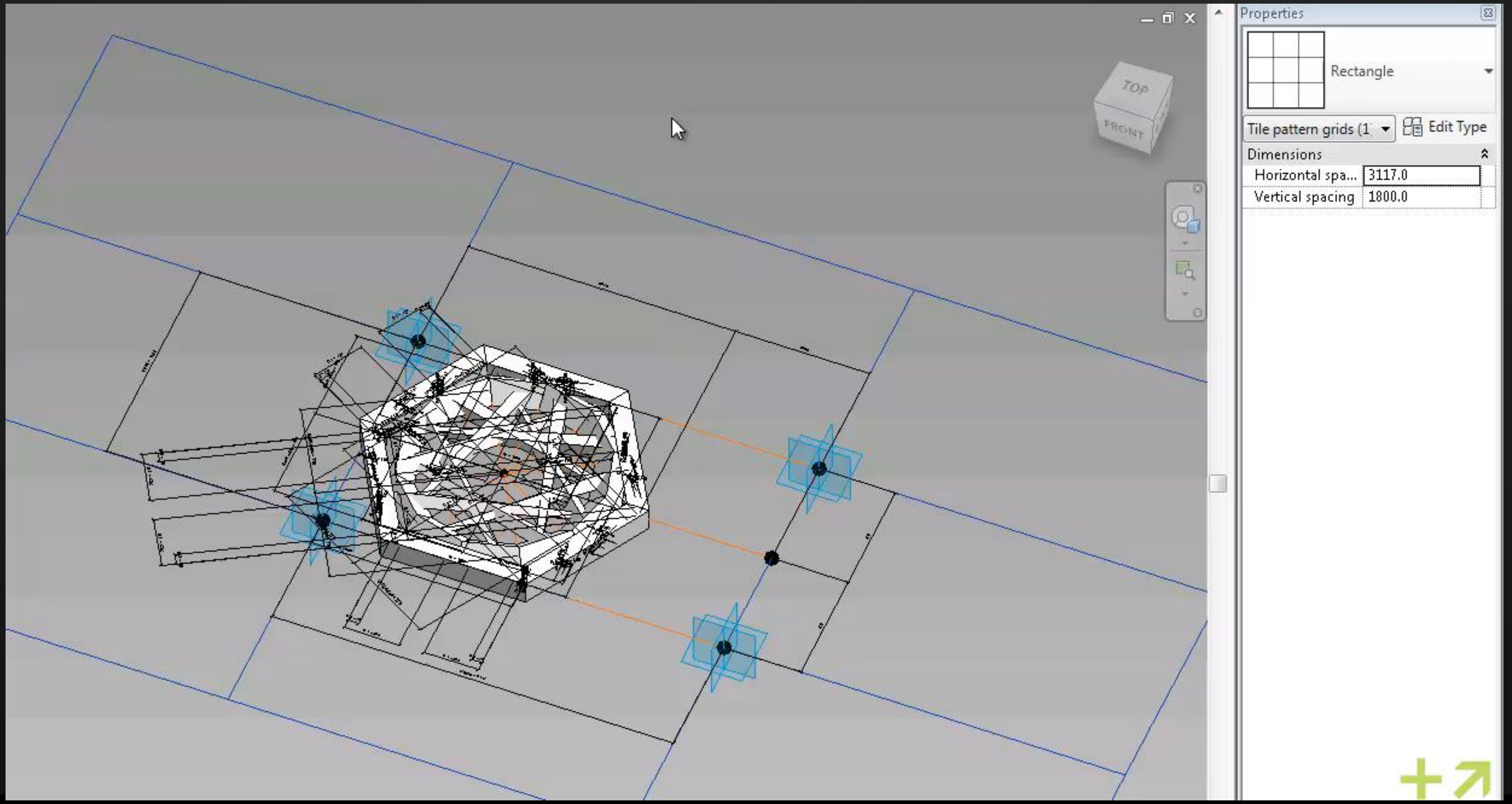


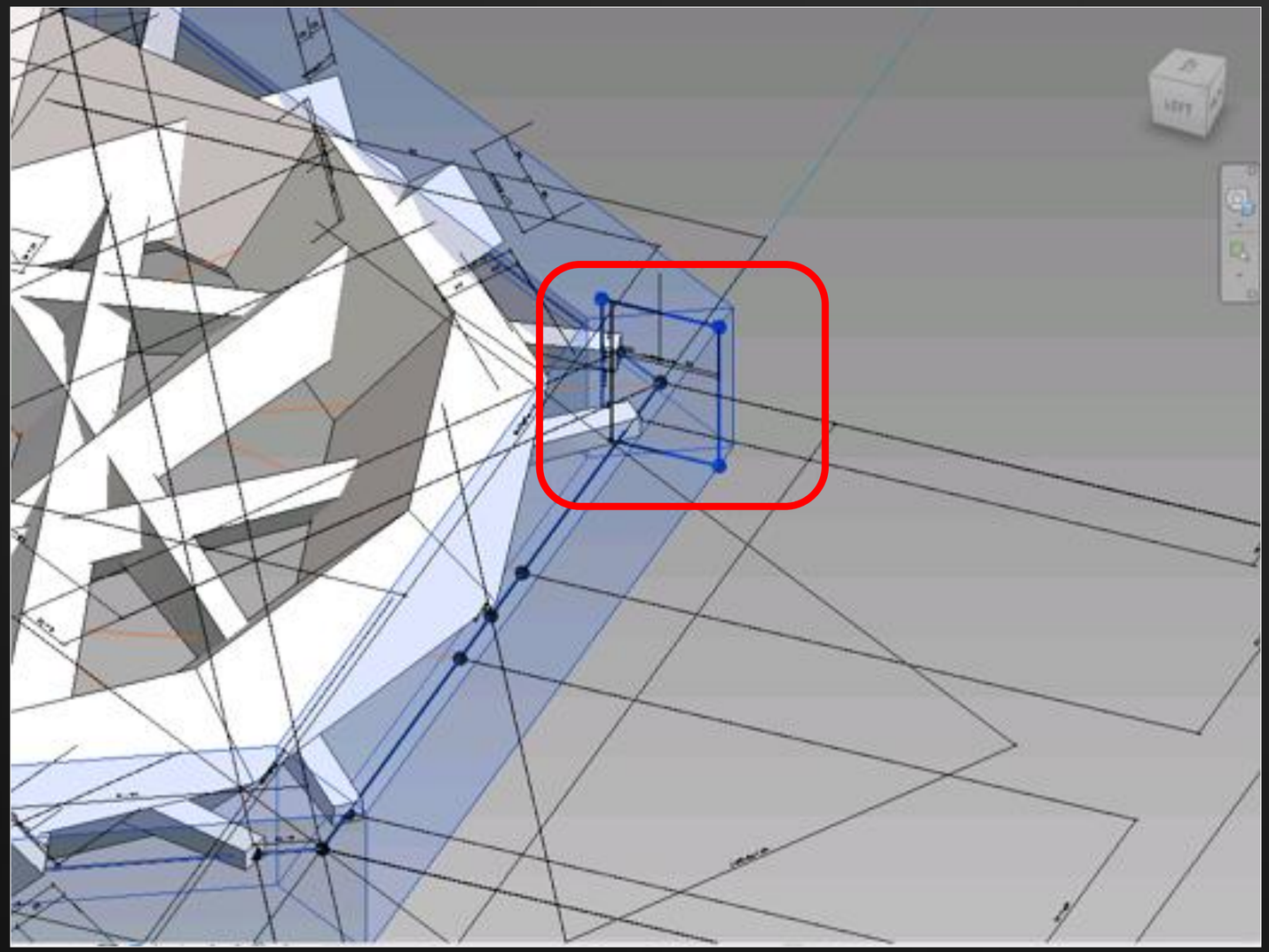


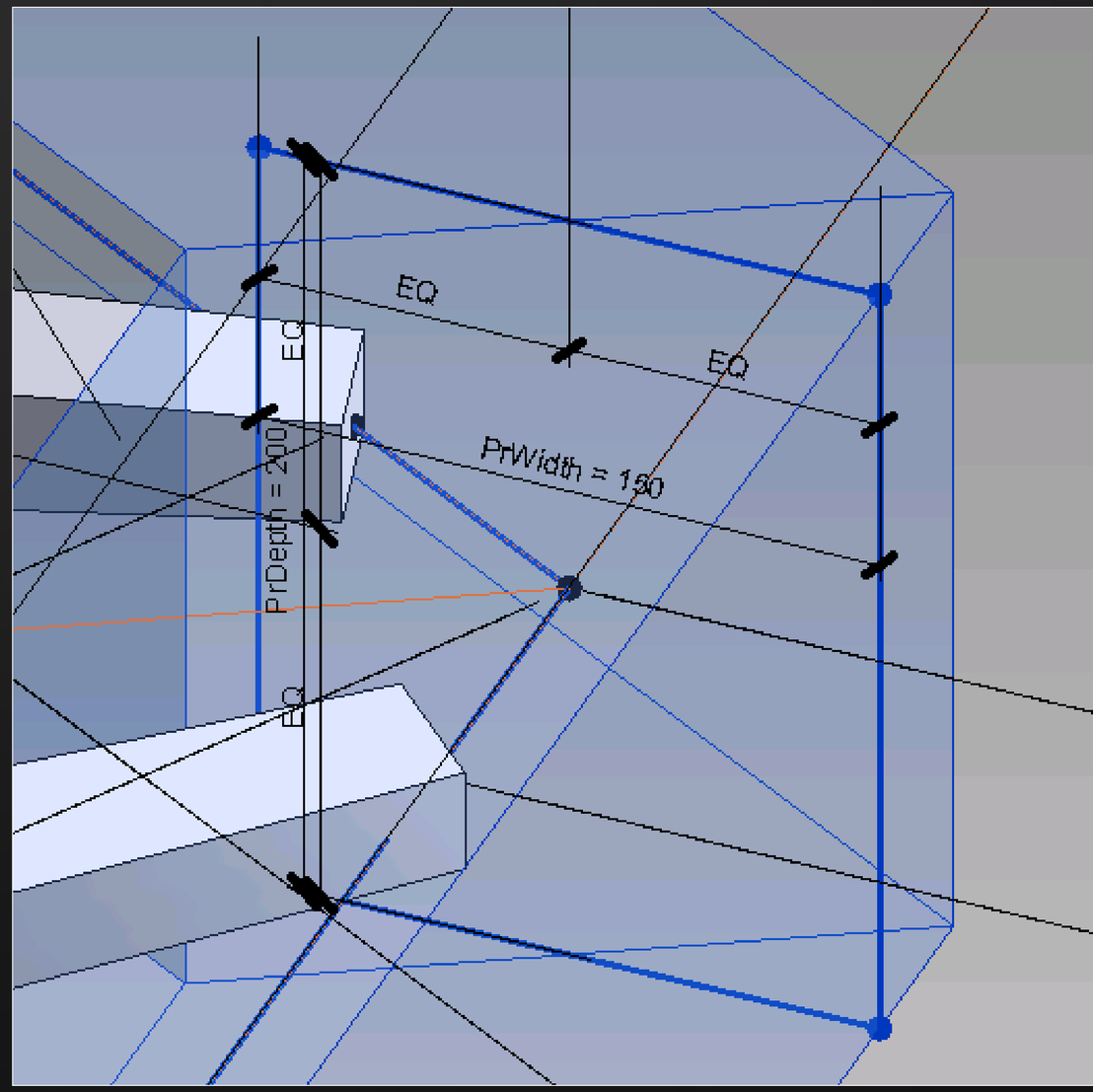



$$H = \frac{W}{\sqrt{3}} \sim W * 0.57735$$





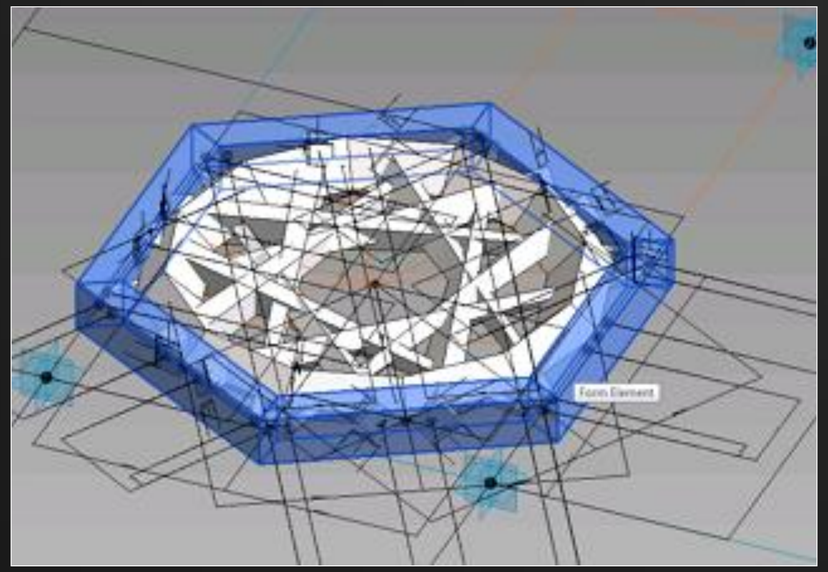


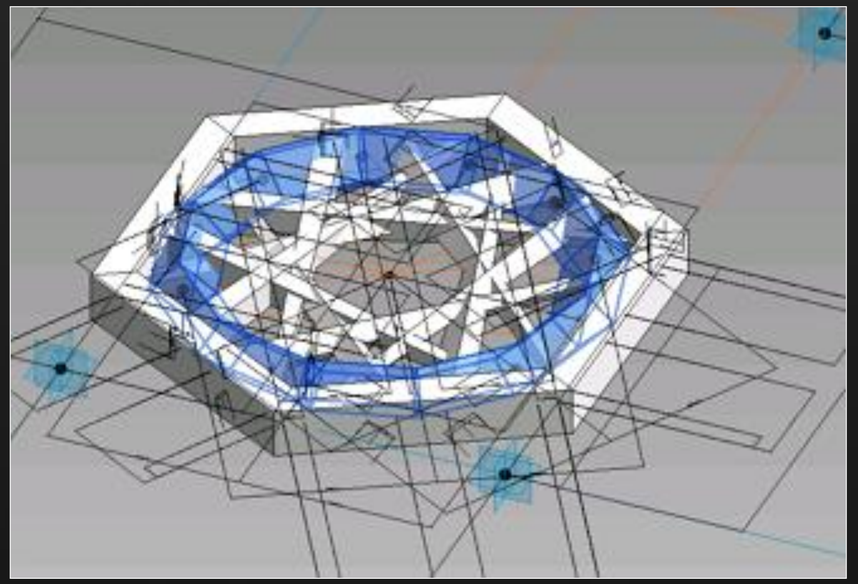


