



# **Advanced Project Delivery** **(Beyond** conventional **CD's)**

Robert Otani, PE LEED AP  
Principal | CORE studio

# Practices



# Reach

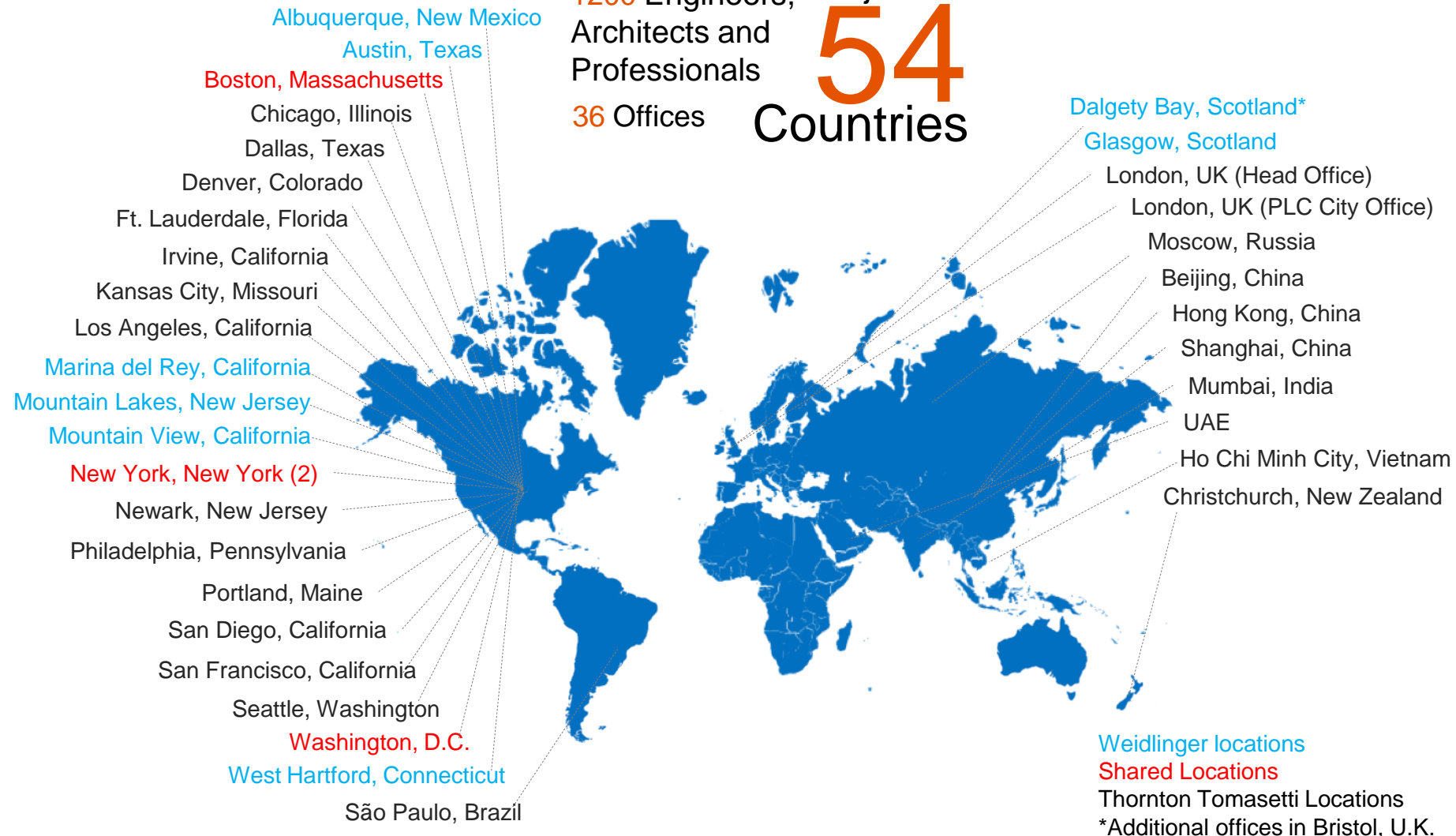
## Our Locations

5 Continents

1200 Engineers, Architects and Professionals

36 Offices

54 Countries



# CORE studio | **Thornton Tomasetti**



Rob Otani  
Nick Mundell  
Ben Howes  
Kenny Tam



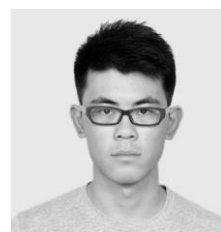
Elcin Ertugrul  
Daniel Segraves  
Hiram Rodriguez  
Michael Kero



Dan Reynolds  
Serena Li  
Margaret Wang  
Emil Poulsen



Shannon McMullan  
Mark Tam  
Leland Jobson  
Richard Schmitt



Sergey Pigach  
David Mans  
Hanshen Sun

# **KONSTRU**



Jonatan Schumacher  
Max Thumfart



# Our Mission

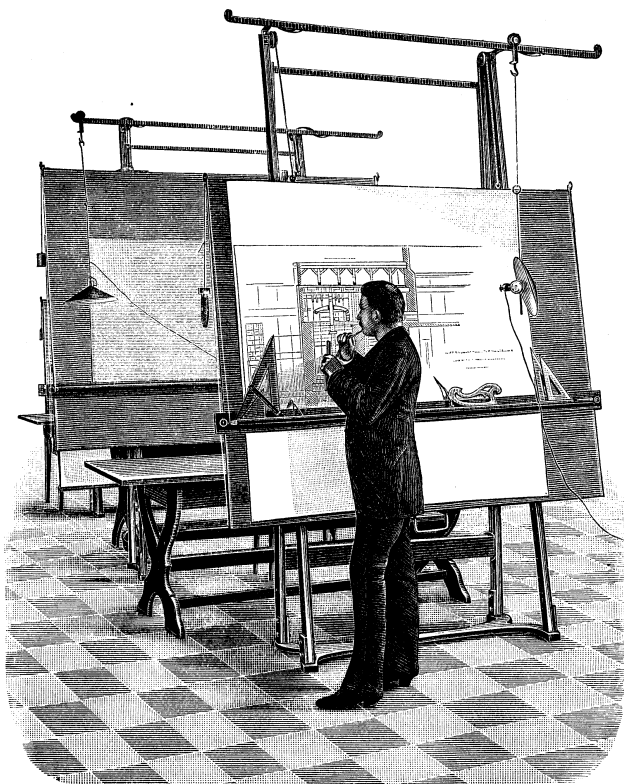
**CORE studio is a firm-wide idea incubator.**

Our mission is to increase the value we bring to clients through innovation.

The studio conducts research, develops custom software applications, designs workflows to optimize project realization, and develops interactive computational models.

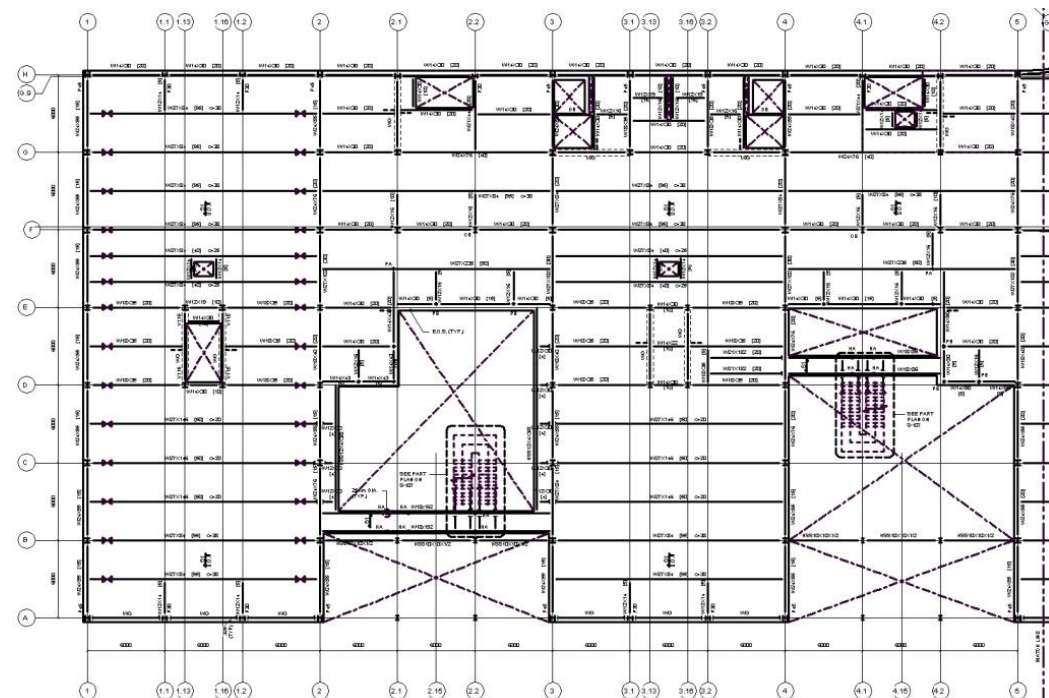
# Evolution of BIM

## Manual Drafting



Better or  
Worse?

## 2-D CAD



# Progress?...

One Liberty Place



1987

The New York Times



2007

60 drawings



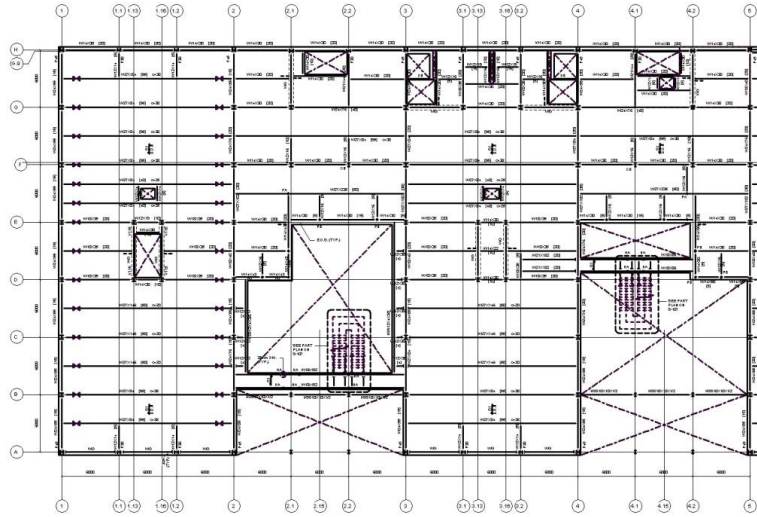
140 drawings



# 60 Drawings vs. 140 Drawings

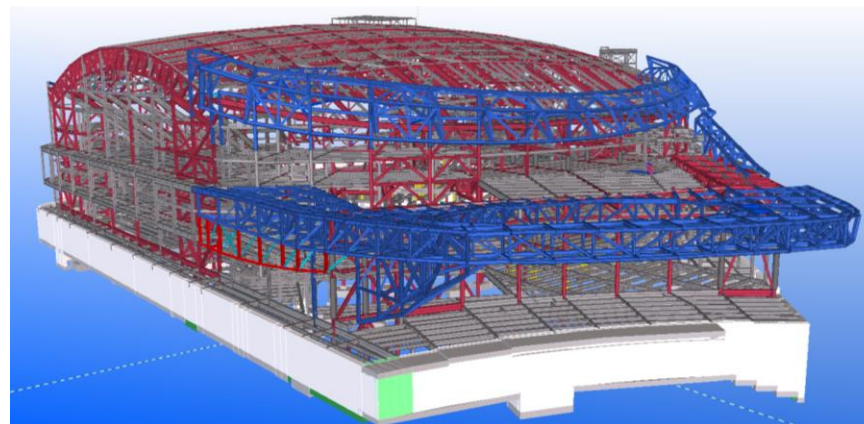
- Production – Better or Worse?
- Dimensional Information – Better or Worse?
- Clarity of Intent – Better or Worse?
- Coordination – Better or Worse?
- RFIs/Extras/Claims/ - Better or Worse?
- Do changes in design occur more or less?

# PROGRESS!!



2-D or 3-D CAD

## BARCLAYS CENTER

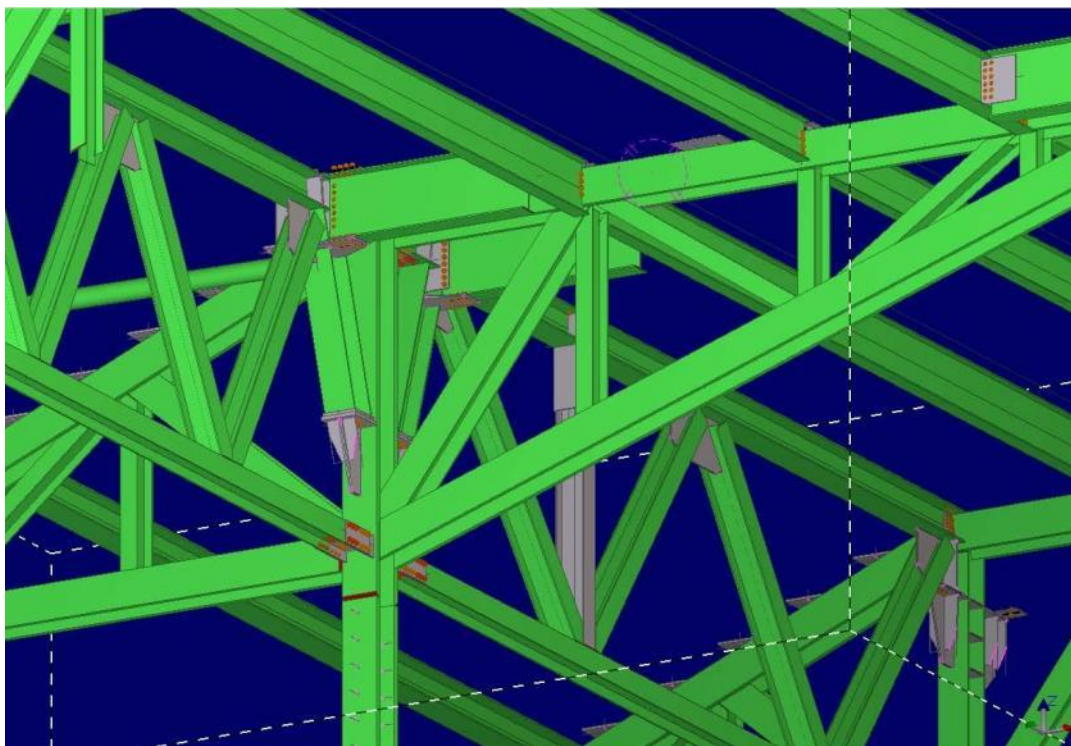


BIM

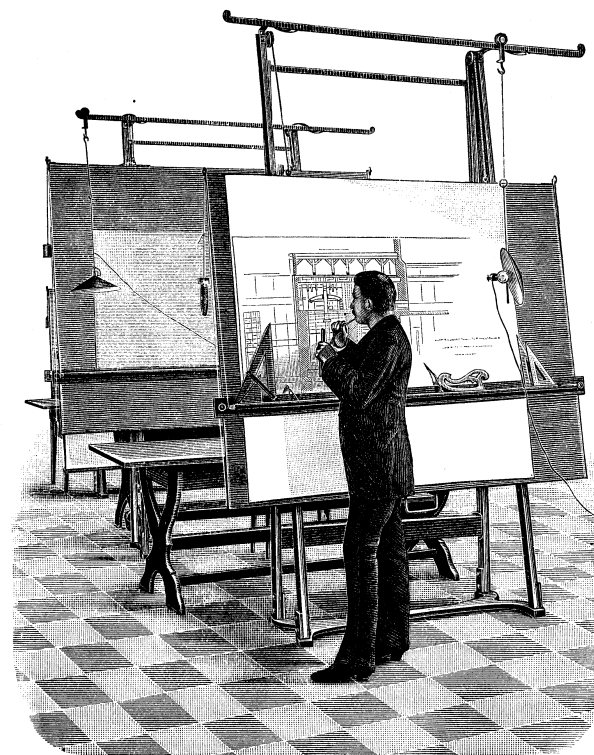


...not if the Model is not the Deliverable

This might as well be ...

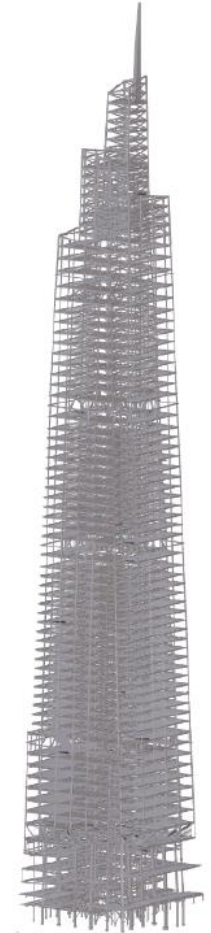


... this.



