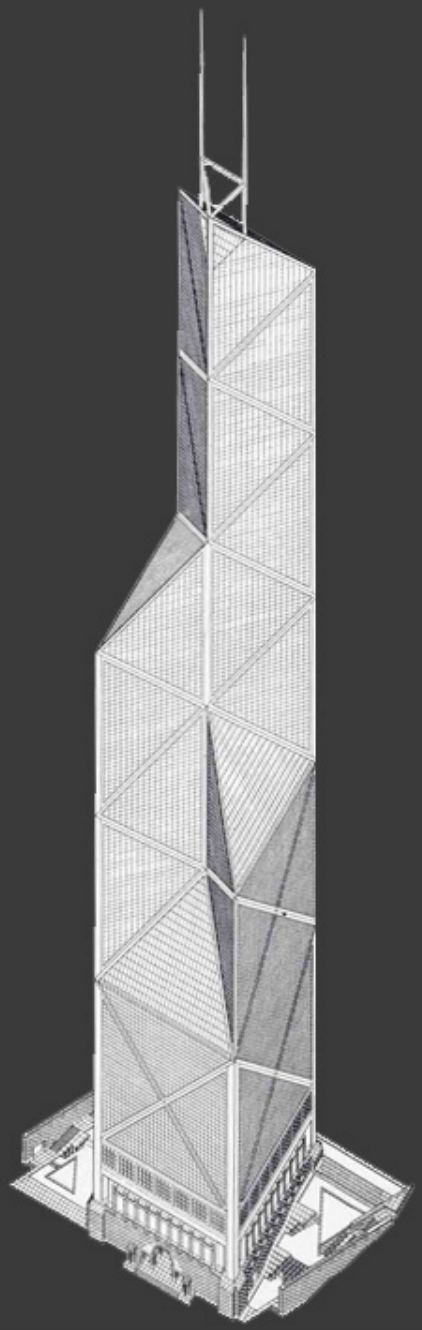


BANK OF CHINA TOWER HONG KONG

Structural Analysis

ARCH 631 FALL 2008

Chaojun Gu Haijuan Yan Yilin Song Yin Jiang Zhouzhou Su

INSTRUCTOR: ANNE NICHOLS

General information

Location: Hong Kong, China

General information

BANK OF CHINA

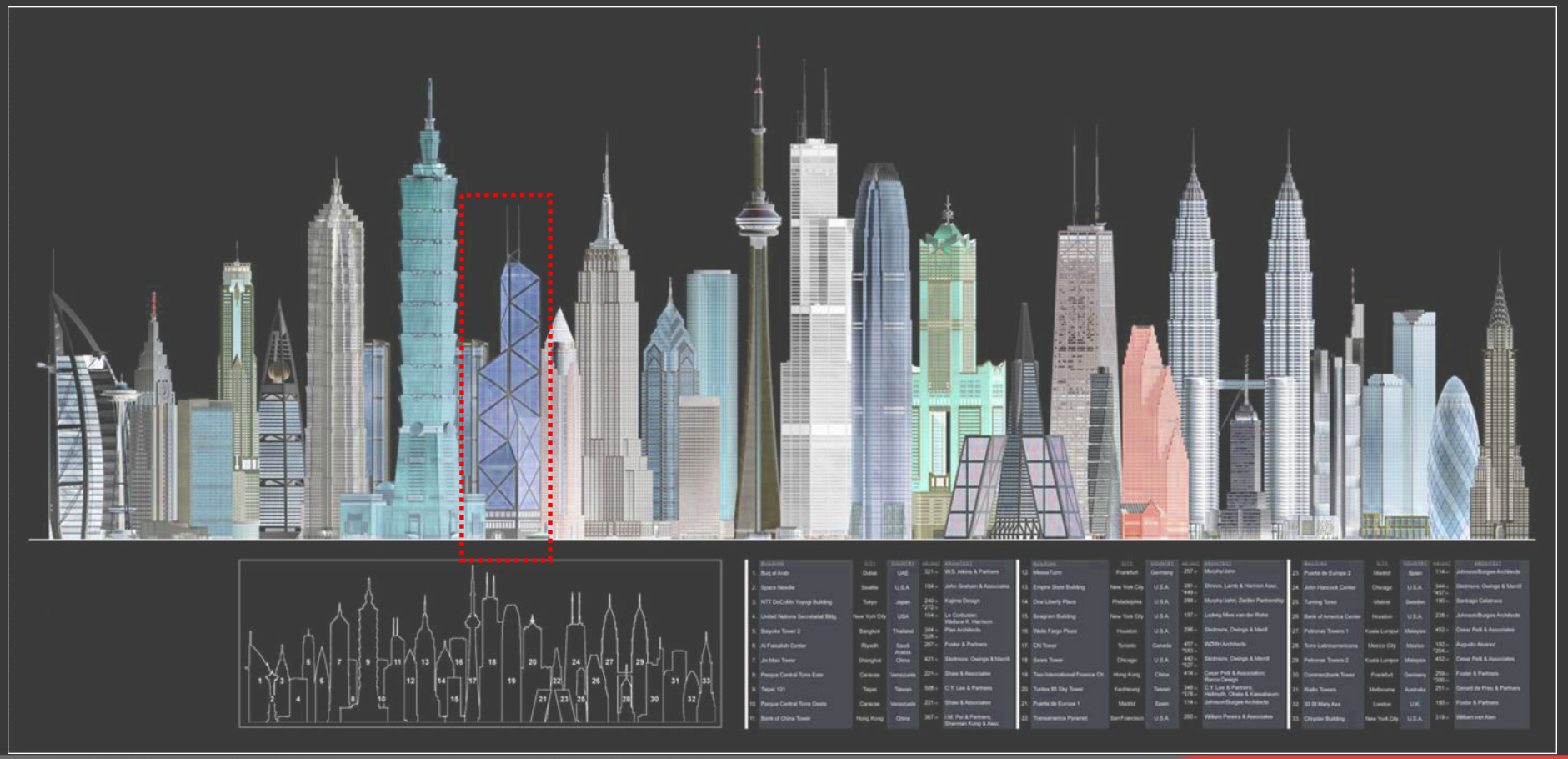
Architect	I. M. Pei
Structural engineer	Leslie Robertson
Height from street to roof	1028ft (367.4 m)
Number of stories	70 stories
Number of levels below ground	4 stories
Space area	1.4 million square feet
Ground floor area	29,000 square feet
The highest floor area	7,265 square feet
Building use	Office
Building cost	$150 million

General information

Frame	Super frame, truss
Frame material	Steel, concrete
Basic wind velocity	143mph
Type of structure	Cross-braced space truss
Foundation conditions	Square granite clad base(170 feet in length)
Footing type	poured in place, caisson
Ground floor column size	14’×26’
Column material	composite concrete and steel
Floor slabs	4” thick

General information

Building height comparison



General information

Inspired by bamboo

symbolic of strength, vitality, growth and enterprise

General information

Awards

2002 "Excellent" Award of Hong Kong Building Environmental Assessment Method

1999 Ten Best Architecture in Hong Kong, HKIA

1992 Marble Architectural Award

1991 AIA Reynolds Memorial Award

1989 Award for Engineering Excellence, ACEC

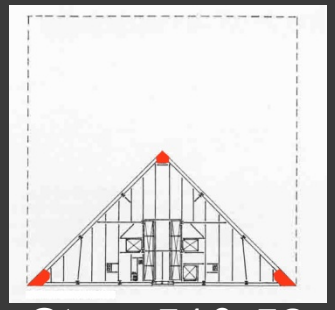
1989 Certificate of Engineering Excellence, NYACE, etc.

