

LYON-SATOLAS RAILWAY AND AIRPORT STATION

SANTIAGO CALATRAVA

1994

BY ART, AVI, RUTWIK, JORDAN



OVERVIEW

- Lyon-Satolas Airport (now Saint Exupéry) Railway Station
- Lyon, France
- Built between 1989-1994
- Cost: 750 million Francs (roughly 146 million USD)
- Architect: Santiago Calatrava
- Collaborators: Alexis Burret, Sebastien Mernet, David Long, L. Burr

OVERVIEW: DESIGN SPECS

- Main span: 100 meters
- Width: 100 meters
- Height: 39 meters
- Total Length: 450 meters (including railway cover)
- Area: 5,600 square meters
- The 1,300 ton steel roof of the main hall measures 120x100 meters

OVERVIEW

- Terminal for the TGV trains (high-speed trains) connecting the airport to the city of Lyon, which is 30 km to the south
- An addition to the airport built to serve TGV trains on the LGV Rhône-Alpes
- The Lyon region is located in Alps, in the mid-southeastern portion of France.
- The main hall accommodates ticket offices, retail shops, restaurant facilities and access to and from the airport via a 180 meter long gallery.
- The station has six tracks. The two central tracks are isolated to permit trains to pass through the station at a full speed of 300 kilometers per hour.
- Above the tracks, a 300 meter long passenger concourse allows for easy access to the platforms.





BACKGROUND: PROJECT ACQUISITION

- Selected winner in an open competition to create a gateway to the city of Lyon, France.
- Clients: French Railways (SNCF), authorities of the Rhône Alpes region, and the Chamber of Commerce and Industry for Lyon (CCIL)
- Together with the air terminal and nearby street, the railway station connects the region's different transportation systems.
- The station is used mainly by travelers that by plane and continue traveling onto the east by train.
- A small portion of land has been put aside for future expansion.

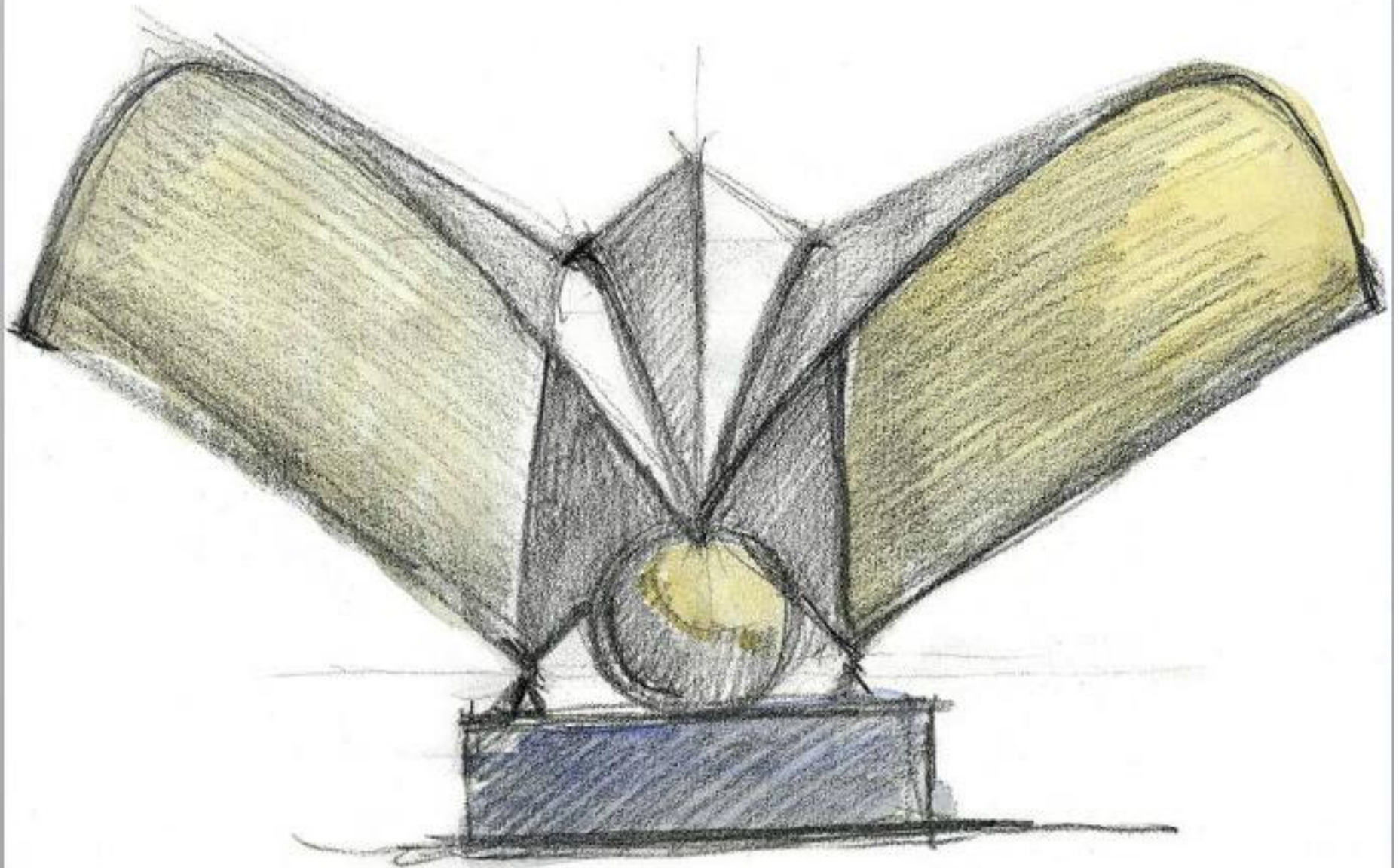
BACKGROUND: ABOUT THE ARCHITECT



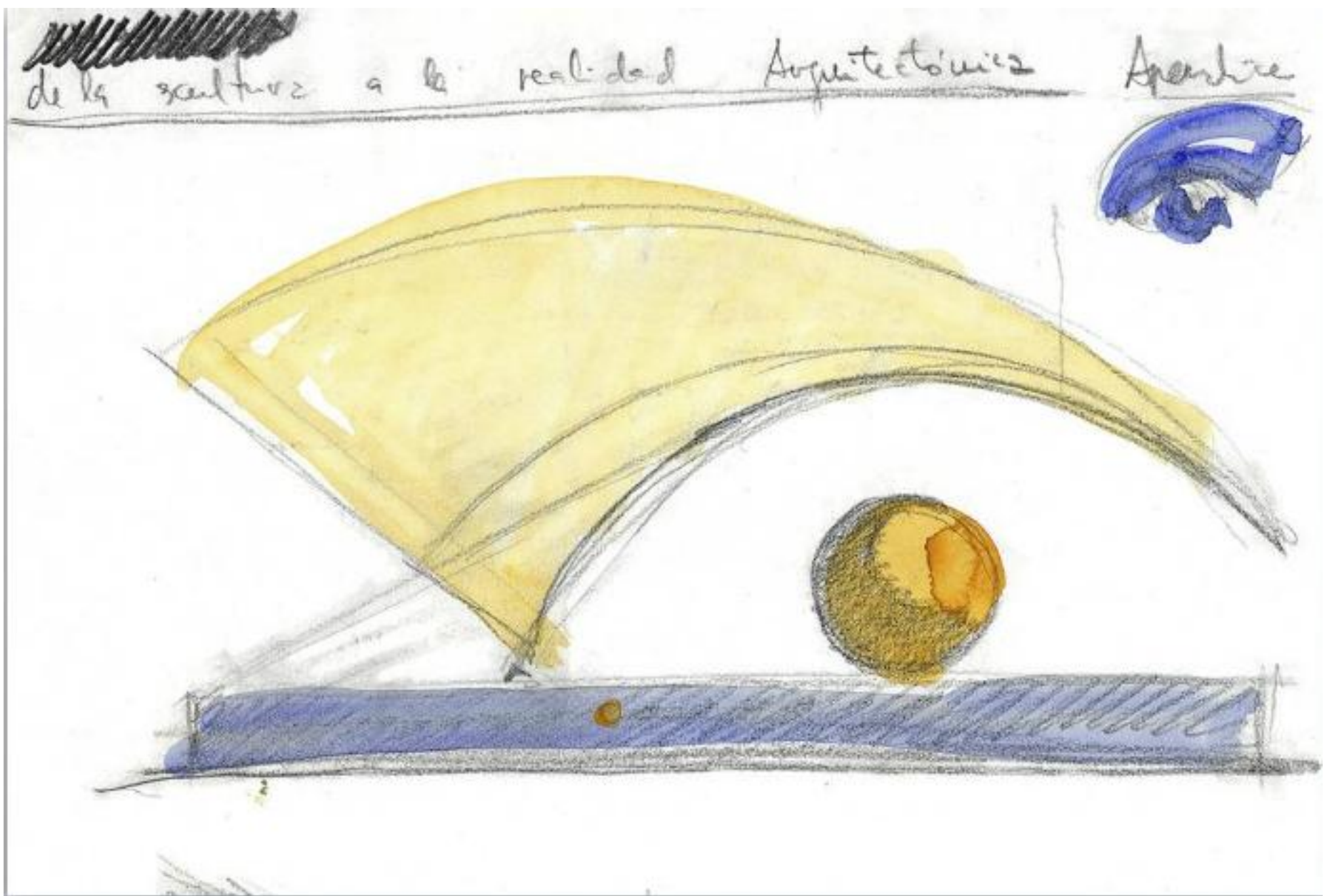
- Born July 28, 1951 in Valencia, Spain
- Architect, sculptor, and structural engineer
- Early career: Calatrava worked as an engineer and began to enter architectural competitions. He began with a series of bridge projects that established his international reputation. In the mid 1980s, he began working on large-scale public projects while exhibiting his sculptures.
- Calatrava has won many awards, including the Gold Medal of the Institute of Structural Engineers, the Auguste Perret UIA Prize, and the AIA Gold Medal.
- Completed dozens of buildings and bridges around the world, and has many more in the works. The architect is known for his highly expressive, curving, organic structures, and Lyon Station is no exception.

BACKGROUND: PROJECT'S IMPORTANCE TO ARCHITECT

- The railway station was built relatively early in his professional career and is very representative of his sculptural style.
- It appears to be expressive of a bird, symbolizing flight with the two main “wing” arches coming together at the bird's “beak”.
- However, Calatrava insists that it is actually inspired more by the shape of the human eye.
- Before the station's construction, he designed a sculpture representing an eye, which later served as inspiration for the station's design.
- “I never thought of a bird, but more of the research that I am sometimes pretentious enough to call sculpture”.



The station is widely thought of as a symbol of a bird, fitting to the theme of flight at the airport.



However, this is the inspiration for Calatrava. This sketch of his human eye sculpture illustrates the profile that he wanted to achieve with the rail station.

