



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

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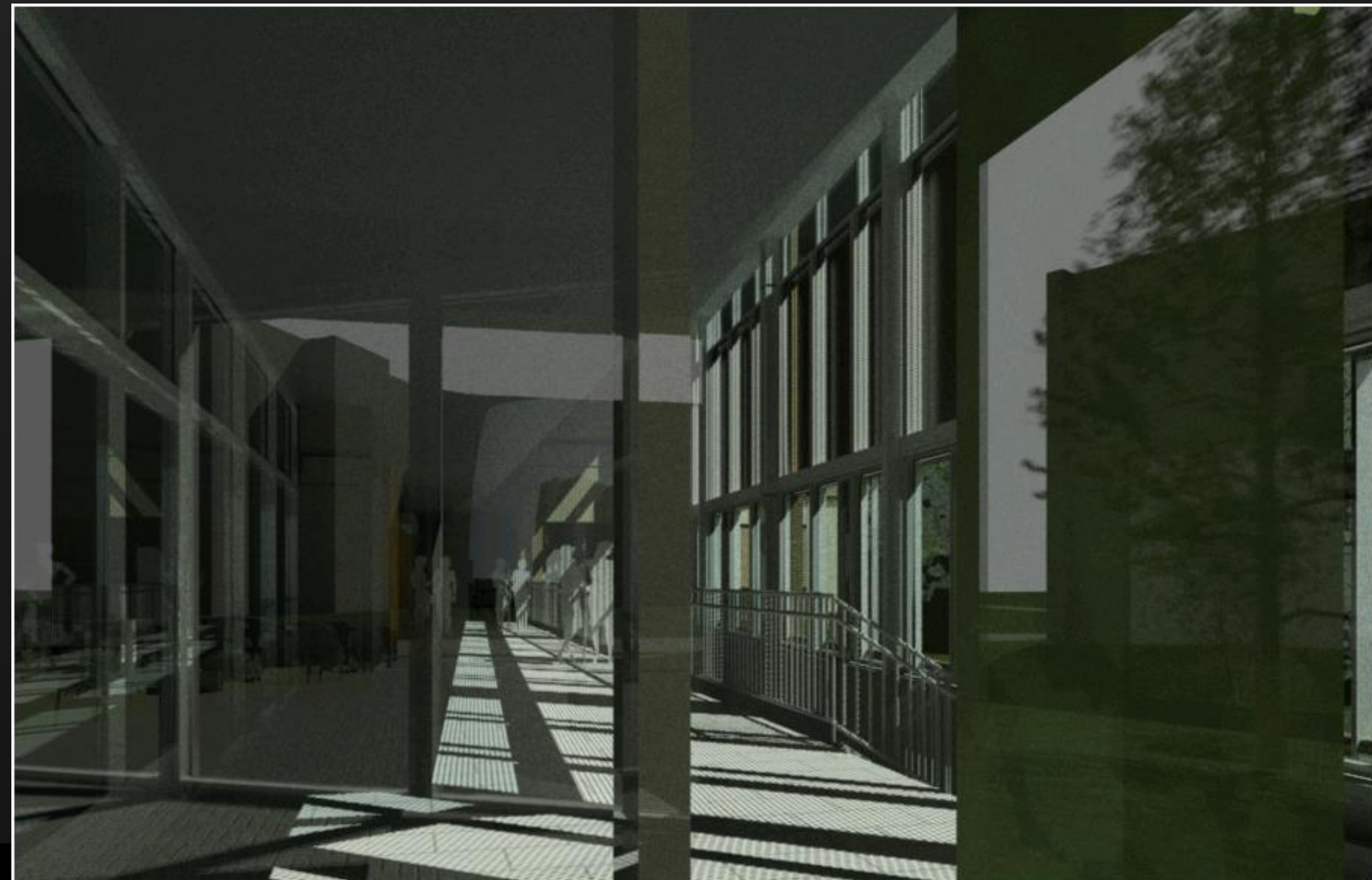
# Learning Objectives – Case Studies

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

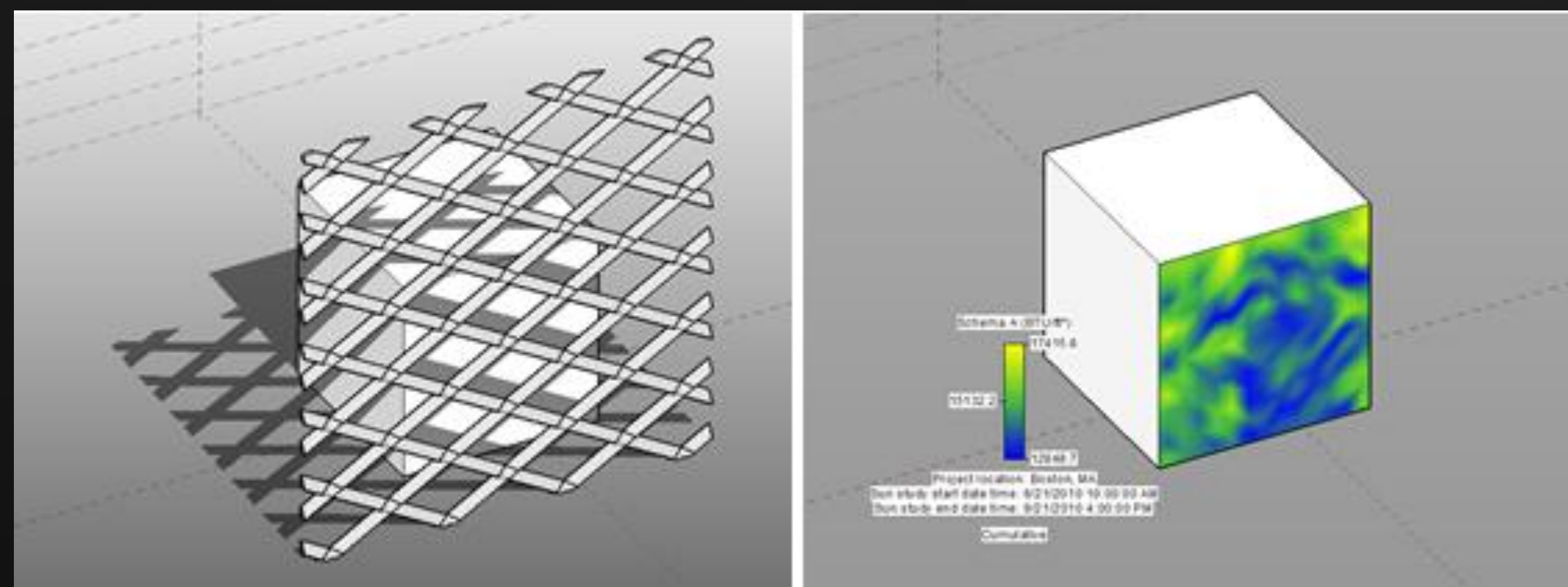
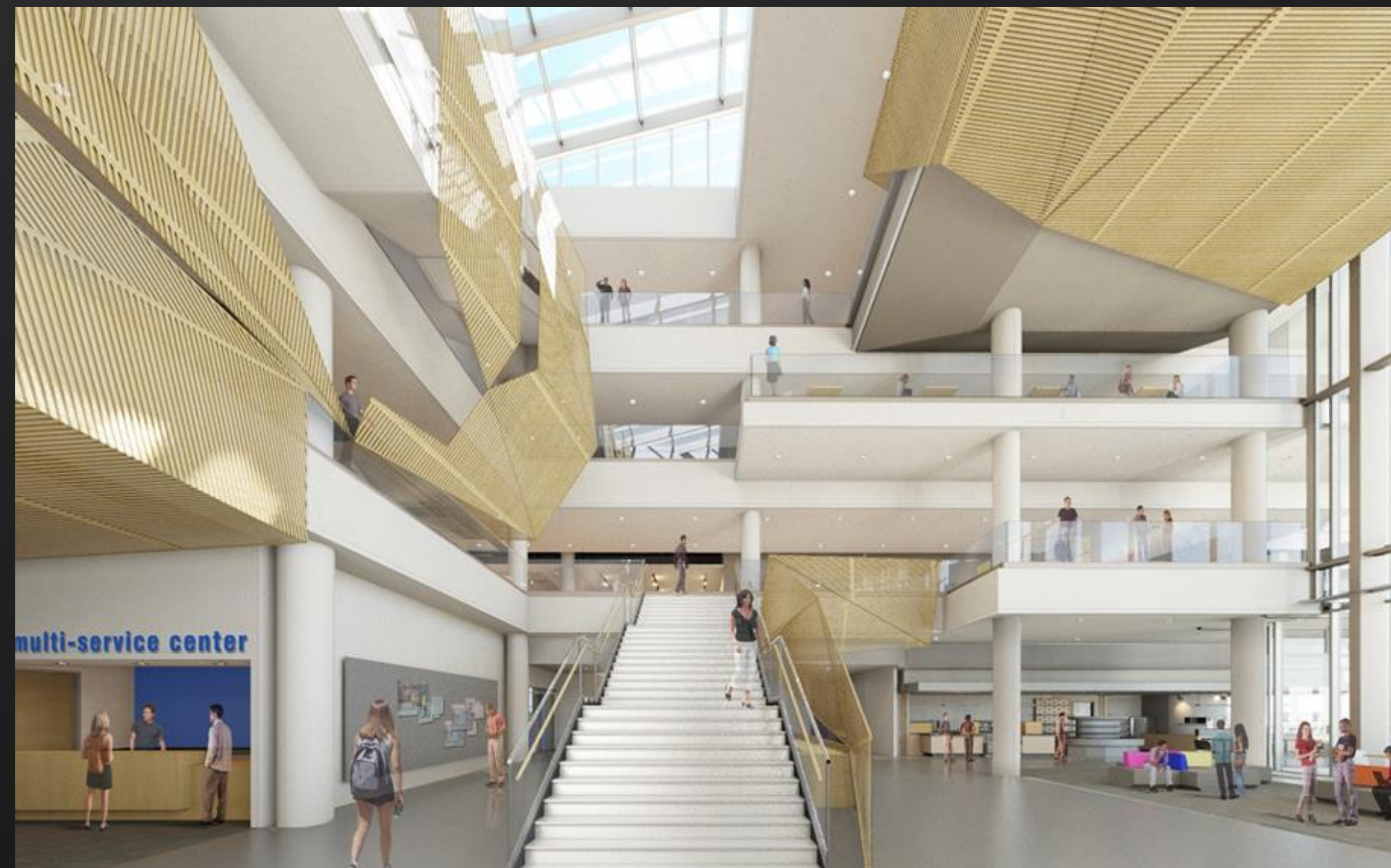


# Case studies





# Case studies





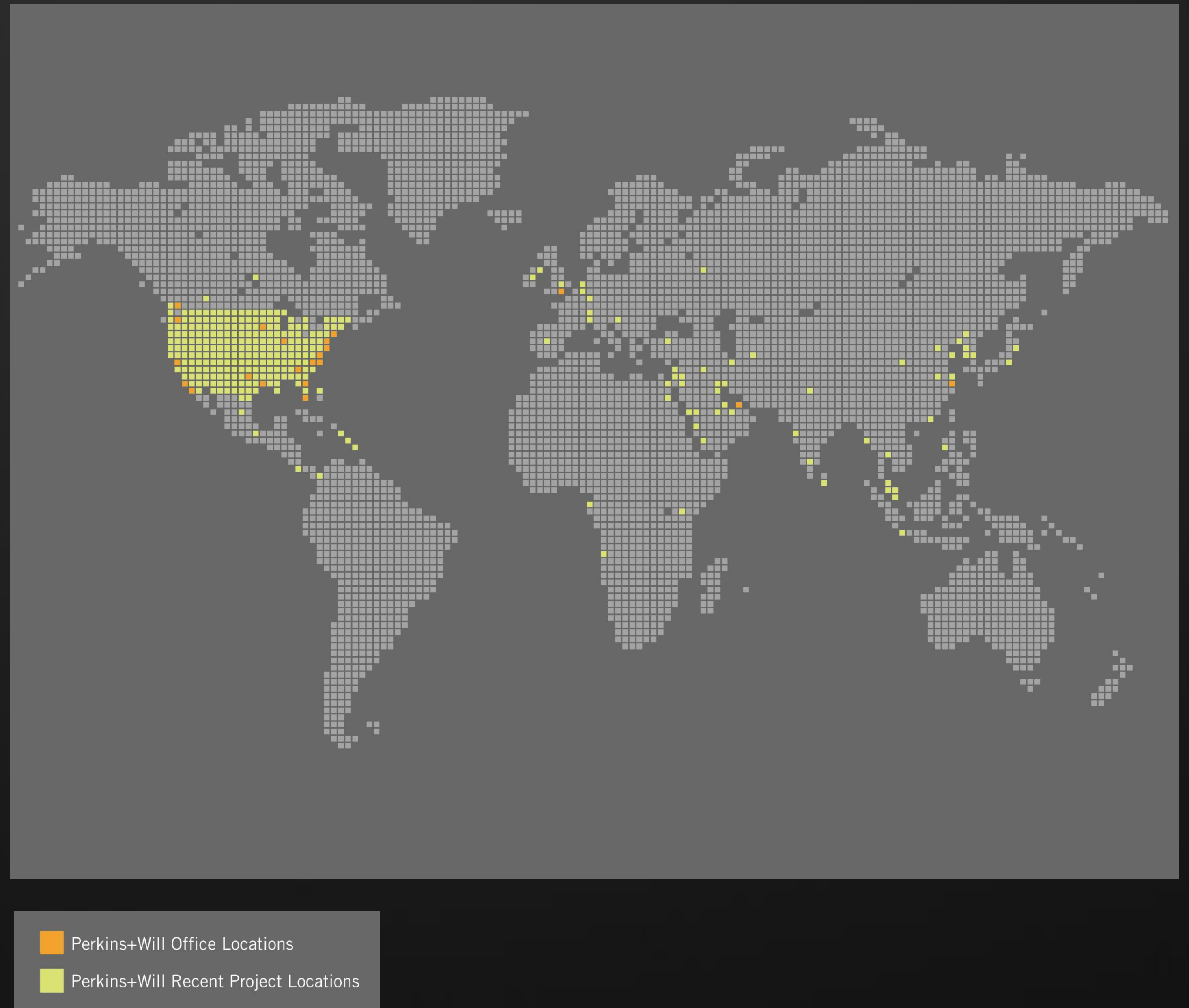
# Team



# 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.





## Market Sectors

Aviation  
Corporate Commercial Civic  
Healthcare  
Higher Education  
K-12 Education  
Science + Technology

## Disciplines

Architecture

Interiors

Planning + Strategies

Branded Environments

Urban Design

Clients'  
Business  
Demands

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**

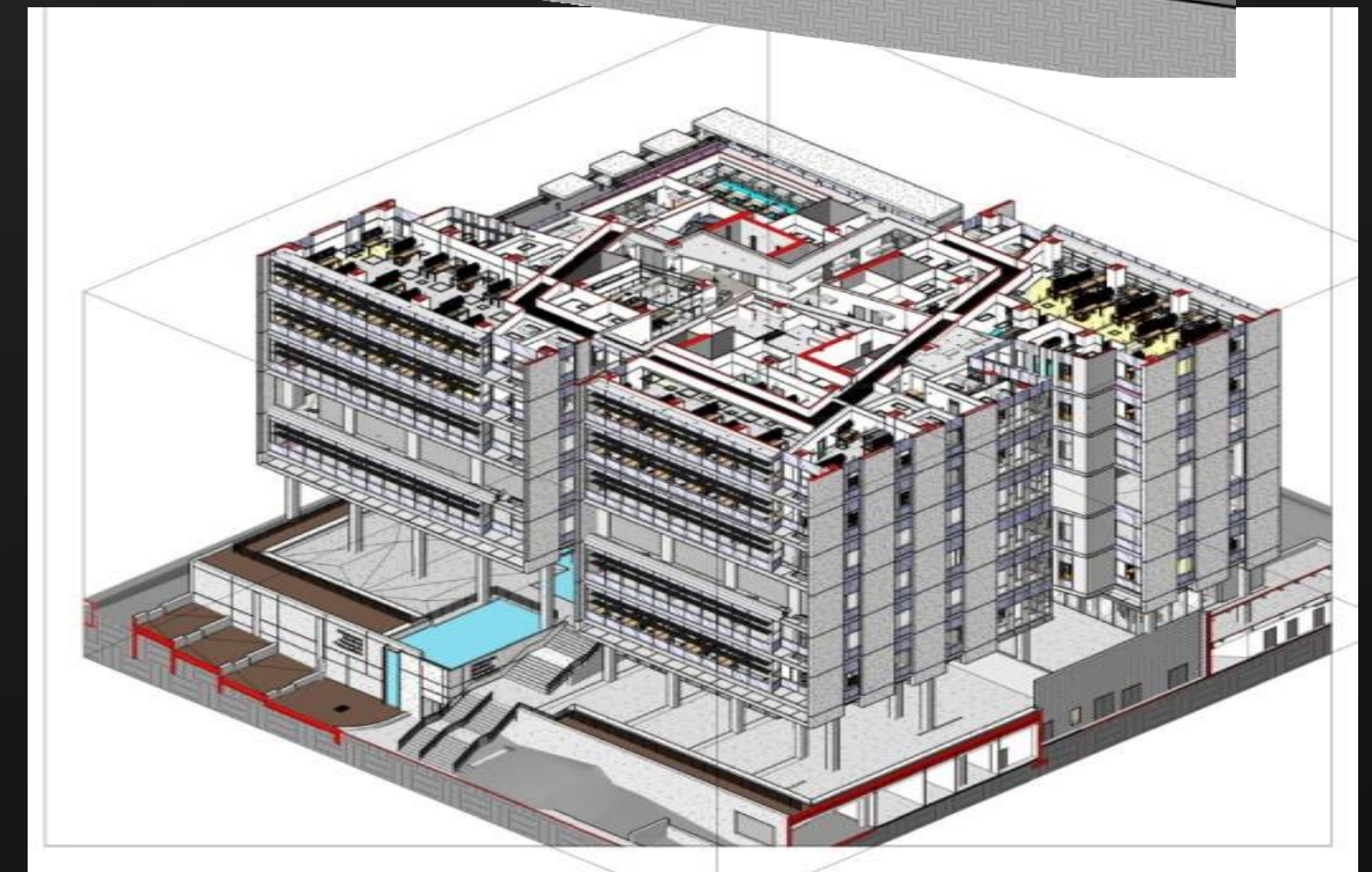
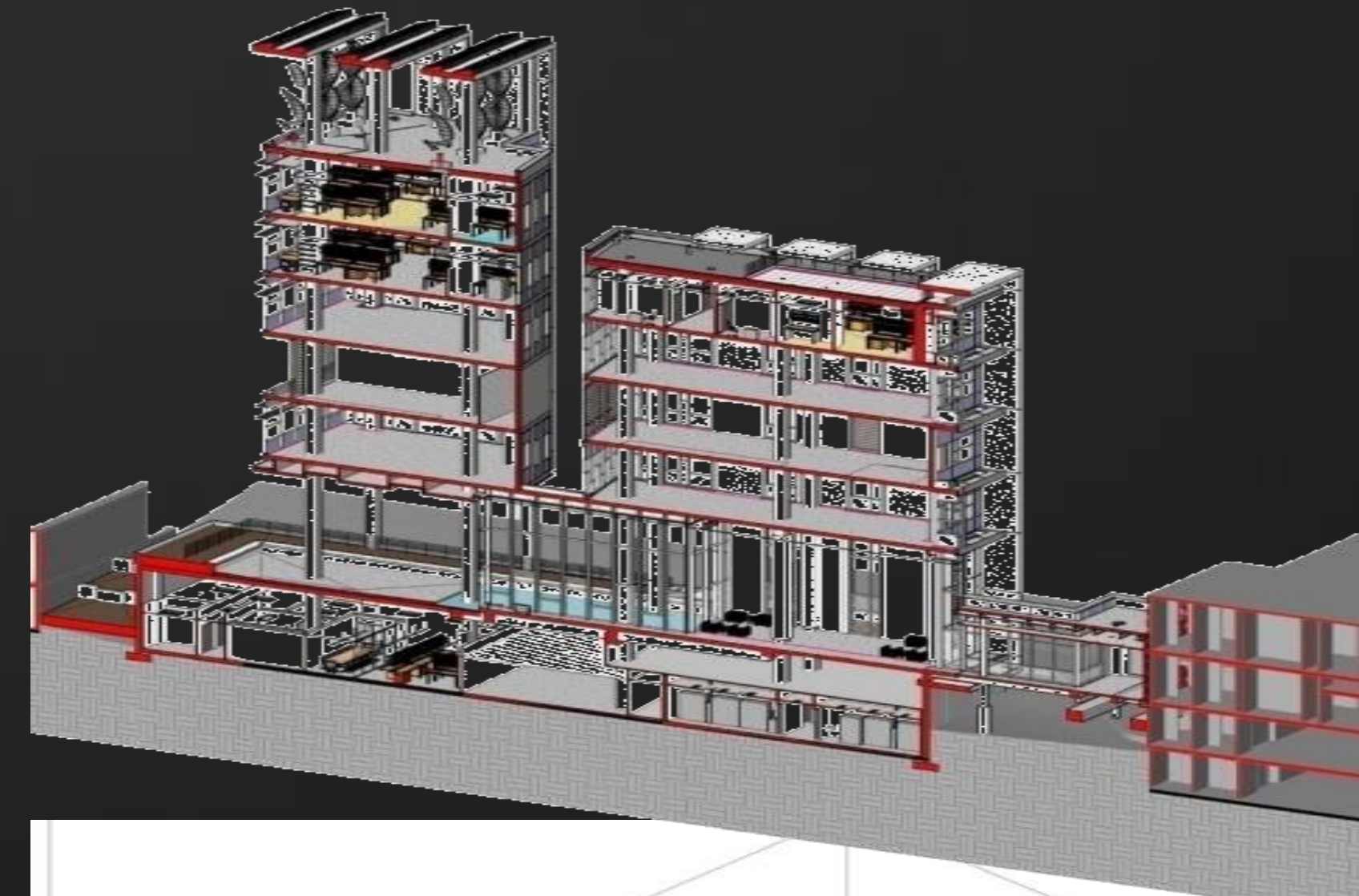


**SCIENCE  
+  
TECHNOLOGY**



# 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

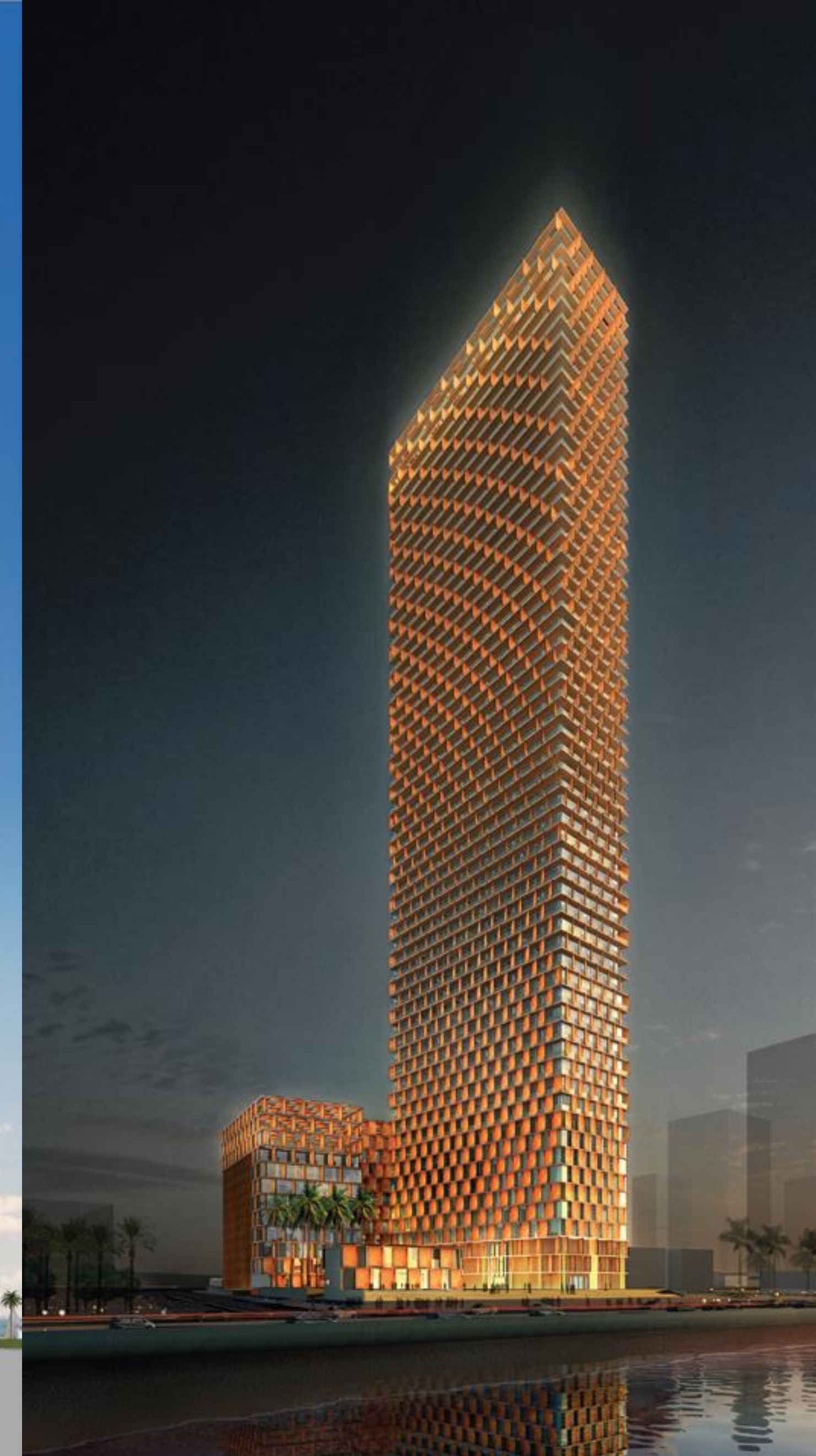




# Smooth Sailing

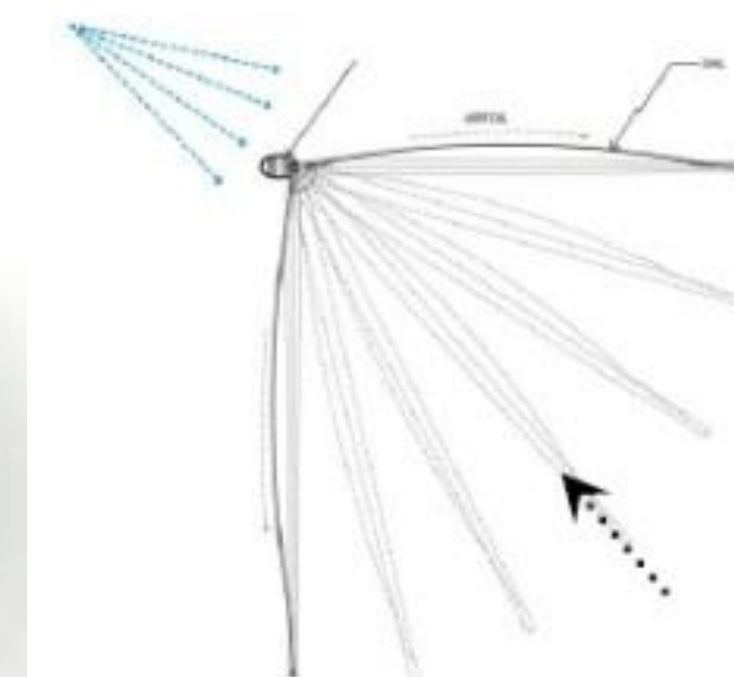
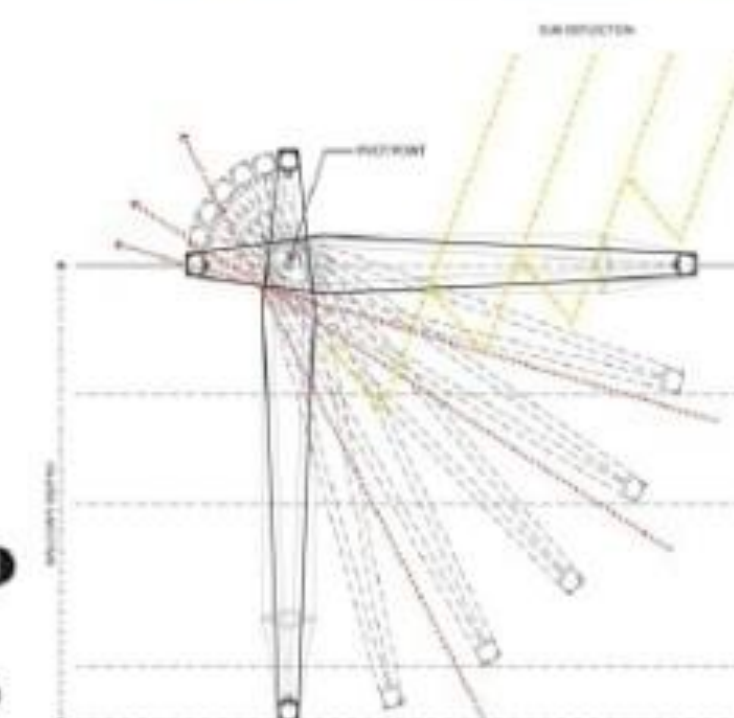
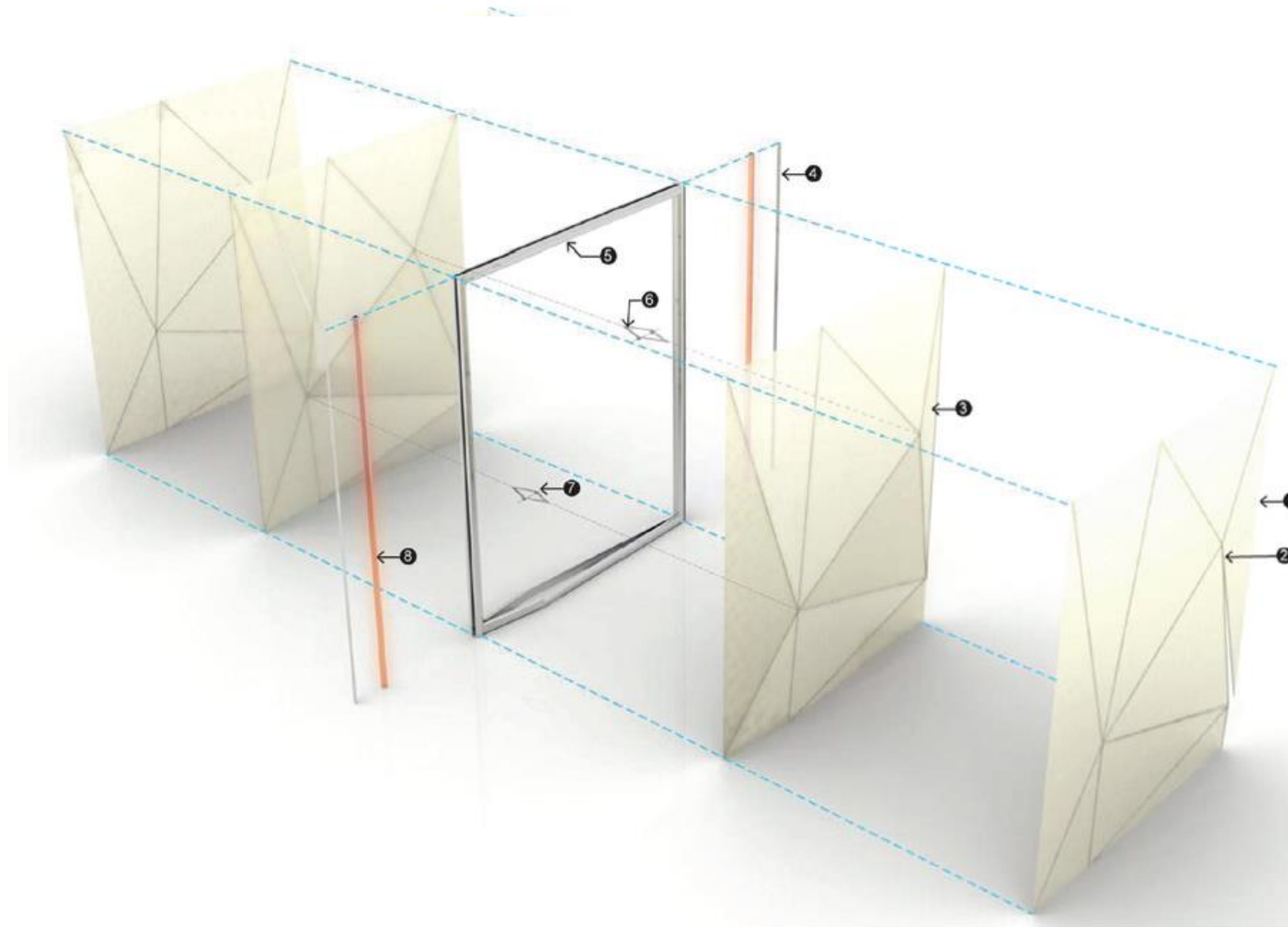


