Aurora Place

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Introduction

1. Background
2. General Information
3. Architects and Engineers
4. Design concept
5. Building layout
6. Interior View

Background

In 1996, in celebration of the **upcoming 2000 Olympic Games in Sydney**, Australian construction company Lend Lease Development commissioned RPBW to design and construct **a commercial tower and a residential building.**
The project was commissioned by Australia's leading construction company and its stated objectives included **the real estate development of the area**, as well as the construction of what was to be considered **a "memorable" building**.
The site is located between Macquarie Street and Phillip Street, in the city's historical centre, which dates back to the mid 19th century; Macquarie Street runs alongside the Royal Botanic Garden and continues all the way up to the Opera House. Some architectural details had to be respected in order to ensure that the structure would be **in harmony with Sydney's symbolic Opera House**, designed by Jørn Utzon.

General Information

Location: 88 Phillip Street, Sydney,

New South Wales, Australia

Height: 218.9 m / 718 ft

Above Ground Floor Count: 41-storey structure

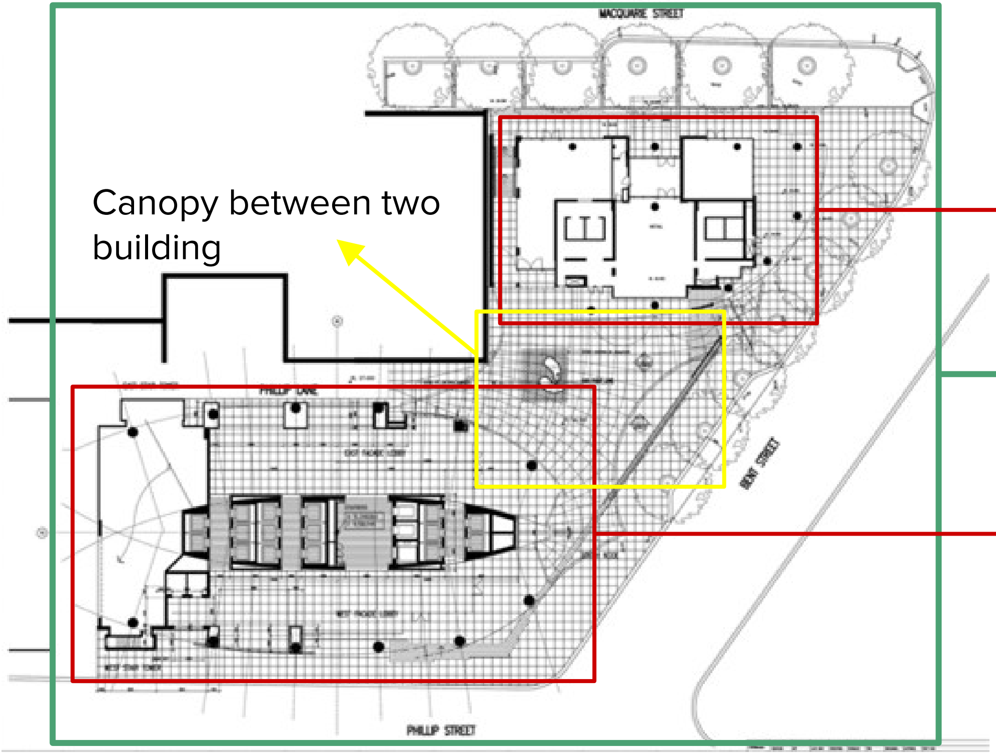
Total Floor Count: 44-storey

Floor Area: 49,500 m^2 (532,620 sq ft)

Construction Start: 1998

Completion: 2000

General Information



Residential Building

Aurora Place Office and Residential Building Location in City.

Our Focus:
Office and Commercial Building

Architect and Engineers

Architects:

Renzo Piano Building Workshop(RPBW)

Renzo Piano

Born: 14 september 1937(age 78)

Nationality: Italian

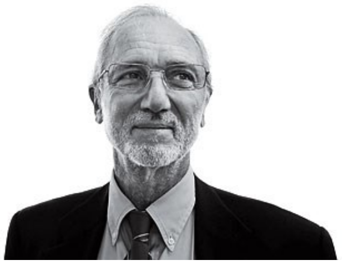
Awards: Pritzker Architecture Prize

RIBA Gold Medal

Sonning Prize

AIA Gold Medal

Kyoto Prize



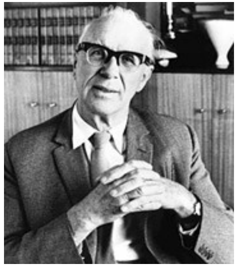
Engineers:

Major Engineers: Bovis Lend lease (structural); Ove Arup and Partners/Environ (mechanical)

Service and Facade Engineers: Arup

Arup

a British multinational professional services firm headquartered in London, UK which provides engineering, design, planning, project management and consulting services for all aspects of the built environment.



Design Concept

1. Harmony with the Sydney symbolic Opera House (Figure 1)
2. Reflect the historical and architectural quality of the existing buildings in Macquarie Street. (Figure 2)
3. Address the powerful urban role of new buildings in Sydney.
4. Responding to the context of the site, the nature of the views, winds and orientation, produce something more memorable than just another skyscraper.
5. The roof is inclined at an angle of 43 degrees to avoid shading the adjacent park. (Figure 3)

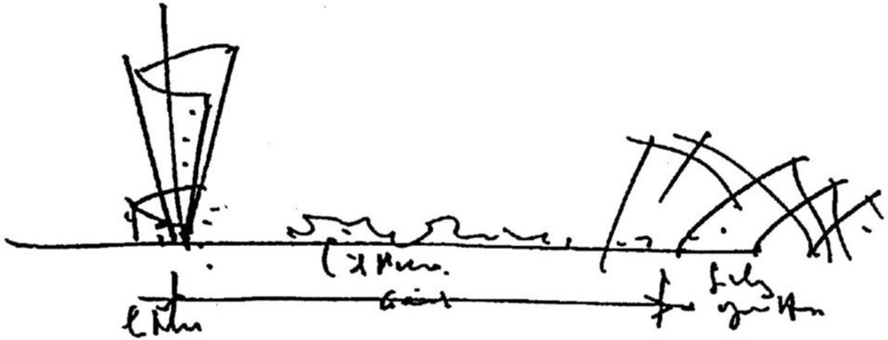


Figure 1

Figure 2

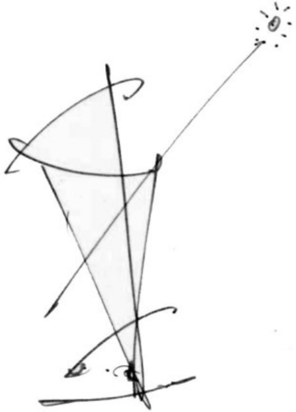
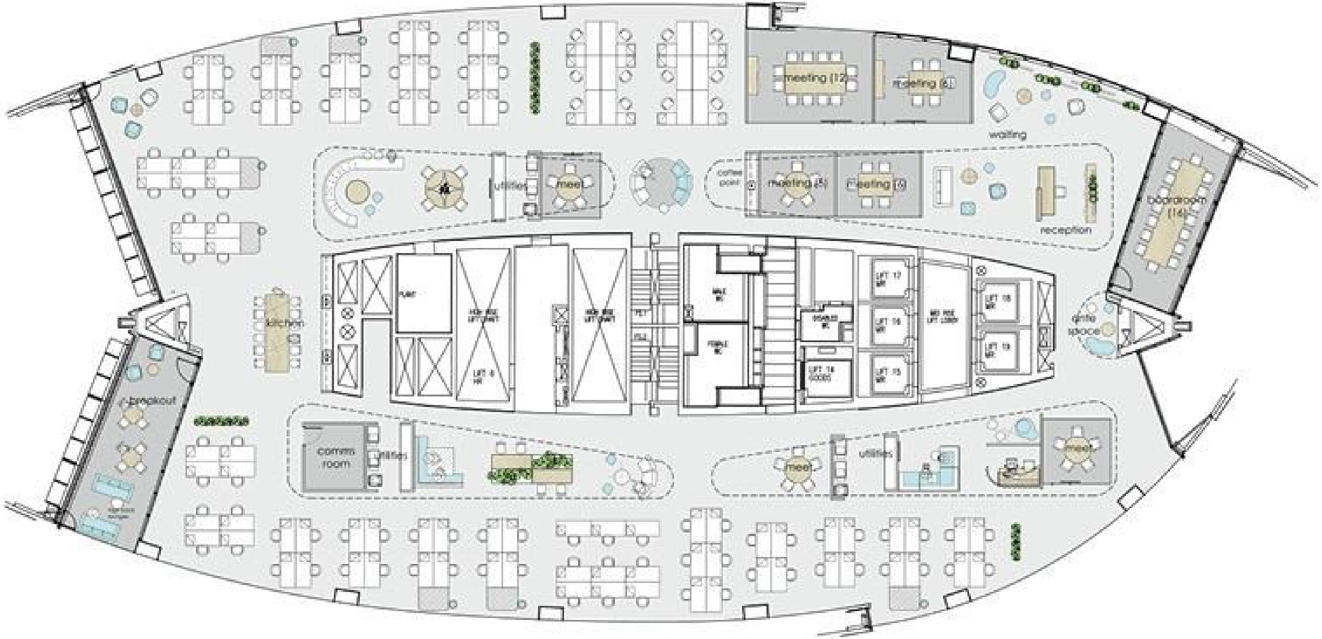