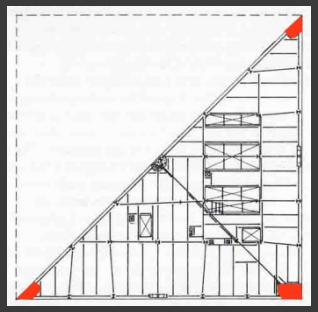
Plans

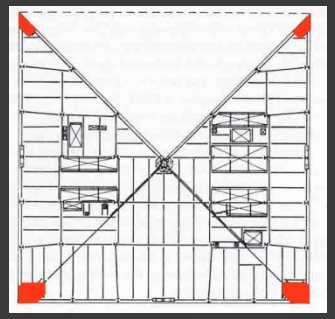
Square plan

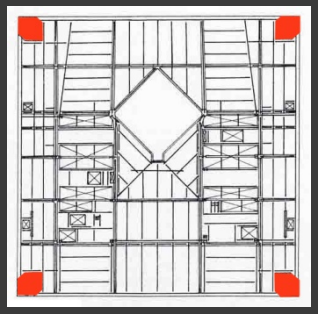
four prism towers rise to different levels:
25th, 38th, 51th, 70th

The 25th floor: the fifth column, exterior


Story 51& 52


Story 38


Story 25


Story 4

Plans

Square plan

four prism towers rise to different levels:
25th, 38th, 51th, 70th

The 25th floor: the fifth column, exterior

Form & Structure

The shape of the envelope changes dramatically

Maintaining the purity of the geometry was the challenge around which the very structural feasibility of the project turned.

Structure design concept:

a series of triangles as a super frame.

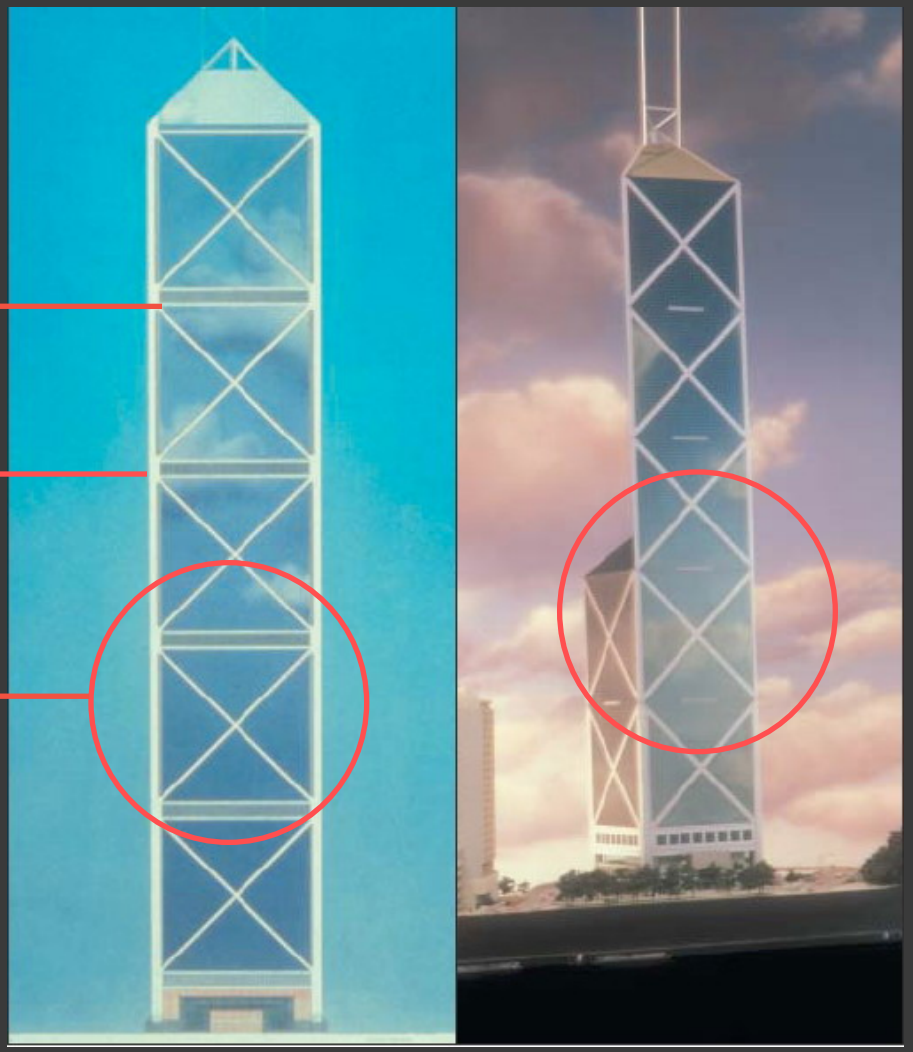



Facade

X's vs. diamond's

refuge floor

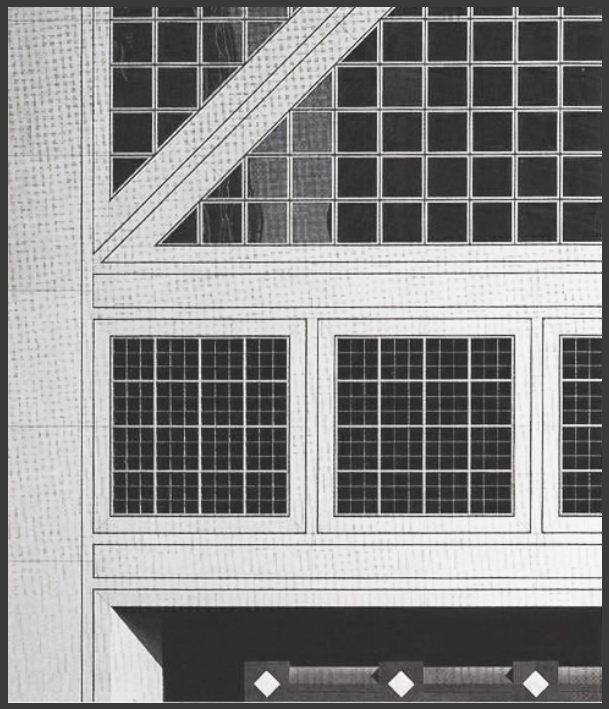
change the form

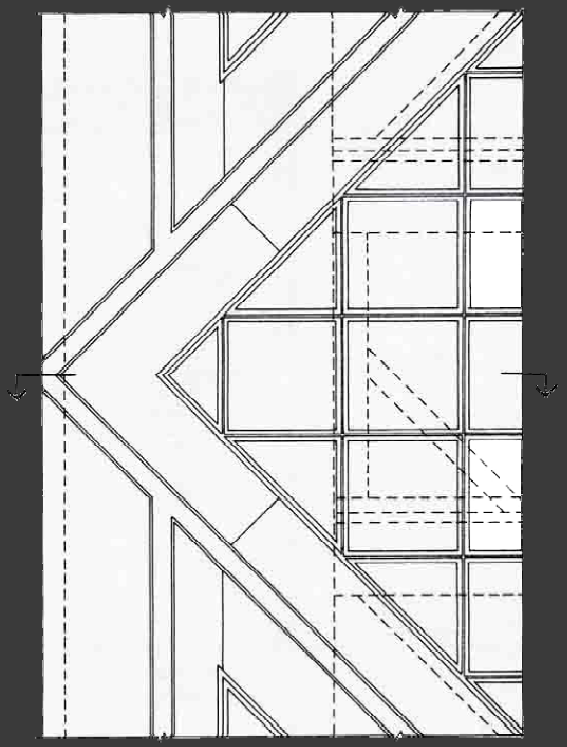


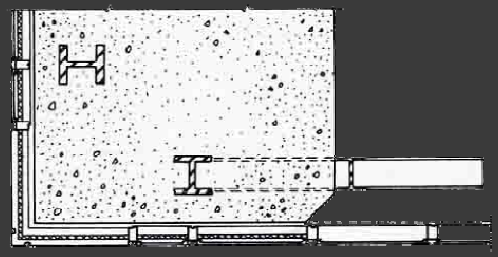
Facade

- “Form and decoration were not enough. The building must be structurally logical and elegant.”