# KEMPINSKI HOTEL AND RESIDENCES JEDDAH, KSA

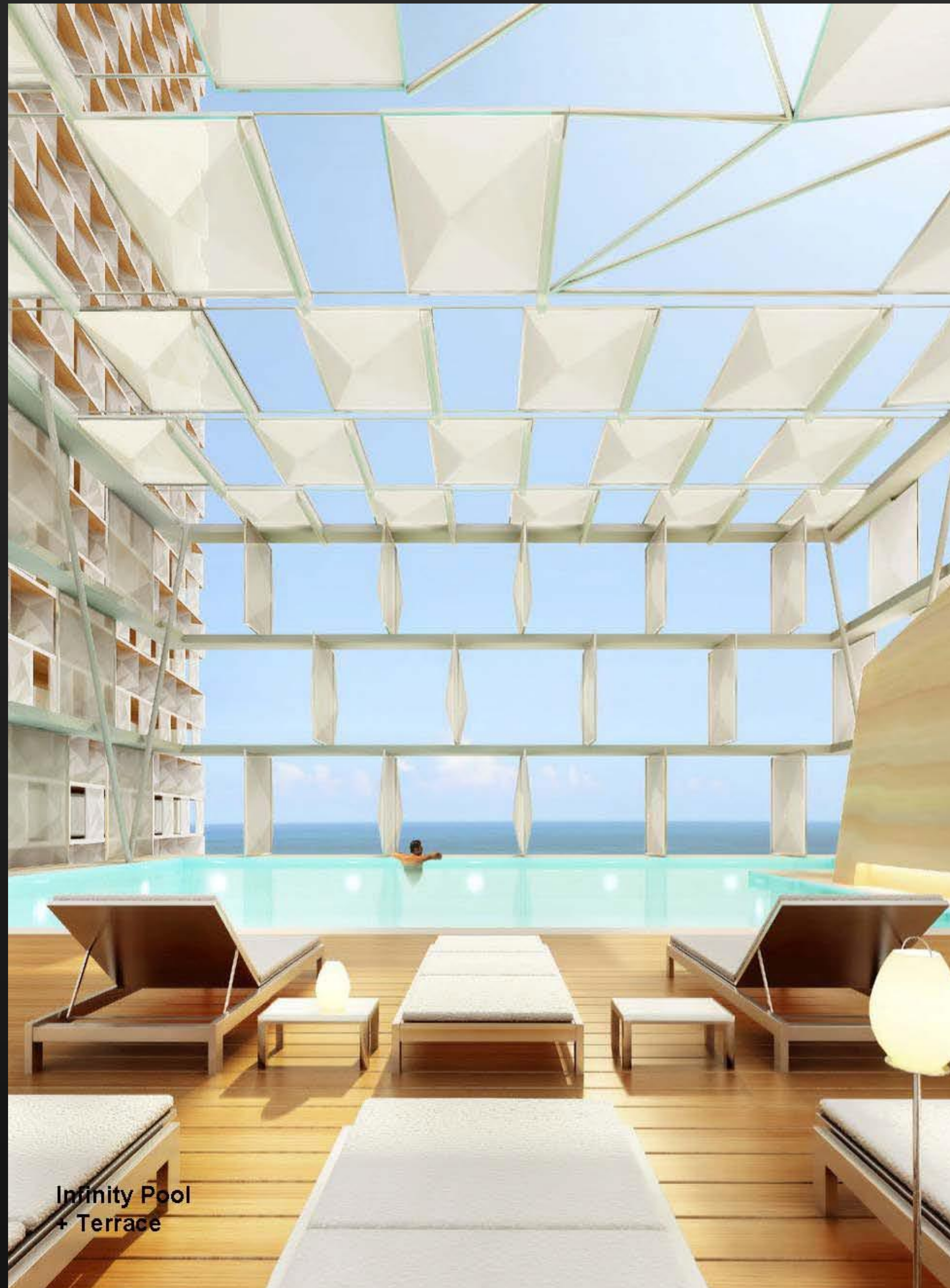




# Kempinski Sails

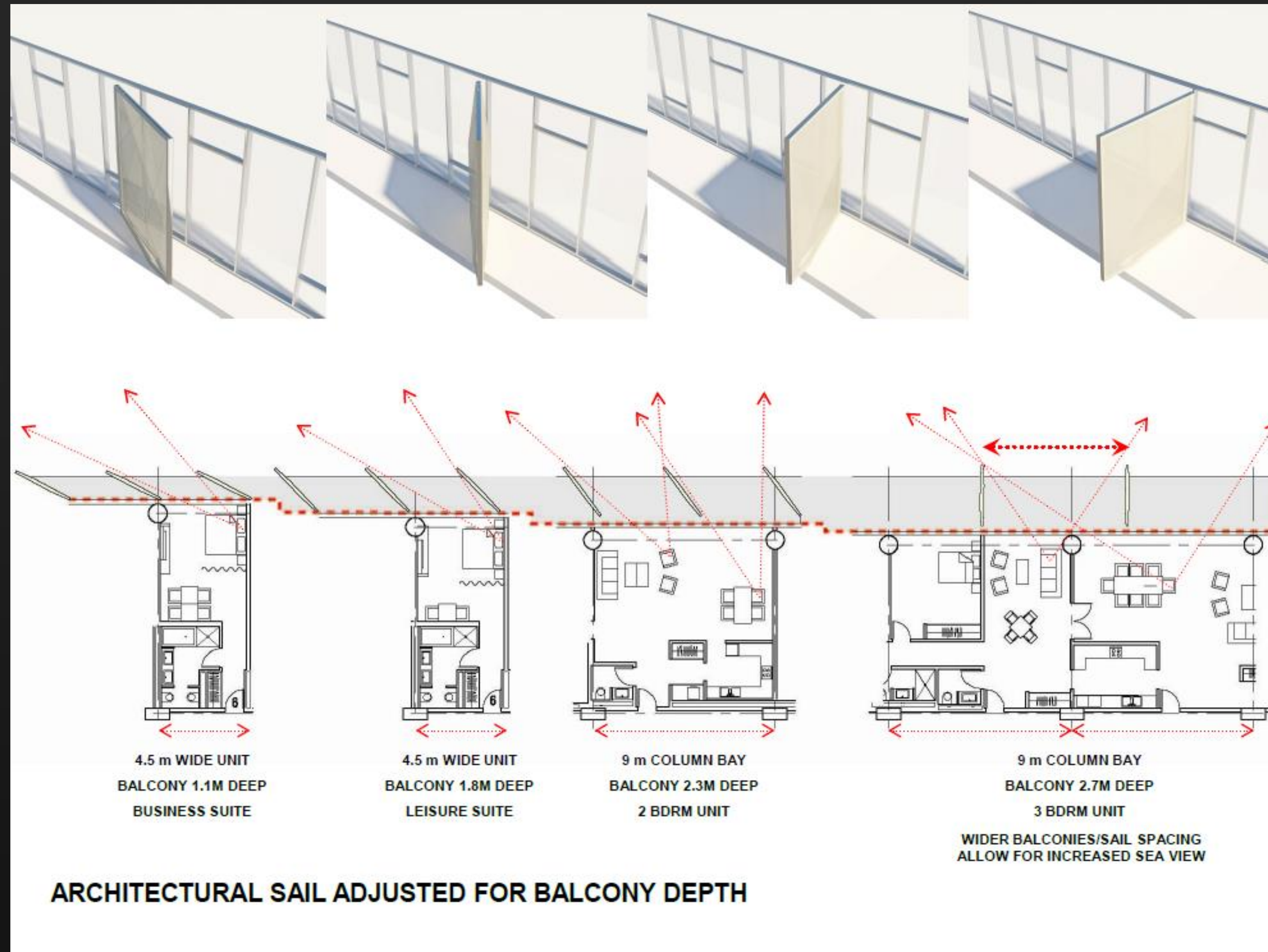








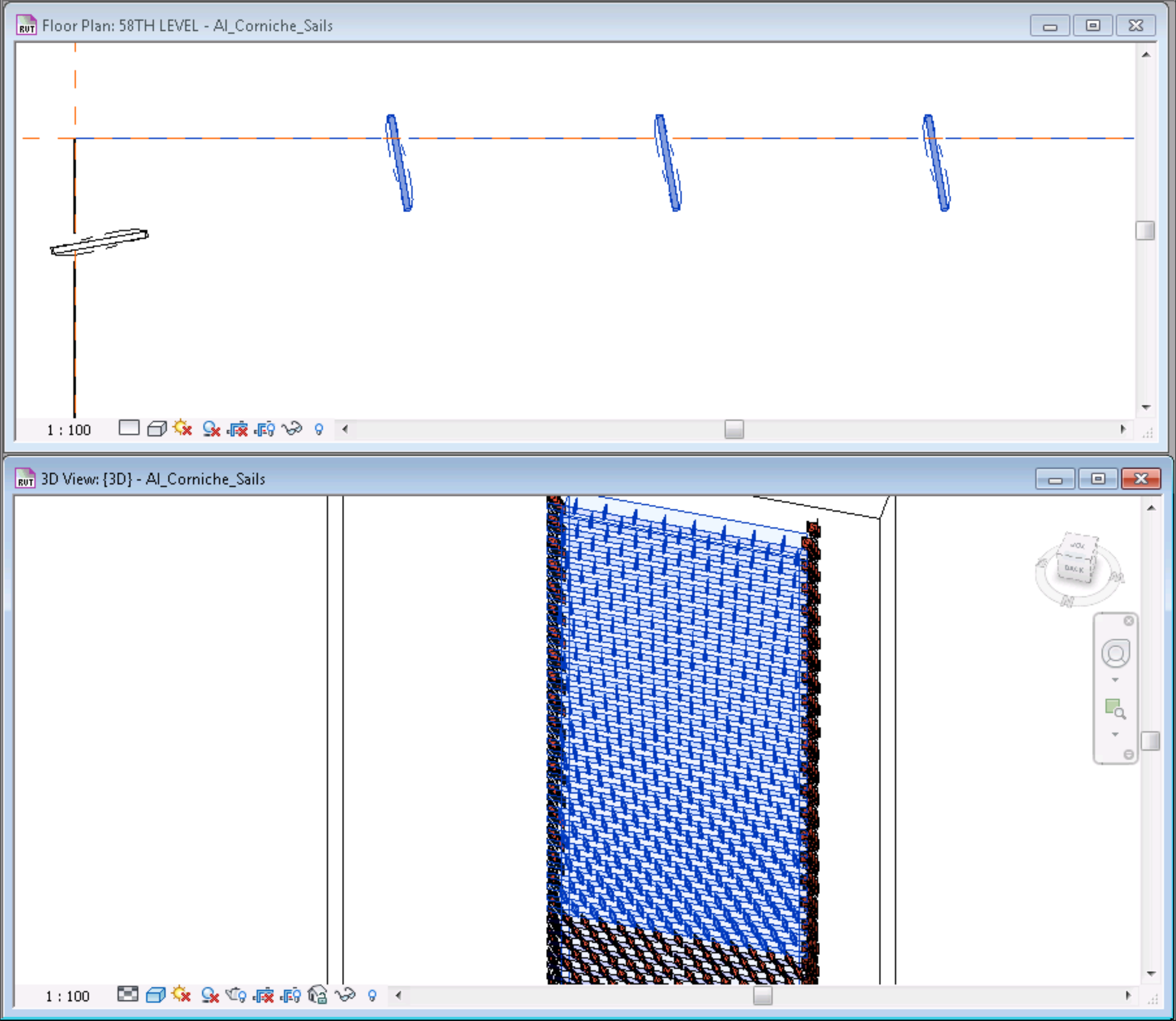
# Kempinski Sails





# 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

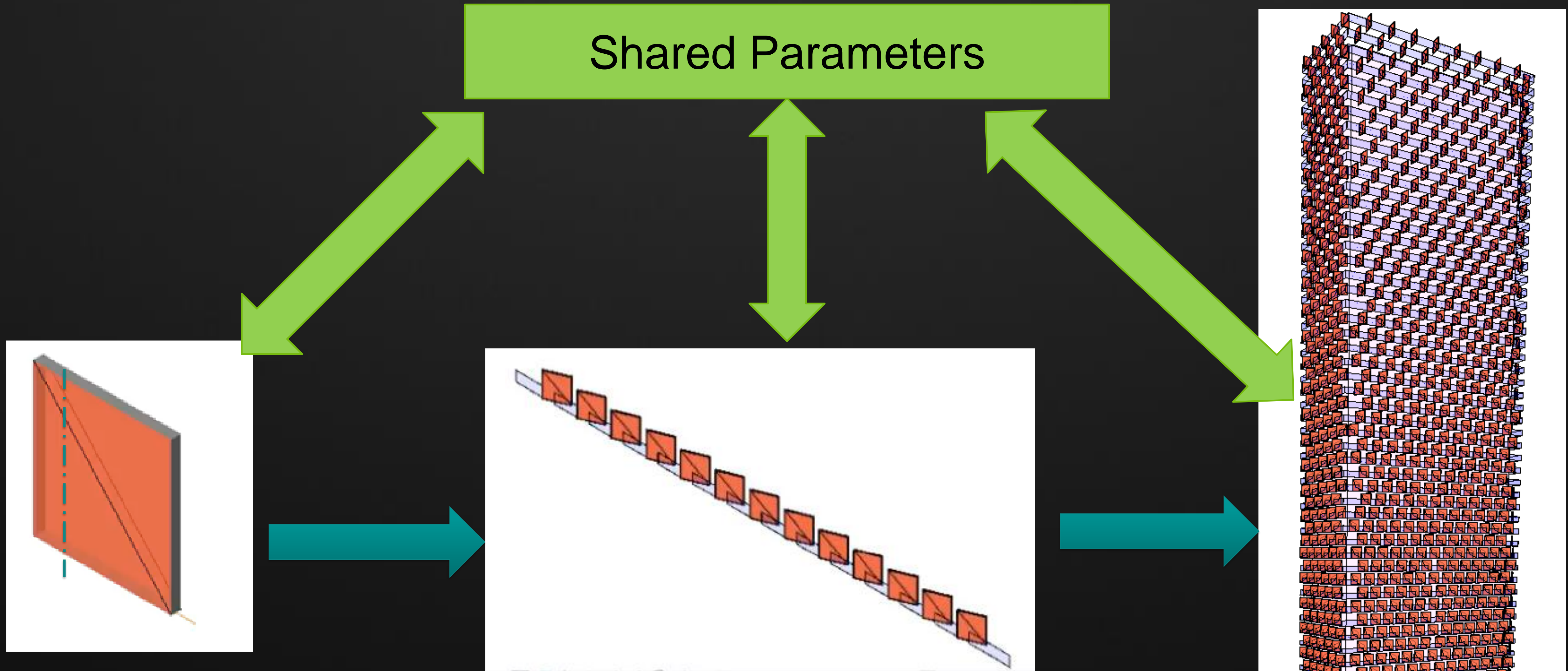


## Parameters for ZONES

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



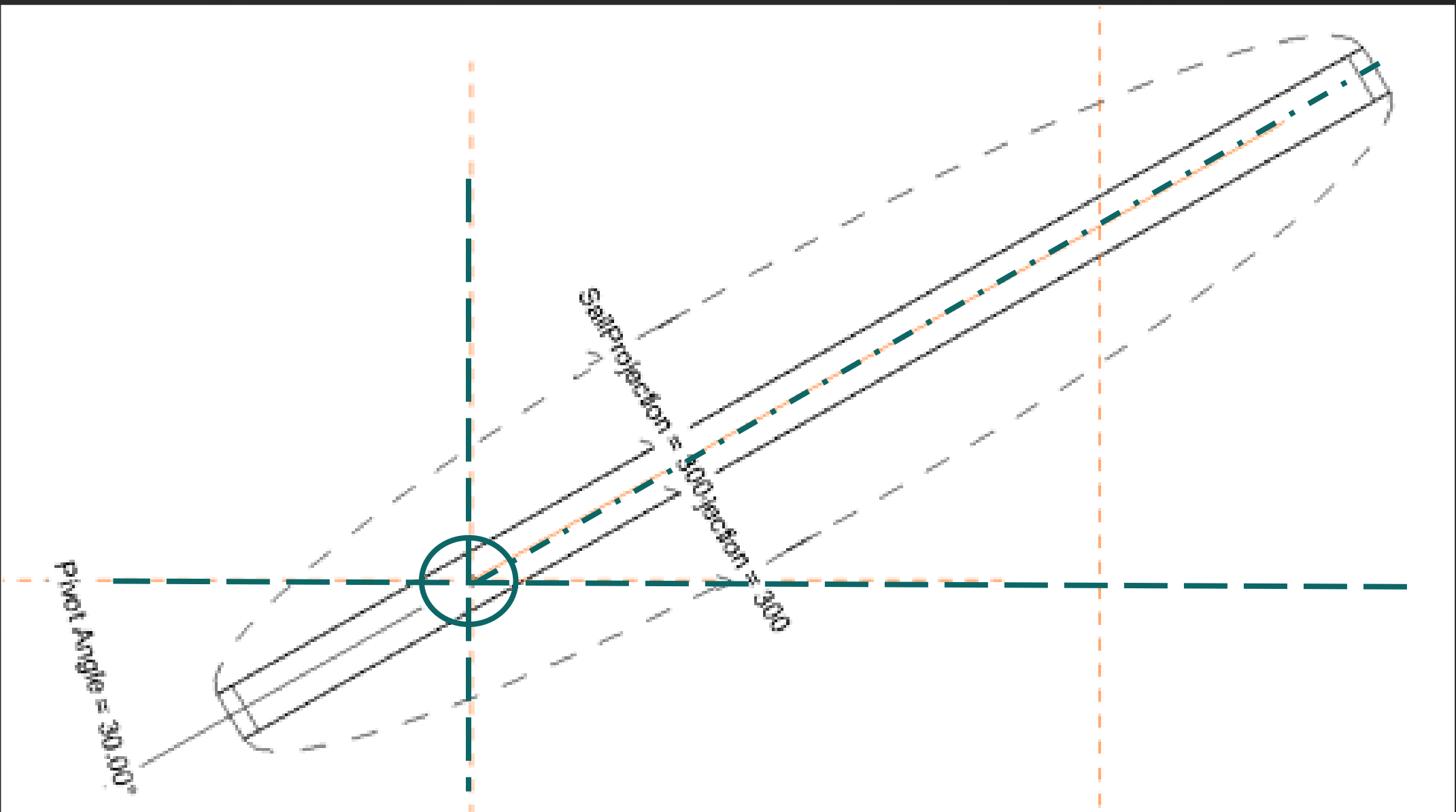
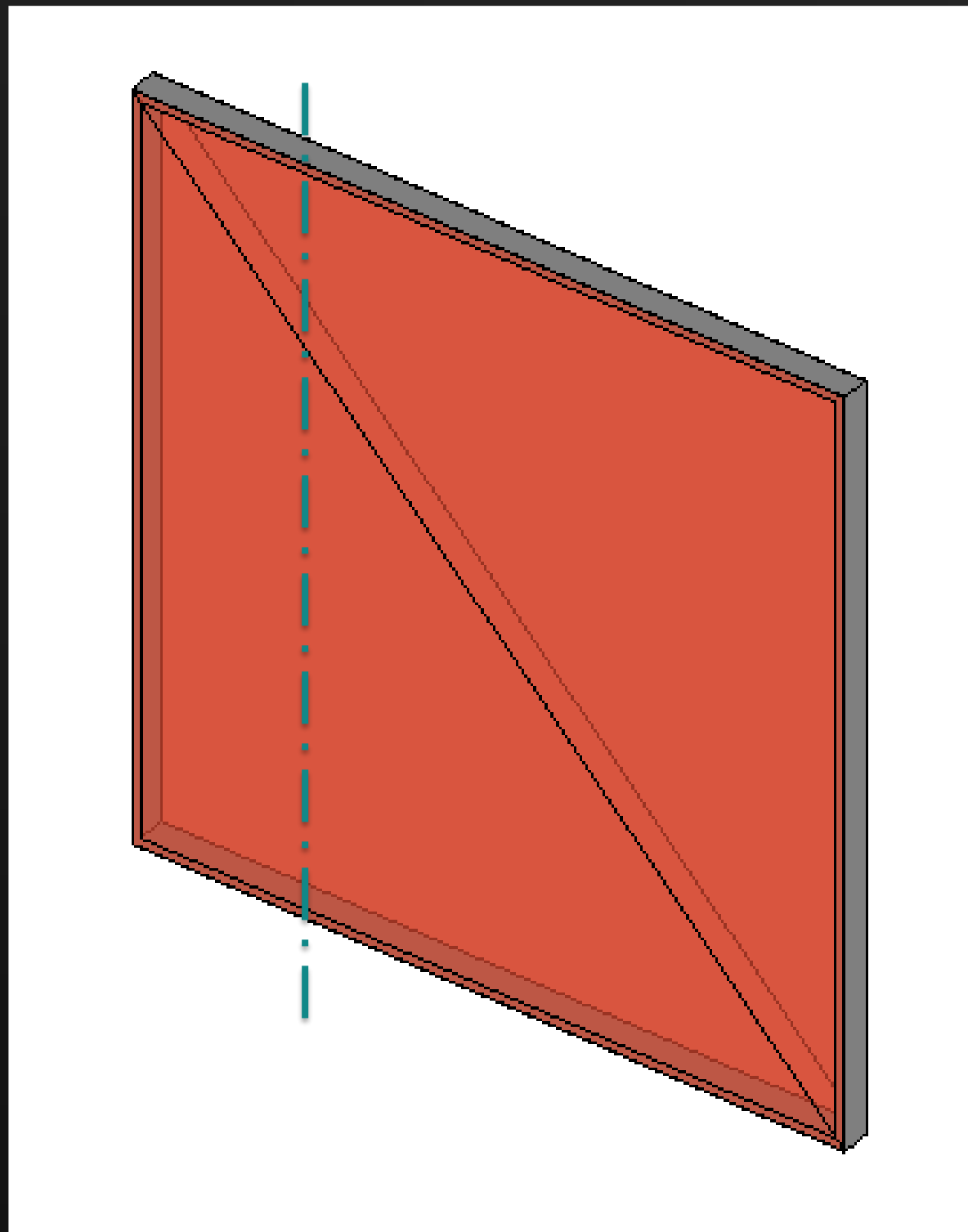
# Kempinski Sails: Shared Parameters





# Kempinski Sails

All parameters are shared



Parameter	Value	Formula	Lock
Constraints			
Level (default)	0	=	<input checked="" type="checkbox"/>
Dimensions			
Width2	800.0	=	<input checked="" type="checkbox"/>
Width1 (default)	3000.0	=	<input checked="" type="checkbox"/>
Thickness	150.0	=	<input checked="" type="checkbox"/>
SailProjection	300.0	=	<input type="checkbox"/>
SailHeight	4000.0	=	<input type="checkbox"/>
Pivot Angle (default)	30.000°	=	<input checked="" type="checkbox"/>

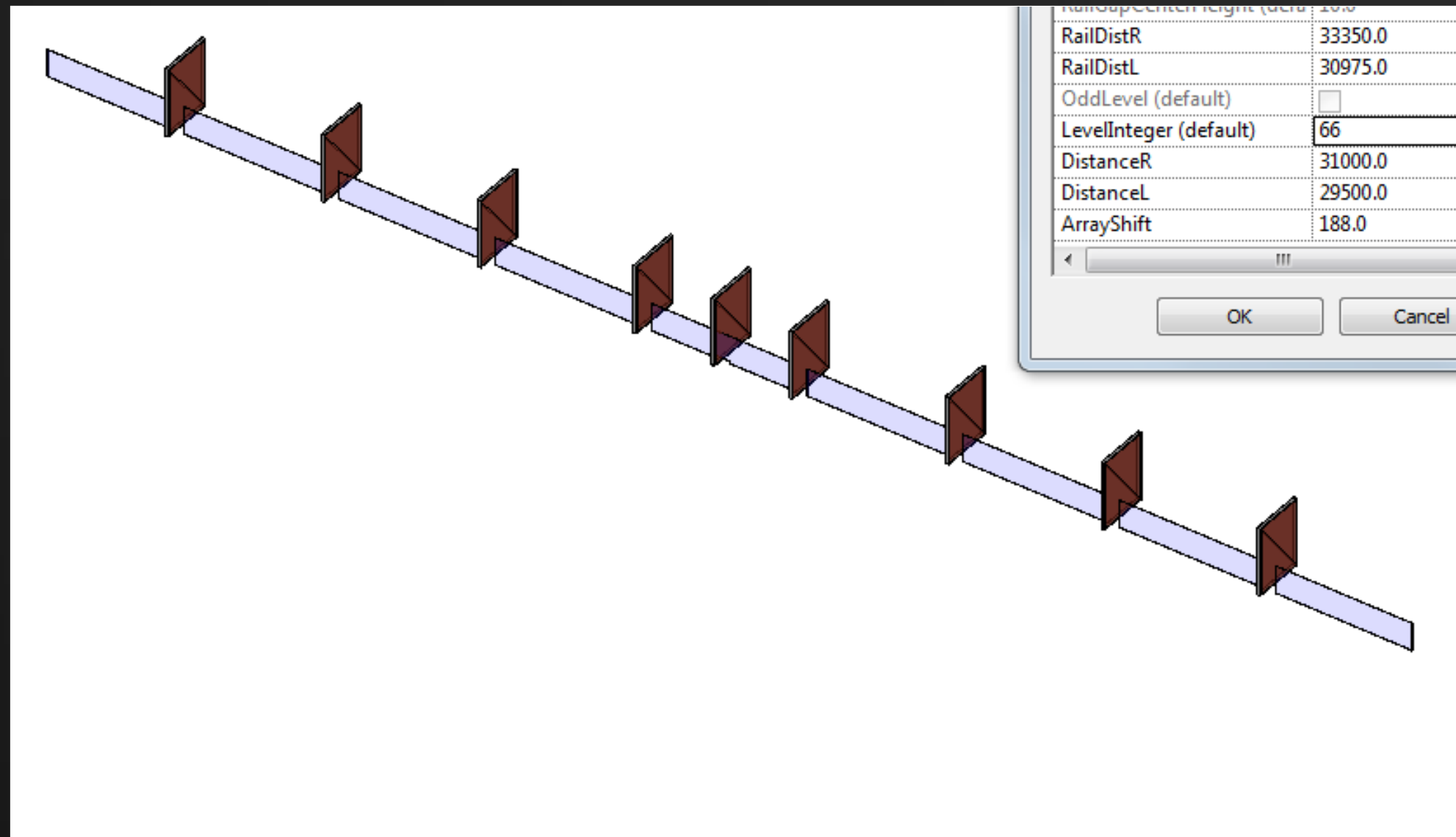


# Sail Array Families

One parameter rules them all



66



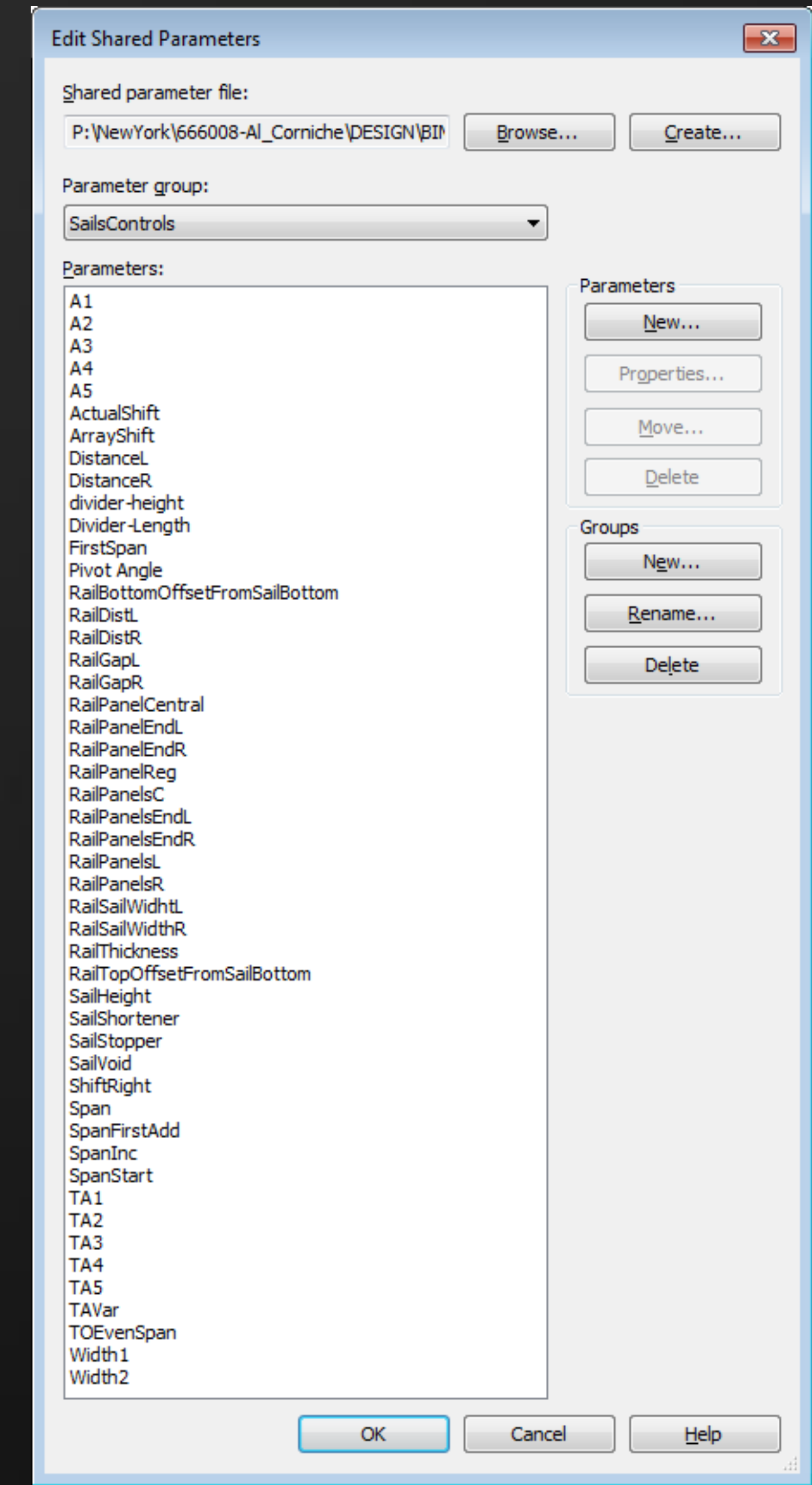
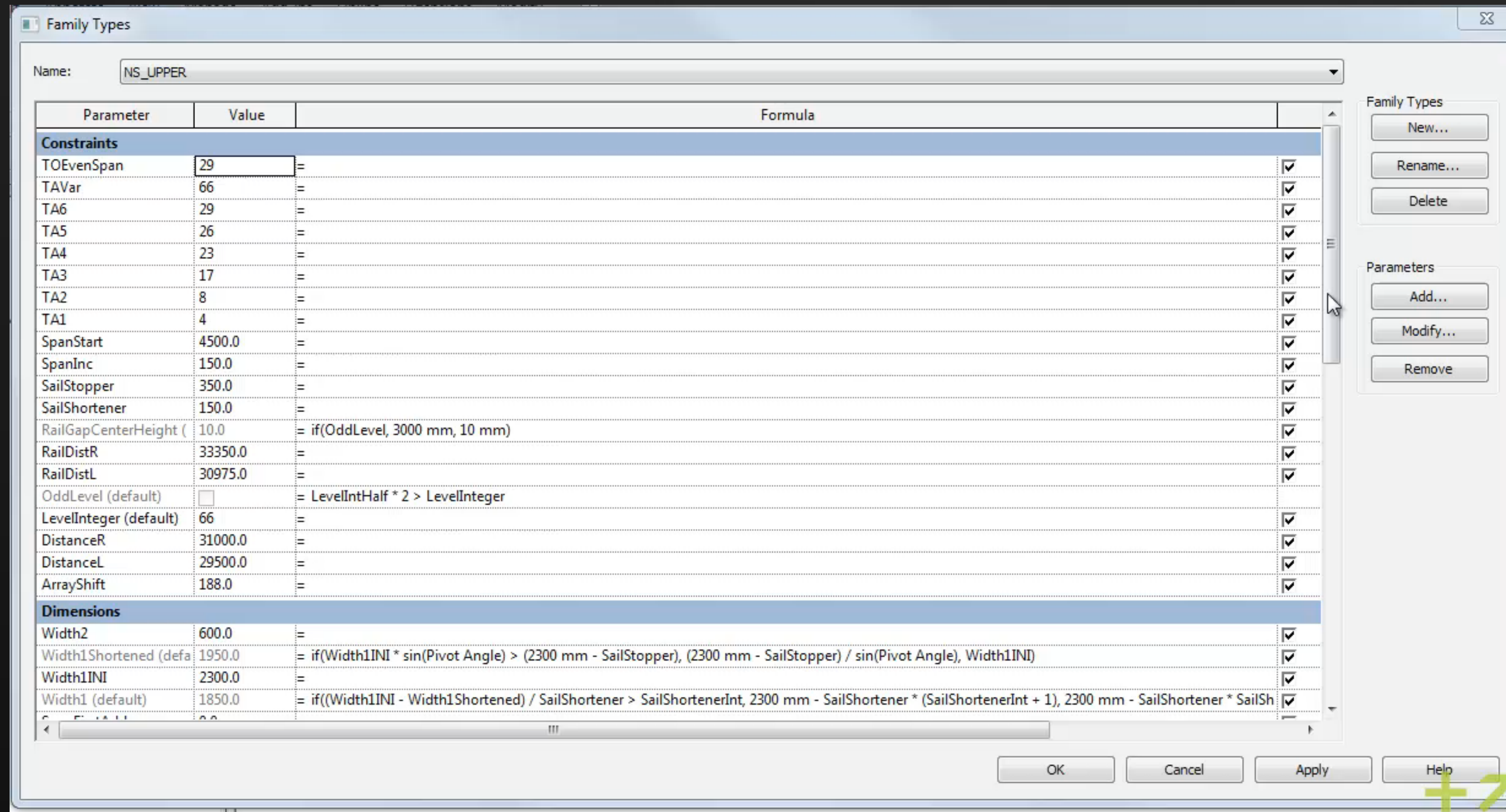
- Two families (long façade and short façade)
- Place on the first level, then paste aligned to other levels
- Level integer is an instance parameter. Easy to assign using schedule
- Everything else is calculated

Sail 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
10TH LEVEL	10



# 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

Family Types		
Name: NS_UPPER		
Parameter	Value	Formula
Width1 (default)	1850.0	= if((Width1INI - Width1Shortened) / SailShortener > SailShortenerInt, 2300 mm - SailShortener * (SailShortenedInt + 1), 2300 mm - SailShortener * SailShortenerInt)
SpanFirstAdd	0.0	=
RailGapR (default)	350.0	= if(RGRInteger > RGR_calc / 50 mm, RGRInteger * 50 mm, (RGRInteger + 1) * 50 mm)
RailGapL (default)	350.0	= if(RGLInteger > RGL_calc / 50 mm, RGLInteger * 50 mm, (RGLInteger + 1) * 50 mm)
RGR_calc (default)	300.0	= if(PivotAngle > 0°, (if(RailSailWidthR / sin(PivotAngle) > Width1, Width1 + 50 mm, RailSailWidthR / sin(PivotAngle) + 50 mm)), Width1 + 50 mm)
RGRInteger (default)	6	= RGR_calc / 50 mm
RGL_calc (default)	300.0	= if(PivotAngle > 0°, (if(RailSailWidthL / sin(PivotAngle) > Width2, Width2 + 50 mm, RailSailWidthL / sin(PivotAngle) + 50 mm)), Width2 + 50 mm)
RGLInteger (default)	6	= RGL_calc / 50 mm
PivotAngle (default)	90.0000°	= (6 - 1) * AngleInc + 45°, if(LevelInteger > TA5, A6, if(LevelInteger > TA4, A5, if(LevelInteger > TA3, A4, if(LevelInteger > TA2, A3, if(LevelInteger > TA1, A2, A1))))))
FirstSpan (default)	3675.0	= if(OddLevel, Span + SpanFirstAdd, HalfSpan + SpanFirstAdd)

AngleInc=(90° -A6)/(TAVar-TA6)

Family Types		
Name: NS_UPPER		
Parameter	Value	
Constraints		
TOEvenSpan	29	=
TAVar	66	=
TA6	29	=
TA5	26	=
TA4	23	=
TA3	17	=
TA2	8	=
TA1	4	=
SpanStart	4500.0	=
SpanInc	150.0	=
SailStopper	350.0	=
SailShortener	150.0	=

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

$$(\text{DistanceR} - \text{FirstSpan} - \text{ActualShift} - \text{Width1} * \cos(\text{Pivot Angle})) / \text{Span}$$

IF(OddLevel,  
Span, Span/2)

## First Span

## Span

## ArrayR

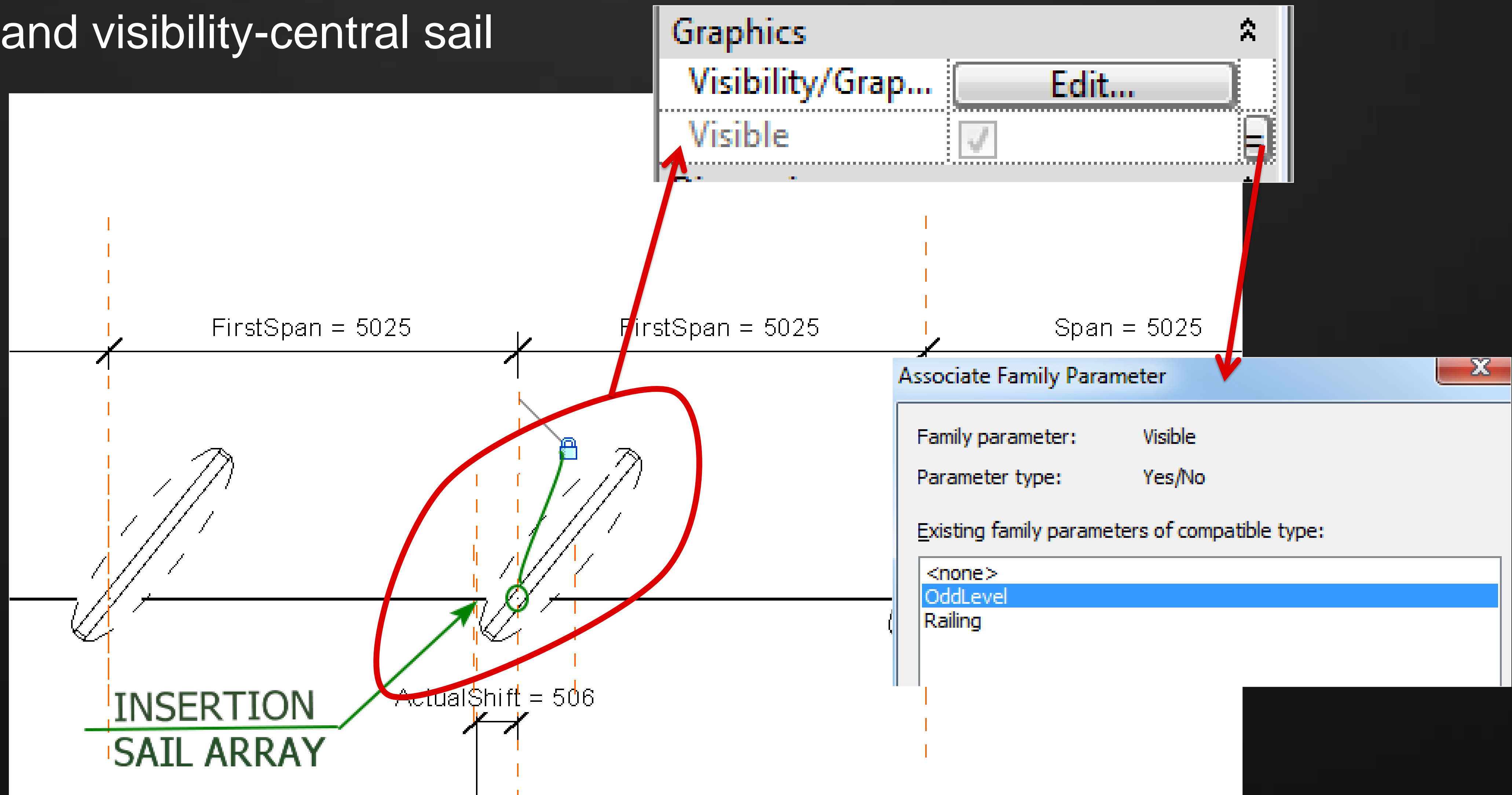
- DistanceR

# LevelInteger, SpanStart, SpanInc



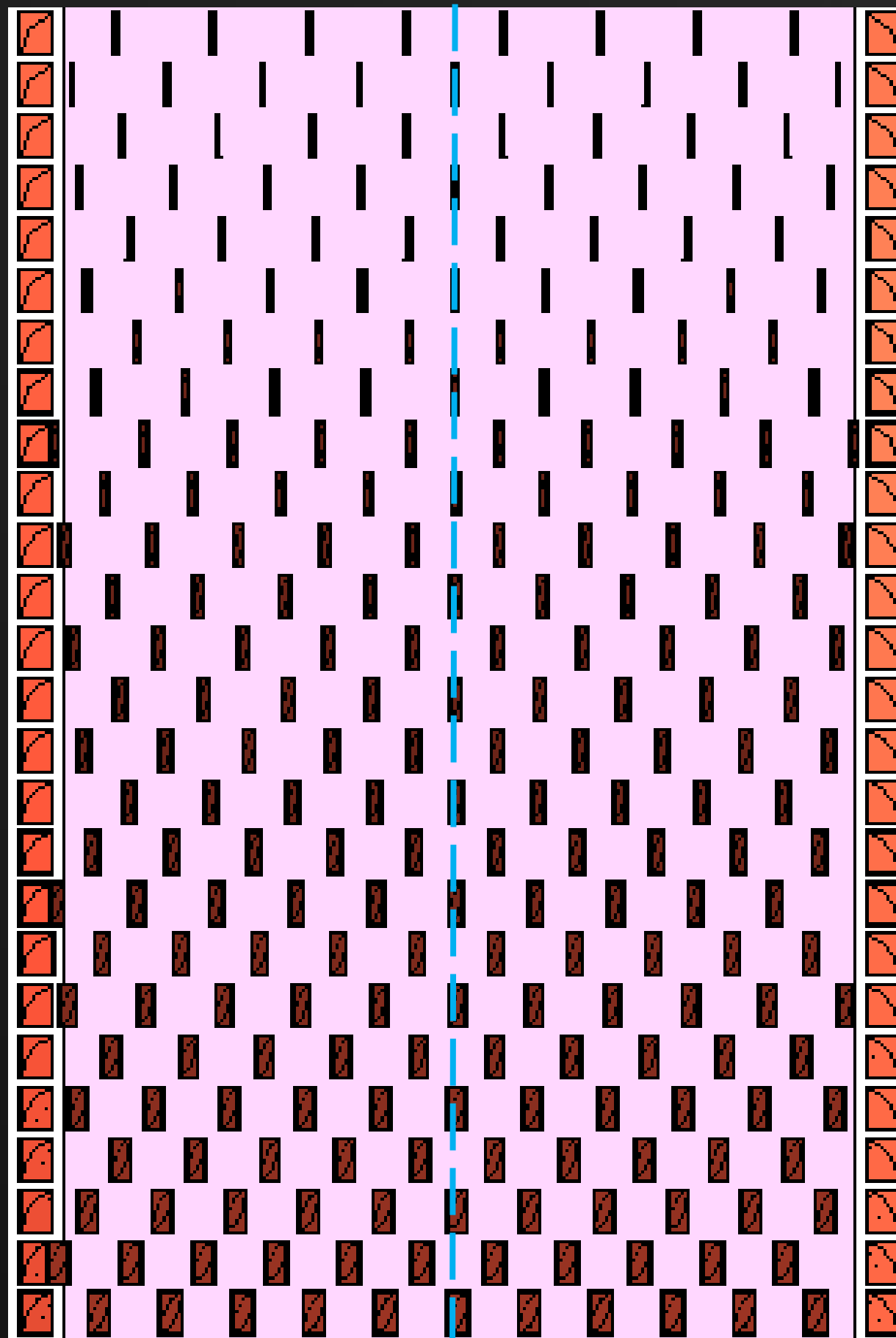
# Sail Array Family

## Location and visibility-central sail

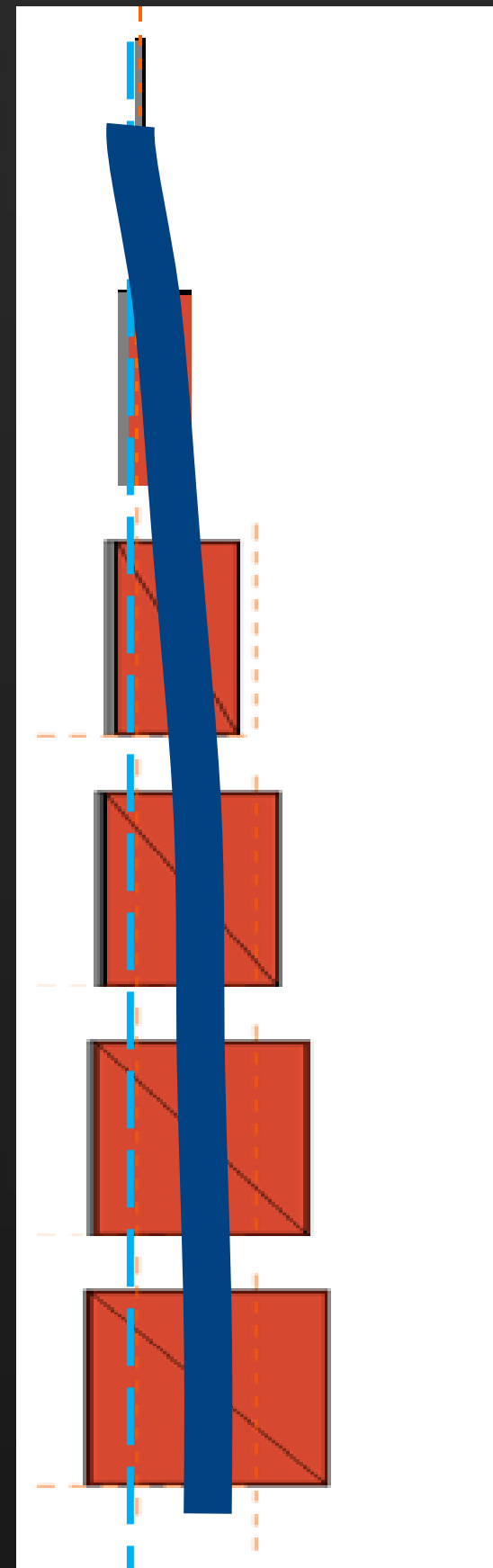




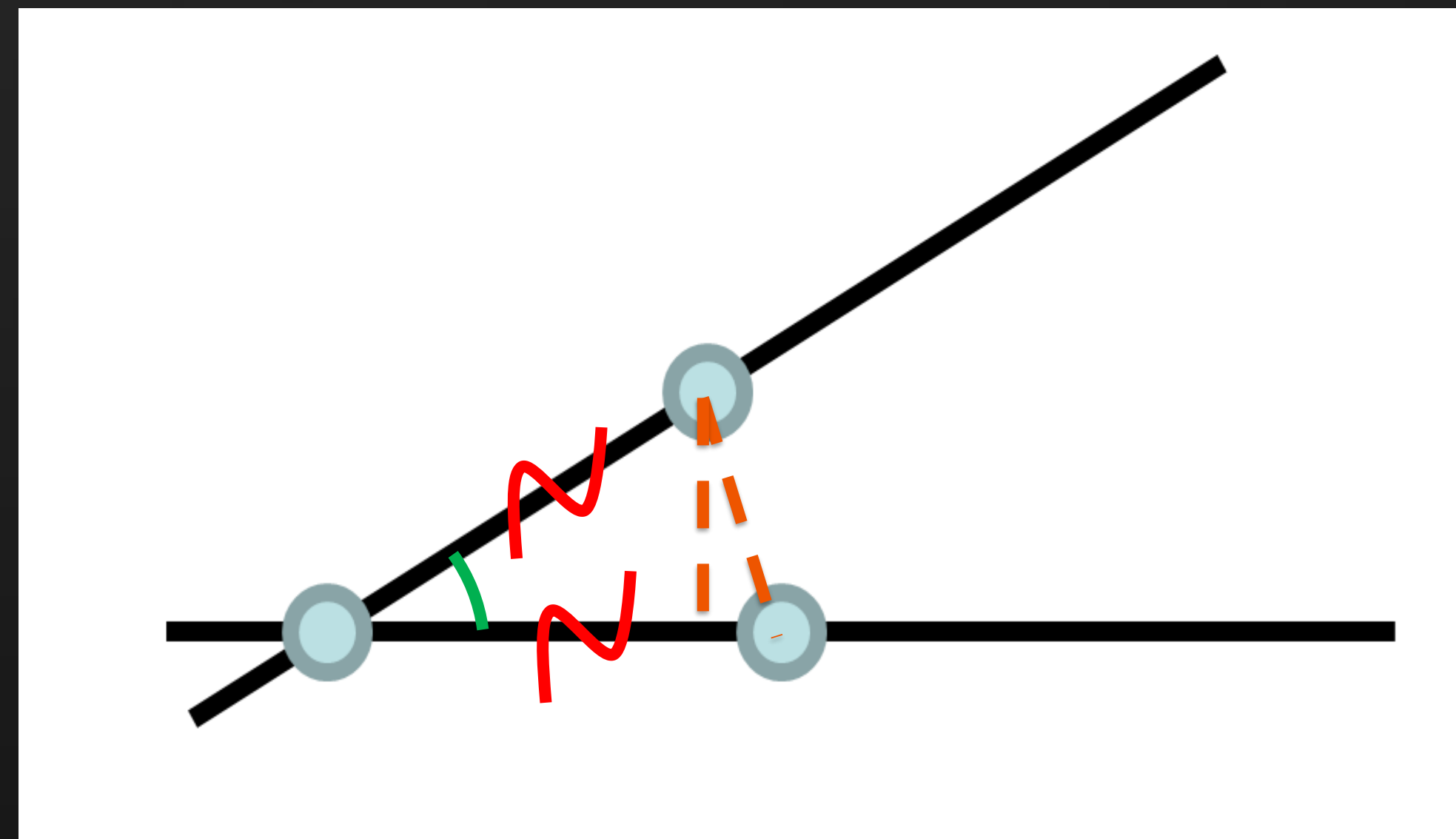
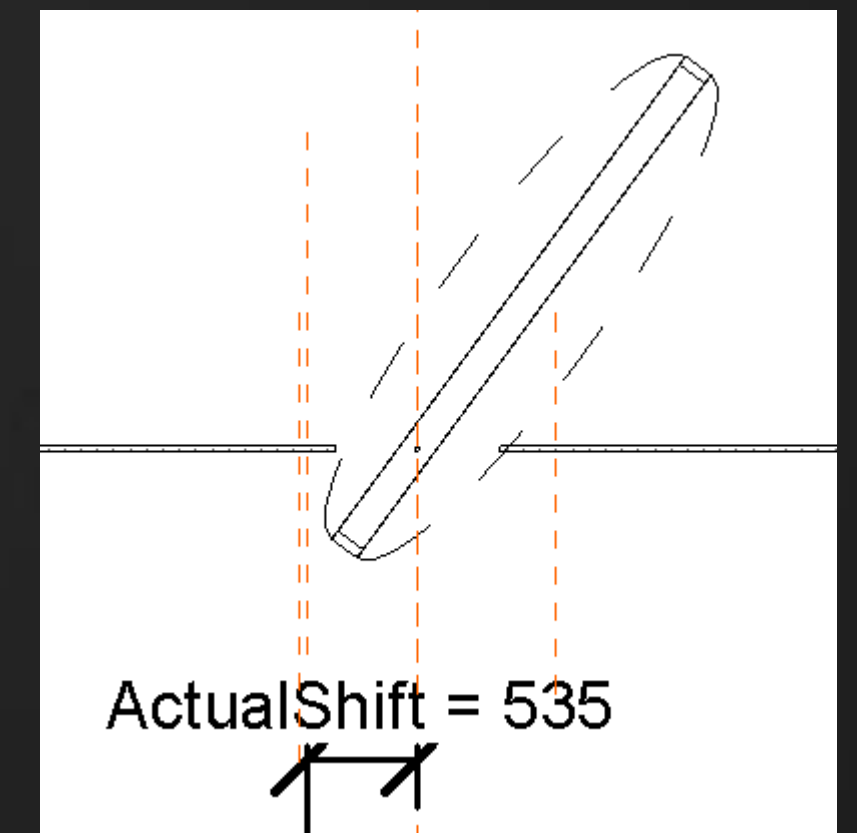
# Sail Array Families



Elevation



Do not slouch!



$$\text{ActualShift} = (\text{Width1} - (\text{Width1} + \text{Width2}) / 2) - (\text{Width1} - (\text{Width1} + \text{Width2}) / 2) * \cos(\text{Pivot Angle})$$



