HSBC

Hongkong and Shanghai Banking Corporation

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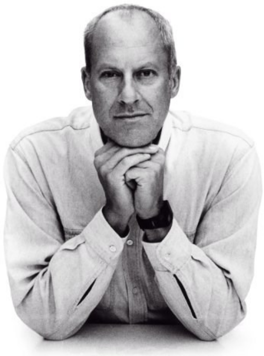
Introduction

- Finished in 1986
- High-tech
- Prefabrication
- Assembly on site
- Cost: $2.3 billion, the most expensive building at that time.

- 594 feet (180m) height
- 47 stories above ground and 4 stories underground
- 1076000 sf (100000㎡) floor space

Designer



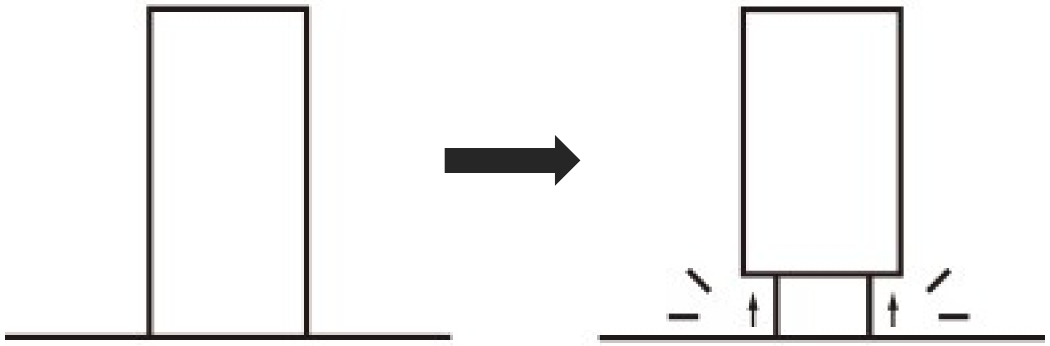
- Architect: Norman Foster

He is one of Britain's most prolific architects of his generation. In 1999 he was awarded the Pritzker Architecture Prize,

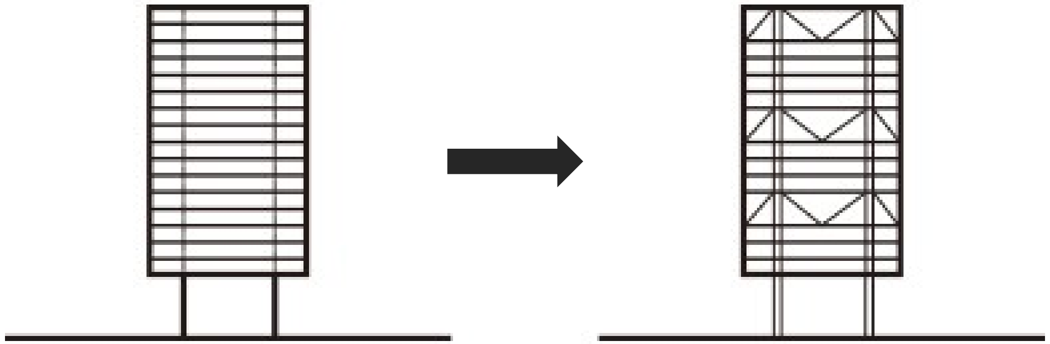
- Structure Engineering: ARUP
- A multinational professional services firm headquar tered in London which designed the structure of CCTV, Sydney Opera House and so on.

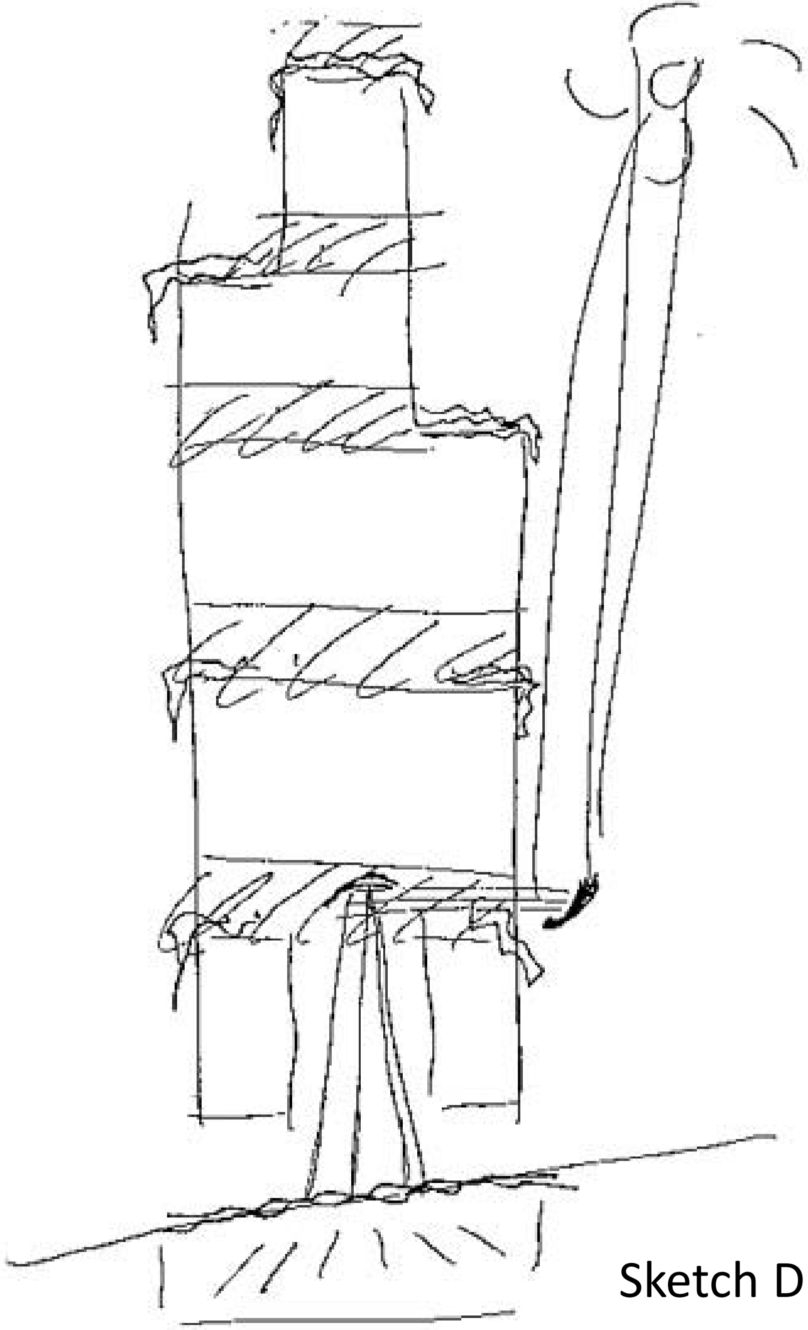
Concept Design

- SOFT 1ST FLOOR (open to the public)



- SUSPENDED STRUCTURE (reconfigure office layouts with ease)

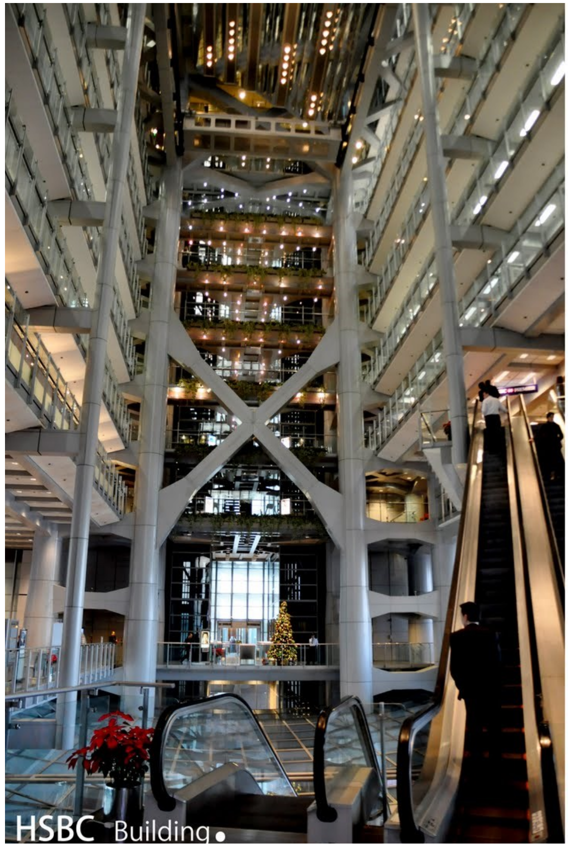




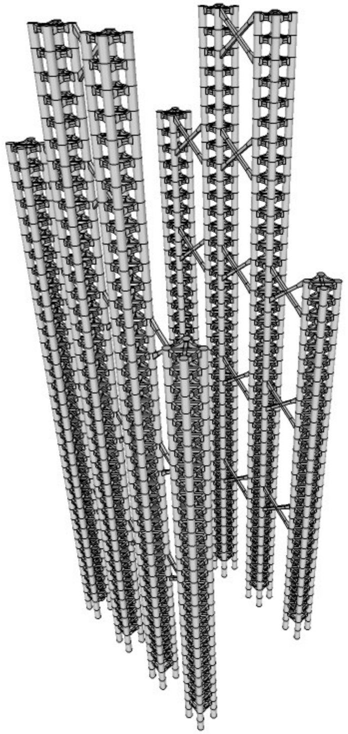
Sketch Drawing

Features

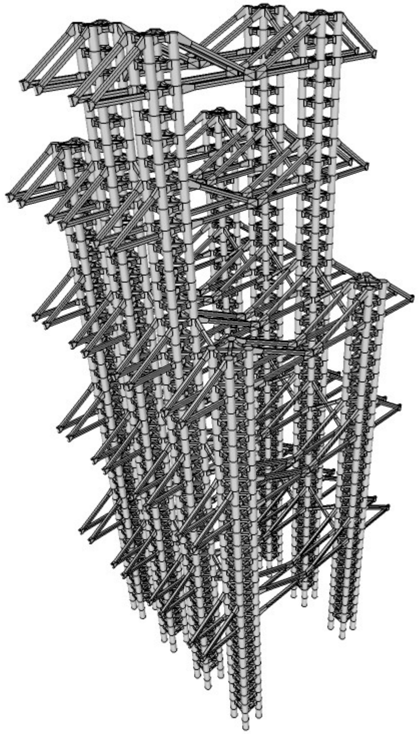
- Large, open and column free space
- Hanging structure
- Exoskeleton steel truss
- Elevate ground floor for public space
- 132 feet (40m) height atrium
- Mirrors on top of atrium were designed to maximize the use of natural light.



