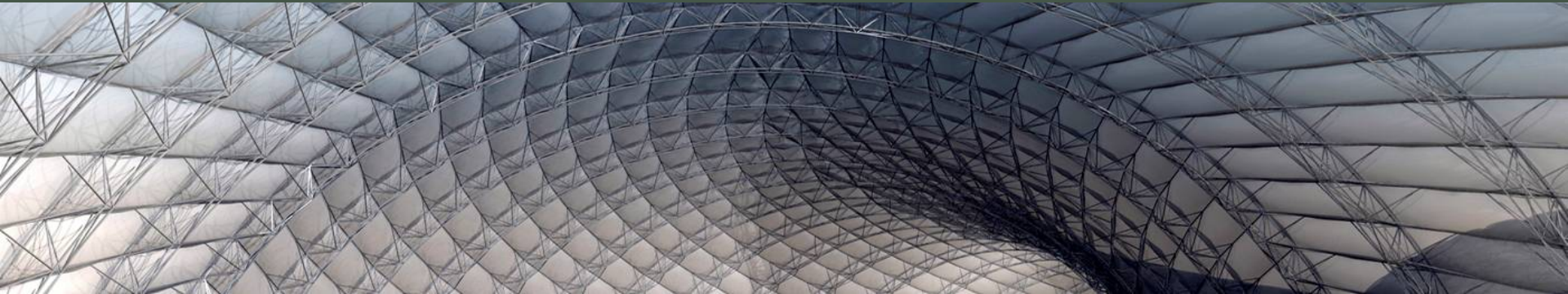


Engineering Complex Geometry Structures
Buro Happold Hong Kong
Rob May



Buro Happold



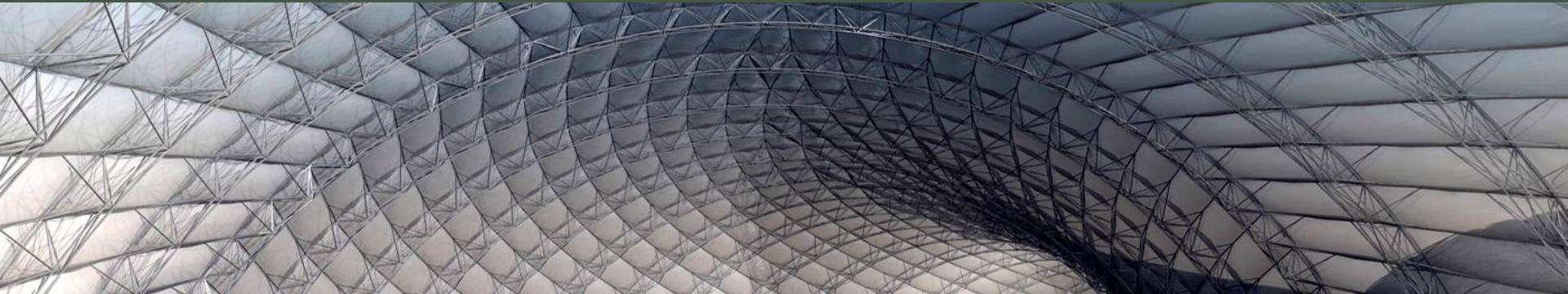
- **Complex Geometry Structures**
- **Structural Tools for Complex Geometry**
- **Building Information Modelling for Complex Geometry**
- **Example Early Projects**
- **Example Recent Project**
- **goBIM**



BIM Complex Geometry Structures



Buro Happold



- Those with highly irregular geometric form
- Typically respond to architectural aspirations.
- May be efficient *if* appropriate tools are employed to rationalise and refine the form.



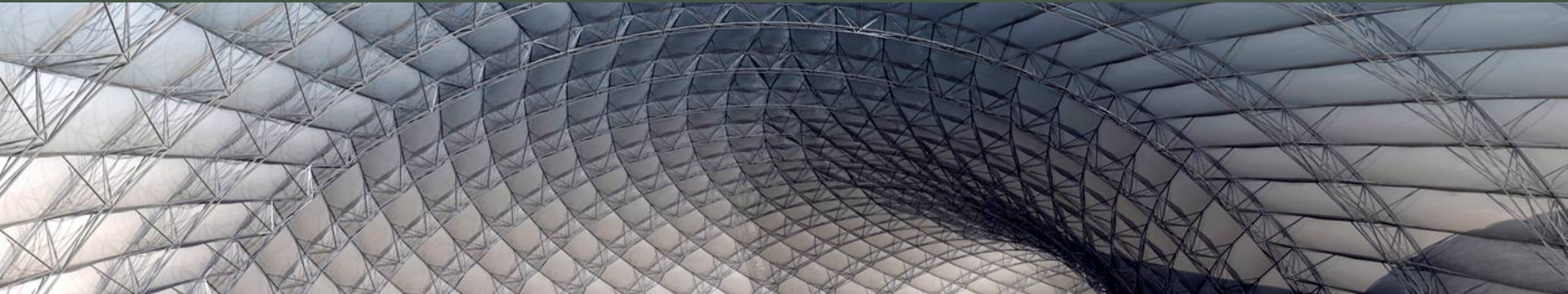
- Buro Happold originally developed a reputation for tensile structures.
- This specialised ability is still carried in the firm, however the company now undertakes most types of engineering activities.



BIM Complex Geometry Components



Buro Happold



- The following are the most a selection of the most common structural systems adopted in complex geometry structure design.



Beam Structures



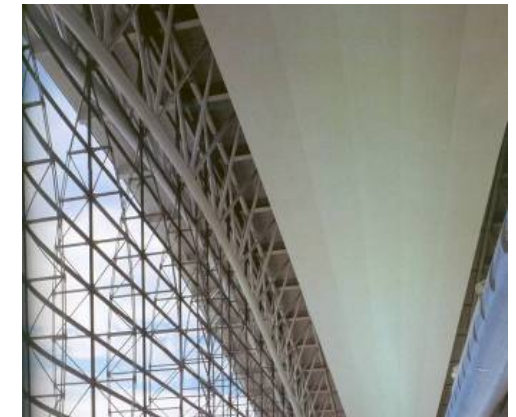
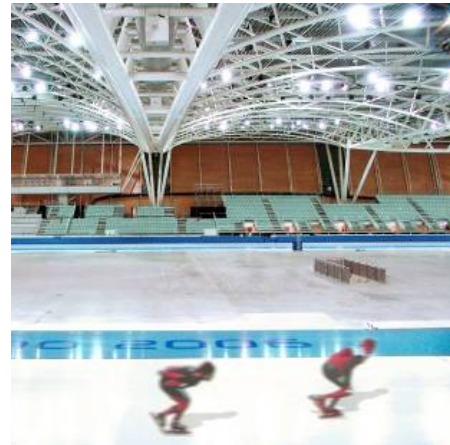
- Interesting forms can be generated through clever use of sequential beam elements.
- Typically manageable to generate via more conventional engineering modelling and drawing processes.



Truss Structures



- Similar to beam structures, although significantly more members to model.
- As the complexity of the structure increases the process required to model the node points becomes more difficult through conventional means.



Arched Structures

- Can be highly efficient depending on dominant load effect on the structure.
- Potential for optimisation comes through formfinding the arch shape.



Sheffield Winter Garden

Space Frame Structures



- Used in two way spanning applications.
- Detailed design typically undertaken by specialist contractor (eg Novuum Structures)
- In purest form tend to provide an out-of-fashion aesthetic if exposed.

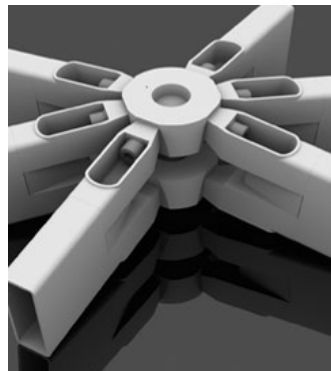




Steel Grillage Roof Structure



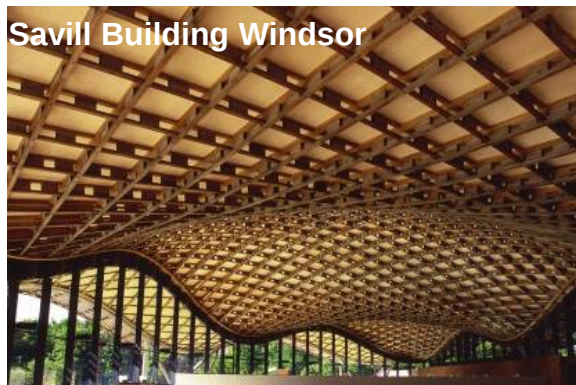
- If an appropriate form is found are extremely structurally elegant.
- Typically costly and requires significant scaffolding.
- Complex nodes which often need site welding.



Timber Gridshell Structures



- A gridshell structure is a lattice of thin timber members laid out in an orthogonal pattern and then pushed or lowered into a doubly curved form.
- Light and efficient, but requires good edge support and even more importantly, capable contractors.



Timber Lamella Grillage Structures



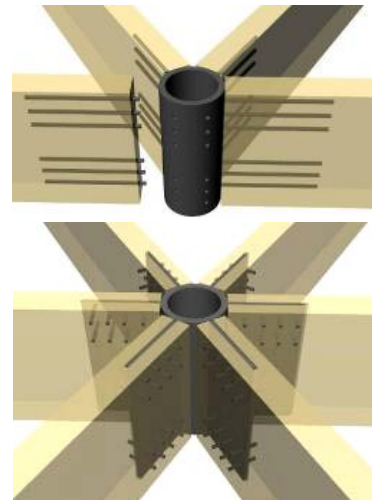
- Lamella roof grids are typically square pattern but can also be rhomboidal (which can be in-filled to give triangular patterns).
- The structure provides increased bending capacity over a gridshell structure – connections may be expensive.



Timber Geodesic Structures



- Provide a structure that can act in both bending and membrane actions depending on the geometry.
- Bending forces can be resisted by introducing ties into the structure as per the Alnwick visitor centre, maintaining some compression in the system.
- Connections can be very expensive!



Typical Node Connection

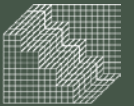


Details

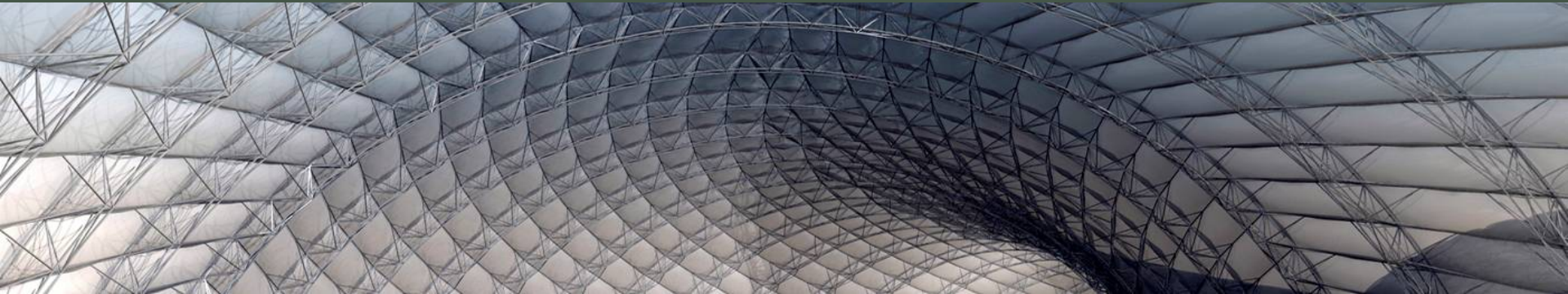
- Tensile Structures require specialist analysis typically involving a form finding process. Can be light and elegant solutions
- Pneumatic structures are those with inflated cladding systems like ETFE or PTFE. These are mounted on structural subframes and are again extremely light.



BIM Tools for Complex Structures

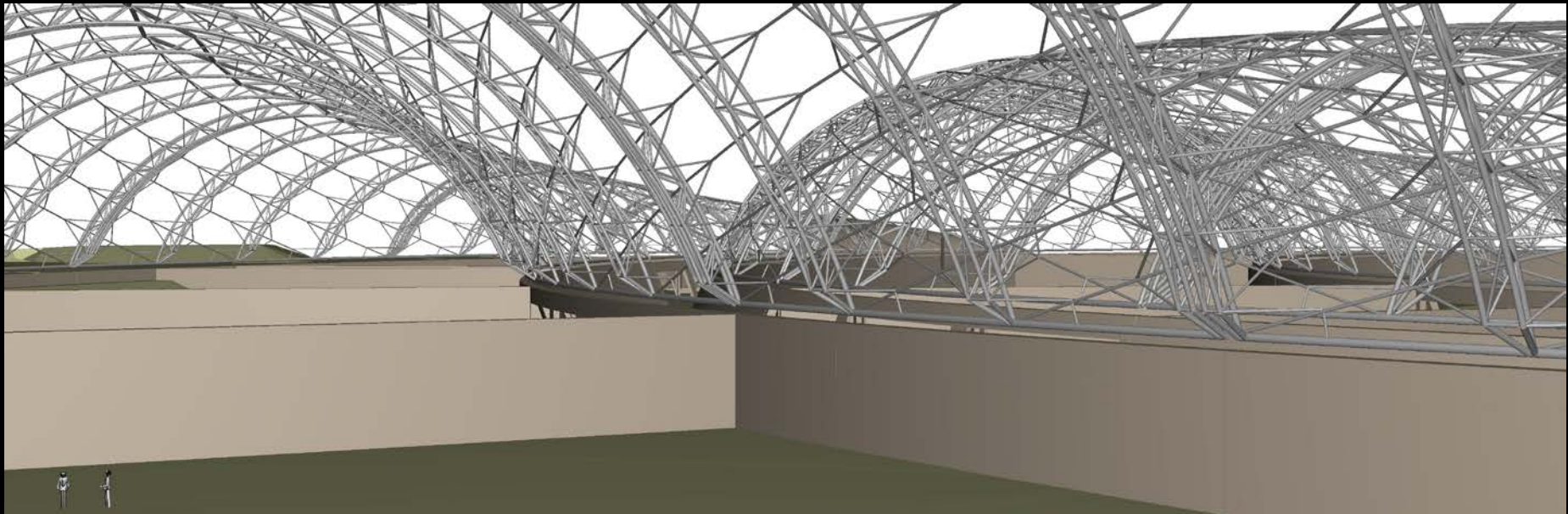


Buro Happold

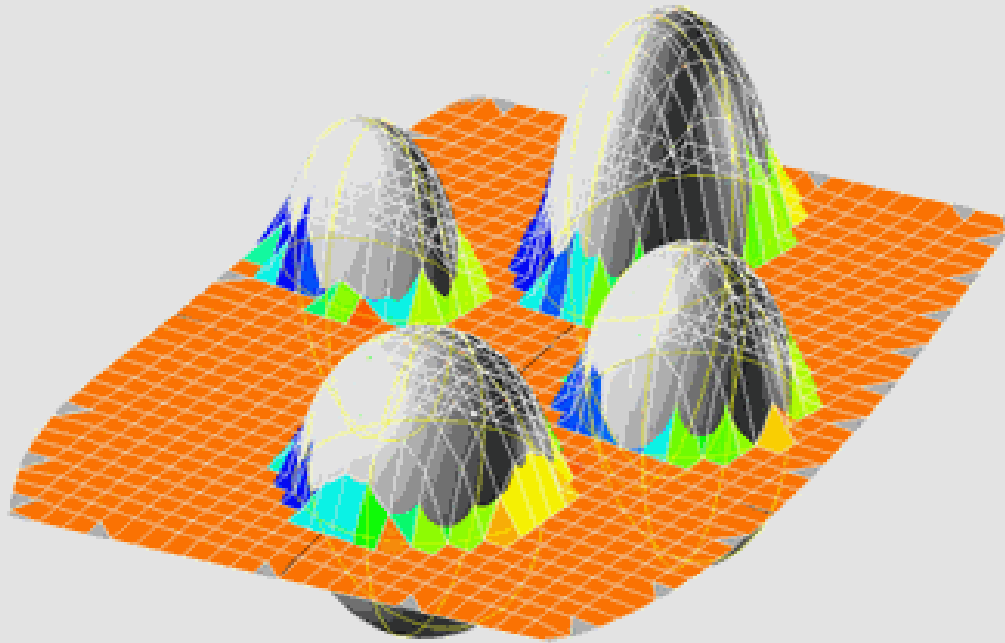


Key activities that are likely to require the structural engineer's attention are:

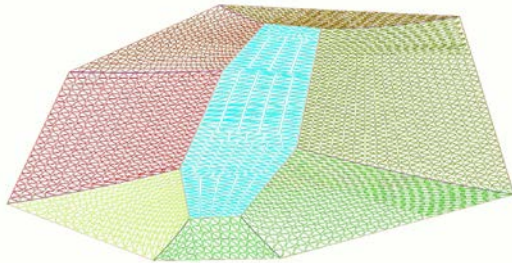
- Formfinding
- Optimisation
- Panelisation
- Form to Fabrication
- Advanced Analysis



- Fabric structures
- Minimal surfaces
- Efficient shapes

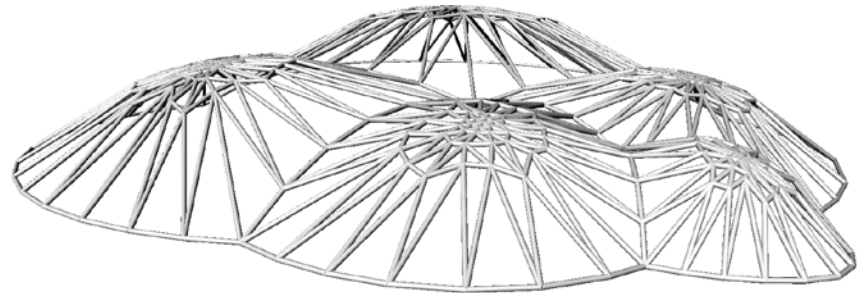


Form



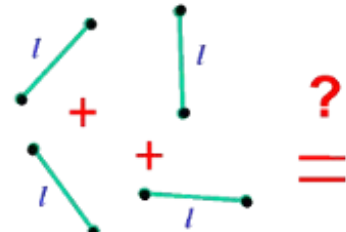
Scunthorpe Sports Academy

Grid

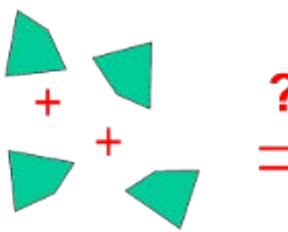




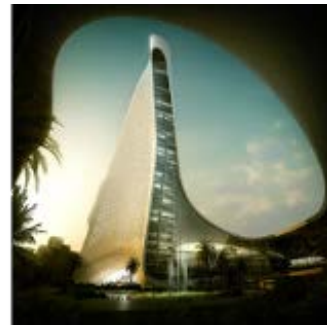
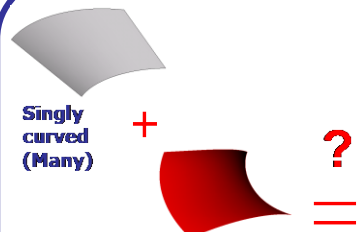
Flat 4-sided panels

Equal length members

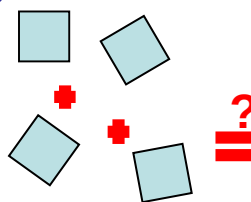



Identical panels

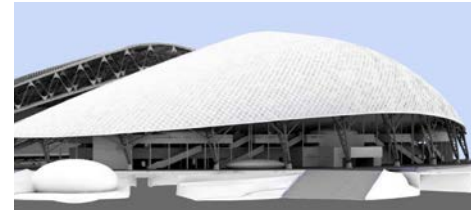



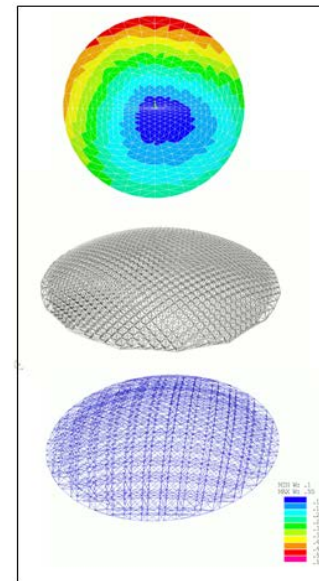
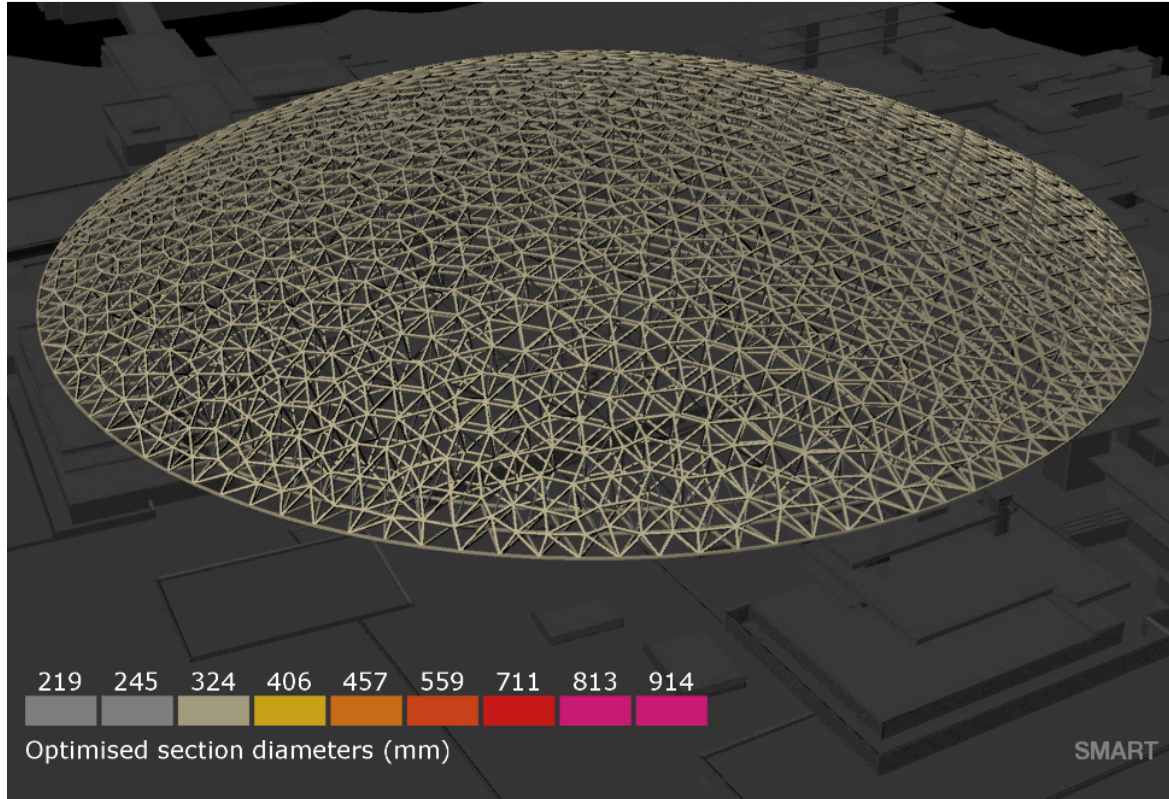
Singly curved (Many)

Doubly curved (Few)

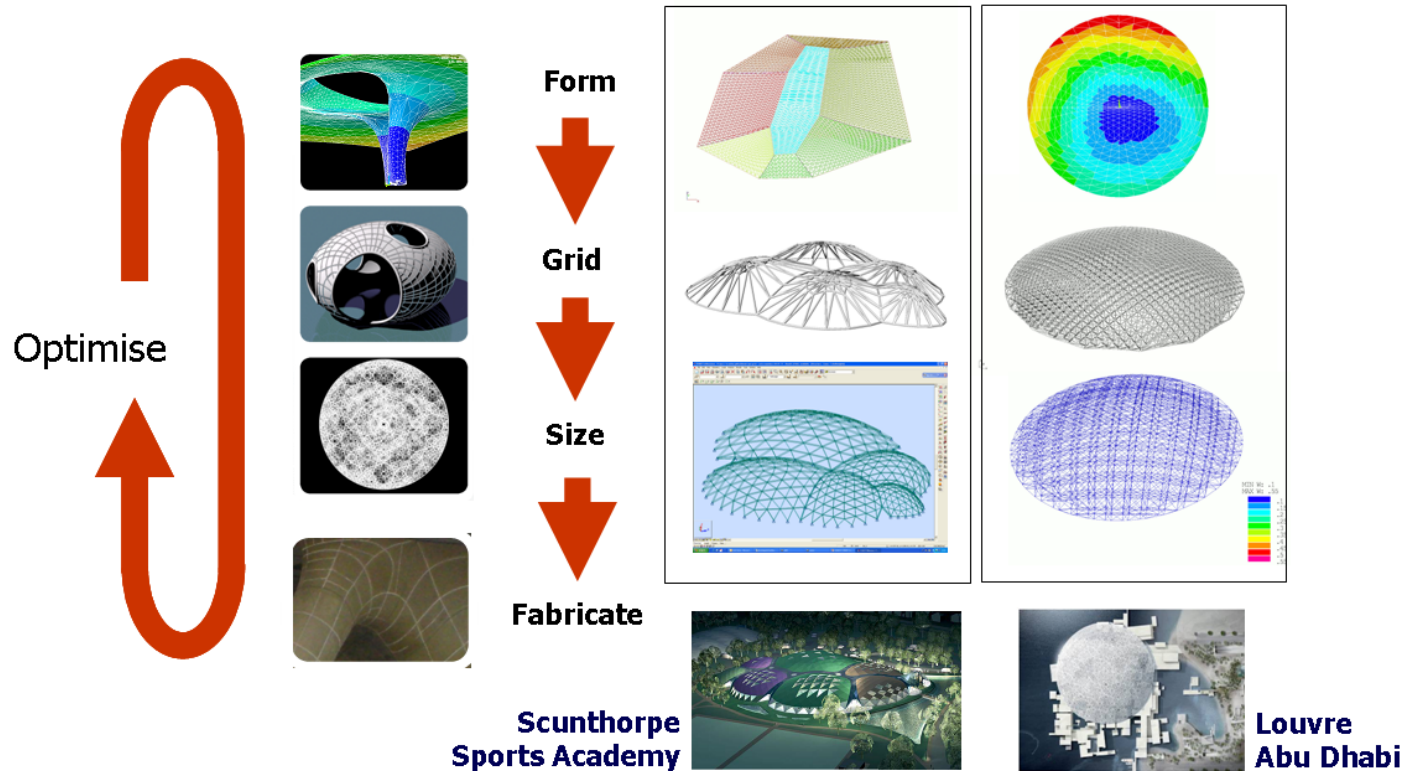
Square panels



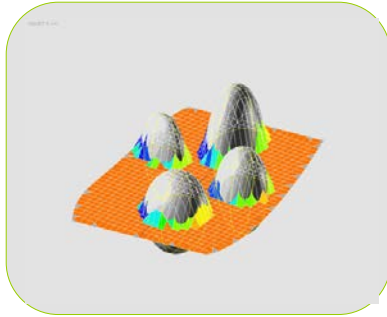


**Louvre
Abu Dhabi**

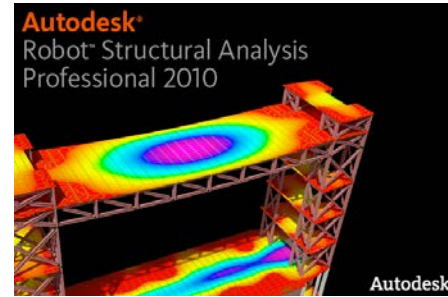
- One-step and iterative
- Stiffness, strength, buckling
- Structure, lighting, etc