FEATURES

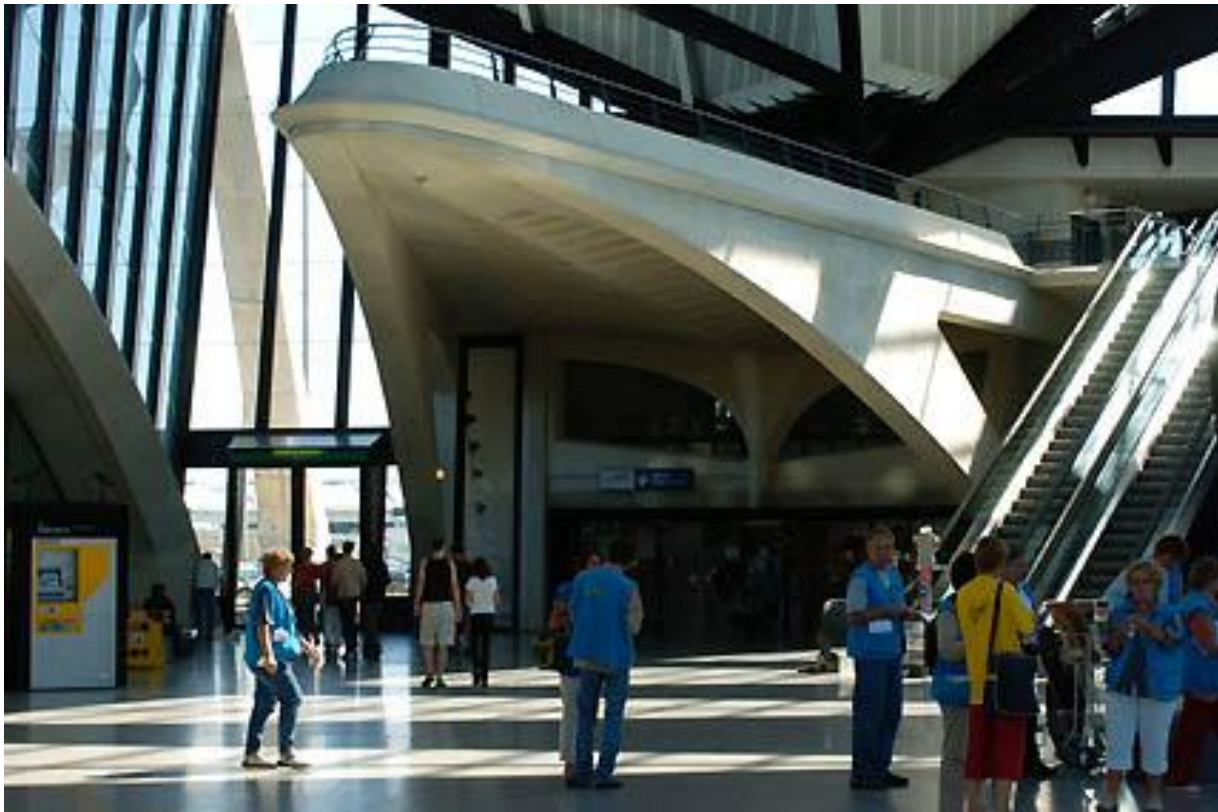
- Large entry gallery is distinct and serves to subdivide user groups and serve as an entry marker connecting Train and Airport programs
- The expressive railway station hall is built astride an existing TGV track beside the Lyon airport.
- People have different experiences walking through the station based on their destinations, either the railroad below ground or the airport above.
 - ❖ Arriving from the airport, one enters the main hall at the “back of the bird” at an elevated level. Travelers descend through a series of escalators into the main concourse. Here the wings spread out on either side above the railway tracks, and more escalators move travelers down to the platform below ground level.
 - ❖ Arriving by train and walking to the airport, travelers gradually ascend from the excavated train tracks to the main concourse above and through the gallery to the airport.





FEATURES

- The expressiveness of Calatrava's structure is seen inside the building as much as outside with two large cantilevered balconies that penetrate the interior space.



FEATURES: RAILWAY COVER

- The station is positioned astride the reinforced concrete railway cover. This adjoining concrete service building is fitted with a steel and glass curtain wall overlooking the main hall.



FEATURES: RAILWAY COVER

- Built with a dense network of white concrete beams and rhomboid-shaped glass skylights, this structure covers more than half a kilometer of the six railways.





FEATURES: RAILWAY COVER

- The ribs of the ceiling rest on inclined pillars that bifurcate.



- Its ceiling is transversely crossed by the large triangular-shaped floor of the station.

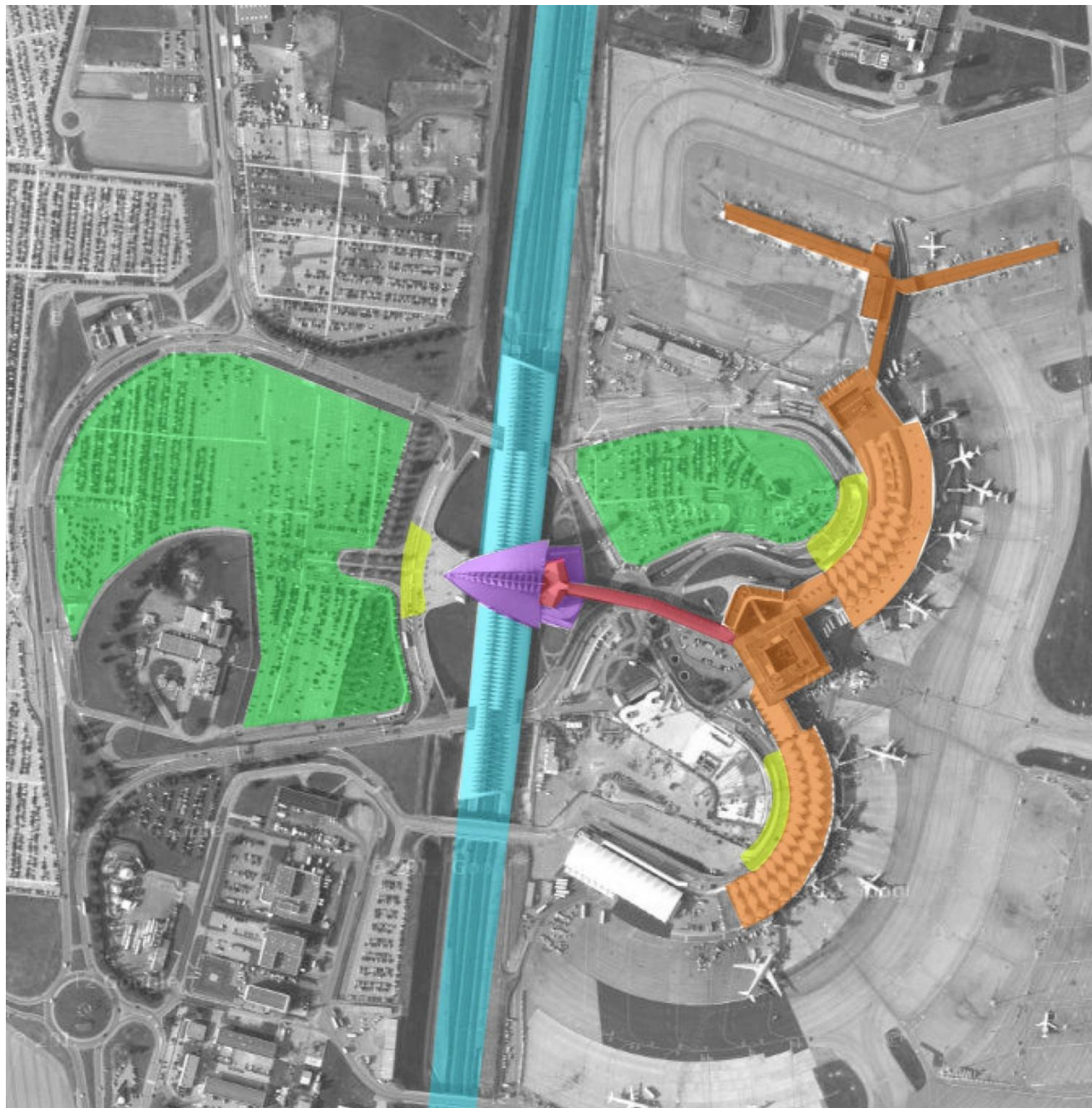
- Because of the density of the concrete beam network and its longitudinal character, the railway cover resembles a tunnel lit by natural light.





SITE PLAN

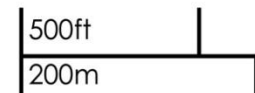
- **3 major transportation programs converge**
 - Airport, high speed rail station, and automobile parking
- **Programs facilitated by unique “transition terminals”**
 - Planometric geometries
 - Plane- Large, radial arching terminals
 - Train- Linear platforms
 - Automobile- Looping pickup/drop-off areas
- **Unified by dramatic main entry gallery/station**



Site Plan Diagram

Program:

-  High Speed Rail
-  Airport
-  Parking
-  Car Pickup/Dropoff
-  Pedestrian Connector
-  Main Entry/Station



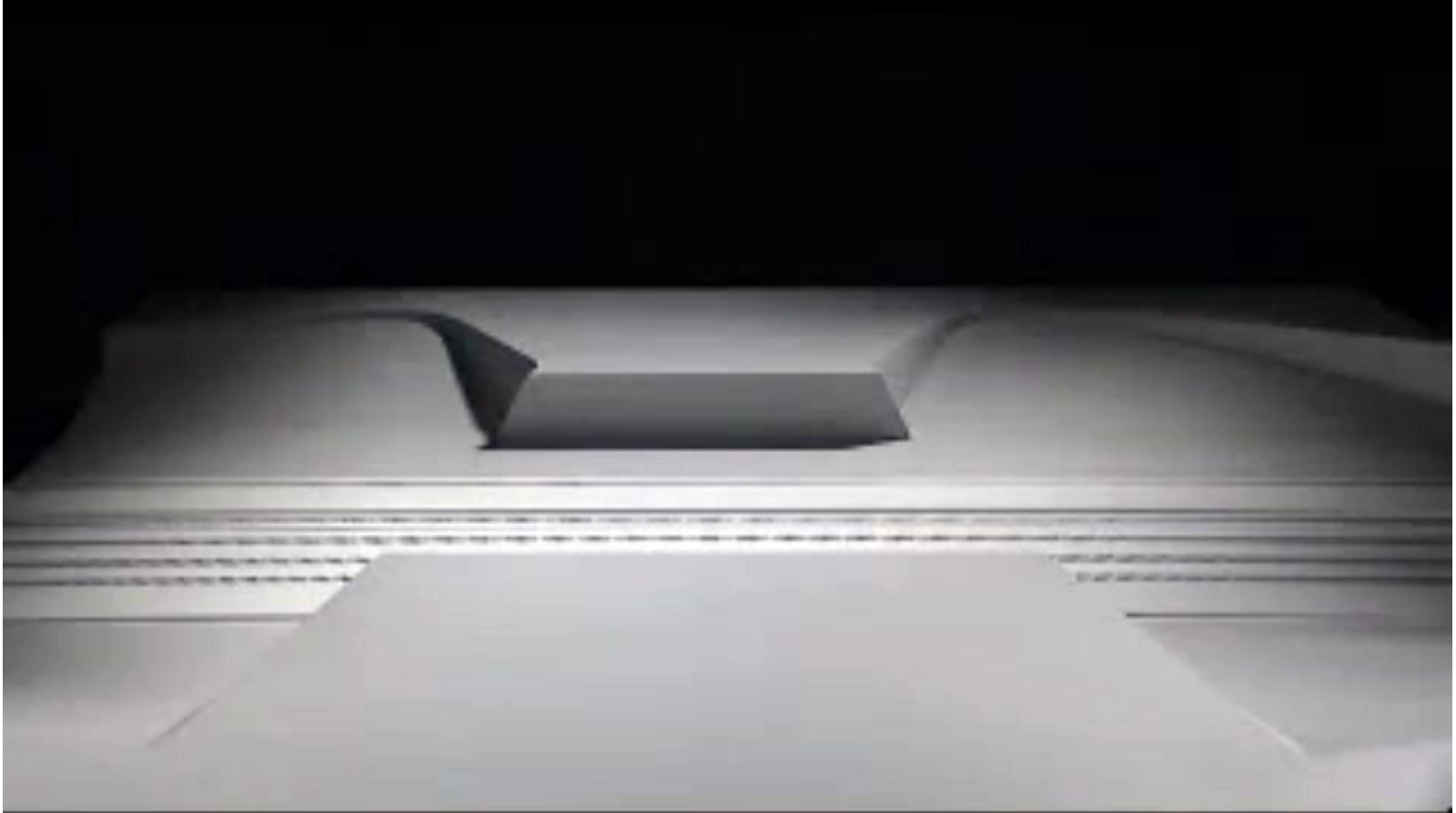
MATERIAL/PROGRAM/DE SIGN SYNTHESIS

- Designed to tie the light entryway to the the rigid linear components of the railway line and Airport connector bridge
- Calatrava used steel and glazing to achieve a sense of lightness and openness in the main lobby
- The lobby is free of any major program, keeping it an open space.

