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High Rise Dubai to Mumbai

By Bob Scott

High Rise in Dubai

Dubai World Trade Centre

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Office Tower
Tallest Building in the Gulf
149 m tall
Built 1978

Burj Al Arab

United Arab Emirates

Luxury Hotel
Tallest Hotel in the World at the time
321m high
Built 1999

Emirates Towers

Two towers Office and Hotel

Office Tower 355m and Hotel Tower 309m
Built 2000

Burj Khalifa

Mixed Use Tower
Tallest Building in the World
830m high
Built 2010

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High Rise Dubai to Mumbai

The Address Hotel

The Address Hotel

The Address Hotel

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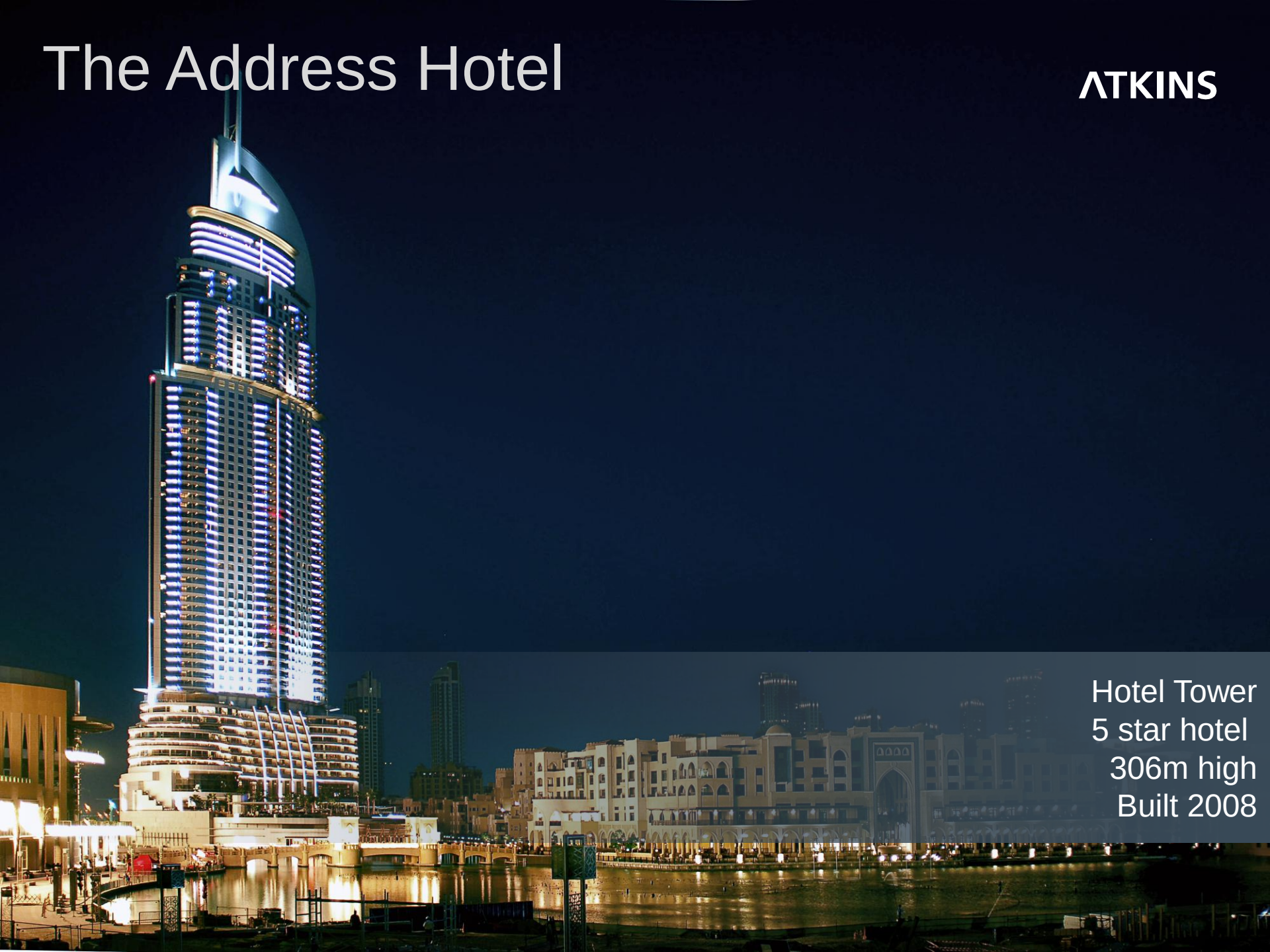


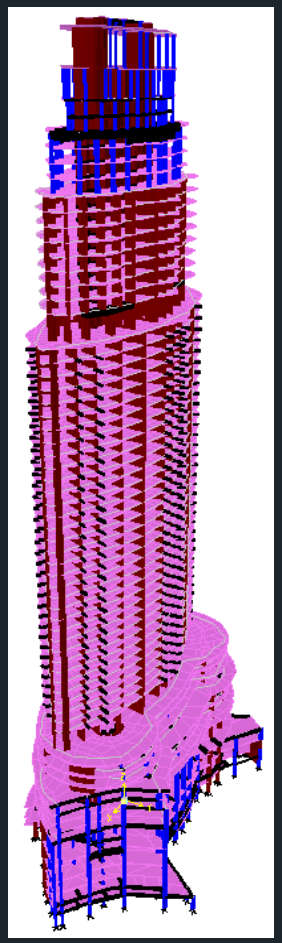
Hotel Tower
5 star hotel
306m high
Built 2008

The Address Hotel

Structural Model of Concrete Frame – Etabs

For overall stability and seismic Analysis

Floors and foundation raft
- Robot



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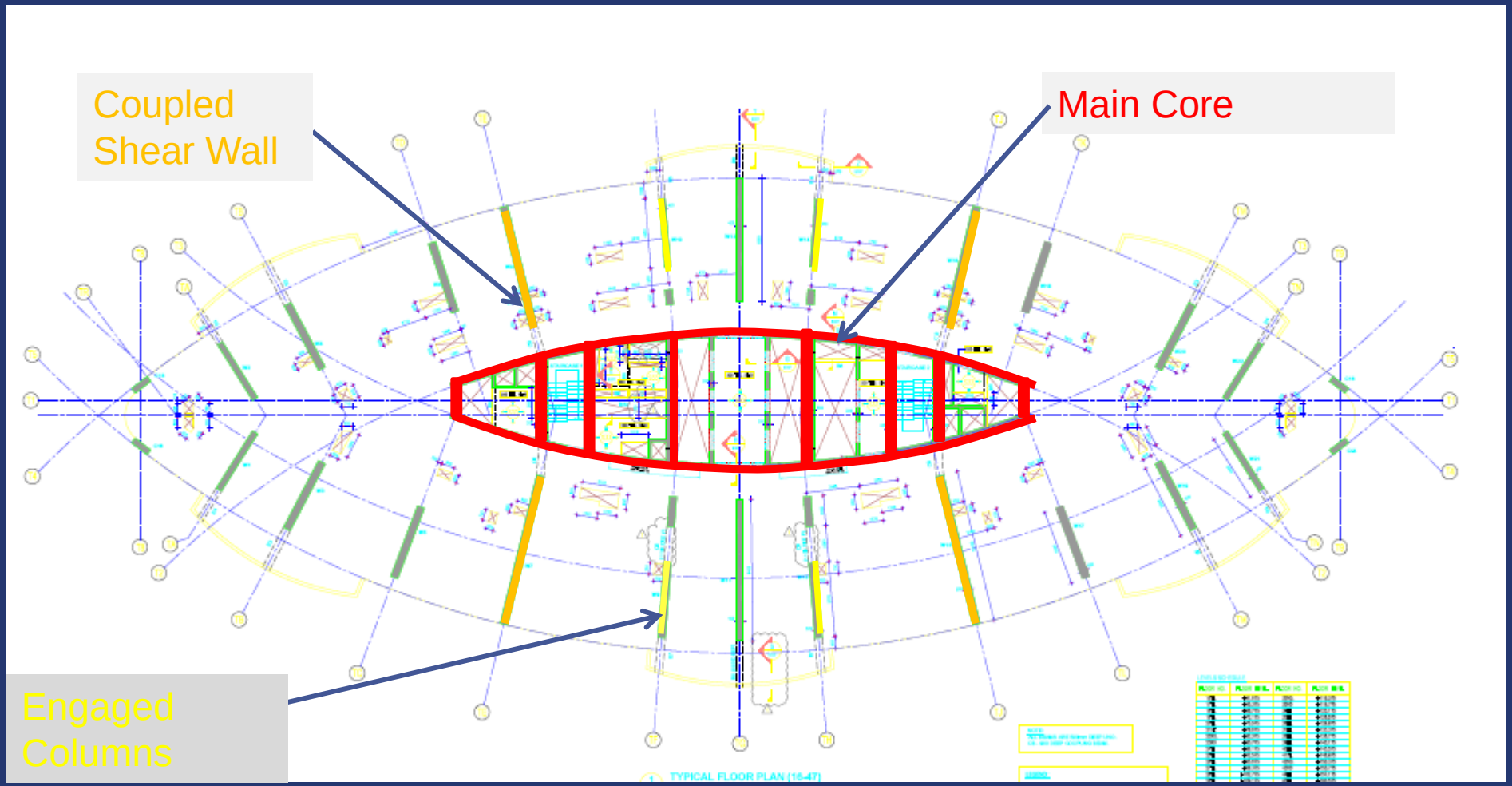
Stability system



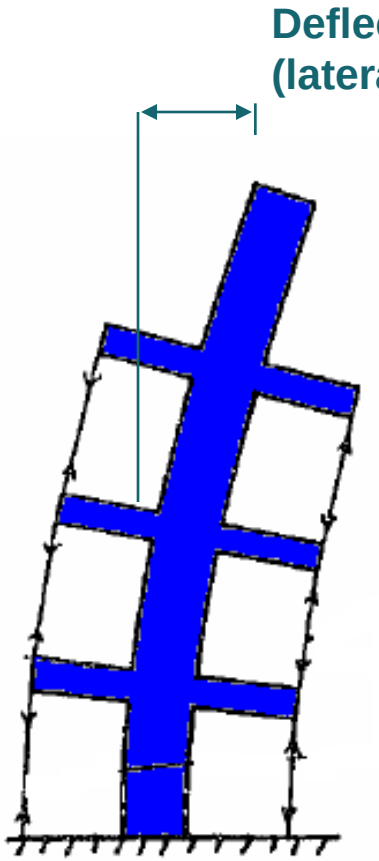
Aspect Ratio h/b 9 : 1

Main Core width 8.8m

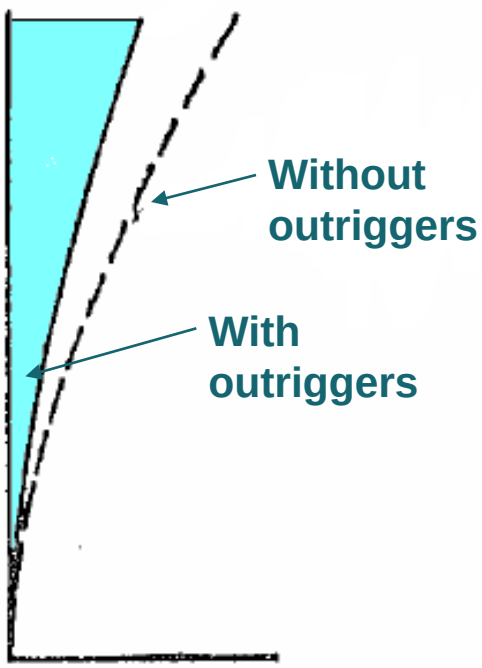
Main structure height 275 m

Highest concrete level 245 m

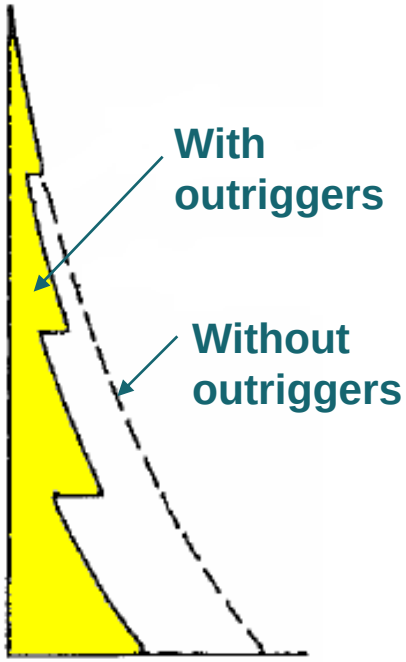
CORE WALL DEFLECTION AND MOMENT



Core wall with outriggers



Deflection (lateral sway)



Core wall Moment

Wind Engineering ~ wind tunnel testing

When to test?