------ Pei

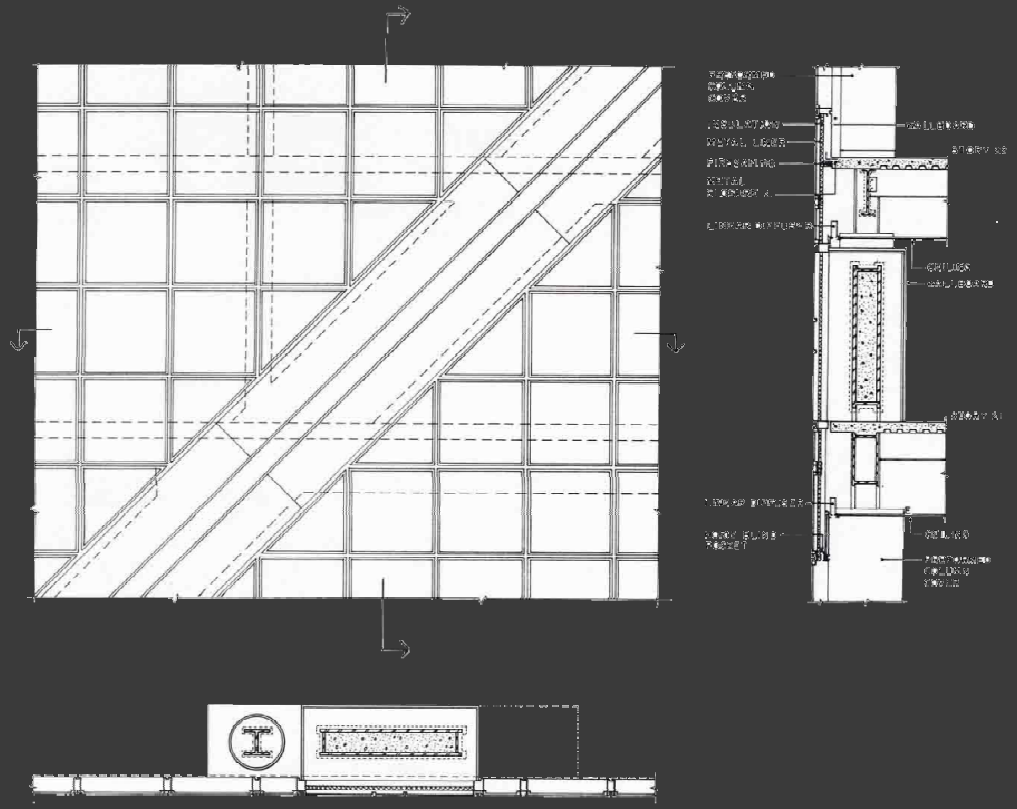




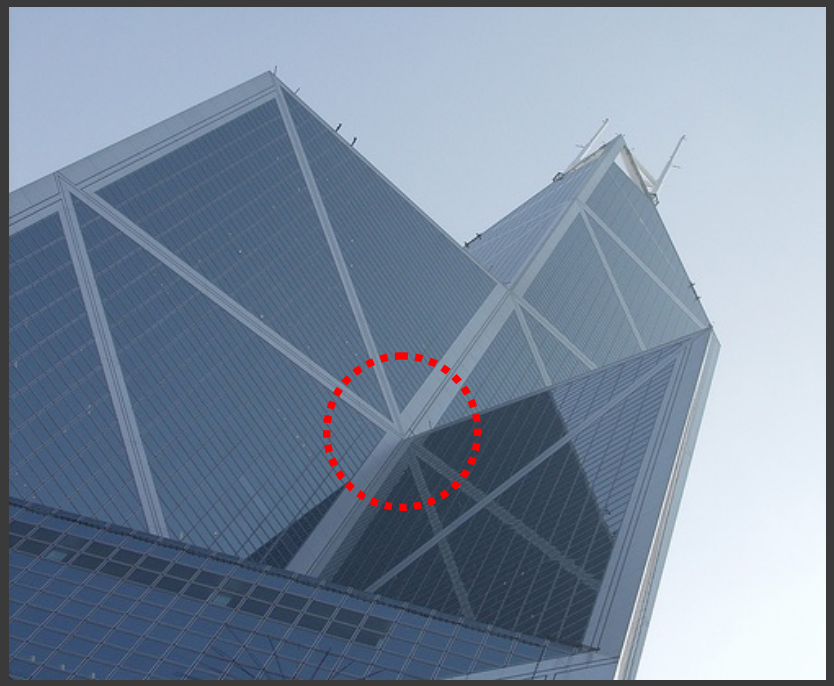


Facade

- The over-all result of the façade's handling is a crisp surface that appears tightly drawn across the faceted faces of the building.



Members



Joints:

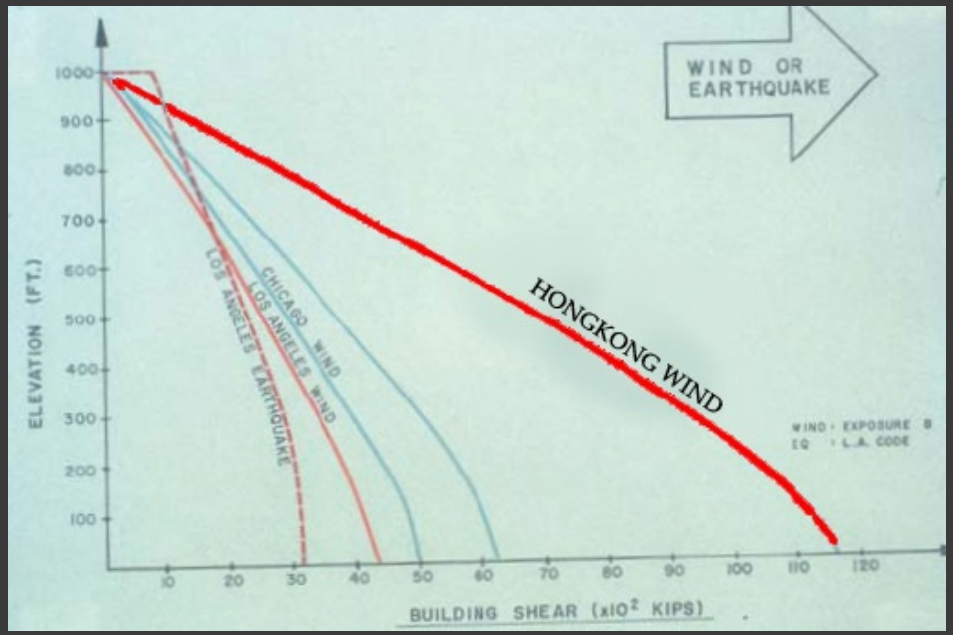
A critical joint at which the vertical, horizontal, and diagonal members of the steel frame all come together.

This joint is not a welded connection, nor is it all steel.

A block of reinforced concrete that envelopes all the columns, stiffening trusses, beams, and cross-braces.

