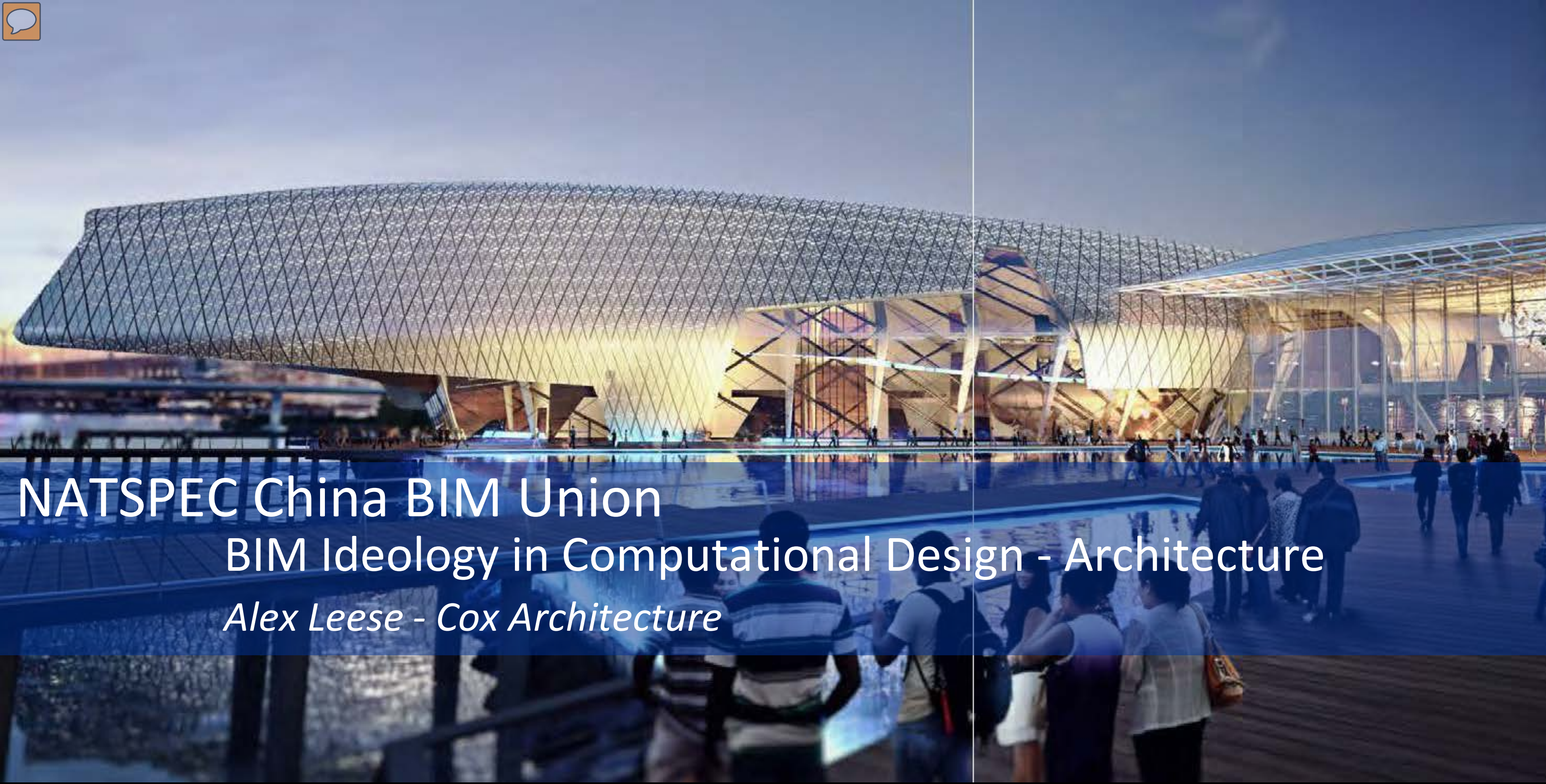


NATSPEC China BIM Union

BIM Ideology in Computational Design - Architecture

Alex Leese - Cox Architecture

Case Study of the Anna Meares Velodrome and the National Maritime Museum of China

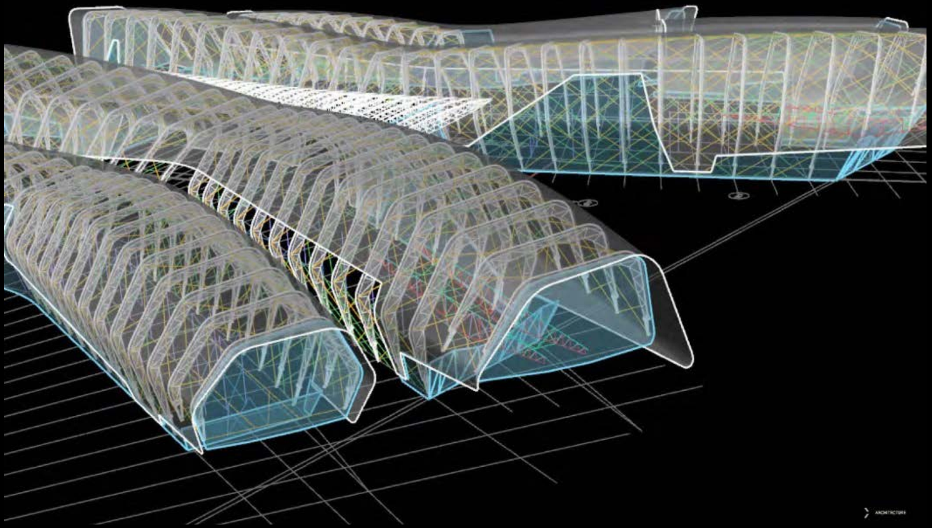
BIM at Cox

BIM through computational design

National Maritime Museum of China

Anna Meares Velodrome

Questions



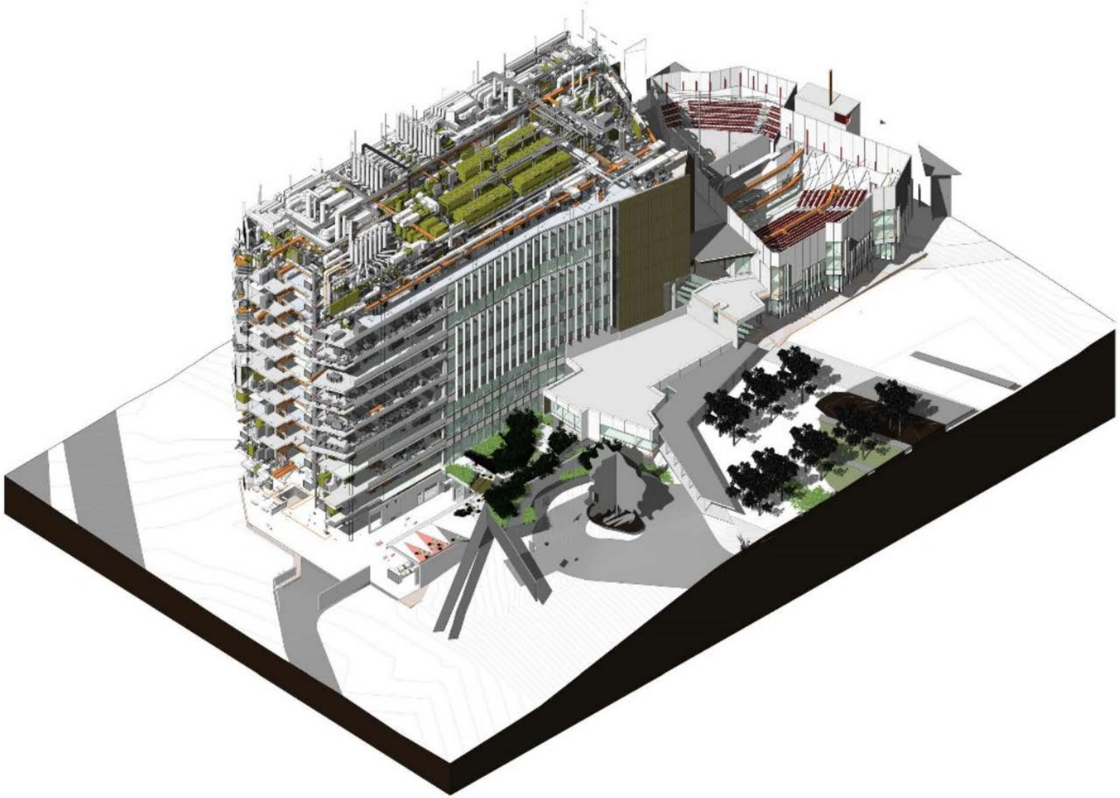
BIM at Cox

Employs best practice standards across national offices as a minimum as internal QA process

Investment in innovation, research and development

Design driven outcomes

Higher levels of BIM currently client or project driven process – could do better!



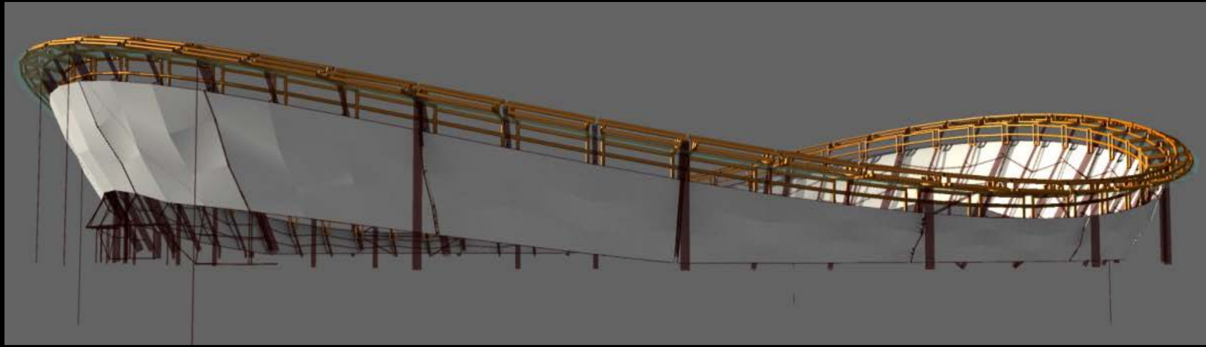
BIM through Computational Design

Single source of data, both information and geometric

Mathematically controlled to reduce manual error

Code is backwards auditable

Source information can pass through multiple stages and uses



National Maritime Museum of China

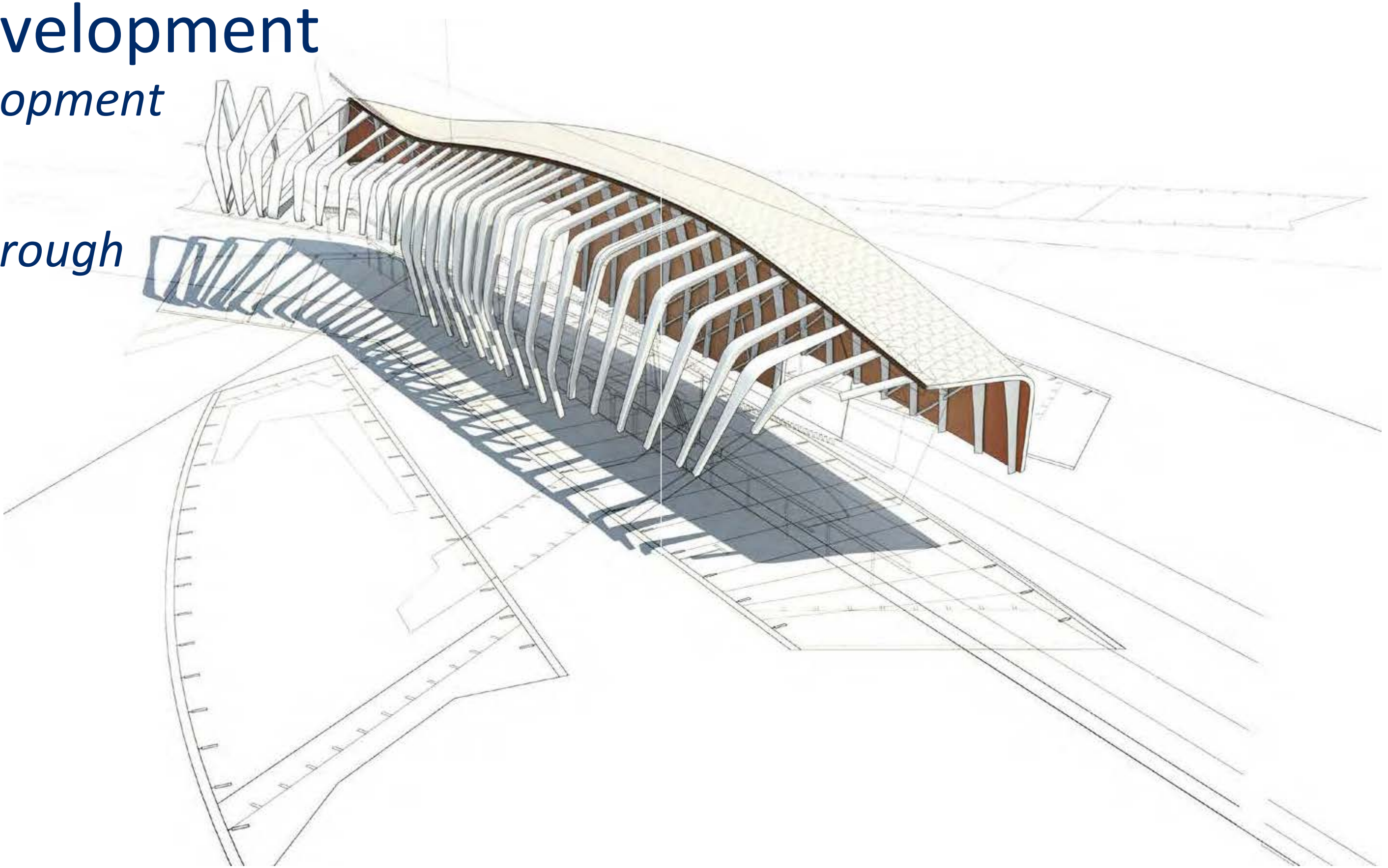
Managing Complexity – BIM procedures, structural and façade development

