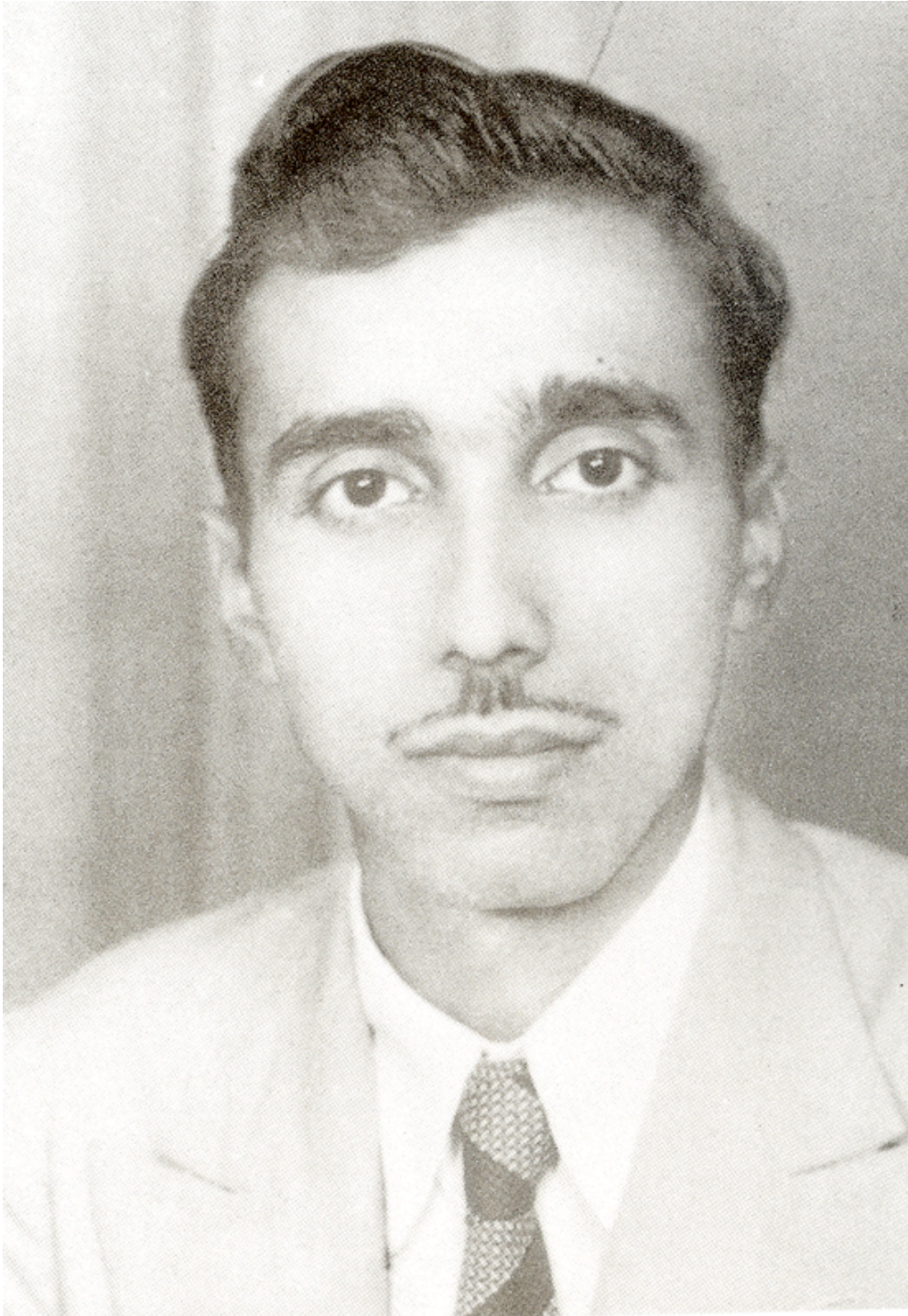


Fazlur Kahn and the tall tube

Part One:

The path to the Super Tube

John Hancock Center



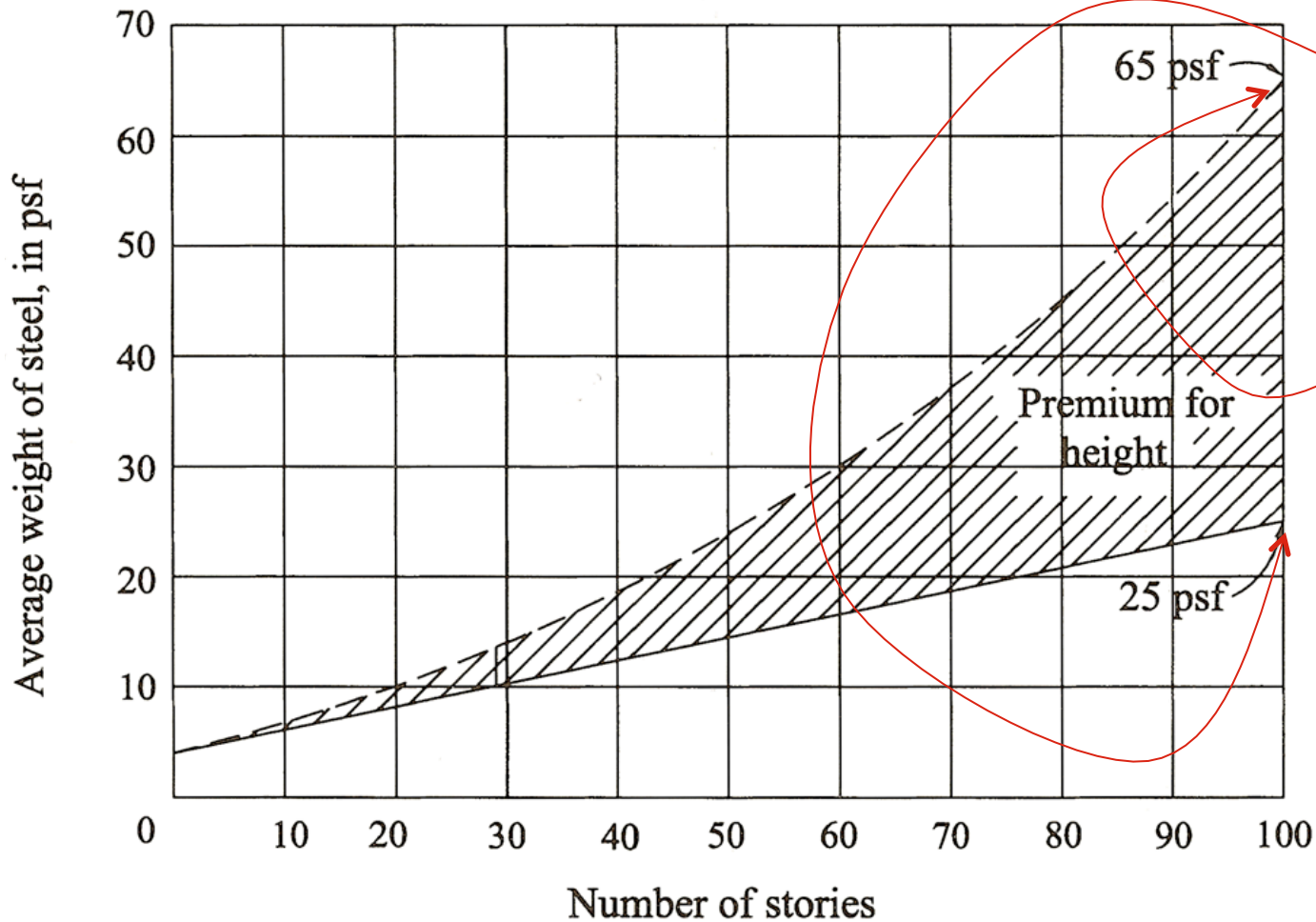
Fazlur Kahn

- Born in Dhaka, Bangladesh
- Taught at Univ. of Illinois
- Project engineer and partner, Skidmore Owings Merrill, SOM, Chicago
- 1976 Haj to Mecca

Heavy Hitters

- Empire State, about 60 lbs of steel per s.f.
- Typical Chicago High Rise in 1960, 50 lbs of steel per s.f.

The cost of wind...and seismic



• Gravity loads only require 25 pounds per s.f. of floor area for a 100 story building

• Depending on the design, lateral loads could add another 40 psf to stiffen the conventional steel frame



1965 Kahn's accidental discovery

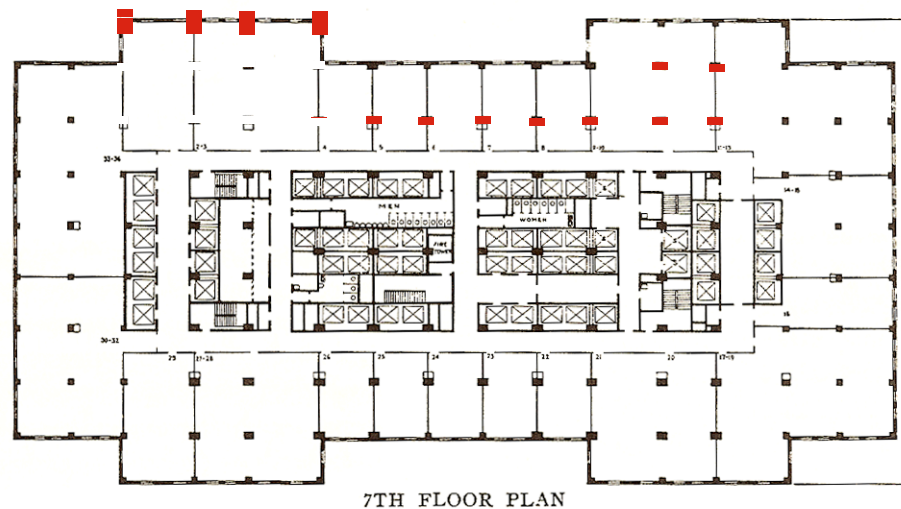
- Think of the wall of a high rise as a thin walled tube with punched holes as the exterior wall
- This led to framed-tube concept shown here in the concrete framed DeWitt-Chestnut Apartments 1965

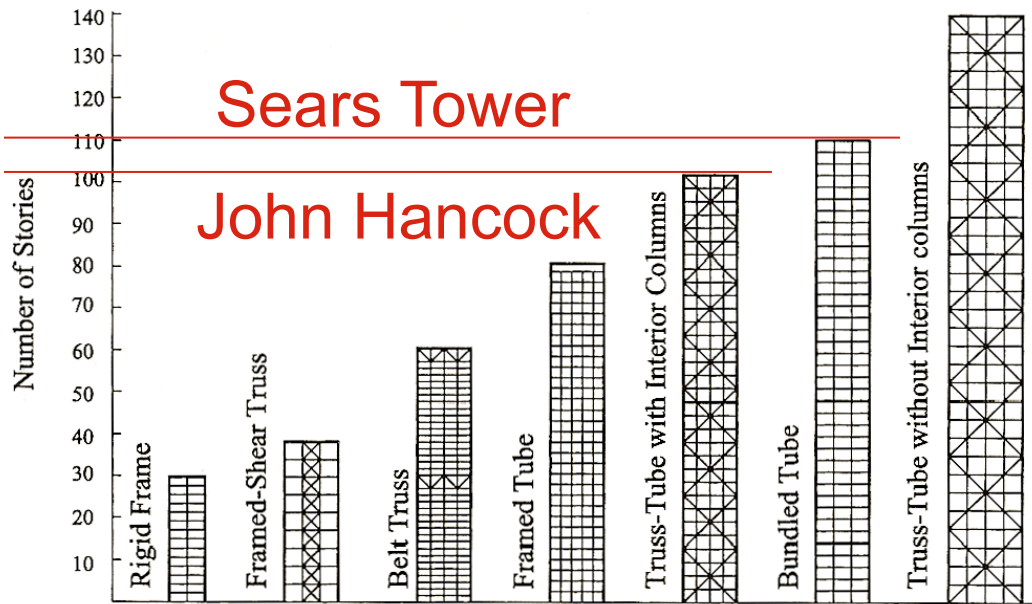
Take out Columns...the key to the efficiency of the tube

- Reverse intuitive but makes sense when you think about it.
 - Interior columns are sized to take gravity loads
 - Combining interior and exterior columns means exterior columns are “naturally” heavier....and now capable of taking the lateral load.
 - Brilliant, but not obvious

Fewer columns=more load per column, heavier column resists wind

- Move interior columns to exterior to make columns naturally heavy enough to resist lateral loads





Family capacity

- Kahn analyzed the capacity for various structural concepts and found the rigid frame began to pay a penalty above 30 floors
- Combining vertical trusses at the core could bring the rigid frame to 40 floors
- Adding belt trusses “stacked” rigid frames to reach 60 floors
- The whole exterior wall as a load bearing tube could reach 80 floors
- Trussing the exterior walls of a tube with some interior columns could reach over 100 floors
- Bundling Tubes could reach 110 floors
- A truss tube without interior columns could reach 140 floors

