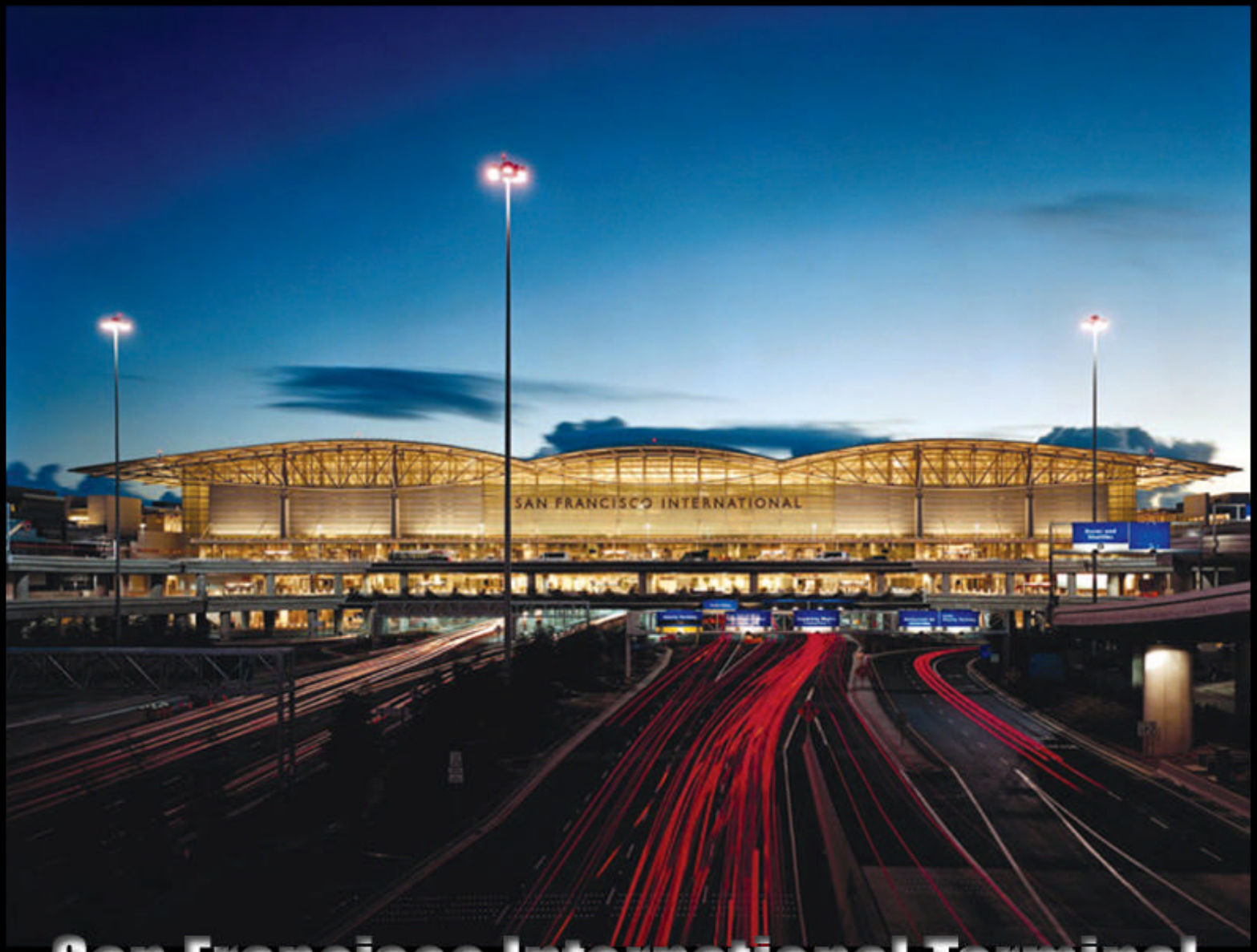


San Francisco International Terminal,
San Francisco, California.

San Francisco International Terminal

The building integrates all aspects of Architectural Engineering

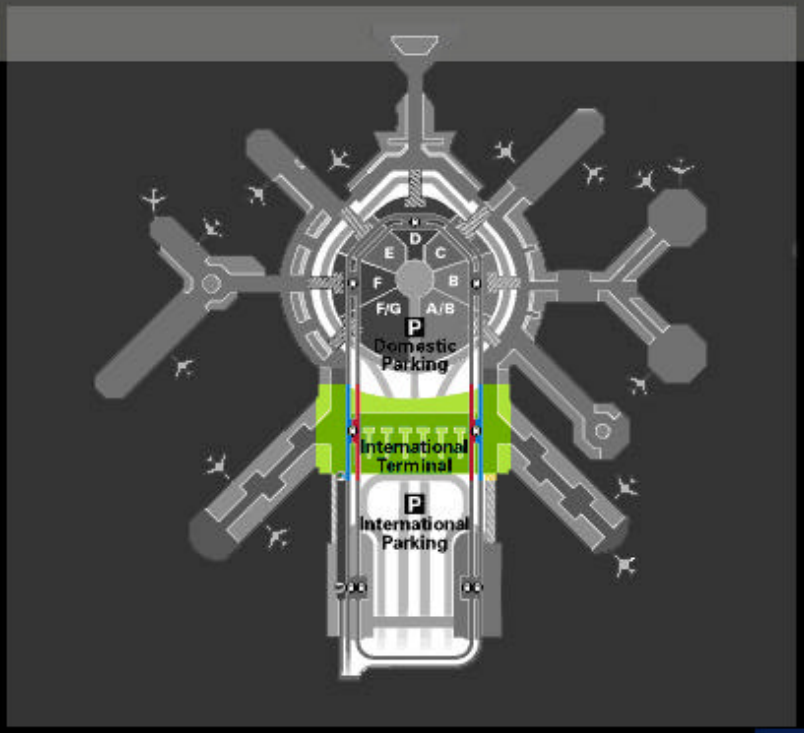
Functions:- Maintain approach roadway access below terminal in east-west direction
Simplify flow of airline passengers

