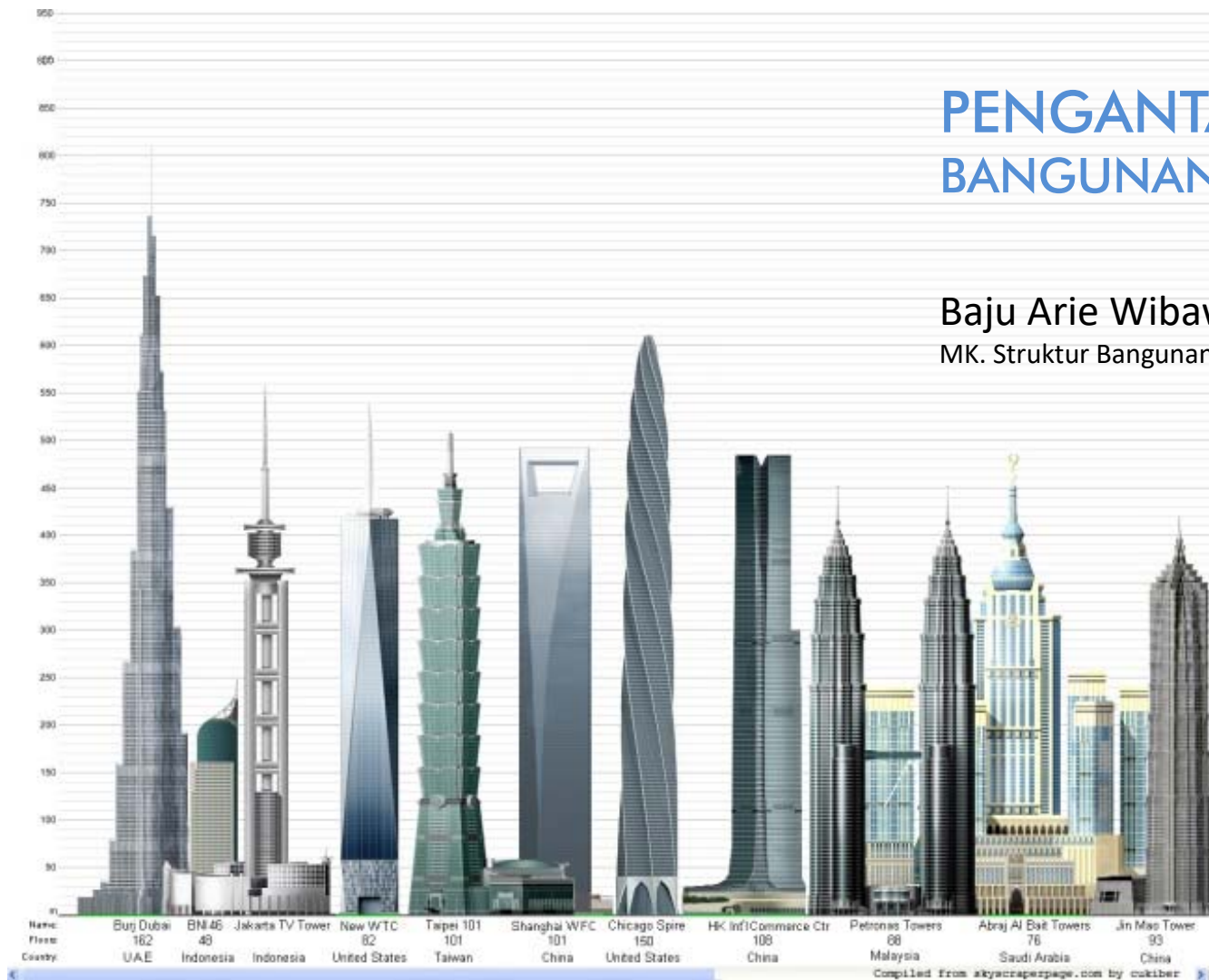


PENGANTAR STRUKTUR BANGUNAN BERTINGKAT TINGGI

Baju Arie Wibawa, S.T., M.T.
MK. Struktur Bangunan Bertingkat Tinggi





Unsur-unsur dasar struktur bangunan tinggi adalah :

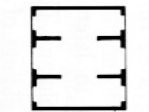
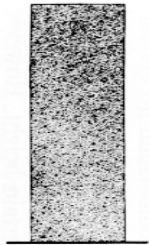
- **Unsur Linear**, berupa kolom dan balok yang mampu menahan gaya aksial dan gaya rotasi
- **Unsur Permukaan**, terdiri dari dinding dan plat
- **Unsur Spasial**, merupakan pembungkus fasade atau core (inti) dengan mengikat bangunan agar berlaku sebagai satu kesatuan



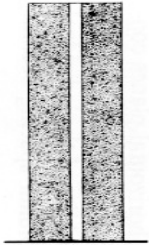
Type sistem struktur bangunan bertingkat tinggi :

1. **Dinding pendukung sejajar** (*Pararel bearing wall*)
2. **Inti dan dinding pendukung fasade** (*Core and fasade bearing wall*)
3. **Boks Berdiri sendiri** (*Self support box*)
4. **Plat terkantilever** (*Cantilevered slab*)
5. **Plat rata** (*Flat slab*)
6. **Interspasial** (*interspatial*)
7. **Gantung** (*suspention*)
8. **Rangka Selang Seling** (*Staggered truss*)
9. **Rangka Kaku** (*Rigid frame*)
10. **Rangka Kaku dan Inti** (*Rigid frame and core*)
11. **Rangka Trussed** (*Trussed frame*)
12. **Rangka Belt trussed dan inti** (*Belt trussed frame and core*)
13. **Tabung dalam tabung** (*Tube in tube*)
14. **Kumpulan tabung** (*Bundled tube*)

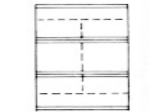
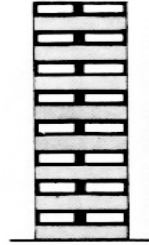
Vertical Structure System



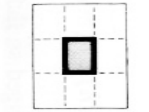
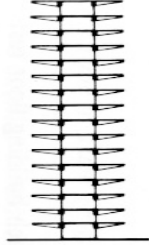
a. (PARALLEL) BEARING WALLS



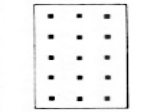
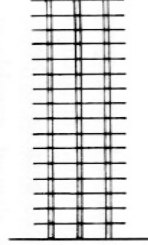
b. CORES AND BEARING WALLS



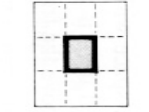
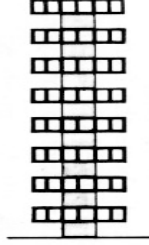
c. BOXES (SELF SUPPORTING)



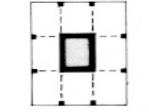
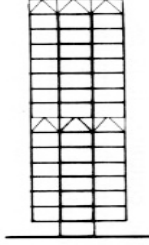
d. CANTILEVERED SLAB



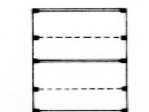
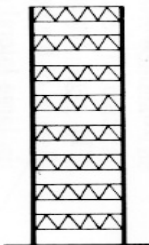
e. FLAT SLAB



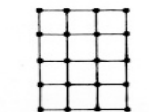
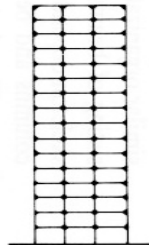
f. INTERSPATIAL



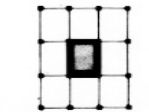
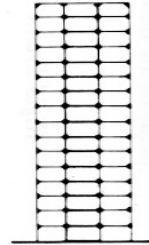
g. SUSPENDED



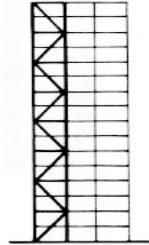
h. STAGGERED TRUSS



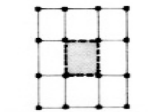
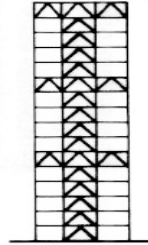
i. RIGID FRAME