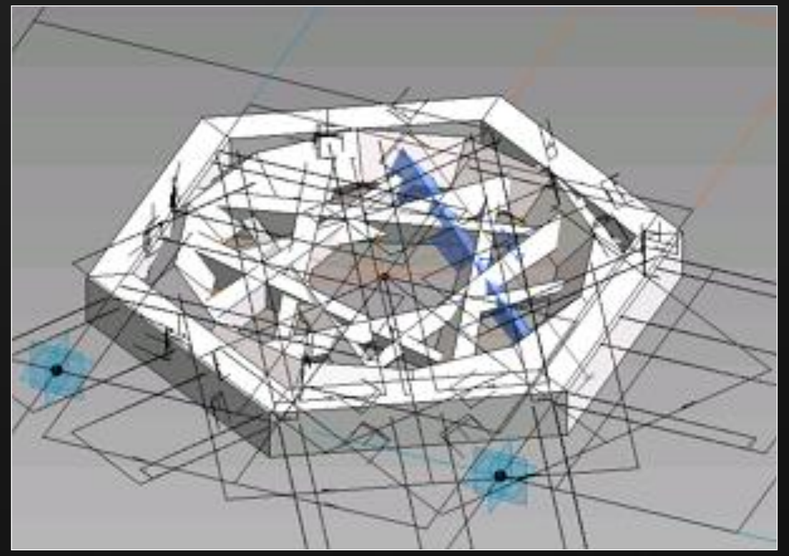
Outer – hexagon (regular when Height=Width/$e$3

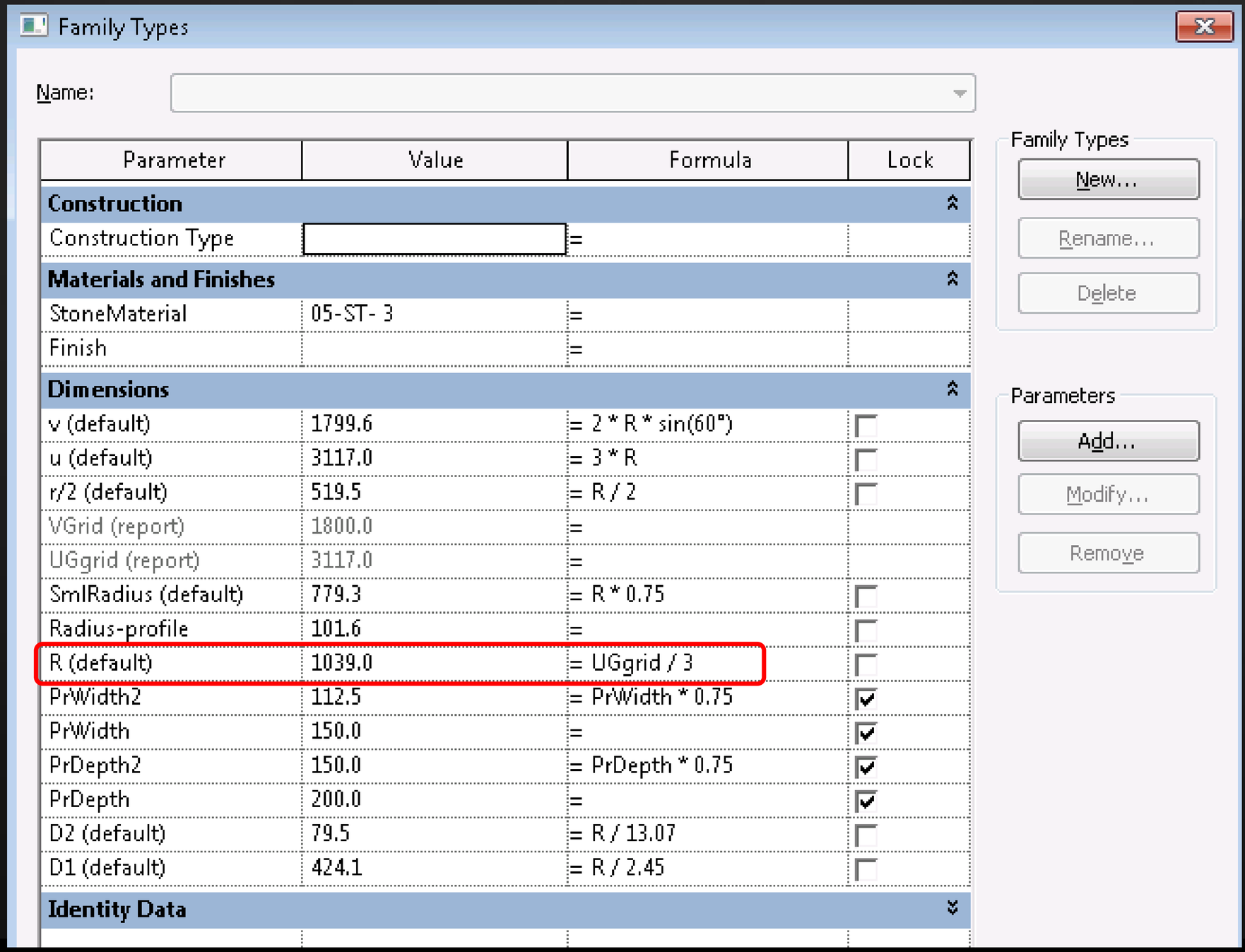
Inner – polygon  with 12 sides

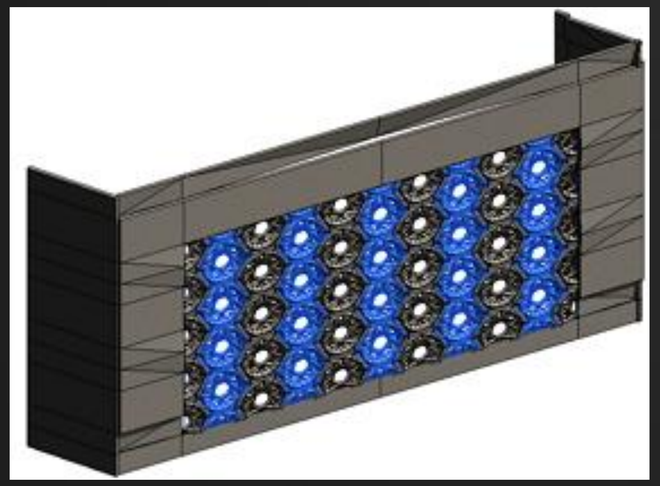
Inner “ribs” – each is controlled by a reference line and two profiles each