- > 10 Storeys in a hurricane area
- Over 25~30 stories in other areas
- Unusual shapes
- Complex surroundings (terrain or structures)
- When optimising cost and safety is key to project
- 1/400 – 1/600 model scale
- Proximity models for radius of 500 to 600 m

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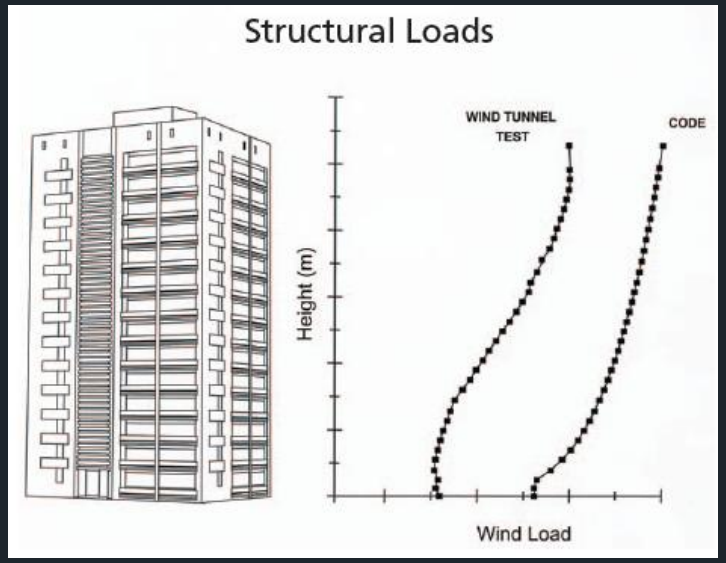
Wind Engineering

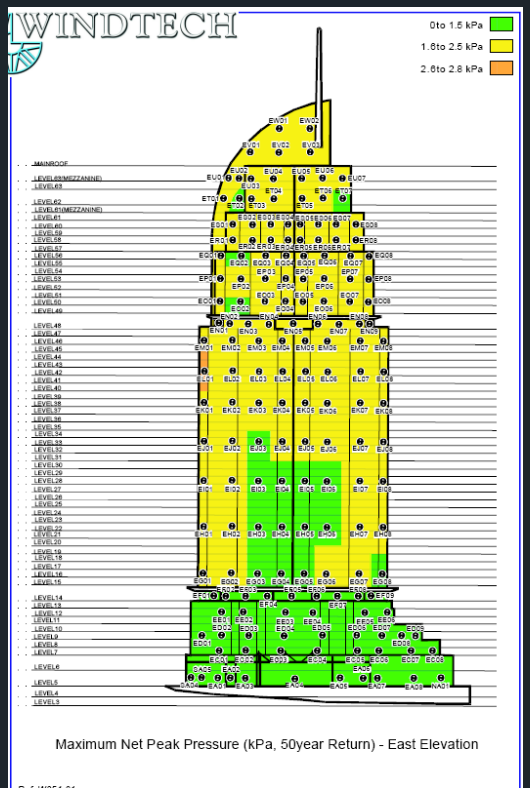
Structural wind loads

- Normal cases ~ wind load reduction of up to 40-50%
- Special cases ~ higher loads than code values
- ASCE recommends the minimum as 80% of code values

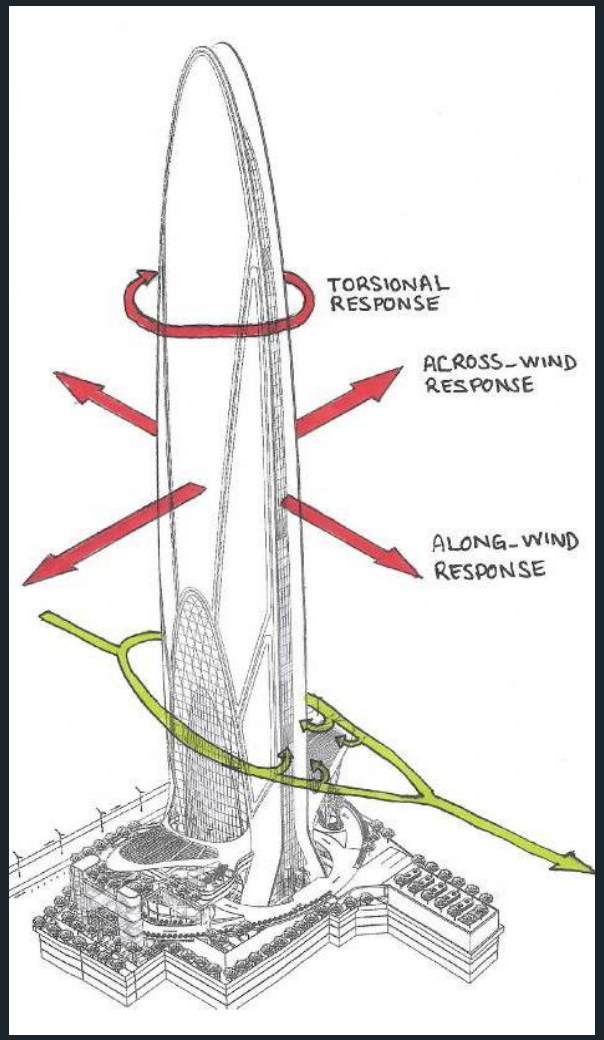


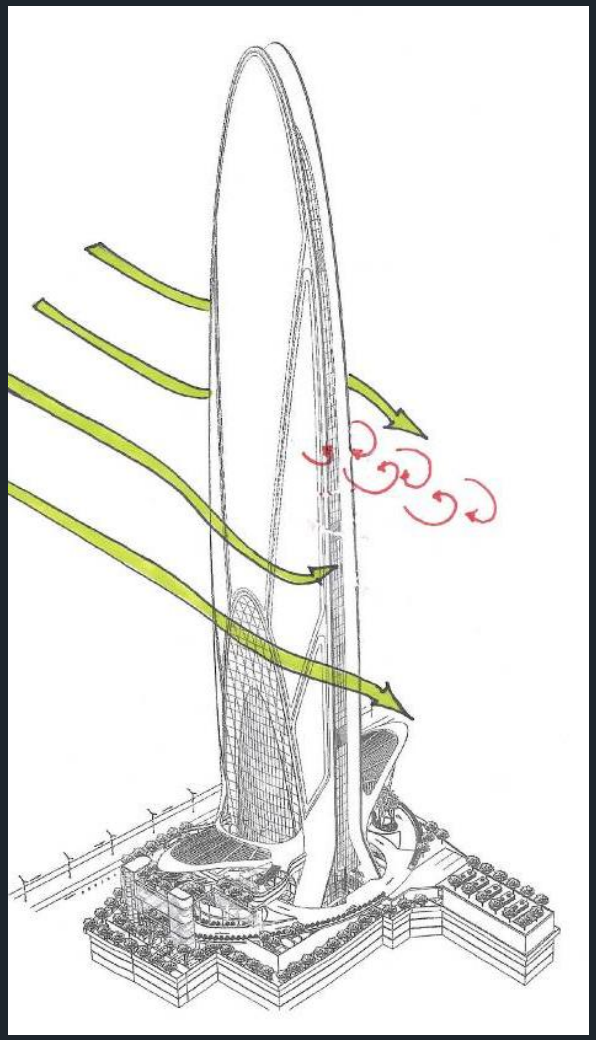
Cladding pressure diagrams

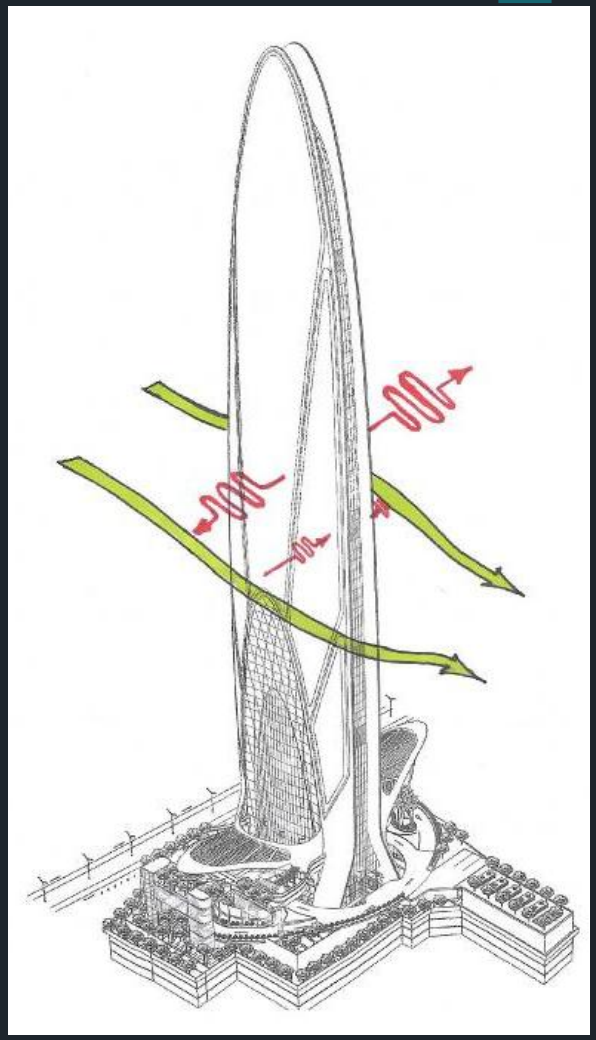
- Maximum pressure up to 2 to 3 times of average pressure