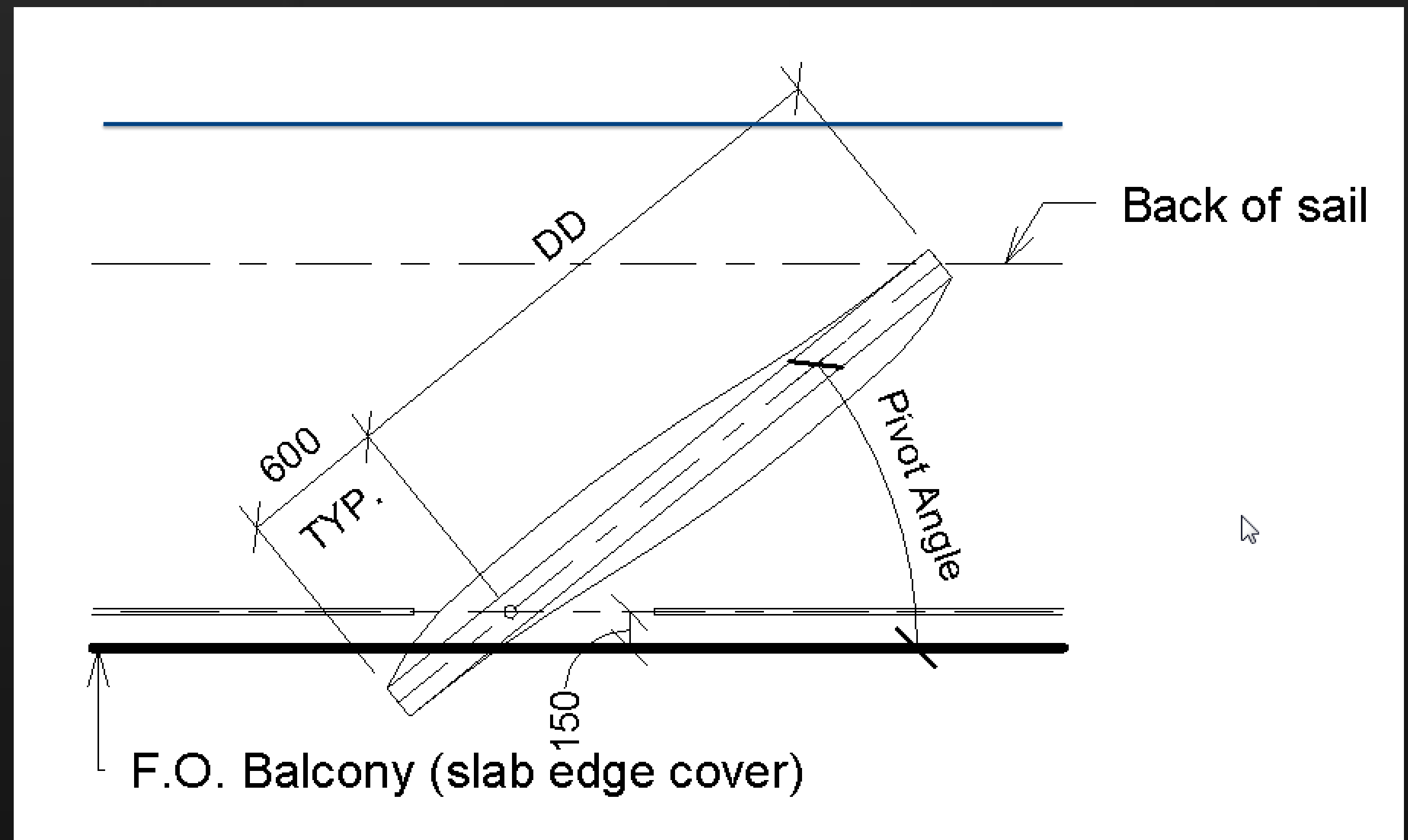
# Sail Array Family

## Interact with facade

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

**SailStopper**

**SailShortener**

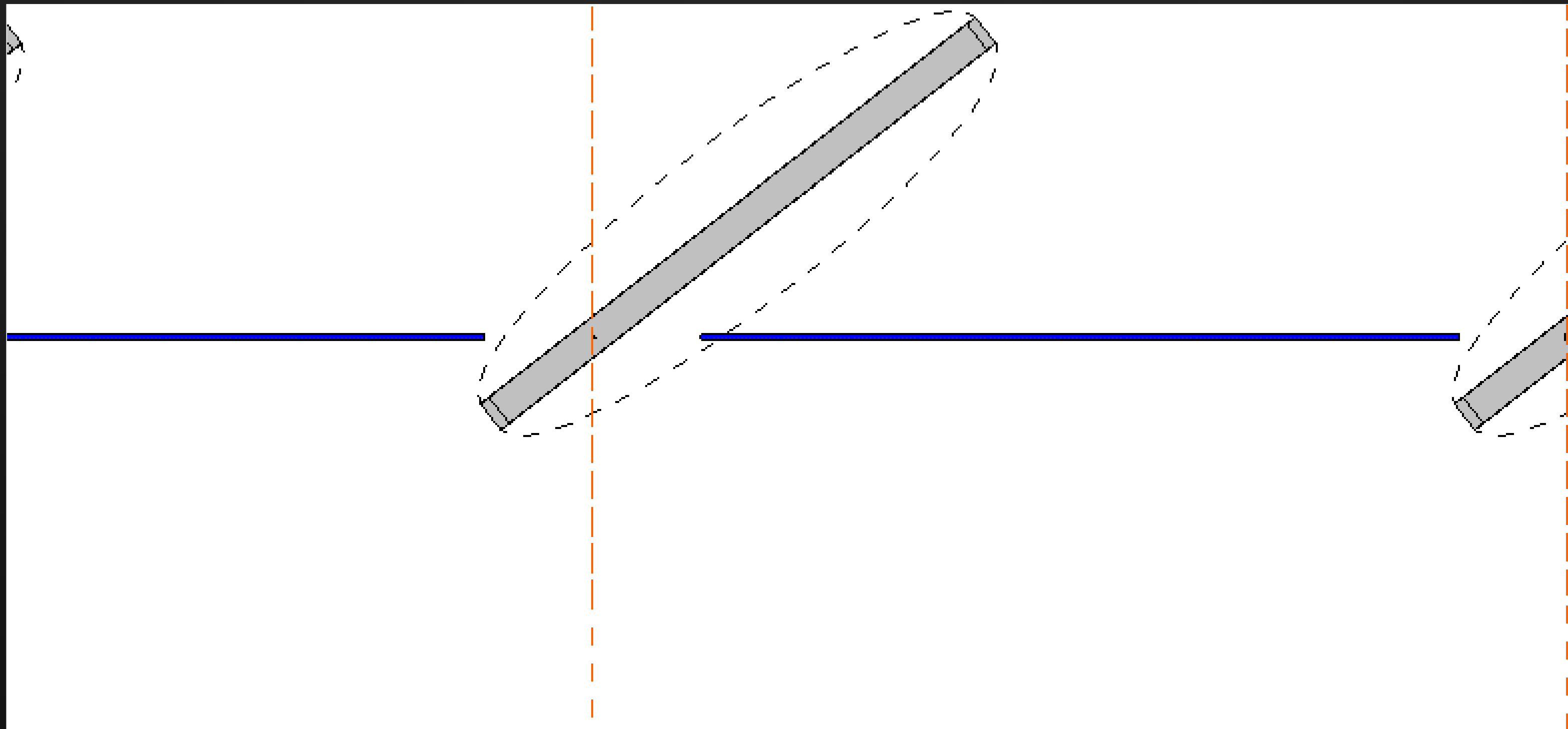




## Sail Array Family

Railing is cooperating with Sail

Examples: Levels 3,5,9,27

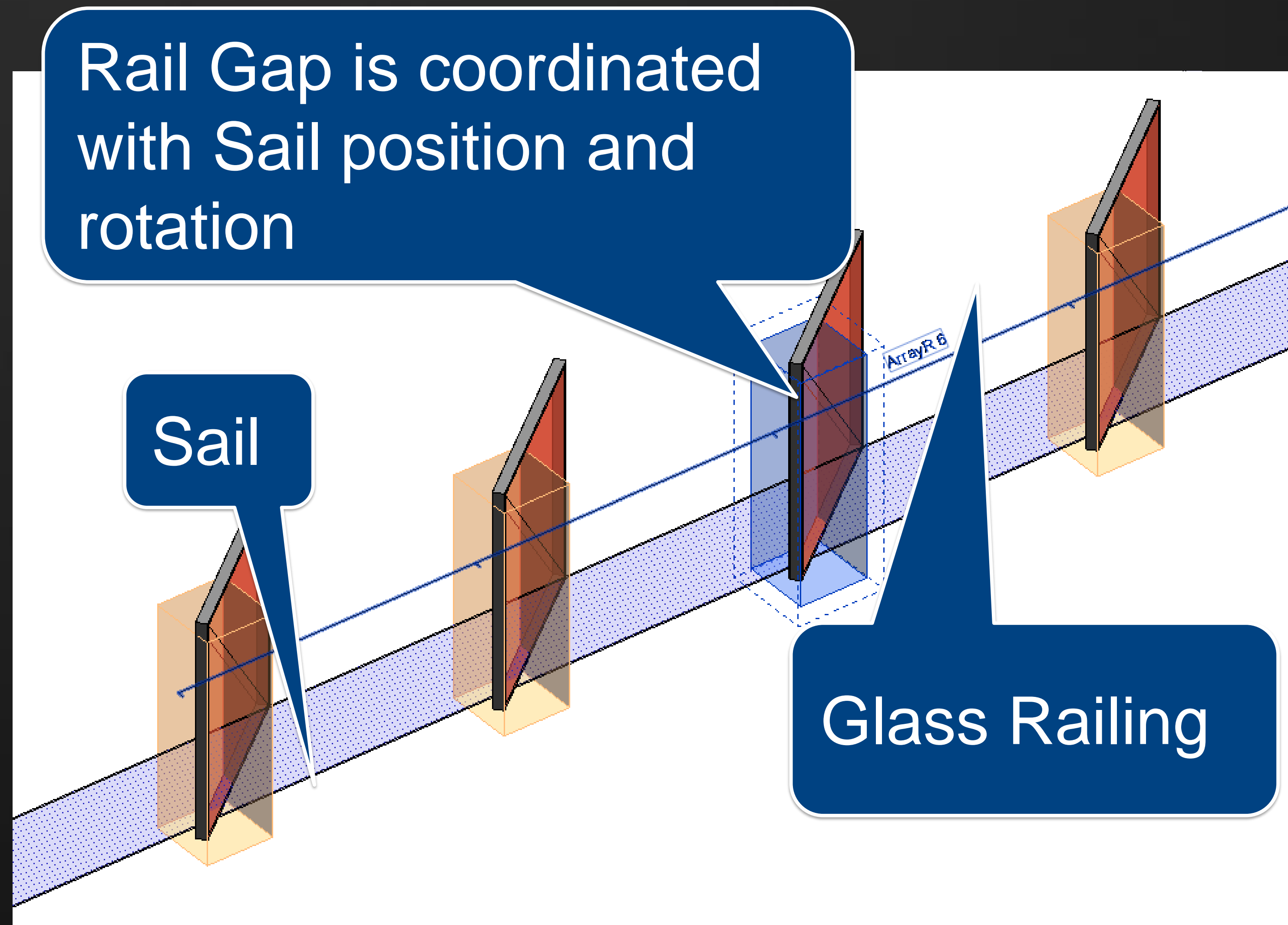




# Sail Array Family

Railing is cooperating with Sail

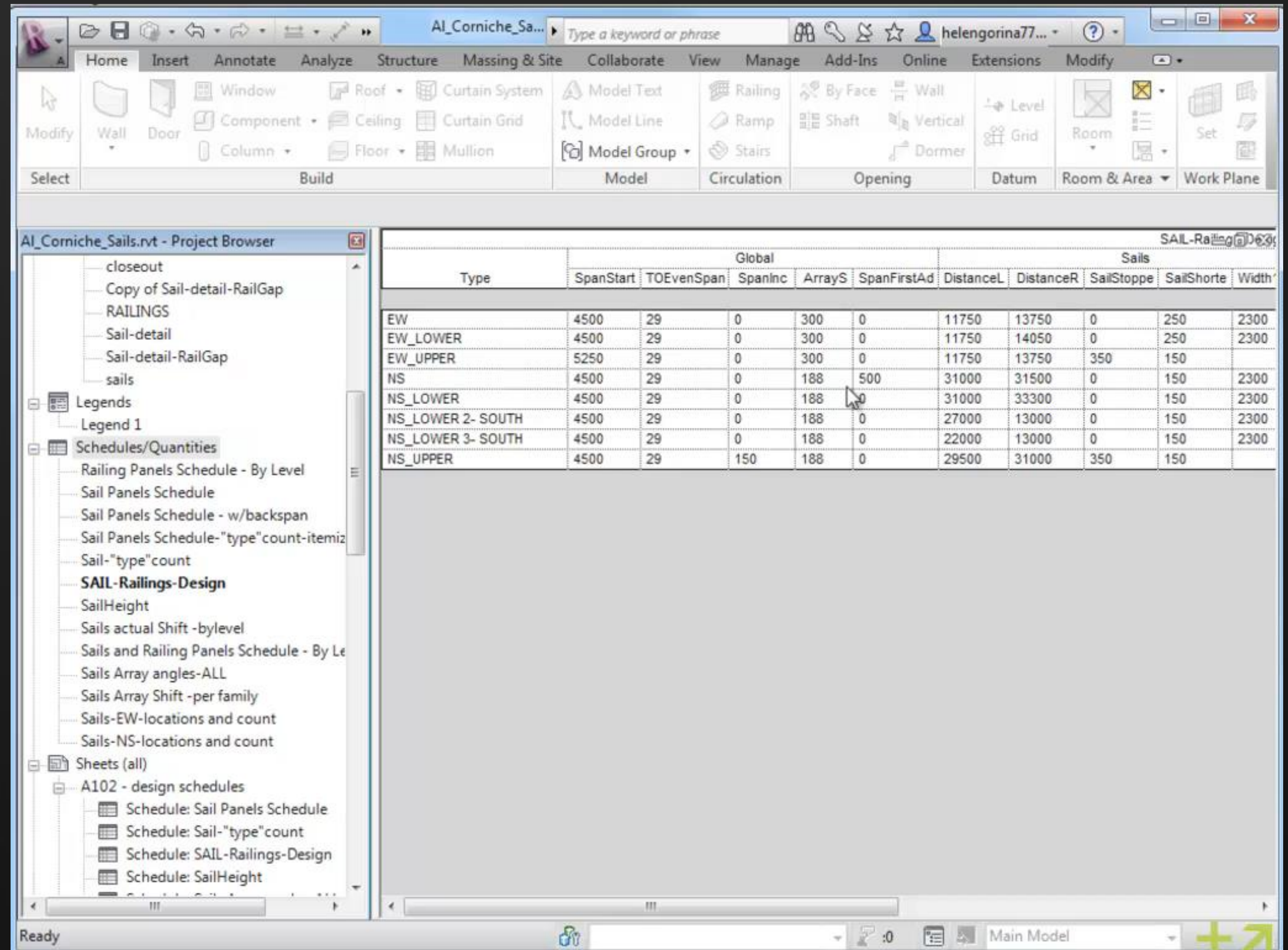
- Overall length is calculated based on DistanceL and DistanceR
- Gaps are controlled using parametric arrayed voids.
- Gap width is calculated based on sail rotation and width.
- Sail and gap position and sail rotation is calculated based on LevelInteger





# Kempinski Sails

- Parameter management and rapid design iterations

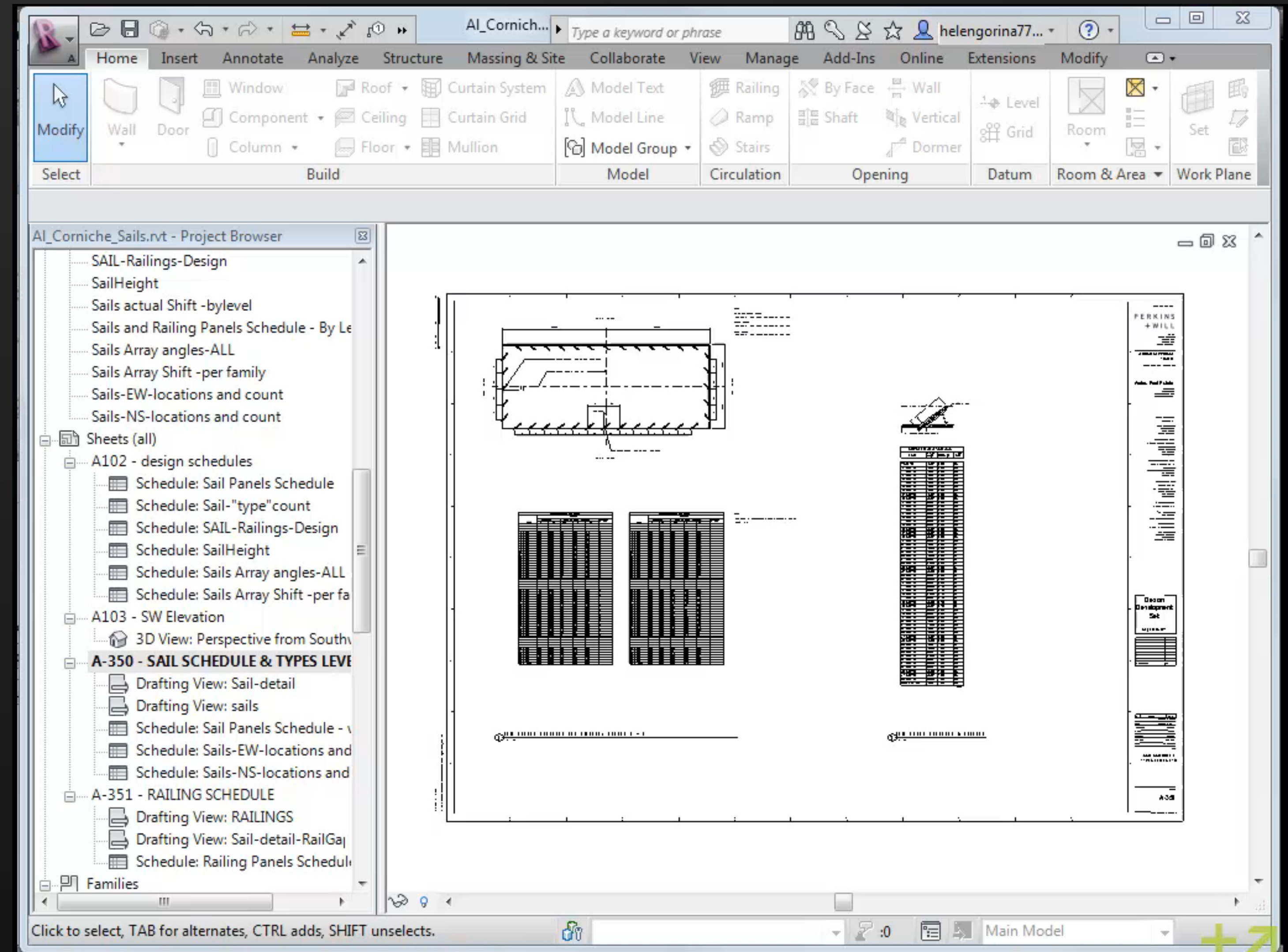


The screenshot shows the Revit software interface with the 'SAIL-Railings-Design' table open in the Project Browser. The table lists various sail types and their dimensions. The table has columns for Type, Global (SpanStart, TOEvenSpan, SpanInc, ArrayS, SpanFirstAd), DistanceL, DistanceR, Sails (SailStoppe, SailShorte), and Width.

Type	SpanStart	TOEvenSpan	SpanInc	ArrayS	SpanFirstAd	DistanceL	DistanceR	Sails	SailStoppe	SailShorte	Width
EW	4500	29	0	300	0	11750	13750	0	250	2300	
EW_LOWER	4500	29	0	300	0	11750	14050	0	250	2300	
EW_UPPER	5250	29	0	300	0	11750	13750	350	150		
NS	4500	29	0	188	500	31000	31500	0	150	2300	
NS_LOWER	4500	29	0	188	0	31000	33300	0	150	2300	
NS_LOWER 2- SOUTH	4500	29	0	188	0	27000	13000	0	150	2300	
NS_LOWER 3- SOUTH	4500	29	0	188	0	22000	13000	0	150	2300	
NS_UPPER	4500	29	150	188	0	29500	31000	350	150		



# Kempinski Sails Documentation Huge time saver



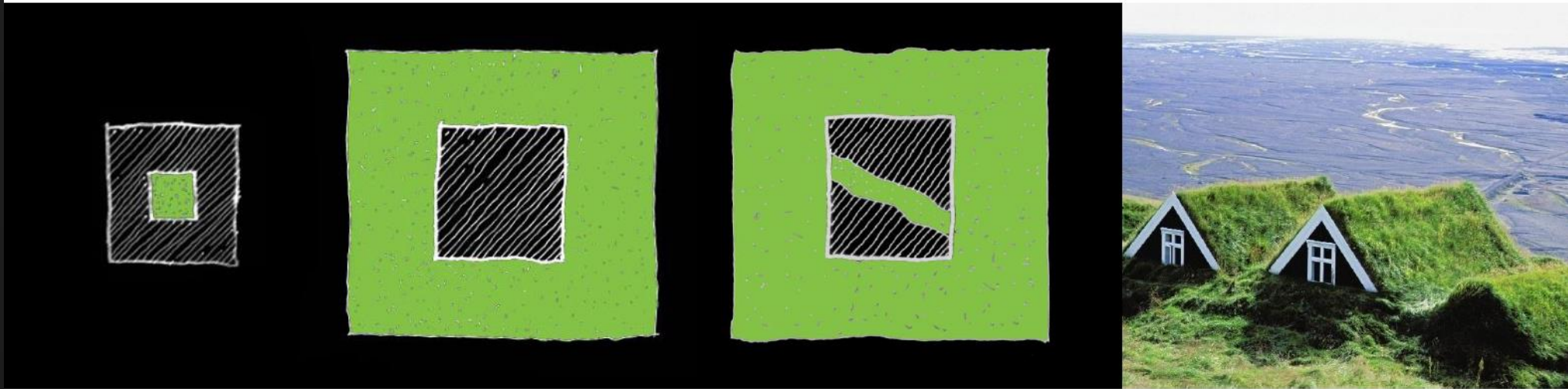


# Meditation Space

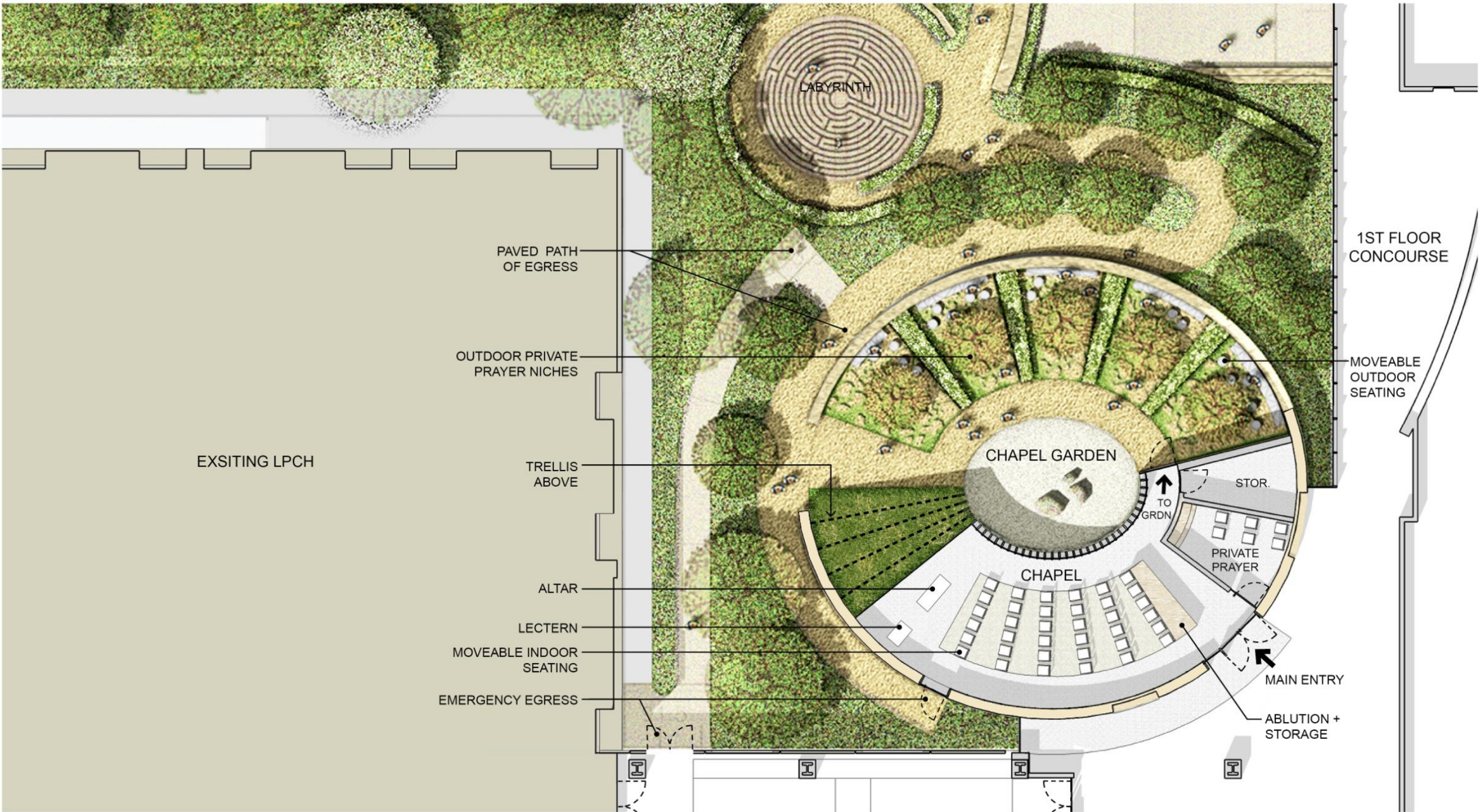


# Concept

## Design Concept - Building + Garden



Nature contained within building      Building within nature      Building within nature and nature within building



Floor Plan  
Chapel 06.17.2010



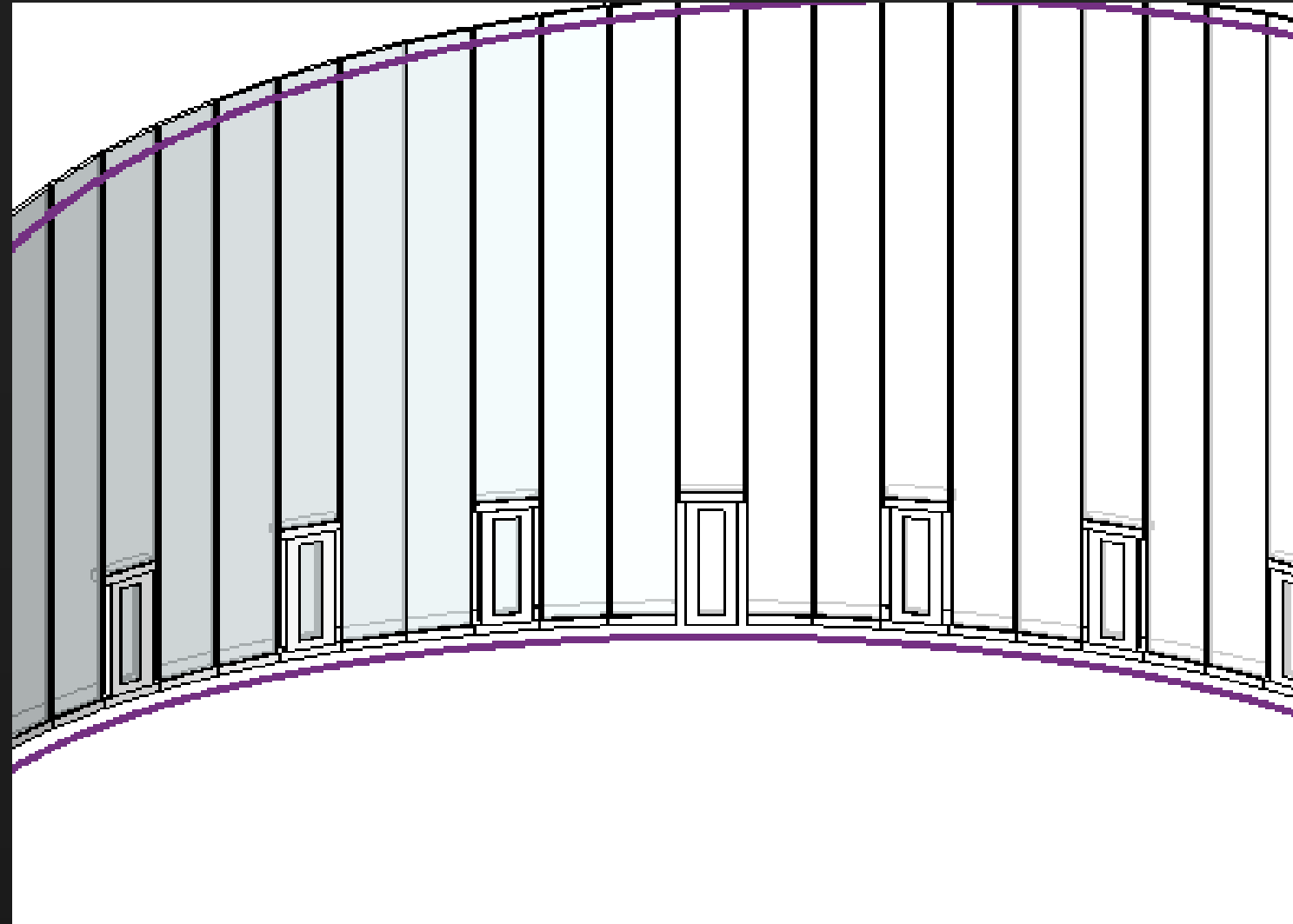
# Chapel / Meditation Space



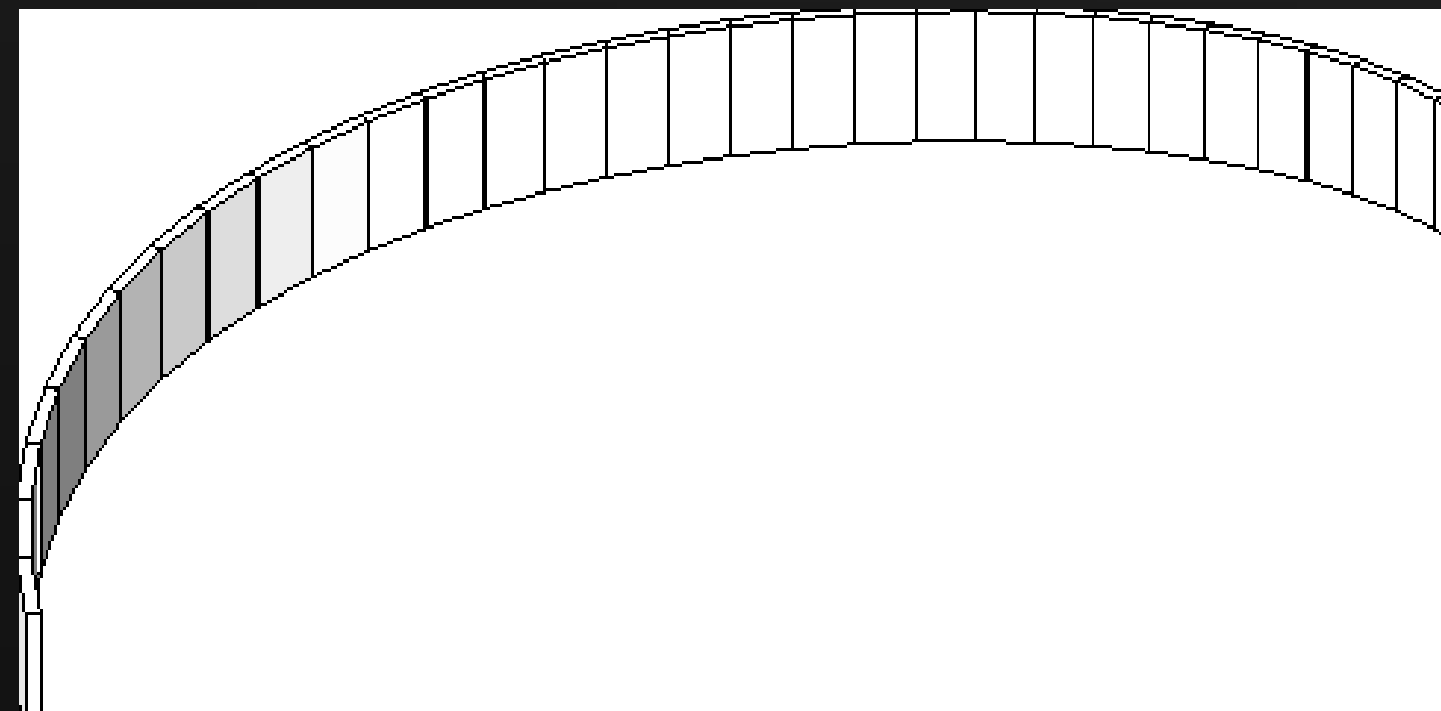
EXTERIOR VIEW – LOOKING SOUTH-EAST



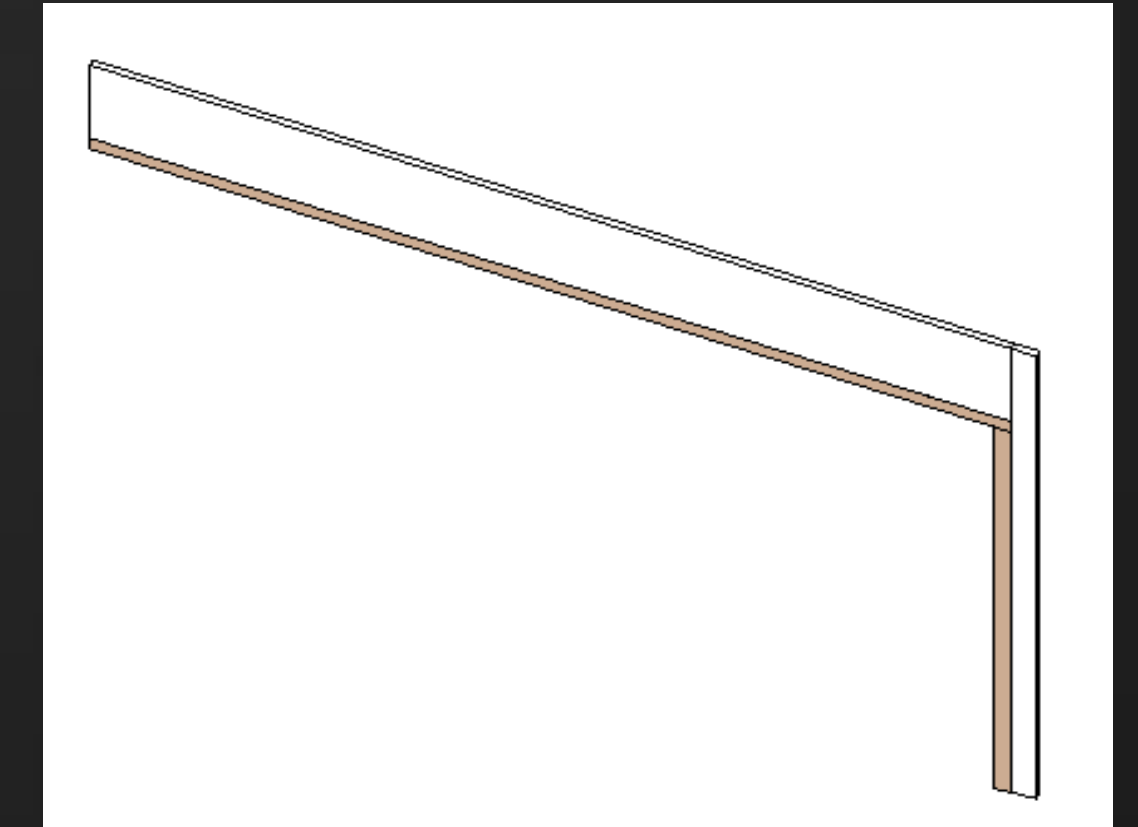
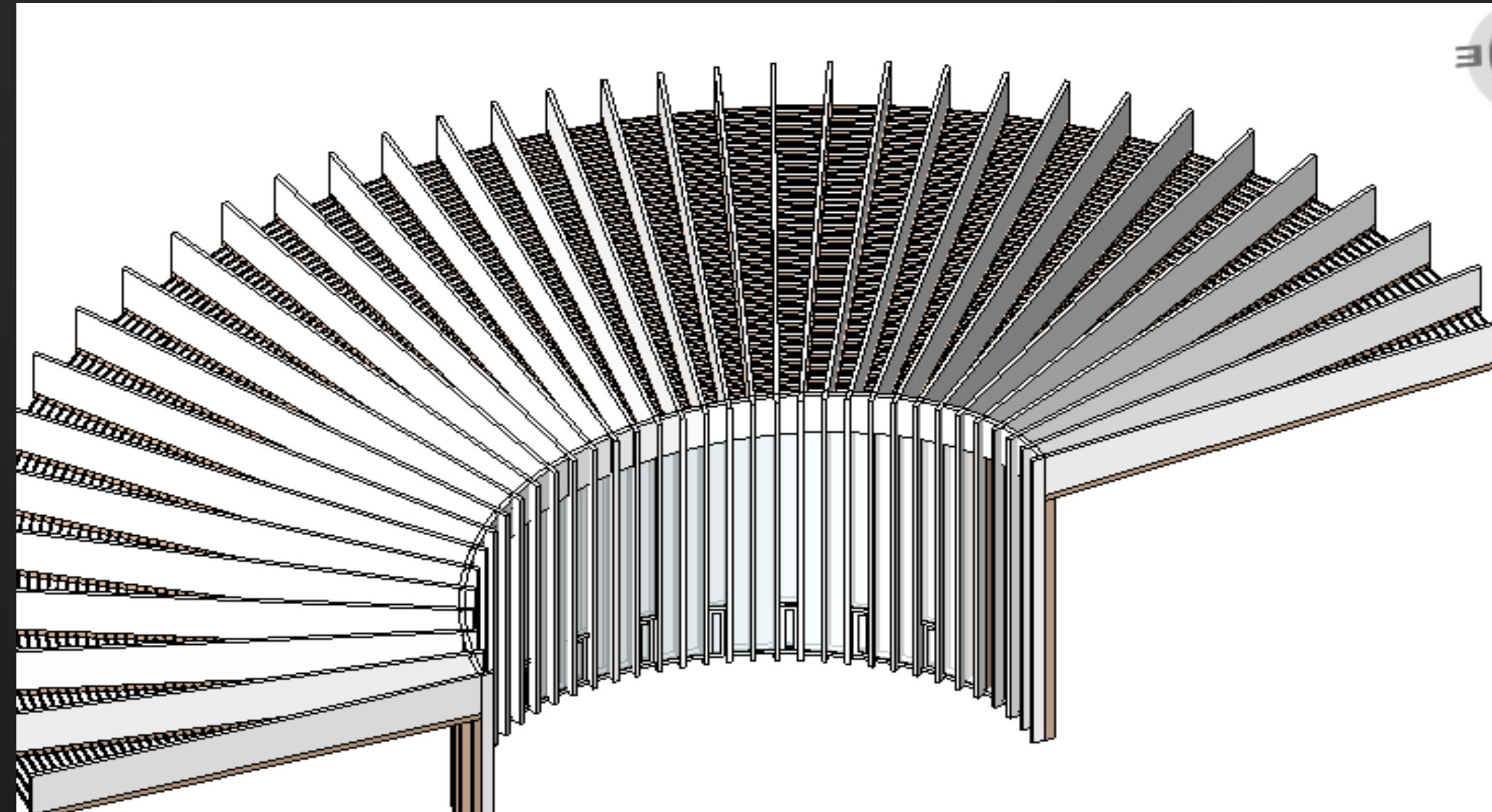
# Round 1: Revit 2010, early development