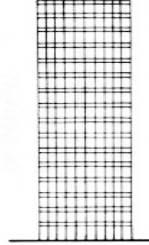
j. CORE AND RIGID FRAME



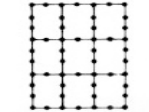
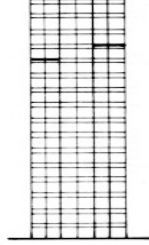
k. TRUSSED FRAME



l. BELT-TRUSSED FRAME AND FRAMED CORE



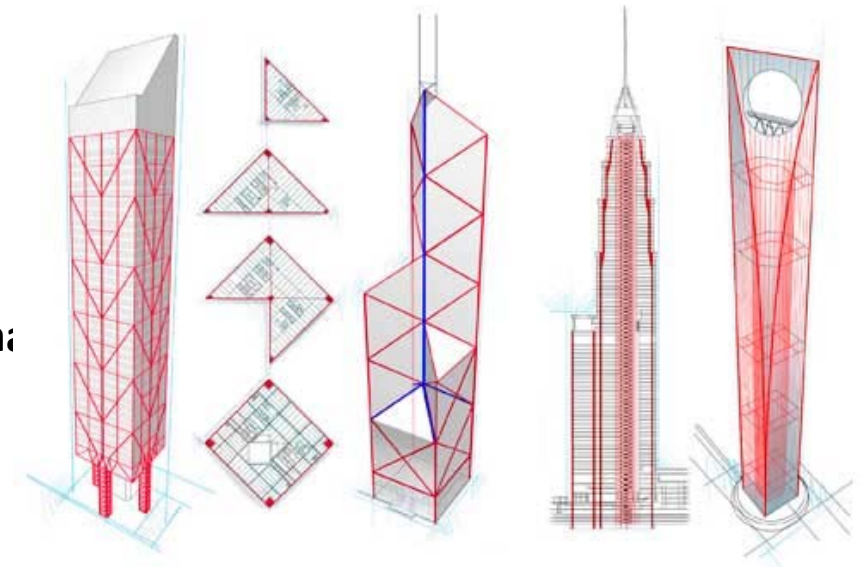
m. TUBE IN TUBE



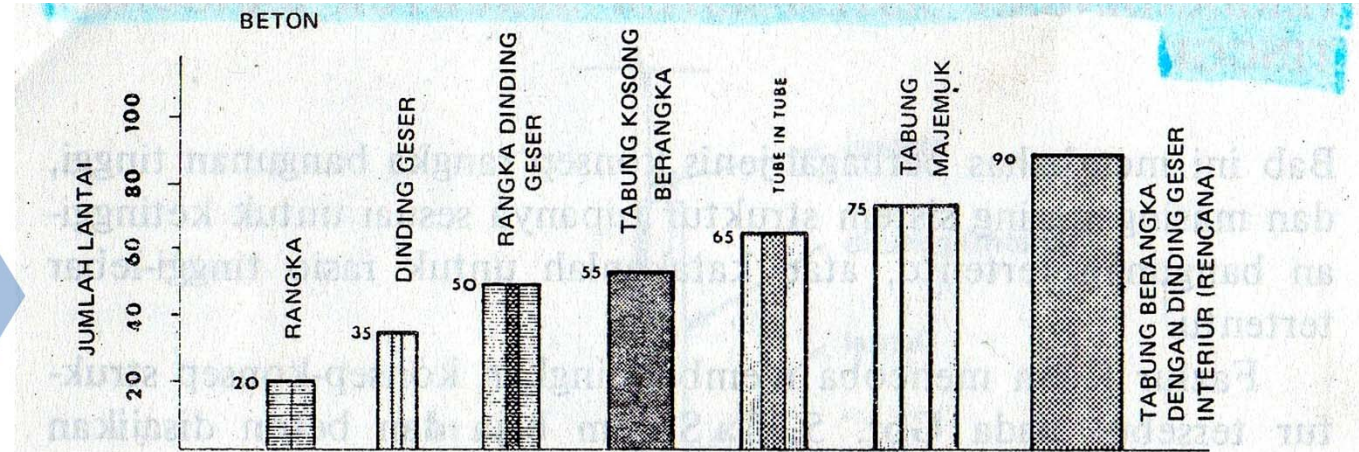
n. BUNDLED TUBE

Beberapa faktor dalam perencanaan sistem pembangunan struktur bangunan tinggi :

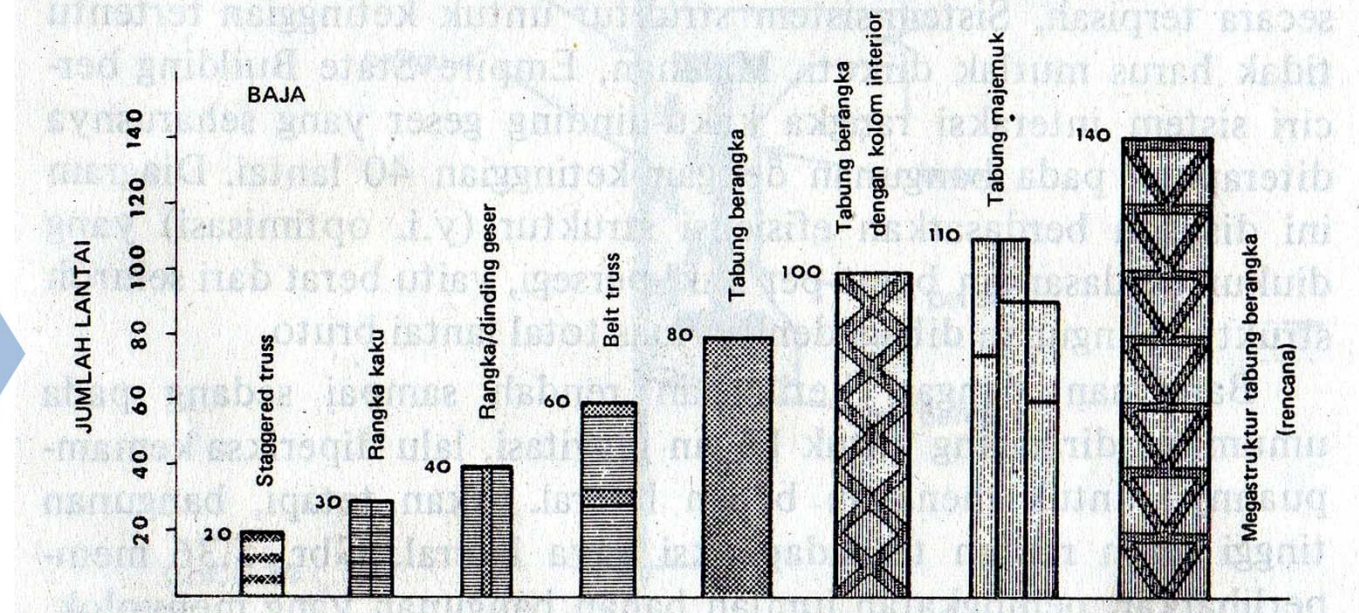
- 1. Pertimbangan umum ekonomi**
- 2. Kondisi tanah**
- 3. Rasio tinggi lebar suatu bangunan**
- 4. Pertimbangan fabrikasi dan pembangunan**
- 5. Pertimbangan mekanis (sistem utilitasnya)**
- 6. Pertimbangan tingkat bahaya kebakaran**
- 7. Pertimbangan peraturan bangunan setempat**
- 8. Ketersediaan dan harga bahan konstruksi utama**