# CASE STUDY – ONE VANDERBILT

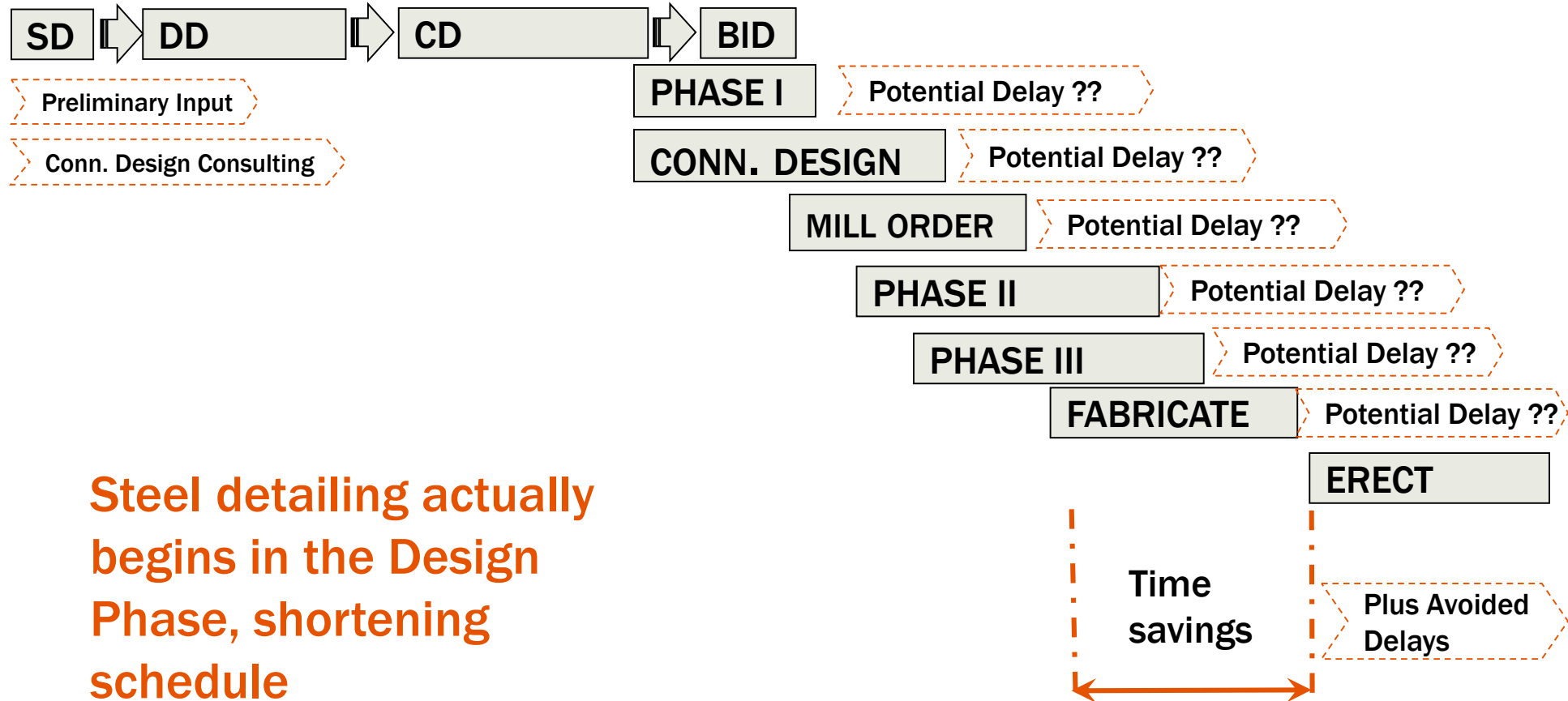
- Engineer of Record is Severud
- Thornton Tomasetti Construction Engineering team hired directly by Hines
- Early involvement in design to understand both the design intent and the Steel Fabricators needs and preferences
- Early release of structural information and advancement of shop/fabrications drawings saved time and money
- **Early completion (Min. 7 months)**
- Happy Client!



Architect: KPF  
Structural Engineer of Record: Severud  
Fabrication/Connection Engineer: Thornton Tomasetti

# Schedule Savings

## Traditional process without TEKLA as Deliverable



Steel detailing actually begins in the Design Phase, shortening schedule

# Benefits to a Project with APD (Advanced Project Delivery)

- More complete and detailed coordinated information earlier which results in an improved project schedule and better cost certainty
- When concrete and steel interact, better coordination can occur between these two trades early
- Schedule savings
- Delivering a model to the fabricators in a format and manner that they can rely on and use (shop drawings creation, drive CNC equipment)
- Tekla model can be converted into almost any format for coordination and early clash detection
- Cost Certainty – Progress model can be issued with bid documents to show complexity and sample connections
- Reduction in RFIs – connection engineering, drawing related issues discovered and addressed during model development before released to fabricator
- Reduced or Validating Change Orders – by producing a Tekla model, quantities and complexity identified as design progresses. Since all information is shared, utilizing a collaborative design/construction approach, potential change orders are identified earlier in the process.
- REDUCED SHOP DRAWING REVIEW (95% FIRST TIME APPROVALS)

# ALL DESIGN DATA SHOULD BE PORTED TO THE SUBCONTRACTORS

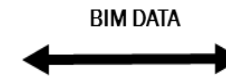
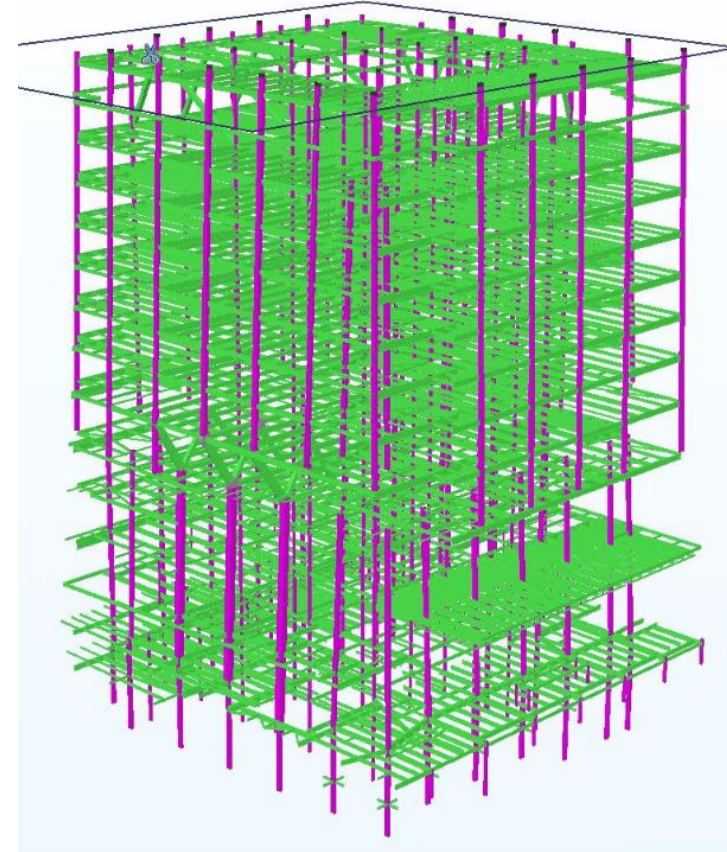
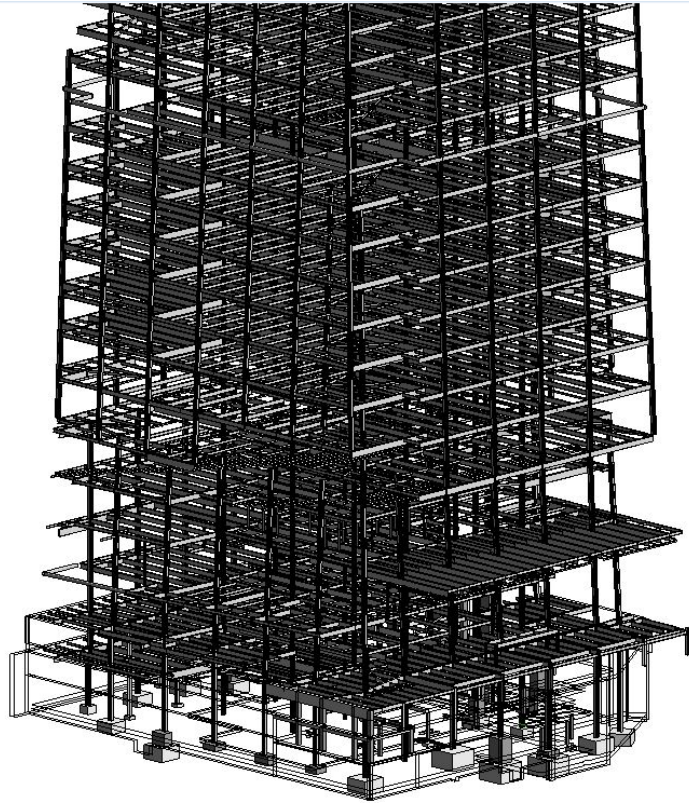
- **Schedule** – Accelerate Contractors understanding of the design
- **Risk Management** – Avoid Misinterpretations of the 2D Drawings
- **Collaboration** – Demonstrate coordination has been completed with all disciplines
- **Expedite Construction** – Allows subcontractors a head start in understanding the design intent and creating shop drawings



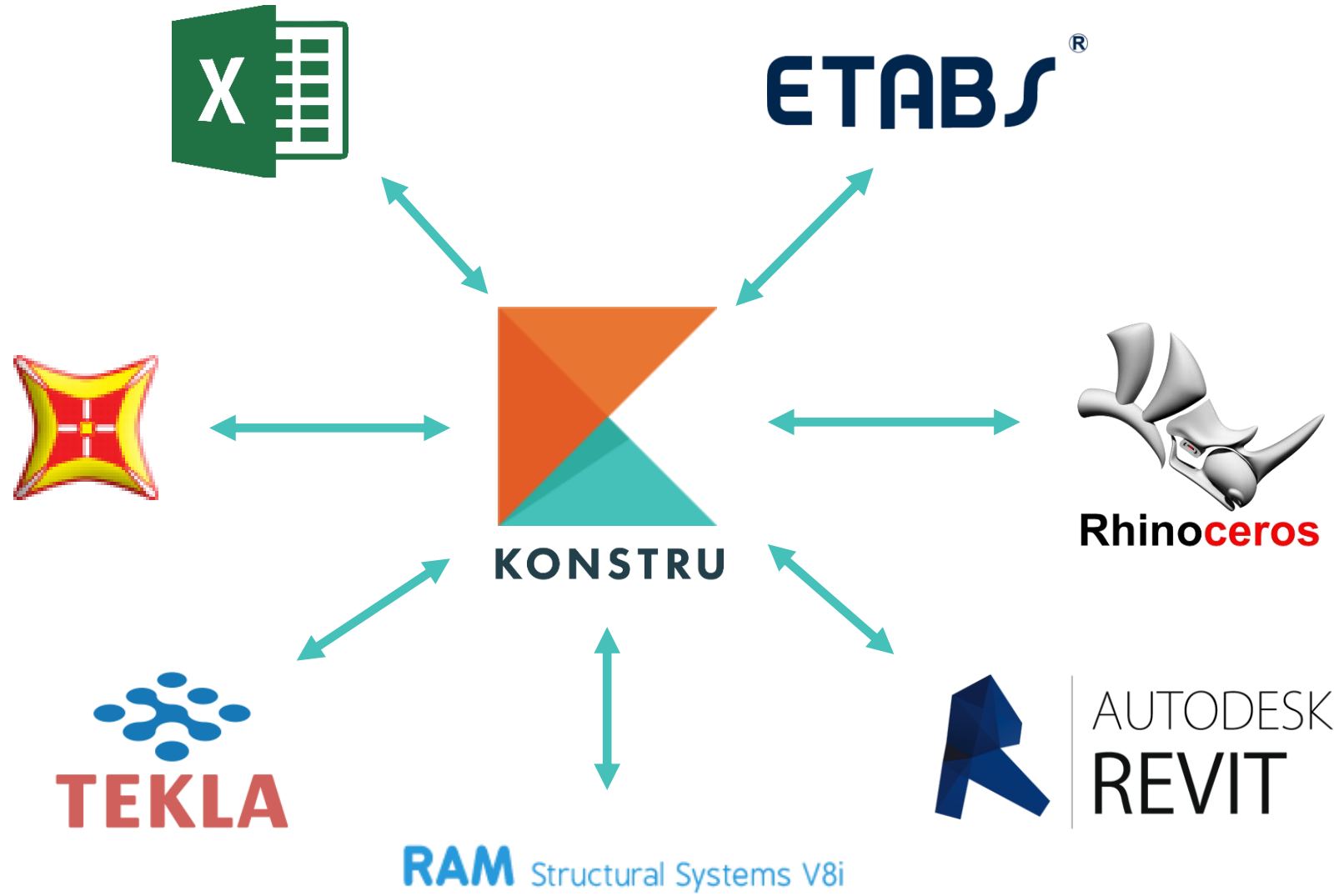
# Custom Apps

# BIM Model to Fabrication Model

Create A Tekla Model Using The Existing Revit Model as a Starting Point

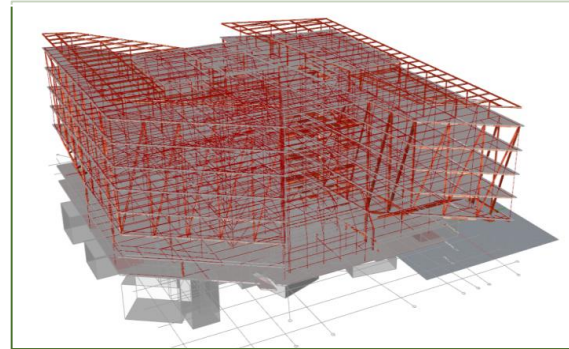
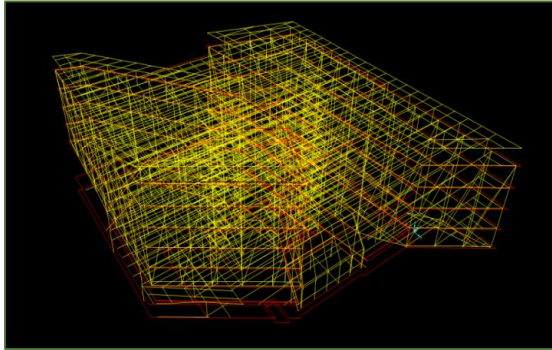


# Interoperability, Cloud and Web Platform - KONSTRU



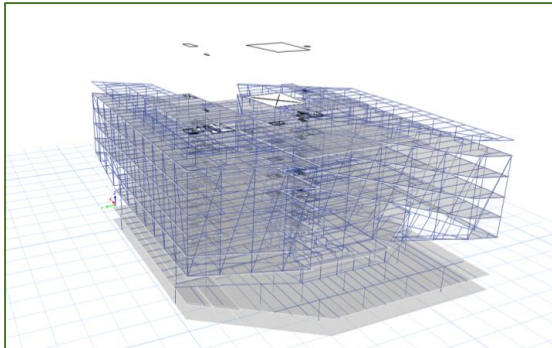
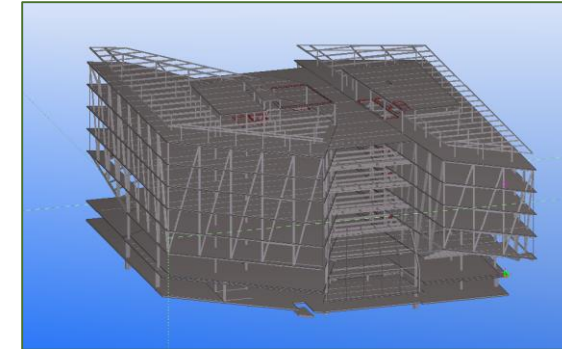
# Interoperability, Cloud and Web Platform - **KONSTRU**

CSI SAP2000

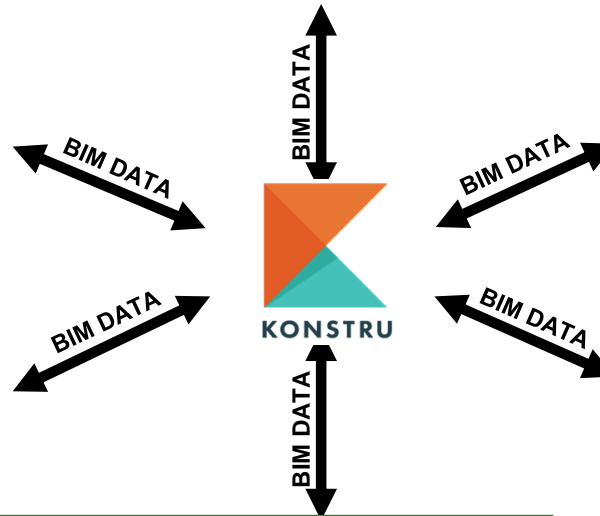


McNeel Rhino: Grasshopper

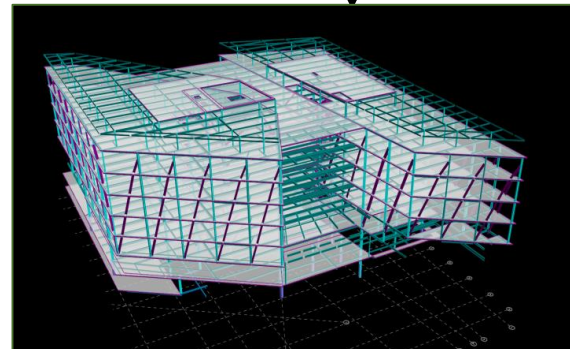
Tekla



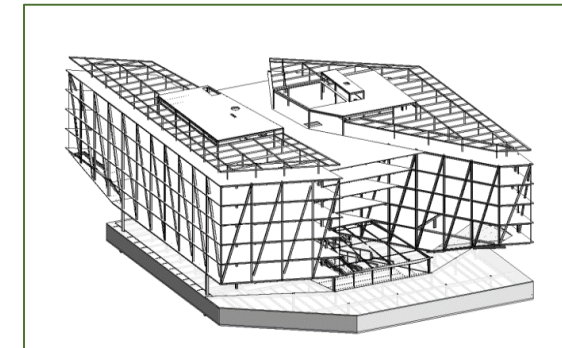
CSI Etabs



KONSTRU



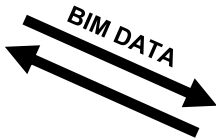
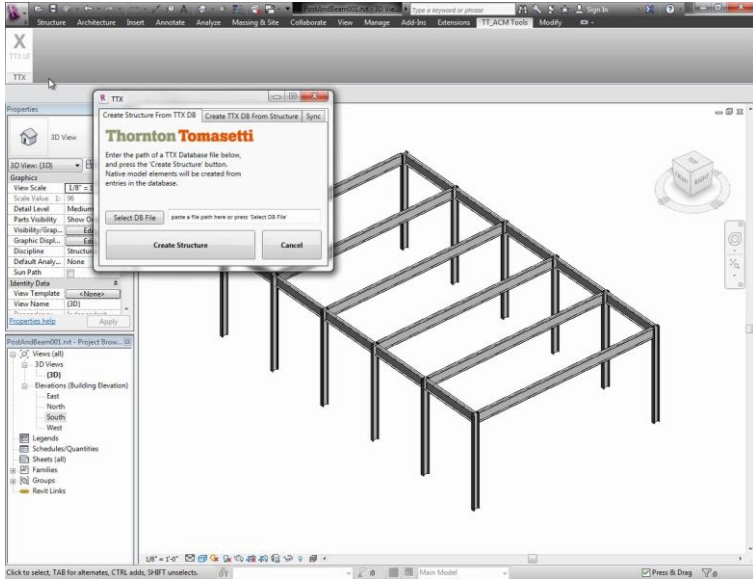
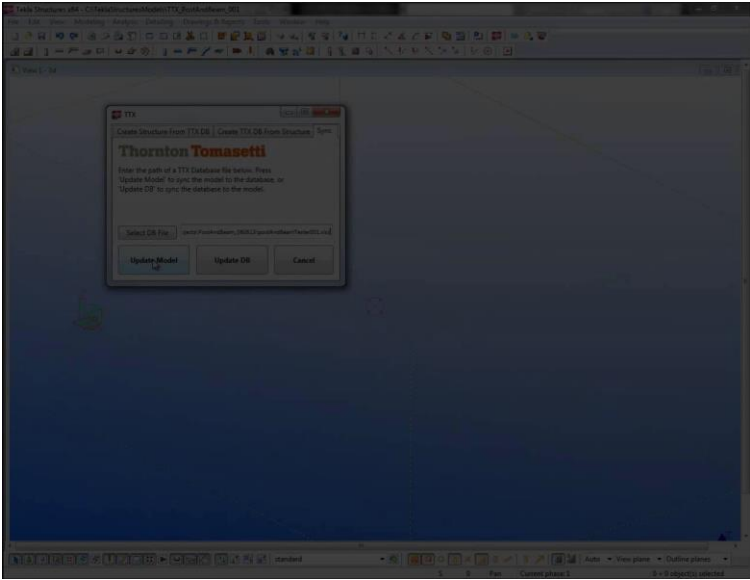
Bentley RAM Structural System



