Kansai International Airport Terminal

Bay of Osaka, Japan 1988-1994

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Ove Arup & Partners – Structural Engineers

INTRODUCTION

- In the late 1960s, the Kansai Region in Japan realized an economic need for a new airport near the Bay of Osaka.
- Two decades passed before groundwork was laid for Kansai International Airport.
- To prevent noise pollution and allow for 24-hour a day operation officials chose to build an island in Osaka Bay on which to construct the passenger terminal and runways.
- 1987-1991: Island construction
- Simultaneously a design competition was held, for which Renzo Piano Building Workshop (in collaboration with Ove Arup) won the commission.
- 1991-1994: Airport Construction

INTRODUCTION

- Largest man-made island – 22,000,000 cubic meters of reclaimed land, 4 km X 1km in size.
- Final cost of constructing both island and passenger terminal was $14 billion US dollars.
- Longest building in the world – 1.7 kilometers
- Since 1987 the island has subsided approximately 10 meters. Since 2002 the rate of submergence has decreased.
- Hit by the Kobe Earthquake of 1995 and the terminal sustained no damage.

GEOMETRY

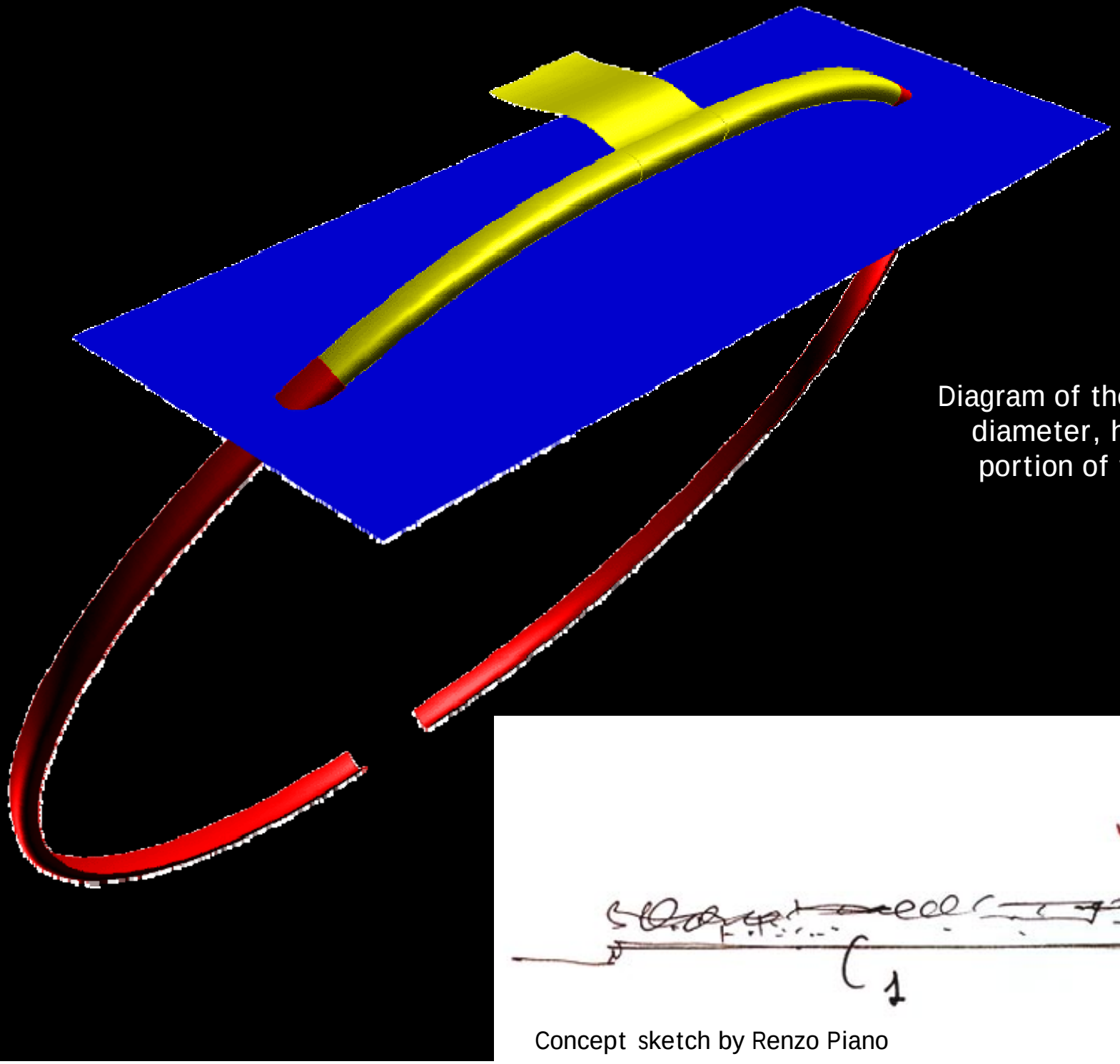
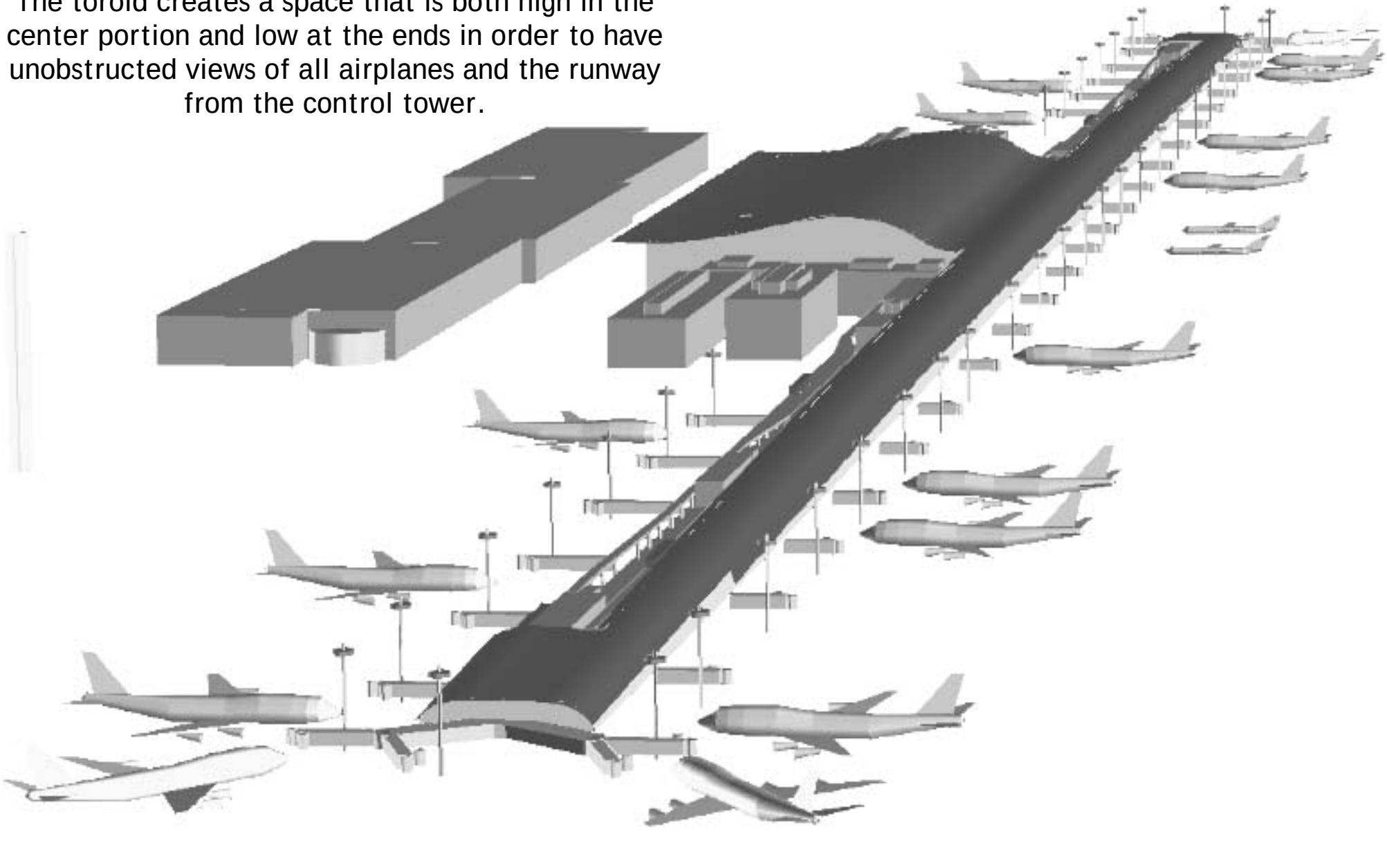