Figure 3

Building Layout



TYPICAL MID RISE FLOOR
- POTENTIAL FINANCIAL SERVICES LAYOUT

SPACE PLAN LEGEND

Total area Sqm -	1375 sqm approx.
Total Number of Staff -	102 Persons
Density -	13 sqm/person approx.
Workstations -	101
Meeting Rooms -	6
Reception/waiting -	1
Utilities -	3
Kitchen -	1
Comms -	1

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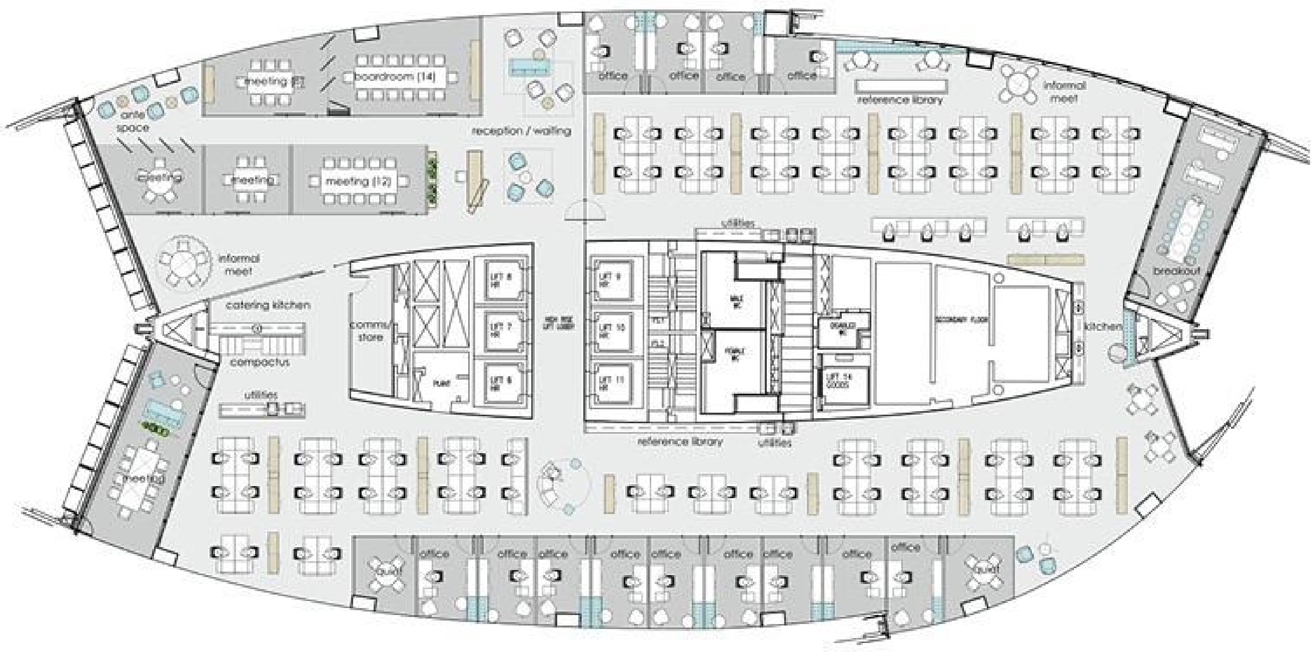
Building Layout



TYPICAL HIGH RISE FLOOR
- MEDIUM DENSITY

SPACE PLAN LEGEND

Total area Sqm -	1380 sqm approx.
Total Number of Staff -	95 Persons
Density -	14.5 sqm/person approx.
Workstations -	81
Meeting Rooms -	10
Reception/waiting -	1
Offices -	13
Utilities -	3
Kitchen -	2
Comms -	1

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Interior View

Structure Features

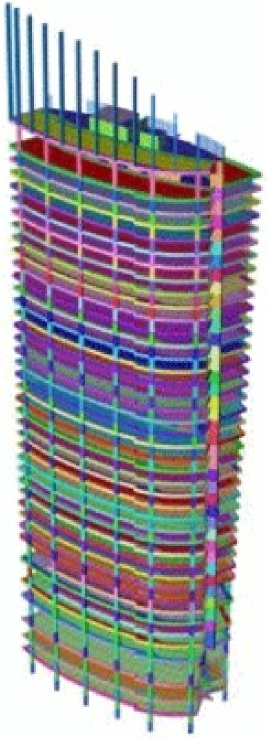
1. Structure Component
    1. Main Structure System
    2. Facade System
2. Connection Description
3. Materials

Structure Component

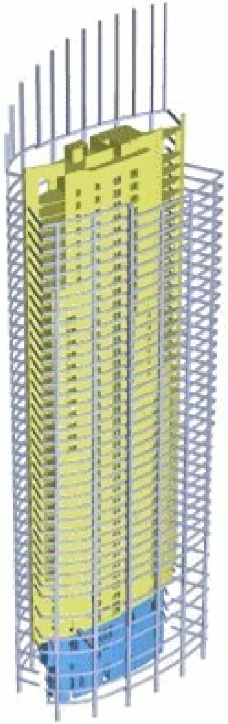
The structural elements of the commercial office tower can be considered as two basic components.

(1) The primary building frame

(2) The secondary structural facade support elements attached to the building frame



Floors and Columns



Internal Core

External Facade

Primary building system

The reinforced concrete core works integrally with the floor plates and columns to form a combined moment resisting frame.