Autodesk Revit



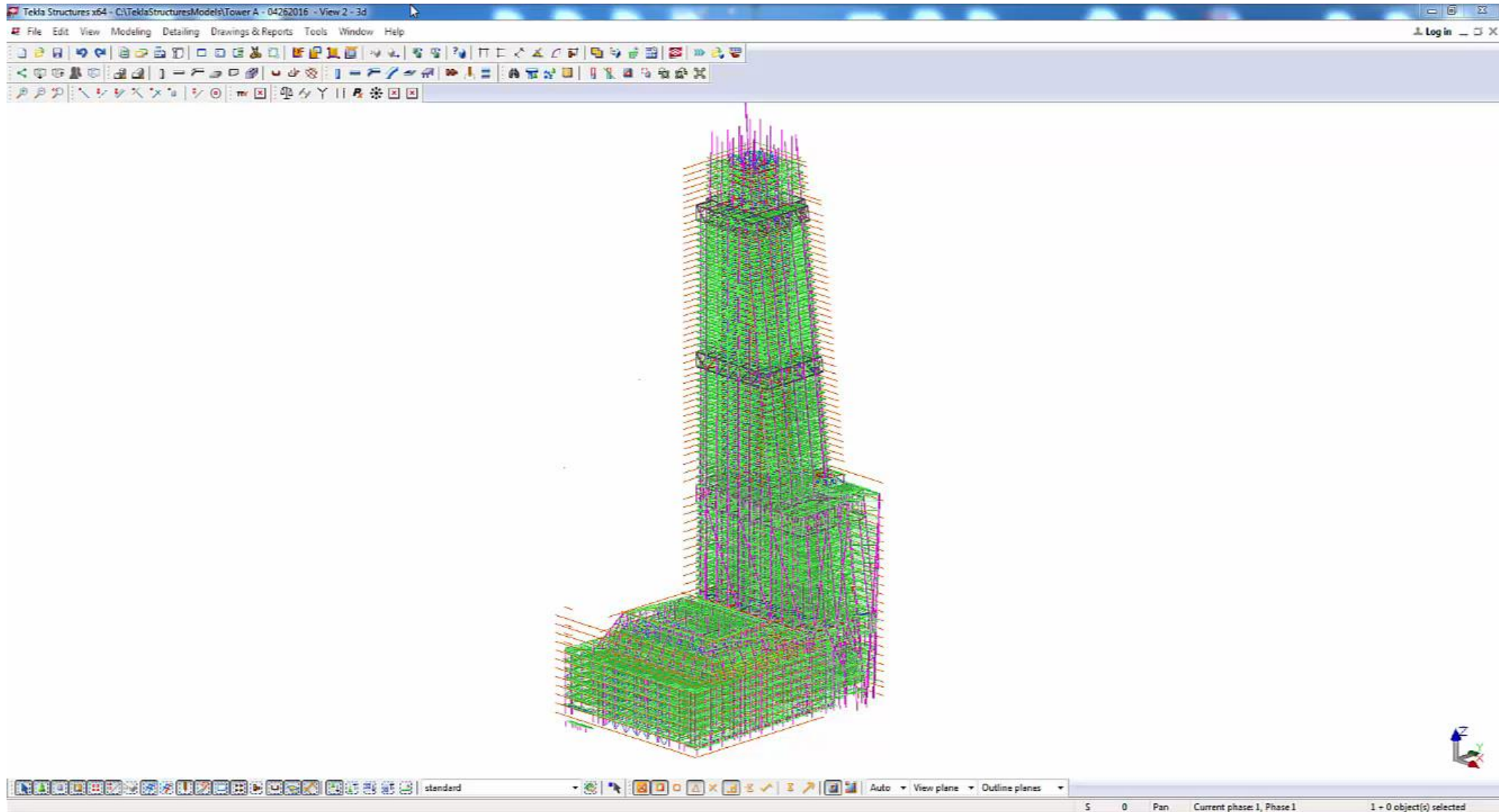
# BIM DATA INTEROPERABILITY (AUTOMATION) USING KONSTRU



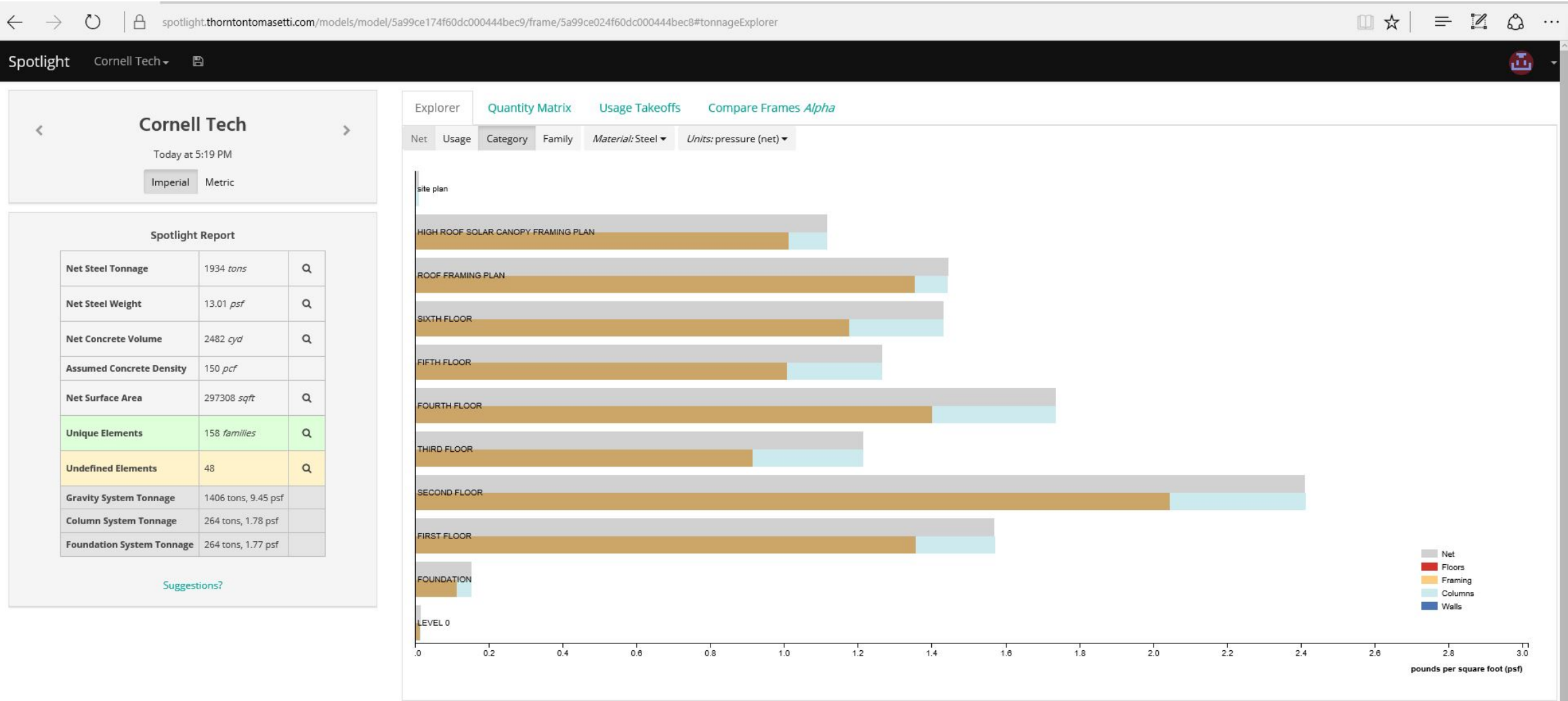


# BIM Model to Fabrication Model

CORE studio Automation Tools



# Spotlight – Automated Quantity Take Off and Visualization



# Spotlight – Automated Quantity Take Off and Visualization

Spotlight

Cornell Tech

<

Cornell Tech

>

Today at 5:19 PM

ImperialMetric

Spotlight Report

Net Steel Tonnage	1934 tons	Q
Net Steel Weight	13.01 psf	Q
Net Concrete Volume	2482 cyd	Q
Assumed Concrete Density	150 pcf	
Net Surface Area	297308 sqft	Q
Unique Elements	158 families	Q
Undefined Elements	48	Q
Gravity System Tonnage	1406 tons, 9.45 psf	
Column System Tonnage	264 tons, 1.78 psf	
Foundation System Tonnage	264 tons, 1.77 psf	

Suggestions?

ExplorerQuantity MatrixUsage TakeoffsCompare Frames Alpha

Download Full Takeoff

Name	Count	NetWeight(lbs)	NetVolume(cyd)	NetLength(ft)	StructuralMaterial	StructuralType
12" Concrete	80	7274477	1796	0	Concrete	Floors
4 1/2" NW Concrete on 2" Metal Deck	10	48850	1810	0	Unknown	Floors
3-1/4" LWC over 2" Verco W2	33	87505	3242	0	Unknown	Floors
3-1/4" LWC over 1-1/2" Verco B	4	3789	140	0	Unknown	Floors
6" Concrete	1	134388	33	0	Concrete	Floors
14" Concrete	2	172168	42	0	Concrete	Floors
3" Roof Deck	1	206	8	0	Unknown	Floors
8" Concrete	1	104921	26	0	Concrete	Floors
W14X68	63	54800	0	874	Steel	Framing
W18X40	55	71865	0	1866	Steel	Framing
W14X99	56	80017	0	824	Steel	Framing
W14X22	419	112039	0	5497	Steel	Framing
W24X55	33	75405	0	1419	Steel	Framing
W14X48	37	22495	0	492	Steel	Framing
W12X14	302	33121	0	2612	Steel	Framing
W14X82	99	90911	0	1183	Steel	Framing
W21X44	99	127322	0	3025	Steel	Framing
W14X61	125	90302	0	1604	Steel	Framing
W18X35	201	185261	0	5548	Steel	Framing
W21X55	8	13688	0	261	Steel	Framing
W24X117	14	61857	0	548	Steel	Framing
W16X36	63	29405	0	885	Steel	Framing
W14X43	121	58308	0	1456	Steel	Framing
W14X120	48	72646	0	622	Steel	Framing
W14X90	124	181522	0	2151	Steel	Framing
W24X84	14	54544	0	666	Steel	Framing
W16X26	122	62701	0	2565	Steel	Framing
W24X131	12	70395	5	549	Steel	Framing

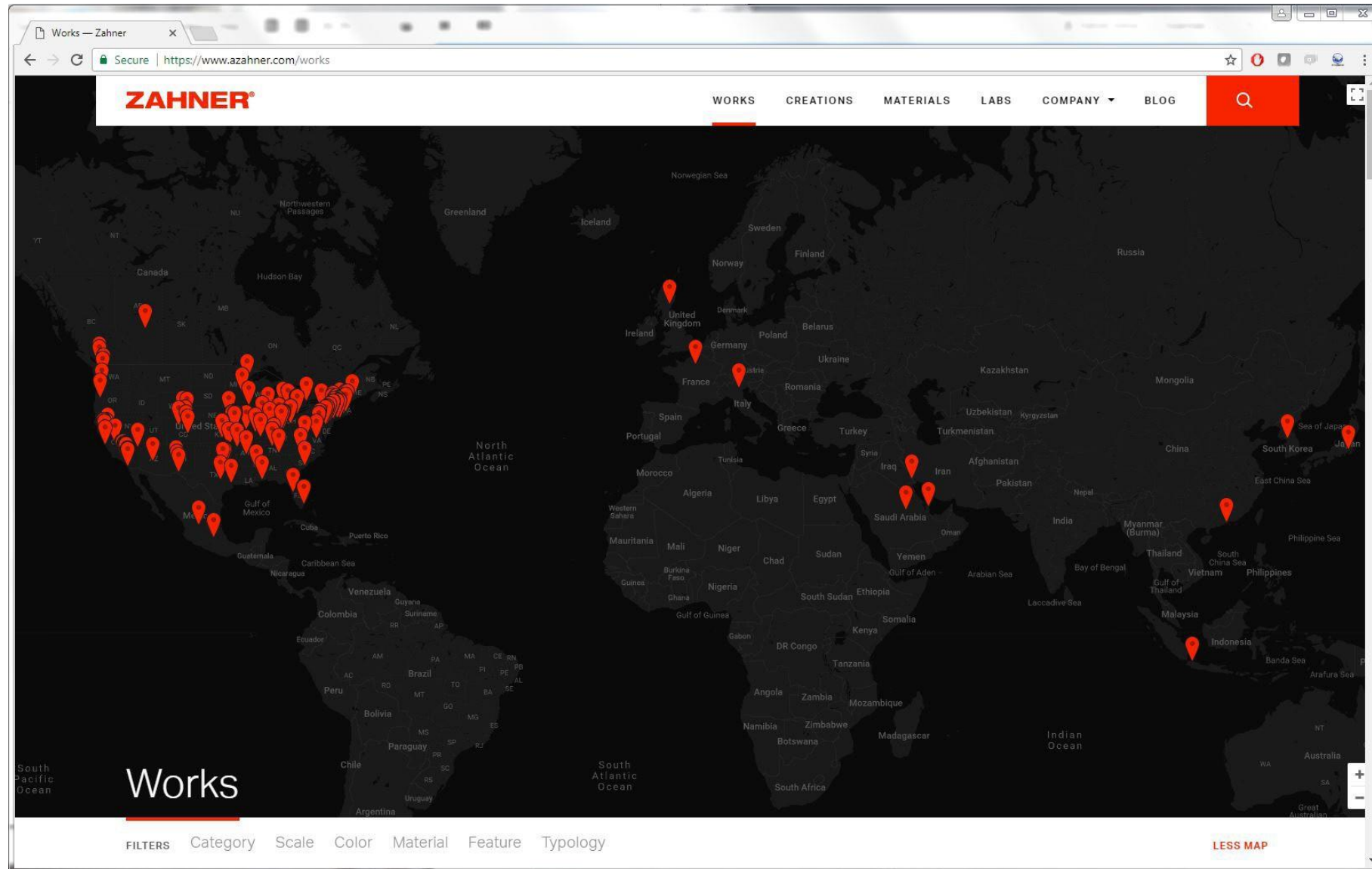
# Thornton Tomasetti

CORE studio

CORE.ThorntonTomasetti.com  
@TT\_CORE









**GEHRY PARTNERS**





**RANDALL STOUT**



**ZAHNER®**



**SNOHETTA**



**ZAHNER®**



**ZAHAHADID**





**MONEO**

**ZAHNER®**



**STUDIO LIBESKIND**



**ZAHNER®**



m0rphosis



**ZAHNER**



m0rphosis



**ZAHNER®**



**HERZOG & DE MEURON**



**ZAHNER®**





SANAA

ZAHNER®



ROJKIND



ZAHNER®



DS +R

**ZAHNER®**



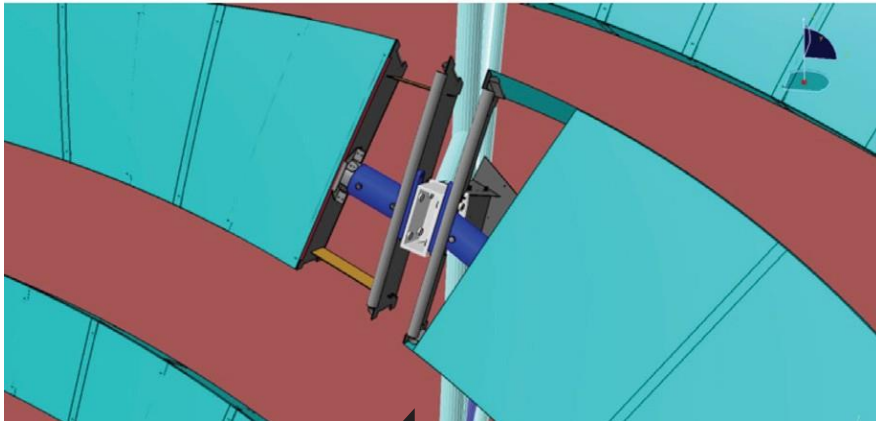
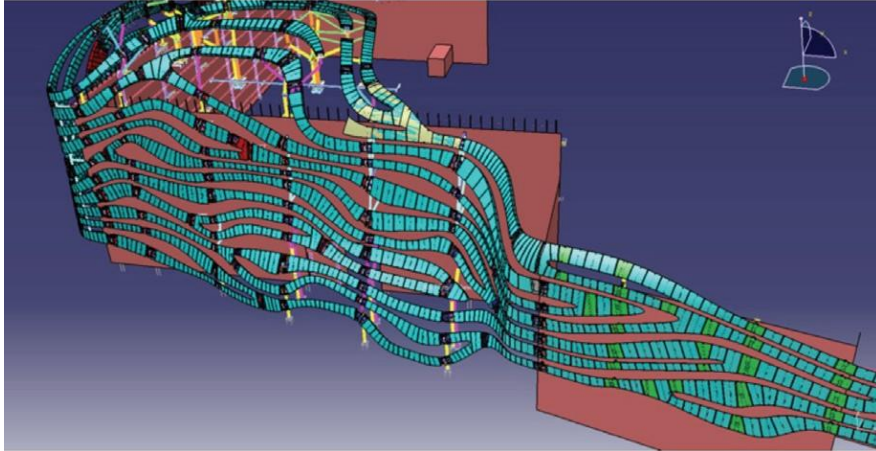
OMA / REX



