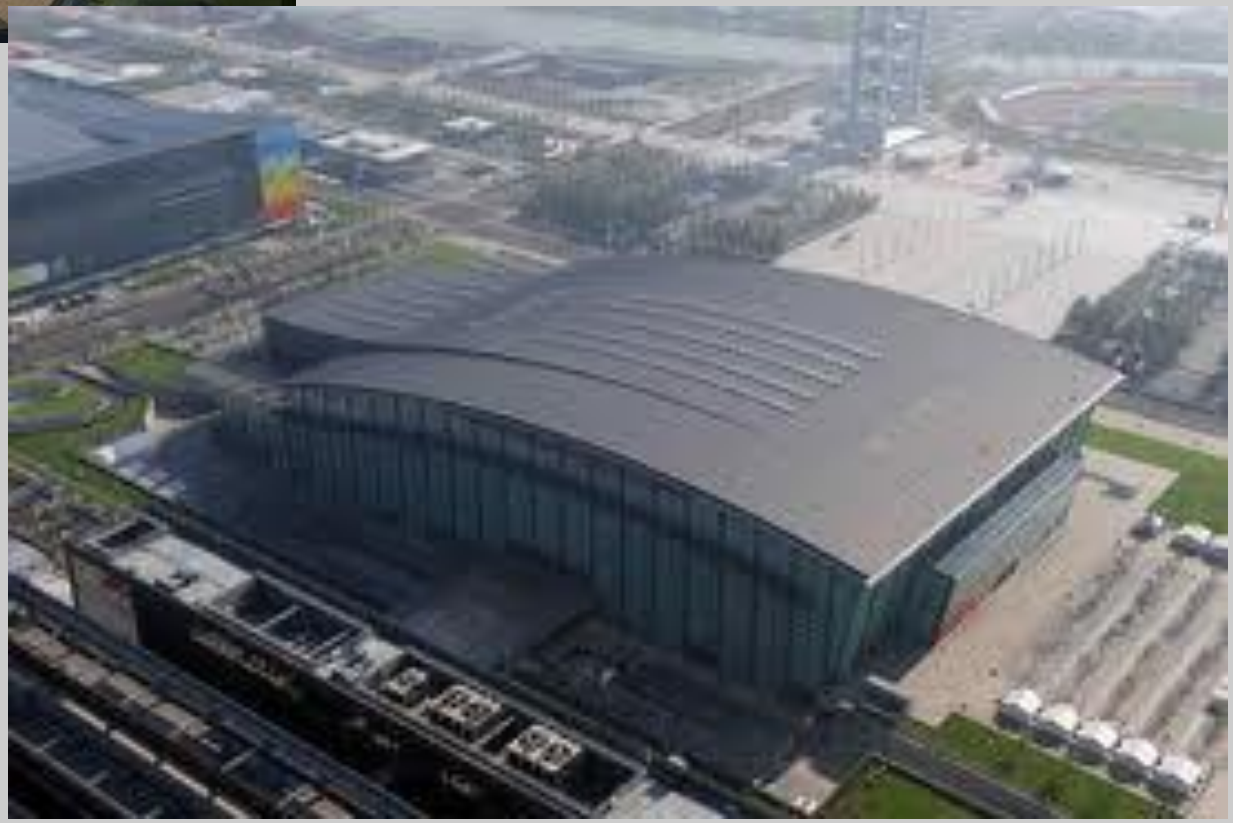
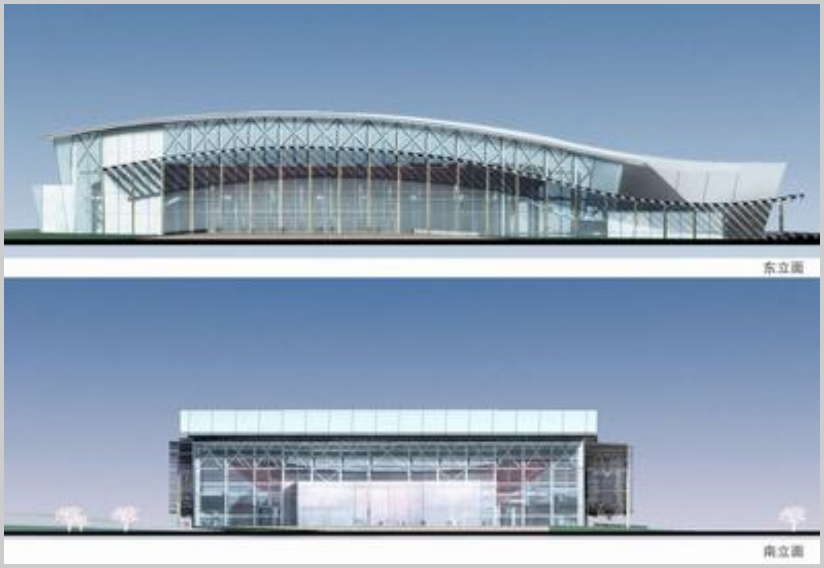
Beijing 2008 Olympic

National Indoor Stadium



Group members:
Meredith Butler
Glenda Fletcher
Emily Scarfe
Maryam Rajabali
Jiayin Li

Venue: **National Indoor Stadium**
Location: Beijing, China center of "Olympic Green"
Total land surface: 80,900 sq m
Events: Artistic Gymnastics, Trampoline, Handball, Wheelchair Basketball
Seating: 20,000

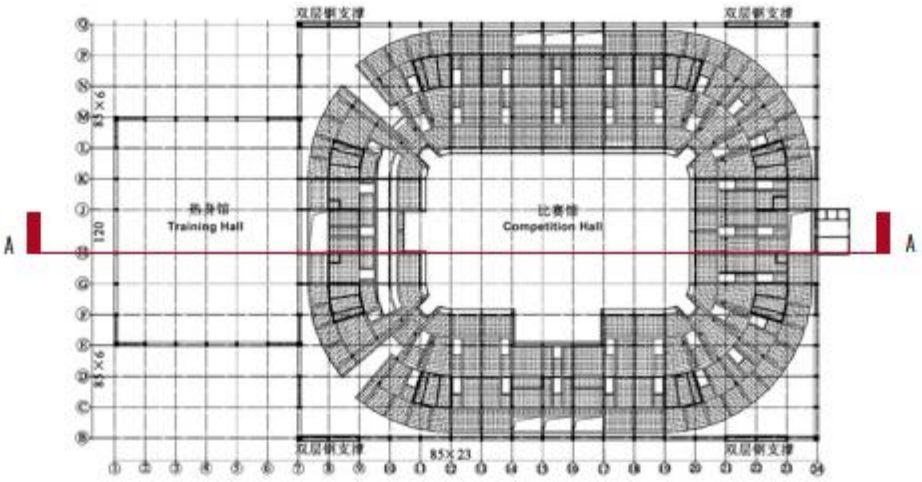


Designed by Glöckner3 Architektur und Städtebau with Beijing Institute of Architectural Design
Concept: Unfolding Traditional Chinese Fan
Cost: $125 million