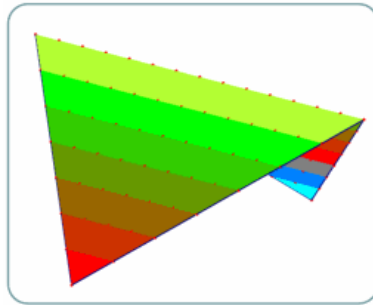
- Geometry optimisation: form and grid
- Structural optimisation: member sizing
- Digital fabrication



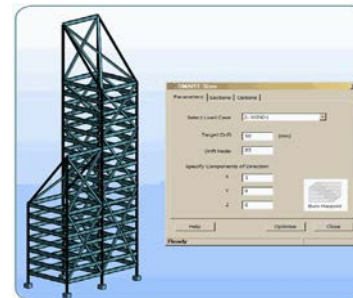
SMART Form
Surface and grid
optimisation



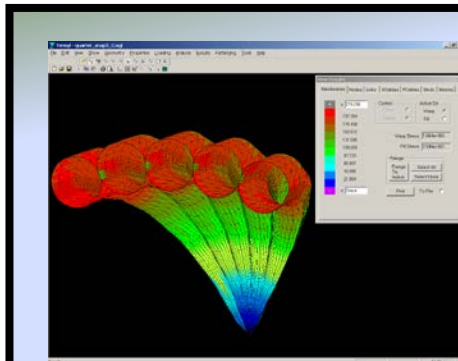
Autodesk Robot
Structural analysis



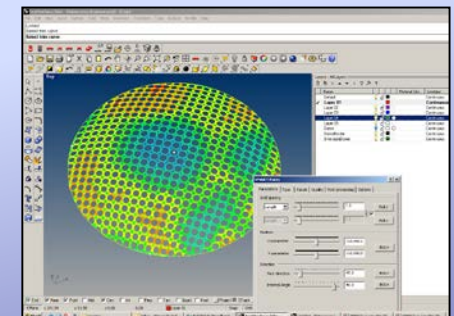
Tensyl
Fabric/form
analysis/design



SMART Sizer
Structural optimisation



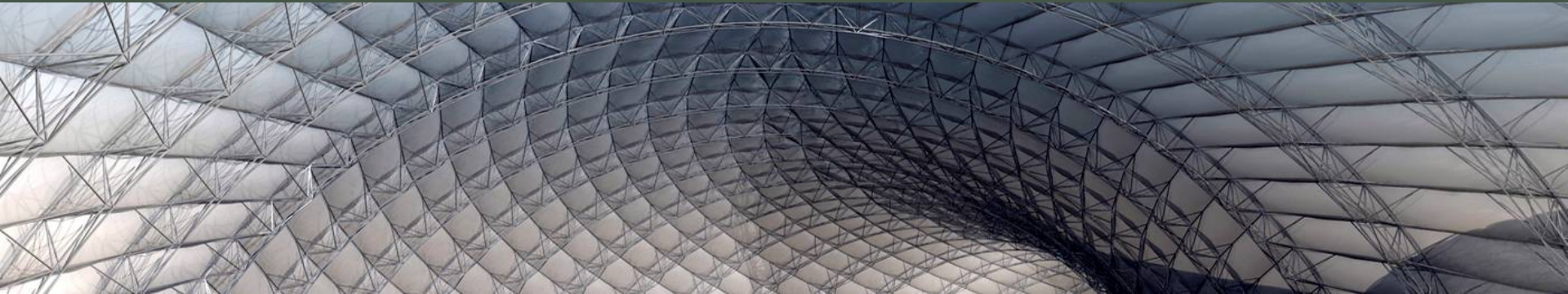
- Full standalone applications
- Plug-ins to Rhino, DP, RSA, Ansys, etc
- Graphic visual



BIM Using BIM for Complex Structures

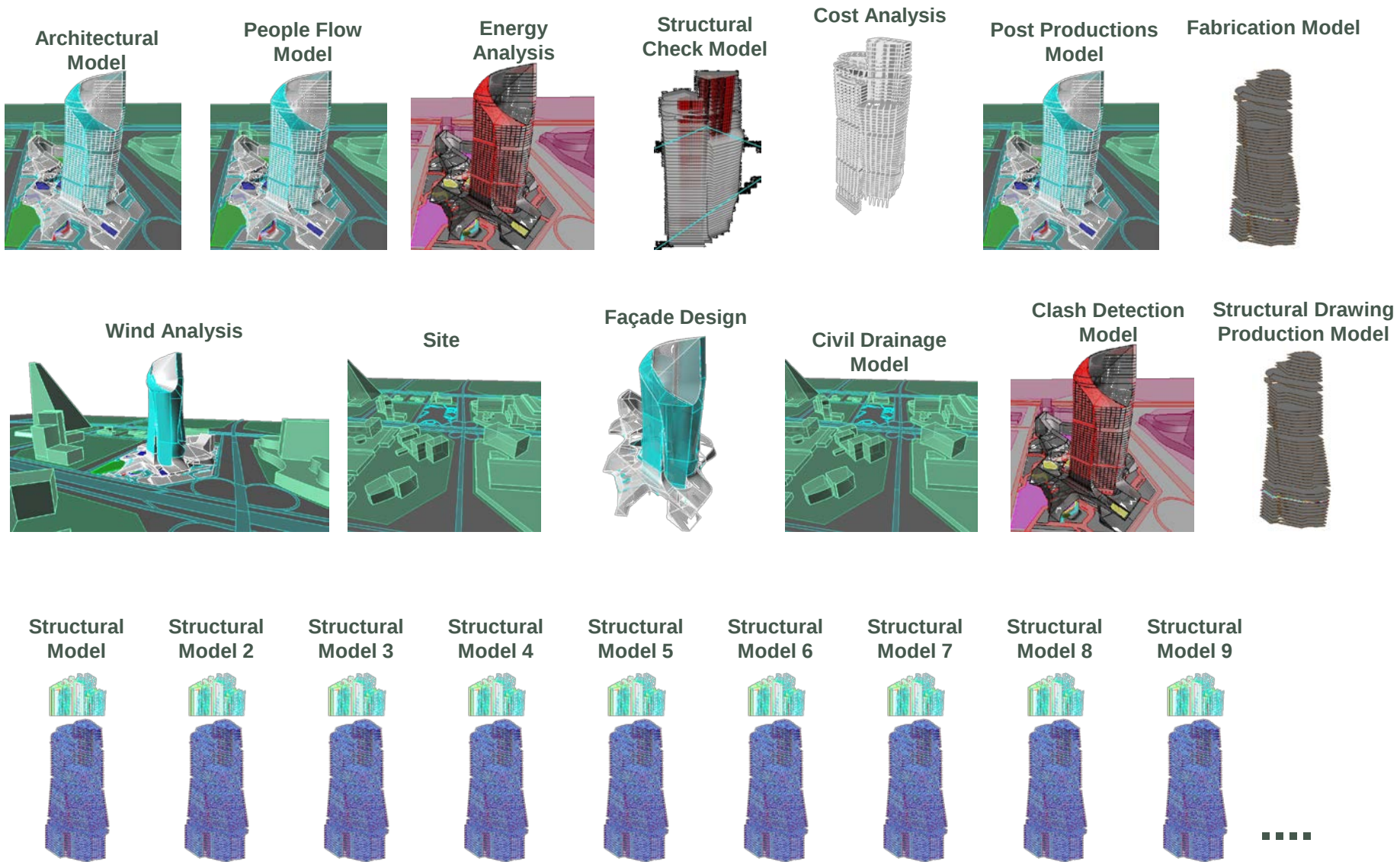


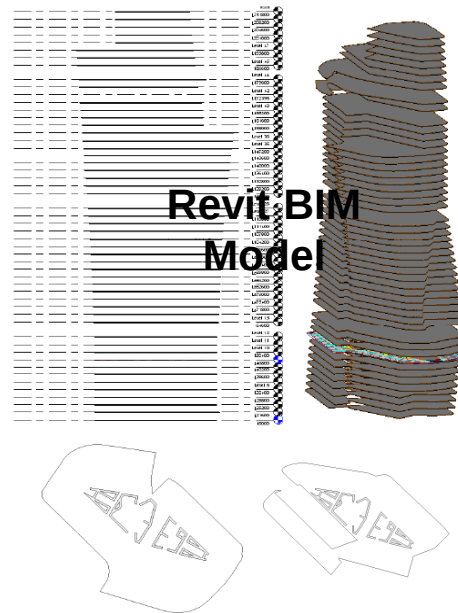
Buro Happold



Parallel Modelling

Engineering Complex Geometry Structures





**Challenge of using multiple
software platforms**

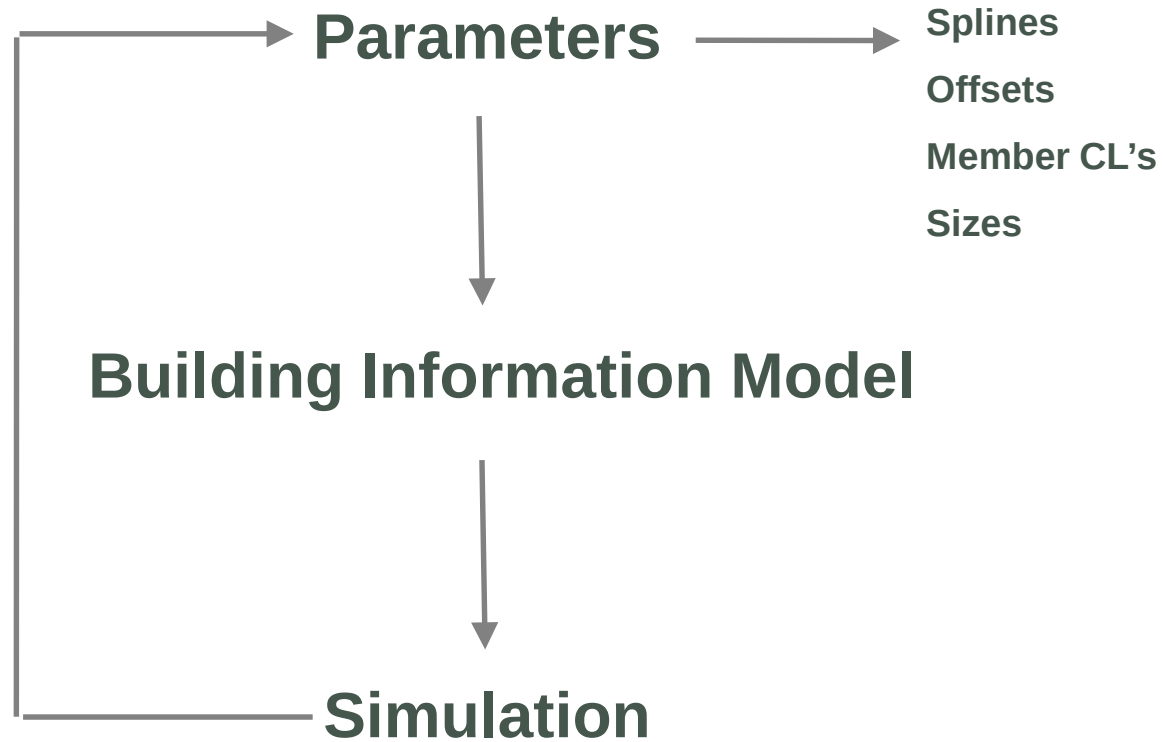


**Custom interface
tools – using API's**

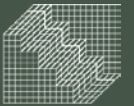
Writing in-house links between Rhino – Revit – Robot - Other



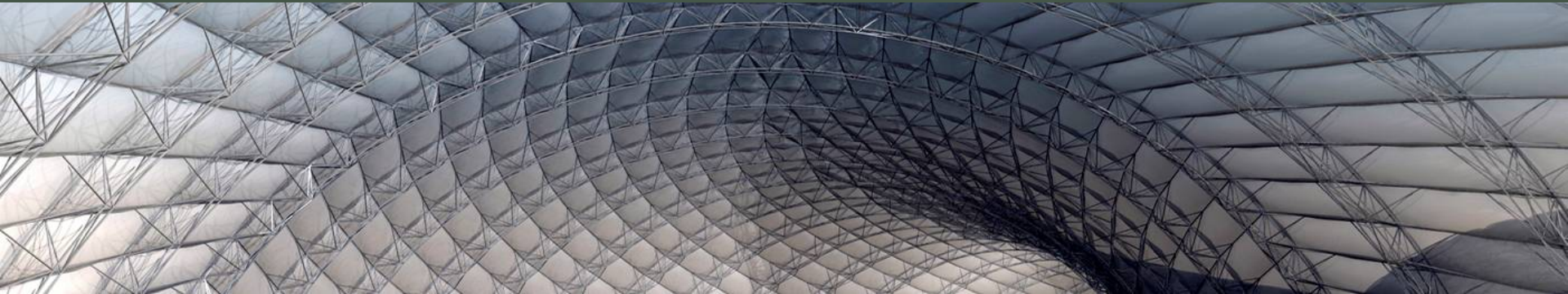
- **Complex/warped slabs/panels**
- **Positioning**
- **Geometric Updates**
- **Custom Parts/Connections**
- **Rhino link does not exist**



BIM Early Examples

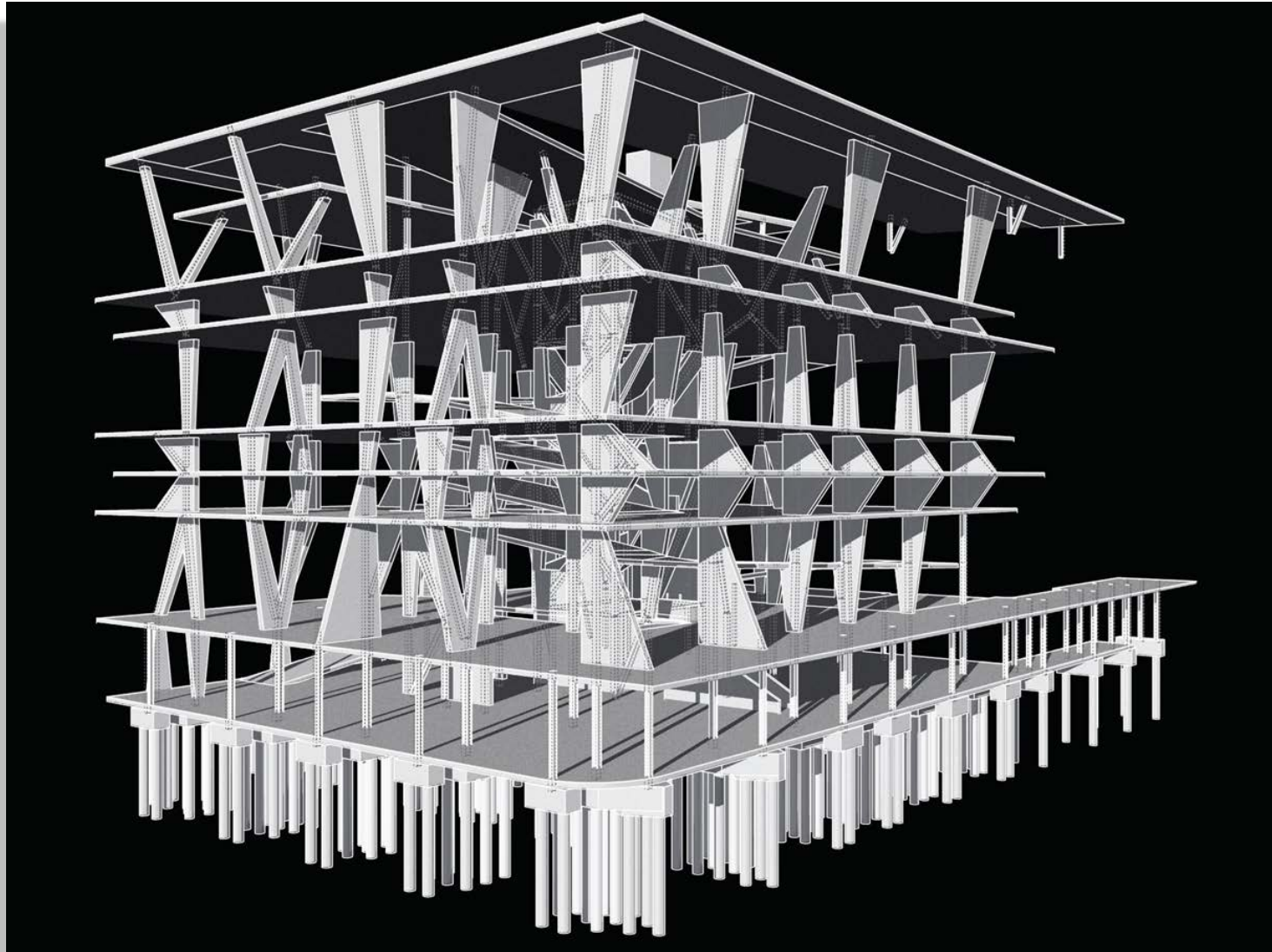


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'Complex' Geometry – Sloping Columns (!)

Engineering Complex Geometry Structures



Autodesk Revit Structure 4

File Edit View Modeling Drafting Site Tools Settings Window Help

3D View: 3D Full Render

LR_Ian.rvt - Project browser

- Views (Sections As Plans)
 - Structural Plans
 - 3D Views
 - 3D Full Analytical
 - 3D Full Render
 - CORE
 - FOUNDATIONS
 - ISO Column A
 - ISO Column B
 - LEVEL 1 RAMPS
 - Stair
 - (3D)
 - Elevations (Building Elevation)
 - Sections (Building Section)
 - Drafting Views (Detail)
 - Graphical Column Schedules
 - Legends
 - Schedules/Quantities
 - DRAWING LIST
 - Structural Connection Schedule
 - Structural Foundation Schedule
 - Structural Foundation Schedule 2
 - Structural Foundation Schedule 3
 - STRUCTURAL FRAMING SCHEDULE
 - VIEW LIST
 - Sheets (all)
 - Families
 - Groups

View: Architectural, Drafting, Rendering, Site, Massing, Modeling

3" = 1'-0"

LR_Ian.rvt - Schedule: STRUCTURAL FRAMING SCHEDULE

BAR_ID	TYPE	LENGTH	WEIGHT	COMPRESSION	TENSION
25	W10X112	12' - 7"	1386 lb	1288 kip	0 kip
26	W10X112	15' - 9 1/2"	1743 lb	1222 kip	0 kip
27	W10X112	13' - 7 1/2"	1481 lb	921 kip	0 kip
28	W10X112	9' - 0"	978 lb	571 kip	0 kip
29	W12X190	24' - 9 1/2"		1928 kip	0 kip
30	W12X190	26' - 4 1/2"		1684 kip	0 kip
31	W12X190	15' - 6 1/2"		1635 kip	0 kip
32	W12X190	11' - 4"		1756 kip	0 kip
34	W12X305	28' - 1 1/2"	7636 lb	2305 kip	0 kip
35	W10X112	10' - 3 1/2"	1062 lb	1339 kip	0 kip
36	W10X112	23' - 10 1/2"	2646 lb	1604 kip	0 kip
37	W10X112	27' - 5"	2996 lb	2231 kip	0 kip
38	W10X112	27' - 5"	2990 lb	2651 kip	0 kip
39	W10X112	9' - 3"	904 lb	1408 kip	0 kip
40	W10X112	25' - 2 1/2"	2567 lb	1118 kip	0 kip
41	W10X112	25' - 5"	2591 lb	1007 kip	0 kip
42	W10X112	25' - 1 1/2"	2559 lb	1397 kip	0 kip
43	W10X112	25' - 4"	2584 lb	919 kip	0 kip
44	W12X305	9' - 0"	2722 lb	1319 kip	-104 kip
45	W12X190	7 1/2"		1518 kip	0 kip
46	W10X112	8' - 8"	849 lb	965 kip	0 kip
47	W10X112	13' - 11"	1535 lb	746 kip	0 kip
48	W10X112	20' - 0"	1975 lb	445 kip	-99 kip
49	W10X112	9' - 6"	1002 lb	598 kip	0 kip
50	W10X112	12' - 8"	1386 lb	203 kip	0 kip
51	W10X112	12' - 8"	1386 lb	99 kip	0 kip
52	W10X112	10' - 7"	1028 lb	177 kip	0 kip
53	W10X112	9' - 6"	1003 lb	975 kip	0 kip
54	W10X112	9' - 1 1/2"	893 lb	727 kip	0 kip
55	W10X112	9' - 6"	1003 lb	1023 kip	0 kip
56	W10X112	20' - 0"	2226 lb	432 kip	0 kip
57	W10X112	8' - 10"	967 lb	1414 kip	0 kip
58	W10X112	15' - 3 1/2"	1613 lb	1053 kip	0 kip
59	W10X112	10' - 3 1/2"	1073 lb	1104 kip	0 kip
60	W10X112	20' - 0"	2226 lb	307 kip	0 kip
61	W10X112	9' - 7 1/2"	1014 lb	1355 kip	0 kip
62	W10X112	10' - 3 1/2"	1073 lb	1074 kip	0 kip
63	W10X112	12' - 4"	1337 lb	1205 kip	0 kip
64	W12X190	14' - 2 1/2"		1449 kip	0 kip
65	W12X190	13' - 2"		1845 kip	0 kip
67	W10X112	10' - 2"	1124 lb	1257 kip	0 kip
68	W12X190	8' - 10"		2091 kip	0 kip
69	W12X190	15' - 8"		2142 kip	0 kip
70	W12X190	20' - 2"		1465 kip	0 kip
71	W10X112	4' - 4"	473 lb	1355 kip	0 kip
72	W10X112	5' - 0 1/2"	552 lb	858 kip	0 kip
73	W10X112	17' - 5 1/2"	1934 lb	748 kip	0 kip
75	W12X190	8' - 4 1/2"		2354 kip	0 kip
76	W12X190	7 1/2"		2180 kip	0 kip

Ready

Start REVISED TAGS 070122 2007 Resourcing LR API Examples Inbox - Microsoft Outlook SourceForge.net: Downl... Autodesk Revit Struc...

4:28 PM

	A	B	C	D	E	F	G	H
4								
5		Robot Analysis Output-Member Forces						
6		Bar	Comp (kips)	Tension (kips)	Section	Length	Axial Comp @E	
7		1	1217	.5	W 10x112	9	Pass	pass W10x11
8		2	996	.6	W 10x112	9	Pass	
9		3	652	.2	W 10x112	23	Pass	
10		4	1031	.6	W 10x112	9	Pass	
11		5	868	.3	W 10x112	9	Pass	
12		6	536	.1	W 10x112	23	Pass	
13		7	446	.9	W 10x112	9	Pass	
14		8	467	.3	W 10x112	9	Pass	
15		9	325	.38	W 10x112	27	Pass	
16		10	390	.38	W 10x112	19	Pass	
17		11	1400	.45	W 10x112	12	NG	
18		12	979	.45	W 10x112	20	Pass	
19		13	604	.53	W 10x112	25	Pass	
20		14	341	.9	W 10x112	21	Pass	
21		15	216	.2	W 10x112	23	Pass	
22		16	669	.1668	W 12x305	24	Pass	
23		17	583	.1	W 10x112	33	Pass	
24		18	472	.10	W 10x112	33	Pass	
25		19	98	.538	W 10x112	12	Pass	
26		20	795	.89	W 10x112	11	Pass	
27		21	349	.1	W 10x112	13	Pass	
28		22	169	.1	W 10x112	13	Pass	
29		23	87	.14	W 10x112	23	Pass	
30		24	429	.9	W 10x112	9	Pass	
31		25	1284	.45	W 10x112	13	Pass	
32		26	1268	.69	W 10x112	16	Pass	
33		27	964	.8	W 10x112	14	Pass	Pass
34		28	548	.14	W 10x112	9	Pass	Pass
35		29	1906	.115	W 12x190	25	NG	Pass
36		30	1708	.33	W 12x190	26	NG	Pass
37		31	1675	.10	W 12x190	16	NG	Pass
38		32	1782	.4	W 12x190	11	NG	Pass
39		33	2550	.87	W 12x190	29	NG	Pass

PlaceComponentByPointsForm

Choose a component to place...