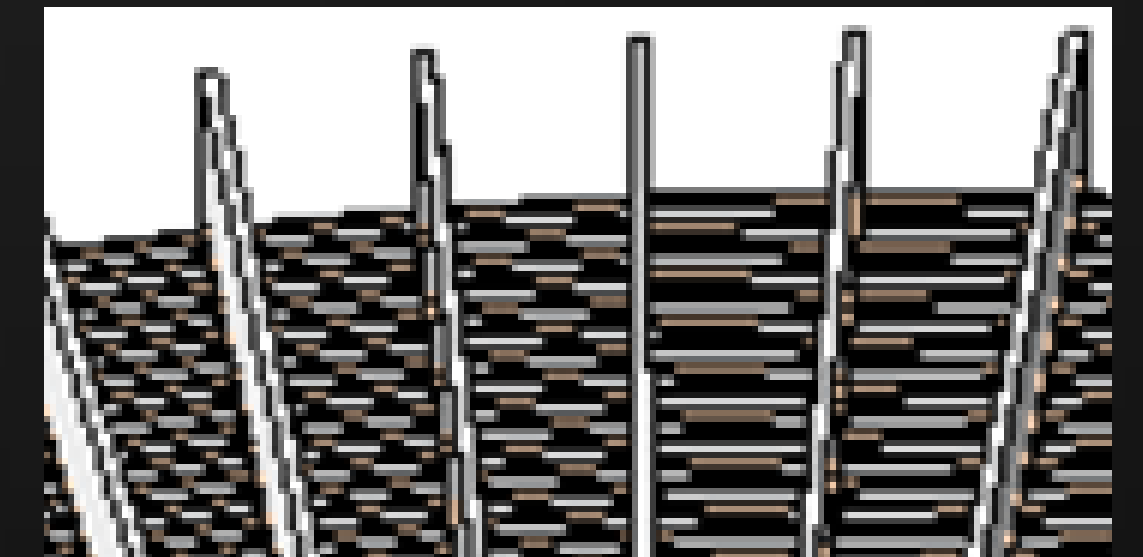
Curtain System



Curtain System



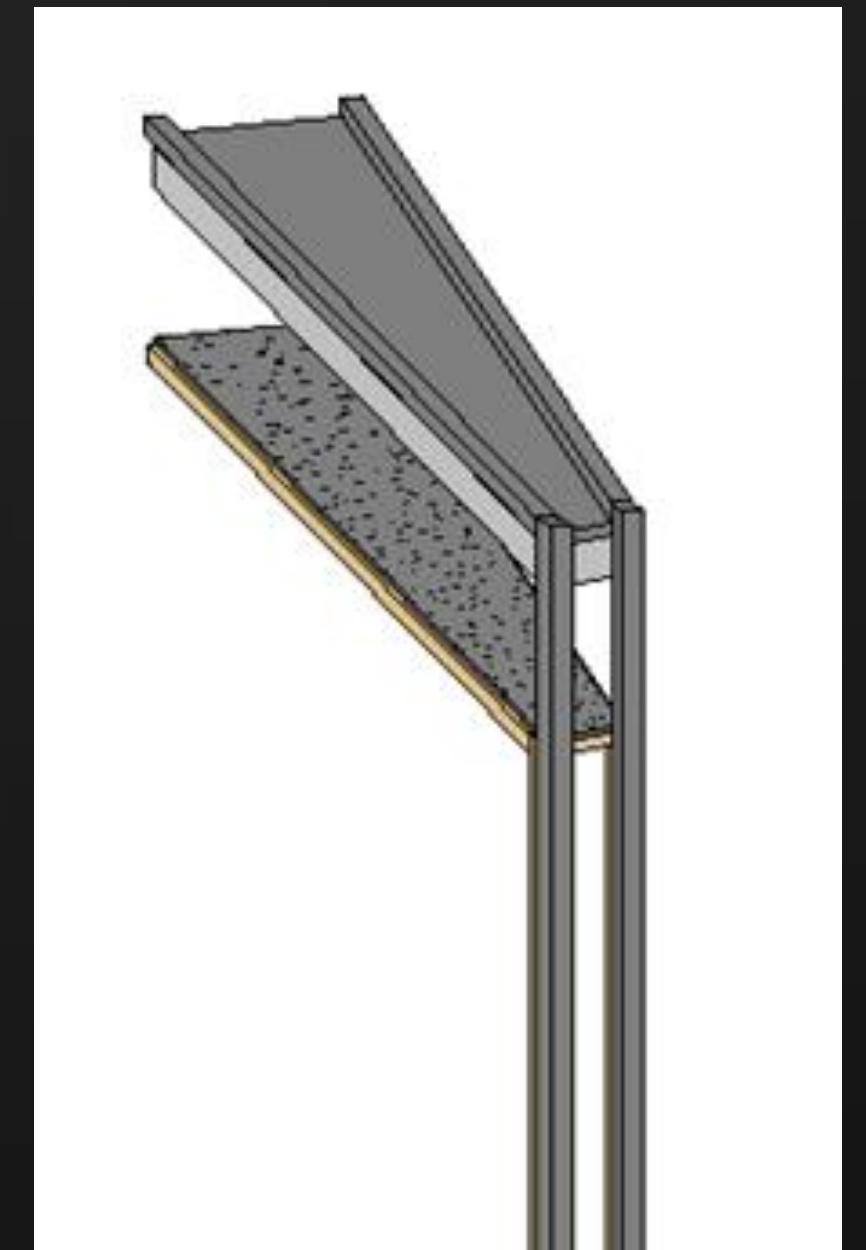
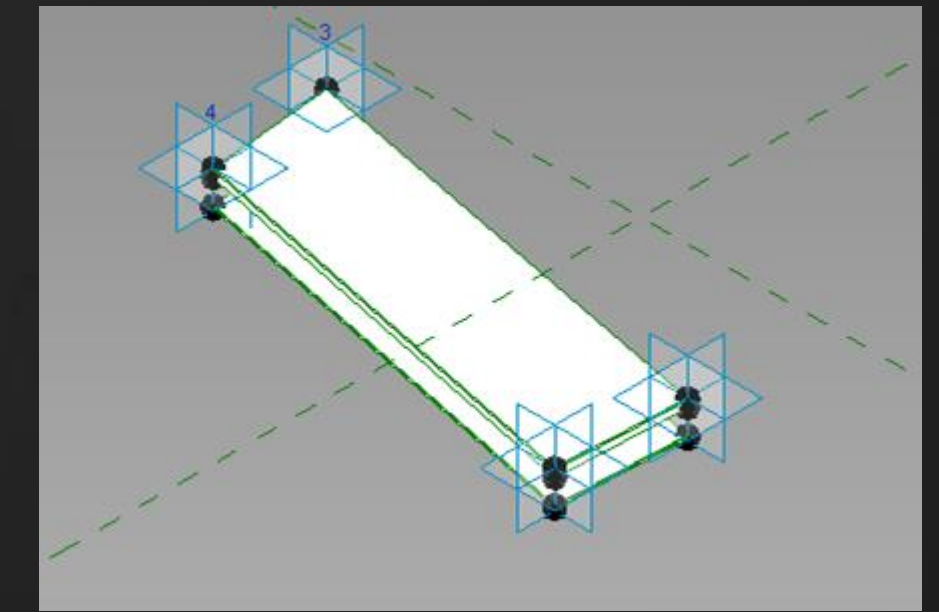
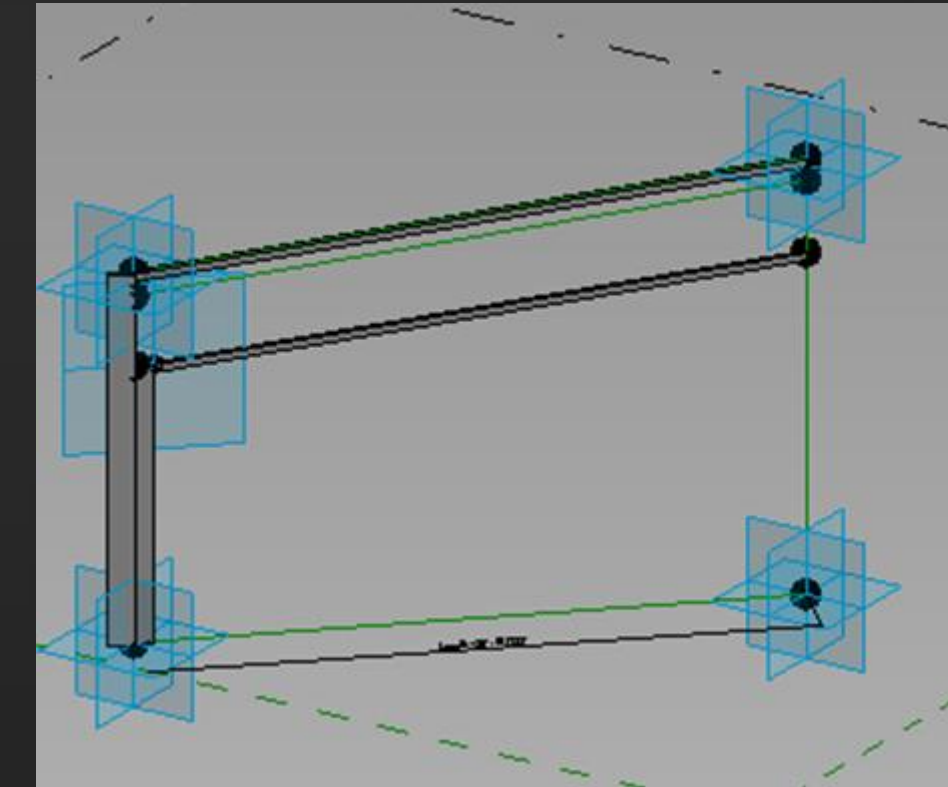
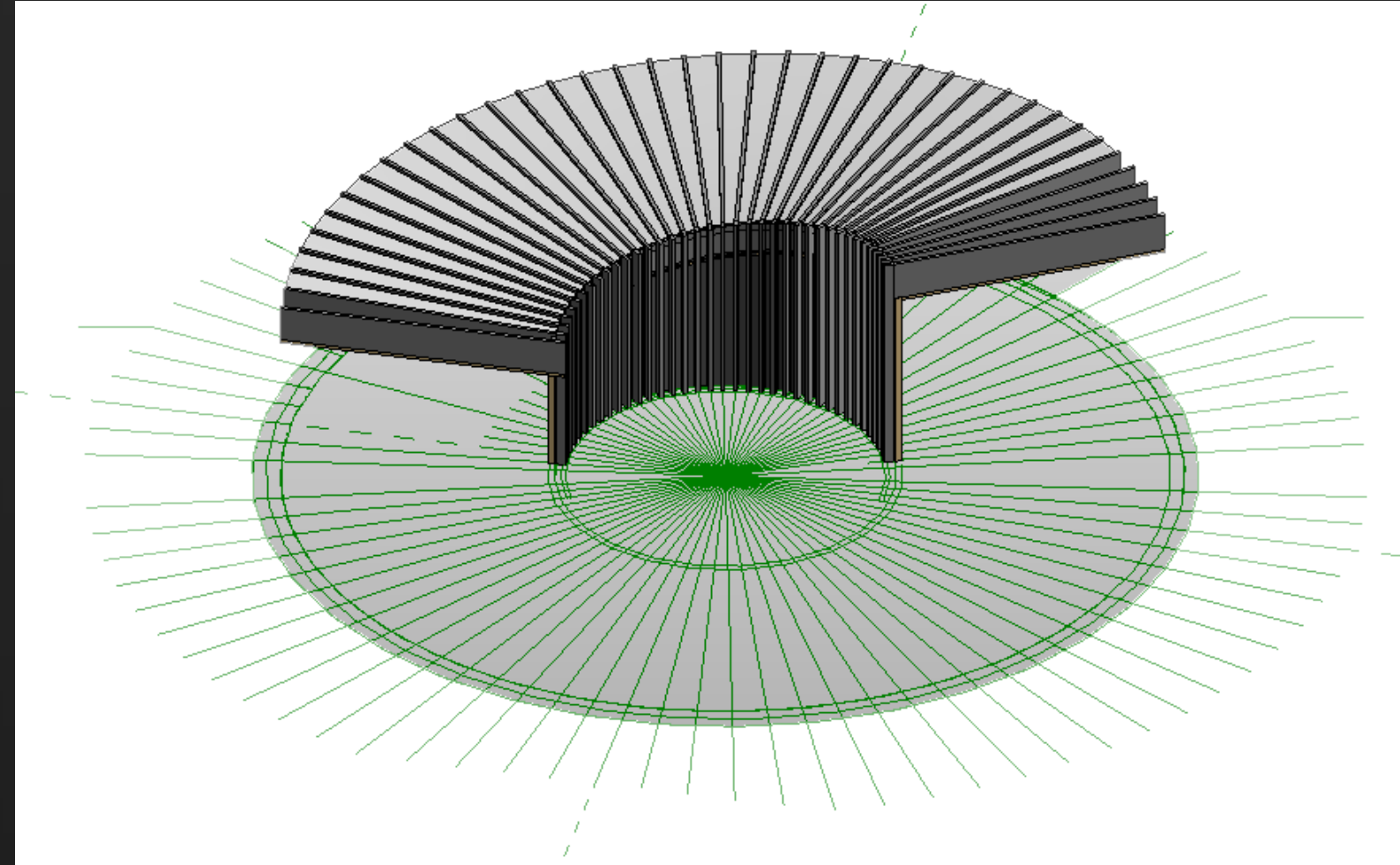
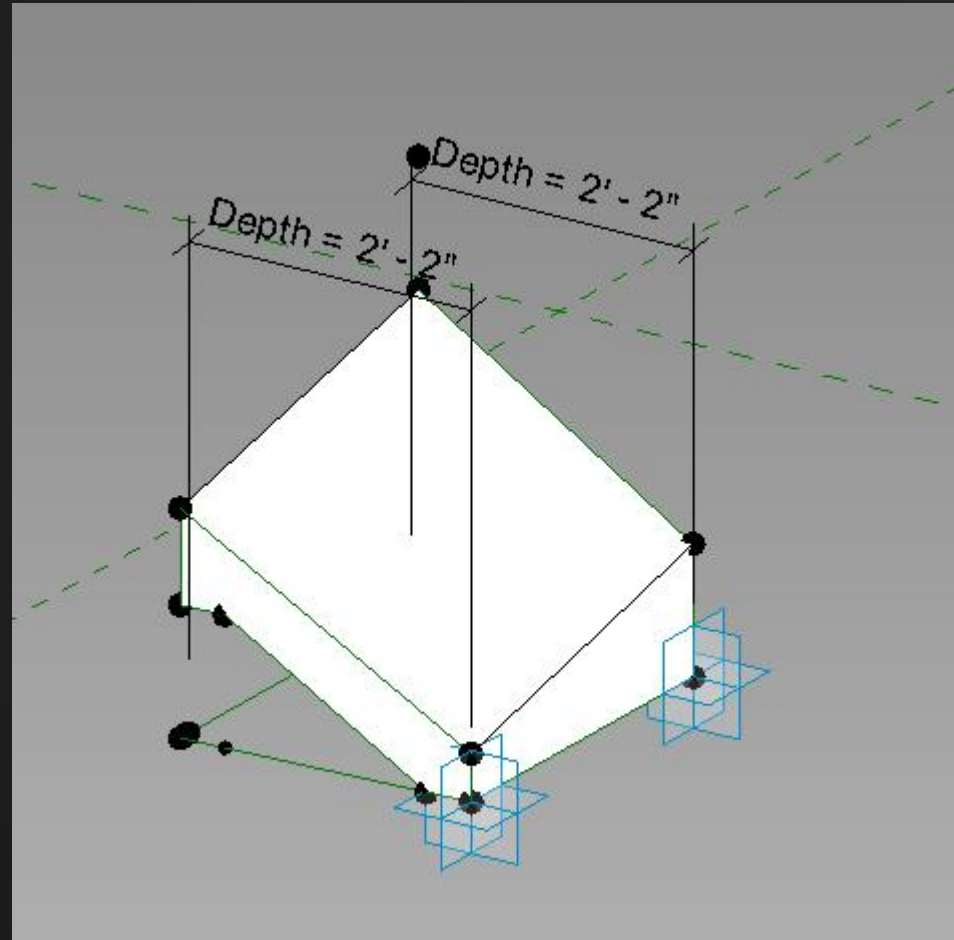
Generic Model



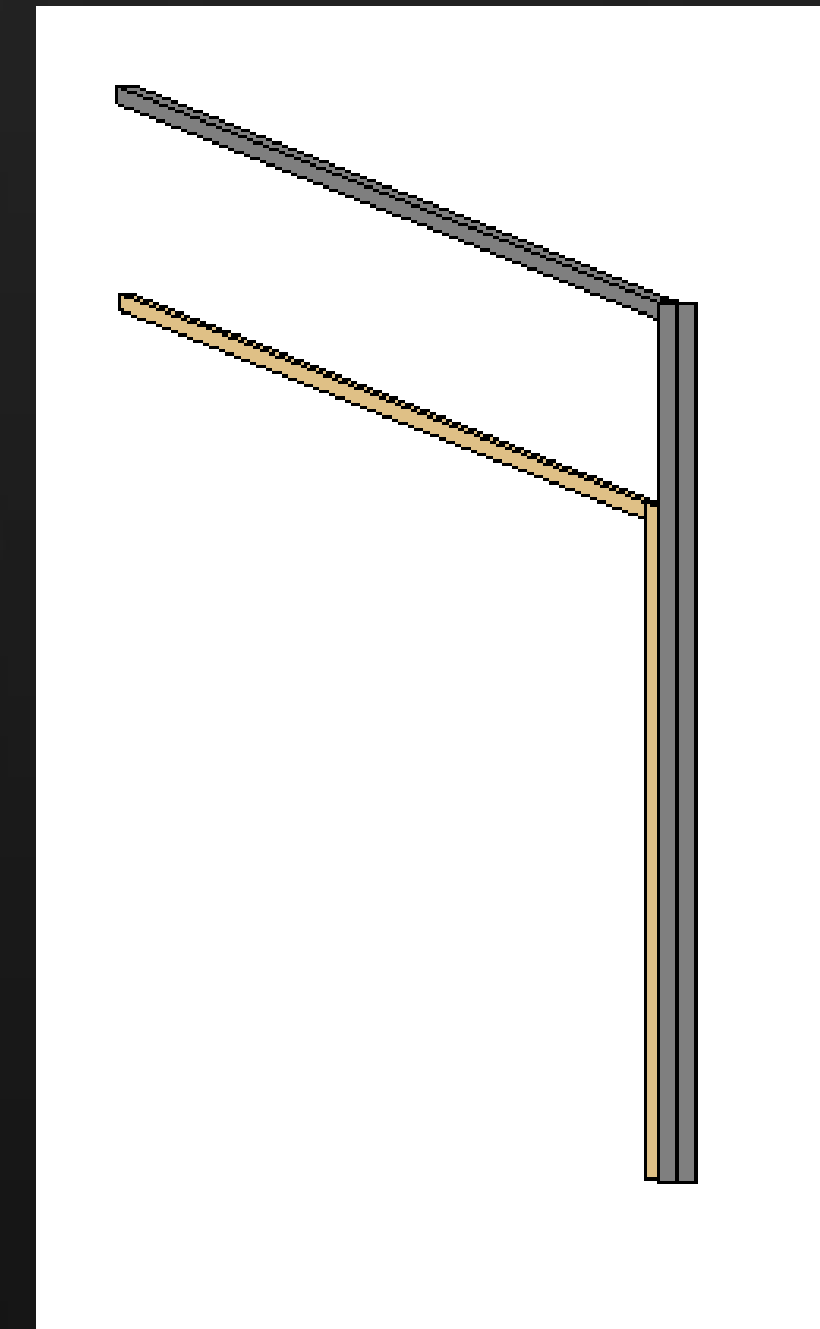
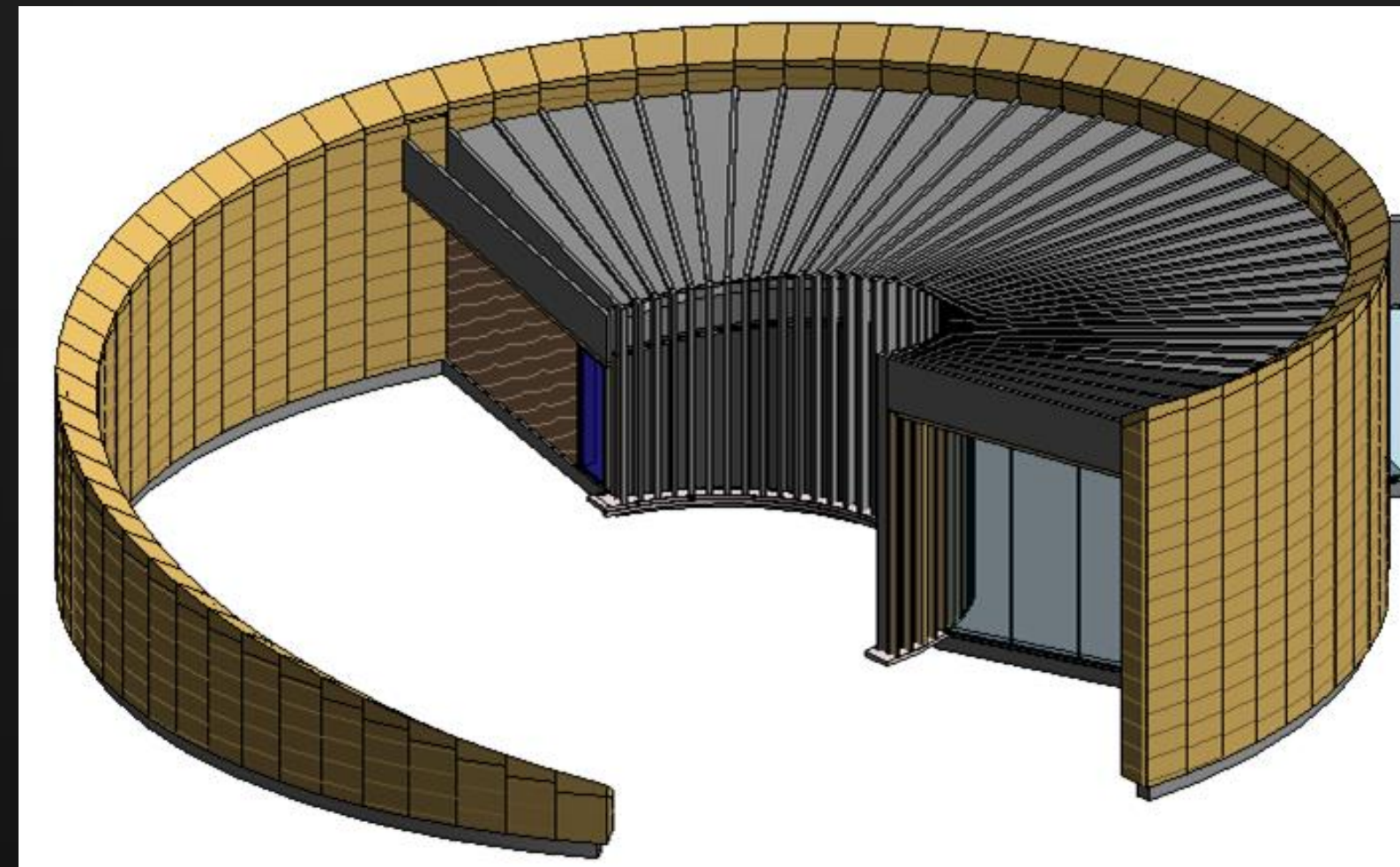
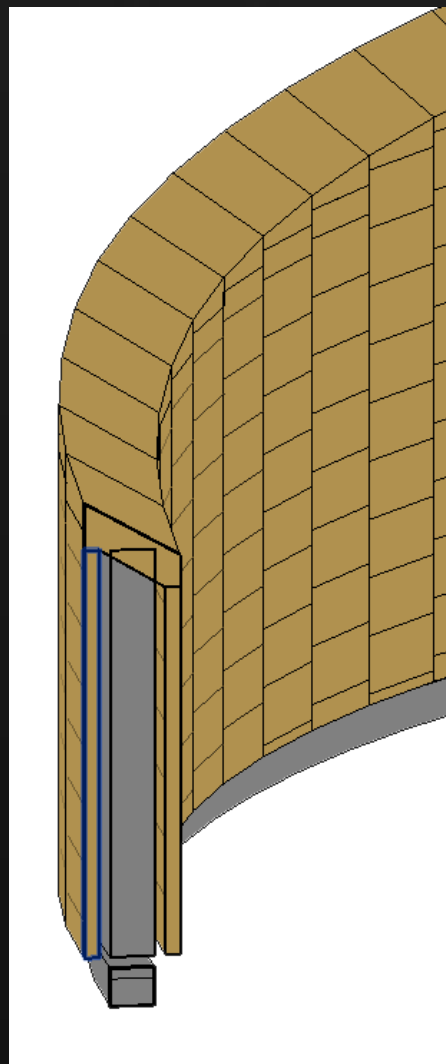
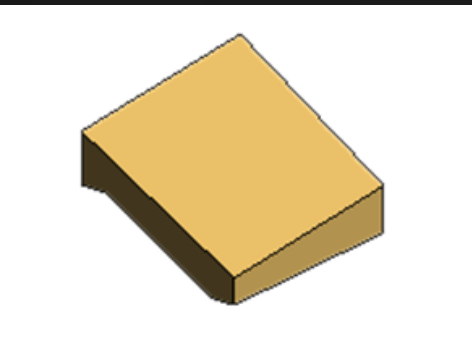
Curtain Systems



# Round 2: Revit 2011 and 2012 , DD

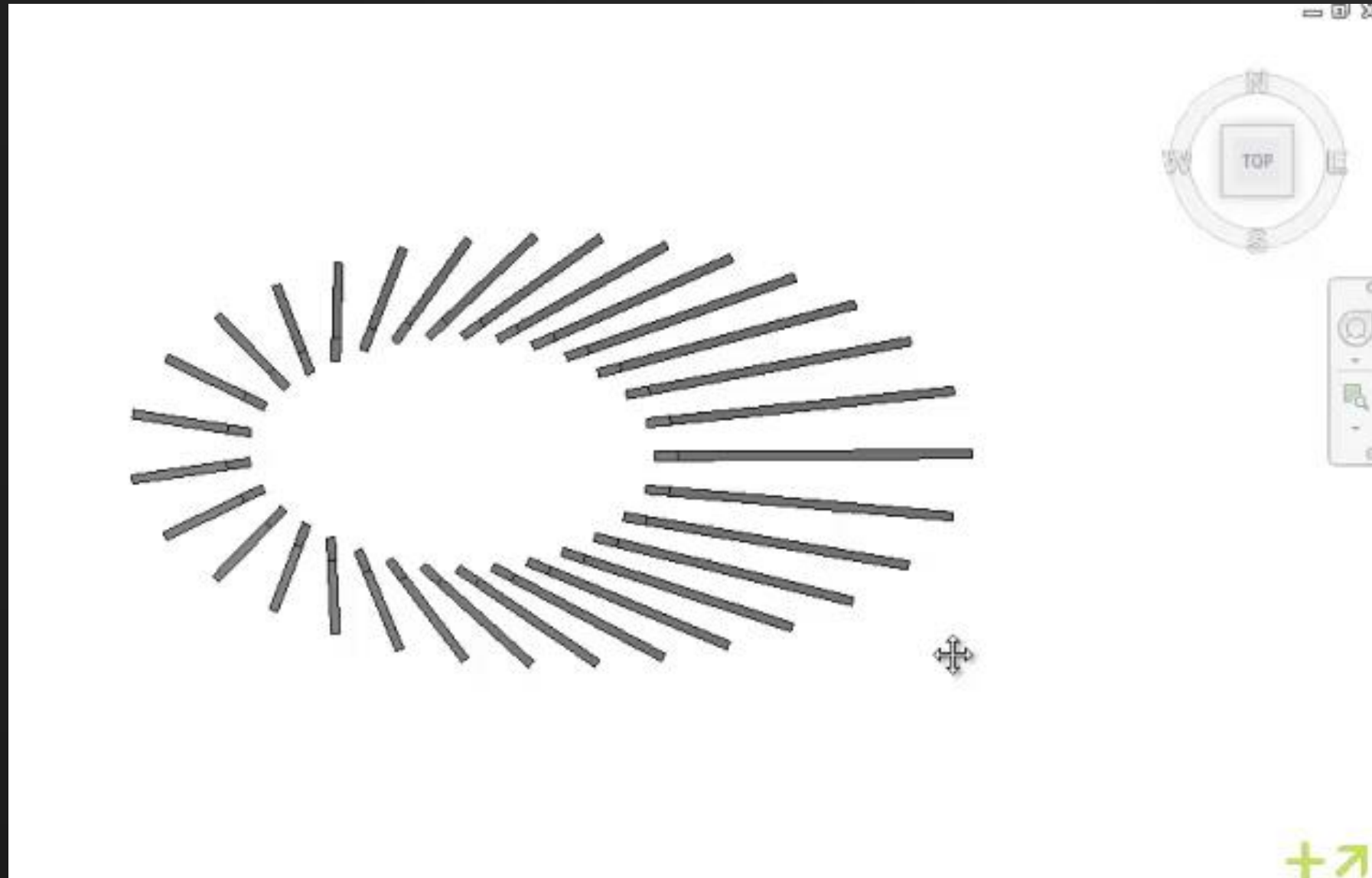


Assembly of Roof –  
metal, concrete, air  
space, wood ceiling





# Round 3: Design Changes



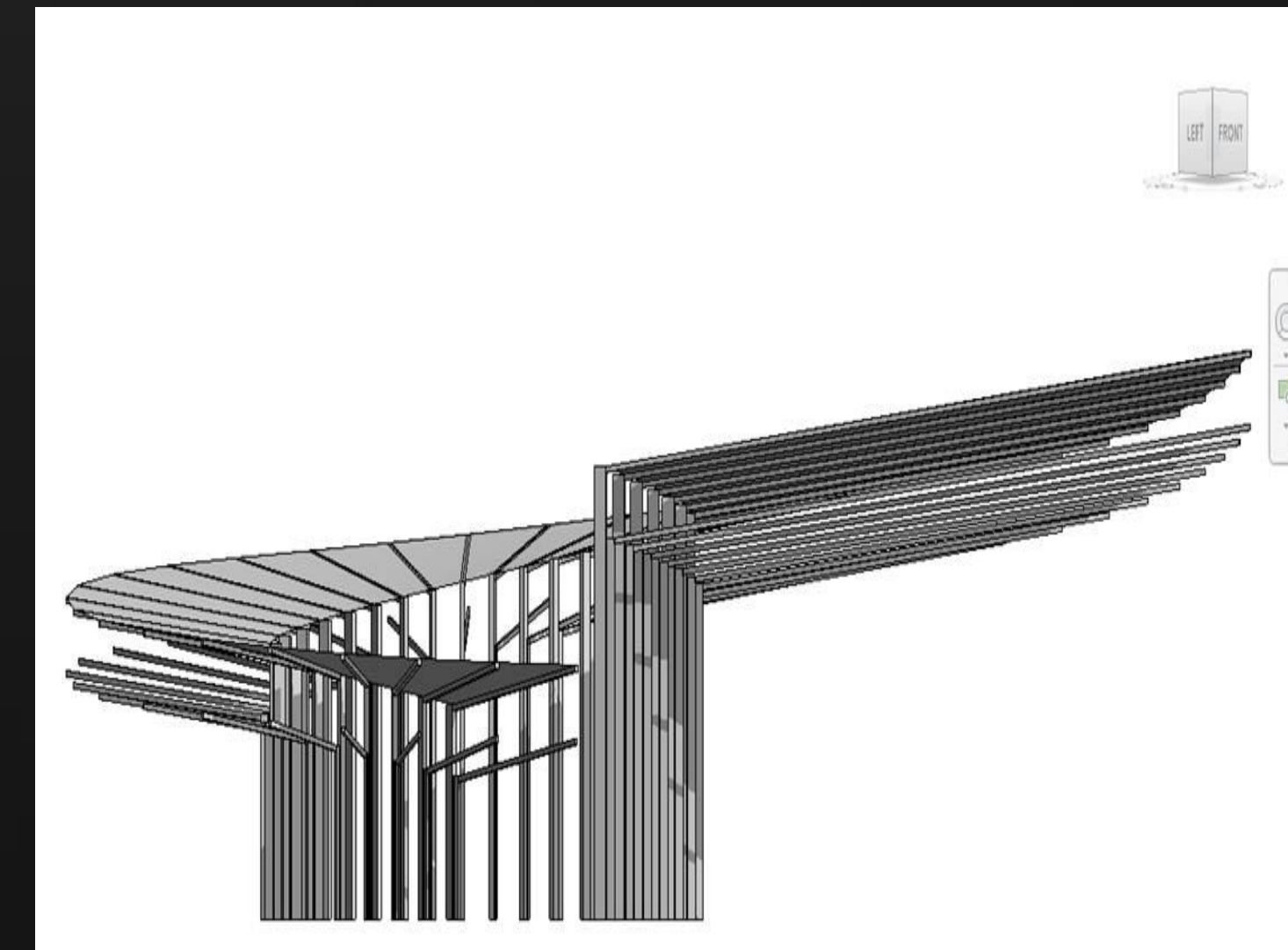
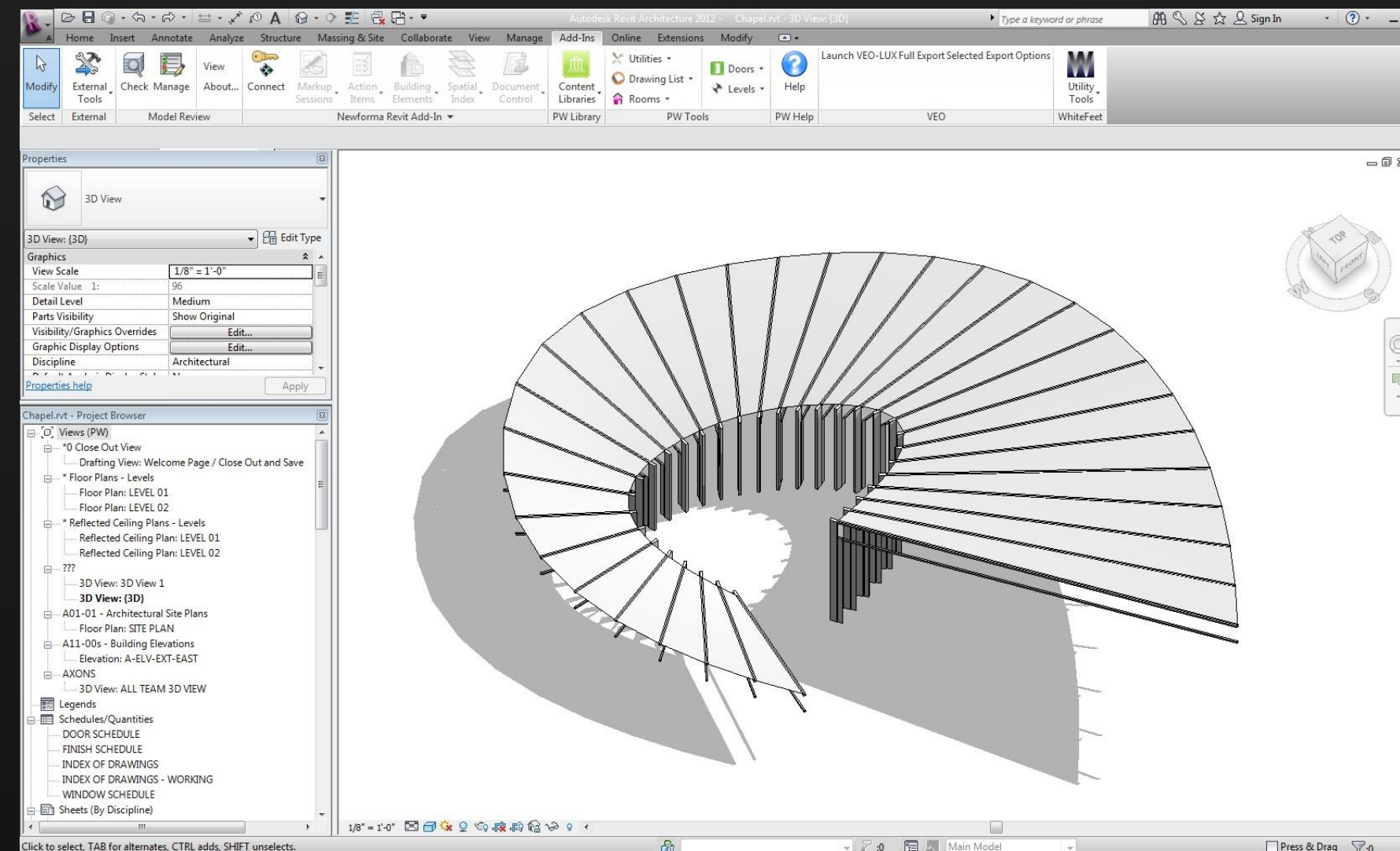
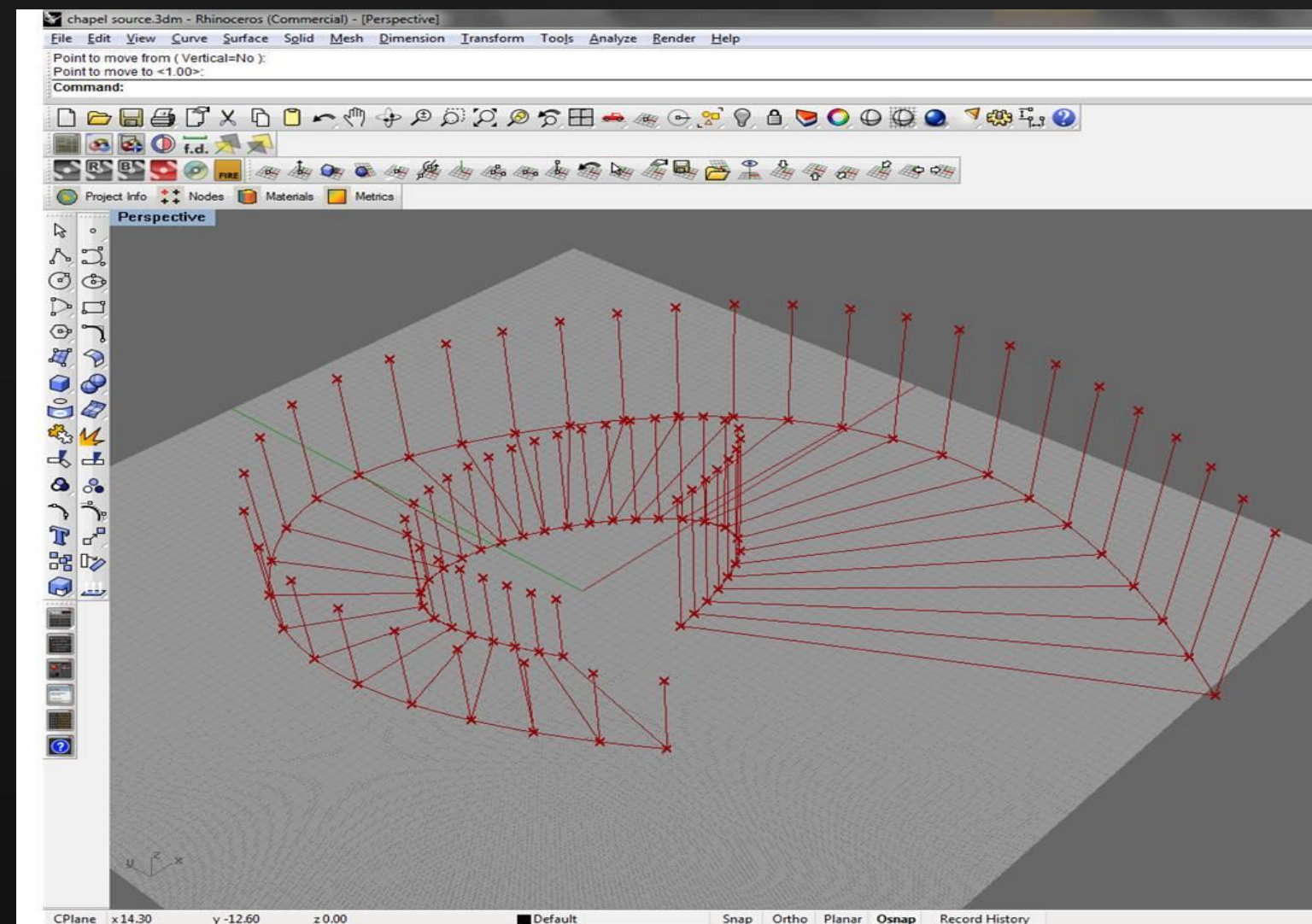
Challenge: circle, ellipse , shifted ellipses...