Structure:- Seismic, structural spanning

Materials:- Steel, glass, concrete, fabric and aluminium cladding

Aesthetics:- Visual cohesiveness and an iconic identity;
San Francisco is front door to the world

San Francisco International Terminal



Architect and Structural Engineering Team:-

Skidmore, Owings, and Merrill (SOM)

Civil Engineering Team:- AGS, Inc.

Area:- 1.8 million Sq. Ft

Cost:- $ 840 million

Time of Construction:- May 1996- December 2000

Largest base-isolated structure in the world.
Required to meet the strictest seismic requirements ever imposed on U S airport terminal.
The building integrates all aspects of architectural engineering.

Materials used are primarily glass, concrete, steel, fabric, aluminum cladding

The roof's shape is an organic expression of the actual stress forces its structure must withstand

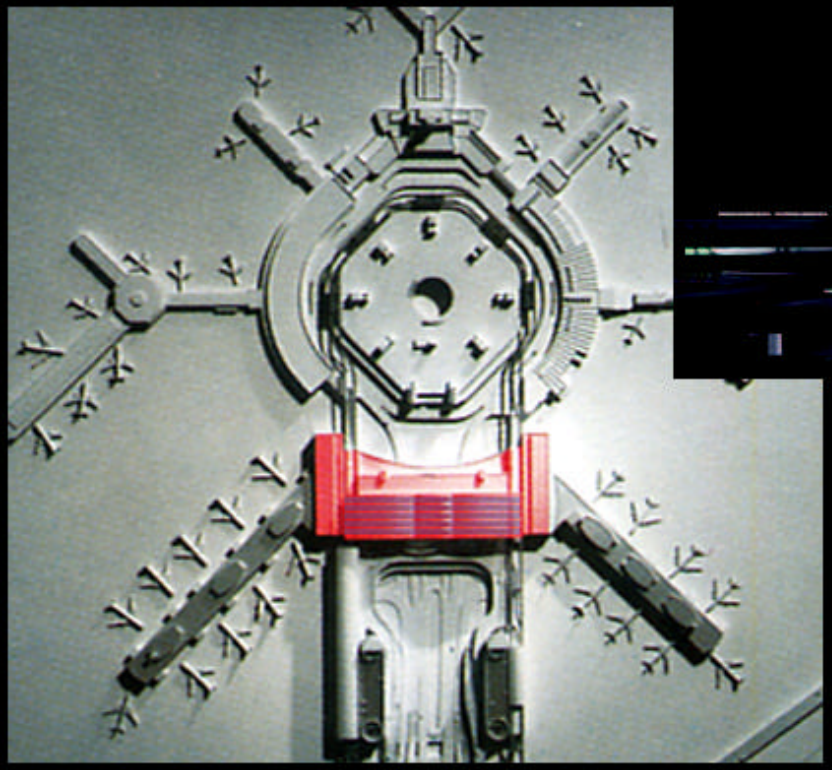
Skidmore, Owings and Merrill LLP

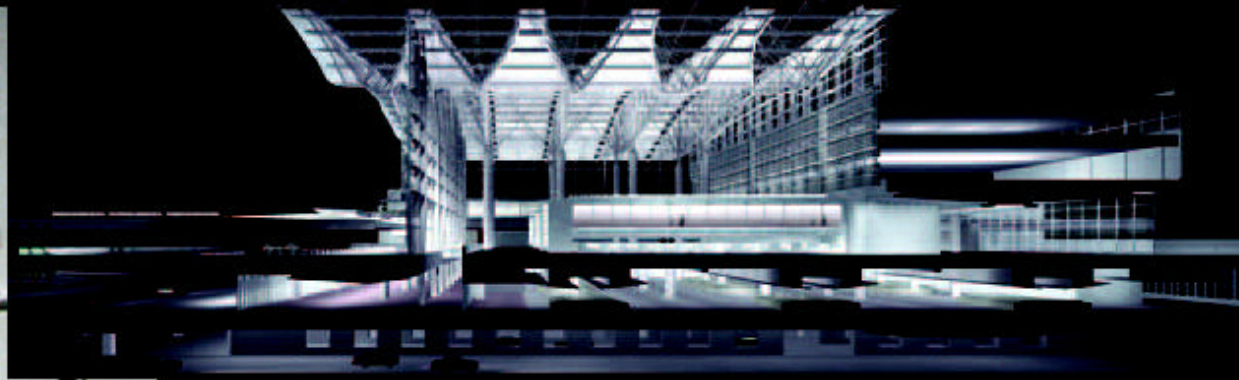
Founded in 1936, Skidmore
One of the world's leading architectural, urban design, engineering and interior architecture firms
Concieved, designed and built projects that include corporate offices, banking and financial institutions, government buildings, health care facilities, religious buildings, airports, recreational and sports facilities,university buildings and residential developments.