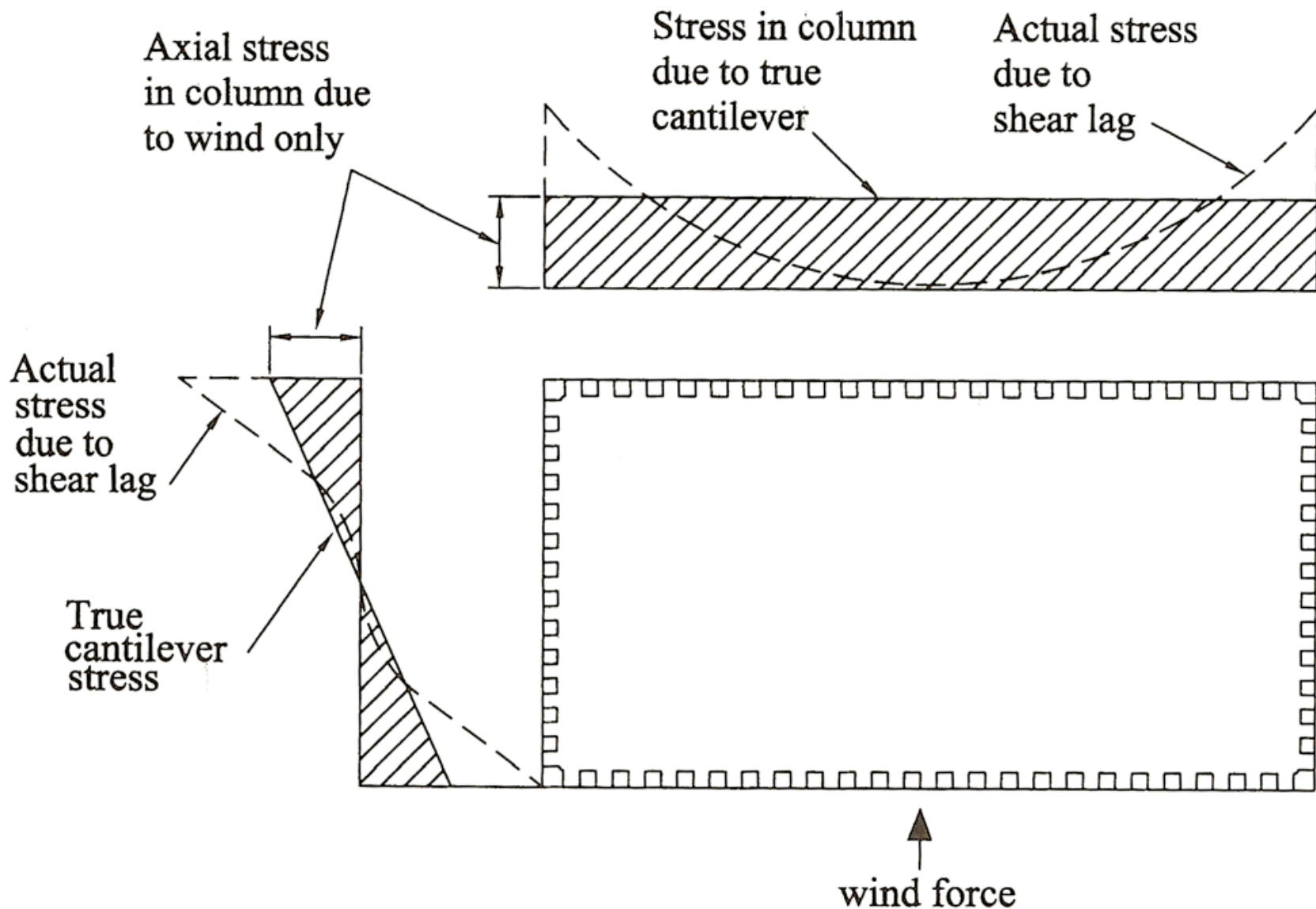


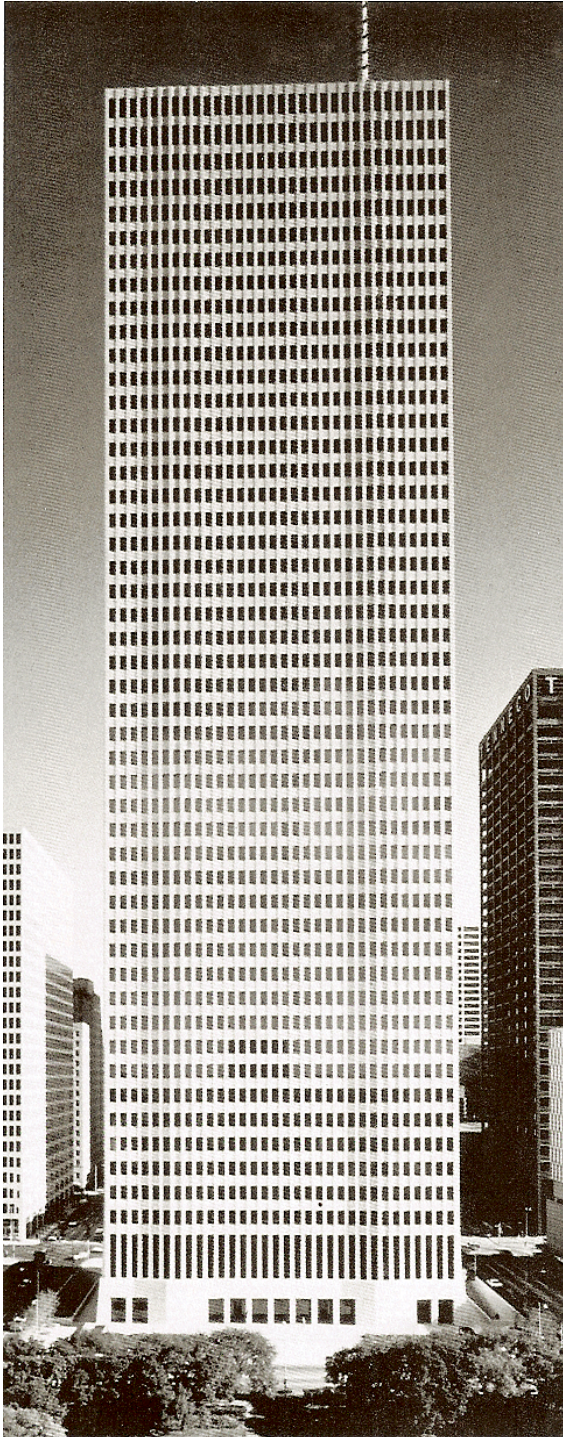
The diagram shows a structural frame with three vertical columns and two horizontal beams. The columns are closely spaced, and the beams are deep. The text 'Closely Spaced Columns max 15'' is written in red across the middle of the frame. A bullet point '• Deep Spandrel Beams' is located in the lower-left corner of the frame.

Closely Spaced Columns max 15'

- Deep Spandrel Beams

A unique tube behavior more force at the columns

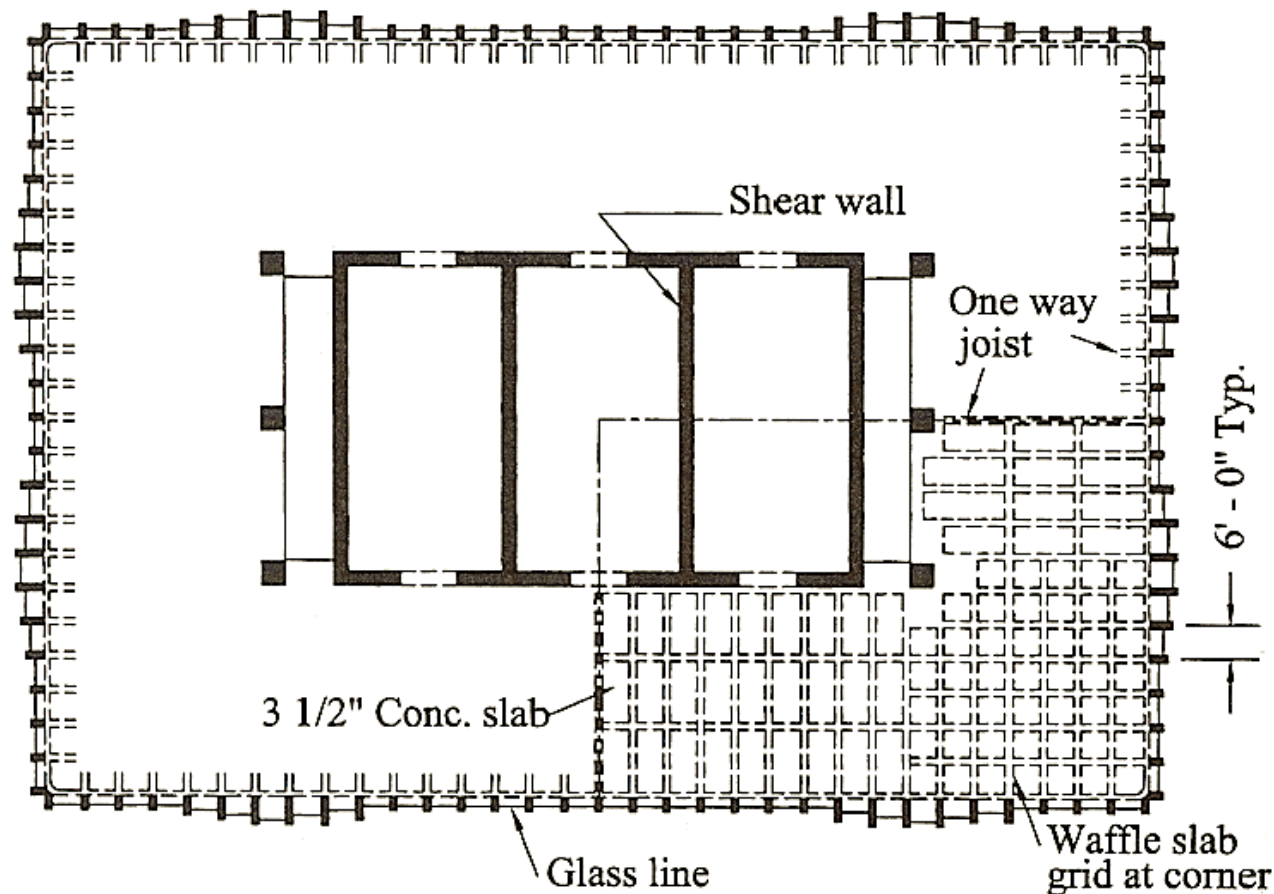




One Shell Plaza 1971

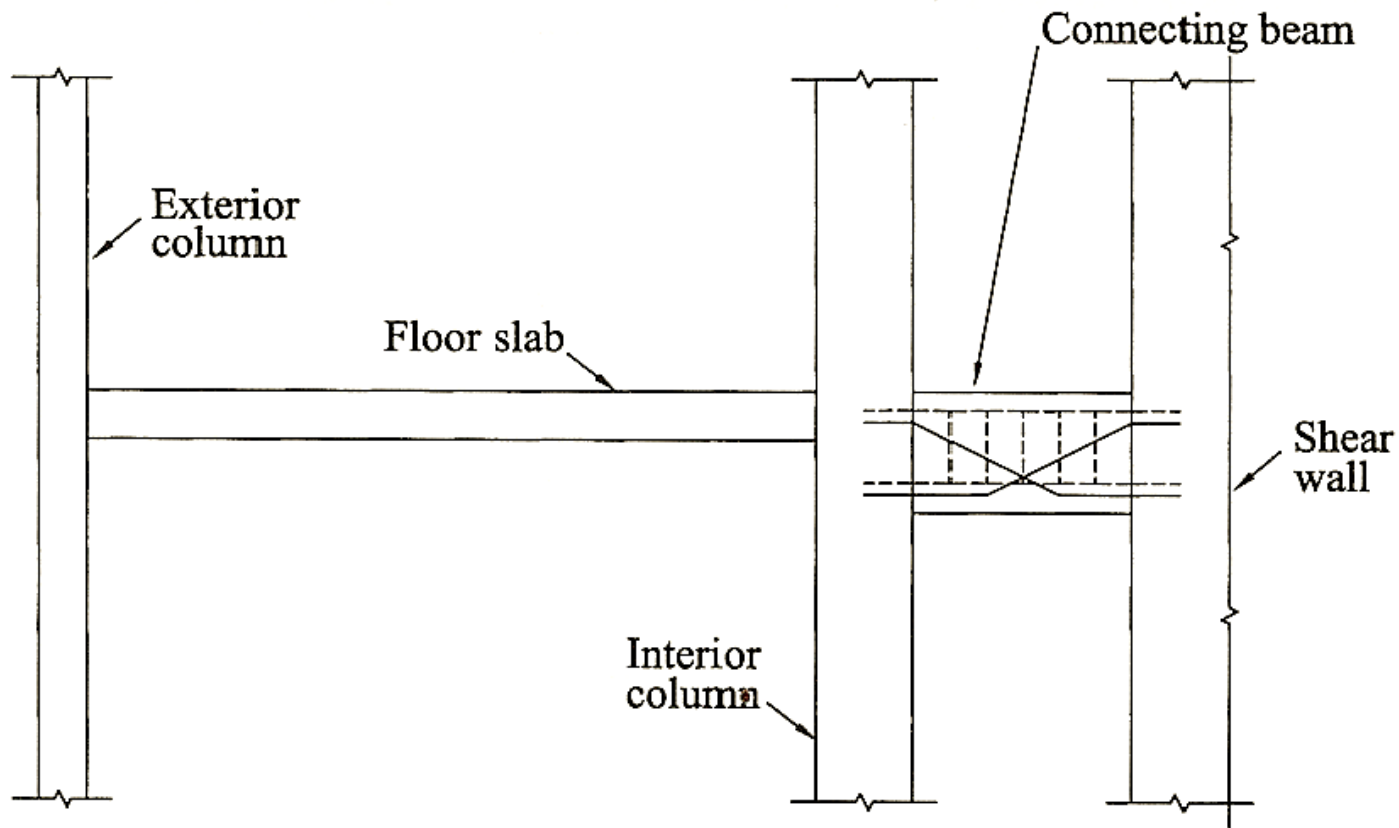
- Column dimensions vary from edge to center
- Glass follows face of column to make undulating facade