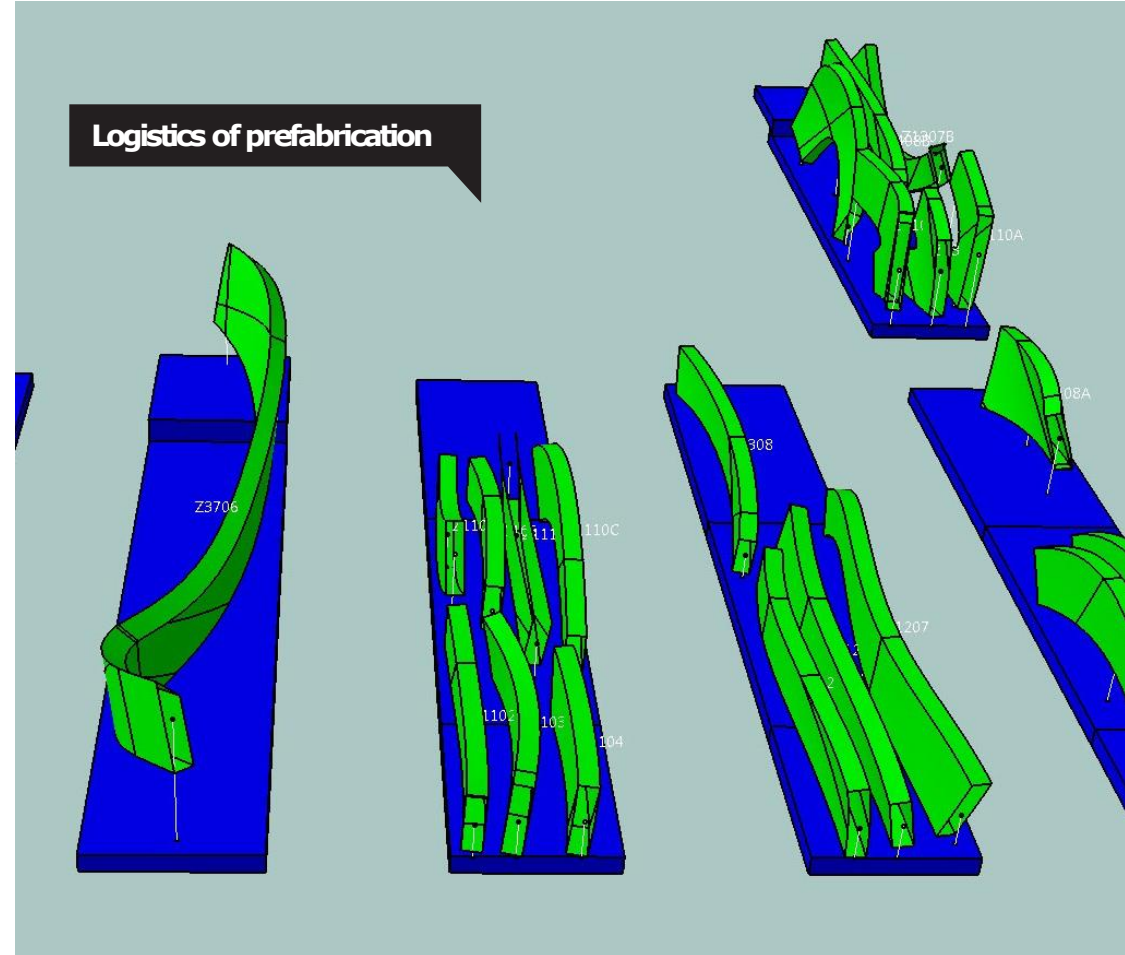








Modelling and verification



Logistics of prefabrication





Coordinated tolerances and short  
'field > model' feedback loop.

**ZAHNER®**







# **DELIVERING THE FUTURE**

AIA PROJECT DELIVERY SYMPOSIUM

**HKS**



# **SETTING THE CONTEXT**

# SETTING THE CONTEXT

FROM AN ARCHITECT'S PERSPECTIVE





# INDUSTRIAL REVOLUTIONS

HOW DO WE MATCH UP

## FROM INDUSTRY 1.0 TO INDUSTRY 4.0

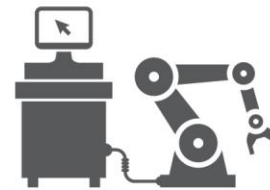
**1.0**  
**Brick & Mortar**



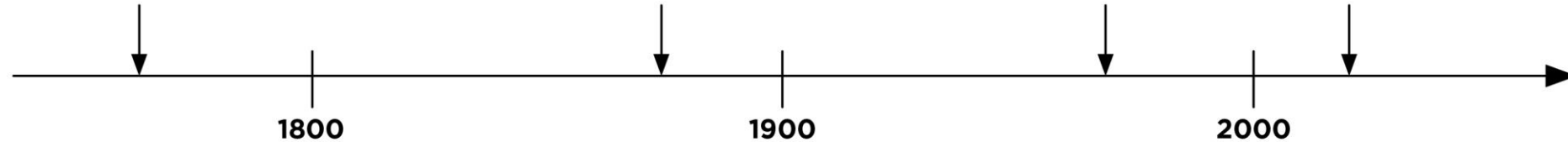
**2.0**  
**(Semi)-Automated**



**3.0**  
**Intelligent Infrastructure**



**4.0**  
**Fully Integrated Infrastructure**





# FROM INDUSTRY 1.0 TO INDUSTRY 4.0

**1.0**  
**Brick & Mortar**



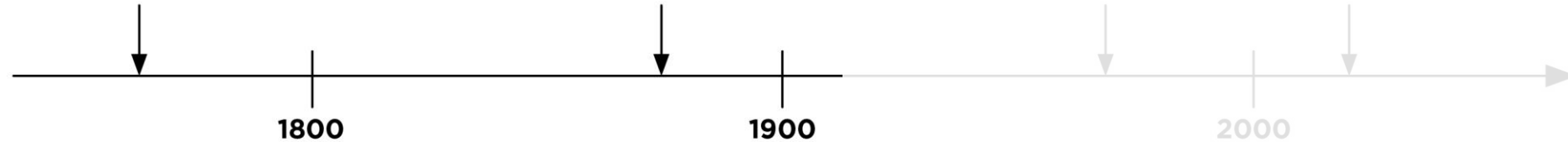
**2.0**  
**(Semi)-Automated**



**3.0**  
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**4.0**  
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# FROM INDUSTRY 1.0 TO INDUSTRY 4.0

