15th U.S.-Japan Workshop on Improvement of Structural Engineering and Resiliency

Seismic Response Control of the having large space with damper and Canyon Mullion

Takeo HAIJIMA
AZUSA SEKKEI Co.,Ltd.
Tokyo , Japan

AZUSA SEKKEI
Architects,Engineers & Consultants

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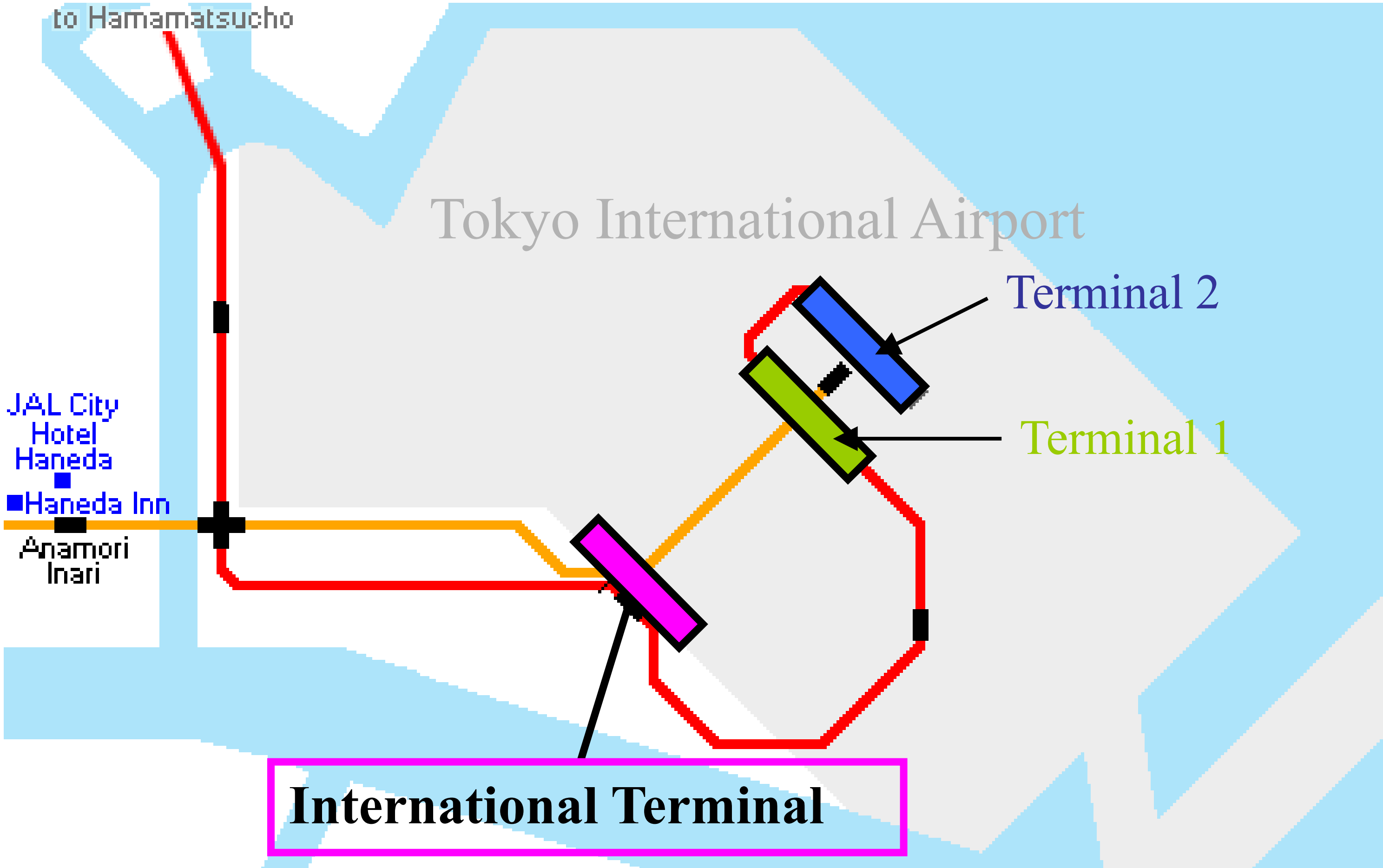
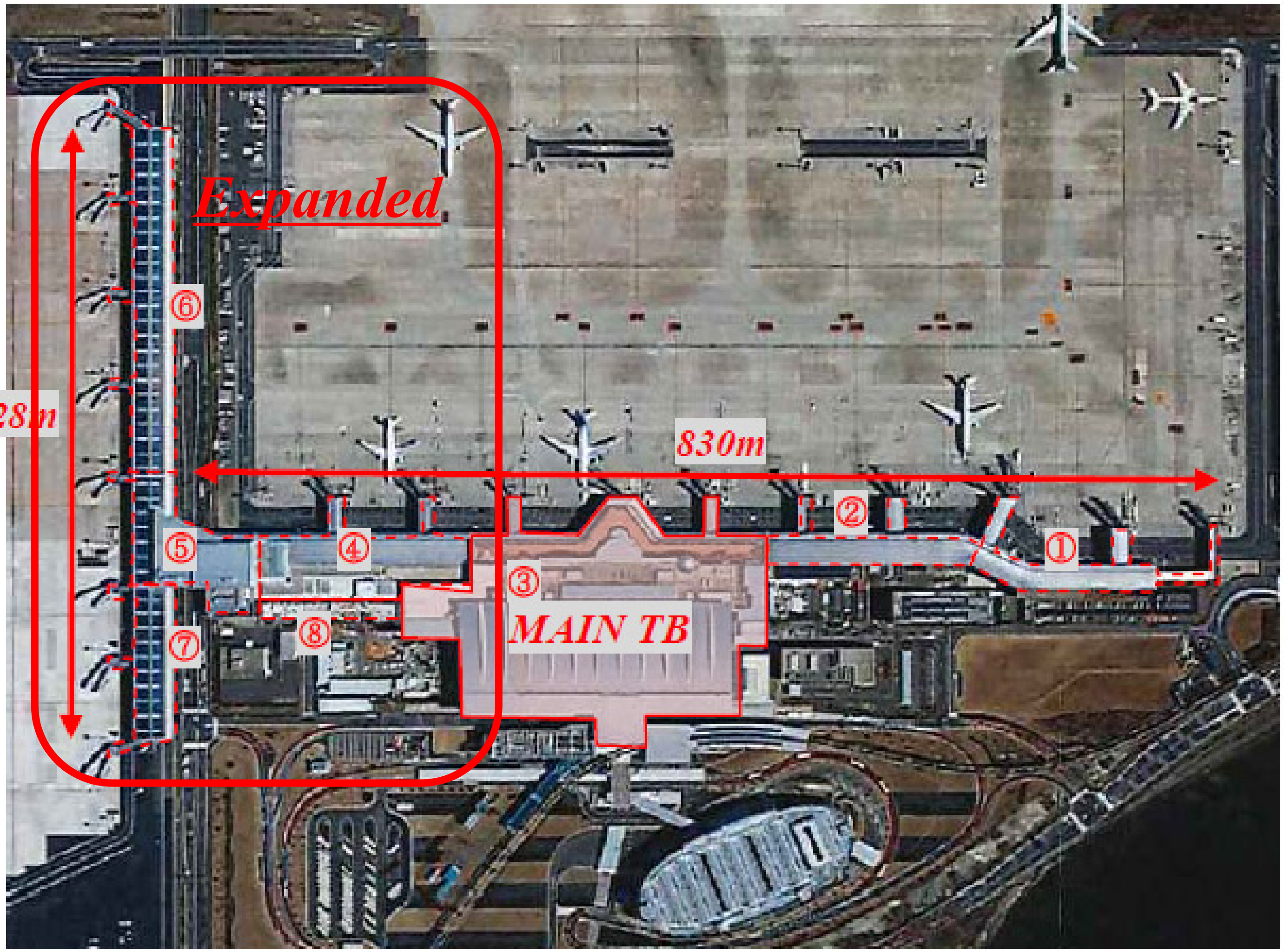
Introduction-1



