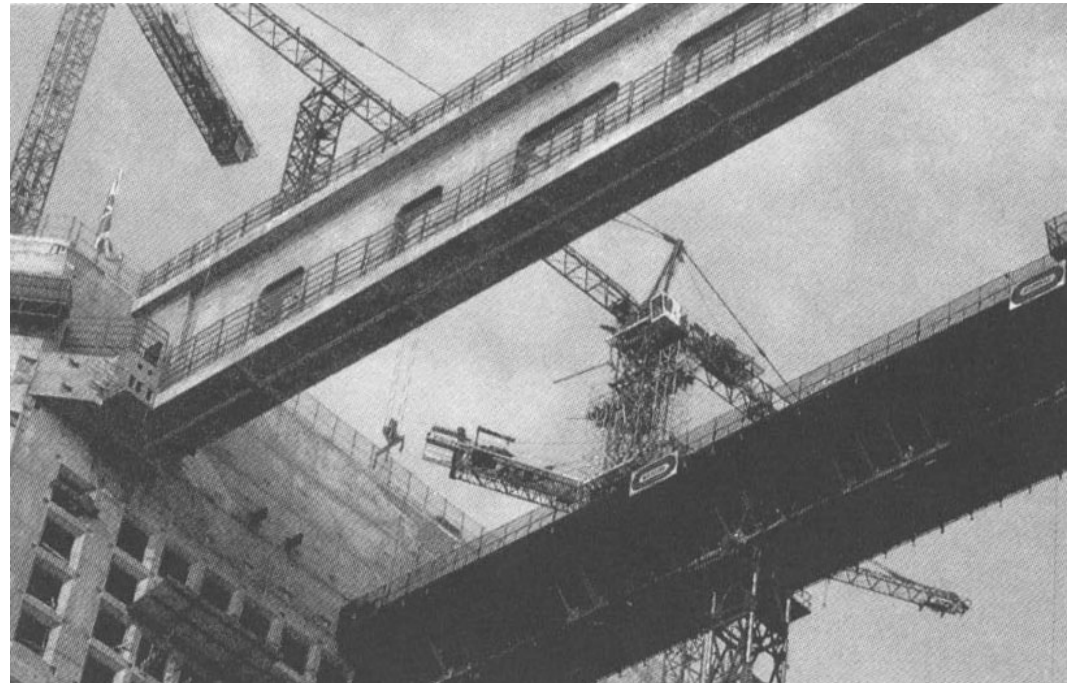
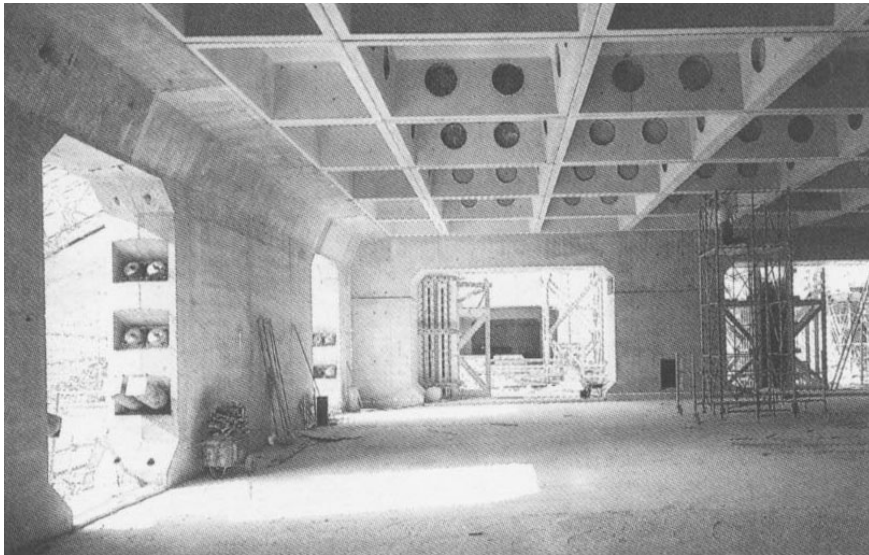



La Grande Arche De La Defense

Bradley Angell - Trenton Jacobs - Elizabeth Viets



“We’re going to show the Americans
a French-designed
skyscraper.”

- Bernard Zehrfuss



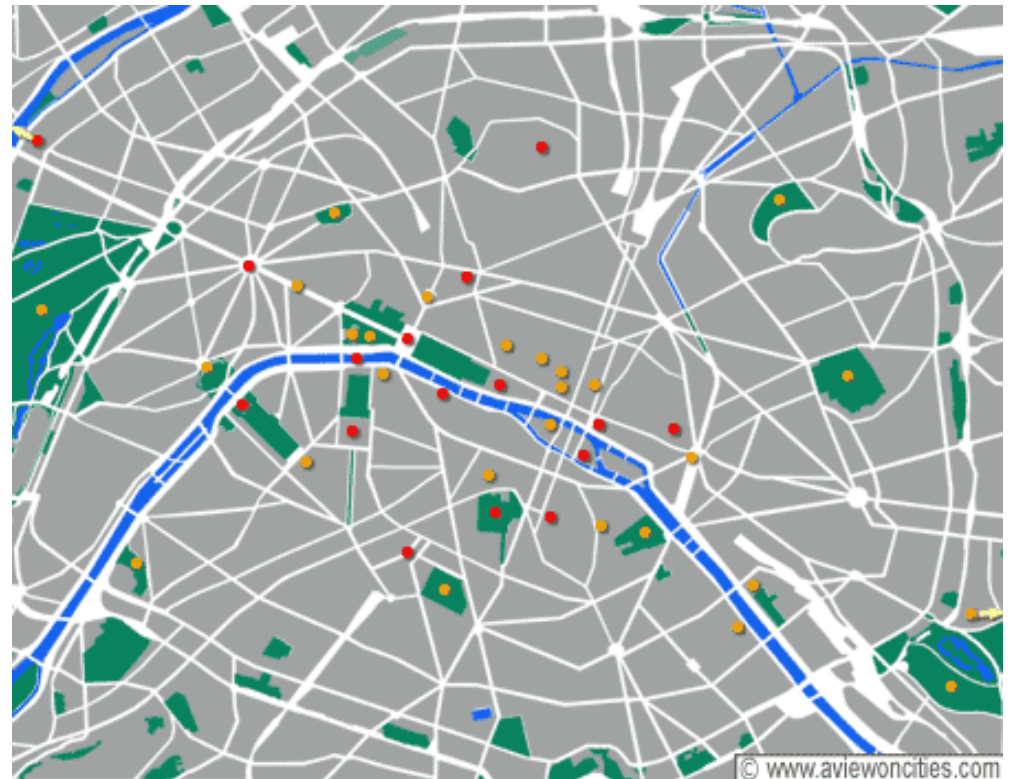
The Beginning

Between 1955 and 1956, it was decided that a new business district featuring a French-designed skyscraper would be built

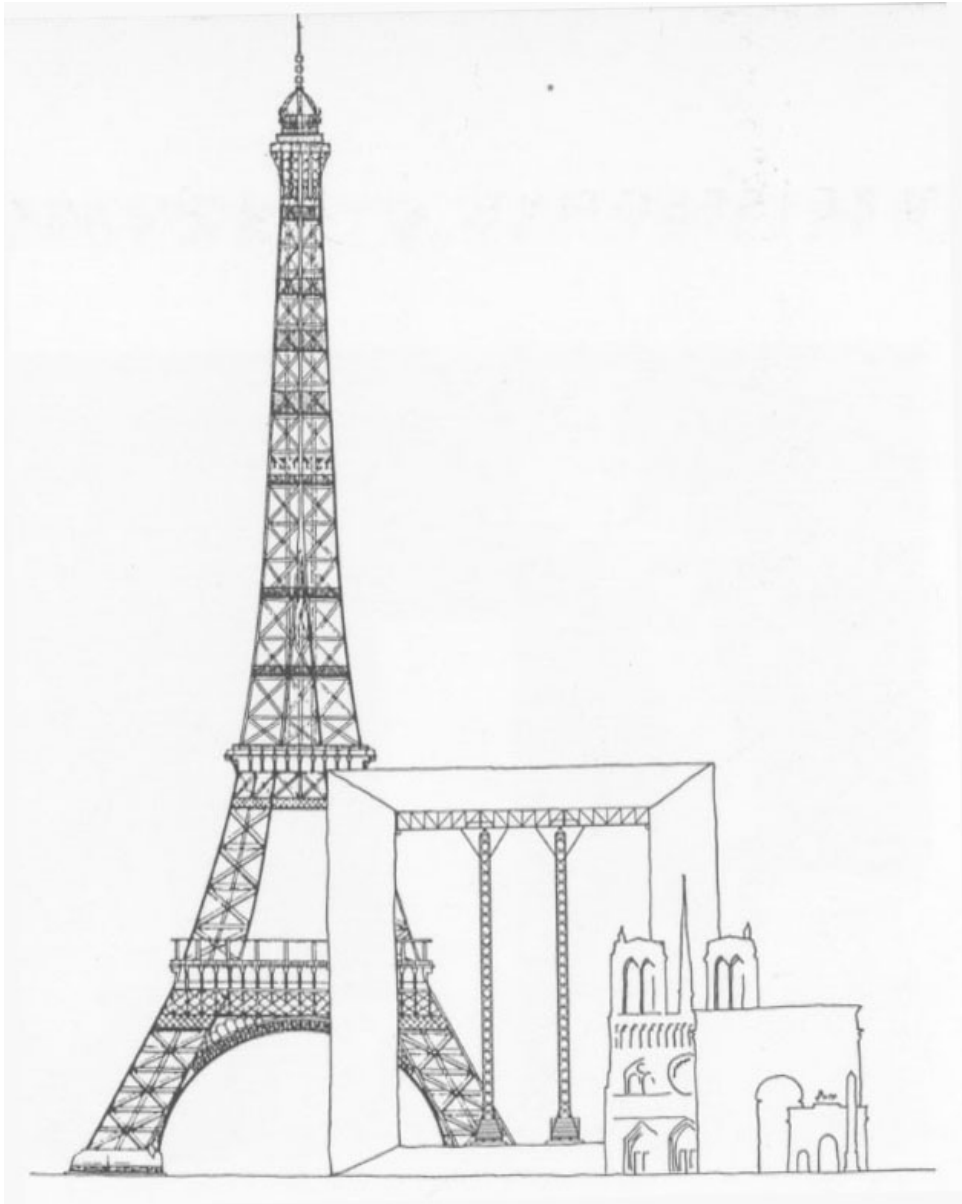
Design Goals:

- 250 meters tall

- An urban endpoint for the Grande Louve/Place de la Concorde/Champs-Elysees/Arc de Triomphe axis.



The Competition



Worldwide design competition for the site of La Defense required:

-a “monumental character”

-“a modern cathedral”

-“to mark the second centenary of the French Revolution just as the Eiffel Tower had marked the first”

-“social appropriateness favoring collective uses stemming from plural initiatives”

-“openness to the world”

The Winner- Johan Otto von Spreckelsen

His design consisted of a hollowed-out cube, creating an arch in white marble that was slightly offset constructing a closed object set on the axis but leaving a large absence that could be perceived through. Spreckelsen called the absence “a window opening on an unforeseeable future.”