Diagram of the toroid which is 20 miles in diameter, however only a very small portion of the toroid is used for the airport.

Concept sketch by Renzo Piano

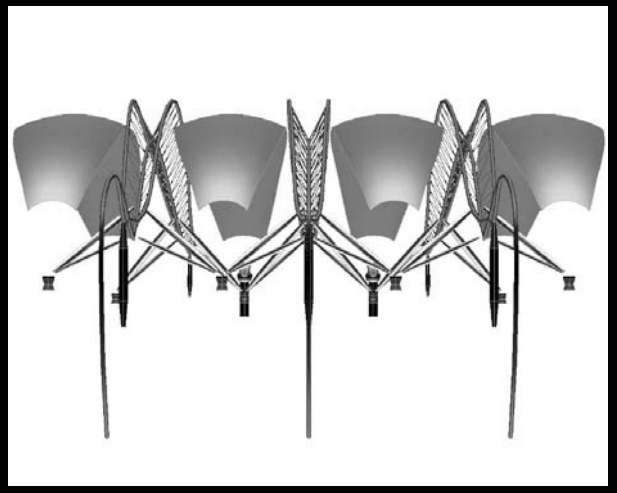
GEOMETRY

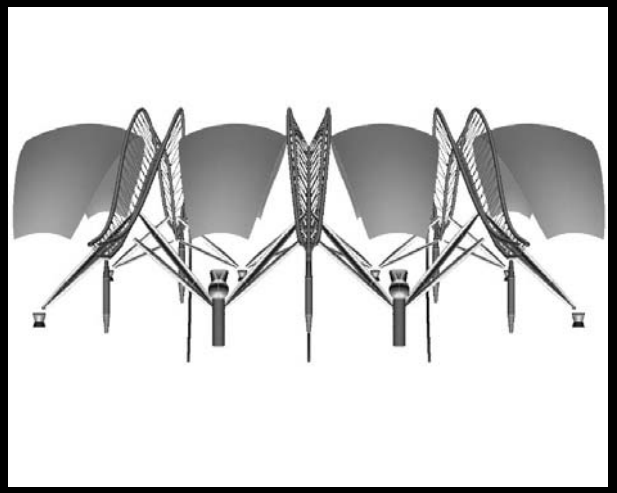
The toroid creates a space that is both high in the center portion and low at the ends in order to have unobstructed views of all airplanes and the runway from the control tower.



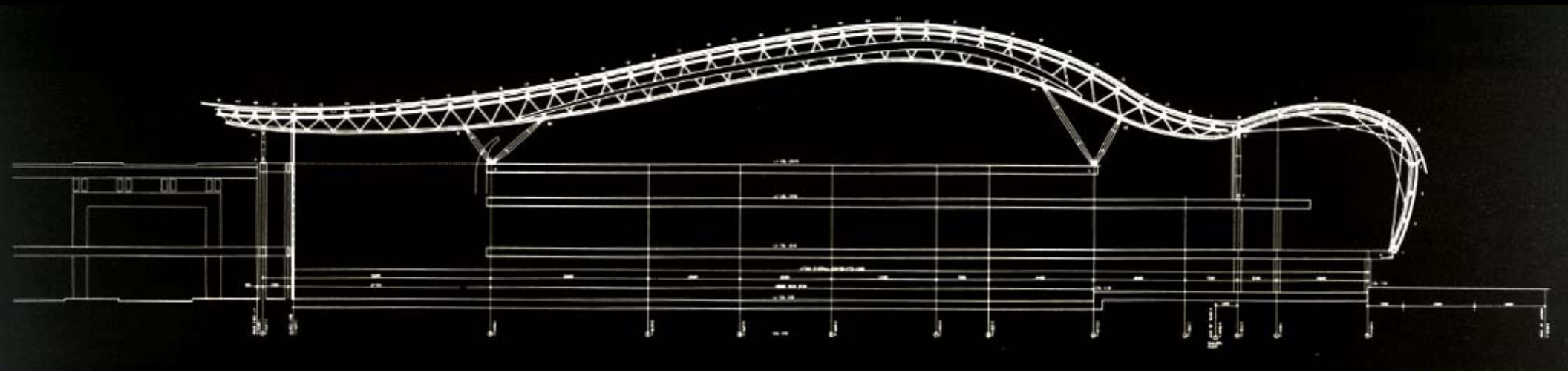
GEOMETRY

Another roof form generating idea was the desire to condition the passenger terminal without a clutter of ductwork hanging from the exposed trusses. This was done by blowing a jet of air from the landside and let it be carried against a ceiling that would be shaped to follow the natural curve of the decelerating air. Huge scoop like ceilings entrain the blown jets of air across the space.

