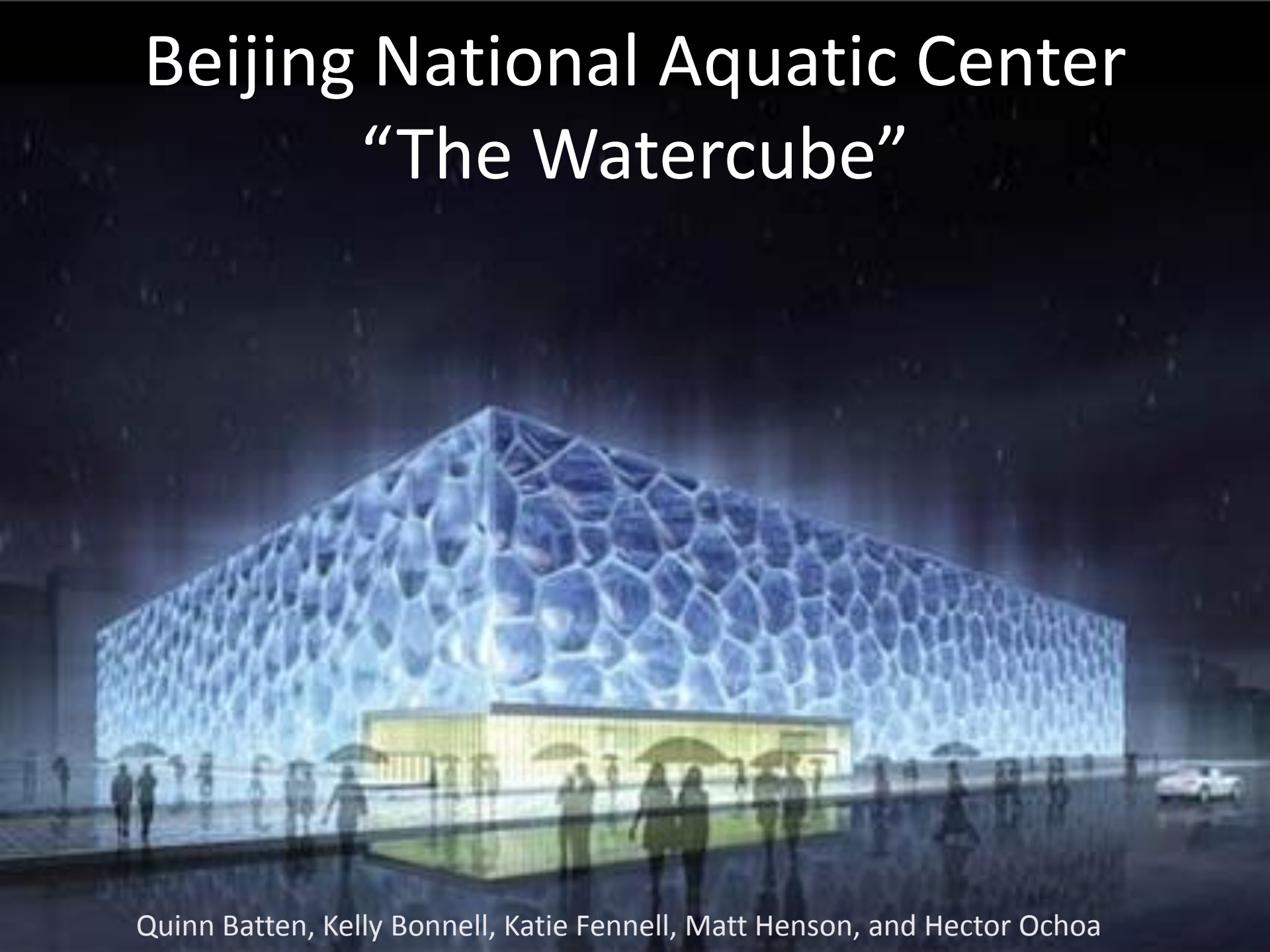
Beijing National Aquatic Center
“The Watercube”