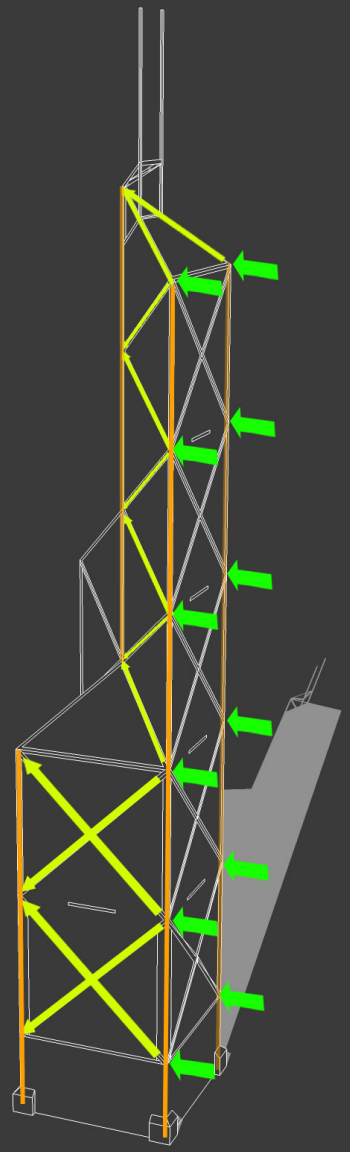
Lateral loads

- Hong Kong is in a typhoon zone . With wind loads twice that for New York City, and equal to four times the earthquake load for San Francisco.

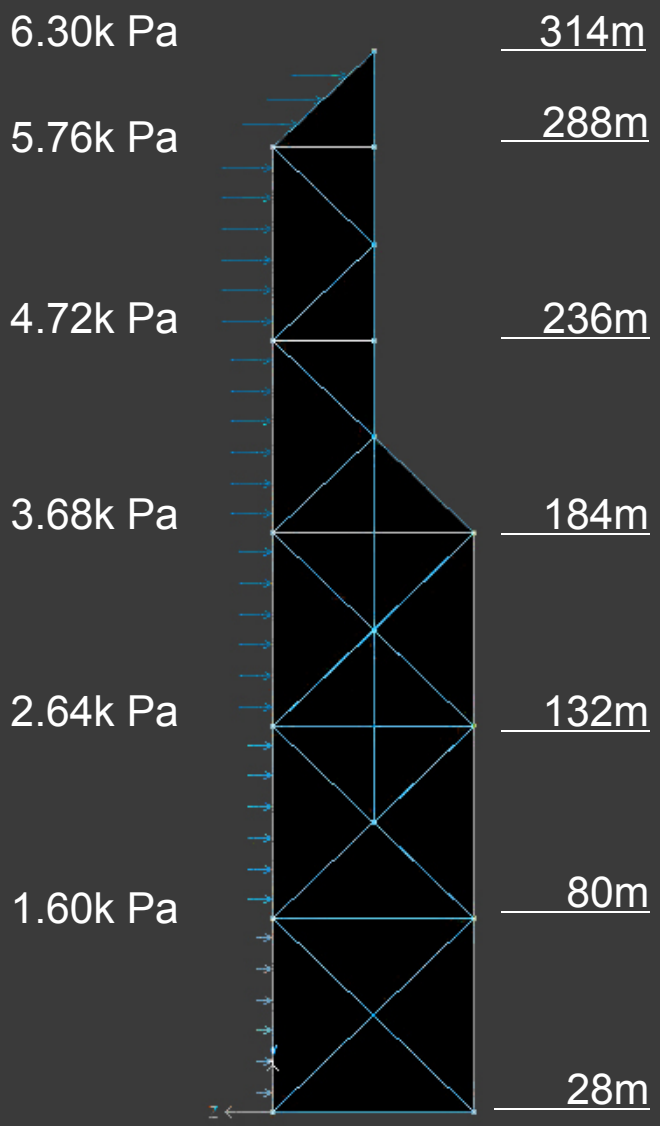


Lateral loads

Trusses used in lateral force system

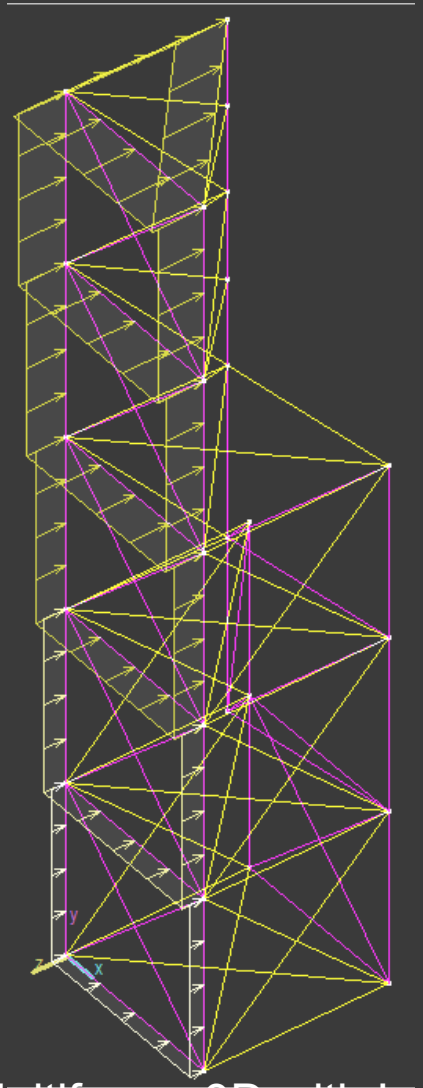


Lateral load: wind load analysis

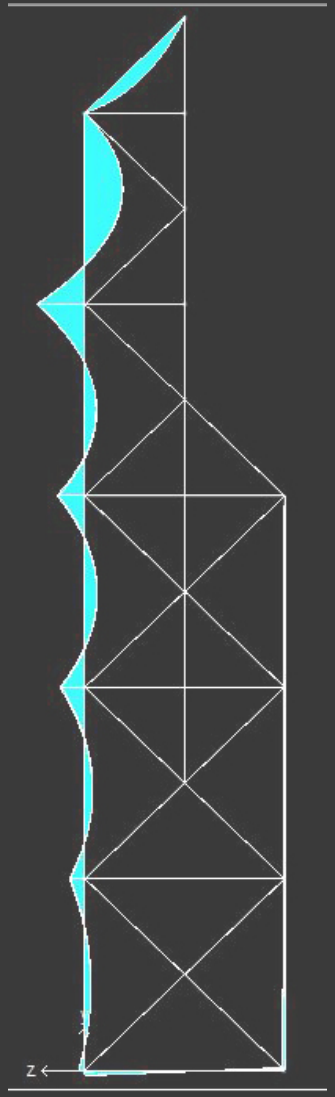


The wind speed in Hong Kong can reach as high as **143mph**.