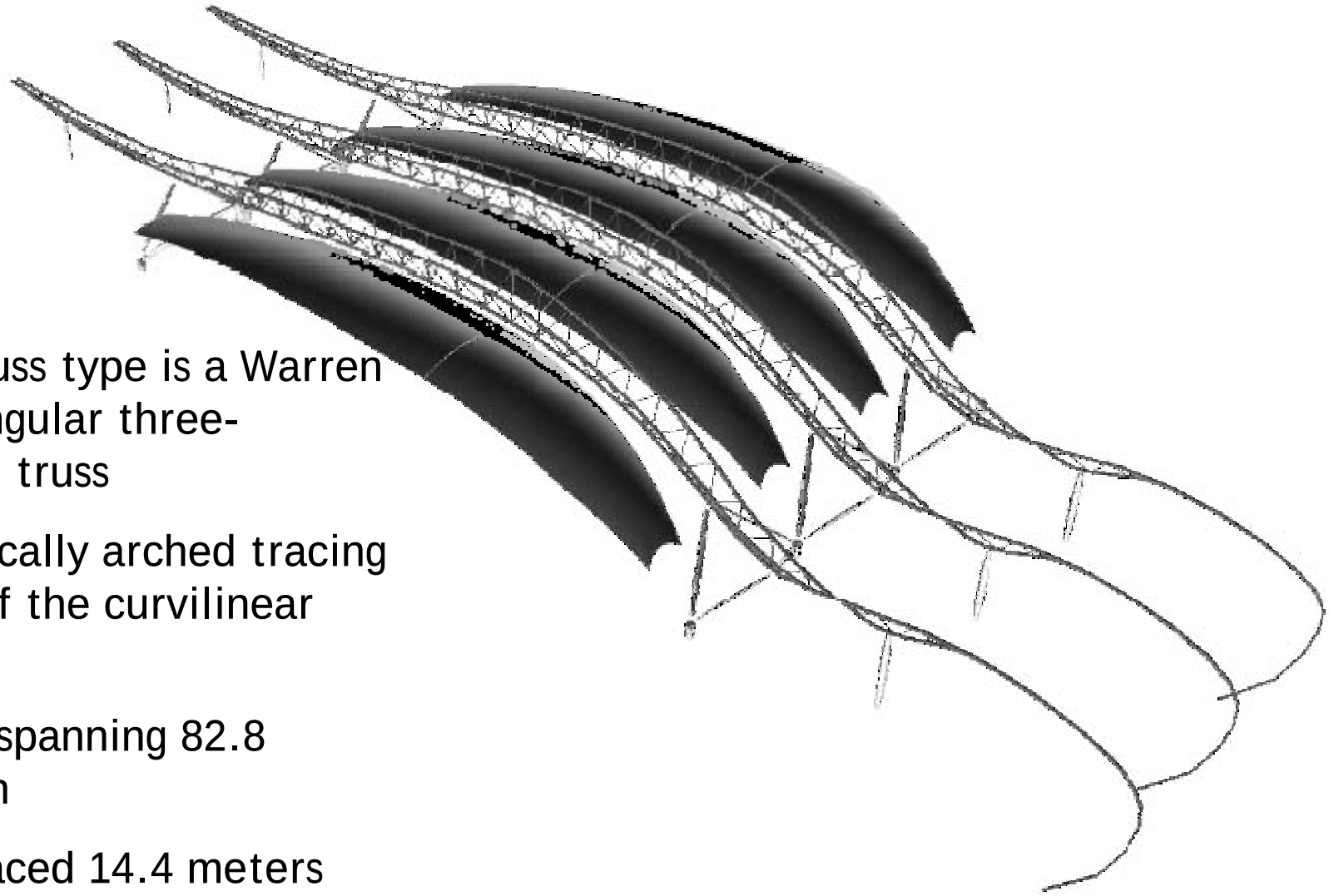




MAIN TERMINAL BUILDING

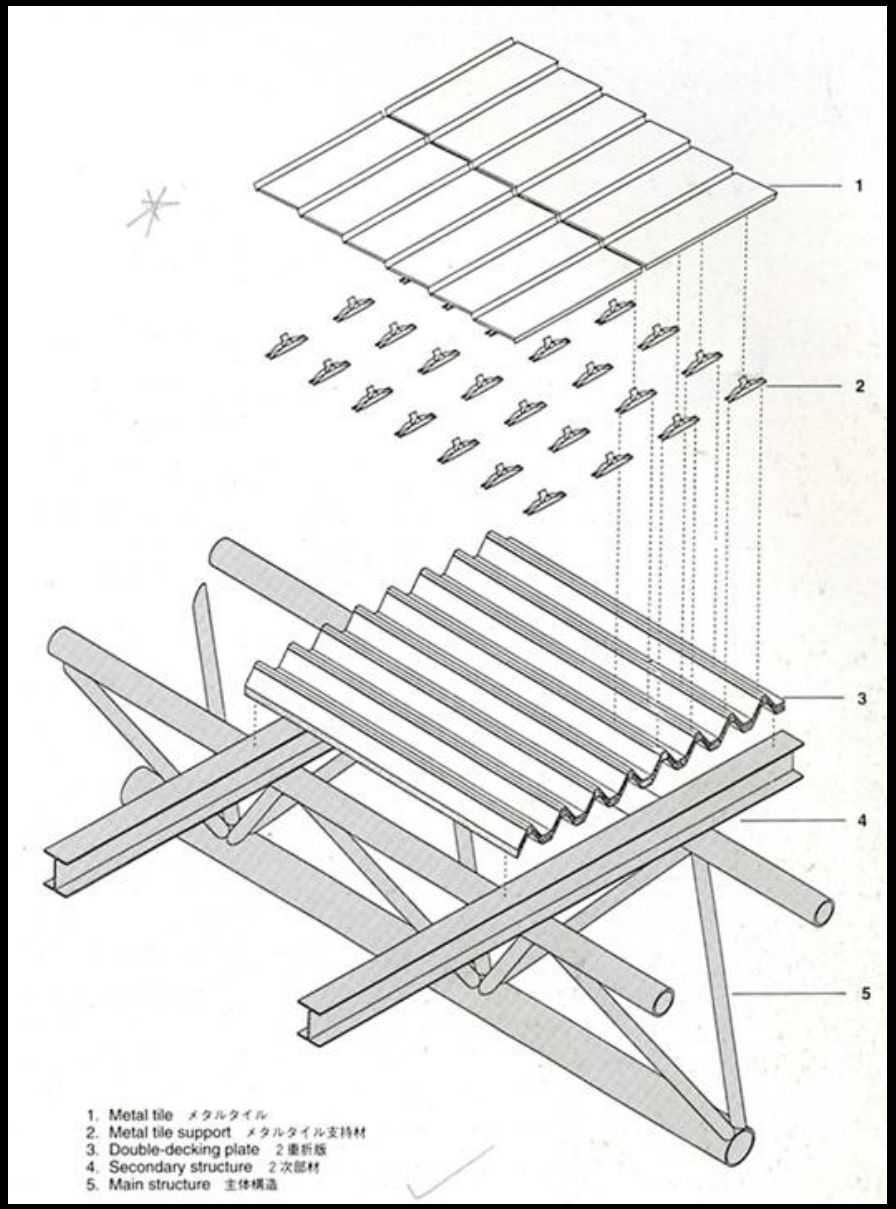


MAIN TERMINAL BUILDING



- Primary truss type is a Warren based, triangular three-dimensional truss
- Asymmetrically arched tracing the shape of the curvilinear roof above
- 18 trusses spanning 82.8 meters each
- Trusses placed 14.4 meters apart

MAIN TERMINAL BUILDING



- A continuous secondary structure spans across the primary trusses