MAIN TRANSIT HUB AIRPORT | RAILWAY CONNECTION



GALLERY STRUCTURAL SYSTEM Existing Site



GALLERY STRUCTURAL SYSTEM Floor Span



GALLERY STRUCTURAL SYSTEM Steel Tubing

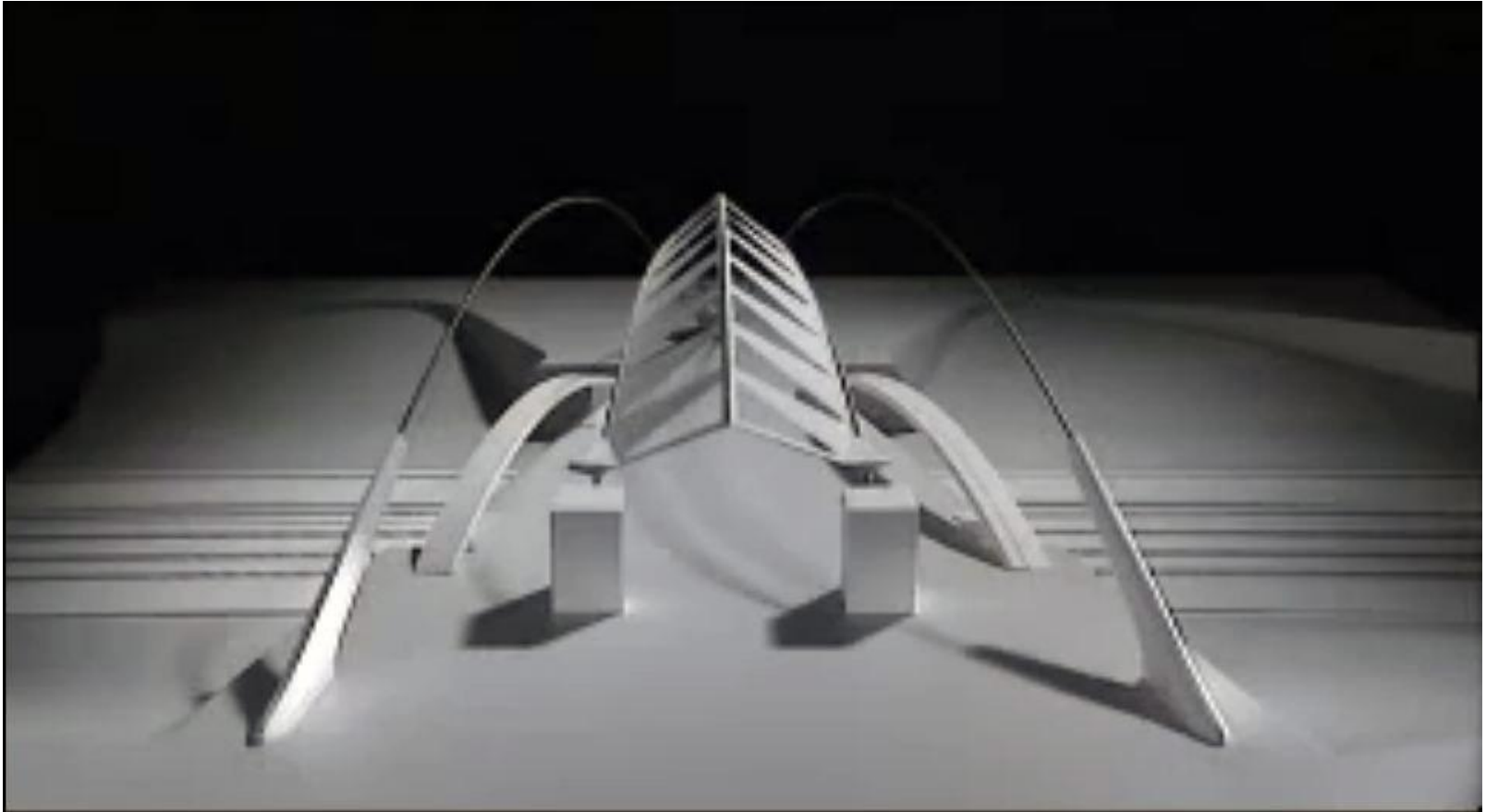


GALLERY STRUCTURAL SYSTEM Inner Steel Tubes



GALLERY STRUCTURAL SYSTEM

Skylight Structure | Concrete Cover



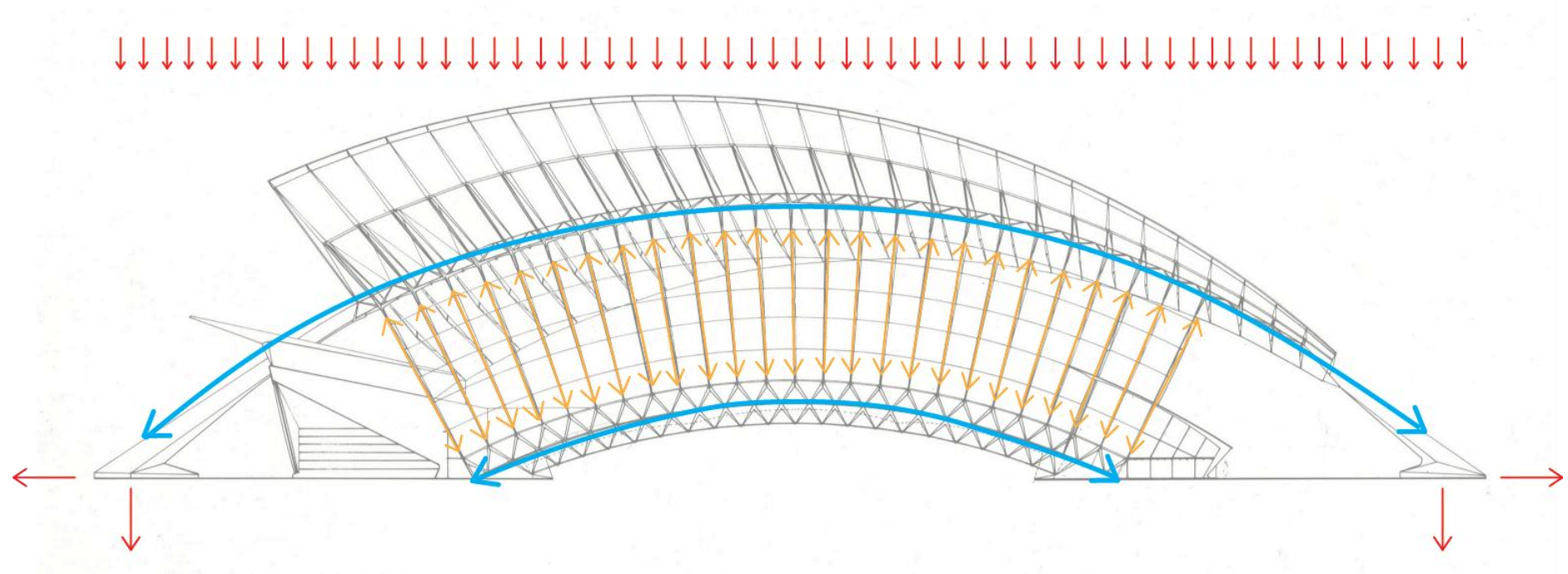
GALLERY STRUCTURAL SYSTEM

Wing Structure | Finished Element

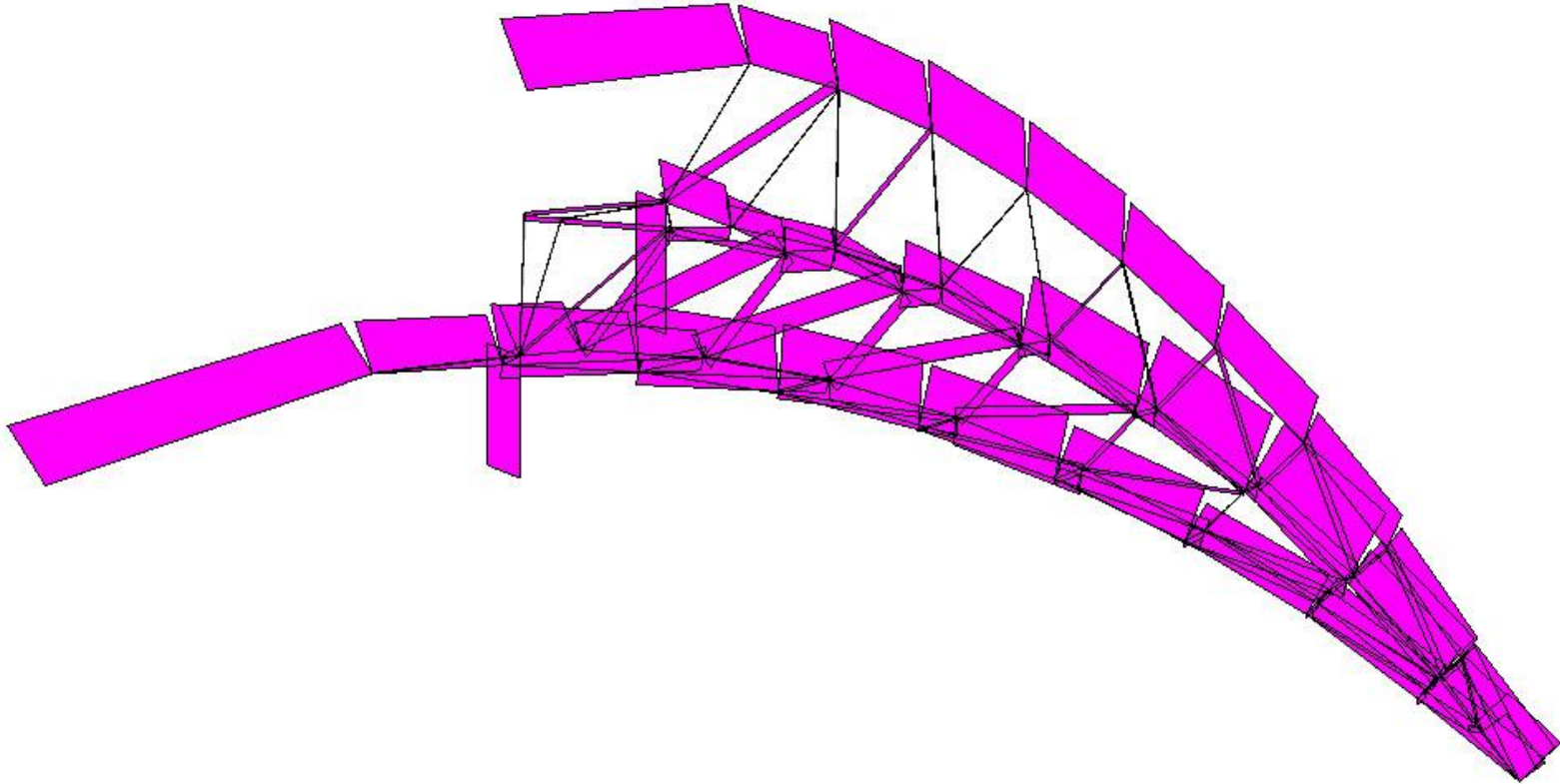


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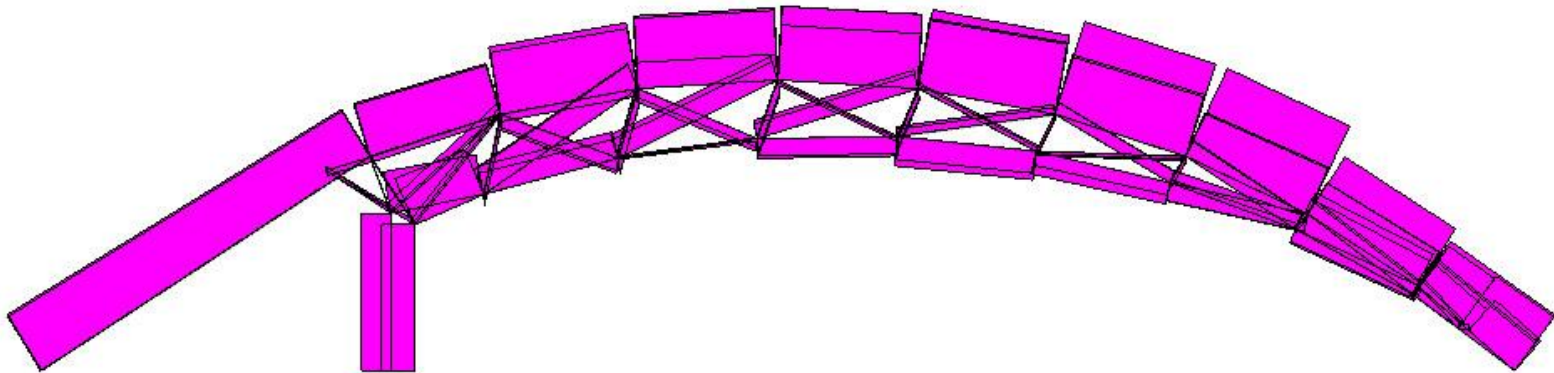
Gravity Loads