Function of the Grande Arche



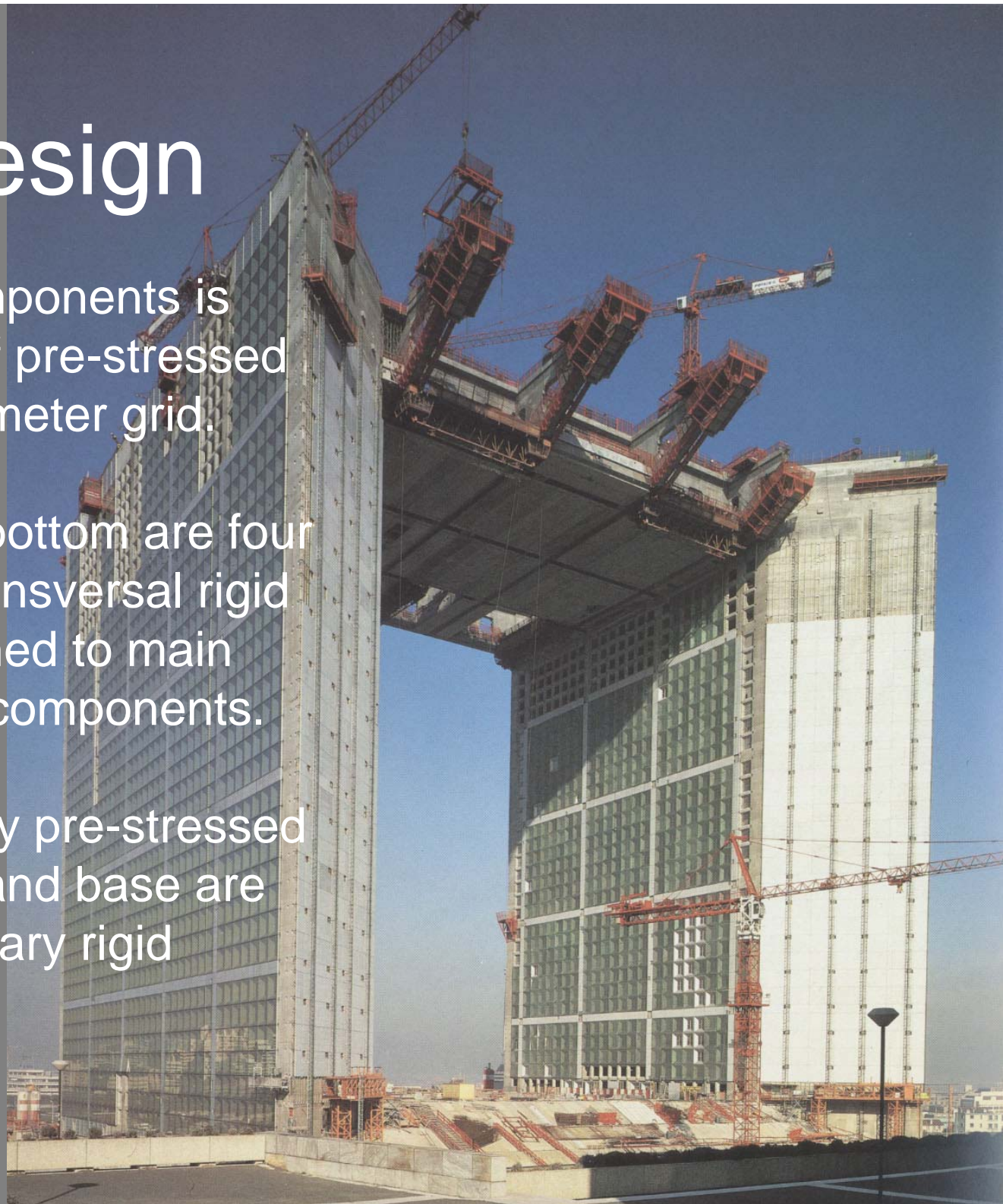
- Cultural icon for the upcoming century
- 158,000 sq. meters of space
- Communications center for the La Defense District
- Digital presentation auditoriums
- Communications infrastructure
- Office space for private parties.

Structural Design

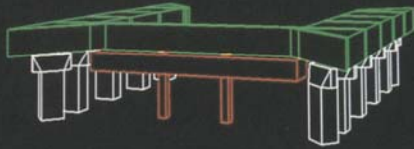
The primary building components is made up of a standard of pre-stressed concrete based on a 21 meter grid.

Mirrored on the top and bottom are four pre-stressed concrete transversal rigid frames of columns attached to main beams of roof and base components.

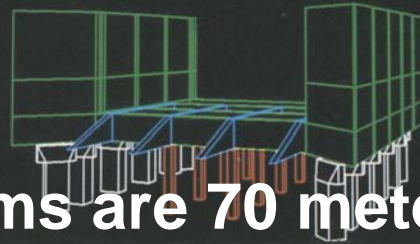
Four additional secondary pre-stressed cross beams in the roof and base are used to stabilize the primary rigid frames.



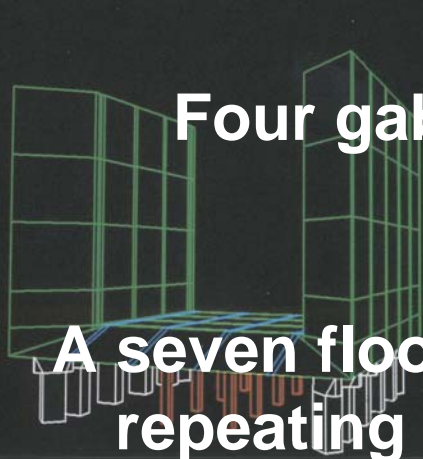
Structural Design



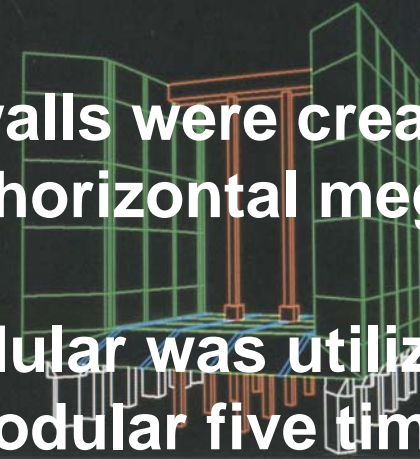
The roof beams are 70 meters long, 9.5 meters tall, and weigh 2000 tons each.



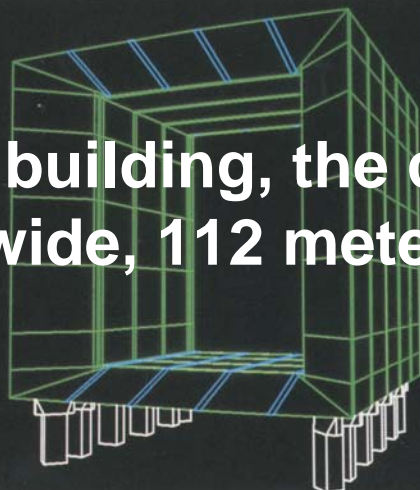
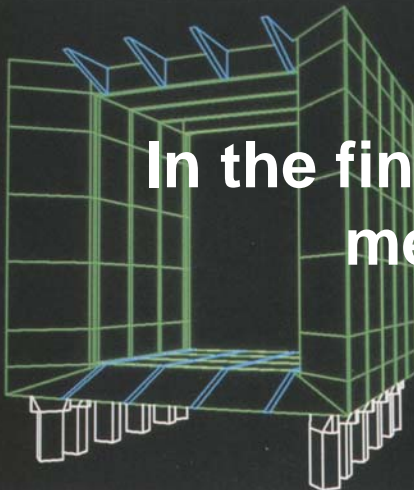
Four gabled walls were created at 45 degrees, holding 6 horizontal mega-structures on either side.



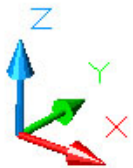
A seven floor modular was utilized to create a substructure, repeating the modular five times and built simultaneously with the superstructure.



In the finished building, the cube's dimensions were 117 meters wide, 112 meters deep and 111 meters tall.

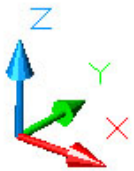
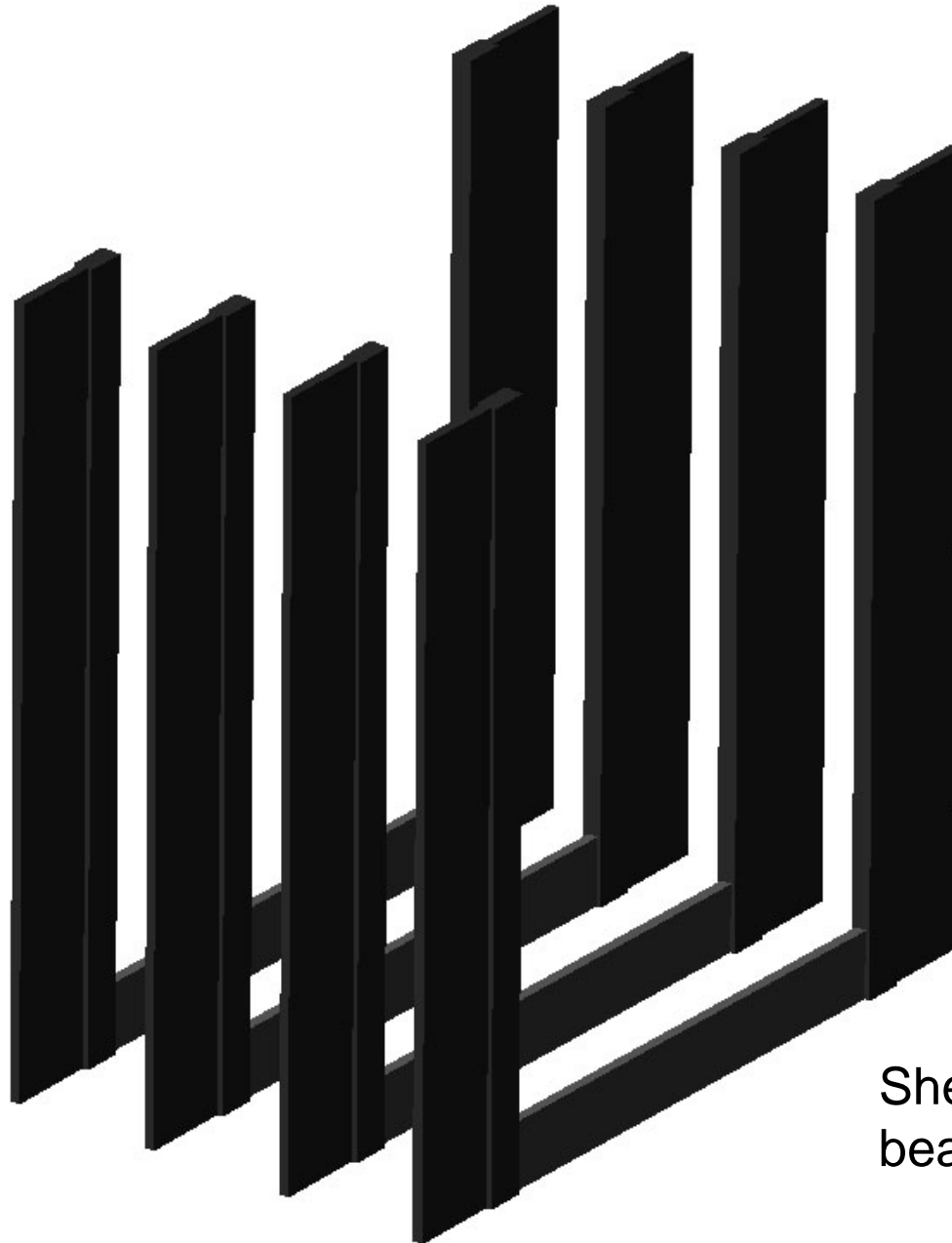