W-Wide Flange : W10x112
W-Wide Flange : W12x305
W-Wide Flange : W8x67
W-Wide Flange : W12x190
Structural Framing 1 : Structural Framing 1
HSS-Round Structural Tubing : HSS8-3/4X.500
AxisWidget : AxisWidget

Choose an EXCEL file from which to query points.

.....

Component Type
☒ Framing ☐ Other

Specify the file units
☒ Feet ☐ Inches ☐ Millimeters

EXCEL startPt X

EXCEL endPt X

EXCEL cell for Mark.

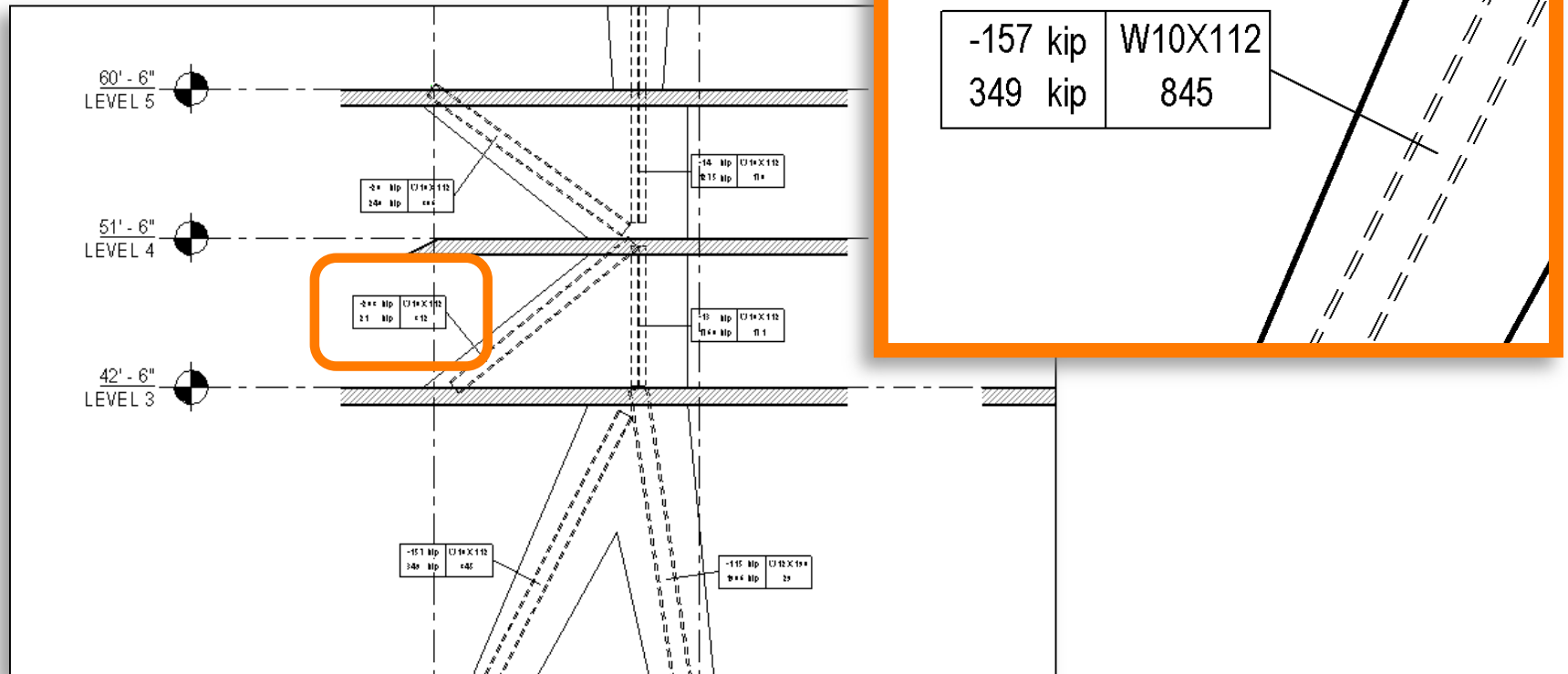
EXCEL Compr.

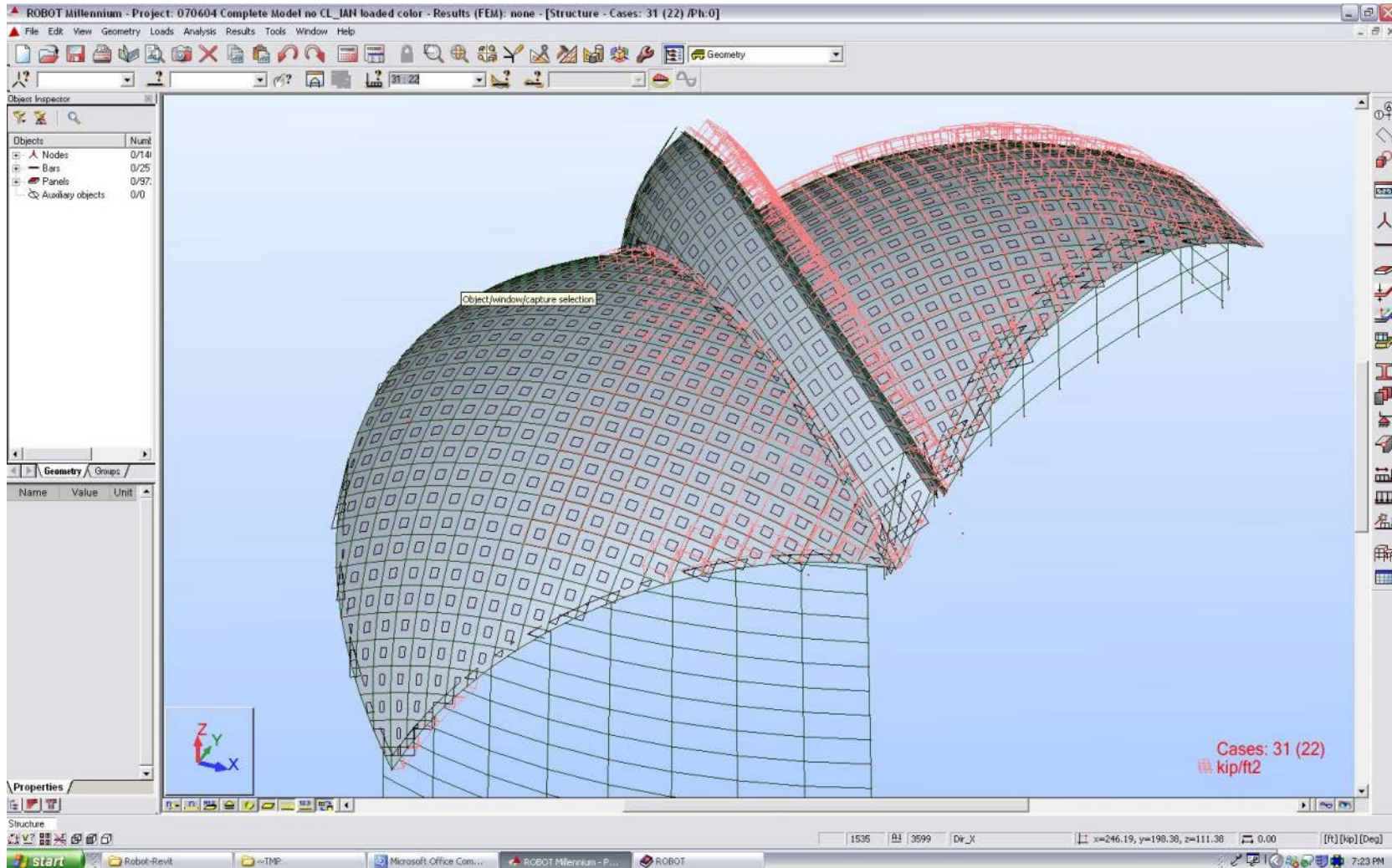
EXCEL Tens.

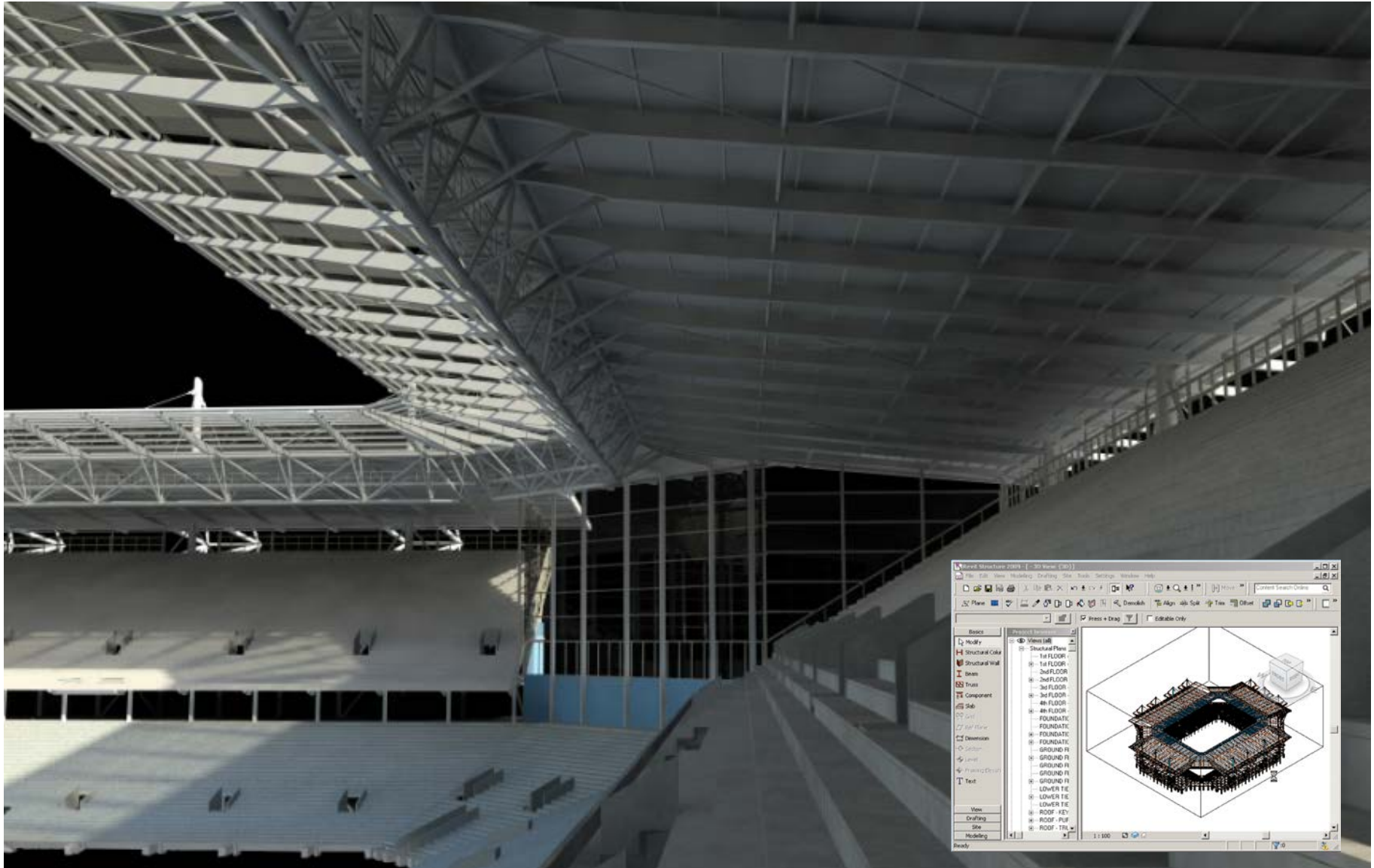
☐ Create Mark

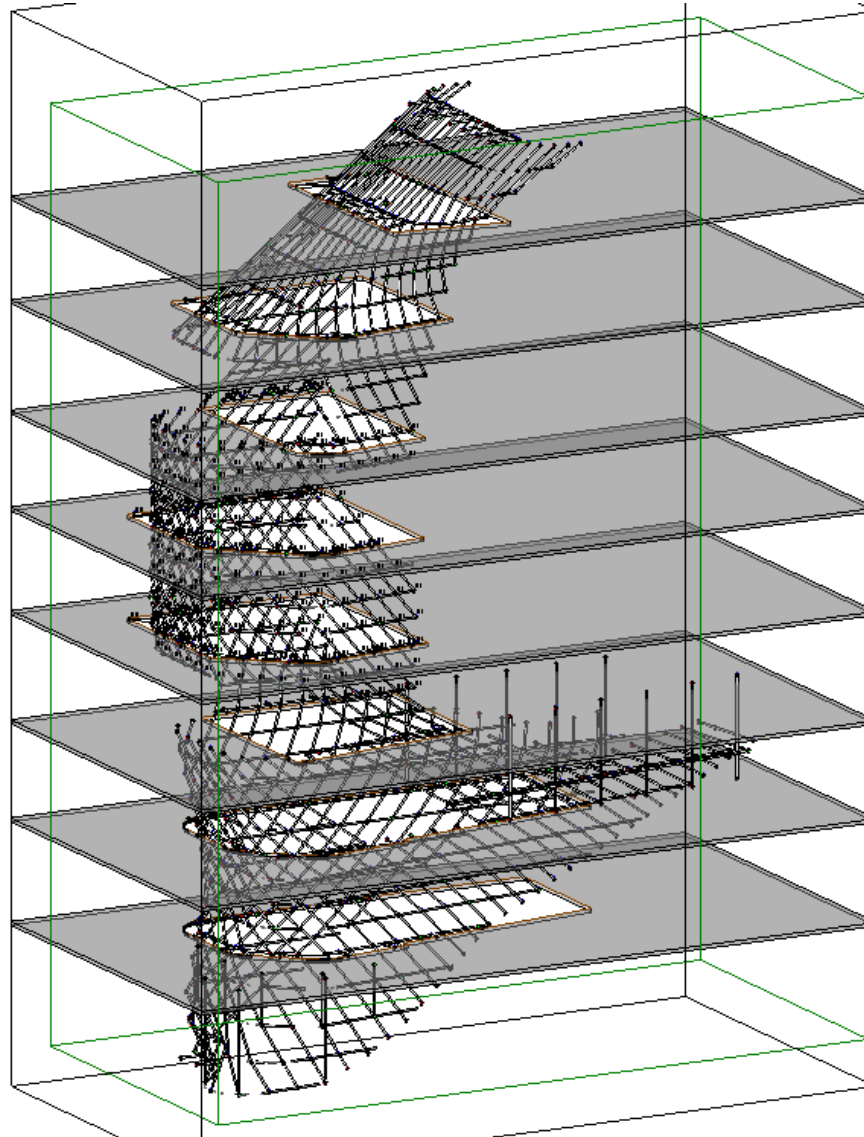
☐ Input Forces

OK Cancel









Integration of Complex and Simple Structures

Engineering Complex Geometry Structures



Revit Structure 2008

File Edit View Modeling Drafting Site Tools Settings Window Help

1/2" = 1'-0"

CU_Structural_070814.rvt - Project browser

- Views (BH Browser)
- Structural Plans
 - Structural Plan
 - LEVEL 0
 - LEVEL 1
 - LEVEL 2
 - LEVEL 3
 - LEVEL 4
 - LEVEL 5
 - LEVEL 6
 - LEVEL 7
 - LEVEL 8**
 - LEVEL 9
 - LEVEL 10
 - LEVEL 11
 - LEVEL 12
 - LEVEL 13
 - LEVEL 14
 - LEVEL 15
 - LEVEL 16
 - LEVEL 17
 - LEVEL 18
 - LEVEL 19
 - LEVEL 20
 - LEVEL 21
 - LEVEL 22
 - LEVEL 23
 - LEVEL 24
 - LEVEL 25
 - LEVEL 26
 - LEVEL 27
 - LEVEL 28
 - LEVEL 29
 - LEVEL 30
 - LEVEL 31
 - LEVEL 32
 - LEVEL 33
 - LEVEL 34
 - LEVEL 35
- 3D Views
 - 3D View
 - 3D Full Analytical
 - 3D Full Render
 - AXD_01
 - AXD_02
 - AXD_03
 - AXD_04
 - AXD_05
 - AXD_06
 - AXD_full (3D)
- Elevations (Building Elevation)

View

- Architectural
- Drafting
- Site
- Massing
- Modeling

CU_Structural_070814.rvt - Structural Plan: LEVEL 8

CU_Structural_070814.rvt - Schedule: LEVELS 1-4 NODE SETTING-OUT TABLE

BH_NODE_ID	BH_NODE_X	BH_NODE_Y	BH_NODE_Z	BH_NODE_X_REL	BH_NODE_Y_REL
98	0.00	0.00	0.00	0.00	0.00
99	73.72	22.01	12.25	-12.80	-18.48
109	69.47	21.67	12.25	-17.06	-18.81
110	70.61	21.45	10.24	-15.92	-19.04
120	65.21	21.33	12.25	-21.32	-19.15
121	67.07	20.95	8.85	-19.45	-19.54
130	60.95	21.20	12.25	-25.57	-19.28
131	62.79	20.59	8.75	-23.73	-19.89
140	57.44	23.50	12.25	-29.09	-16.98
141	58.46	20.24	8.75	-28.07	-20.24
157	56.25	27.47	12.25	-30.28	-13.01
158	54.27	20.95	8.75	-32.26	-19.54
173	57.84	31.42	12.25	-28.69	-9.06
174	52.03	24.51	8.75	-34.50	-15.97
188	59.13	35.44	12.25	-27.39	-5.04
189	53.31	28.53	8.75	-33.22	-11.96
202	59.34	39.71	12.25	-27.18	-0.78
203	56.34	31.65	8.75	-30.19	-8.84
227	59.55	43.98	12.25	-26.98	3.49

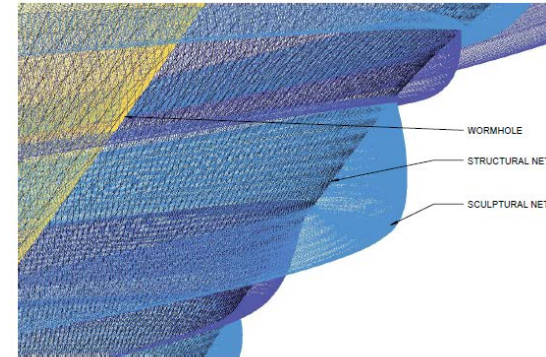
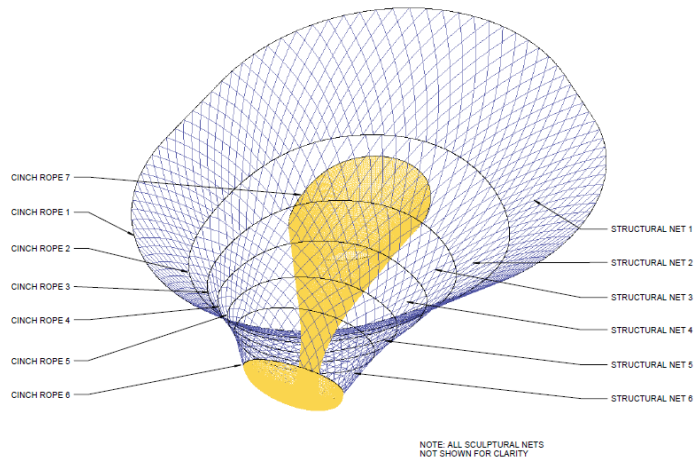
CU_Structural_070814.rvt - 3D View: (3D)

1/4" = 1'-0"

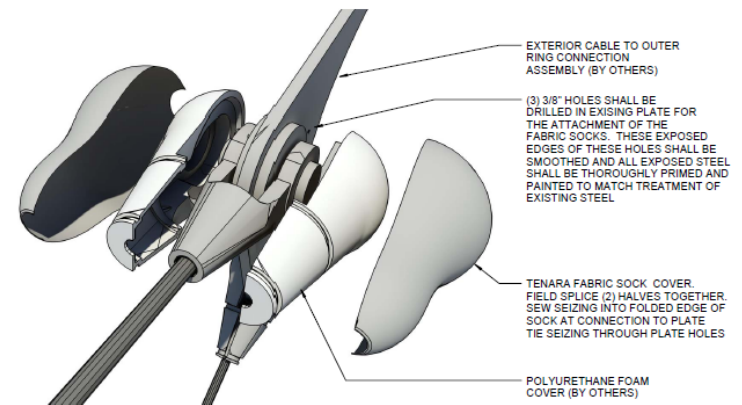
Click to select, TAB for alternates, CTRL adds, SHIFT unselects.

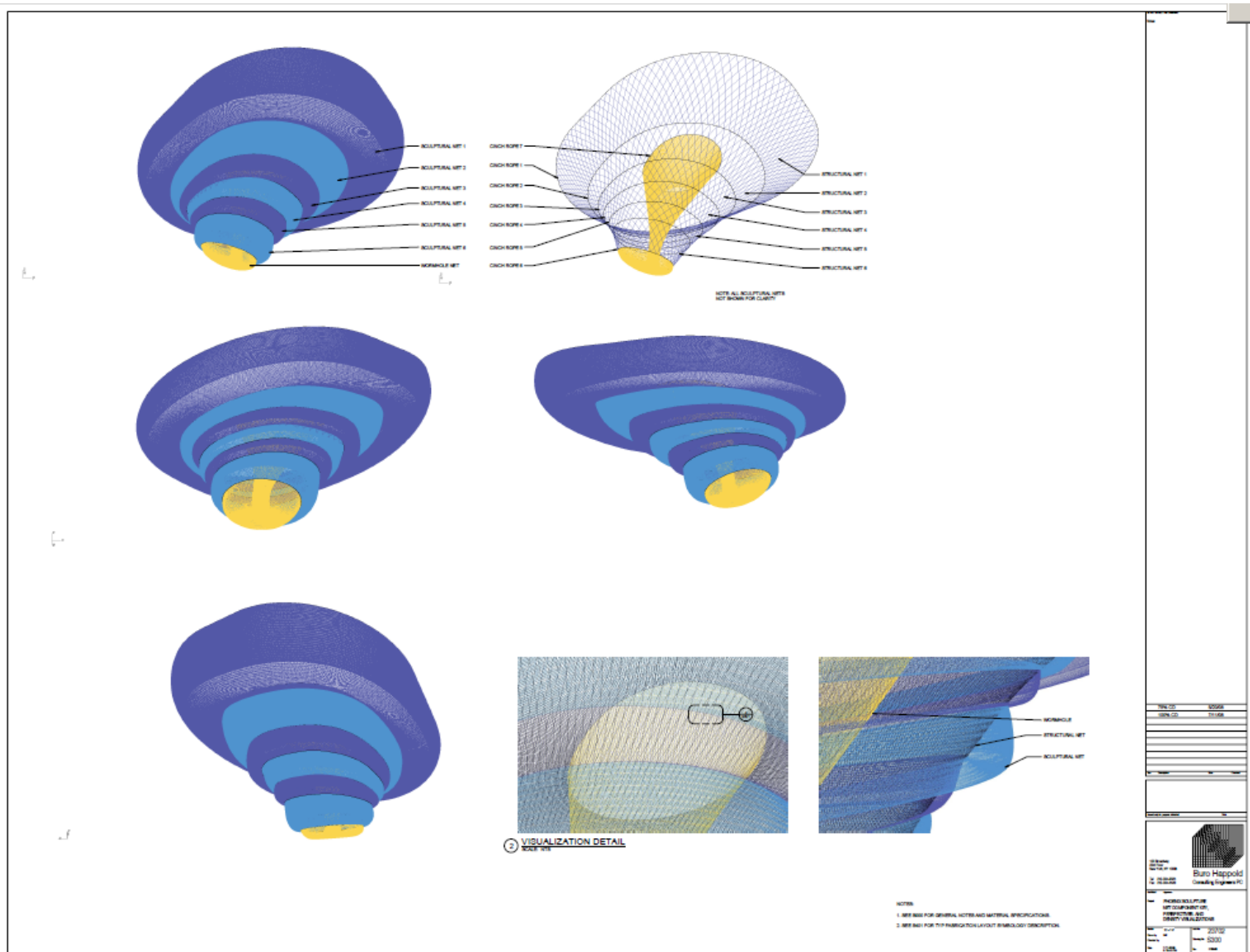
start Microsoft Office Com... Inbox - Microsoft Out... DWF BH Revit 070820.ppt BH Revit.ppt Revit Structure 2008 10:57 AM