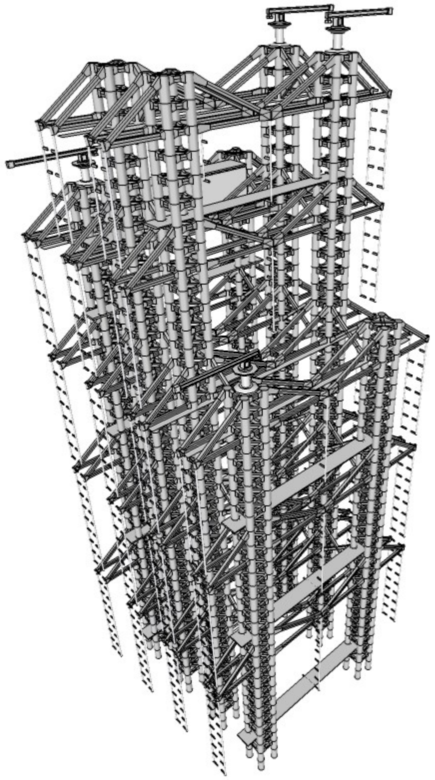
Structure System



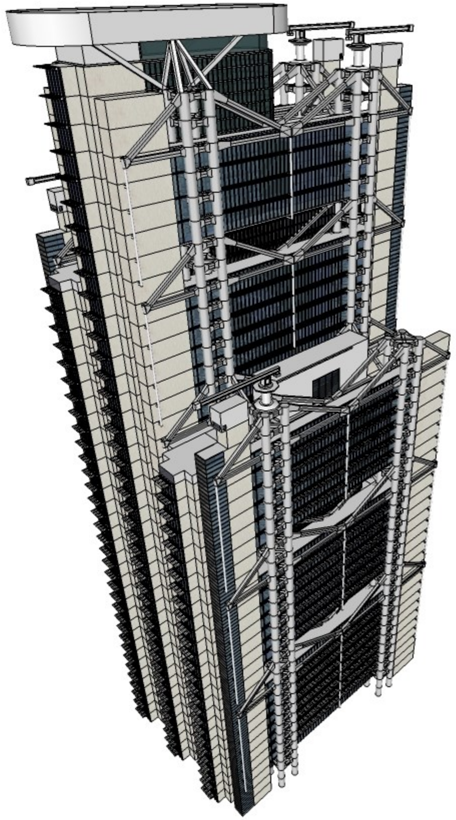
Mast



Truss

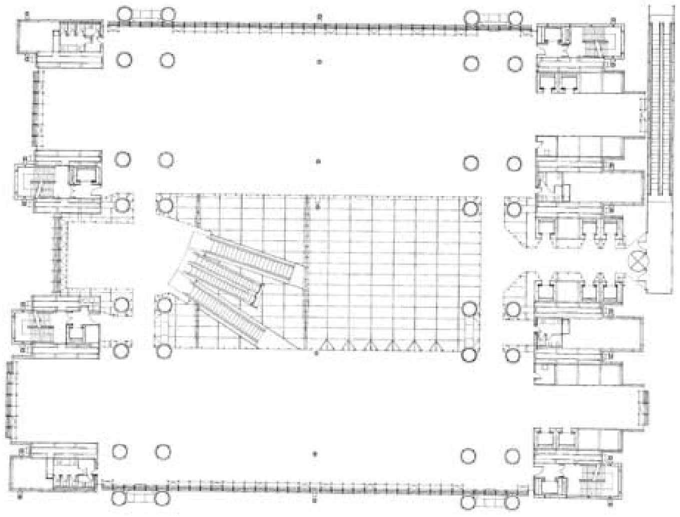


Cantilever

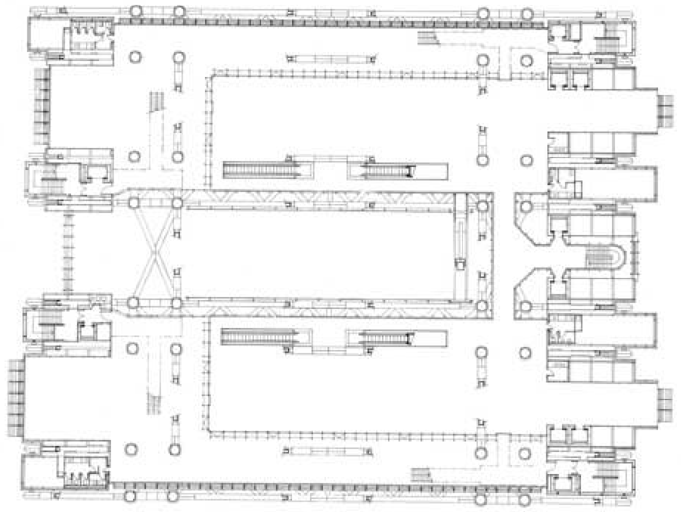


Skin

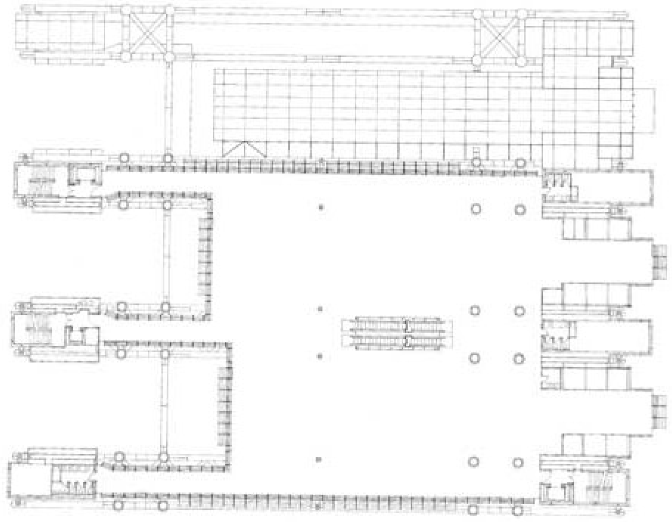
Floor Plans



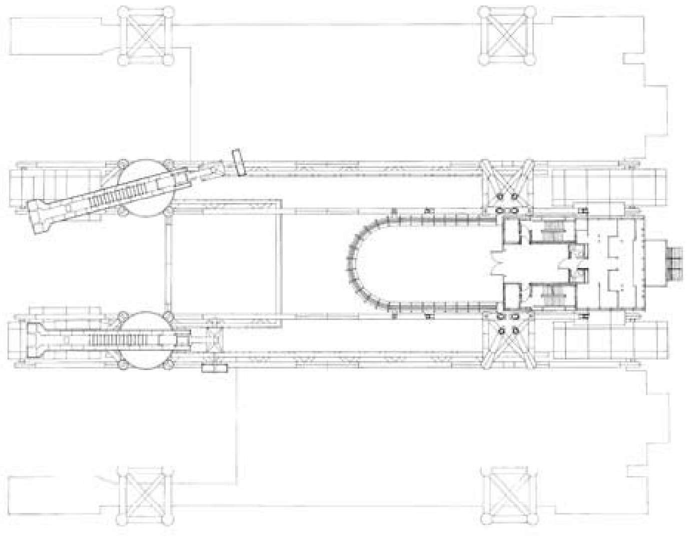
3st Floor Plan



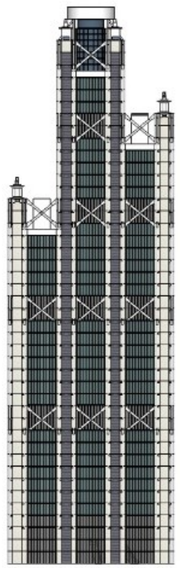
18th Floor Plan



30st Floor Plan



37st Floor Plan



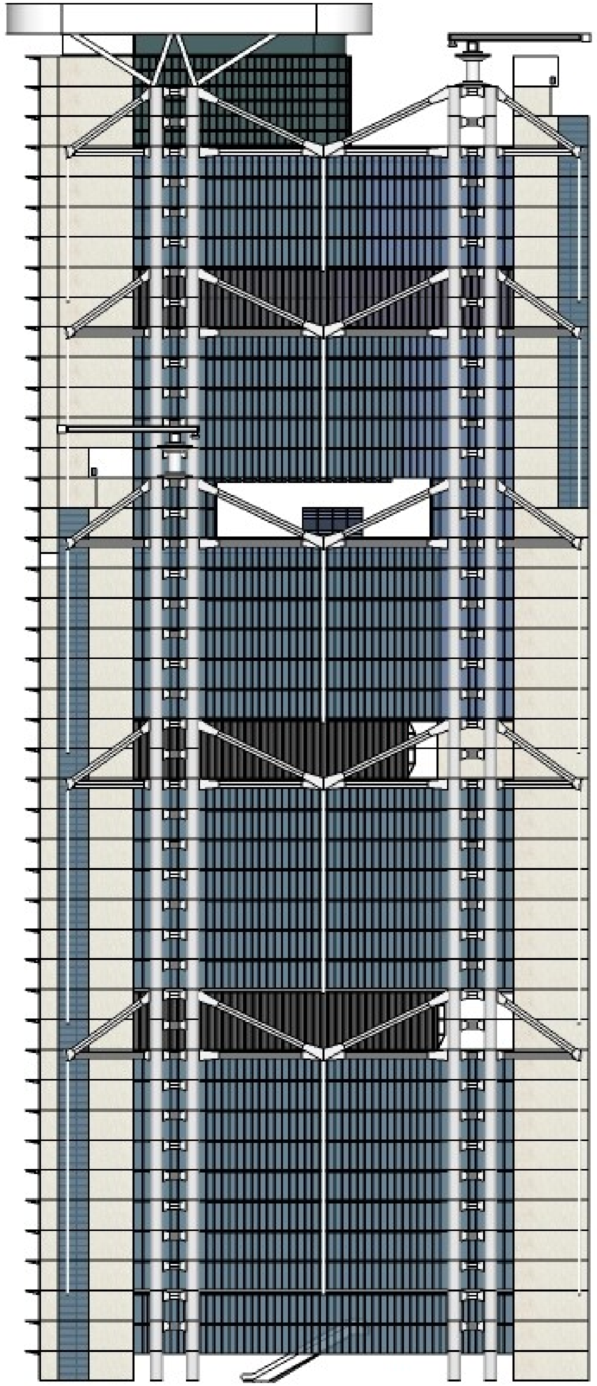
37-41 floors

30-35 floors

1-28 floors

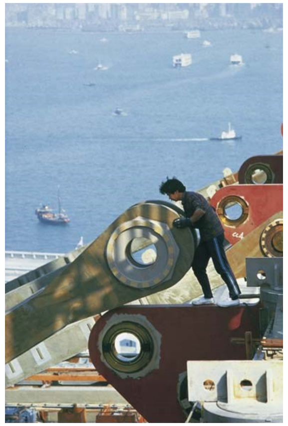
Structure System

- Exoskeleton steel truss
- 8 masts- each consists of 4 columns, supporting five discrete two-story height steel suspension structure.
- The span is 112ft (33.5m) between the masts and cantilever 36ft (10.7m) beyond them.
- Hanging structure
- 132ft (40m) height mirrored atrium.