Structural Composition



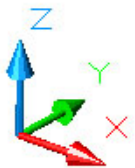
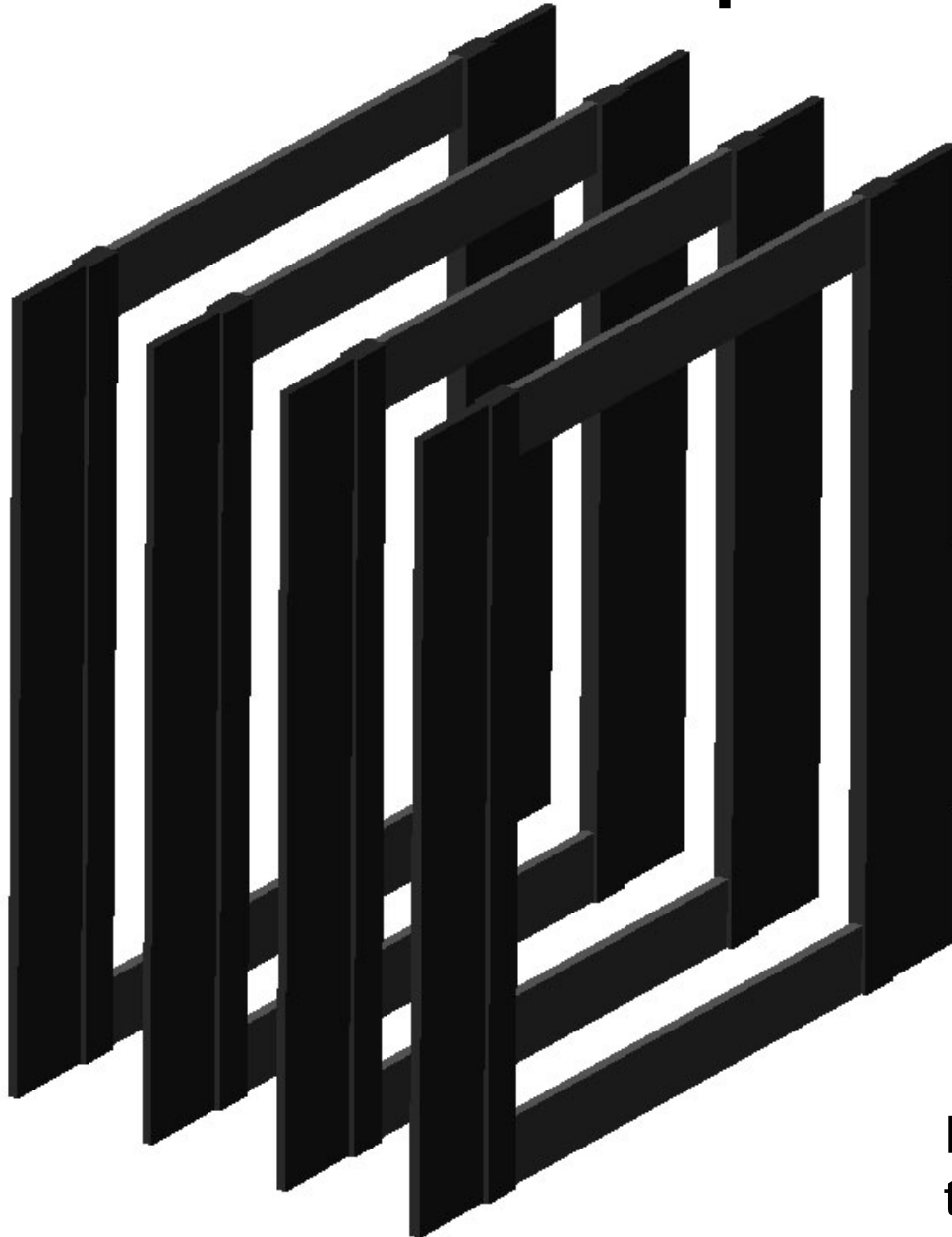
Base beams rest on foundation piles.

Structural Composition



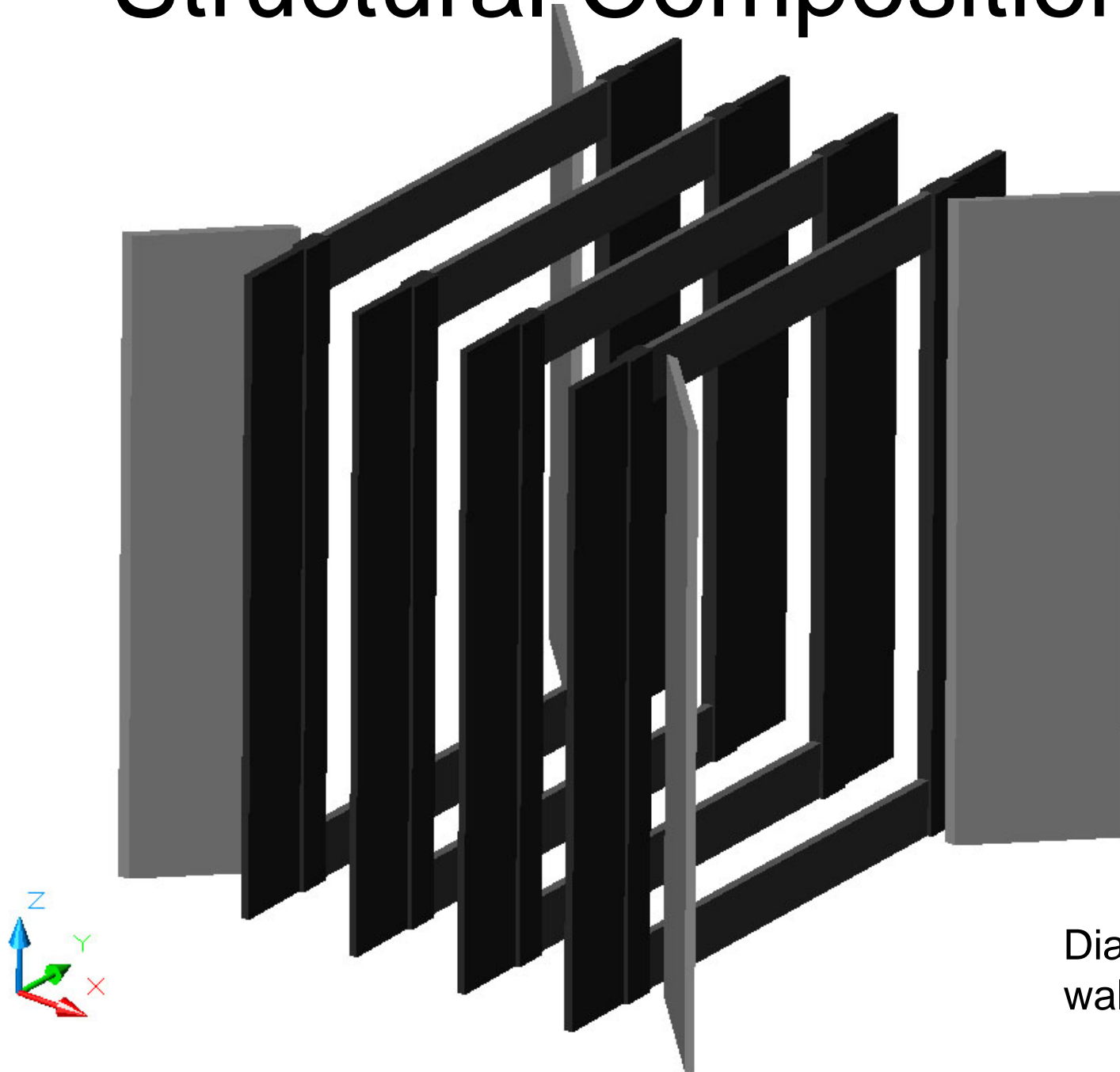
Shear walls act as load-bearing columns.

Structural Composition



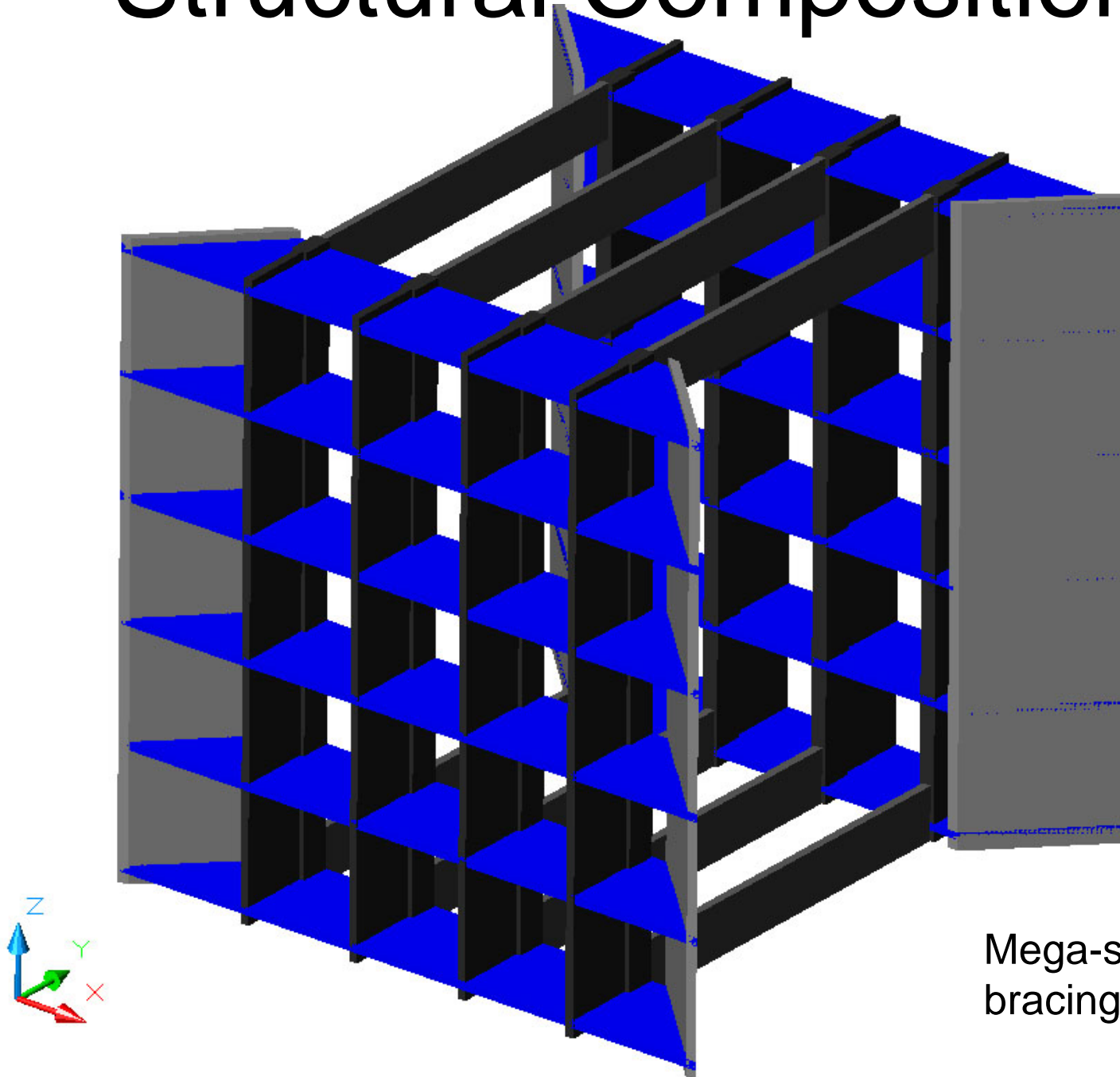
Roof beams complete the frames.