Structural Development

Portal frame development

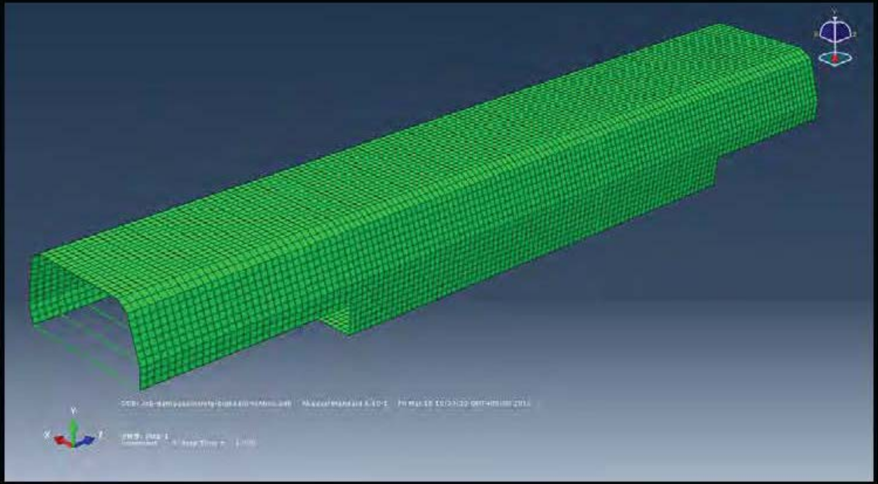
Bracing logic

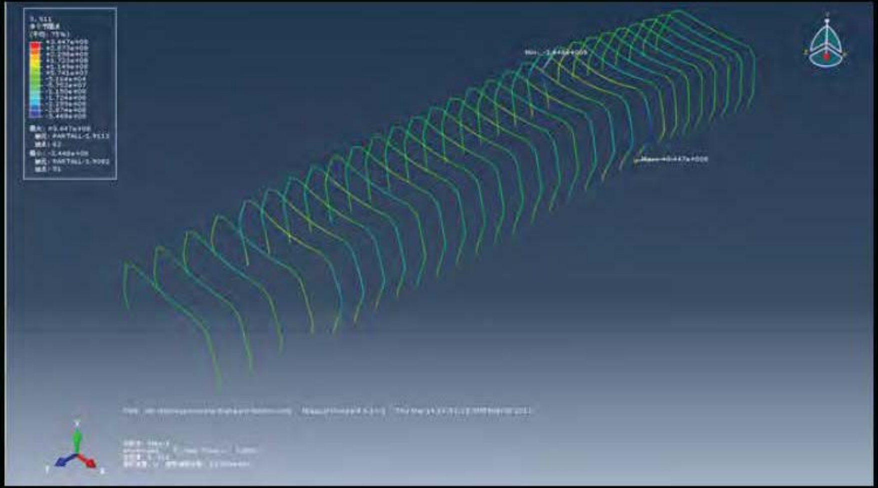
Communication through models

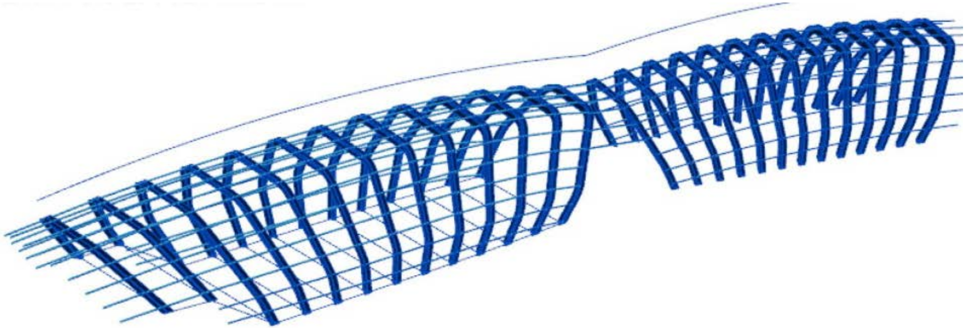


Early engineering analysis was not coordinated through software packages or defined BIM workflow.

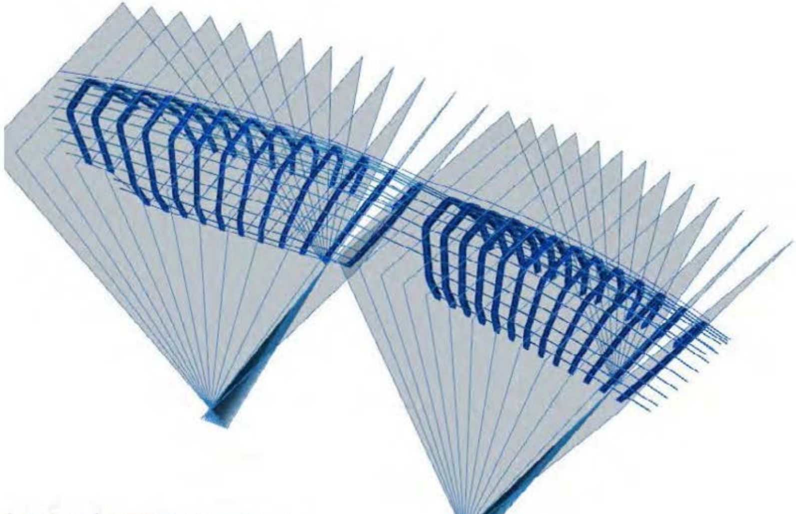
A better system was required to translate design intent through all packages accurately



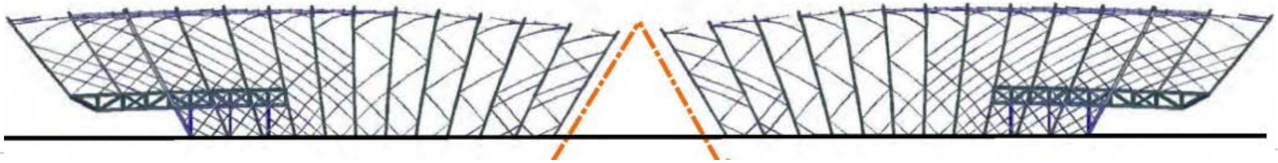




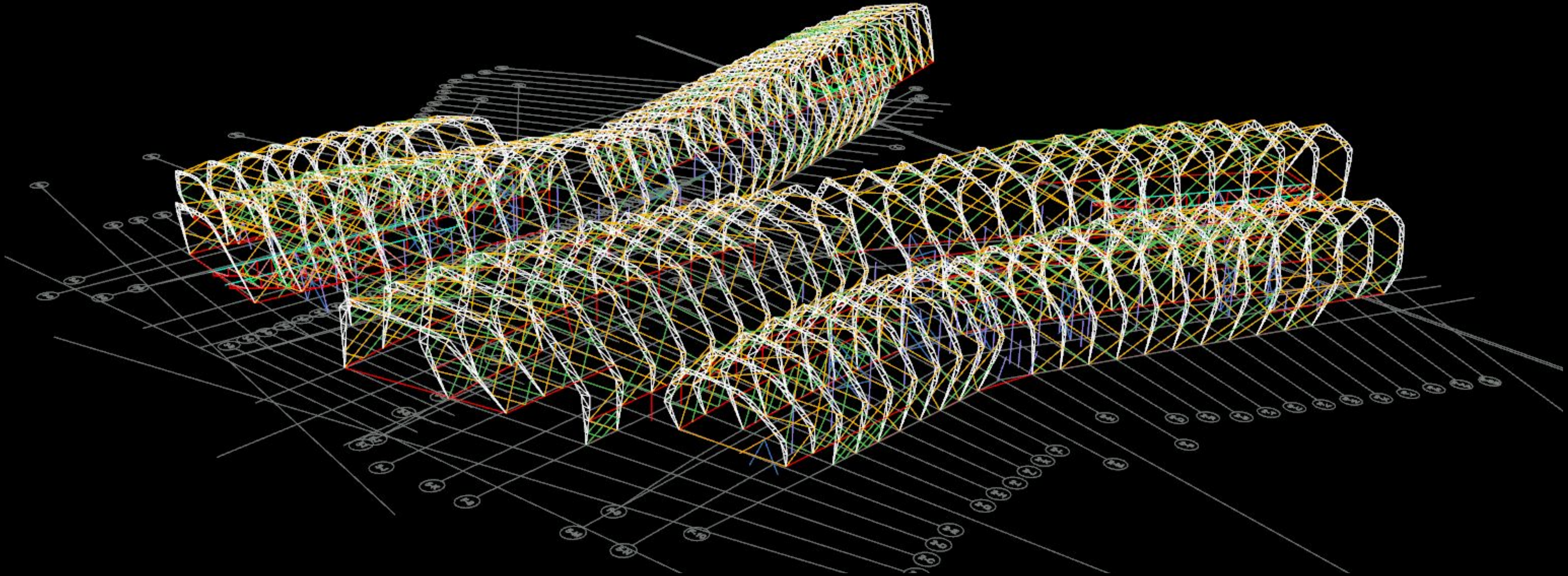
The defining geometry for the frames was established using angled planes that intersected the façade forms.