**1.0**  
**Brick & Mortar**



**2.0**  
**(Semi)-Automated**



**3.0**  
**Intelligent Infrastructure**



**4.0**  
**Fully Integrated Infrastructure**







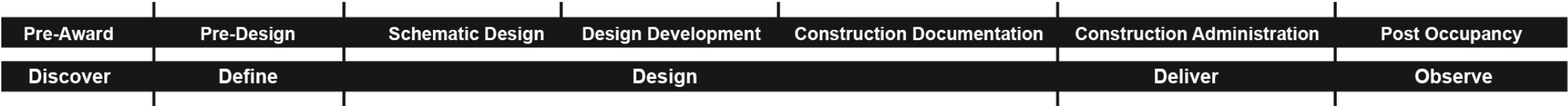
# THE PROCESS

A PROCESS THAT IS FUNDAMENTALLY BROKEN

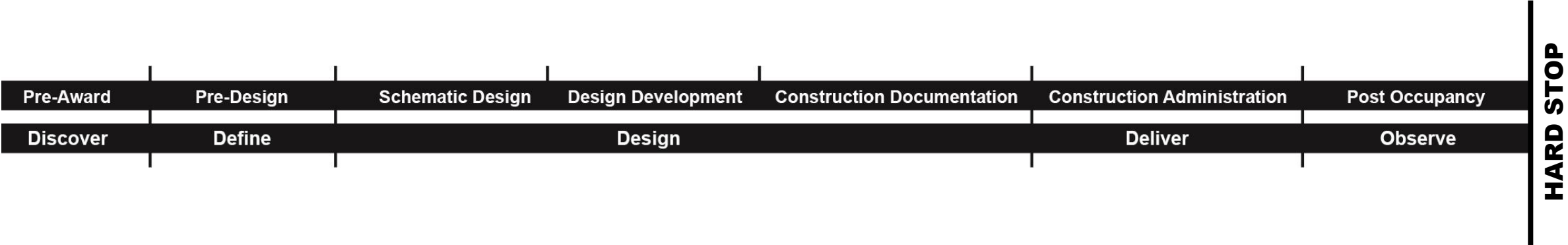


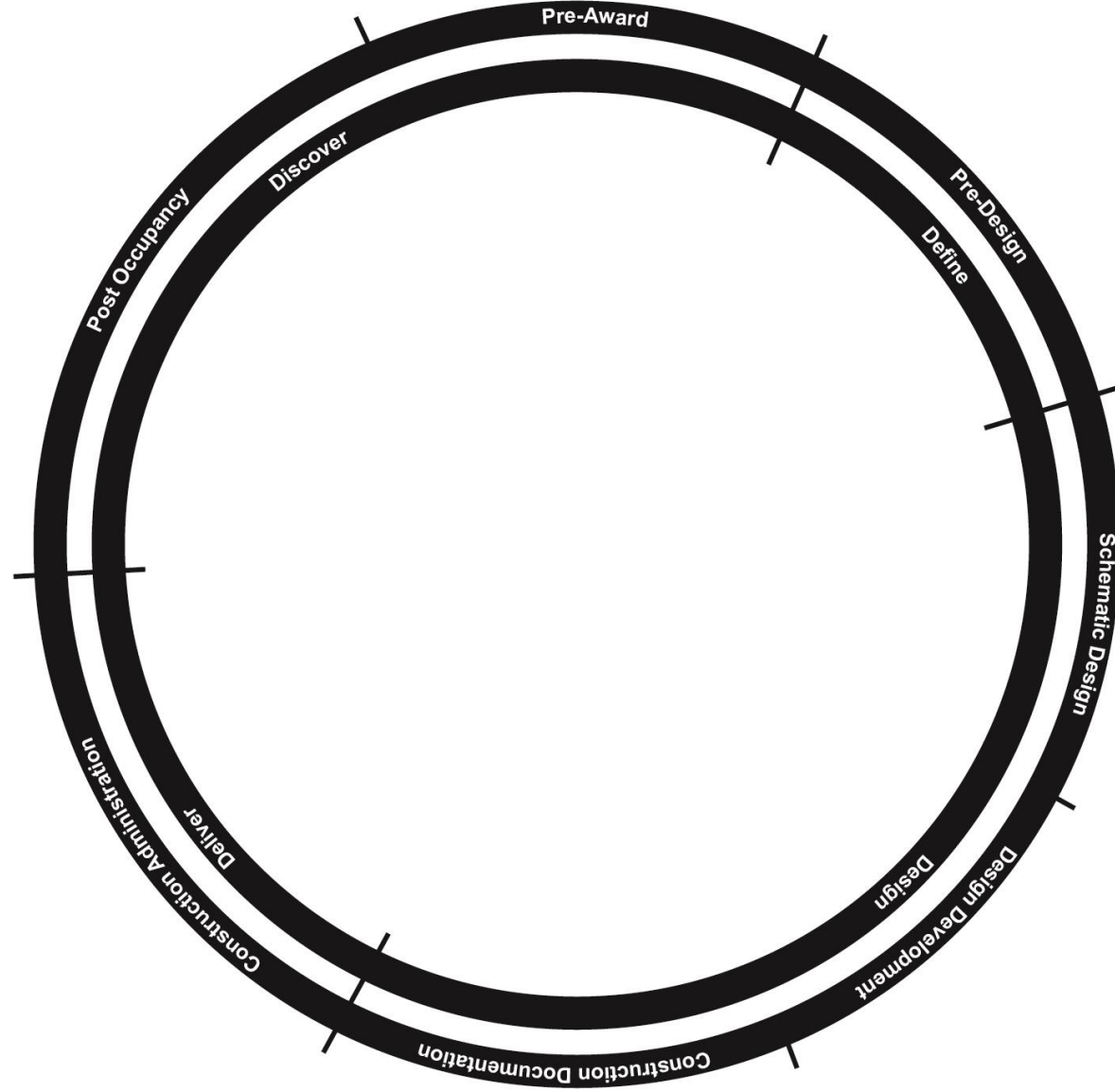




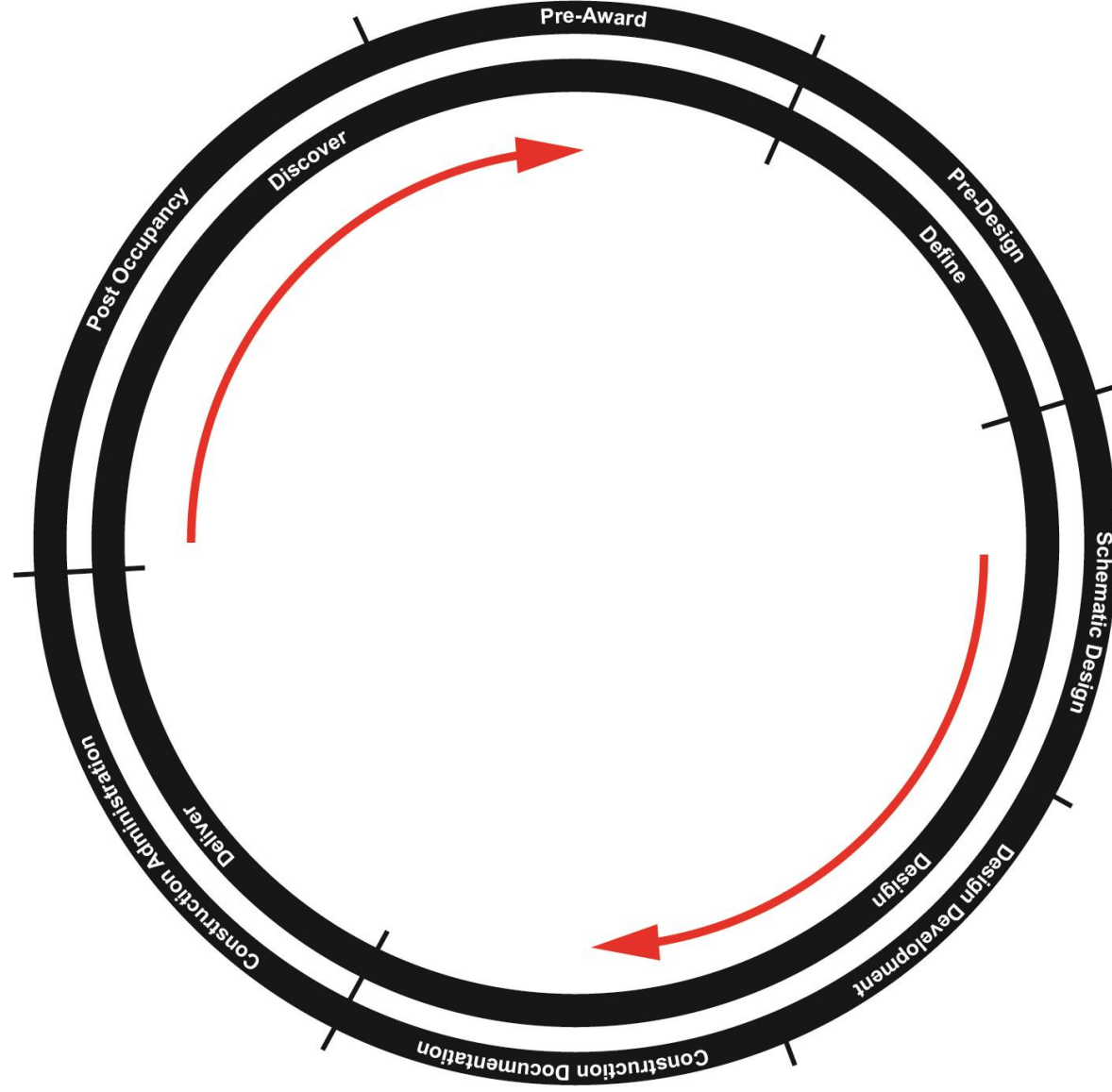


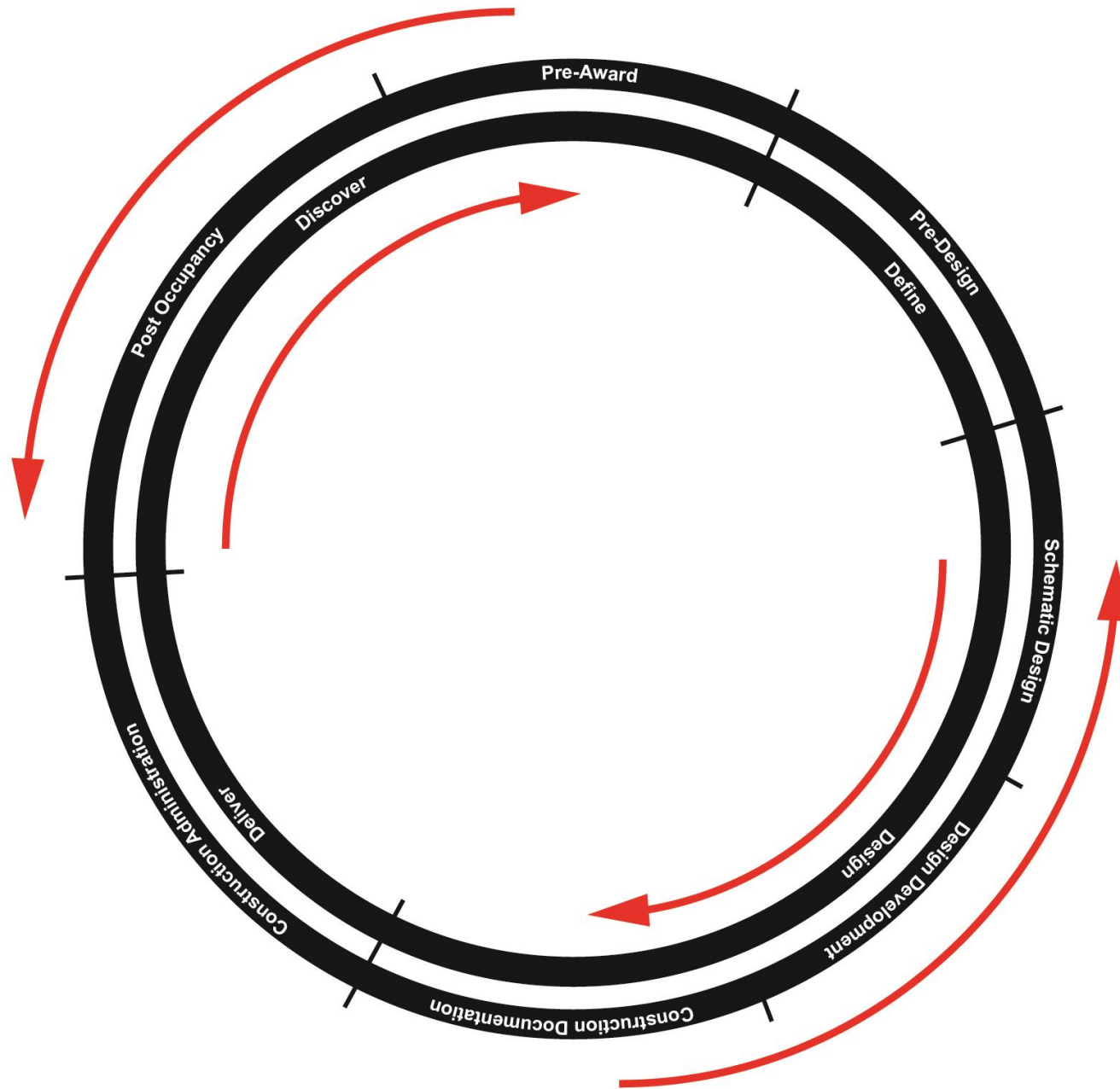
















# A FEW CASE STUDIES

ATTEMPTING TO CHALLENGE THE NORM





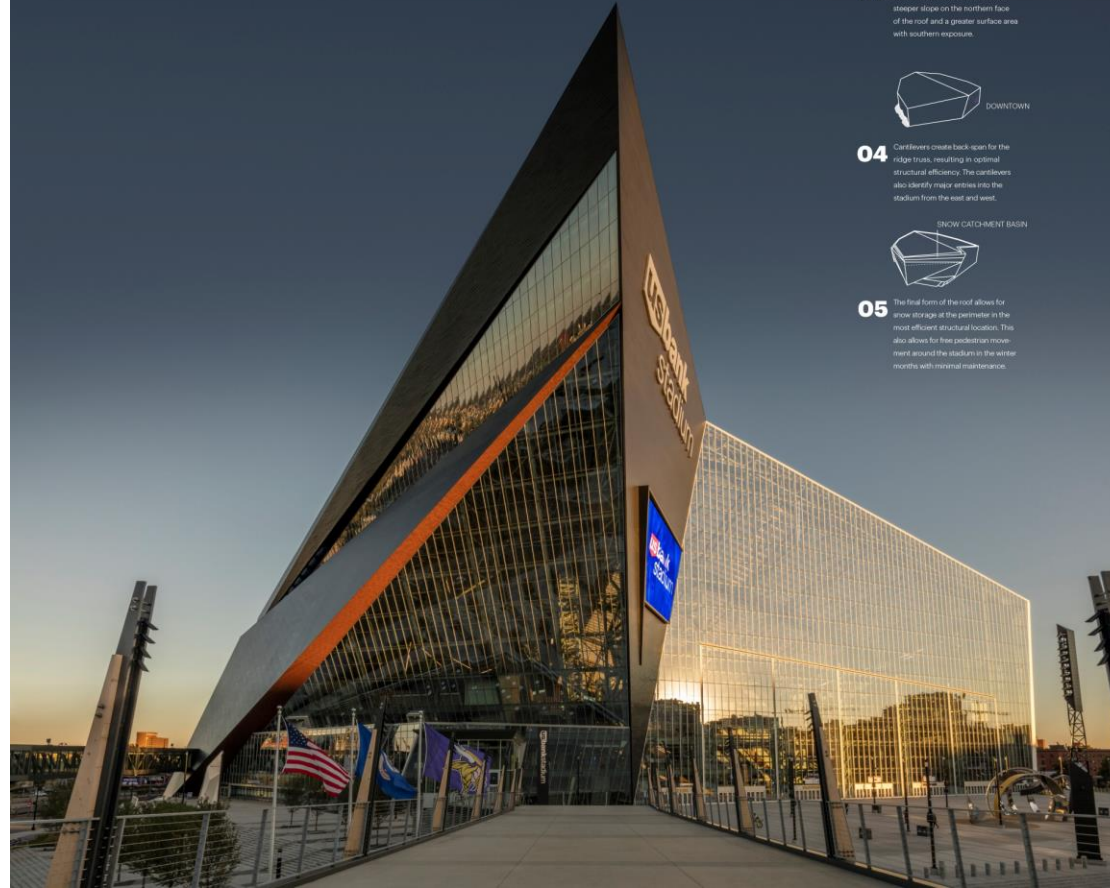
usbankstadium

# MINNEAPOLIS

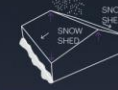
US BANK STADIUM | COMPLETED | HKS



# MINNEAPOLIS US BANK STADIUM



**01** If we used a typical shallow sloped or domed roof a huge premium would have been added to the structure of the stadium due to the snow loading requirements of Minnesota.



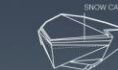
**02** Creating a steep sloped roof forms a modern-day equivalent of indigenous structures built in northern climates and allows for snow to be efficiently shed from the roof.



**03** The ridge line is modified into an asymmetrical shape, allowing for a steeper slope on the northern face of the roof and a greater surface area with southern exposure.

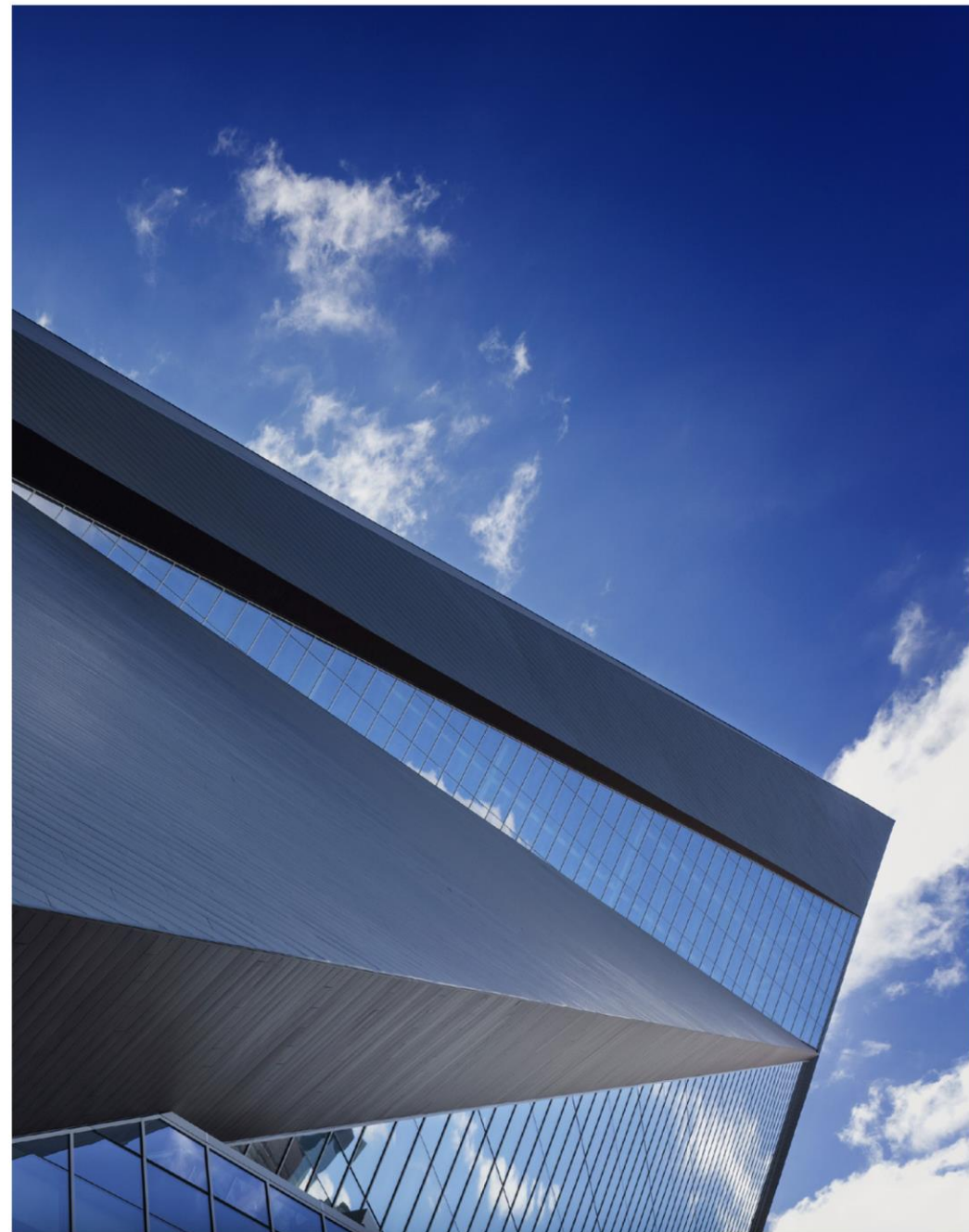


**04** Cantilevers create back-span for the ridge truss, resulting in optimal structural efficiency. The cantilevers also identify major entries into the stadium from the east and west.



**05** The final form of the roof allows for snow storage at the perimeter in the most efficient structural location. The also allows for free pedestrian movement around the stadium in the winter months with minimal maintenance.





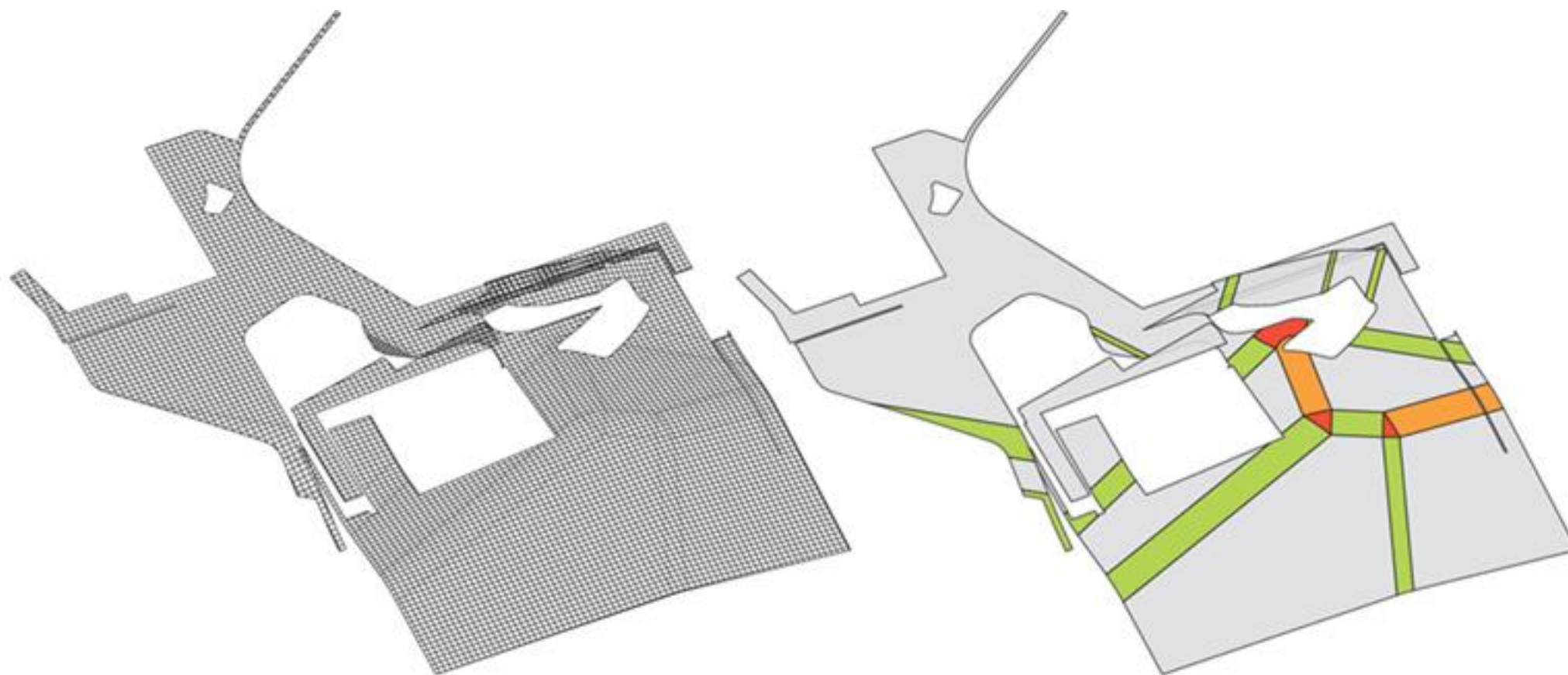




# DALLAS

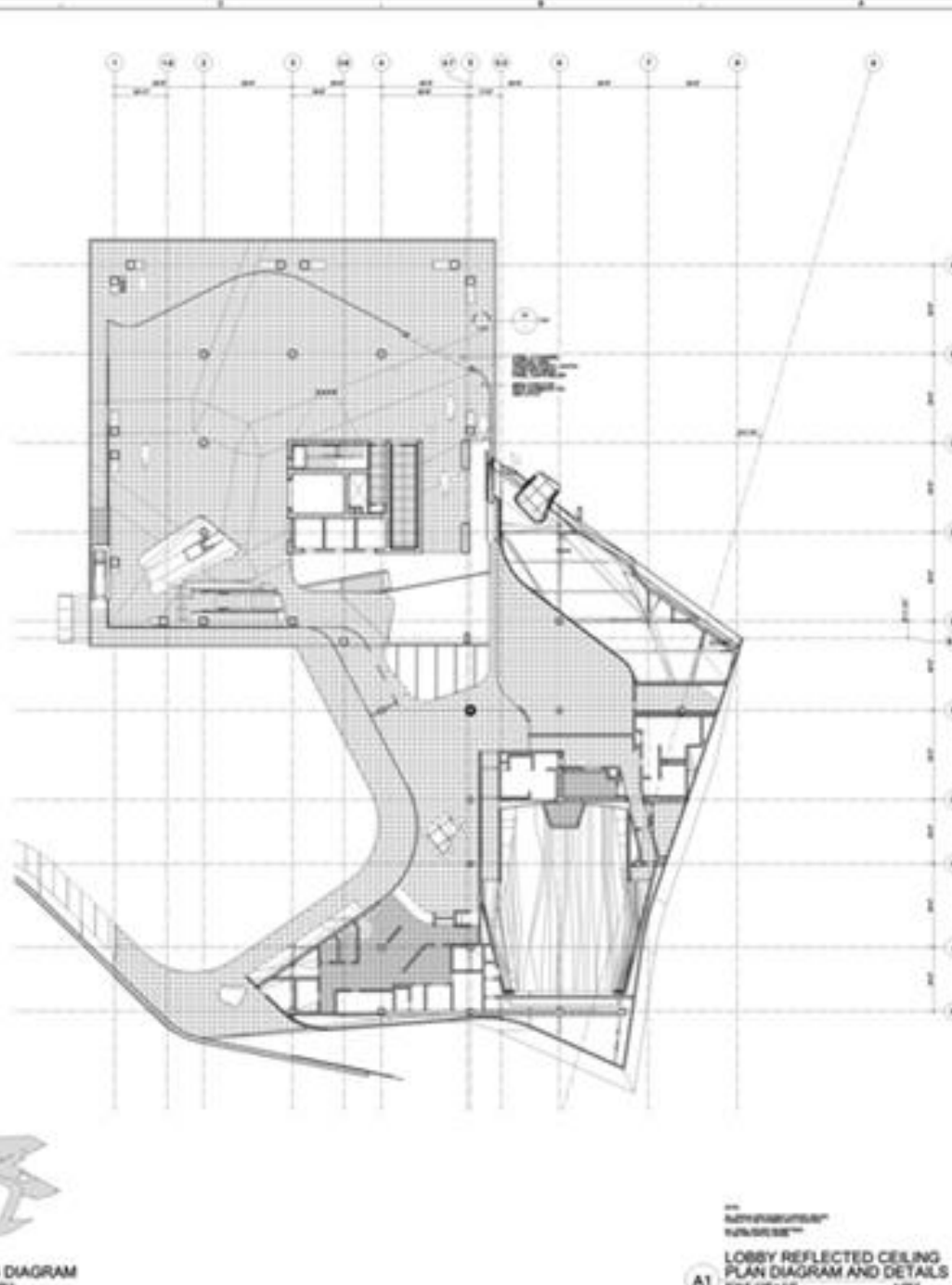
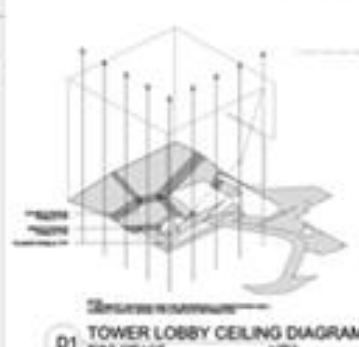
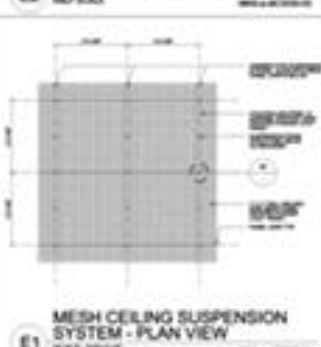
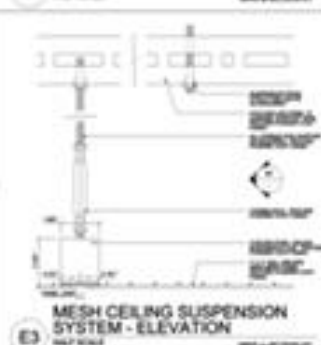
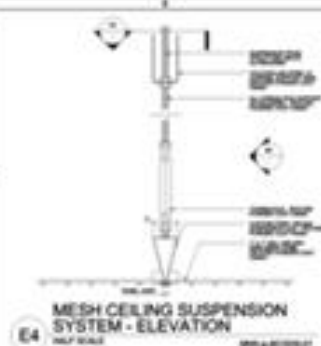
PEROT MUSEUM OF NATURE AND SCIENCE | COMPLETED | MORPHOSIS