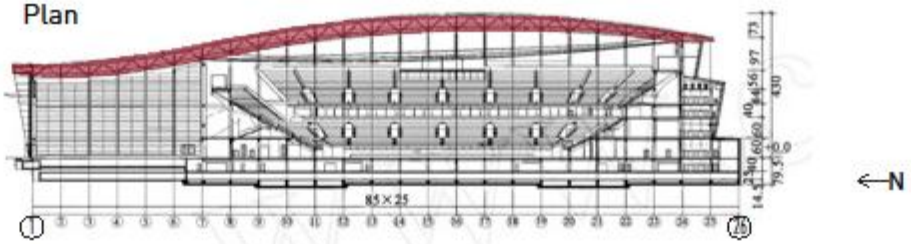
The "green" features are the photovoltaic generators installed under the roof and behind the curtain wall which put out approximately100 kilowatts of electricity daily. Additionally public walking areas are constructed of water-permeable material to allow rainwater to seep into the ground for harvesting.

The steel roof trusses stretch144 meters tall and 114 meters wide. The frame is composed of 14 steel beams weighing a total of 2,800 tons. It is a bi-directional truss string structure made of a multi layer laminated metal composite material that is strong and light weight while reducing noise. The roof required 9 robots to assist in construction.

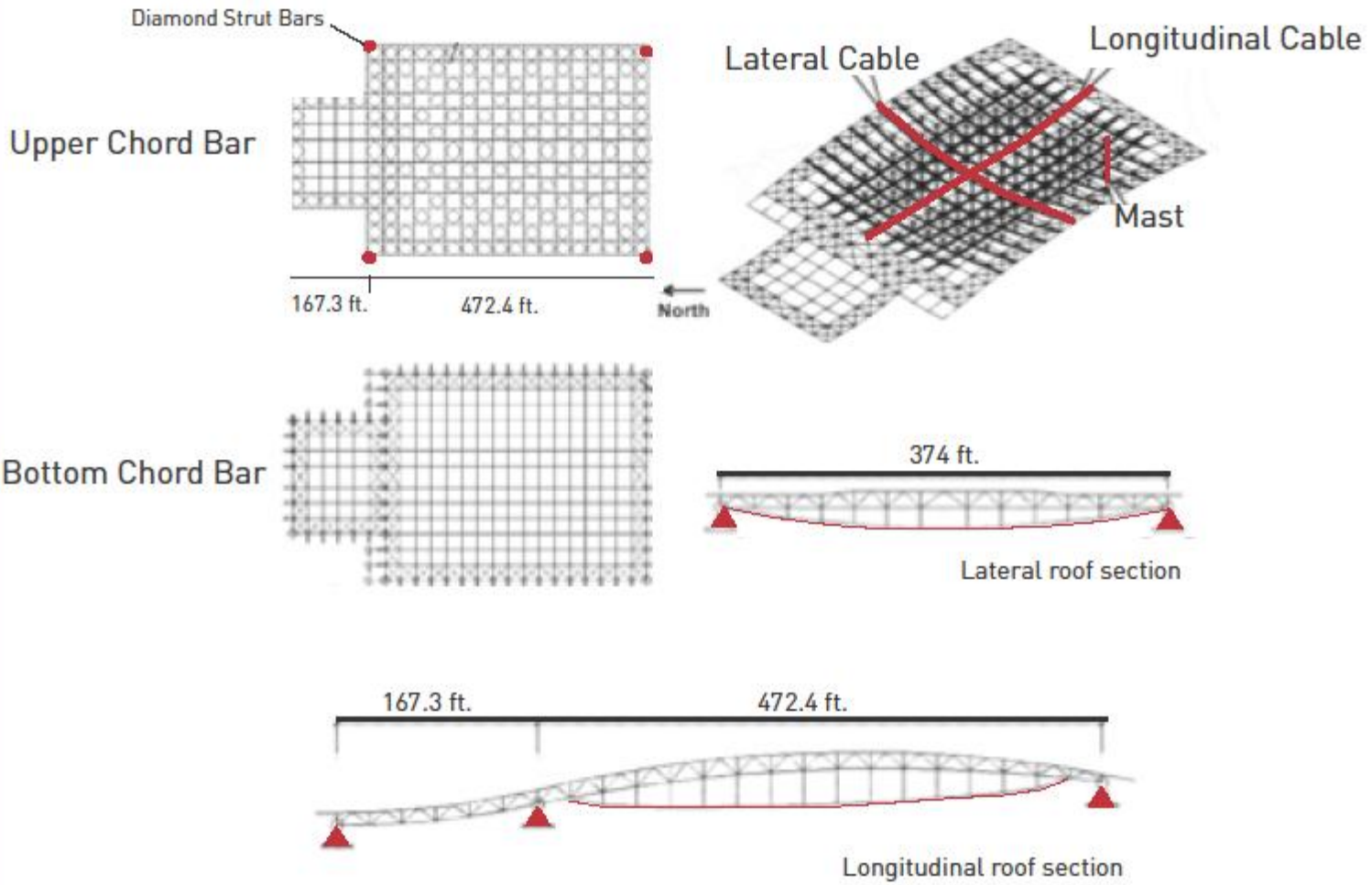
Plan and Section



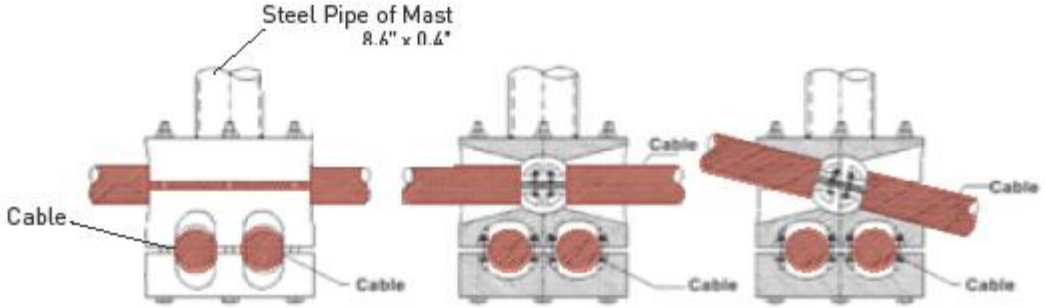
Plan



Section and Elevation


Diamond Strut Bars
Upper Chord Bar
Lateral Cable
Longitudinal Cable
Mast
167.3 ft.
472.4 ft.
North
Bottom Chord Bar
374 ft.
Lateral roof section
167.3 ft.
472.4 ft.
Longitudinal roof section