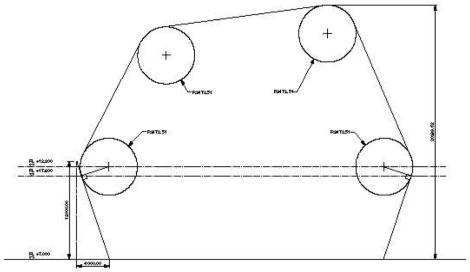
Bracing logic written in parametrically with a structural logic for eroding the fill bracing to create the final bracing pattern

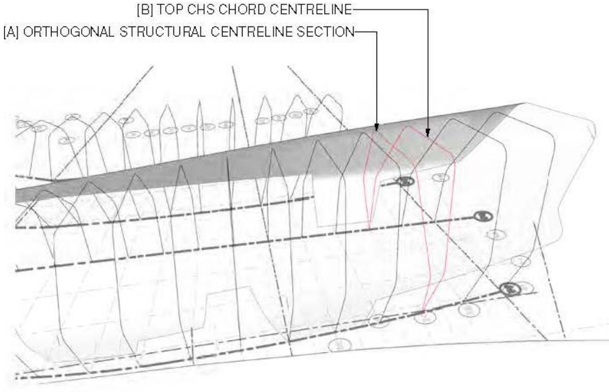


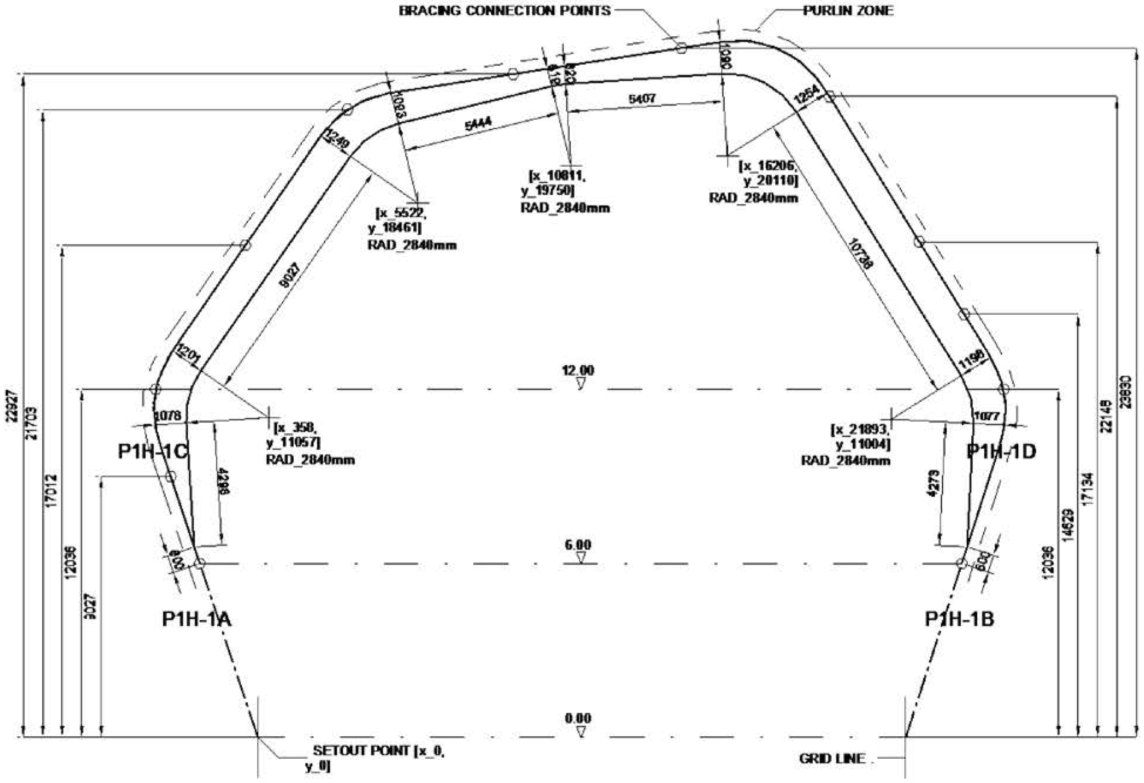
The final forms communicated with structural centre lines



Automated documentation of portal frames – 2D project requirement







P1H-1 PORTAL LEAN_4.44° CHS DIAMETER_400mm

Steel construction

Manufacture of steel from model information

Portal construction

Formed portal sheaths in GRC from the model information

Façade Development

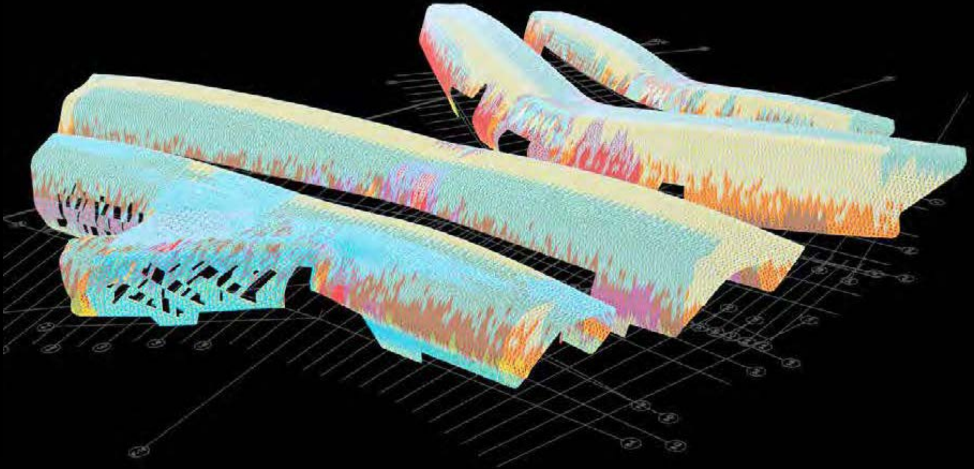
Development of simple panel system that responds to an organic form

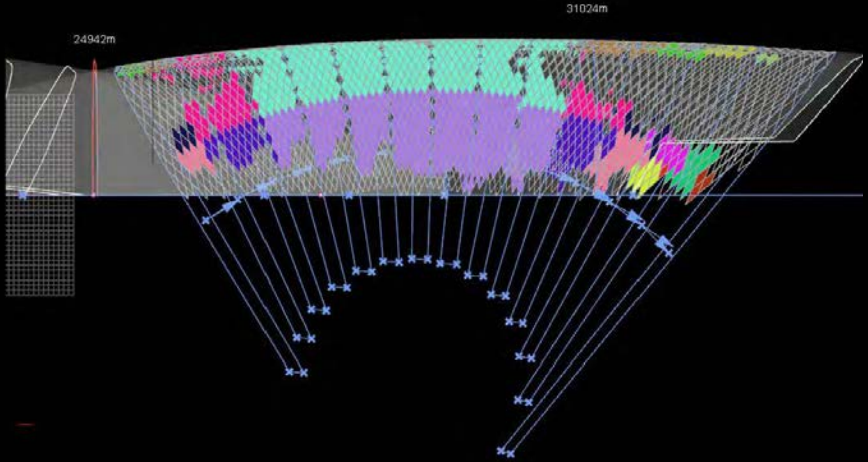
Development of code that allows great flexibility and accuracy

Standardisation and managing tolerance within building systems

Standardisation

Controlling the degree of standardisation through distortion of panel grids





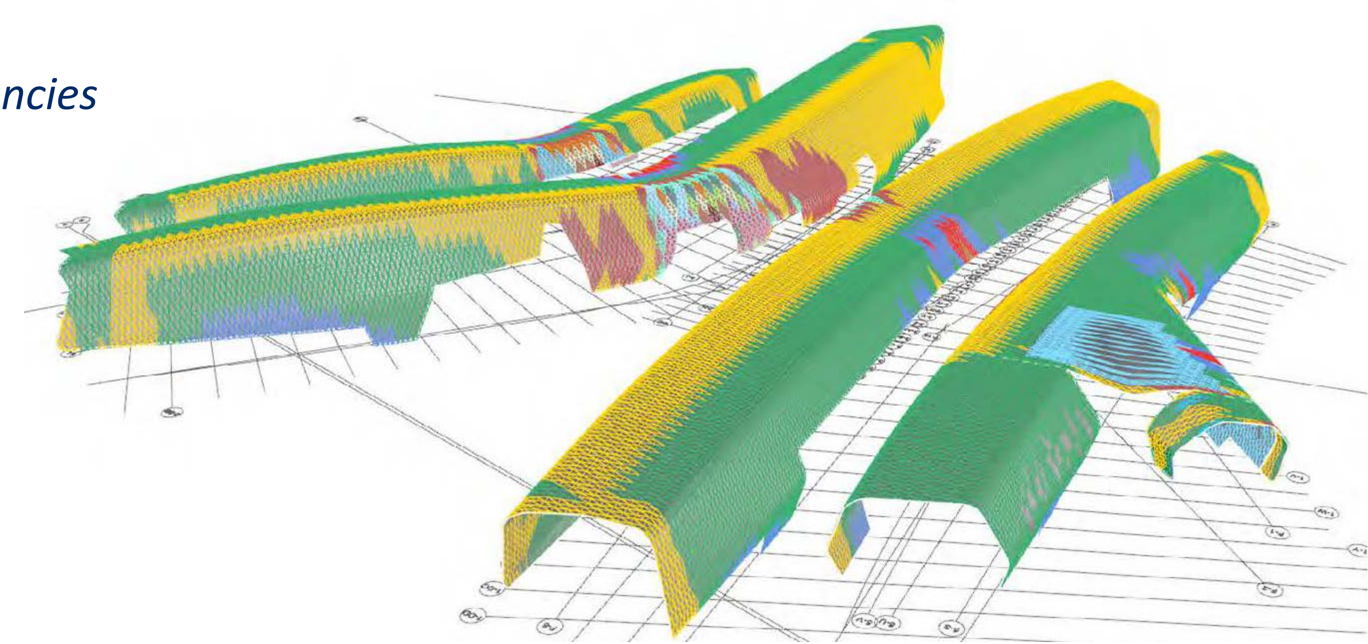
PANEL TYPE	i	j	PANEL HEIGHT	PANEL WIDTH	HALL 1			HALL 2			HALL 3			HALL 4			TOTAL	% OF TOTAL
					P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3		
a			1764	759	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
b			1771	809	0	0	0	0	0	0	0	0	0	0	9	0	9	0%
c			1777	859	0	0	0	0	0	0	18	23	0	18	58	4	121	0%
d			1782	909	0	1	0	3	6	0	115	50	1	62	35	11	284	1%
e			1787	959	22	43	3	57	14	2	98	28	120	38	56	304	785	2%
f			1792	1009	109	111	356	201	314	217	616	850	230	156	581	497	4240	10%
g			1796	1059	3827	1375	255	4750	2027	361	5151	987	177	2985	1047	162	23104	53%
h			1799	1109	1419	407	102	4581	581	38	3605	737	29	1224	381	53	13157	30%
i			1803	1159	89	128	0	122	52	2	343	384	18	88	8	0	1234	3%
f			1806	1209	4	6	0	76	16	0	80	36	3	8	0	0	229	1%
j			1809	1259	0	1	0	38	2	0	28	14	1	56	0	0	138	0%
k			1811	1309	0	2	7	33	23	0	38	2	0	0	0	0	105	0%
l			1814	1359	0	0	0	12	10	0	22	2	0	26	6	0	78	0%
m			1816	1409	0	0	3	2	5	0	26	6	0	0	0	0	42	0%
n			1818	1459	0	0	0	0	1	0	6	2	0	6	1	0	16	0%
o			1820	1509	0	0	0	0	0	0	10	5	0	4	10	0	29	0%
p			1822	1559	0	0	0	0	0	0	0	1	0	0	0	0	1	0%
q			1824	1609	0	0	0	0	0	0	0	6	0	1	2	0	9	0%
r			1829	1759	0	0	0	0	0	0	0	6	0	0	0	0	6	0%
SUB TOTALS					5470	2074	726	9875	3061	620	10154	3139	578	4674	2194	1031	43587	
TOTALS					8270			13546			13872			7899			43587	100%

Panel Analysis

Algorithms determined façade panelling efficiencies

Aim to limit number of unique panel types

Minimise number of bespoke panel types requiring curvature

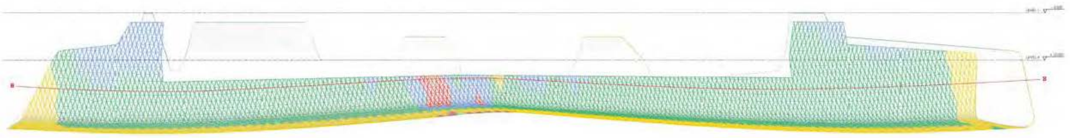


Façade Documentation

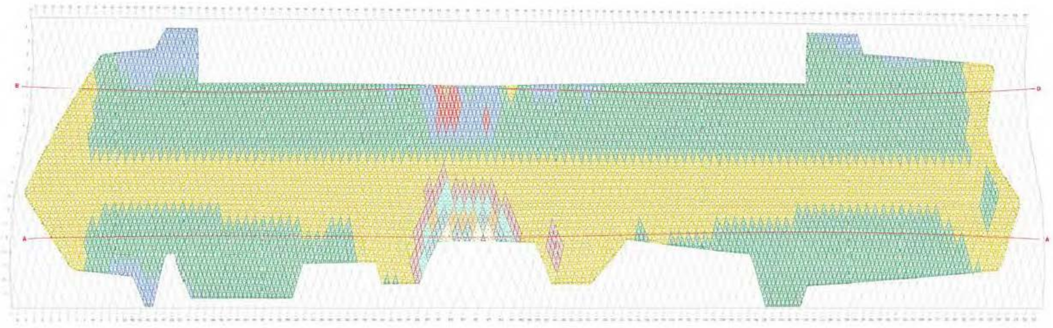
Development of flat panel location plans that are automatically generated from code to ensure accuracy