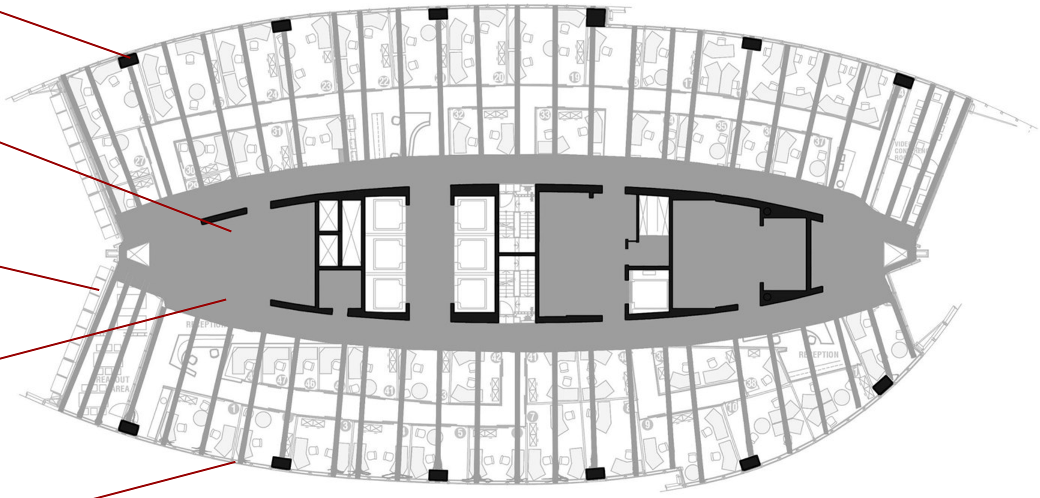
12 columns spaced at 10.8 meter centers

The core consists of shearing walls

band beams

320mm thickened slab section Reinforced Slab

Circumferential post-tensioned cables



High rise floor framing plan

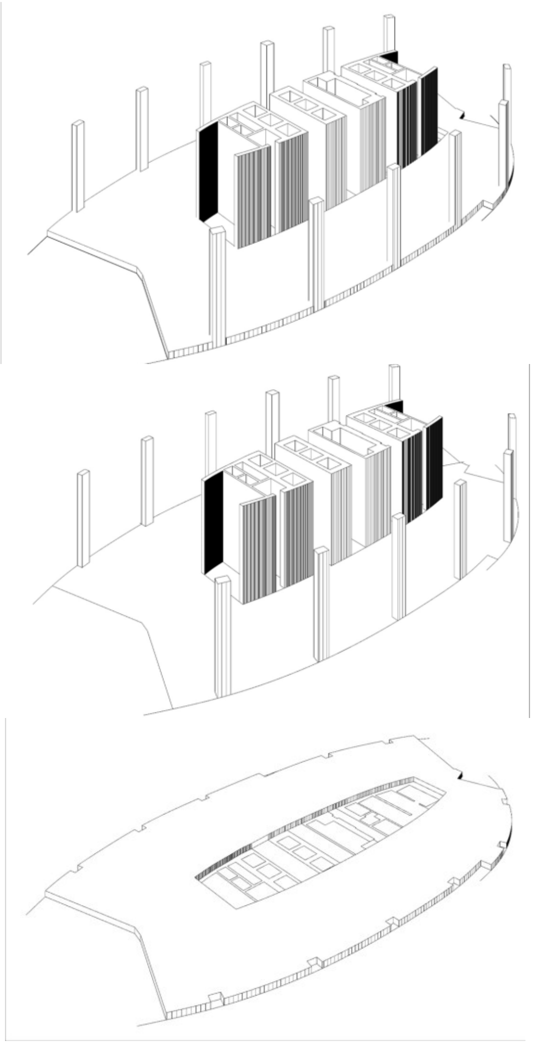
Primary building system

Core System

Dimension： 40m Length 9.5m width

The frame action of the core, slabs and tower columns contribute to the lateral stability of the building.

Slab around the core enhances the floor to core moment connection.



Facade System

The aluminium and glass curtain wall system spans from floor to floor and is supported by the edge beams with cast-in anchorage brackets.

The external layer of glass is chemically treated with a ceramic silk screen frit that helps to reduce the effects of direct solar heat gains and re-radiated heat gains.

The frit also modulates the transparency of the vision panels and hides the column and spandrel structures.

High-energy, maximum thermal performance and optimum visual comfort are achieved by using a moderately reflective glass and a low-E coating.

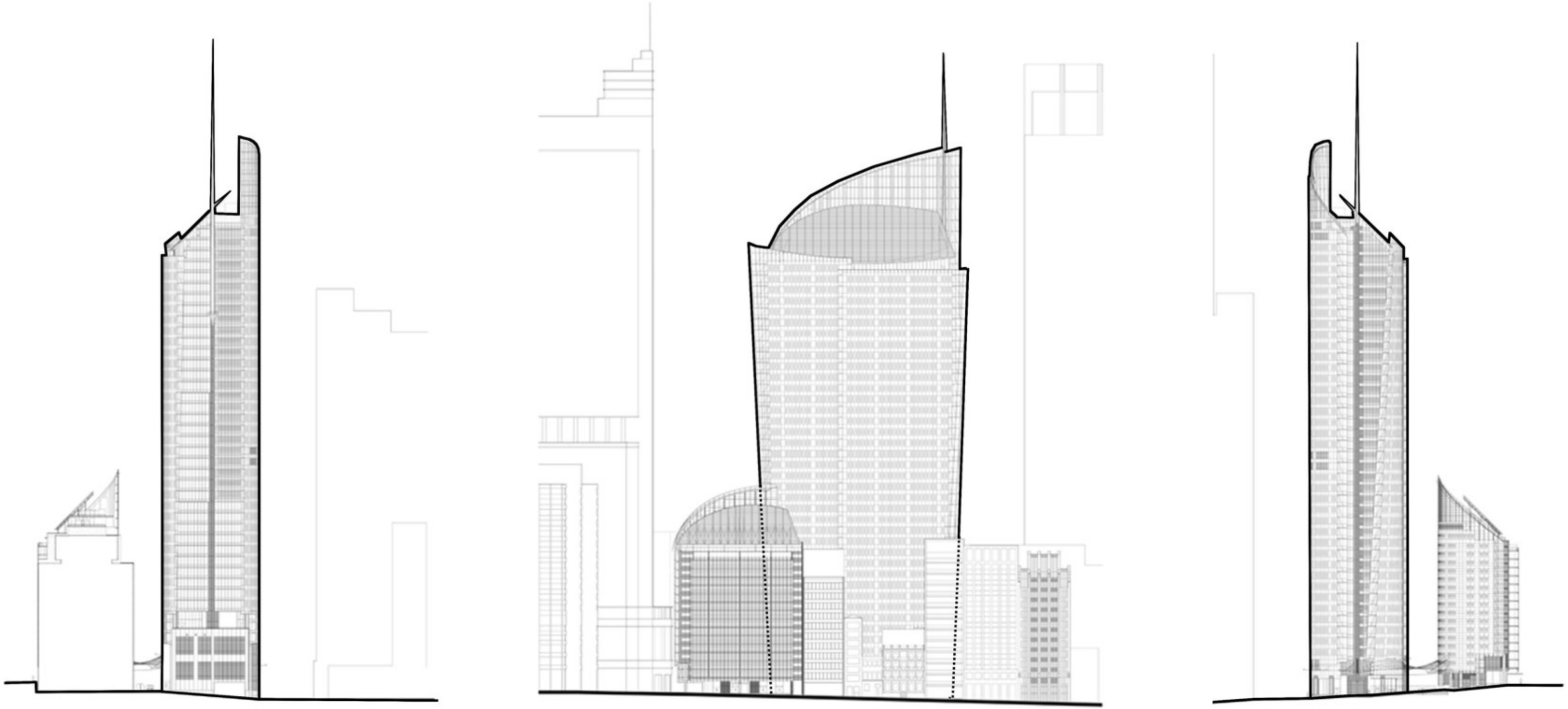
Facade System

Fins / Tusks / Sails / Mast

The fins are supported by cantilevered structural steel framing attached to the edge beams

The sail needles are laterally restrained by composite structural steel floor systems

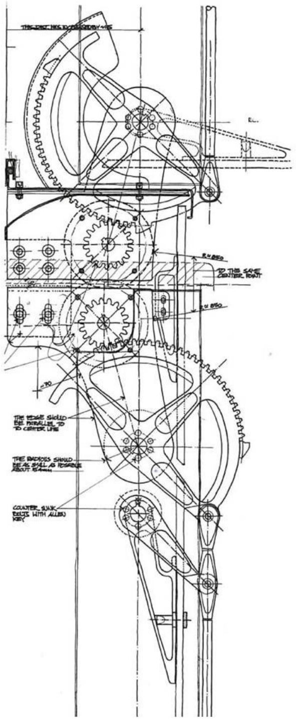
Facade System



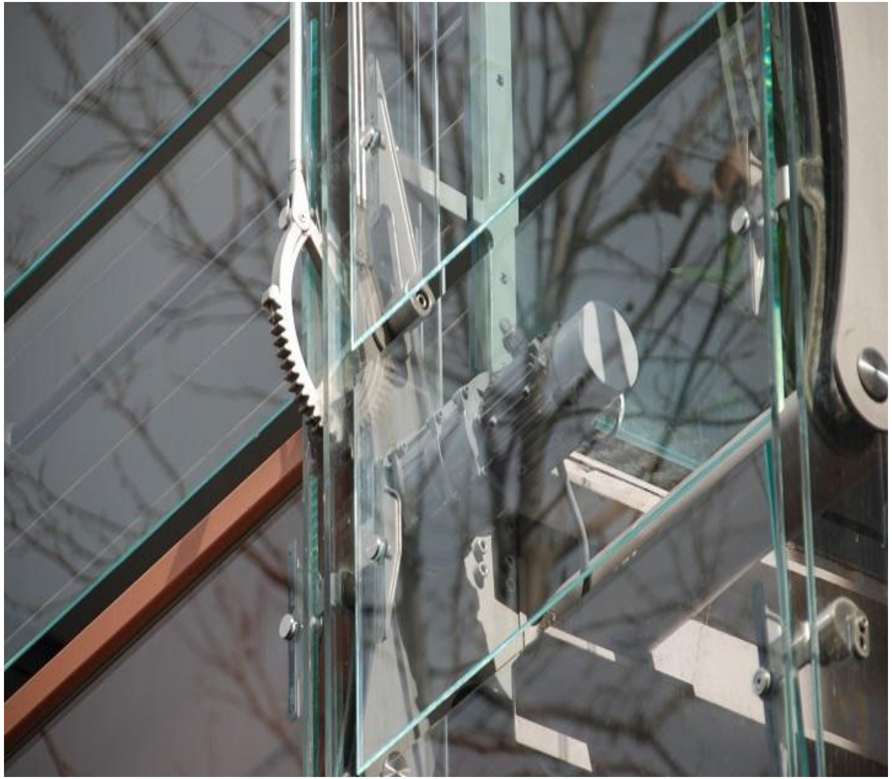
Connection Description

Detail mechanism of rotating glass louvers

The design brief was to create operable glass louvres supported within a glass mullion framework. The operating mechanism to rotate the louvres mullions was also incorporated within the glass mullion framework.