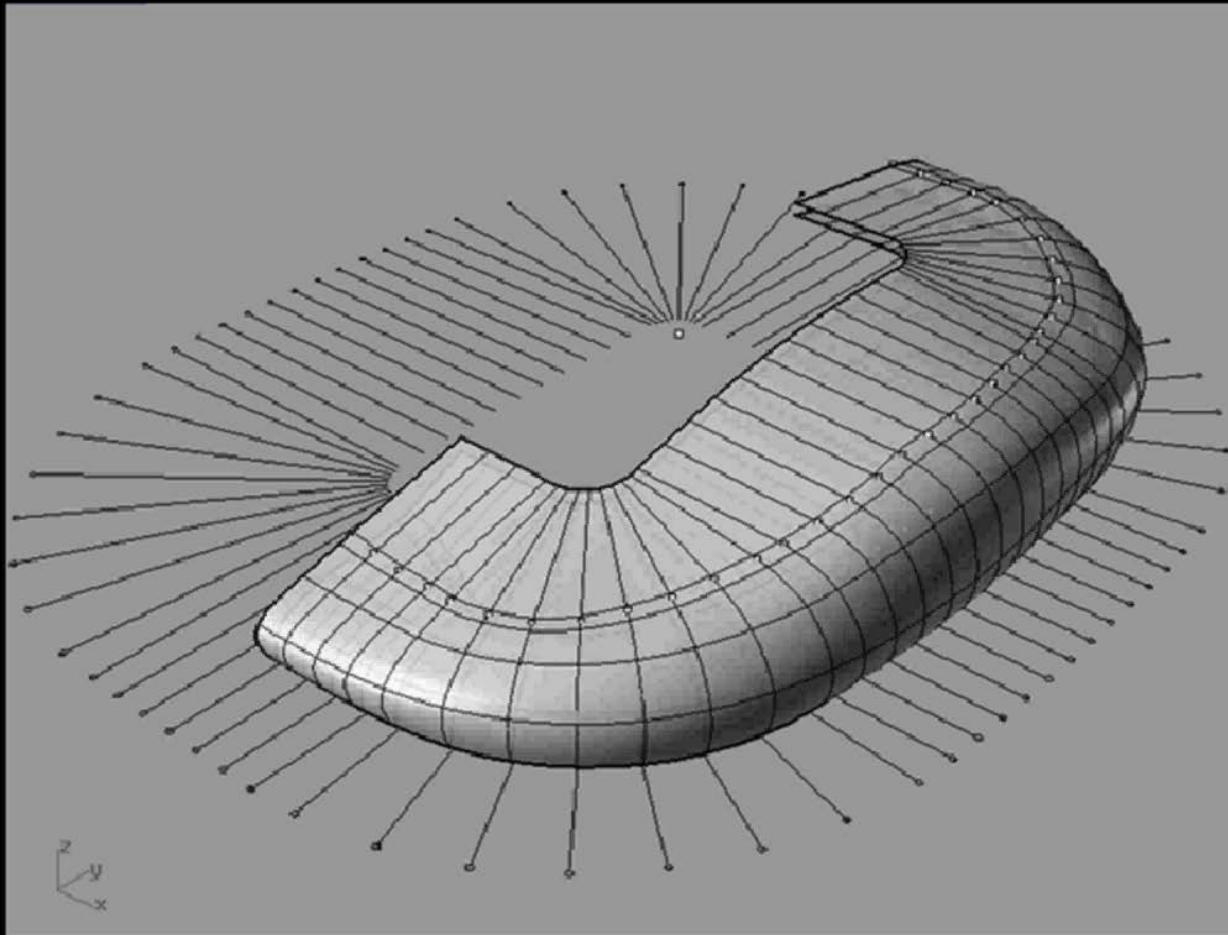
• Linking Buro in house analysis software (Tensyl) with Revit

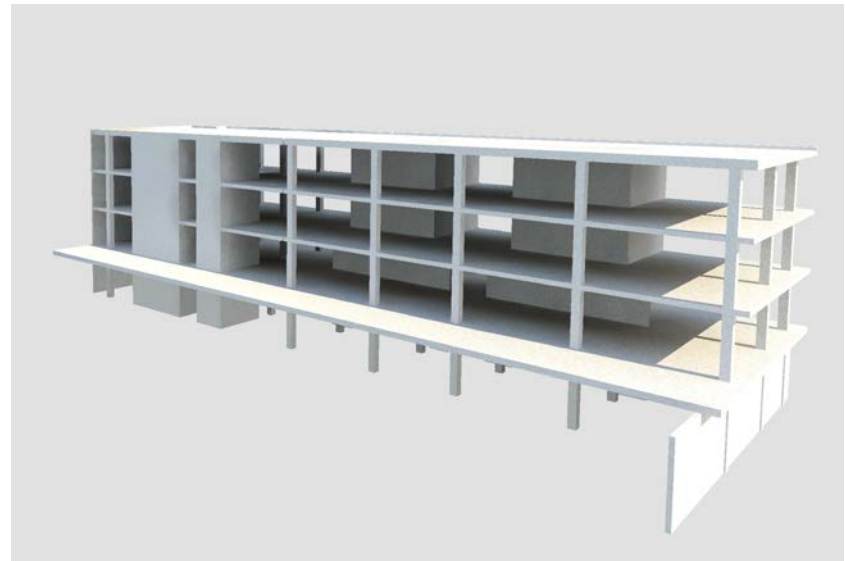
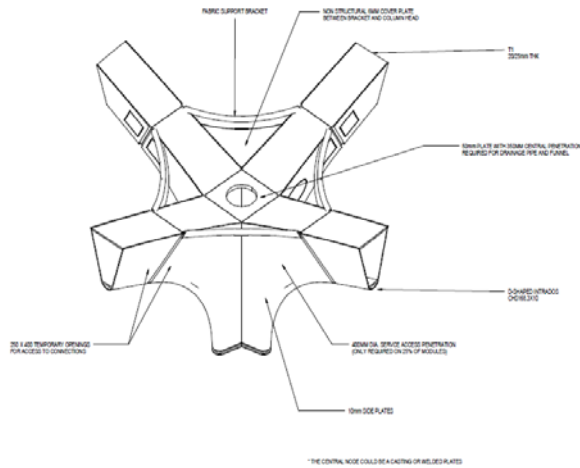
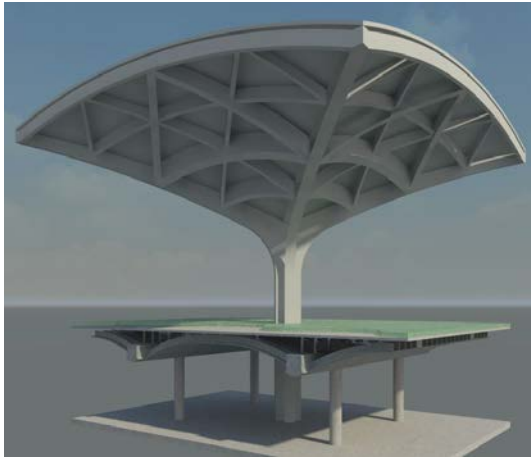


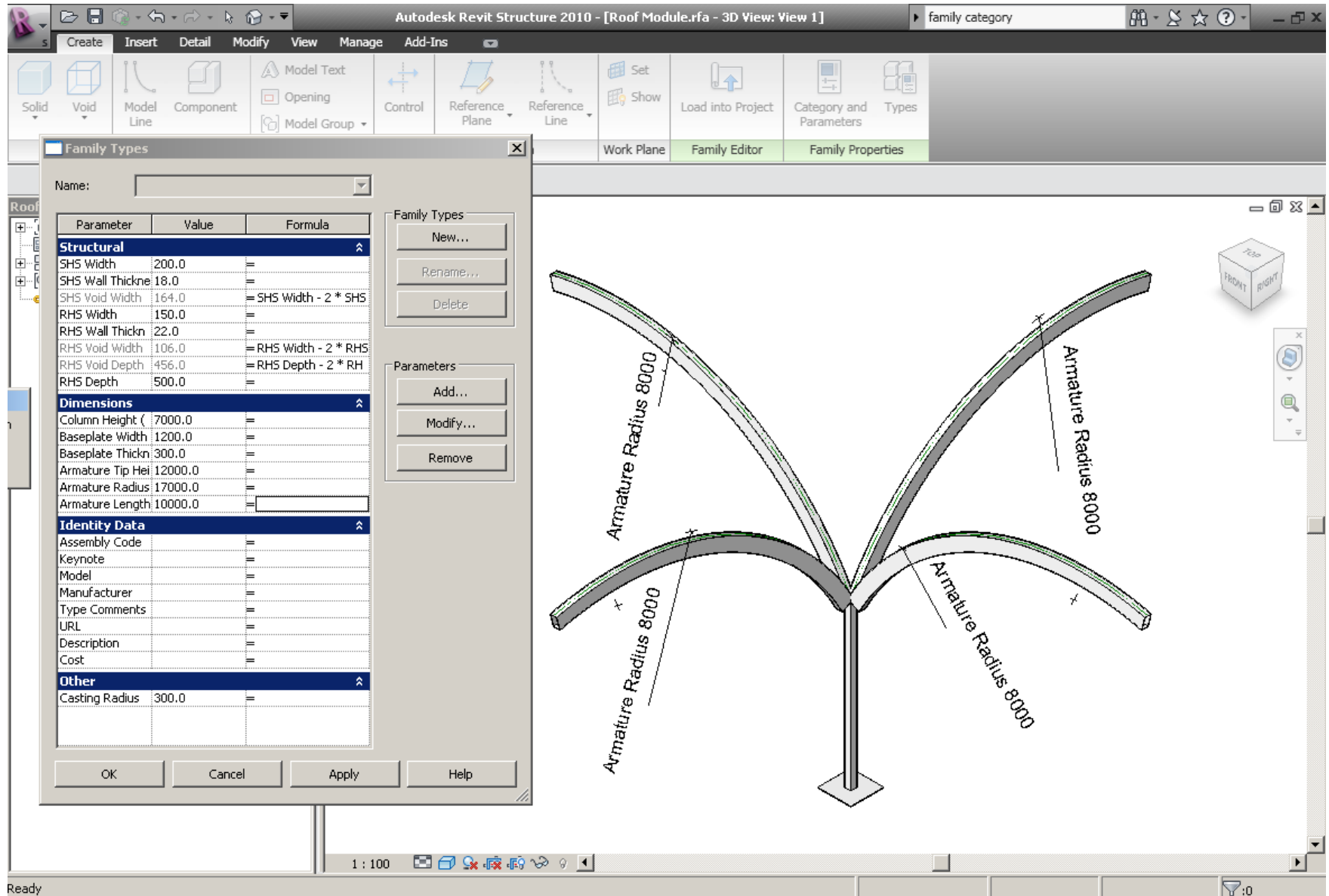
53L	1' - 11 1/4"	1' - 9 7/8"	1' - 9"	1' - 7 7/8"
54L	1' - 10 1/8"	1' - 8 7/8"	1' - 8 1/8"	1' - 7"
55L	1' - 9 1/8"	1' - 8"	1' - 7 1/4"	1' - 6 1/4"
56L	1' - 8 1/8"	1' - 7 1/8"	1' - 6 1/2"	2' - 2 1/8"
57L	1' - 7 3/8"	2' - 4 1/8"	2' - 2 5/8"	2' - 0 5/8"
58L	2' - 4 5/8"	2' - 2 1/2"	2' - 1 1/8"	1' - 11 3/4"
59L	2' - 3"	2' - 1 1/2"	2' - 0 3/8"	1' - 11 1/2"
60L	2' - 2"	2' - 1 1/8"	2' - 0 1/8"	1' - 11 5/8"
61L	2' - 1 3/4"	2' - 1 1/4"	2' - 0 1/4"	1' - 4"
62L	2' - 1 7/8"	1' - 4 1/2"	1' - 4 1/4"	1' - 4 3/8"
63L	1' - 4 3/4"	1' - 4 3/4"	1' - 4 5/8"	1' - 4 3/4"
64L	1' - 5"	1' - 5 1/8"	1' - 4 7/8"	1' - 5 1/8"
65L	1' - 5 3/8"	1' - 5 1/2"	1' - 5 1/2"	1' - 5 3/4"
66L	1' - 5 7/8"	1' - 6 1/8"	1' - 6"	1' - 6 3/8"
67L	1' - 6 3/8"	1' - 6 3/4"	1' - 6 3/4"	1' - 7 1/4"
68L	1' - 7 1/8"	1' - 7 1/2"	1' - 7 5/8"	1' - 8 1/4"
69L	1' - 7 7/8"	1' - 8 1/2"	3' - 7 3/8"	