Cable Connection

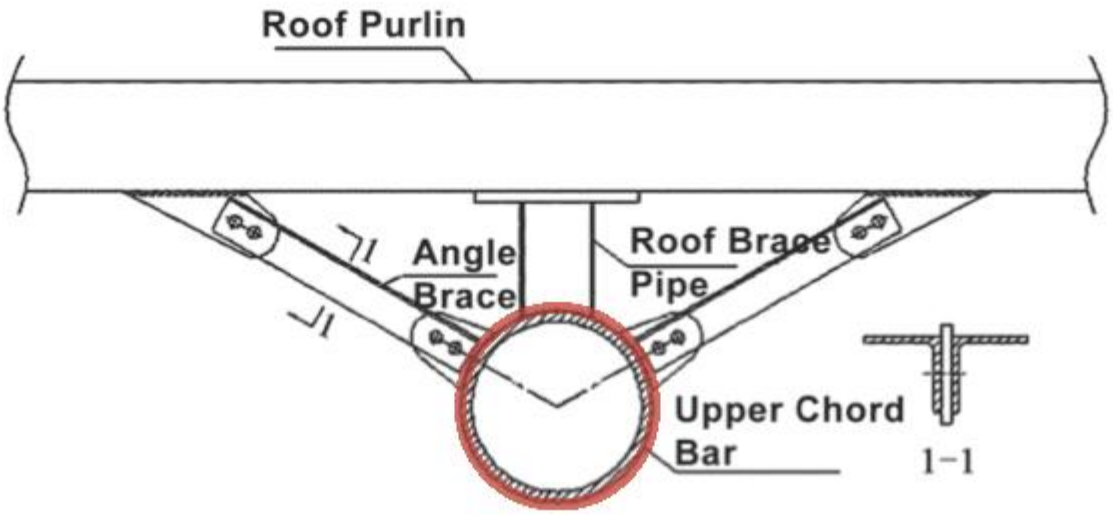


Elevation

Section

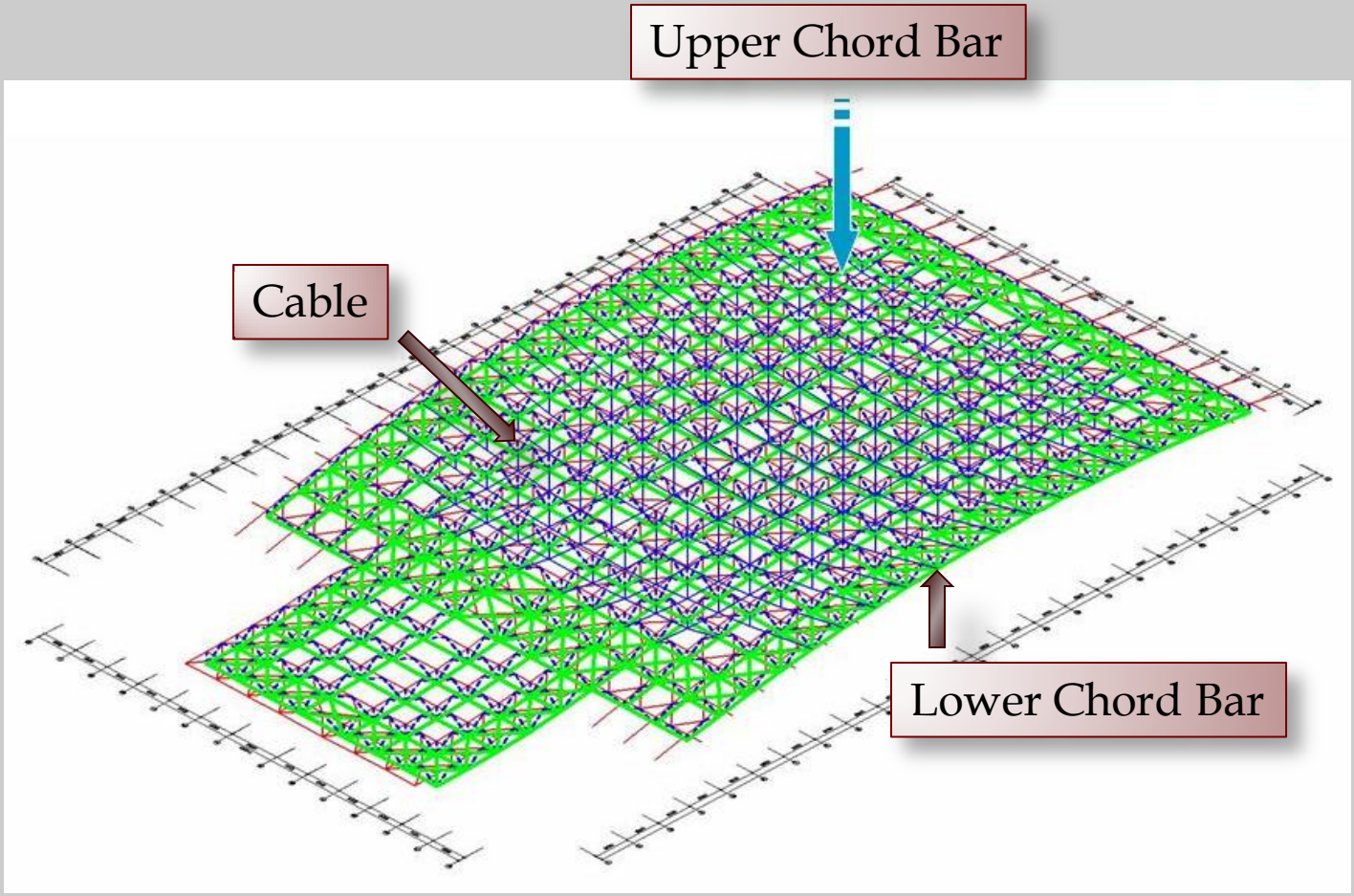
Schematic Turning Section

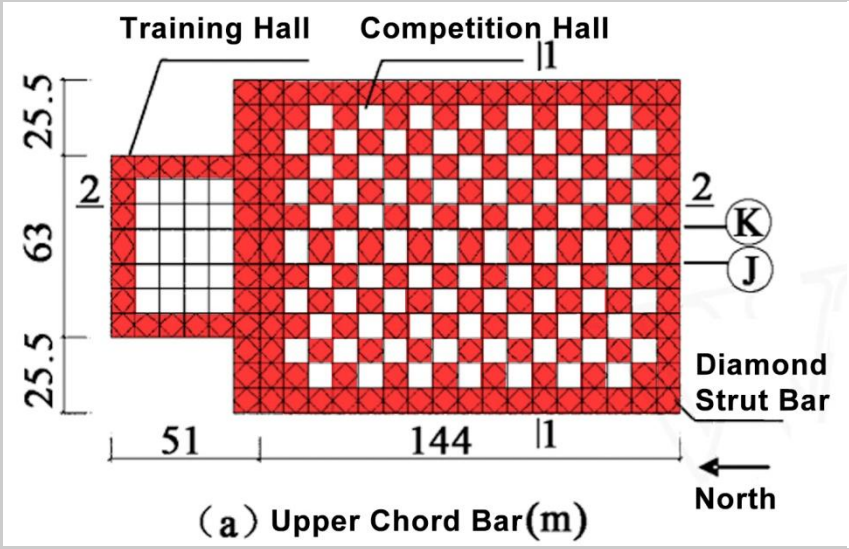
Roof Connection