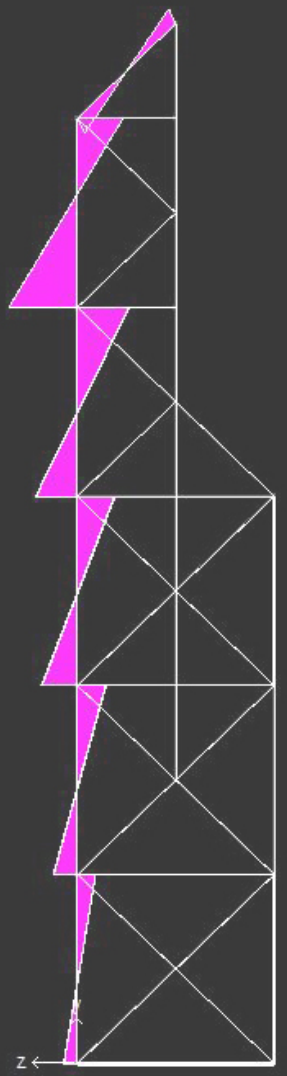
Lateral load: wind load analysis



Multiframe 3D with Lateral load applied

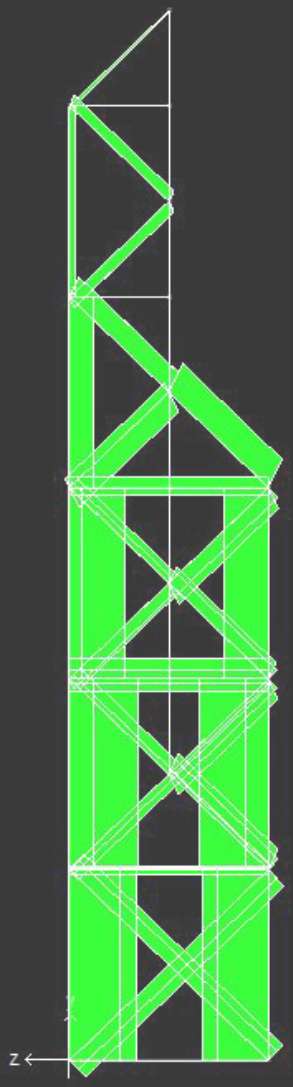


Bending moment

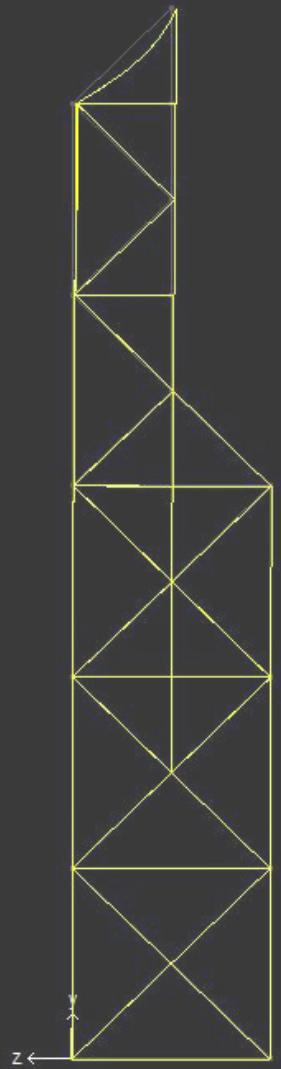


Shear force

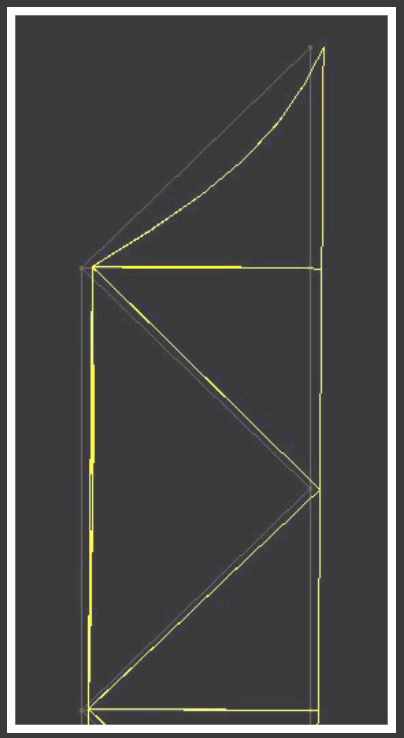
Lateral load: wind load analysis



Axial load

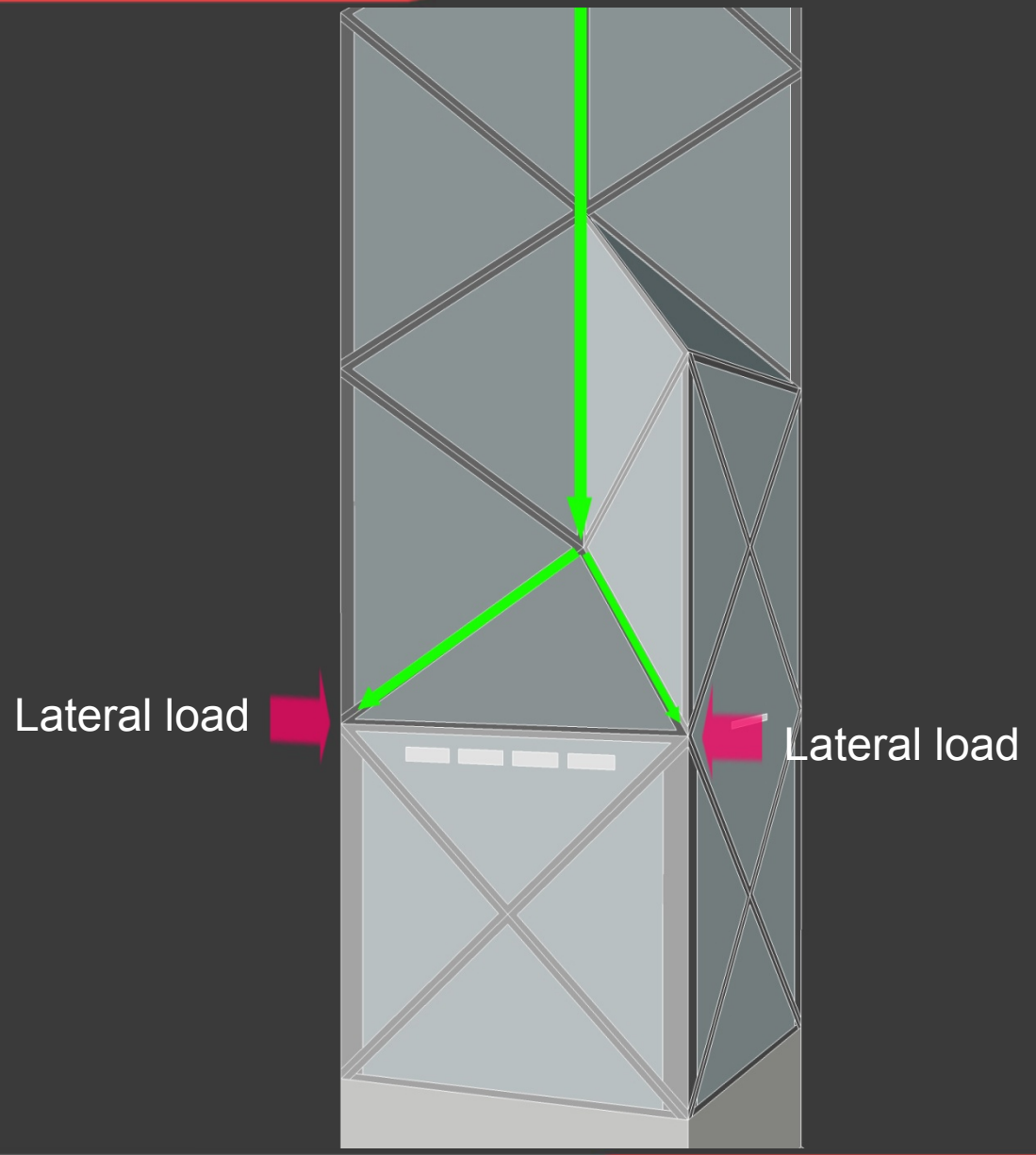


Deflection



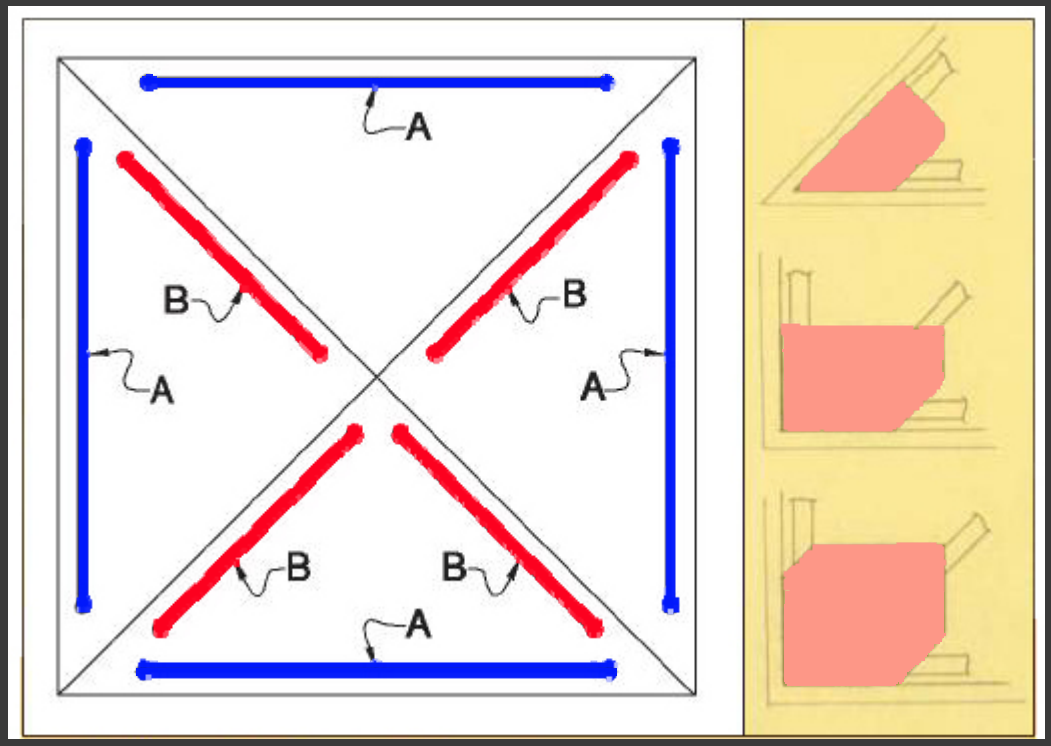
Lateral load: additional mechanism

The additional downward force from the transfer increases the effective stance of the building to resist lateral loads.



Lateral load: Planar trusses

- Transfer truss that wrap around every 13th story as the **horizontal bracing** were concealed, thus the horizontal expression was removed
- Create planar trusses in structural steel with the frames of but two different geometries