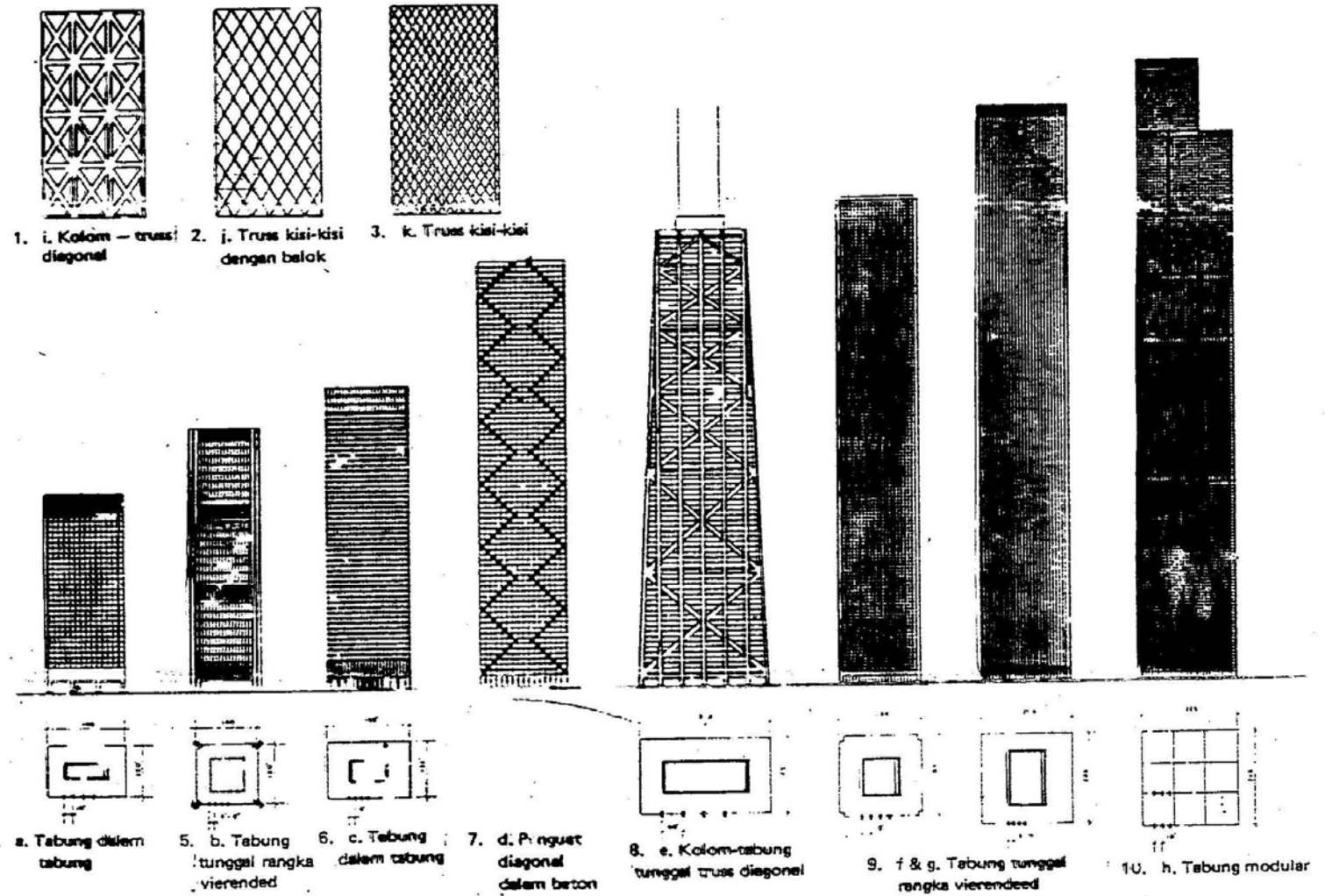
Konstruksi Beton



Konstruksi Baja

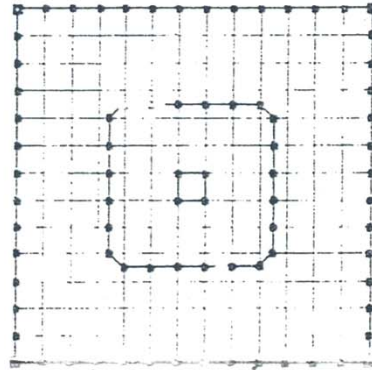


Kombinasi
Sistem Tabung
Menciptakan
Bangunan
yang lebih
tinggi

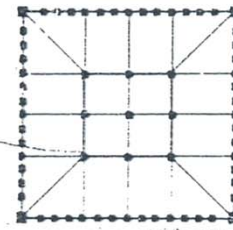




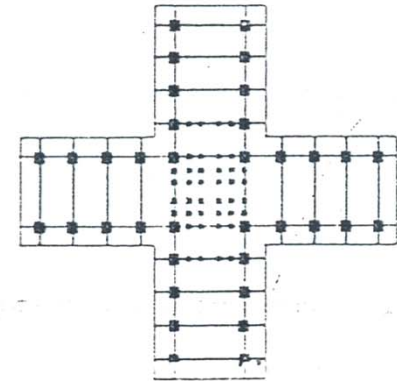
1. Rangka melintang dua arah



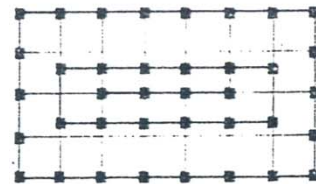
2. Bungkus eksternal dan internal



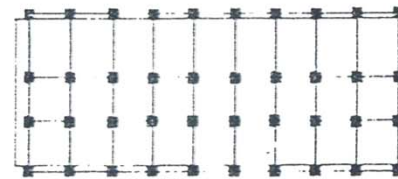
3. Bungkus eksternal dengan rangka inti internal



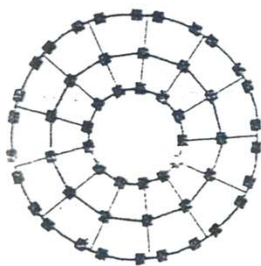
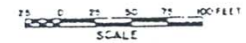
4. Rangka melintang sejajar pada dua sumbu



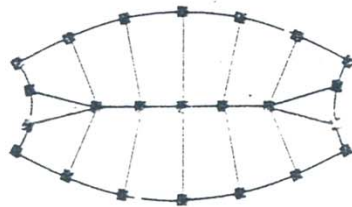
5. Rangka melintang sejajar dengan kolom interior sebagian tidak segaris



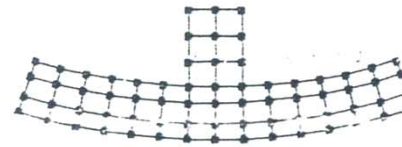
6. Rangka melintang sejajar



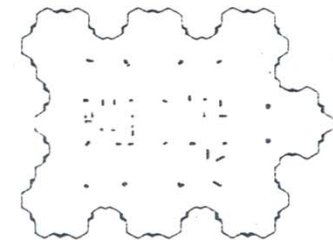
7. Bungkus lingkaran eksternal dan internal (rangka melintang pada grid radial)



8. Rangka melintang pada grid lengkung

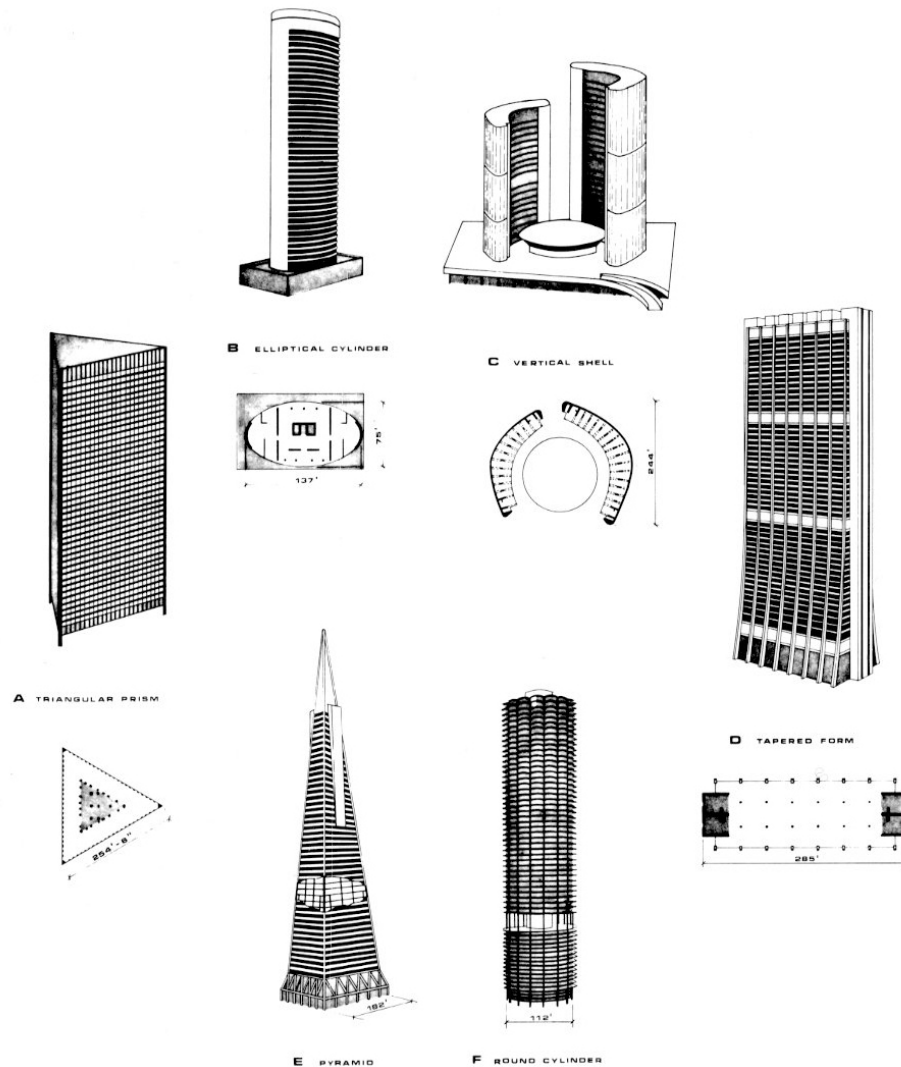


9. Rangka melintang pada grid radial



10. Kolom-kolom grid nonpersegi

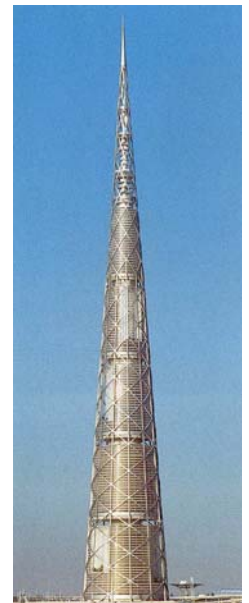
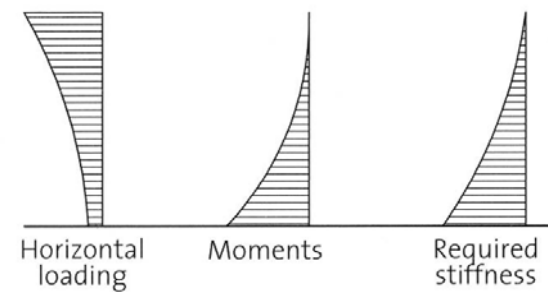
Berbagai Pola sistem truktur rangka pada bangunan tinggi yang umum dipergunakan



Bentuk Bangunan Tinggi yang Efisien

Bentuk penampang melingkar lebih aerodinamic, sehingga meminimalkan gaya akibat tekanan angin 20-40% daripada bentuk persegi

Bentuk yang semakin mengecil di atas, lebih efisien, karena gaya angin semakin besar di daerah atas

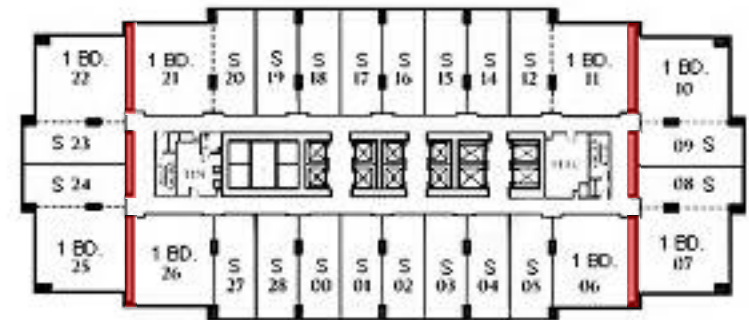
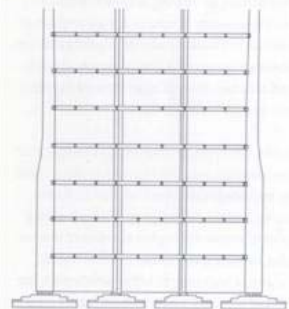