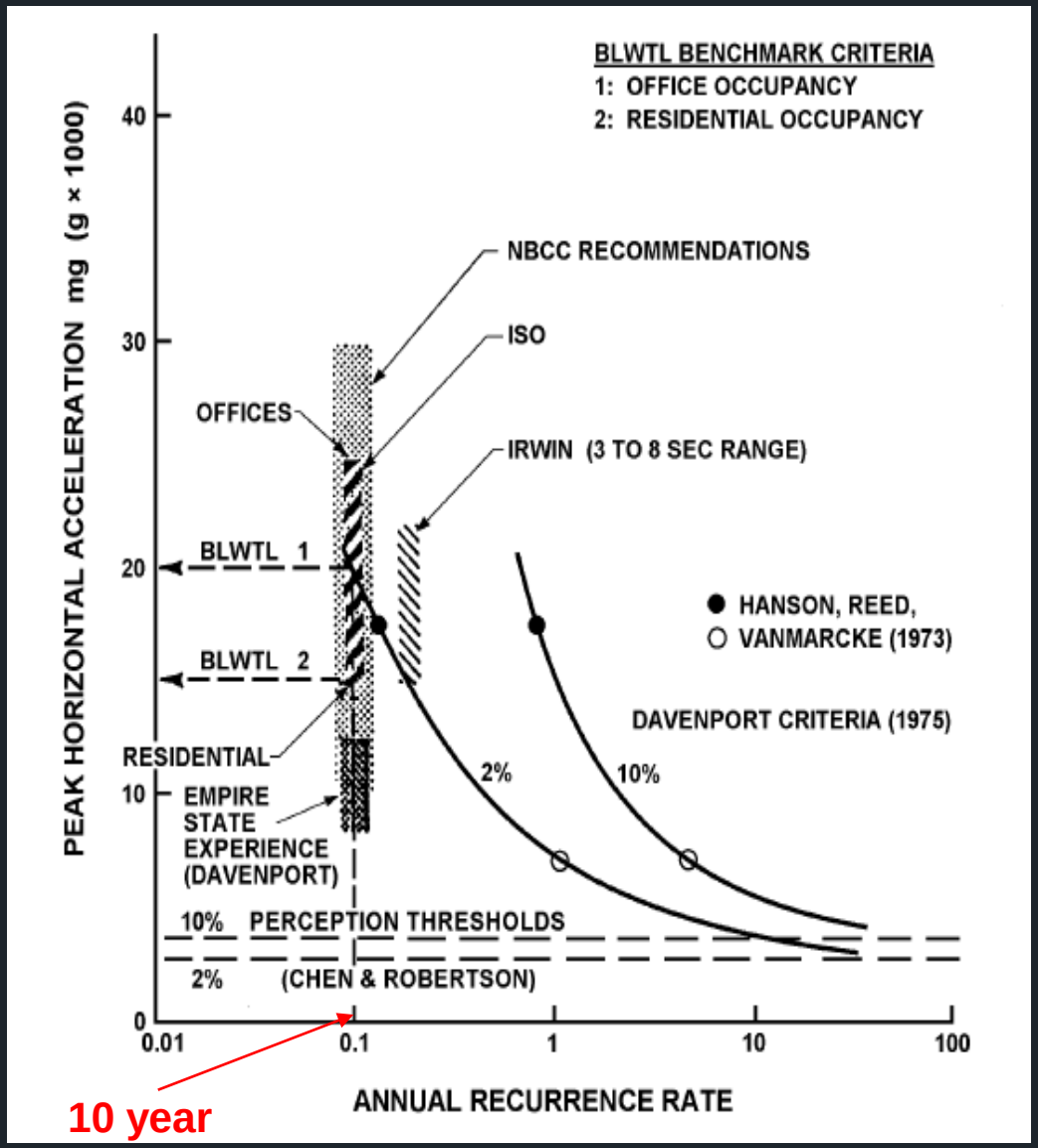
Wind Engineering







Wind Engineering ~ criteria for occupant comfort



NBCC Standard

- Max. wind in 10 years
  2% objection
- 5 milli-g: perception limit
- Residential:
  15 milli-g (1.5% of gravity)
- Offices: 20 mili-g

Acceleration control

- Increasing lateral stiffness
- Increasing mass
- Adding dampers
- Change shape

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Wind Engineering ~ criteria for occupant comfort

CTBUH guideline similar to assumptions in NBCC)

CTBUH Guidelines For Evaluating the Acceptability of Wind-Induced Motions of Tall Buildings*

STEP 1 – Evaluation of Horizontal Acceleration	Maximum Peak Effective Acceleration (milli-g)	
	1-Year	10-Year
Occupancy Type:		
- Residential	5 – 7	10 – 15
- Hotel	7 – 9	15 – 20
- Office	9 – 12	20 - 25

STEP 2 – Evaluation of Visual Effects	Maximum Peak Torsional Velocity (milli-rad/s)	
	1-Year	10-Year
All Occupancies	1.5	3

* These guidelines are given in a paper by N. Isyumov published in the Proceedings of the CTBUH World Congress, Amsterdam, 1995.

Wind Engineering ~ Wind Tunnel Testing

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Useful tips

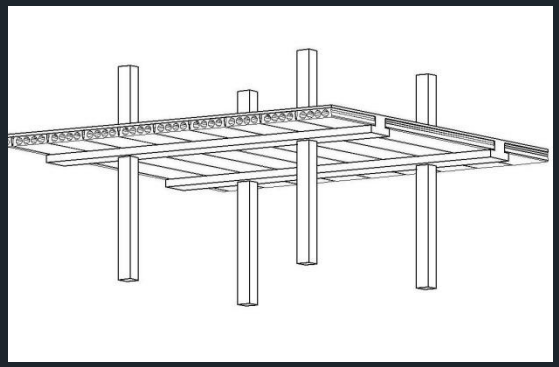
- Use the best
- Get a peer review
- Allow for additional interim testing (design is very iterative)
- Start as early as possible - at concept stage
- Costs:

  Initial model: $15,000

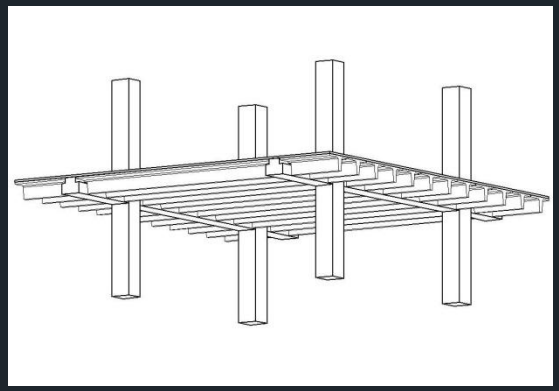
  HF Force balance model: $50,000

  Aero-elastic Model: $250,000

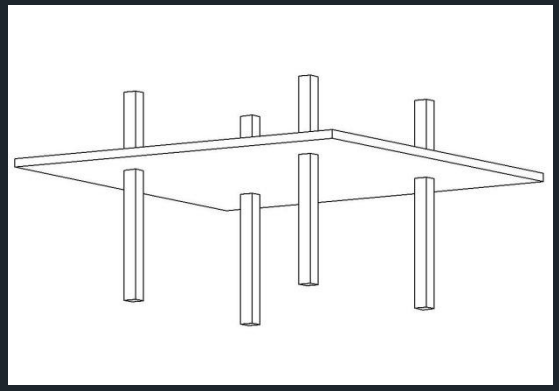
Floor Slab System



- Precast planks + structural topping
- Depths vary between 150 ~ 500mm

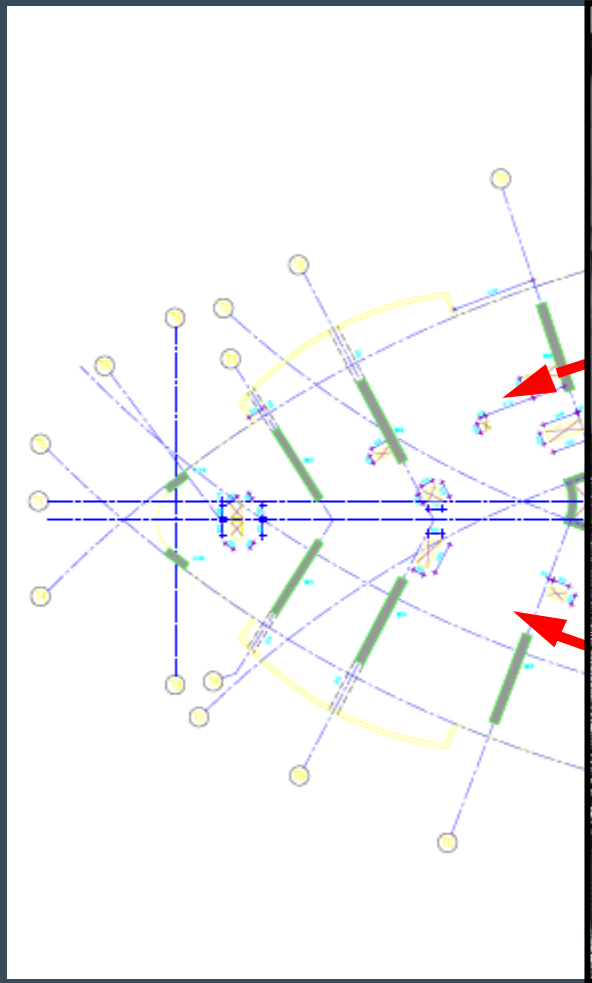


- Precast double T-Slabs + structural topping
- Overall depths up to 1.5 m larger spans



- PT /RC flat slab
- Overall depth varies depending on span

Floor Slabs

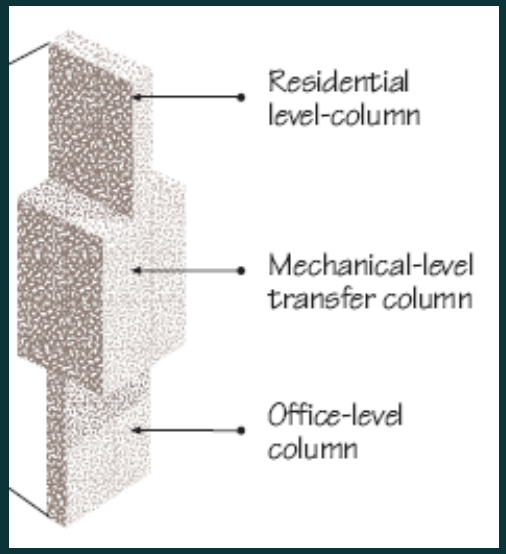


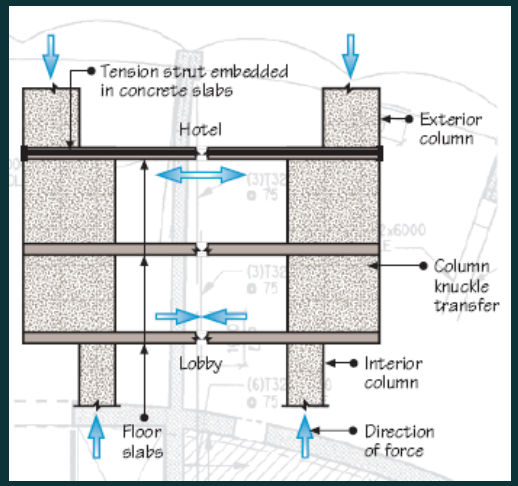
Post Tensioned One Way

Floor Cycle 4 to 5 days

Plant Room and lower levels reinforced concrete flat slabs

COLUMN TRANSFERS





Open space required in public spaces

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The Address Hotel

Concrete Grades C 57/70 to C 35/45
Reinforcement Grade 460

Tower piled raft 2.5m thick
Tower piles 1.2 m diameter bore piles
Number of tower piles 185
Piles skin friction in weak sandstone and conglomerates 50 m long