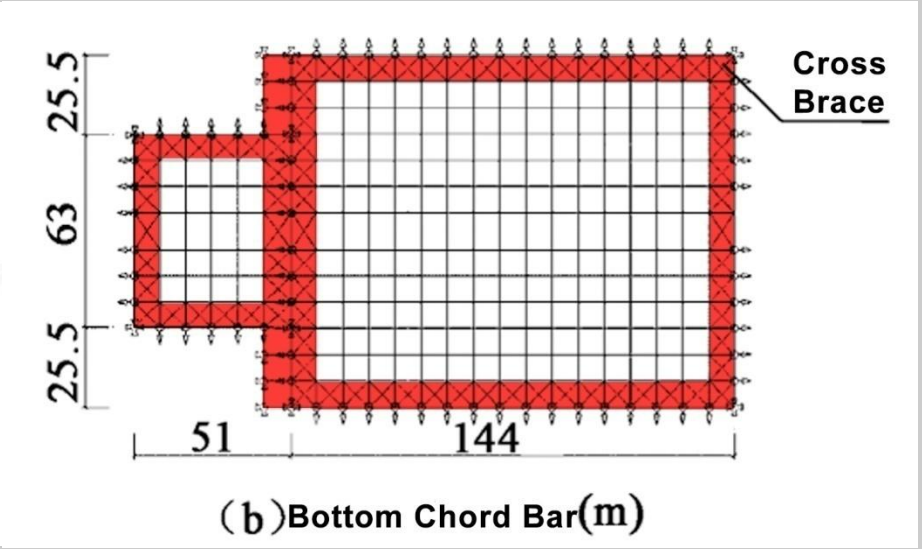
Roof System

TWO-WAY STRING OF SPACE GRID STRUCTURE

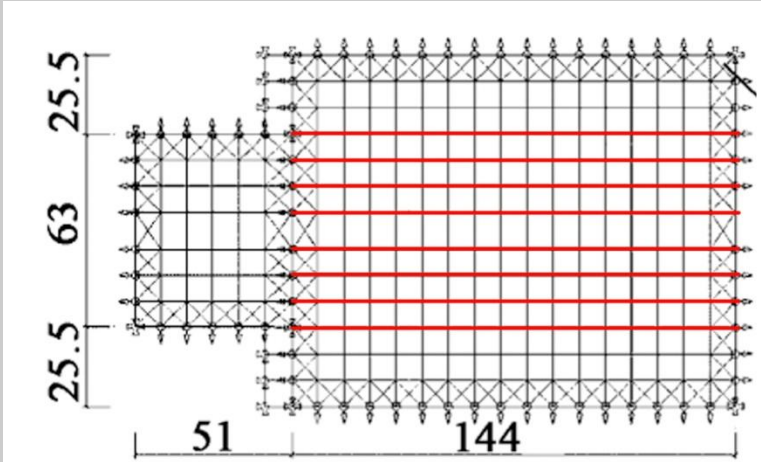




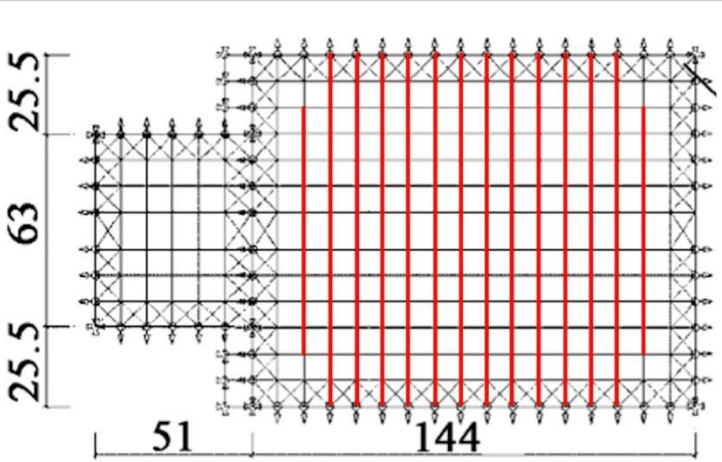
(a) Upper Chord Bar(m)