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**



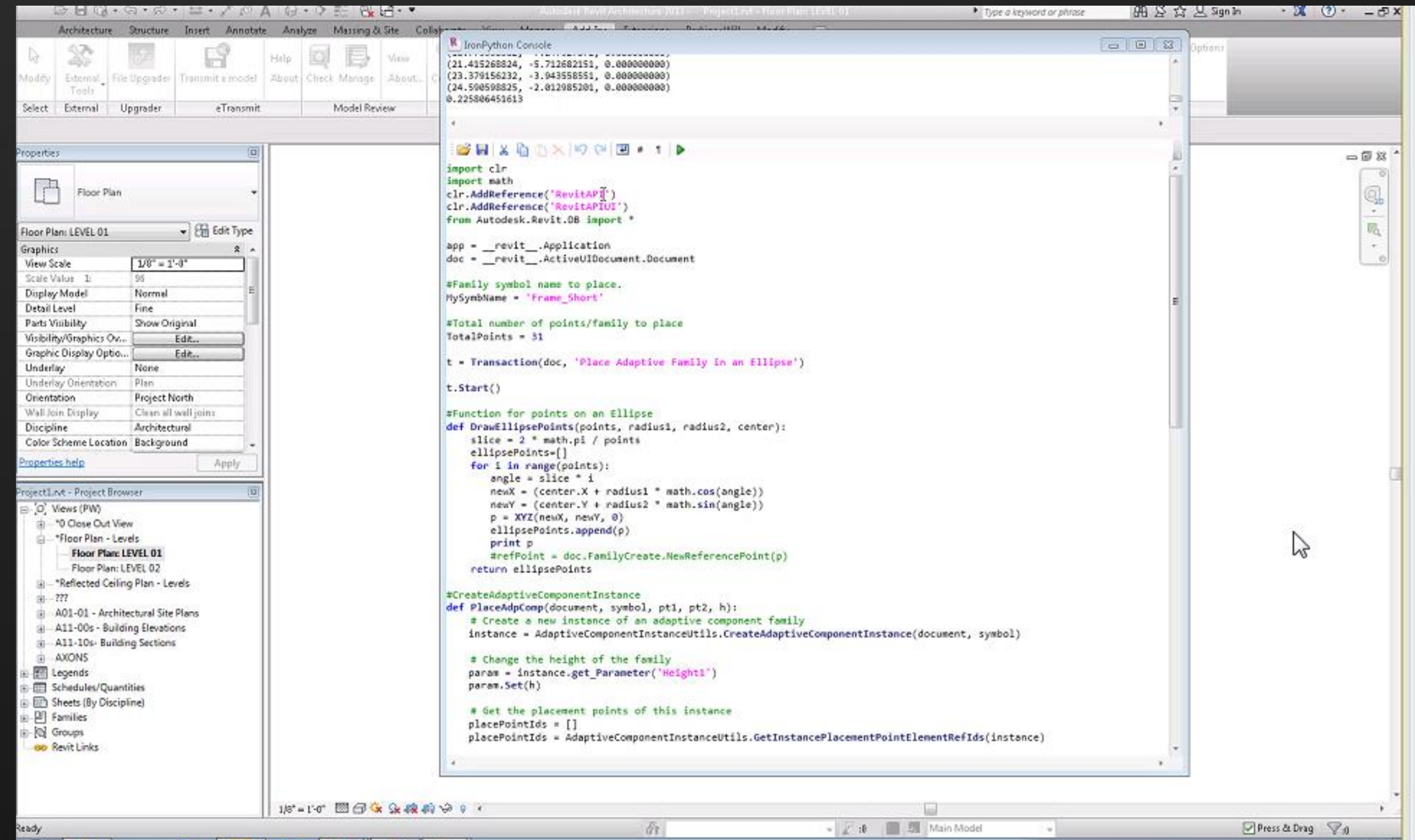


# Round 3: Another Approach

Script with Revit Python Shell

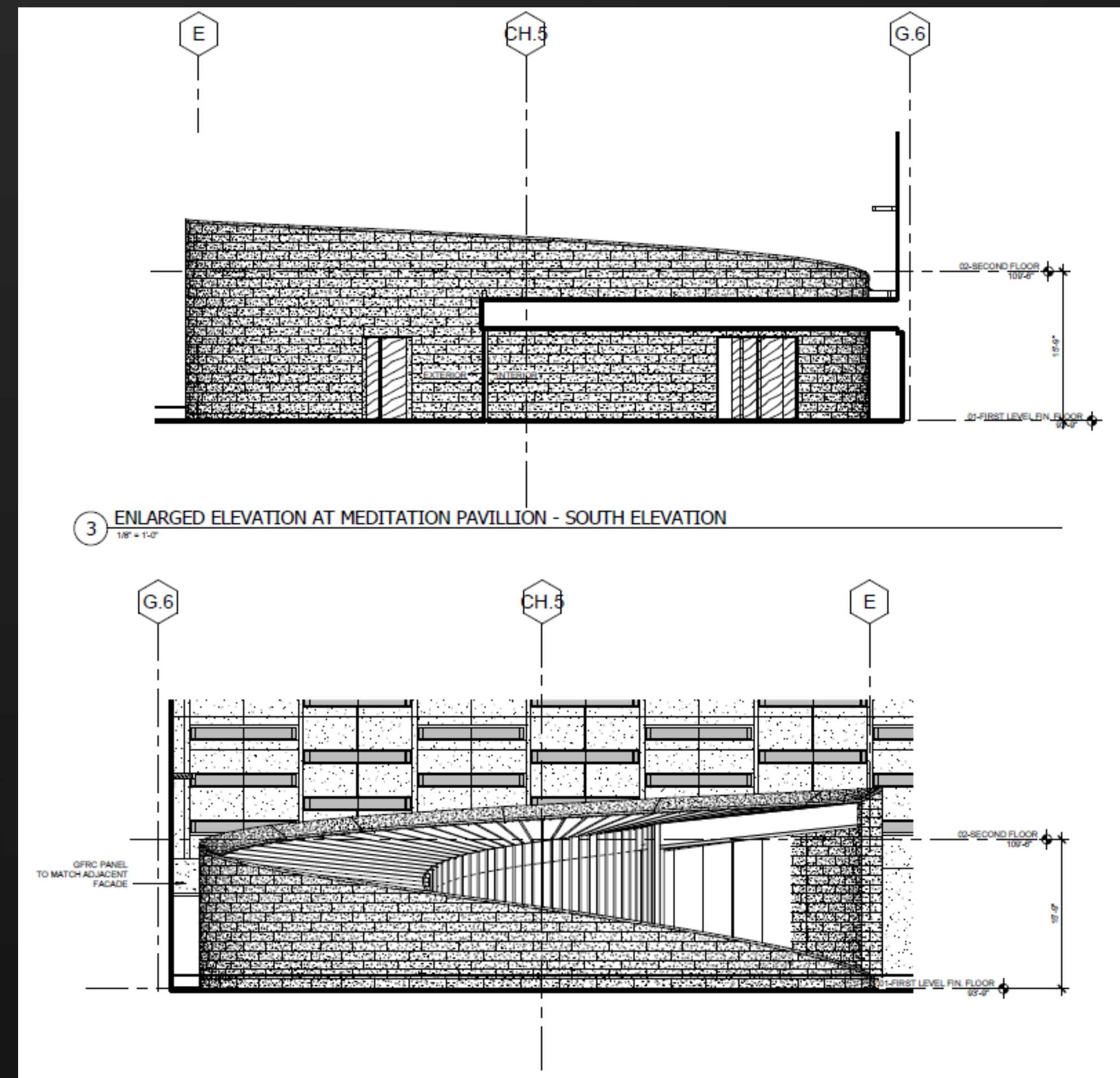
Rapid iterations, one software environment

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





# Results





# Shade in the Desert

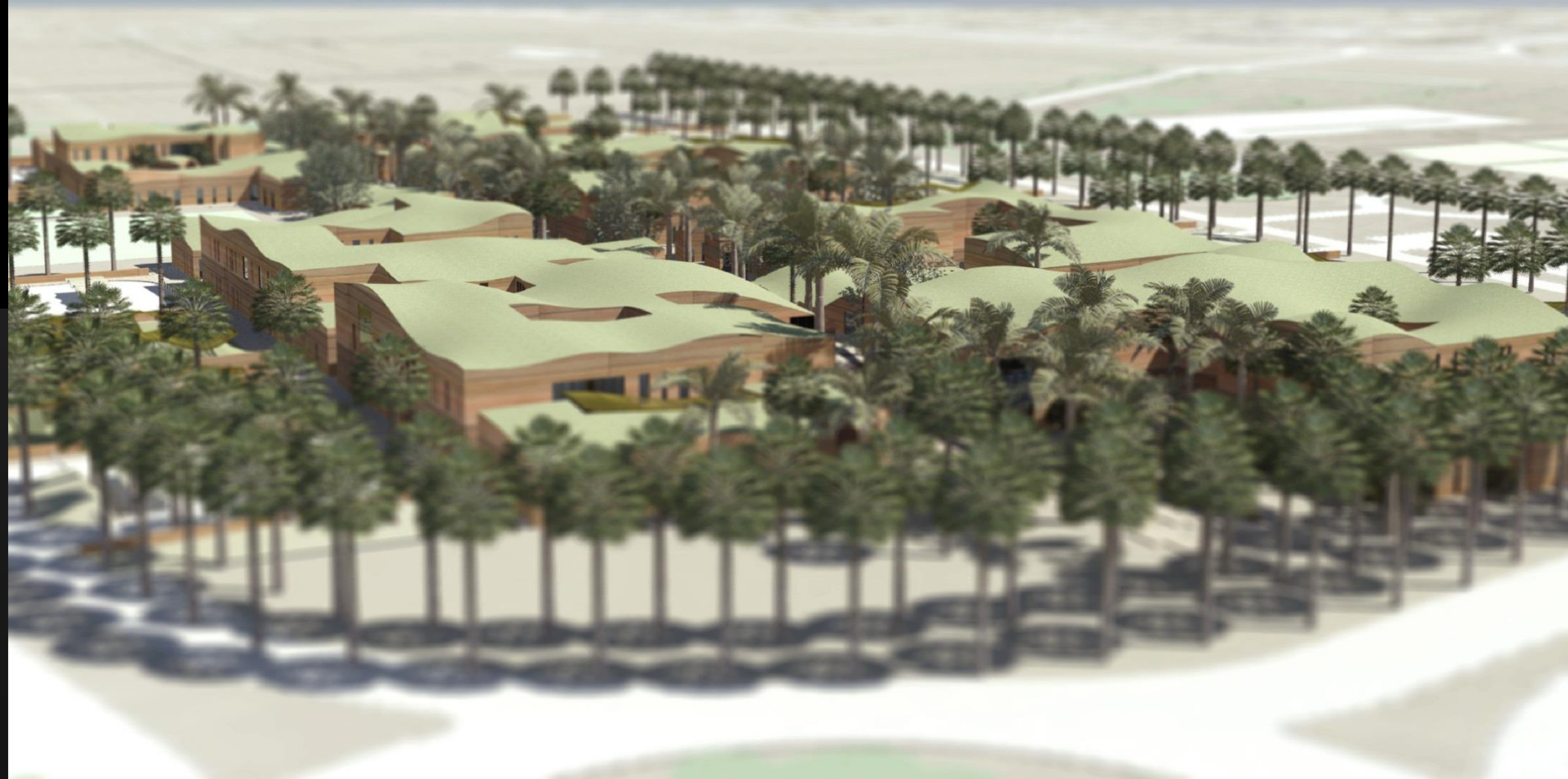


# Kuwait University

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

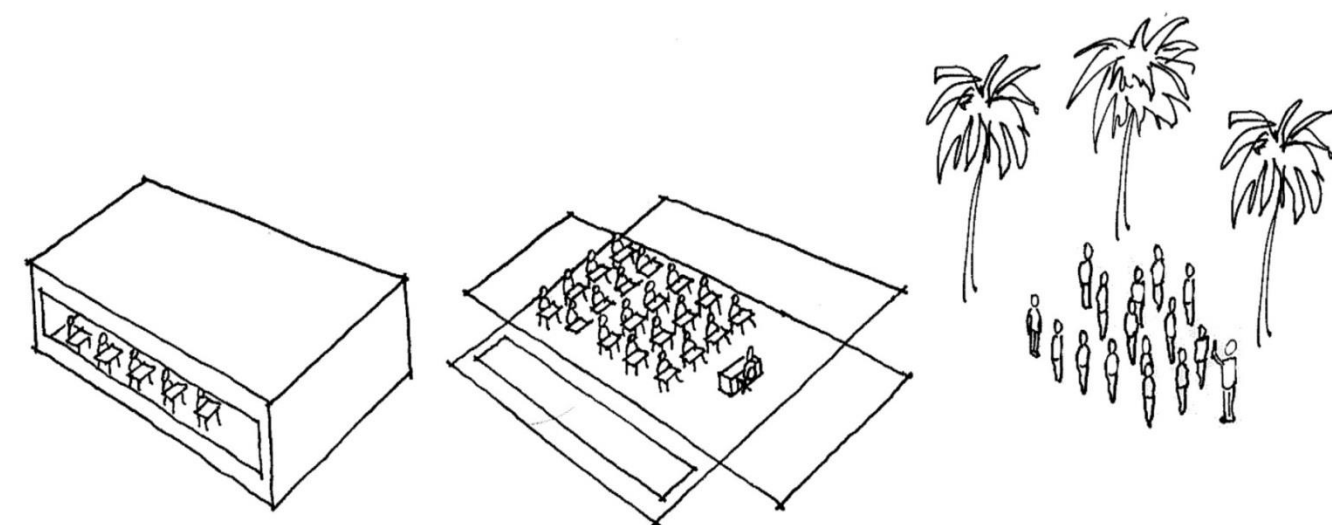
## AERIAL VIEW OF TEACHING SCHOOL

The 21st Century School understands that learning extends beyond class-based instruction and includes a robust program of direct hands-on engagement. The Kuwait Teaching School functions as both a K-12 school and a teaching environment for the University students at the nearby School of Education. To that end, we have richly programmed the outdoor spaces both at grade and atop the school's landscaped roofs for both students and teachers – laboratories, gardens, observatories and play spaces for learning that cannot be duplicated in conventional educational environments.





**A1:** DESIGN A SCHOOL AS  
LEARNING LABORATORY





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



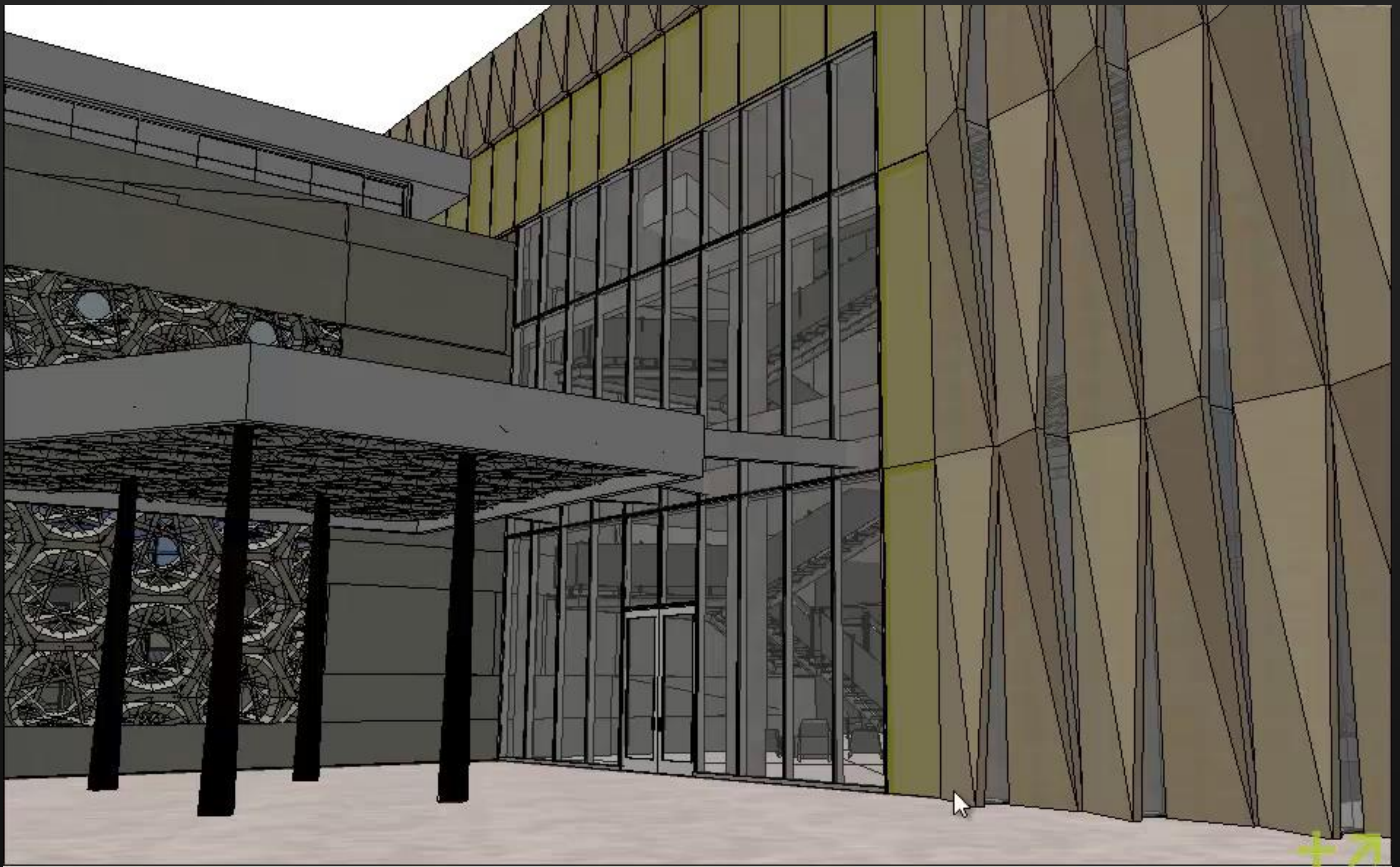








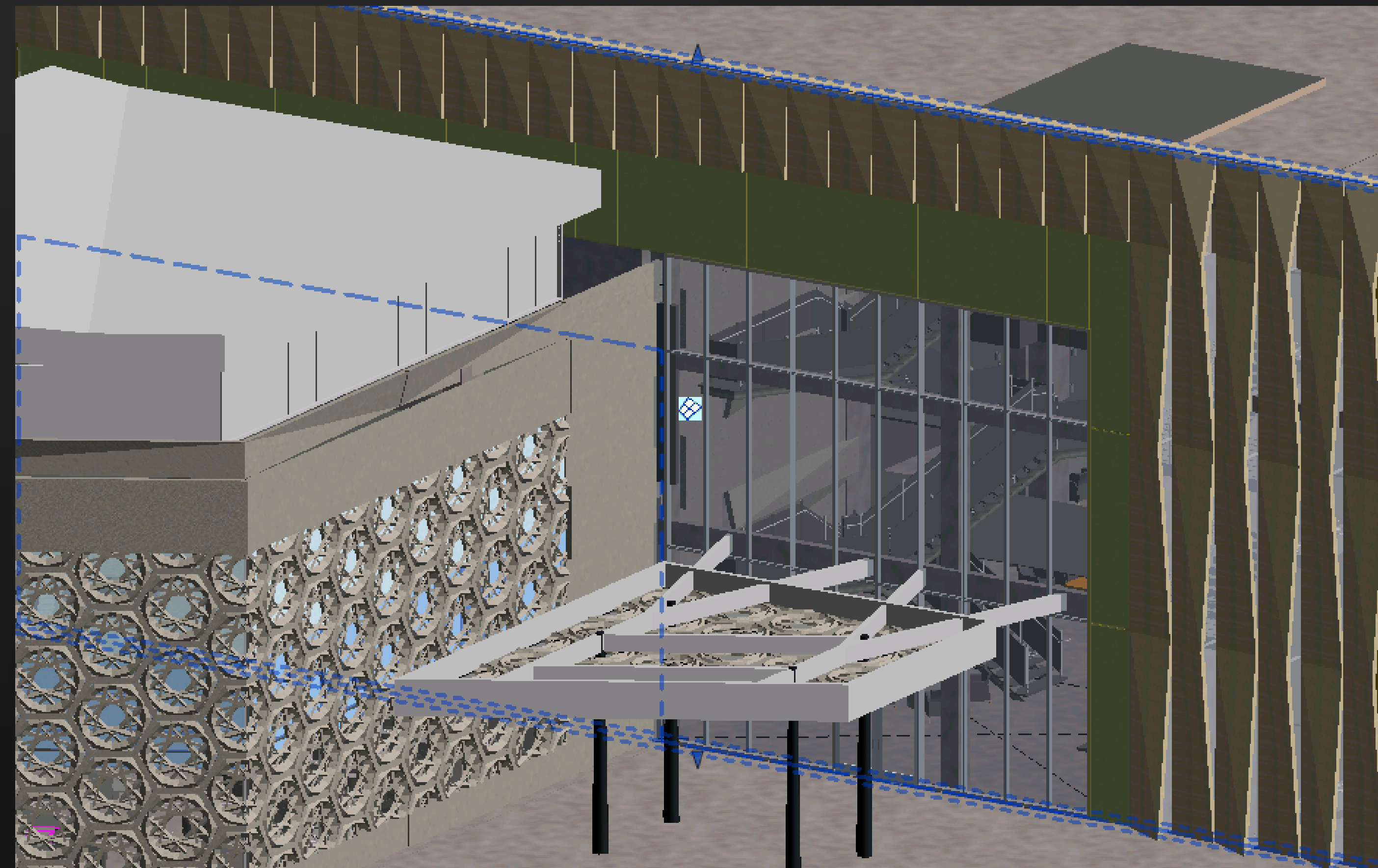
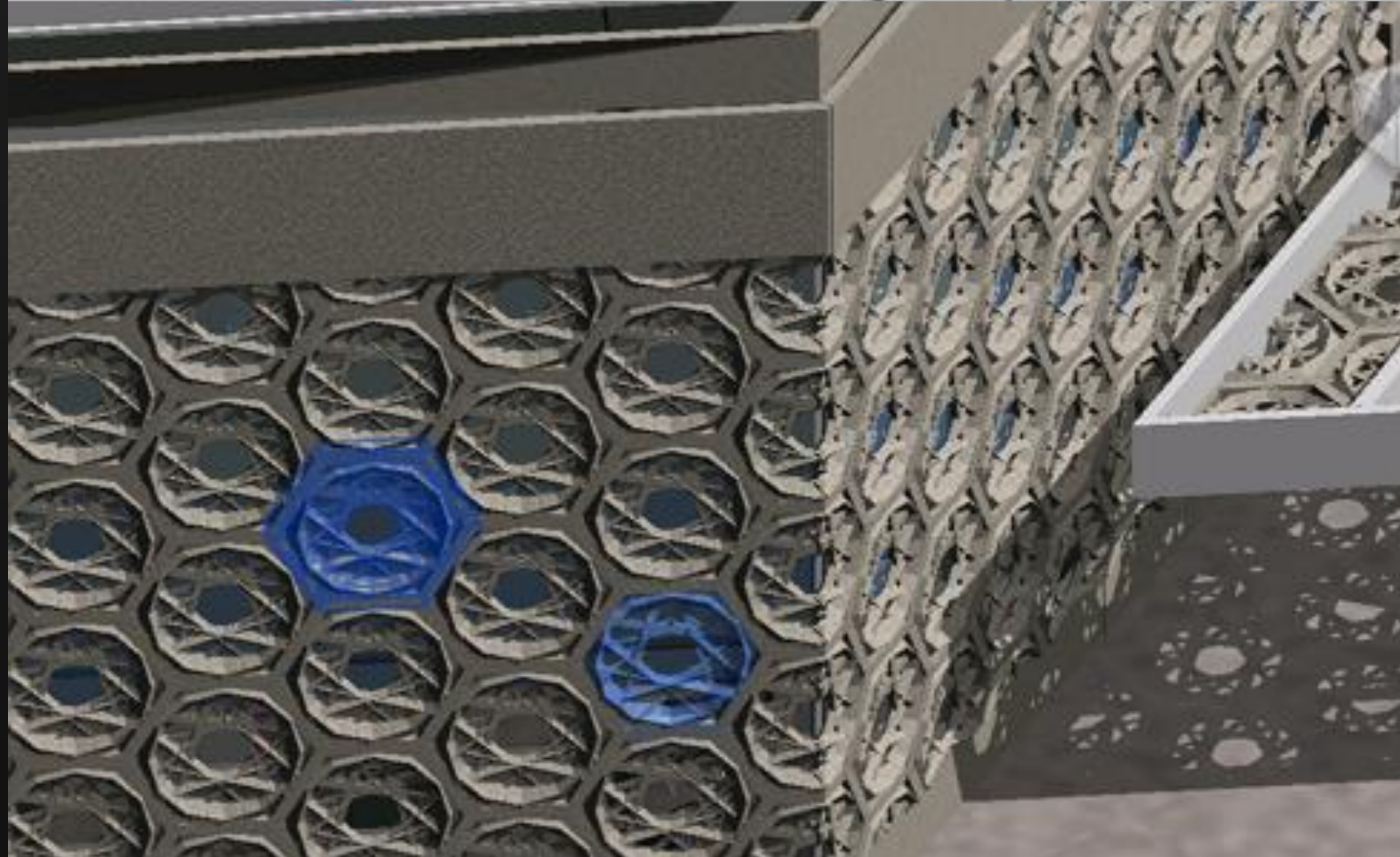
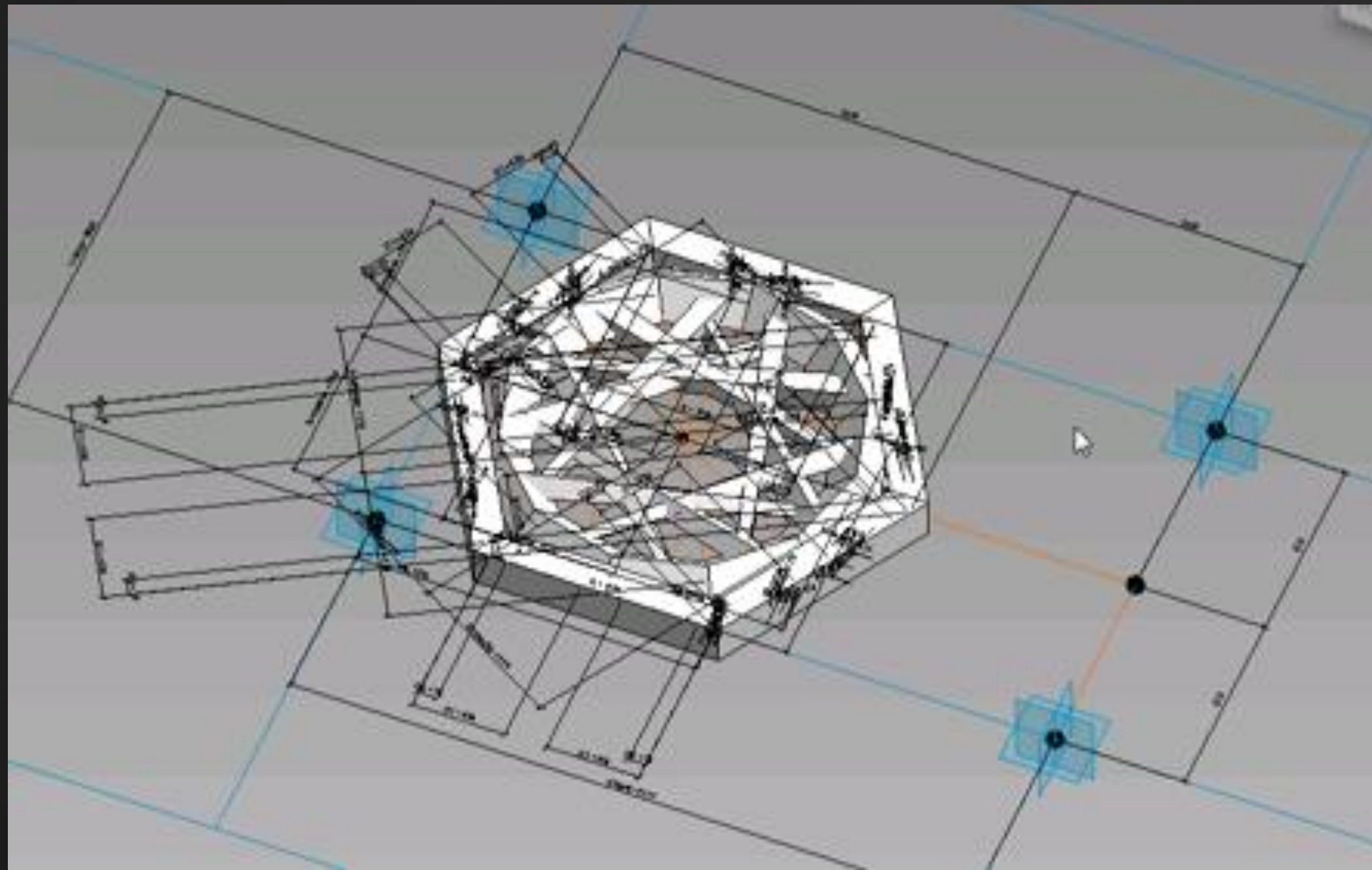




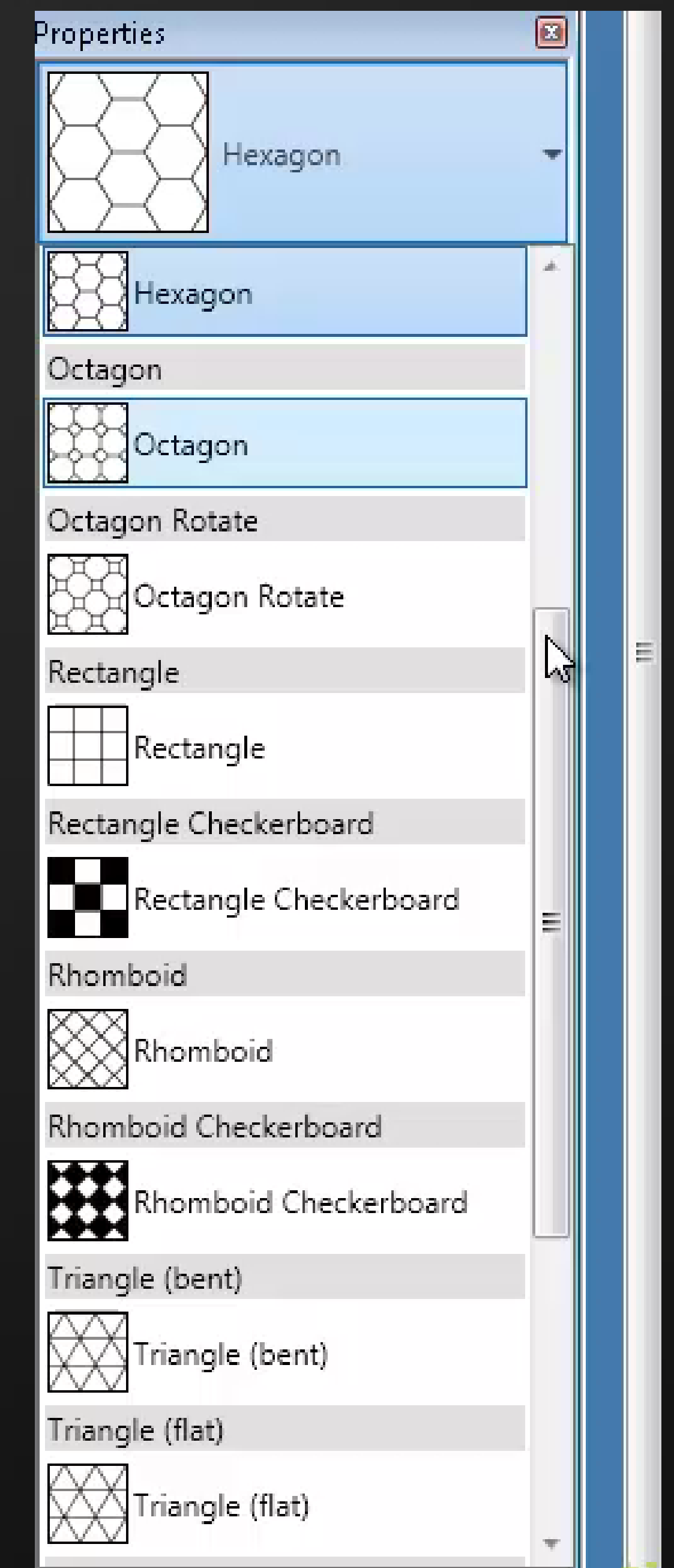
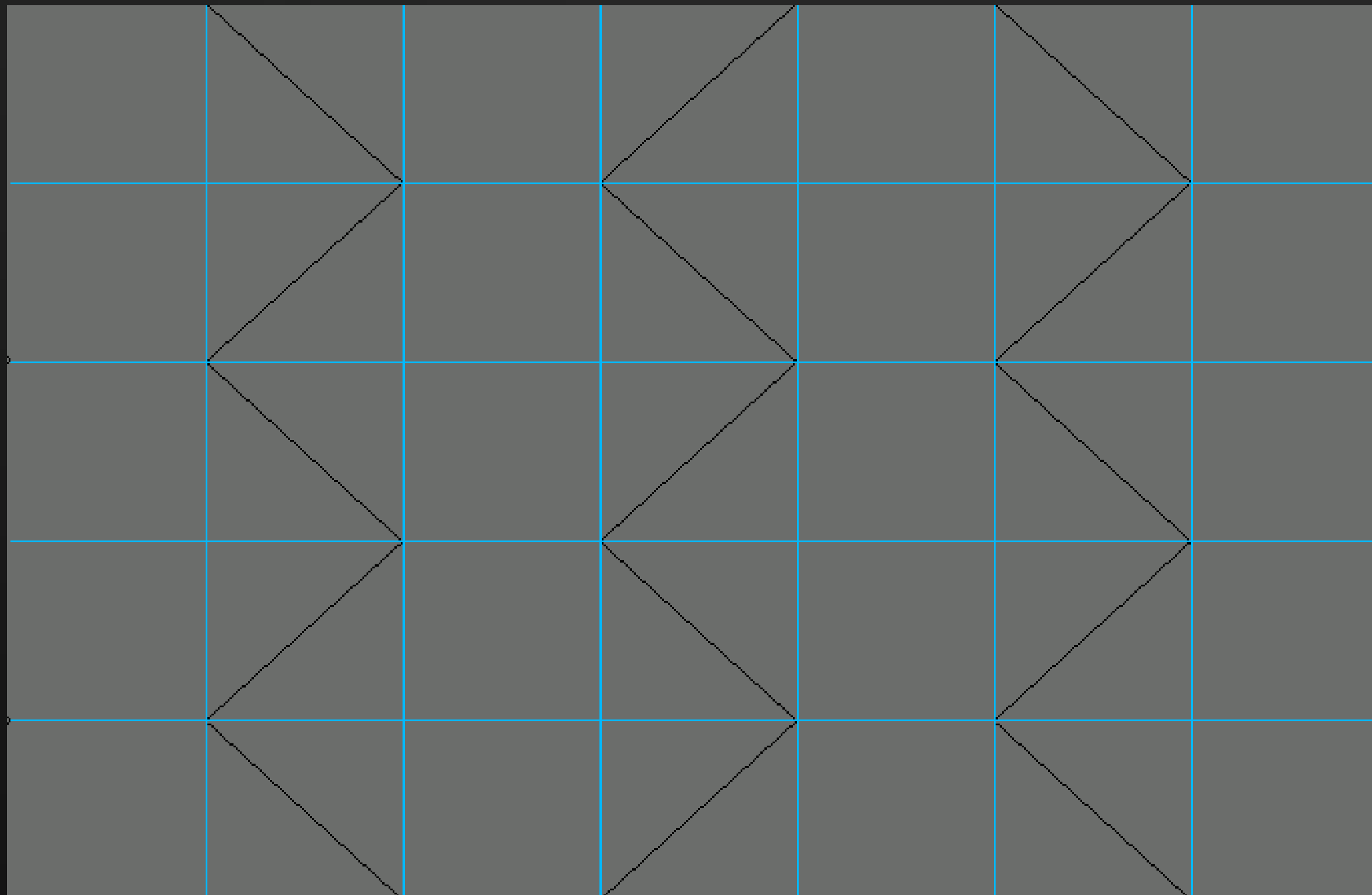
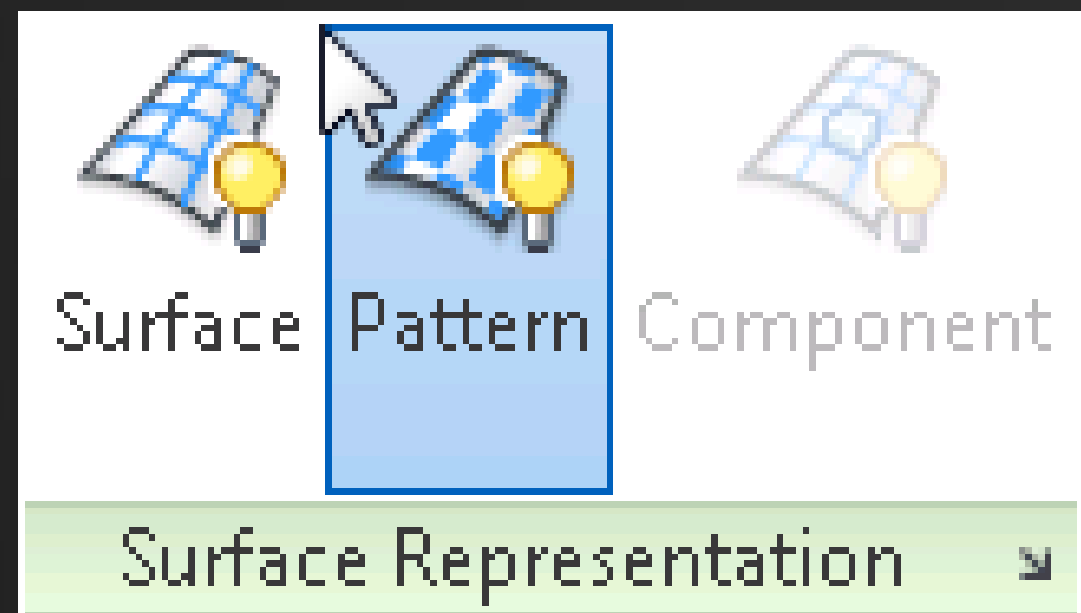


Infinite variety of visually distinctive types:

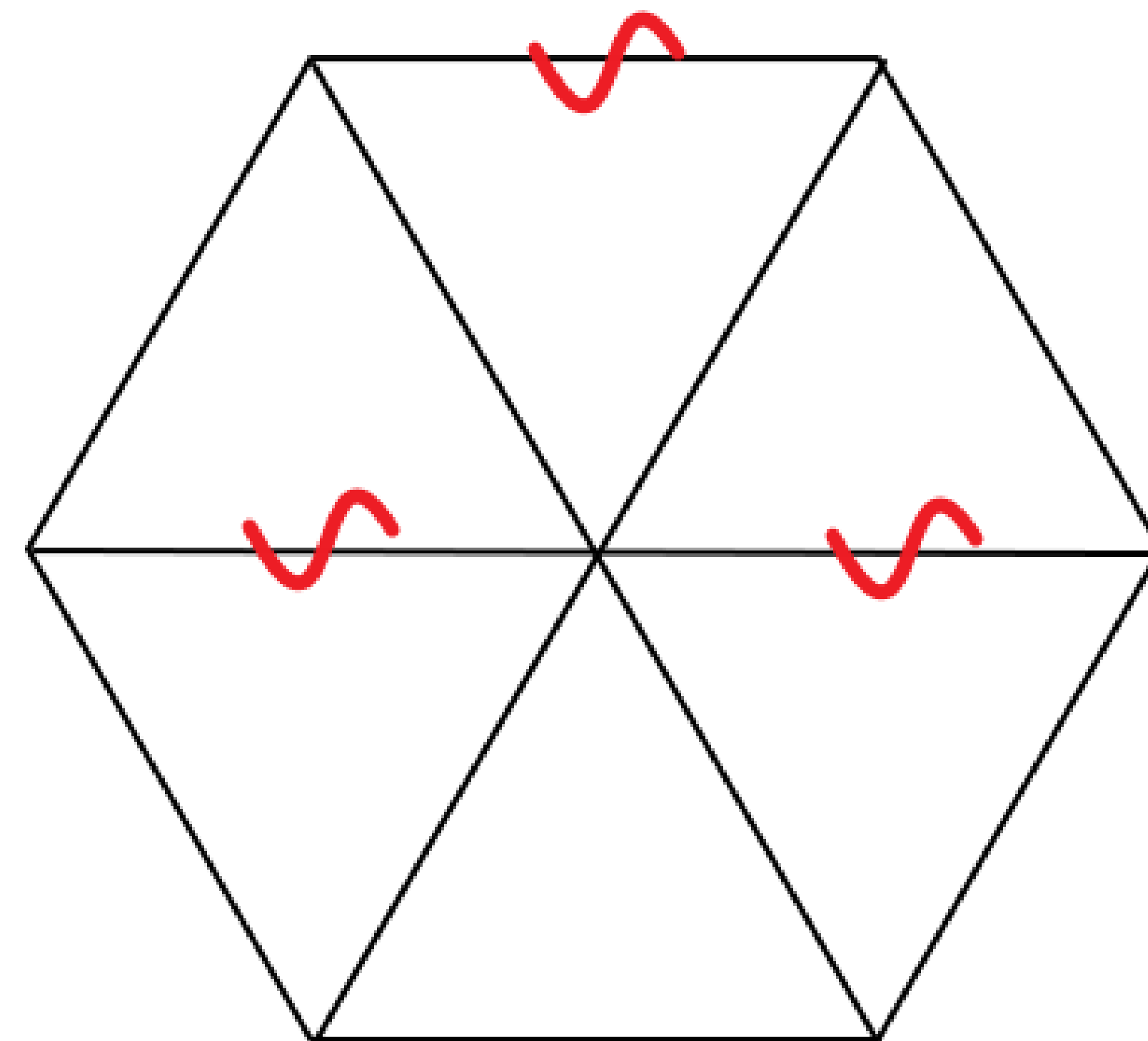
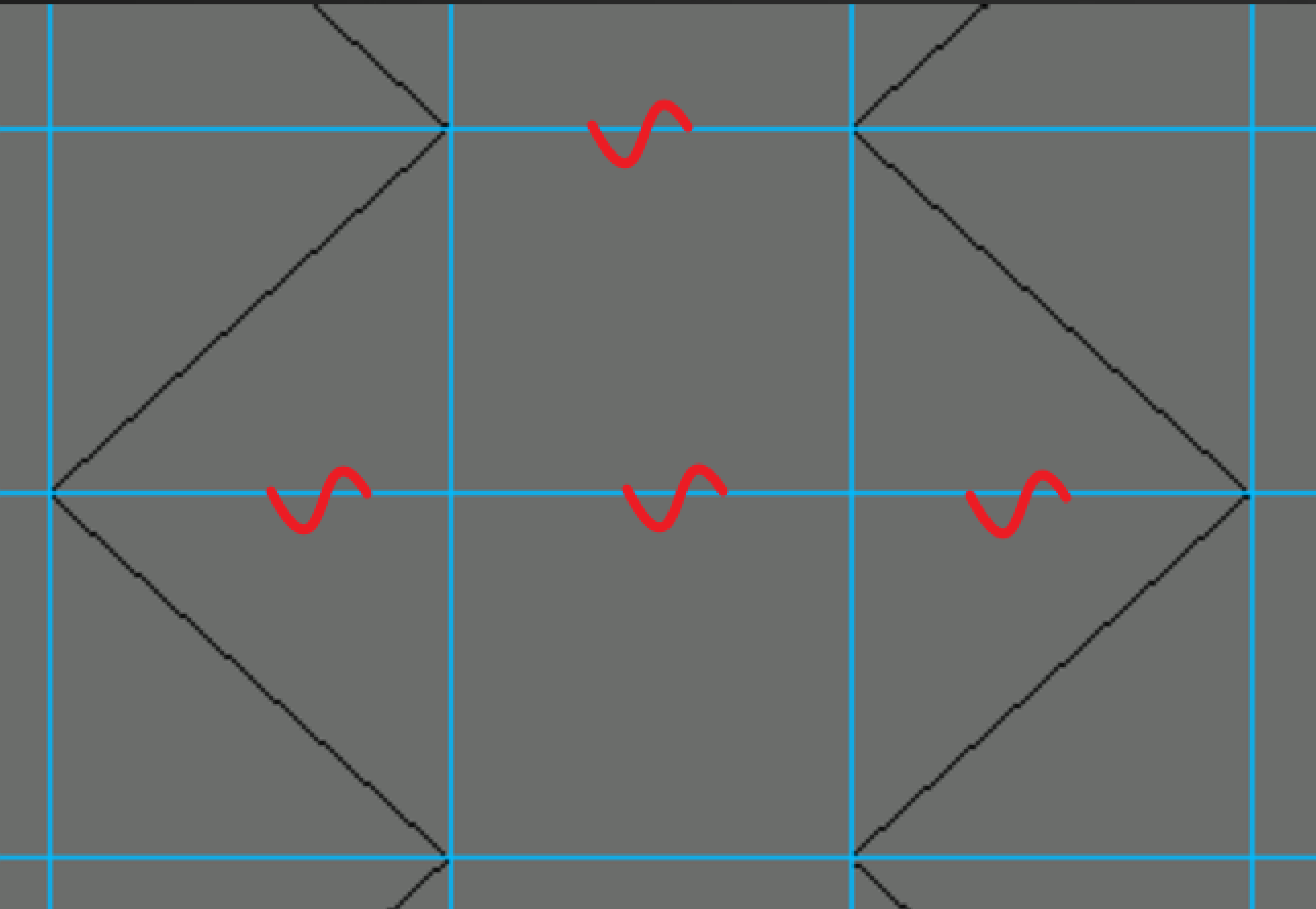
- Dimensional parameters
- Visibility parameters
- Material parameters