Application of unique panel codes which relate to panel schedules

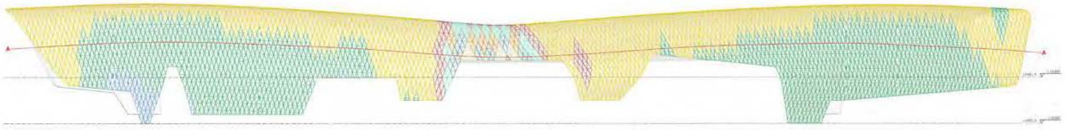
Automated application of colour to define types



WEST ELEVATION
SCALE 1:250



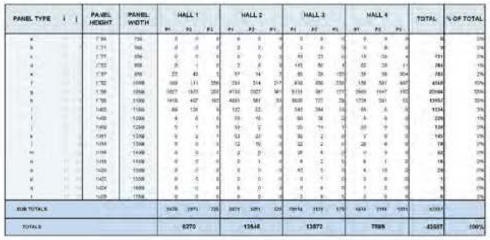
UNROLLED PANEL SETOUT
SCALE N/A



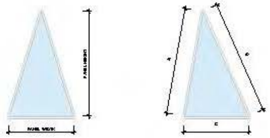
EAST ELEVATION
SCALE 1:250

Panel documentation

Code developed to enable whole building panel dimensions to generate from different originating sheet dimensions



① PANEL SCHEDULE - STANDARD TYPES



STANDARDISED PANEL DIMENSIONING KEY (ISOSCELES TRIANGLE)

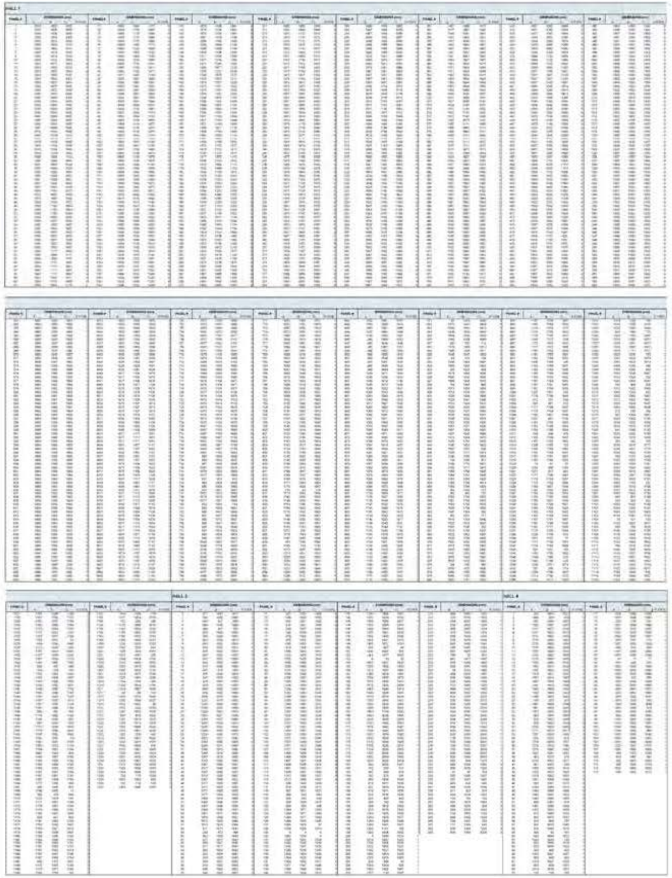
BESPOKE PANEL DIMENSIONING KEY (SCALENE TRIANGLE)

④ PANEL DIMENSION KEY

EXAMPLE CUTTING TEMPLATE 1: PANEL TYPE H (1109 x 1799)
SHEET SIZE: 1200mm

EXAMPLE CUTTING TEMPLATE 2: PANEL TYPE M (1409 x 1816)
SHEET SIZE: 1500mm

③ PANEL EXAMPLE CUTTING TEMPLATES



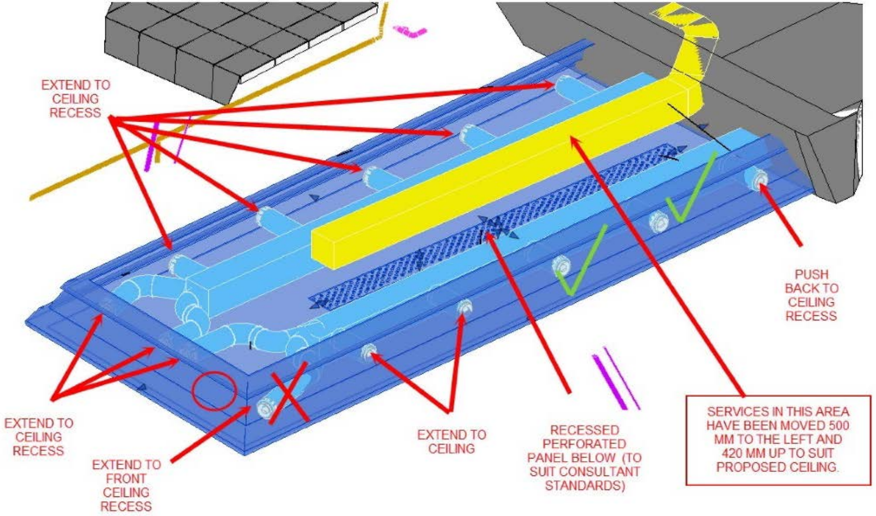
② PANEL SCHEDULE - WARPED

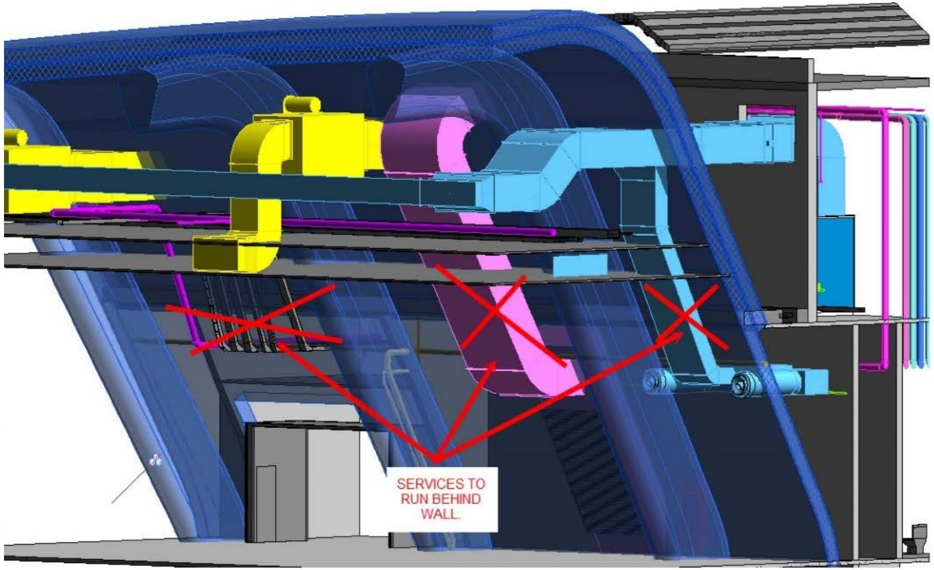
Cladding Construction

Manufacture of cladding panels from model and schedule information

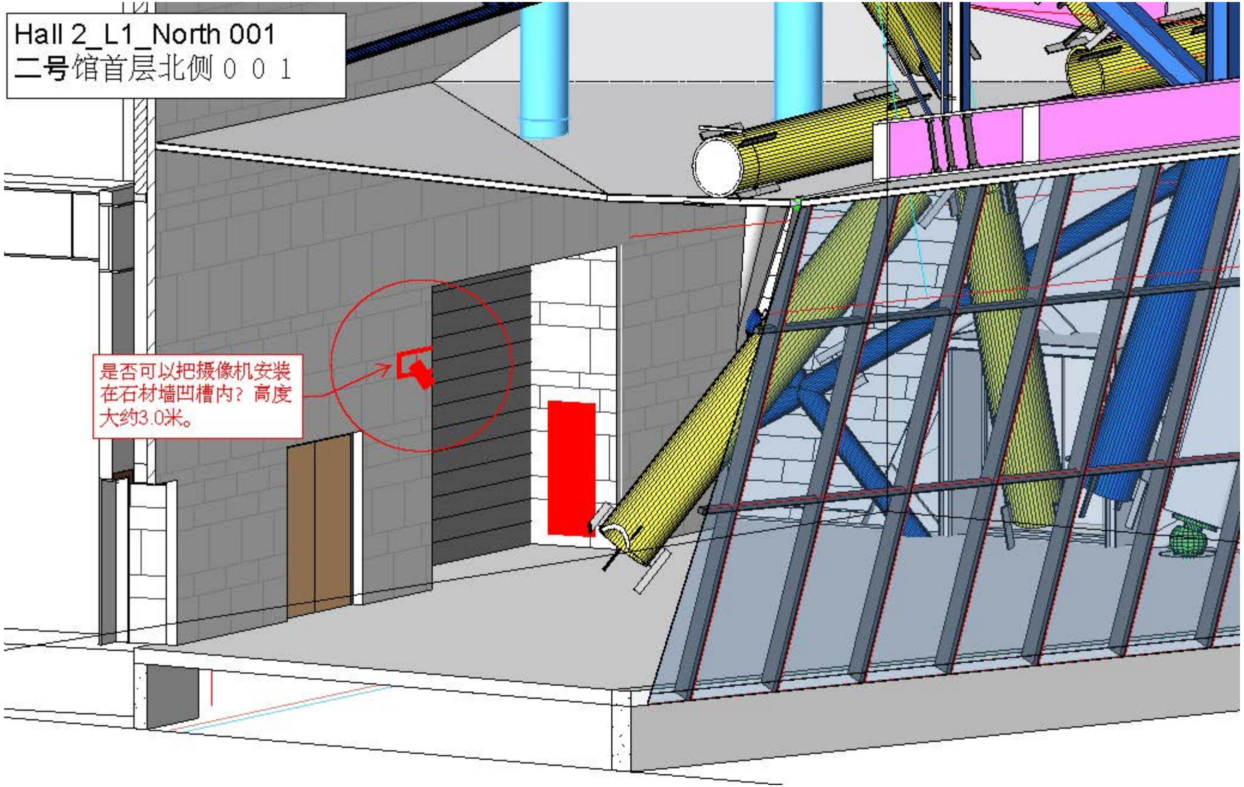
Communication through models

Navisworks model and mark up exchange





Detailed coordination and development of the services strategy was made through the transfer of models

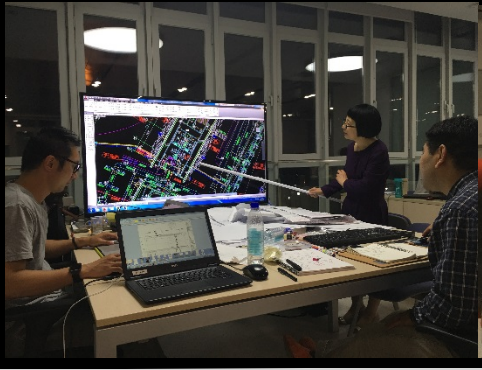


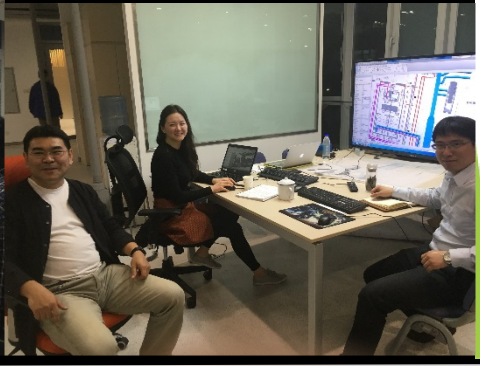
是否可以把摄像机安装在石材墙凹槽内？高度大约3.0米。

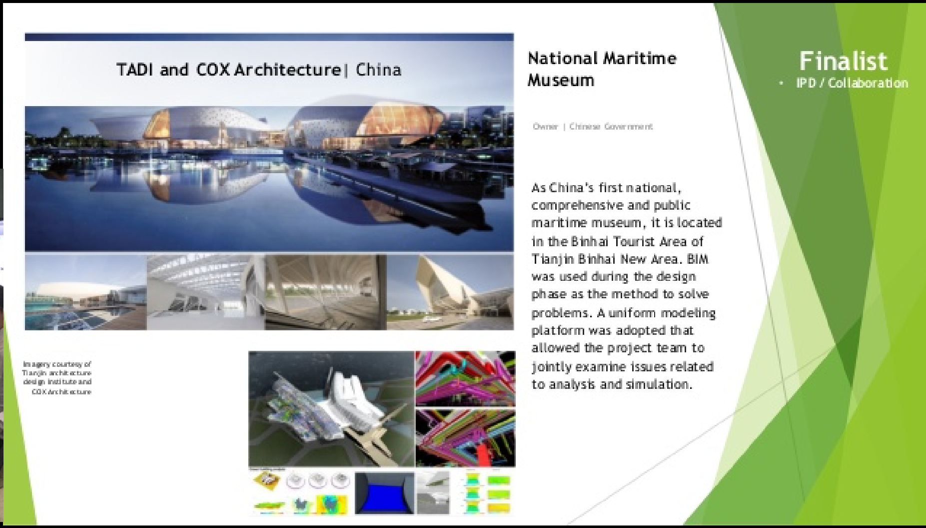
BIM awards!