Connection Description



Materials

reinforced and post-tensioned concrete

steel

→ main structural system (shearing walls beams and columns)

aluminium

glass

(silicon)

→ glass curtain wall system

fins,tusks, sails and mast

glass canopy

Foundation System

1 The geological feature of the site

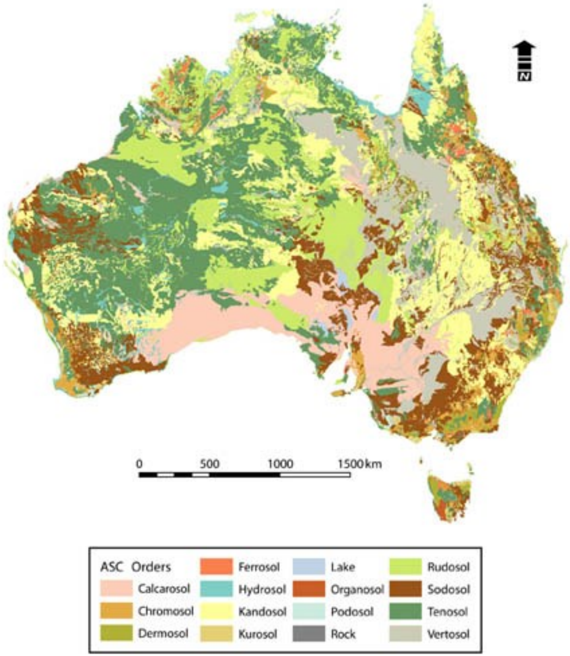
2 Foundation Design Analysis

3 The advantage of piled raft foundation

4 Other discussions on aseismatic measures in the foundation

The Geological Feature of The Site

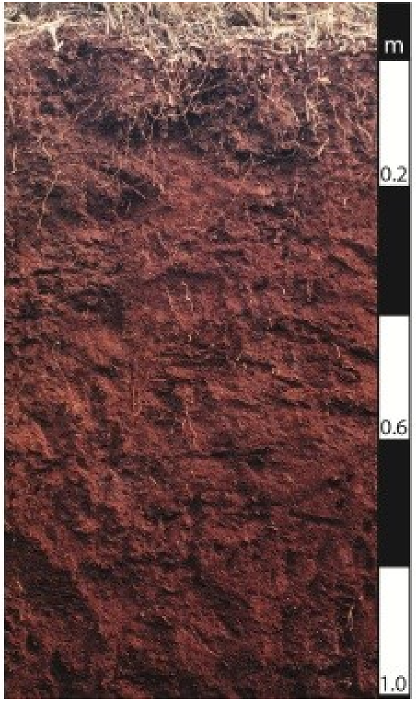
According to Australian Soil Classification mapping (Ashton and Mckenzie, 2001), the upper level soil of the site is Kandosols.



The Geological Feature of The Site

Kandosols have a sandy to loamy-surface soil, grading to porous sandy-clay subsoils with low fertility and poor water-holding capacity.

(https://www.qld.gov.au/environment/land/soil/soil-testing/types/)



The Geological Feature of The Site

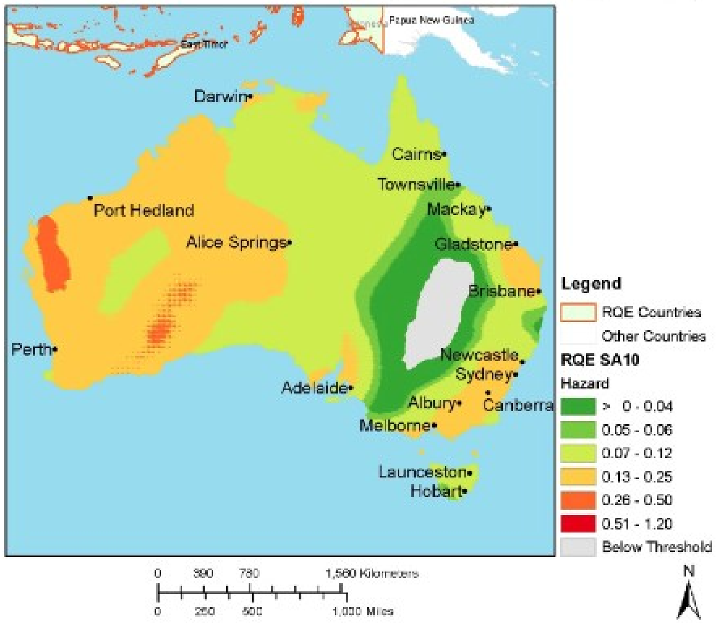
Bedrock has been found underneath the site. Six kilometres of sandstone and shale lie under Sydney.

Class2 and Class3 Sydney sandstone(Sydney Basin Hawkesbury Sandstone) are the bedrocks that the build found upon.

The Geological Feature of The Site

According to the 2500-Year Seismic Hazard Map of Mid-Period SA in Australia for Firm-Soil Site Conditions, Sydney is located at a seismically active zone, which is of 0.13-0.25g.

“Melbourne approaches 0.1 g for a return period of 1000 years, followed closely by Canberra, Perth and Sydney. ”



(http://www.nzsee.org.nz/db/2013/Paper_6.pdf),

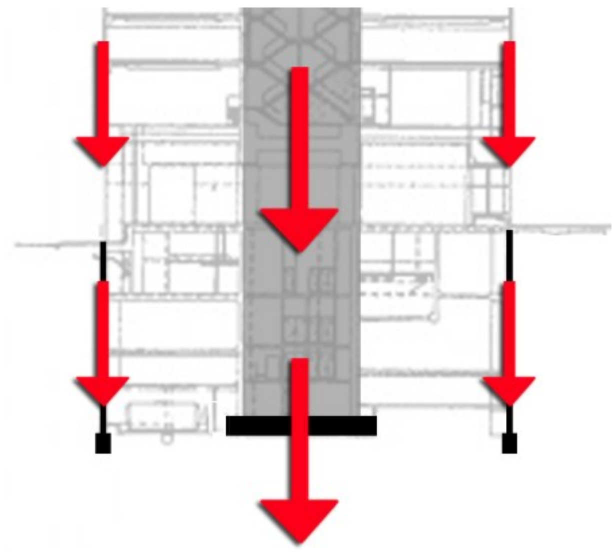
Foundation Design Analysis

1) The relationship between structure and foundation
2) The relationship between foundation and the geological features of the site
3) The Relationship Between Foundation and the Previous Building

The Relationship Between Structure and Foundation

“Maximum tower column working loads are in the order of 40,000 kN and are supported on **reinforced pad footings**.

The central core having a total working load in the order of 730,000 kN is supported on a 1.5 metre thick continuous core **raft** projecting 1.5 metres beyond the external perimeter wall lines.



(quoted from Rocco Bressi’s paper: Aurora Place Commercial Office Tower)

The Relationship Between Structure and Foundation

A concrete raft that is heavily reinforced is under the core of the building.