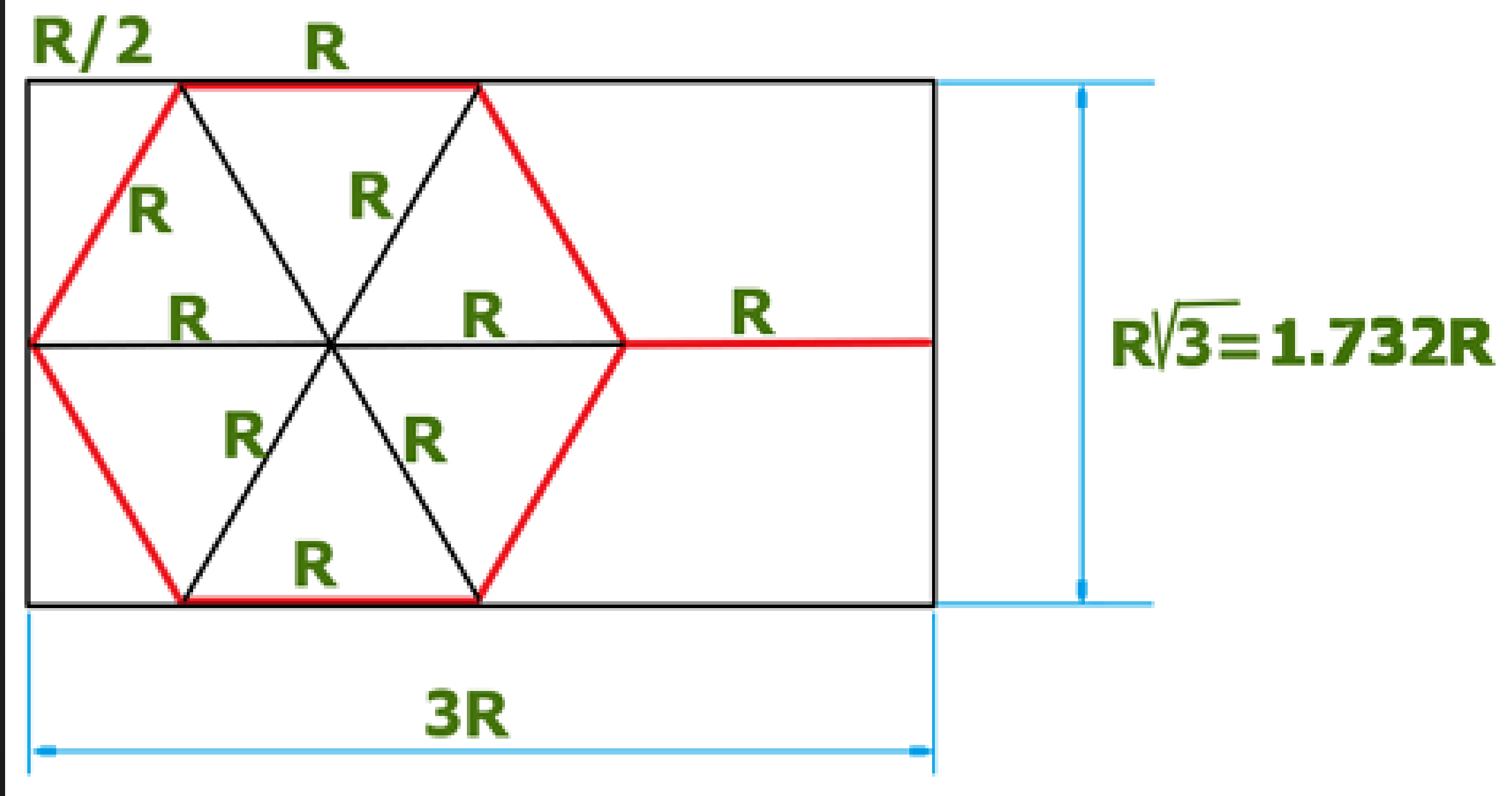




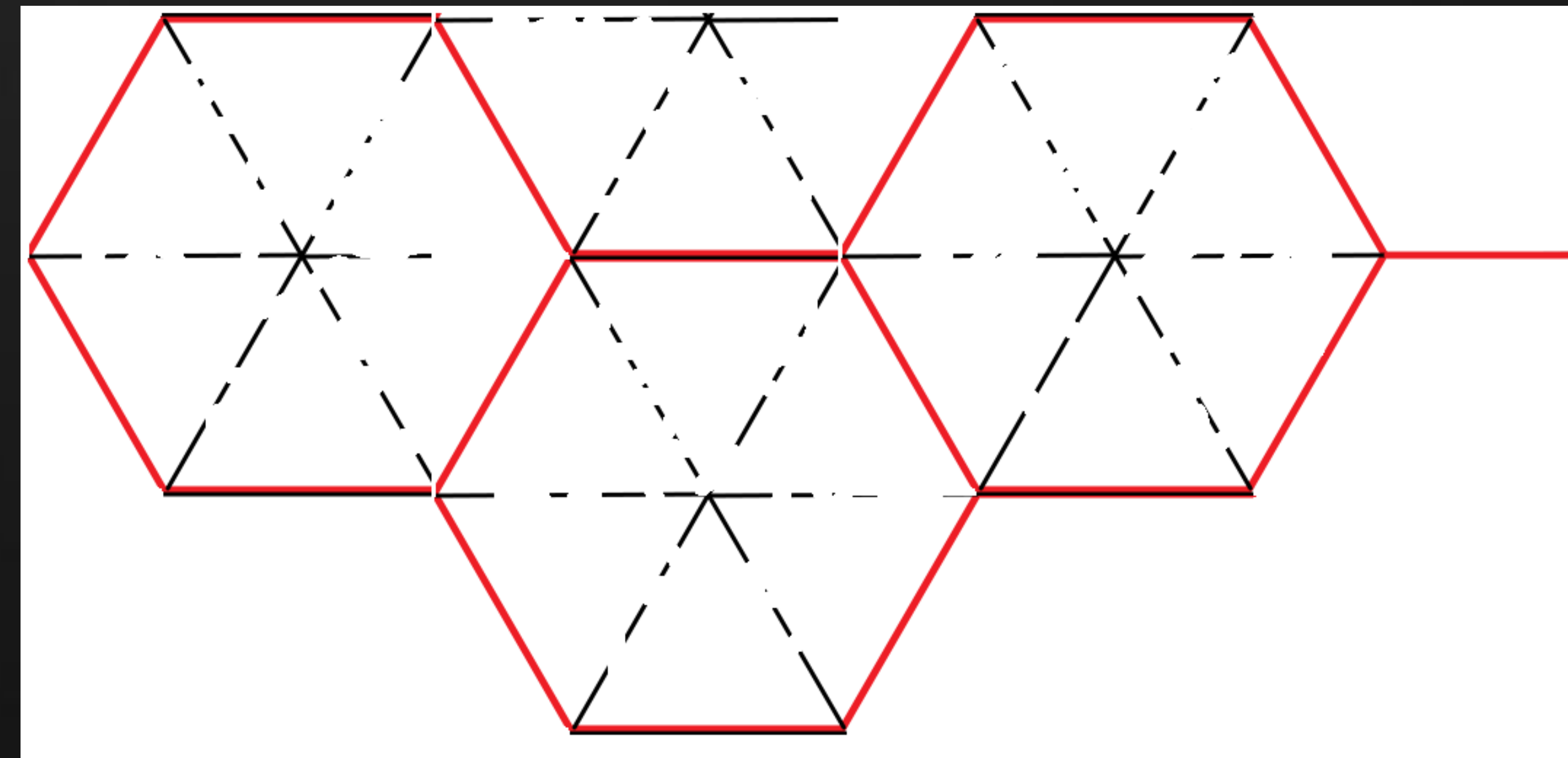








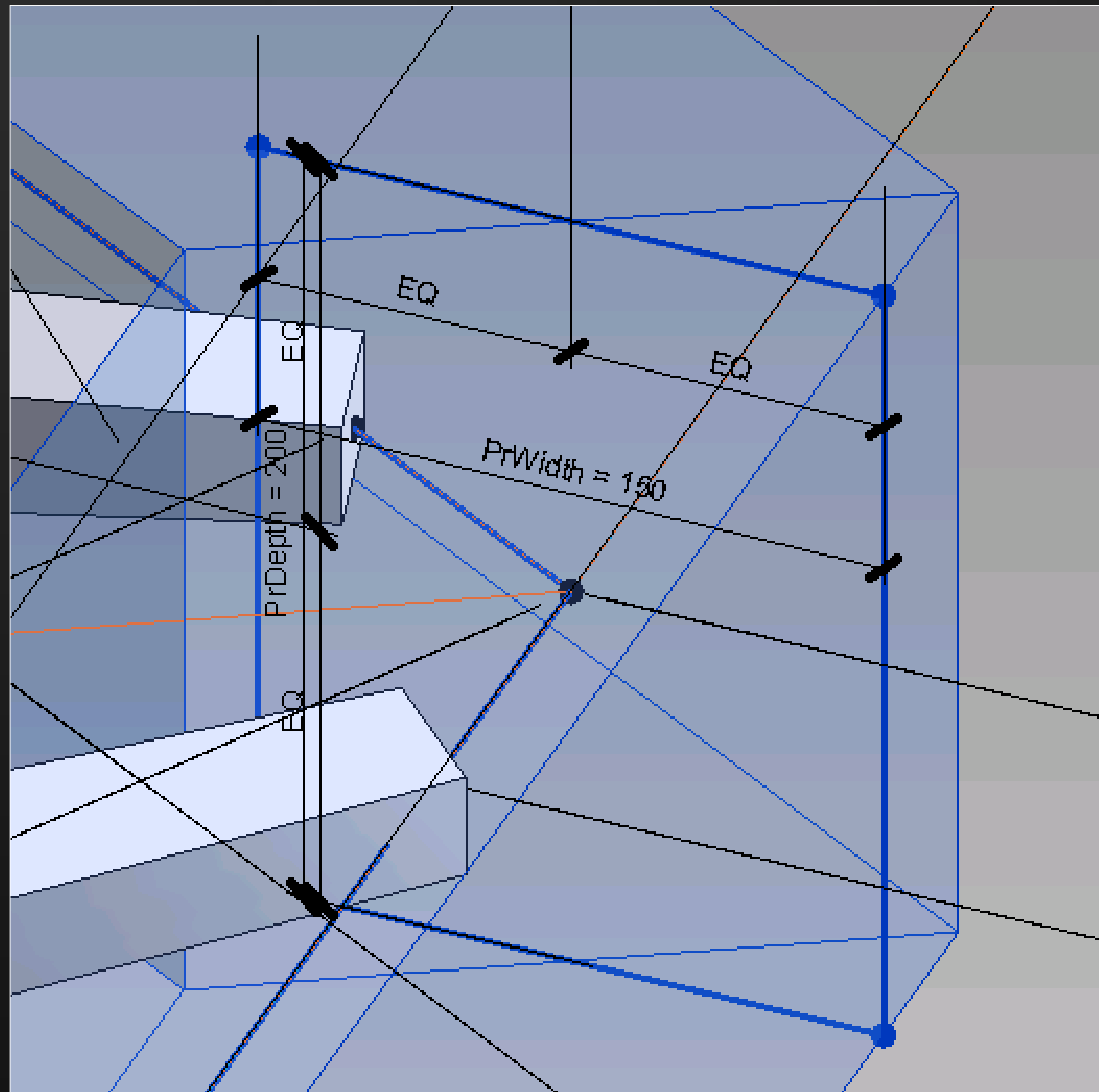
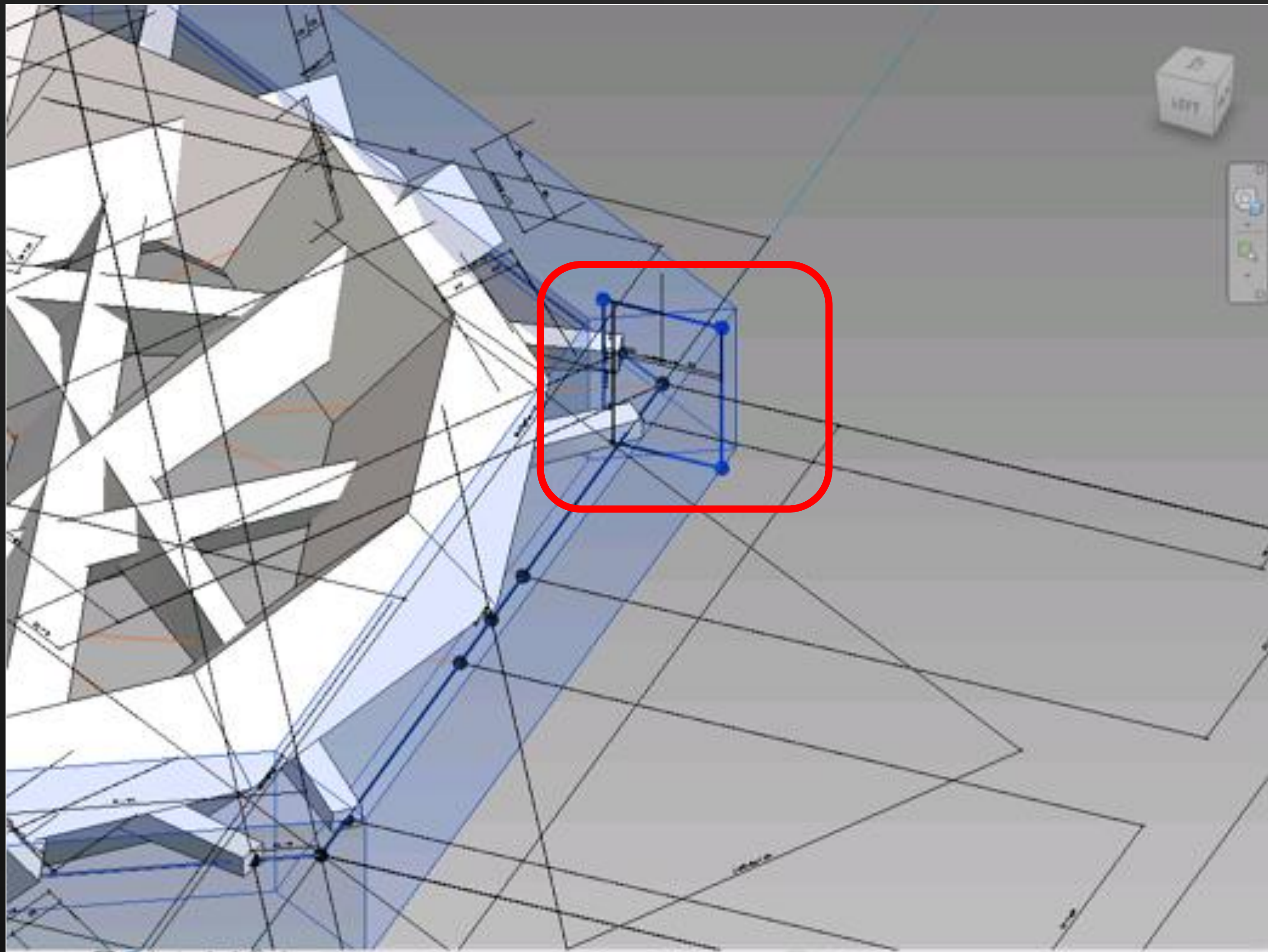
$$H = \frac{W}{\sqrt{3}} \sim W * 0.57735$$









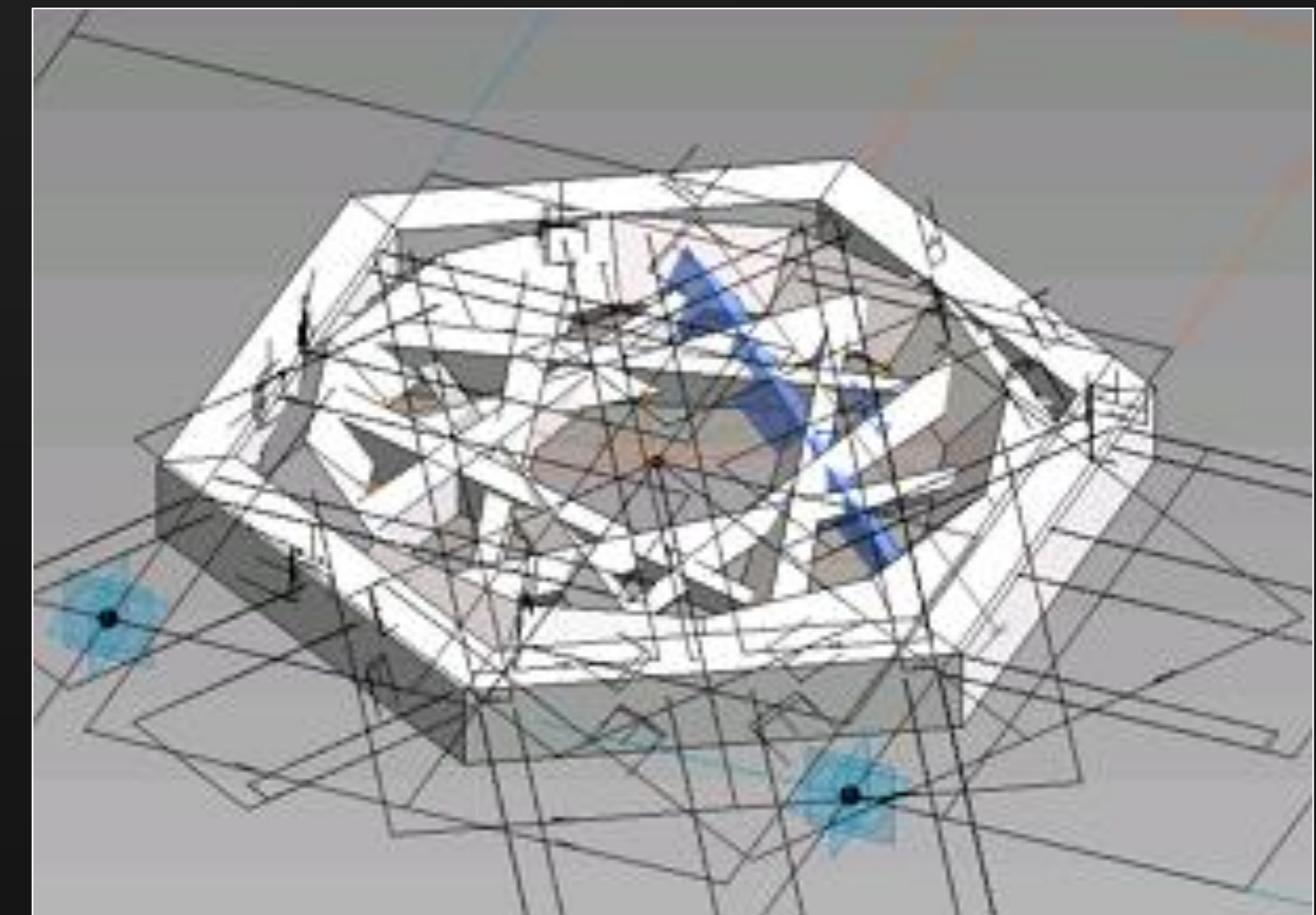
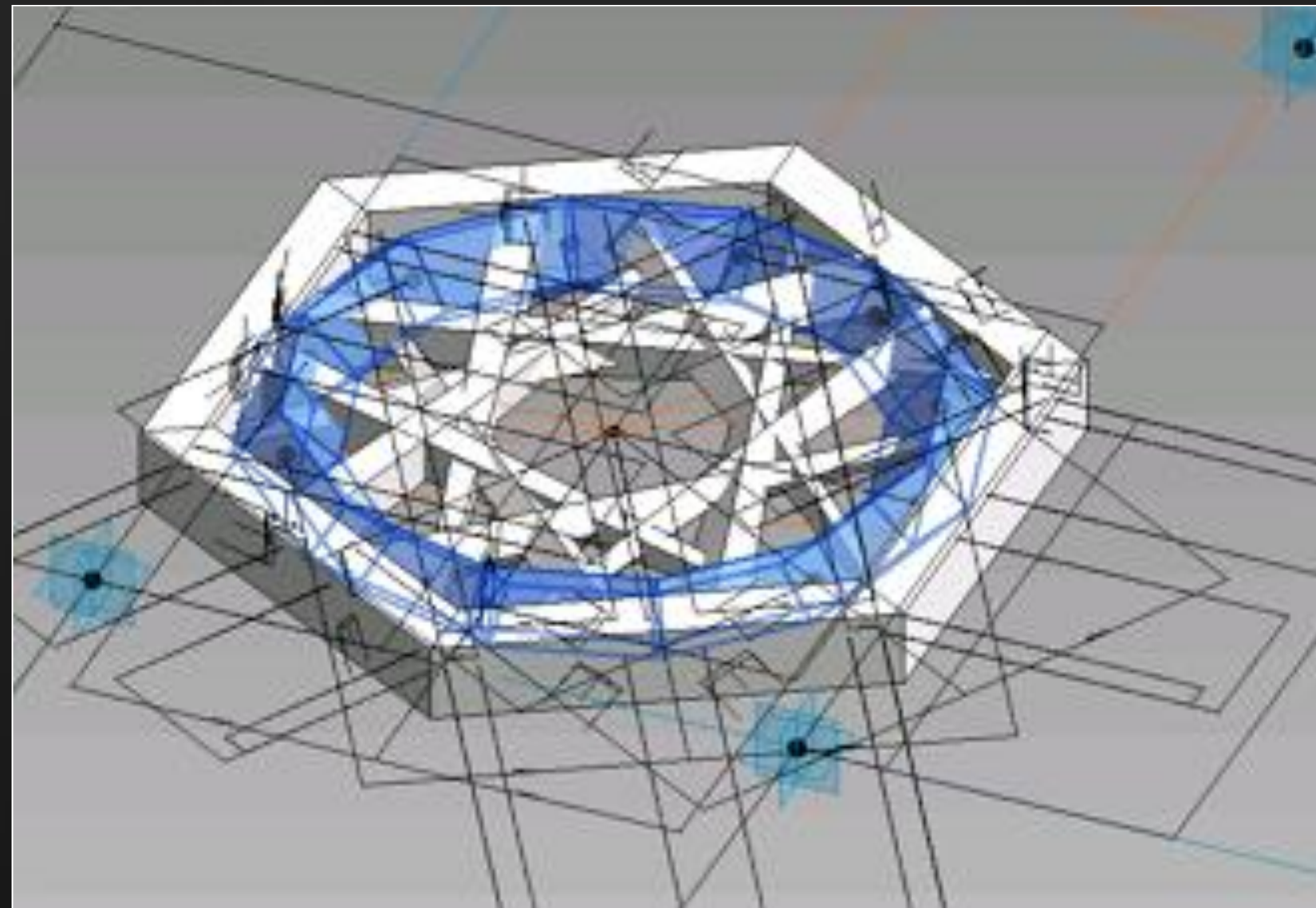
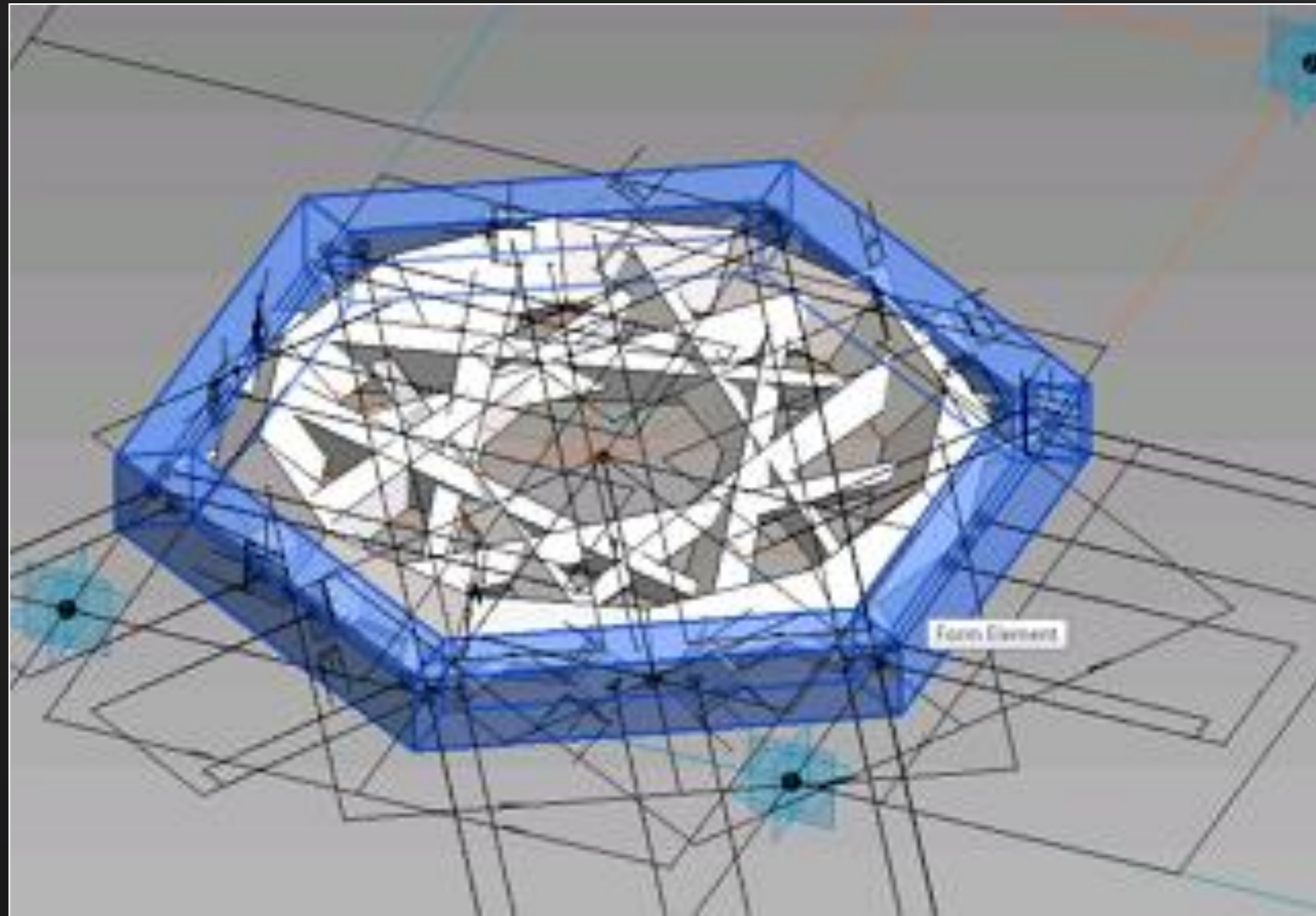




Outer – hexagon (regular when  
 $\text{Height} = \text{Width} / \sqrt{3}$ )

Inner – polygon with 12 sides

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





Family Types

Name:

Parameter	Value	Formula	Lock
<b>Construction</b> ^			
Construction Type		=	
<b>Materials and Finishes</b> ^			
StoneMaterial	05-ST- 3	=	
Finish		=	
<b>Dimensions</b> ^			
v (default)	1799.6	= 2 * R * sin(60°)	<input type="checkbox"/>
u (default)	3117.0	= 3 * R	<input type="checkbox"/>
r/2 (default)	519.5	= R / 2	<input type="checkbox"/>
VGrid (report)	1800.0	=	
UGgrid (report)	3117.0	=	
SmlRadius (default)	779.3	= R * 0.75	<input type="checkbox"/>
Radius-profile	101.6	=	<input type="checkbox"/>
R (default)	1039.0	= UGgrid / 3	<input type="checkbox"/>
PrWidth2	112.5	= PrWidth * 0.75	<input checked="" type="checkbox"/>
PrWidth	150.0	=	<input checked="" type="checkbox"/>
PrDepth2	150.0	= PrDepth * 0.75	<input checked="" type="checkbox"/>
PrDepth	200.0	=	<input checked="" type="checkbox"/>
D2 (default)	79.5	= R / 13.07	<input type="checkbox"/>
D1 (default)	424.1	= R / 2.45	<input type="checkbox"/>
<b>Identity Data</b> v			

Family Types

New...

Rename...

Delete

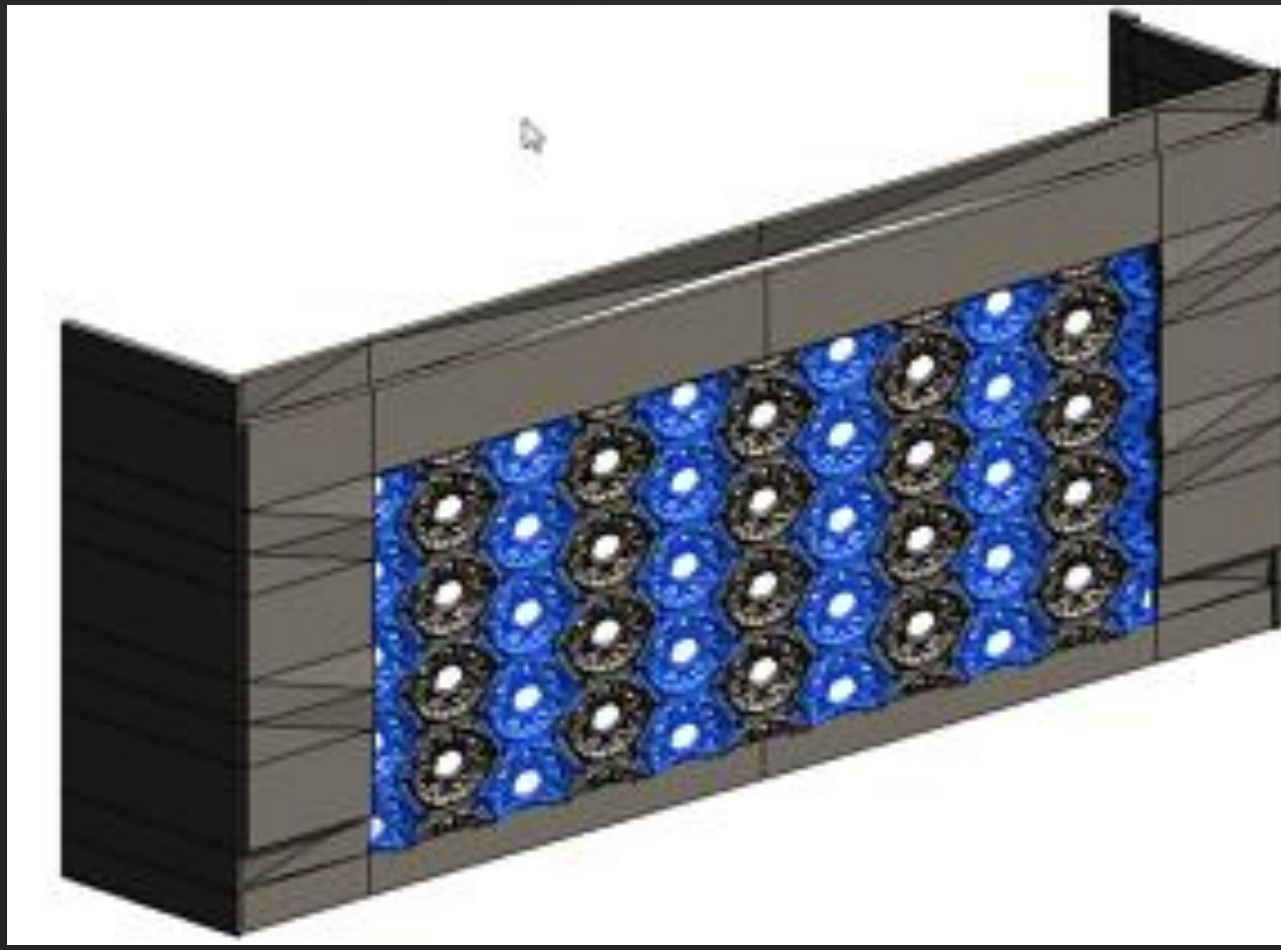
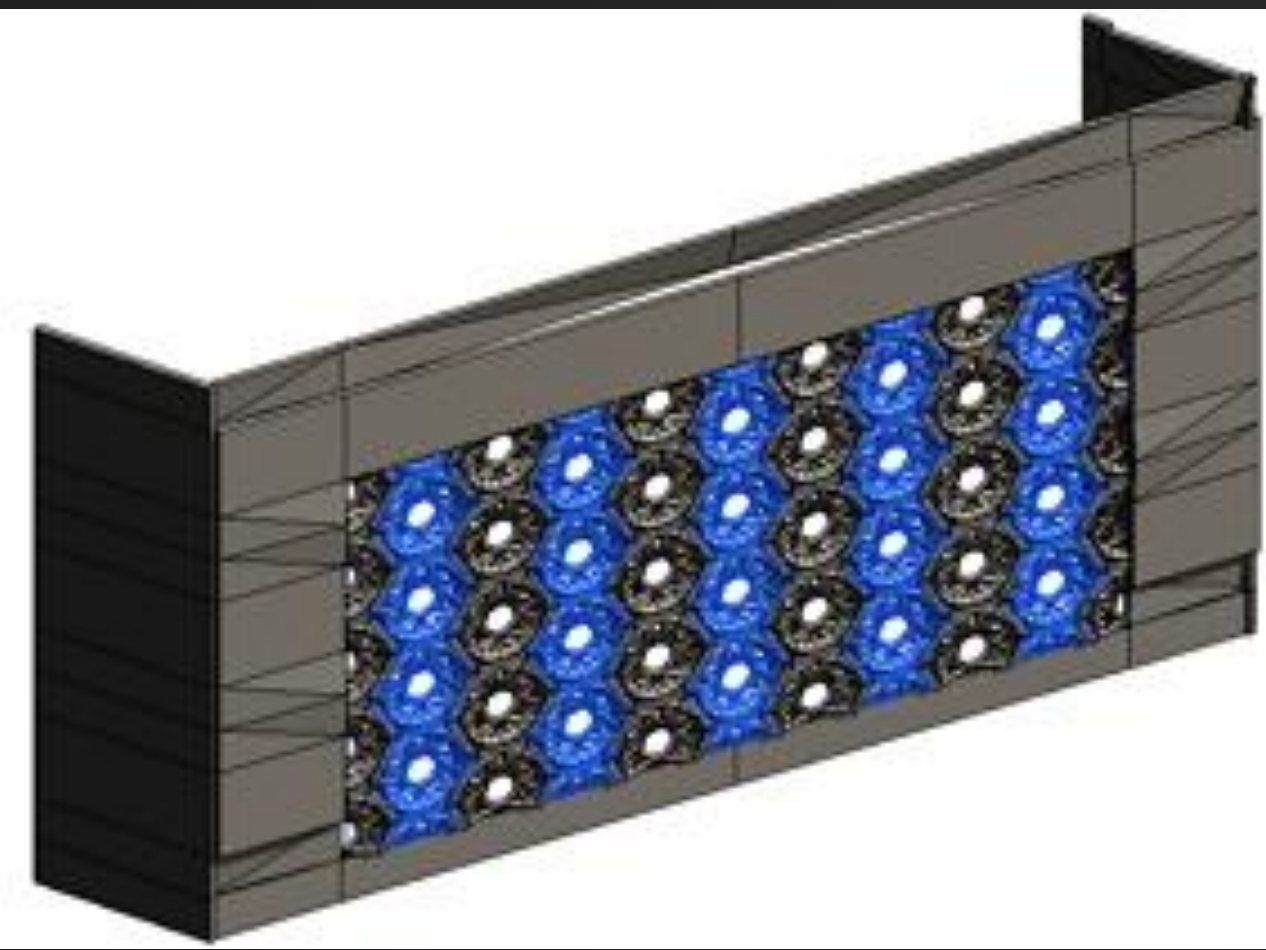
Parameters

Add...

Modify...

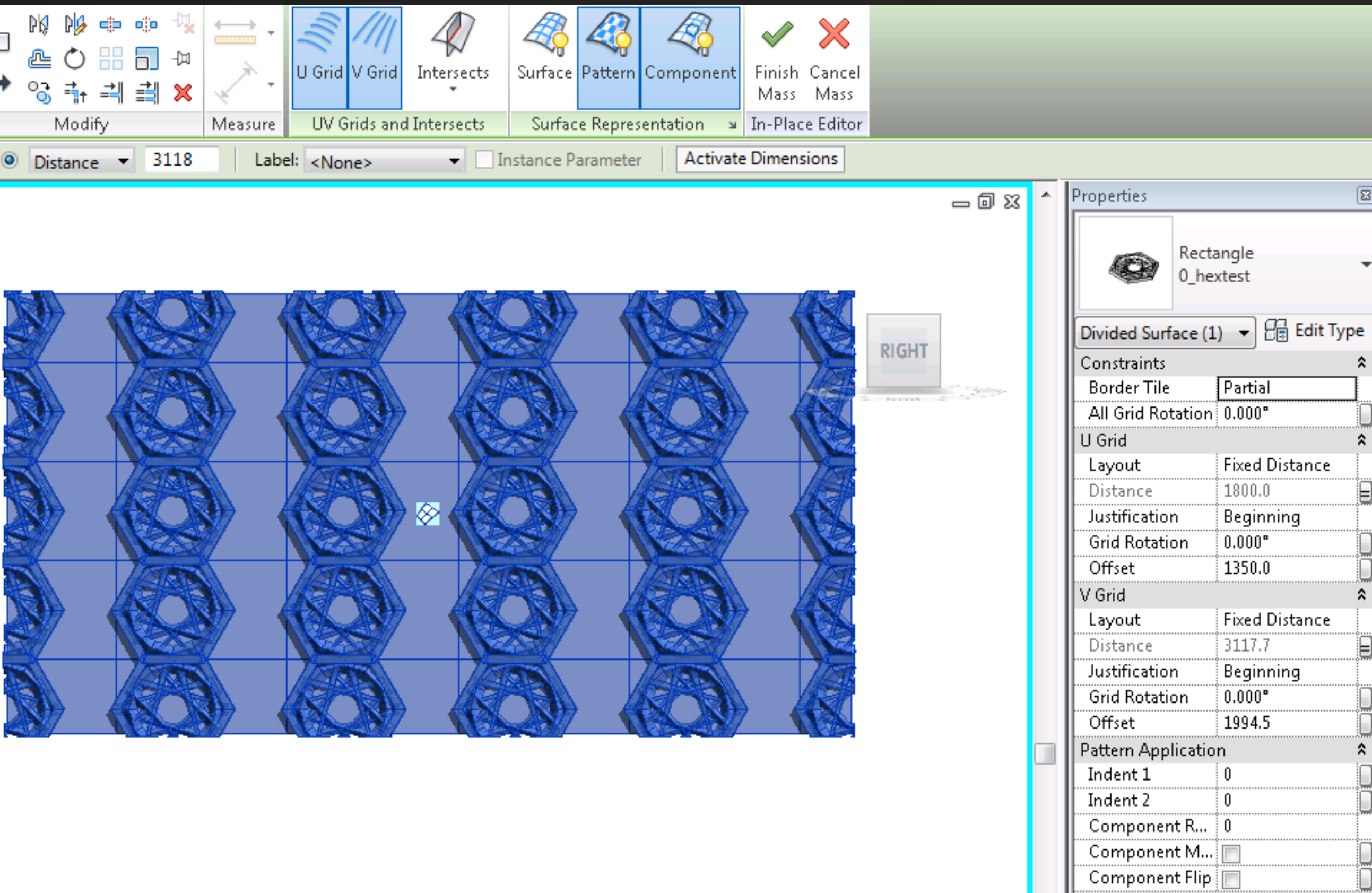
Remove





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

Different offsets- vertical and horizontal shift

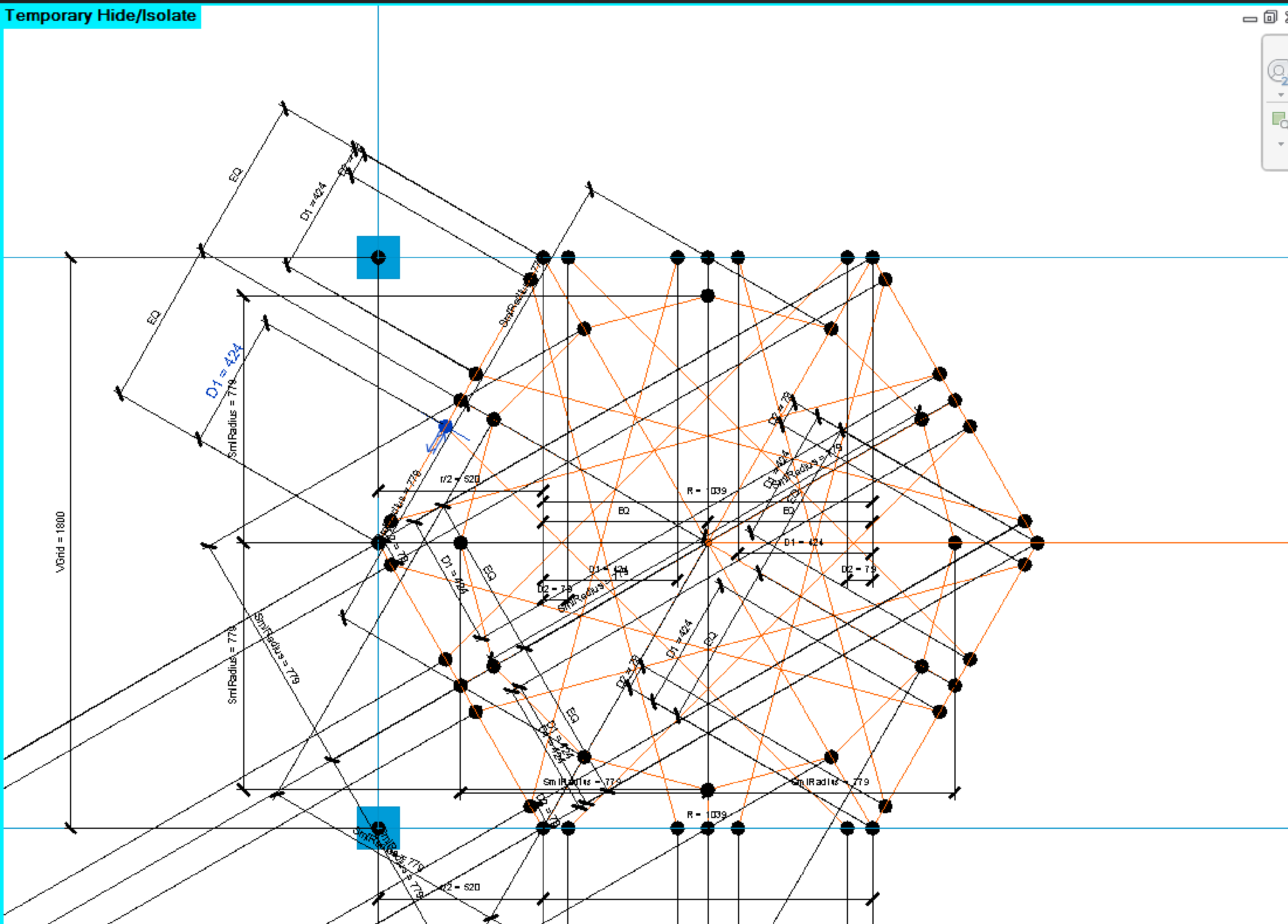


U Grid	
Layout	Fixed Distance
Distance	1800.0
Justification	Beginning
Grid Rotation	0.000°
Offset	1350.0
V Grid	
Layout	Fixed Distance
Distance	3117.7
Justification	Beginning
Grid Rotation	0.000°
Offset	1994.5



# Round 2: All is Relative

Temporary Hide/Isolate



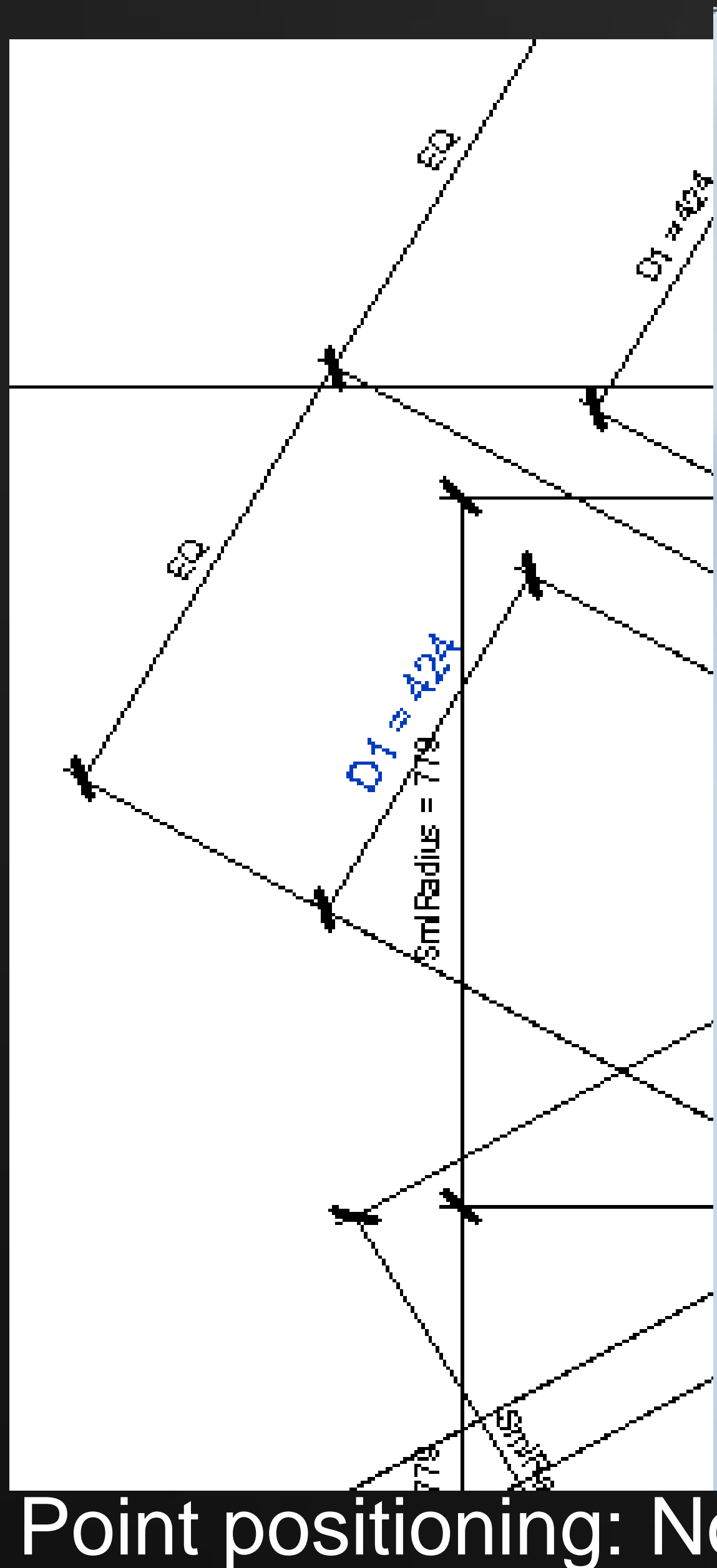
Family Types

Name:

Parameter	Value	Formula	Lock
<b>Construction</b>			
Construction Type	<input type="text"/>	=	
<b>Materials and Finishes</b>			
StoneMaterial	05-ST-3	=	
Finish		=	
<b>Dimensions</b>			
v (default)	1799.6	$= 2 * R * \sin(60^\circ)$	<input type="checkbox"/>
u (default)	3117.0	$= 3 * R$	<input type="checkbox"/>
r/2 (default)	519.5	$= R / 2$	<input type="checkbox"/>
VGrid (report)	1800.0	=	
UGgrid (report)	3117.0	=	
SmIRadius (default)	779.3	$= R * 0.75$	<input type="checkbox"/>
Radius-profile	101.6	=	<input type="checkbox"/>
R (default)	1039.0	$= UGgrid / 3$	<input type="checkbox"/>
PrWidth2	112.5	$= PrWidth * 0.75$	<input checked="" type="checkbox"/>
PrWidth	150.0	=	<input checked="" type="checkbox"/>
PrDepth2	150.0	$= PrDepth * 0.75$	<input checked="" type="checkbox"/>
PrDepth	200.0	=	<input checked="" type="checkbox"/>
D2 (default)	79.5	$= R / 13.07$	<input type="checkbox"/>
D1 (default)	424.1	$= R / 2.45$	<input type="checkbox"/>
<b>Analytical Properties</b>			
Analytic Construc		=	
Visual Light Trans		=	
Solar Heat Gain C		=	
Thermal Resistan		=	
Heat Transfer Coe		=	

OK Cancel Apply Help





Technical drawing showing a circular segment with dimensions: EQ, D1 = 424, Sm Radius = 779, and 513.5.