Dinding Pendukung Sejajar *Parallel Bearing Wall*

Sistem dinding geser yang diletakkan dengan arah melintang dari panjang bangunan

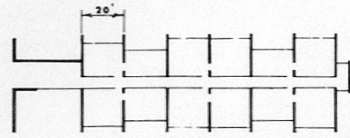


6.3 a Monadnock Building, Chicago

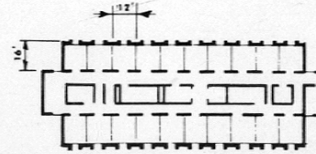


Condo - Hotel Units Location
Floor Plan 16 - 59

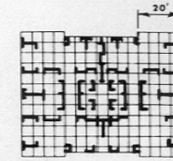
Berbagai Macam Bearing Wall System



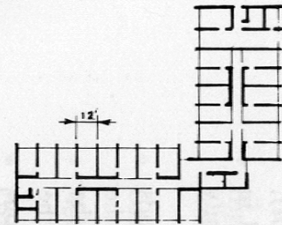
a. CROSS WALL SYSTEM



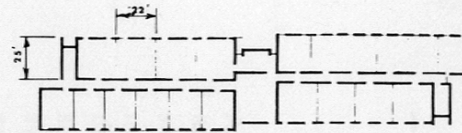
b. LONG WALL SYSTEM



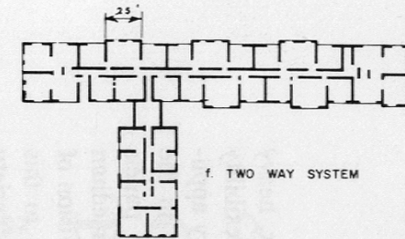
c. LOAD-BEARING PARTITION WALL



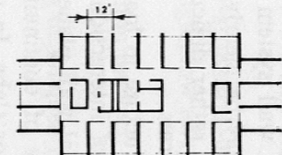
d. CROSS WALL SYSTEM ON TWO AXES



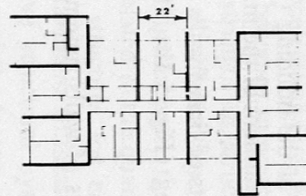
e. LONG WALL SYSTEM



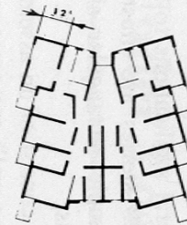
f. TWO WAY SYSTEM



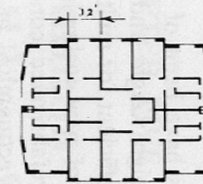
g. PERIMETER CROSS WALL SYSTEM



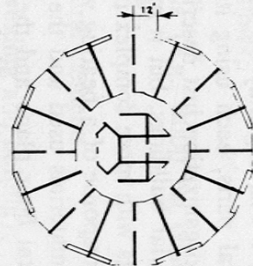
h. CROSS-LONG WALL SYSTEMS



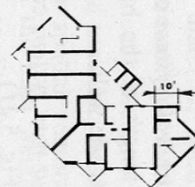
i. SKEWED TWO WAY SYSTEM



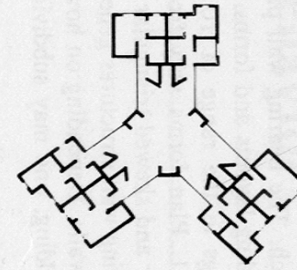
j. TWO WAY SYSTEM



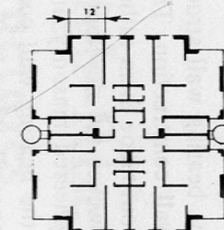
l. RADIAL CROSS WALL SYSTEM



m. CROSS WALL SYSTEM ON TWO AXES



n. TWO WAY SYSTEM



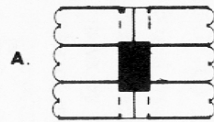
o. TWO WAY SYSTEM

Inti dan Dinding Pendukung Fasad *Core & Fasad Bearing Wall*

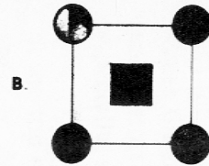
Sistem dinding geser yang diletakkan sebagai core bangunan dan pada dinding fasad



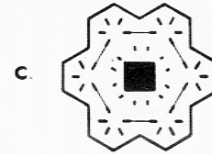
Berbagai Macam Bearing Wall dan Core System



A.
Longitudinal Shear Walls
& Central Core



B.
Closed Corner Cores
& Central Core



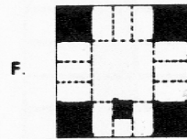
C.
Perimeter Walls
Radial Core Walls
& Central Core



D.
Facade Walls
& Off-Center Cores



E.
Cross Shear Walls
& Corner Cores



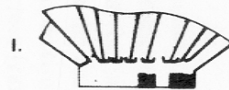
F.
Open Corner Cores



G.
Core Assemblage



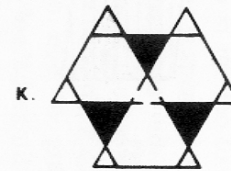
H.
Cross Shear Walls
& Central Cores



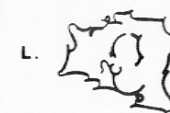
I.
Radial Cross Shear Walls
& Exterior Cores



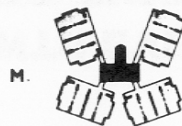
J.
Open Corner Cores
& Exterior Core



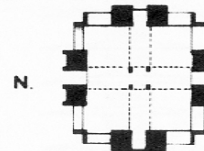
K.
Triangular Perimeter Cores



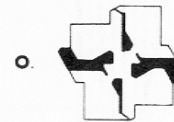
L.
Curved Shear Walls



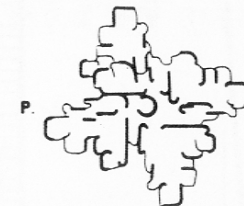
M.
Building Assemblage
& Central Core



N.
Open & Closed
Perimeter Cores



O.
Open Central Core
- Shear Wall Comb.



P.
Curved Shear Walls
Forming Open Core Assemblage

Box yang berdiri sendiri (*Self Support Box*)

Sistem struktur rangka biasa dengan rangka beton, baja, atau komposit, tanpa core. Untuk bangunan bertingkat sedang.

Rangka Kaku (*Rigid frame*)

Sistem yang paling banyak dipakai pada masa-masa awal perkembangan pencakar langit. Sistem rangka beton/baja/komposit. Paling banyak dipakai untuk bangunan bertingkat sedang – cukup tinggi

Rangka Kaku dan Inti (*Rigid frame and core*)

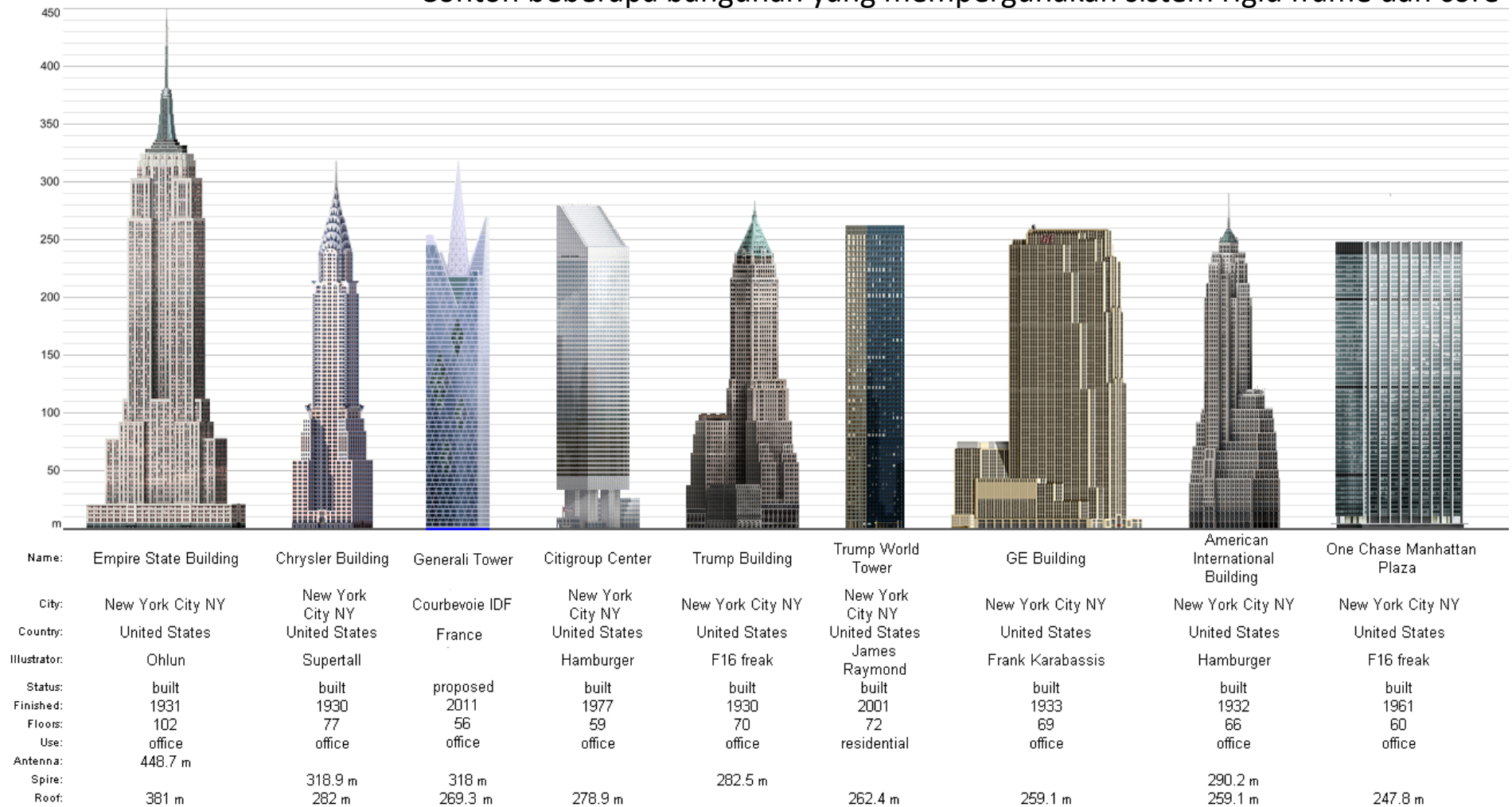
Sistem yang paling banyak dipakai untuk bangunan tinggi. Core berfungsi secara struktural