Summary of key data

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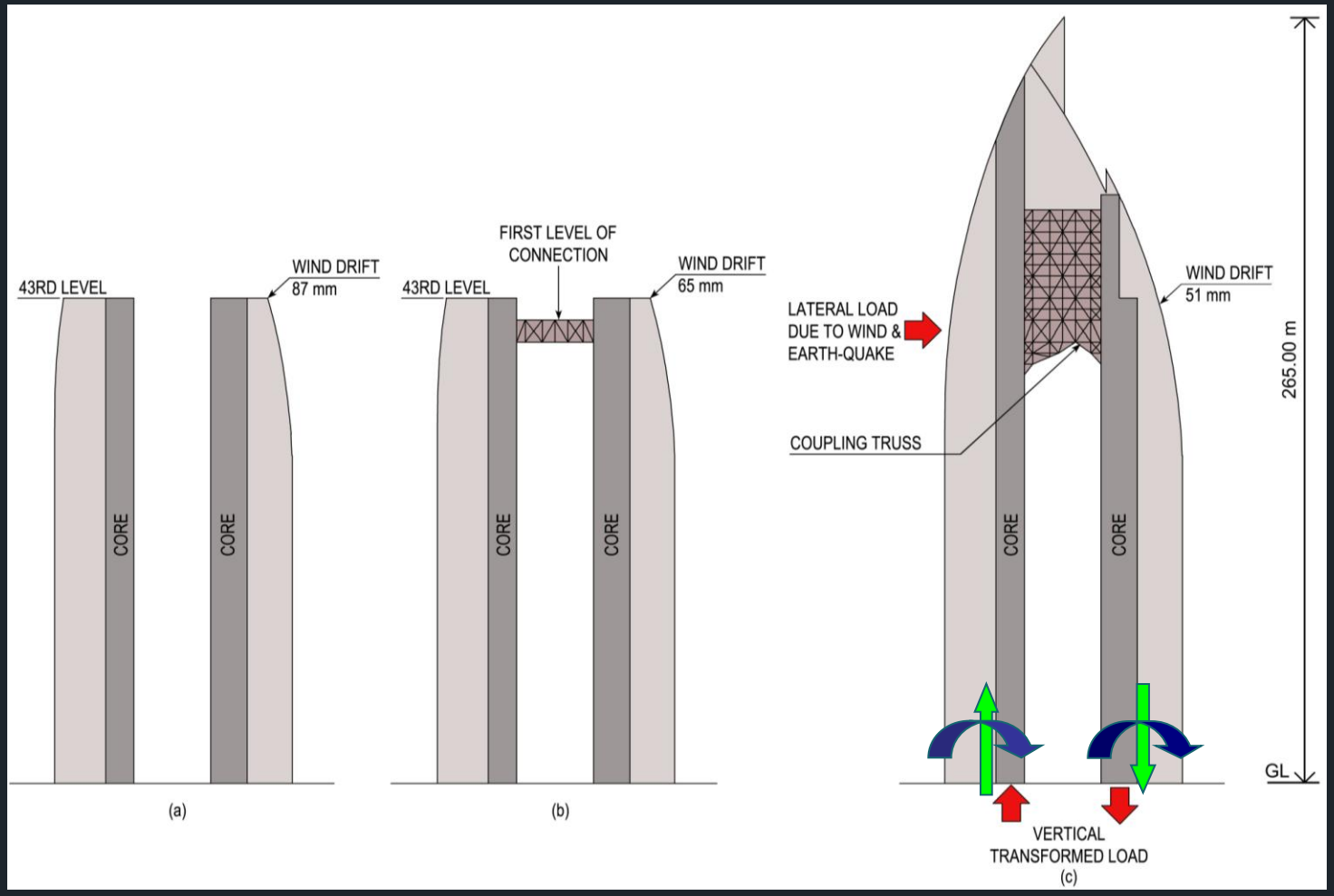
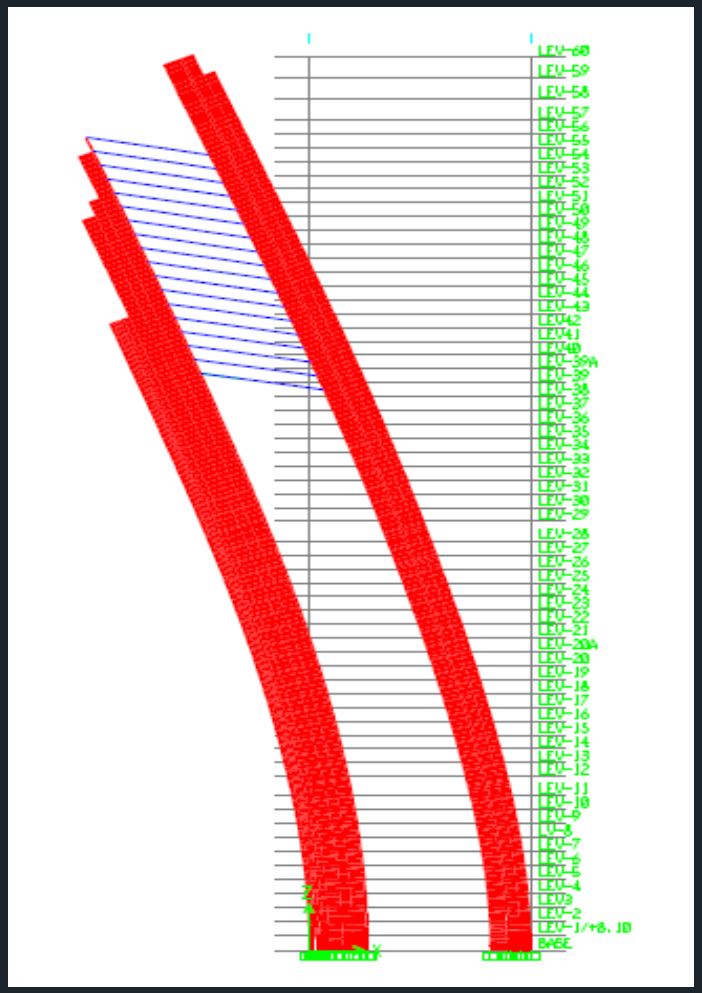
Trump Hotel

Trump Tower

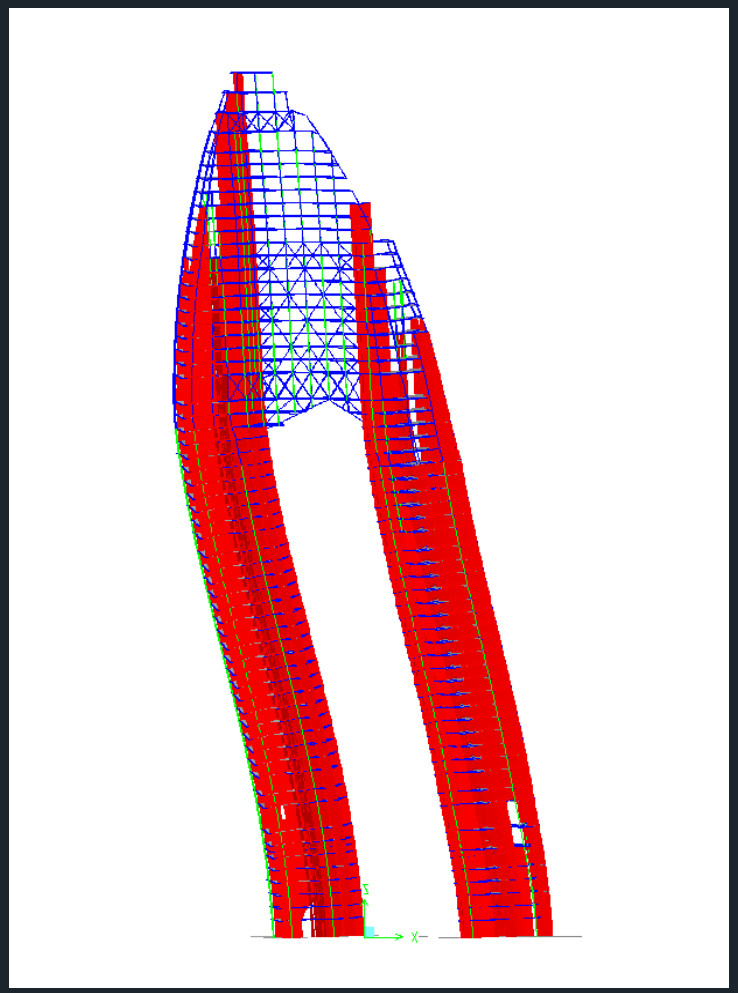
Hybrid Solutions Trump Tower



Trump Tower Coupling of the Concrete Cores



Lateral displacement of the core walls uncoupled



Coupling action reduces the lateral drift by over 70%

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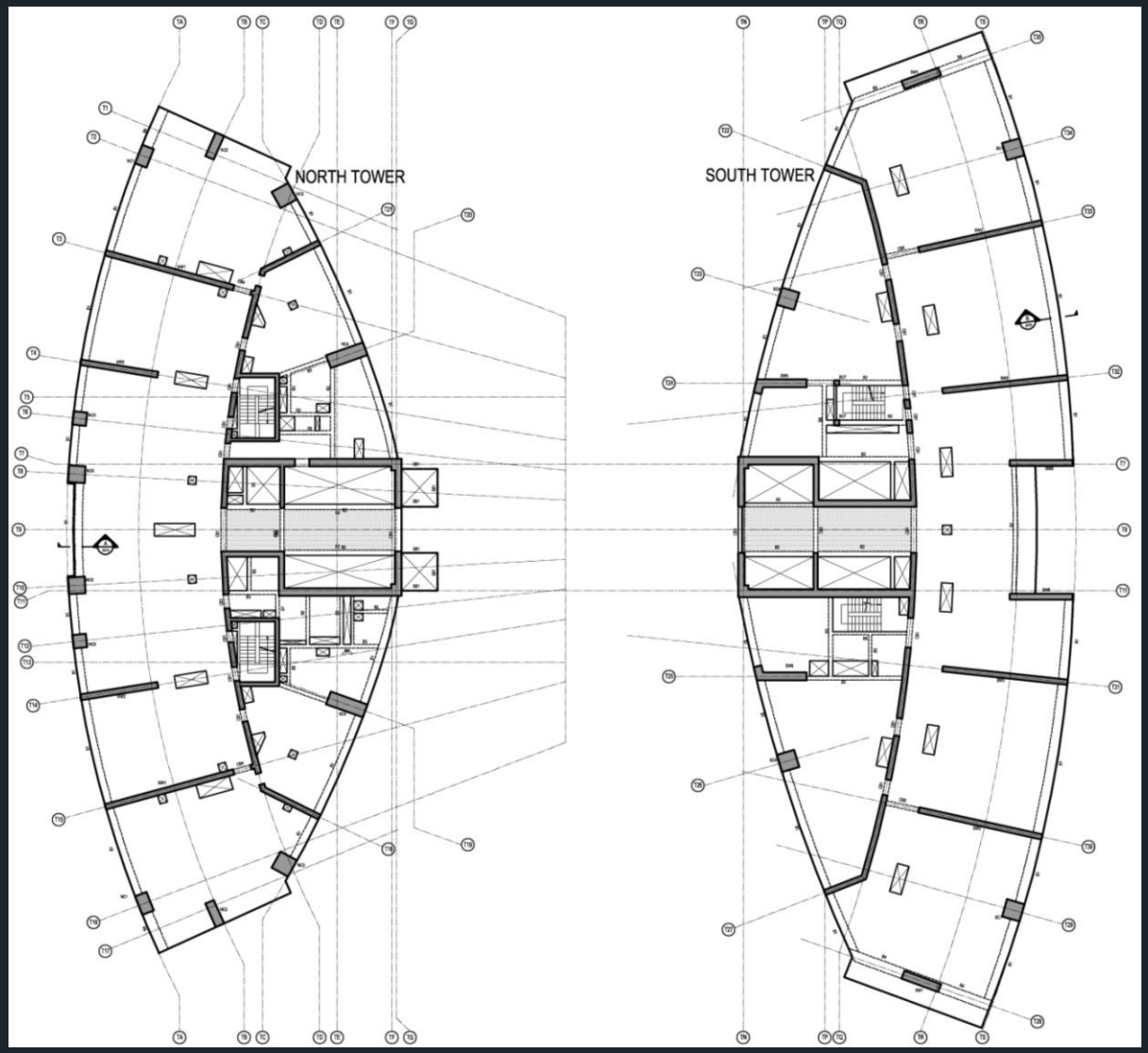
Trump Tower General Layout Below Level 40