Construction of core raft

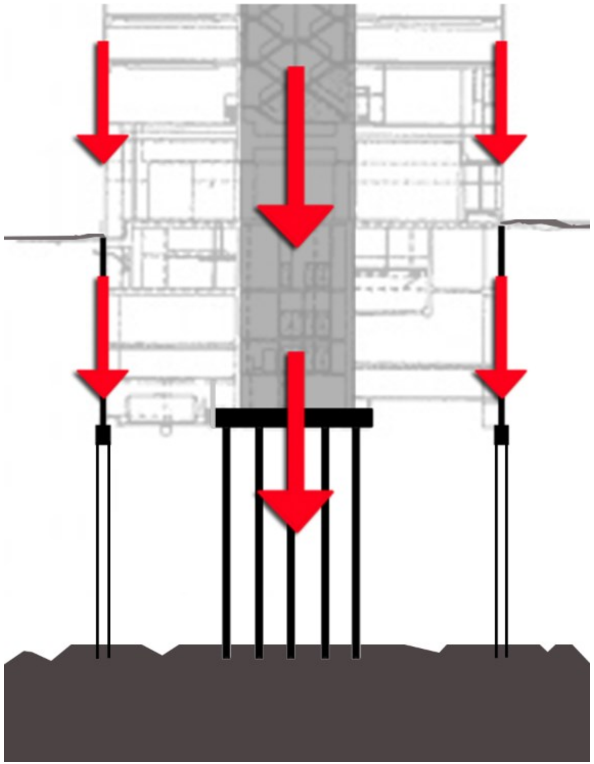
Axial core stresses (raft interface)

The Relationship Between the Geological Features of the Site and Foundation

10 piles below the raft extend to reach the bedrock layer.

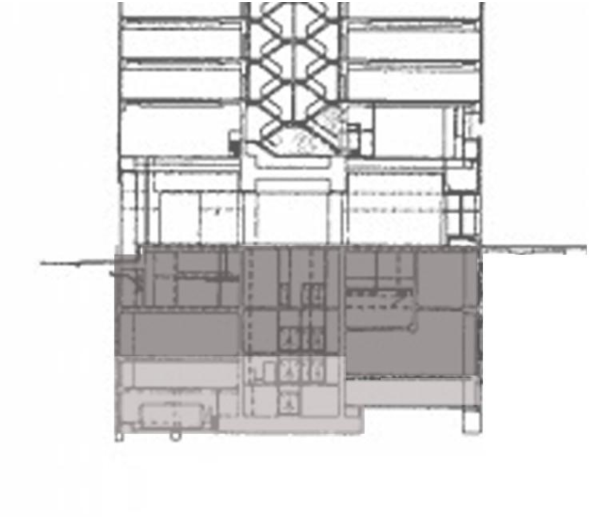
"Founded onto Class II and III sandstone, the design bearing pressures vary between 3.0 MPa to 6.0 MPa as recommended by the geotechnical investigation work carried out by Coffey Partners International Pty Ltd. "

(quoted from Rocco Bressi's paper: Aurora Place Commercial Office Tower)



The Relationship Between Foundation and the Previous Building

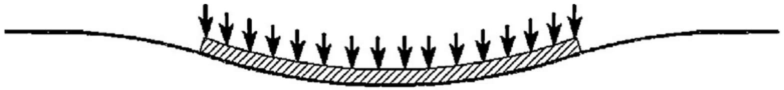
A two-three levels basement of the state office was retained and underpinned. Two additional levels of basement was added underneath. 98% materials of de-building were recycled.



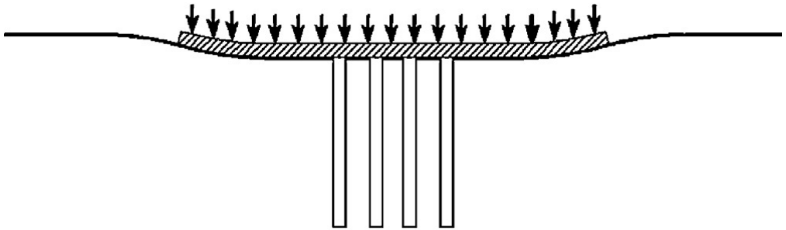
The Advantage of Piled Raft Foundation

A piled raft foundation is a combination of raft and piles, so it has the advantages of both.

The raft and pile can work together to avoid differential settlement.



(a) Unpiled raft.



(b) Raft plus settlement reducing piles.

https://www.ut.edu.sa/ar/web/u54708

Other Discussions on Aseismatic Measures in the Foundation

The 1.5meters-thick raft, the structure system of the basement, the column pad footings, and the piles may have ductile reinforcing steel in it so that damping action is achieved.

In general, except the strength of structural elements should meet the requirement of National Construction Code of Australia, ductility of structural members should be achieved in order to cope with earthquake inertial forces.

Loading Analysis

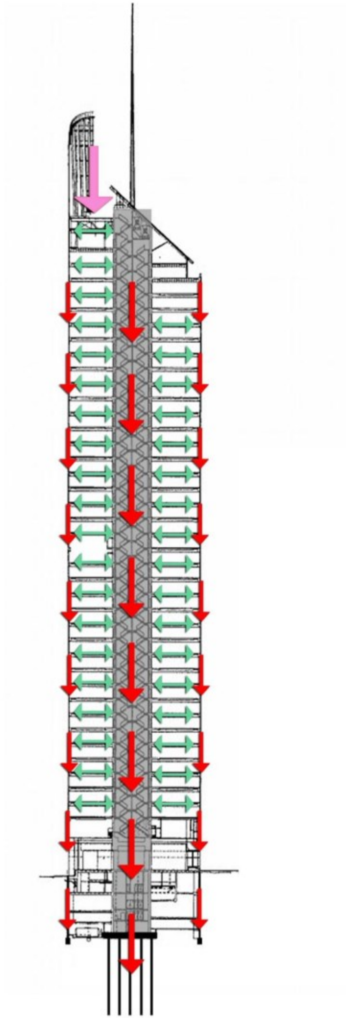
1. Vertical Loading Analysis
2. Core Jump Form System Construction
3. Lateral Loading Analysis

Vertical load analysis

The vertical loads are distributed on each floor.

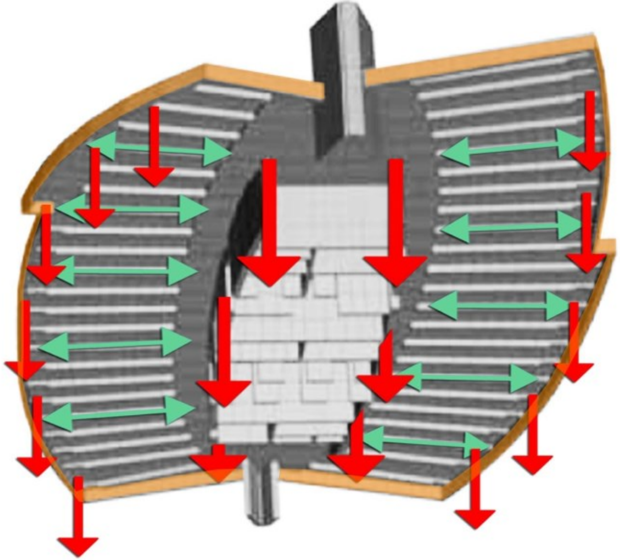
Loads travel through the steel beam (the thickened slab section) out to the core and the perimeter columns.

The shearing walls of the core and the columns transfer the loads to the foundation.



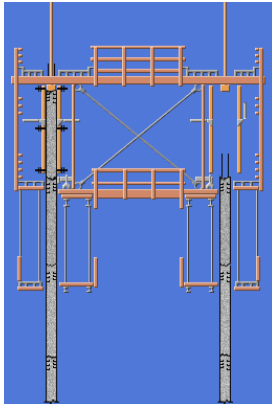
Vertical load analysis

Typical floors loads:
Live loads:
3.0 kPa = 63 psf
Dead loads:
Concrete $1.6x10^8$ lbs
Steel   7200 tons = $1.6x10^7$ lbs
Glass $4.48x10^6$ lbs
Partitions   1.0 kPa = 21 psf
Services and ceilings   0.5 kPa = 10 psf
Raised computer floors 0.6 kPa = 63 psf