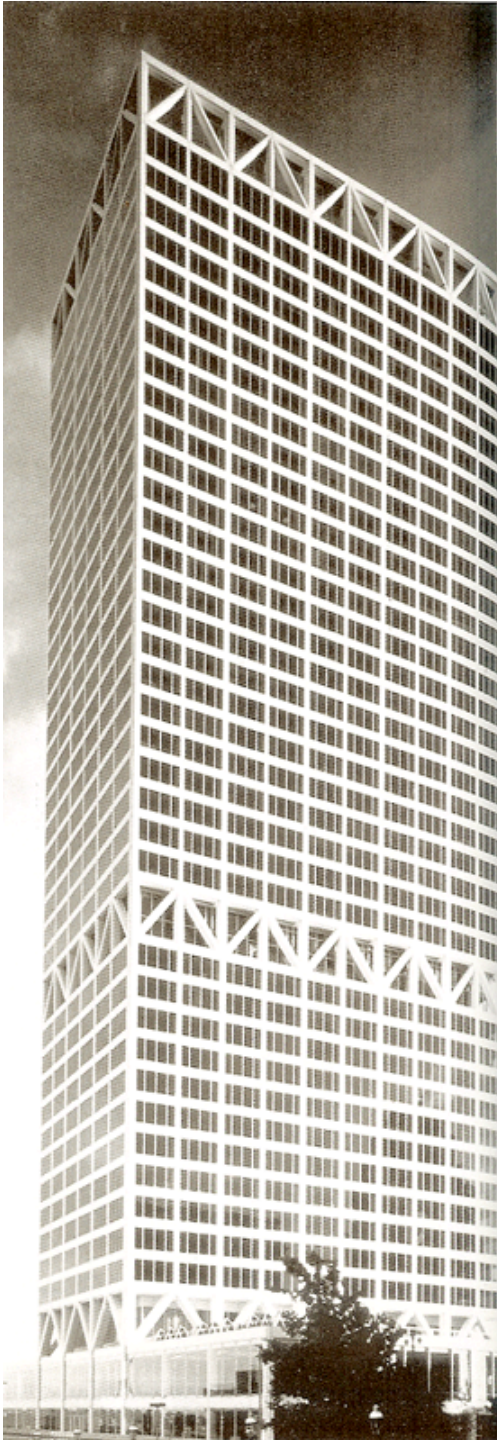
Concrete Tube in Concrete Framed-Tube



- Shear core linked to tube through stiff floor
- Stronger corners with waffle slab
- Deeper columns at corners

Floor transfers lateral to core





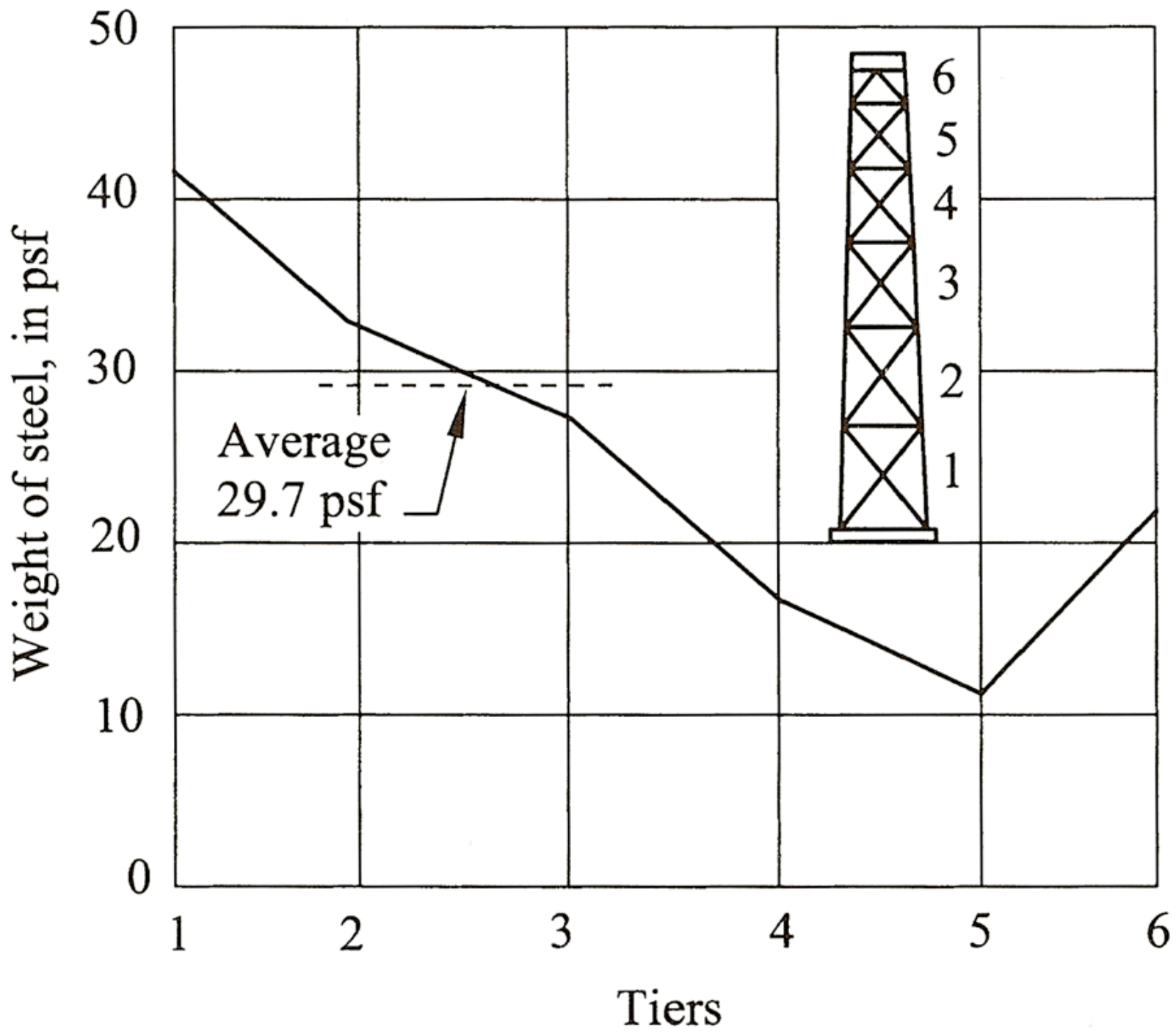
1973 First Wisconsin Center

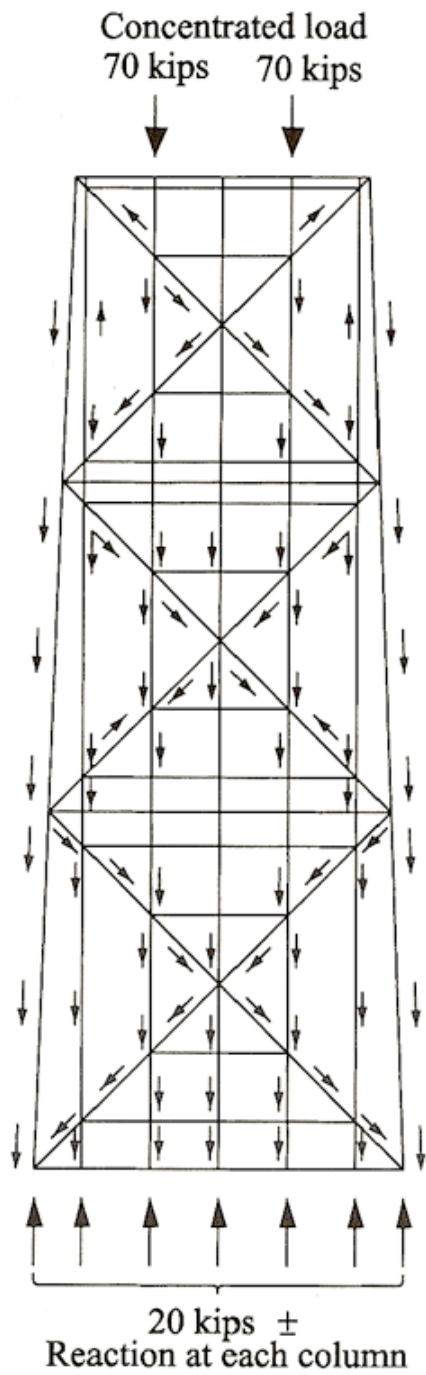
- Belt truss innovation to make building into two stacked rigid frames
 - To reduce the shear lag
- Belt truss floors became mechanical unit spaces



Radical in our midst: 1970 John Hancock

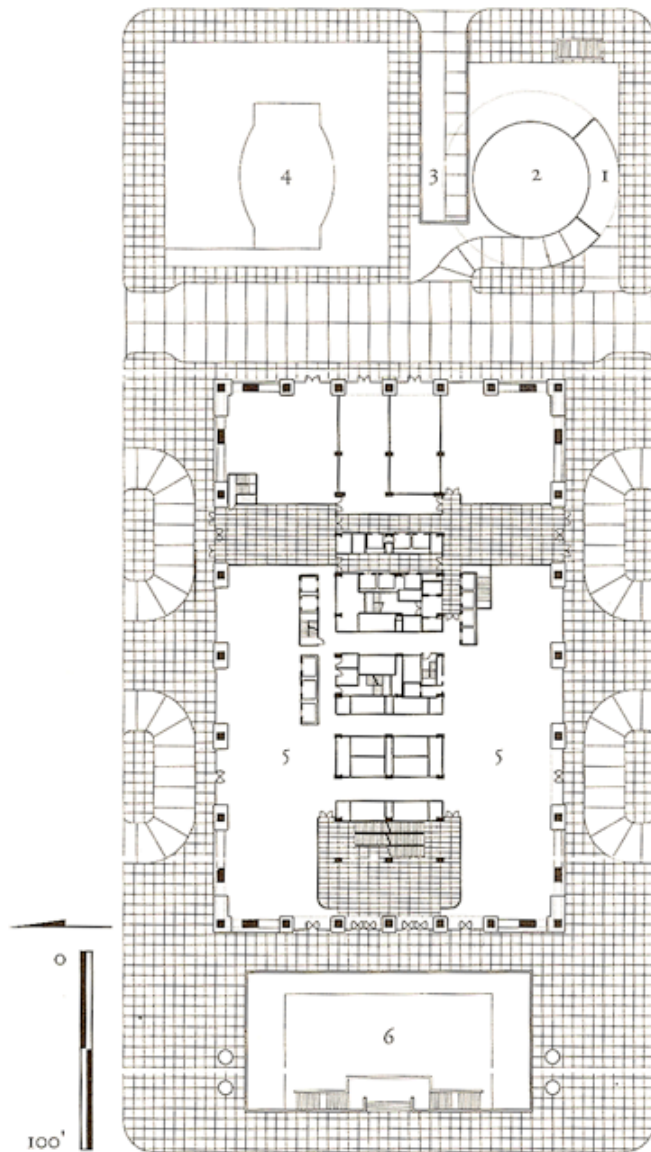
- 29.7 lbs of steel per s.f.
- 40% less
- 40% savings
- Twice the height - 100 floors (1,500 ft to antenna top)
- Frame drifts 2.5 ft. at max wind
- Frame cost the same as a 45 floor building





Mixed Use for Market absorption

- FI 1-5 commercial
- FI 6-12 parking
- FI 13-41 office
- FI 44-92 apartments
- 93-102 observatory, restaurant, television transmitters
- 853,000 s.f.
- 4 year build