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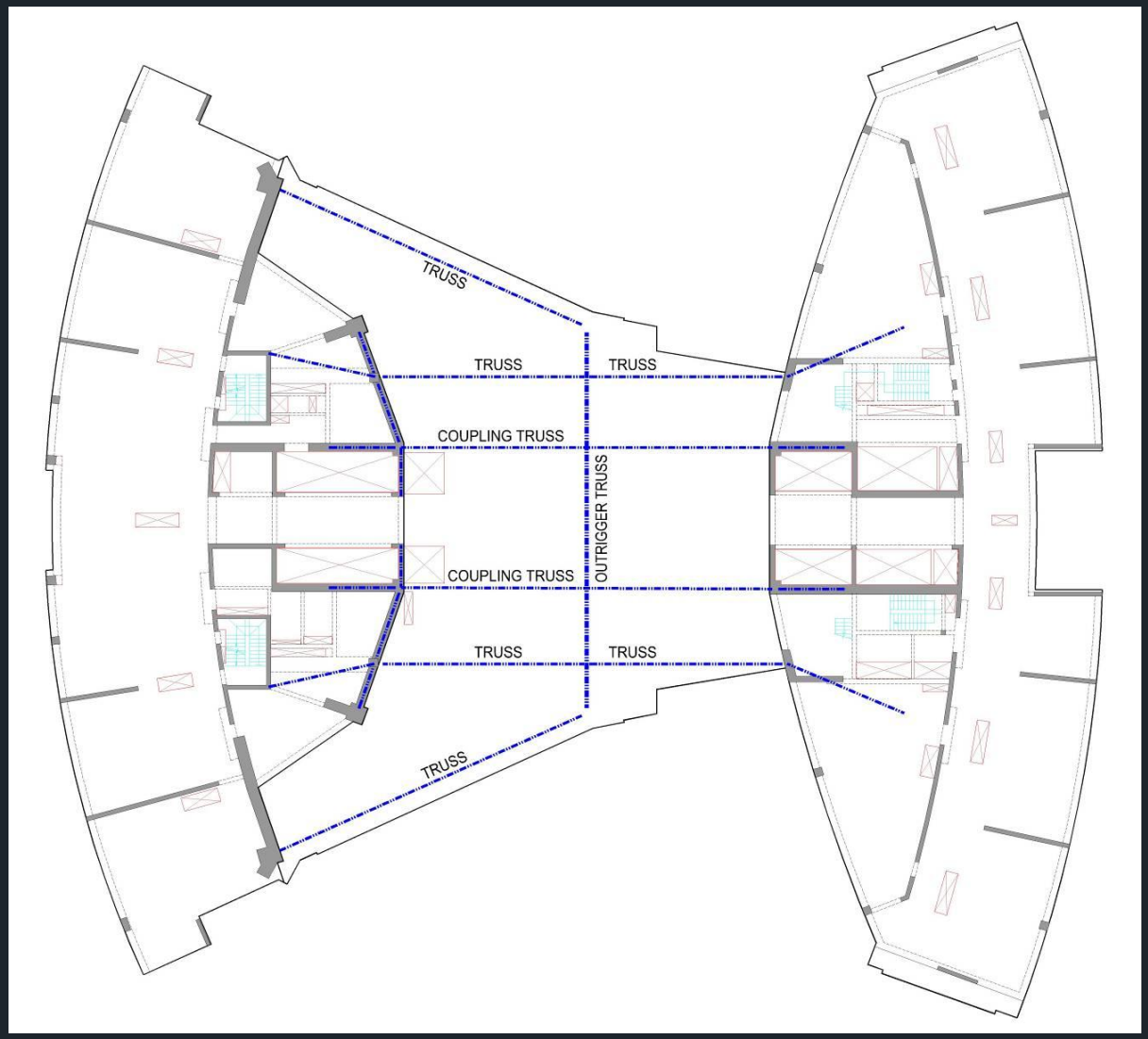
Trump Tower General Layout at Level 40



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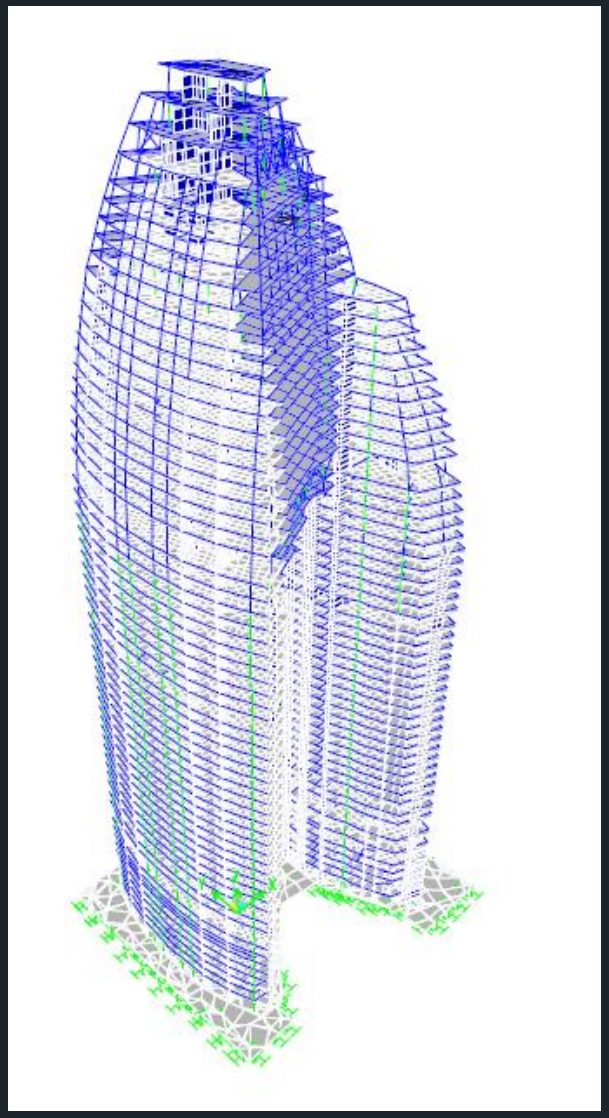
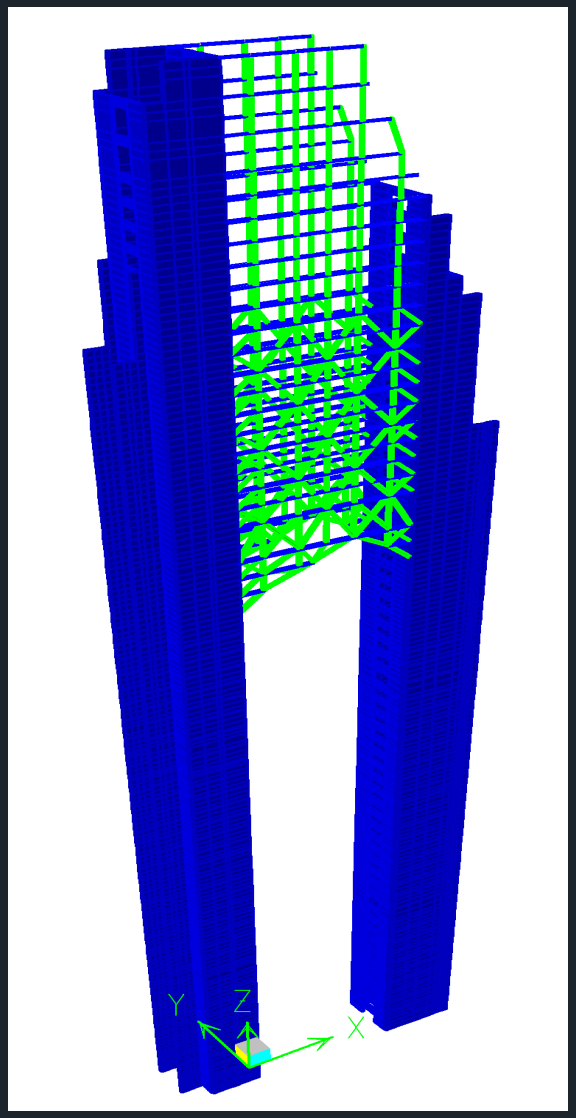
Trump Tower Structure & Primary Framing