- Built out of standard I-sections with traditional cross bracing
- Designed to absorb lateral forces generated by earthquakes
- Also helps restrict potential buckling of the primary trusses

MAIN TERMINAL BUILDING

- Gable ends of main terminal are double bow trusses
- Used to avoid complexity of joining a truss and glazing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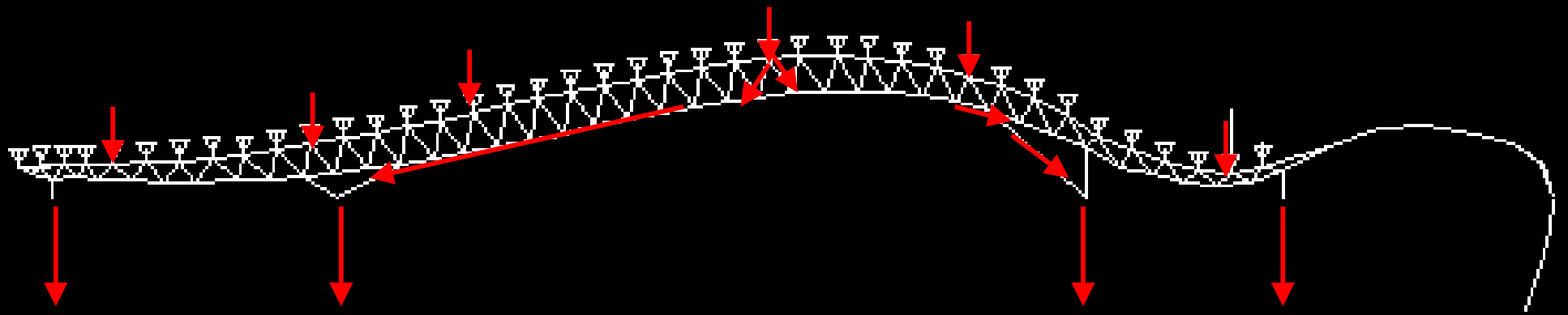
STRUCTURAL LOADING