☐ MNS CEILING GRID
 2011/05/20

- ☐ FLAT AREA : Panels can be repeatable except at the edge
- ☐ SINGLE CURVATURE (CYLINDRICAL) AREA : Panels can be repeatable except at the edge within each area  
 Each panel need to be bent, faceted or allowing gaps
- ☐ SINGLE CURVATURE (CYLINDRICAL) AREA : Panels cannot be repeatable  
 Each panel need to be bent, faceted or allowing gaps
- ☐ DOUBLE CURVATURE AREA : Panels cannot be repeatable  
 Each panel need to be bent, faceted or allowing gaps



**MUSEUM OF  
NATURE &  
SCIENCE**  
DALLAS, TEXAS

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**PROJECT:** mOrchestra®  
 100% Construction Documents  
 100% Construction Documents  
 100% Construction Documents

**Good Fulton & Farnell**  
 100% Construction Documents  
 100% Construction Documents  
 100% Construction Documents

---

**REVISIONS:**

DATE	BY	DESCRIPTION
01-10-2010	WFL	100% CONSTRUCTION DOCUMENTS
01-10-2010	WFL	100% CONSTRUCTION DOCUMENTS
01-10-2010	WFL	100% CONSTRUCTION DOCUMENTS
01-10-2010	WFL	100% CONSTRUCTION DOCUMENTS

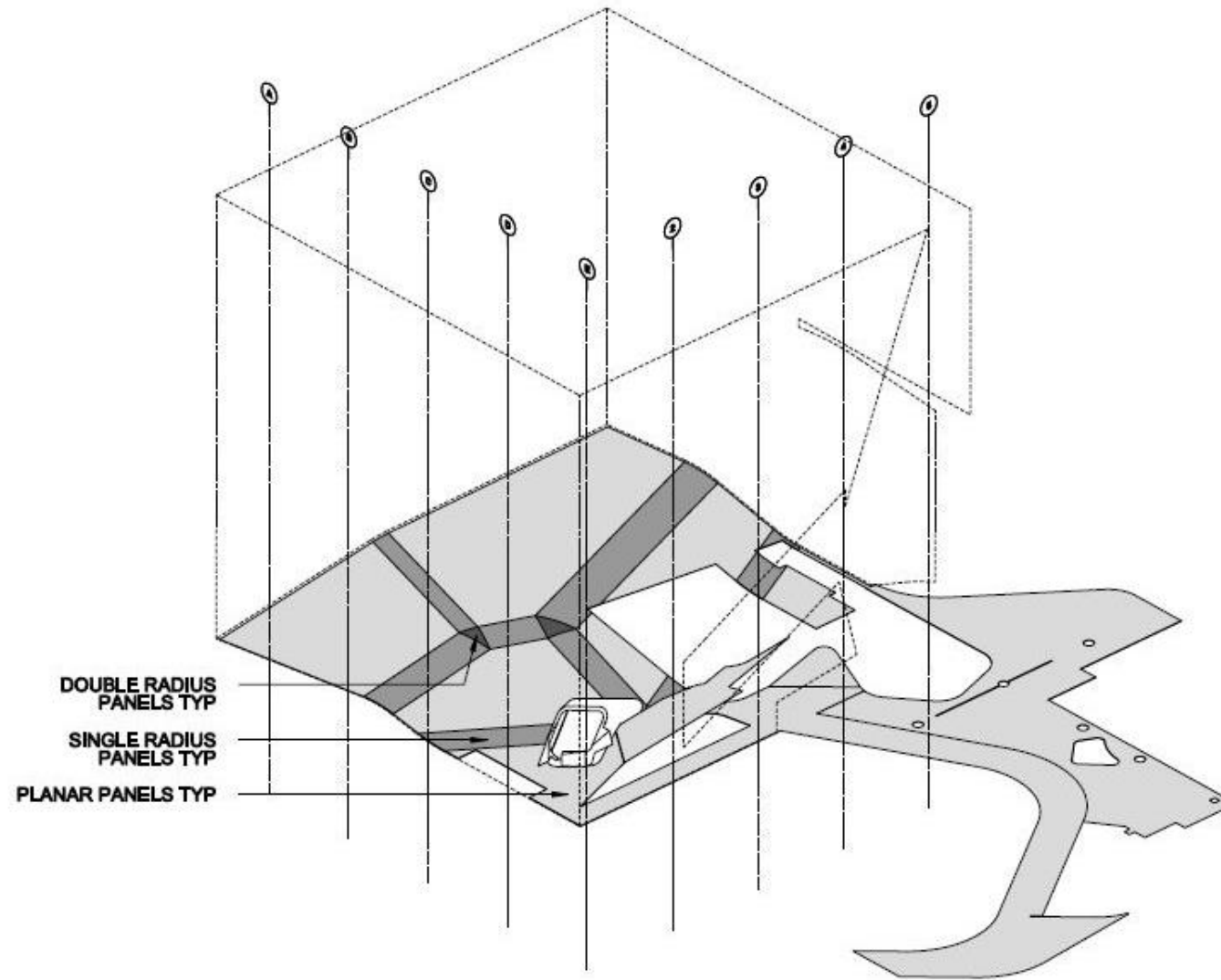
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**100% CONSTRUCTION DOCUMENTS**

**LOBBY RCP DIAGRAM AND DETAILS**

**A-160.0**





D1

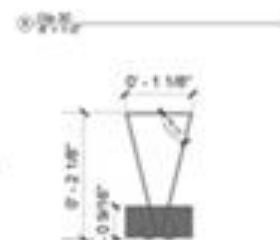
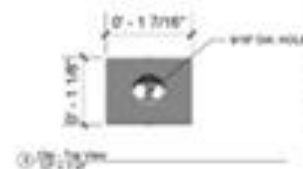
# TOWER LOBBY CEILING DIAGRAM

SCALE: 1/16" = 1'-0"

a-160.0







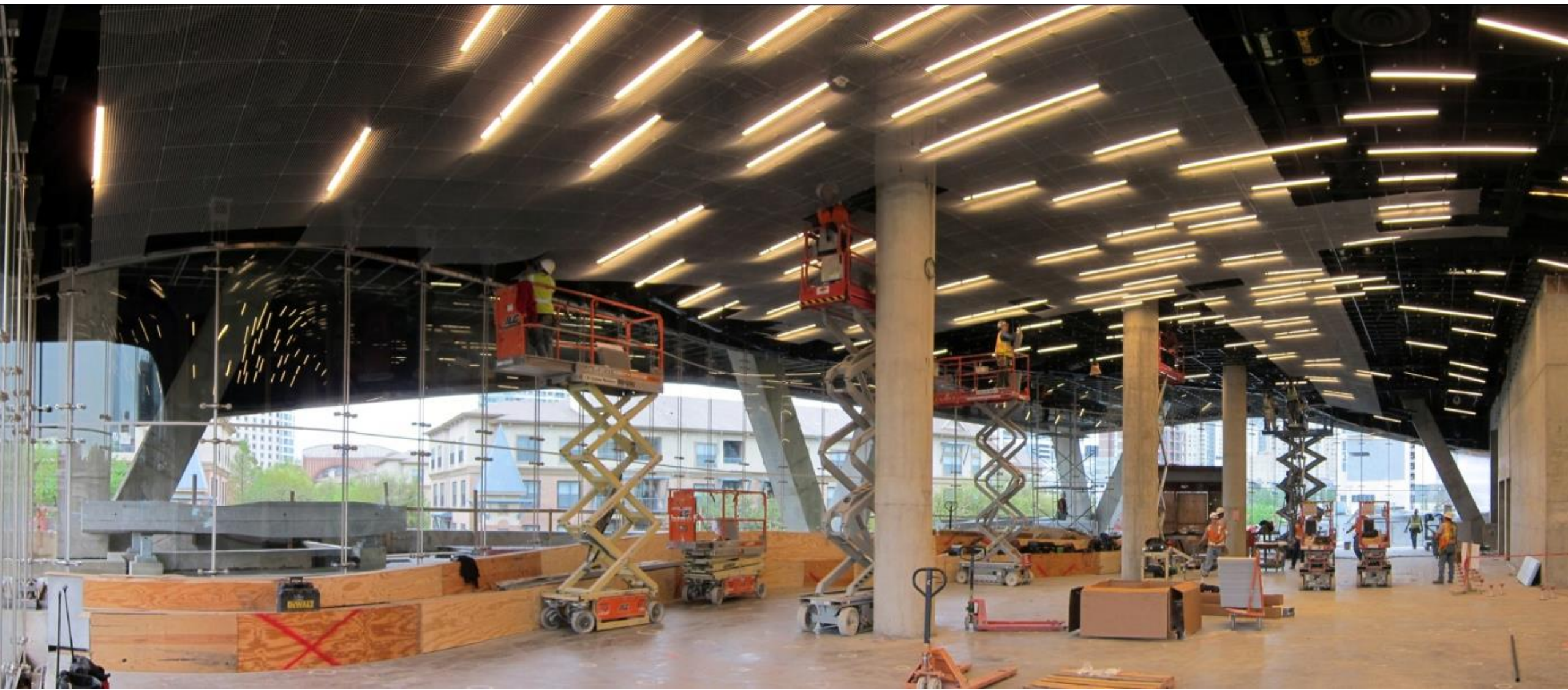
Time	As indicated
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MNS.09580.012









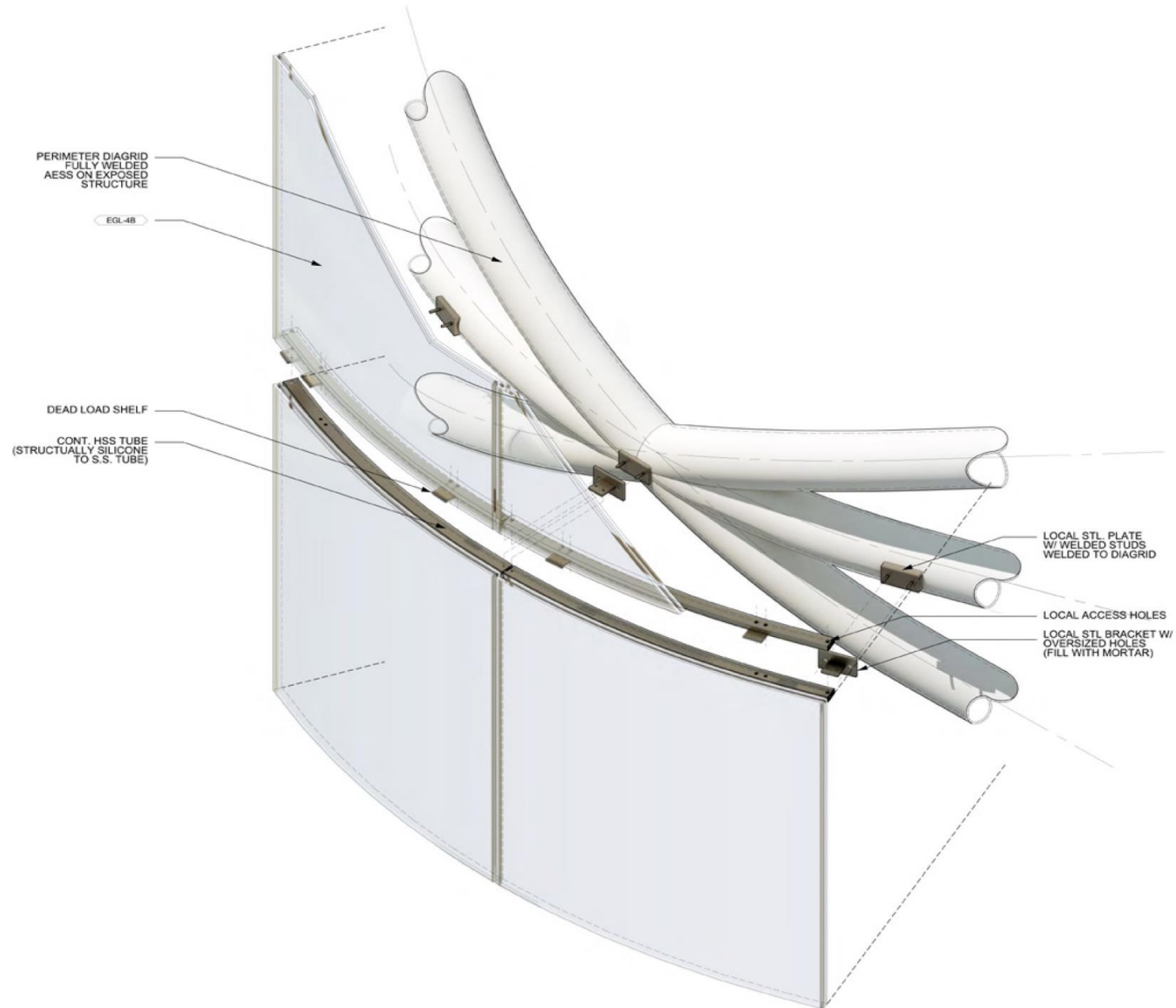




# NEW YORK

BLOOMBERG CENTER | COMPLETED | MORPHOSIS

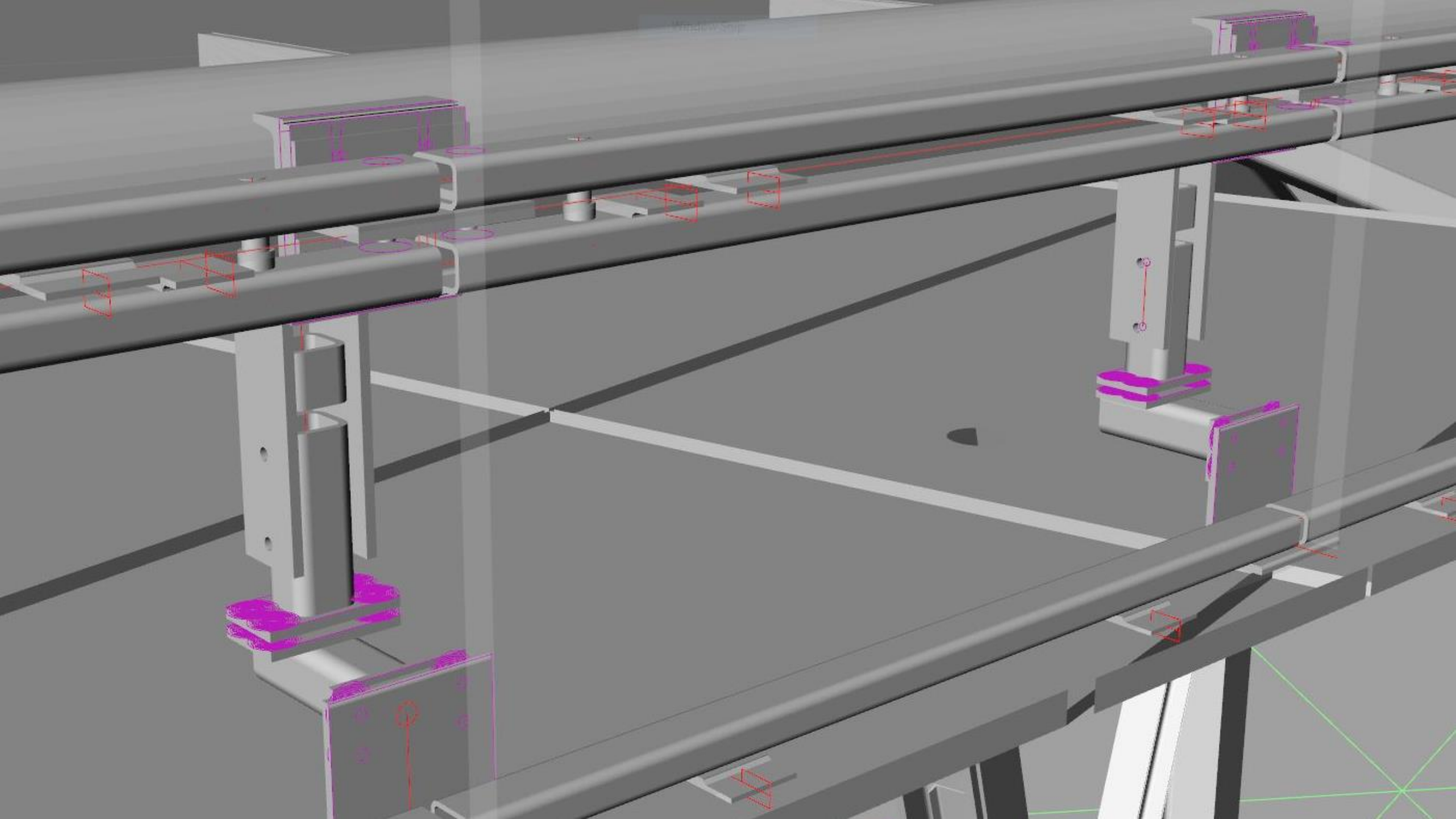




**B1** STAIR 5 CURTAIN WALL AXON

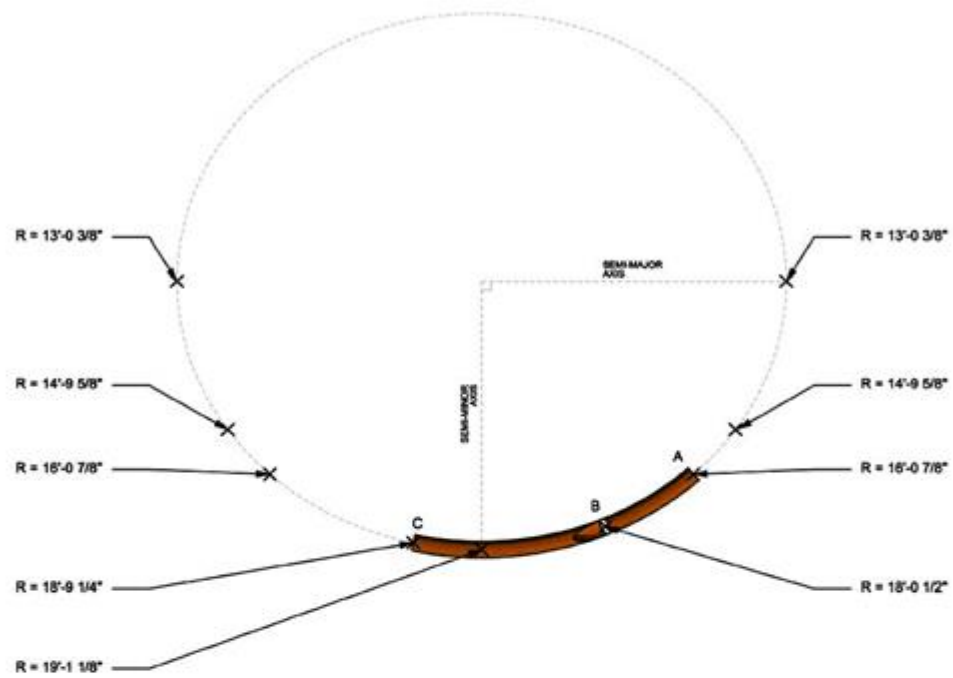
SCALE: N.T.S.