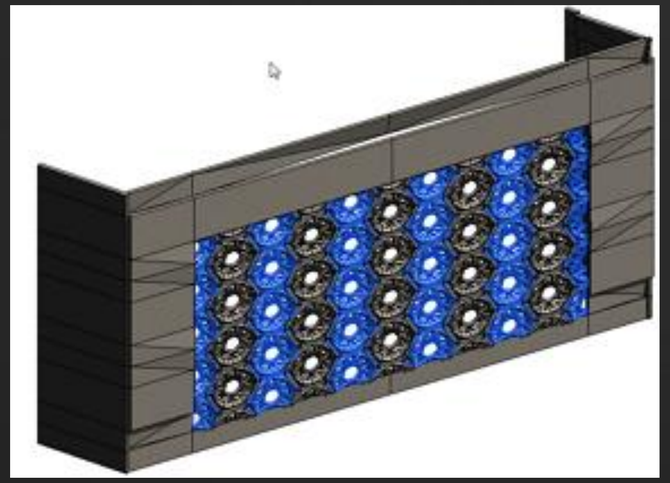






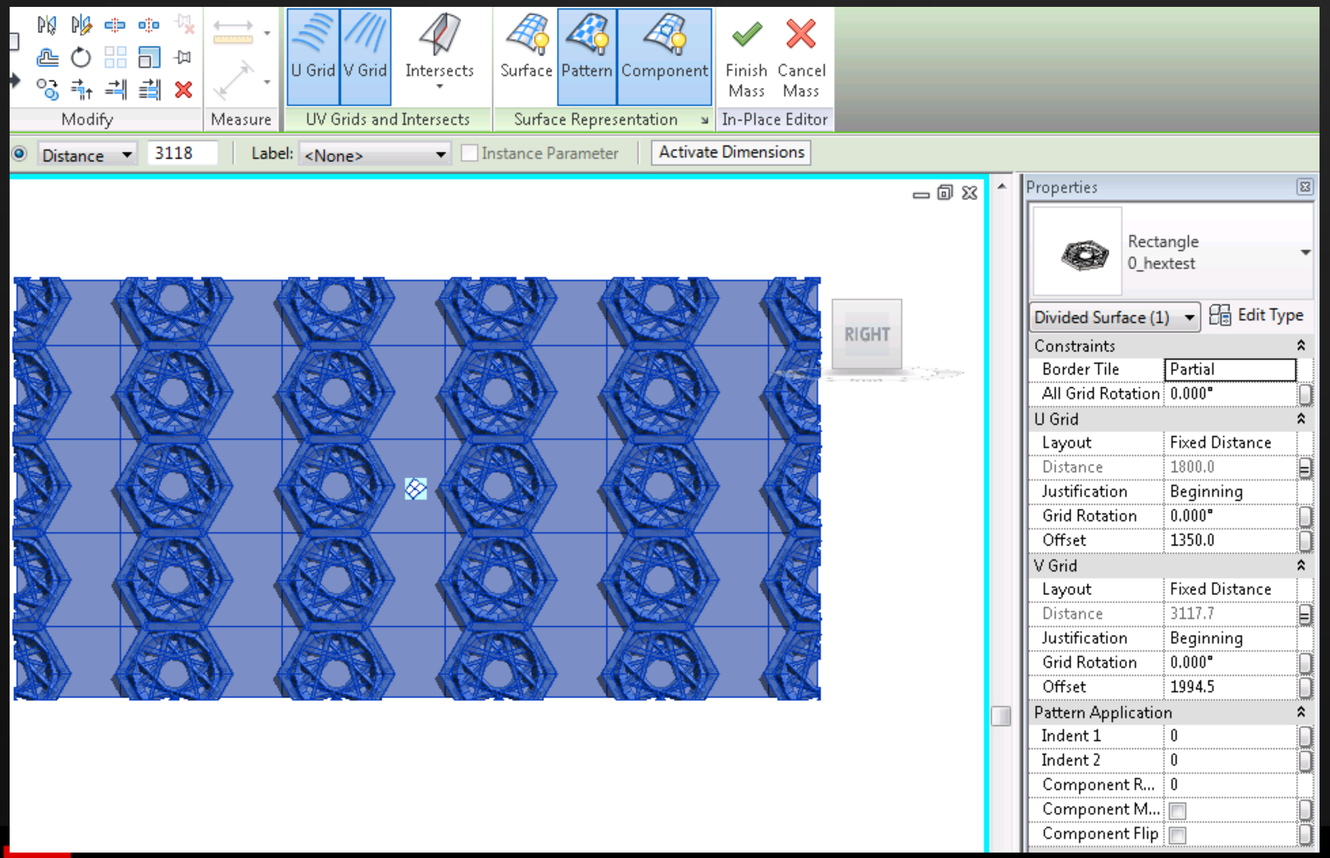


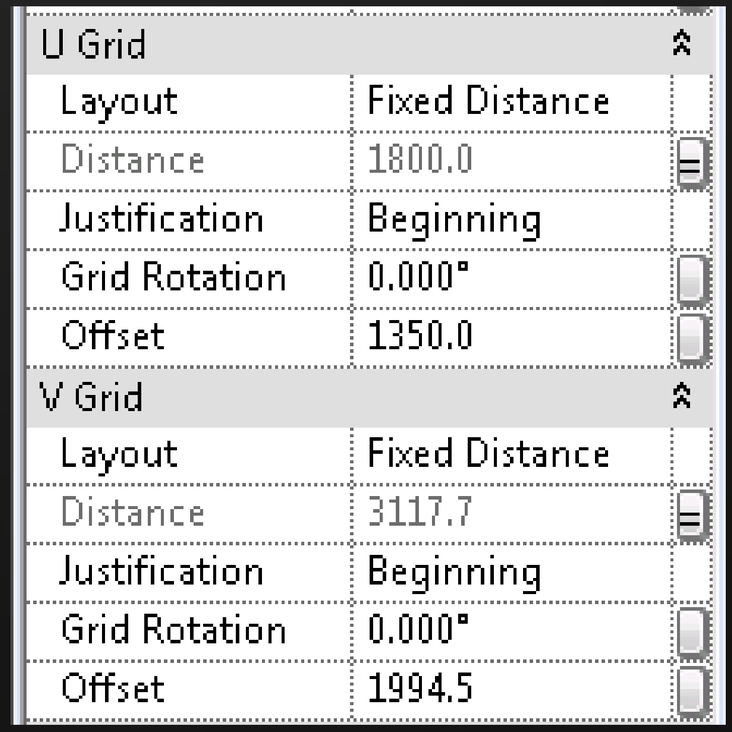




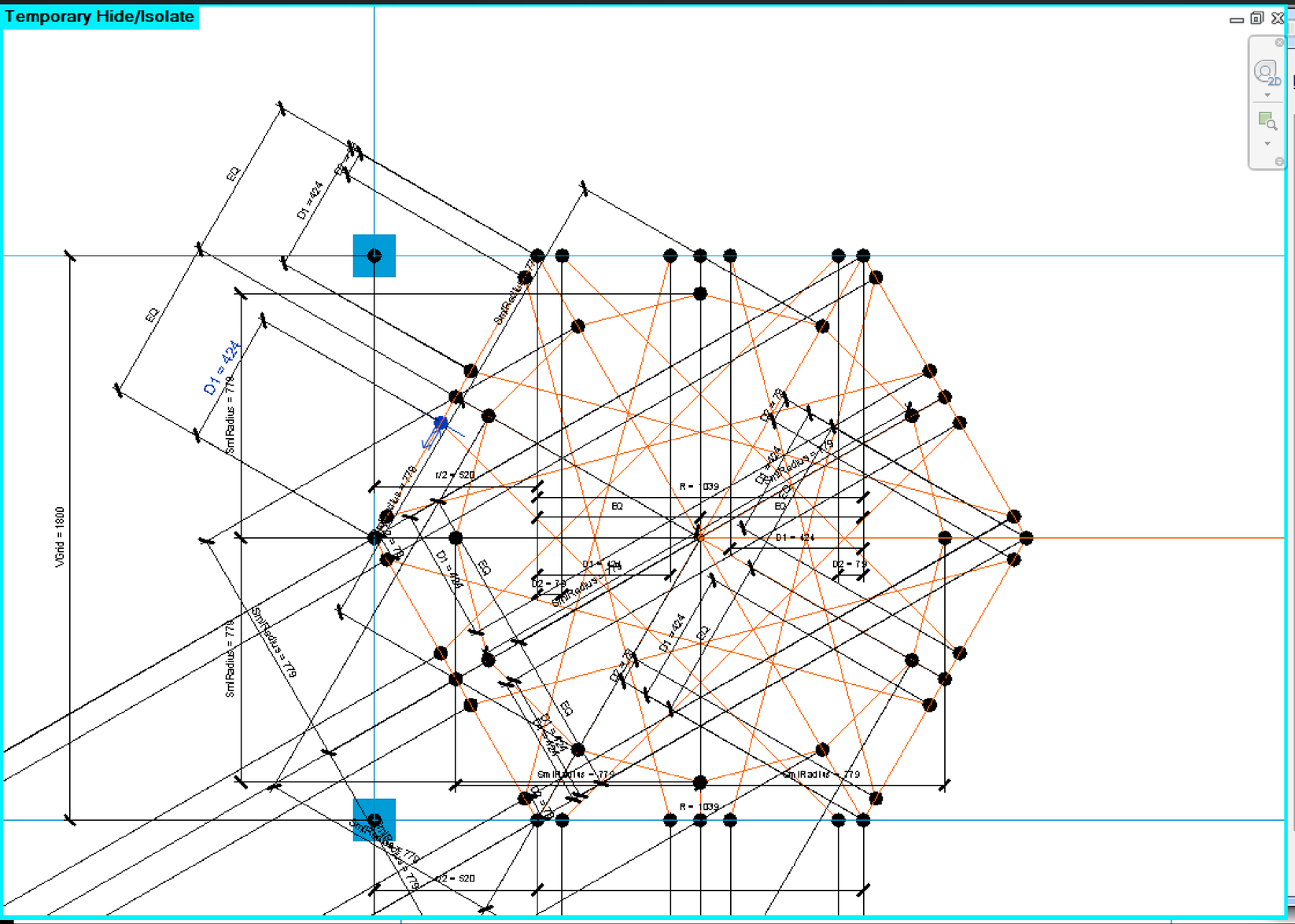
Two masses (surfaces) duplicated in the same place. The same pattern and panel

Different offsets- vertical and horizontal shift



# Round 2: All is Relative




Family Types

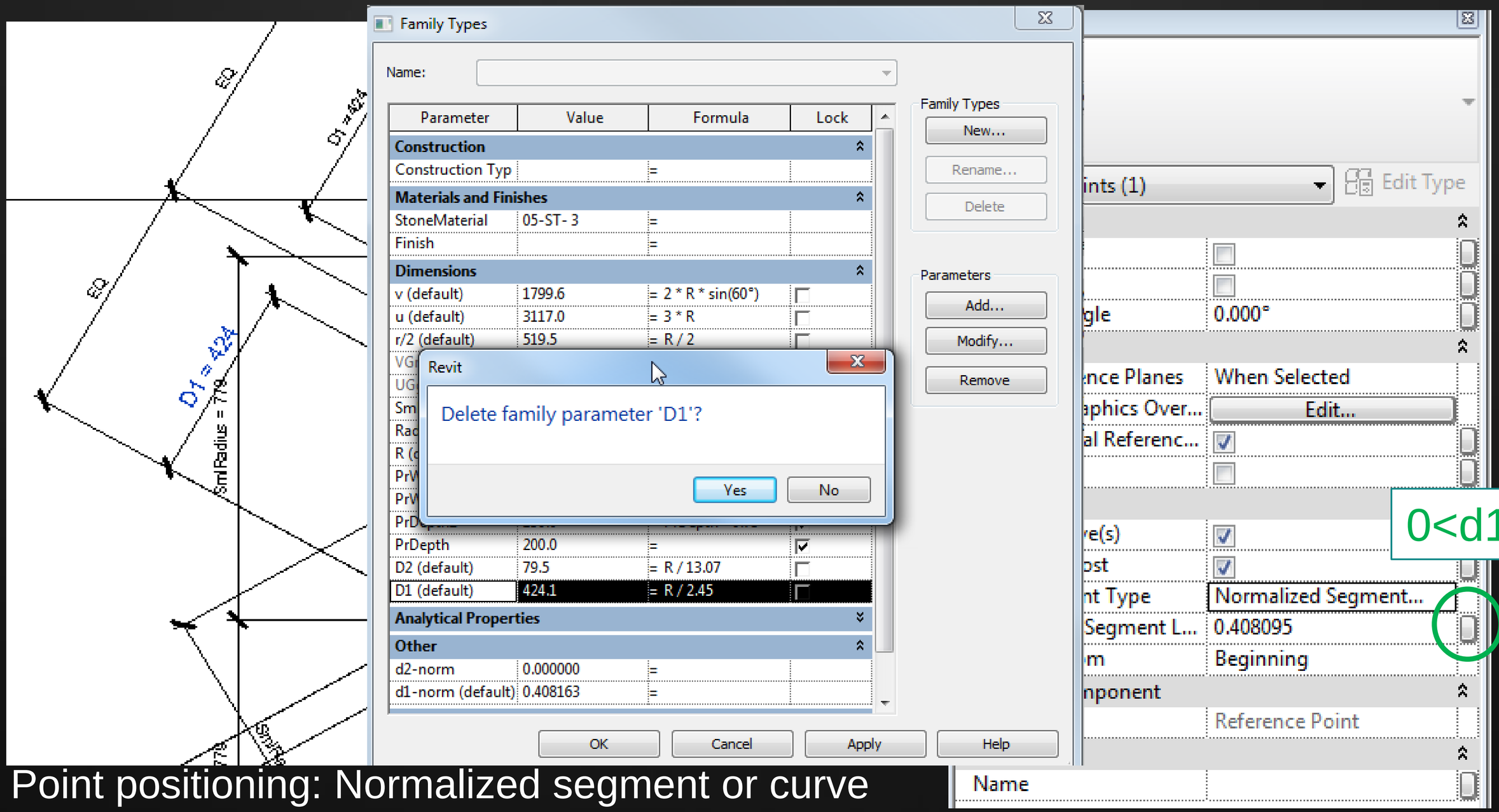
Name:

| Parameter | Value | Formula | Lock |
|---|---|---|---|
| **Construction** | | | |
| Construction Typ | | = | |
| **Materials and Finishes** | | | |
| StoneMaterial | 05-ST- 3 | = | |
| Finish | | = | |
| **Dimensions** | | | |
| v (default) | 1799.6 | = 2 * R * sin(60°) | ☐ |
| u (default) | 3117.0 | = 3 * R | ☐ |
| r/2 (default) | 519.5 | = R / 2 | ☐ |
| VGrid (report) | 1800.0 | = | |
| UGgrid (report) | 3117.0 | = | |
| SmlRadius (defaul | 779.3 | = R * 0.75 | ☐ |
| Radius-profile | 101.6 | = | ☐ |
| R (default) | 1039.0 | = UGgrid / 3 | ☐ |
| PrWidth2 | 112.5 | = PrWidth * 0.75 | ☑ |
| PrWidth | 150.0 | = | ☑ |
| PrDepth2 | 150.0 | = PrDepth * 0.75 | ☑ |
| PrDepth | 200.0 | = | ☑ |
| D2 (default) | 79.5 | = R / 13.07 | ☐ |
| D1 (default) | 424.1 | = R / 2.45 | ☐ |
| **Analytical Properties** | | | |
| Analytic Construc | | = | |
| Visual Light Trans | | = | |
| Solar Heat Gain C | | = | |
| Thermal Resistan | | = | |
| Heat Transfer Coe | | = | |

Family Types: New... Rename... Delete

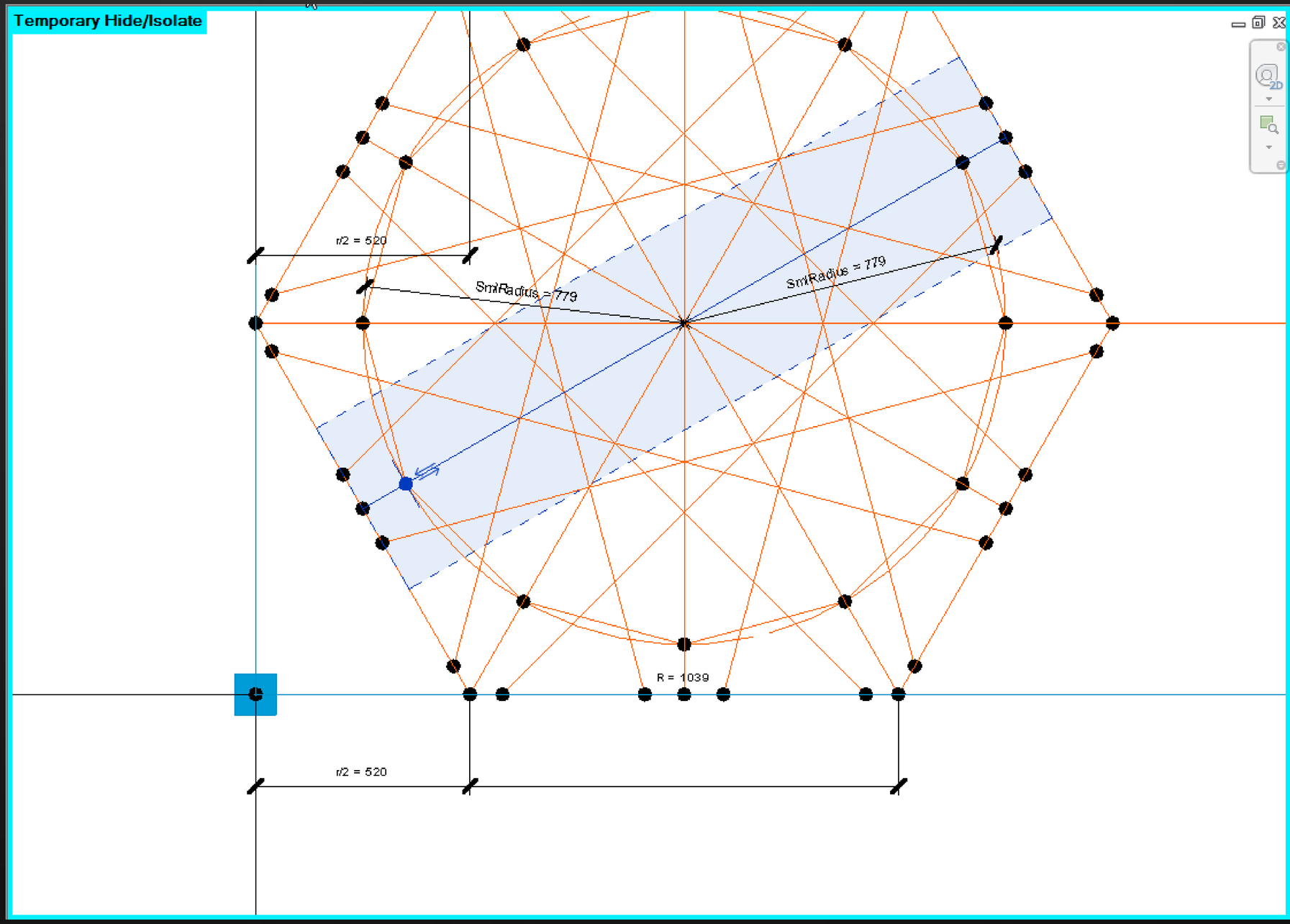
Parameters: Add... Modify... Remove

OK Cancel Apply Help



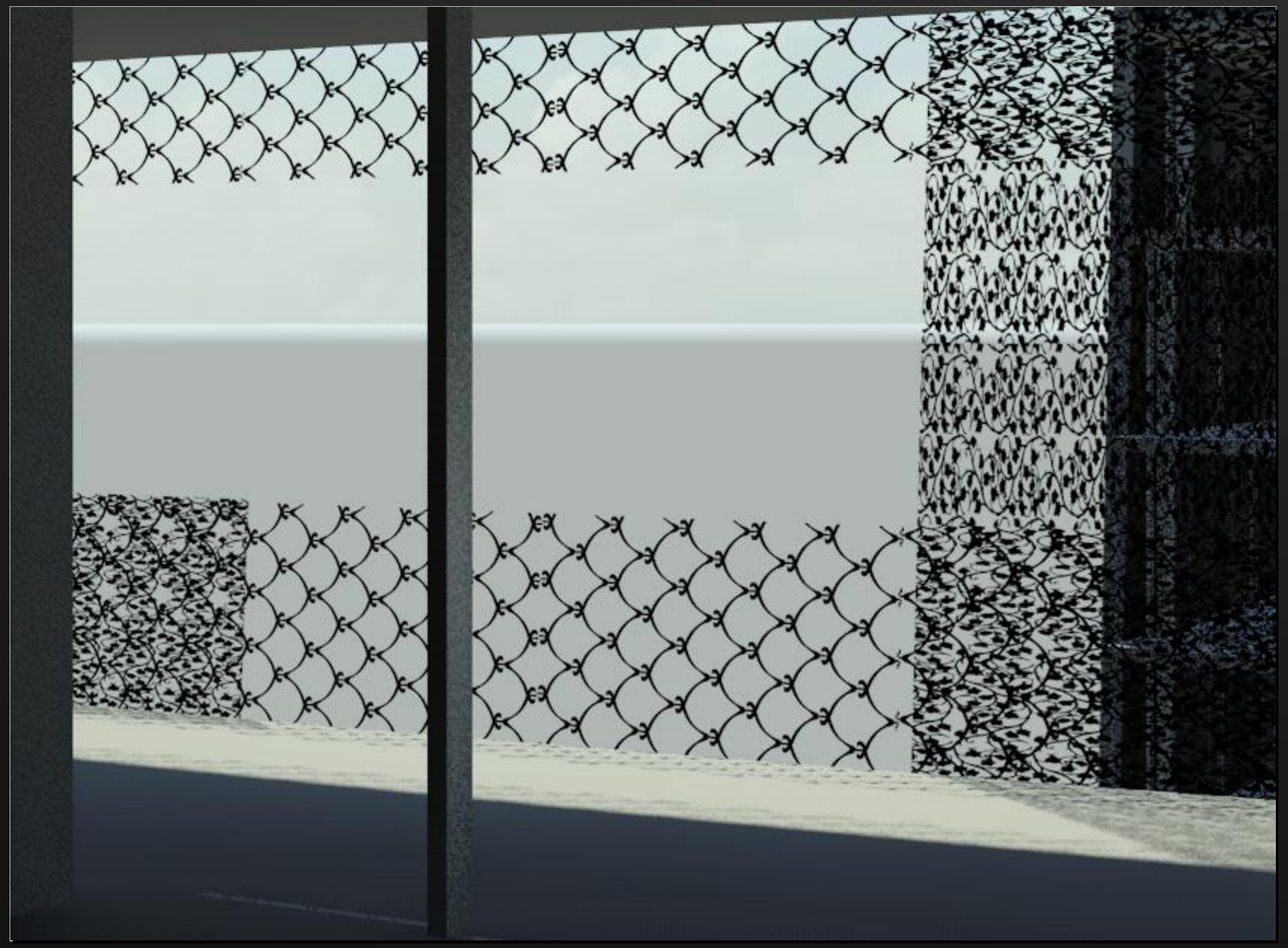

# Point positioning: Normalized segment or curve

- Point positioning: Normalized
- Points on small radius are hosted by intersection