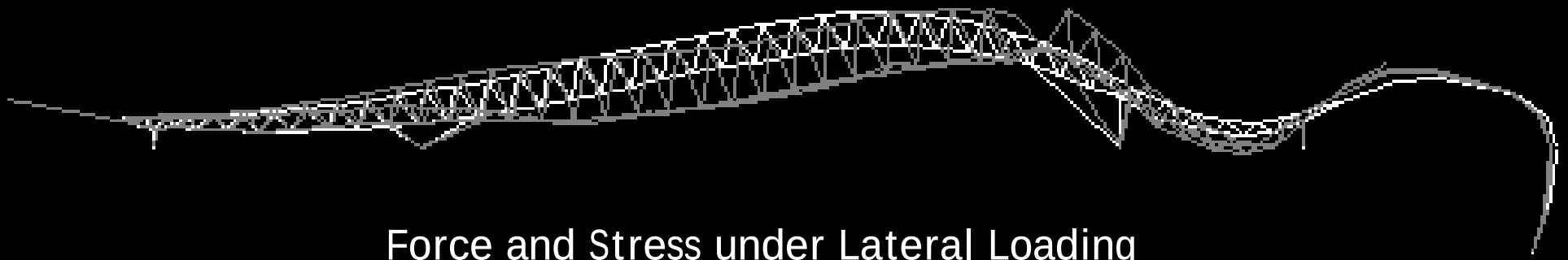
Modeled Warren Truss Under Uniform Load

STRUCTURAL LOADING

Force and Stress under Vertical Loading

Exaggerated deformation under Vertical Loading

STRUCTURAL LOADING

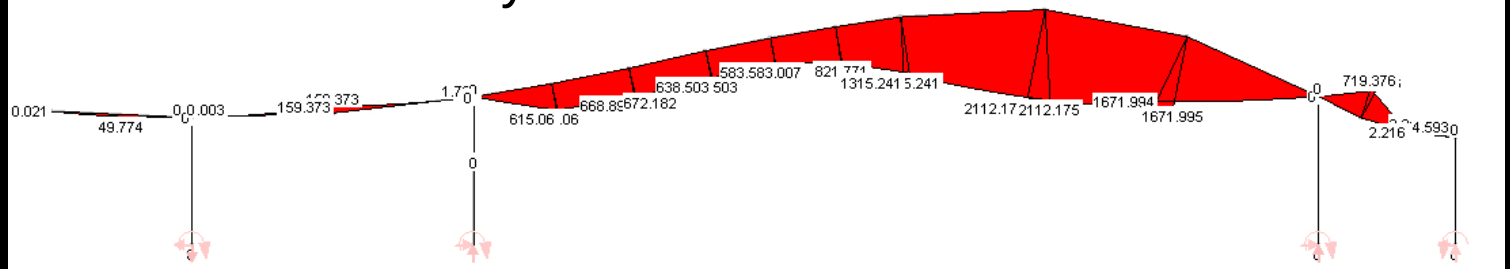


Force and Stress under Lateral Loading

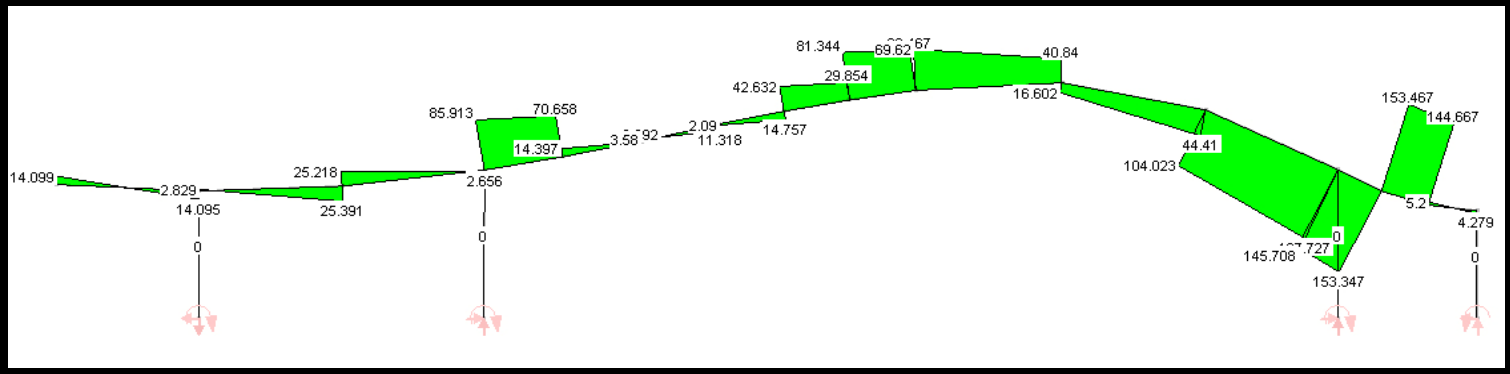
Exaggerated deformation under Lateral Loading

STRUCTURAL LOADING

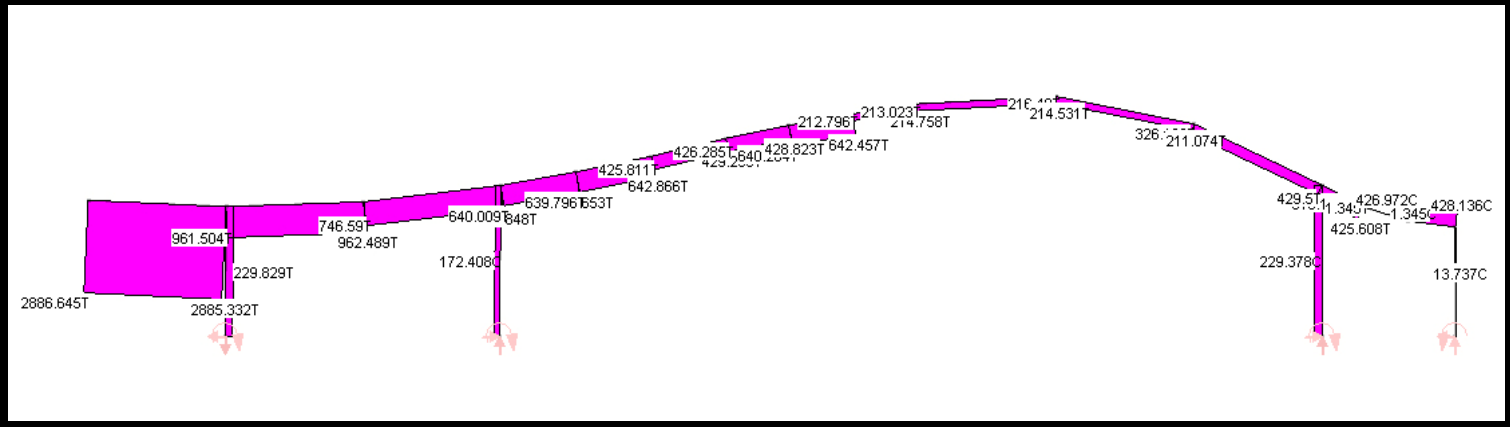
Multiframe 2D Analysis



Moment Diagram



Shear Diagram



Axial Load Diagram

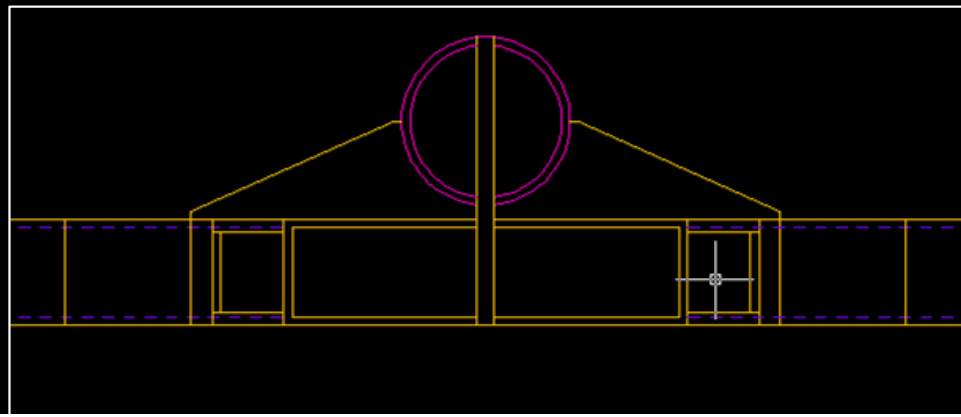
WING

Airside

- The Wing runs the entire 1.7 km span of the structure. This is the side that faces the sea, and therefore receives the blunt of the high force winds during storms.
- The wing has a separate structural system from the main terminal building. Here, the truss changes to a single tubular steel member supported by tension cables.