Introduction-2

Introduction-3



①South Wing 2
②South Wing 1
③Main TB
④North Wing
⑤Satellite 1
⑥Satellite 2
⑦Satellite 3
⑧Hotel

Main Building Outline-1

Location : Tokyo , Japan

Total floor area : 134,400㎡

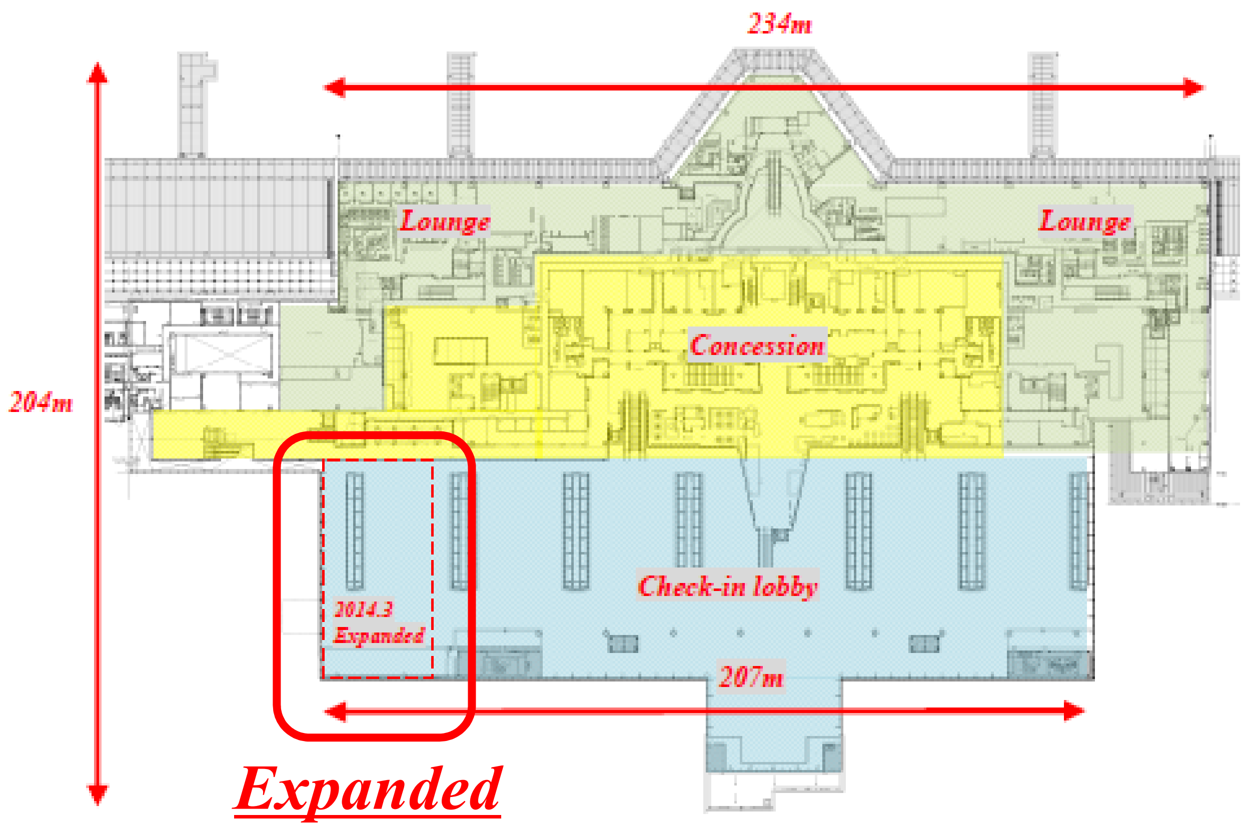
Number of stories : 5 stories

Height of building : 43.15m

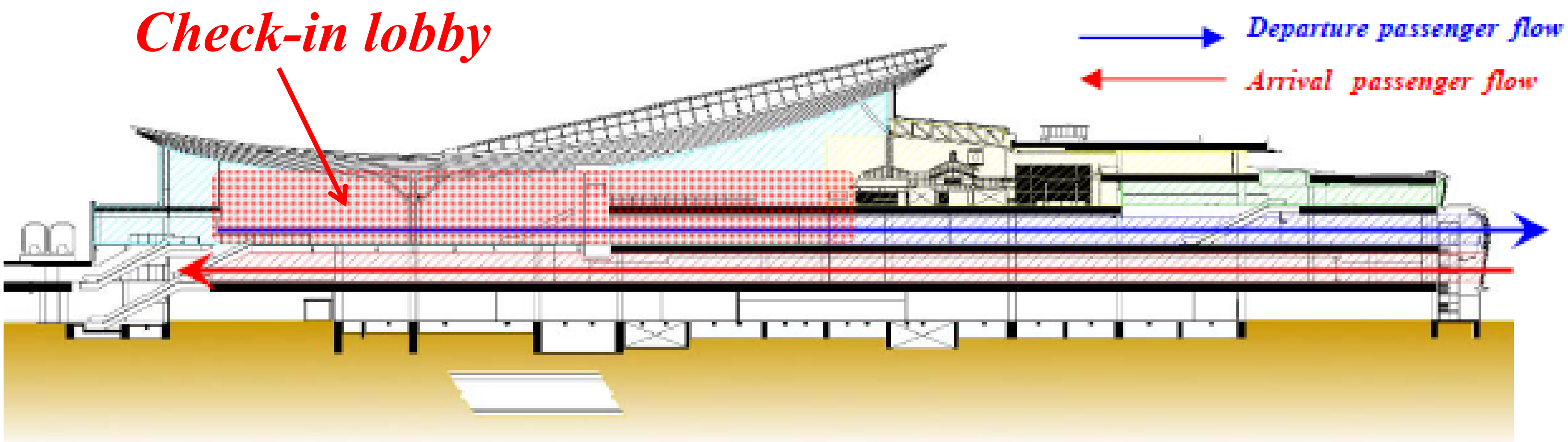
Structure : Steel structure
with CFT Column
partly SRC or RC