Structural Composition



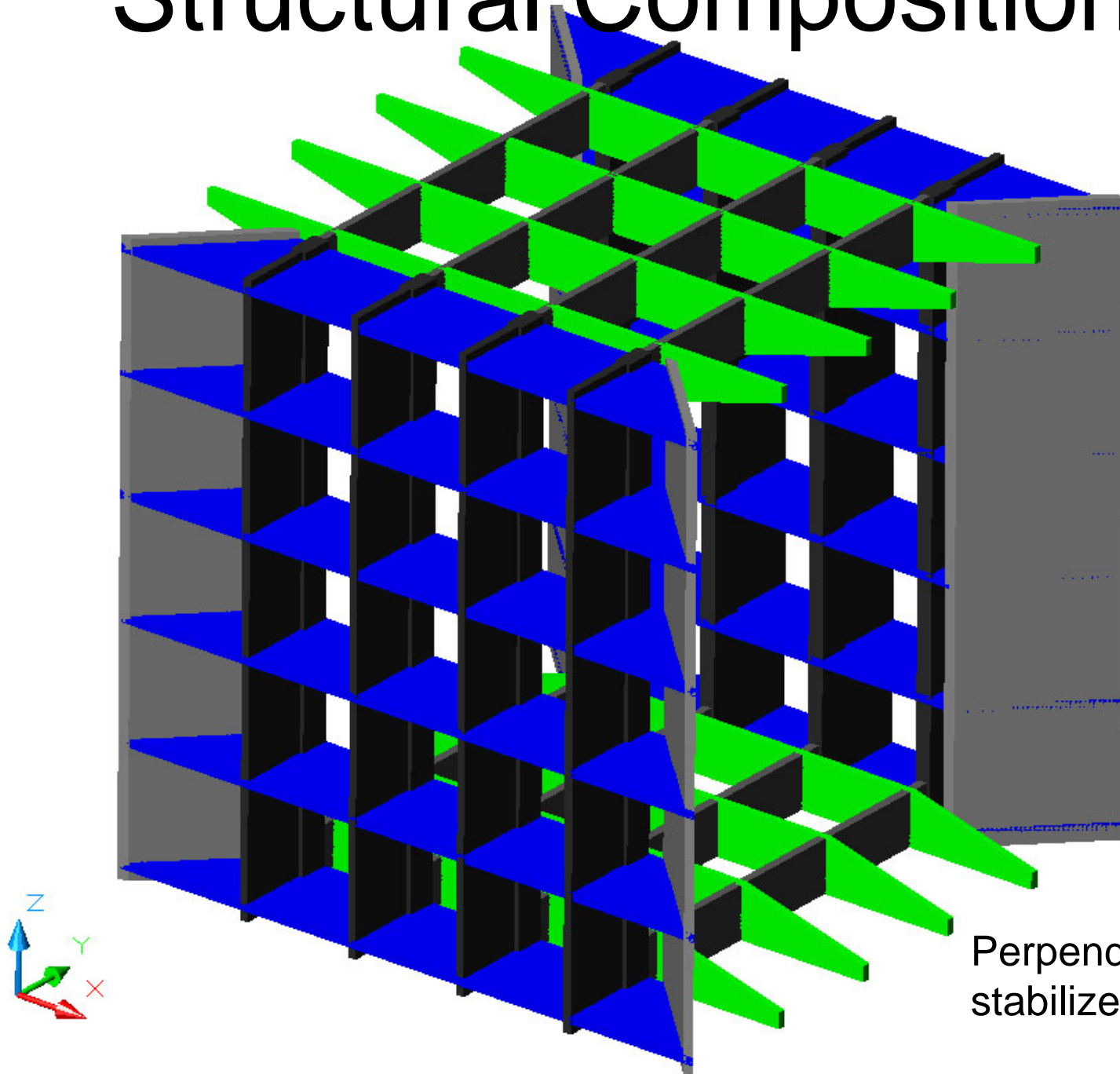
Diagonal shear walls add stability.

Structural Composition



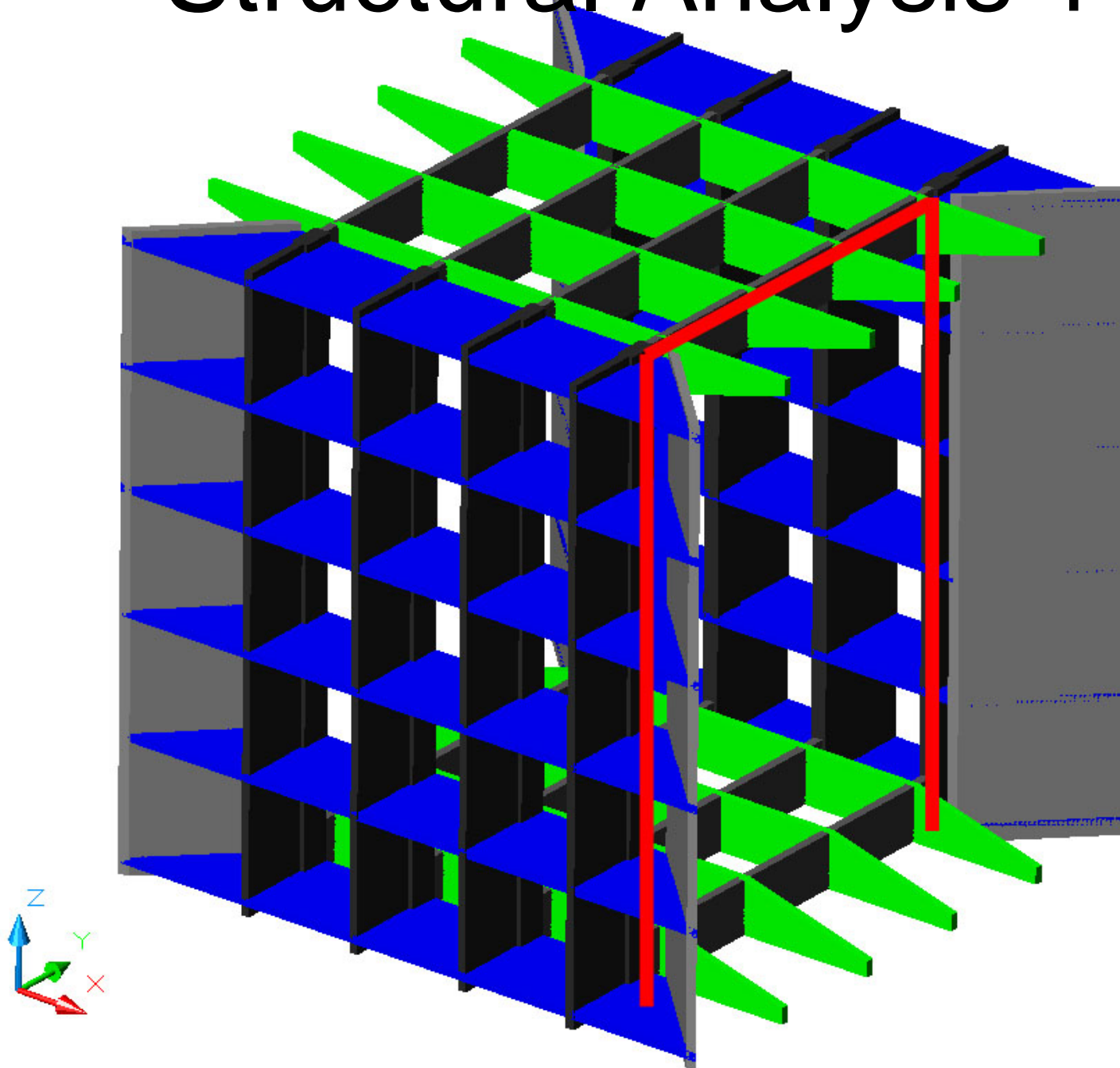
Mega-structure adds bracing to frames.