Plan of center

1. RAMP TO GARAGES

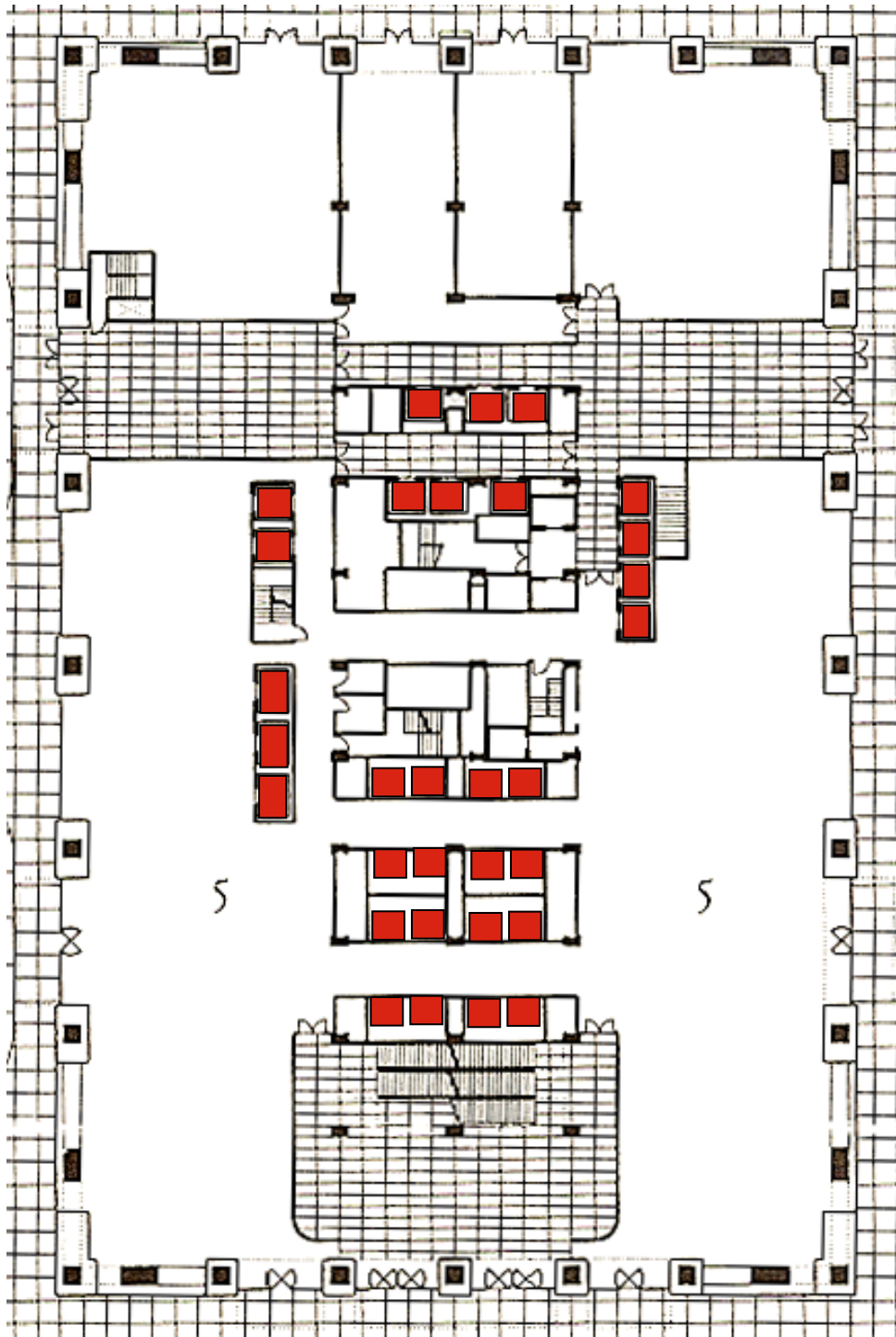
2. MECHANICAL

3. SERVICE RAMP

4. CLUB

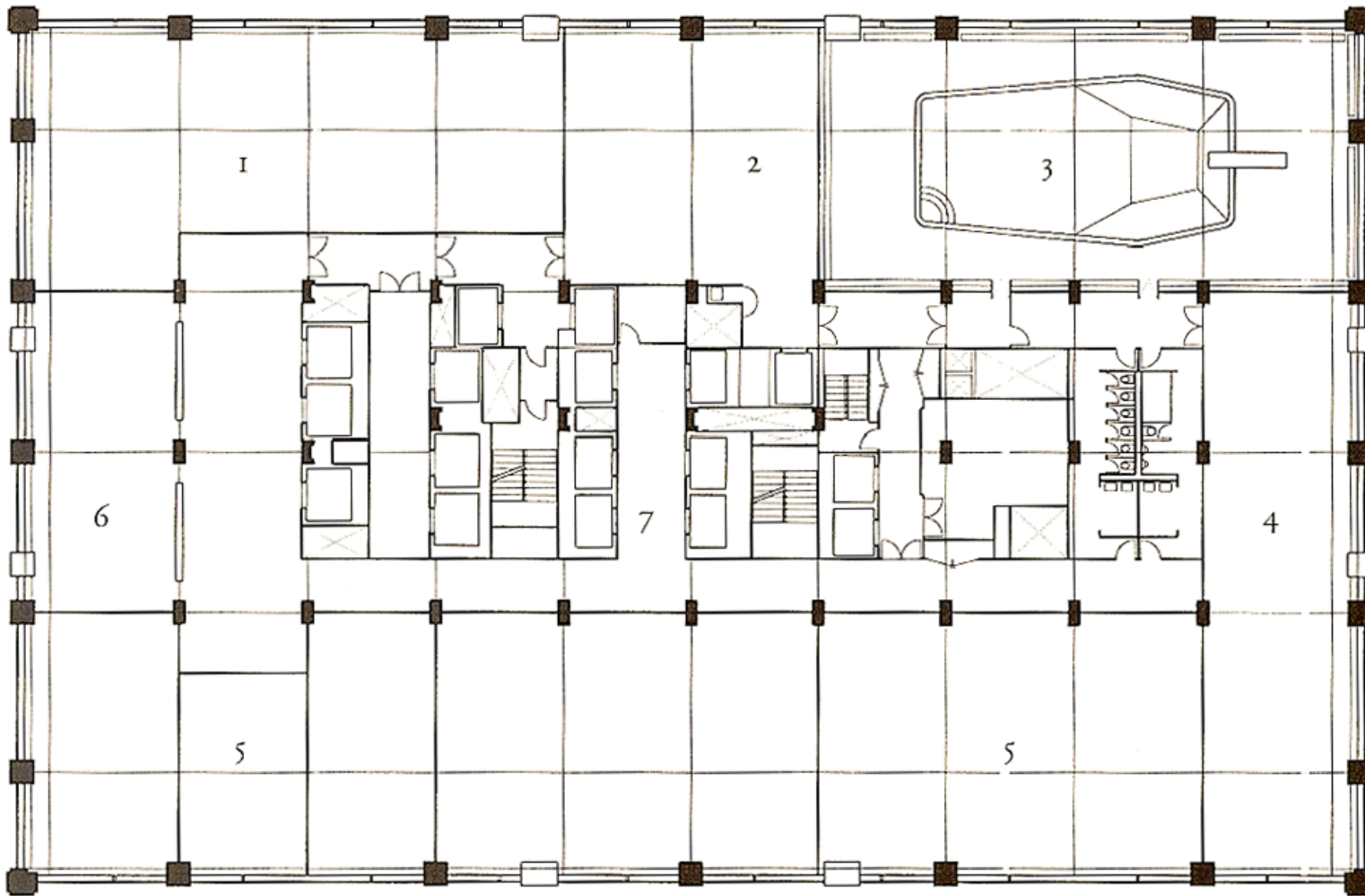
5. LOBBY

6. COURT



Elevator racing

- Fastest is 1,800 feet per minute
- 50 cabs in 31 shafts
- 1 cab per 17,000 s.f. ...luxury!
Common to find 1 per 45,000 s.f. of office space



Plan of 44th floor Sky Lobby

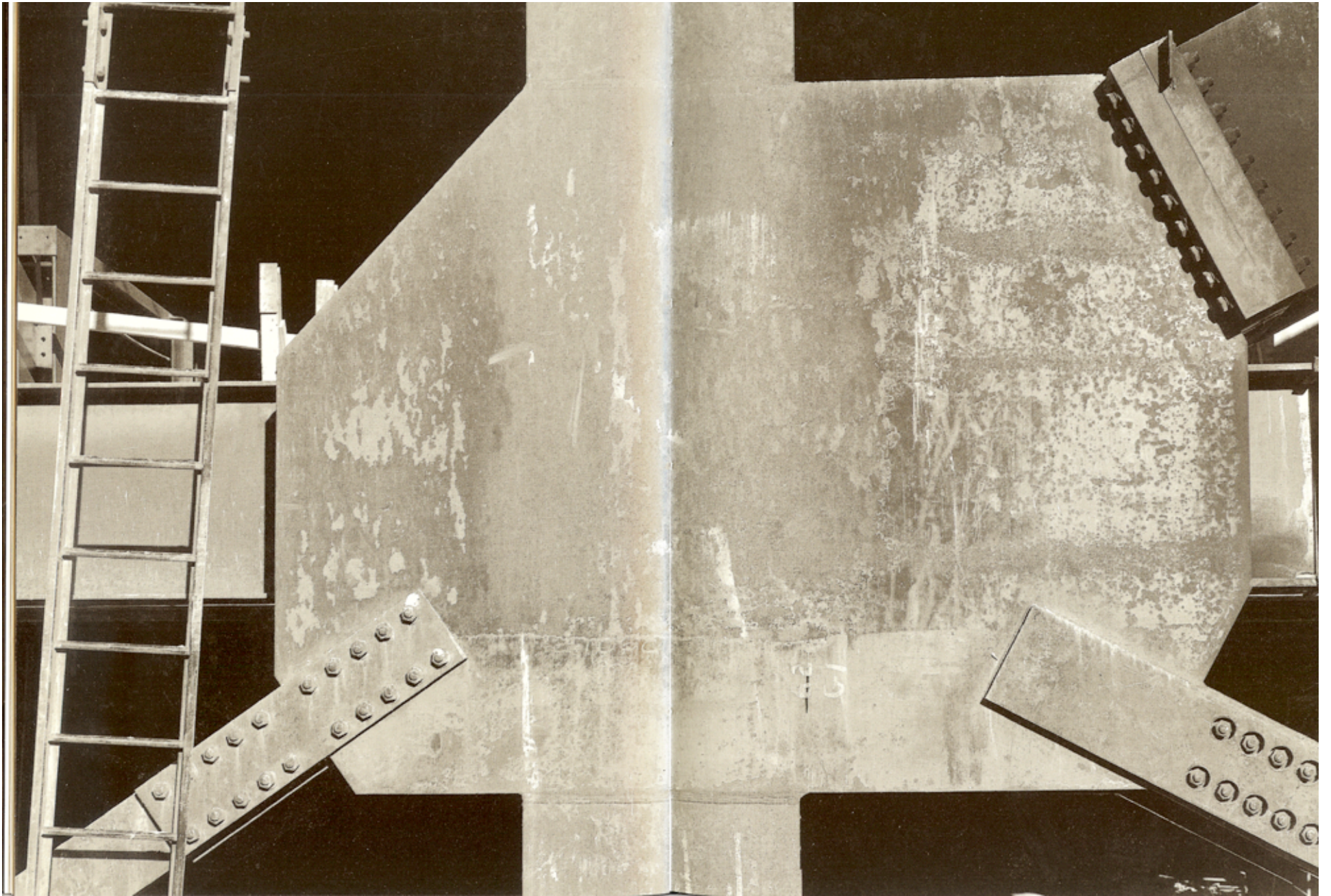
- | | | |
|---------------|----------------|-----------------|
| 1. RESTAURANT | 3. POOL | 6. LOBBY |
| 2. RECEIVING | 4. HEALTH CLUB | 7. SERVICE CORE |
| | 5. SHOPS | |