Chrysler Building

Empire State Building

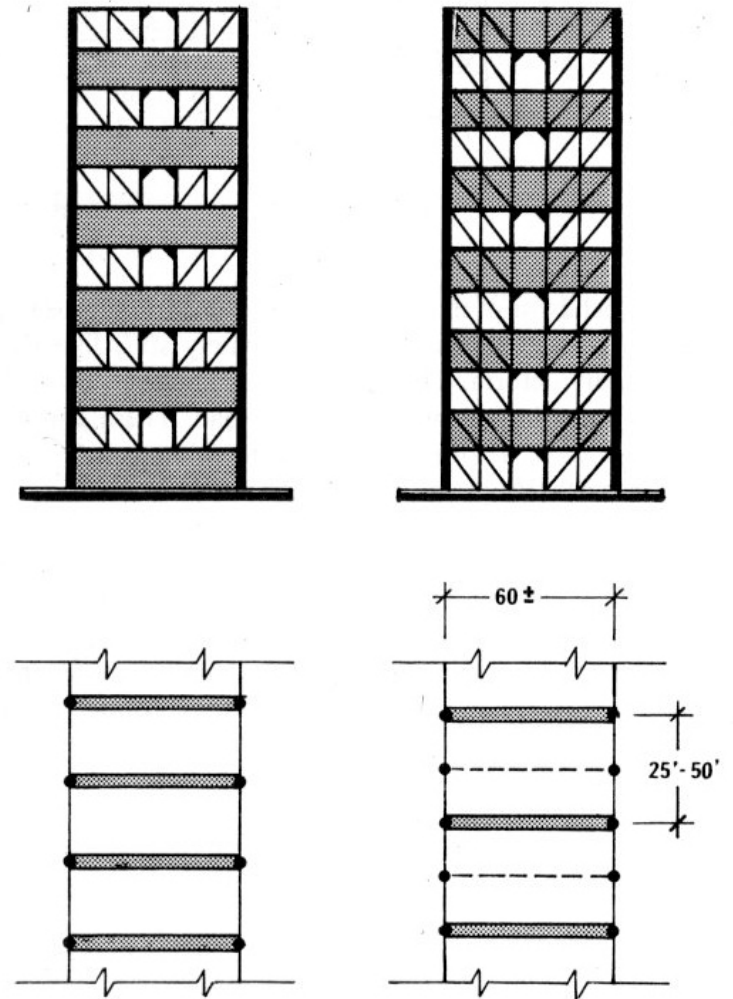
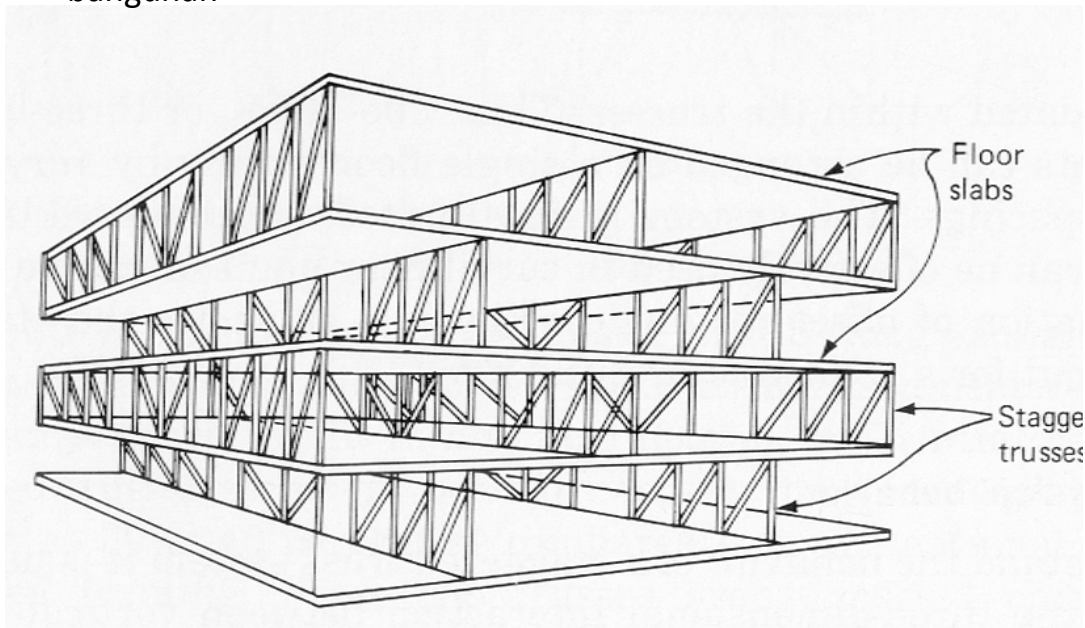


Contoh beberapa bangunan yang mempergunakan sistem rigid frame dan core



Interspasial (*interspatial*) vs Staggered Truss

Sistem struktur dengan melakukan beberapa lantai (interspatial) atau beberapa modul (staggered truss) pada bangunan

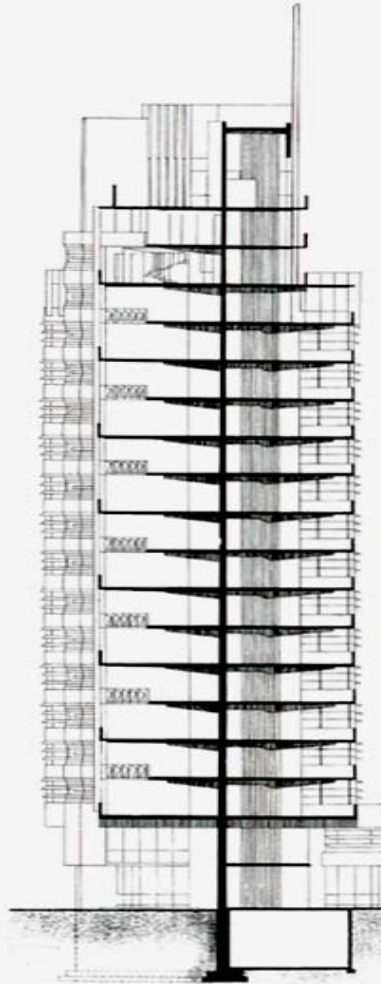
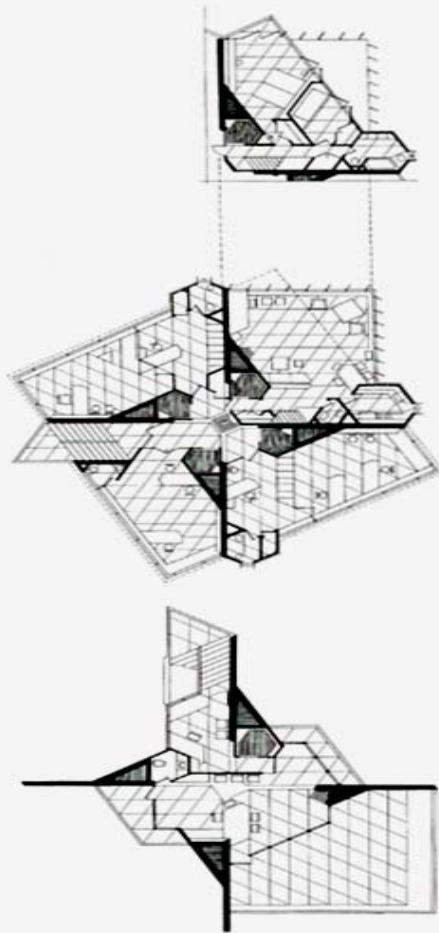


Plat terkantilever (*Cantilevered slab*)
Plat rata (*Flat slab*)

Sistem struktur dengan plat lantai yang menumpu pada core. Biasanya dipergunakan bersama-sama dengan sistem struktur yang lain