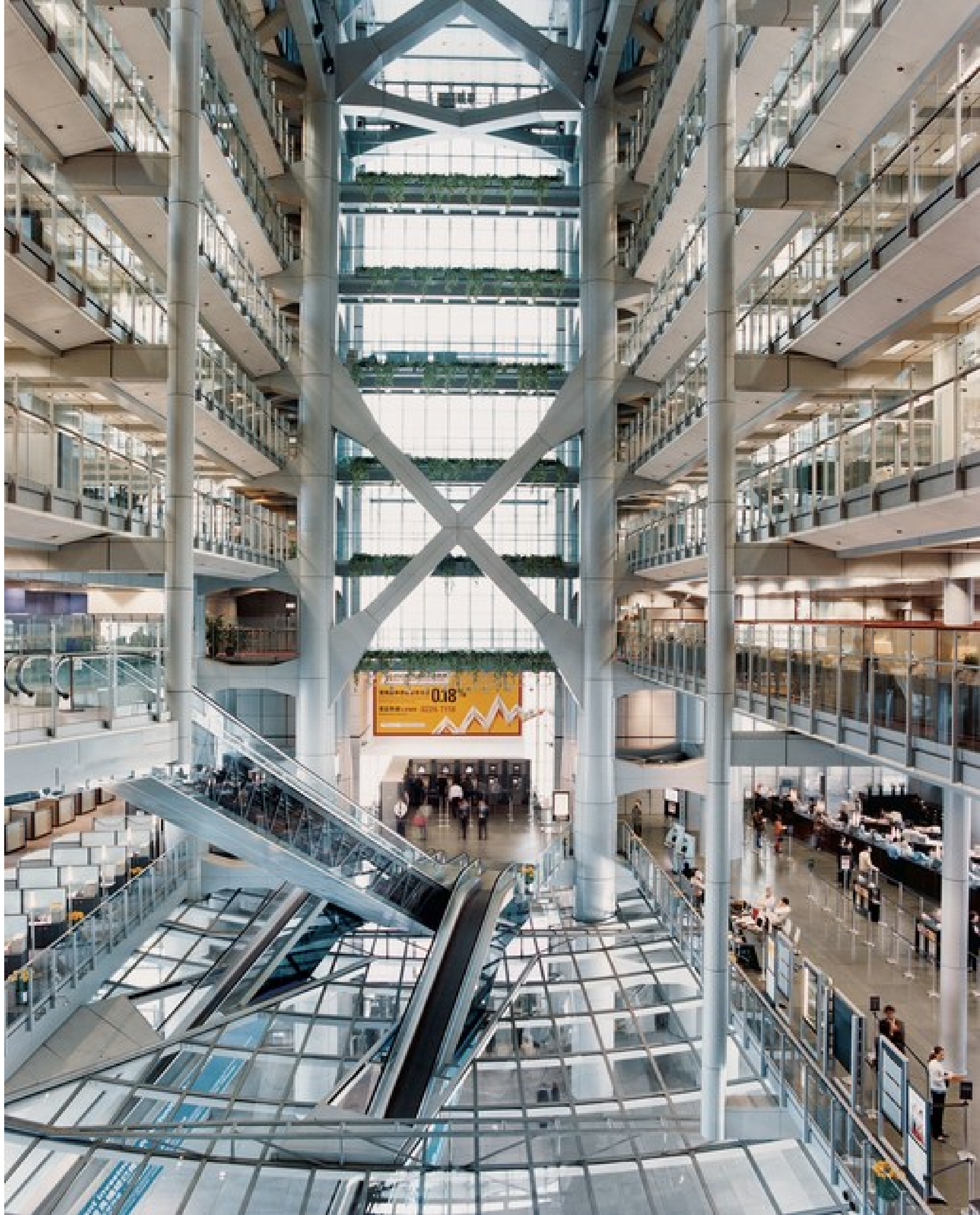
Connection

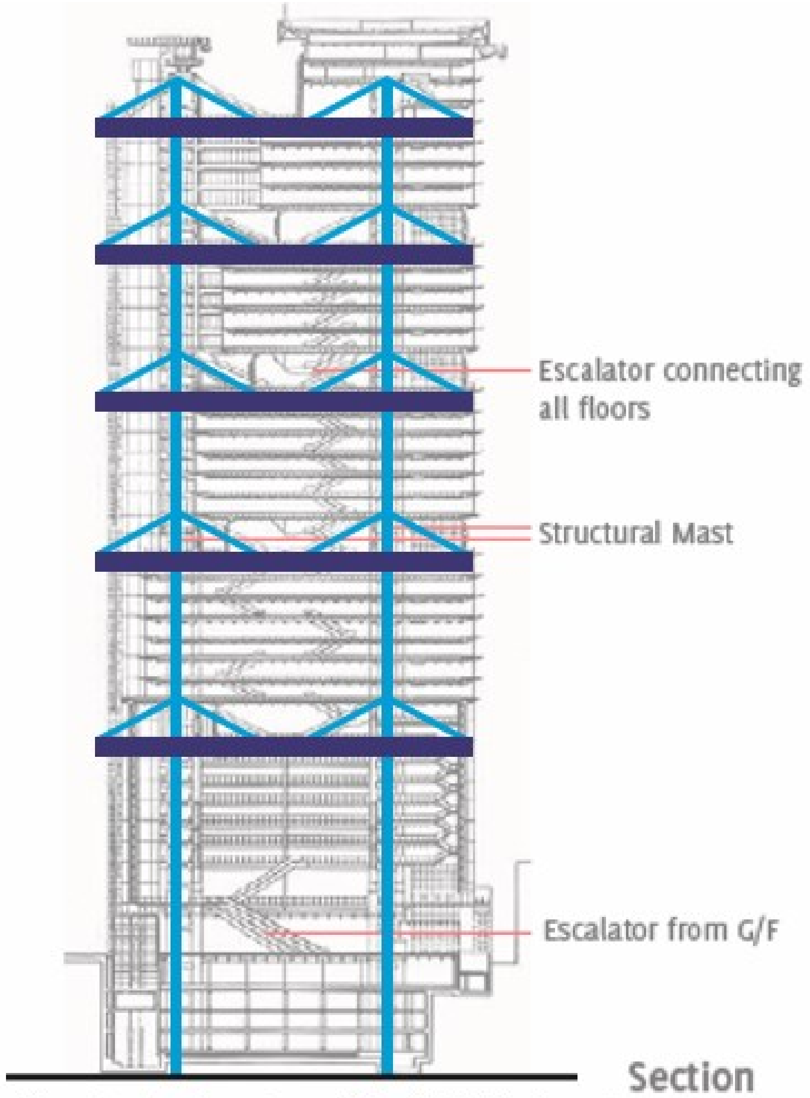
- Pinned Connection- Trusses
- Rigid Connection- Floor Slab, Masts, Cross Braces
- Weld Joints, Bolts and Rivets, Cast in site



Loads

- Gravity Loads
- Lateral Loads (wind, earthquake)