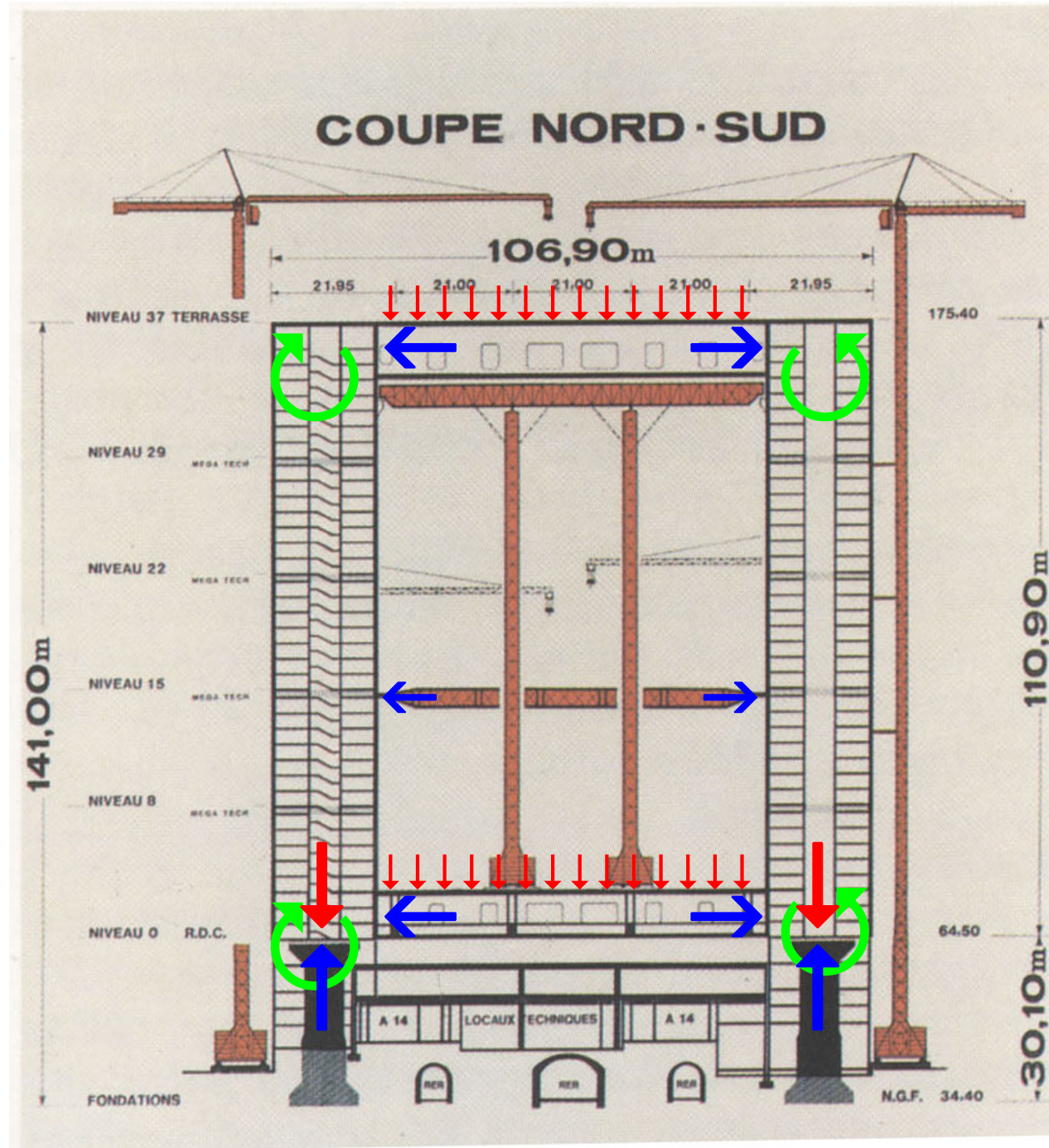
Structural Composition






Perpendicular beams stabilize roof and floor.

Structural Analysis 1

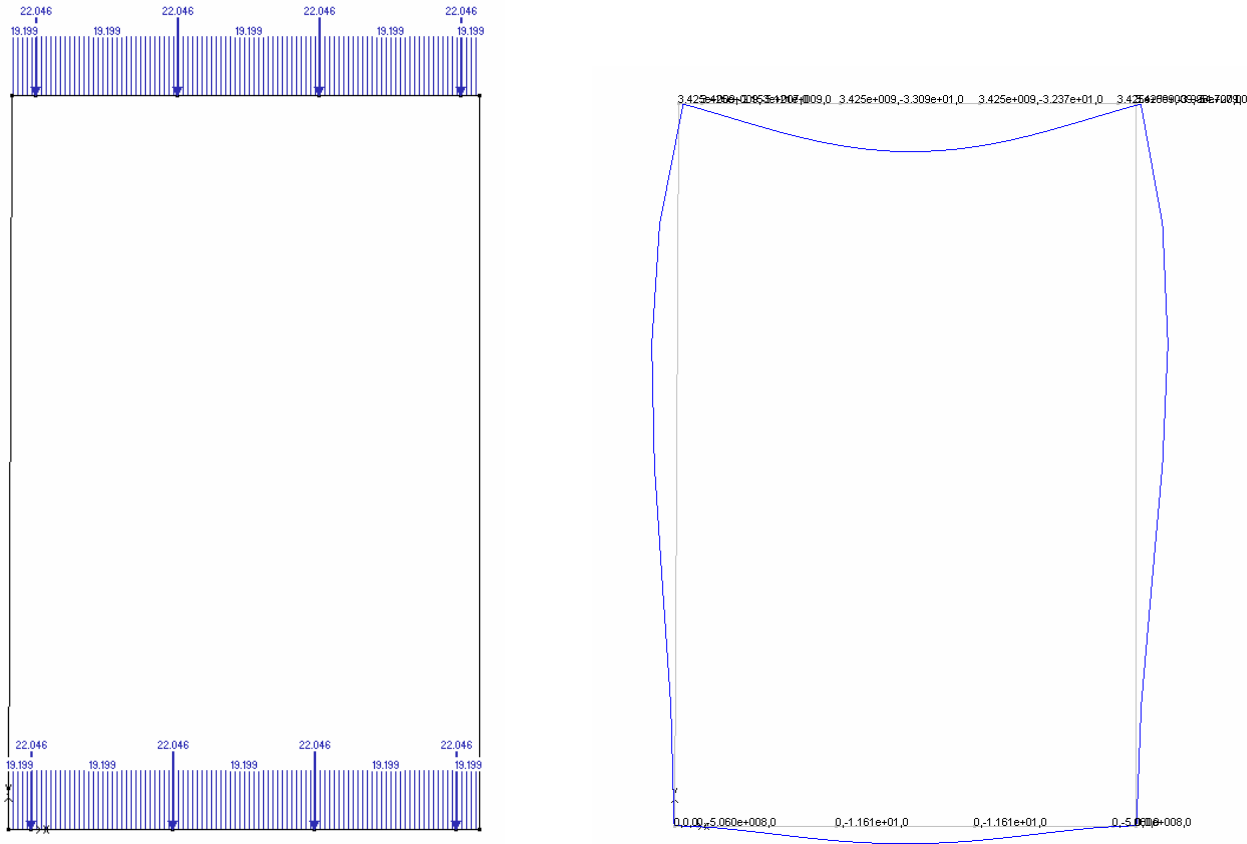




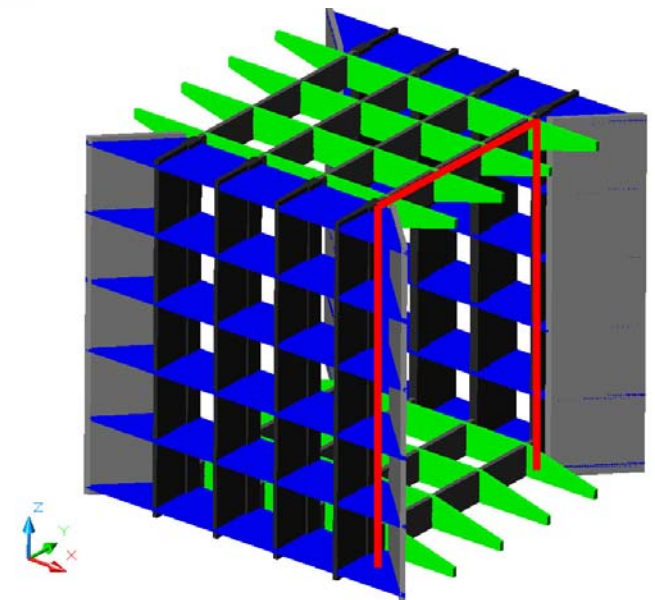
Forces:

-  **Loads**
-  **Moments**
-  **Reaction forces**

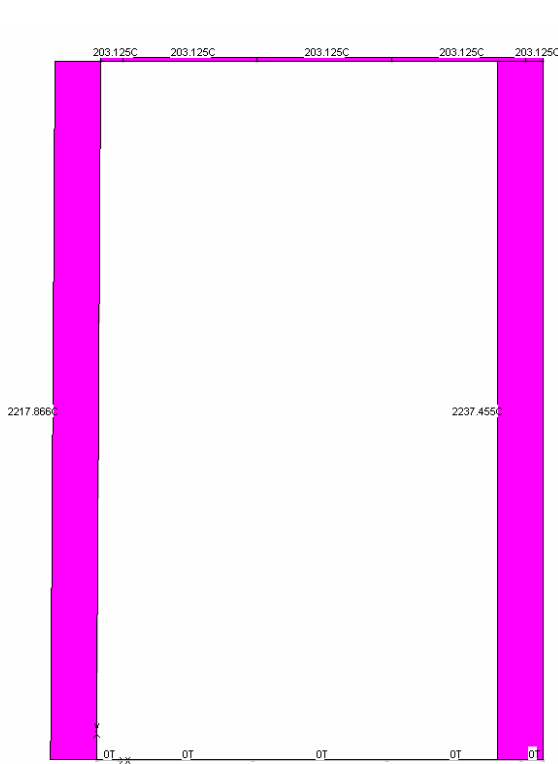
Structural Analysis 1



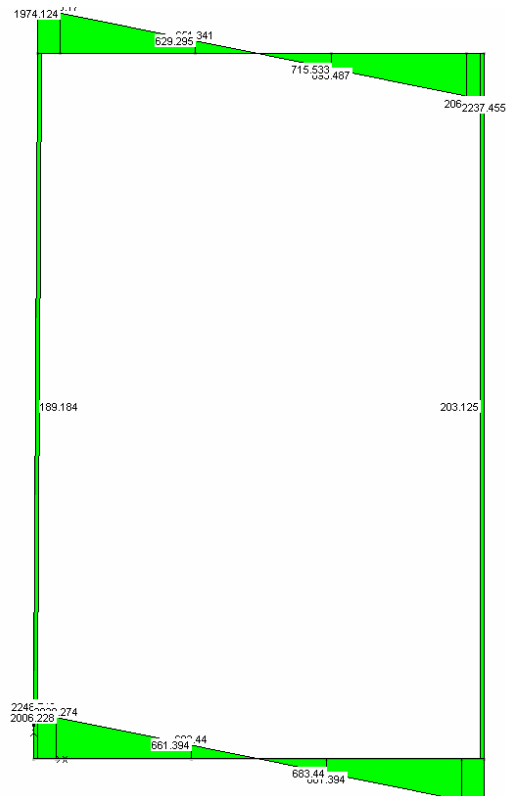
Loading diagram: The distributed load is the self-weight of the main beams. The point loads are self-weight of secondary beams running perpendicular to the distributed load.



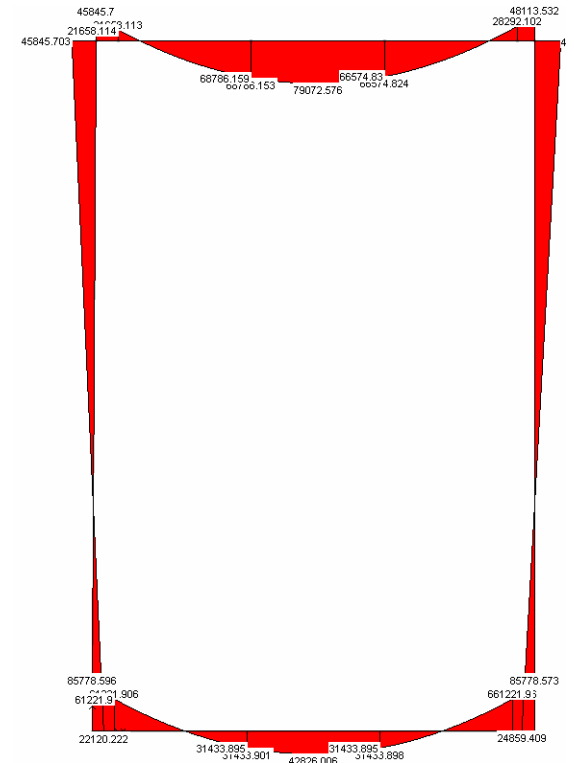
Structural Analysis 1



Axial Reactions:
The purple bars show that there are uniform axial compressive forces on both vertical elements.