WING

- A strong secondary system provides the shear support
- Connection detail between the primary structural system (tube) and the secondary structural system (rectangular grid)

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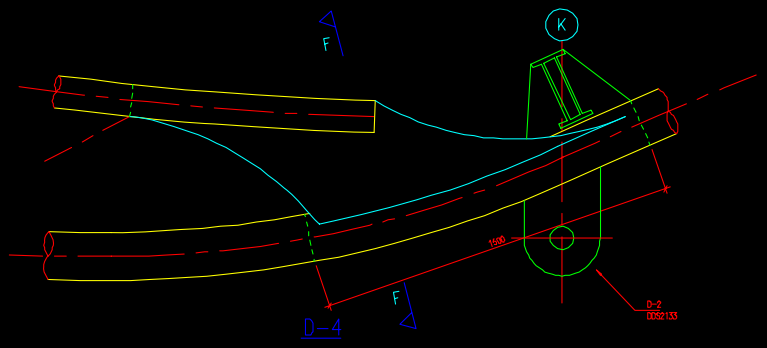
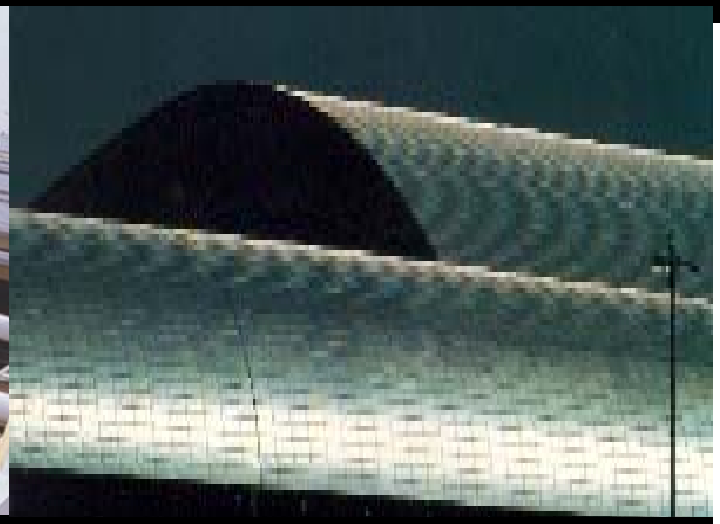
WING

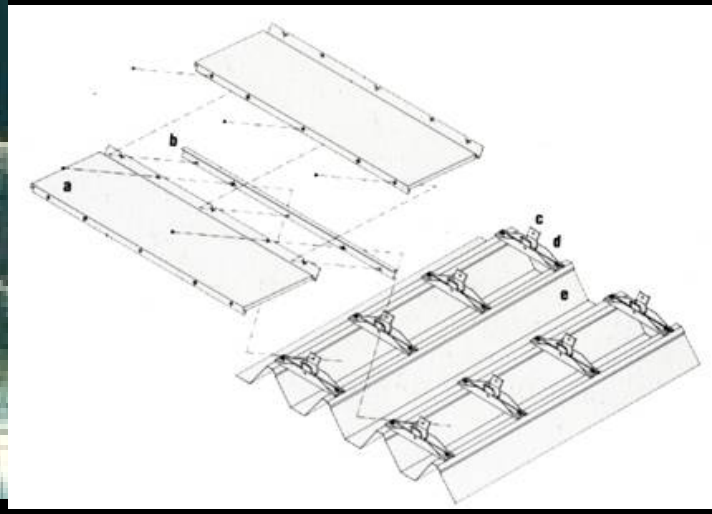


- The ground connection and the row of columns provide the vertical supports

- Connection Detail between the truss (left side) and the single tubular member (right)