SOM

Responsible for the design and construction of America's tallest buildi
the 4,600,000 square foot, 109 storey Sear's Tower in Chicago

Have completed more than 10,000 architecture, engineering, interior
architecture, and planning projects in more than 50 countries around t
world.





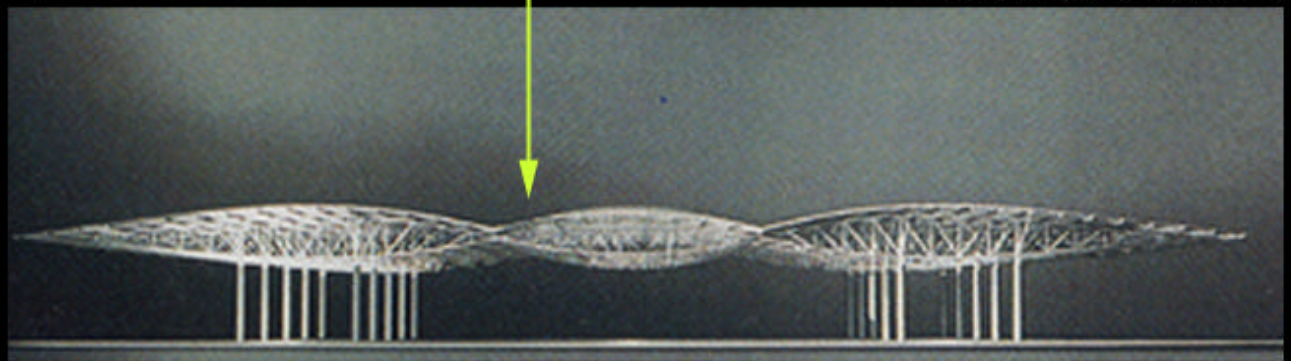
System

5 sets of trusses 40' center.
Consist of two of balanced cantilevered trusses supporting a 3rd central truss linked together to create a wing like form
Central truss spans 380 ft

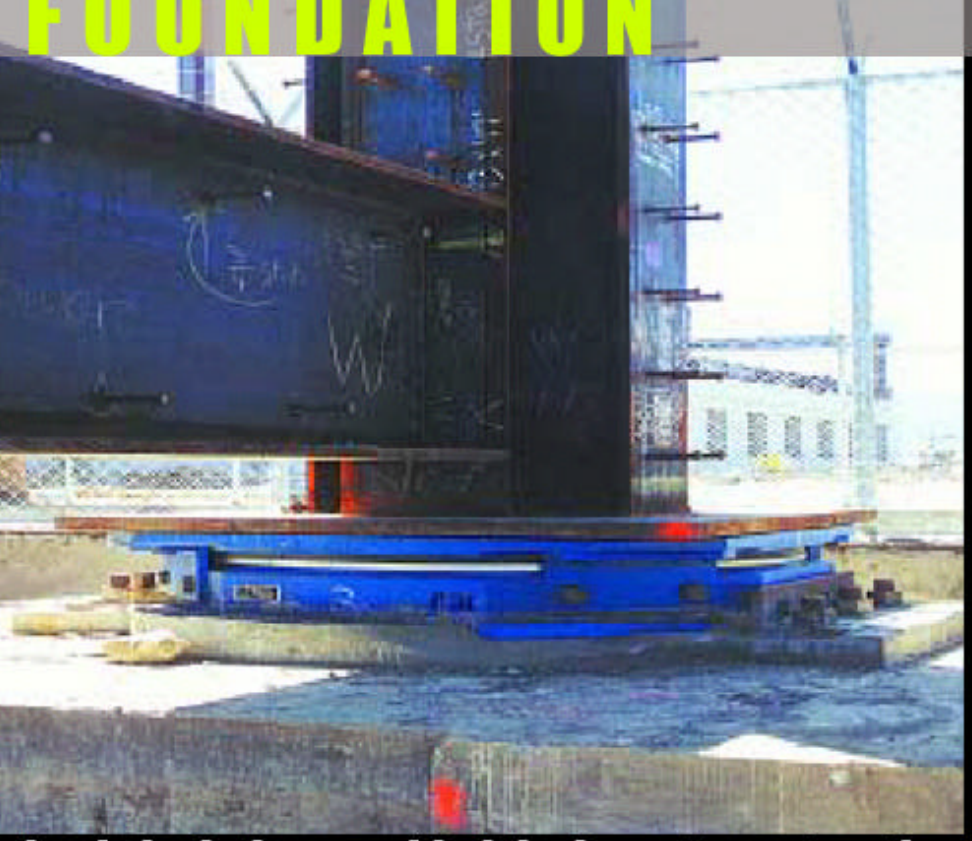
Two way system

Central truss system spans existing 10 lane airport entrance road
Cantilevered trusses span 160'
One way system
Spans overall length of 860'
Tubular truss members range from 12 to 20" diameter
Truss size 35 ft wide, 27 feet high, 140 tons each

FOOTBALL !!!
Gig'em!