Quinn Batten, Kelly Bonnell, Katie Fennell, Matt Henson, and Hector Ochoa

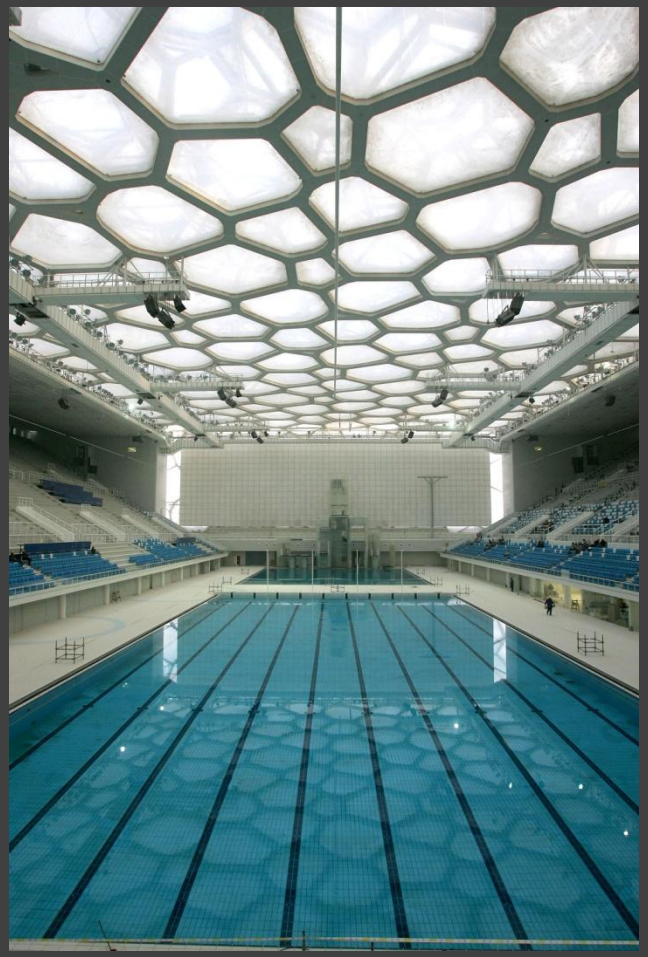
Project Facts:

Location:	Olympic Green, Beijing, China
Purpose:	Held Water Activities for the Summer Olympics
Gross Floor Area:	90000m2
Cost:	$100 million
Collaborators:	PTW Architects China Construction Design Institute (CCDI) China State Construction Engineering Co (CSCEC)

Project Concepts:

- Shaped as a cube to symbolize earth

- Covered with “bubbles” to symbolize water



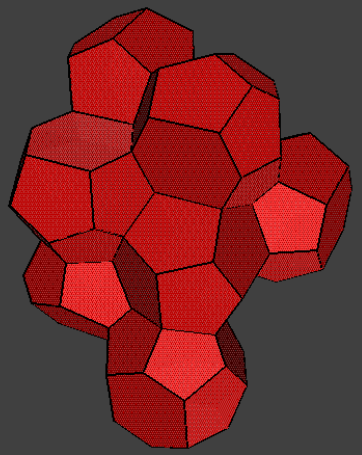
Project Concept:

What shape would soap bubbles in a continuous array of soap bubbles be?

Project Concept Solution:

What shape would soap bubbles in a continuous array of soap bubbles be?

Lord Kelvin proposed finding a form of equal volume that would distribute the loads equally within a space.