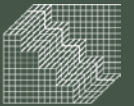




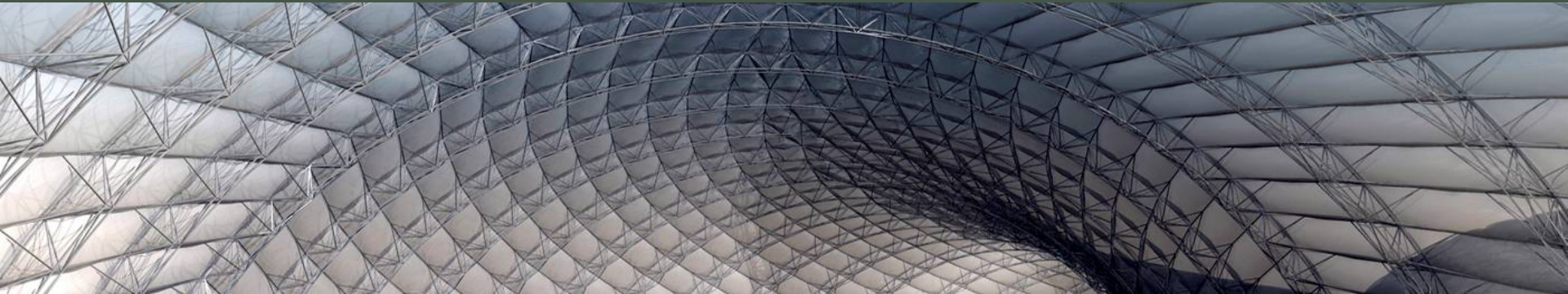


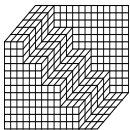


BIM Recent Example



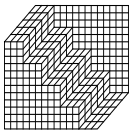
Buro Happold



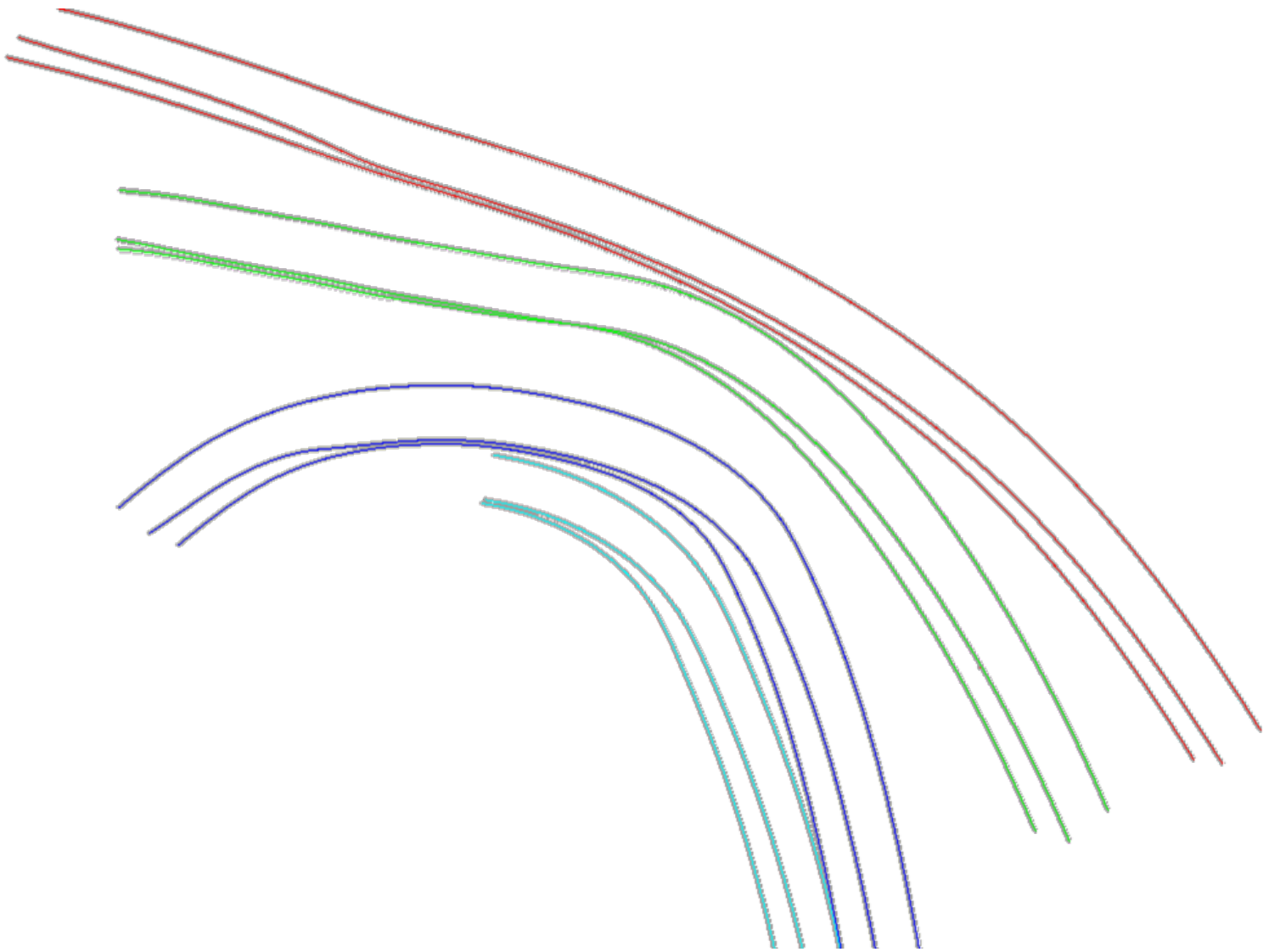


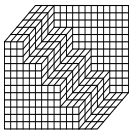
Buro Happold



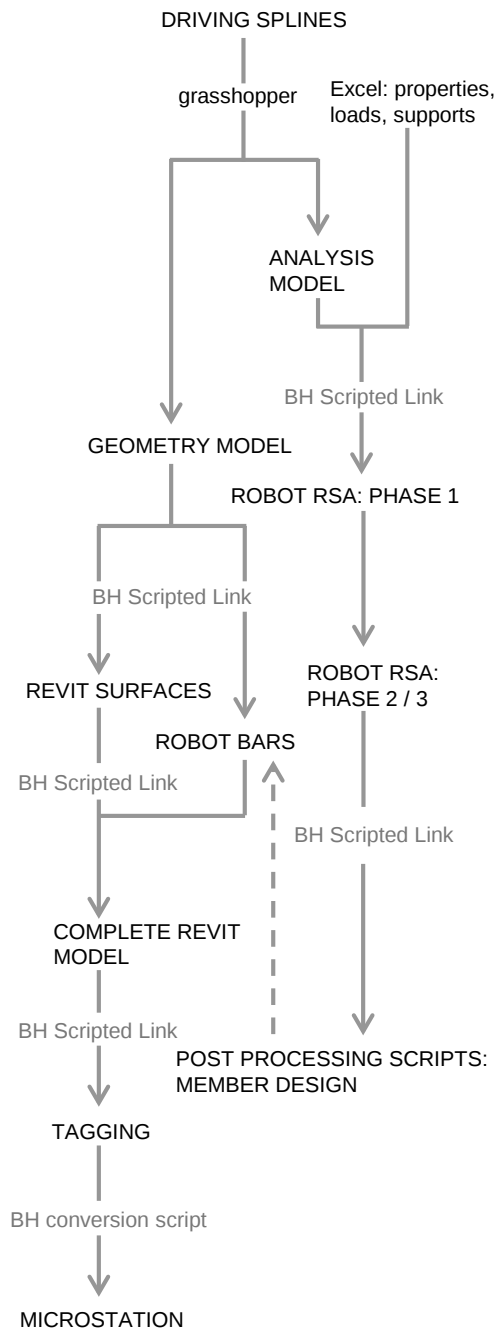


Buro Happold





Buro Happold





grasshopper

Excel: properties,
loads, supports

ANALYSIS MODEL

BH Scripted Link

GEOMETRY MODEL

ROBOT RSA: PHASE 1

BH Scripted Link

ROBOT RSA:
PHASE 2 / 3

ROBOT BARS

BH Scripted Link

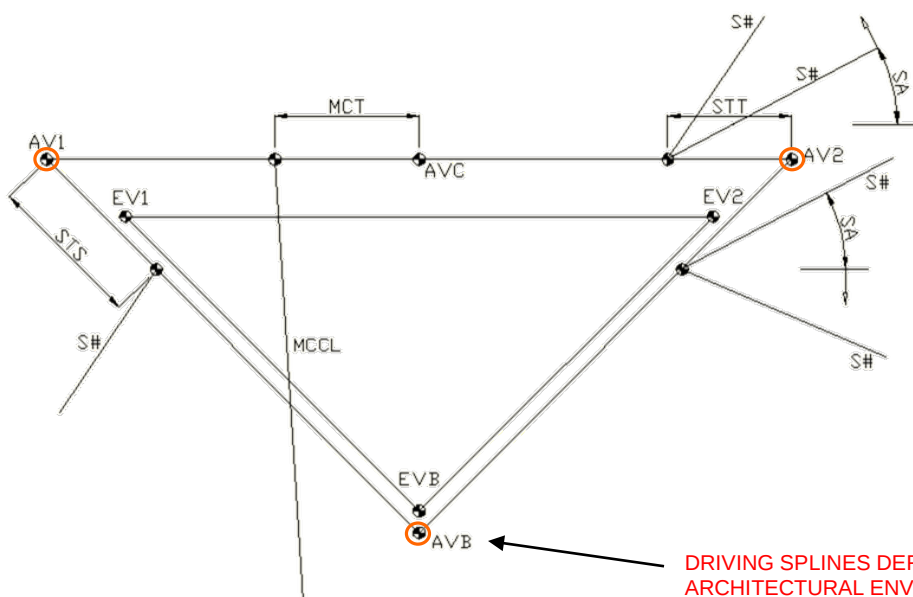
COMPLETE REVIT
MODEL

POST PROCESSING SCRIPTS: MEMBER DESIGN

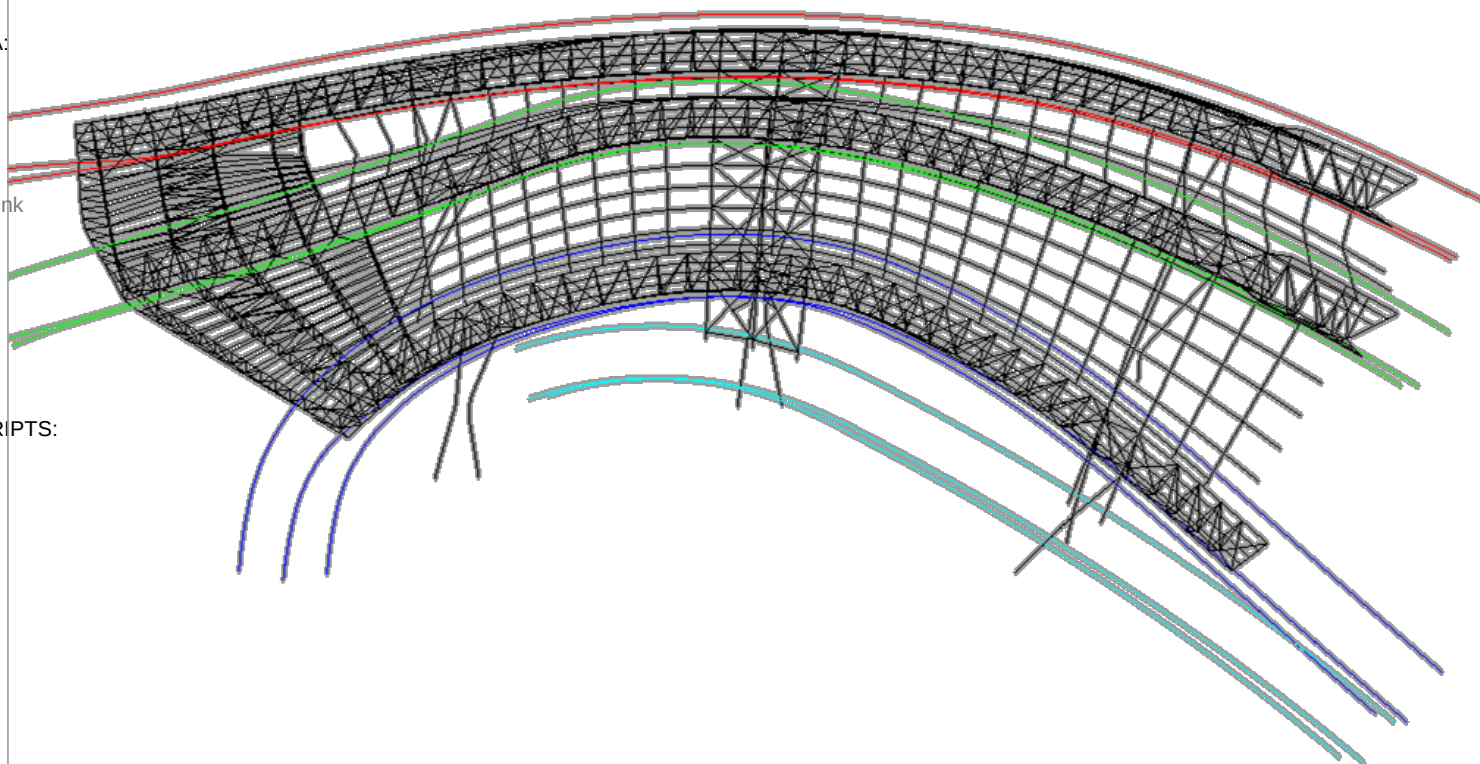
TAGGING

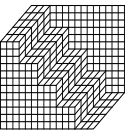
BH conversion script

MICROSTATION



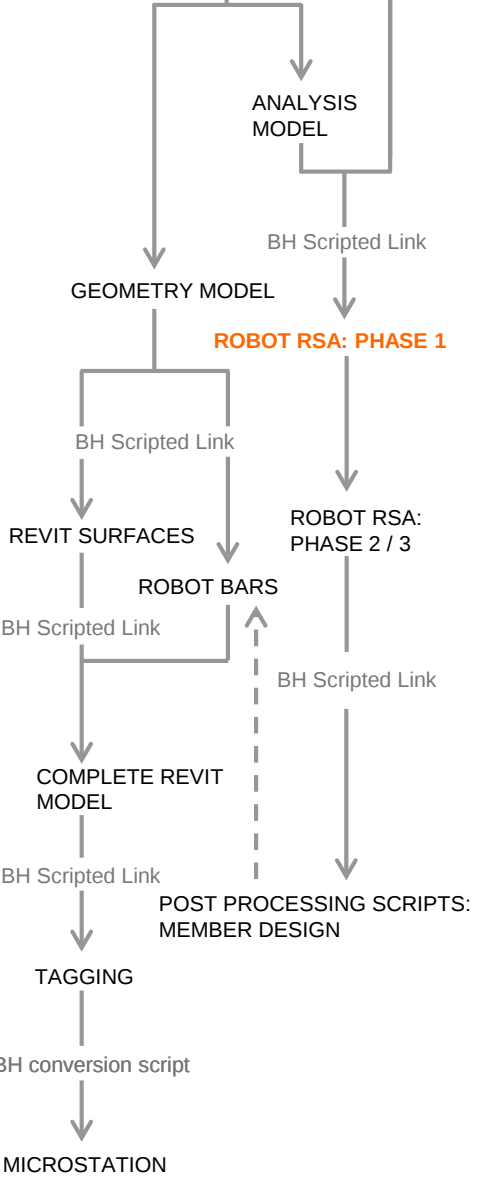
DRIVING SPLINES DEFINE ARCHITECTURAL ENVELOPE



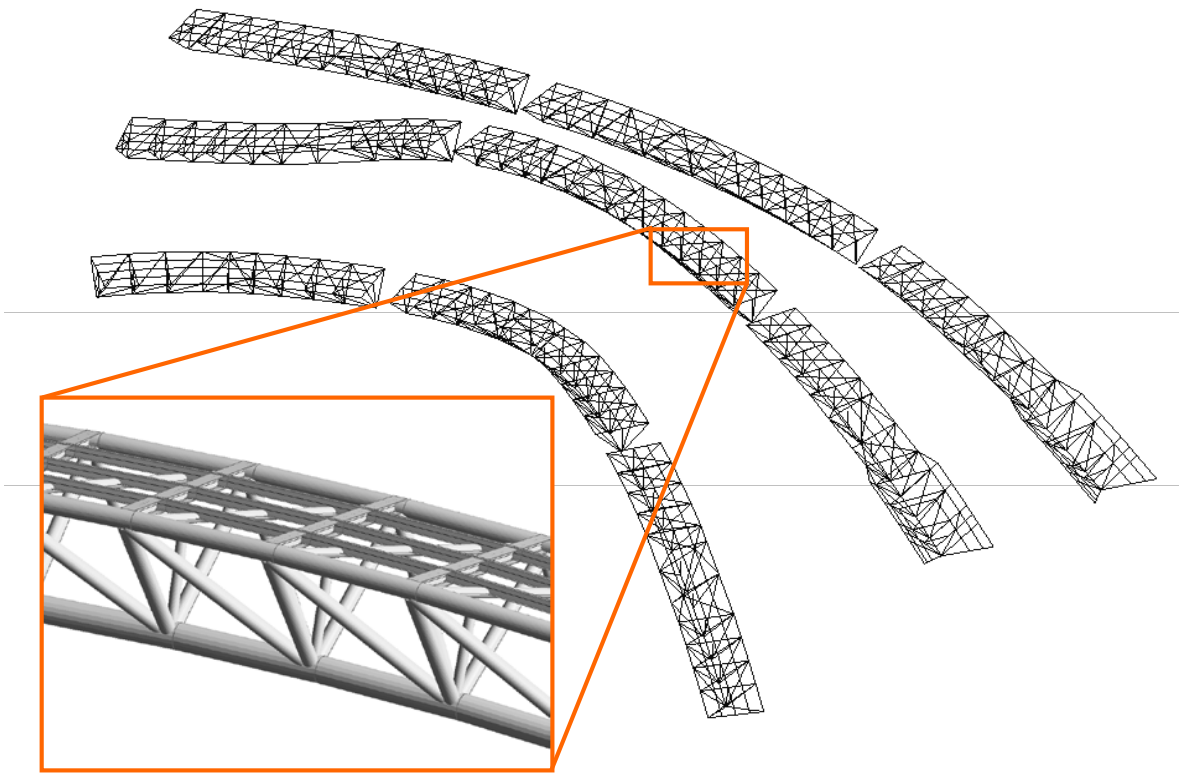


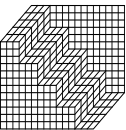
DRIVING SPLINES

Buro Happold



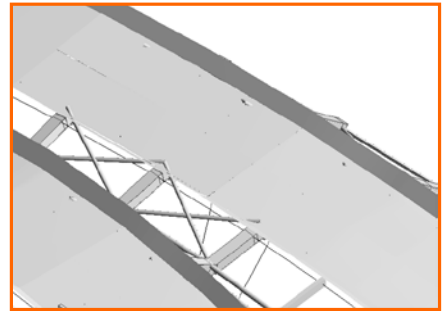
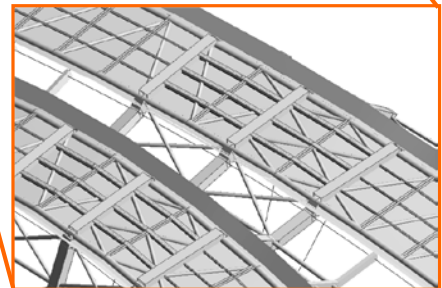
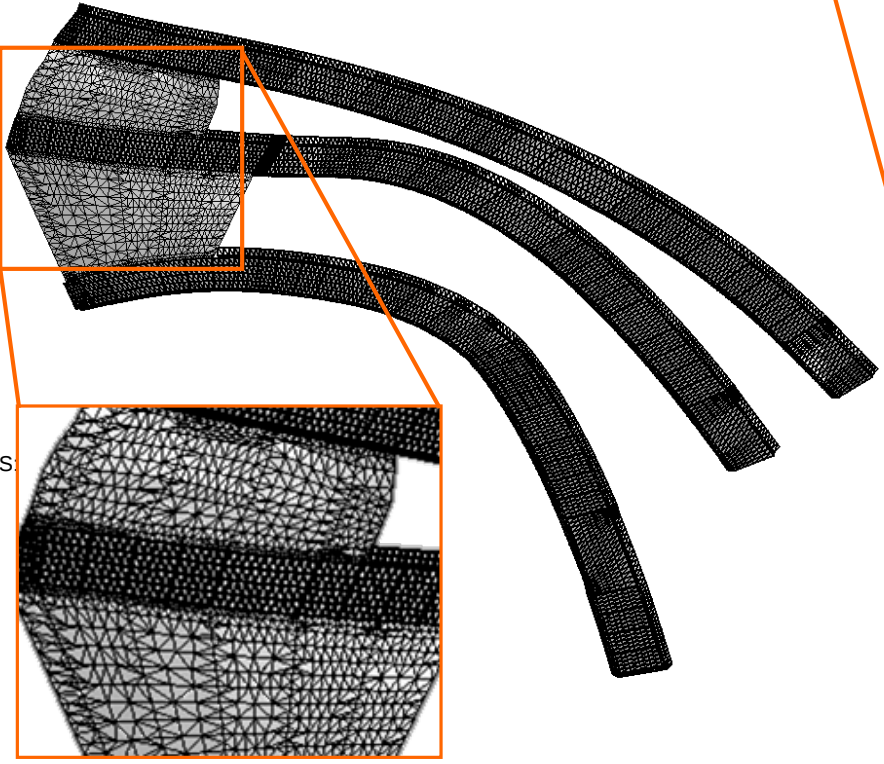
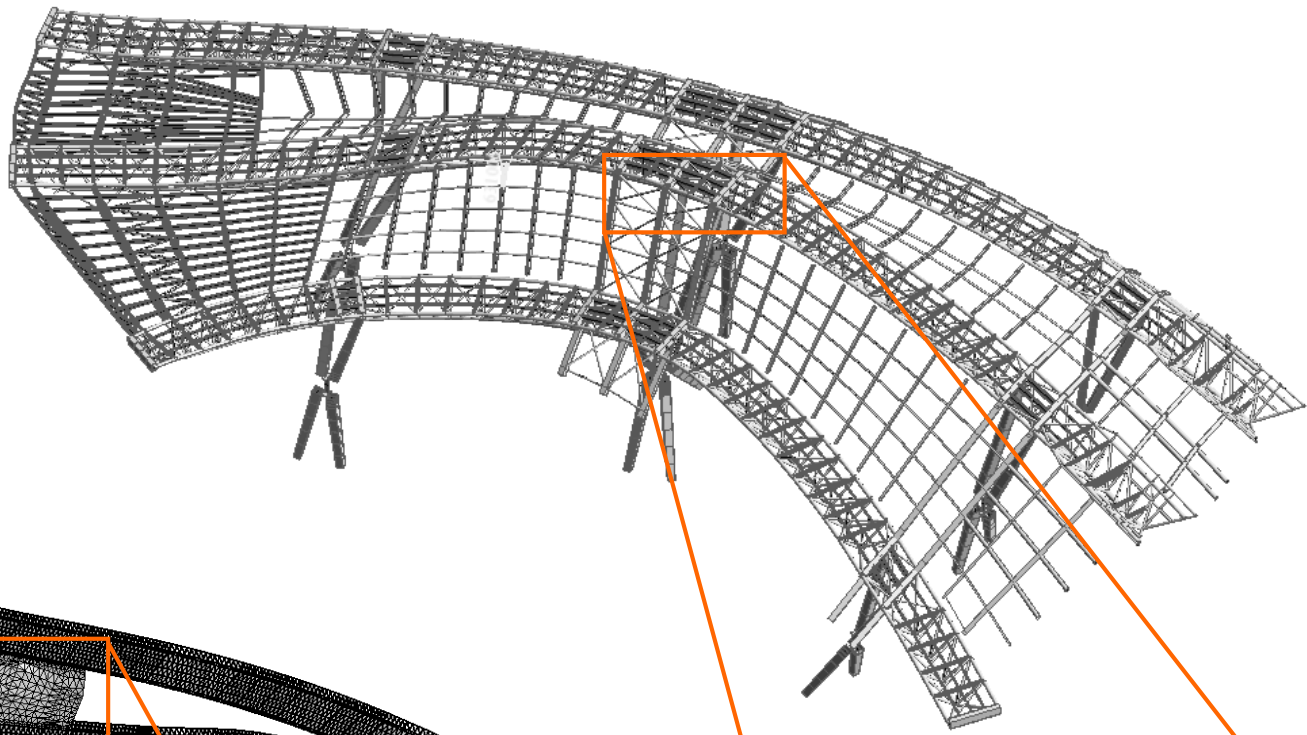
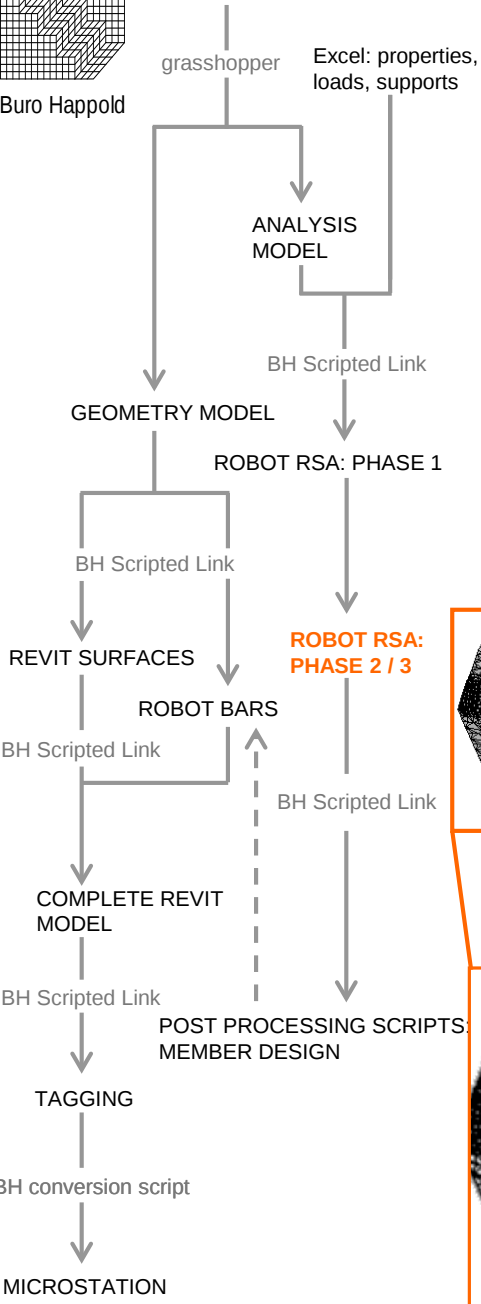
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2																				
3																				
4				DESCRIPTION:																
5				Support Definitions																
6																				
7																				
8																				
9																				
10				NOT USED																
				List of Edges	List of Objects	UX	UY	UZ	RX	RY	RZ	Alpha (deg)	Beta (deg)	Gamma (deg)	KX (kN/m)	KY (kN/m)	KZ (kN/m)	HX (kNm/Deg)	HY (kNm/Deg)	HZ (kNm/Deg)
11	YES	P2_south_1210010	1210010			I_RBT_ELASTIC	I_RBT_FREE	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_FREE	4.3			2000000		1500000			
12	YES	P2_south_1220010	1220010			I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_FREE	0					1500000			
13	YES	P2_mega_s_9210010	9210010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	10000000	6250000			3000000
14	YES	P2_mega_s_9211010	9211010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	10000000	6250000			3000000
15	YES	P2_mega_c_9212010	9212010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	10000000	6250000			3000000
16	YES	P2_mega_c_9213010	9213010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	10000000	6250000			3000000
17	YES	P2_mega_n_9214010	9214010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	11000000	6250000			4500000
18	YES	P2_mega_n_9215010	9215010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	11000000	6250000			4500000
19	YES	P2_north_1210390	1210390			I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_FREE	0					1200000			
20	YES	P2_north_1220400	1220400			I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_FREE	0					1200000			
21	YES	P3_mega_s_9310010	9310010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			9500000	8000000	5000000			2750000
22	YES	P3_mega_s_9311010	9311010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.5E+07	10000000	6250000			3000000
23	YES	P3_mega_c_9312010	9312010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.8E+07	11000000	17800000			2700000
24	YES	P3_mega_c_9313010	9313010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			1.8E+07	11000000	17800000			2700000
25	YES	P3_mega_n_9314010	9314010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			2.5E+07	9350000	18000000			2700000
26	YES	P3_mega_n_9315010	9315010			I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_ELASTIC	13.3			2.5E+07	9350000	18000000			2700000
27	YES	P3_north_1310480	1310480			I_RBT_ELASTIC	I_RBT_FREE	I_RBT_ELASTIC	I_RBT_FREE	I_RBT_FREE	I_RBT_FREE	20.5			600000		1200000			

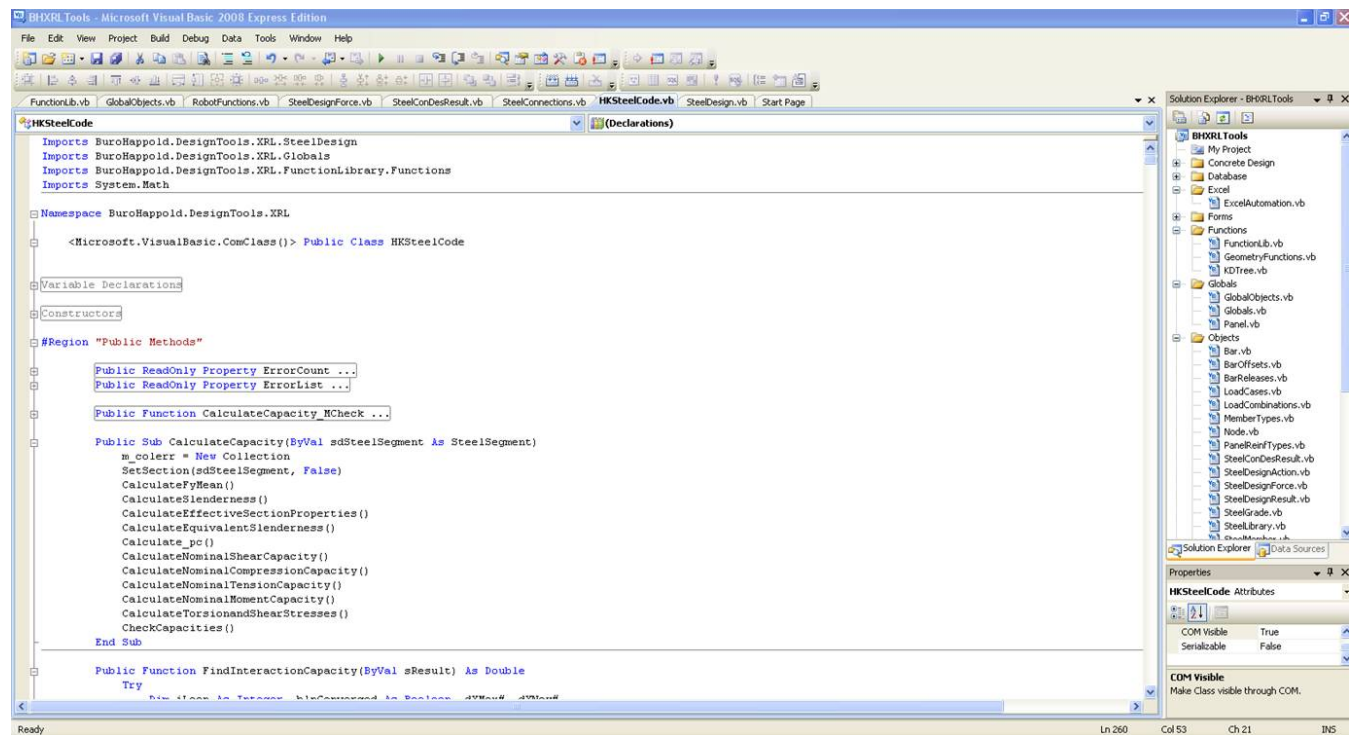




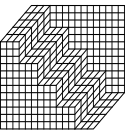
Buro Happold

DRIVING SPLINES



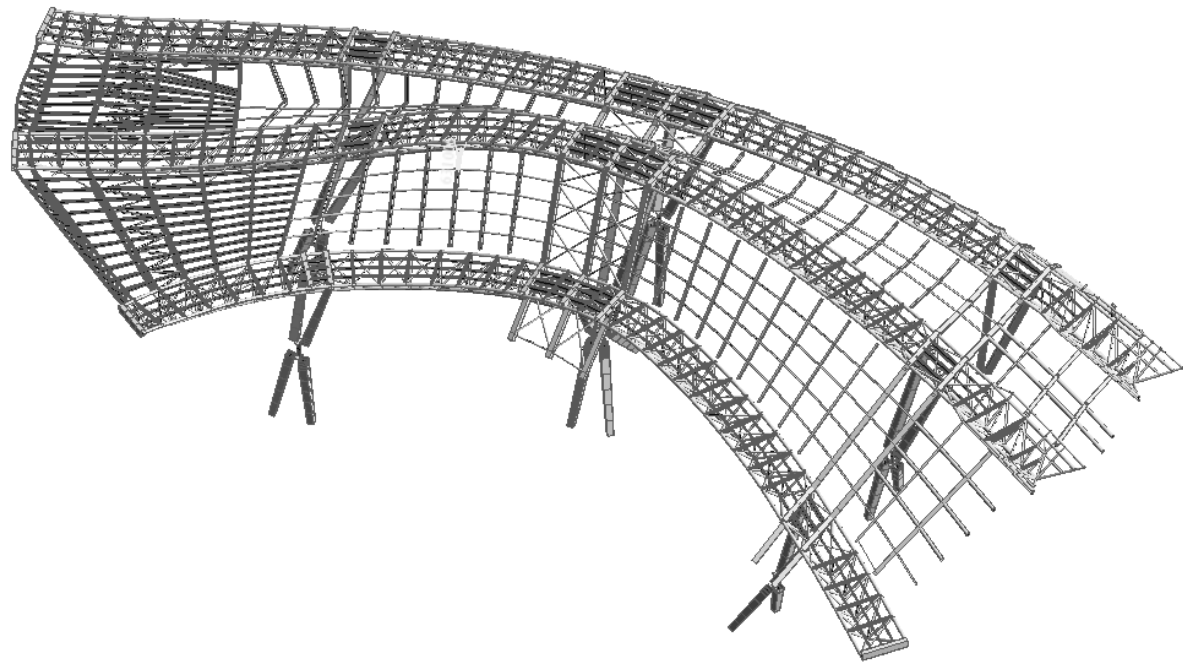
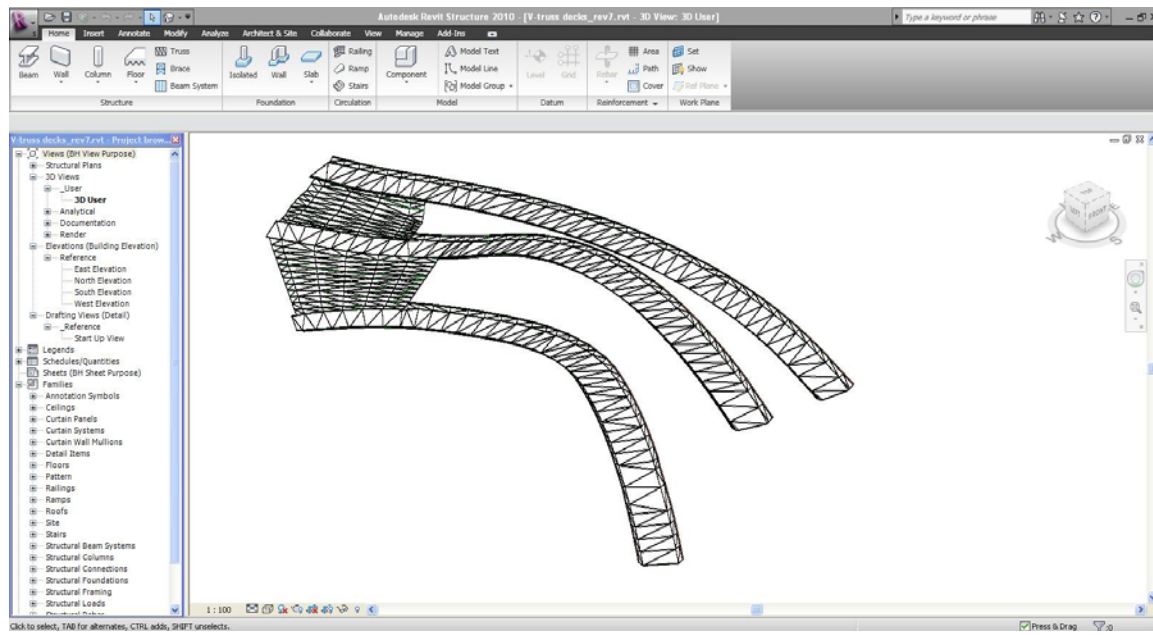
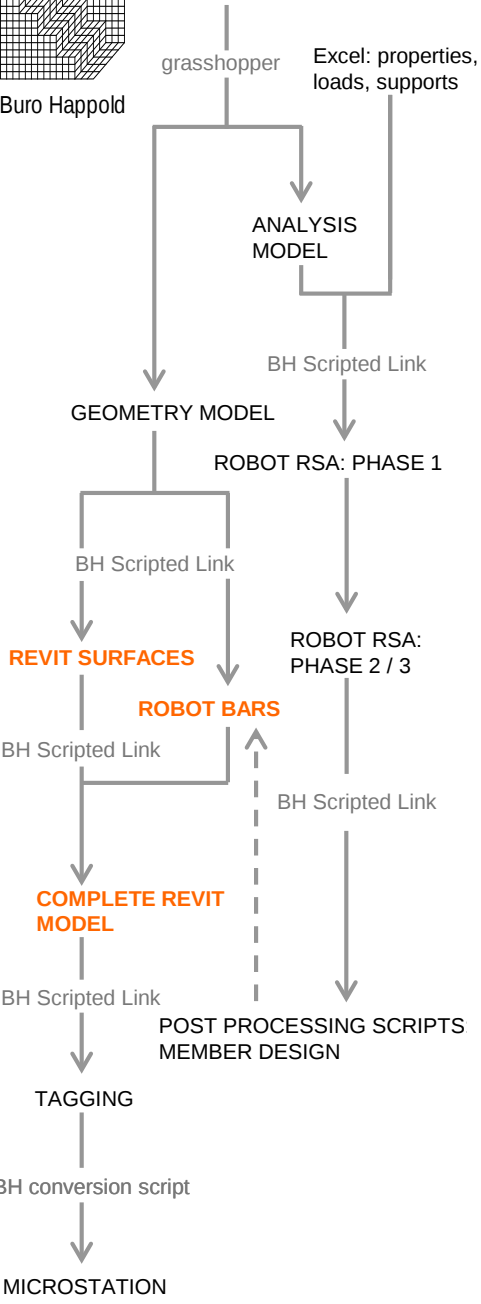