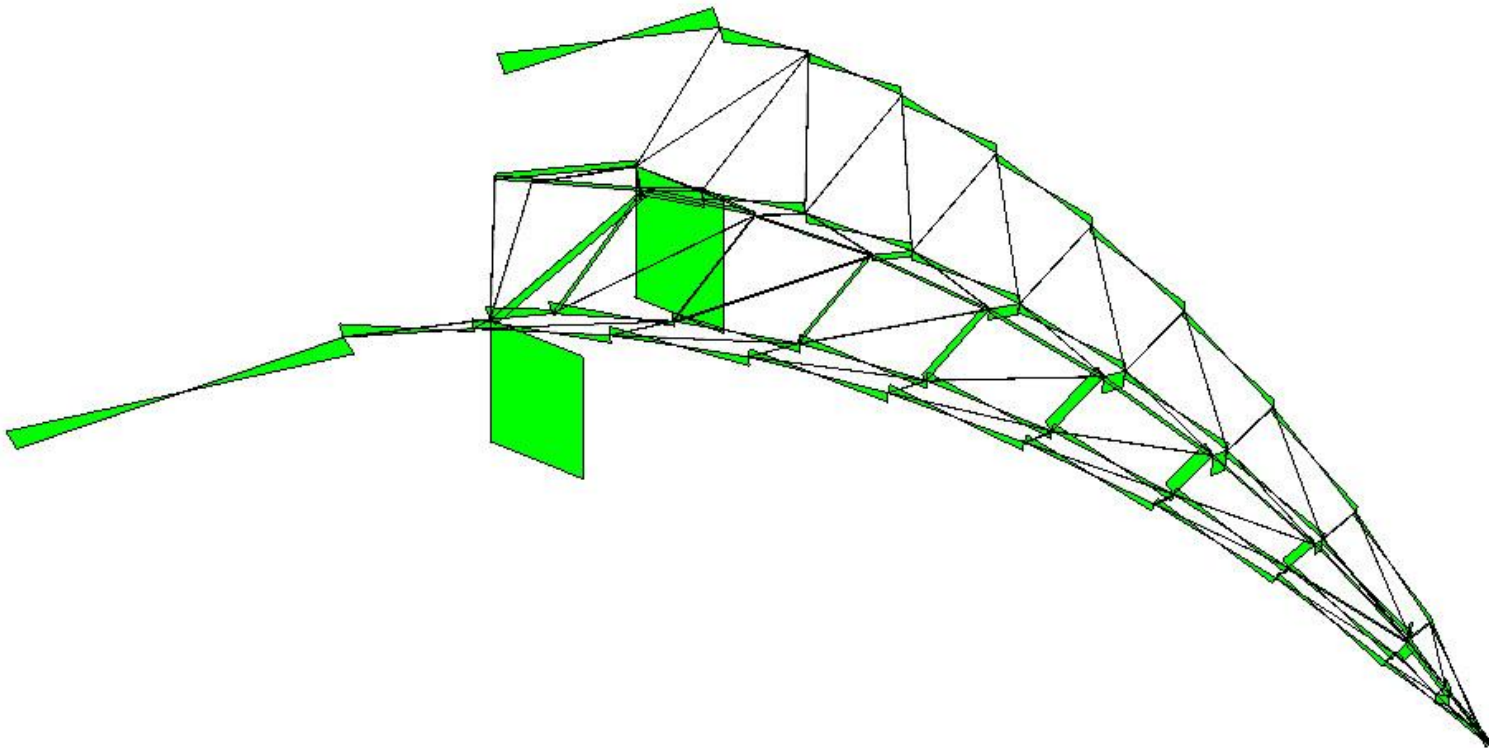
STRUCTURAL ANALYSIS: AXIAL LOADING DIAGRAM



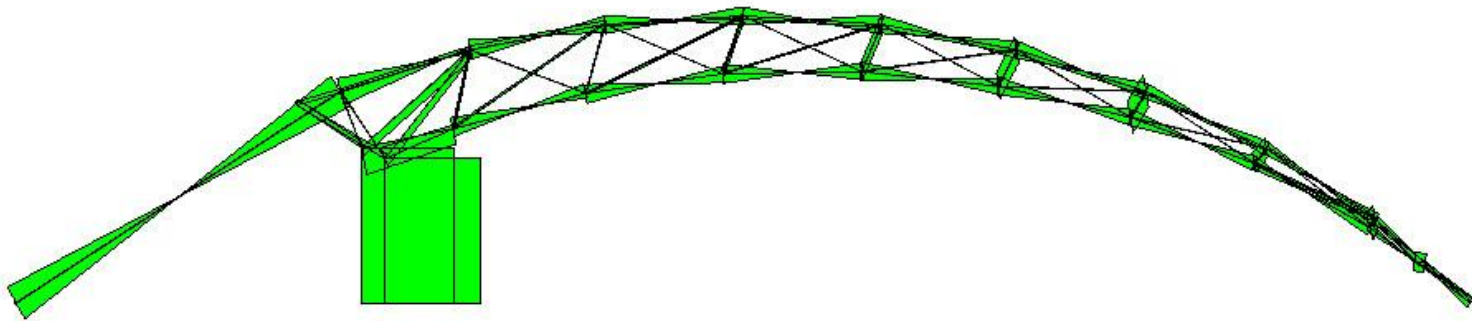
STRUCTURAL ANALYSIS: AXIAL LOADING DIAGRAM



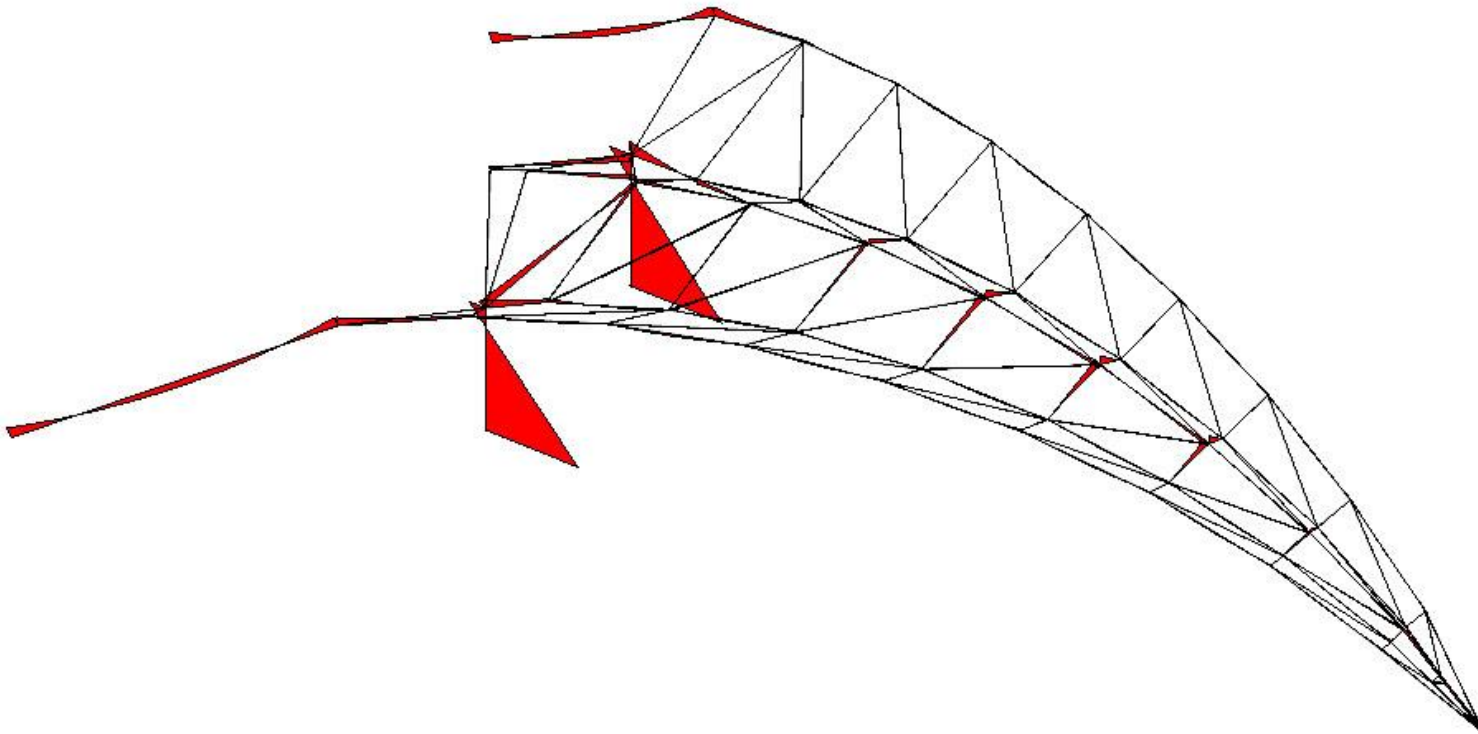
STRUCTURAL ANALYSIS: SHEAR DIAGRAM



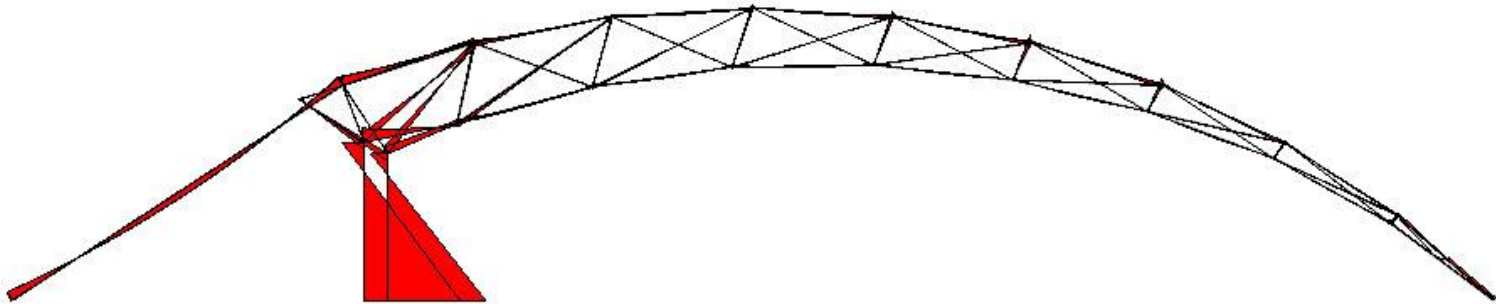
STRUCTURAL ANALYSIS: SHEAR DIAGRAM



STRUCTURAL ANALYSIS: MOMENT DIAGRAM



STRUCTURAL ANALYSIS: MOMENT DIAGRAM

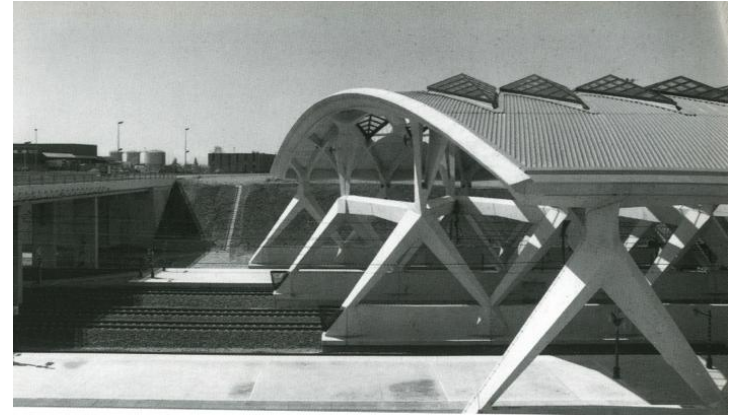


RAILWAY COVER STRUCTURAL SYSTEM

- Majority reinforced concrete
- Entirely rigid frame
- Hybrid space frame/lamella cylinder roof structure