No whitecaps in windstorms

First impression...Looks like a lightweight

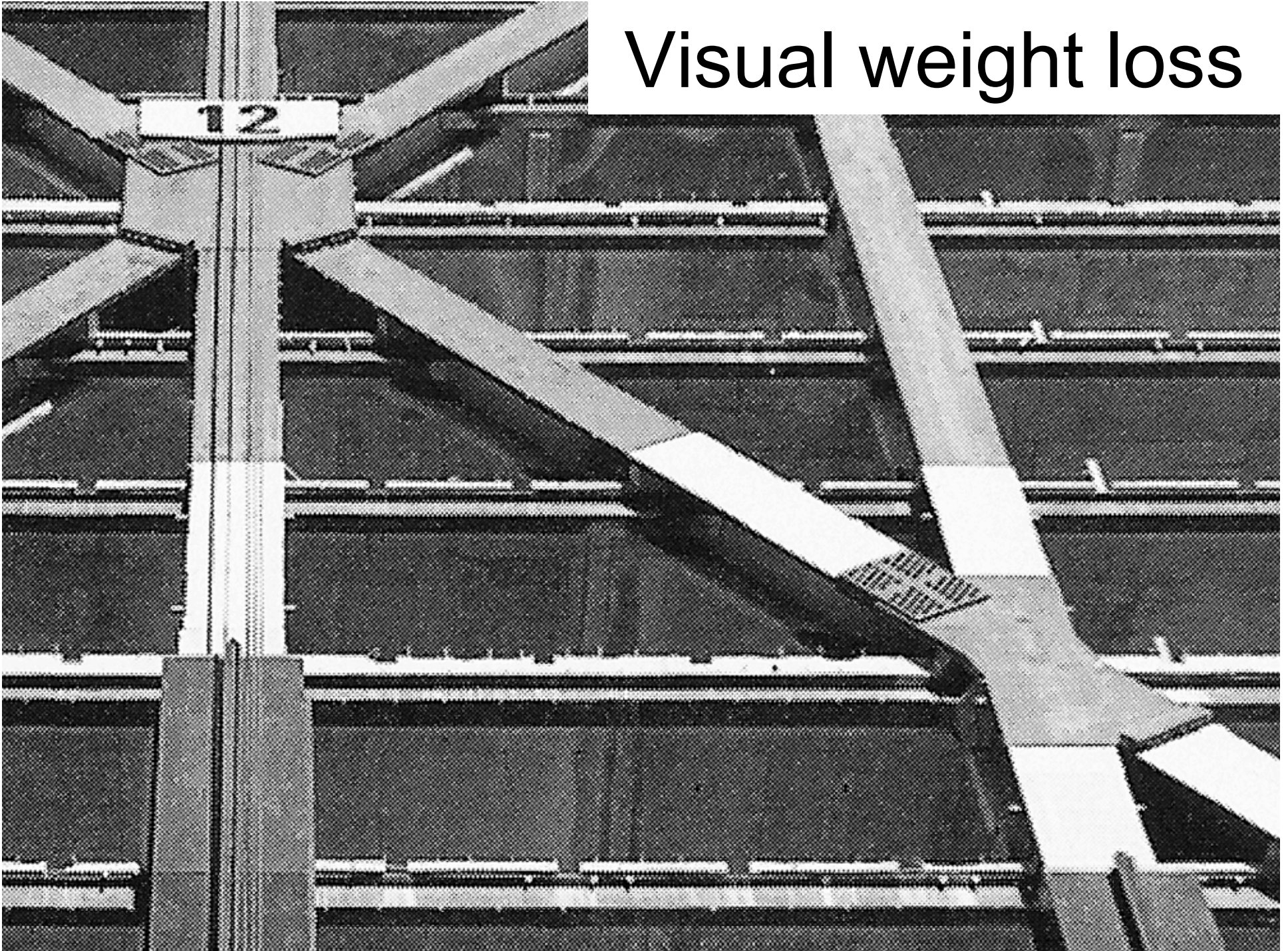


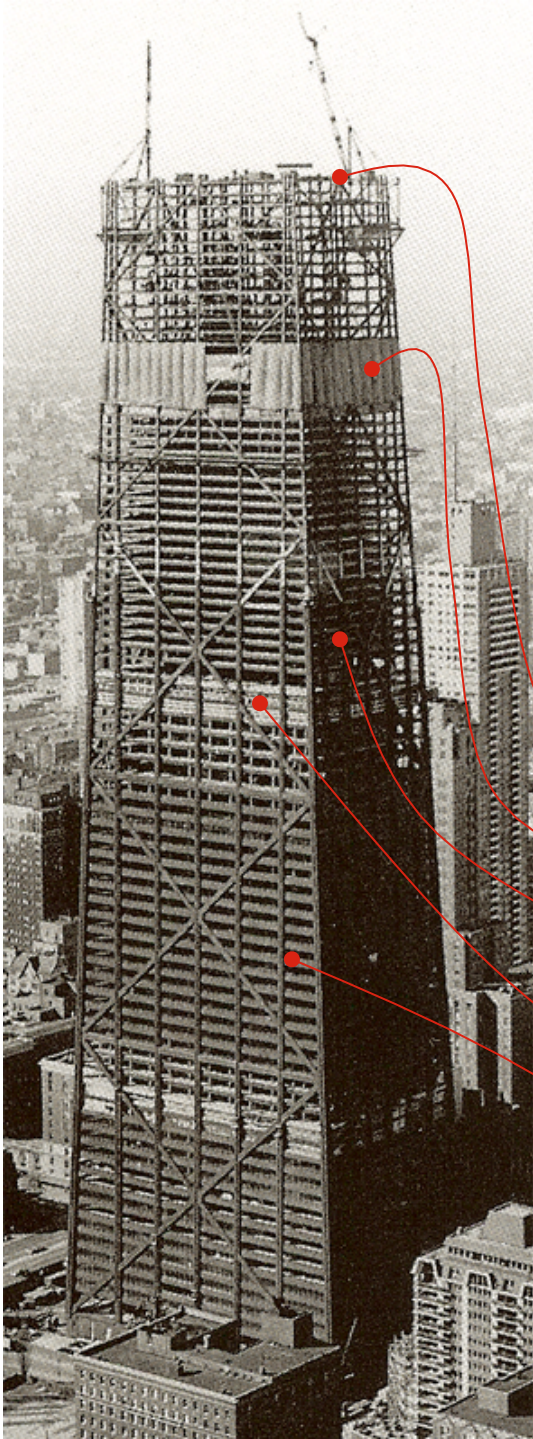




Cladding
adds
visual
bulk

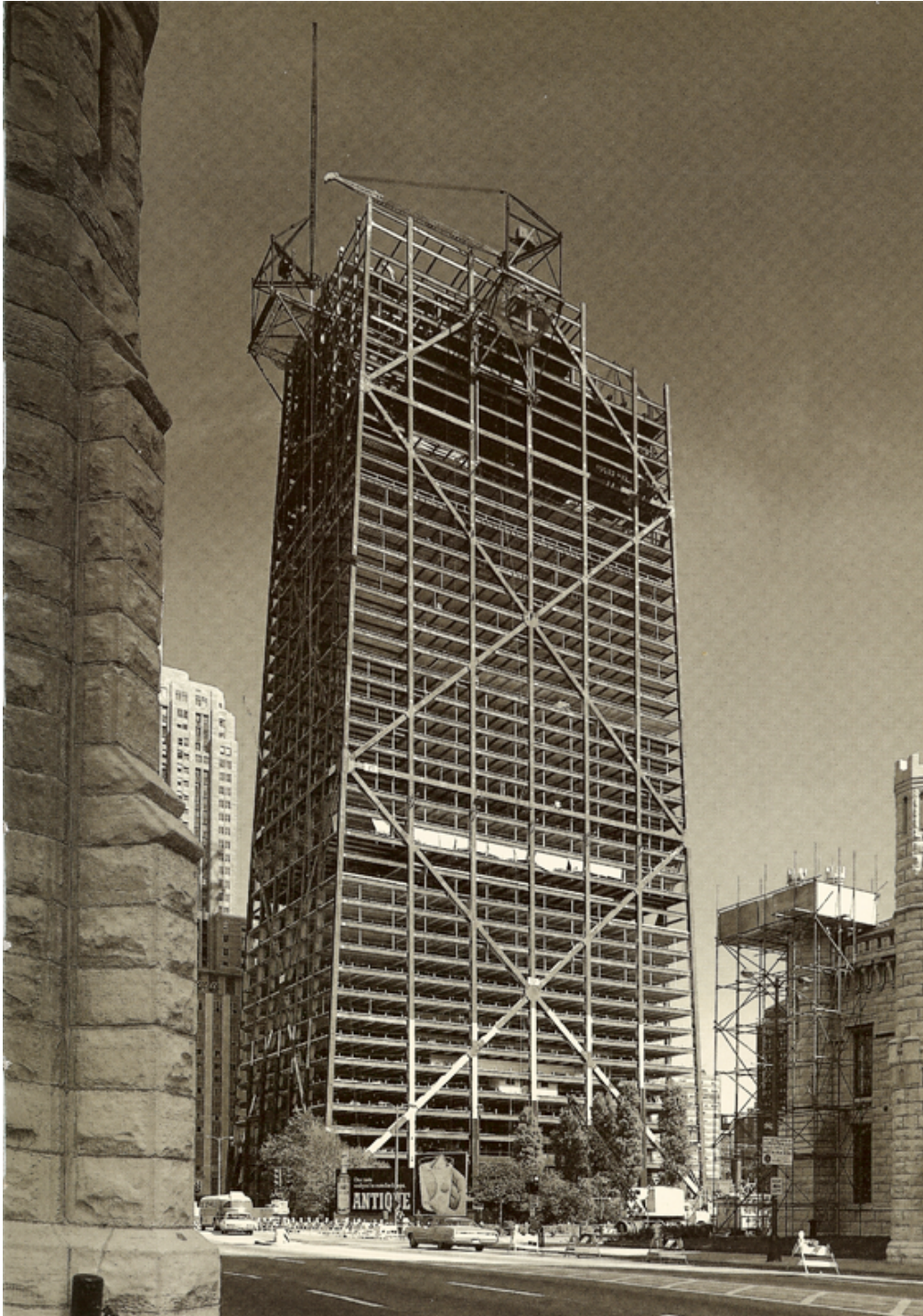
Visual weight loss





Vertical Assembly line

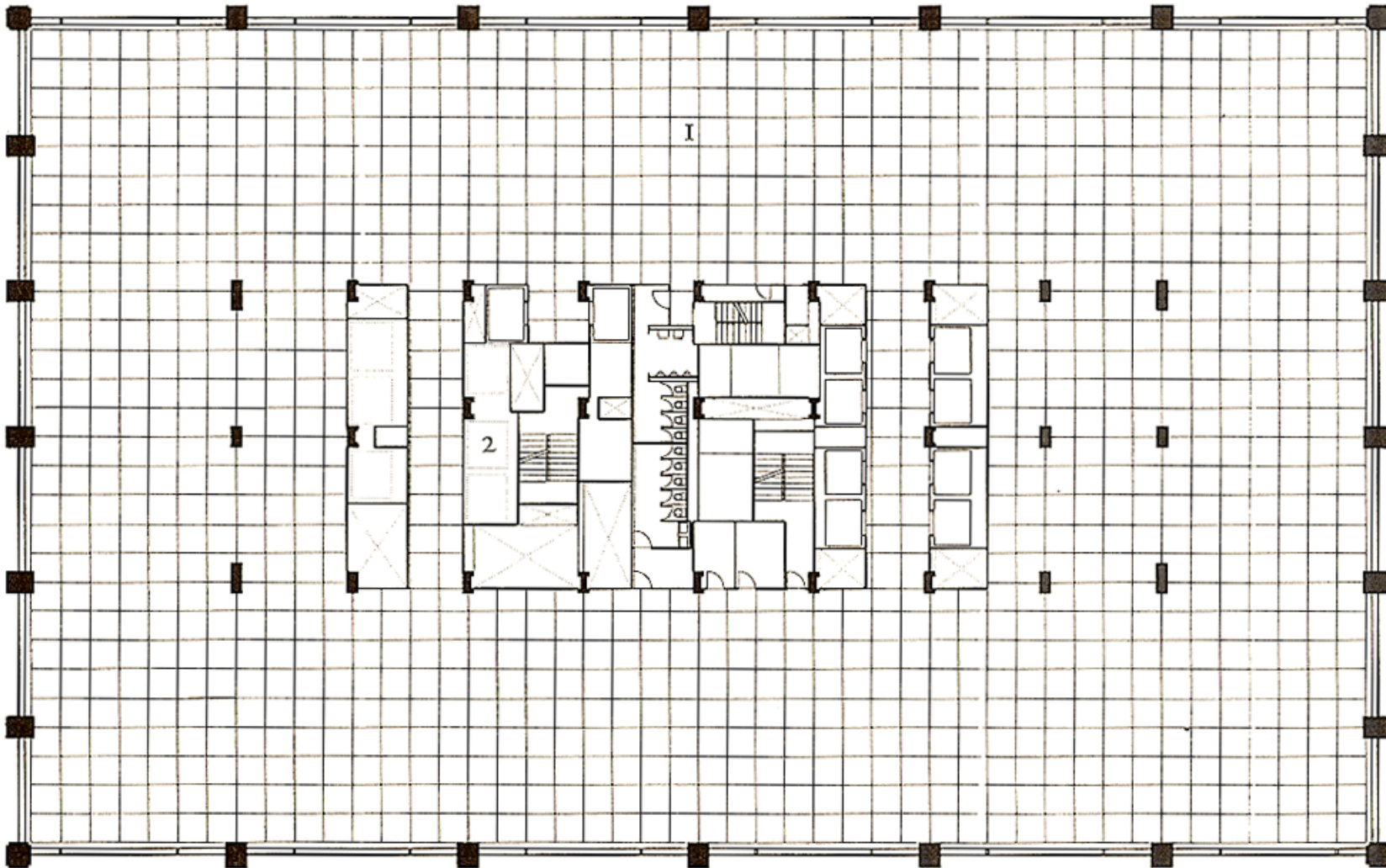
- Unlike midrise or lowrise
- Multiple operations in progress simultaneously
 - Steel Assembly
 - Fireproofing
 - Exterior cladding
 - Interior slabs and partitions
 - Exterior glazing