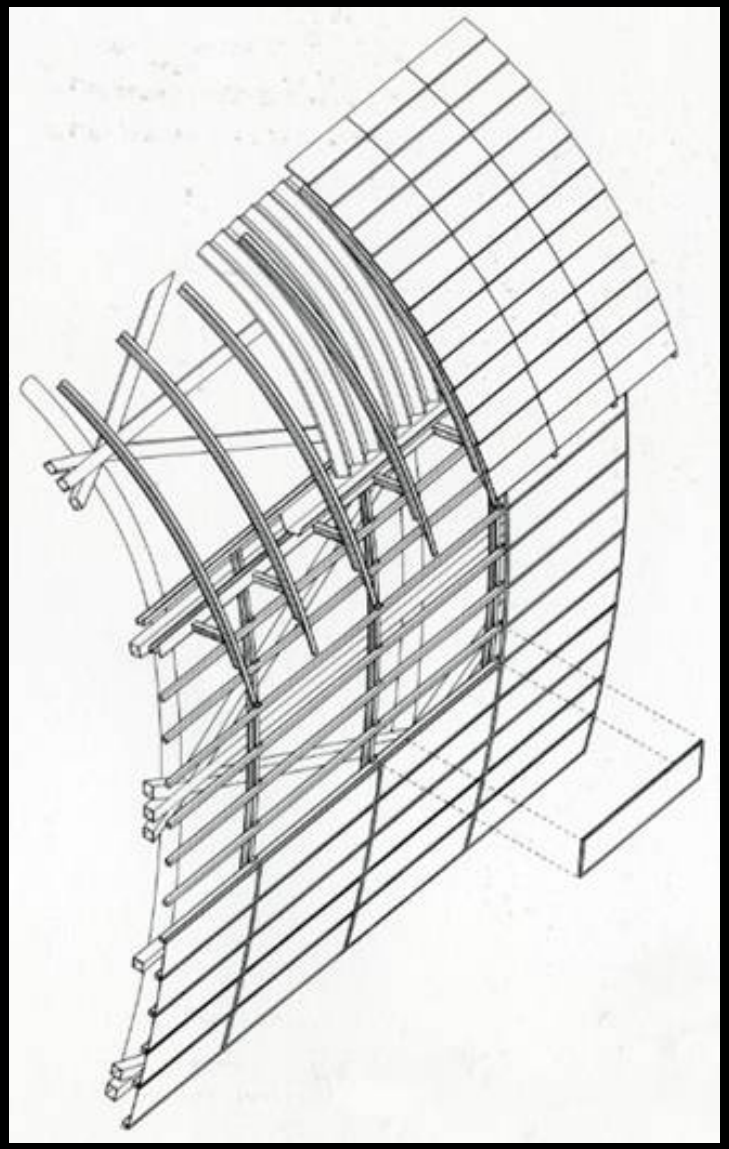
CLADDING





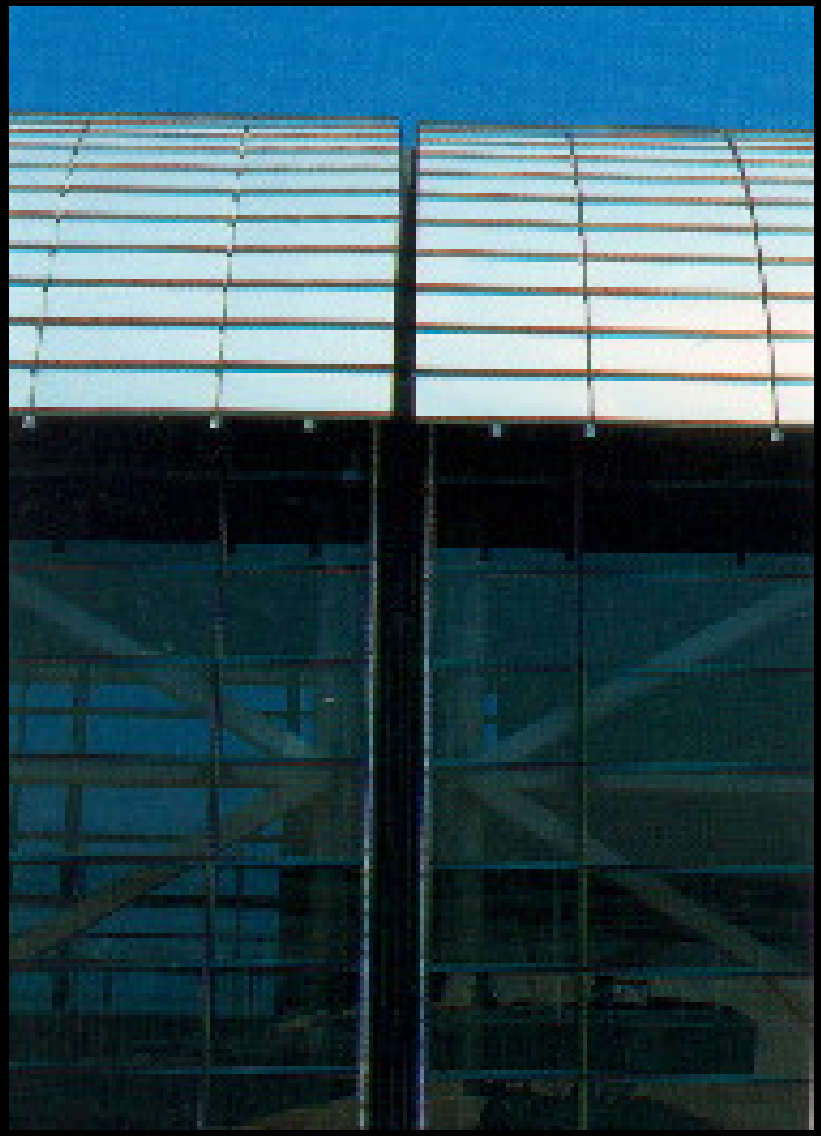
- 82,000 Stainless steel tiles cover a double roof
- Each tile 1.8 x 0.6 meters and 10 kilograms
- Reasons for choosing a double roof
  - Reflectivity protects inner roof
  - Ease of installation of inner roof
  - Drainage keeps outer roof in good condition
- Tiles flex and lift in their middle to combat uplift

GLAZING



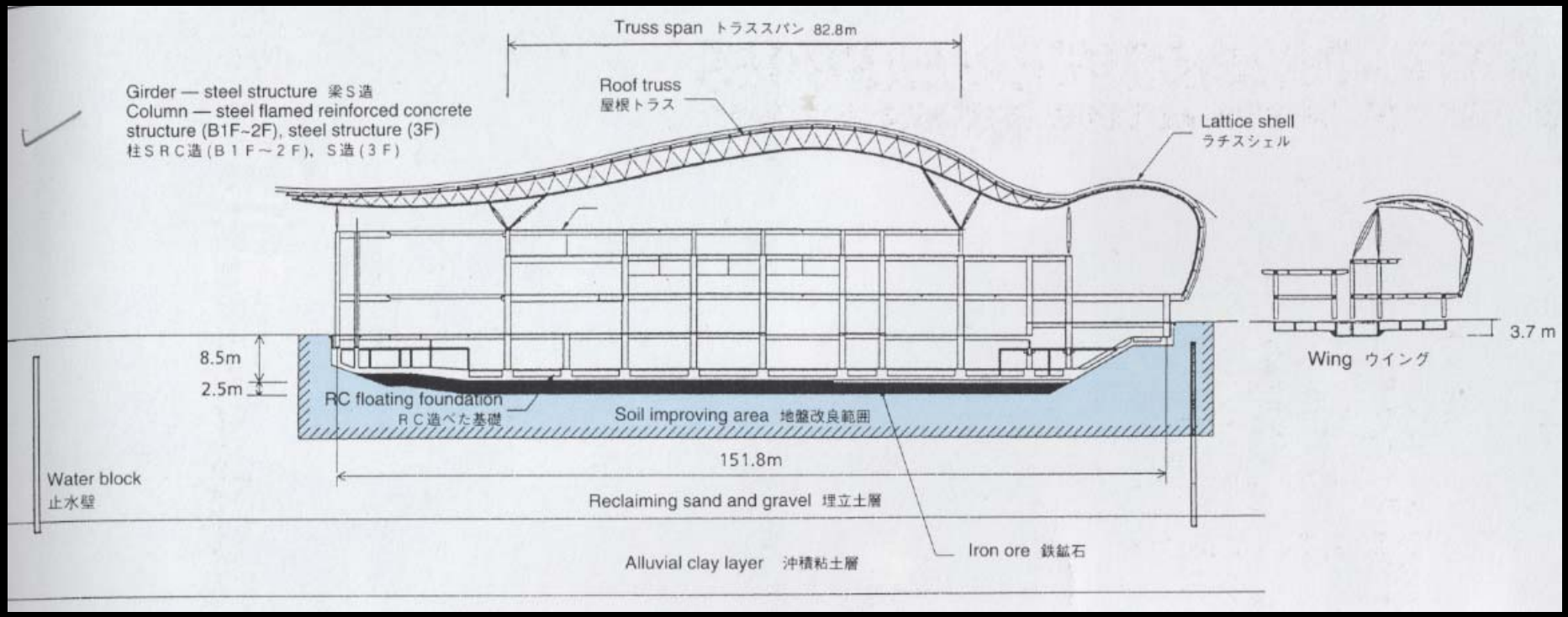
- Each pane of glass treated as in individual unit
- Each panel 3.6 x .6 meters
- Follows the same geometry of the roof