RAILWAY COVER STRUCTURAL SYSTEM

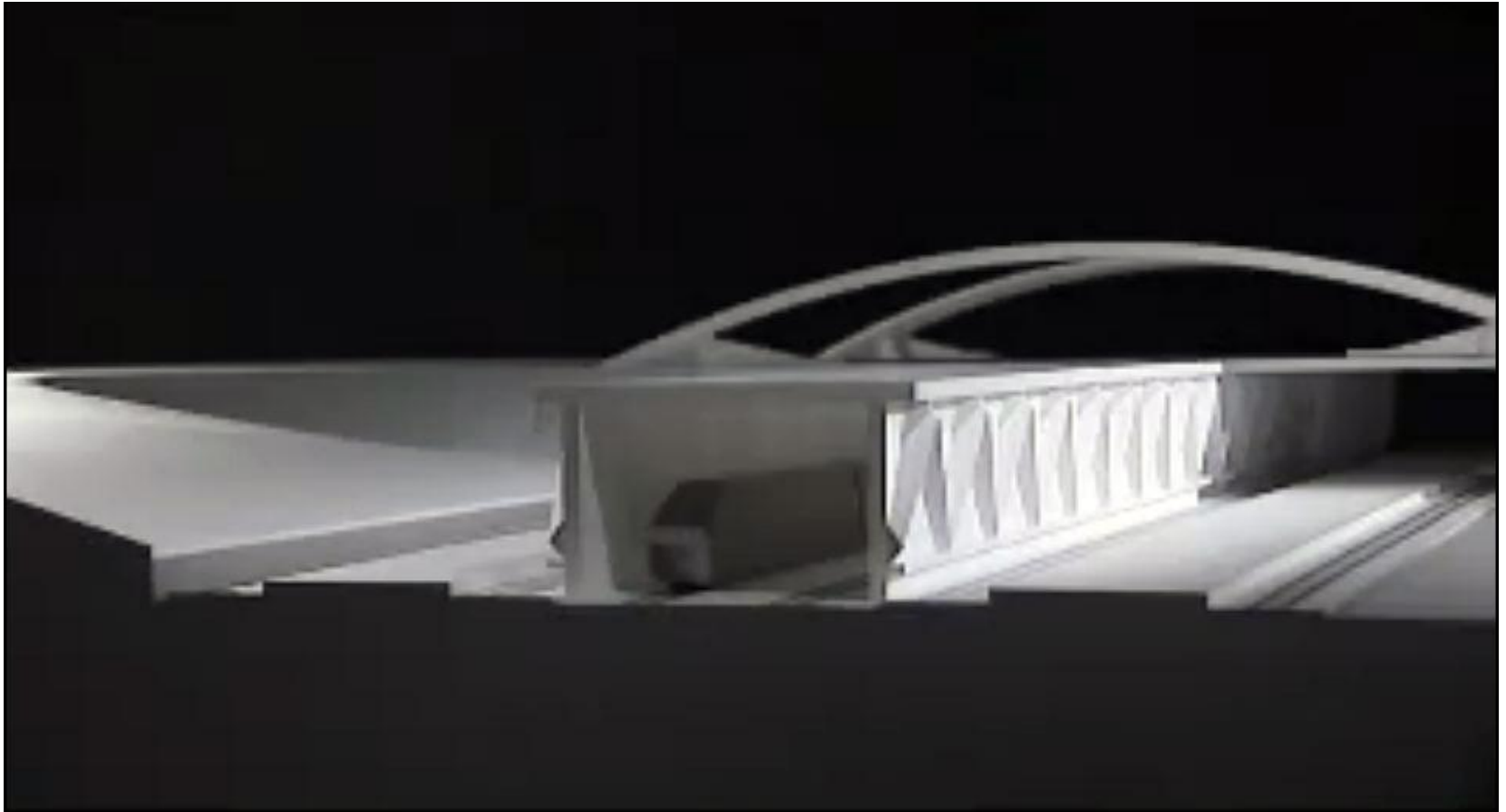
- **Space frame vertical elements**
- Connect diagonally vaulted arches to foundation.
 - Exterior: diagonal concrete piers
 - “Y” Shaped ends
 - Interior: concrete bay system
 - “X” Shaped ends
- **Lamella cylinder (shell) roof**
 - Diagonally vaulted arches support roof
 - Precast concrete roof slabs span most of the lozenges
 - Alternating lozenges are spanned by vaulted glass supported by aluminum mullions



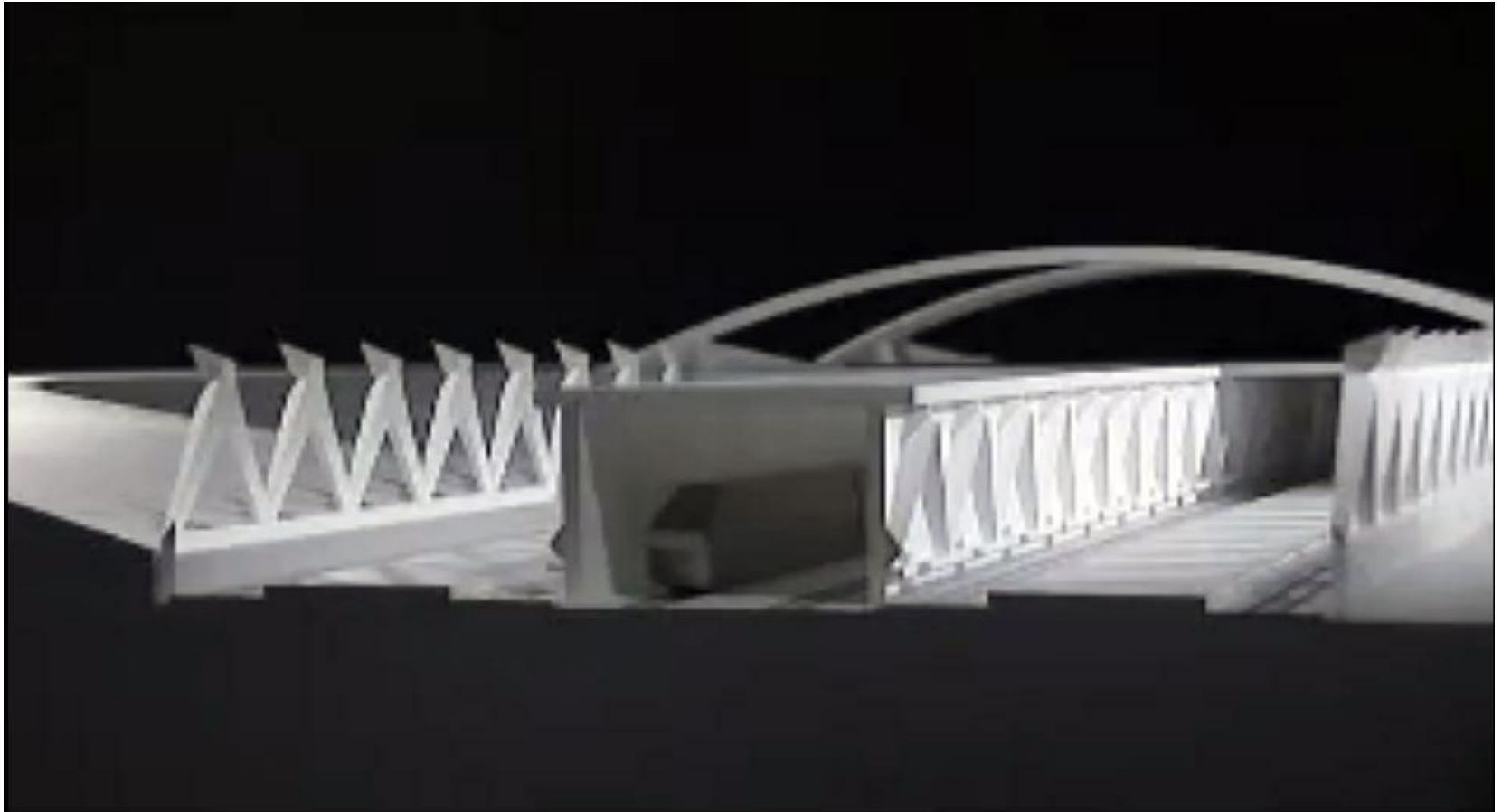
RAILWAY COVER STRUCTURAL SYSTEM



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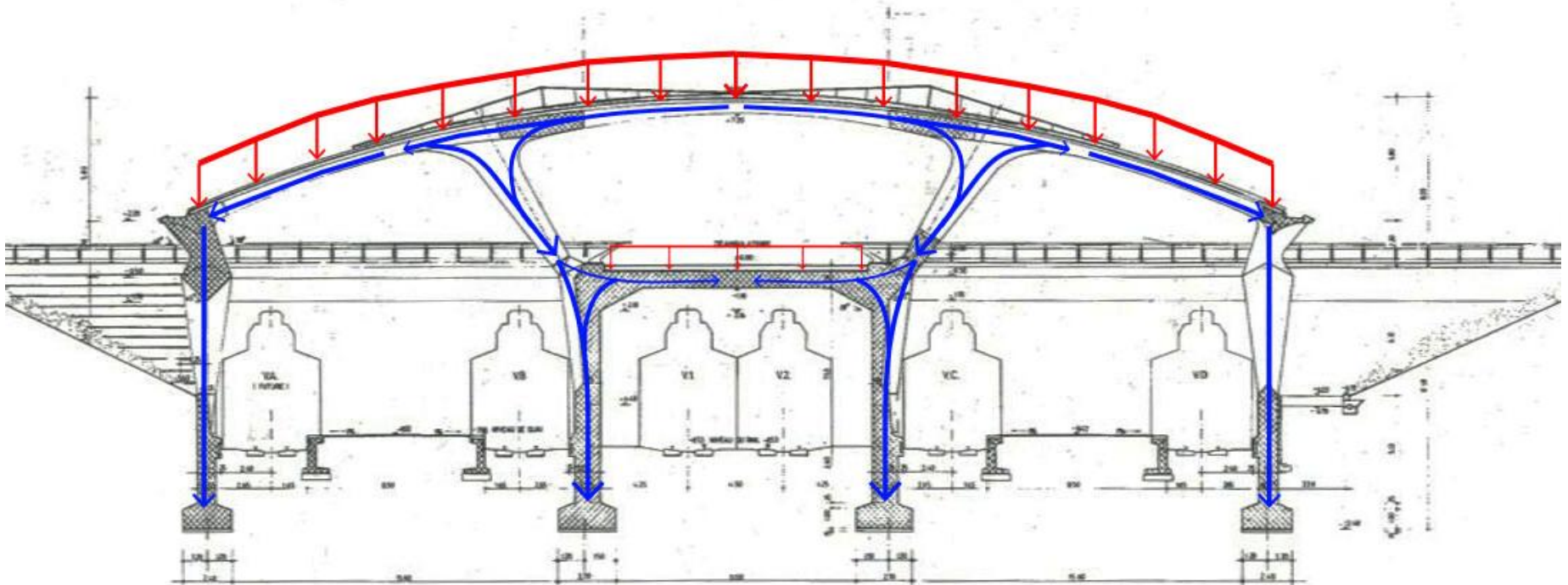