TADI and Cox won the following awards in the BIM field

- *AEC excellence awards (AU 2016)*
- *Gold Award for Structure and Design*
- *Design Integration (RTC 2015)*
- *Design Presentation (RTC 2105)*







TADI and COX Architecture| China

National Maritime Museum

Owner | Chinese Government

As China's first national, comprehensive and public maritime museum, it is located in the Binhai Tourist Area of Tianjin Binhai New Area. BIM was used during the design phase as the method to solve problems. A uniform modeling platform was adopted that allowed the project team to jointly examine issues related to analysis and simulation.

Imagery courtesy of Tianjin architecture design institute and COX Architecture

Finalist

- IPD / Collaboration

Anna Meares Velodrome

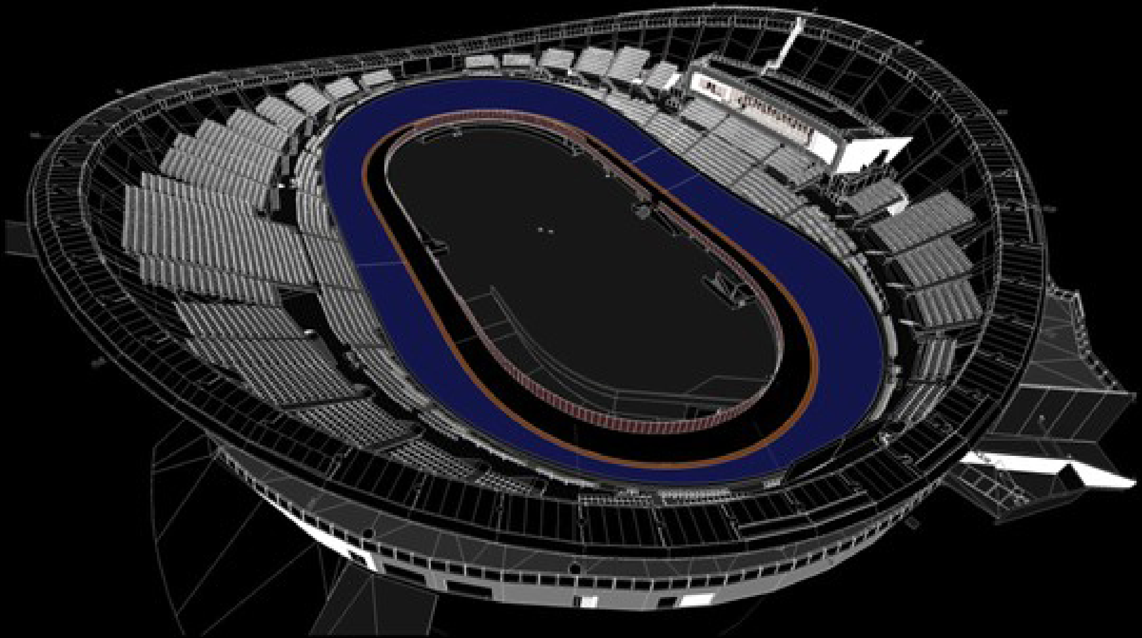
Design through parametric modelling

Project Brief Overview

Development of the roof forms

Development of the walls and cladding

Delivery of information for production



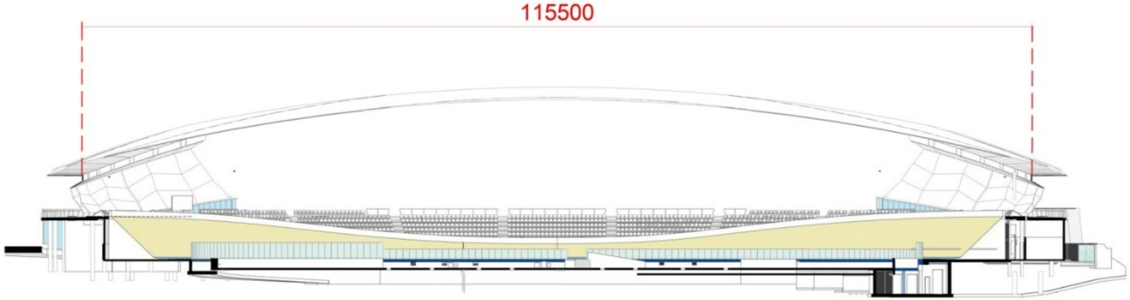
Project Brief Overview

Permanent seating for 1500 spectators with provision for temporary seating capacity of 4000

250m timber track

Fully enclosed stadium with no sight line restrictions from structure

Elevated function and judging space



CROSS SECTION – TRACK BENDS

CROSS SECTION – FUNCTION ROOM AND SEATING

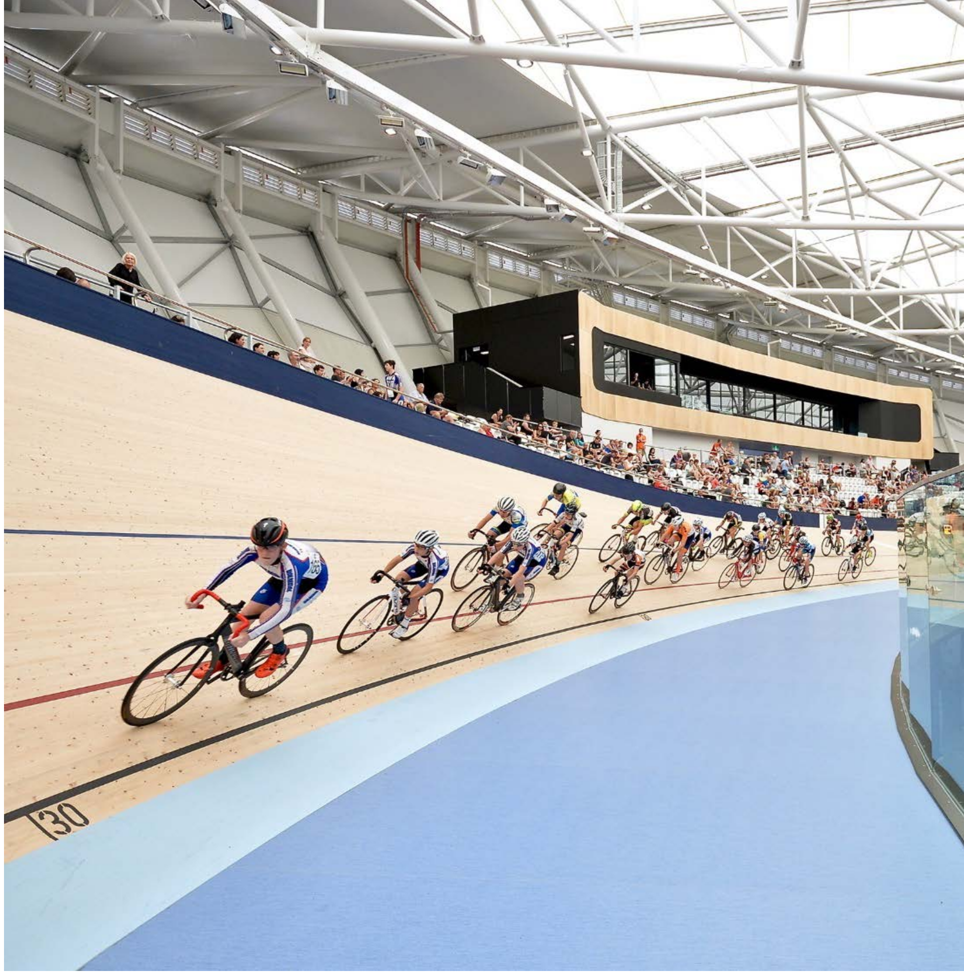
Project Brief Overview

Large span in two directions

Form provides height for temporary seating at the optimum areas along the straights

Low roof at bends to reduce building footprint and control drainage

Sightlines to be min C60



Development of the roof forms

Form finding through Grasshopper

Design Flexibility

Technical Analysis

Structural Coordination

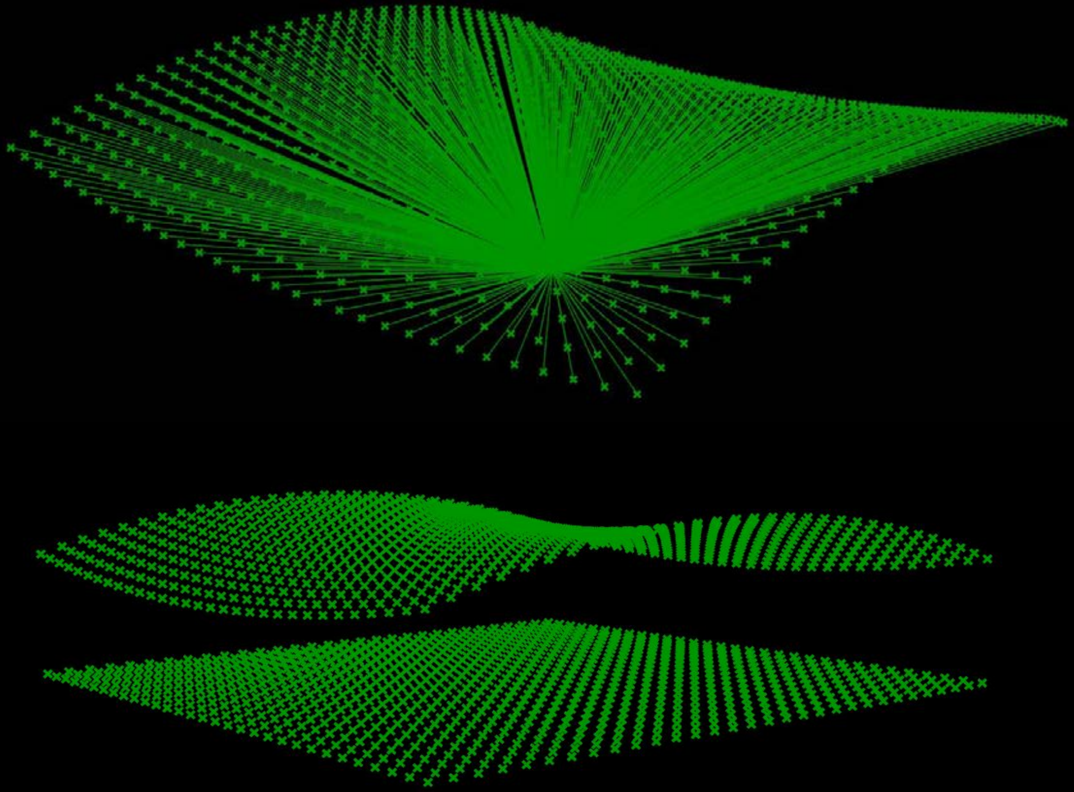
Design Auditing

Form finding through Grasshopper

Hyperbolic Parabola roof (pringle chip) form is generated mathematically from a single center point.