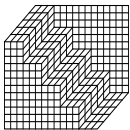
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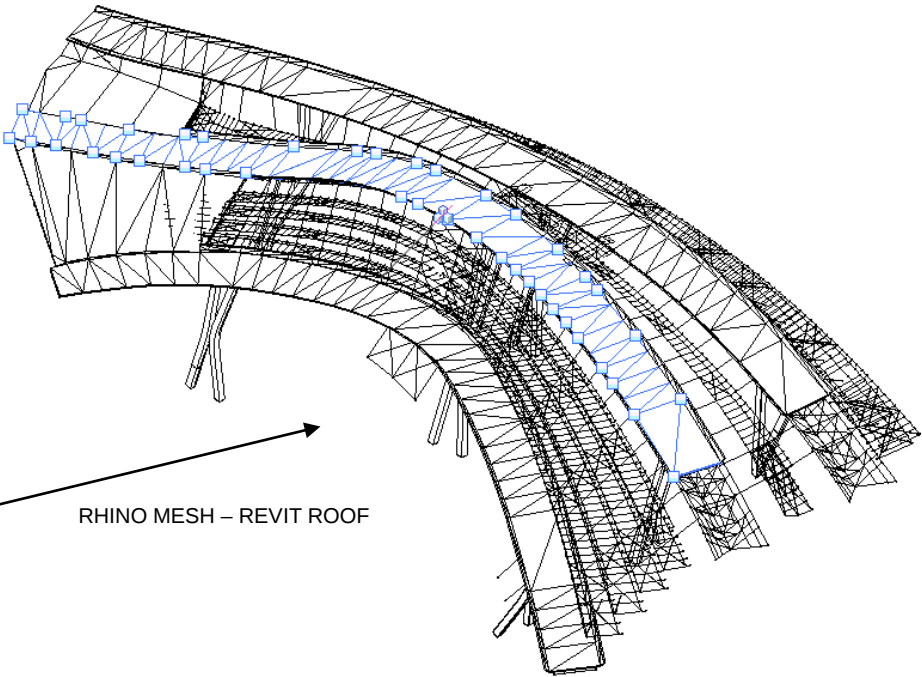
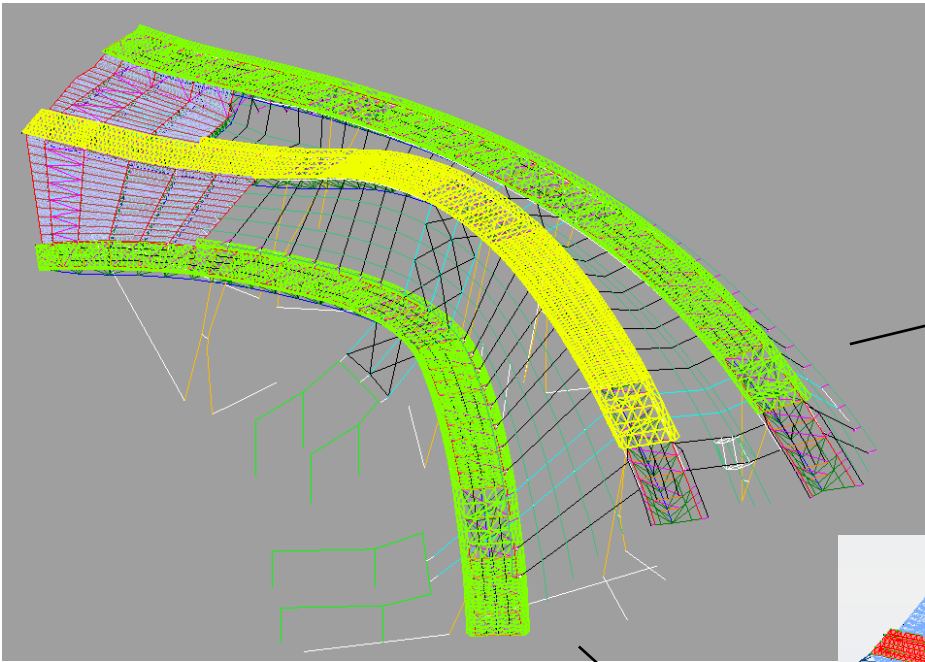
DRIVING SPLINES

Buro Happold



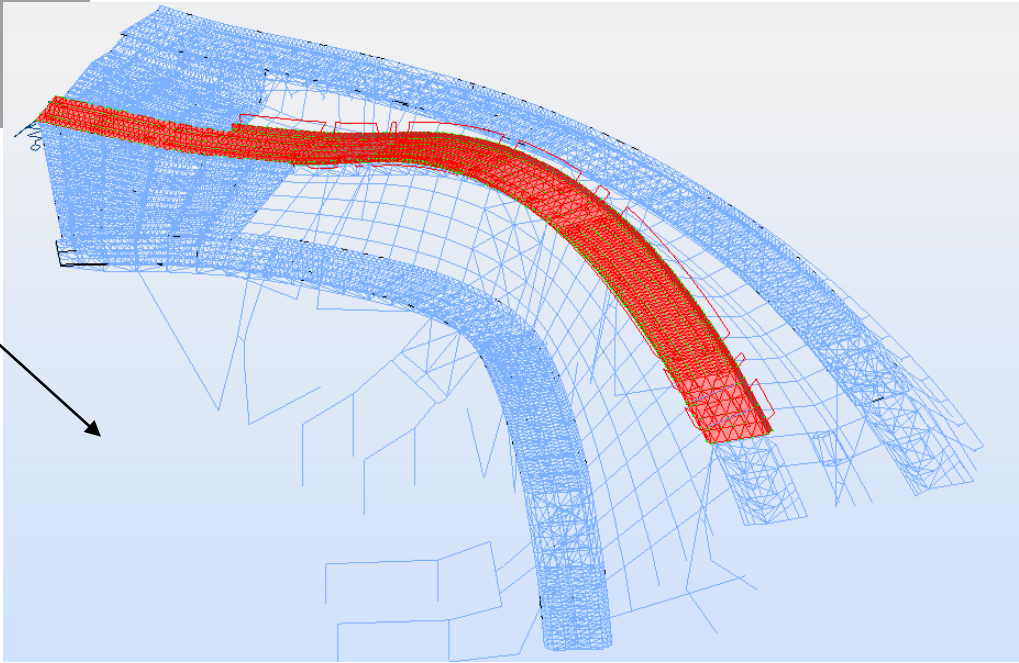


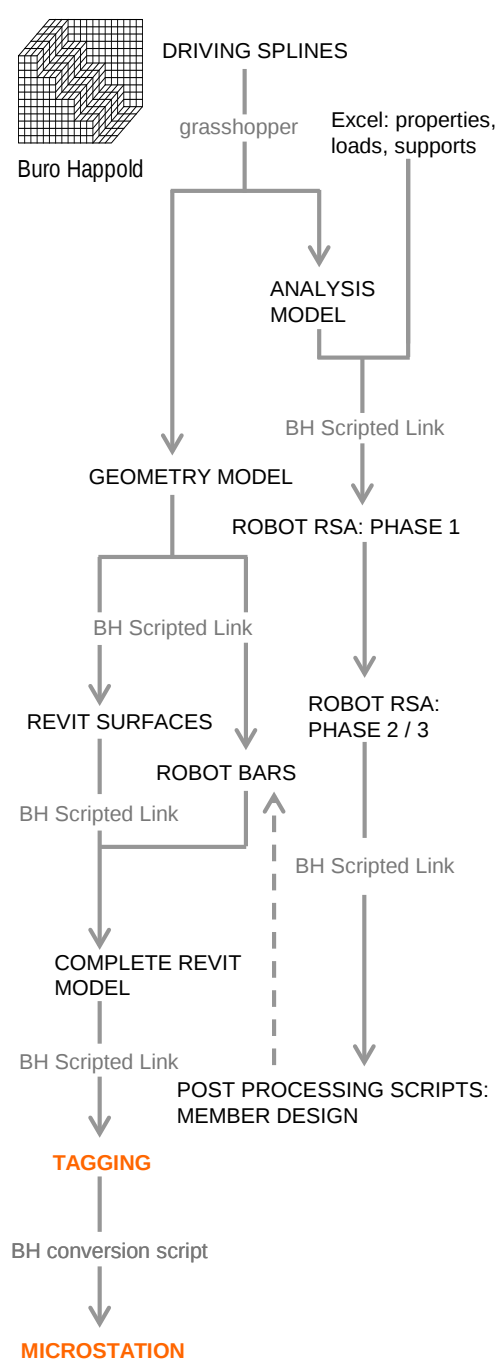
Buro Happold



RHINO MESH – REVIT ROOF

RHINO MESH – ROBOT MESH





Instance Properties

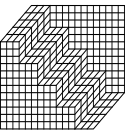
Family: Load...

Type: Edit Type...

Instance Parameters - Control selected or to-be-created instance

Parameter	Value
Constraints	
Reference Level	LEVEL 1
Start Level Offset	18670.0
End Level Offset	32571.5
z-Direction Justification	Center
z-Direction Offset Value	0.0
Lateral Justification	Center
Cross-Section Rotation	-172.570°
Graphics	
Visibility	Secondary Frame
Paint Specification	Internal Exposed - No FRP
Materials and Finishes	
Beam Material	Metal-Steel
Structural	
Stick Symbol Location	Center of Geometry
Moment Connection Start	None
Moment Connection End	None
Cut Length	15500.3
Structural Usage	Other
Camber Size	
Number of studs	
Dimensions	
Length	15513.0
Volume	0.553 m³
Identity Data	
Comments	
Mark	6201
_Filter Comments 01	
_Filter Comments 02	
_Filter Comments 03	
_Filter Comments 04	
_Filter Comments 05	

OK Cancel



DRIVING SPLINES

Buro Happold

grasshopper

Excel: properties,
loads, supports

ANALYSIS
MODEL

BH Scripted Link

GEOMETRY MODEL

ROBOT RSA: PHASE 1

BH Scripted Link

REVIT SURFACES

ROBOT BARS

BH Scripted Link

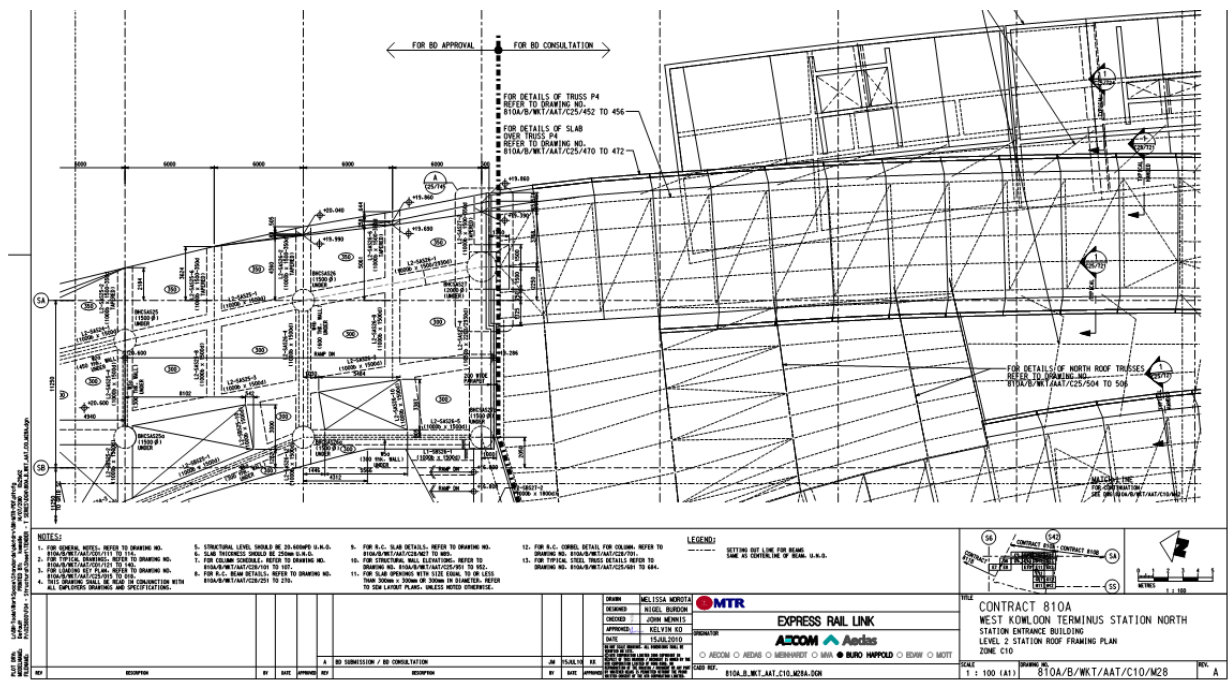
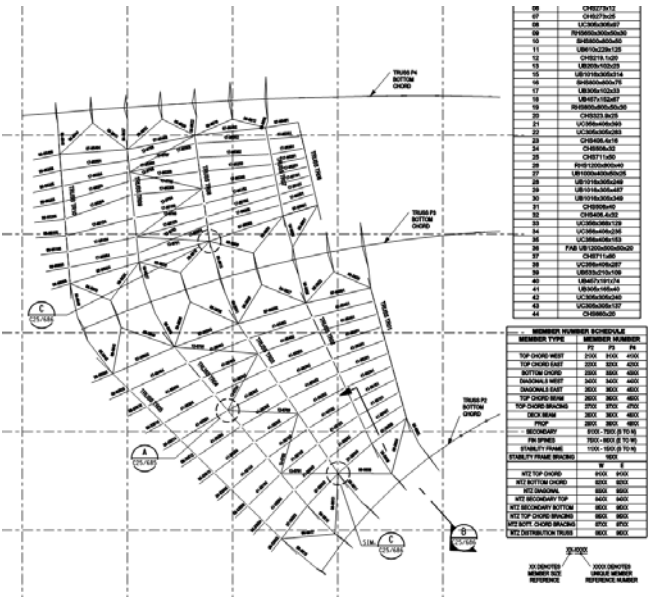
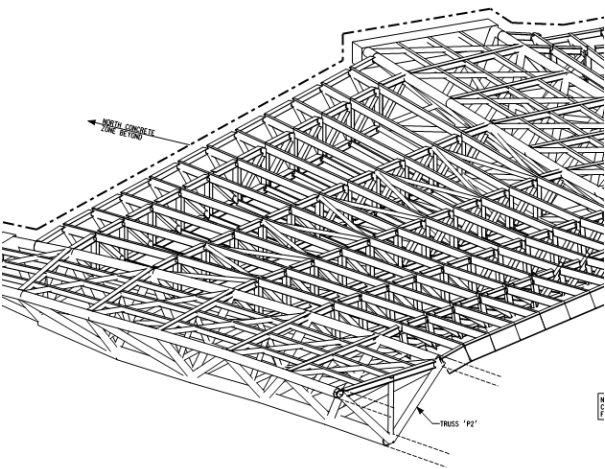
COMPLETE REVIT
MODEL

BH Scripted Link

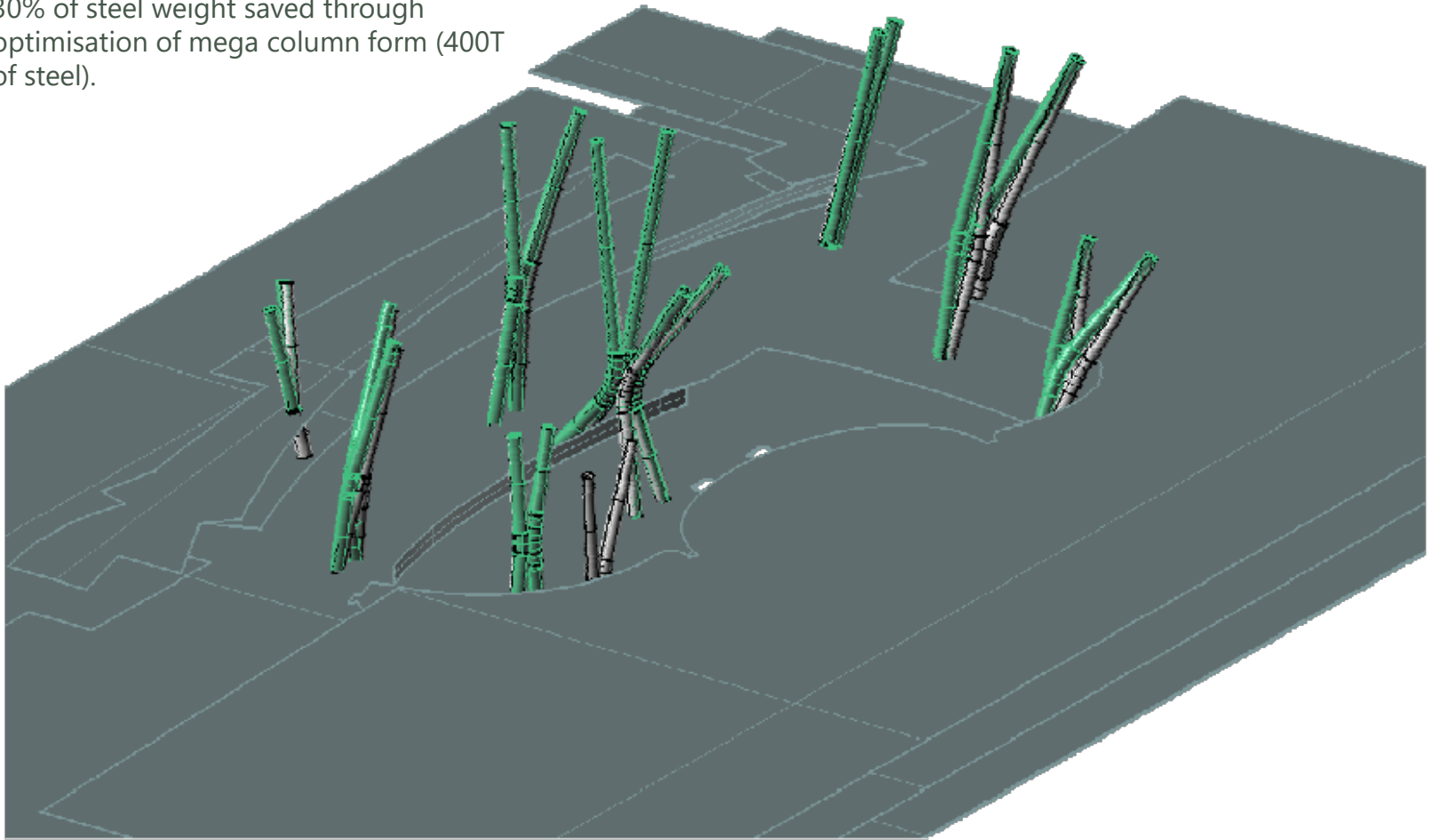
TAGGING

BH conversion script

MICROSTATION



- 30% of steel weight saved through optimisation of mega column form (400T of steel).

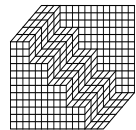


Refined column form in gray

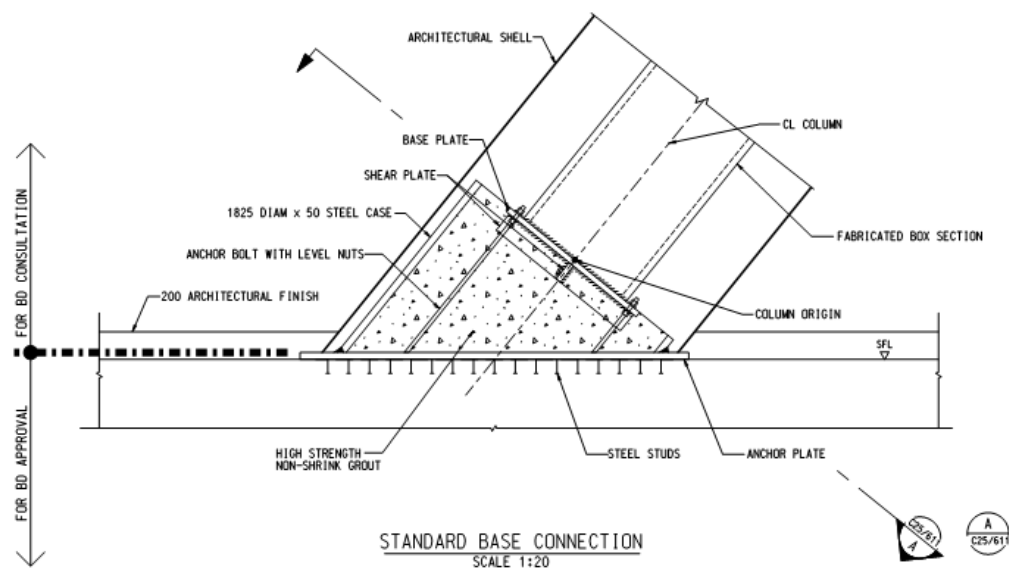
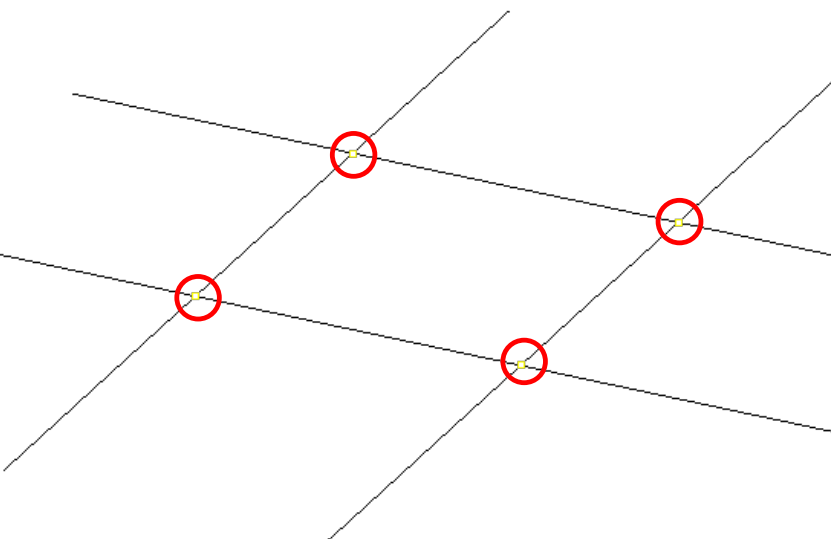
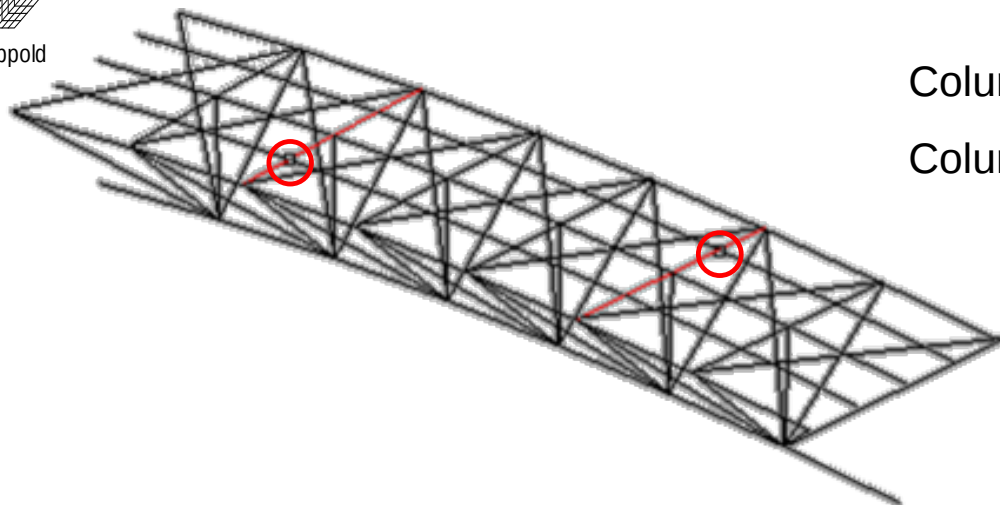
Constraints