RAILWAY COVER STRUCTURAL SYSTEM

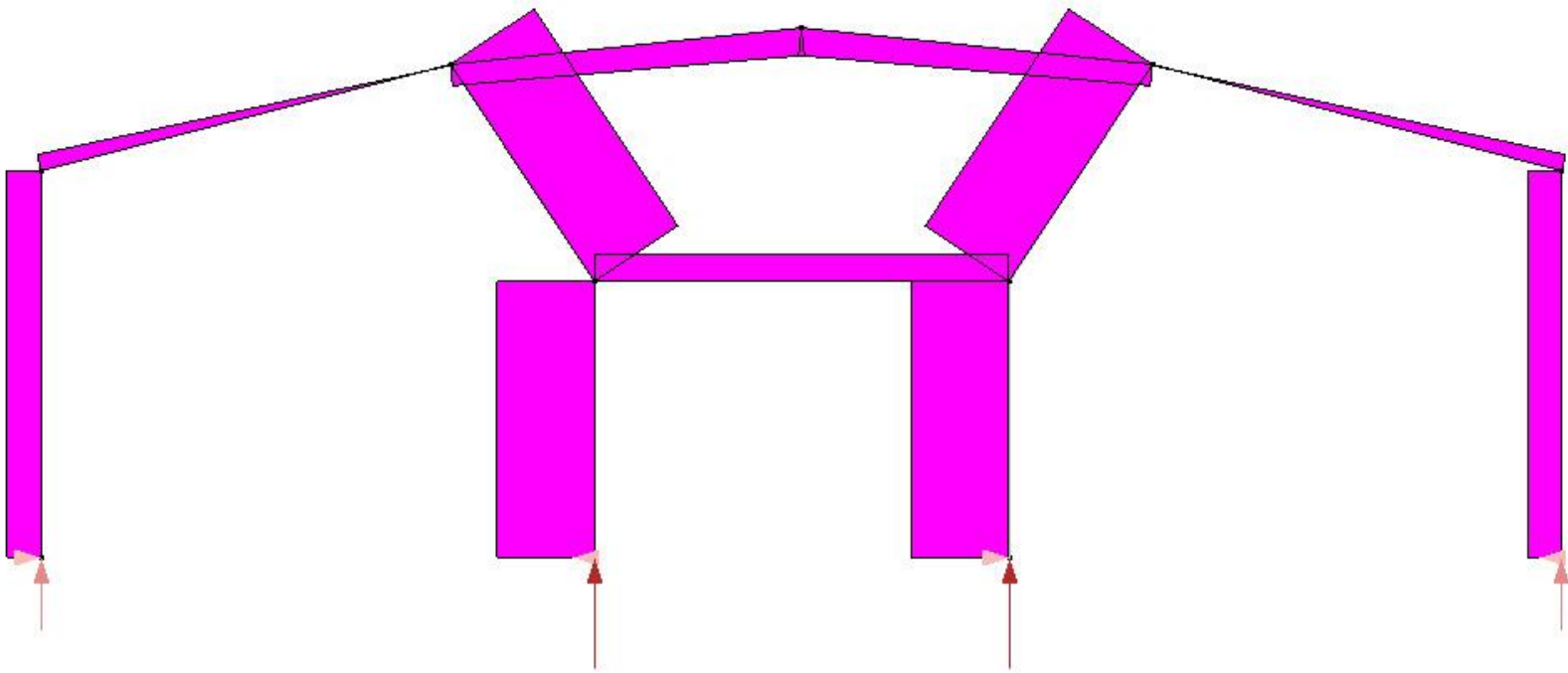


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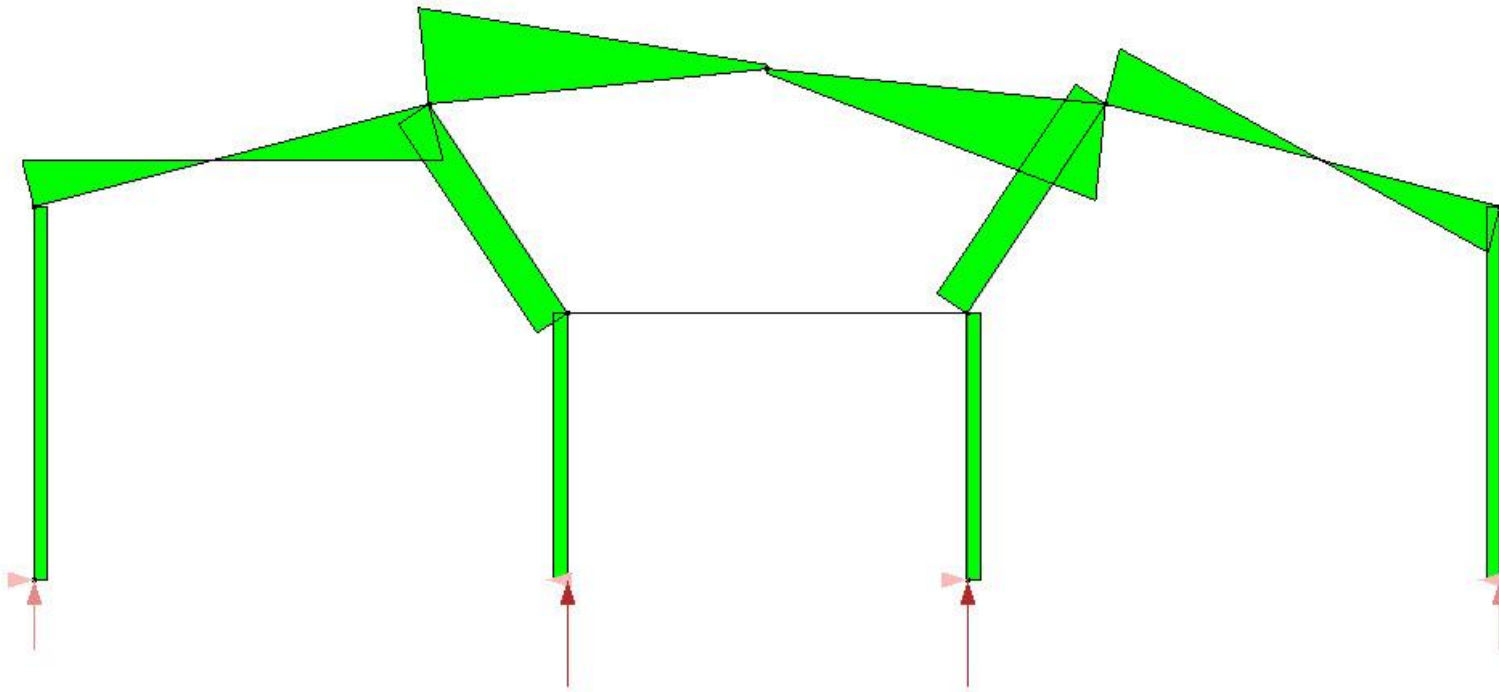
Gravity Loads