Being a mathematical representation the form remains pure and accurate.

$$[z=ax^2-by^2]$$

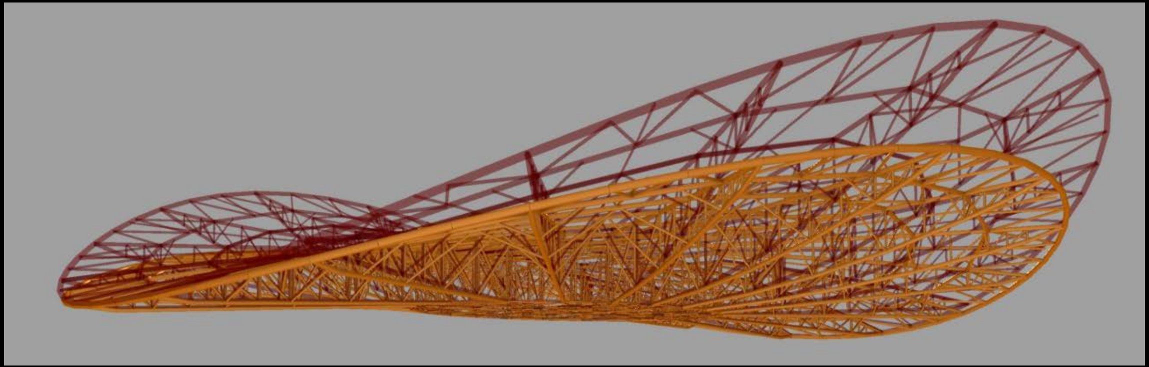


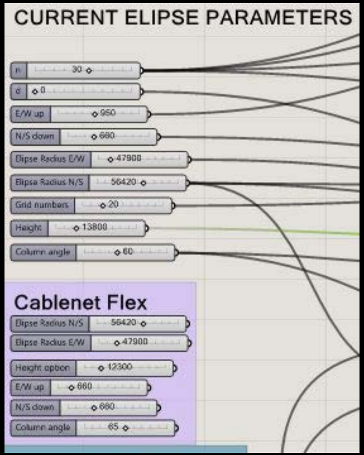
Design Flexibility

Using parametric work flow allows great flexibility throughout the development of the design

Immediate visual feedback of

In this model control ratios are used to adjust the flex of the form in both directions that allowed studies of form generated by the constraints of different cladding materials



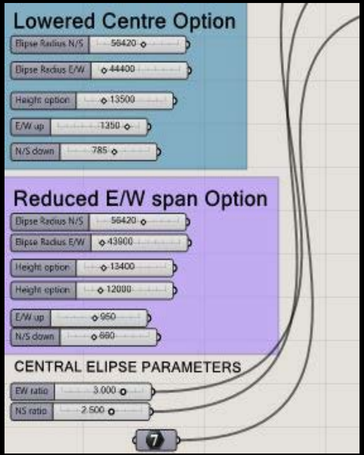


CURRENT ELIPSE PARAMETERS

n 30
d 0
E/W up 950
N/S down 680
Elipse Radius E/W 47900
Elipse Radius N/S 56420
Grid numbers 20
Height 13800
Column angle 60

Cablenet Flex

Elipse Radius N/S 56420
Elipse Radius E/W 47900
Height option 12300
E/W up 660
N/S down 680
Column angle 65



Lowered Centre Option

Elipse Radius N/S 56420
Elipse Radius E/W 44400
Height option 13500
E/W up 1350
N/S down 785

Reduced E/W span Option

Elipse Radius N/S 56420
Elipse Radius E/W 43900
Height option 13400
Height option 12000
E/W up 950
N/S down 680

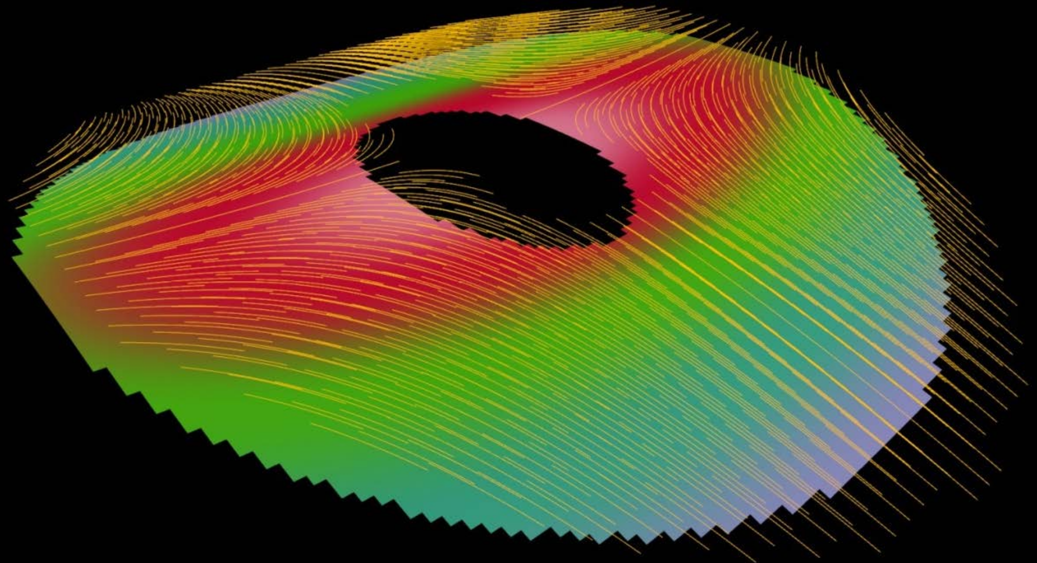
CENTRAL ELIPSE PARAMETERS

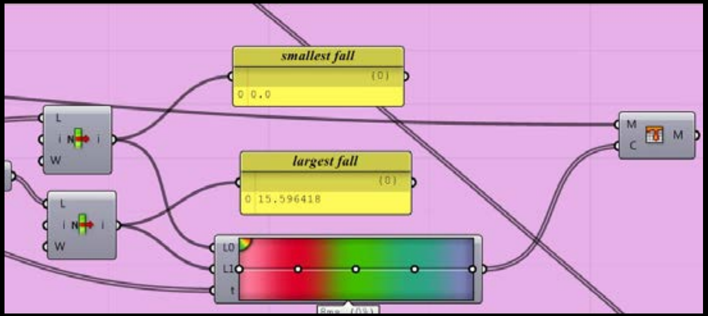
EW ratio 3.000
NS ratio 2.500

Technical Analysis

Roof curvature analysis allowed the building form to be adjusted to suit the properties of different roofing systems. These options could be quickly assessed for cost to prove efficiency

Additionally rainwater paths were created to establish the optimal location for gutter systems



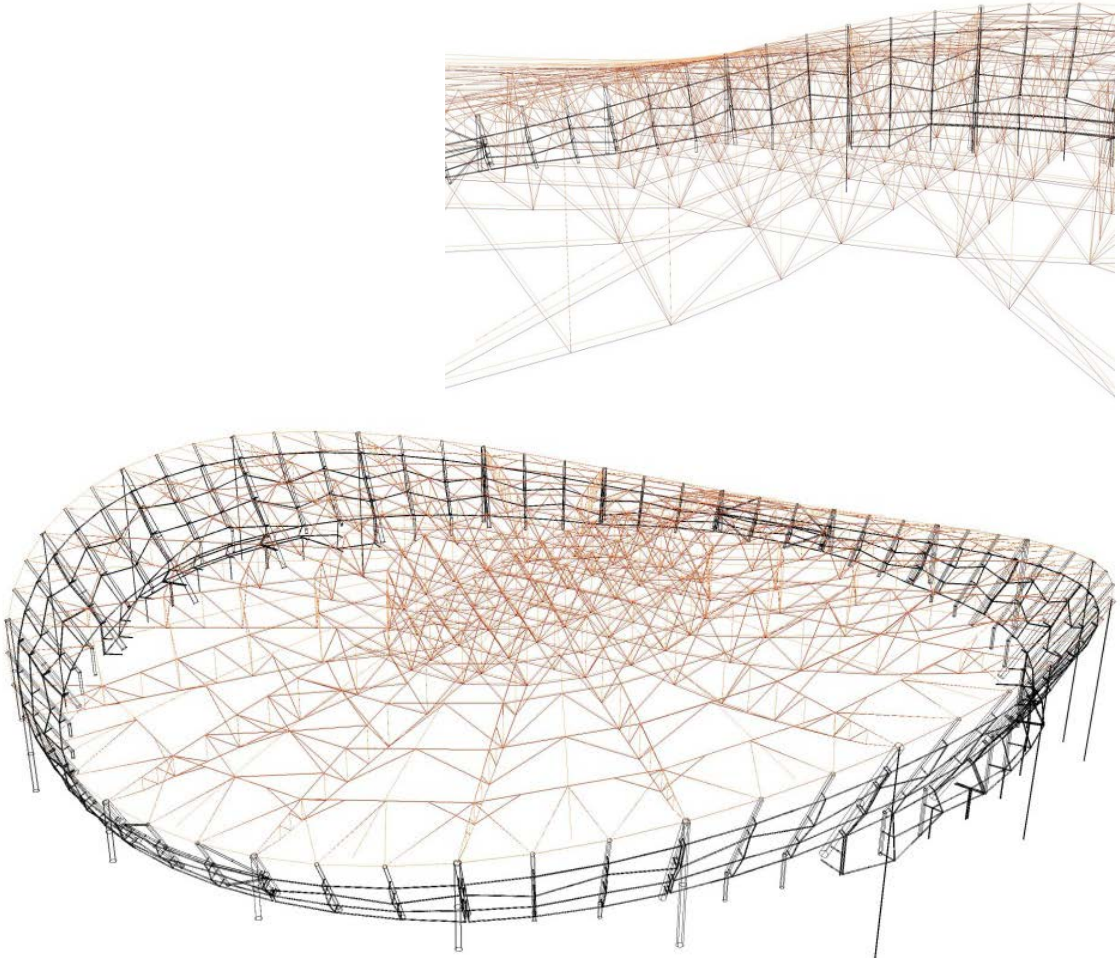


Structural Coordination

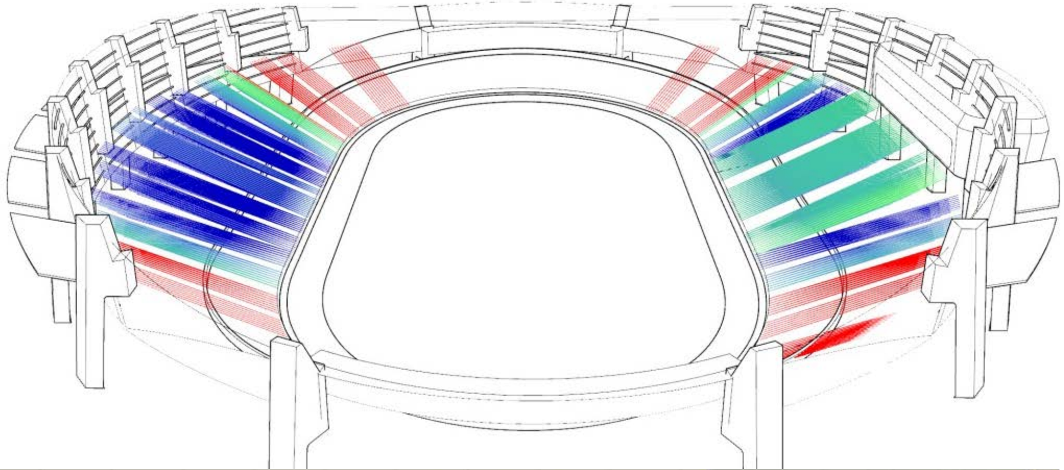
Controlling structural geometry through centreline modelling

Single Source information

Application of pre-camber form for shop drawing coordination



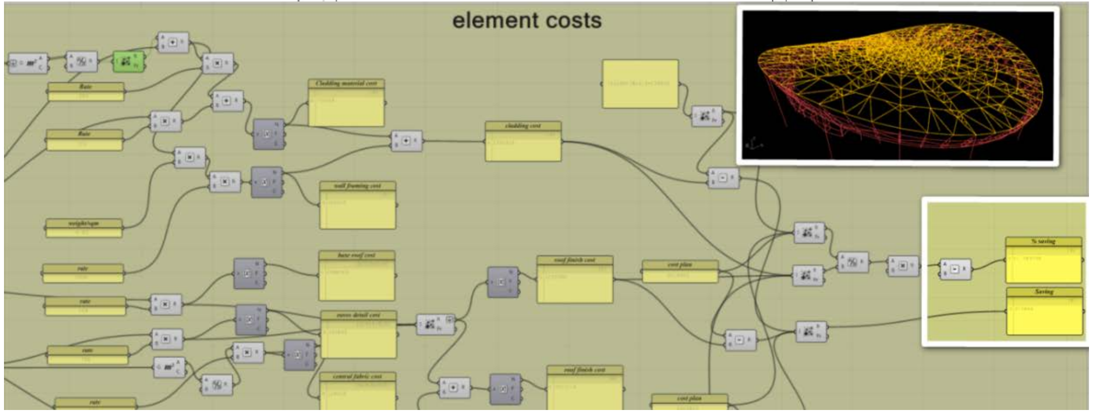
Design Auditing



Structural constraints can be added into the code to maintain relationships when design options are being explored.