- In the corners of the towers, we knitted the columns of the planar frames into space-trusses – all within a reinforced concrete column



A: Vertical trusses

B: Planar trusses

Lateral load: Columns

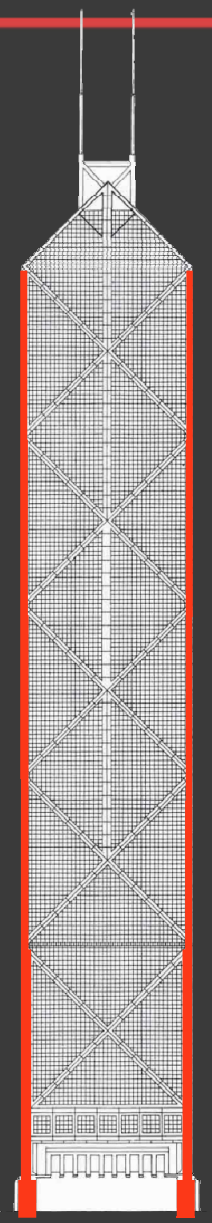
Columns:

The shape causes **eccentric load**.

Off-center loads would cause excessive stresses in columns.

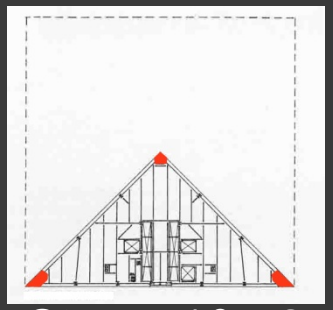
The solution is that using **uniform shear force mechanism** that could counteract and eliminate the bending.

The system is outstanding of its economy of material.

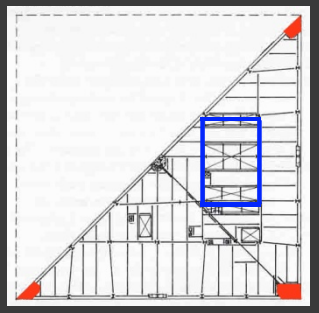


Lateral load: Shear walls

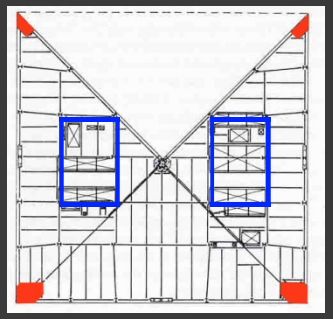
- Only a small portion of the loads carried to the service cores in the lower floors flows directly to the foundations.