a-dtB2010-58

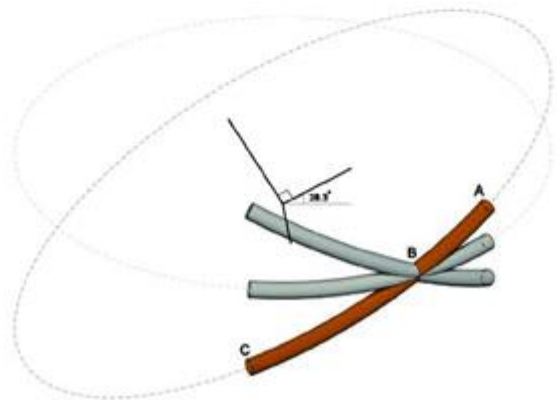
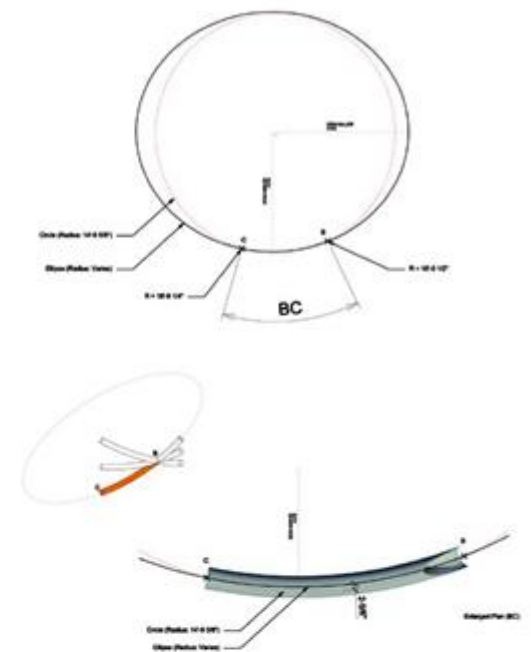
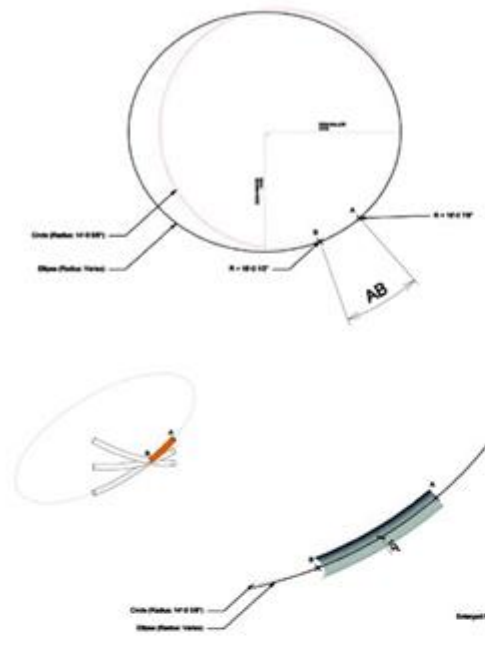


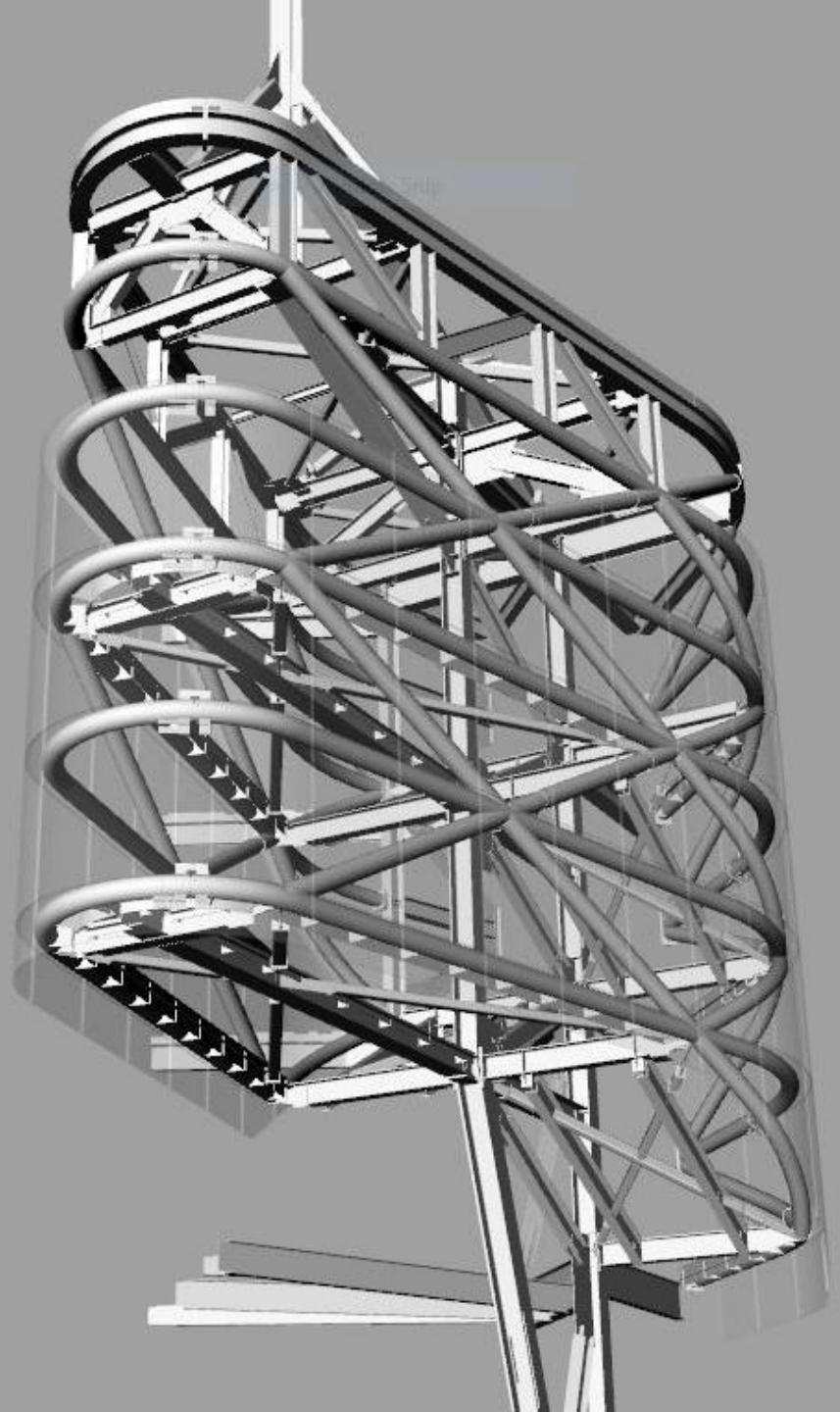
Window Strip





Plan - Ellipse

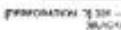






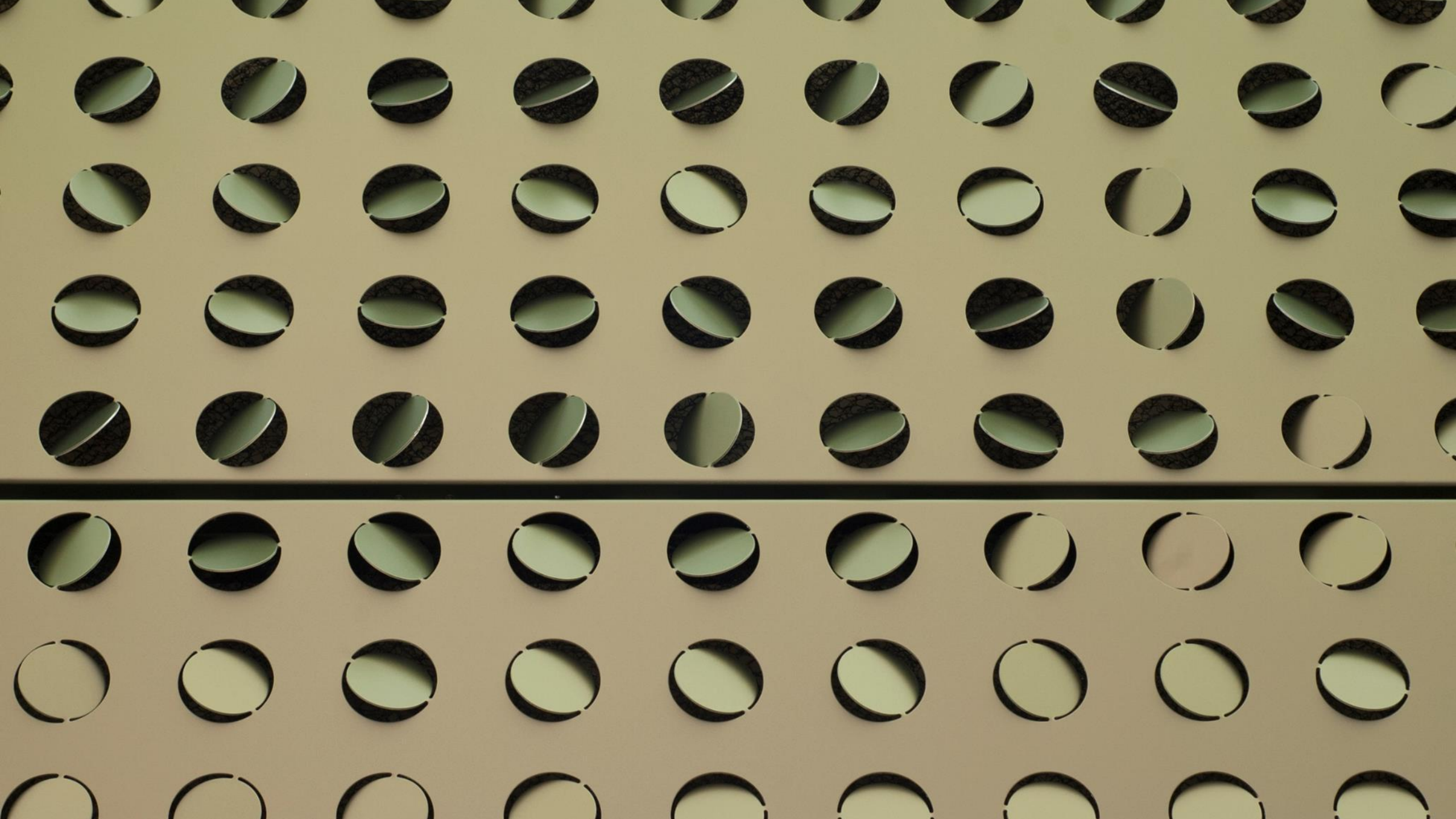




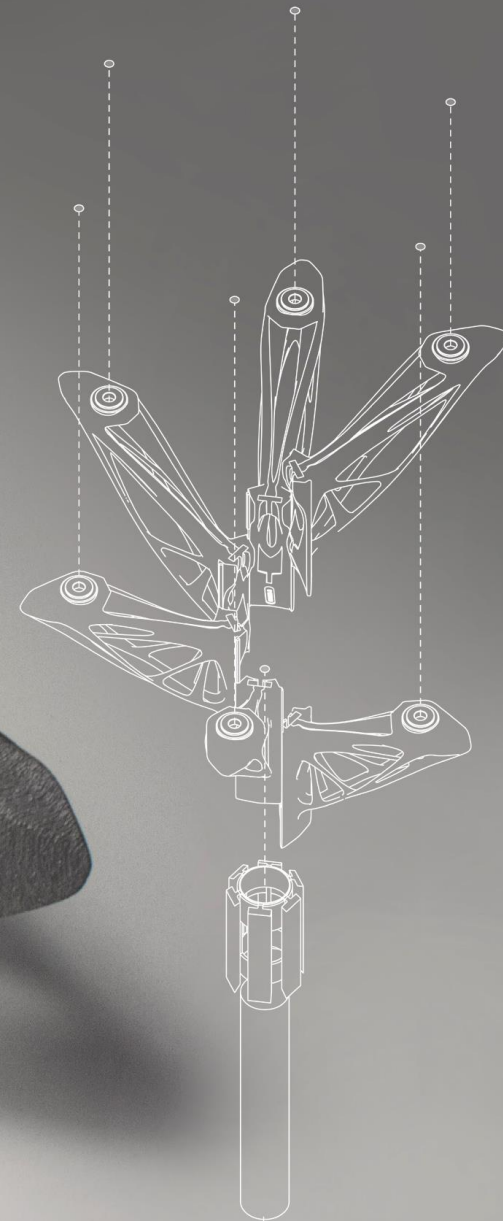
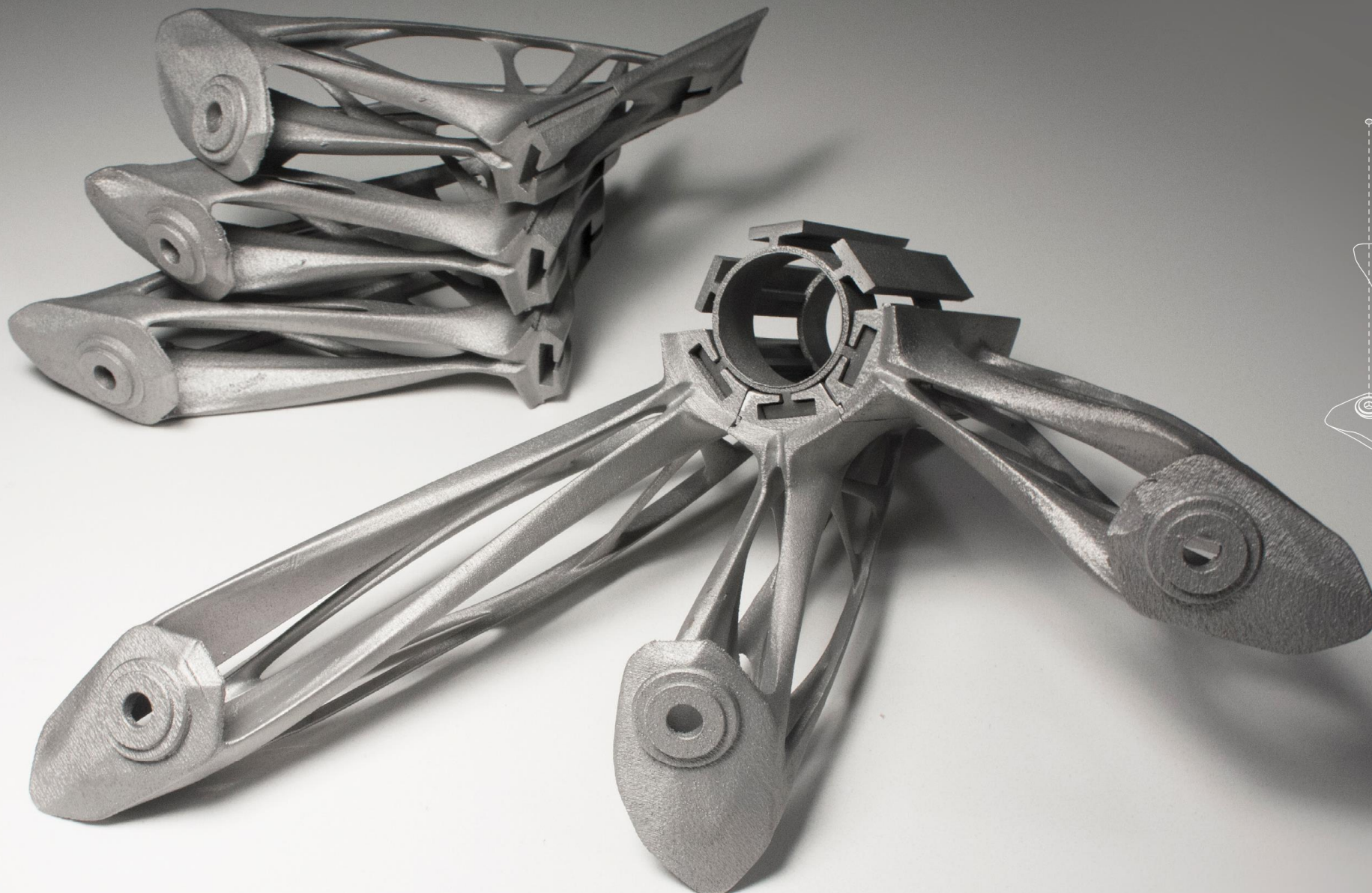






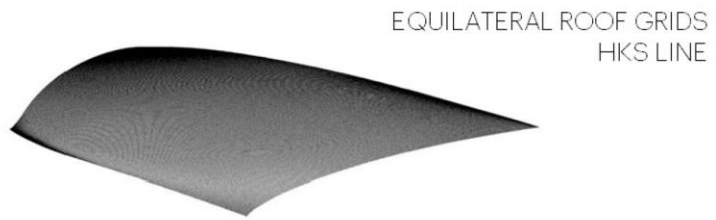






# UNDISCLOSED

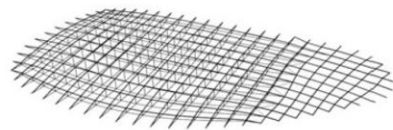
UNDISCLOSED // UNDER CONSTRUCTION // HKS