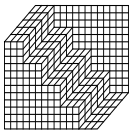
Column base on grid-lines

Column head to align with truss elements

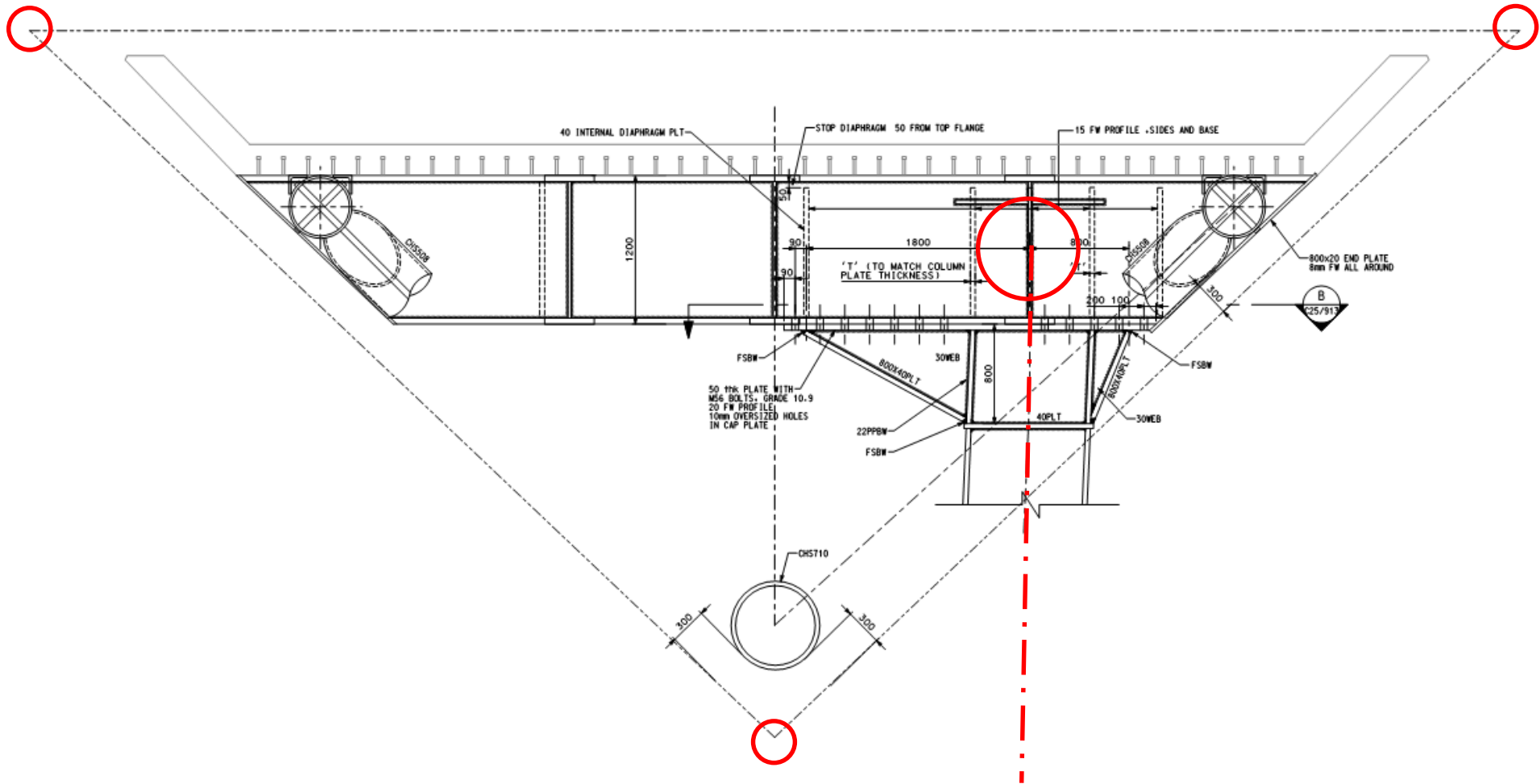


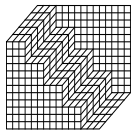
Buro Happold



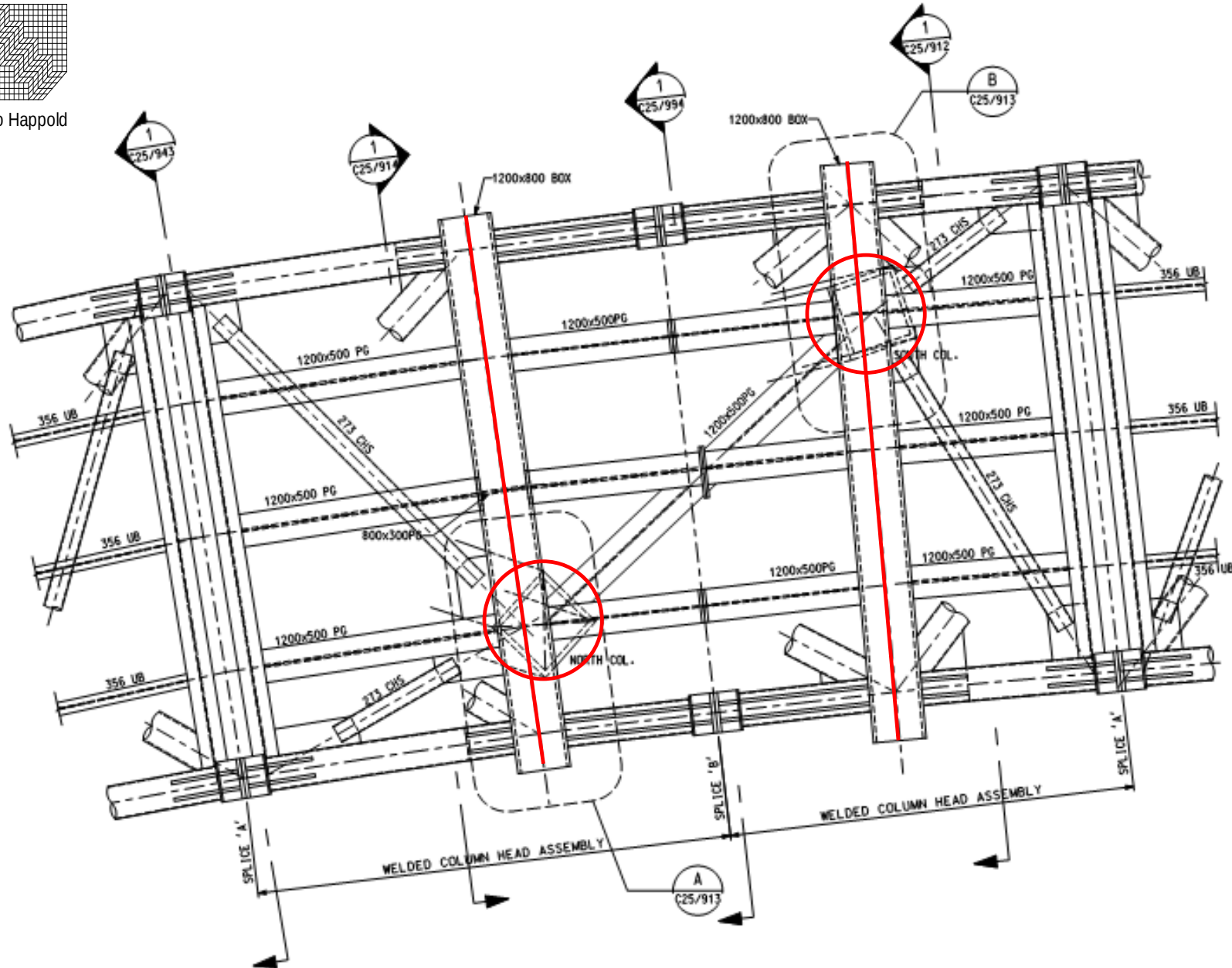


Buro Happold

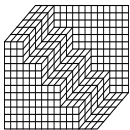




Buro Happold



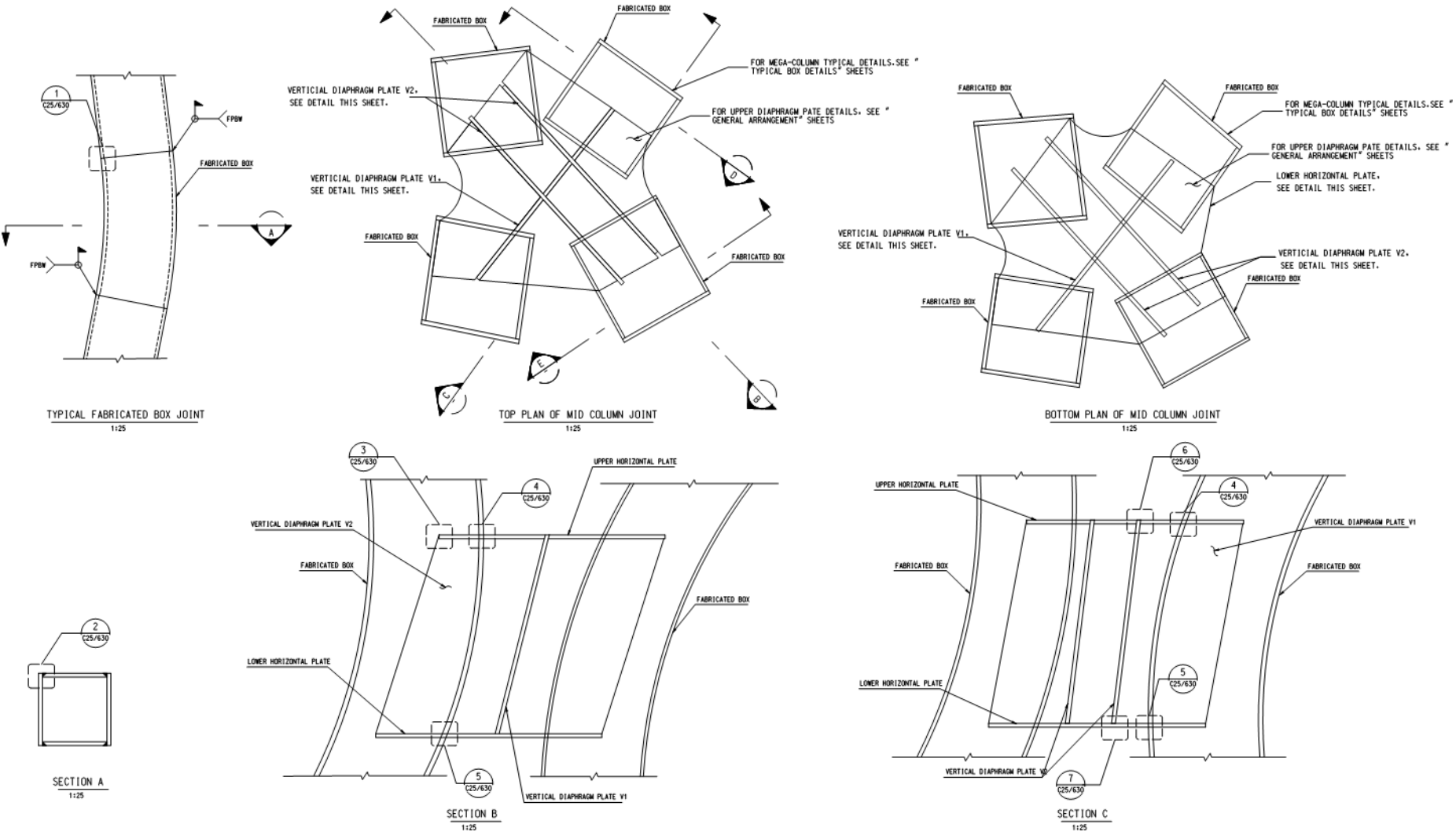
DETAIL
SCALE C10/M29, C10/M43

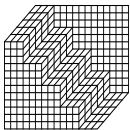


Buro Happold

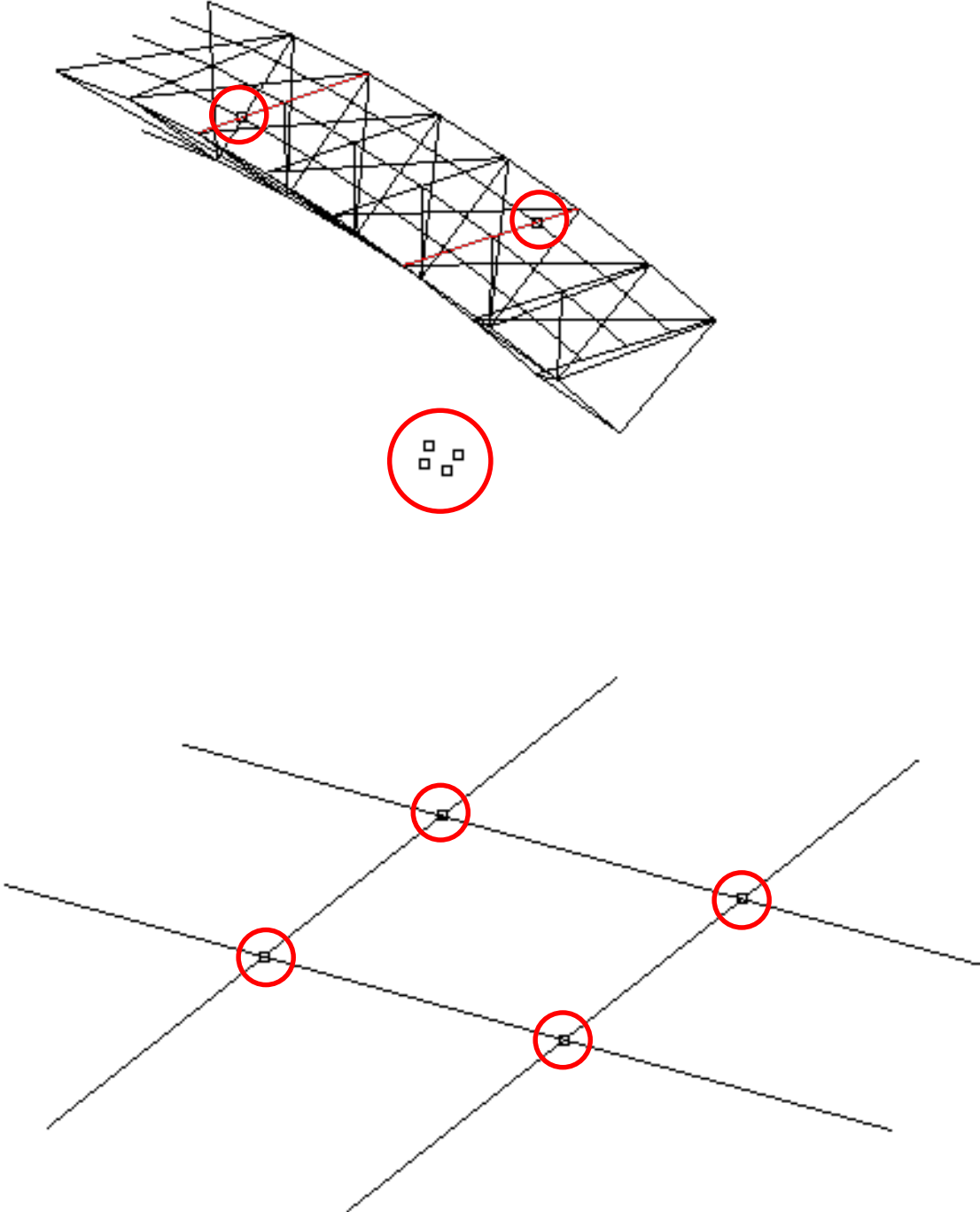
Constraints

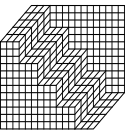
Node fabrication and construction



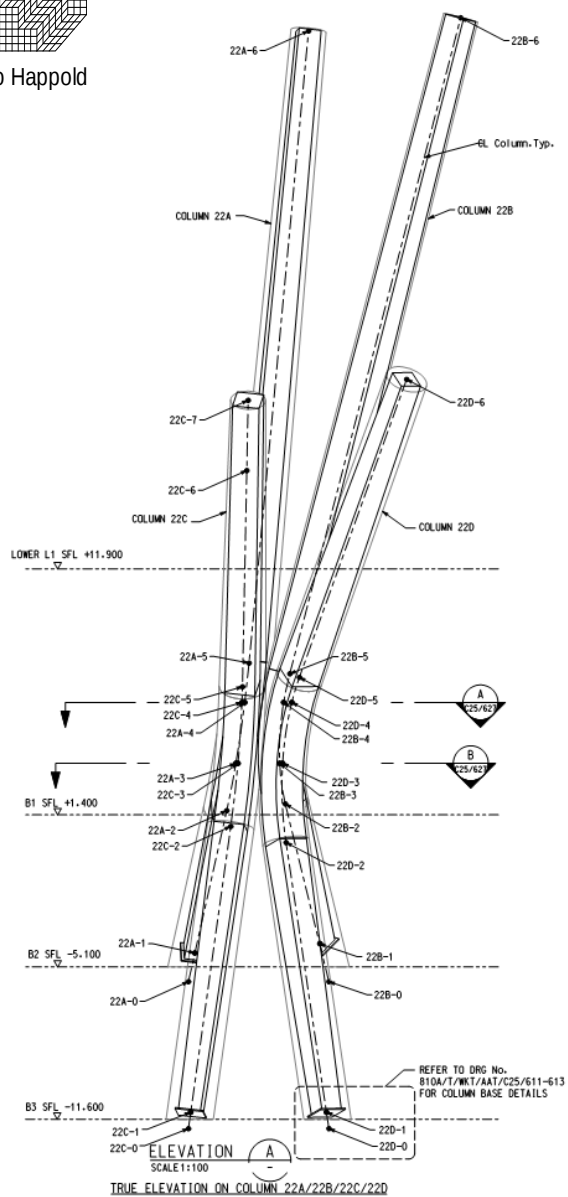


Buro Happold

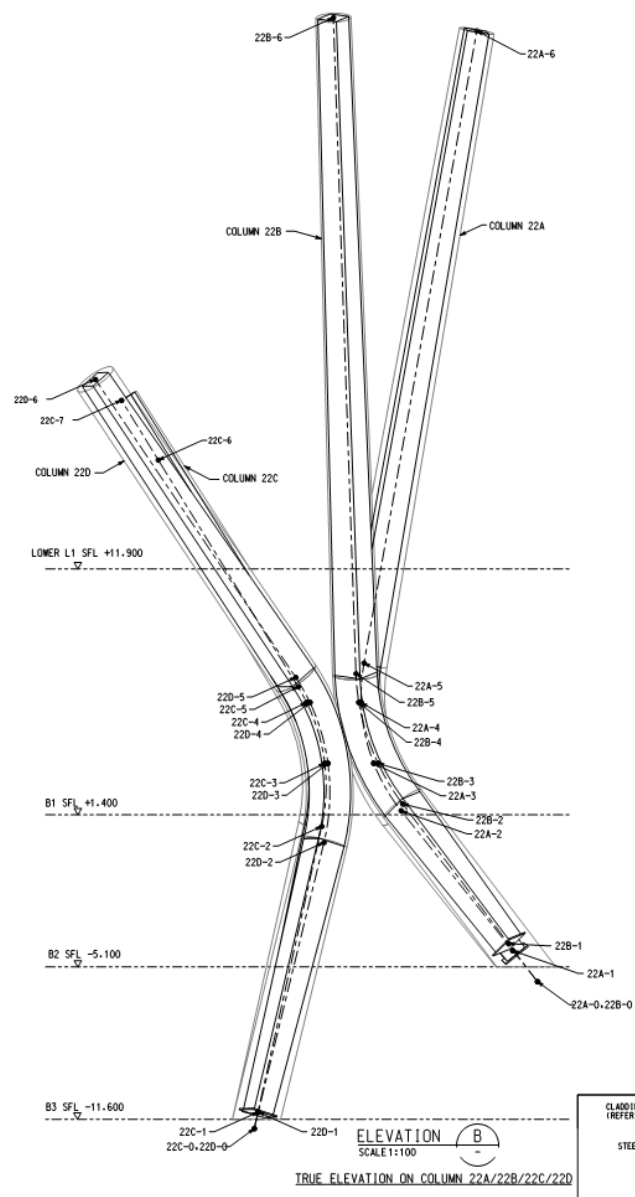




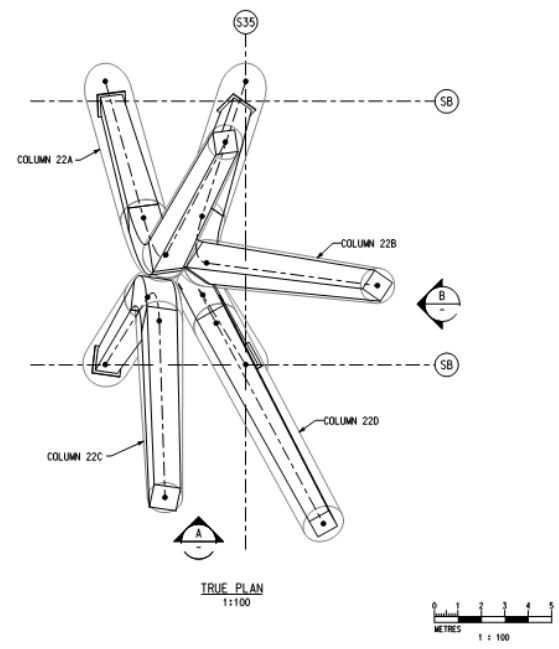
Buro Happold



TRUE ELEVATION ON COLUMN 22A/22B/22C/22D

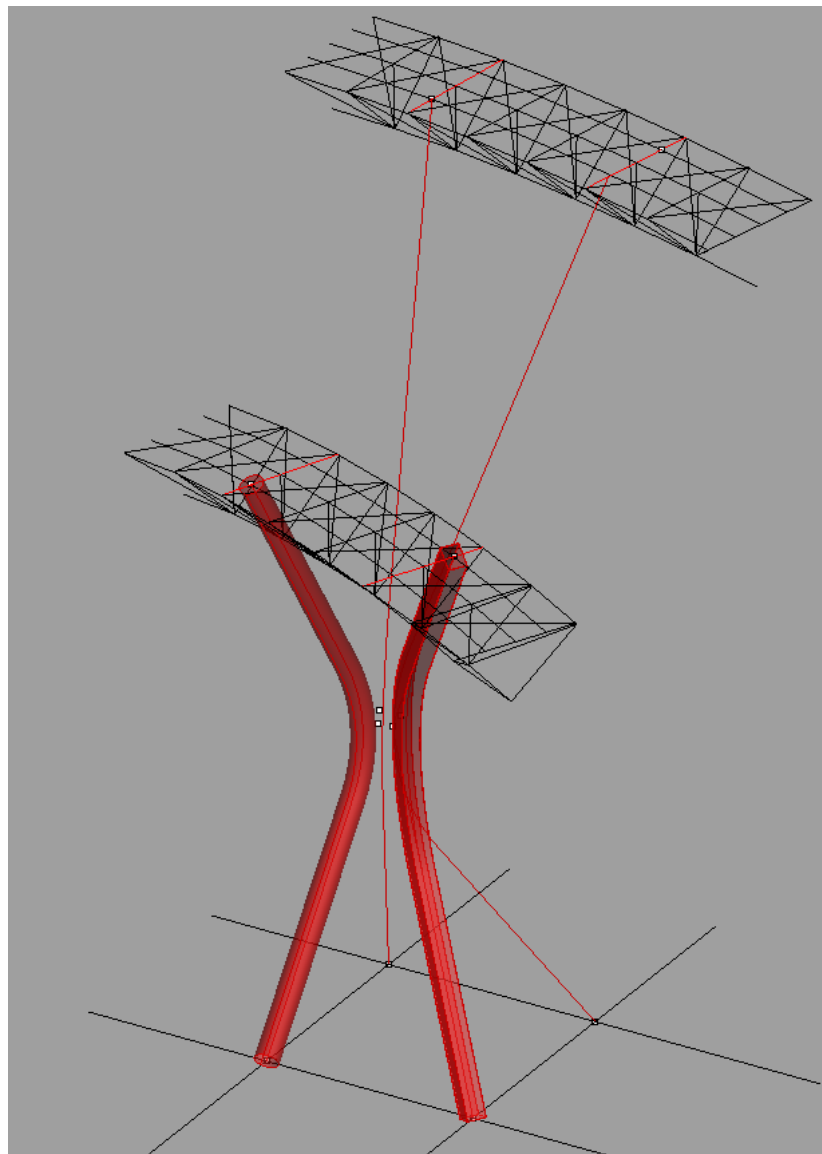
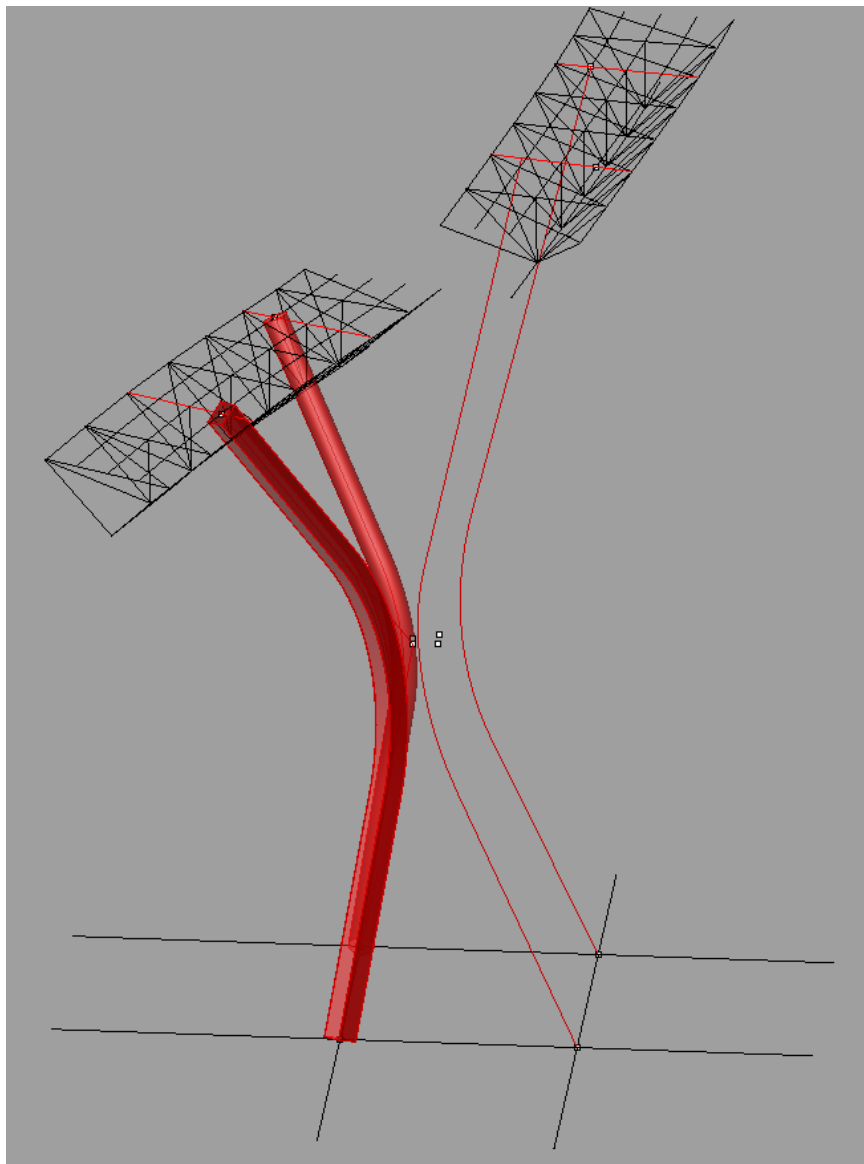