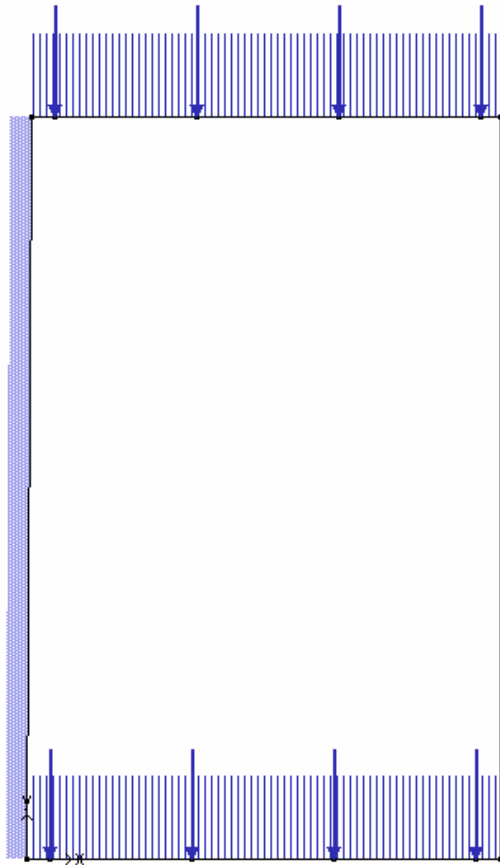


Shear: The highest shear is located at the edges of the roof and floor.

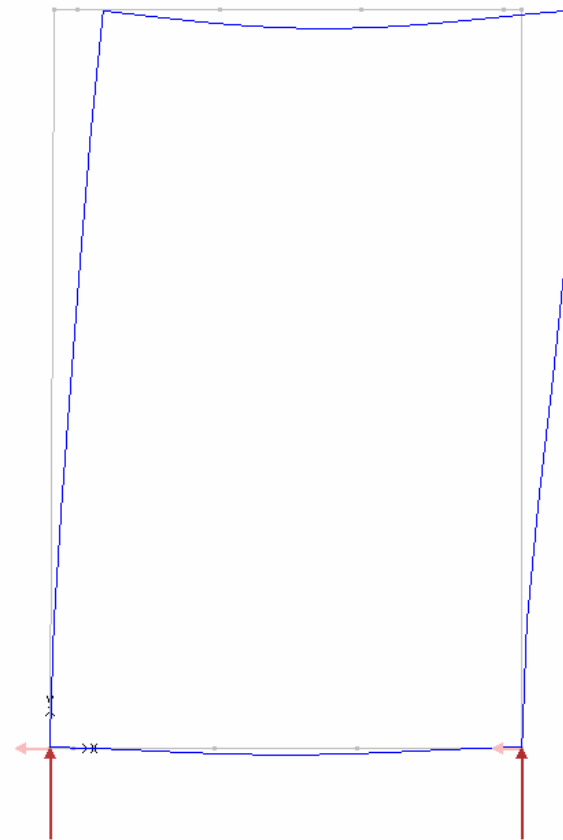


Moment Distribution:
Bending moments are highest in the center of the roof and floor.

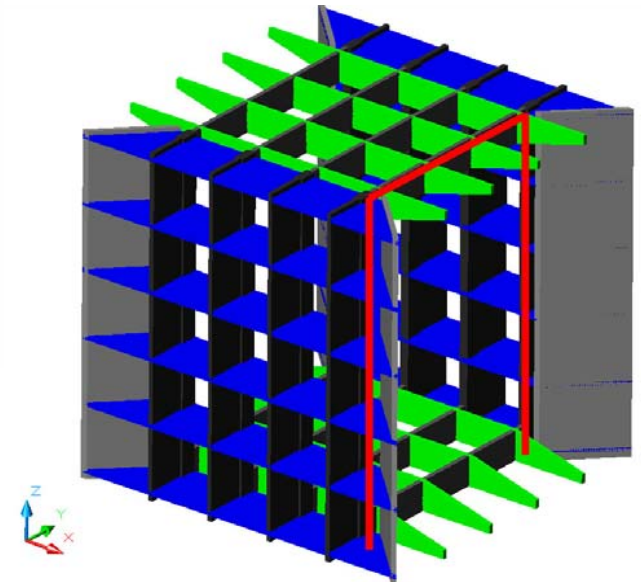
Structural Analysis 1- Wind Load



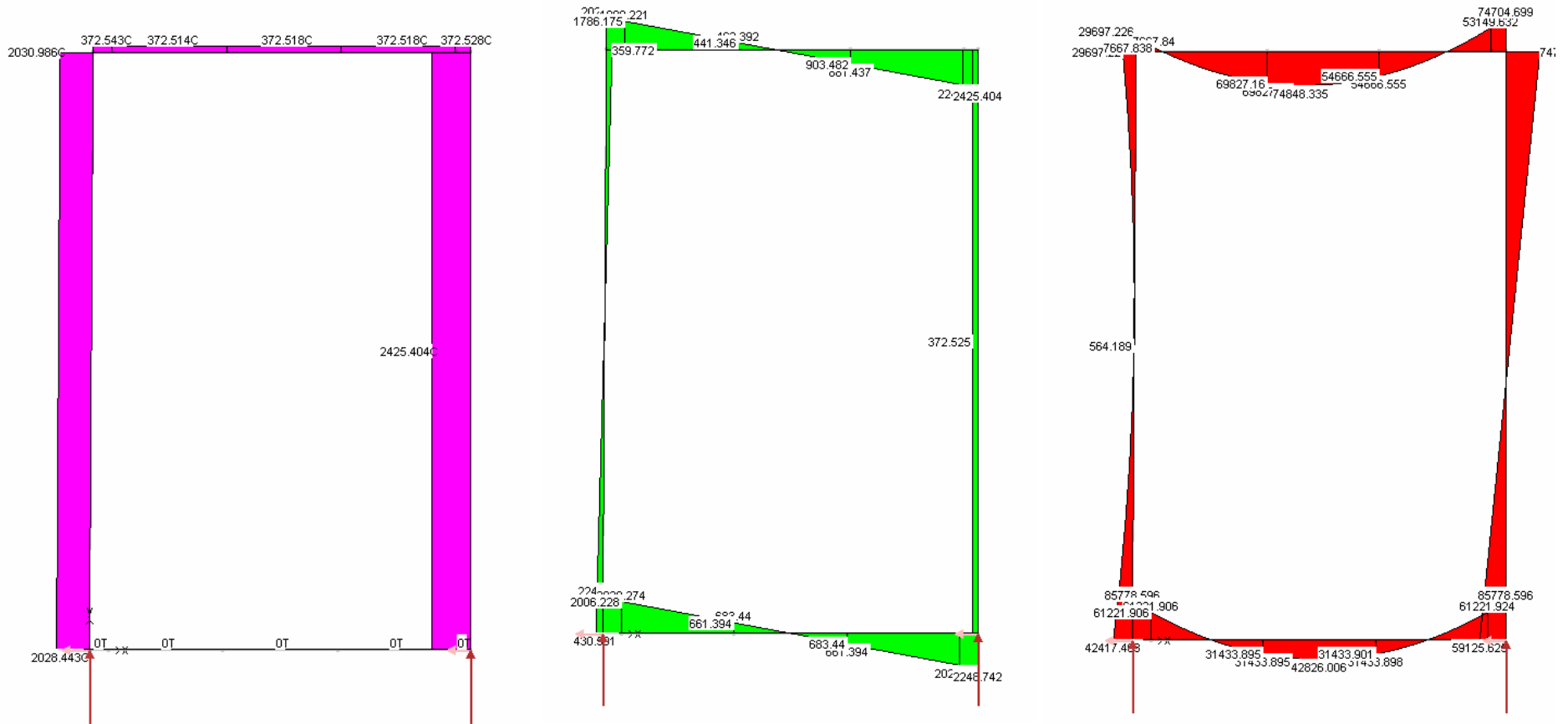
Applied Wind Load
(85mph)