FOUNDATION



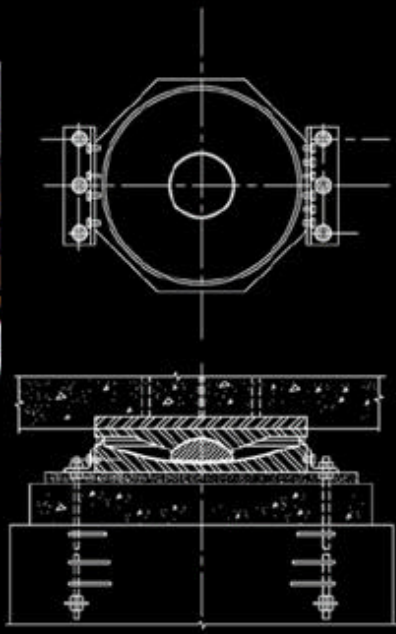
eismic isolation provided the lowest construction cost
or achieving the desired seismic performance.

he steel seismic isolators provided the necessary
trength and stability to mitigate a magnitude eight
arthquake and yet deliver the desired expected
erformance.

he seismic design are with long spans and tall
urtain walls aws accomplished with the use of 267
riction pendulum seismic isolation bearing.

Isolation System

Three isolation systems (friction pendulum bearing, lead rubber and high damping rubber bearing) were identified as practical isolation systems for this project.



Friction Pendulum
Seismic Isolation Bearing

These Friction Pendulum joints are installed between the superstructure and the foundation.

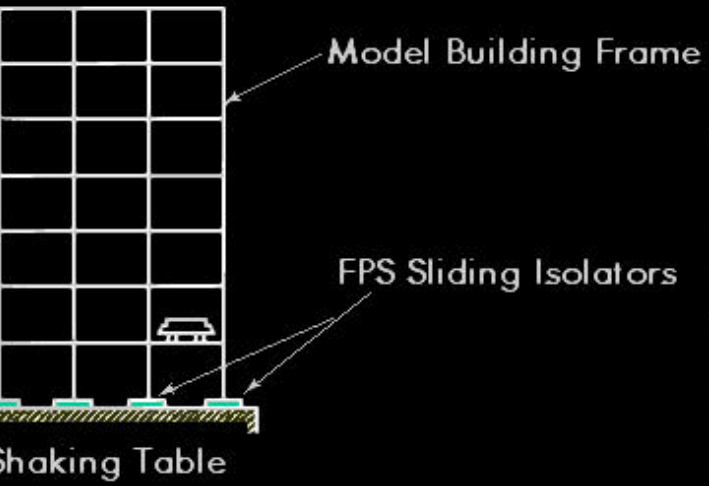
The function of this joint is to isolate the structure from the the earthquake motions by the basic fundamental of a pendulum and and reducing the structures natural period.

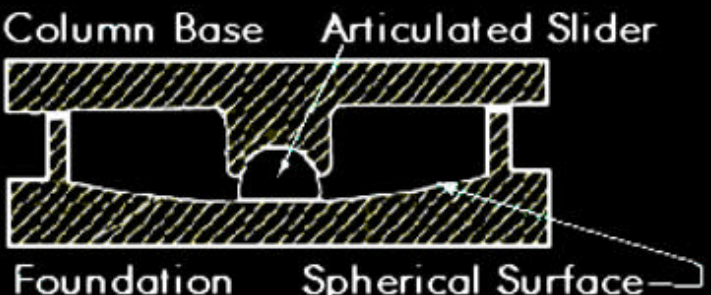
When hit by an earthquake, the articulated slider moves along the concave surface, causiing the structure to move with small pendulum motions.

The dynamic frictional force hence produced helps to generate the required damping to absorb the energy of the earthquake.

The result being that the lateral forces and shaking movements transmitted to the structure is greatly reduced.

This system can accomodate strong earthquake of even magnitute 8.