Bartlesville Tower



Rangka Trussed (*Trussed frame*)

Sistem struktur yang mempergunakan prinsip mengakukan dinding luar dengan menggunakan truss. Menjadi elemen struktur yang ditonjolkan secara estetis



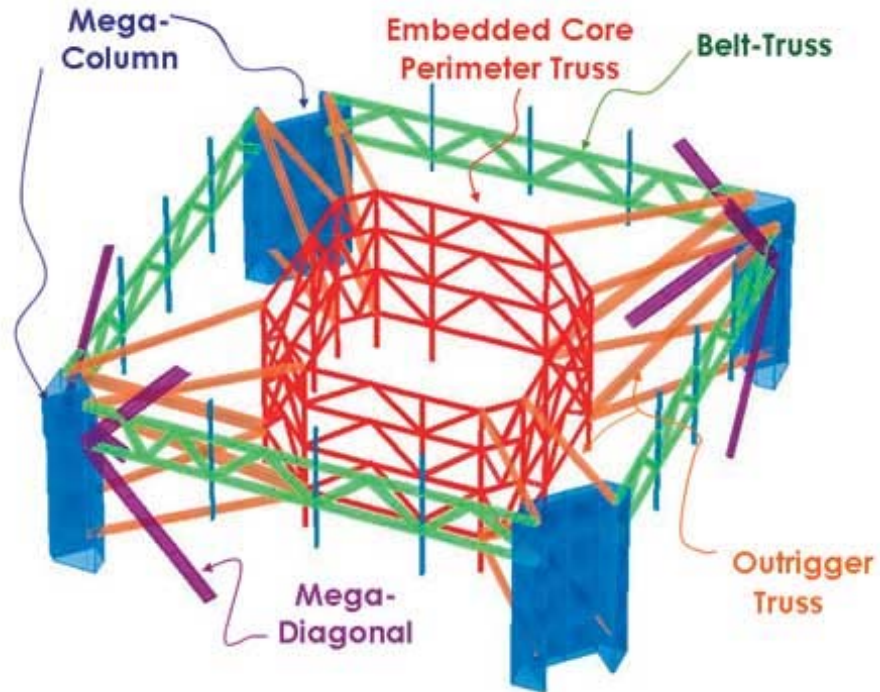


John Hancock Bld



Rangka Belt trussed dan inti (*Belt trussed frame and core*)

Mirip sistem Staggered Truss, tetapi diperkuat dengan core, untuk bangunan yang lebih tinggi



Hongkong Bank

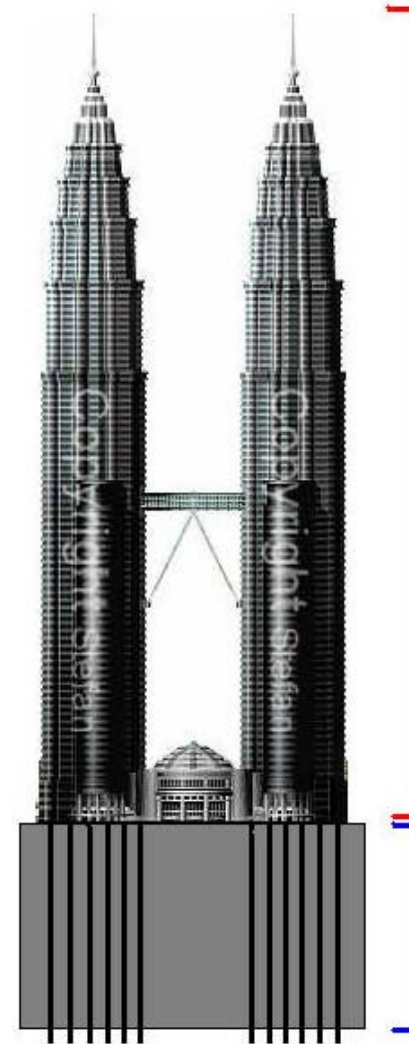
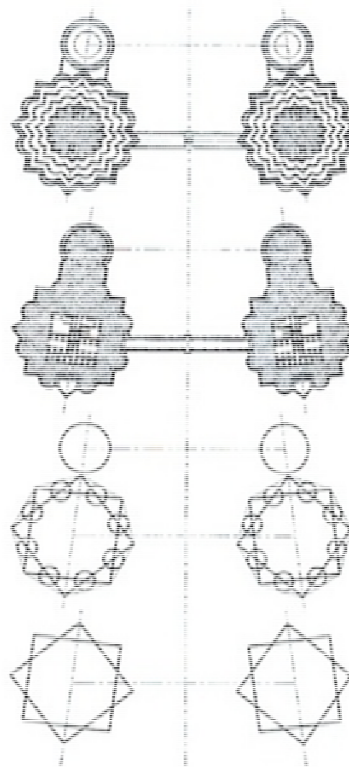


SWFC



Tabung dalam tabung (*Tube in tube*)

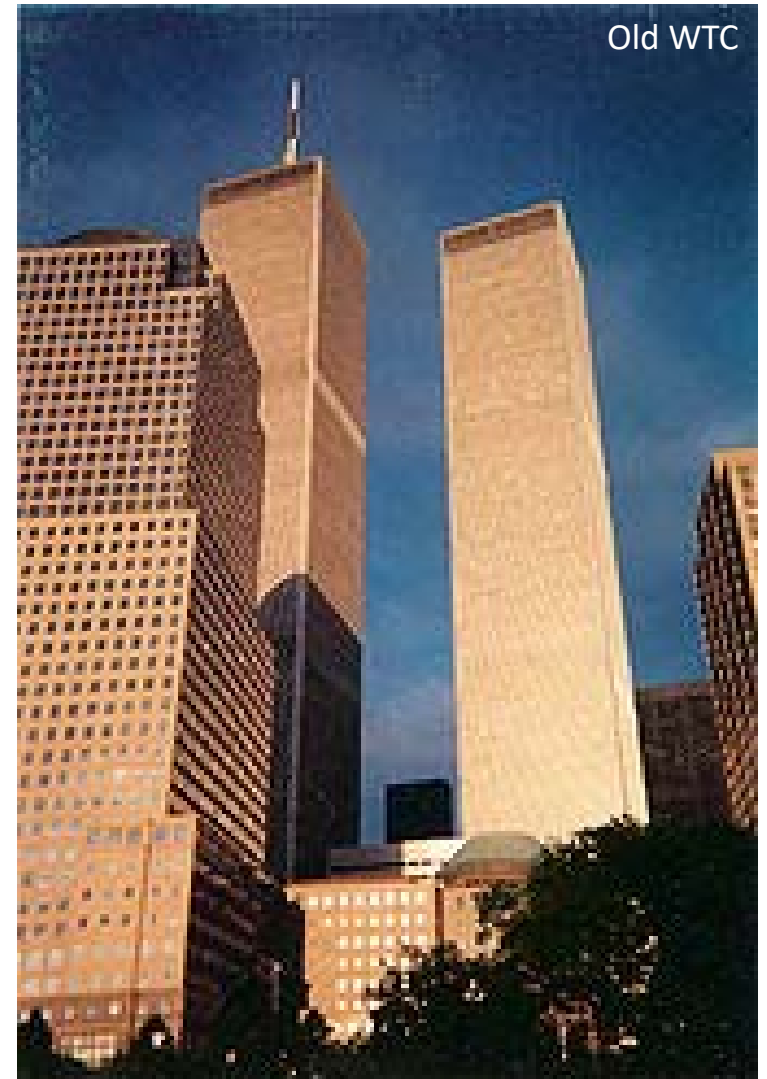
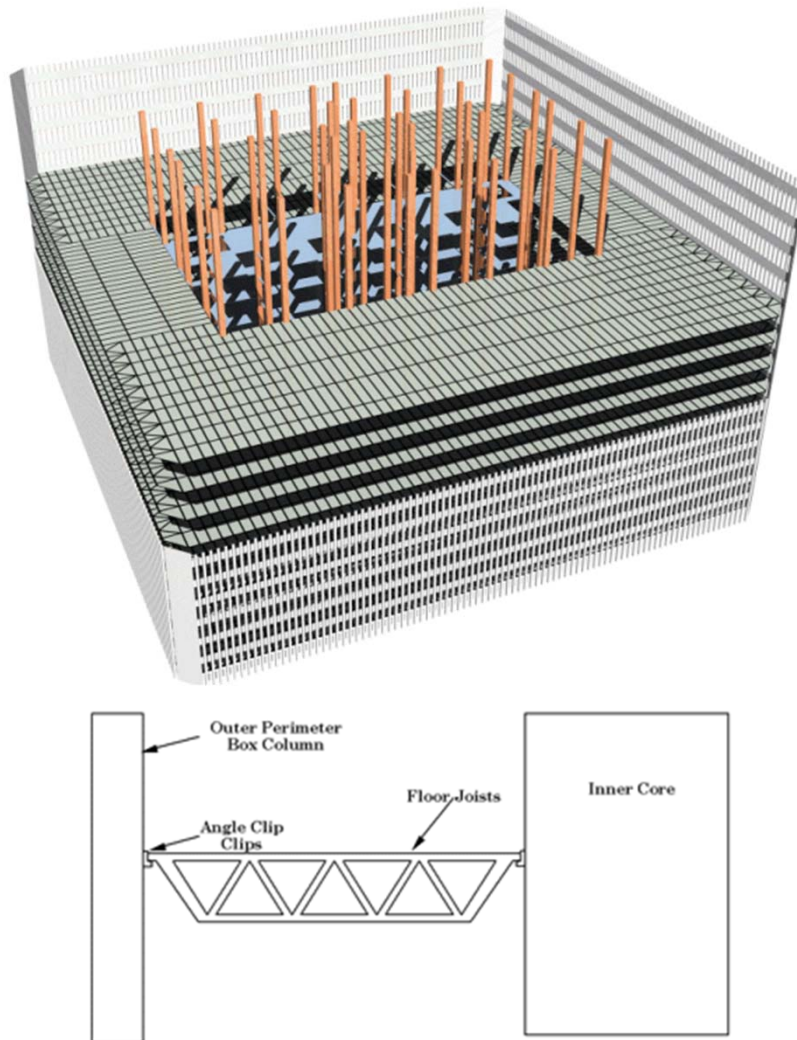
Sistem yang juga sangat banyak dipakai untuk bangunan tinggi, menggunakan kolom yang sangat rapat pada bagian luar sehingga menyerupai tabung masif.