Foundation : Steel pipe piles
PHC piles

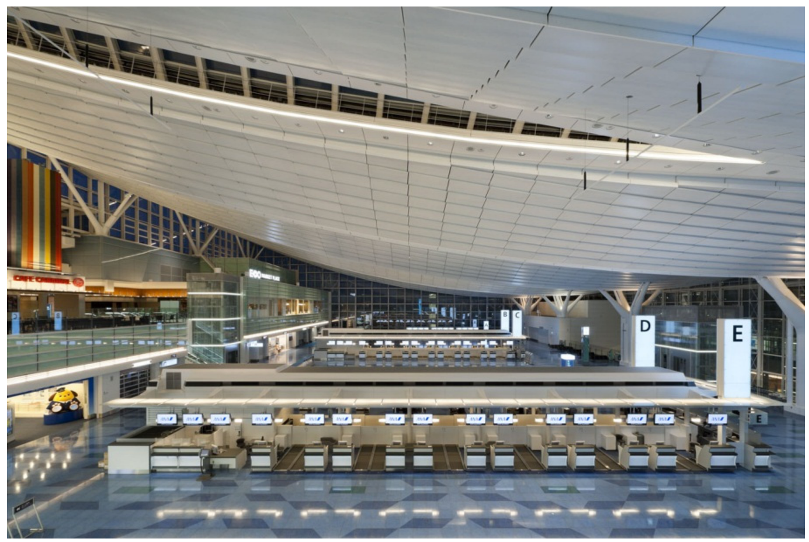
Roof finishing : Waterproofing
with stainless
steel sheet