PENDULUM MOTION

SLIDING PENDULUM MOTION

West Facade- Curtain wall

Laminated glass used
705' long
210' wide
83' high

Glass on the facade plays an important role in seismic and security/ safety

Each glass designed to take part of the movement in a repeating unitized curtain wall (like fish scales)

11" allowable displacement between top and bottom of window wall

Breaks overall building moment into smaller components

Flexible

In event of the glass breakage, glass stays in frame/ blast resistant

COLUMNS

Two floors of conventional beam and column framing

20 slender steel columns used for support

The roof load is transfered to the column through the purlin at the top of the column

The column tapers at the top at the truss connection

It has a pinned support which performs like a fixed support

The support enables some amount of rotation to occur

ROOF SYSTEM

nction:- The roof truss diaphragm and supporting box column remain elastic during extreme earthquake motions

esign includes both horizontal and vertical response pectra analysis resulting in design spectra shears of % horizontal and 100% vertical of main roof structure mass

Form

Floating Quality

Tripartite roof form suggests flight

Roof form based on double cantilevered truss concept

Curving lines of its top and bottom truss chords precisely follow the compressive and tensile froces created by its long span

ROOF OF THE STRUCTURE

Overview of the Structure Frames showing
Roof Truss- with lateral bracing
3D Space Truss- with skylights

5 sets of trusses at 40' center
Picture shows one of the bays

Consists of two of balanced cantelivered trusses supporting a third central truss linked together to create a wing- form

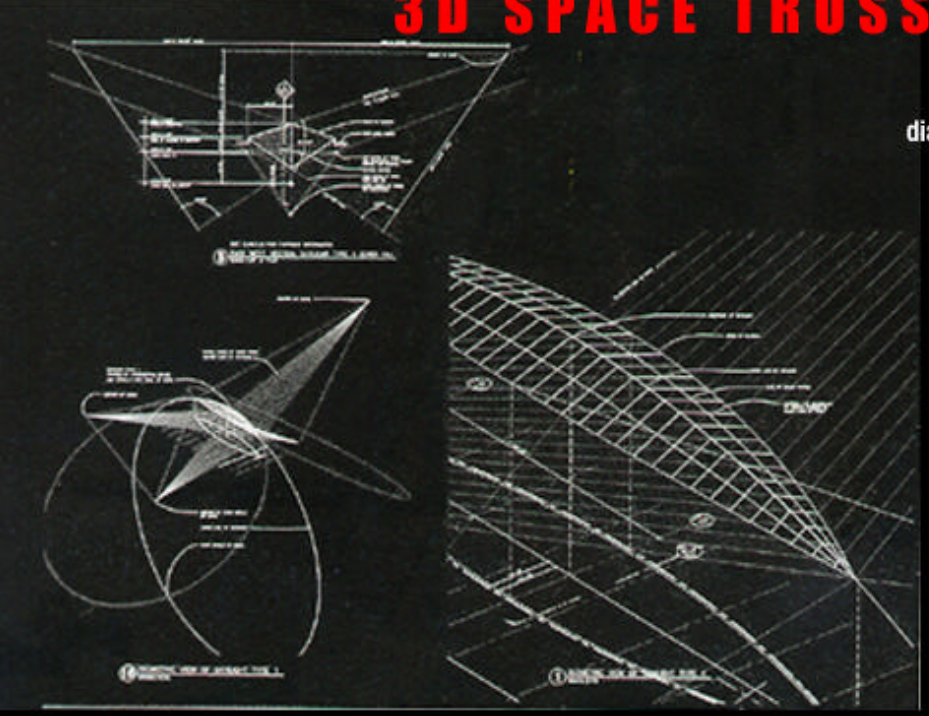
Central truss spans 380'

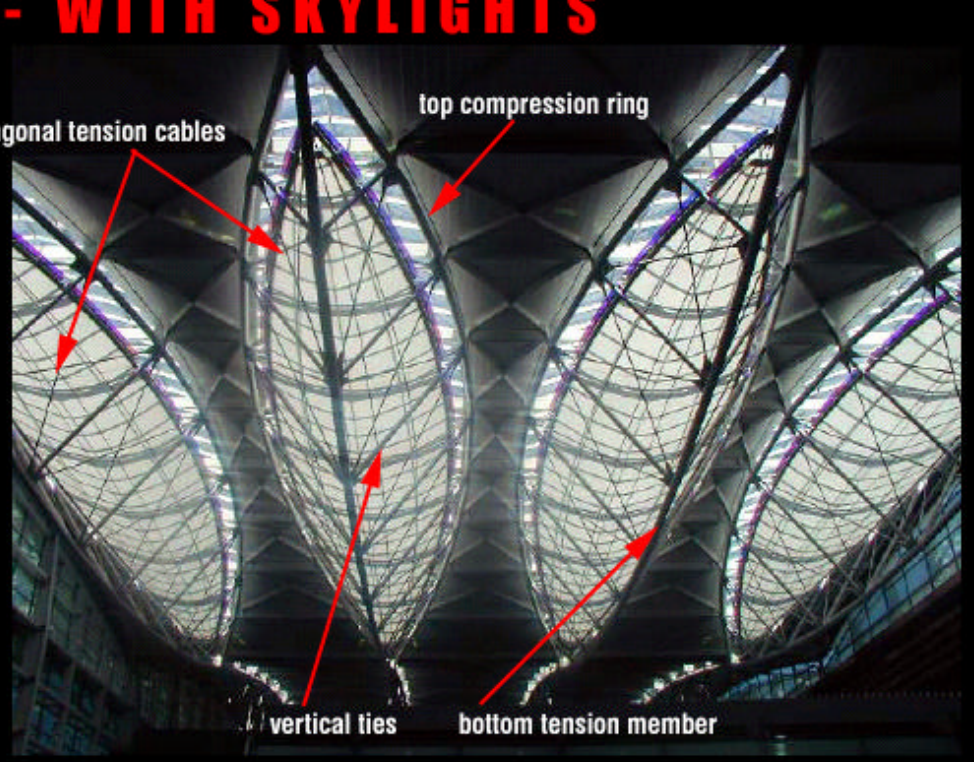
Close up of Roof Truss with 2 diagonal tensio
cables