Family Types

Name:

Parameter	Value	Formula	Lock
<b>Construction</b>			
Construction Type	=		
<b>Materials and Finishes</b>			
StoneMaterial	05-ST- 3	=	
Finish	=		
<b>Dimensions</b>			
v (default)	1799.6	= 2 * R * sin(60°)	<input type="checkbox"/>
u (default)	3117.0	= 3 * R	<input type="checkbox"/>
r/2 (default)	519.5	= R / 2	<input type="checkbox"/>
VG			
UG			
Sm			
Rac			
R (c			
PrV			
PrV			
PrD			
PrDepth	200.0	=	<input checked="" type="checkbox"/>
D2 (default)	79.5	= R / 13.07	<input type="checkbox"/>
D1 (default)	424.1	= R / 2.45	<input type="checkbox"/>
<b>Analytical Properties</b>			
<b>Other</b>			
d2-norm	0.000000	=	
d1-norm (default)	0.408163	=	

OK Cancel Apply Help

Revit

Delete family parameter 'D1'?

Yes No

Family Types

New... Rename... Delete

Parameters

Add... Modify... Remove

ints (1)

Edit Type

	<input type="checkbox"/>	
	<input type="checkbox"/>	
gle	0.000°	
ence Planes	When Selected	
aphics Over...	Edit...	
al Referenc...	<input checked="" type="checkbox"/>	
	<input type="checkbox"/>	
re(s)	<input checked="" type="checkbox"/>	
ost	<input checked="" type="checkbox"/>	
nt Type	Normalized Segment...	
Segment L...	0.408095	
m	Beginning	
nponent		
	Reference Point	

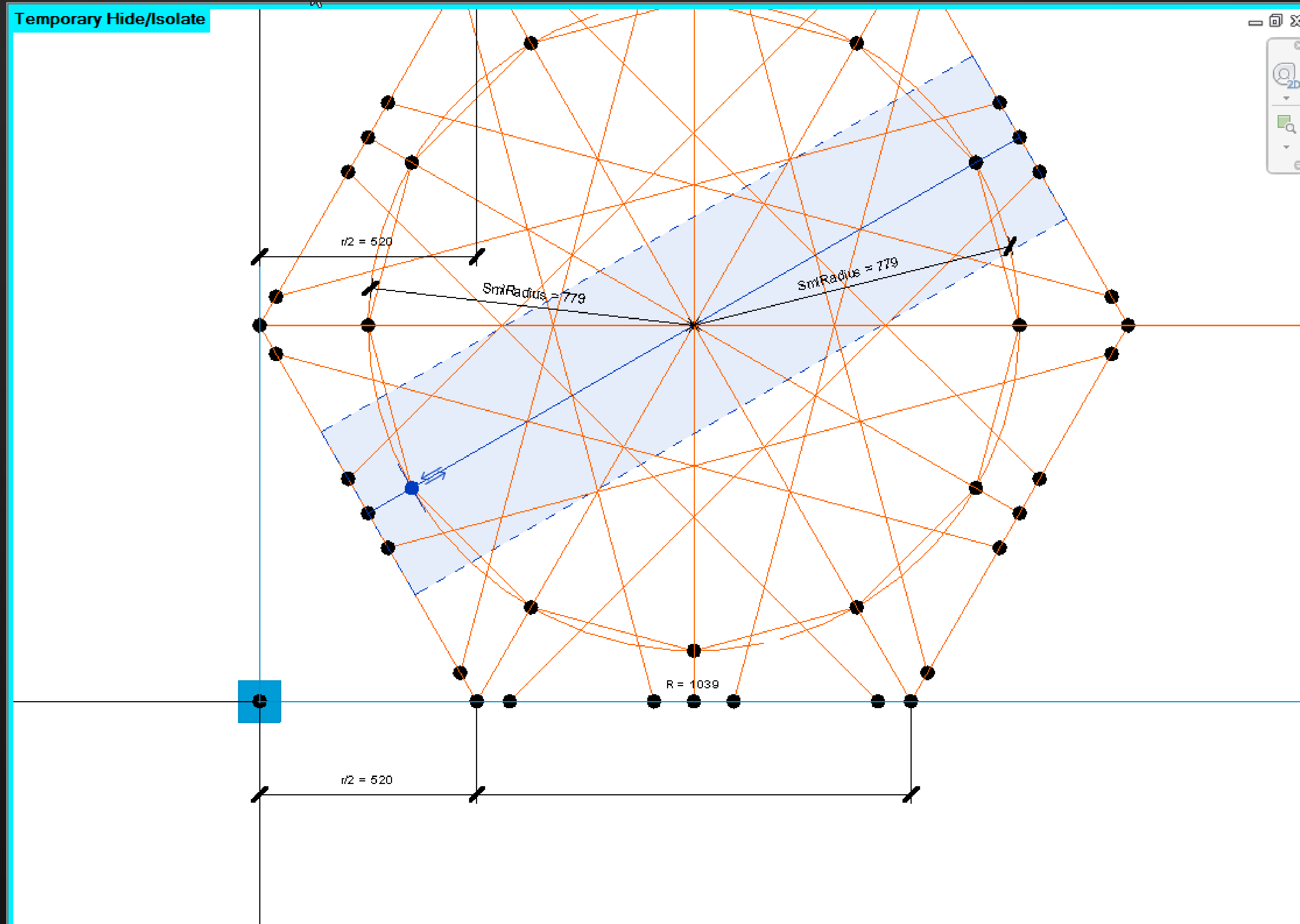
Name

0 < d1 < 1

Point positioning: Normalized segment or curve



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

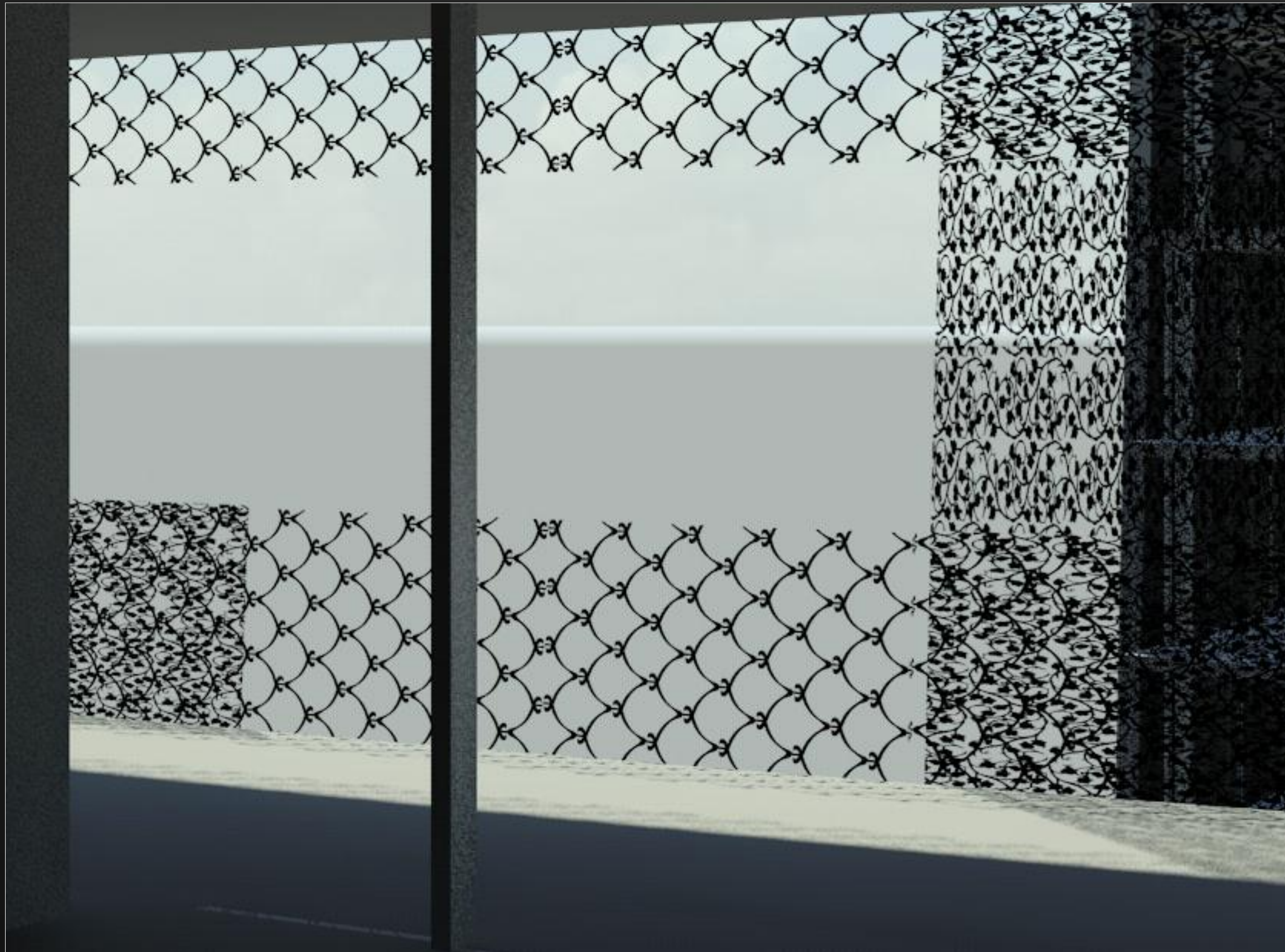




# Material Matters



# Materials with cutouts



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



# Materials with cutouts



**Shaded View**  
**Realistic View**  
**Raytrace**  
**within Revit**



# Live Demo Frit Glass Panel

Family Types

Name: FrittPattern1

Parameter	Value	Formula	Lock
<b>Construction</b>			
SealantOn	<input checked="" type="checkbox"/>	=	
Construction Type		=	
<b>Materials and Finishes</b>			
Sealant	<By Category>	=	
Glass	07-GL-06	=	
Fritt Pattern	07-GL-05	=	
FrittTransparency	07-GL-06	=	
Finish		=	
<b>Dimensions</b>			
MullionThickness	0' 0 1/4"	=	<input type="checkbox"/>
GlassOffset	0' 0"	=	<input type="checkbox"/>
Glass Depth	0' 1"	=	<input type="checkbox"/>
Fritt Offset	0' 0 1/4"	=	<input type="checkbox"/>
Fritt Location	0' 0 1/4"	=	<input type="checkbox"/>
<b>Analytical Properties</b>			
Analytic Construct	<None>	=	
Visual Light Trans		=	
Solar Heat Gain Co		=	
Thermal Resistanc		=	
Heat Transfer Coef		=	
<b>Identity Data</b>			

Family Types

New...

Rename...

Delete

Parameters

Add...

Modify...

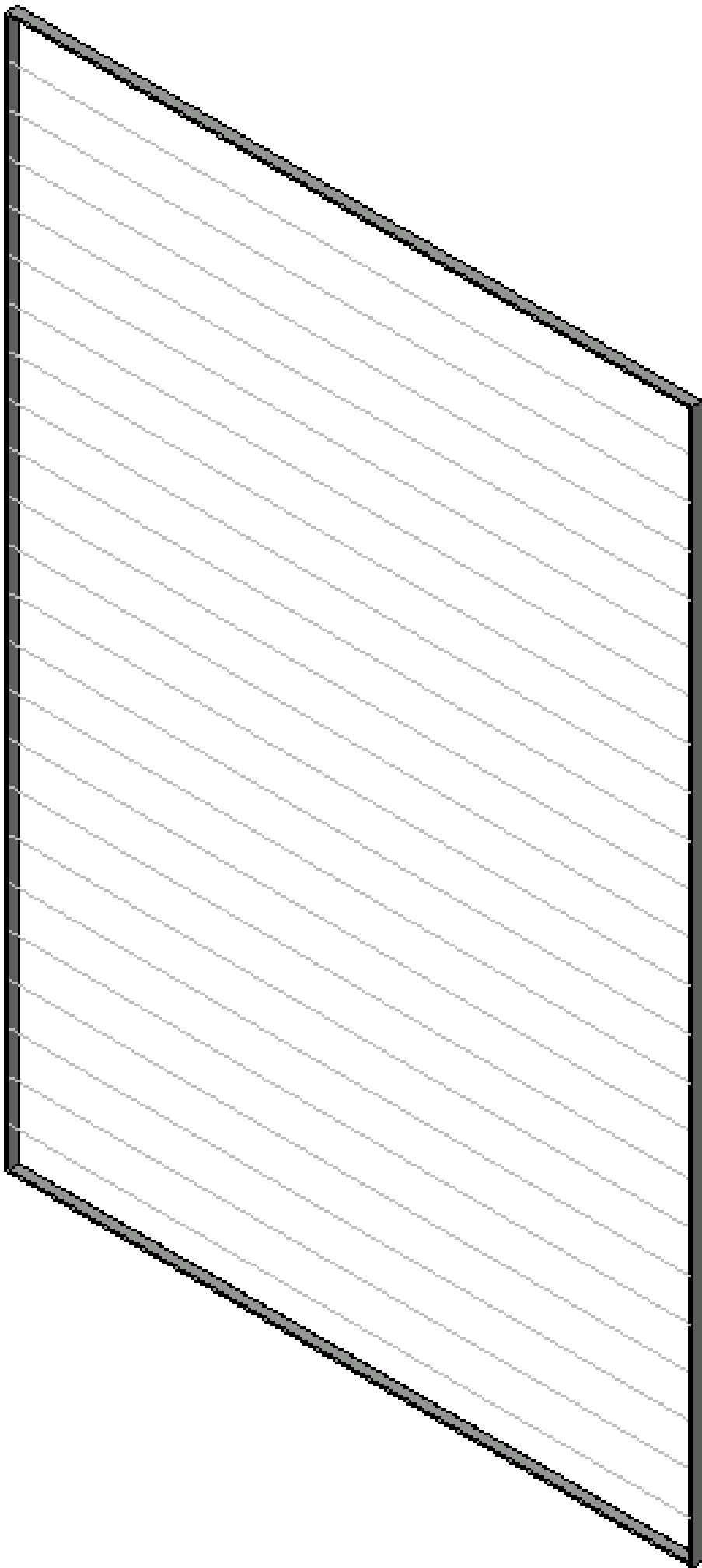
Remove

OK

Cancel

Apply

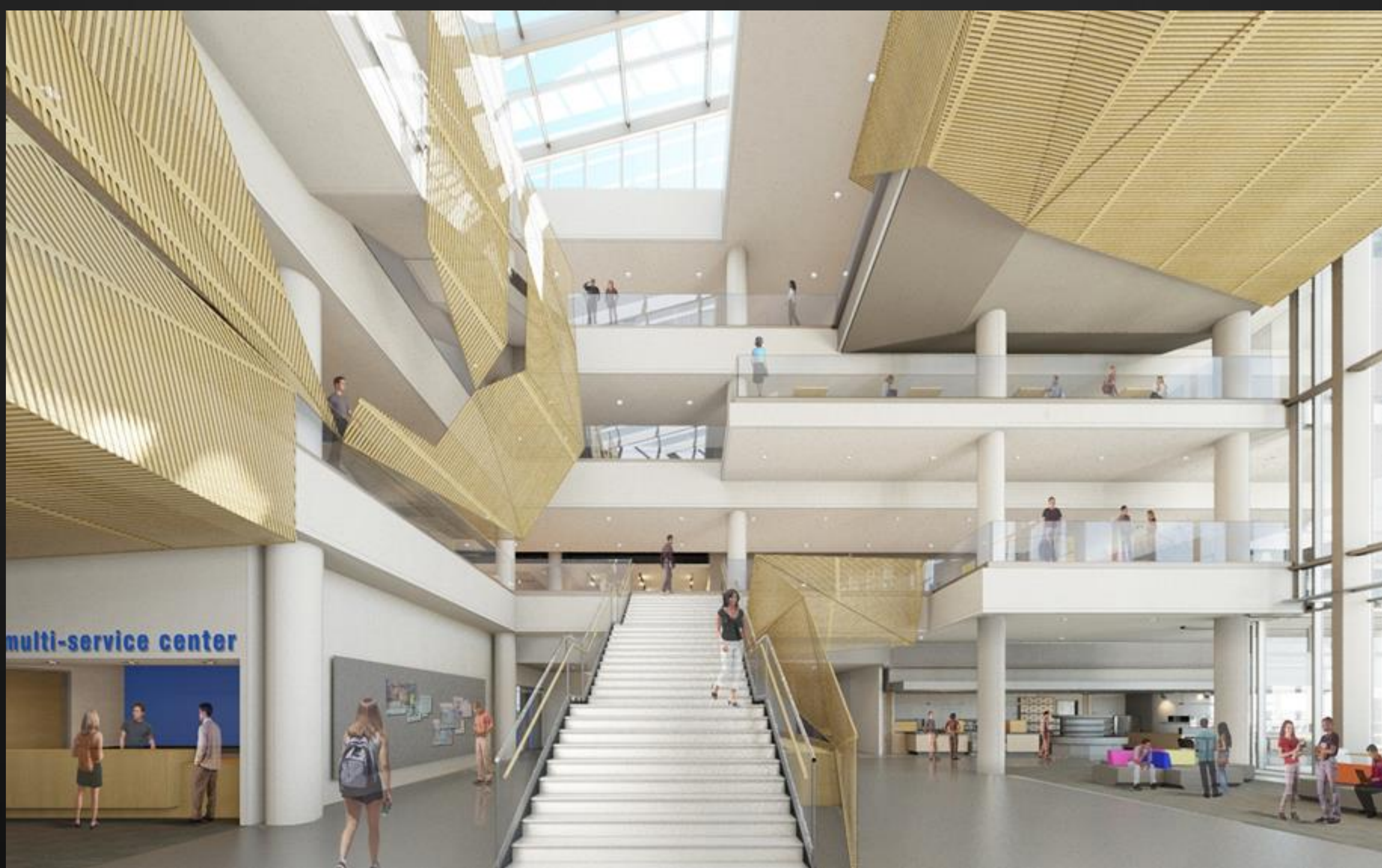
Help





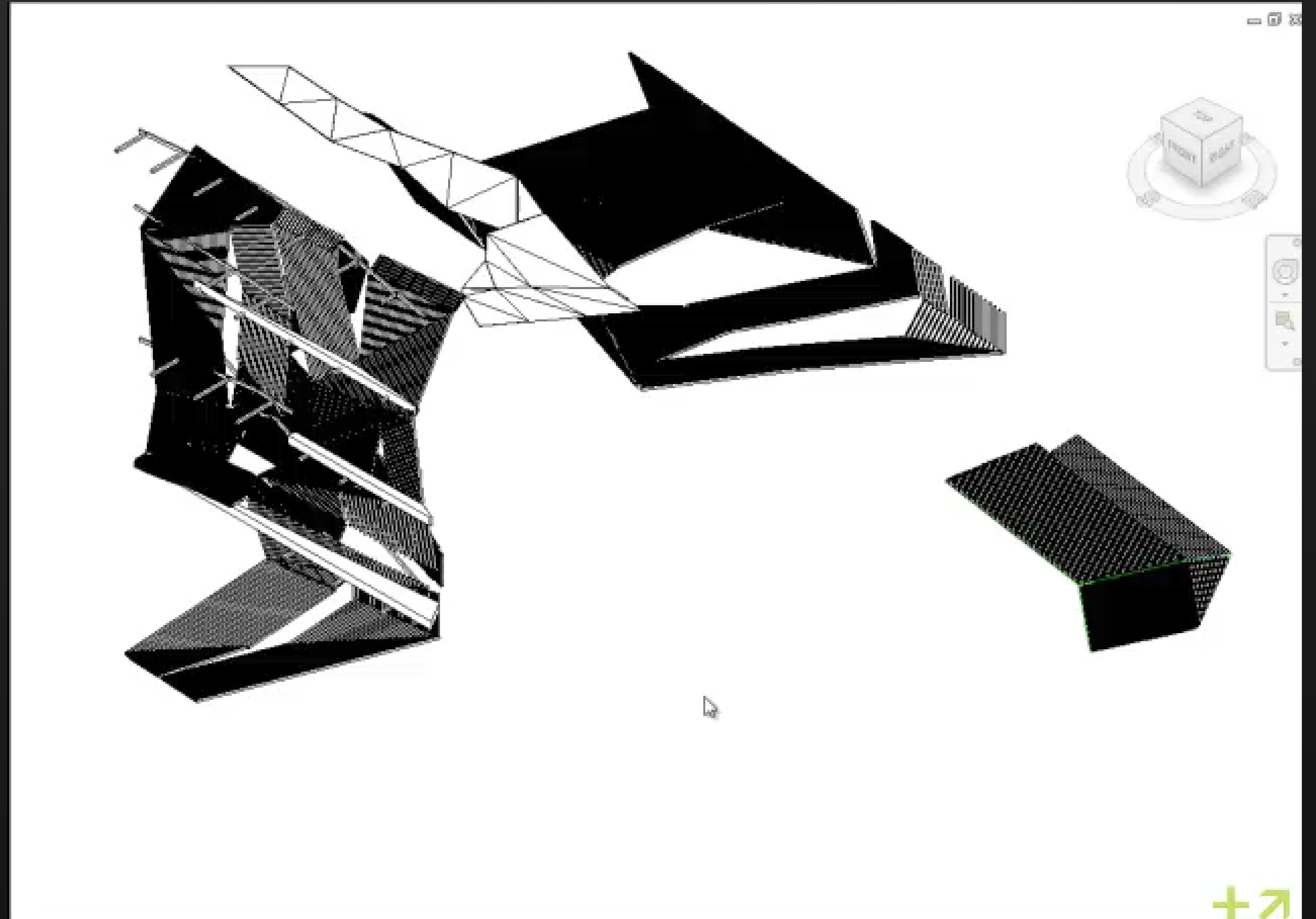
# Magic Lantern







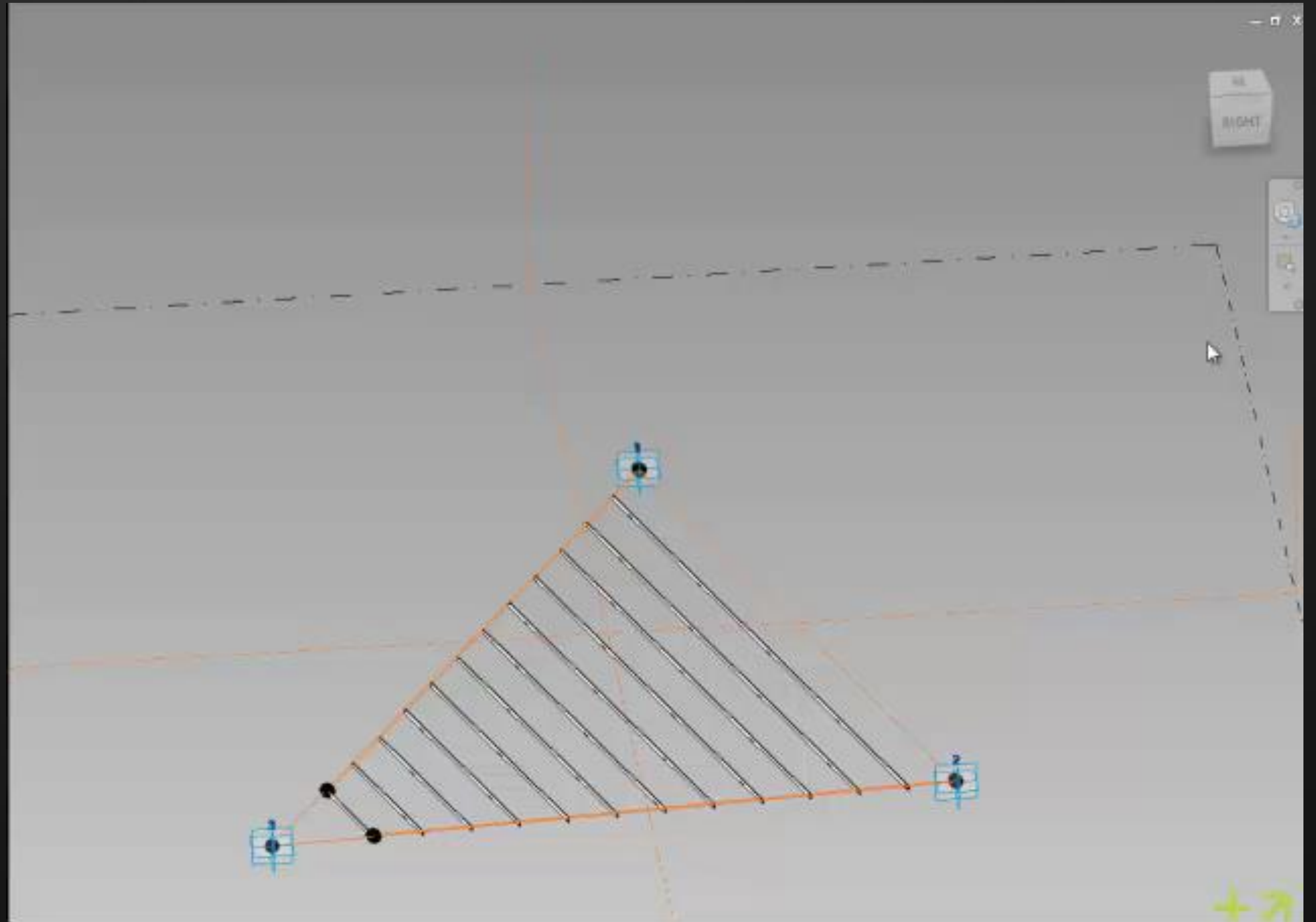
# Initial Approach. v2012





Initial Approach. v2012

3 point Adaptive component  
with divided surface



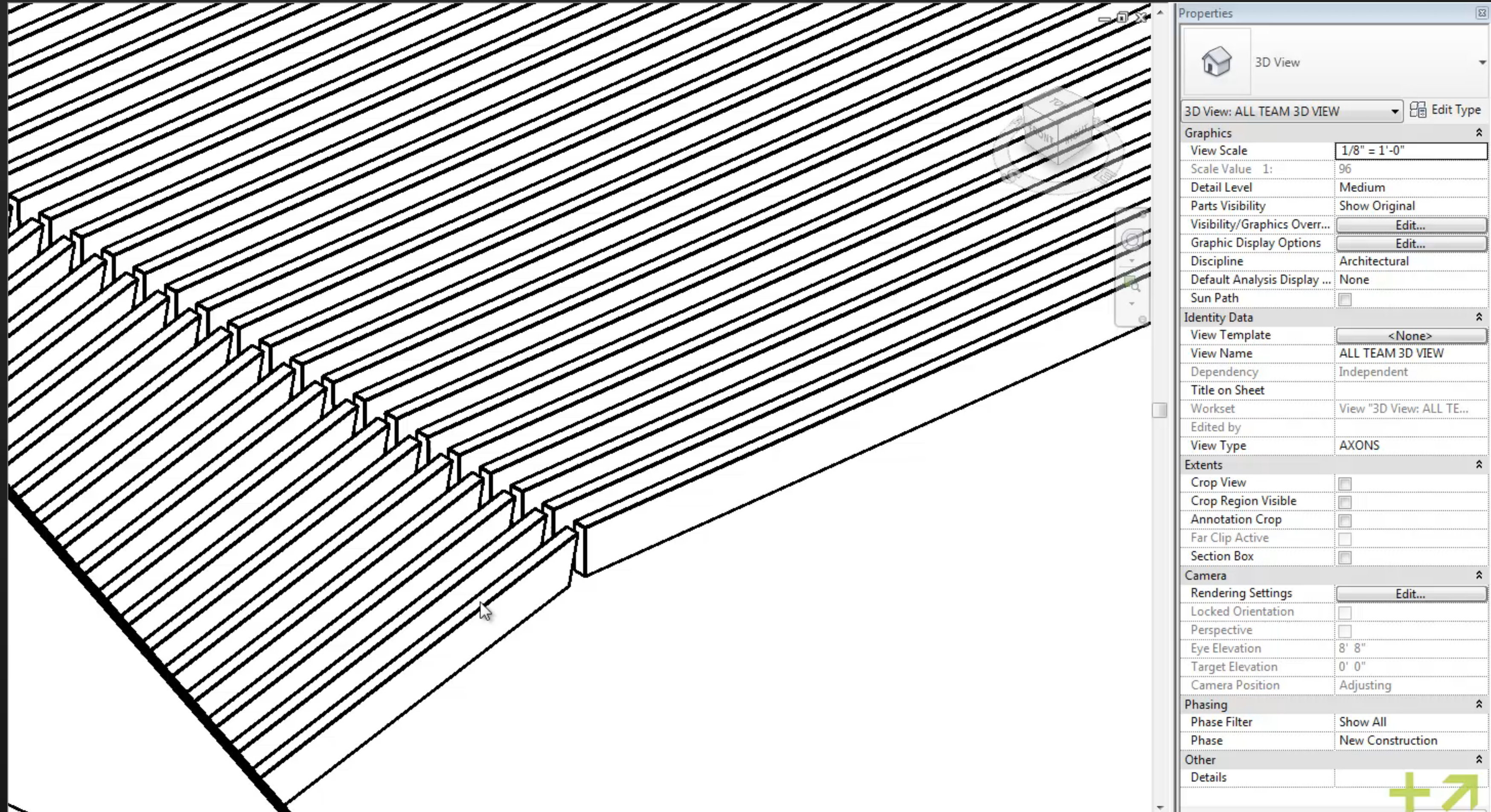


# Refinement. v2013

## Swap family

## 3 point Adaptive component

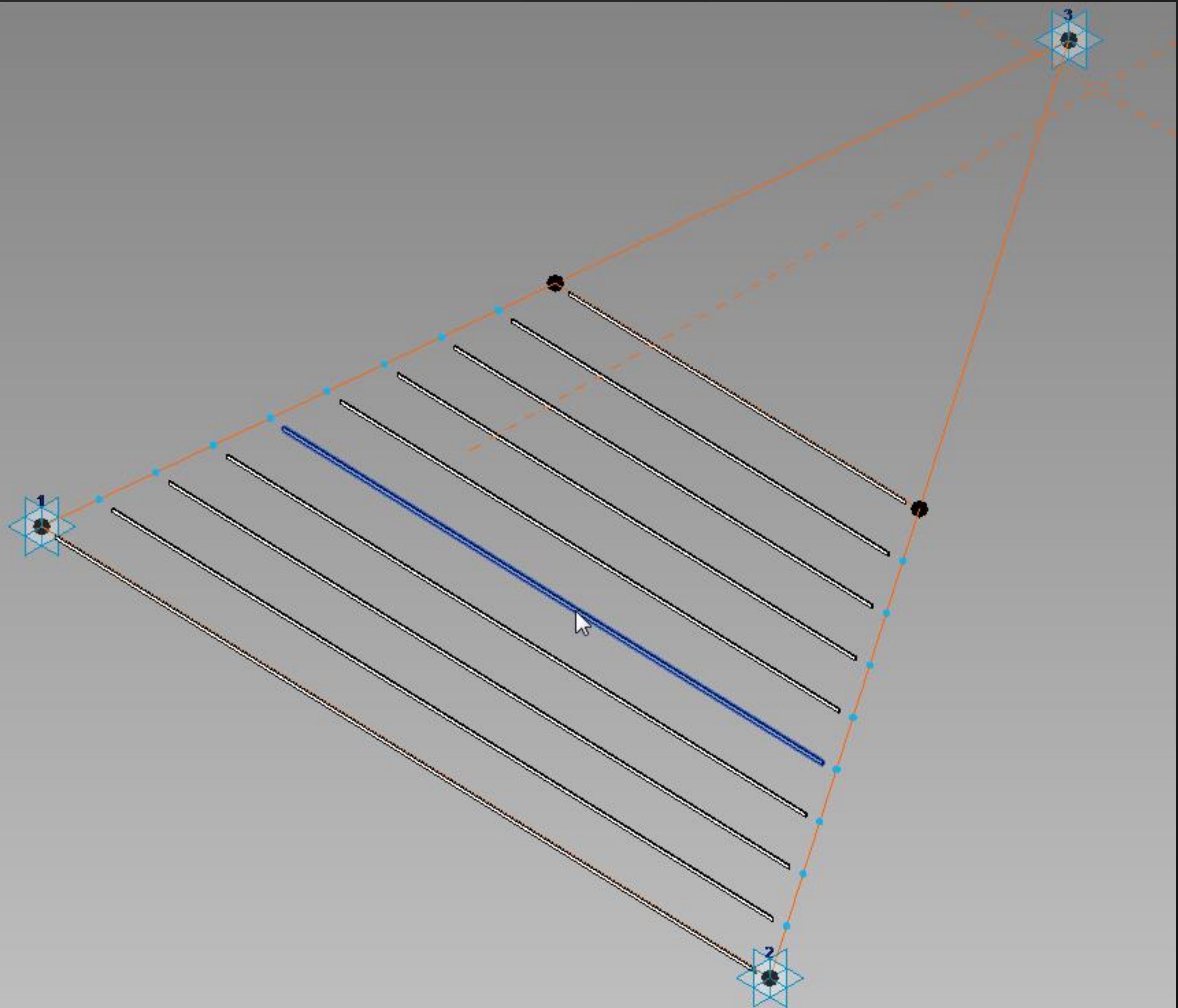
## Divided paths hosting nested adaptive component