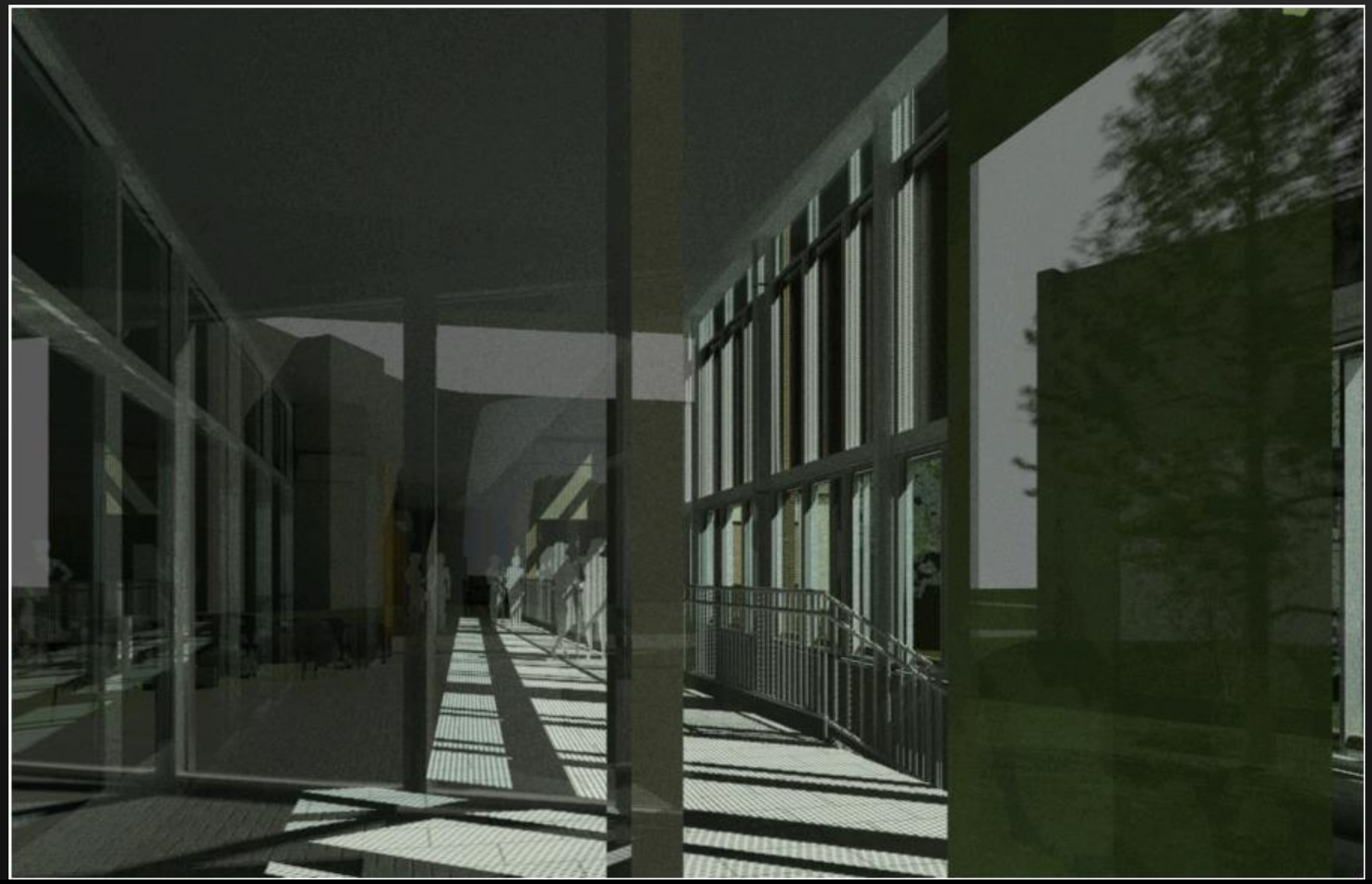
# Material Matters

# Materials with cutouts



**Shaded View**
**Realistic View**
**Rendered View**

# Materials with cutouts

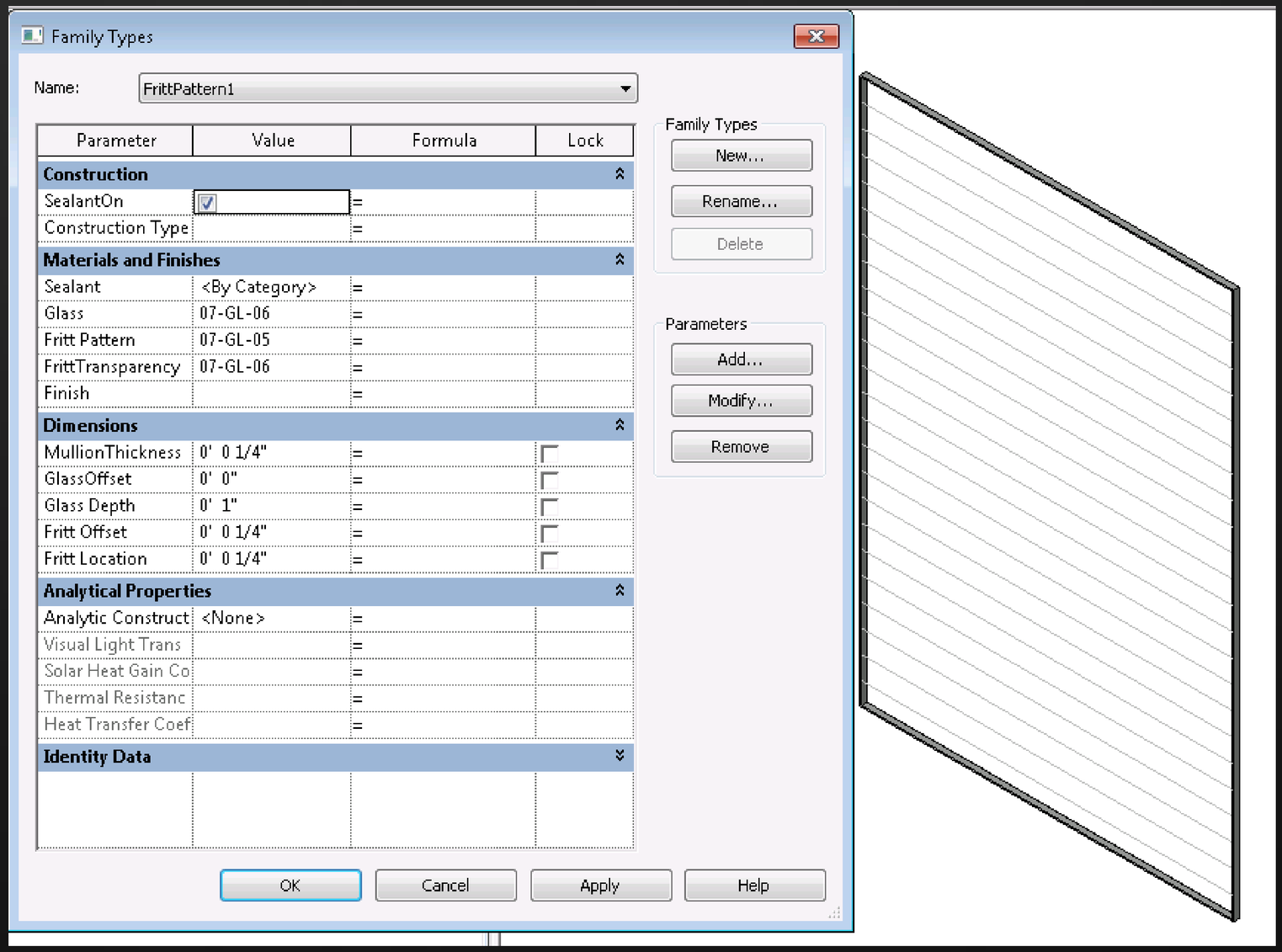


**Shaded View**

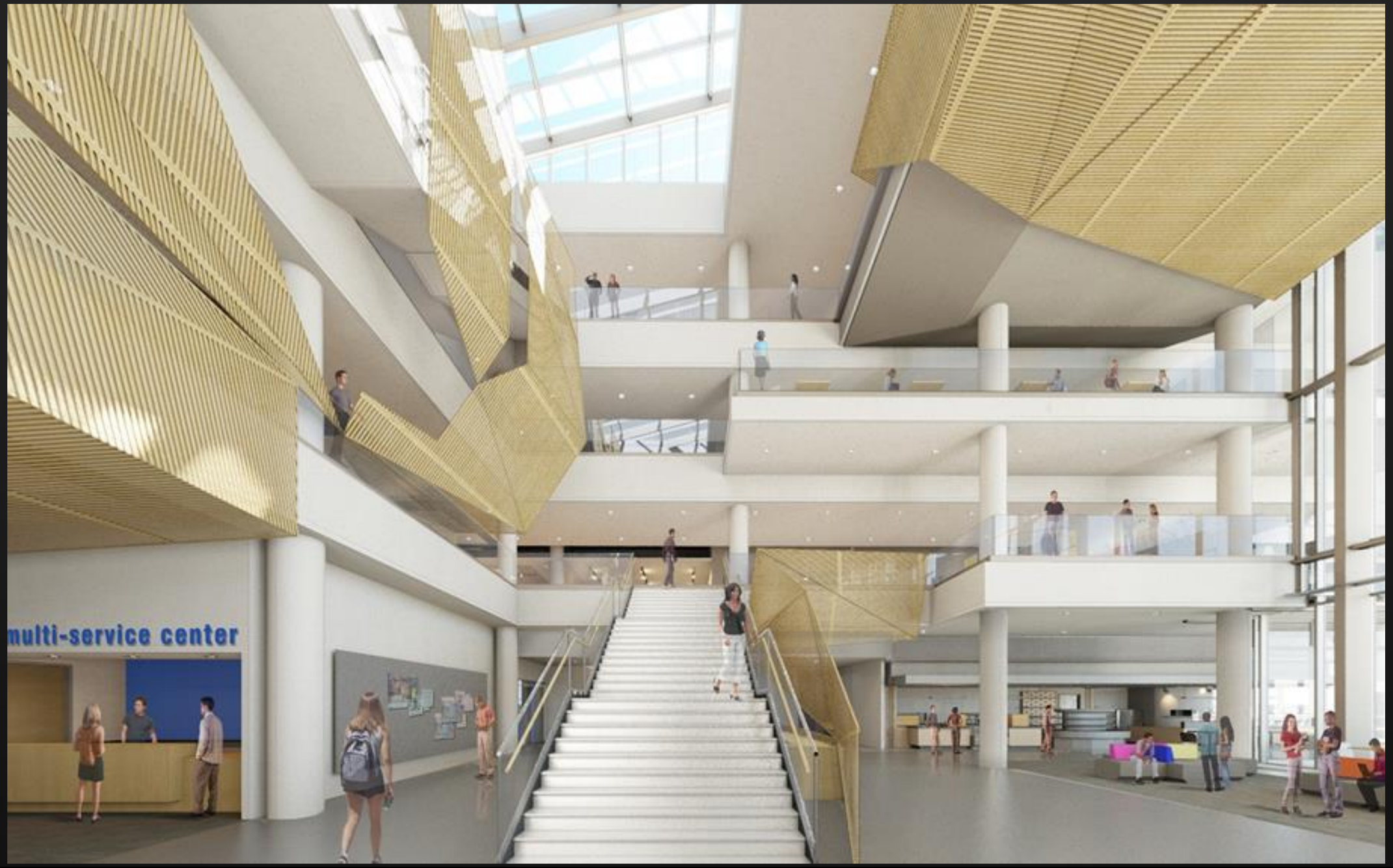
**Realistic View**

**Raytrace within Revit**

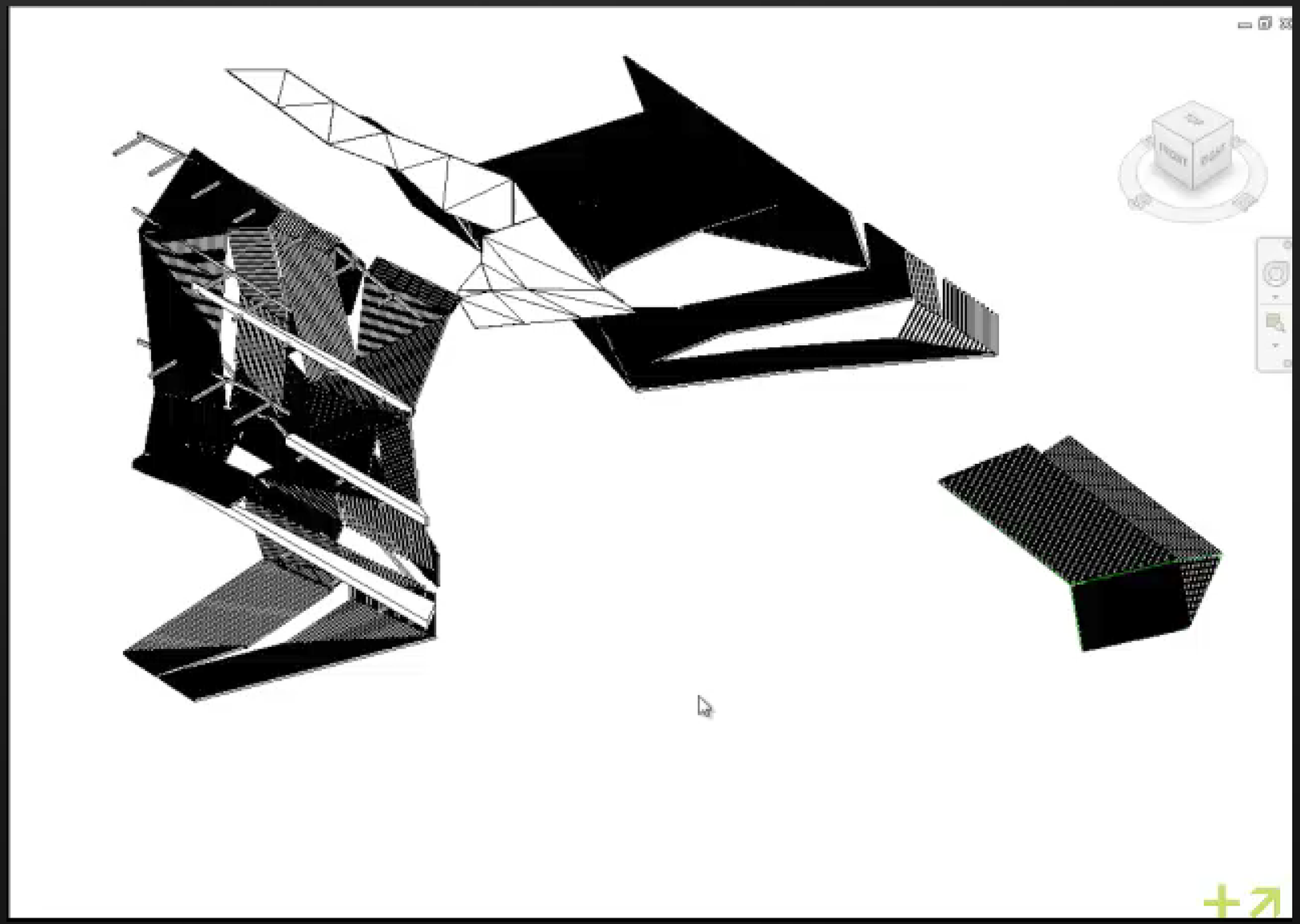
# Live Demo Frit Glass Panel



# Magic Lantern



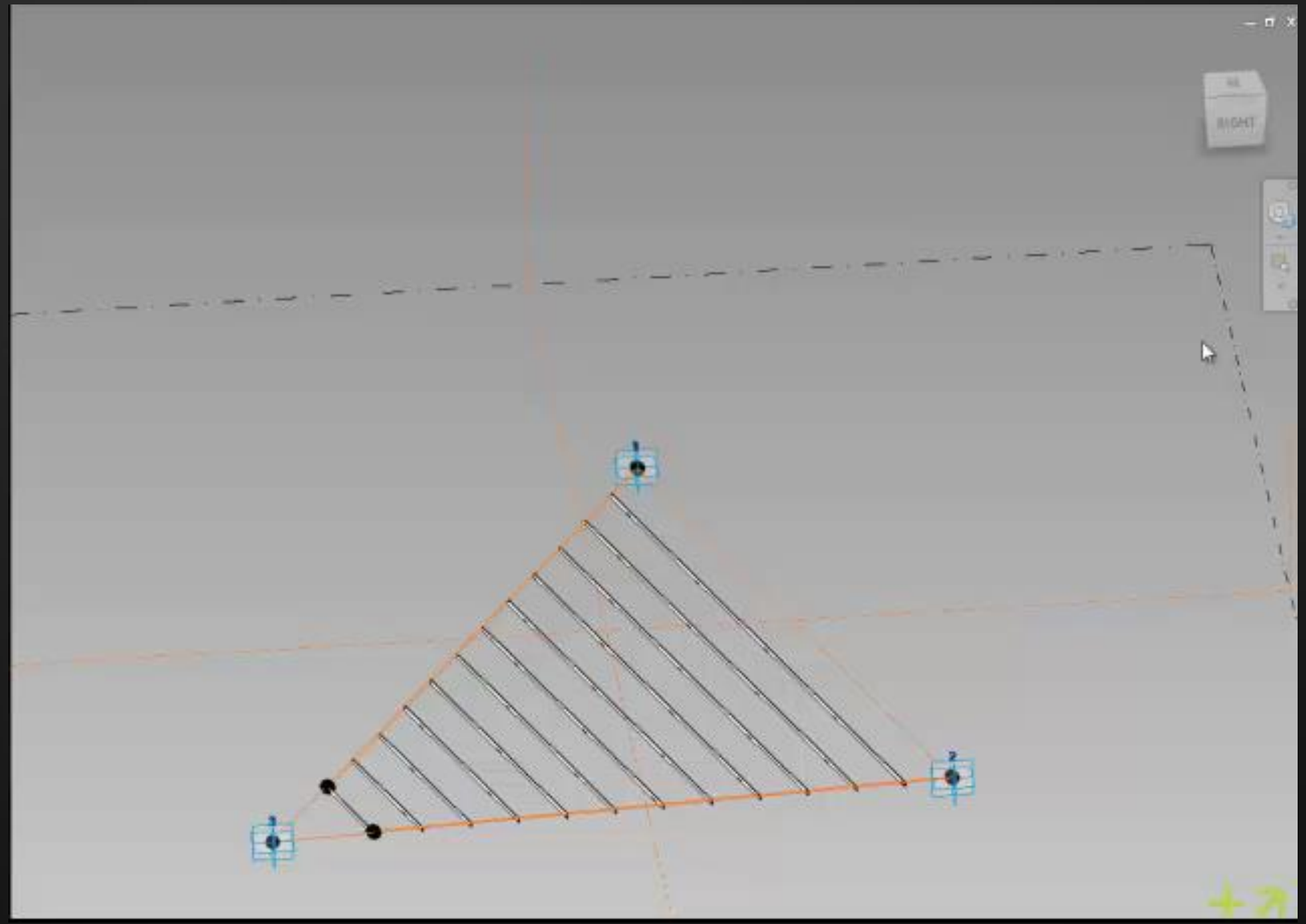