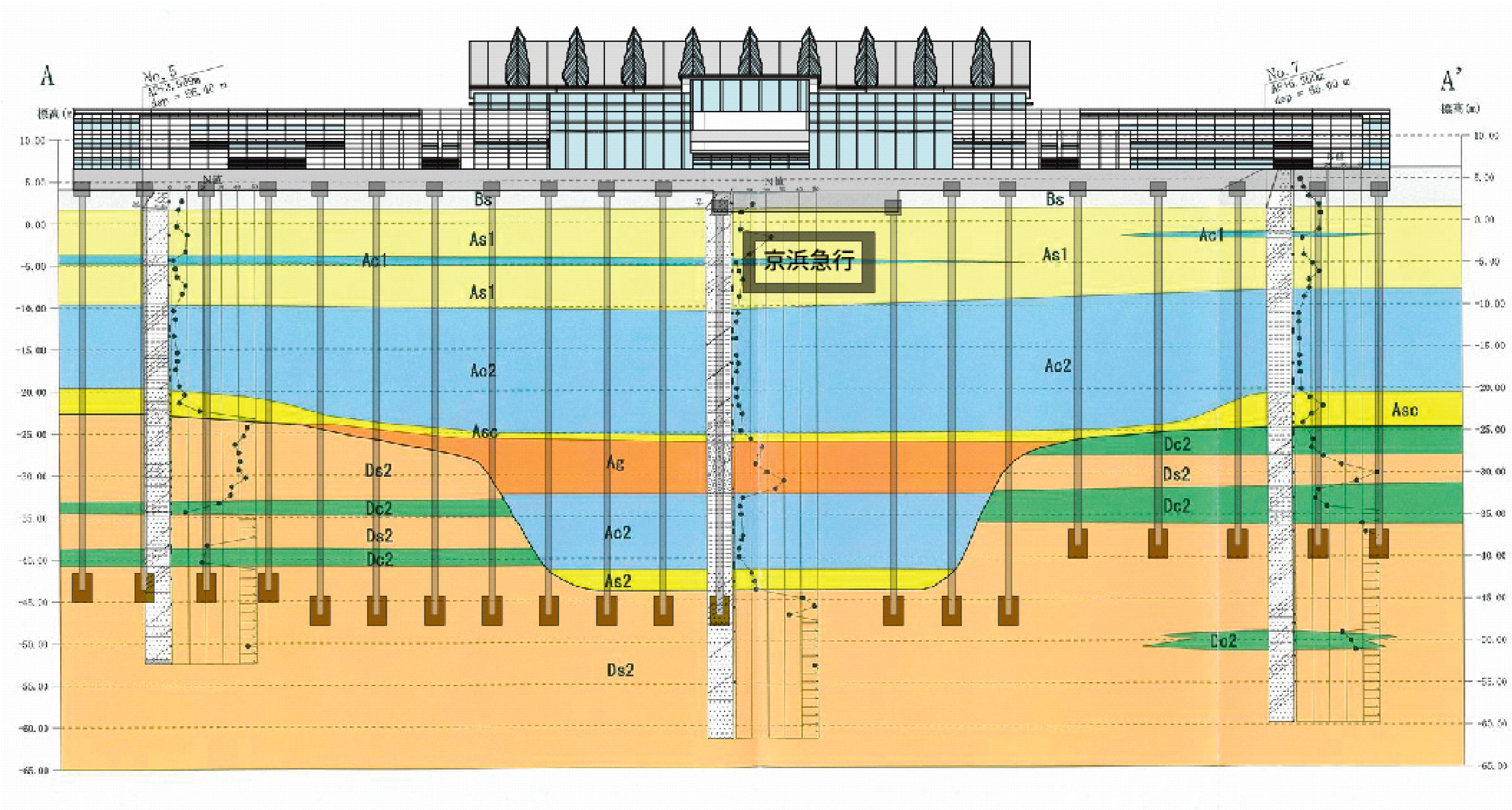
Main Building Outline-2



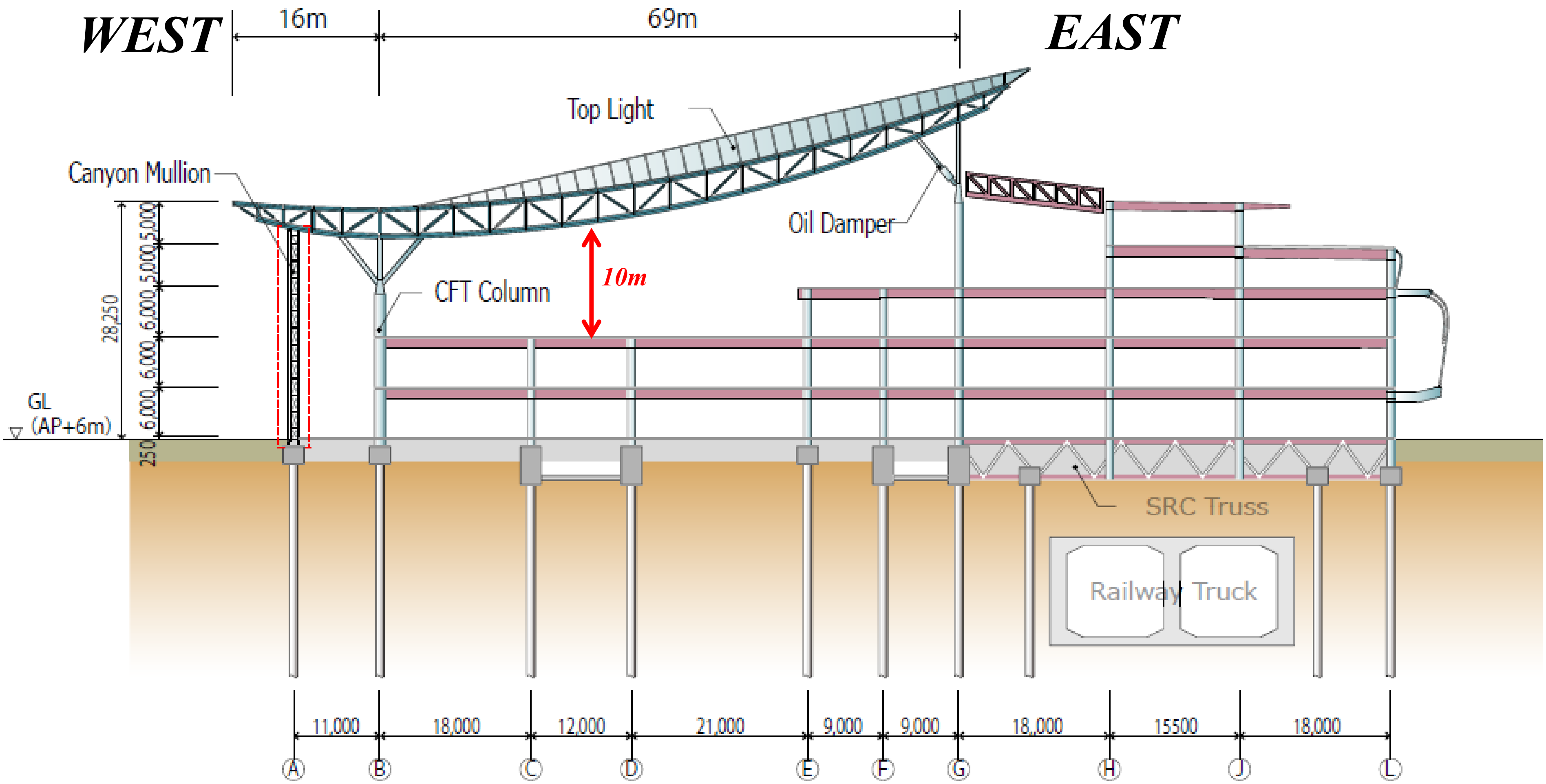
Check-in Lobby



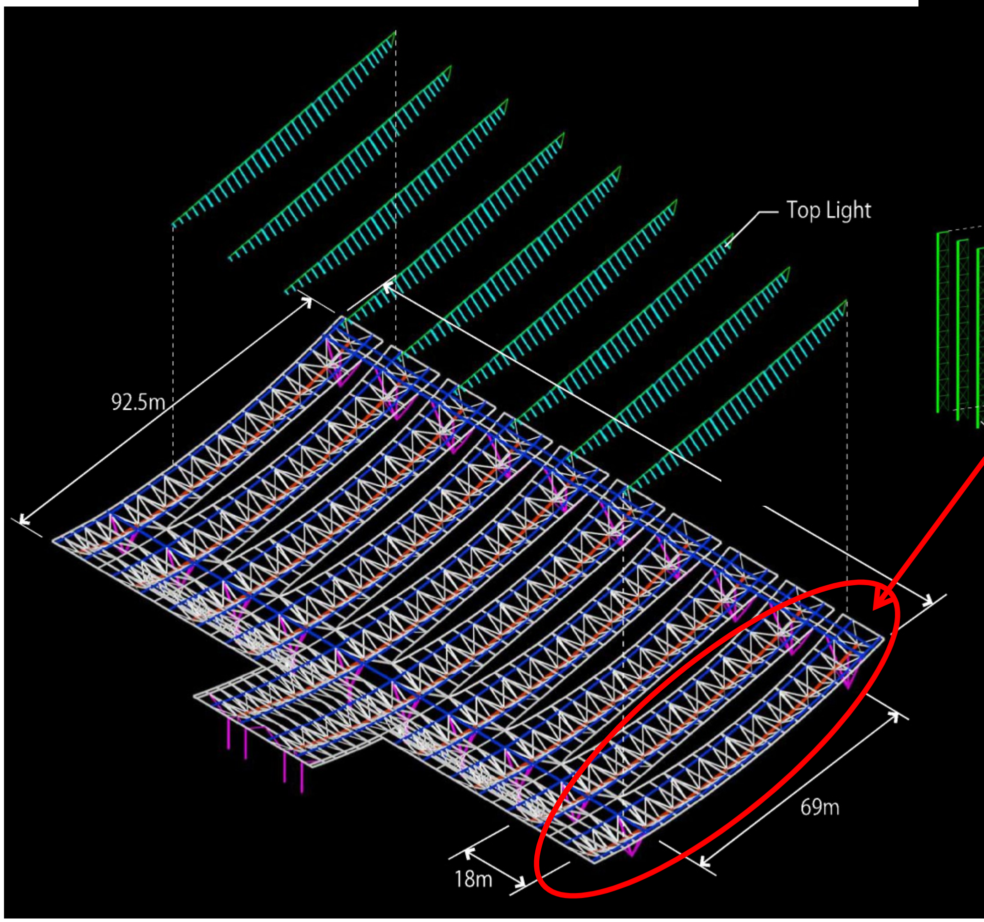
Ground / Foundation

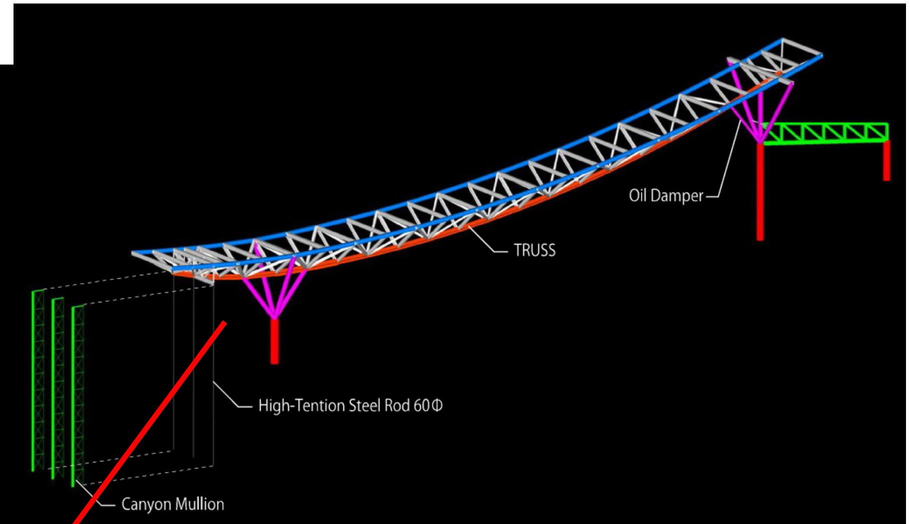


Upper Structure and Huge Roof Structure

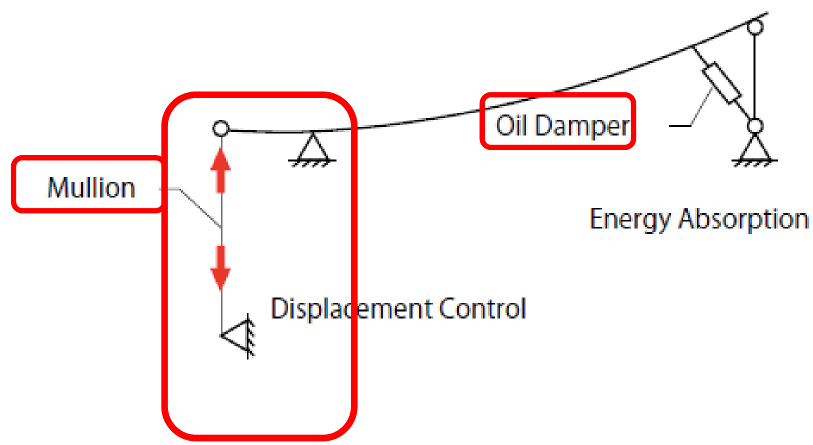


Huge Roof Structure

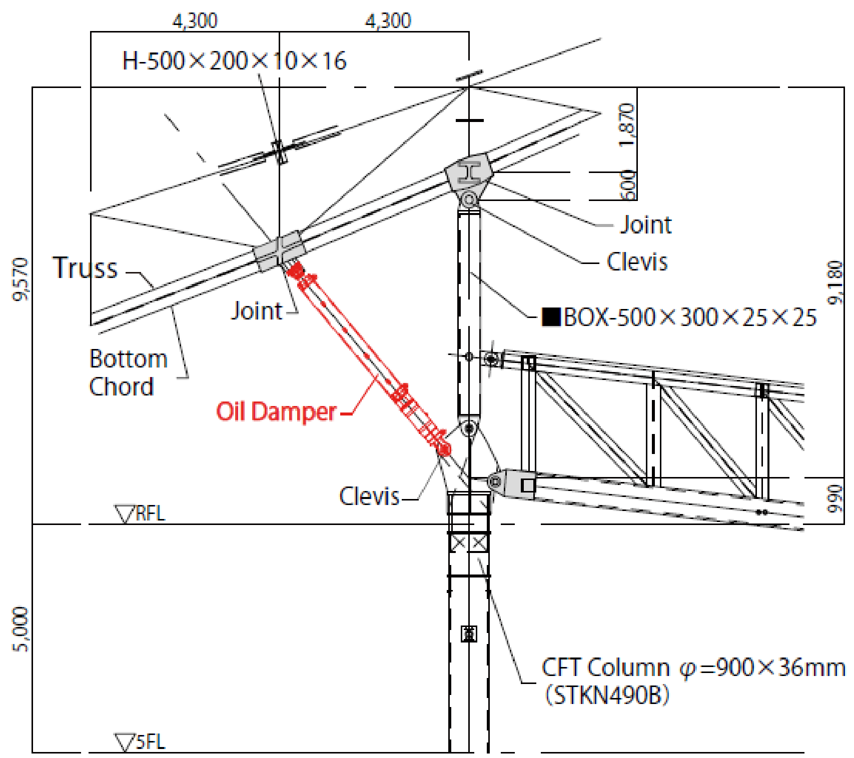


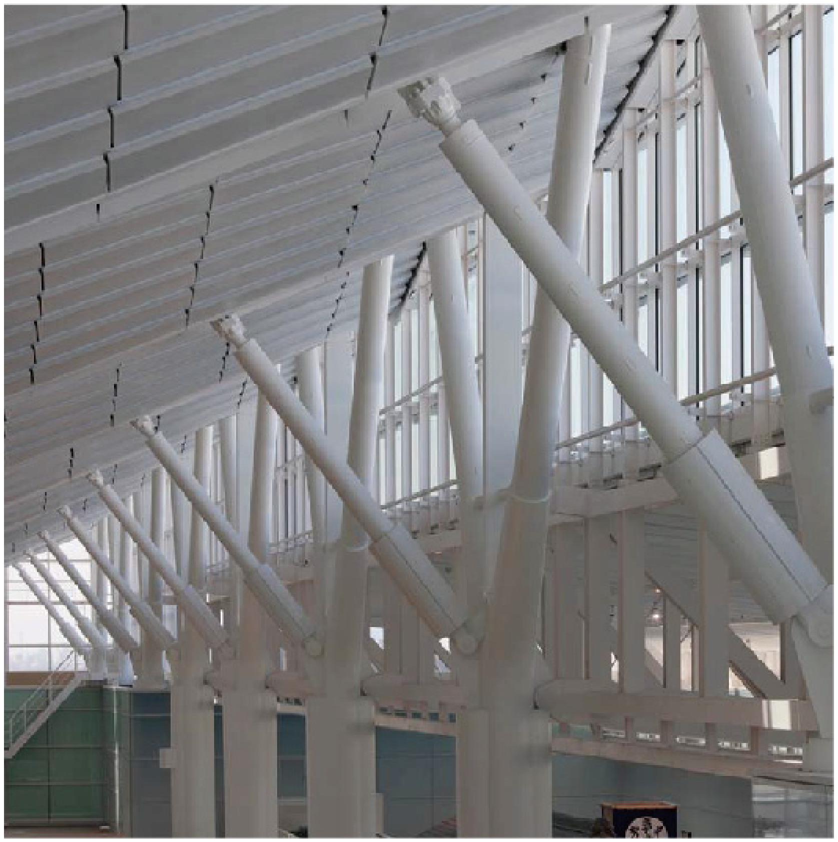


Truss + Oil Damper + Mullion

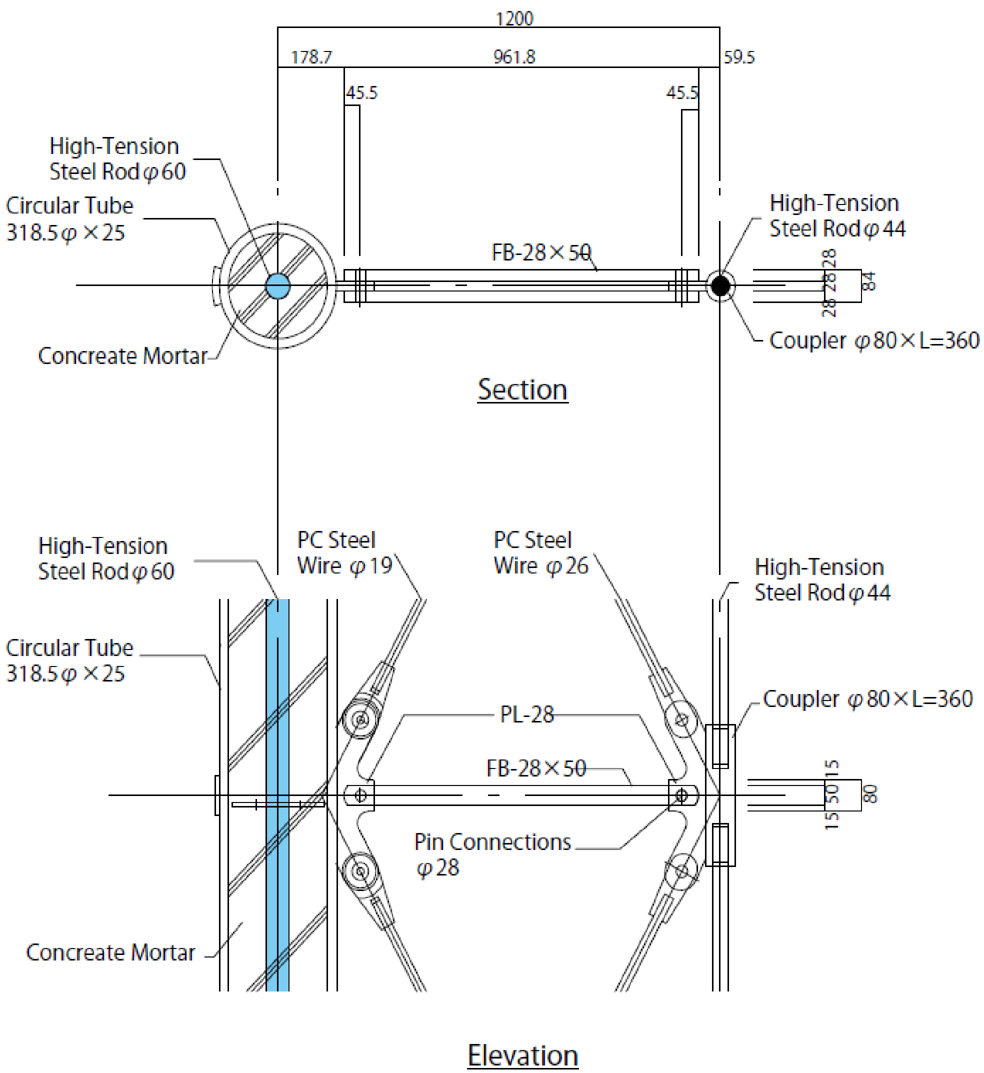


Damper System