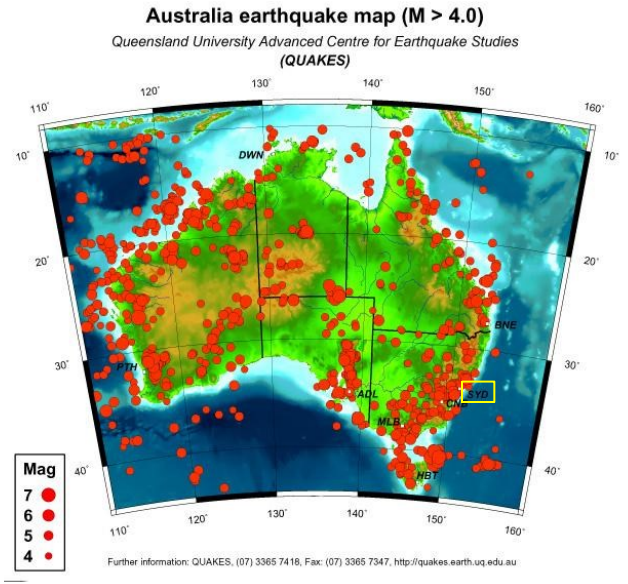


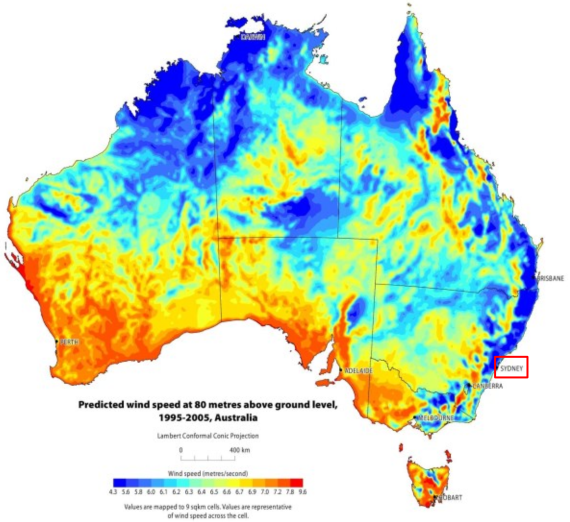
Core Jump Form System Construction

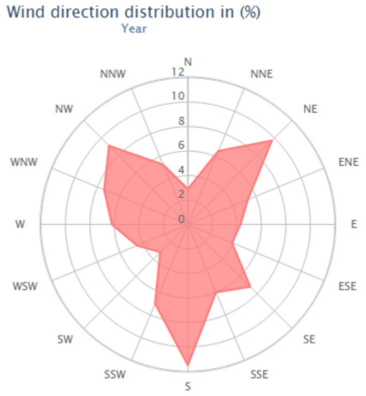
A frame is constructed from structural steel members over the central core. Steel formwork panels are hung from this frame, some supported on rollers. After the concrete walls are poured, the formwork is released and rolled back from the concrete face. Jacks then lift or climb the whole frame up one level. All the formwork panels are attached to the frame. This process takes approximately one and a half hours.



Lateral Loads







As mentioned before, Sydney is located at a seismically active zone and windy area, lateral load resisting system is critical.

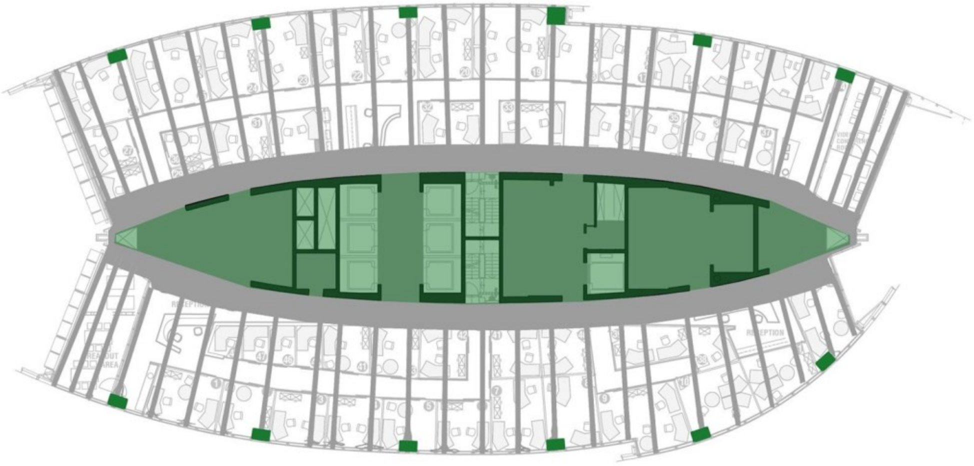
Lateral Loads Resisting System

The lateral resisting system is comprised of:

1. exterior 12 columns
2. an interior reinforced concrete core
3. band beams

4. rigid joint of columns, beams and the core

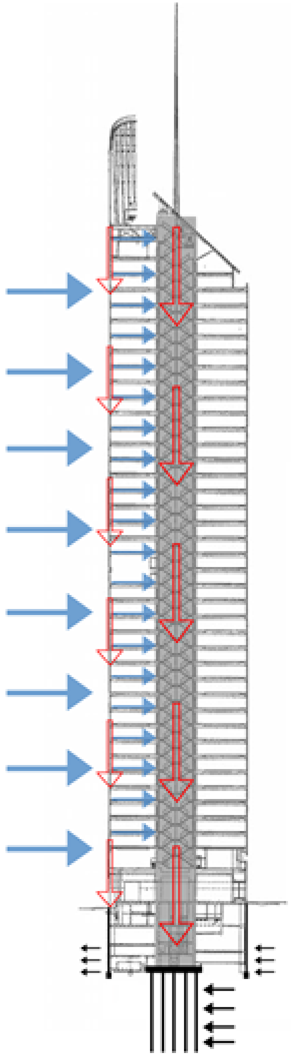
5. 320mm thickened reinforced slab around core



Lateral Loads Transfer Path

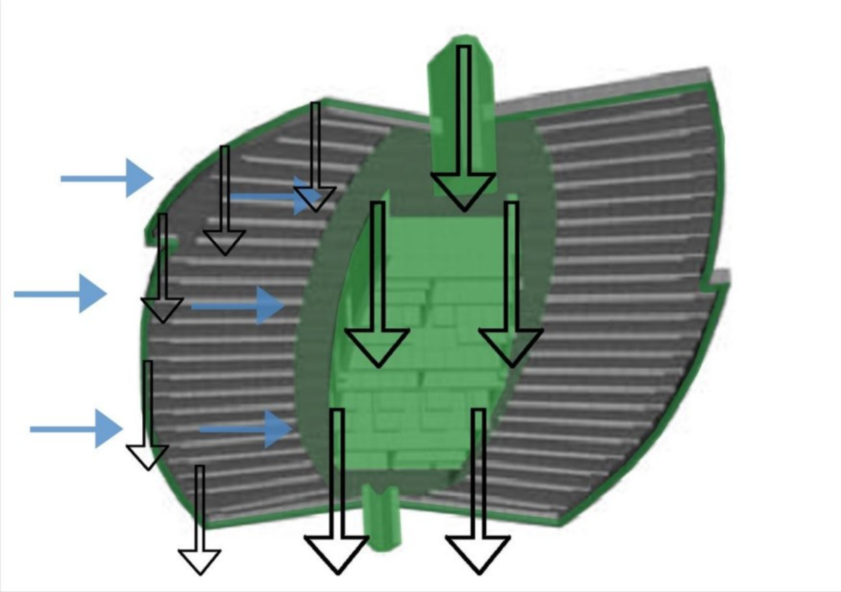
Structure components	Lateral force
The core	70%
The slabs & columns	30%

Wind loads reach the surface of the building. 30% of lateral force is transferred to the outside columns then to the foundation. 70% of the lateral force is transferred by floor slabs to the core, then taken by the piled-raft foundation.



Lateral Loads Transfer Path

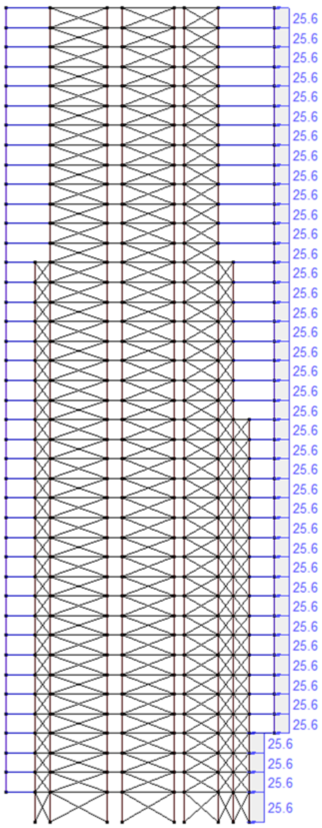
The frame action of columns, beam and core contribute to the lateral stability. The floor and slab around the core strengthen the stiffness of whole systems.