(b) Bottom Chord Bar(m)

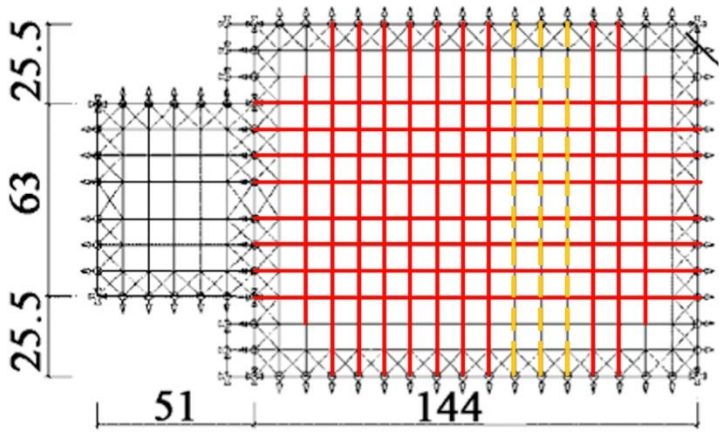


(b) *Upper level--Single Cable* (m)

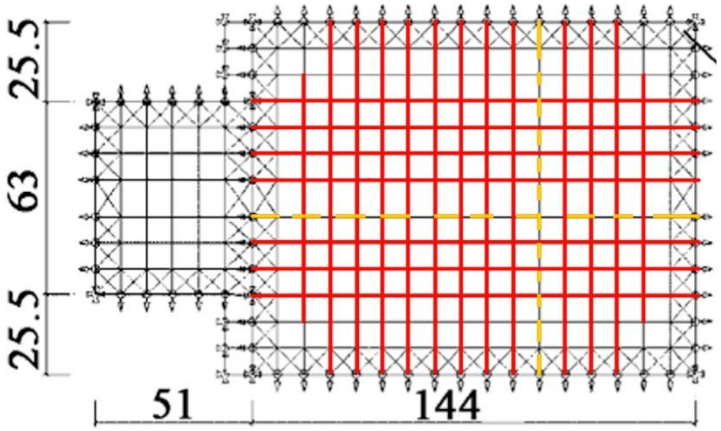


(b) *Lower level--Double Cables* (m)

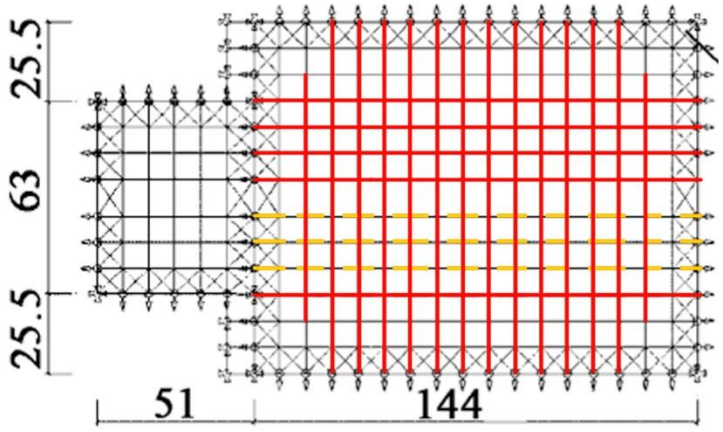
Cable Test



(b)Cable test--one(m)



(b)Cable test--three(m)



(b)Cable test--two(m)

Roof Load:

$$490\ \frac{lb}{ft^2} \times \left(3.28\frac{ft}{m}\right)^2 \times \frac{KN}{224.81lb} \times 0.875m \times 8.77m = 590.21\frac{KN}{m}$$

Snow Load:

$$0.55\frac{KN}{m^2} \times 8.77m = 4.8235\frac{KN}{m}$$

Wind Load (for top face):