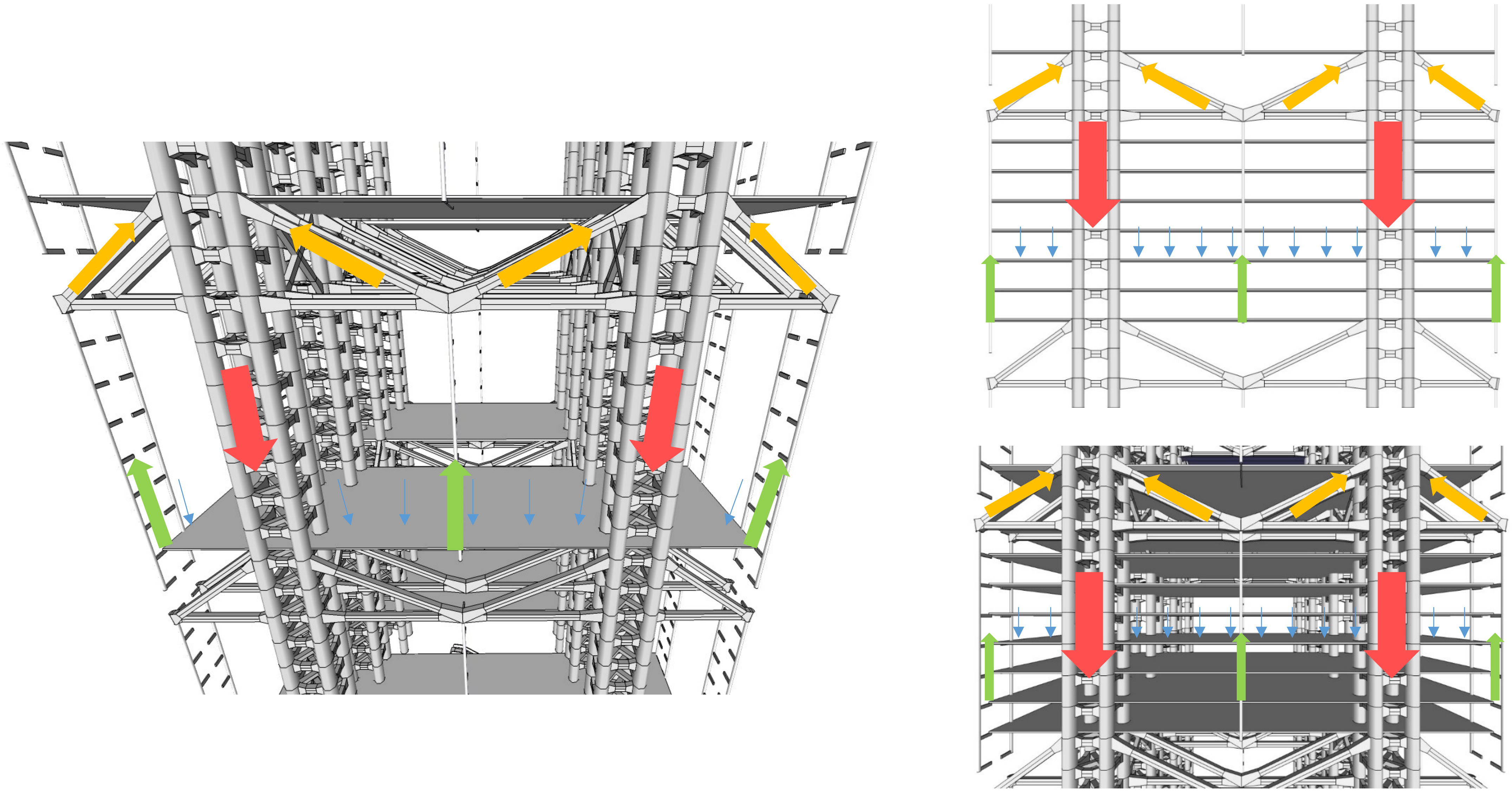


The structural system of the HSBC Headquarters

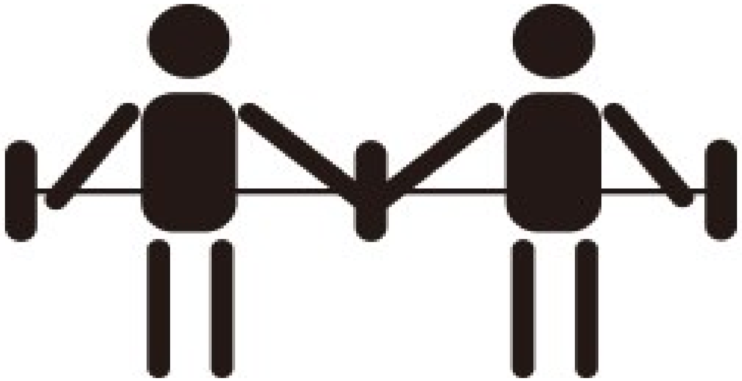
Exoskeleton Truss Frame

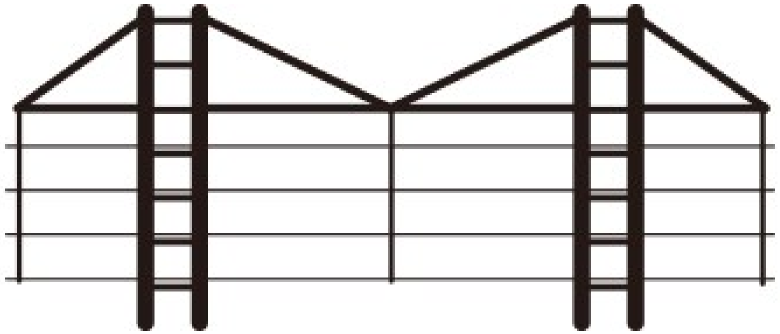
- Gravity Loads
- Floor Slab
- Pair of Trusses
- Structural Mast
- Underground Structure

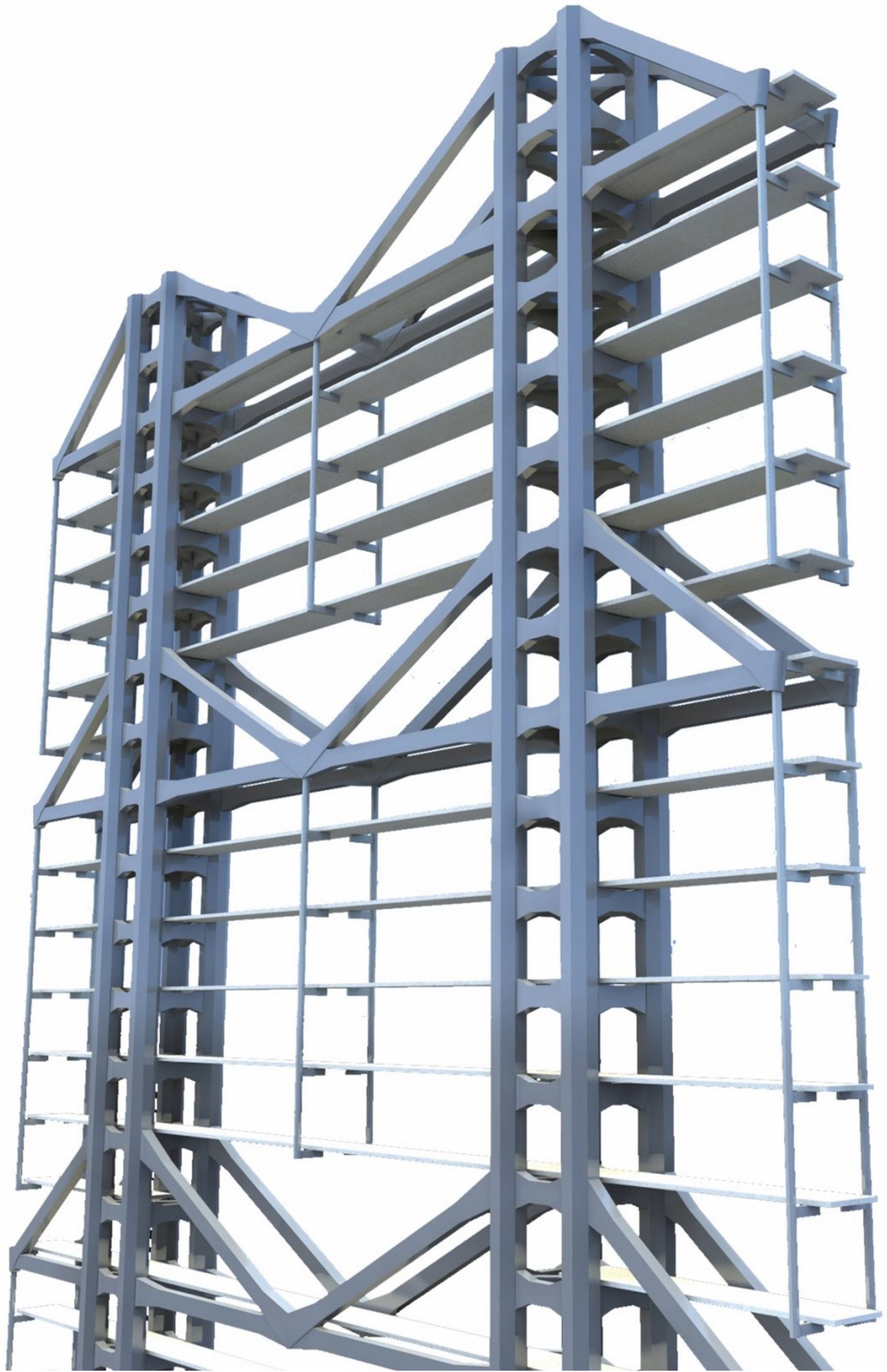
Gravity Loads



- Simplified Structure Figure







Seismic

- The design basic acceleration of ground motion in Hong Kong is 0.1g ~ 0.15g($0.9m/s^2$~$1.5m/s^2$)
- Hong Kong is not belong to any seismic belt
- The ground of Hong Kong is sediment or backfill soil

Wind

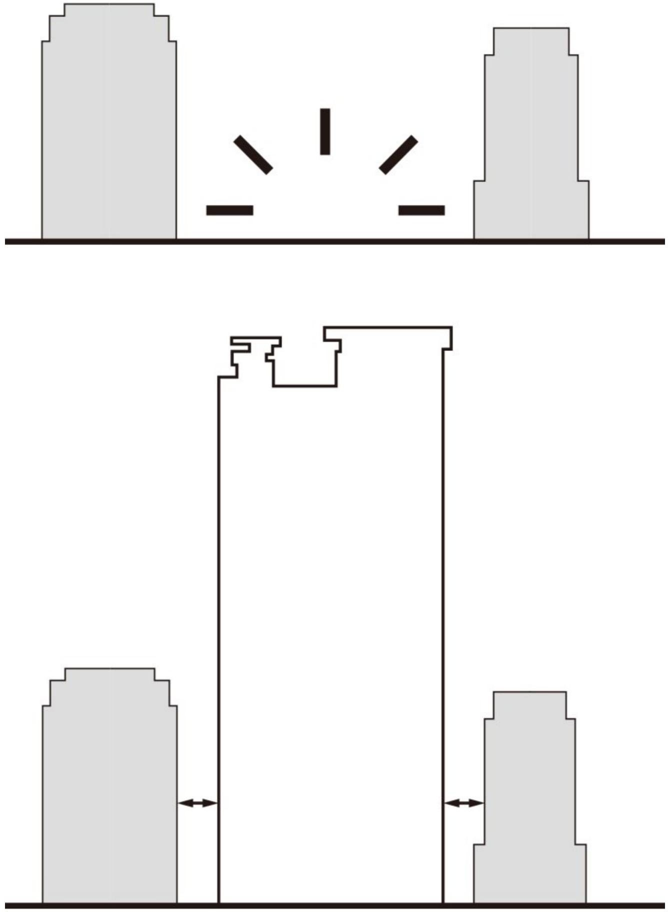
- Hong Kong is located in typhoon area, the maximum speed is 155mile/h
- 3~4 times typhoon a year