STRUCTURAL ANALYSIS: AXIAL LOADING DIAGRAM



STRUCTURAL ANALYSIS: SHEAR DIAGRAM



STRUCTURAL ANALYSIS: MOMENT DIAGRAM

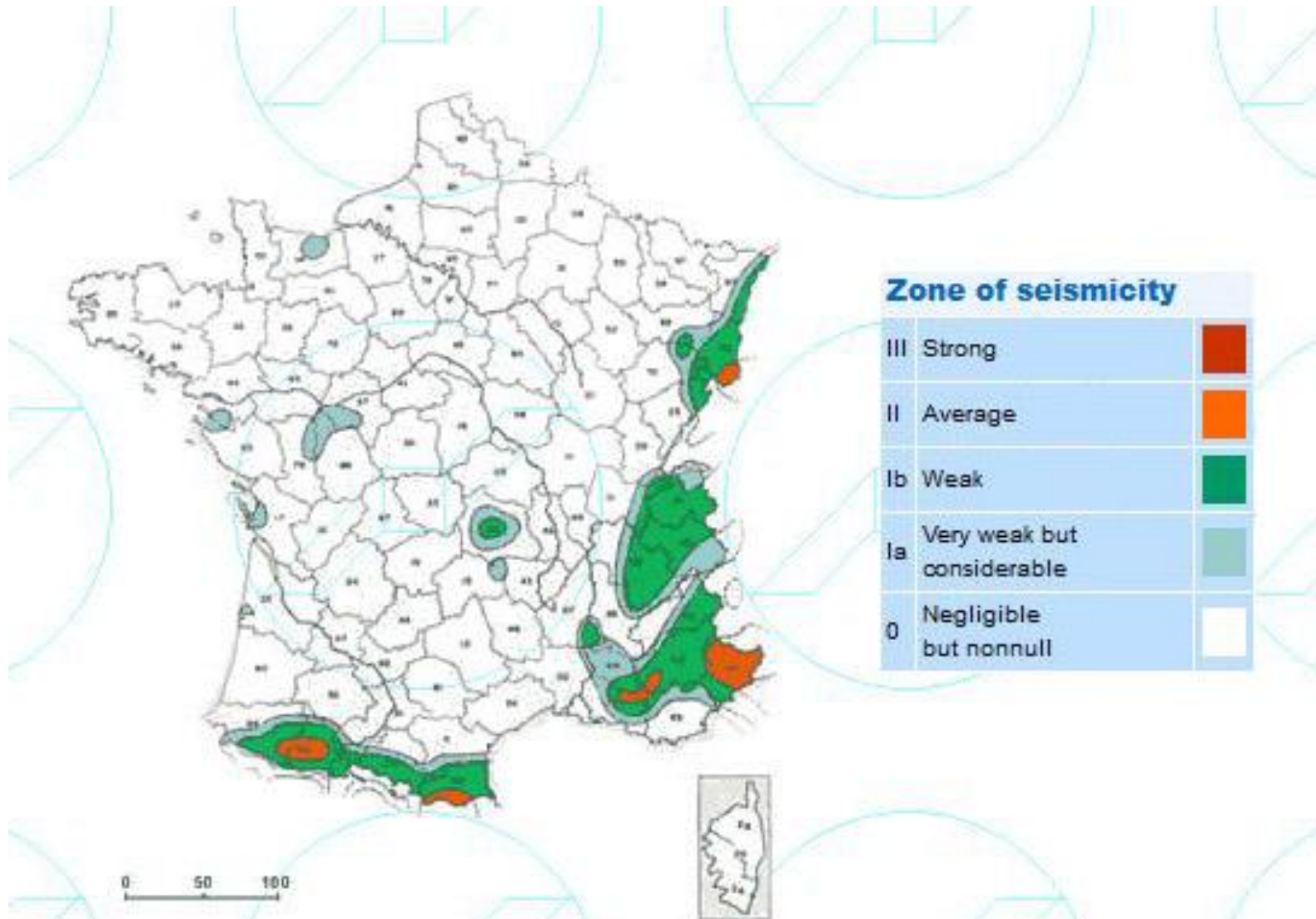




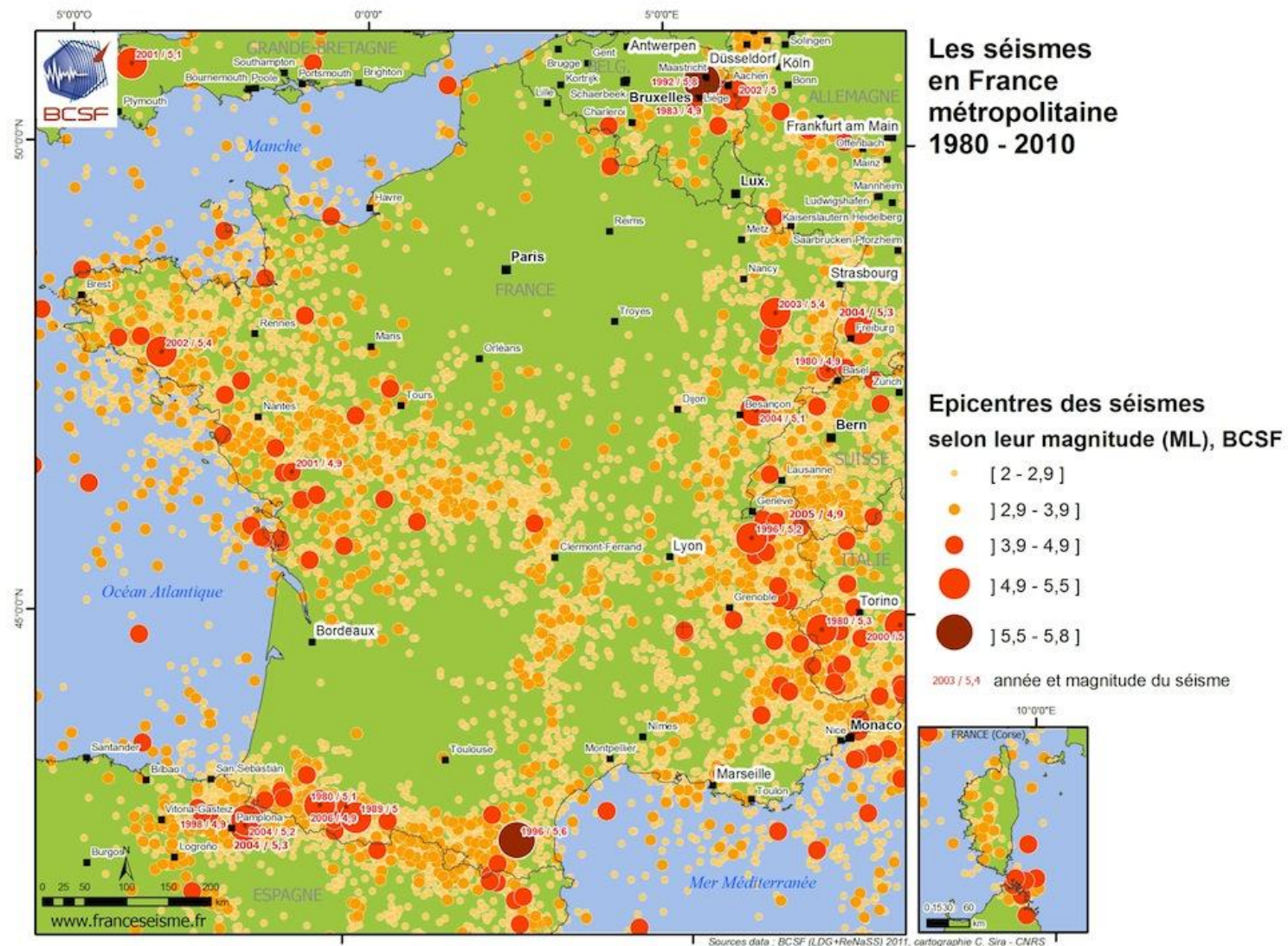
LATERAL LOADING

- Lateral loading is not an extreme design concern.
- France is part of the Eurasian tectonic plate and is not along a major fault line. Lyon is not noted for its Earthquake activity as it seldom suffers from large-scale quakes.
- Seismic loading is negligible, but not totally absent. It is rare for Lyon, France to experience earthquakes that cause significant damage.
- The climate of the region is subject to cold winds from the Alps and warm breezes from the Mediterranean. There is moderate precipitation year round and no extreme wind or snow loads.

SEISMIC ZONE



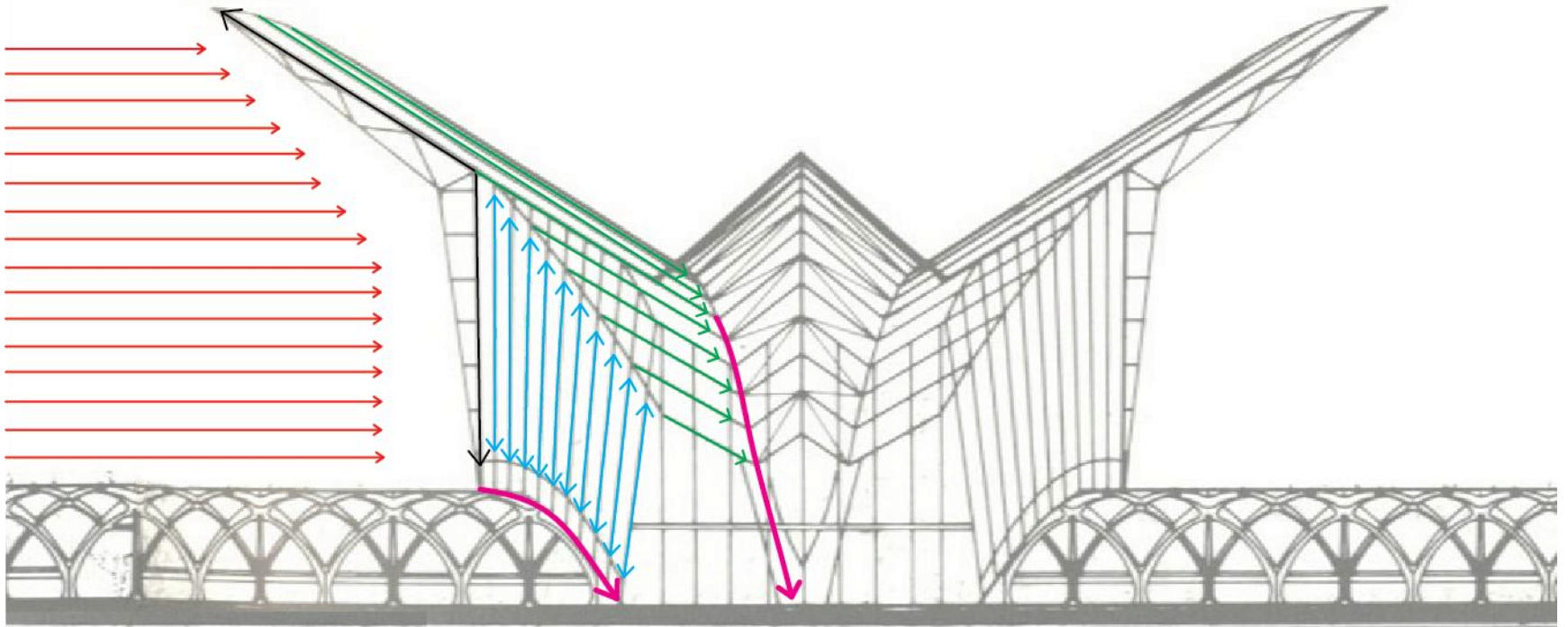
SEISMIC ZONE



LATERAL LOAD RESISTING SYSTEM

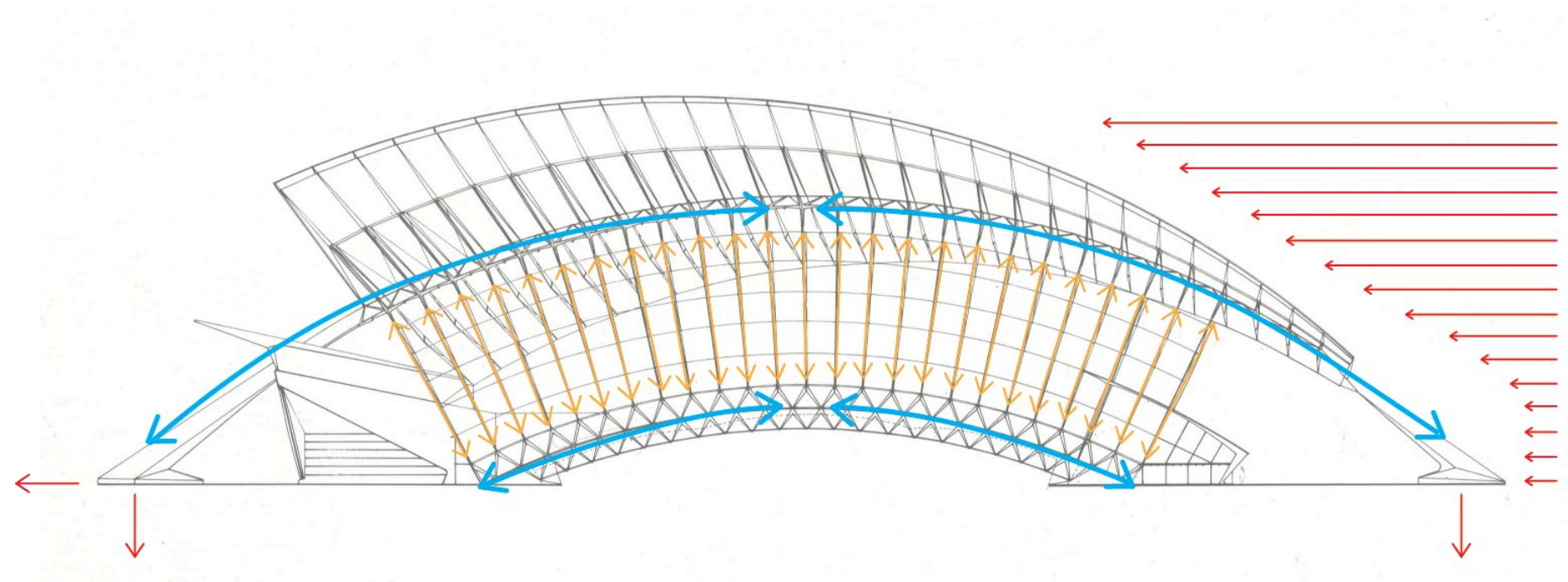
- Lateral loads are applied to the face of the glazing and create a high pressure region between the glazing system and the cantilevered roof portion.
- The high pressure region causes uplift and an overturning moment about the base of the cantilevered roof portion.
- The four cross-braced steel arches and the exterior trusses resist the lateral load and overturning moment about the base of the façade.

LATERAL LOAD RESISTING SYSTEM



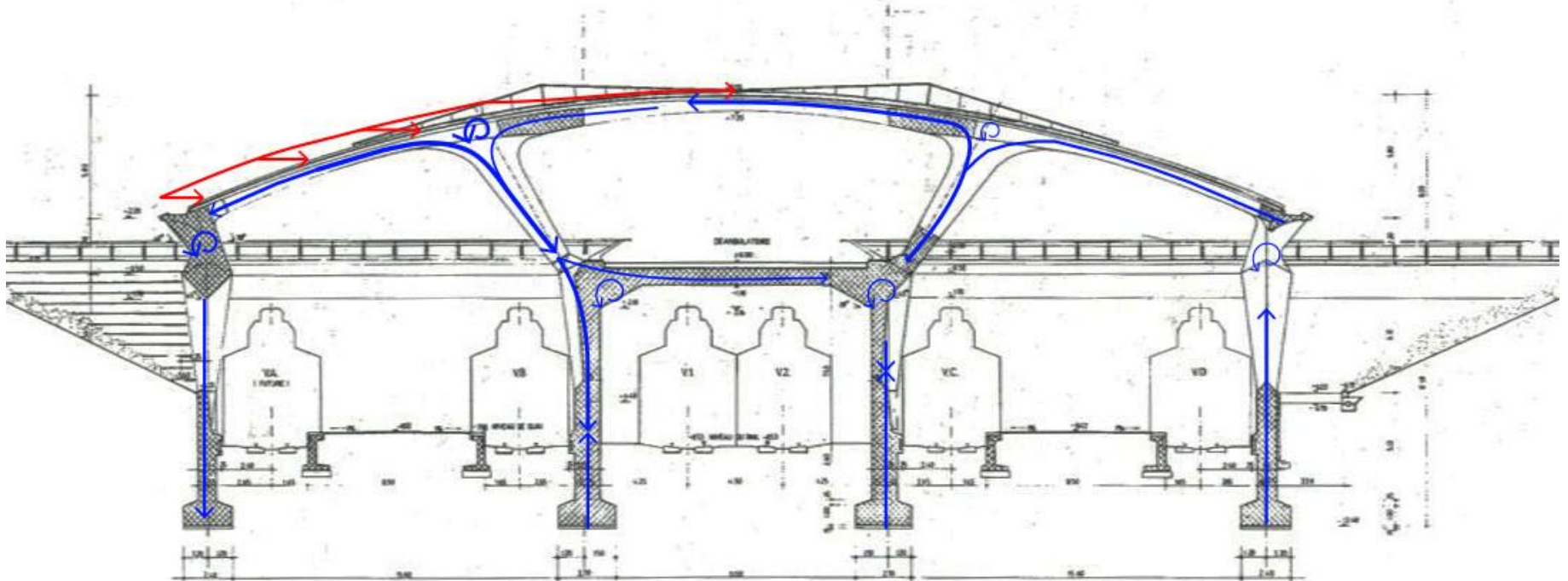
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Lateral Loads