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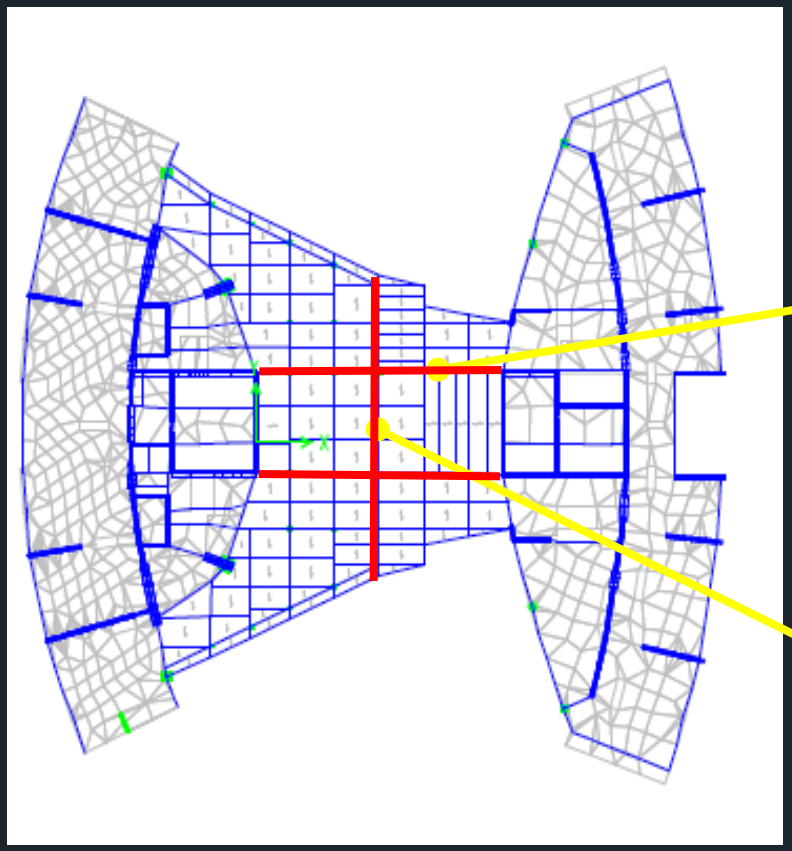
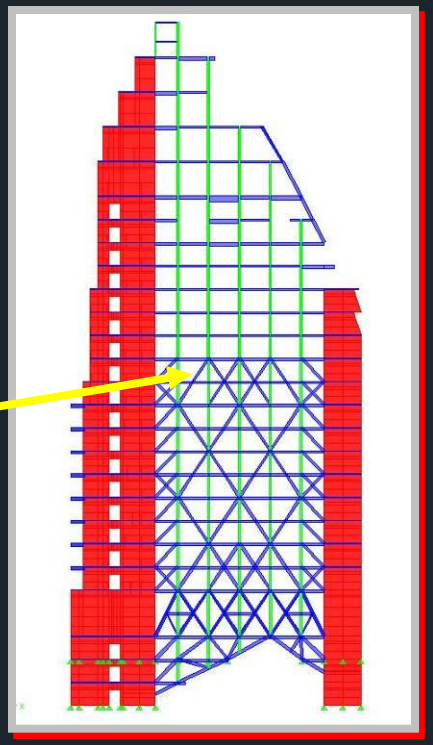
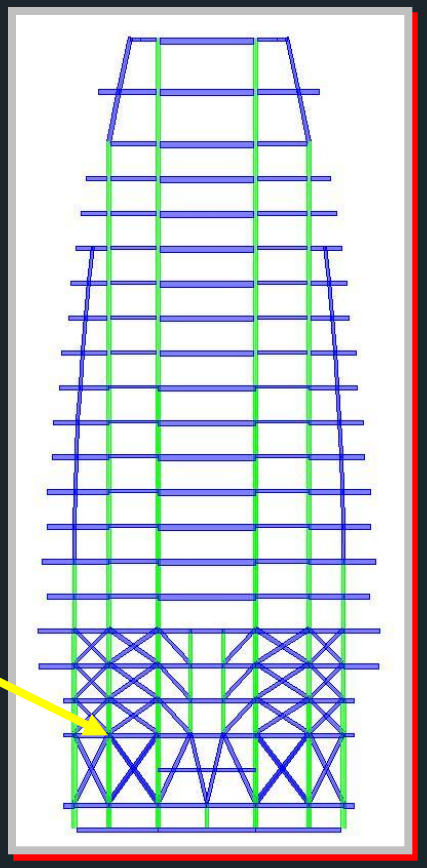
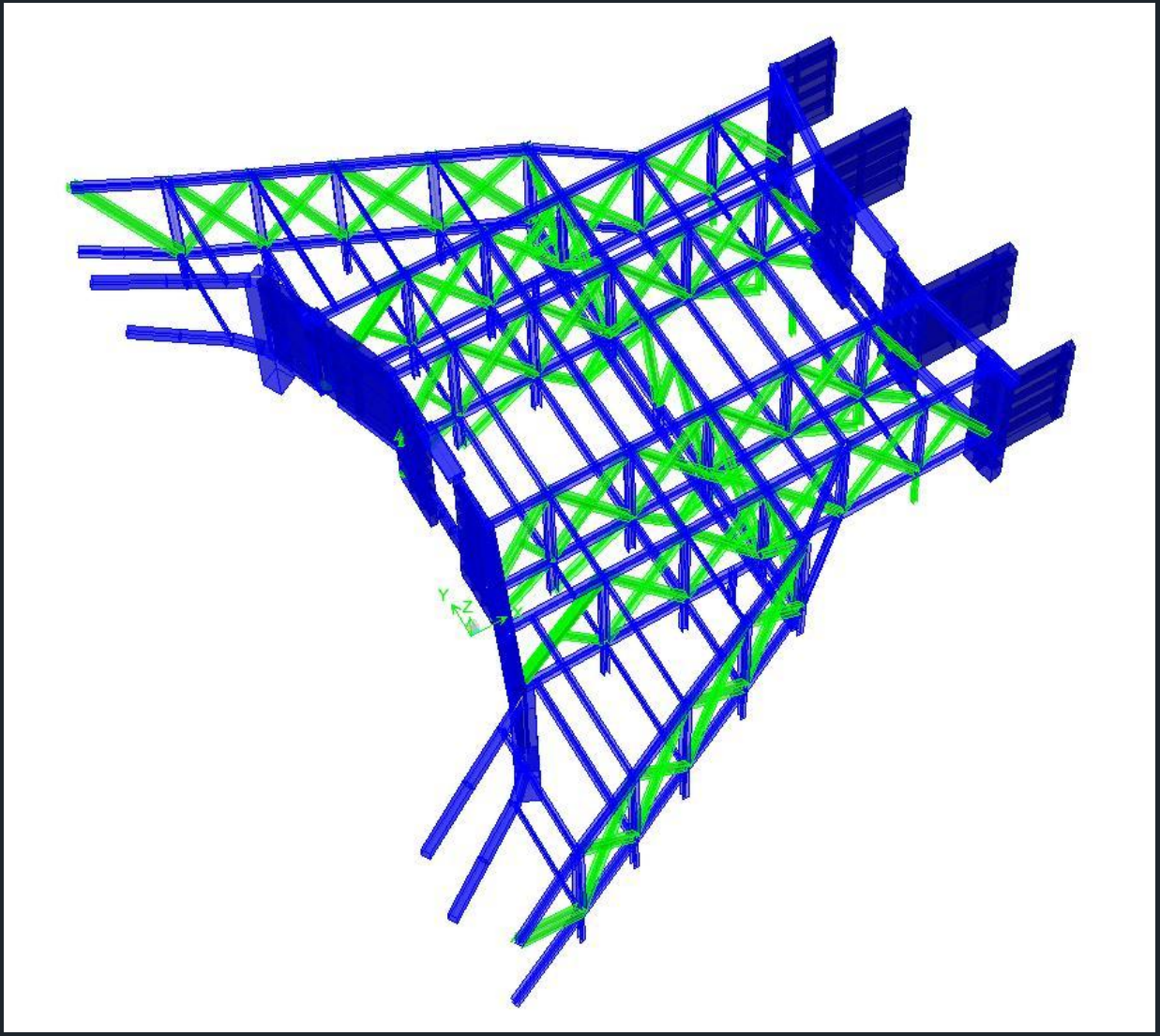
Trump Tower Transfer Structure: Level 40 to 41







Trump Tower Transfer Structure: Level 40 to 41



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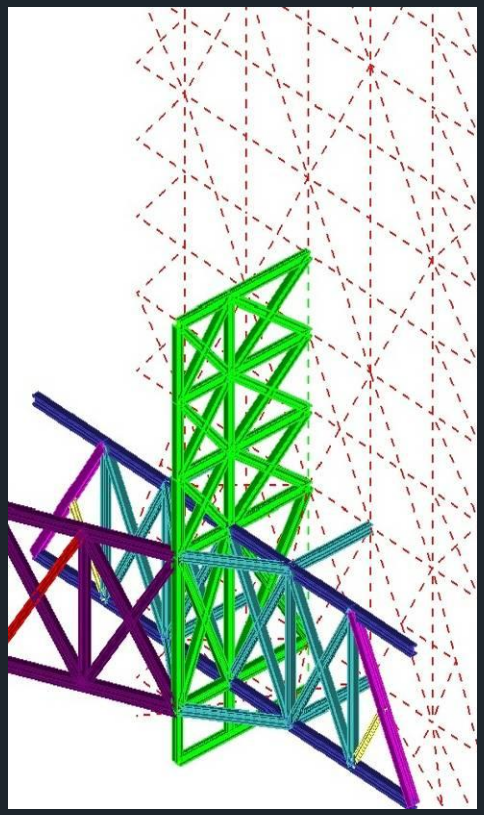
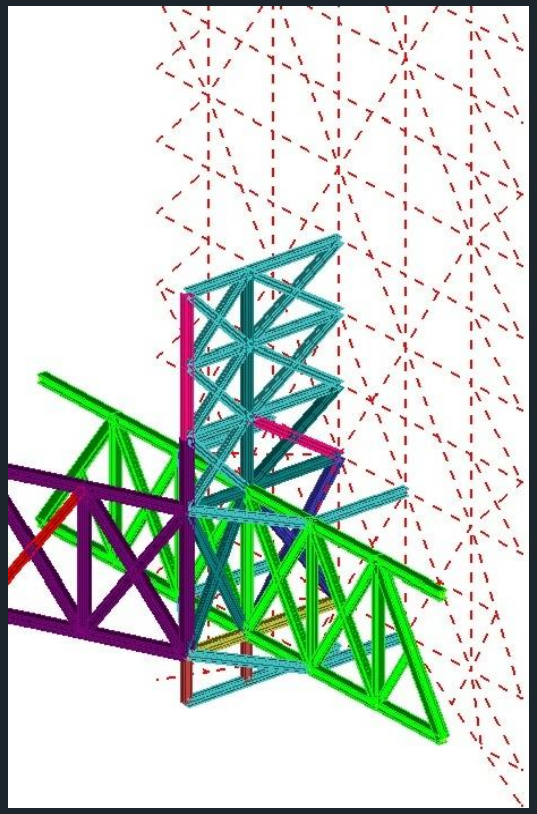
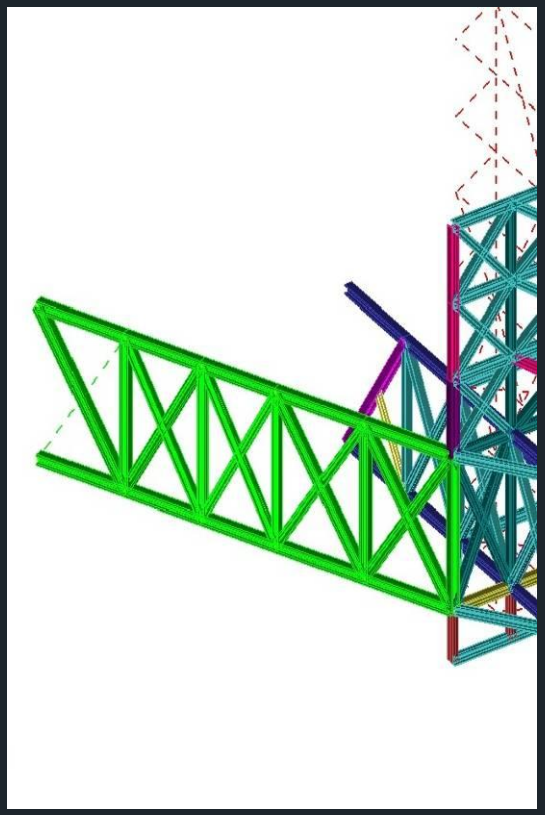
Trump Tower Hierarchy of Structure



Outrigger Cantilevers from Coupling Trusses



Trusses Span Continuously Between Outrigger and Walls.