Material

- Steel (30000t) : with natural ductile and also could be designed with fully continuous
- Aluminum (4500t)

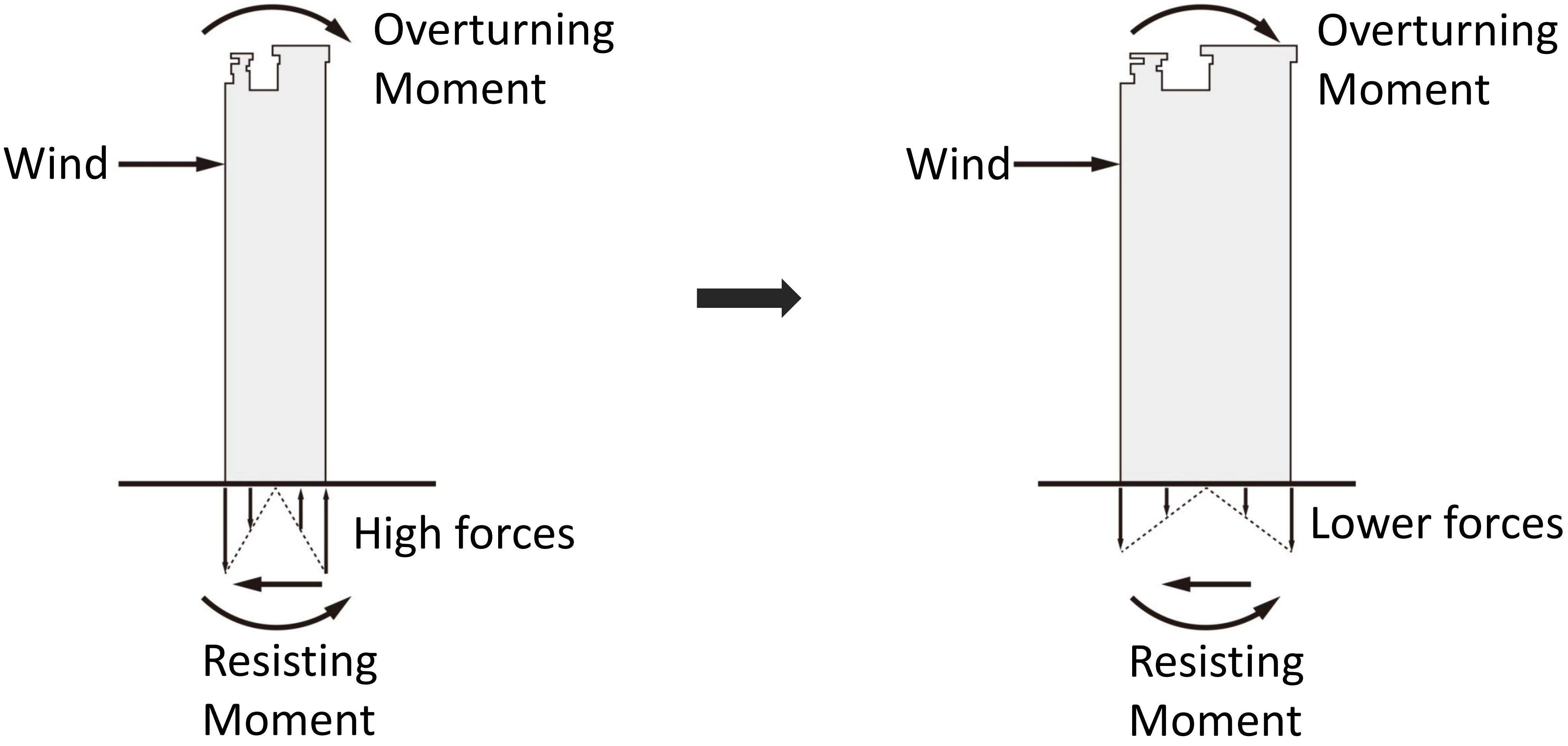
Large separation --- preferred

- Hong Kong has the highest density of tall buildings all over the world.



Lower & Wider --- Better

(Ratio of height and width)

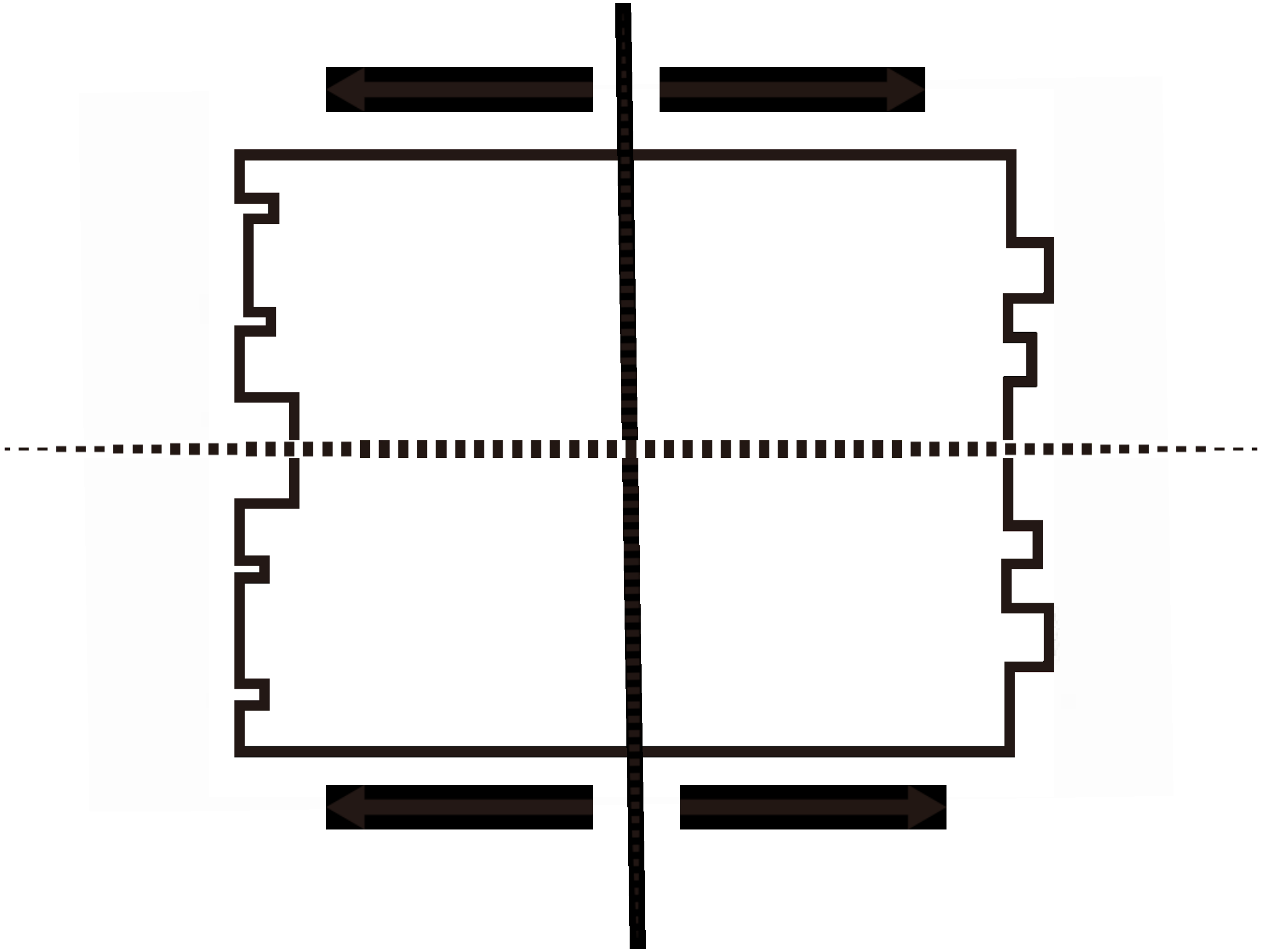


Symmetry

- Structures are designed in symmetric
- Stairs and elevator cores are arranged in symmetric

Increase resistance to bending

- Greatest amount of material should be located in the outer, rather than the inner, vertical elements.

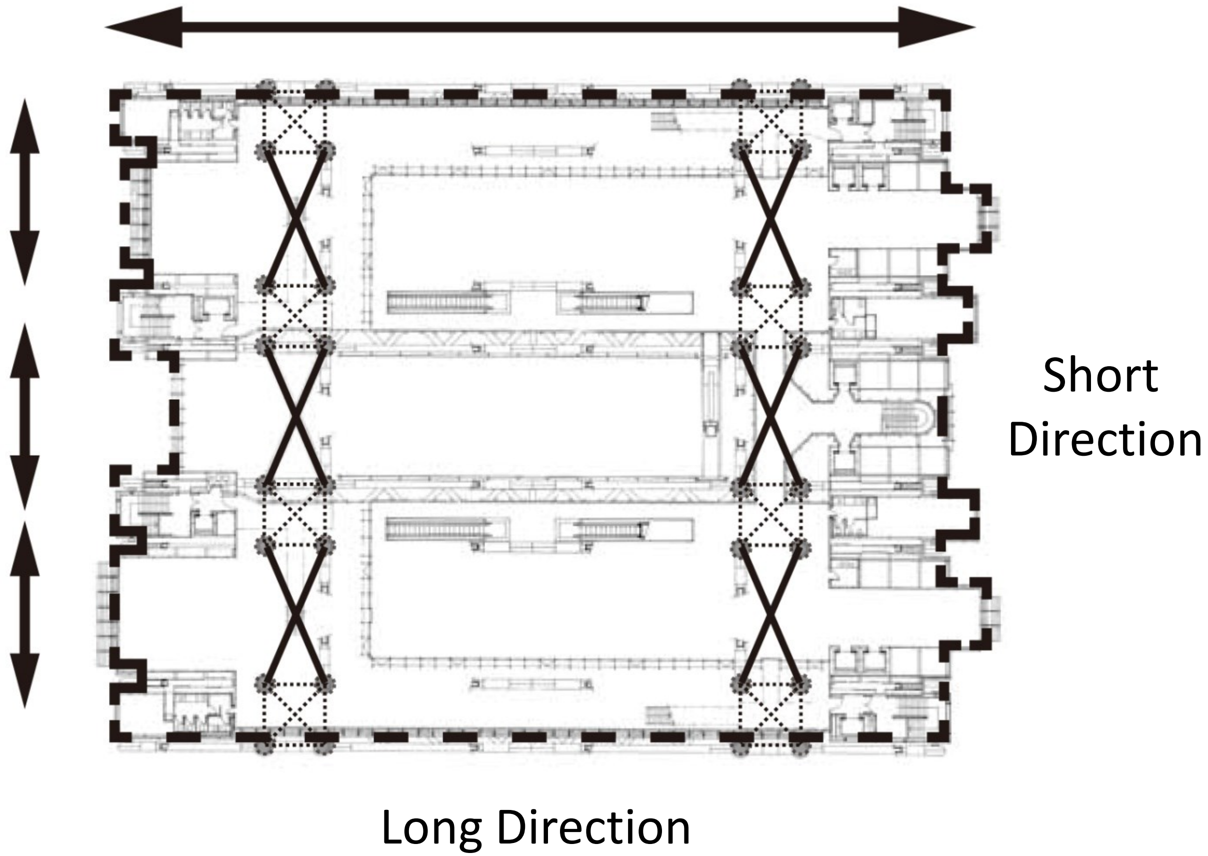


Short direction is important

- In rectangular buildings, the greatest problem with lateral forces is in the short direction of the building, although stability must be assured in both directions.