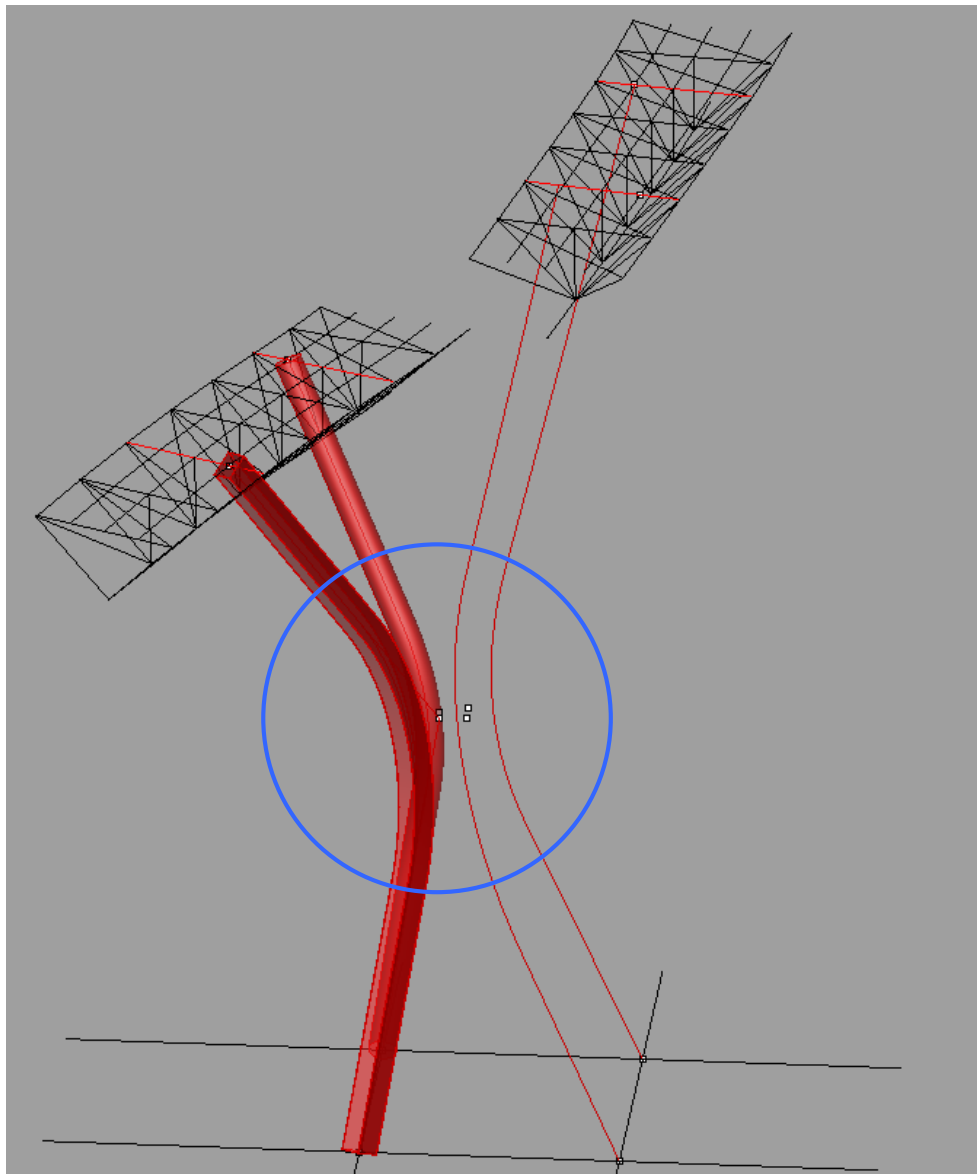
TRUE ELEVATION ON COLUMN 22A/22B/22C/22D



- NOTES:**
1. FOR GENERAL NOTES, REFER TO DRAWING NO. 810A/T/M/T/AAT/C01/111 TO 114.
 2. FOR TYPICAL DRAWINGS, REFER TO DRAWING NO. 810A/T/M/T/AAT/C01/121 TO 140.
 3. FOR LOADING KEY PLAN, REFER TO DRAWING NO. 810A/T/M/T/AAT/C01/015 TO 018.
 4. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL EMPLOYER'S DRAWINGS AND SPECIFICATIONS.
 5. NODE COORDINATES ARE PROVIDED ALONG CL OF COLUMNS.
 6. COLUMN BOX WIDTHS VARY LINEARLY BETWEEN NODES.
 7. COLUMN BOX PLATES CONNECTED BY PARTIAL PENETRATION BUTT WELDS TYPICAL AND BY FULL STRENGTH BUTT WELDS IN JOINT ZONE EXTENDING 500 PAST TOP & BOTTOM DIAPHRAGM (REFER DETAIL).
 8. FOR FIRE PROTECTION DETAILS REFER DRAWINGS.

TYPICAL COLUMN PLATE ARRANGEMENT REFER NOTE 1	DETAIL 1 (TYPICAL)	DETAIL 1 (NEAR JOINT ZONES)
4-HOUR COLUMN FIRE RATING DETAILS	2-HOUR COLUMN FIRE RATING DETAILS	





195%

Leg_1_fillet_radius_m 20

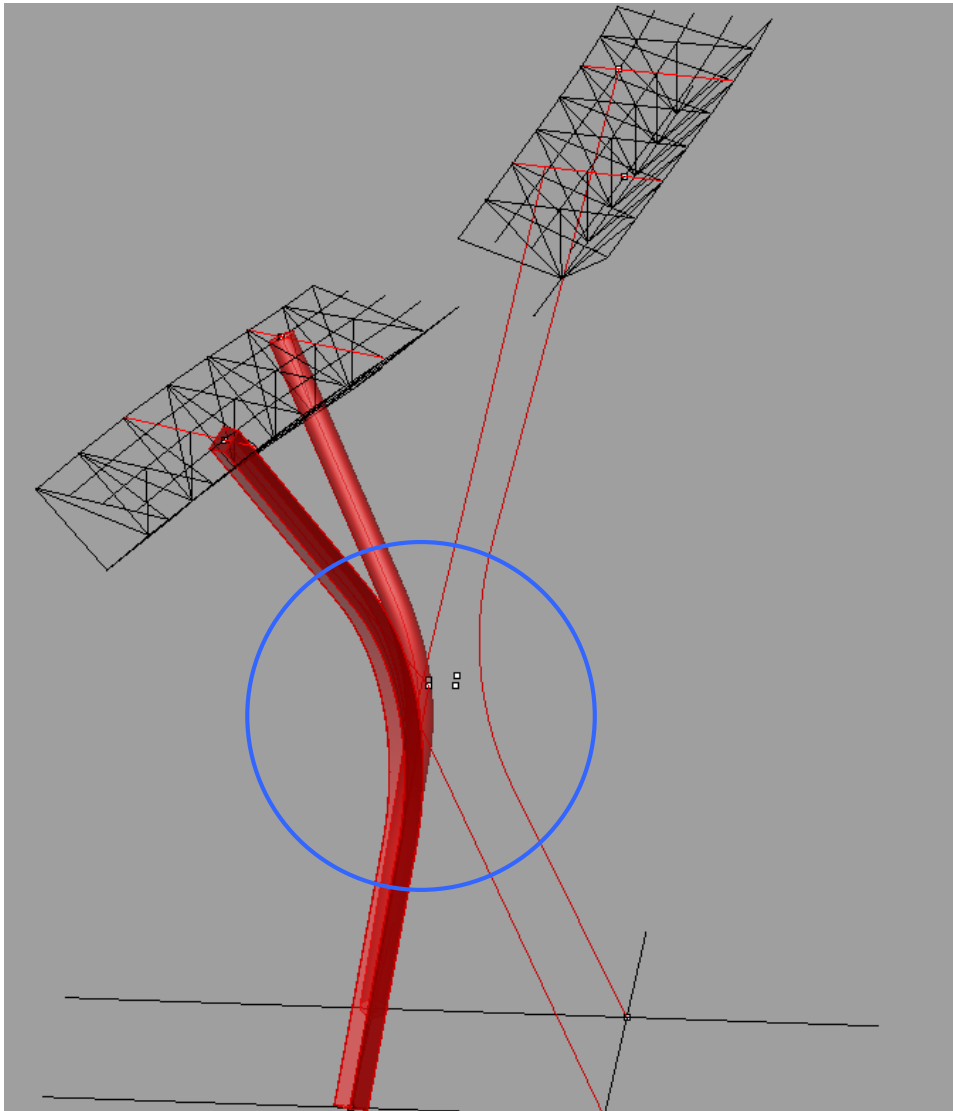
Leg_1_plane_rotation_radians -0.057

Leg_1_Node_height -0.04

Leg_1_Node_spacing 0.13

Leg_1_Head_Location 0.53

Leg_2_fillet_radius_m 20



195%

Leg_1_fillet_radius_m 1

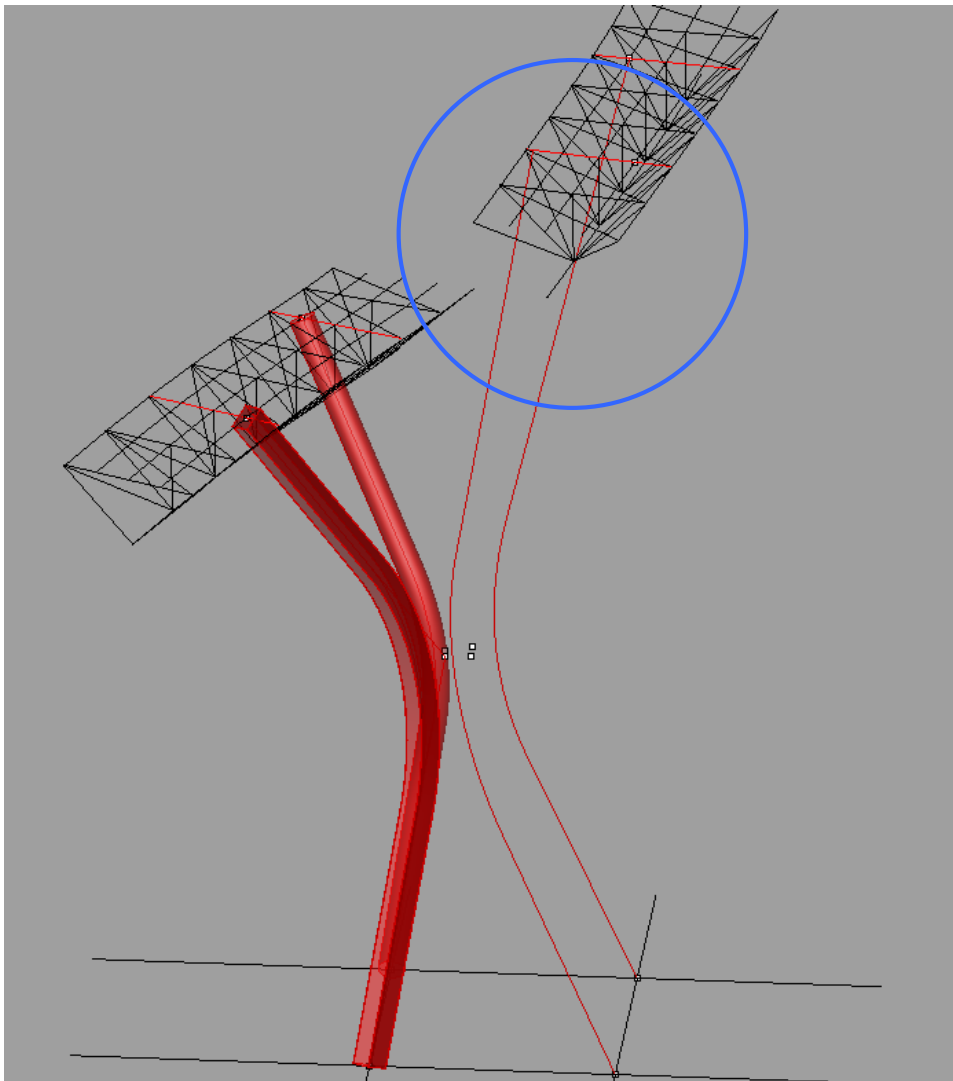
Leg_1_plane_rotation_radians -0.057

Leg_1_Node_height -0.04

Leg_1_Node_spacing 0.13

Leg_1_Head_Location 0.53

Leg_2_fillet_radius_m 20



195%

Leg_1_fillet_radius_m 16

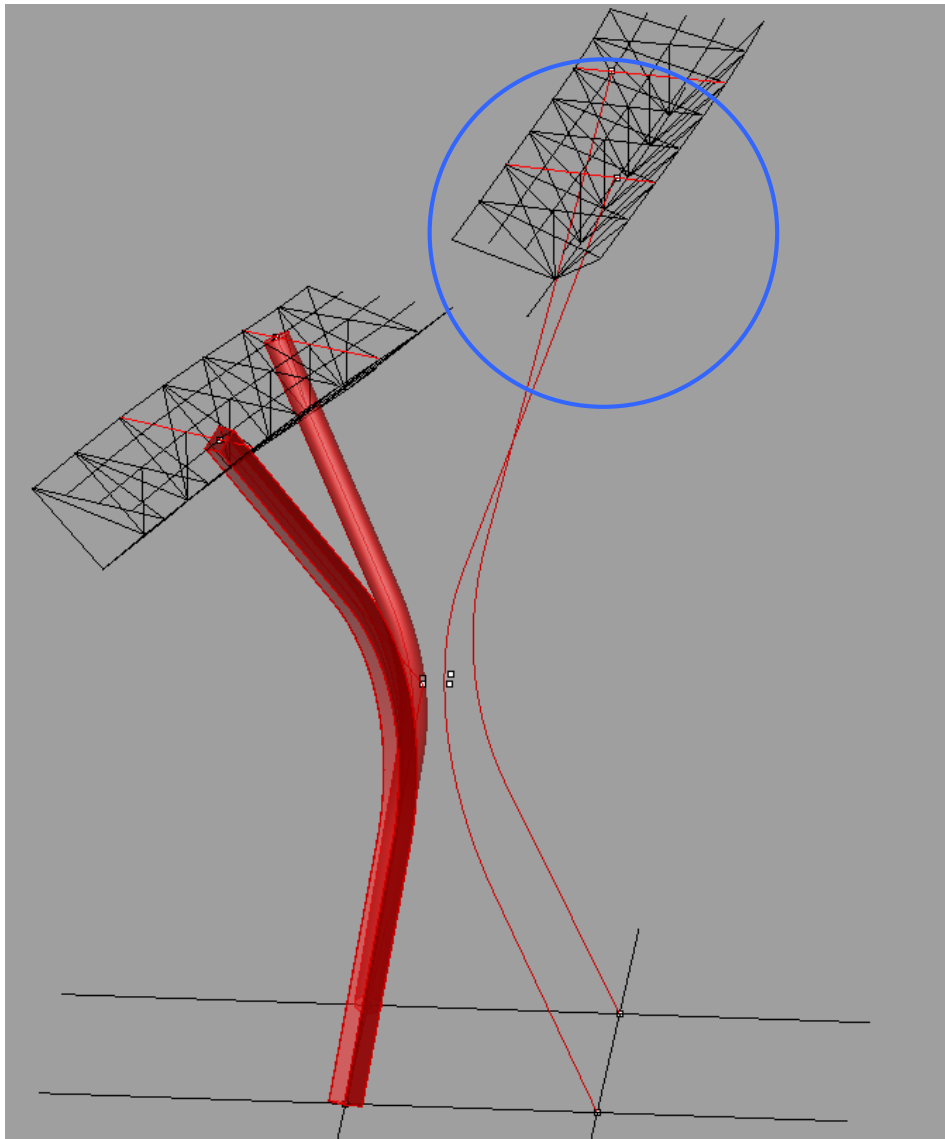
Leg_1_plane_rotation_radians -0.057

Leg_1_Node_height -0.04

Leg_1_Node_spacing 0.13

Leg_1_Head_Location 0.70

Leg_2_fillet_radius_m 20



195%

Leg_1_fillet_radius_m 16

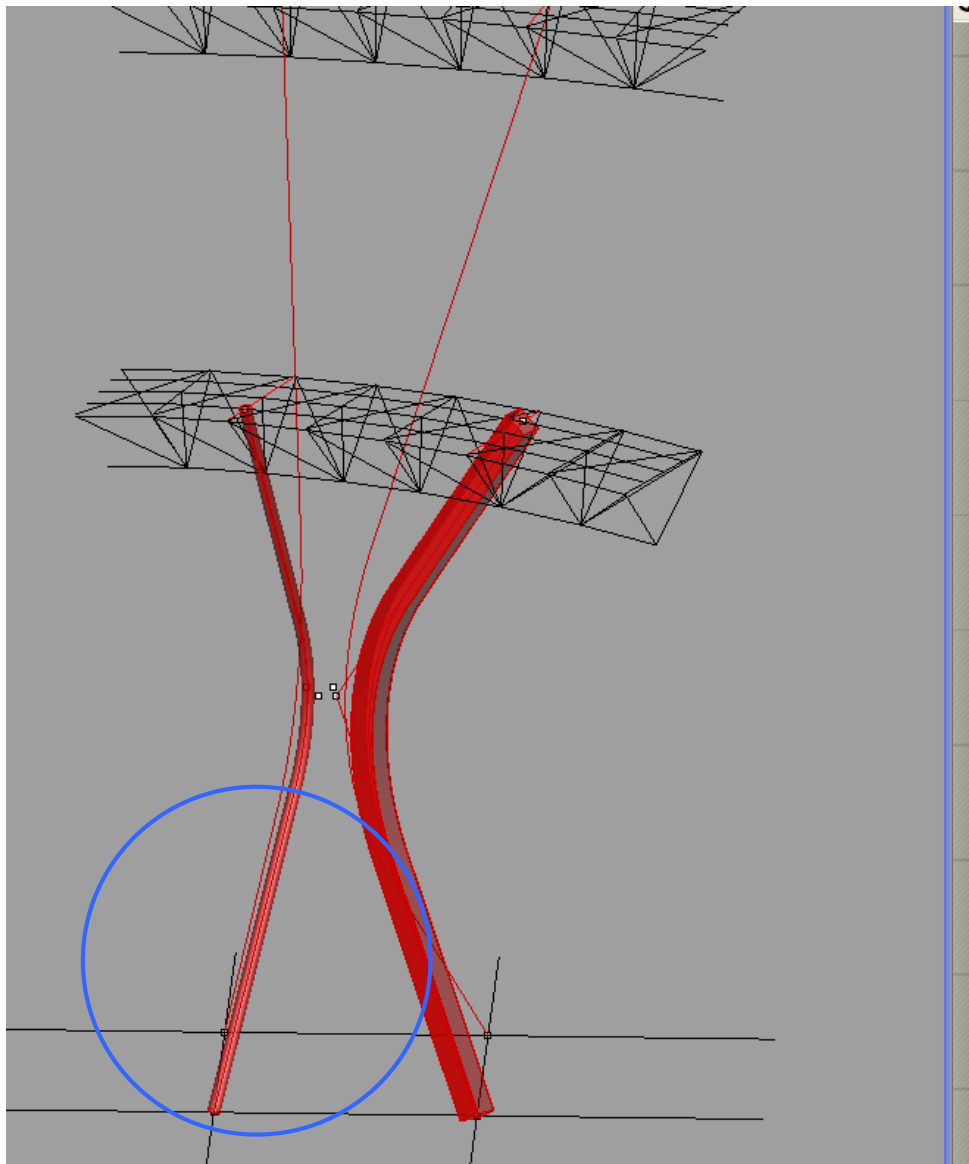
Leg_1_plane_rotation_radians -0.057

Leg_1_Node_height -0.04

Leg_1_Node_spacing 0.13

Leg_1_Head_Location 0.02

Leg_2_fillet_radius_m 20



Leg_1_Head_Location

0.09

Leg_2_fillet_radius_m

20

Leg_3_fillet_radius_m

12

Column_diameter_m

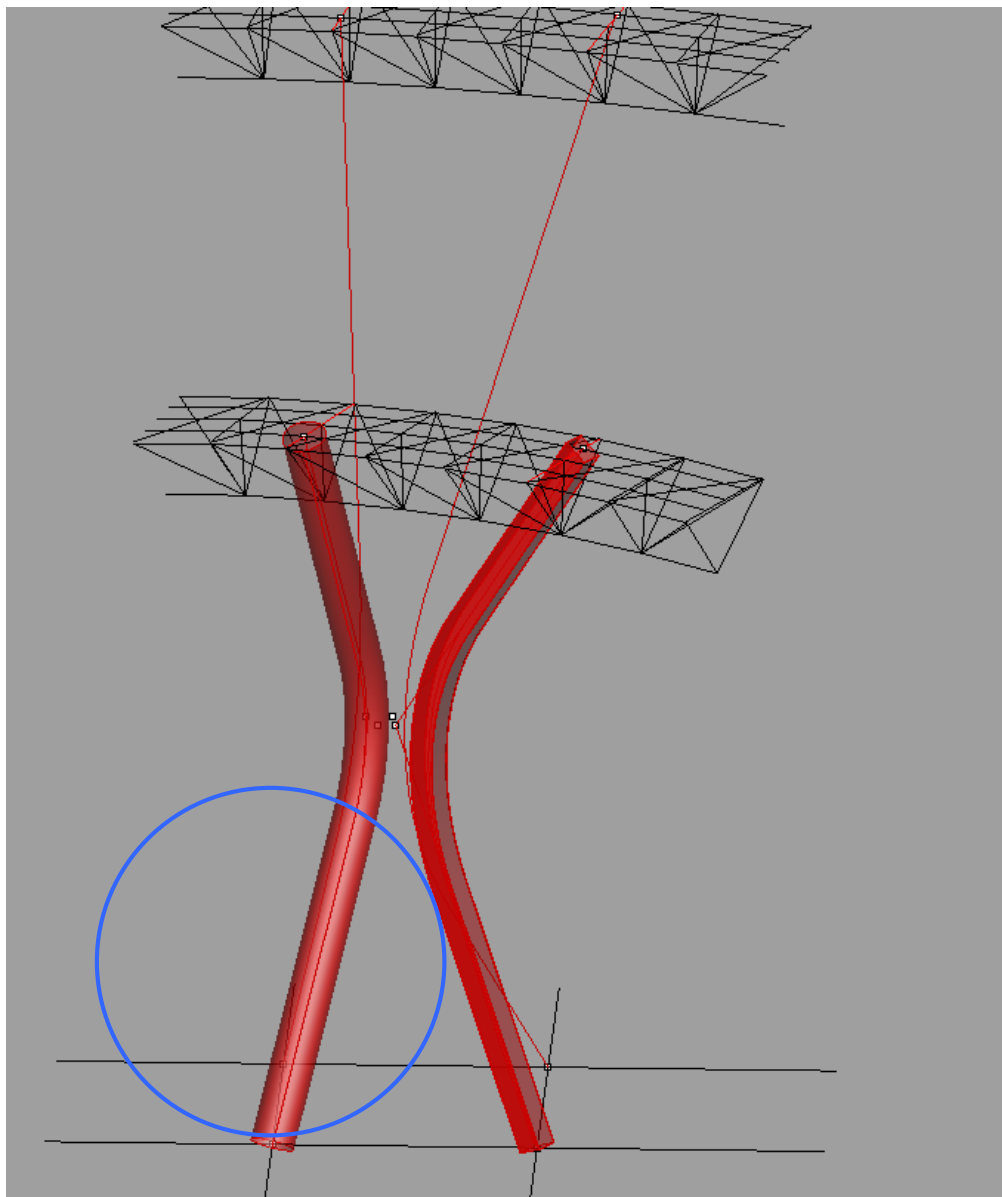
0.6

Leg_4_fillet_radius_m

14

d

1.30



156%

Leg_1_Head_Location 0.09

Leg_2_fillet_radius_m 20

Leg_3_fillet_radius_m 12

Column_diameter_m 2.0

Leg_4_fillet_radius_m 14

d 1.30

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Released: Jan 14, 2010

Version: 1.0

15.2 MB

Languages: English

Seller: Ian Keough

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Rated 4+

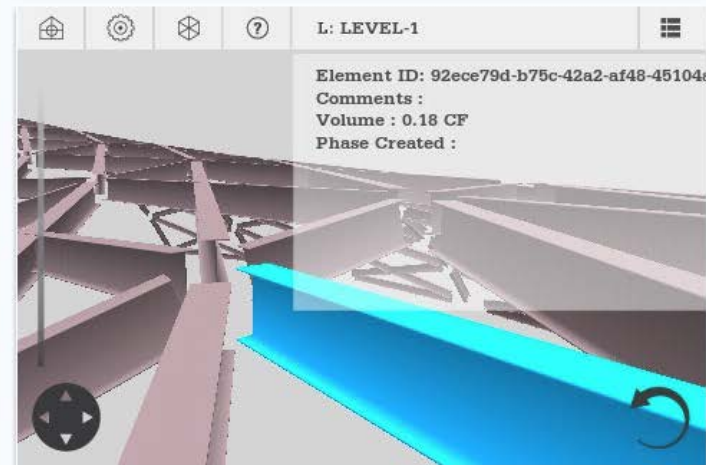
Requirements: Compatible with iPhone and iPod touch. Requires iPhone OS 3.1.2 or later.

Customer Ratings

We have not received enough ratings to display an average for

Description

goBIM allows you to view BIM models on your iPhone! Using a goBIM exporter for your favorite BIM application, you can now create a .gbm file. Load the file onto a web server and you have your models whenever, wherever you want them.

[Ian Keough Web Site](#) [goBIM Support](#)[...More](#)**Screenshots**

TA