3 point Adaptive  
component

Divided paths hosting  
repeated adaptive  
component

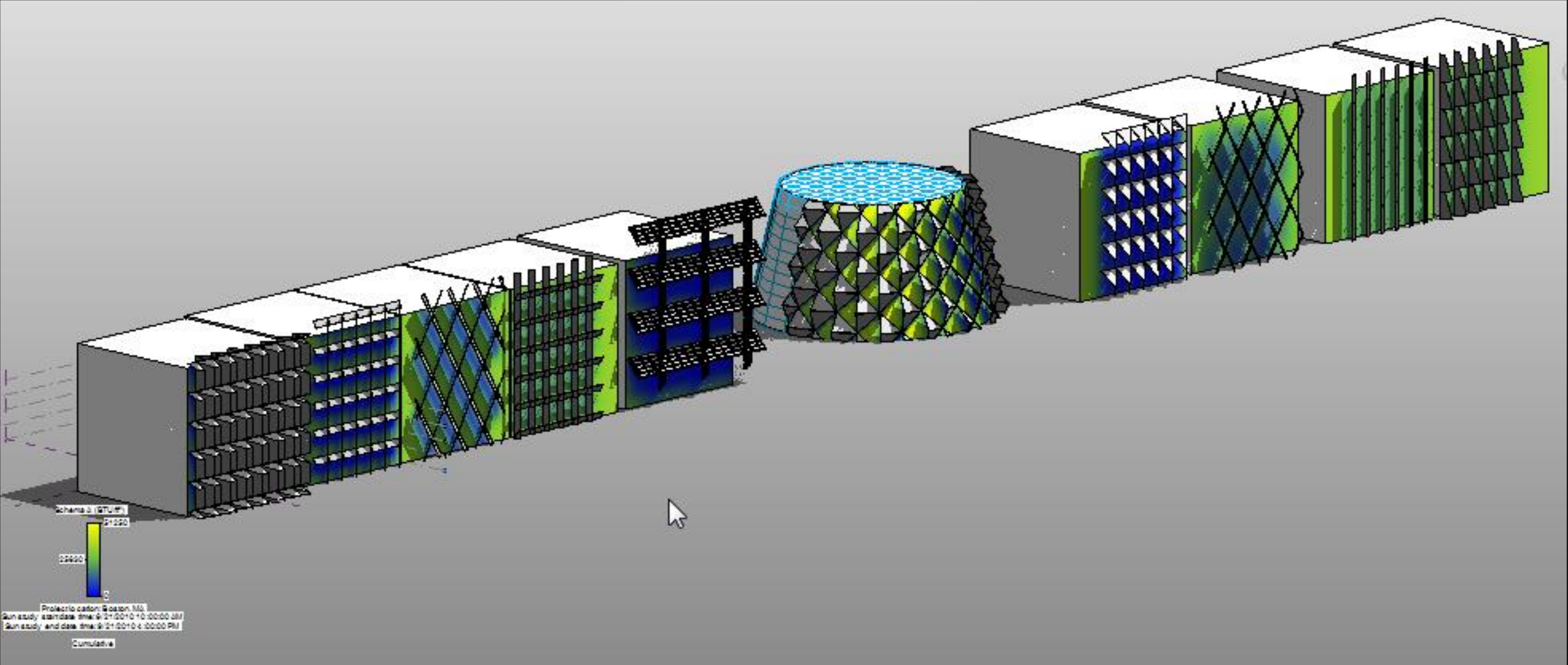




# Solar radiation – Rapid design iterations

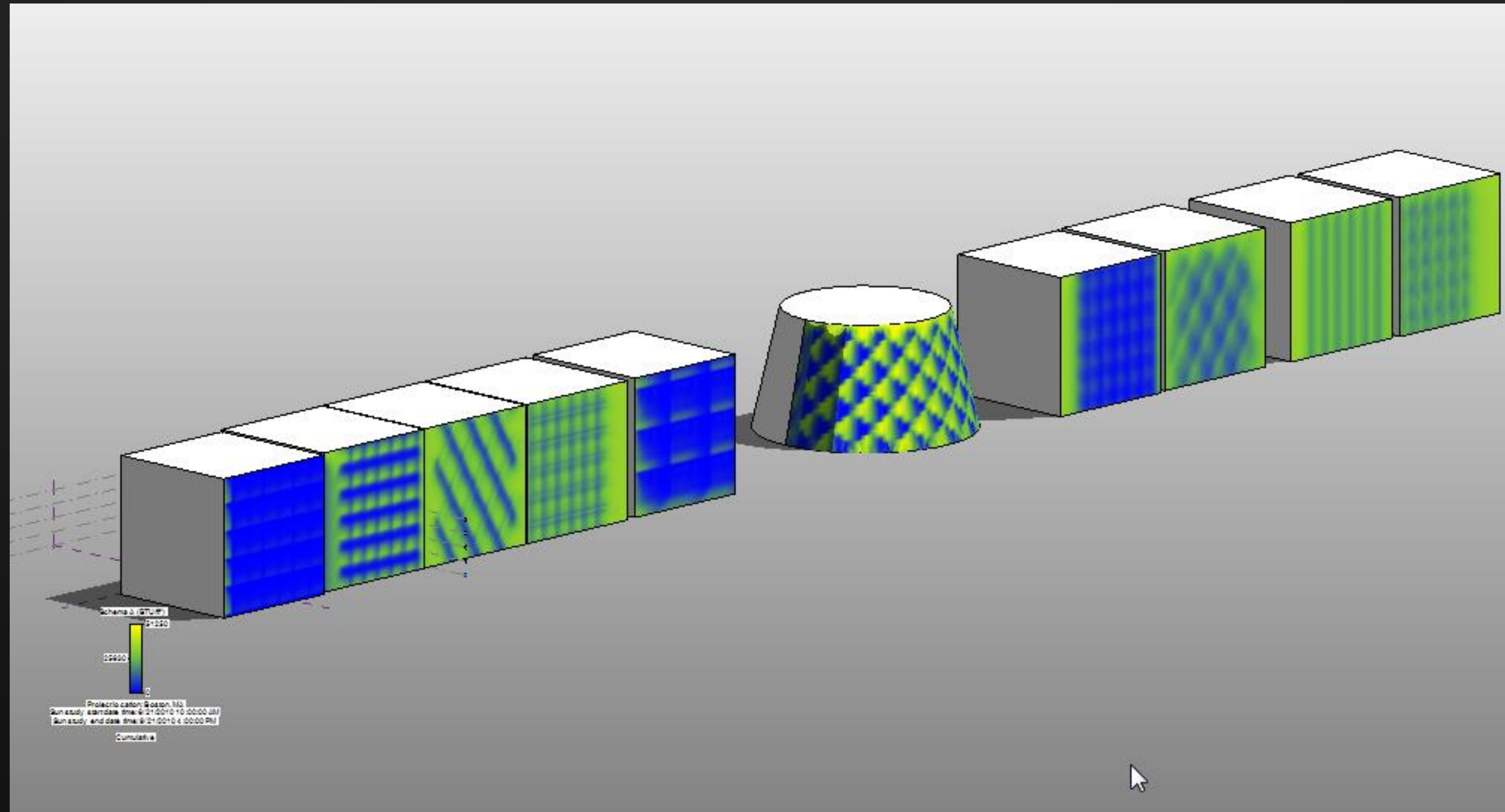


# Pre-built parametric families. Rapid design iterations



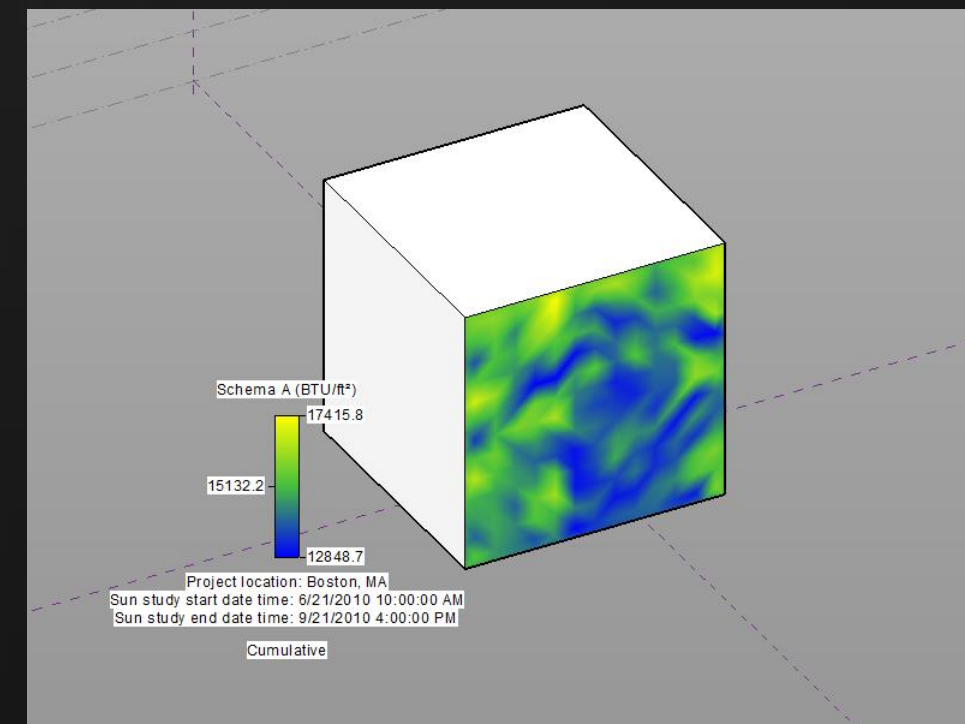
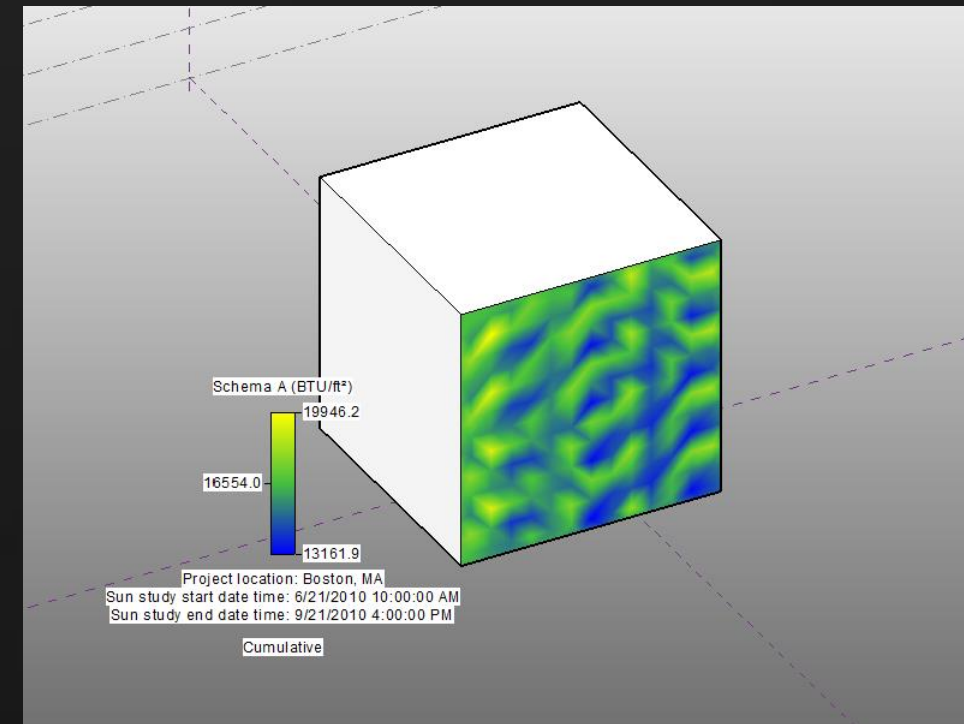
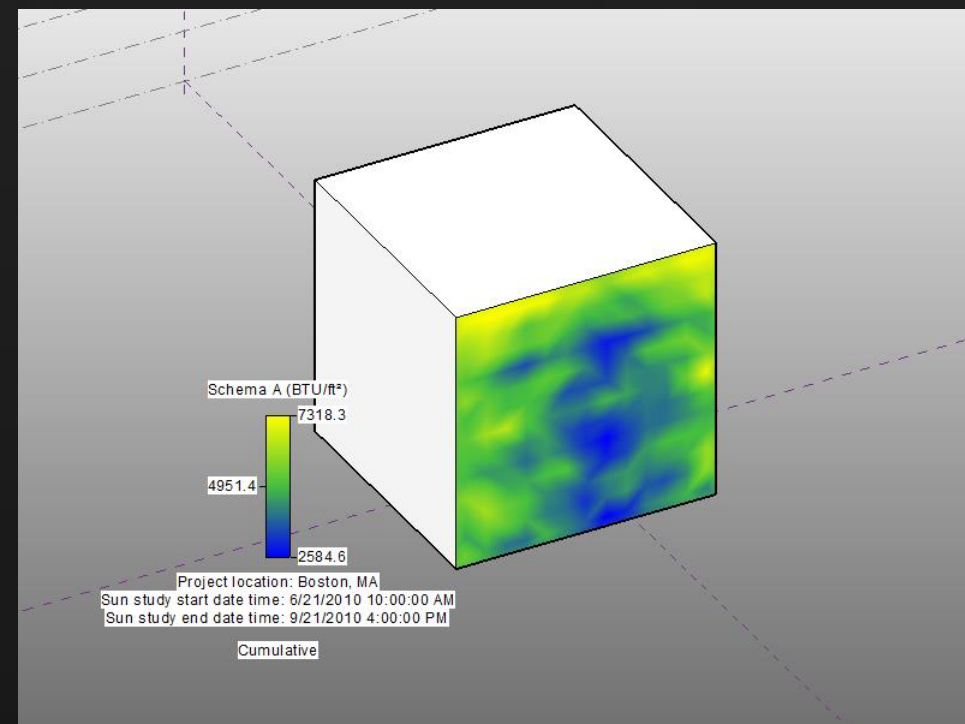
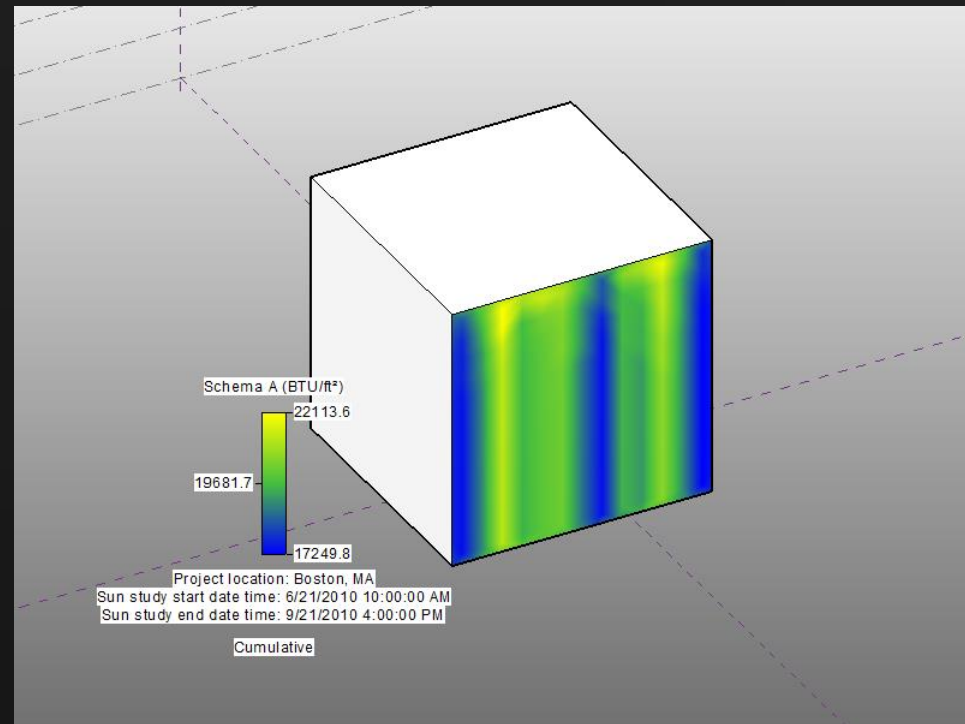
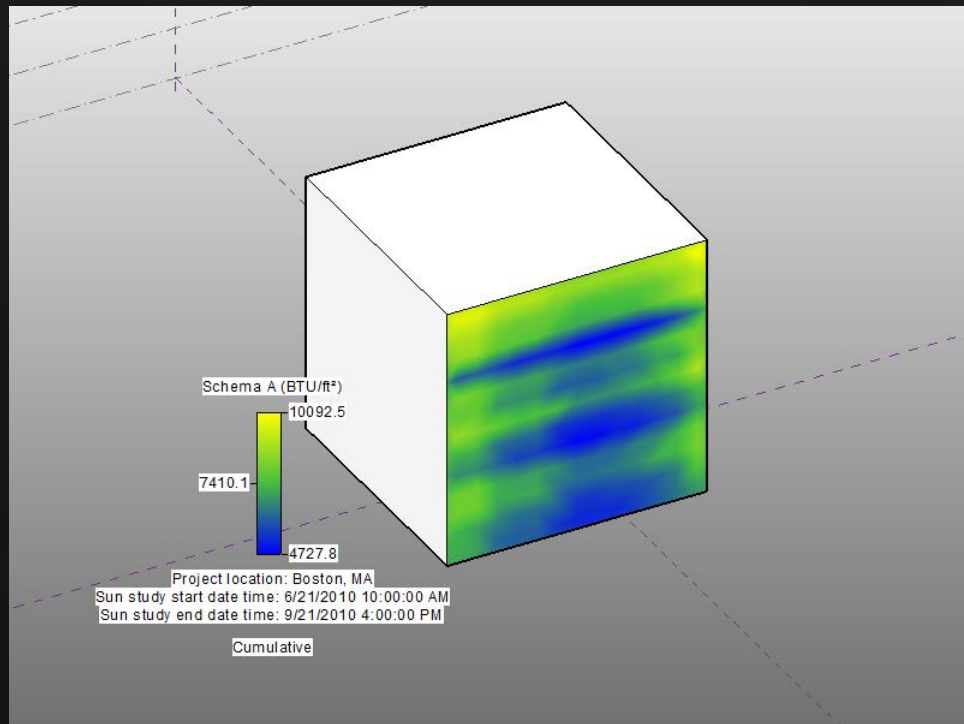
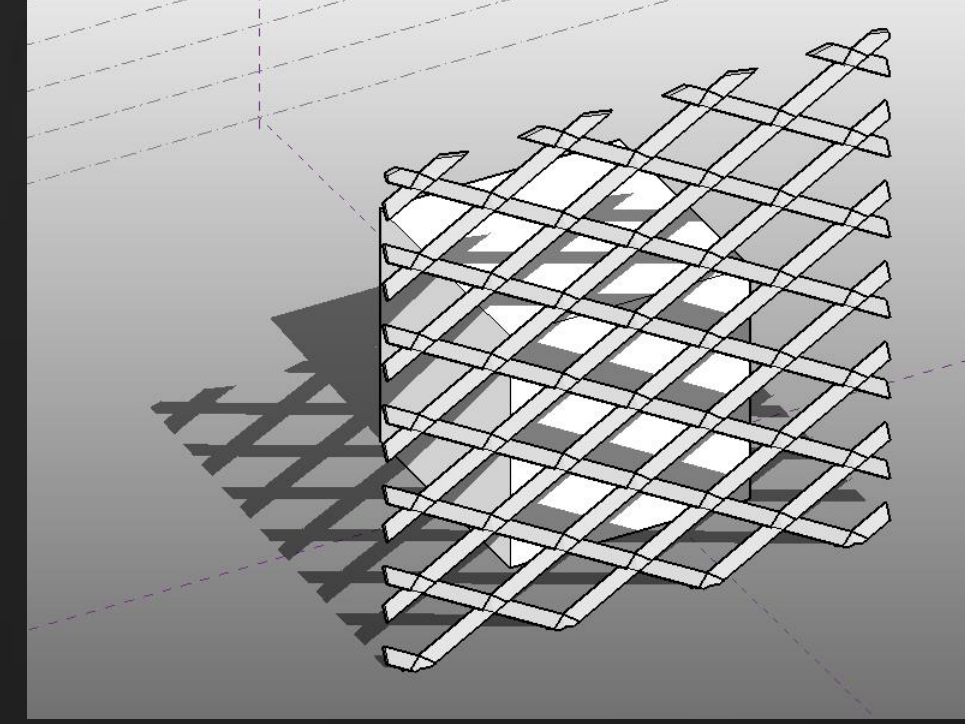
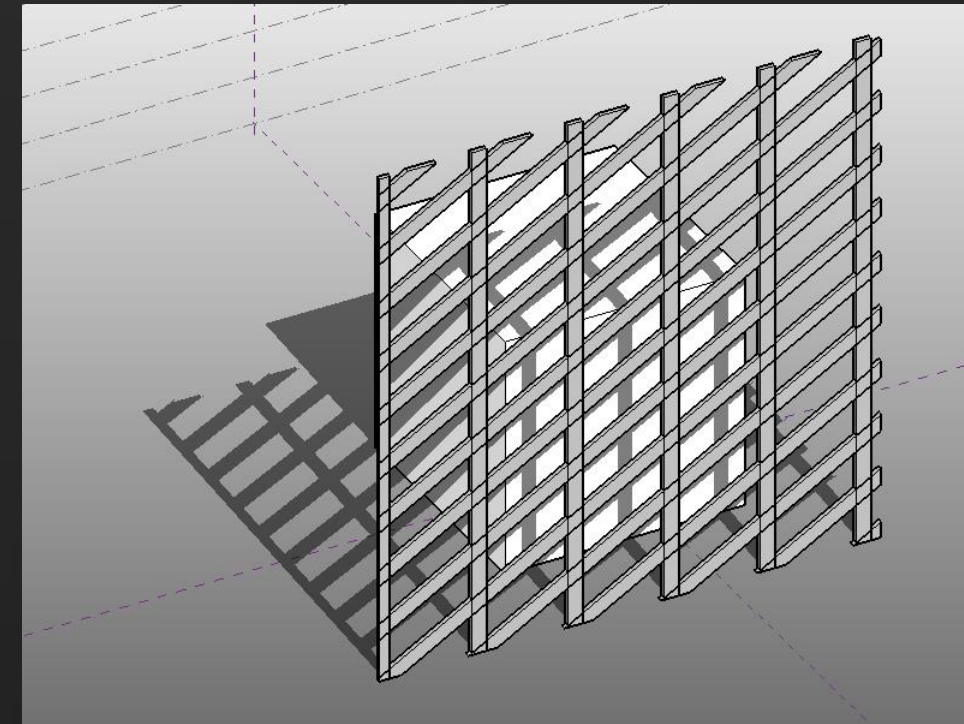
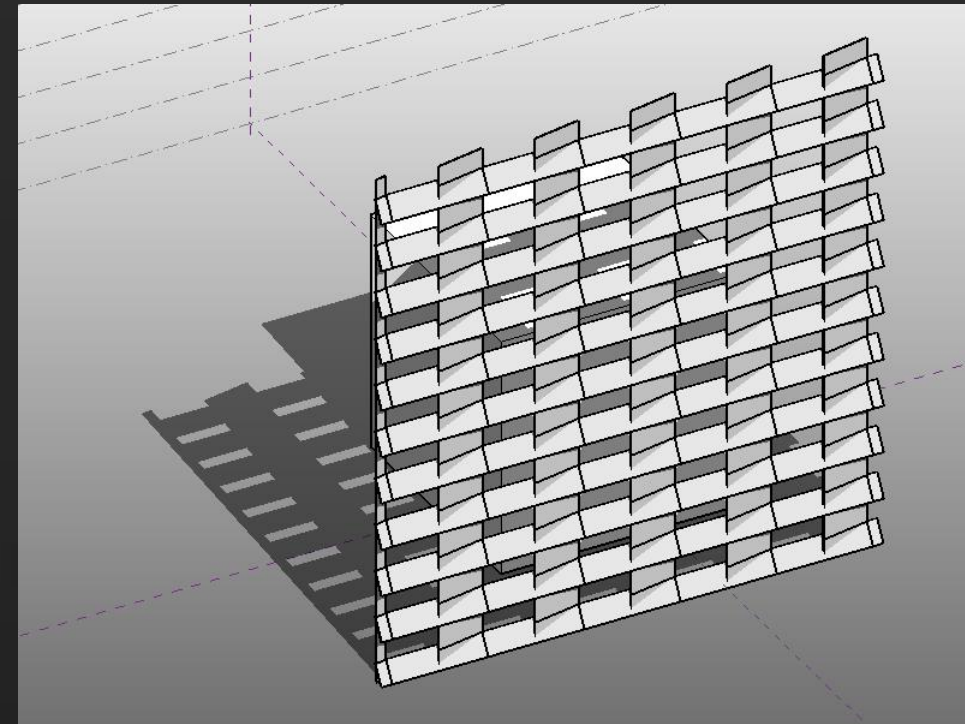
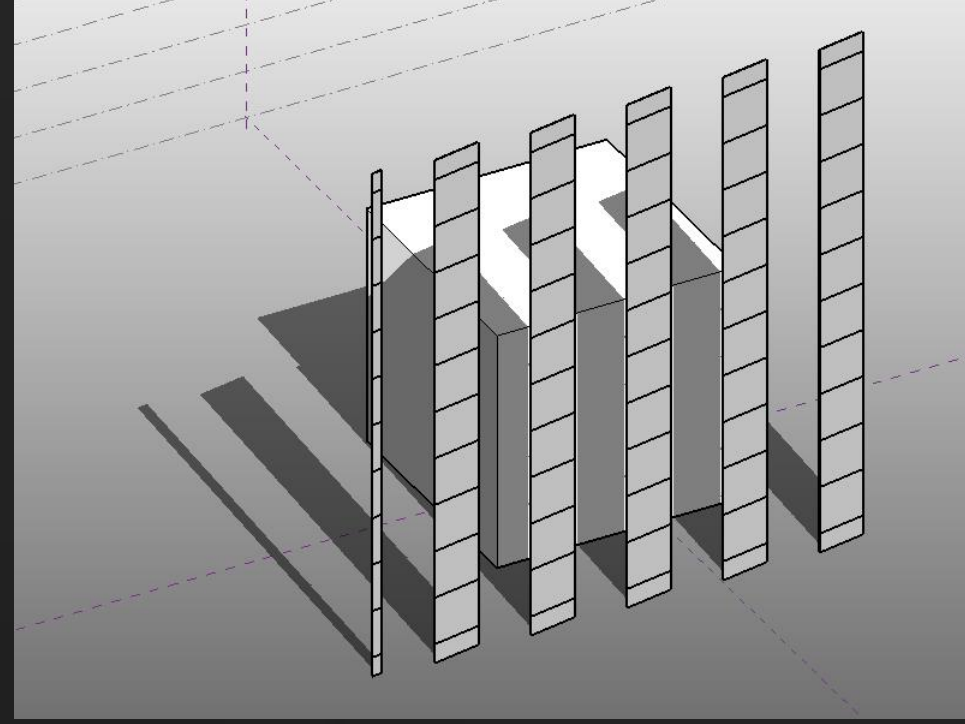
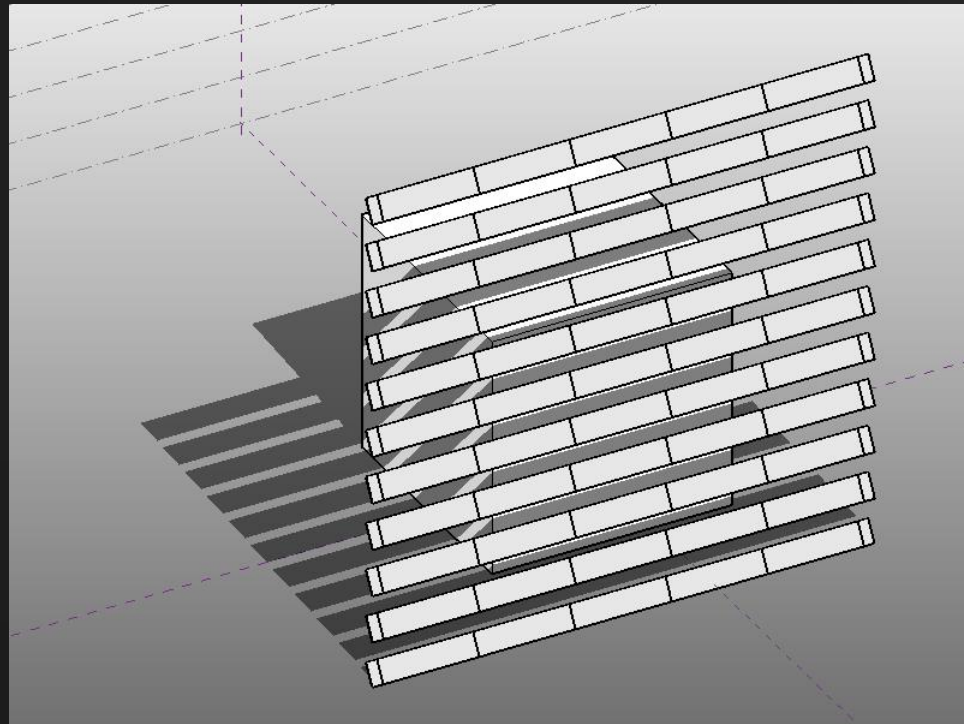


# Solar radiation patterns



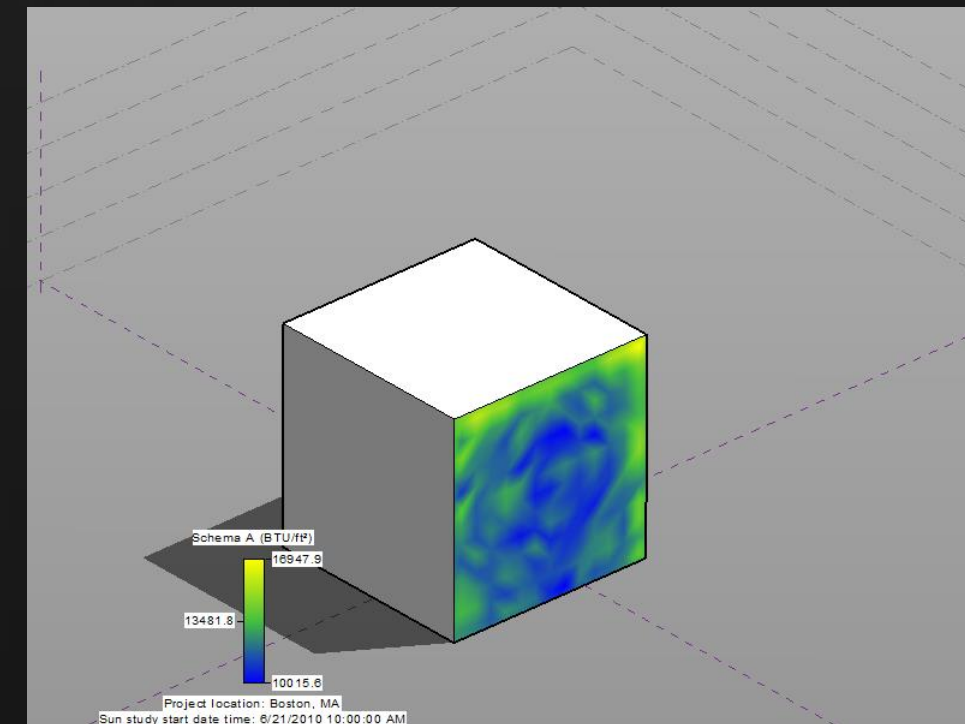
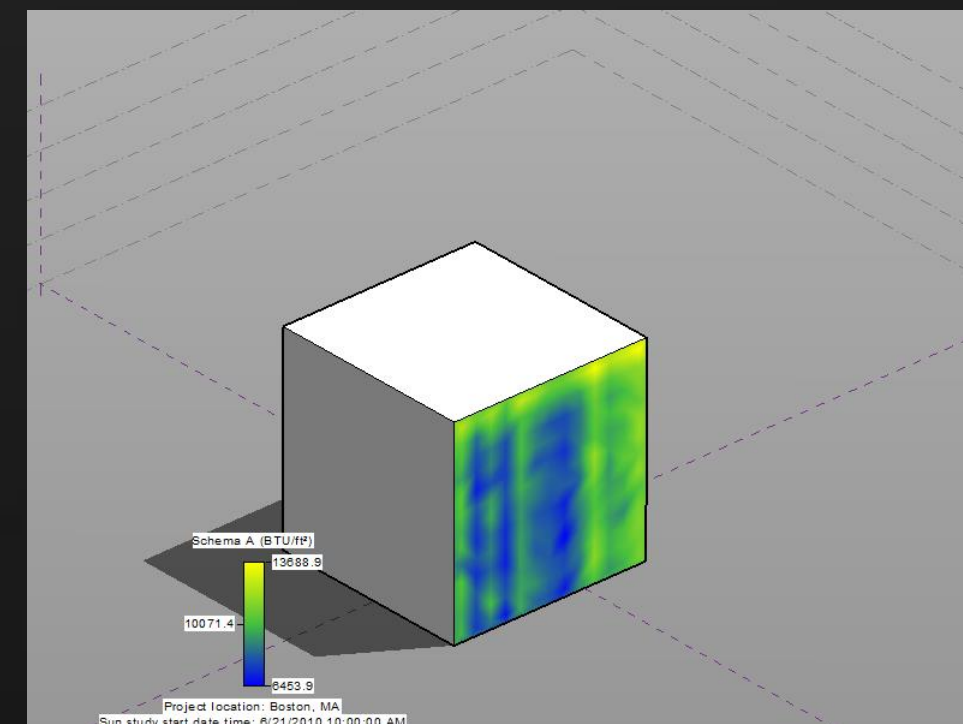
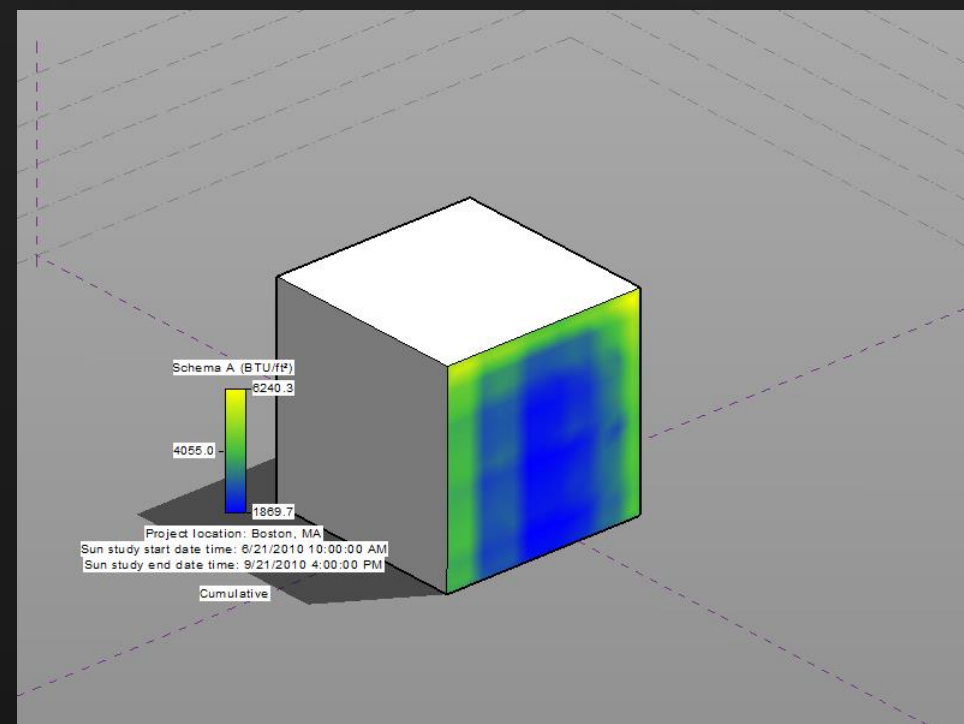
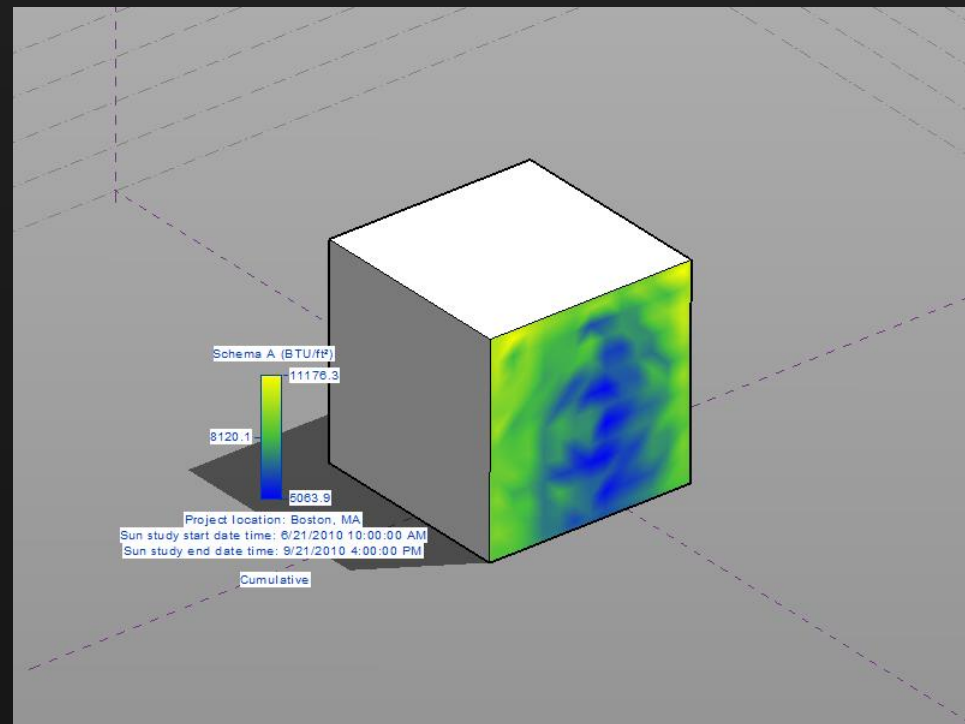
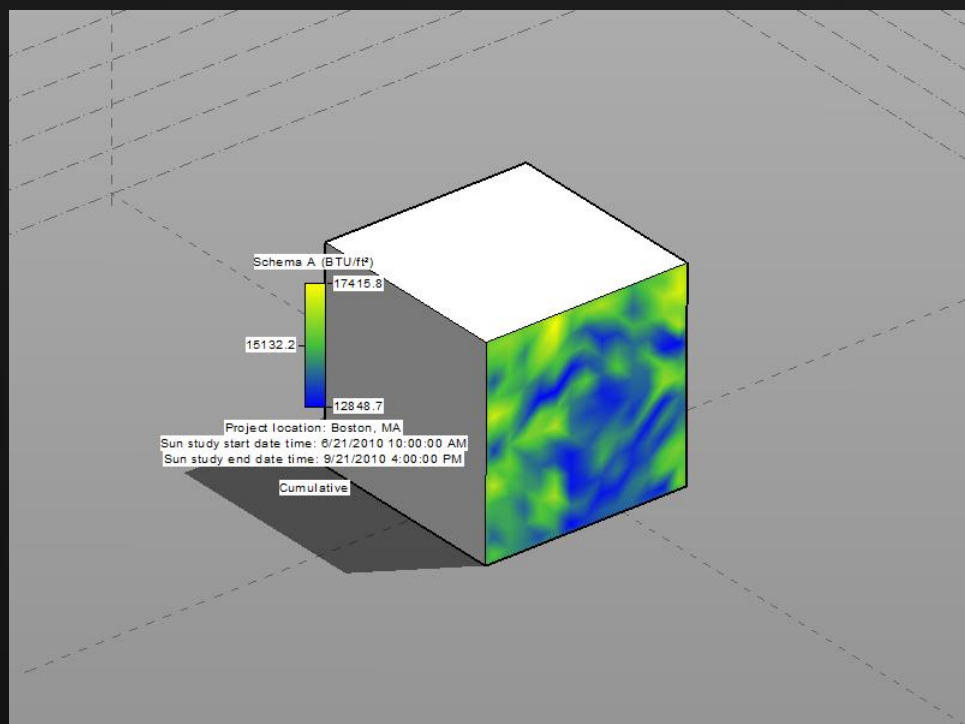
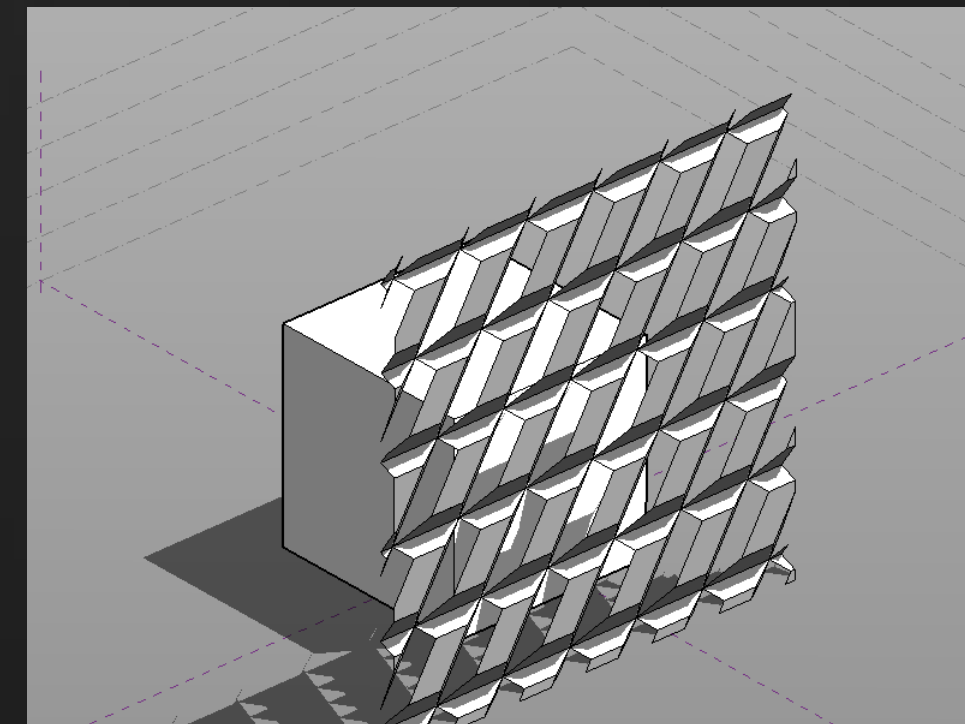
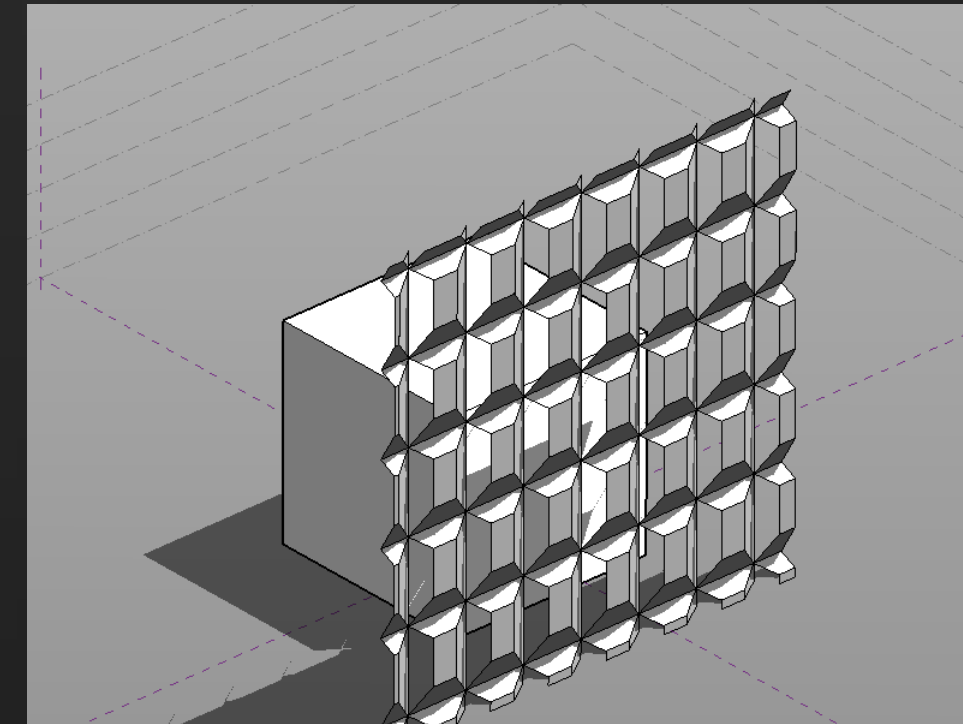
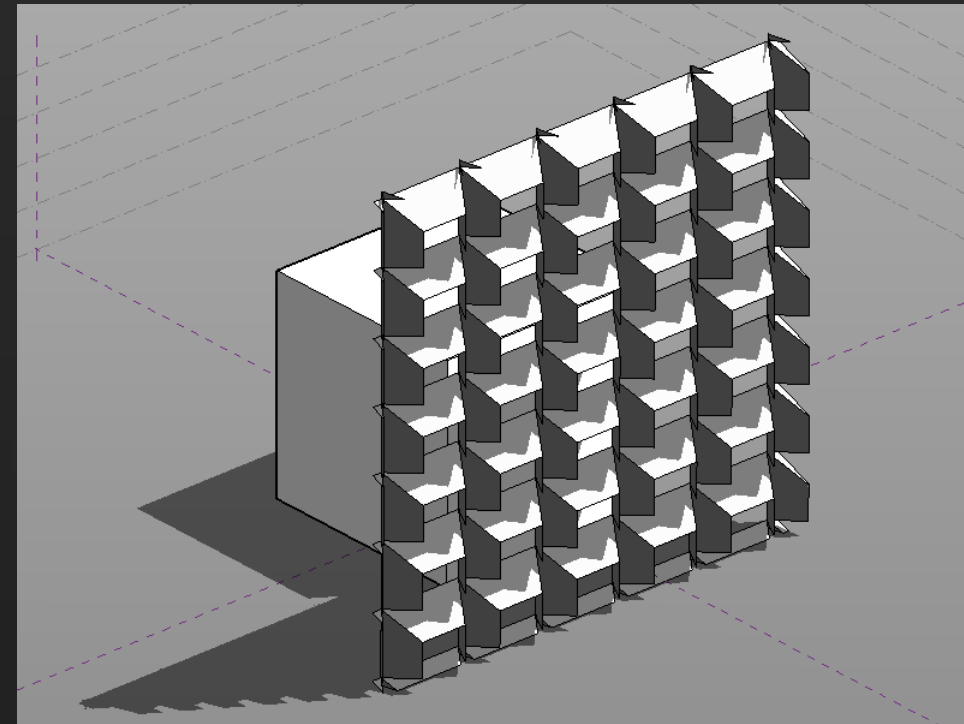
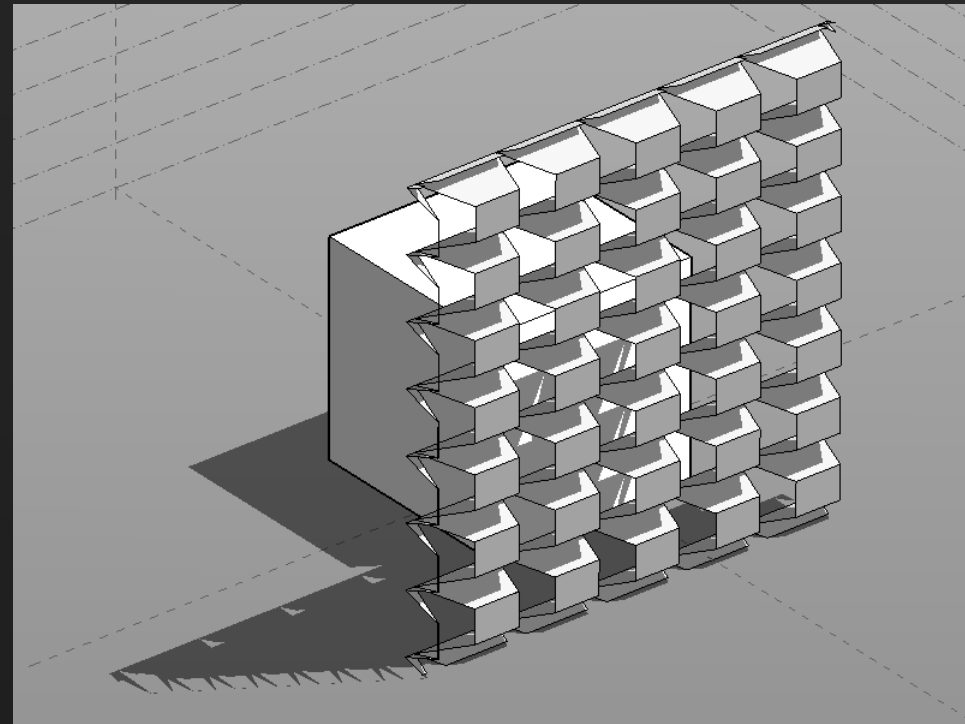
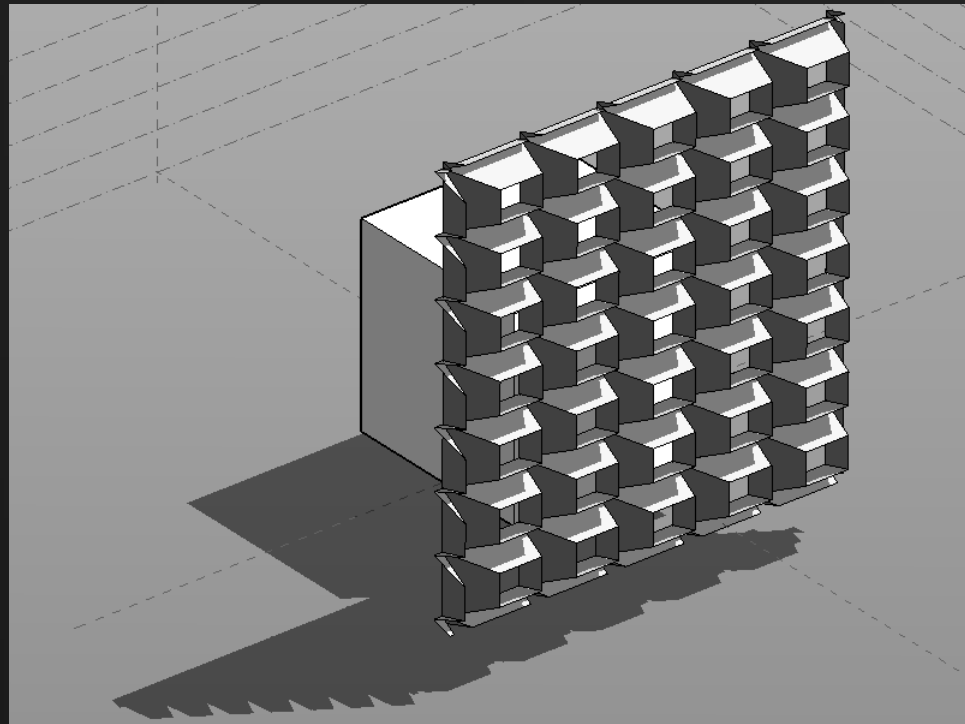


# Louvers: some variations





# Aperture : some variations





# Aperture : some variations