$$0.6\frac{KN}{m^2} \times 8.77m = 5.262\frac{KN}{m}$$

Table 17-12 (cont.).
Weights and Specific Gravities

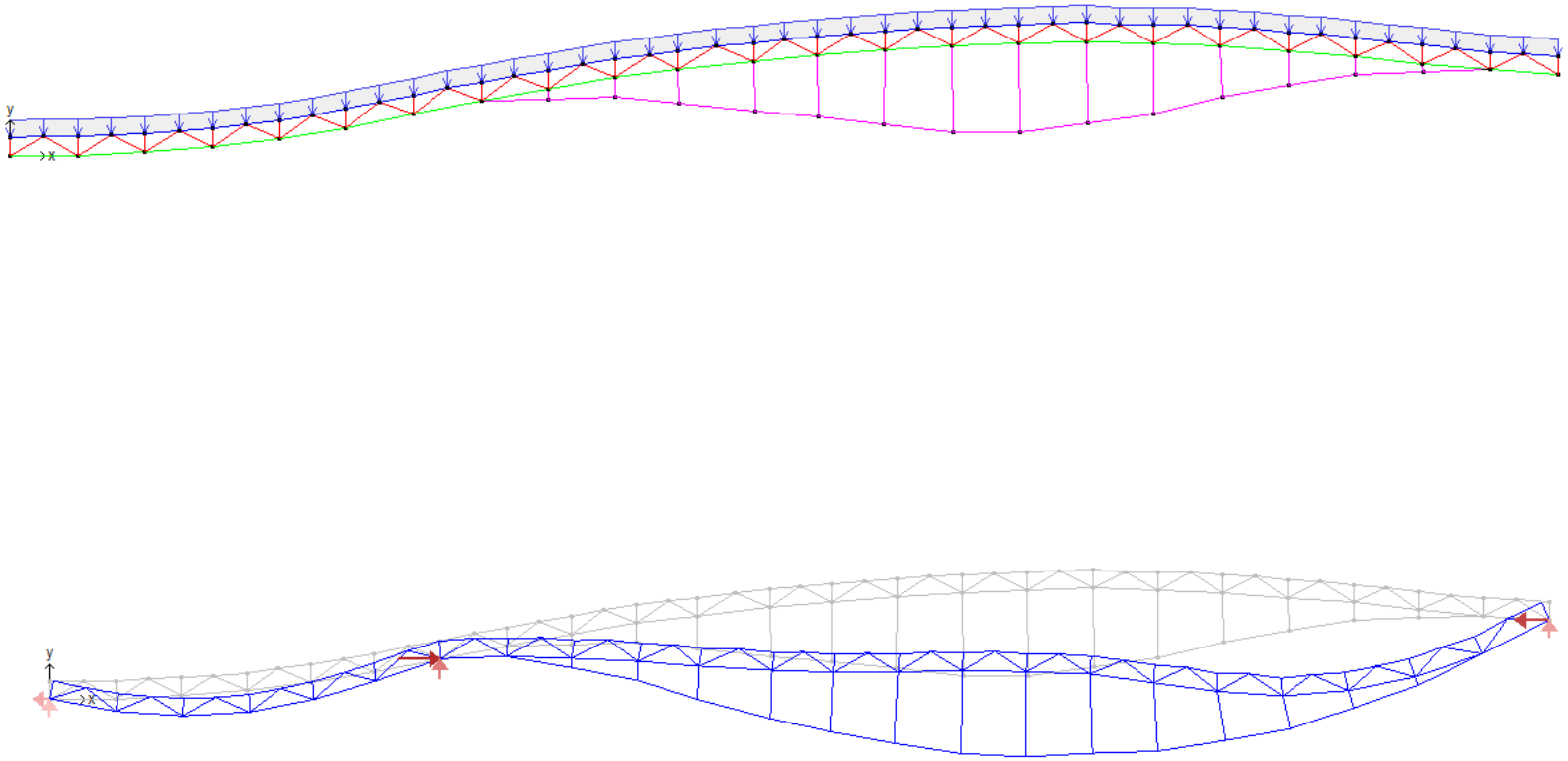
Substance	Weight lb per cu ft	Specific Gravity
METALS, ALLOYS, ORES		
Aluminum, cast, hammered	165	2.55–2.75
Brass, cast, rolled	534	8.4–8.7
Bronze, 7.9 to 14% Sn	509	7.4–8.9
Bronze, aluminum	481	7.7
Copper, cast, rolled	556	8.8–9.0
Copper ore, pyrites	262	4.1–4.3
Gold, cast, hammered	1205	19.25–19.3
Iron, cast, pig	450	7.2
Iron, wrought	485	7.6–7.9
Iron, spiegel-eisen	468	7.5
Iron, ferro-silicon	437	6.7–7.3
Iron ore, hematite	325	5.2
Iron ore, hematite in bank	160–180	–
Iron ore, hematite loose	130–160	–
Iron ore, limonite	237	3.6–4.0
Iron ore, magnetite	315	4.9–5.2
Iron slag	172	2.5–3.0
Lead	710	11.37
Lead ore, galena	465	7.3–7.6
Magnesium, alloys	112	1.74–1.83
Manganese	475	7.2–8.0
Manganese ore, pyrolusite	259	3.7–4.6
Mercury	849	13.6
Monel Metal	556	8.8–9.0
Nickel	565	8.9–9.2
Platinum, cast, hammered	1330	21.1–21.5
	656	10.4–10.6
Steel, rolled	490	7.85
Tin, cast, hammered	459	7.2–7.5
Tin ore, cassiterite	418	6.4–7.0
Zinc, cast, rolled	440	6.9–7.2
Zinc ore, blende	253	3.9–4.2
VARIOUS SOLIDS		
Cereals, oats ..... bulk	32	–
Cereals, barley ..... bulk	39	–
Cereals, corn, rye ..... bulk	48	–
Cereals, wheat ..... bulk	48	–
Hay and Straw ..... bales	20	–
Cotton, Flax, Hemp	93	1.47–1.50
Fats	58	0.90–0.97
Flour, loose	28	0.40–0.50
Flour, pressed	47	0.70–0.80
Glass, common	156	2.40–2.60
Glass, plate or crown	161	2.45–2.72
Glass, crystal	184	2.90–3.00
Leather	59	0.86–1.02
Paper	58	0.70–1.15
Potatoes, piled	42	–
Rubber, caoutchouc	59	0.92–0.96
Rubber goods	94	1.0–2.0
Salt, granulated, piled	48	–
Saltpeter	67	–
Starch	96	1.53
Sulphur	125	1.93–2.07
Wool	82	1.32
TIMBER, U.S. SEASONED		
Moisture content by weight:		
Seasoned timber 15 to 20%		
Green timber up to 50%		
Ash, white, red	40	0.62–0.65
Cedar, white, red	22	0.32–.038
Chestnut	41	0.66
Cypress	30	0.48
Fir, Douglas spruce	32	0.51
Fir, eastern	25	0.40
Elm, white	45	0.72
Hemlock	29	0.42–0.52
Hickory	49	0.74–0.84
Locust	46	0.73
Maple, hard	43	0.68
Maple, white	33	0.53
Oak, chestnut	54	0.86
Oak, live	59	0.95
Oak, red, black	41	0.65
Oak, white	46	0.74
Pine, Oregon	32	0.51
Pine, red	30	0.48
Pine, white	26	0.41
Pine, yellow, long-leaf	44	0.70
Pine, yellow, short-leaf	38	0.61
Poplar	30	0.48
Redwood, California	26	0.42
Spruce, white, black	27	0.40–0.46
Walnut, black	38	0.61
Walnut, white	26	0.41
VARIOUS LIQUIDS		
Alcohol, 100%	49	0.79
Acids, muriatic 40%	75	1.20
Acids, nitric 91%	94	1.50
Acids, sulphuric 87%	112	1.80
Lye, soda 66%	106	1.70
Oils, vegetable	58	0.91–0.94
Oils, mineral, lubricants	57	0.90–0.93
Water, 4° C max. density	62.428	1.0
Water, 100° C	59.830	0.9584
Water, ice	56	0.88–0.92
Water, snow, fresh fallen	8	.125
Water, sea water	64	1.02–1.03
GASES		
Air, 0° C 760 mm	.08071	1.0
Ammonia	.0478	0.5920
Carbon dioxide	.1234	1.5291
Carbon monoxide	.0781	0.9673
Gas, illuminating	.028–.036	0.35–0.45
Gas, natural	.038–.039	0.47–0.48
Hydrogen	.00559	0.0693
Nitrogen	.0784	0.9714
Oxygen	.0892	1.1056