# Initial Approach. v2012



# Initial Approach. v2012

3 point Adaptive component

with divided surface

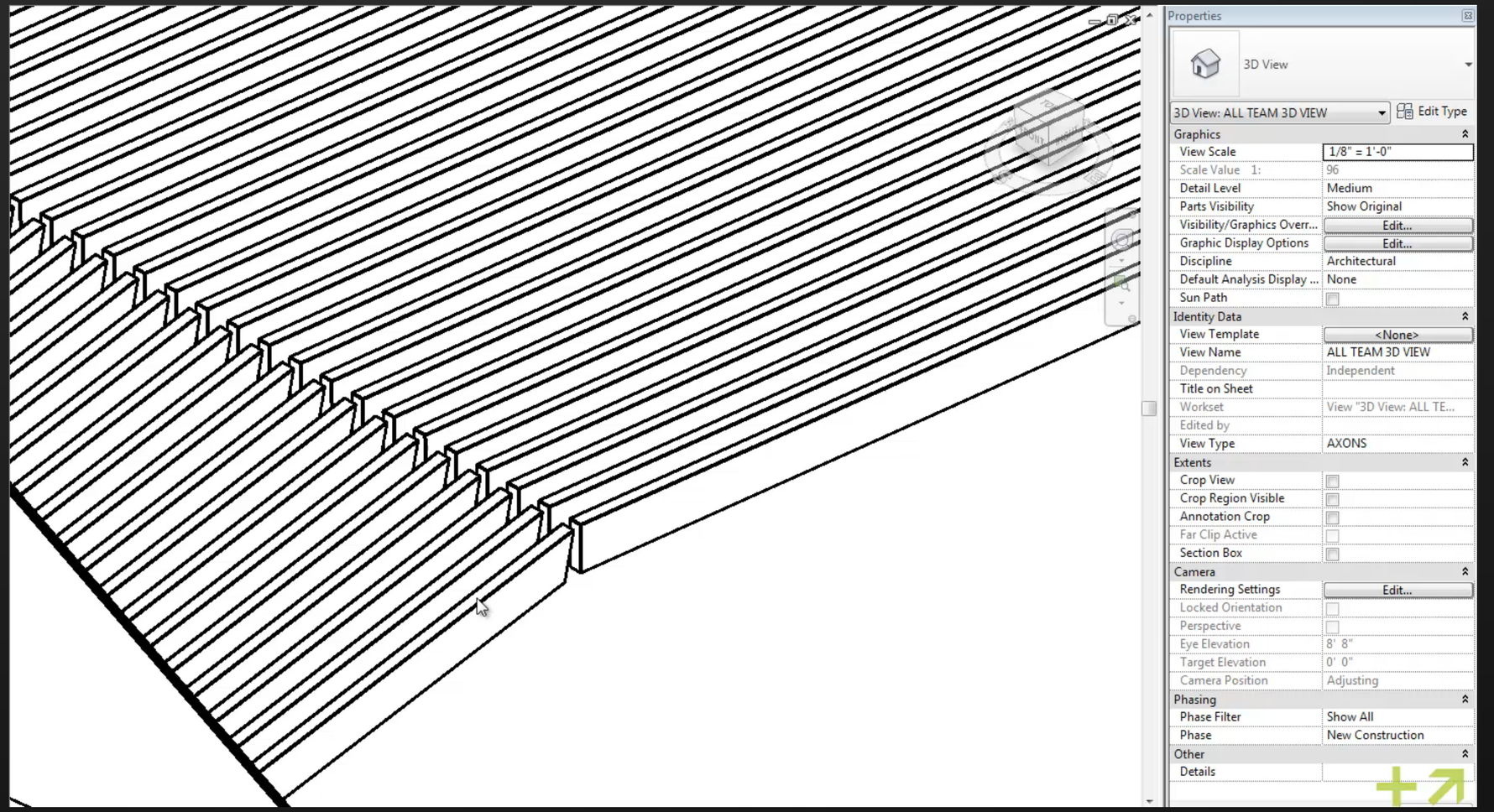


# Refinement. v2013

Swap family

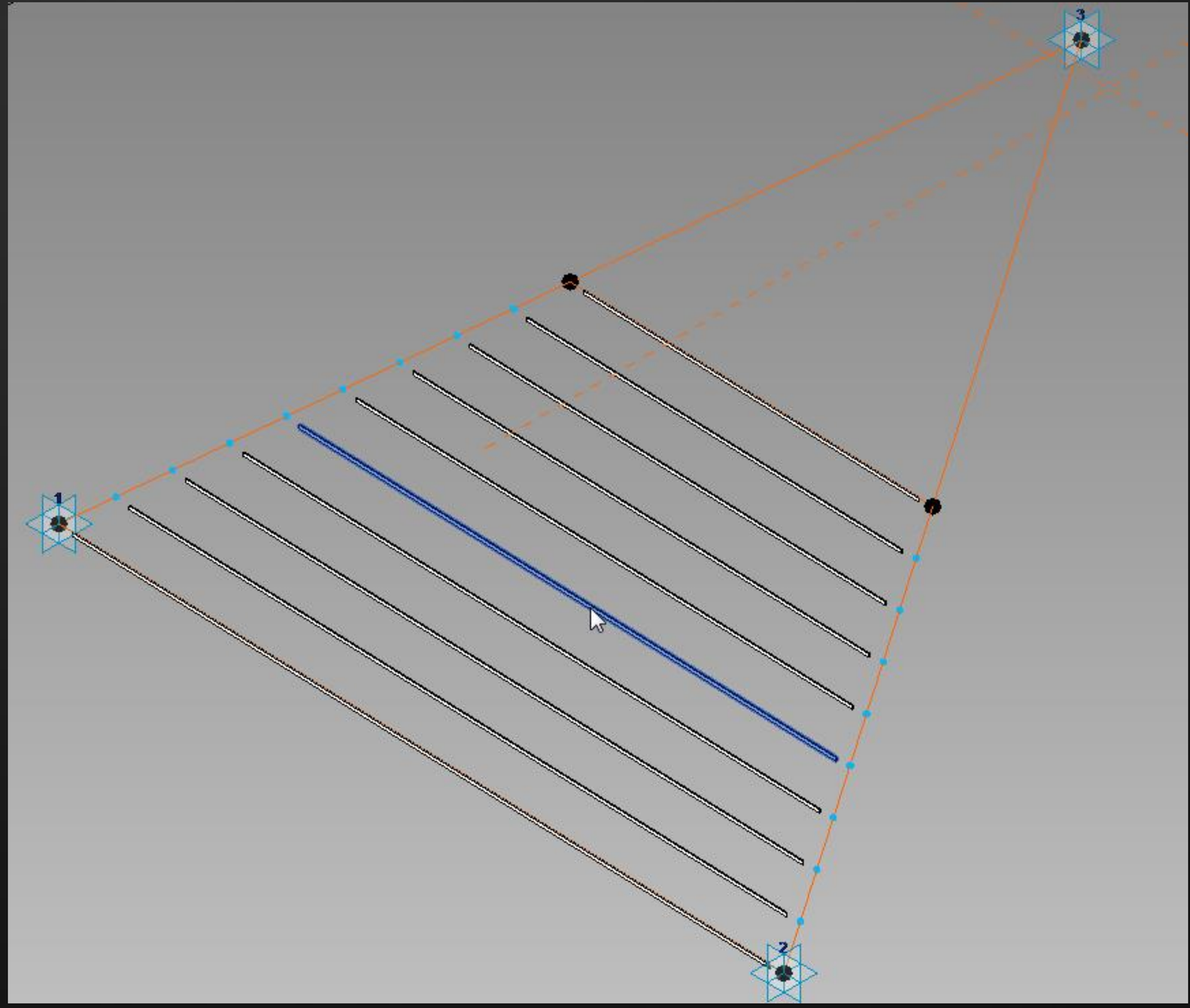
3 point Adaptive component

Divided paths hosting nested adaptive component



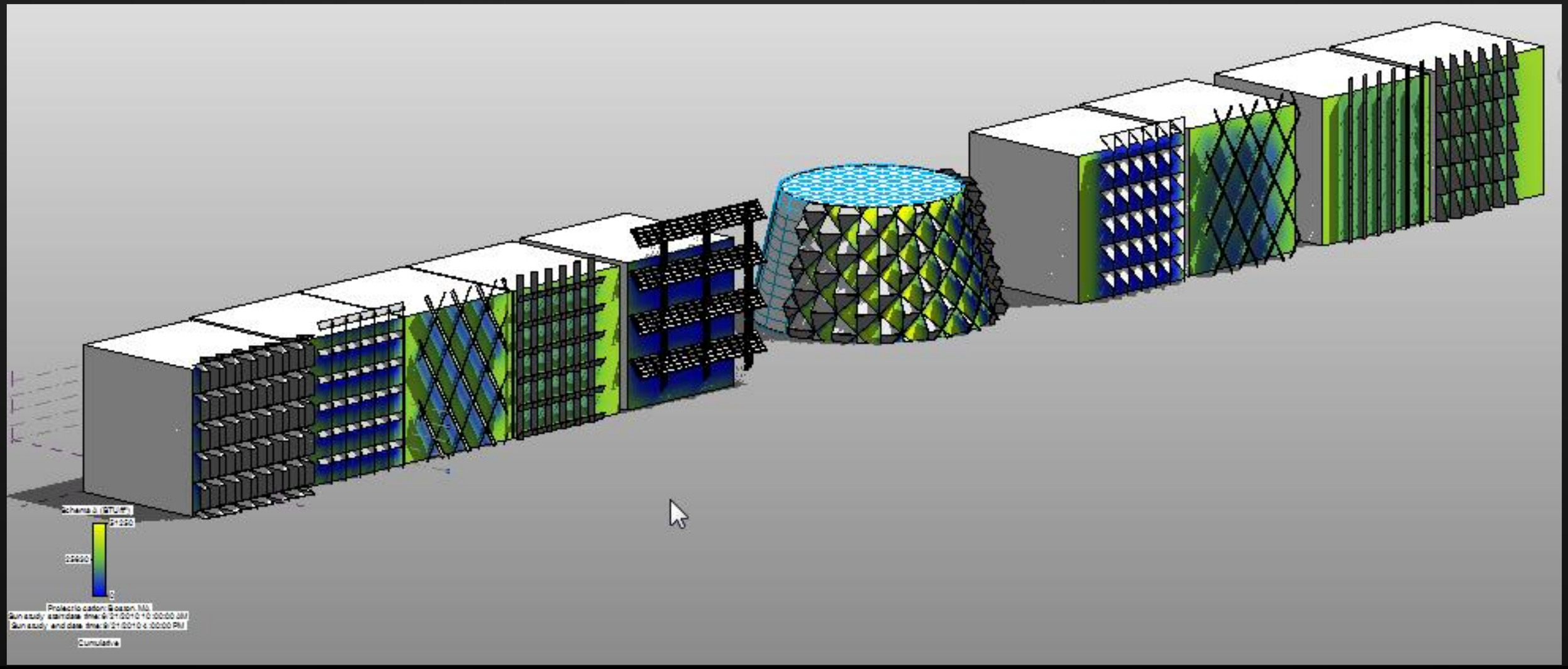
3 point Adaptive component