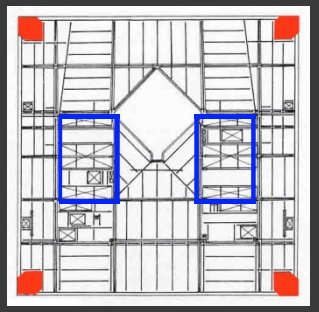
Story 51& 52



Story 38



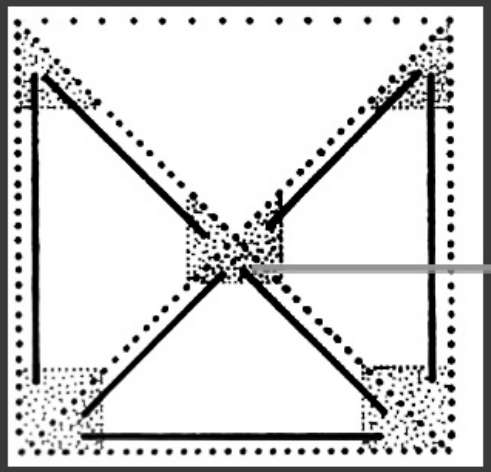
Story 25

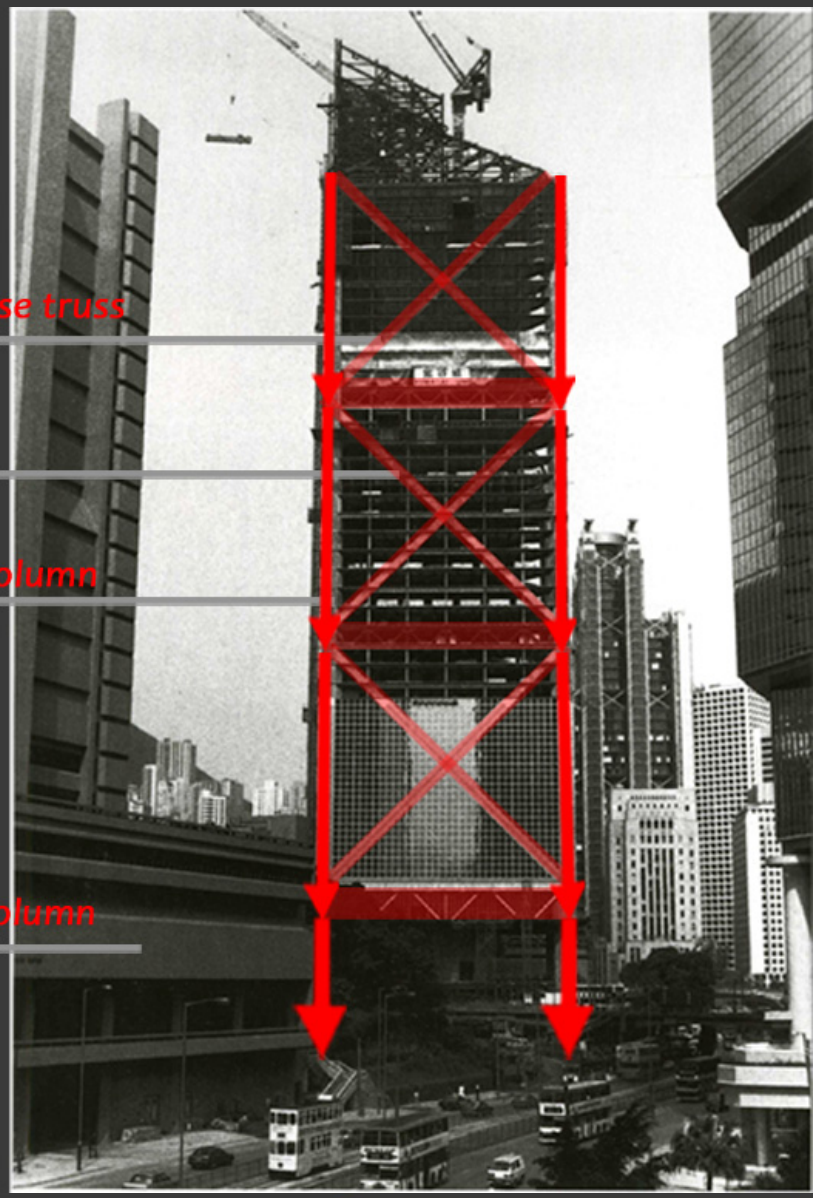


Story 4

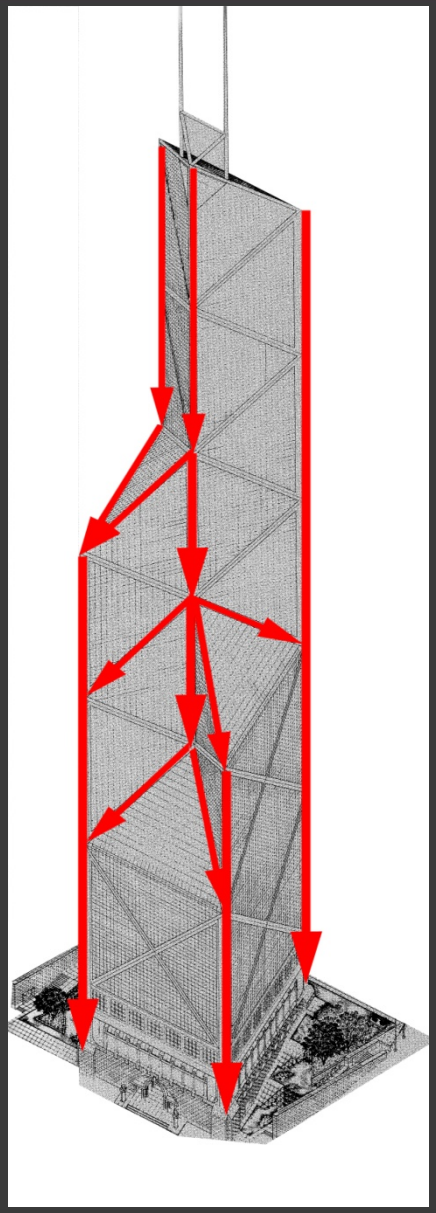
Vertical load

The vertical force are transferred through braces, columns, space trusses , transverse truss and diaphragms.



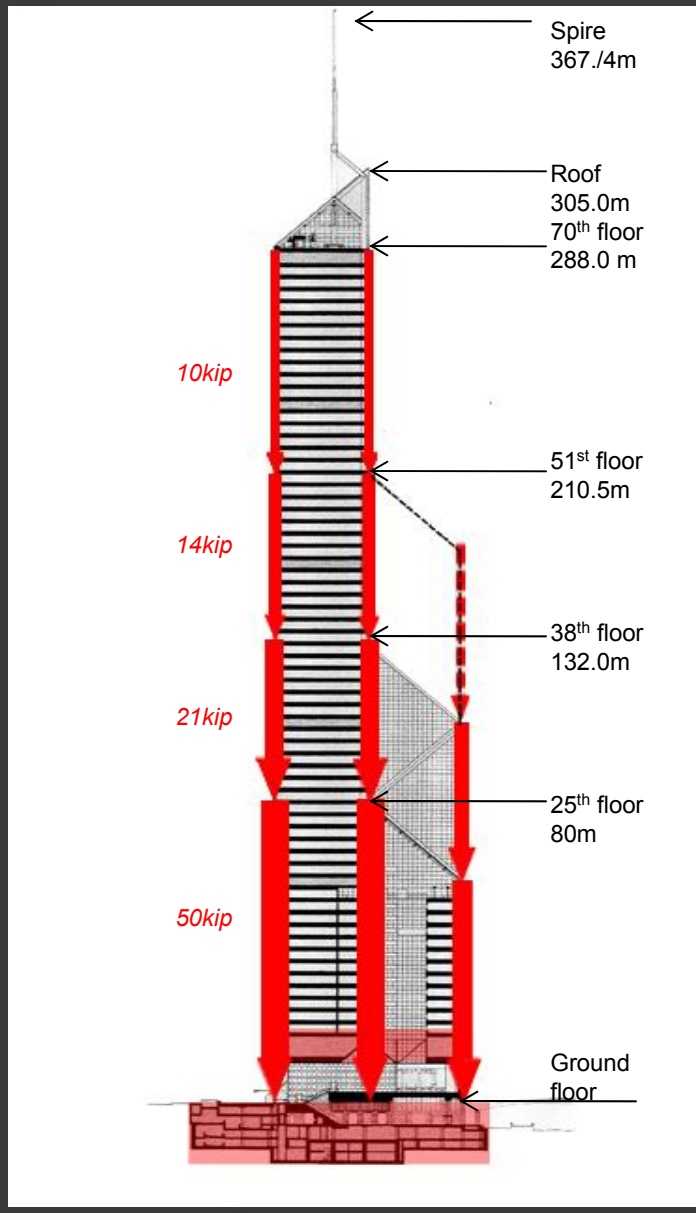


Vertical load



Space Truss:
Allows for the vast majority of the gravitational load to be supported at the exterior. By doing so, this eliminated about half of the dead load that there usually is in tall buildings (less steel was needed).

The center column, rising from the 25th floor, bears the gravitational load and resists the overturning moment.