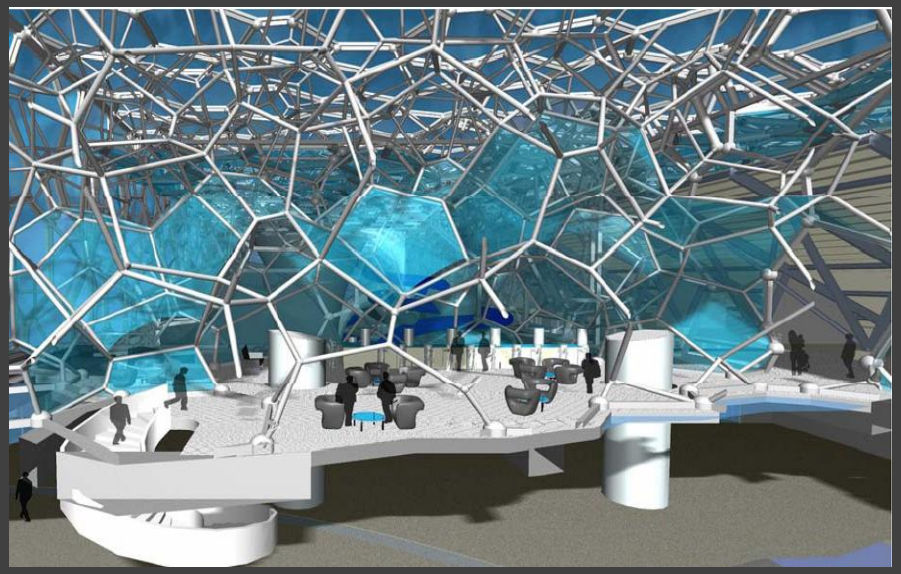
Phelan-Weaire discovered that the 12 sided and 14 sided polyhedrons satisfied the question proposed by Lord Kelvin.

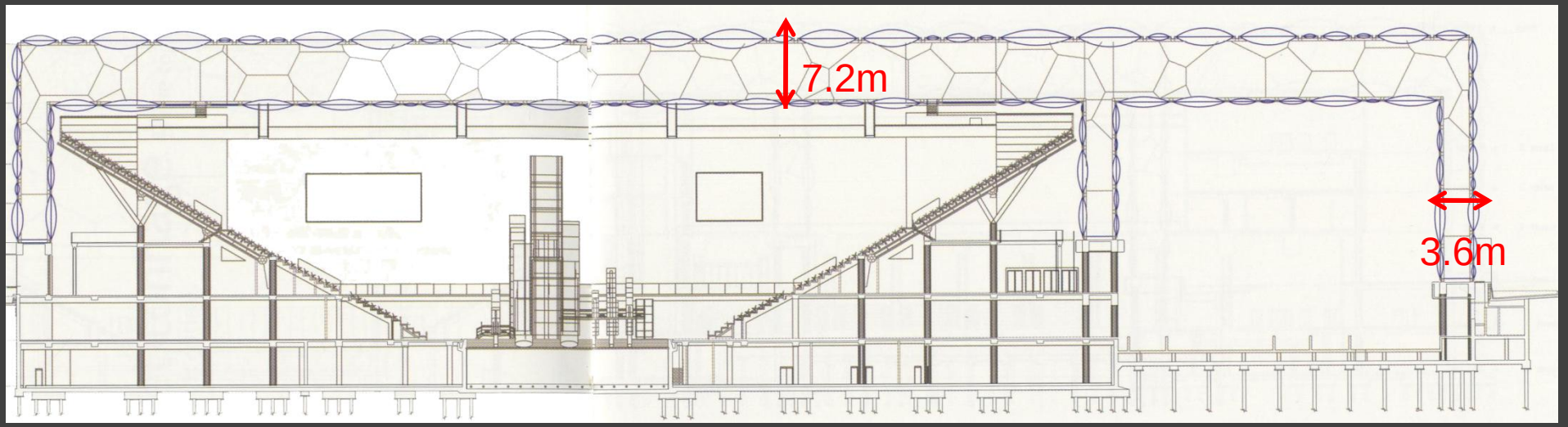
The geometry of building is based on Phelan-Weaire Polyhedral Array

Structural Form :

- 176m * 176m * 29m
- **3D Vierendeel space frame**

- All walls are approximately 3.6m thick and the roof zone 7.2m deep.