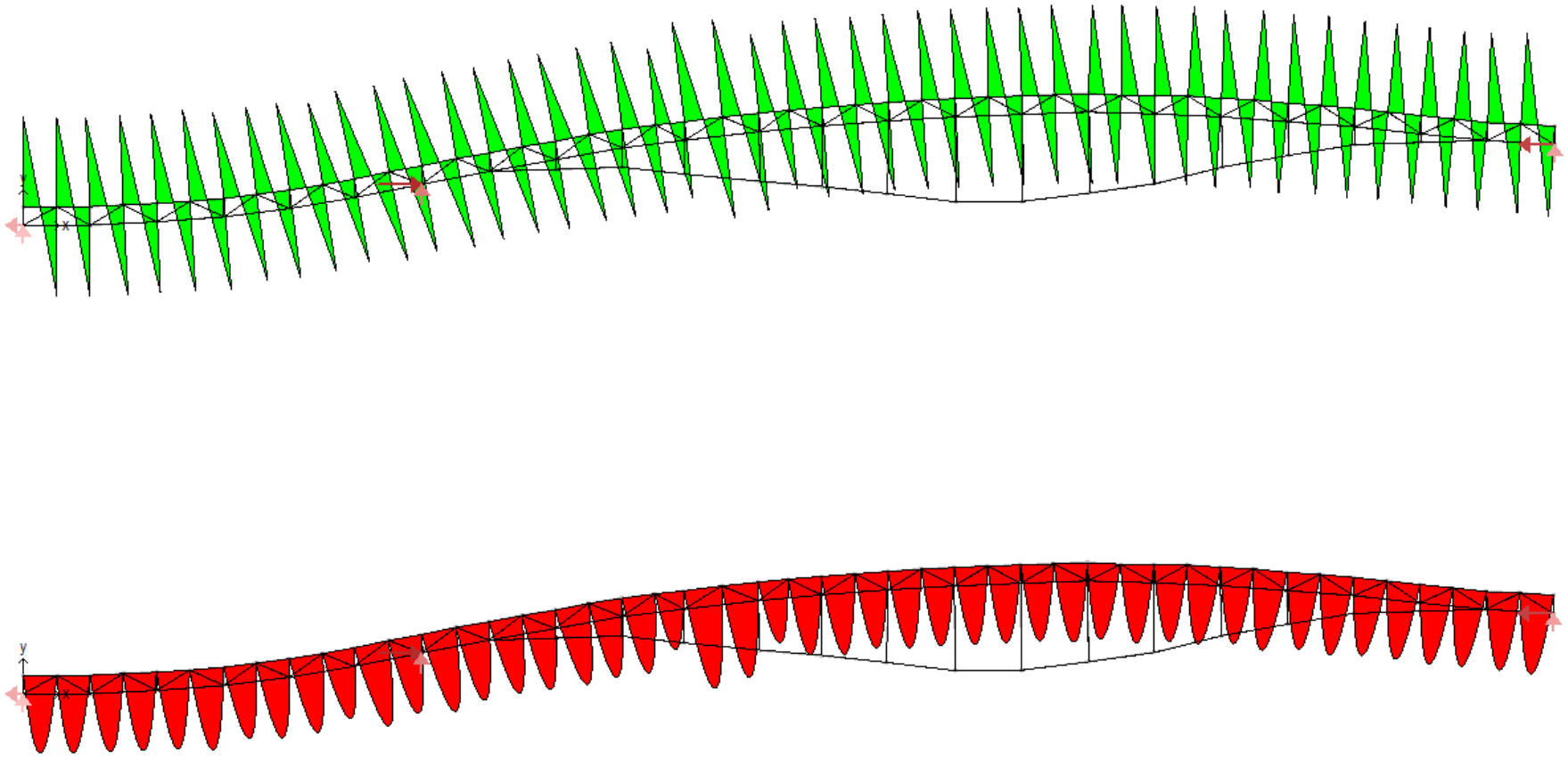
The specific gravities of solids and liquids refer to water at 4° C, those of gases to air at 0° C and 760 mm pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped, or loose material, etc.

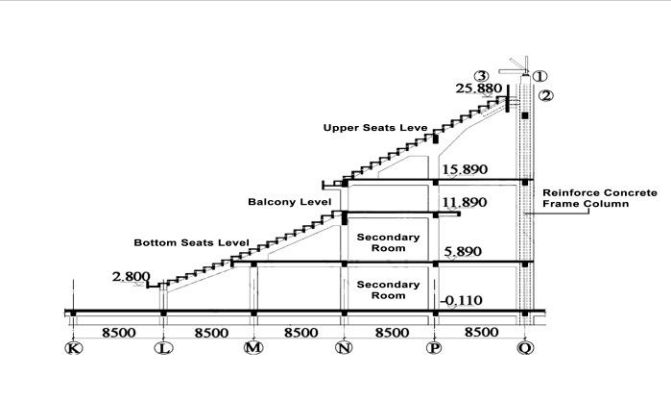
AMERICAN INSTITUTE OF STEEL CONSTRUCTION

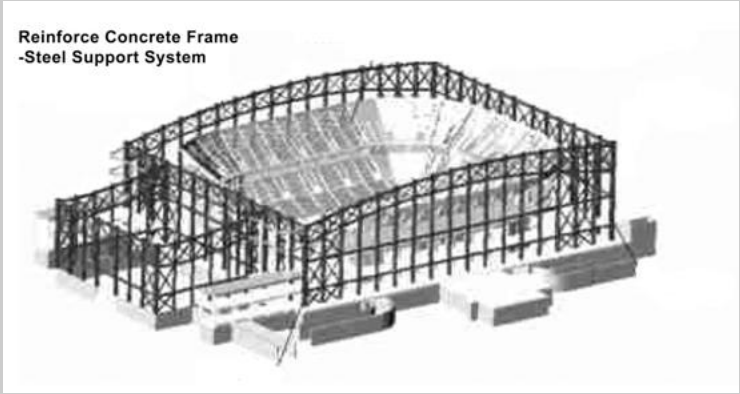
LRFD:

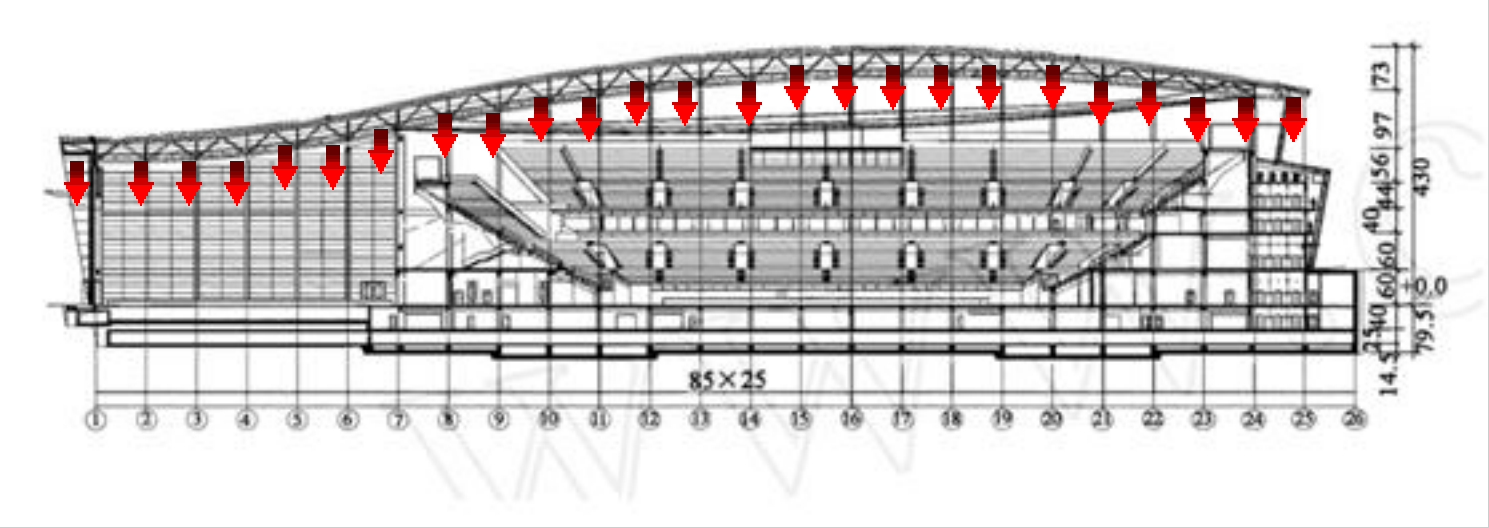
$$1.2DL + 1.6S + 0.8W = 1.2\left(590.21\frac{KN}{m}\right) + 1.6\left(5.262\frac{KN}{m}\right) + 0.8\left(4.8235\frac{KN}{m}\right) = 720.53\frac{KN}{m}$$


Sections
450.275
tube_480
tube_159
cable
Default Colour
All loads
y
x
y
x







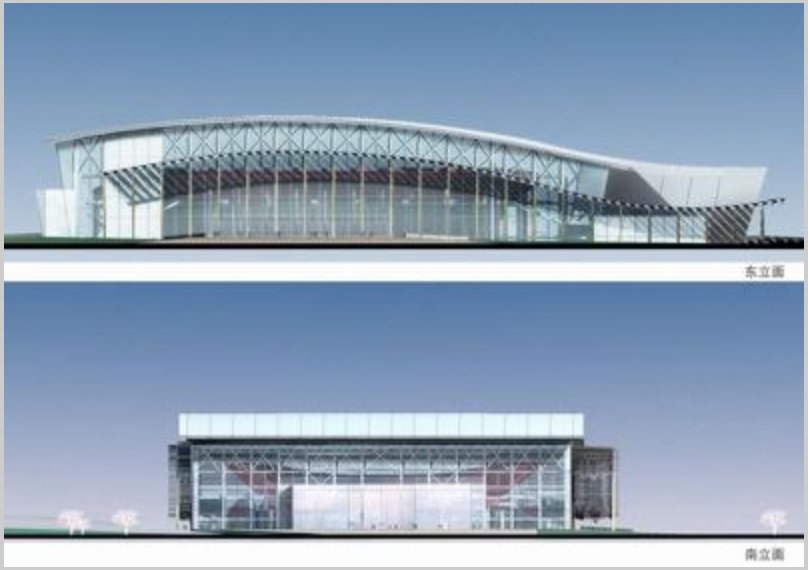


Loads from the roof trusses are transferred to the ground through a frame consisting of 437 beams and 78 columns of steel reinforced concrete.

Construction Considerations

- Durable structural design of 100 years
- Base structure reliability of 50 years
- Seismic design category “B” which indicates almost no limitations
- Seismic intensity of 8, which means
  - People have difficulty walking during activity
  - Moderate destruction occurs, including structural destruction
  - Peak acceleration is 2.5 m/s^2
  - Peak speed is 0.25 m/s

Seismic Evaluation



- Performance Evaluation: maximum displacement angle of 1/138 occurred in the y direction in the first group under the action of natural seismic waves

Seismic Evaluation

- Shear wall structure is main structural system for straightforward earthquake transmission and has very good stiffness and deformation
- Concrete cylinders supporting the balcony structure have good lateral force stiffness and the ability to stand as part of the reinforced concrete frame

Seismic Evaluation

- Steel structural system strengthens the balcony and enhances the in-plane stiffness, integrity, rigidity and stability of the reinforced concrete columns
- A steel reinforced concrete frame can maximize steel's good ductility and concrete's resistance to stress to improve seismic performance

Seismic Analysis

- Multi-structural system is good for seismic forces in large span structures
- Good ductility and stiffness of the system has influence over the large-span areas, improving their overall security
- Structure meets severe earthquake need in maximum story displacement
- Working condition is maintained
- Has reserves of strength and deformation capacity

The Beijing 2008 Olympic National Indoor Stadium is an example of a modern structural accomplishment.

It meets structural design standards in terms of aesthetics, safety and reliability while creating an incredibly interesting vision and a monumentality successful functional building to be enjoyed by generations to come.