X marks the
spot



Braced for Market Rejection

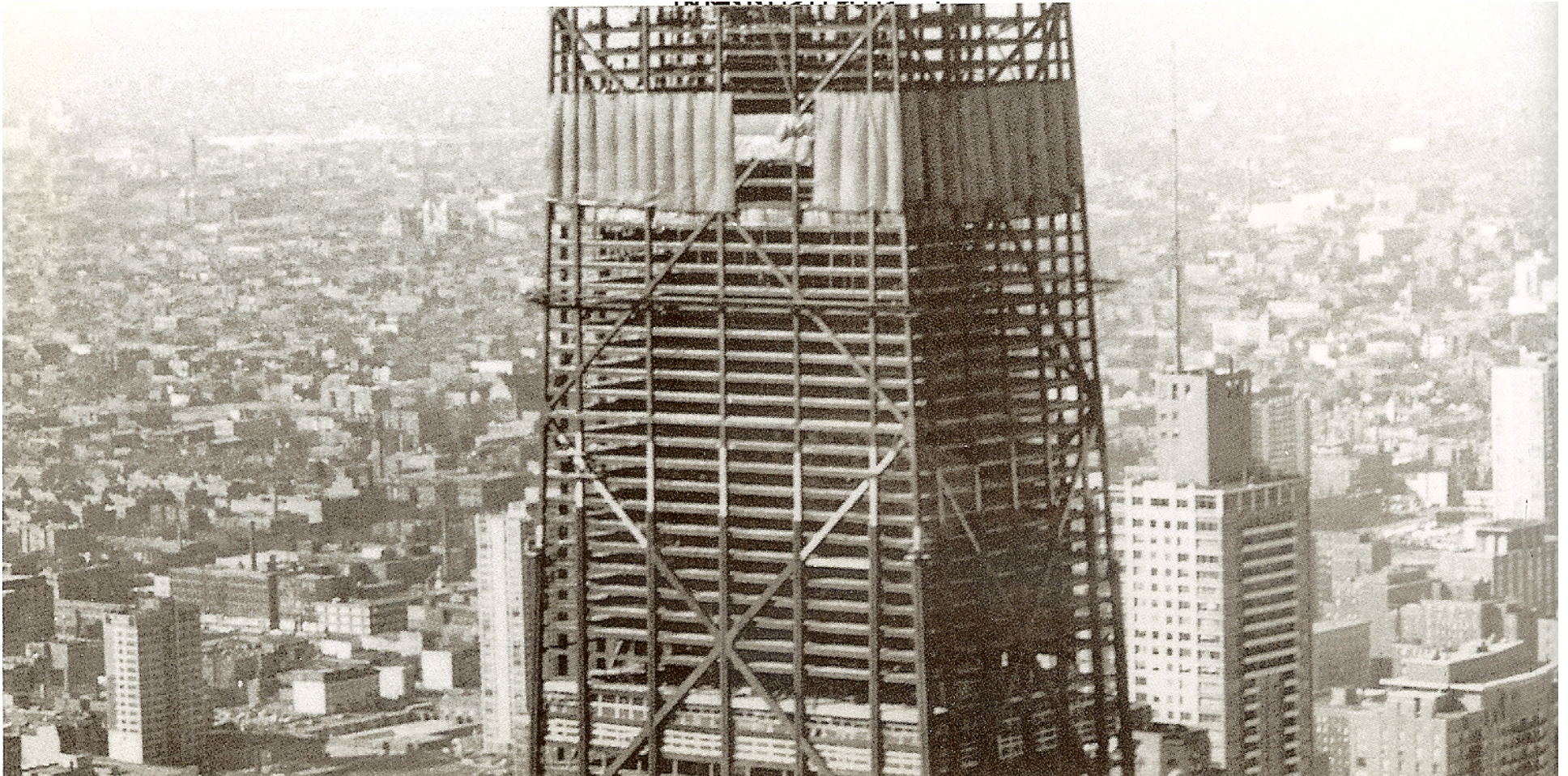


Plan of typical office level, floors 26-33

I. OPEN-PLAN OFFICE SPACE 2. SERVICE CORE

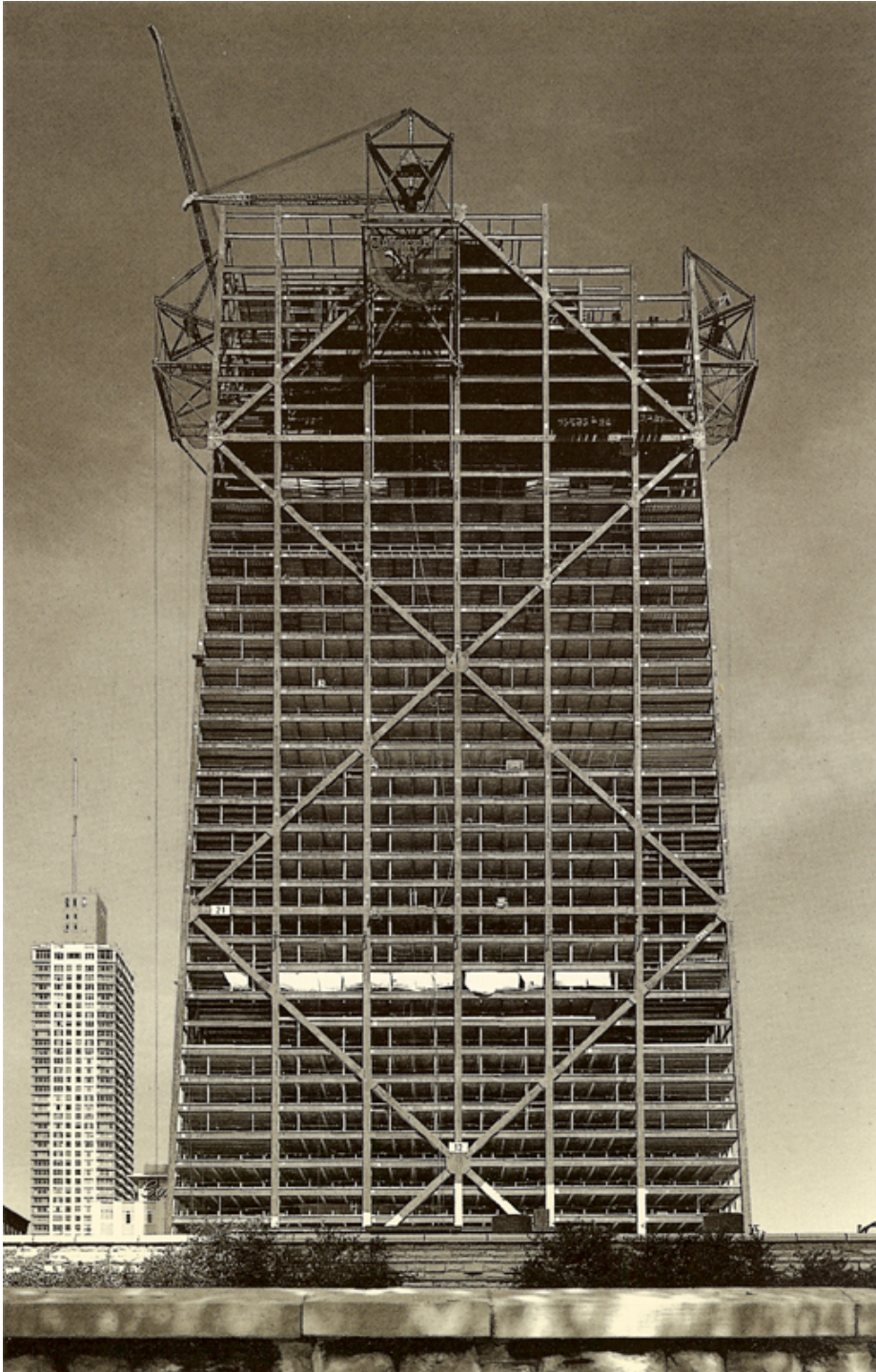


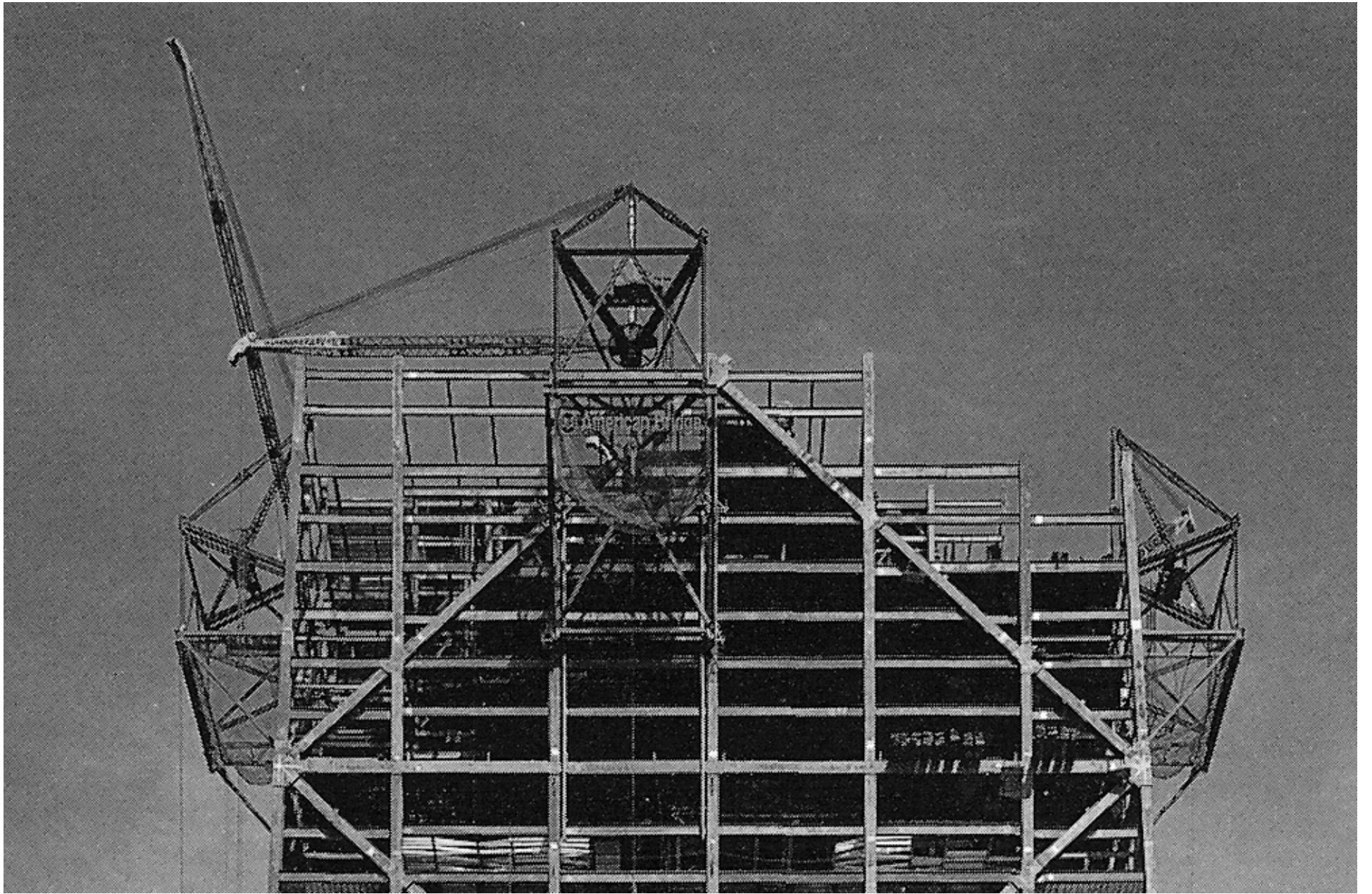
Framing fireproofing cladding pouring

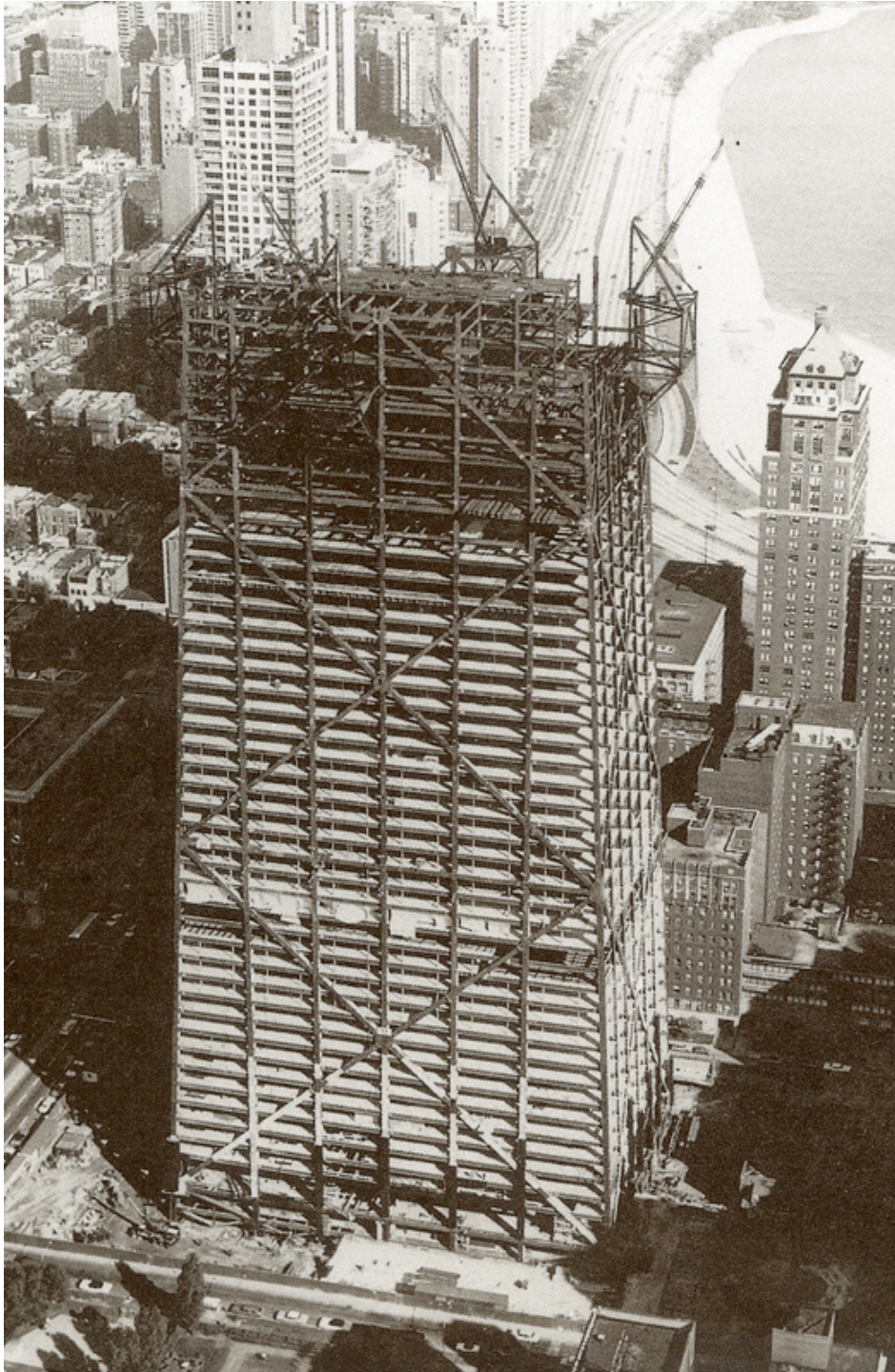