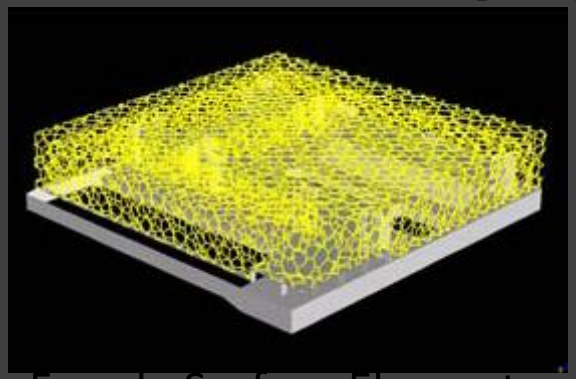
Structural Form :

- The final structure is comprised of **22,000** tubular steel members connected by **12,000** nodes

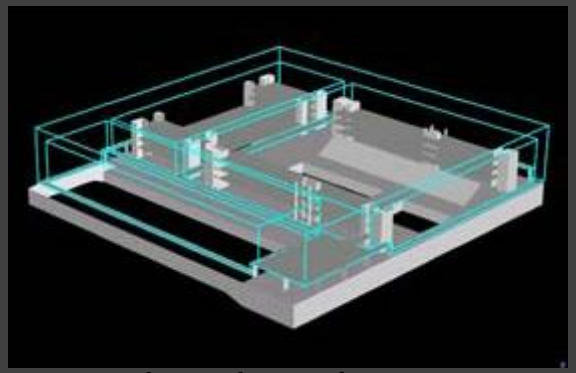
- Repetitive geometric polyhedrons

- Ductile structure to deal with the seismic conditions found in Beijing

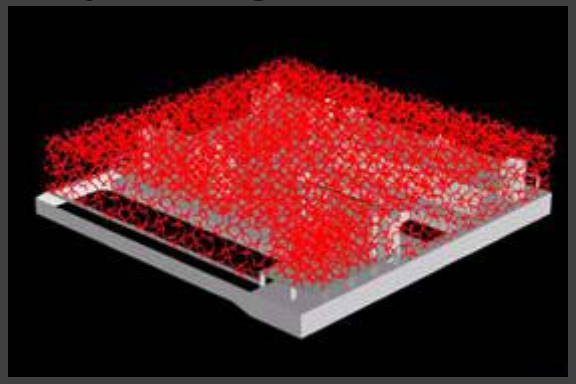
Vierendeel Space Truss:



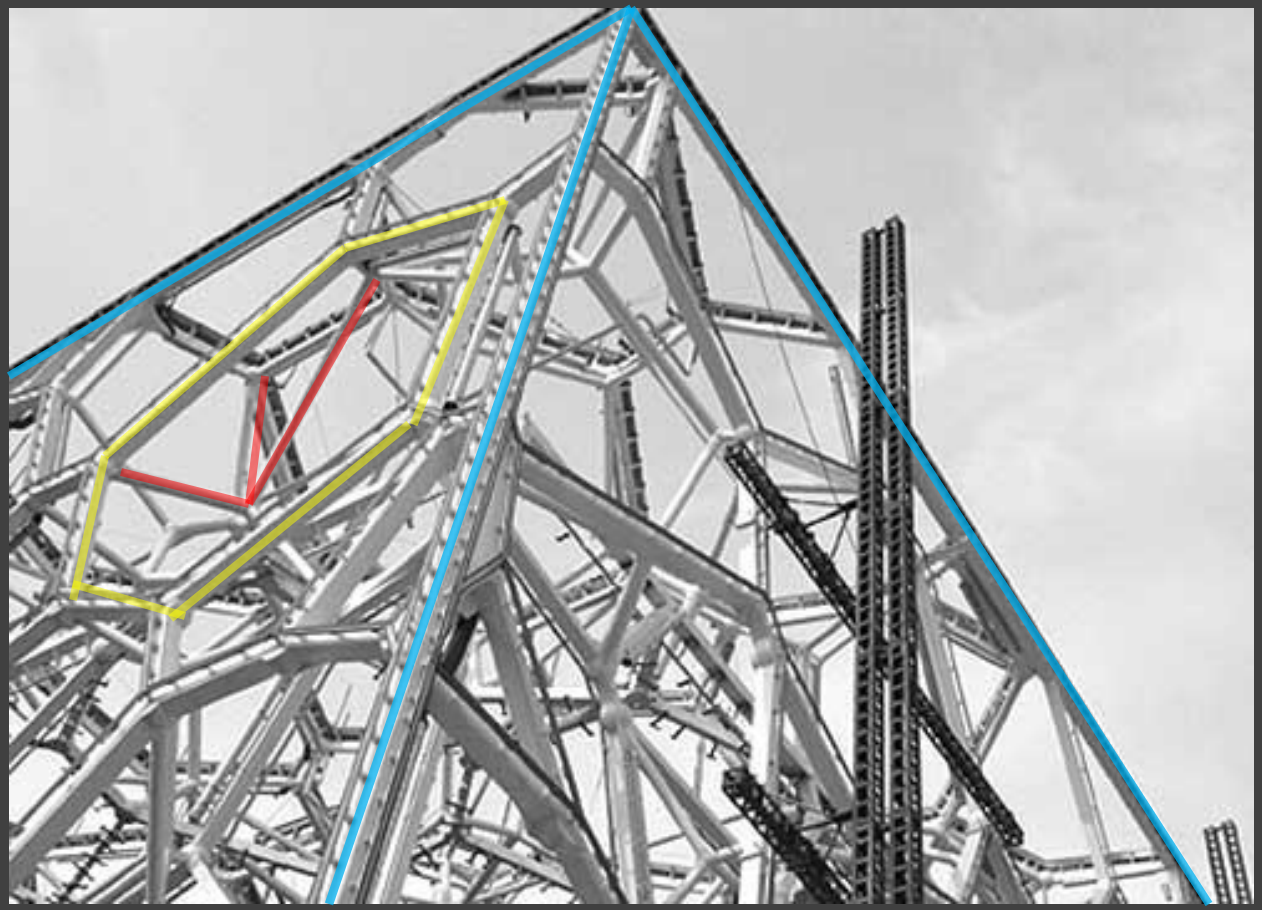
•Façade Surface Elements



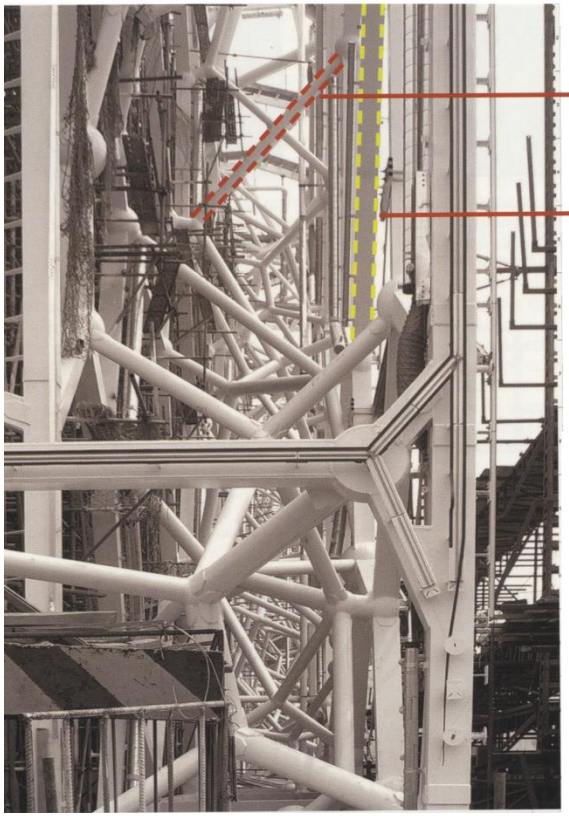
•Façade Edge Elements

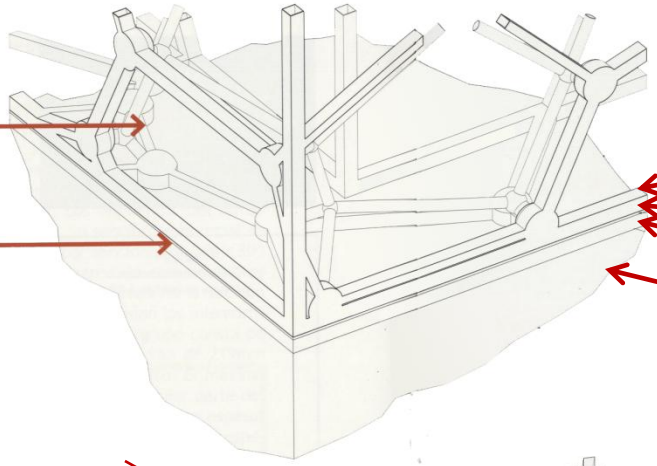


•Internal Web Members



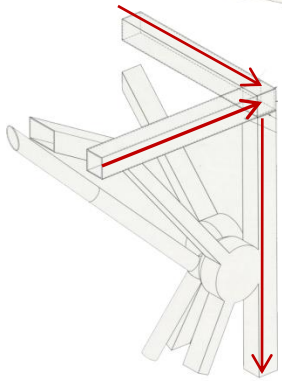
Structural Details:

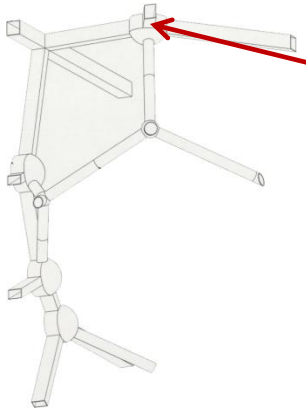




Slab Detail

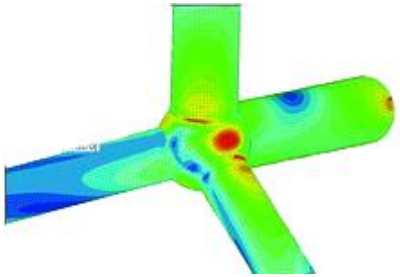
Base of Space Frame
Steel Plate
Steel Angle
Concrete Slab





Connections

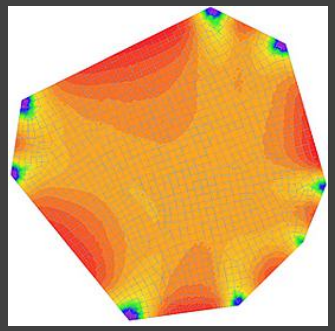