Divided paths hosting repeated adaptive component

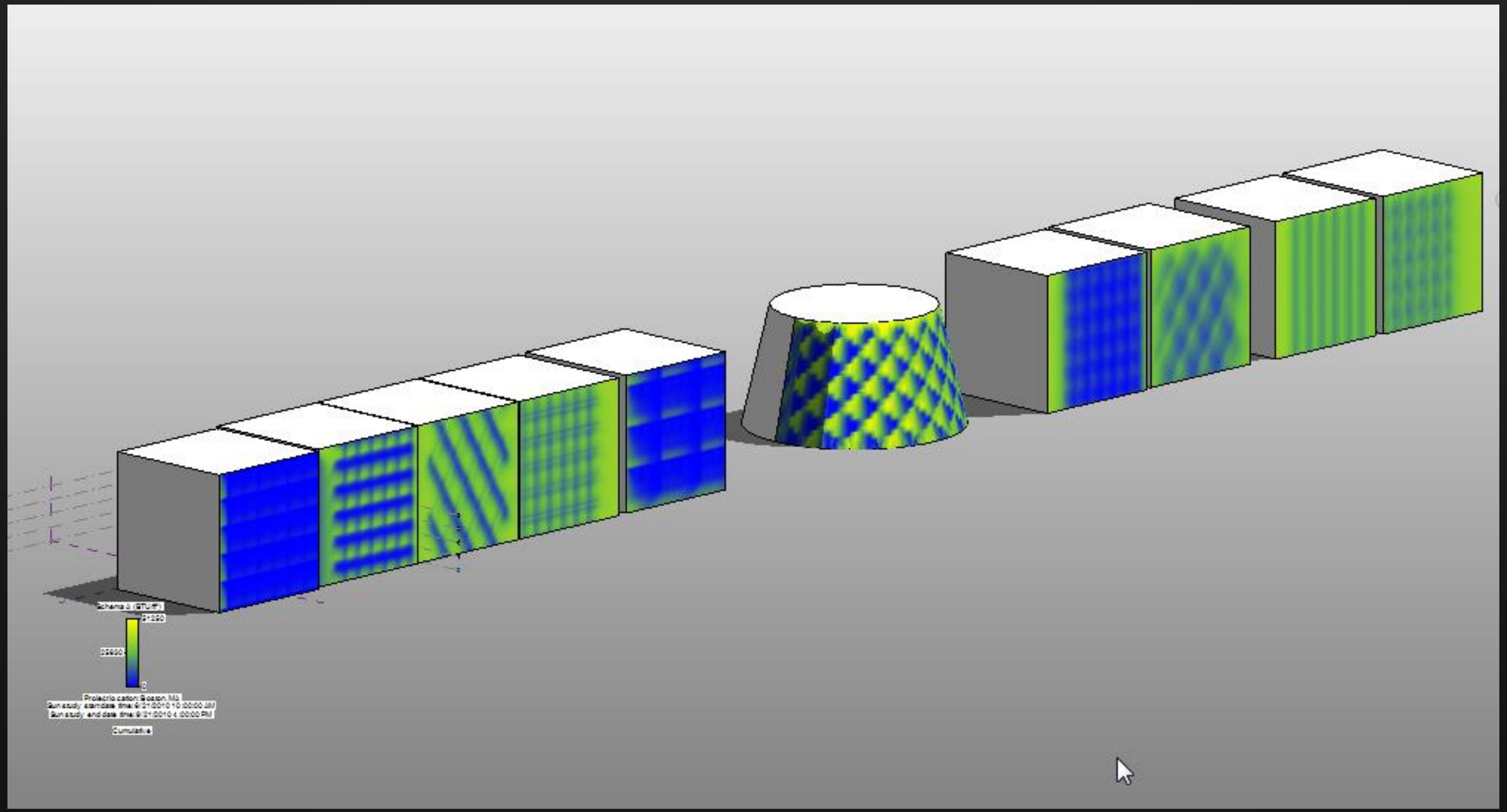


# Solar radiation – Rapid design iterations

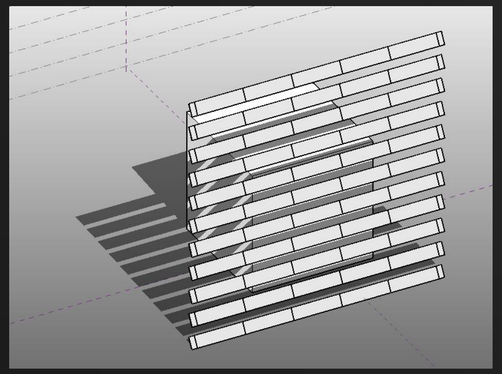
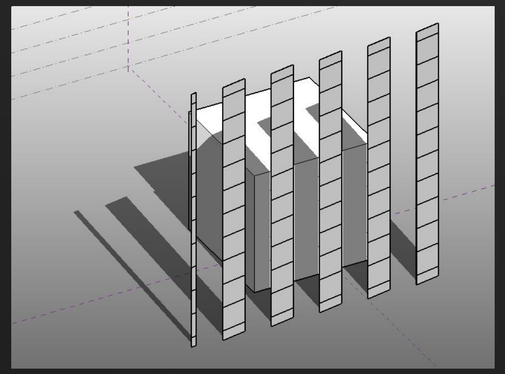
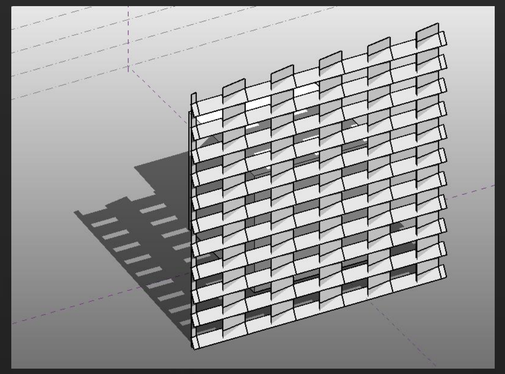
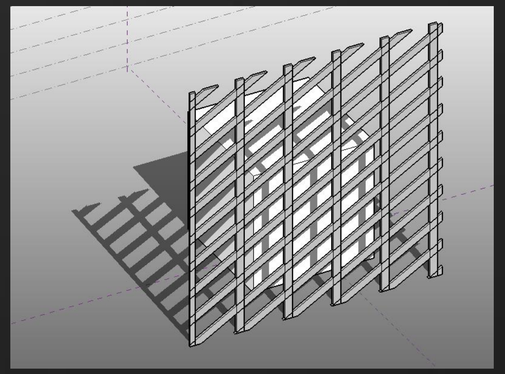
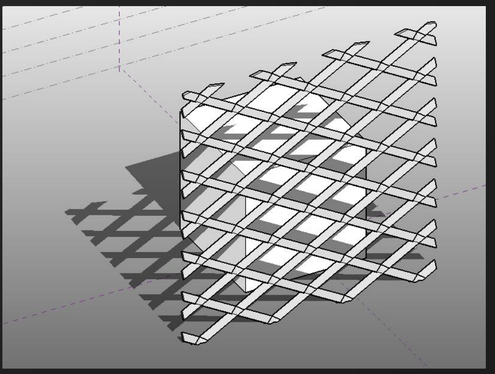
# Pre-built parametric families. Rapid design iterations