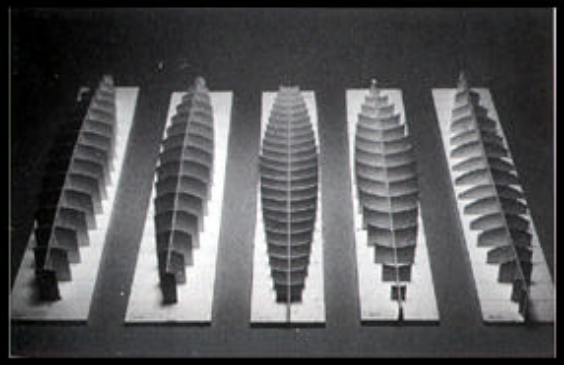
Two way System:-
Central truss system spans existing 10 lane airport entrance road
Cantilevered trusses span 160'

One way System:-
Spans overall lenght of 860'
tubular truss members range from 12" to 20" diameter
Truss size 35' wide, 27' high and 140 tons each

3D SPACE TRUSS- WITH SKYLIGHTS







Skylight system Responds to truss design.
Incorporates very long thin slivers of laminated glass over the double cantile vered truss

Material
Membrane panels give skylight a volume, shape and the illuminated fabric in turn is integral to the wave-form steel trusses that race the length of the terminal.

Two way System:-
Central truss system spans existing 10 lane airport entrance road

JOINT DETAILS

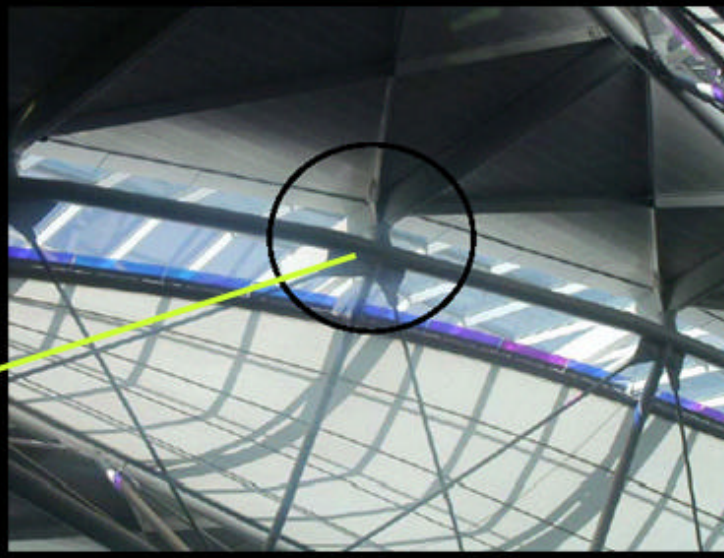
Penetration welds used for all joints

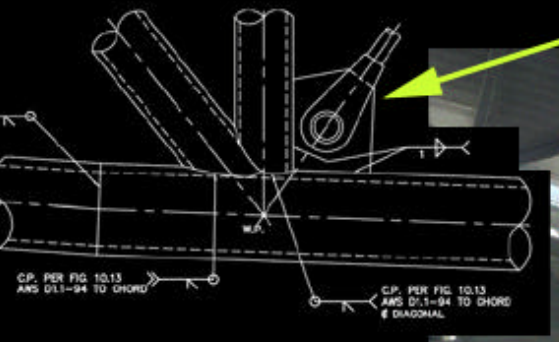
State of the art steel tubular t-y-k joint detailing and fabrication (diagram)

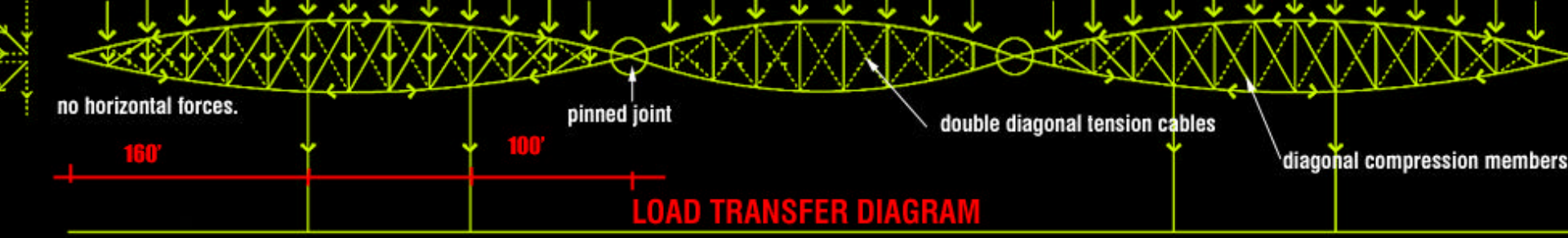
Steel trusses sit on spherical ball-joints atop 20 cantilevered steel concrete filled box columns