Definition of sight lines

Quantity analysis can be built into the model such that instant quantity comparisons can be made with the benefit of the visual forms.



Developing the facade

Fabric form finding

Eaves design

Computational design process

Fabric form finding

Basic form inspired by track

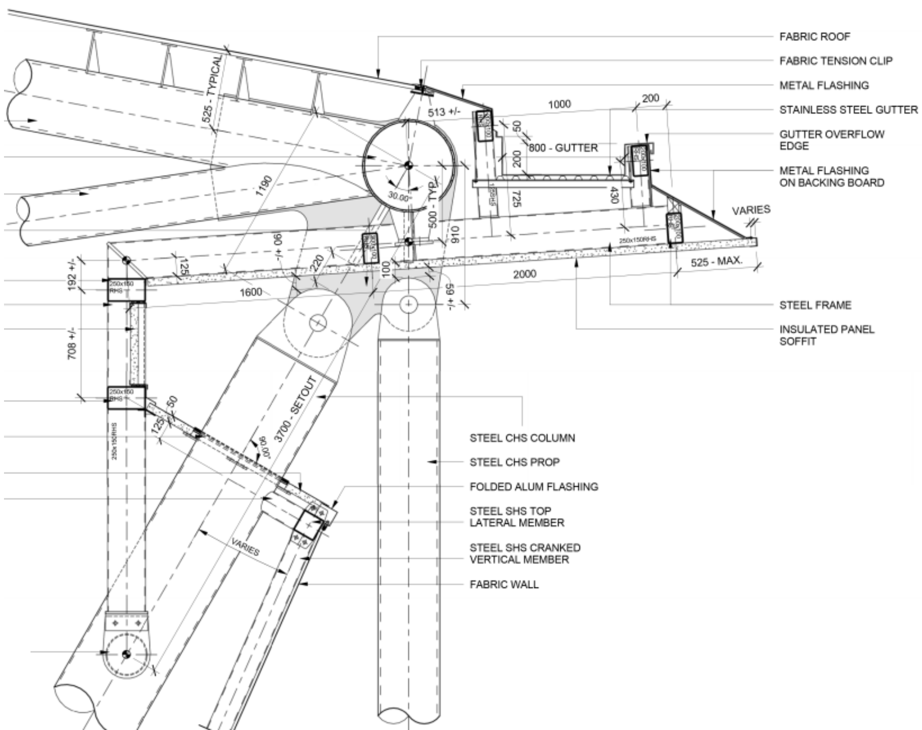
Utilising nature of material

Straight section steel to form twisted fabric shapes

Eaves design

Prefabricated design system

Hyperbolic shape with flat planes

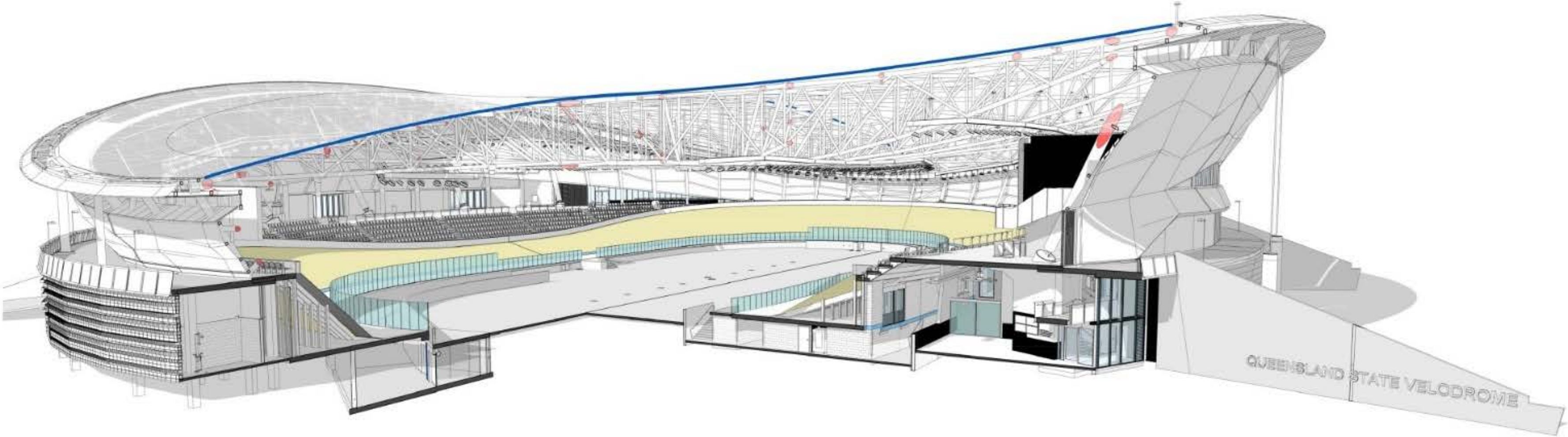


BIM integration

Documentation in Revit

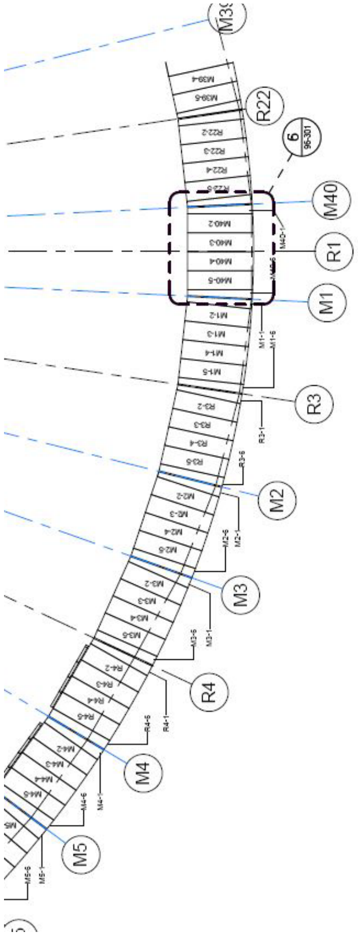
Wire frame for structural analysis and documentation

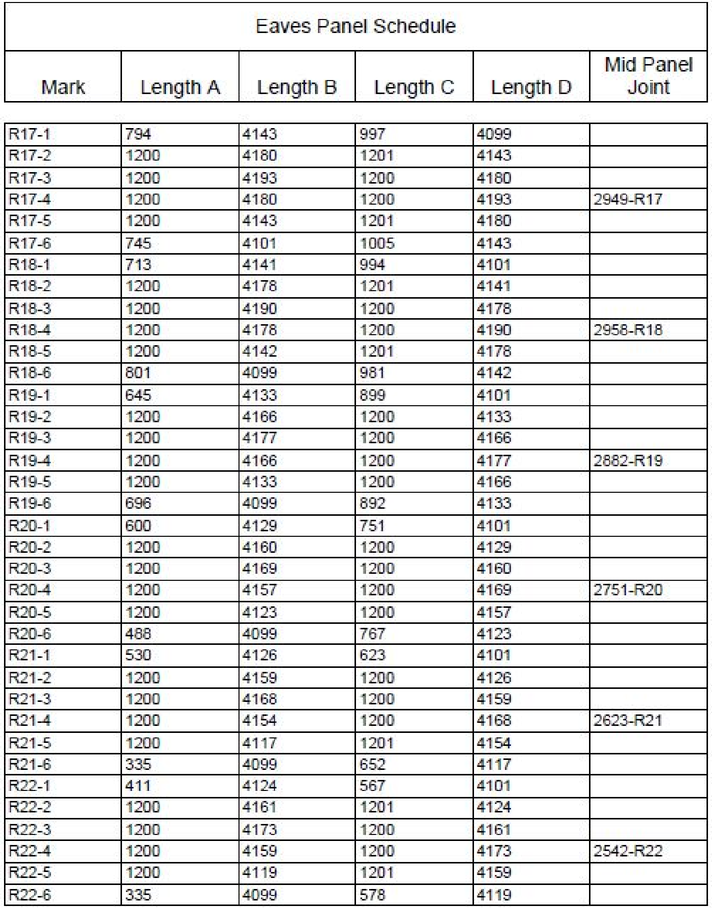
Integration into fabrication drafting



Data directly to Revit

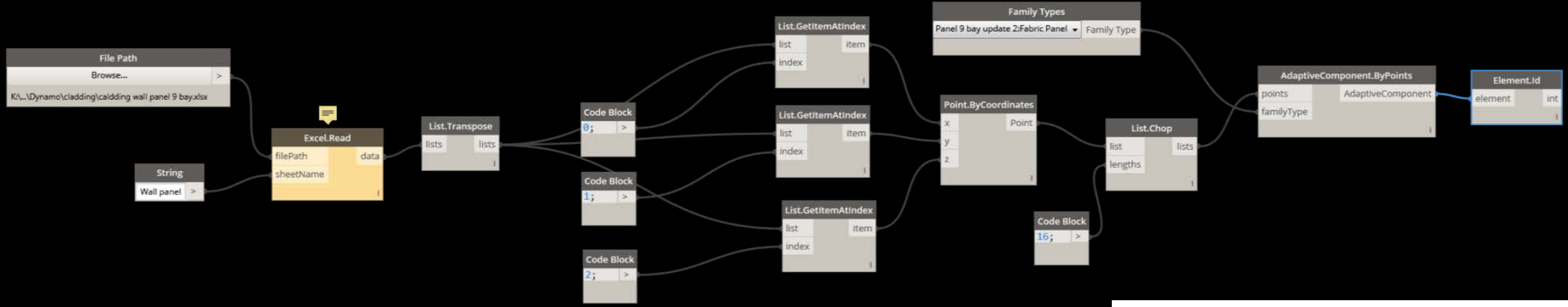
Geometric data generated from grasshopper code can be translated into Revit geometry with associated data from a single source.





Eaves Panel Schedule

Mark	Length A	Length B	Length C	Length D	Mid Panel Joint
R17-1	794	4143	997	4099	
R17-2	1200	4180	1201	4143	
R17-3	1200	4193	1200	4180	
R17-4	1200	4180	1200	4193	2949-R17
R17-5	1200	4143	1201	4180	
R17-6	745	4101	1005	4143	
R18-1	713	4141	994	4101	
R18-2	1200	4178	1201	4141	
R18-3	1200	4190	1200	4178	
R18-4	1200	4178	1200	4190	2958-R18
R18-5	1200	4142	1201	4178	
R18-6	801	4099	981	4142	
R19-1	645	4133	899	4101	
R19-2	1200	4166	1200	4133	
R19-3	1200	4177	1200	4166	
R19-4	1200	4166	1200	4177	2882-R19
R19-5	1200	4133	1200	4166	
R19-6	696	4099	892	4133	
R20-1	600	4129	751	4101	
R20-2	1200	4160	1200	4129	
R20-3	1200	4169	1200	4160	
R20-4	1200	4157	1200	4169	2751-R20
R20-5	1200	4123	1200	4157	
R20-6	488	4099	767	4123	
R21-1	530	4126	623	4101	
R21-2	1200	4159	1200	4126	
R21-3	1200	4168	1200	4159	
R21-4	1200	4154	1200	4168	2623-R21
R21-5	1200	4117	1201	4154	
R21-6	335	4099	652	4117	
R22-1	411	4124	567	4101	
R22-2	1200	4161	1201	4124	
R22-3	1200	4173	1200	4161	
R22-4	1200	4159	1200	4173	2542-R22
R22-5	1200	4119	1201	4159	
R22-6	335	4099	578	4119	



K:\...\Dynamo\cladding\caldding wall panel 9 bay.xlsx

Wall panel

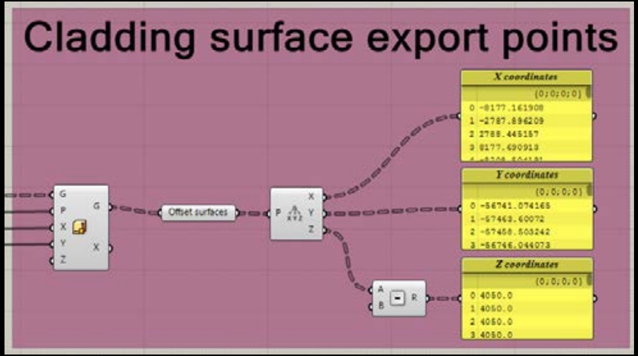
Panel 9 bay update 2:Fabric Panel

```
0;
```

```
1;
```

```
2;
```

```
16;
```