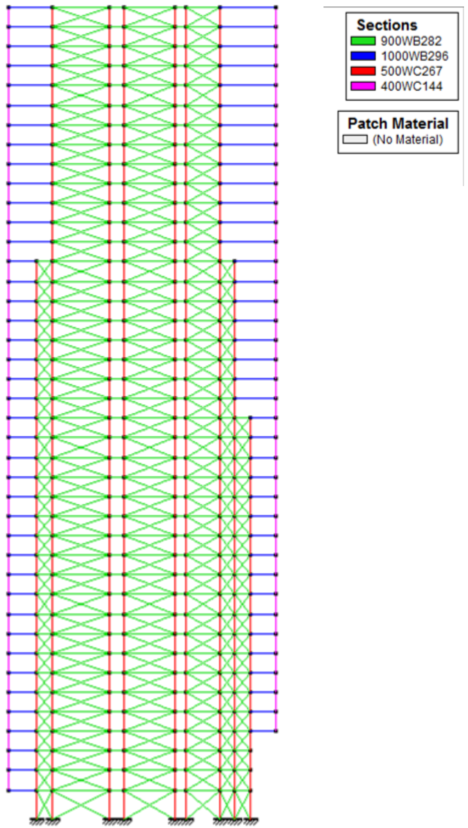


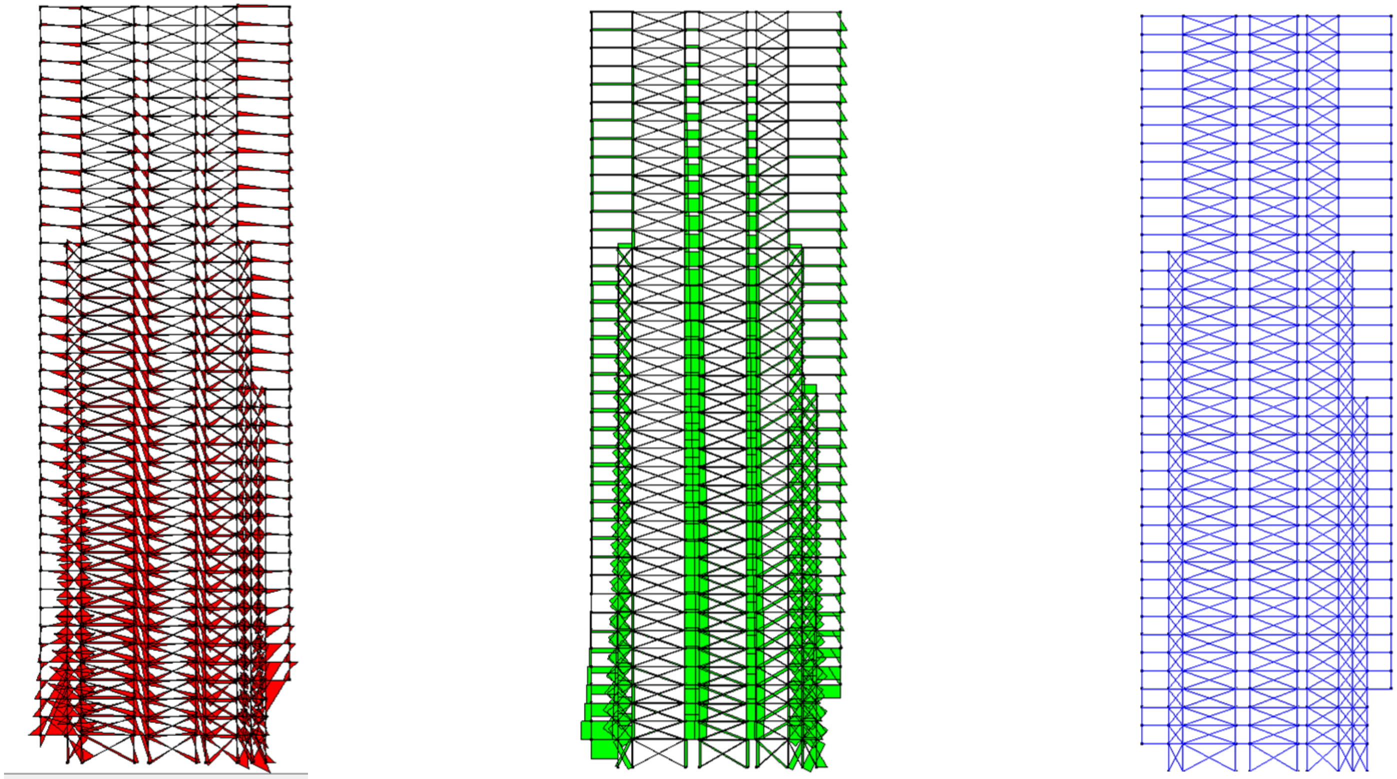
Wind load in south direction

= Pressure caused by maximum wind speed x length of the south side

= 36.9 psf x 511.15 ft= 18861.435 lb/ft (25.6 kN/m)





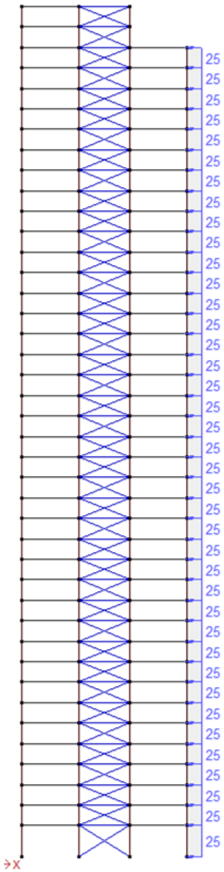


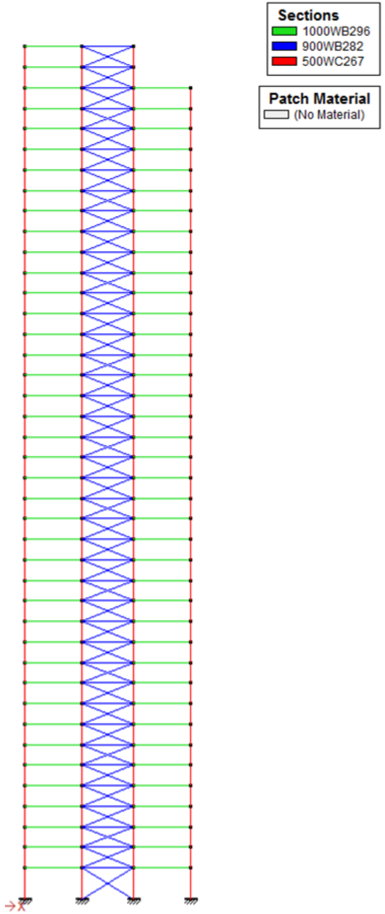
From left to right, the force in the beam changed from compression to tension. Piled-raft foundation must transfer the horizontal force to the surrounding soil， the building tend to lift up on the left and the largest deflection appears at the top of the building

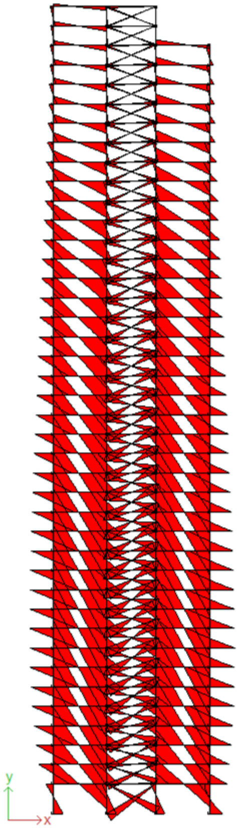
Wind load in west direction

= Pressure caused by maximum wind speed x length of the west side

= 36.9 psf x 511.15 ft= 18861.435 lb/ft (25.6 kN/m)



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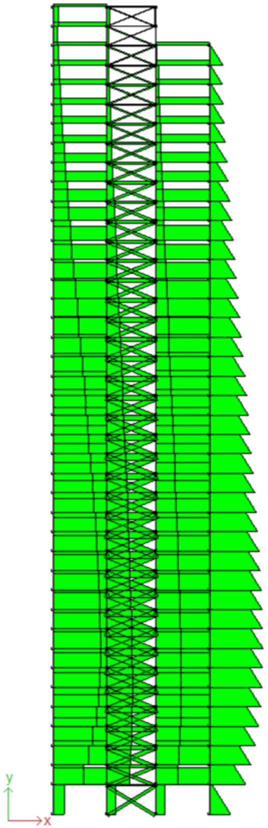
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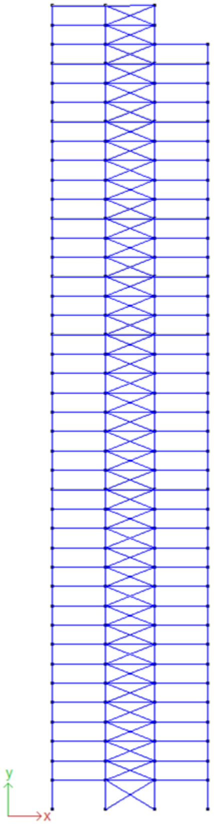
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Building Live Load