EXPANSION JOINTS



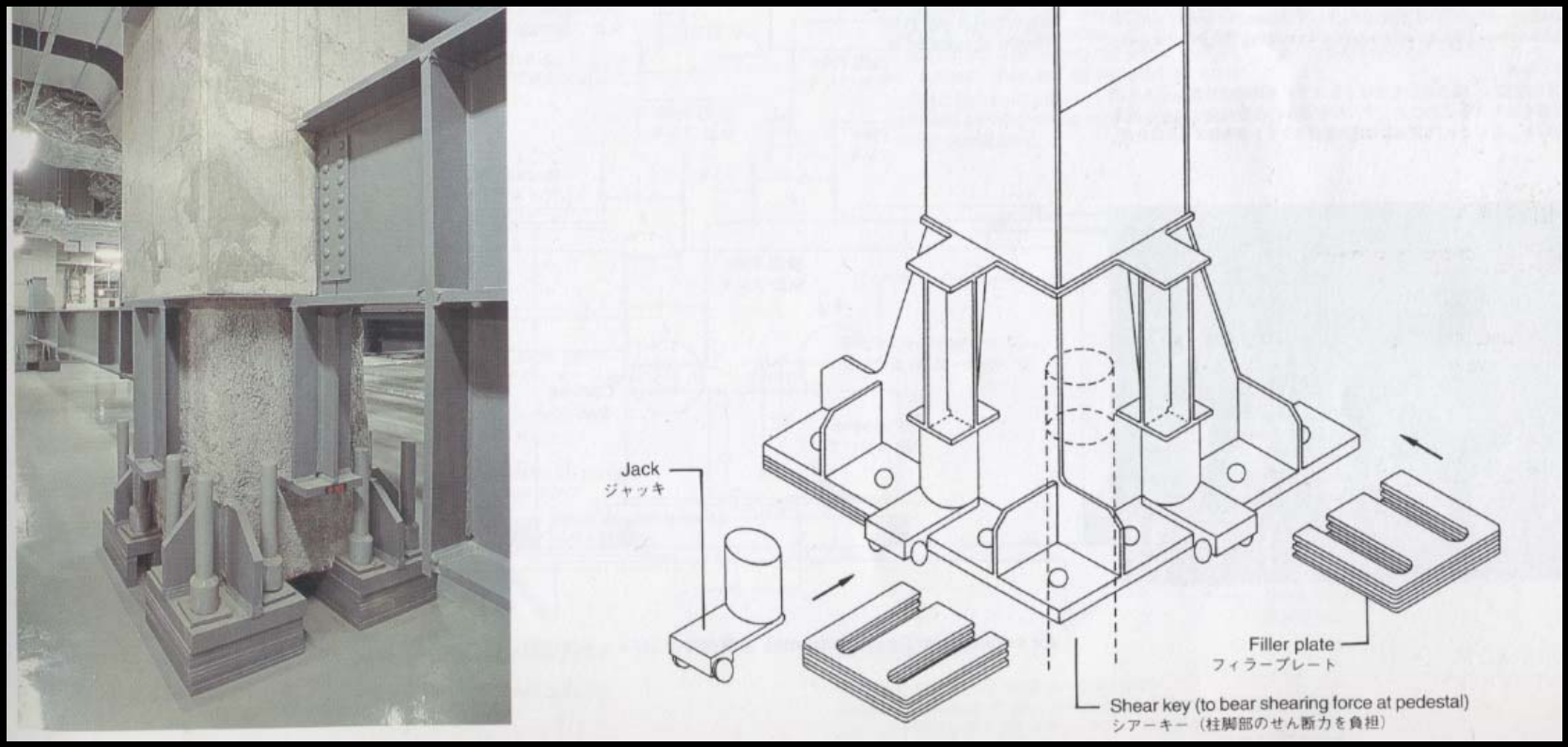
- Design of cladding and glazing must consider movement
- Expansion joints used to absorb movement
- Gaps 450-600 millimeters wide placed every 150-200 meters
- Rubber elements used to provide weatherproofing

FOUNDATION



- Built on a man-made island
- Stabilized alluvial clay with one million sand piles and a meter thick layer of sand
- Construction upon diluvial clay is unknown

FOUNDATION



- The structure needs to sink at the same rate as the island
- 360,000 tons of iron ore below foundation replaced excavated soil
- Foundation consists of 900 pillars
- Jack system with plates keeps the pillars level

KANSAI INTERNATIONAL AIRPORT

WORKS CITED

Buchanan, Peter. Renzo Piano Building Workshop, Complete Works Volume III. New York: Phaidon Press Inc., 1997.

Kansai International Airport. Hsin Sze-man, Celia, et. al. Department of Architecture, University of Hong Kong. November 2005. <http://courses.arch.hku.hk/precedent/1996/kansai/>

"Kansai International Airport." Everything2.com. 2000. November 2005. <http://www.everything2.com/index.pl?node_id=853021>

"Kansai International Airport." Wikipedia, The Free Encyclopedia. Vers. 1.2. Nov. 2005. Wikipedia. Nov. 2005. <http://en.wikipedia.org/wiki/Kansai_International_Airport>.

"Kansai International Airport, Osaka, Japan." Arup. Nov. 2005. <http://www.arup.com/airports/project.cfm?pageid=1829>

"Kansai International Airport Terminal, Osaka - Japan." Renzo Piano Building Workshop Official Website . 1998. 8. Nov. 2005. <http://www.rpbw.com/>.

Okabe, Noriaki. "Kansai International Airport Passenger Terminal Building." Passenger Architecture. Dec. 1994: 8 - 194.

Sims, Calvin. "Losses Mount at Kansai While the Airport Sinks." New York Times 29 July 2001: 1-2. New York Times Online. 8 Nov. 2005. <http://travel2.nytimes.com/mem/travel/article page.html?res=9506EEDE113AF93AA15754C0A9679C8B63>.

Super Structures of the World: Kansai International Airport. Videotape. Unipix, 2000.

PHOTOGRAPH REFERENCES

- www.rpbw.com

  Slide: 1, 3, 4, 5, 6 (left), 8, 19 (right), 21 (left)

- http:/en.wikipedia.org.wikipedia.org/wiki/Kansai_International_Airport

  Slide: 2,

- Renzo Piano Building Workshop, Complete Works Volume III

  Slide: 9, 10, 18, 19 (left), 21 (right), 22, 23, 24,

- http://cuckoo.com/daniel/pictures/japan2002kix/oap

  Slide: 6 (right), 11, 12, 13,

- http://courses.arch.hku.hk/precedent/1996/kansai

  Slide: 14, 15, 16,

- www.nouvelle-vie.com

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- Passenger Architecture

  Slide: 25, 26

- www.iadmfr.org/congresses/ osaka/images3-osaka.htm

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