Lifting contraption

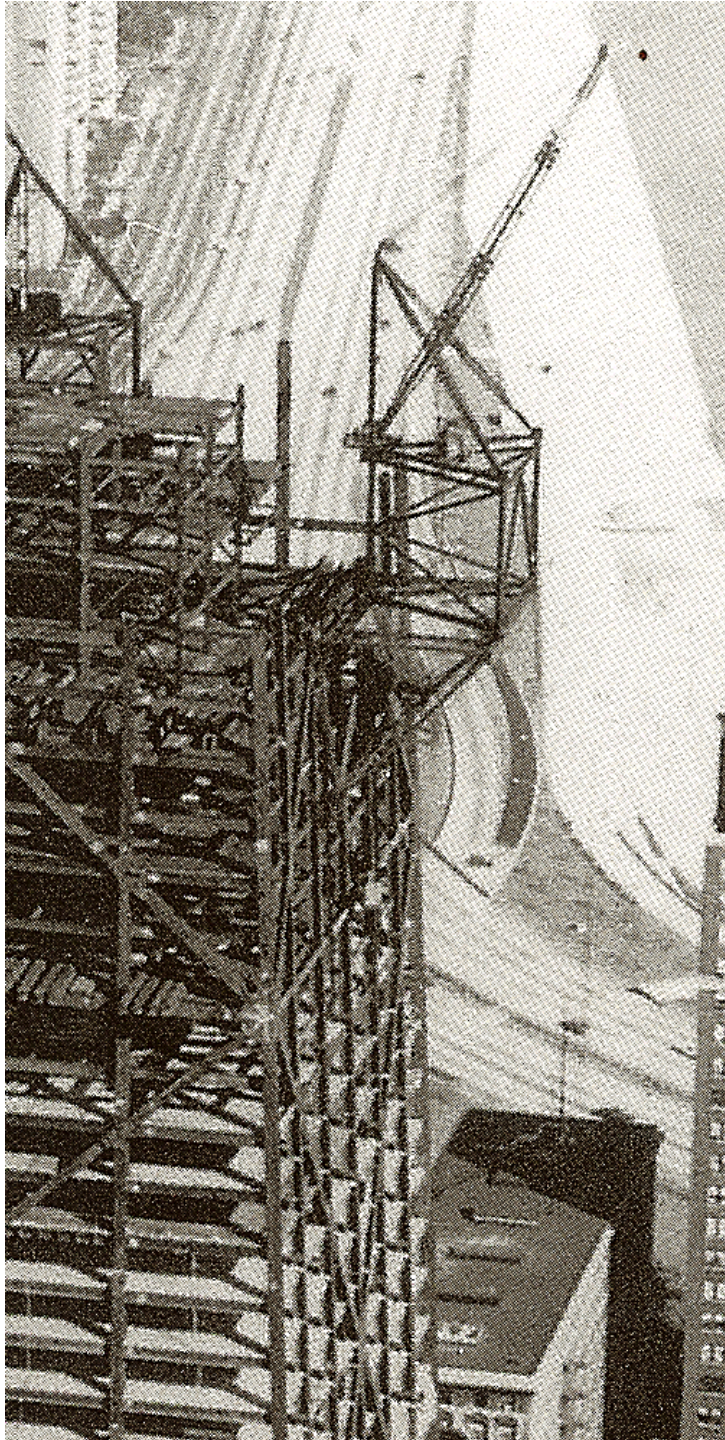




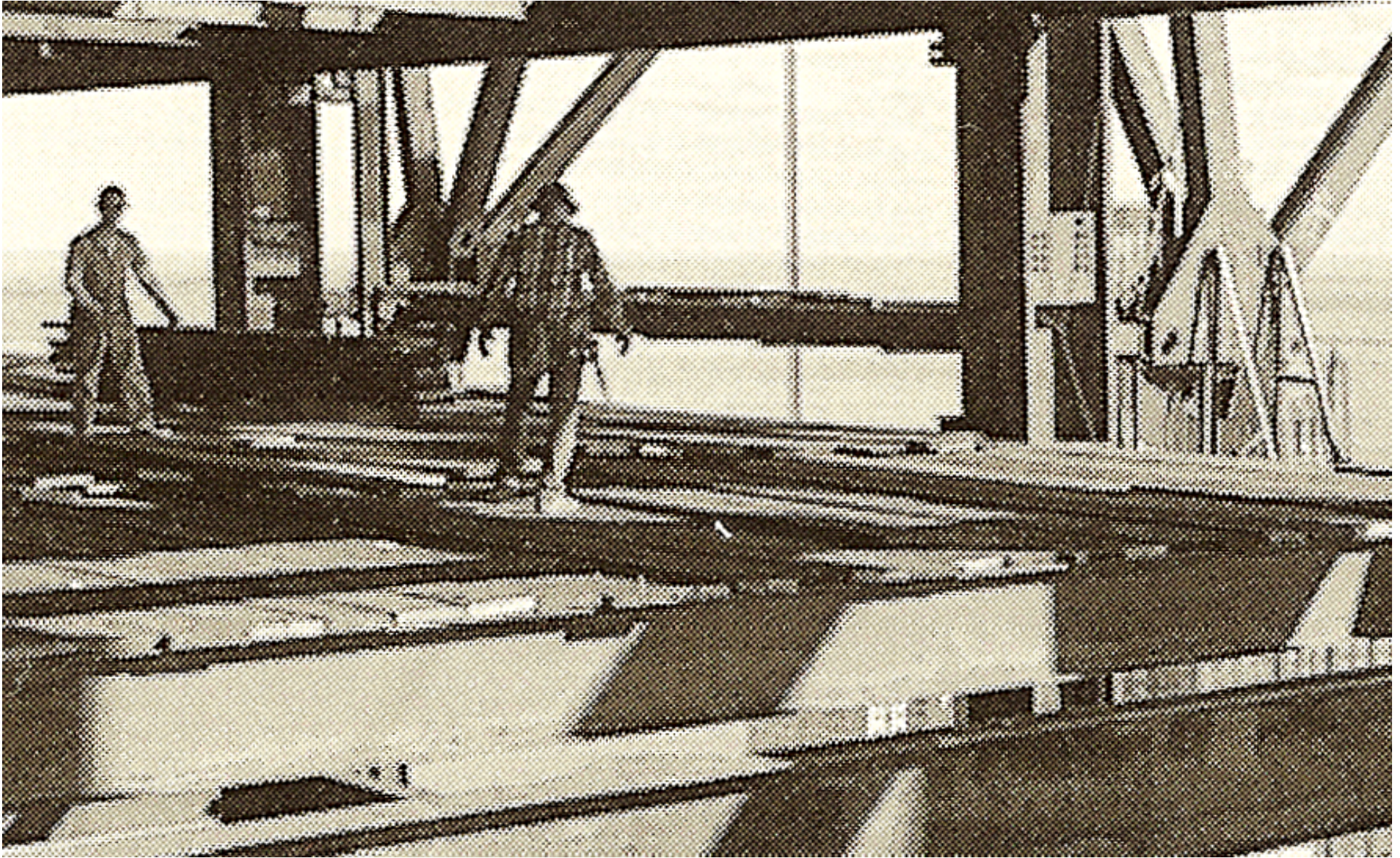


51 ft. of taper... No Setbacks

- Tapered tube gave steel assemblers extra challenge: reach out to lift up
- 104x62 at top
- 264x164 at bottom

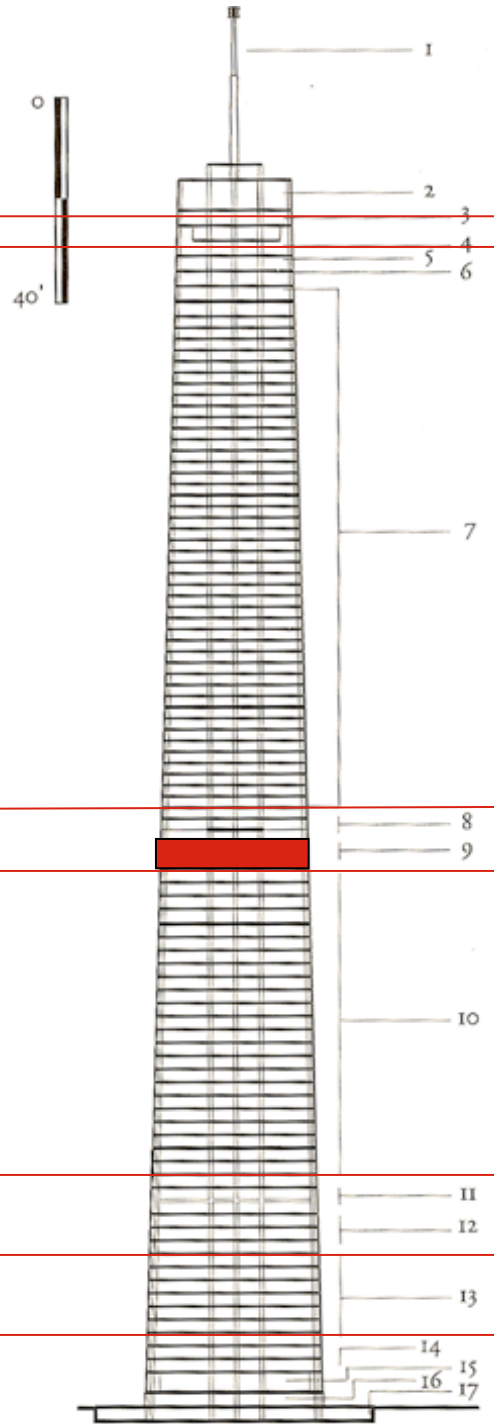
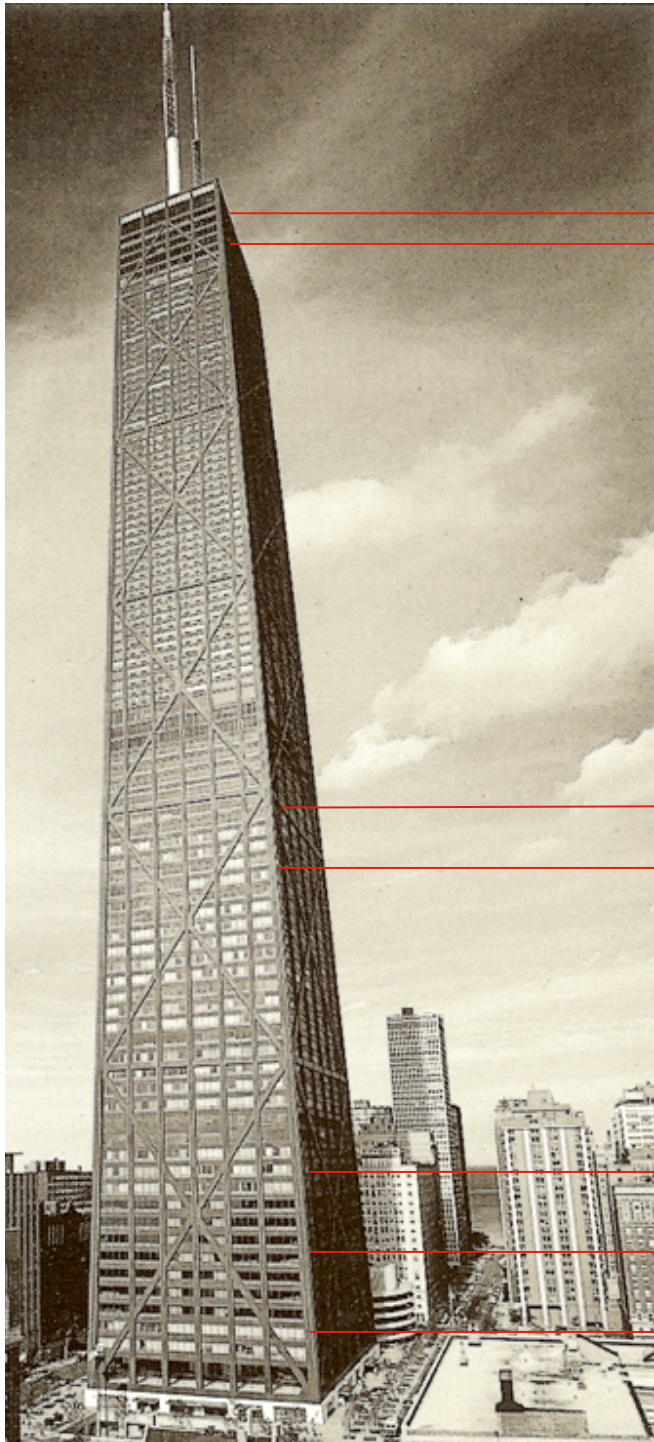