Resulting Deformation

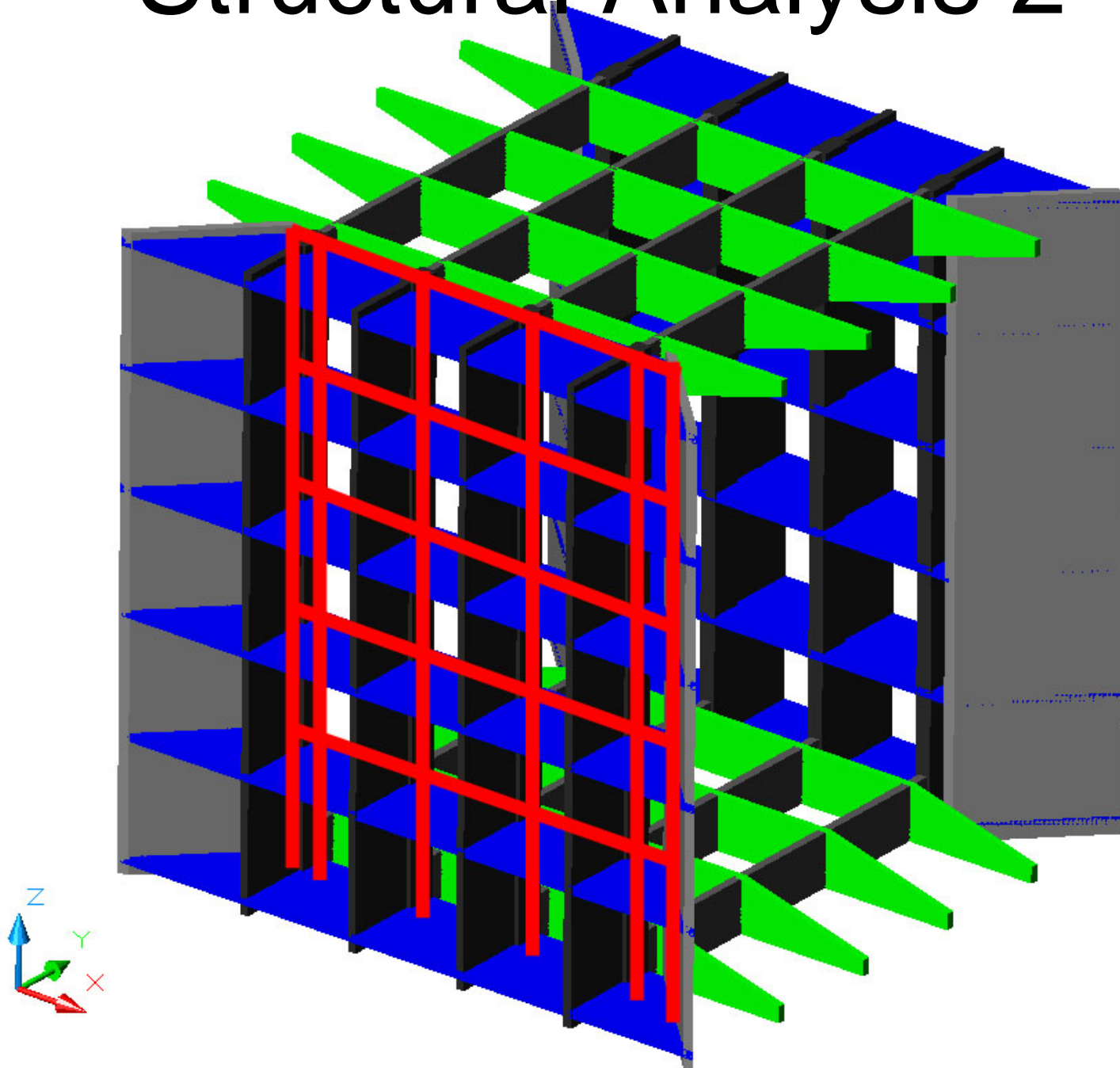


Structural Analysis 1- Wind Load

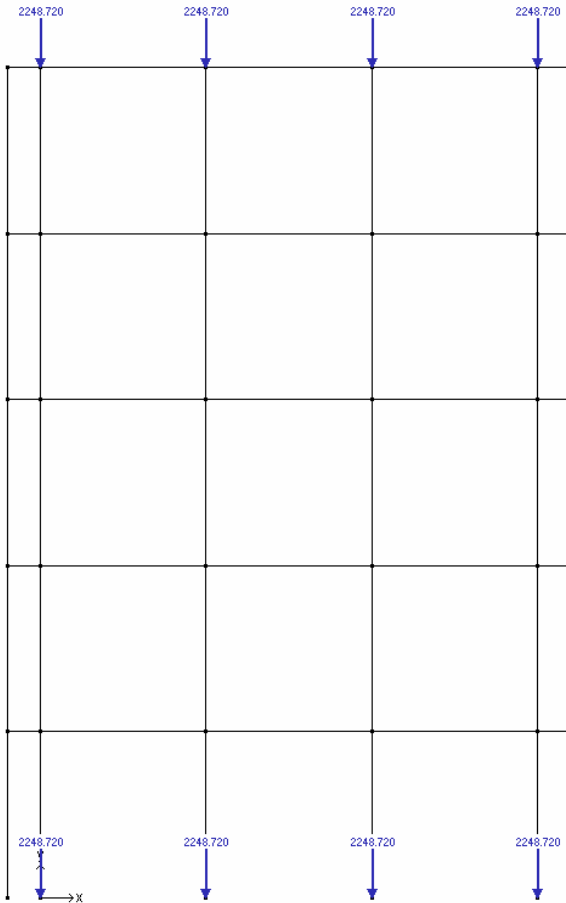


Deep Shear Members Resist Lateral Wind Forces

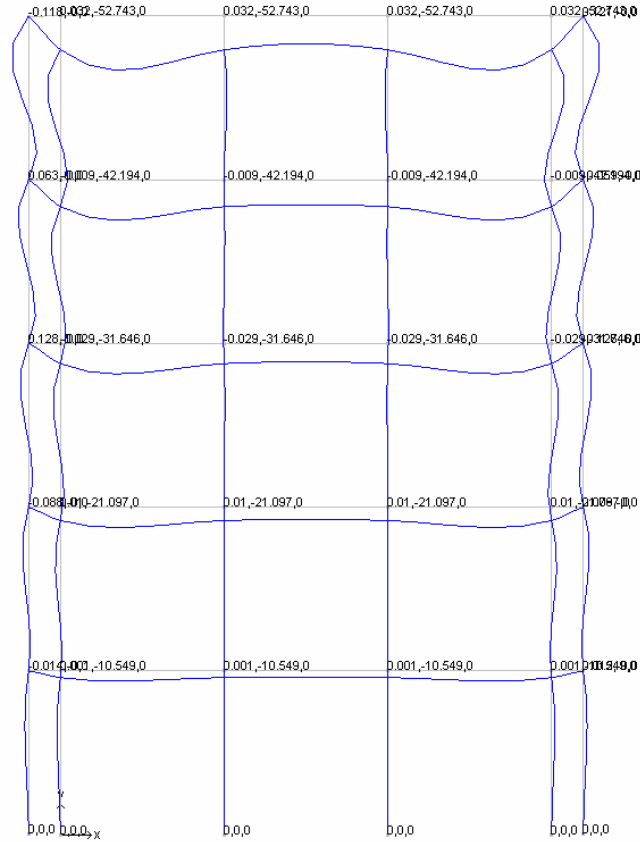
Structural Analysis 2



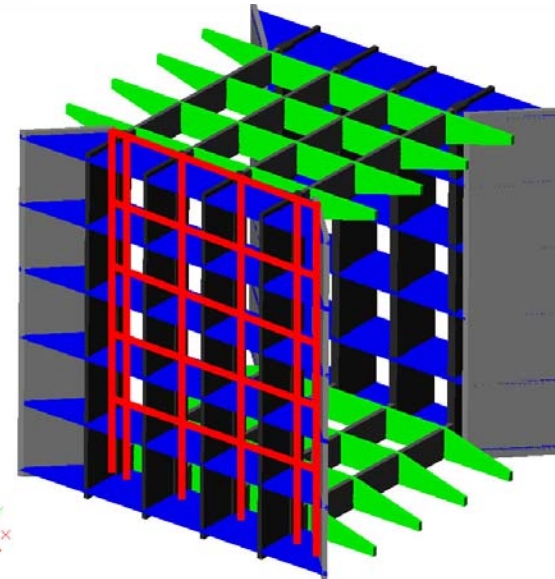
Structural Analysis 2



Loading diagram showing the loads caused by the self-weight of roof.



Deformation from roof loads.



Foundation

Twelve foundation piles rest on a limestone shelf fourteen meters below the surface ground level.

The piles are eight meters in width at the base, and the use of elliptical bases required custom-made concrete formworks.

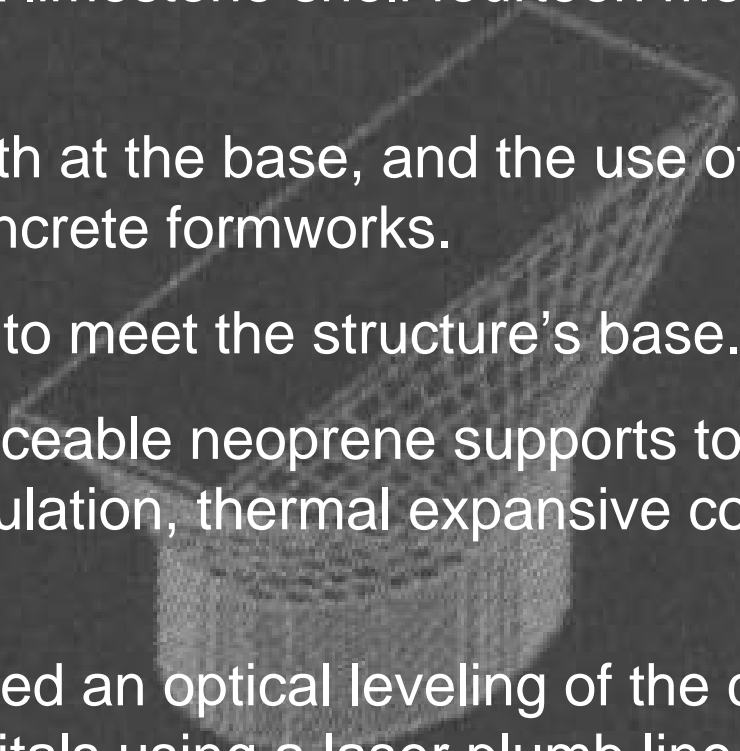
The piles flared to fifteen meters to meet the structure's base.

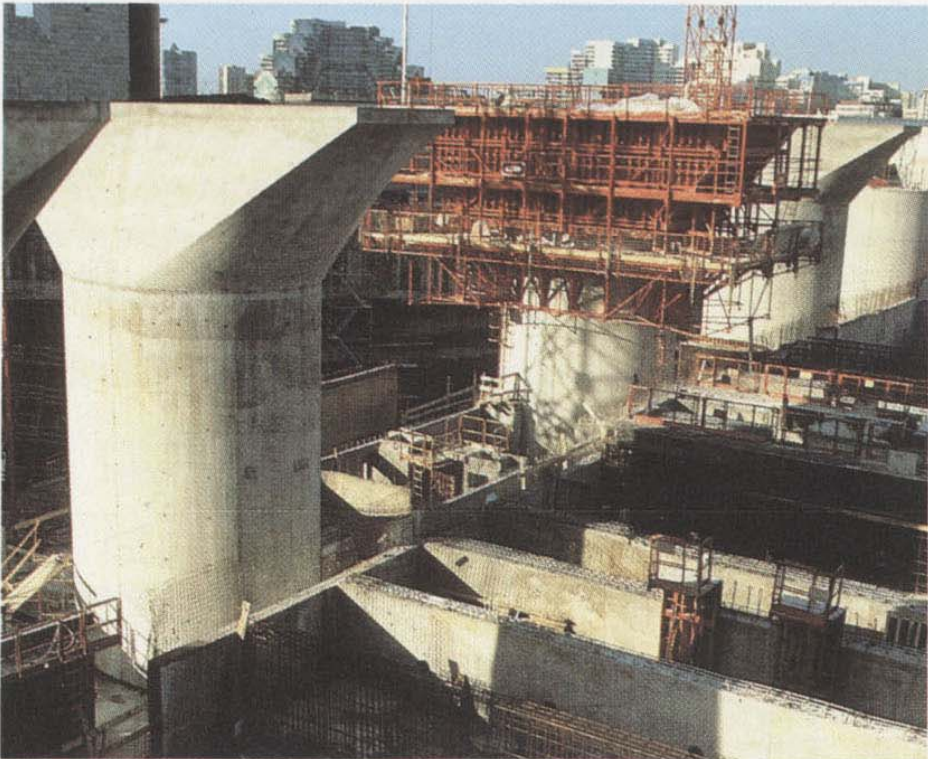
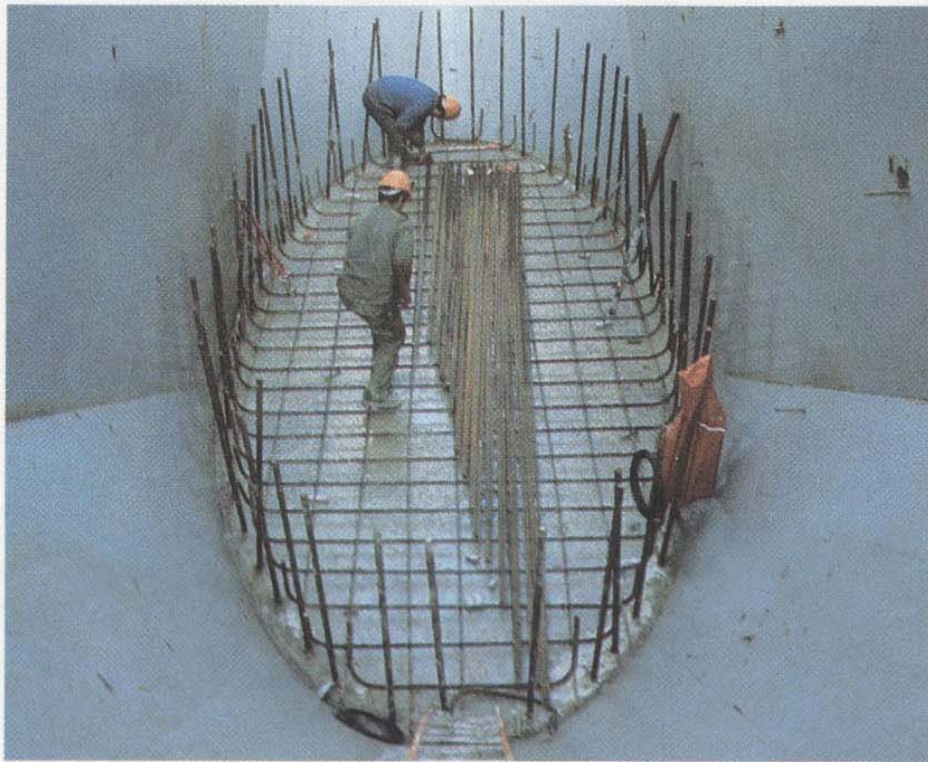
The top of the capital holds replaceable neoprene supports to suffer the vibrations from underground circulation, thermal expansive contractions, and wind effects.