Structure
1483 ft (452m)

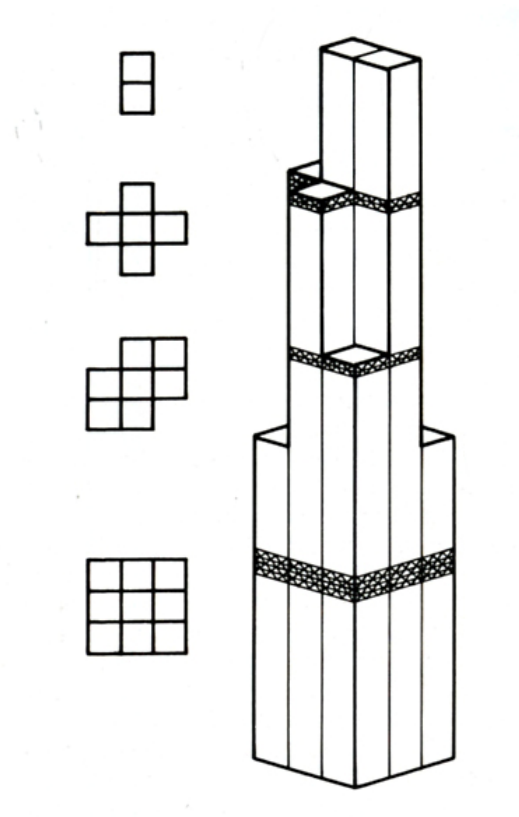
Foundation
394 ft (120m)

Contoh bangunan
yang
mempergunakan
sistem tube in
tube



Kumpulan tabung (*Bundled tube*)

Sistem yang menggabungkan beberapa *self support box* menjadi 1, sehingga lebih kaku. Disebut juga sistem tabung majemuk



Sears Tower



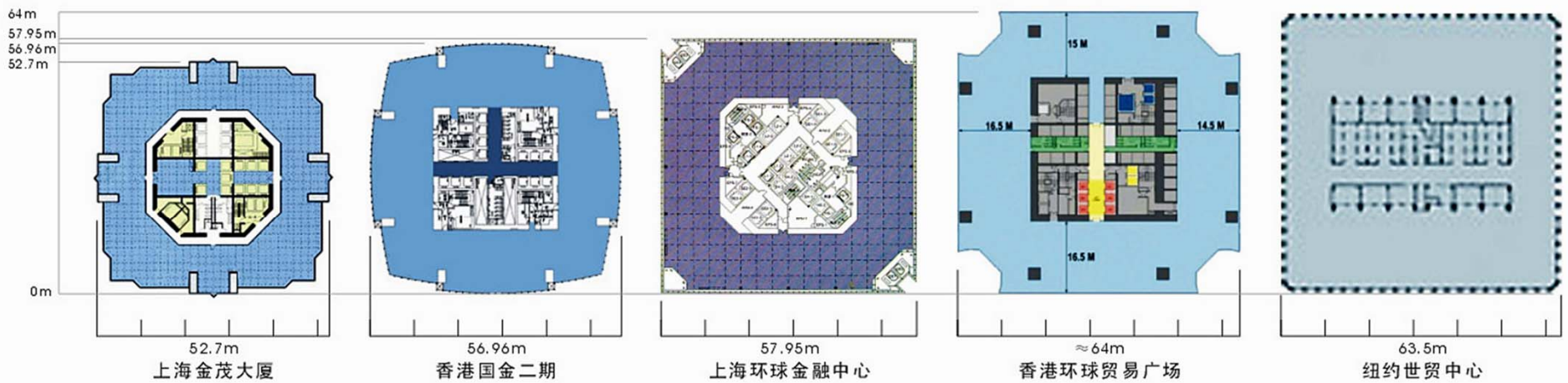
Perbandingan tinggi beberapa gedung pencakar langit yang terbaru



Perbandingan sistem struktur dengan melihat potongan struktur

Taipei 101

Old WTC



几幢摩天楼楼层平面对比

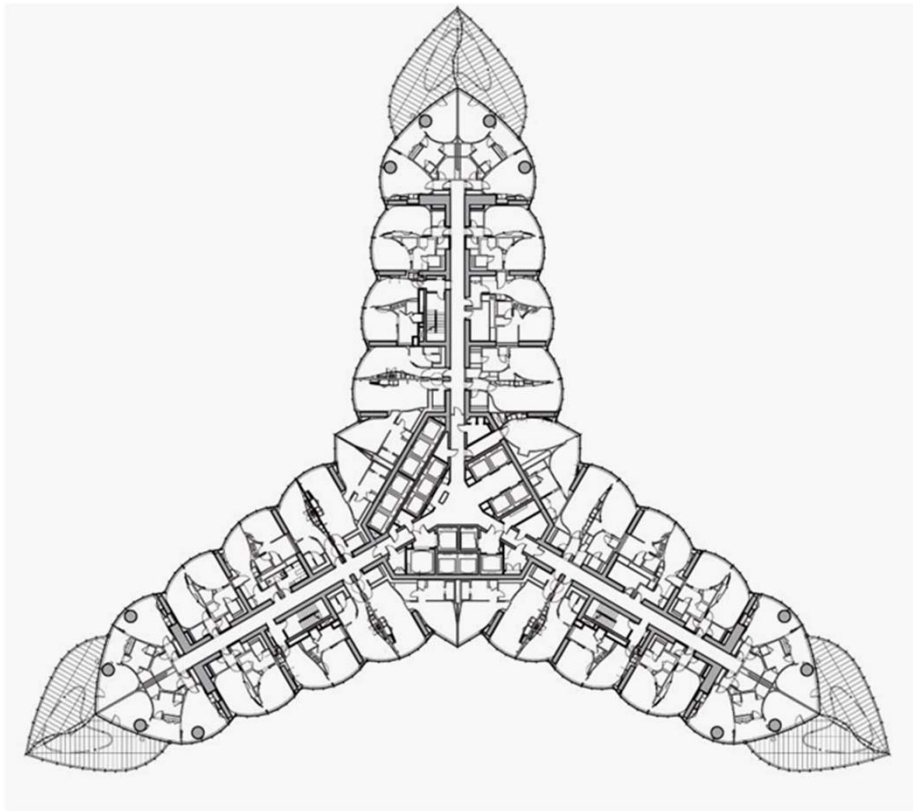
注：除世贸外其他大厦上下楼层均有变化，这里的平面图以大厦低区为准，往上均有缩小
整理：moyan808

Daftar Gedung pencakar langit yang telah terbangun

Built	Building	City	Country	Roof		Floors	Pinnacle		Current status
1873	Equitable Life Building	New York City	United States	142 ft	43 m	8			Destroyed by fire in 1912
1889	Auditorium Building	Chicago	United States	269 ft	82 m	17	349 ft	106 m	Standing
1890	New York World Building	New York City	United States	309 ft	94 m	20	349 ft	106 m	Demolished in 1955
1894	Manhattan Life Insurance Building	New York City	United States	348 ft	106 m	18			Demolished in 1930
1895	Milwaukee City Hall	Milwaukee	United States	353 ft	108 m	15			Standing
1899	Park Row Building	New York City	United States	391 ft	119 m	30			Standing
1901	Philadelphia City Hall	Philadelphia	United States	511 ft	155.8 m	9	548 ft	167 m	Standing
1908	Singer Building	New York City	United States	612 ft	187 m	47			Demolished in 1968
1909	Met Life Tower	New York City	United States	700 ft	213 m	50			Standing
1913	Woolworth Building	New York City	United States	792 ft	241 m	57			Standing
1930	40 Wall Street	New York City	United States			70	927 ft	283 m	Standing
1930	Chrysler Building	New York City	United States	927 ft	282.9 m	77	1,046 ft	319 m	Standing
1931	Empire State Building	New York City	United States	1,250 ft	381 m	102	1,454 ft	443 m	Standing
1972	World Trade Center (North tower)	New York City	United States	1,368 ft	417 m	110	1,727 ft	526.3 m	Destroyed in 2001
1974	Willis Tower (formerly Sears Tower)	Chicago	United States	1,450 ft	442 m	108	1,729 ft	527 m	Standing
	Petronas Tower		Malaysia		452 m				Standing
2004	Taipei 101	Taipei	Taiwan	1,474 ft	449 m	101	1,671 ft	509 m	Standing
2010	Burj Khalifa	Dubai	United Arab Emirates	2,717 ft	828 m	160	2,717 ft	828 m	Standing

