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 200 pa, giving an effect similar to a cavity wall
Dead Loads:

- ETFE: $\omega_0 = 0.25 \text{ kN/m}^2$
- Facilities and piping: $\omega_0 = 0.25 \text{ kN/m}^2$
- Acoustic Materials: $\omega_0 = 0.15 \text{ kN/m}^2$
- Structure: $\omega_0 = 0.4 \text{ kN/m}^2$

ETF E $\omega_0 = 0.25 \text{ kN/m}^2$  Structure $\omega_0 = 0.4 \text{ kN/m}^2$  Facilities $\omega_0 = 0.25 \text{ kN/m}^2$
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: $\omega_0 = 0.55 \text{ kN/m}^2$
Wind Loads:

- Basic design wind pressure: \( \omega_0 = 5 \text{ kN/m}^2 \)
- Windward Face: \( \omega_0 = 0.8 \text{ kN/m}^2 \)
- Leeward Face: \( \omega_0 = -0.5 \text{ kN/m}^2 \)
- Side Face: \( \omega_0 = -0.7 \text{ kN/m}^2 \)
- Top Face: \( \omega_0 = -0.6 \text{ kN/m}^2 \)
- \( \omega_0 = 2 \text{ kN/m}^2 \)
- Wall coefficient of wind pressure: \( \mu_z = \mu_{20} = 1.25 \)
- Roof coefficient of wind pressure: \( \mu_z = \mu_{30} = 1.42 \)