Cross bracing

- Frame action is less efficient than either shear walls or cross bracing



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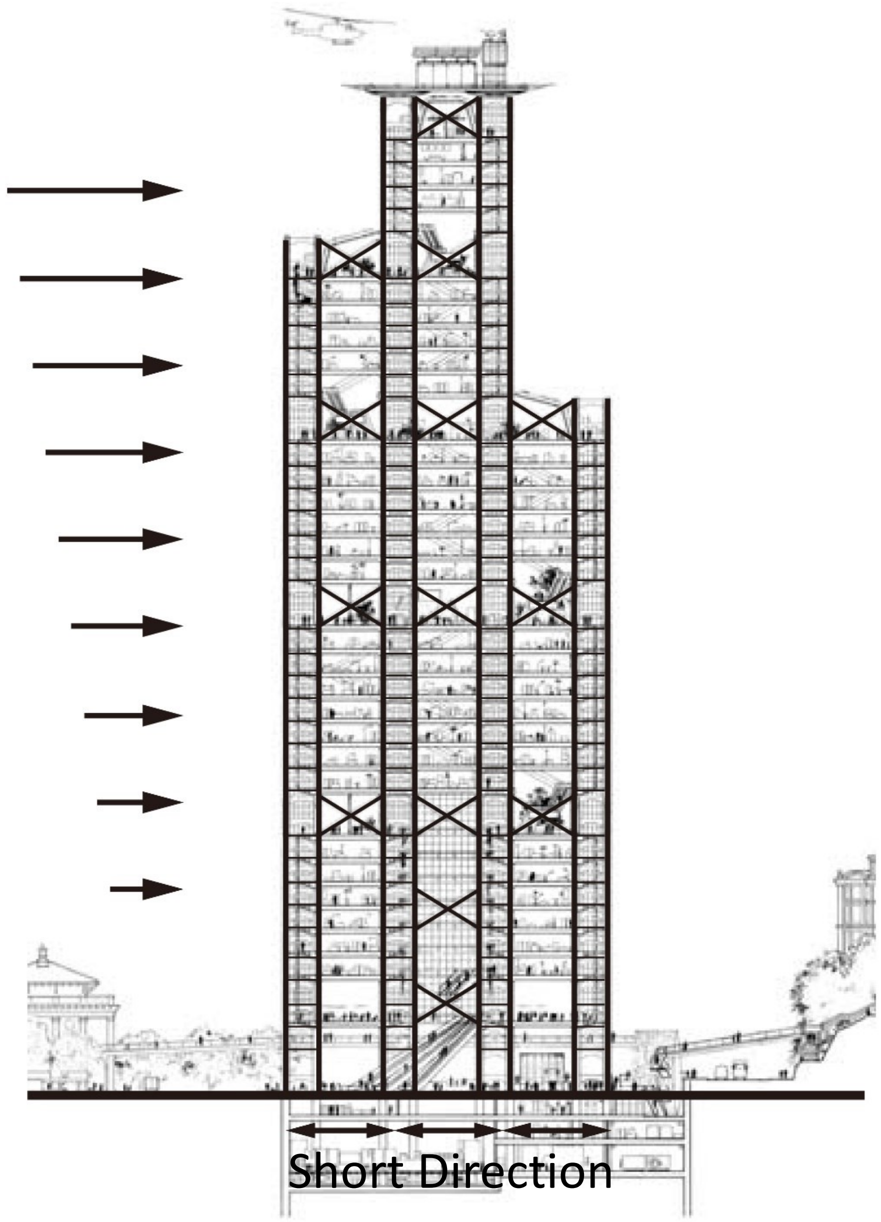
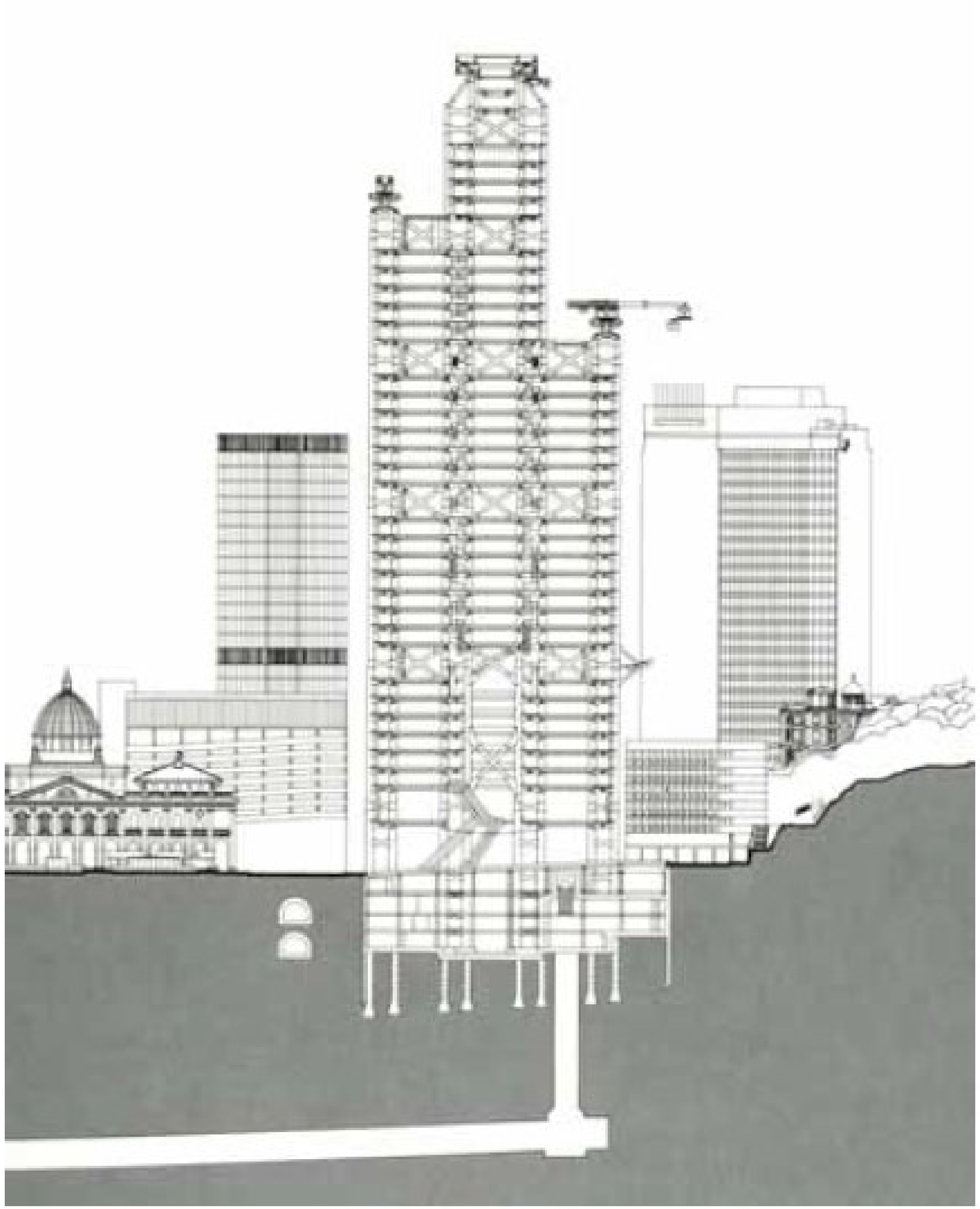


Foundation and Soil

- 4 Stories basement
- A total of 32 reinforced concrete piles
- Based on sediment soil condition, The designers chose to dig out 20 meters of infill and place four additional levels below grade.