Connecting Nodes

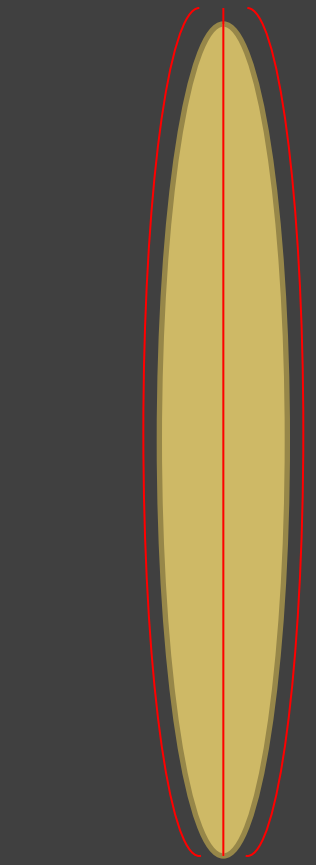


Structural Elements :

- Ethylene Tetra Fluoro Ethylene (ETFE) foil cushions that form the cladding

- The large cushions are actually in three layers (outer, middle and inner), with their contained air pressurised to 200pa, giving an effect similar to a cavity wall





Dead Loads:

- ETFE: ω_o=.25 kN/m²
- Facilities and piping: ω_o=.25 kN/m²
- Acoustic Materials: ω_o=.15 kN/m²
- Structure: ω_o=.4 kN/m²