Outer Trusses Span Between Outrigger and Walls.

Adjustments

Two Parts

Column Shortening

Movement of Transfer Structure

Options Recommended

Column shortening to be overcome by adjusting the length of columns incrementally with height

Continuous jacking of columns during the construction stage

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Almas Tower

Almas Tower Dubai (360m)

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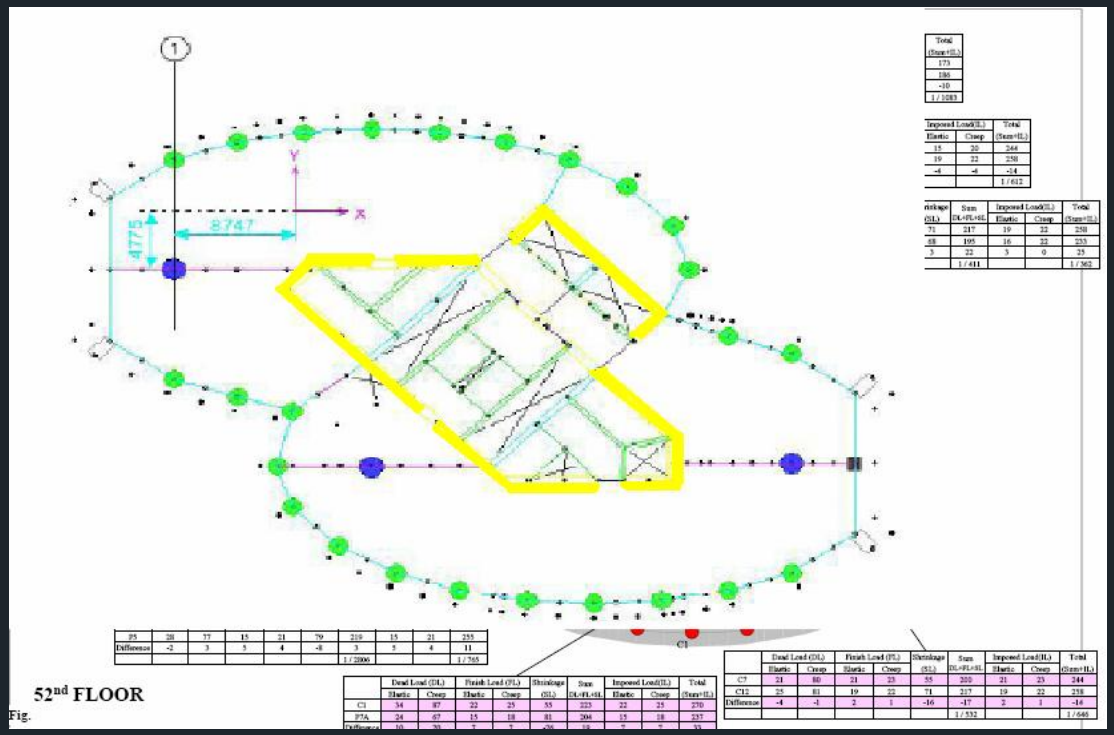
COLUMN AND WALL SHORTENINGS



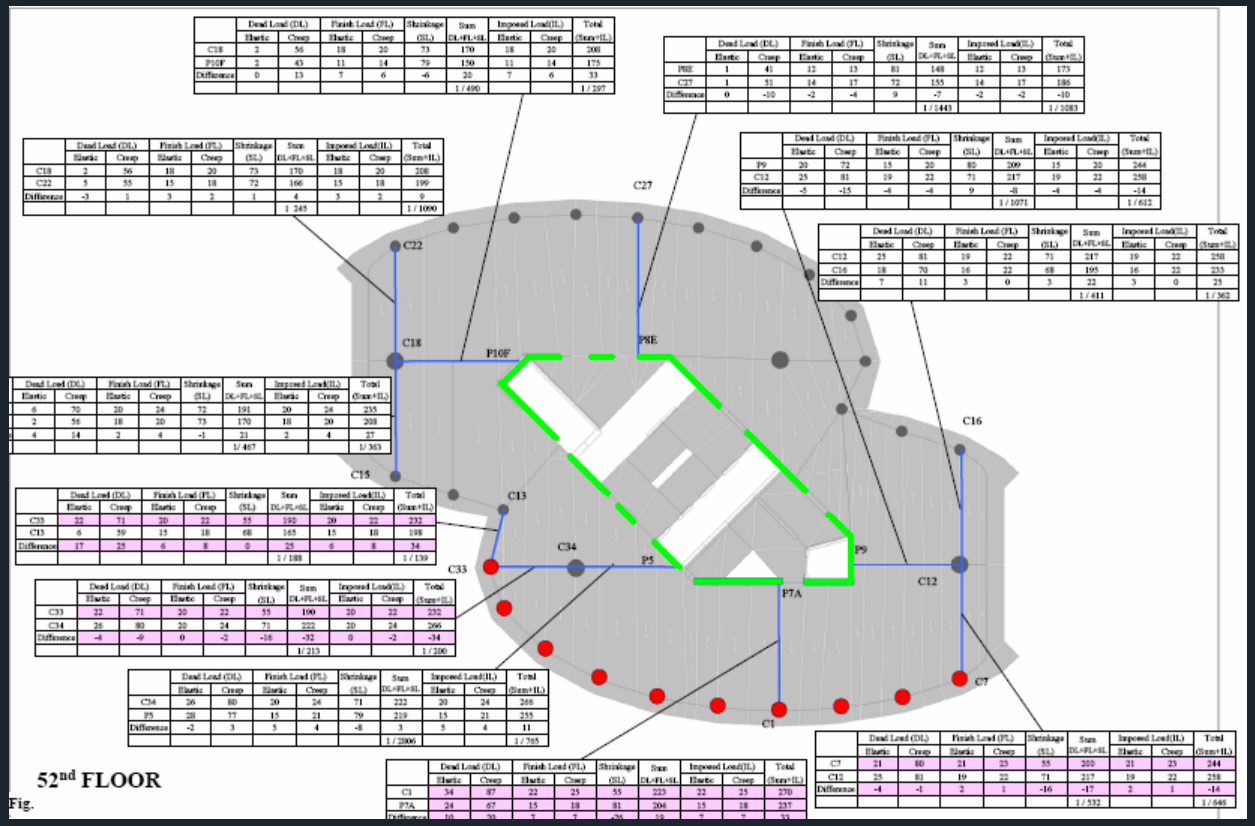
Nature of Shortenings:

- Columns - gravity elements: more shortening
- Core walls - lateral elements: less shortening

Shortenings result from:

- Elastic (axial loads)
- Creep
- Shrinkage
- Long-term effect

COLUMN SHORTENING ANALYSIS



Controlling Factors:

- Column size/ length
- Concrete strength
- Conc. properties
- Member sizes
- Reinforcing amount
- Floor dead loads
- Superimposed loads
- Construction time
- Construction loads
- Humidity at curing
- Temperature

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Iris Bay

Iris Bay Dubai (174m)

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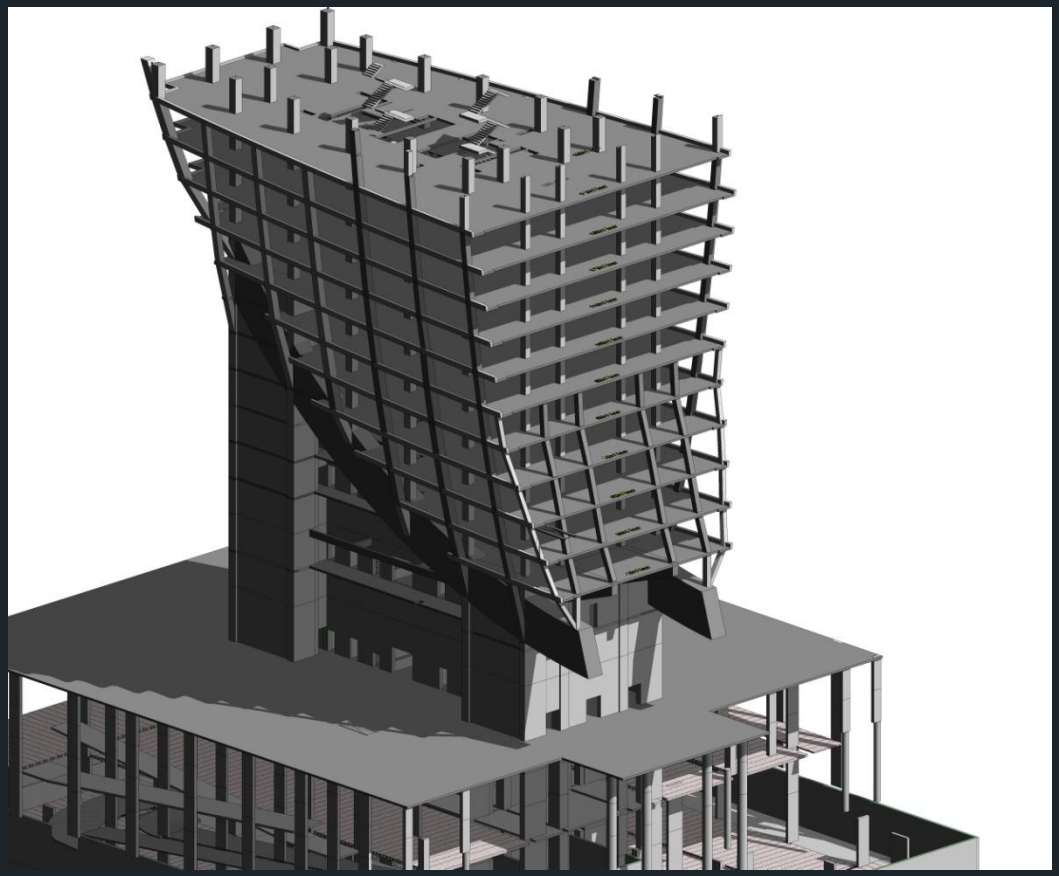
Iris Bay