Center spans are interconnected by cast steel pinned joined assemblies

6" diameter pins







LOAD TRANSFER DIAGRAM

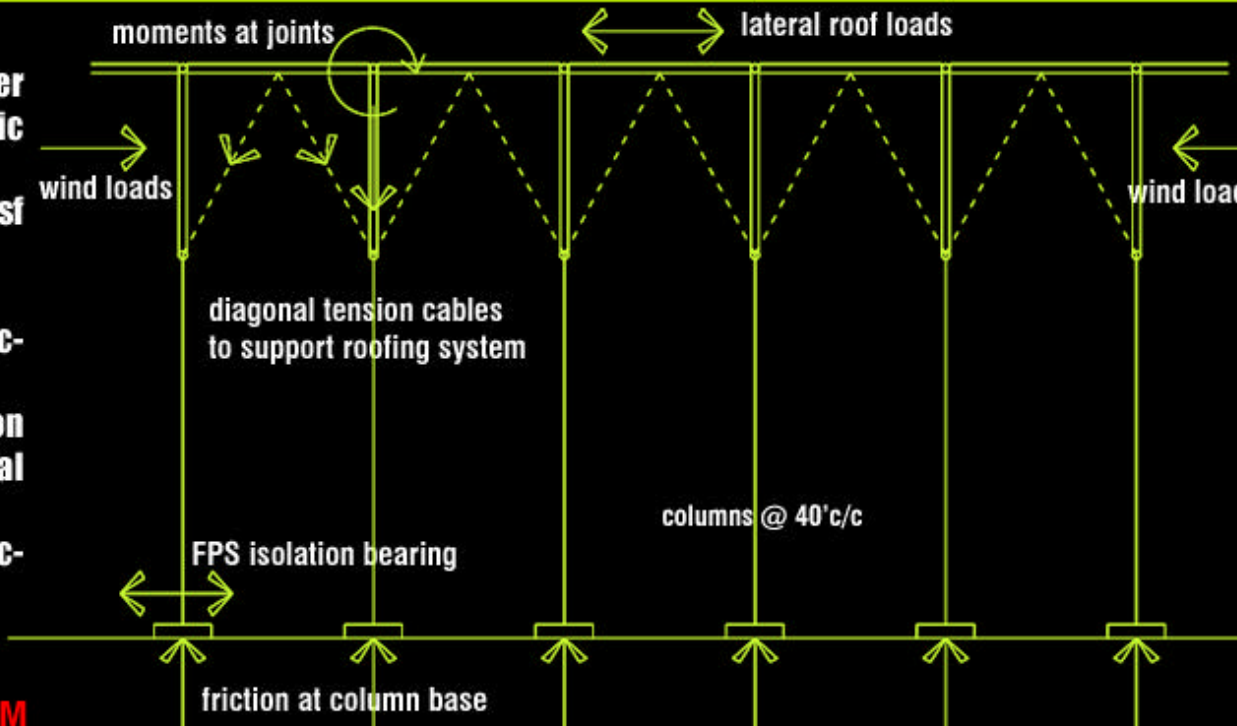
LENTICULAR TRUSS vertical forces due to external loading conditions are transferred down to the columns by vertical supports.The diagonal members are zero-force members and cater only to stabilize the truss under varying loading conditions.The cantilevers that support the central truss are given an uplift by the overhanging cantileversat the outboard edges of the building.