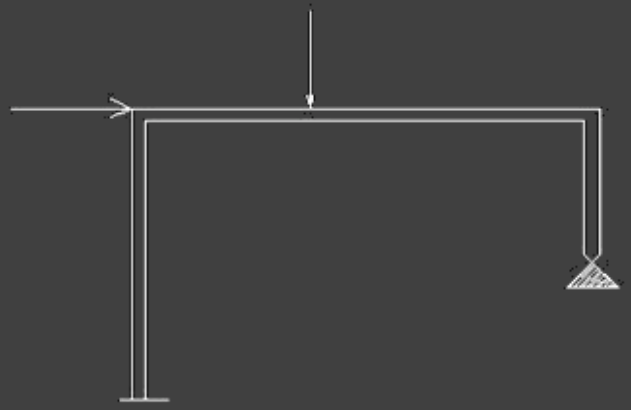
ETFE ω_0=.25 kN/m²

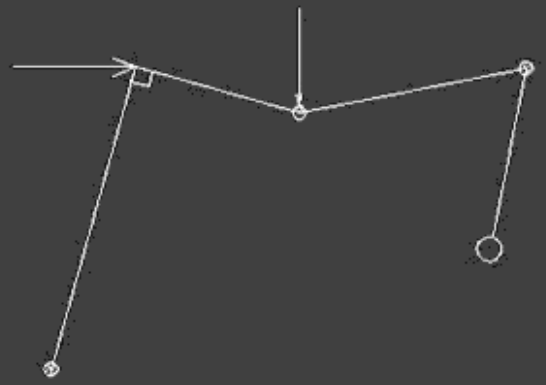
Structure ω_0=.4 kN/m²

Facilities ω_0=.25 kN/m²

Earthquake Loads:

- Located on a type III site
- To allow for seismic loads plastic hinges are used in the design of the structure
- Plastic hinge - a type of energy damping device allowing plastic deformation of an otherwise rigid column connection



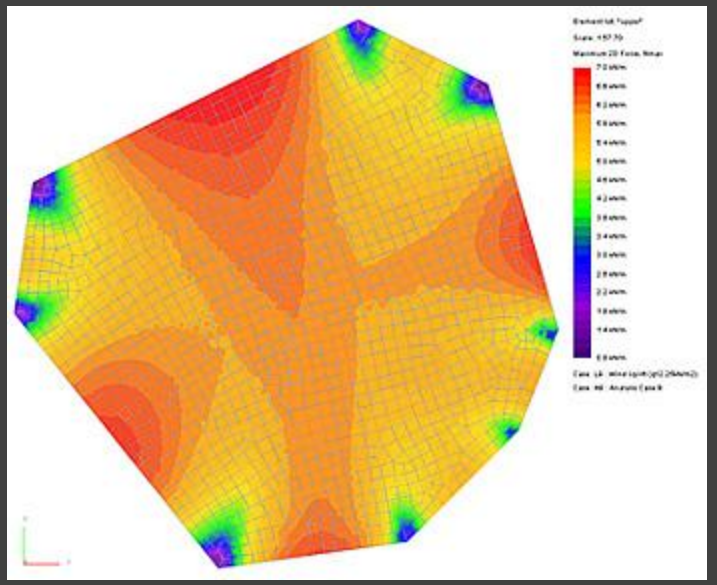


Roof Live Loads:

- Snow loads are the most stringent: $\omega_o = .55\ kN/m^2$

Wind Loads:

- Basic design wind pressure: $\omega_o = 5\ kN/m^2$
- Windward Face: $\omega_o = .8\ kN/m^2$
- Leeward Face: $\omega_o = -.5\ kN/m^2$
- Side Face: $\omega_o = -.7 kN/m^2$
- Top Face: $\omega_o = -.6 kN/m^2$
- $\omega_o = 2\ kN/m^2$
- Wall coefficient of wind pressure: $\mu z = \mu_{20} = 1.25$
- Roof coefficient of wind pressure: $\mu z = \mu_{30} = 1.42$



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