Mullion System



Structural Design Load-1

The following 7 types of design loads are adopted.

ⅰ)Dead load (G): self-weight of steel frames, catwalks, equipment loads,
finish loads, and the like

ⅱ)Live load(P)

ⅲ)Snow load(S): snow depth of 30cm

ⅳ)Temperature load(T): ±20℃

ⅴ)Wind load(W): division Ⅱ of ground surface roughness
Standard wind velocity of 38m/s (under a return period of 100 years)
Wind force coefficients are according to wind tunnel tests

ⅵ)Seismic load(K): at the time of first-order design : $C_0=0.2$
at the time of second-order design : $C_0=0.6$

ⅶ)Vertical load at the time of seismic loading (KV): $K_V=0.5G$

Structural Design Load-2

The following 6 types of combines design loads are adopted.

Long-term loading stress : (Ⅰ) G＋P＋T

(Ⅱ) G＋P－T

Short-term loading stress : (Ⅰ) G＋P＋S－T

(Ⅱ) G＋P＋W

(Ⅲ) G＋P＋K＋KV＋T

(Ⅳ) G＋P＋K＋KV－T

Seismic Force for Design

Seismic Forces: Modal Analysis (SRSS)

Eigenvalue analysis model

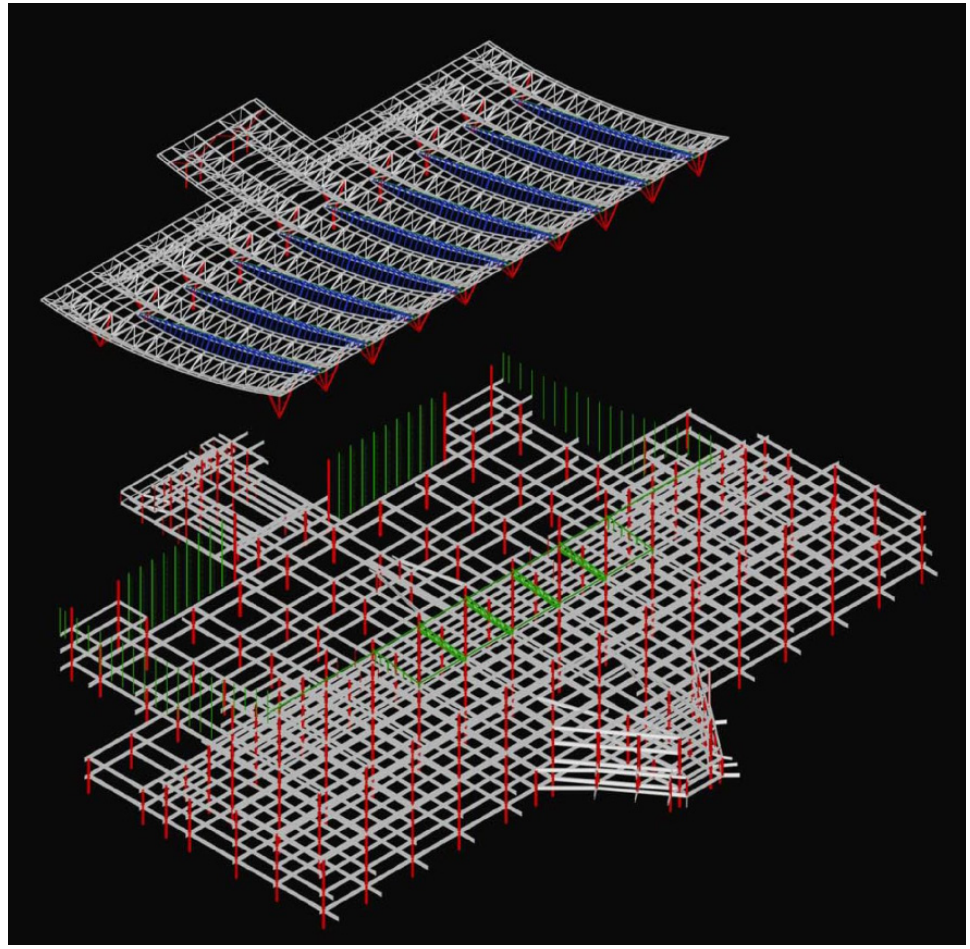
- 3-dimensional space analysis model
- The node mass