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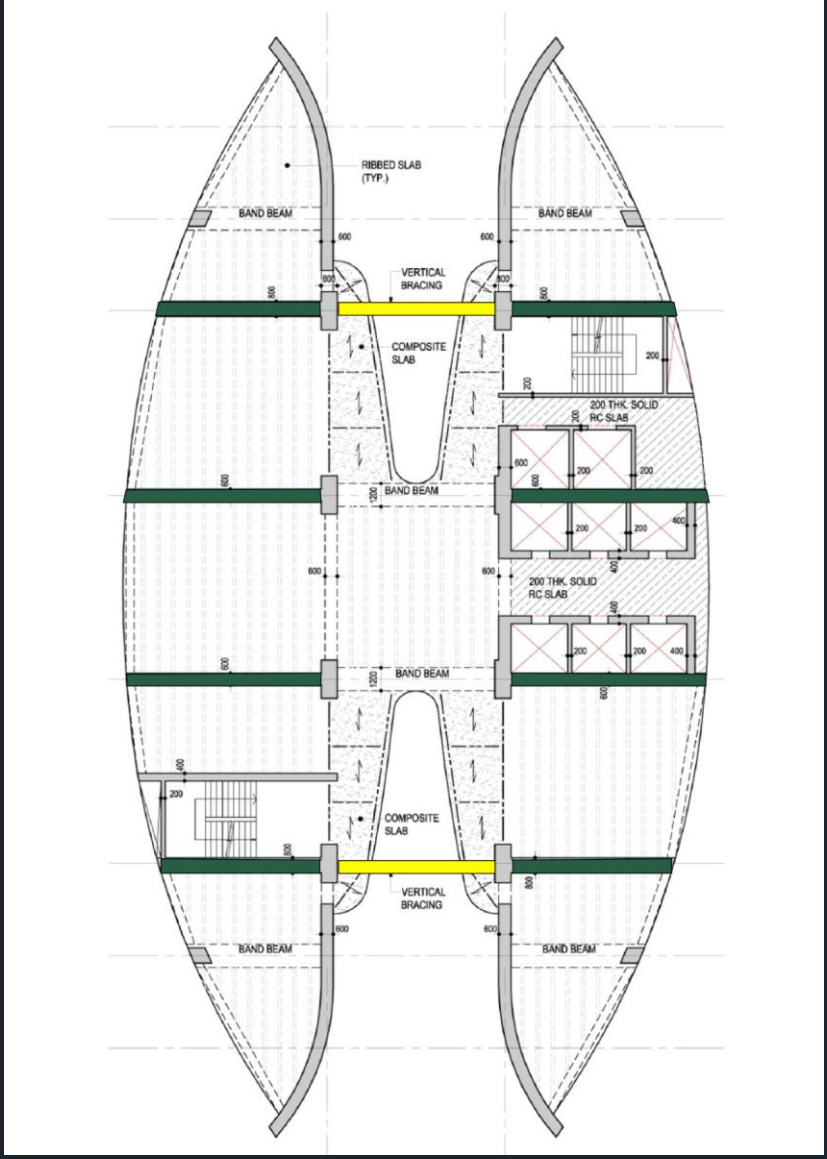
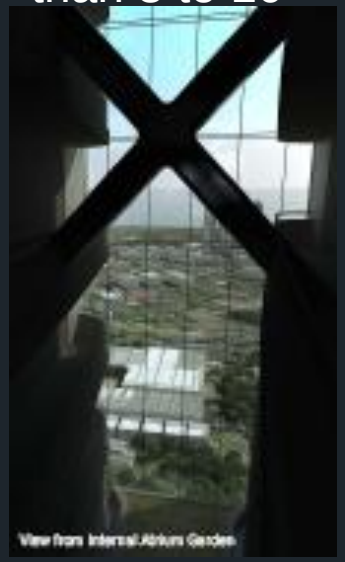
Namaste Hotel

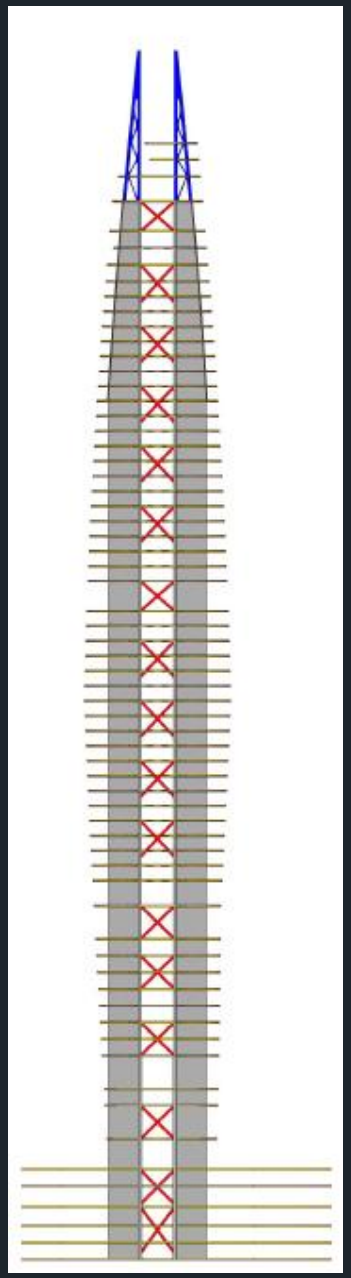
Project in Mumbai

Lateral Stability



Magic number:
Height over Depth ratio less than 8 to 10





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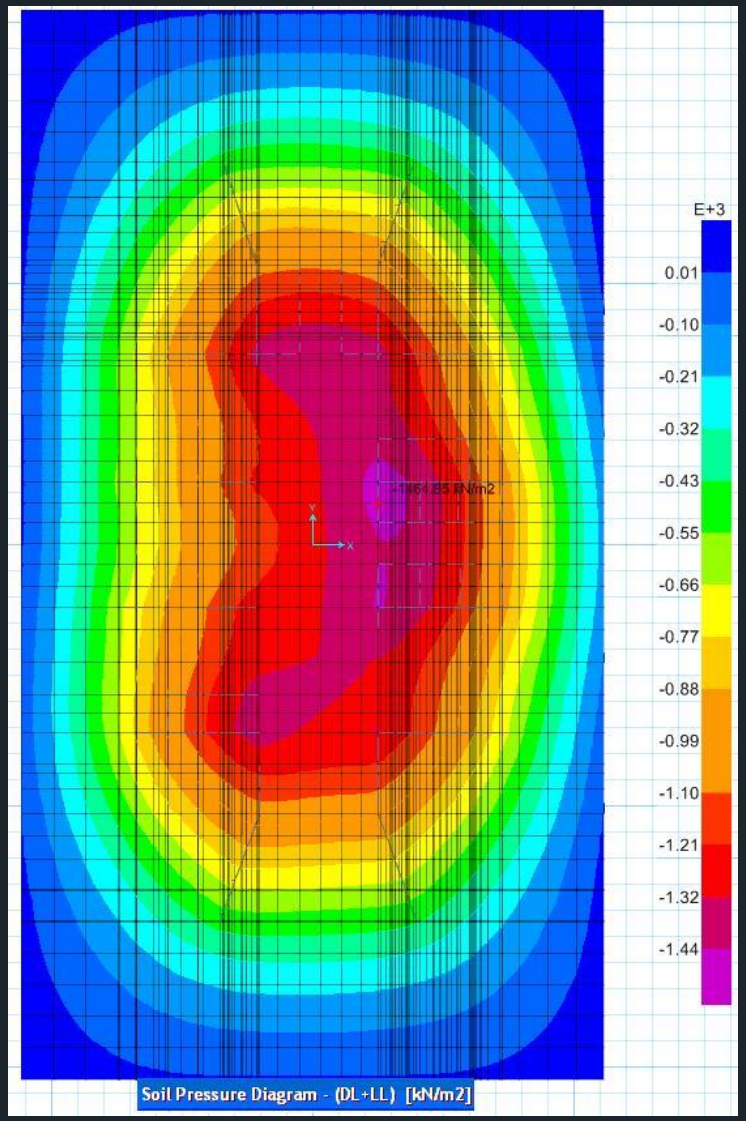
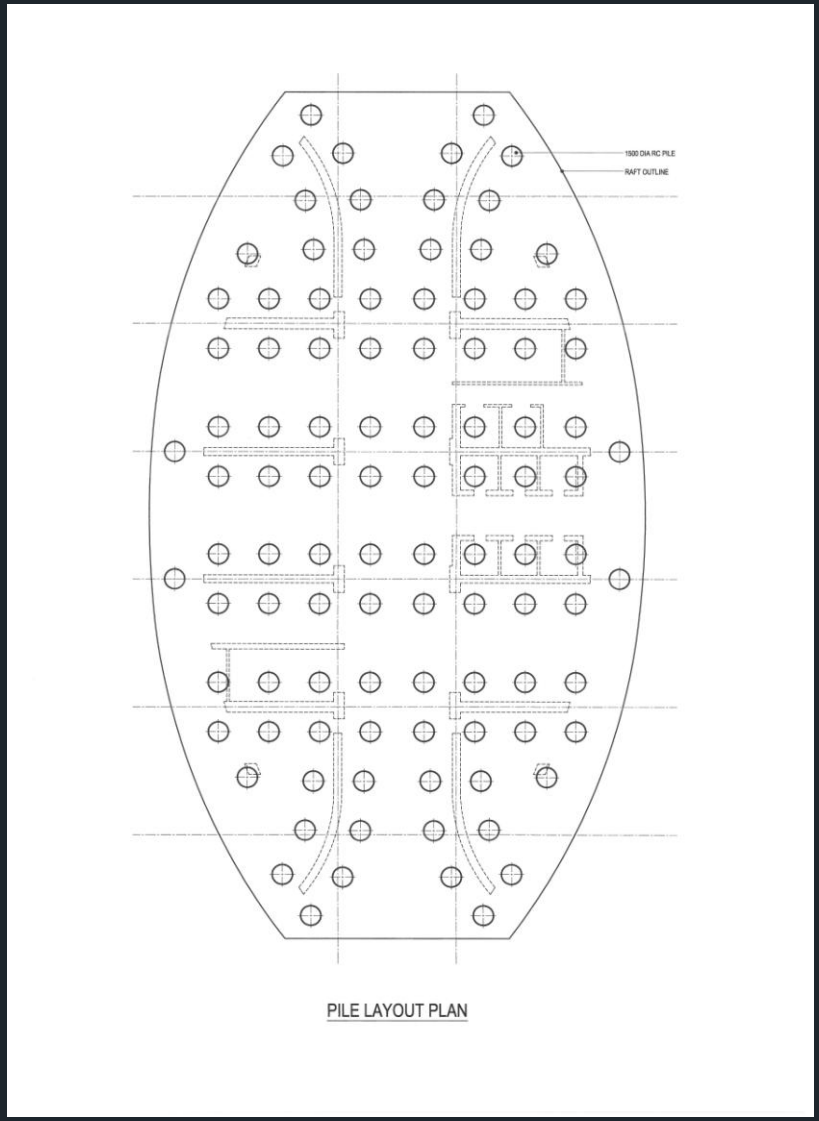
Foundation





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Other Aspects of High Rise

Design Codes

- Traditionally British Standards
- Due to location seismic considerations required throughout most of the GCC
- Trend towards adopting US codes (specially IBC) but a mix of codes prevalent
- Seismic provisions outlined in ASCE / AISC and ACI are key
- Seismic Zoning Low to Moderate UBC Zone 2A PGA 0.15g
- Seismic effects critical for low to medium rise buildings with wind governing the design for tall buildings

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Materials

- Most buildings are of RC construction
- Steel becoming more widely used
- Floor plates are generally of PT
- Foundations usually piled
- Recent trend toward hybrid structures

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Design Programme

- Usually very tight
- Procurement traditional – FIDIC
- Design stages RIBA
  - Stage C – Concept Design
  - Stage D – Preliminary / Schematic Design
  - Stage E / F – Detailed Design
  - Stage G – Tender Documentation
- Design duration typically 6 - 10 months
- Enabling works pack expected in stage D with piling information expected at the end of Stage D
- Engineering involvement at Concept Stage critical

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Statutory Authorities

- Divided amongst a number of bodies
  e.g three bodies in Dubai alone
- Reliant on 3D modelling
- Make use of a mix of design codes
- Require a peer review for very tall buildings
- Approval process can be time consuming

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