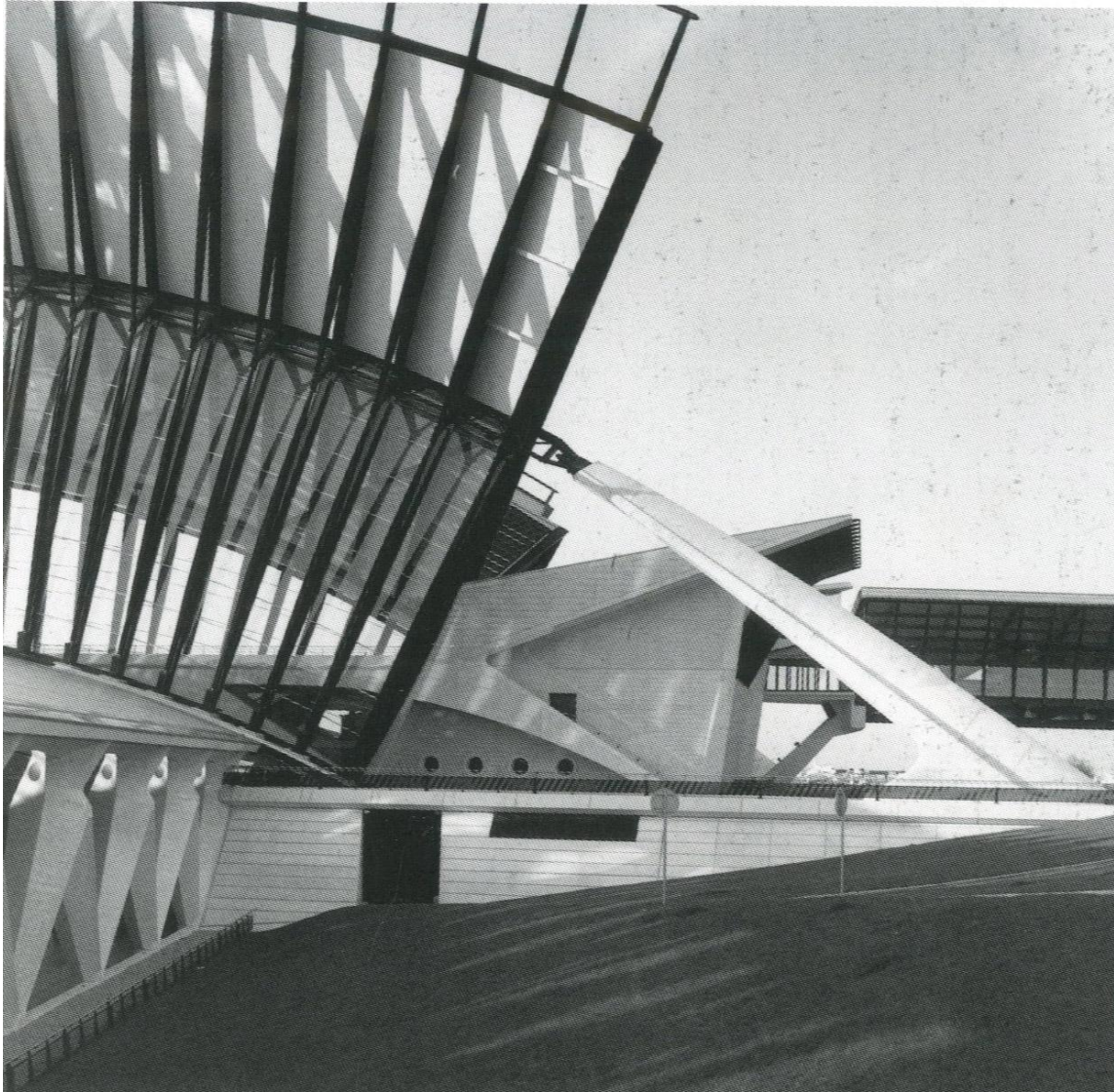


LOAD TRACING DIAGRAM

Lateral (wind) loads

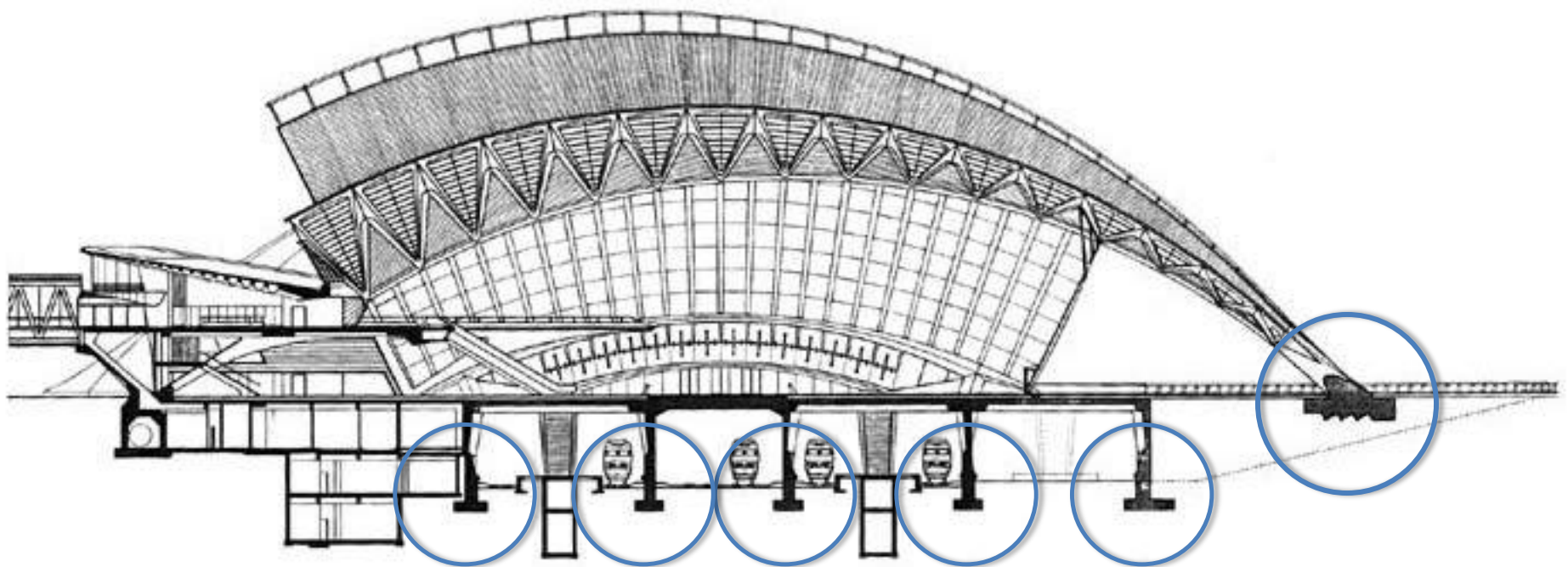


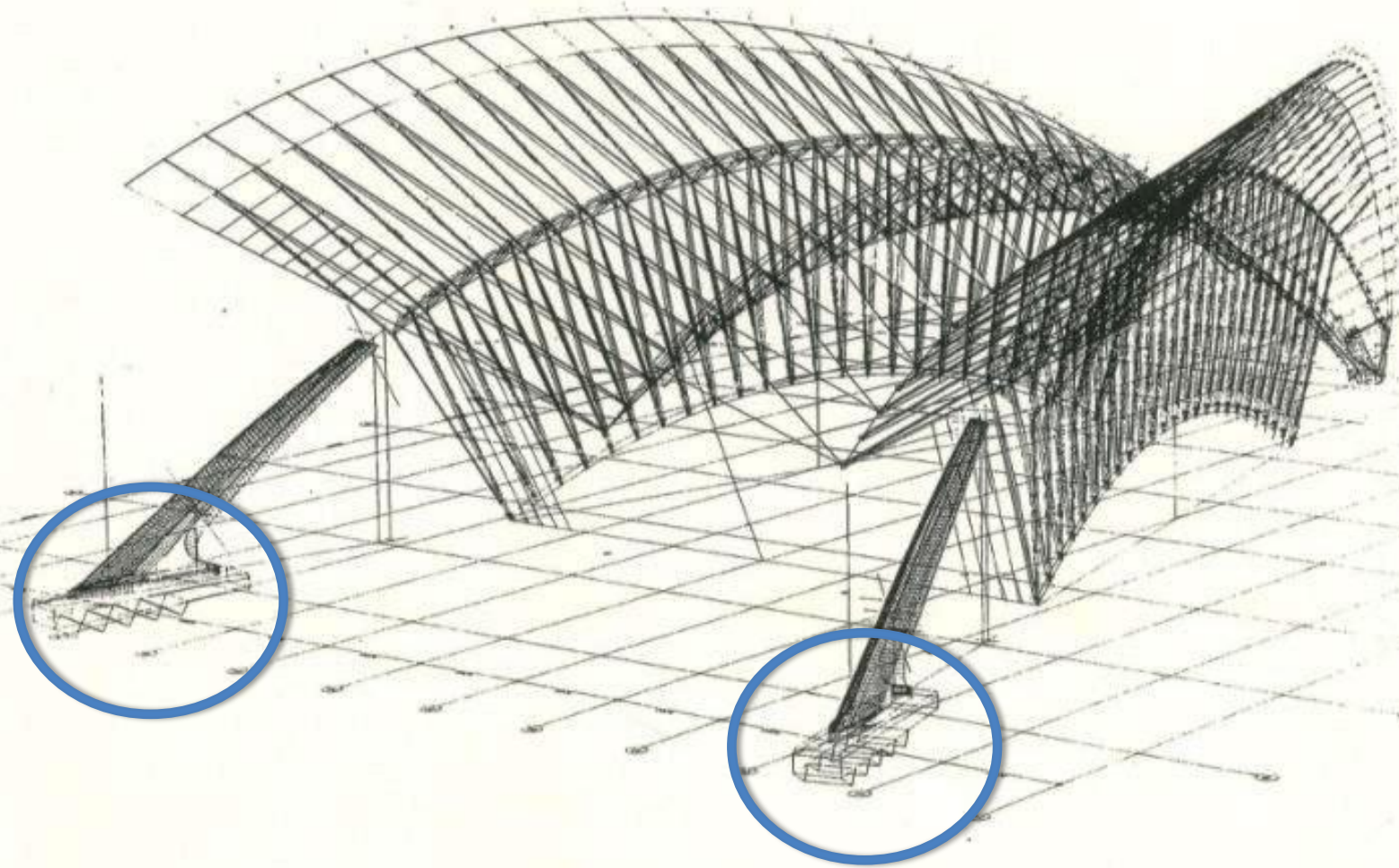
LATERAL LOAD RESISTING SYSTEM



SOIL AND FOUNDATION

- The soil in this area is generally granite with a mixture of shingle with clay and layered stones on the hillsides.
- This soil condition is stable to support the structure and allows the foundation to be relatively simple.
- The foundation system used is isolated concrete spread footings.
- The front concrete housing of the main steel arches (the “beak”) has a modified pad footing with a saw-tooth base





COMPOSITE CONNECTIONS

- The Main Lobby is primarily a steel structure composed of four arches which are connected to an isolated reinforced concrete foundation
- The outer steel arches are connected to the foundation through a concrete housing
- The inner steel arches are supported by concrete shear walls on one side and a housing on the other.
- Exposed structural steel members are cased with concrete as they join the foundation or floor of the structure.
- Concrete casing at the joints makes the structure rigid.

COMPOSITE CONNECTIONS



COMPOSITE CONNECTIONS



COMPOSITE CONNECTIONS



COMPOSITE CONNECTIONS





SOURCES

1. “Santiago Calatrava” (2012). *Milwaukee Art Museum*. <http://mam.org/info/details/calatrava.php>
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