Reach out to lift up



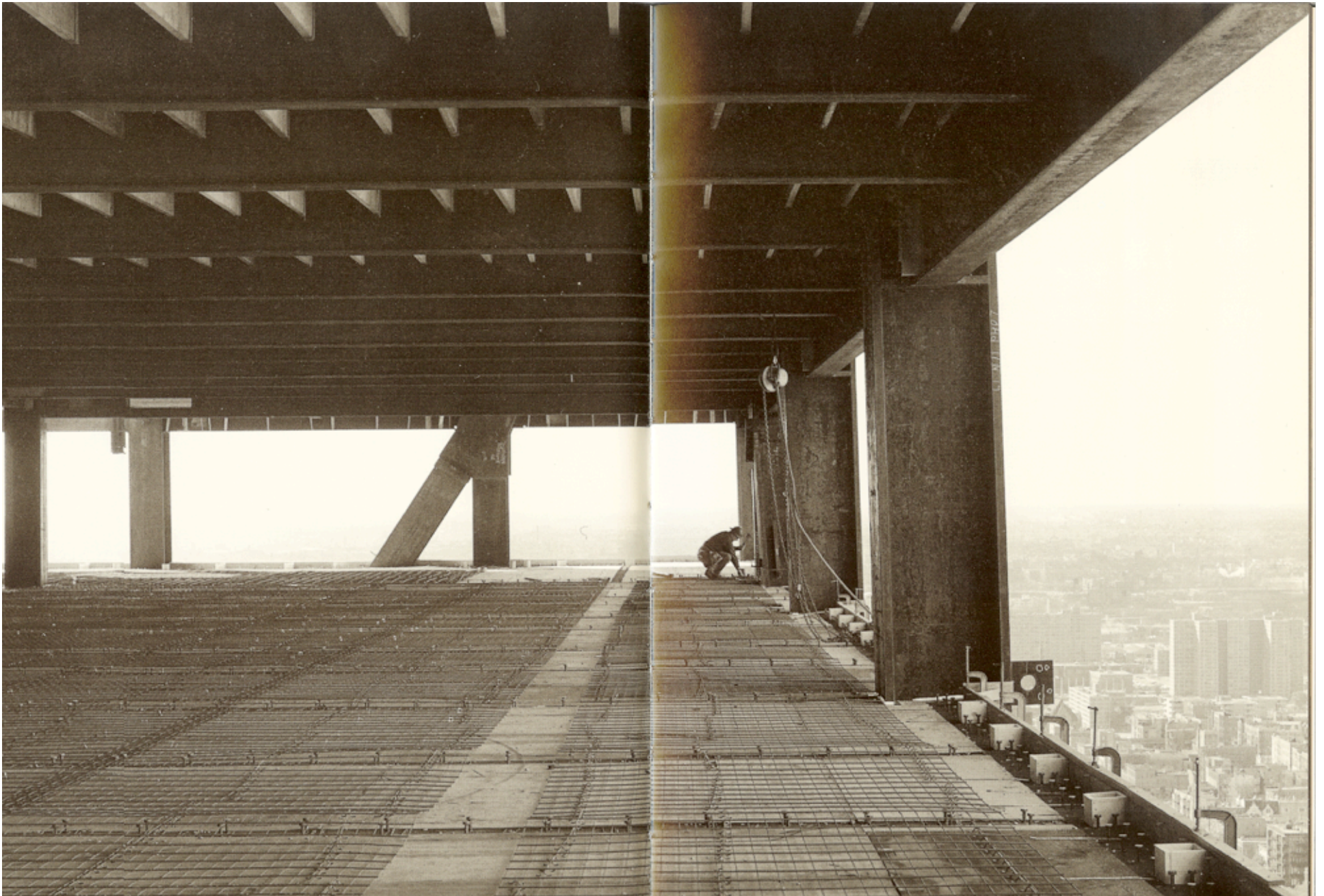
Still planking after all these years





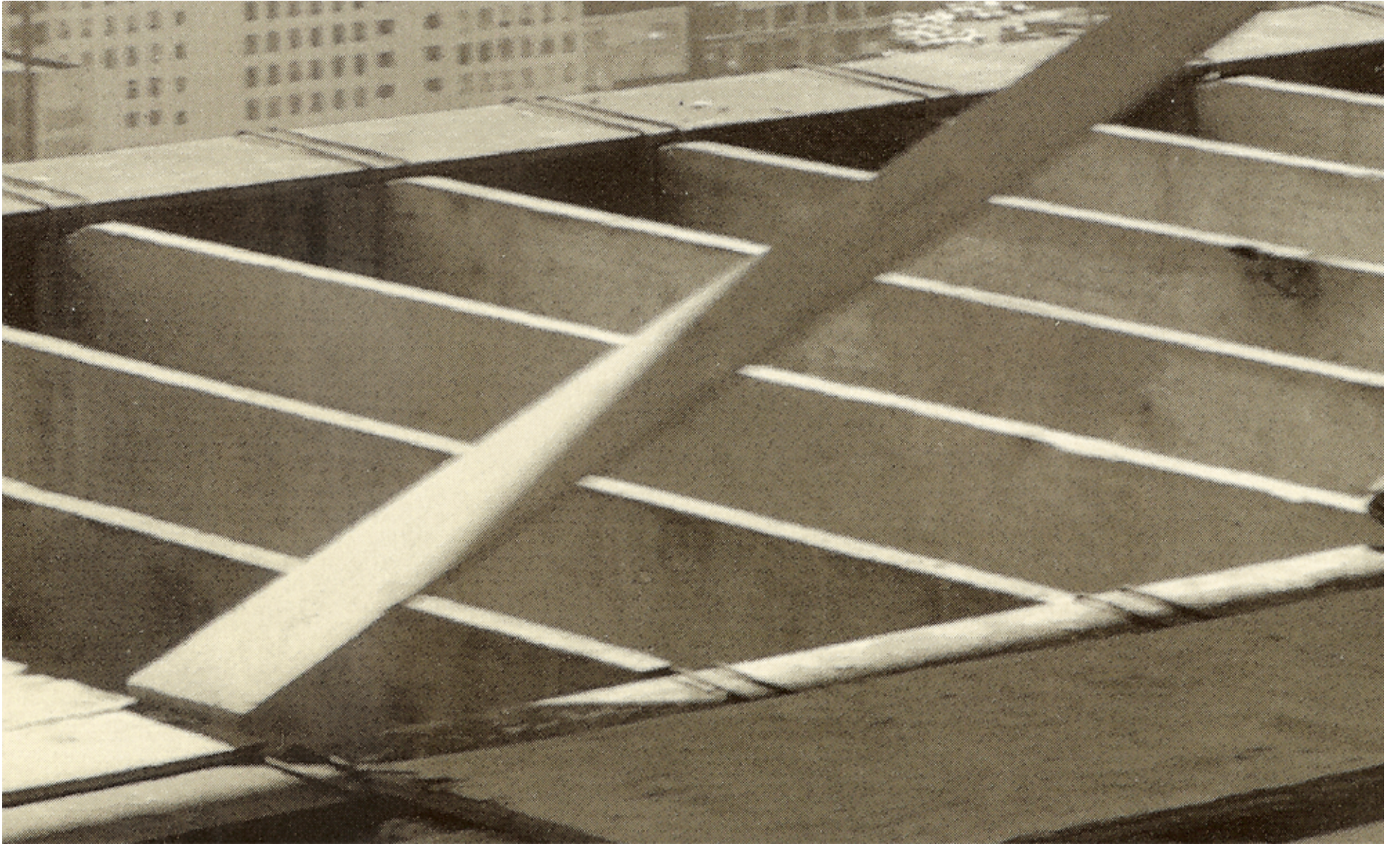
Section

- I. ANTENNAE
- 2. MECHANICAL
- 3. TELEVISION
- 4. RESTAURANT
- 5. OBSERVATORY
- 6. TELEVISION
- 7. APARTMENTS
- 8. SKY LOBBY
- 9. MECHANICAL
- 10. OFFICES
- II. MECHANICAL/OFFICES
- 12. OFFICES
- 13. PARKING
- 14. COMMERCIAL
- 15. OFFICE LOBBIES
- 16. STREET LEVEL LOBBIES
- 17. BELOW GRADE SERVICE & COMMERCIAL CONCOURSE

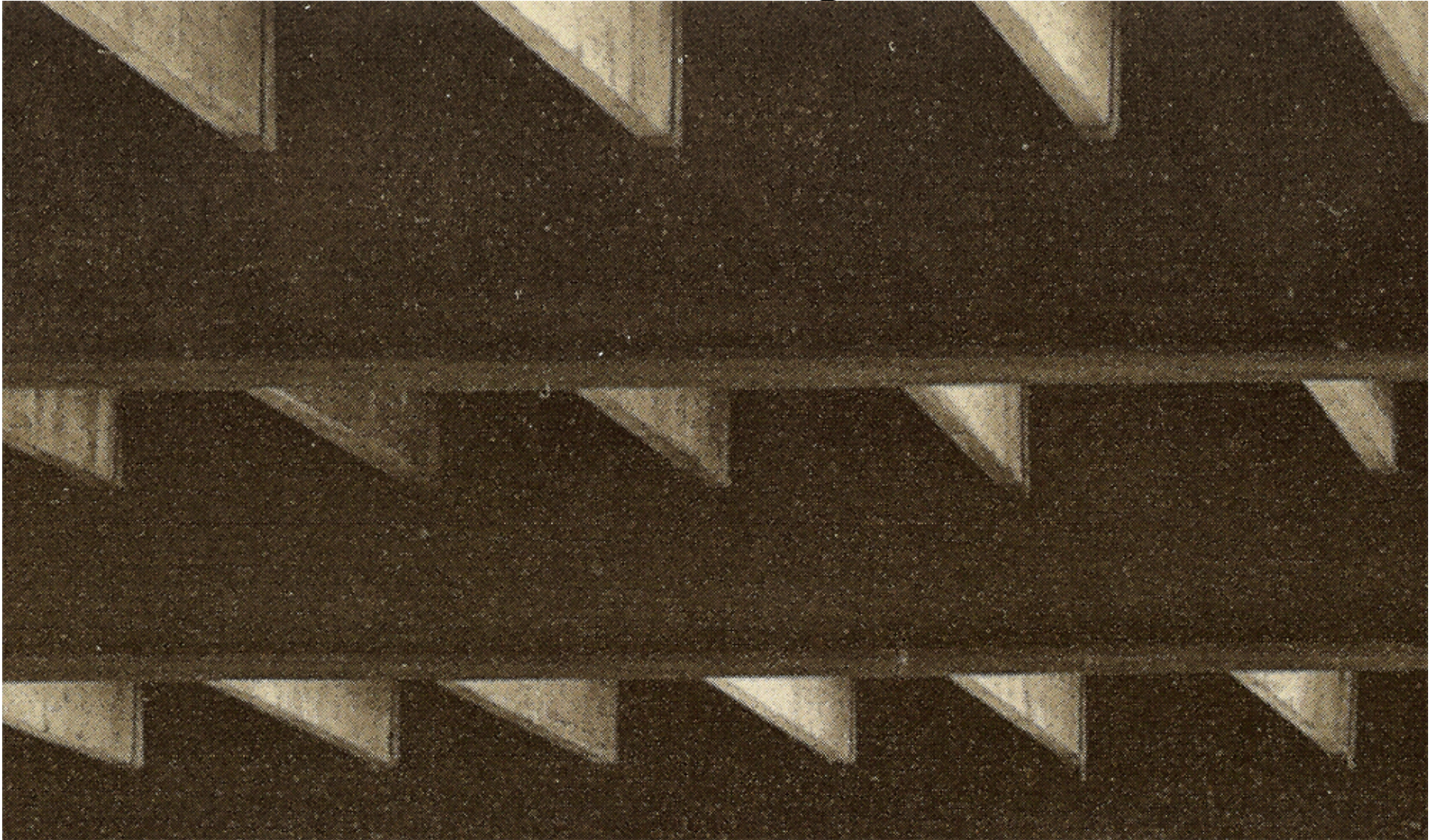


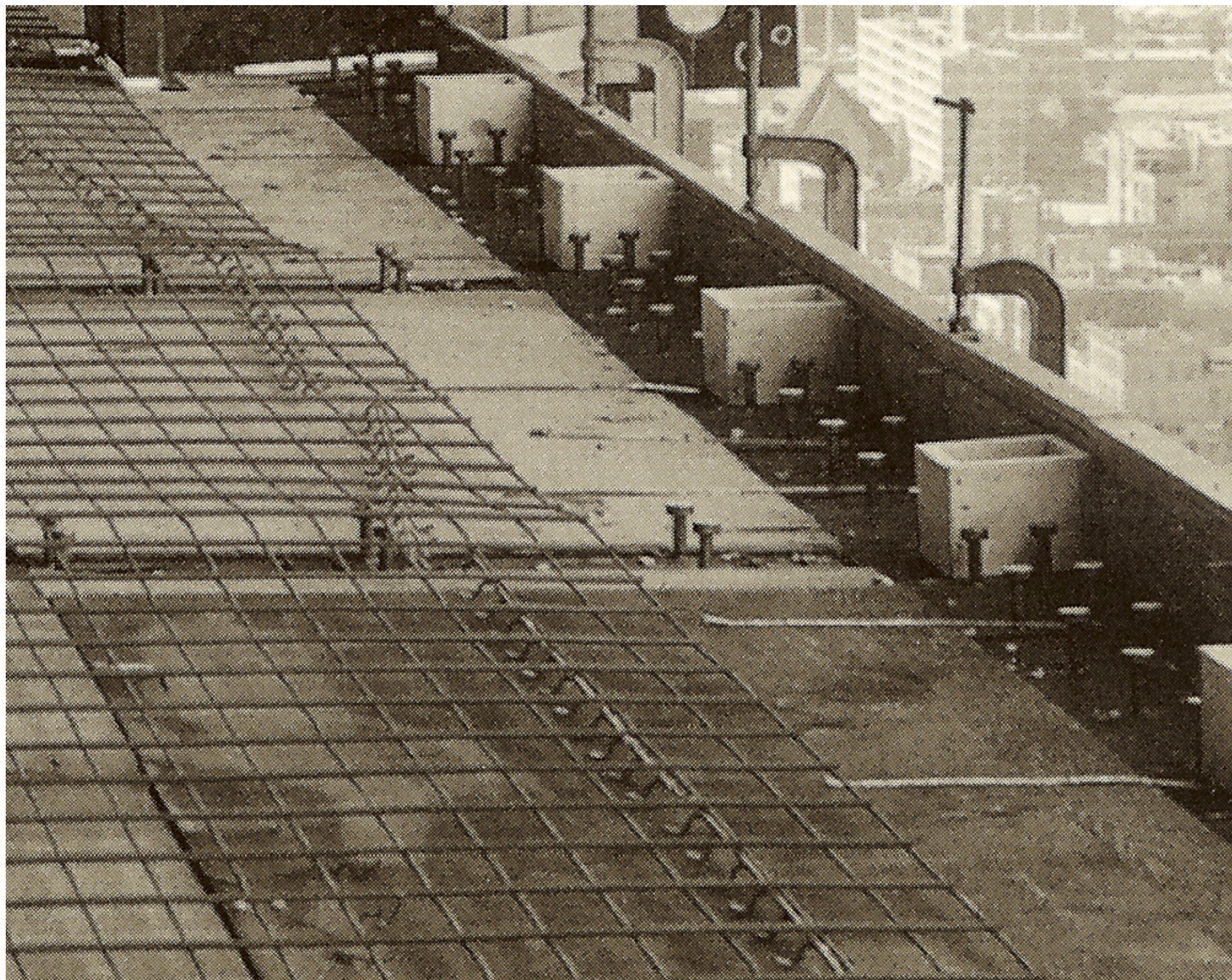
2x12's and plywood





Joist hangers







Hi rise ramp

- Concrete double-helix brings cars up and down from the parking on floors 6-12



American Bridge Company

- Set steel for Eads bridge 1860
- Set steel for John Hancock building in 1969

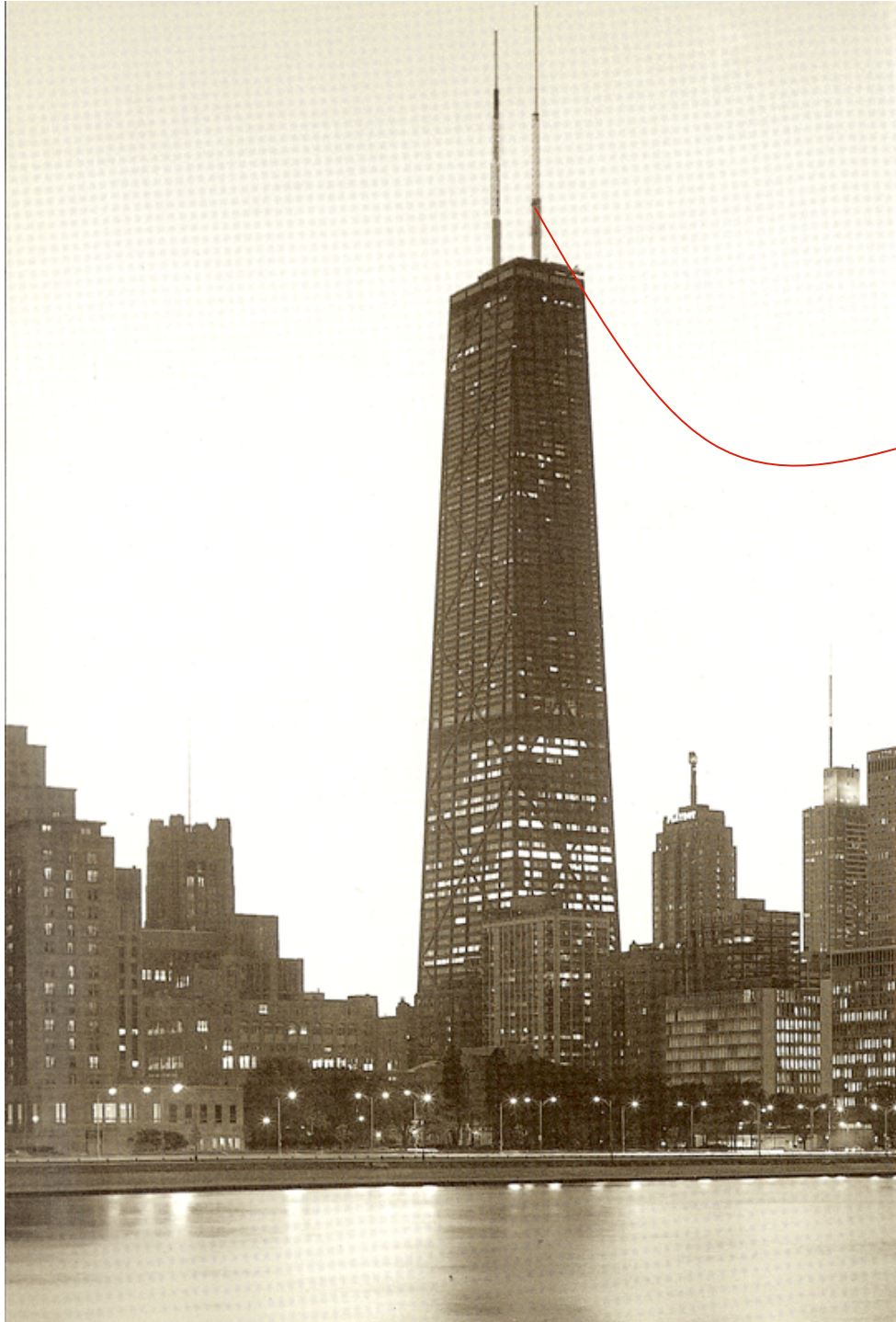


Sky-City



Where is the worlds 16th tallest building?

- Same problem as the Empire State Building, you don't know it's tall from the street



Dad's mark on Chicago

- I R here (was)