Seismic Load Calculate

Table 3.2.2

Seismic precautronary intensity	7
Design basic acceleration of ground motion	0.1-0.15g
Seismic Zone	2A

Table 8.1.1 The highest allowable height of steel structure (ft)

Structure type	7 (0.1-0.15g)
Frame with central bracing	730 (220m)

Table 16-1

Seismic Zone	2A
Z	0.15

Table 3.2.2

Site class	Z
	0.15
S_E	0.5

Seismic Load Calculate

$T = C_r h^x = 0.02 * (730)^{0.75} = 2.81$

$C = 1.25 S_E / T^{2/3} = 1.25 * (0.5) / 2.81^{2/3} = 0.31$

Table 1 Approximate Fundamental Period Parameters

Structure type	C_r
All Other Structure Systems	0.02

Table 1 Approximate Fundamental Period Parameters

Structure type	x
All Other Structure Systems	0.75

Table 5-14

Lateral load-resisting system description	R_w
4. Concentrically braced frames a. Steel	8

Load of structure: 338235KN

Load of DL: $4.5KN/M^2 * 100000M^2 = 450000KN$

Load of LL: $2.5KN/M^2 * 100000M^2 = 250000KN$

Total Load : 1038235KN (233364.081Kips)

$C = (ZIC/R_w)W = (0.15*1.0*0.31/8)*233364.081 = 1356.43Kips$

Wind Speed Calculate

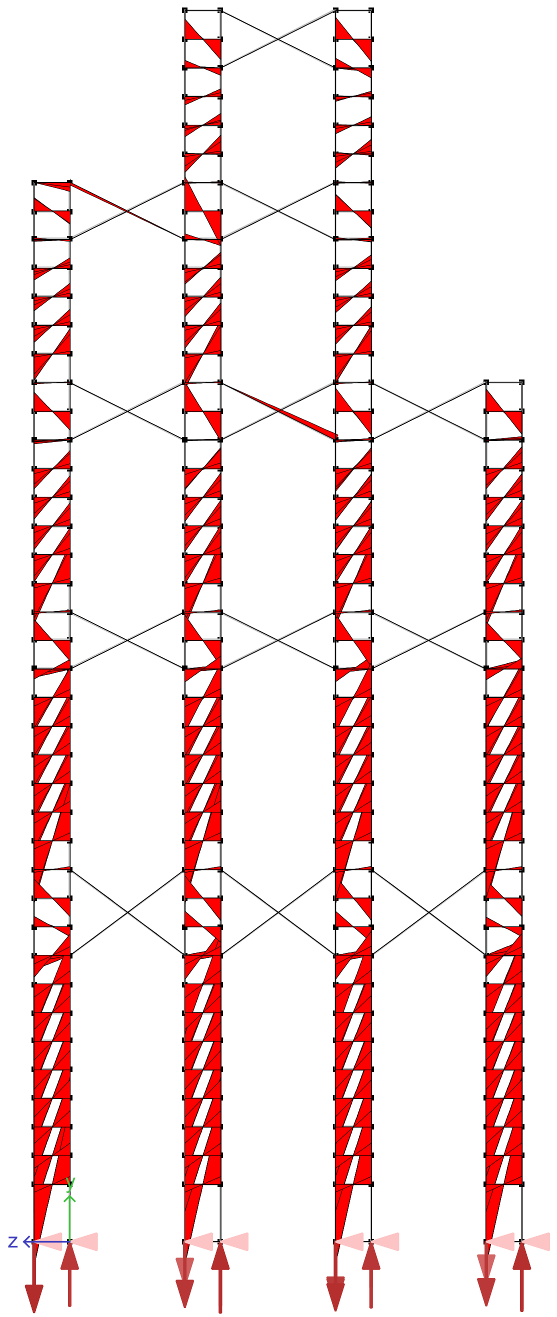
- Wind speed and Height
- $V=V_0(H/H_0)^n$

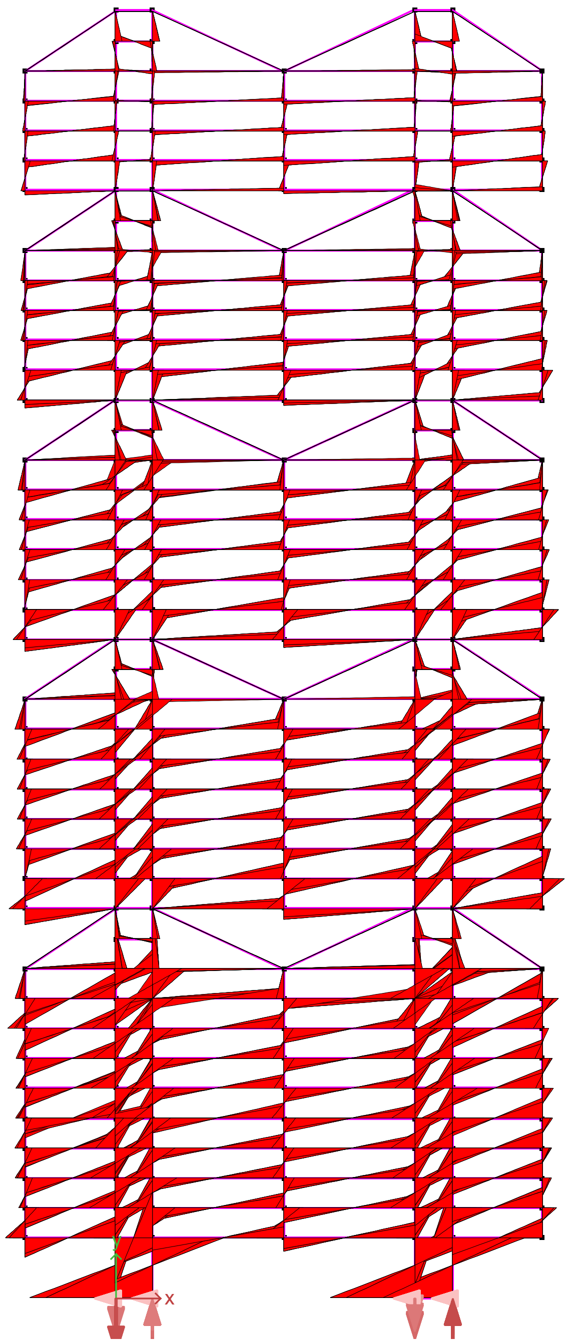
- V: wind speed at height H
- V_0: wind speed at height H_0 (H_0, usually 10m, n=0.1~0.4)

	Height m	Velocity m/s
1	10.000	69.000
2	60.000	83.000
3	120.000	89.000
4	180.000	93.000