  Pillar about 600 nodes

  Roof about 1000 nodes

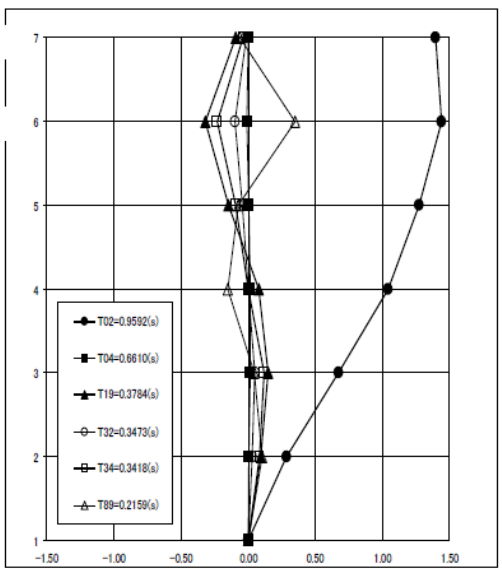
- Eigenvalue analysis

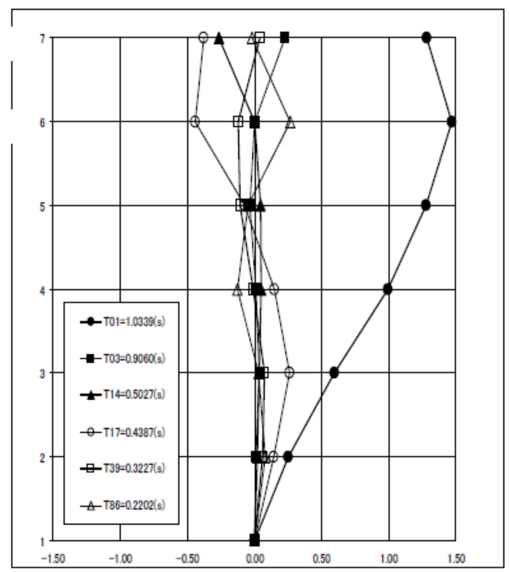
  100-order.



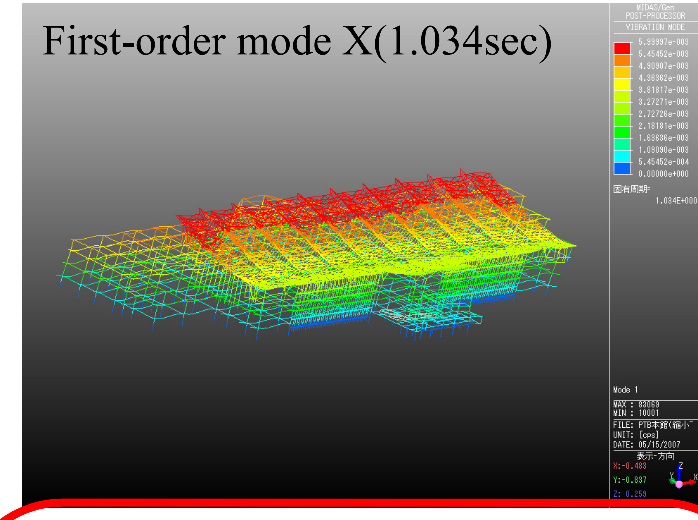
Eigenvalue Analysis -1

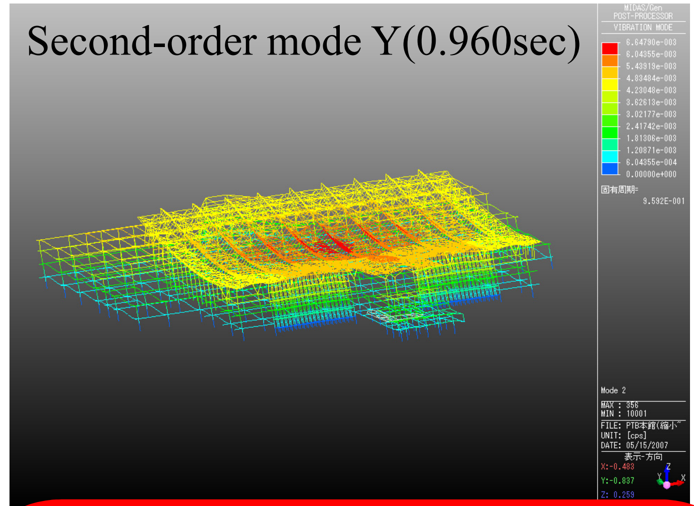
Modal order	Natural frequency (Hz)	Natural period (sec.)	Participation factor		
			βx	βy	βz
1	0.967	1.034	281.81	0.68	0.01
2	1.043	0.960	-0.76	290.71	-4.65
3	1.104	0.906	54.94	0.63	0.15
4	1.513	0.661	0.10	35.33	37.97
5	1.548	0.646	1.97	-0.59	-0.15
6	1.583	0.632	-0.06	-6.49	-17.45
7	1.645	0.608	-4.42	0.30	0.25
8	1.700	0.590	-0.07	2.79	9.47
9	1.775	0.563	-6.55	-0.18	-0.05
10	1.860	0.538	0.13	4.74	-7.14