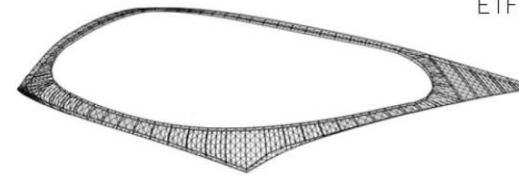
EQUILATERAL ROOF GRIDS  
HKS LINE



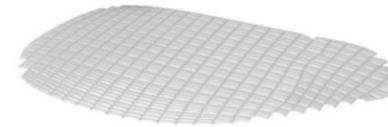
METAL PANEL SYSTEM  
LINE / HKS LA / WPM



STRUCTURAL SHELL  
WPM

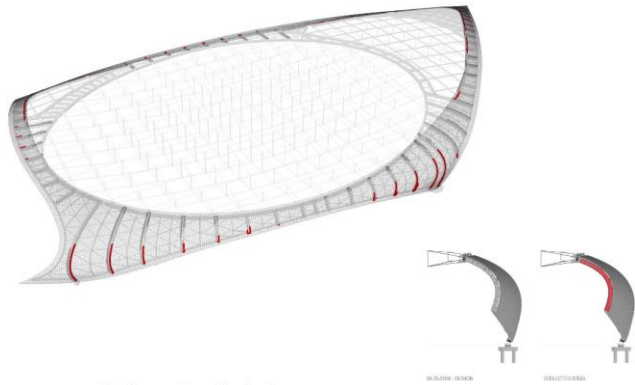


ETFE STRUCTURE  
WPM



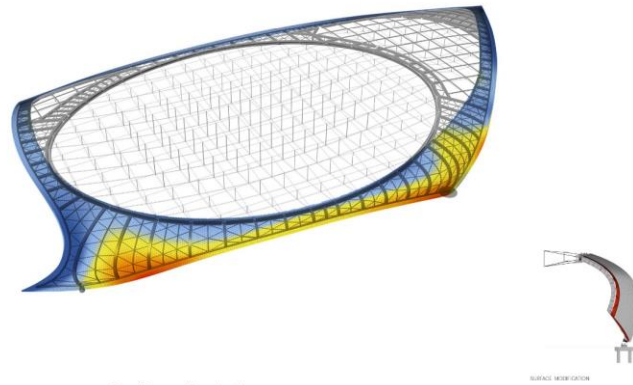
ETFE PANELS  
WPM





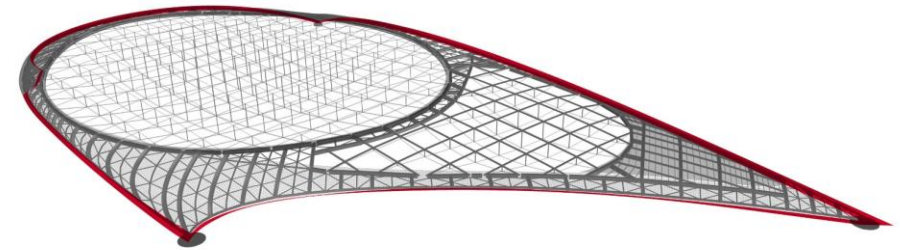
### Deformation Analysis

Analysis demonstrates non-conforming clearances between deflected primary steel girders and desired design surface.



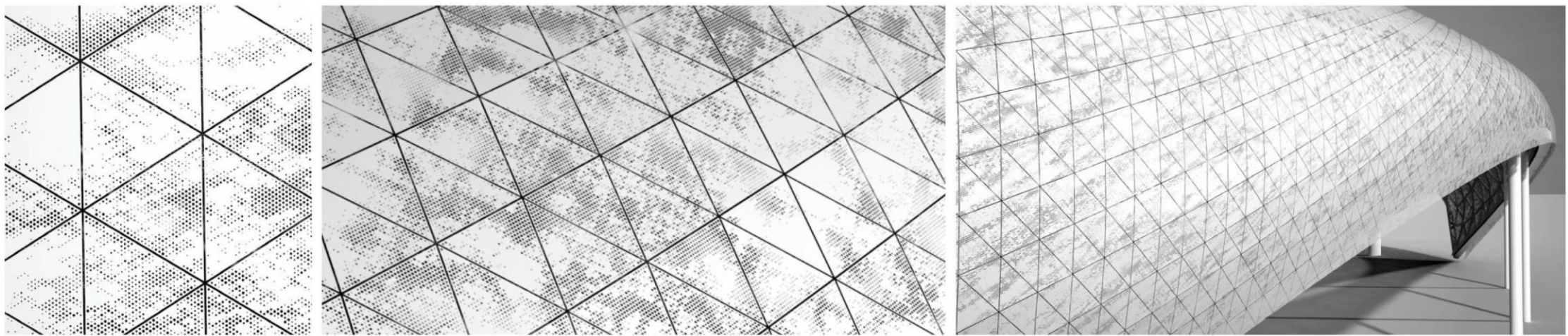
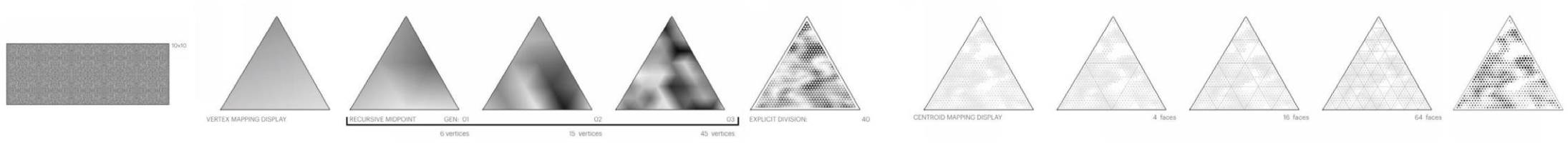
### Surface Deviation

Visualization of surface modifications required for adequate clearance between deformed primary structure and prefabricated skin.

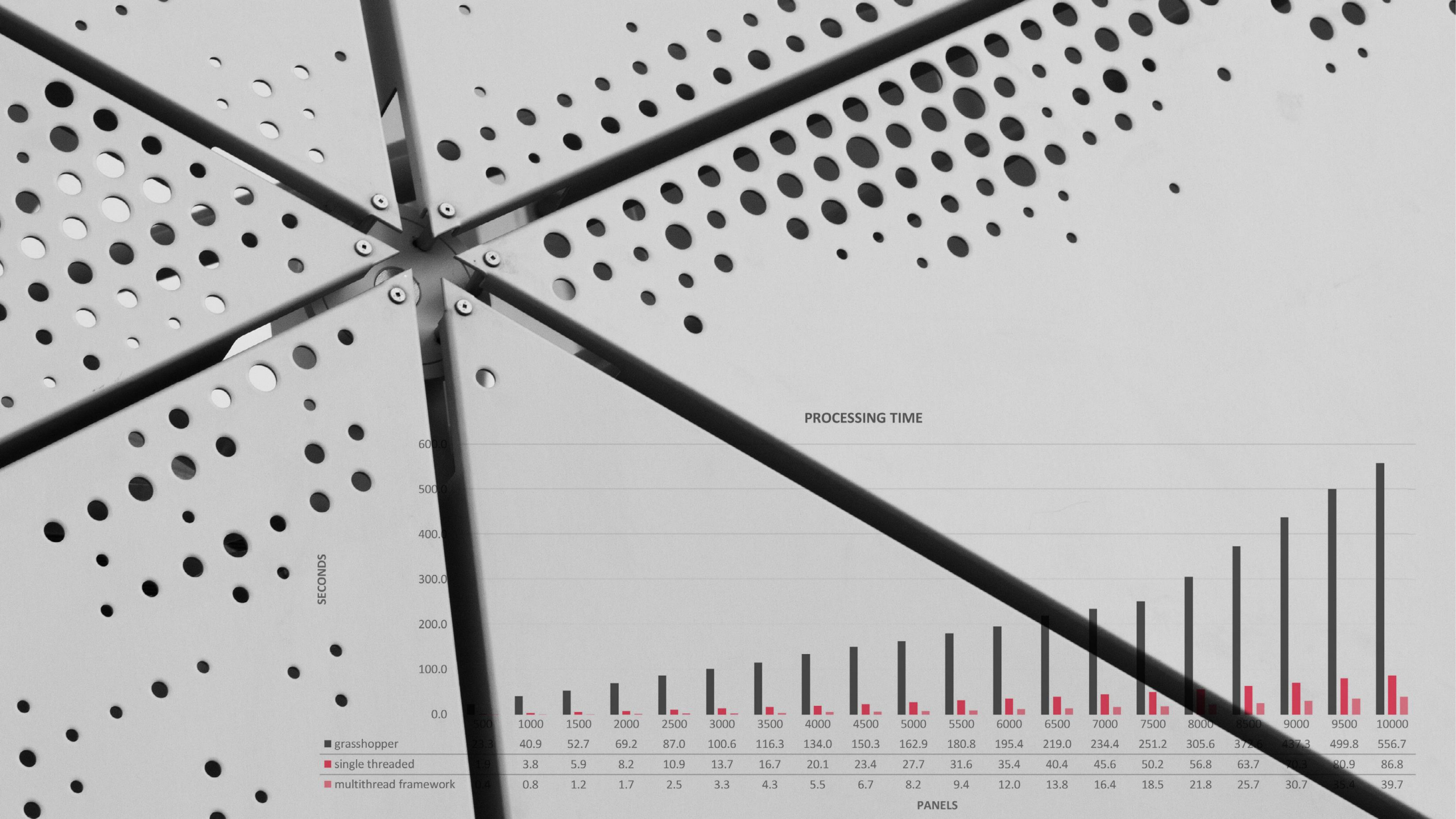


### Fascia Modifications

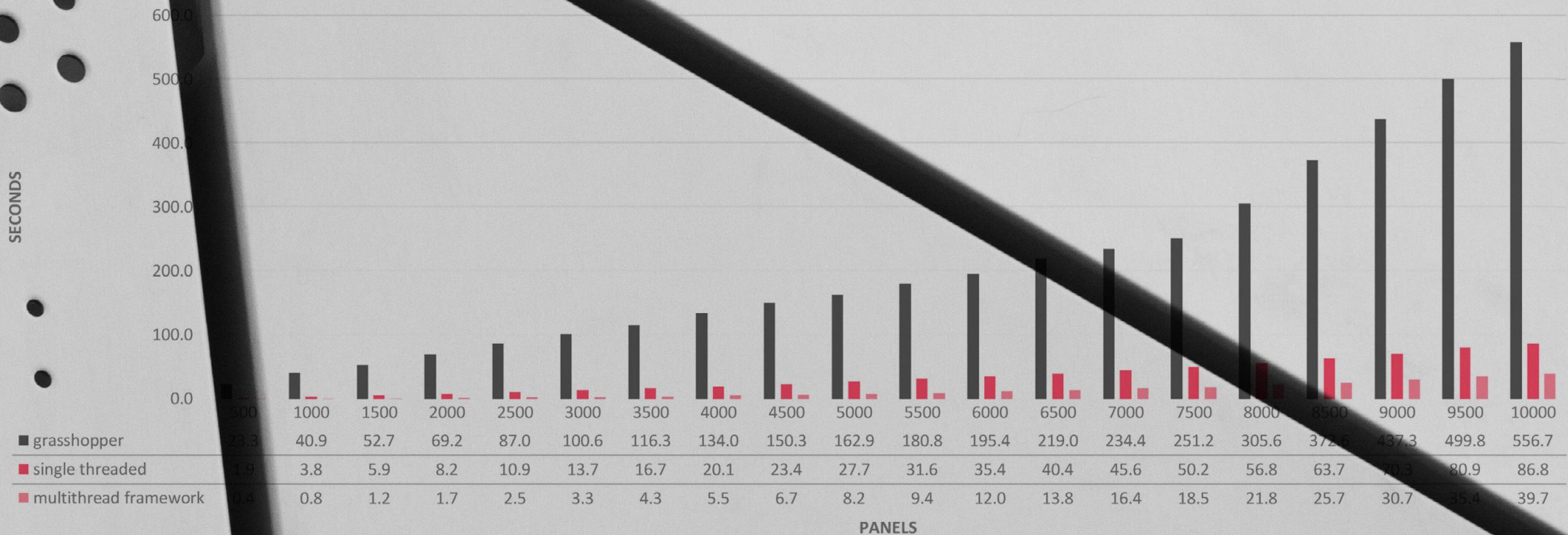
Surface area increases resulting from skin modification was partially offset by refinements to fascia and soffit conditions.







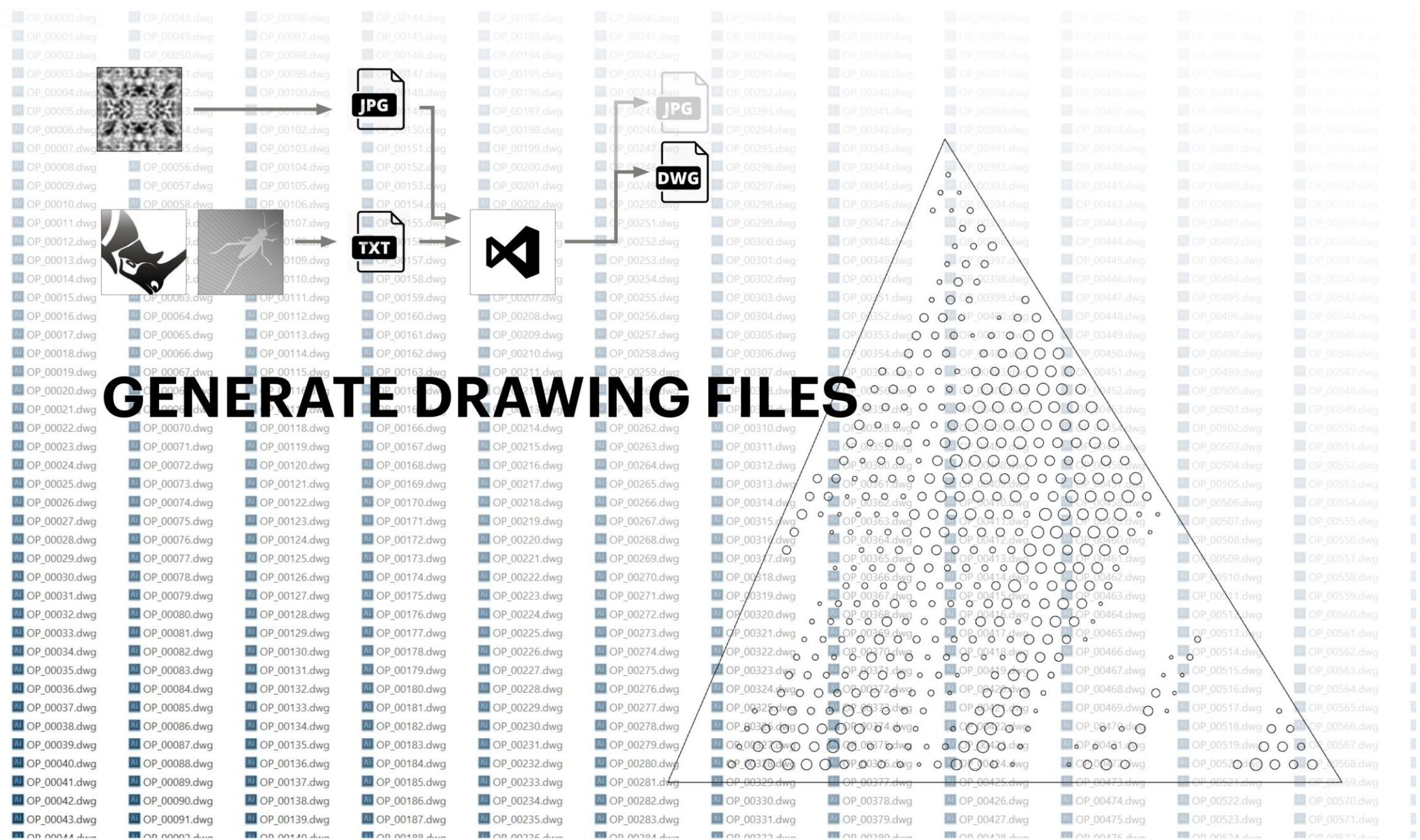
PROCESSING TIME



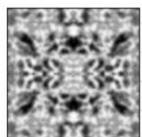




**GENERATE DRAWING FILES**







**ZAHNER®**

**GENERATE TEXT FILES**

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3 // PANEL PARAMETERS | UNITS [ INCHES ]
4 // RELEASE DATE: 2016:1:19 | TIME: 8:41:51
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16 // UVM: ( 0.03967894, 0.99998828, 0.00000000 )
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18 // AREA GROSS: 2354.503906 [ SQ.INCH ]
19 // AREA NET: 2104.919096 [ SQ.INCH ]
20 // CAPACITY: 10.600314 [ % ]
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22 // [ DEGREES ]
23 // A1: 39.7
24 // A2: 54.9728
25 // SUM: 180
26
27 // NODE POSITIONS:
28 // [ LOCAL COORDINATES ]
29 // ( X, Y, Z )
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34 // PANEL ORIENTATION VECTOR:
35 // VEC: ( 0, 0, 1 )
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37 // CORNER POSITIONS:
38 // FASTENER POSITIONS: { POS: DIAMETER: }
39 // PERFORATION DATA: { POS: DIAMETER: }
40 // PERFORATION COUNT: 5950457
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70 POS: ( 57.3871994, 1.86246407, 21 ) DIA: 0
71 POS: ( 59.33842087, 1.86246407, 22 ) DIA: 0.75
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Digital Seal - Verify

Project Name:  
**HKS Project**

Project Number:  
**00000.000**

Issue Date:  
**04/07/2017**

Issue Name:  
**CONSTRUCTION DOCUMENTS**



John H. Doe

Issue File:

Local File:

Project Team:

Architect - Bowl / Interiors / Branding  
HKS, Inc.  
350 N Saint Paul, Suite 100  
Dallas, TX 75201

Files In Issue:

File Name	Valid
2016-04-01 OVIS - UPDATED TRISKIN LAYOUT.3dm	Valid
Cnvs_Faceted_Spiral.json	Valid
Experimental_Triangles.gh	Valid
Zahner-panel fastener spacing .pdf	Valid

Extract

Check

Load Issue

Close


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Zahner-panel fastener spacing .pdf	Unchecked

Extract

Check

Load Issue

Close





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