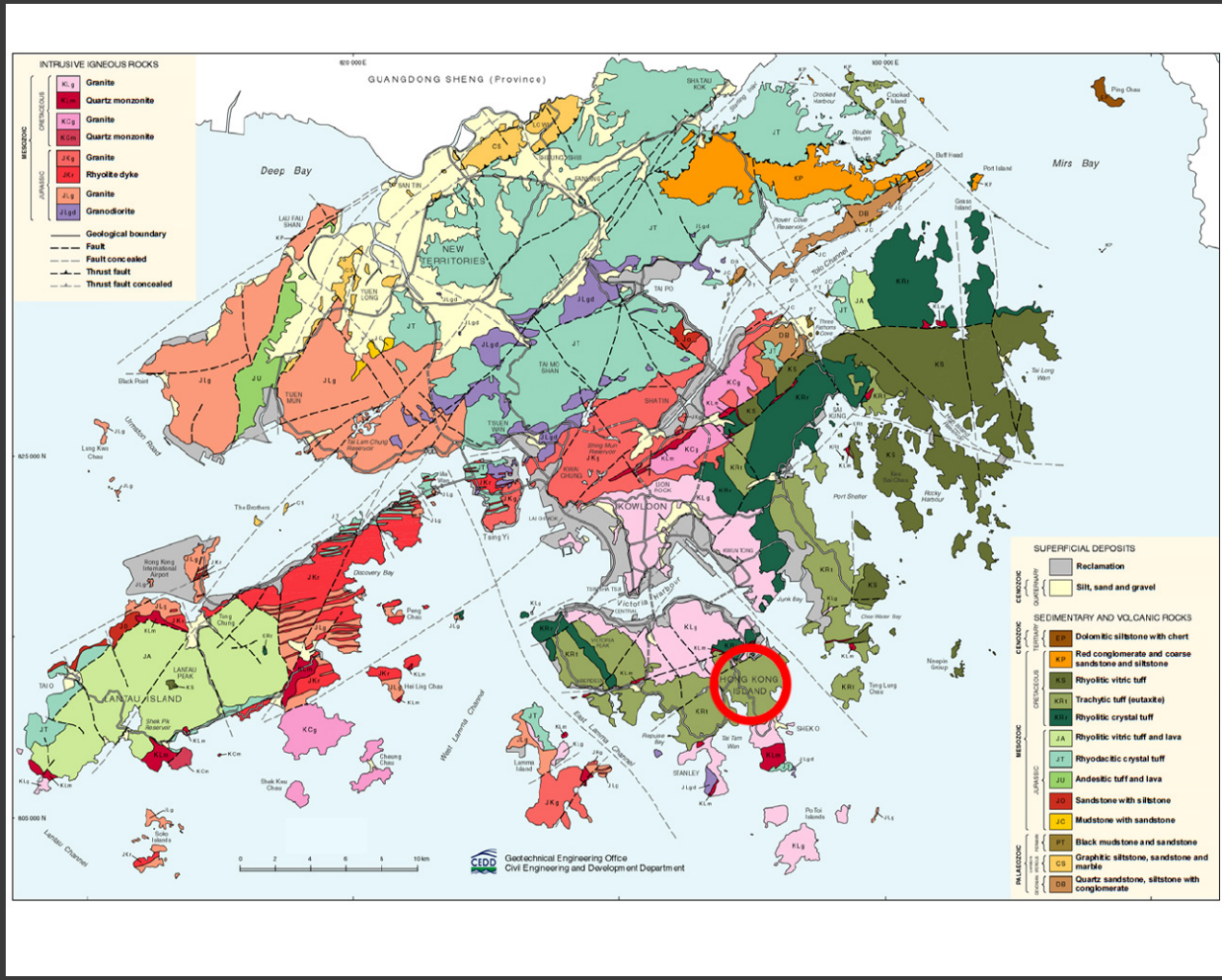


Geological map of Hong Kong

Hong Kong:
It is located on the sedimentary rocks and volcanic rocks.

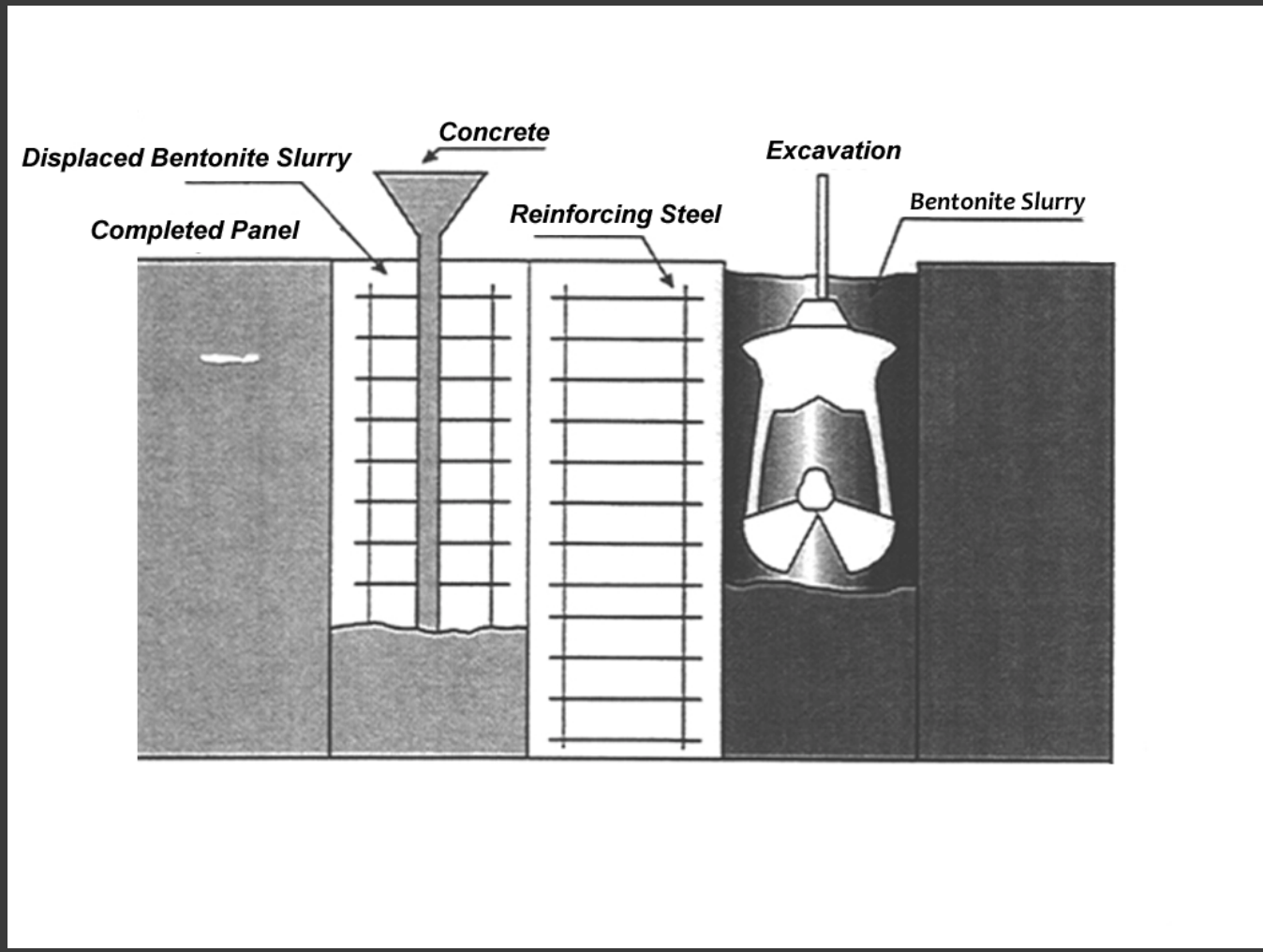
Superficial Deposits:
Beach sand, intertidal mud and sand, and estuarine mud, clayey silt and sand
Alluvial sand, silt gravel and colluviums.

Due to its location, it was designed for twice the live load that is required in the United States for this type of building.



Foundation construction

The foundation was poured in place, and it is set on several caissons.
These caissons were then surrounded by concrete diaphragming walls.
Around the vaults, the concrete surrounding the stell plate is three feet thick, so this type of support system for the base is carried up to the fourth floor (Wilson, p.3)



Construction process

man on spandrel

man lassoing girder

men on hanging beam

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Thank you.