Hong Kong maximum wind speed

Multiframe



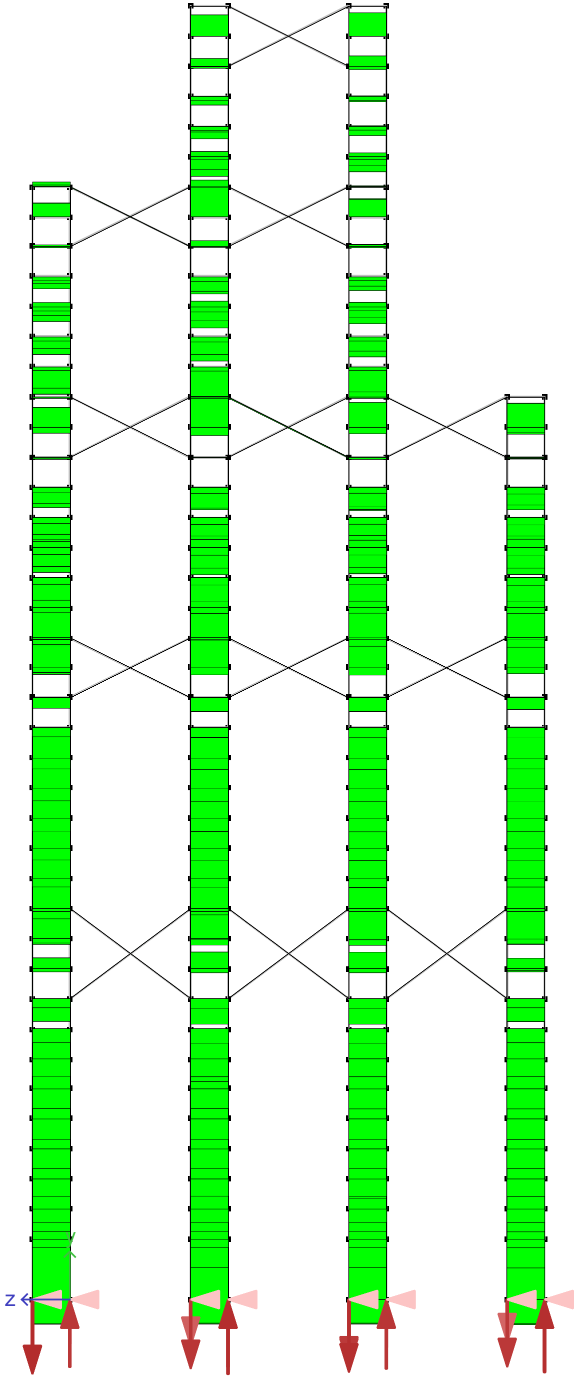


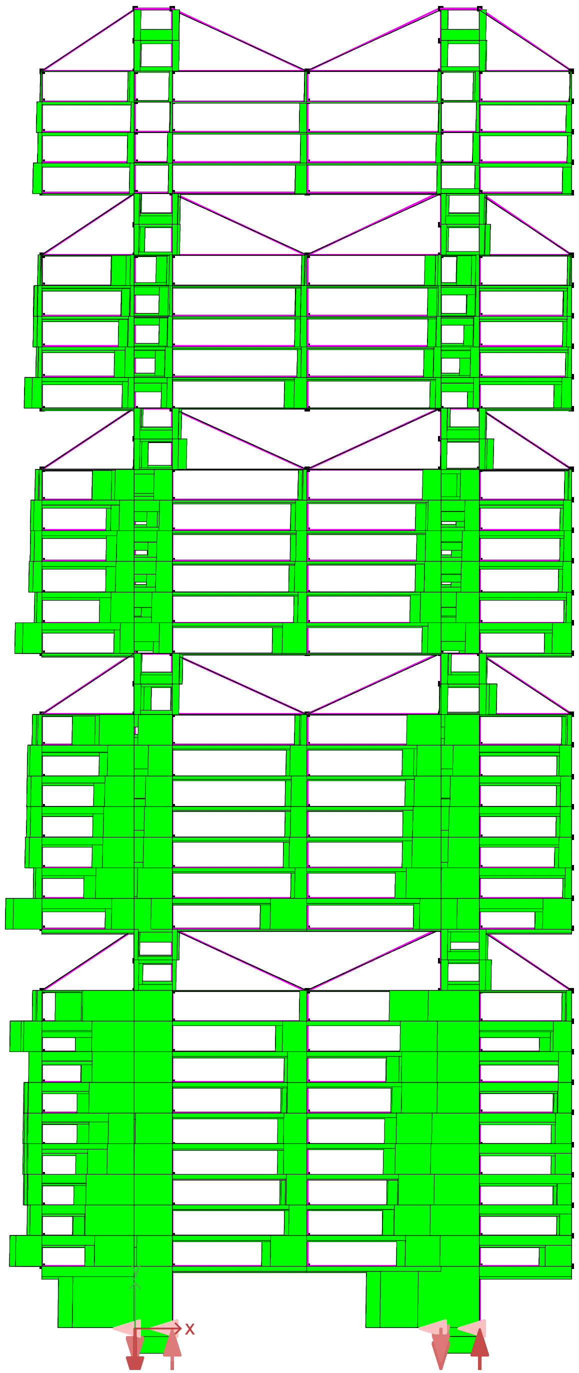
Moment Diagram

a. Front wind

b. Side wind

Multiframe

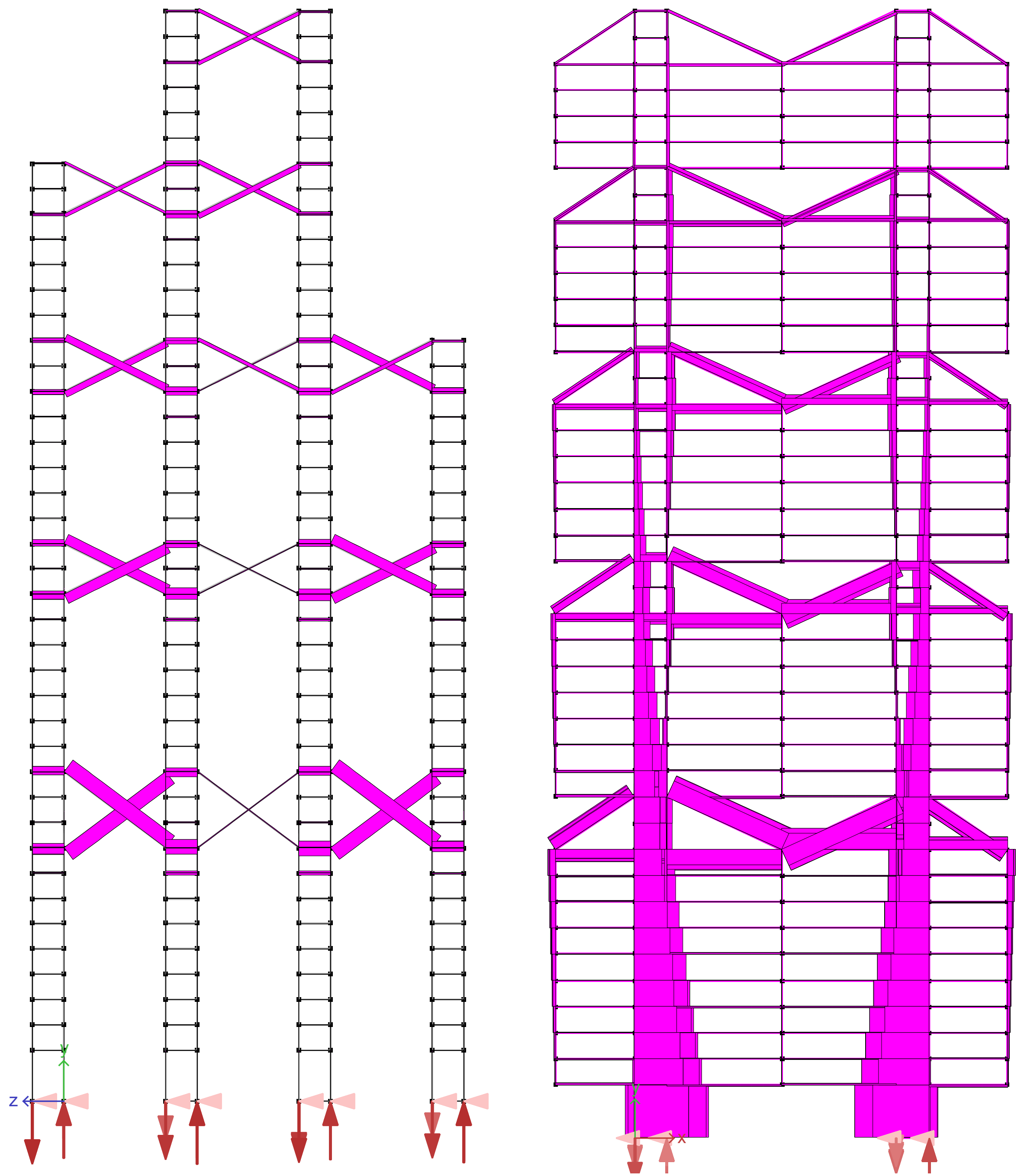




Shear Diagram

a. Front wind

b. Side wind

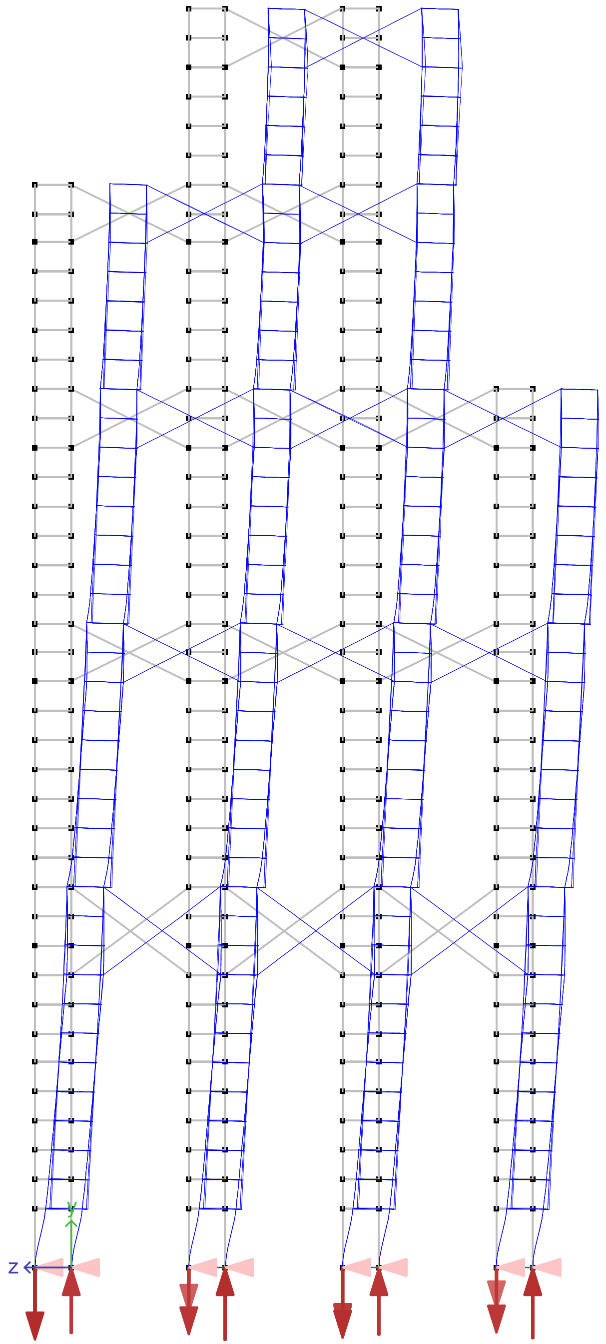


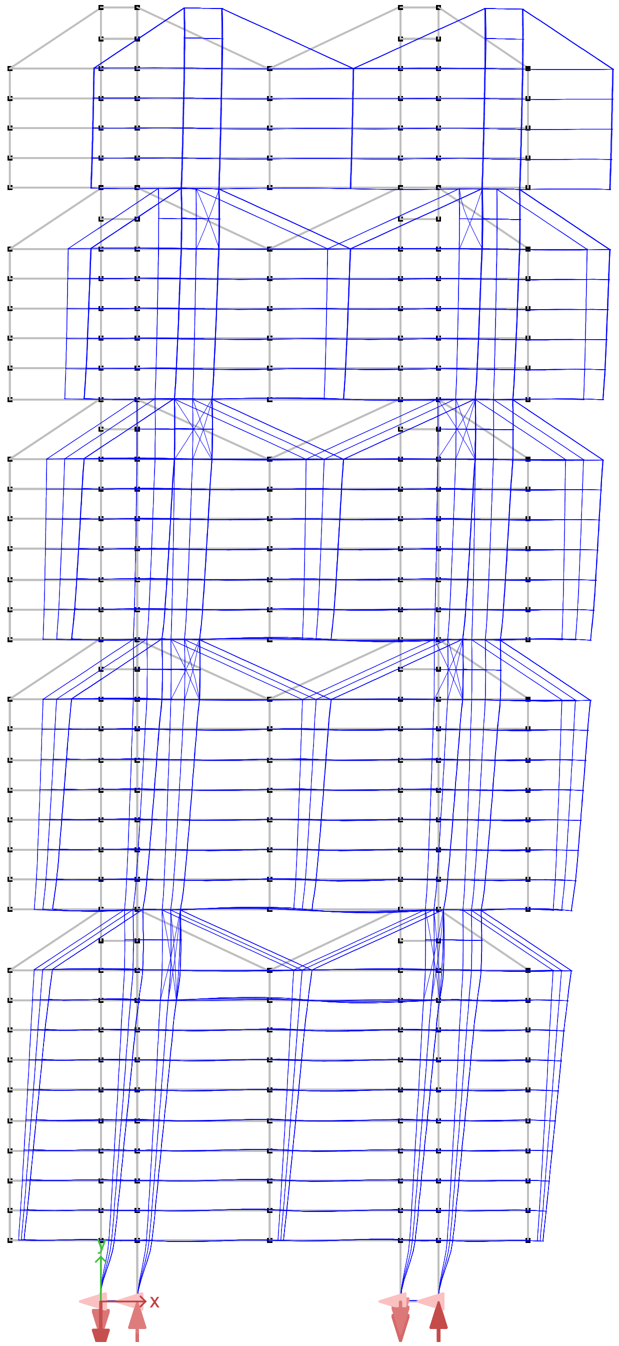
Axial Force Diagram

a. Front wind

b. Side wind

Multiframe





Deflection Diagram

a. Front wind

b. Side wind

Conclusion

The structure system not only satisfied the design safety requirement, but also created splendid inner spaces. In other words, the architecture was well expressed by the structure. But at same time, the building was based on high cost which is hard to spread to other buildings.

Technical Tectonic Expensive

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Thank you!