Cladding surface export points

X coordinates

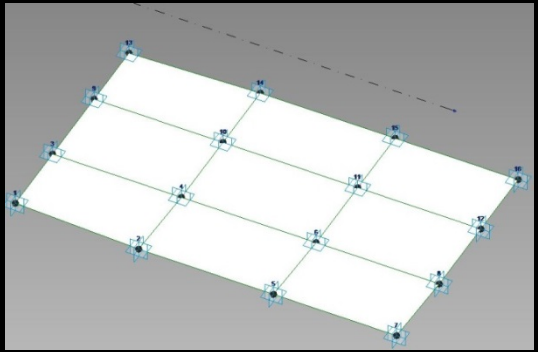
```
{0;0;0;0}
0 -8177.161908
1 -2787.896209
2 2788.445157
3 8177.690913
```

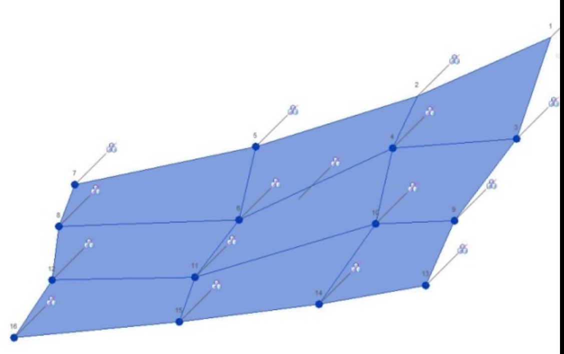
Y coordinates

```
{0;0;0;0}
0 -56741.074165
1 -57463.60072
2 -57458.503242
3 -56746.044073
```

Z coordinates

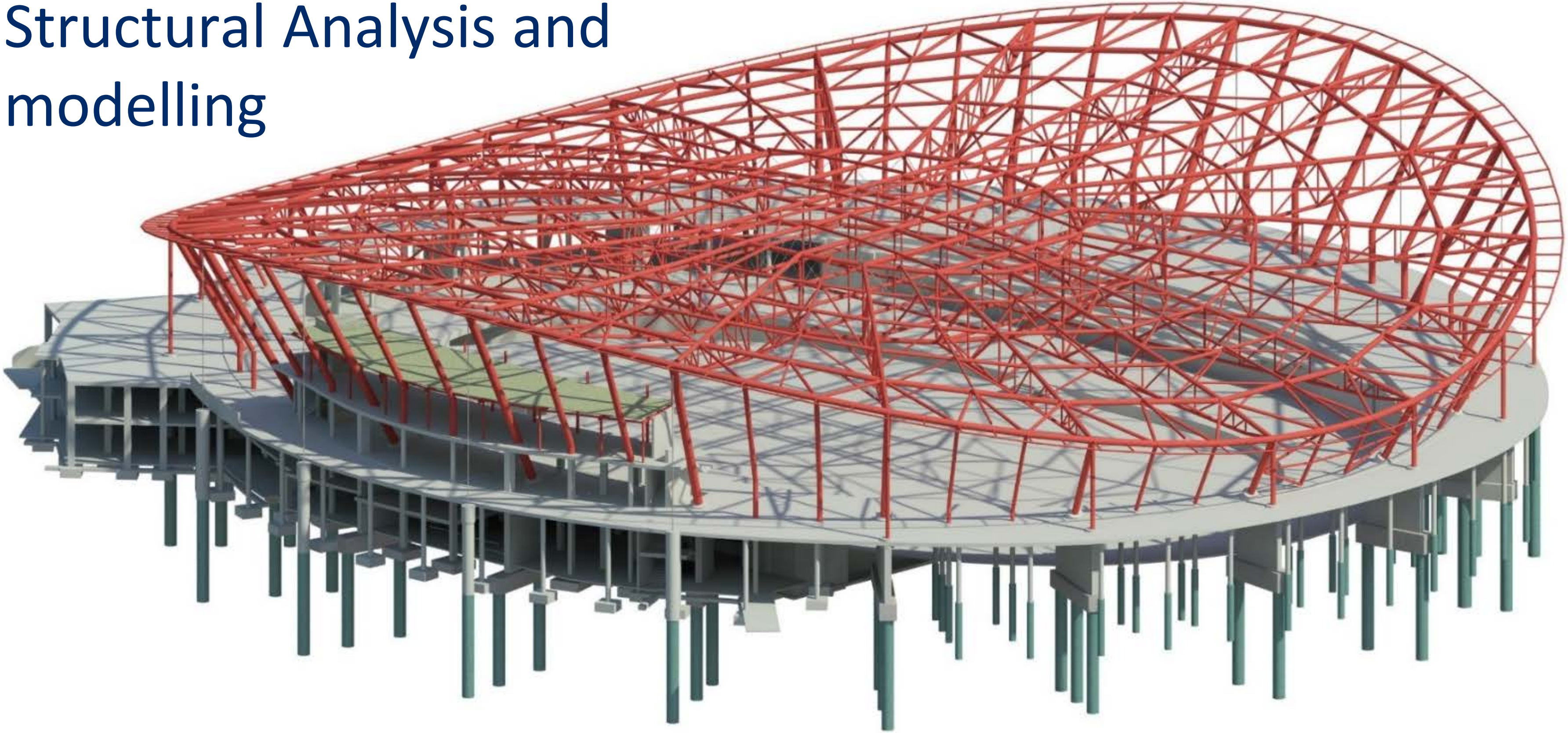
```
{0;0;0;0}
0 4050.0
1 4050.0
2 4050.0
3 4050.0
```





Conversion of cladding panel into Revit geometry using 16 point adaptive component family

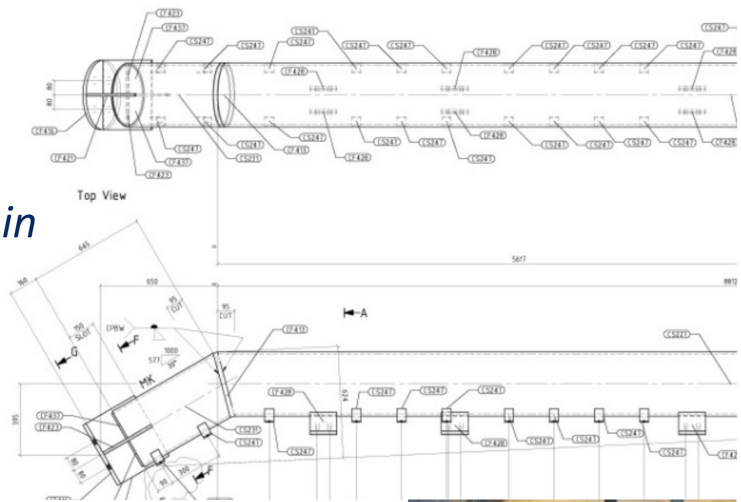
Structural Analysis and modelling

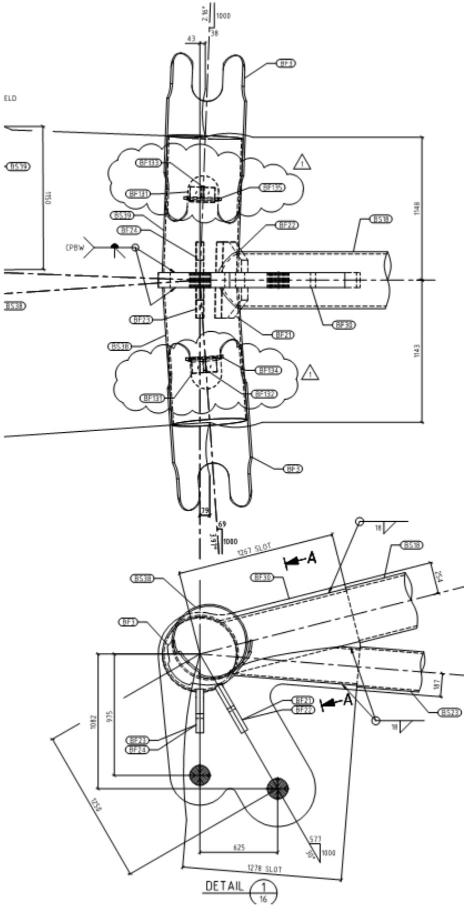


Steel Fabrication

Centre line data used directly in fabrication drawing packages with structural sizing.

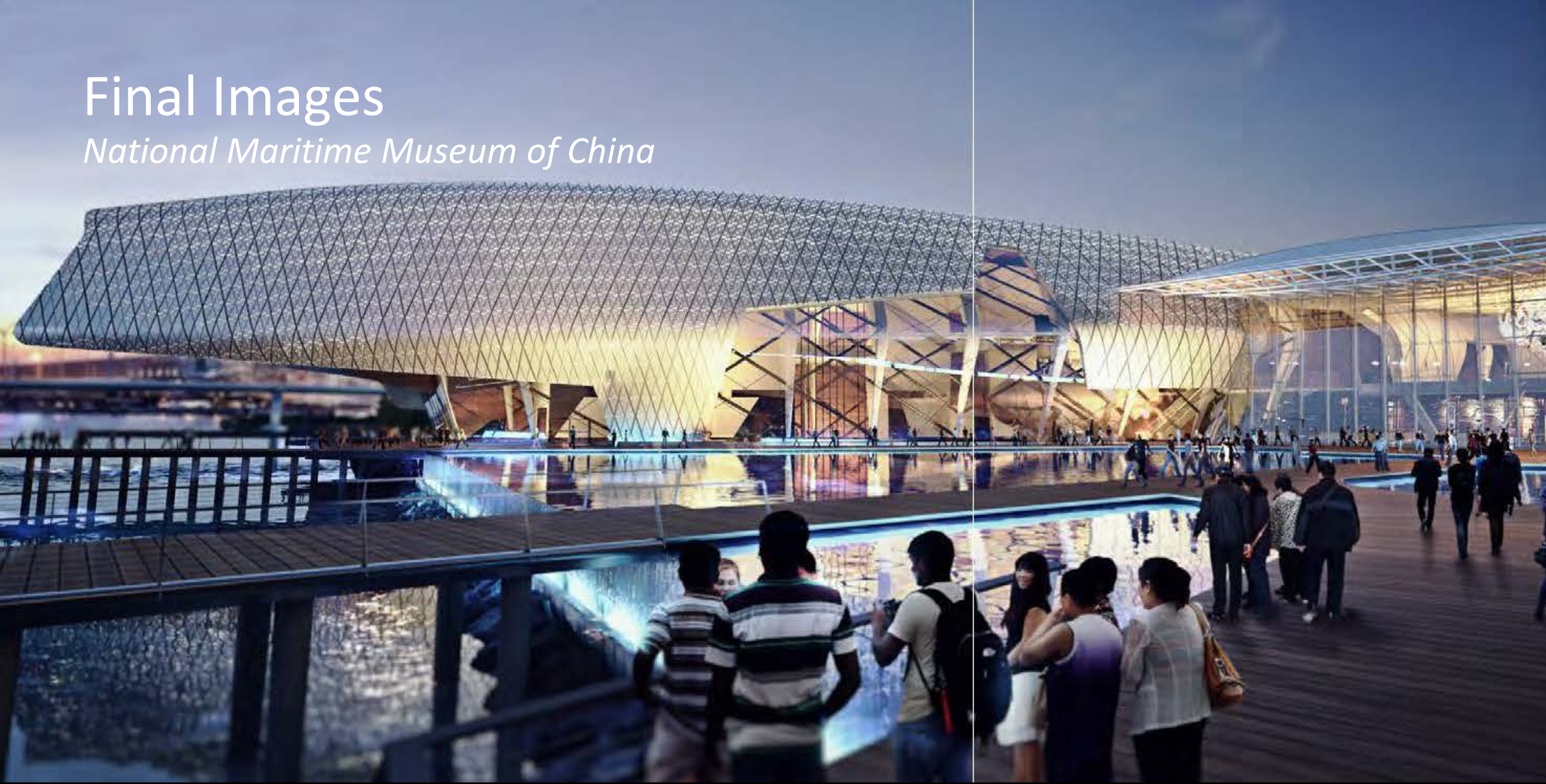
Joint design developed in workshops or adaptive models





Final Images

National Maritime Museum of China




COFFEE & CAKES
BIG BURGER BAR

Questions

BIM Ideology in Computational Design - Architecture

Alex Leese

Cox Architecture