Studi Kasus : Burj Khalifa, Dubai

Ground breaking : January 2004
Top off : January 2009
Cladding Completed : September 2009



SOM

CONTEXT PLAN

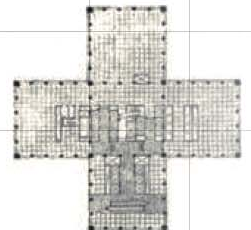
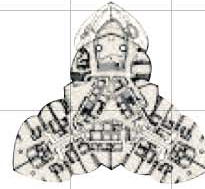
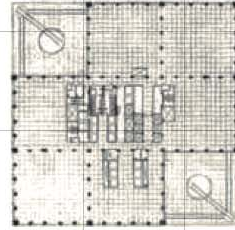
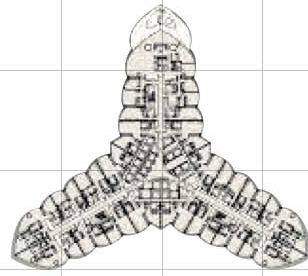
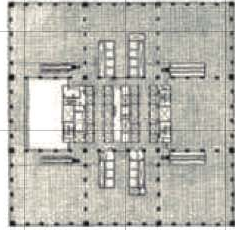
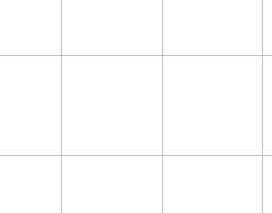
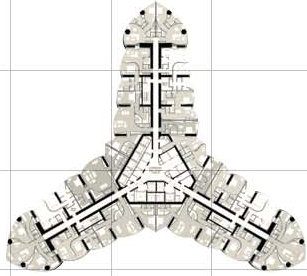
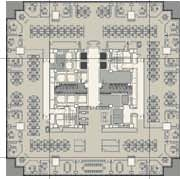
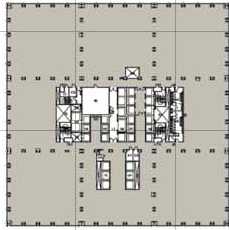
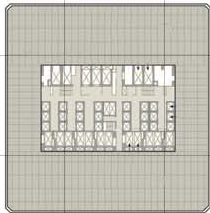
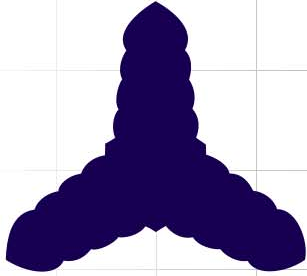
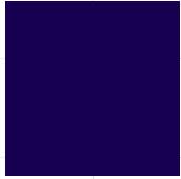
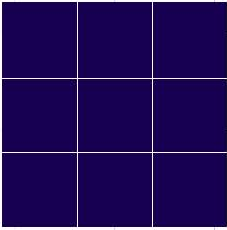
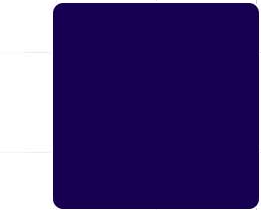


WTC
TOWERS

WILLIS
TOWER

TAIPEI
101

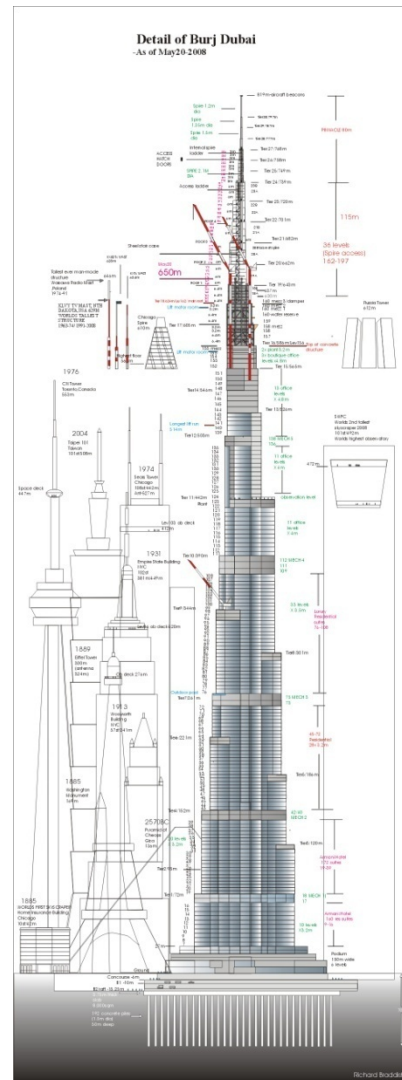
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KHALIFA



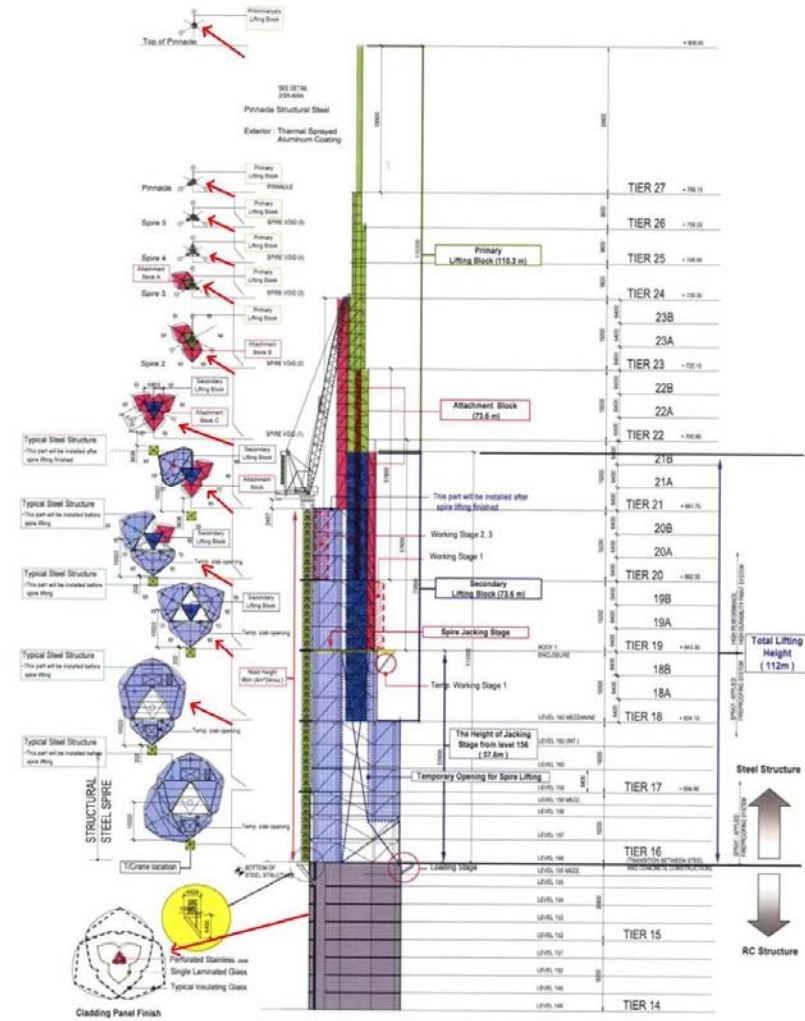
1 PIXEL = 1 FT.

Potongan :

- Di bawah level 155 menggunakan struktur beton
- level 156 ke atas menggunakan struktur baja dengan sistem Spire Structure (mirip kantilever)



■ Spire Erection Methodology - Summary







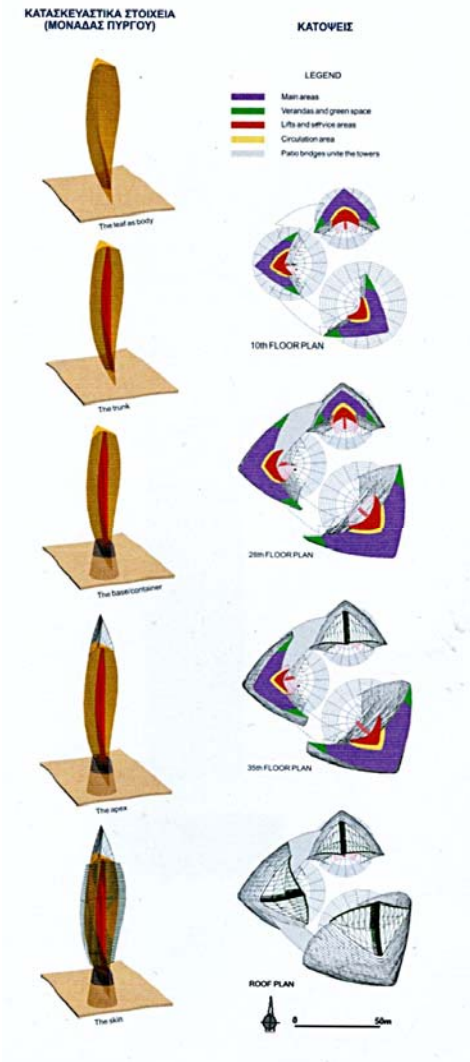


Future Skyscraper : **Dynamic Tower**



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Future Skyscraper : West Athens Tower



Thank
You



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