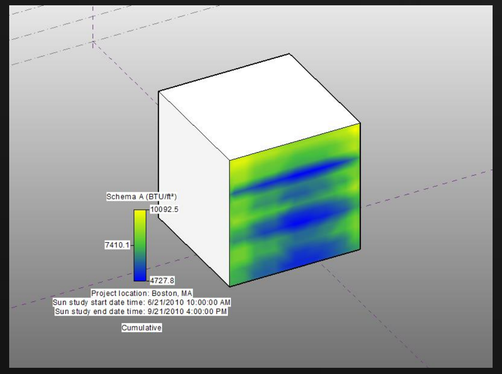


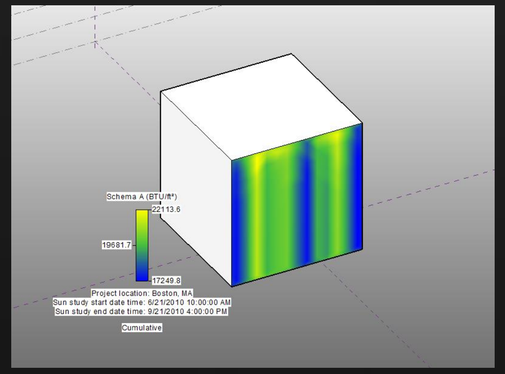
# Solar radiation patterns

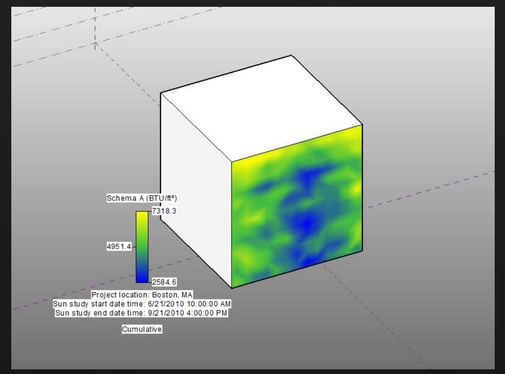


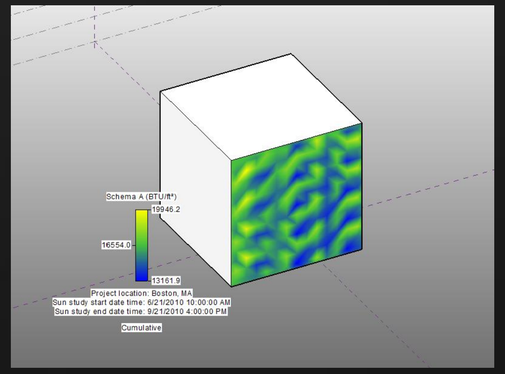
# Louvers: some variations

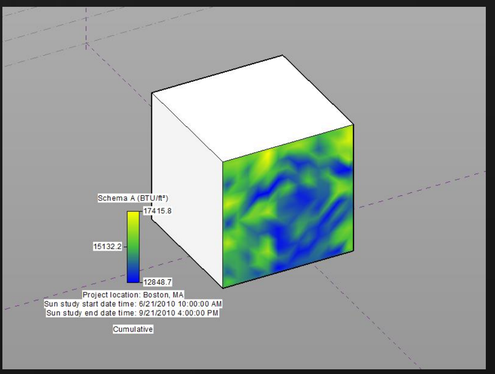








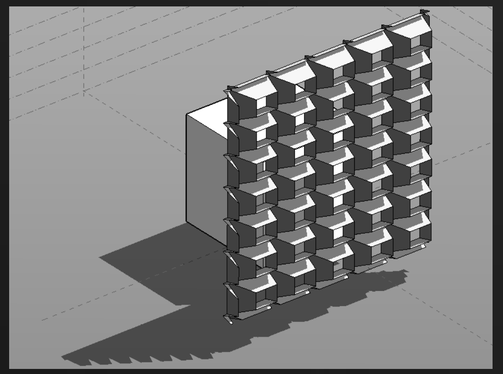
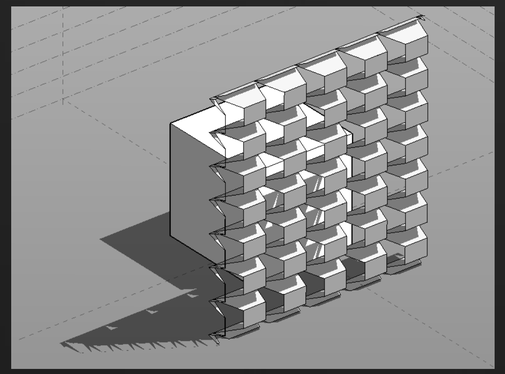
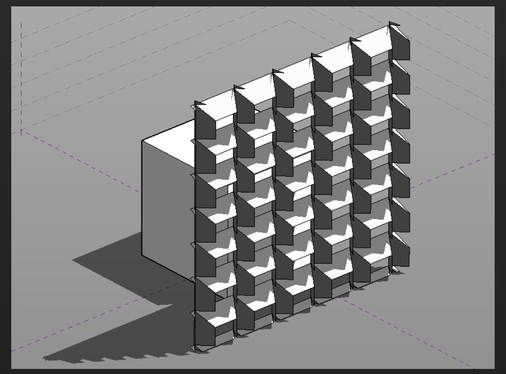
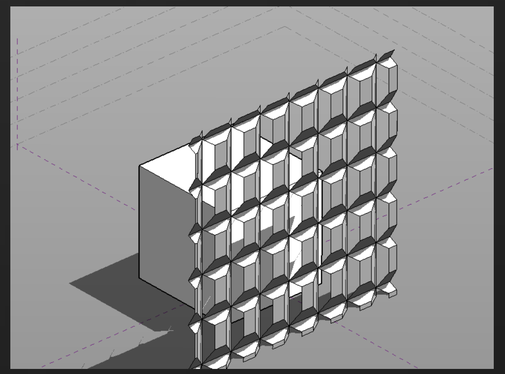
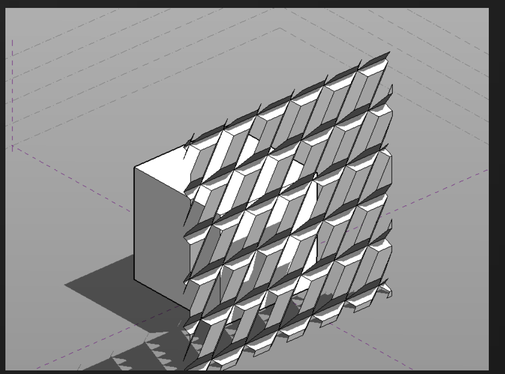
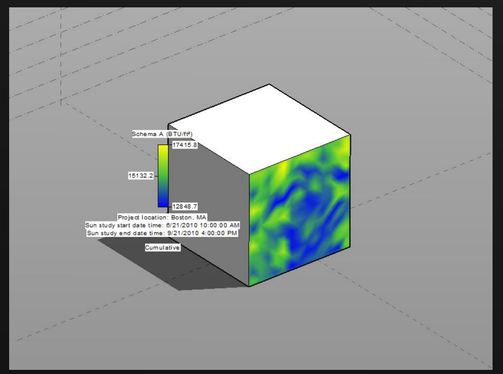


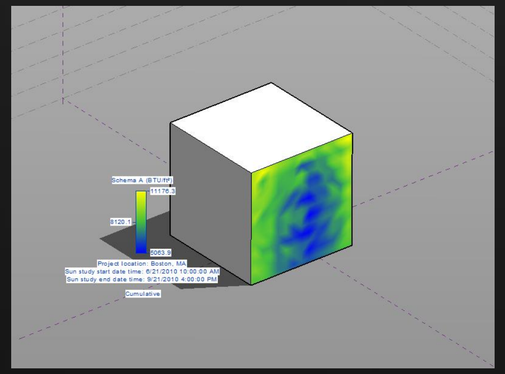


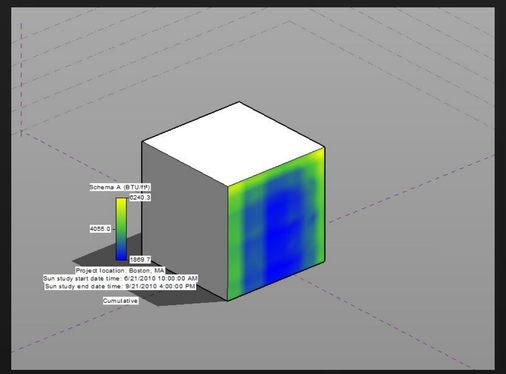


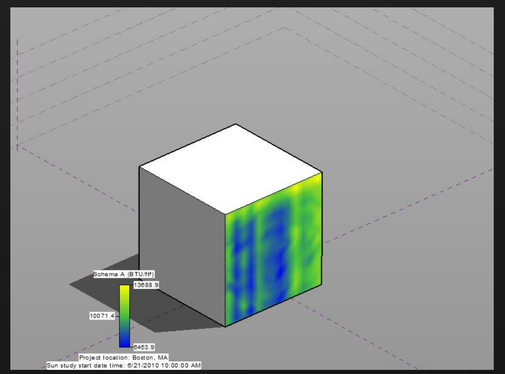


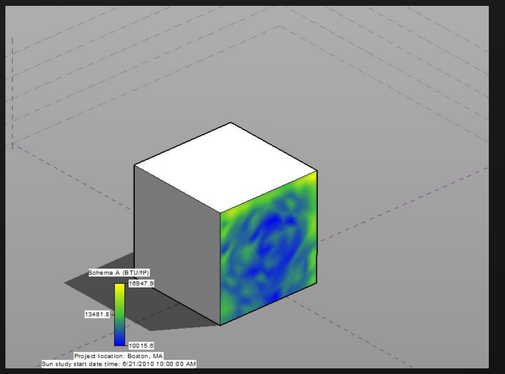
# Aperture : some variations









# Aperture : some variations