BENDING MOMENT DIAGRAM

LENTICULAR TRUSS

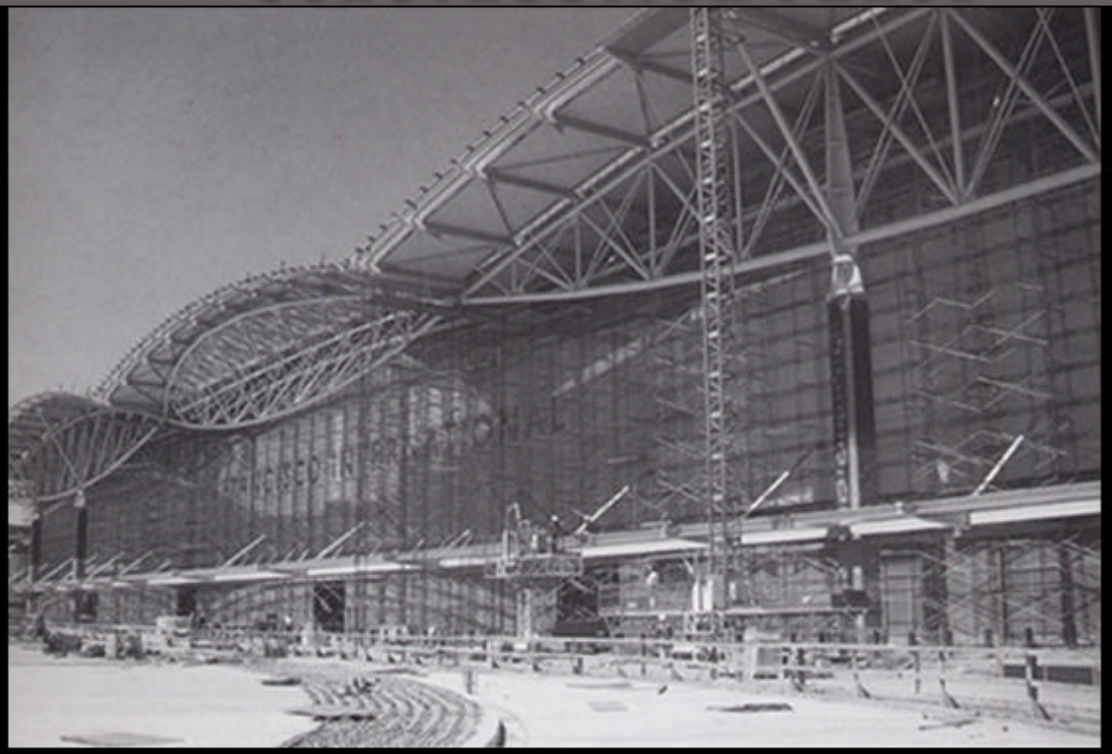
Maximum vertical deflections were 4.5" under dead and live loads and 9" peak seismic loading.
Frame steel weight of 30 psf and 60 psf including roof construction.

Bending moment is zero at the pinned connections.
The columns are based on the FPS isolation bearings. This allows for about 20" of lateral displacement.
Friction at the column base enhances structural stability.



LOAD TRANSFER DIAGRAM

CONSTRUCTION PHASE



The five center span trusses are three chord trusses consist-
ing of two pipe top chords and one pipe bottom chord.

The 182", 100-ton trusses were shipped on cradles in one piece
from the fabrication plant.

They were lifted with a Manitowoc M250 crawler crane using
nylon strings at four pick points, and walked into position.

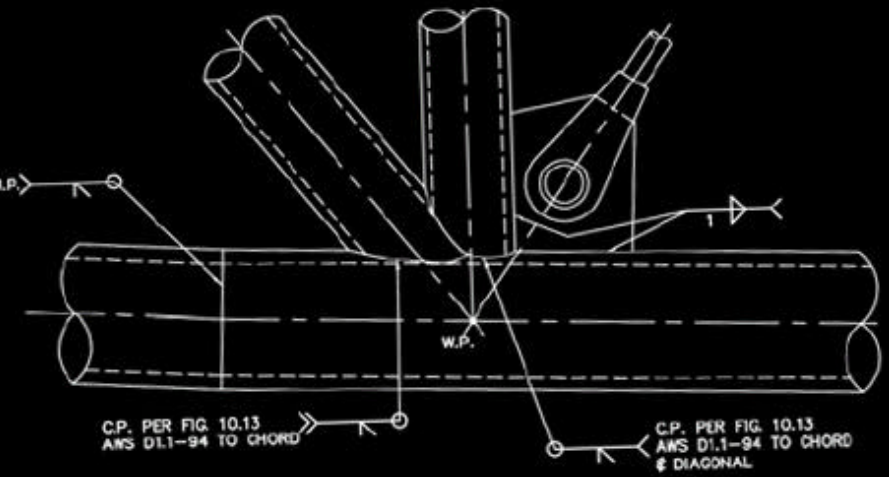
The roof structure purlins and bracing was framed between the
football trusses while they were resting on the third floor.

ROOF CONSTRUCTION

The main roof structure, with a total weight of 4,200 tons, includes five sets of trusses at 40' centers. Each truss incorporated two 320' long double cantilever one-way sections resting atop sherical bearing and a two-way 180' long threechord center section.

The tubular truss members range from 12 to 28" in diameter.

All joints were complete penetration welds.



INTERNAL CONSTRUCTION

Below the trusses are two floors of conventional beam and column framing.

The 20 tall columns supporting the roof plate are made of 4" square box columns.

Partial penetration weld details are adopted in the fabrication of these box columns while full penetration weld details are adopted at column splice locations.

The connections are designed with pre-Northridge moment connection details for the moment resisting frames since the joints stresses remain elastic with the base isolation for the earthquake.


CLAYTON
(MORAL SUPPORT)
JULIE
GAURAV
LAURA
SAON
ASHMI
MEGHAN
SAMEER
ELEPHANT WALK
SOM

REFERENCES

WWW.SOM.COM

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GROUP

Ashmi Mehta

Gaurav Khadse

Julie Hrozek

Laura Schilling

Meghan Mahoney

Sameer Balvally

Saon Das