Settlement measurements required an optical leveling of the cube's supports with markers at the capitals using a laser plumb line.

Also taken were deformation measurements of pile concrete using vibrating ropes sunk into the trunk of the pile.

Soundings were also administered for measurement into the deep layer settlement.







Surfacing



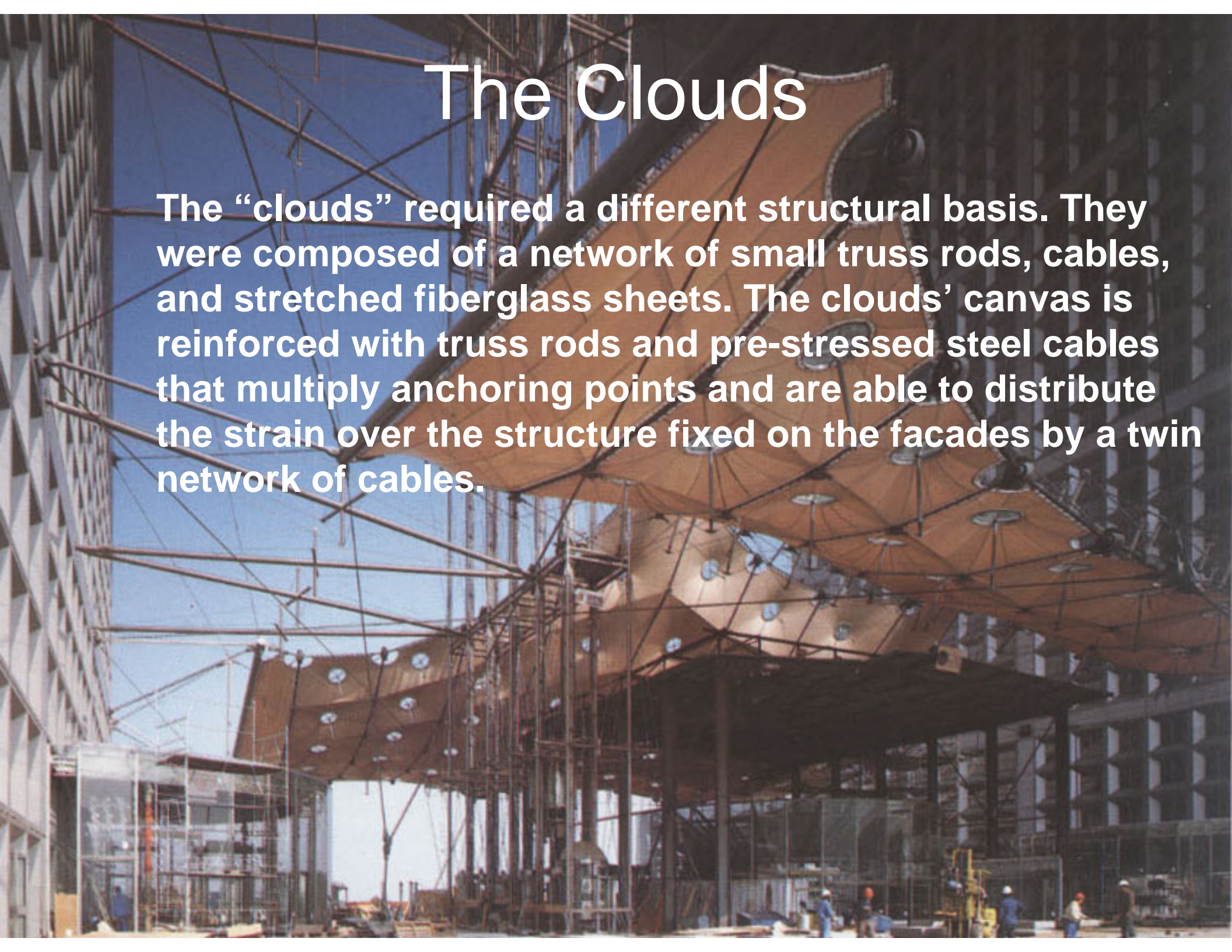
External panels were created of Carrara marble, weighing 800 kg each, and laminated glass, weighing 300 kg each.

The outside facades required the marble panels, while the laminated glass was used for the interior facades.

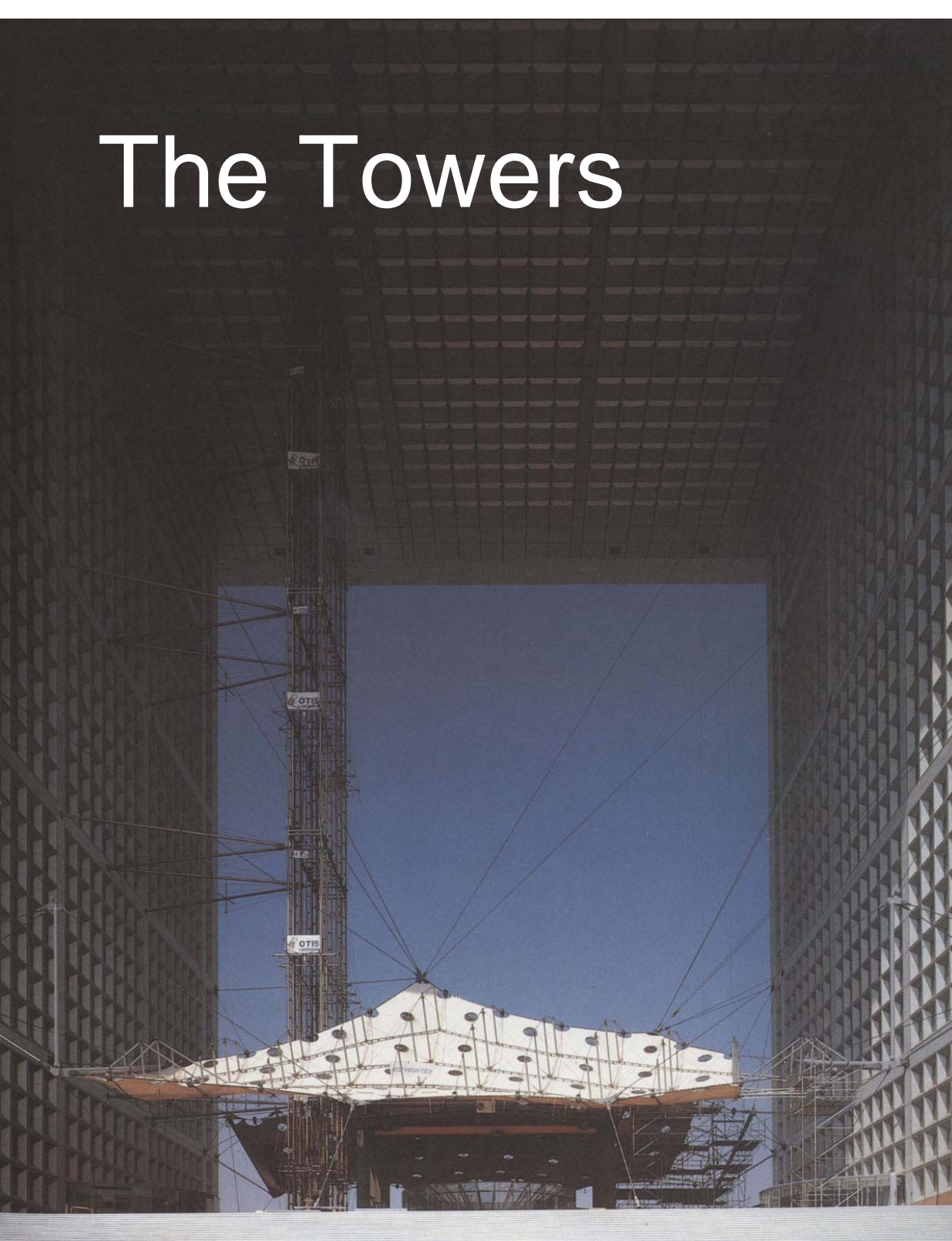
The dimensions of the panels were 2.8 meters square, creating 3 hectares of surfacing materials to complete the empty cube.

The Clouds

The “clouds” required a different structural basis. They were composed of a network of small truss rods, cables, and stretched fiberglass sheets. The clouds’ canvas is reinforced with truss rods and pre-stressed steel cables that multiply anchoring points and are able to distribute the strain over the structure fixed on the facades by a twin network of cables.



The Towers



The panoramic lift towers piercing the clouds required twelve vertical pillars forming five lift wells, each at 2.8 meters square.

Only four of the towers are actually used, and they reach a height of 99 meters.

The columns of the lifts are pre-stressed stainless steel, and operate in pairs so that no counterweights are required for usage.

The piles and their components create a total height of thirty meters and have a bearing weight of 300,000 tons.

Bibliography

- Ghirardo, Diane; Architecture After Modernism, Thames and Hudson, 1996, pgs.204-5
- Chaslin, Francois and Picon-Lefebvre, Virginie; La Grande Arche de la Defense, Electa Moniteur, 1985