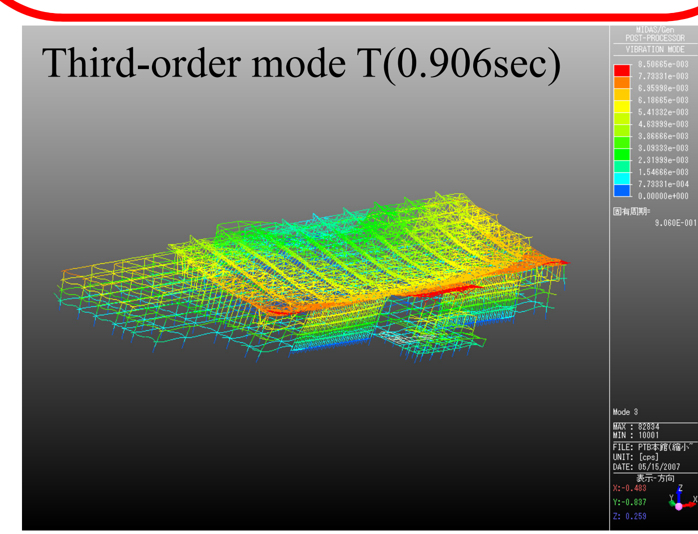


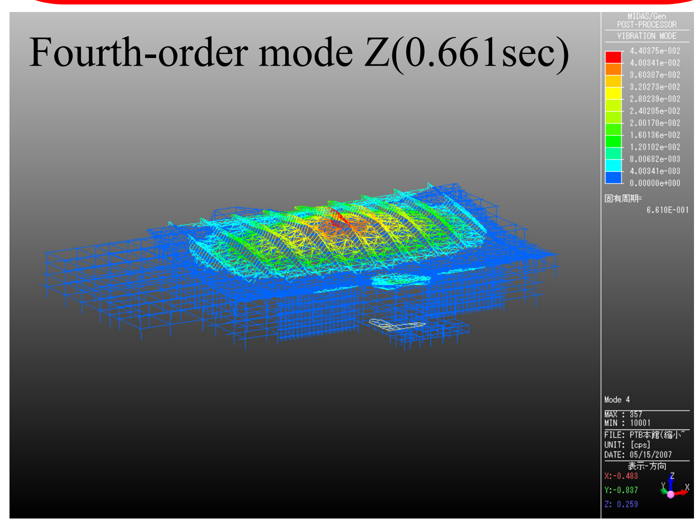


Eigenvalue Analysis-2

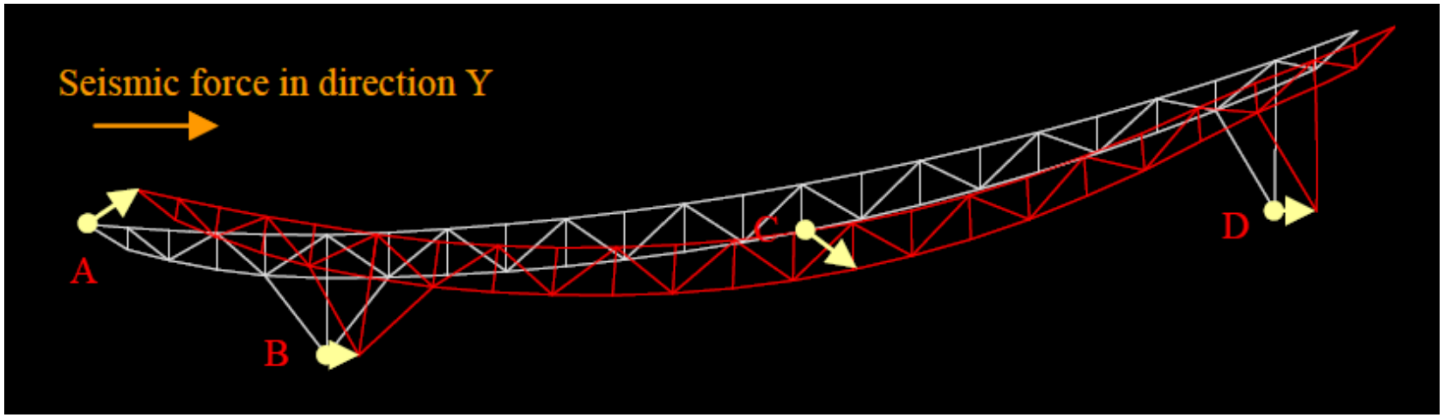

First-order mode X(1.034sec)


Second-order mode Y(0.960sec)


Third-order mode T(0.906sec)


Fourth-order mode Z(0.661sec)

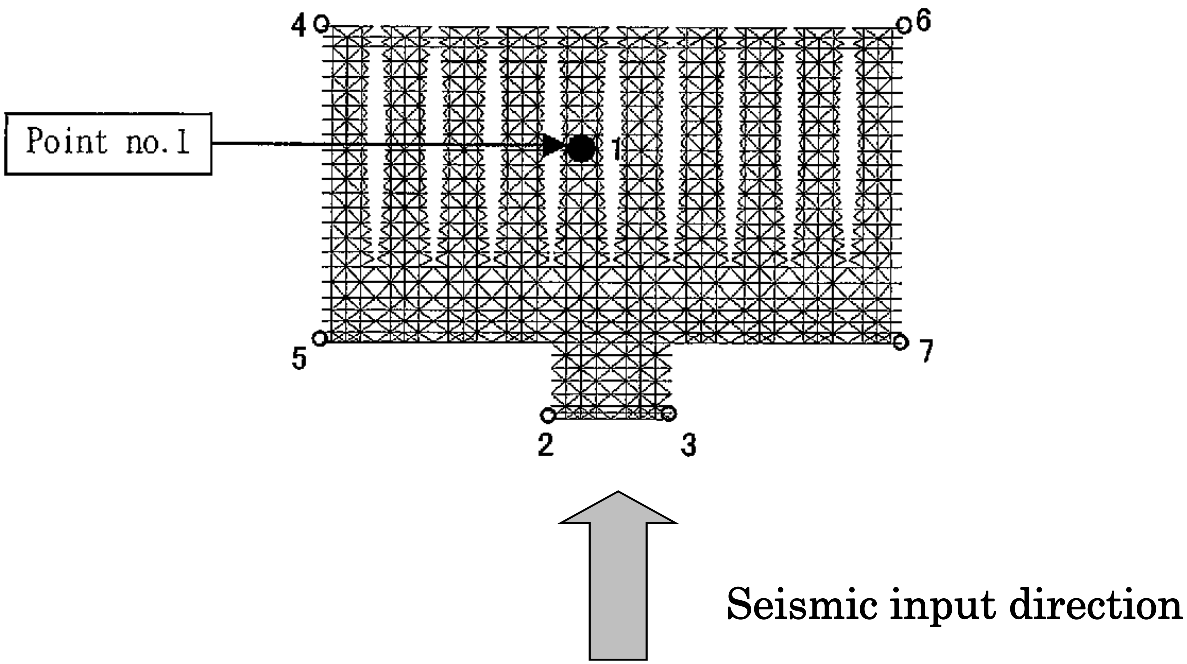
Seismic Displacement of the Huge Roof



Location	Direction	Case 1	Case2	Case1/Case2
A	Δy	261	315	0.83
	Δz	84	210	0.40
B	Δy	198	195	1.02
C	Δy	264	306	0.86
	Δz	-159	-234	0.68
D	Δy	249	255	0.98

Seismic Response Analysis results

Wave	Acceleration(cm/sec2)			Displacement(mm)		
	Case1	Case2	Case1/Case2	Case1	Case2	Case1/Case2
HACHINOHE	666	993	0.67	-130	-160	0.82
KOBE	-675	1804	0.38	130	-240	0.55
RANDOM1	-821	1853	0.44	-150	-250	0.60
RANDOM2	786	1801	0.44	140	-260	0.54
RANDOM3	785	-1762	0.45	160	-240	0.67



Conclusions

★ High-strength steel between cantilever beams in the large roof and basement made it possible to reduced vertical movement when huge earthquakes happen.

★The result assured that oil-damper made it possible to reduced acceleration and displacement when huge earthquake happen.

Thank you very much for kind attention