= Designed live load capacity per square foot = 63 psf

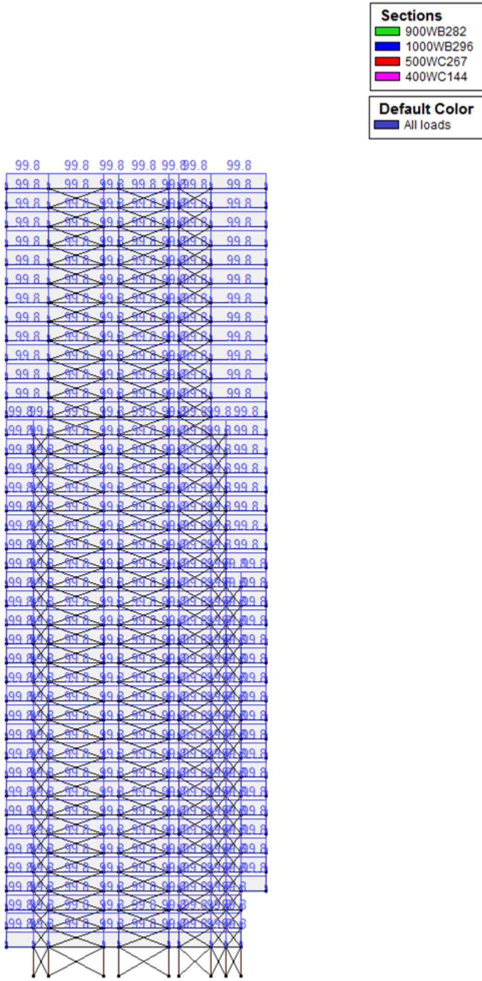
Total Dead Load

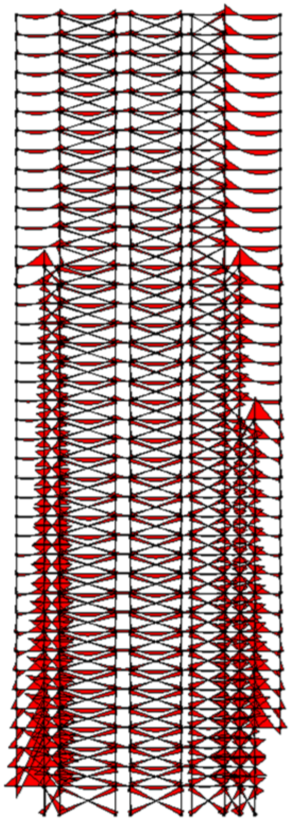
= (Glass Load + Steel Load + Concrete Load + Partitions Load + Services & Ceilings Load) /Total leasable area

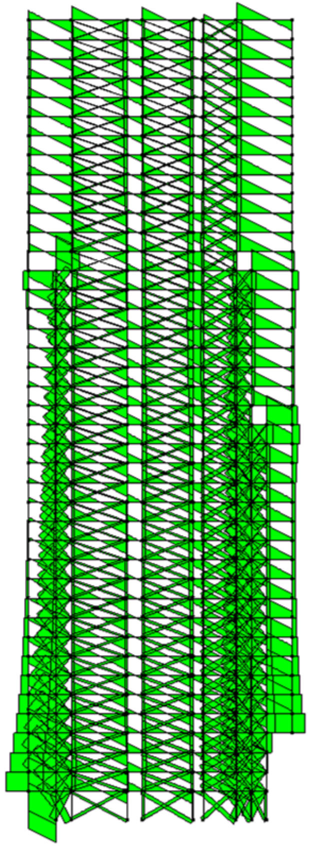
= (4.162×10^6 lbs + 15.873×10^6 lbs + 11.08×10^6 lbs + 5.27×10^6 lbs)/448,317 sf = 81.1 psf

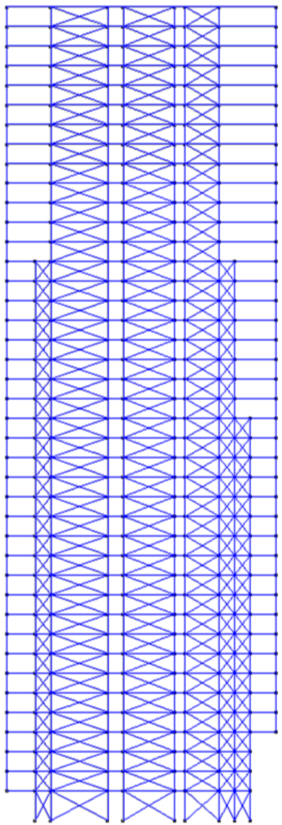
Total Load = 63 psf + 81.1 psf =144.1 psf

144.1 psf x 511.15 ft= 73656 lb/ft (99.8 kN/m)



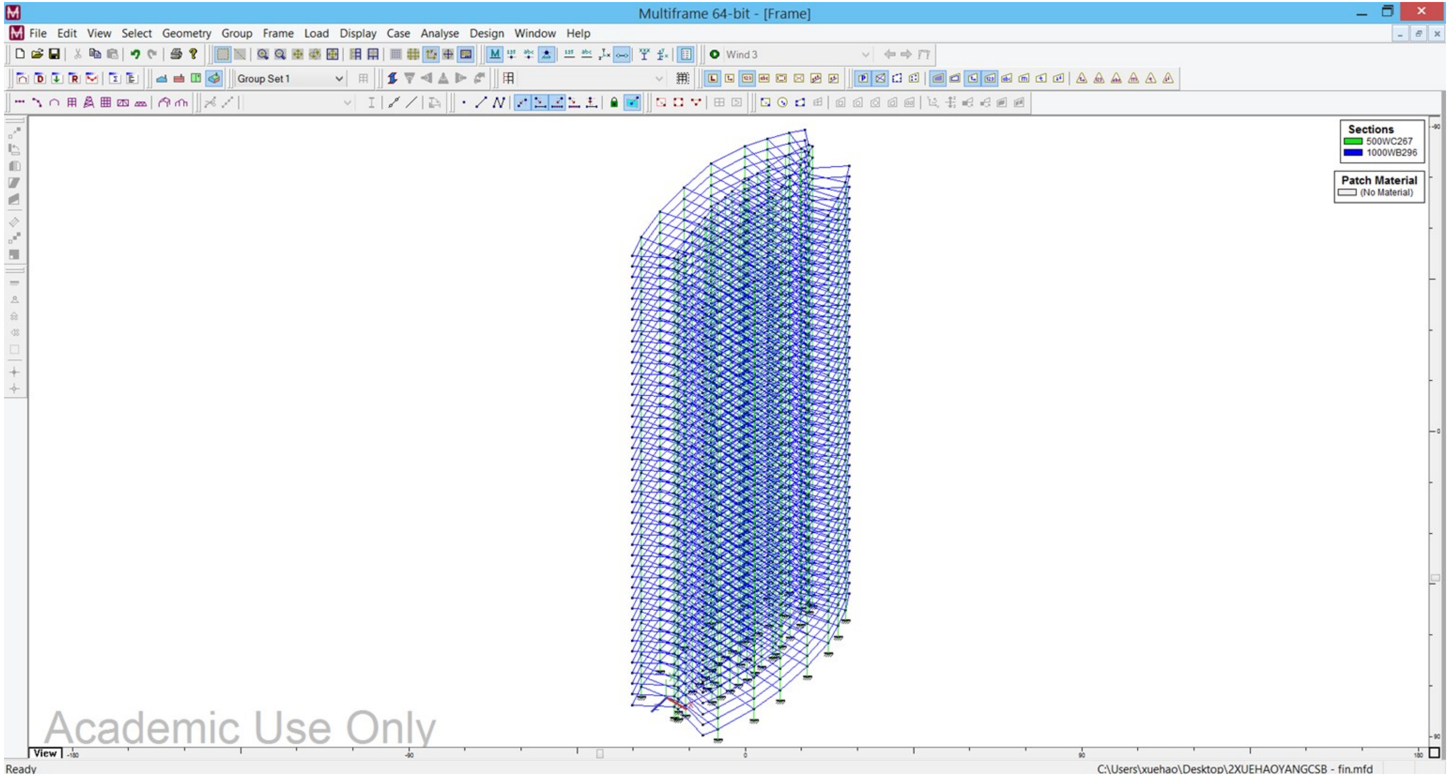






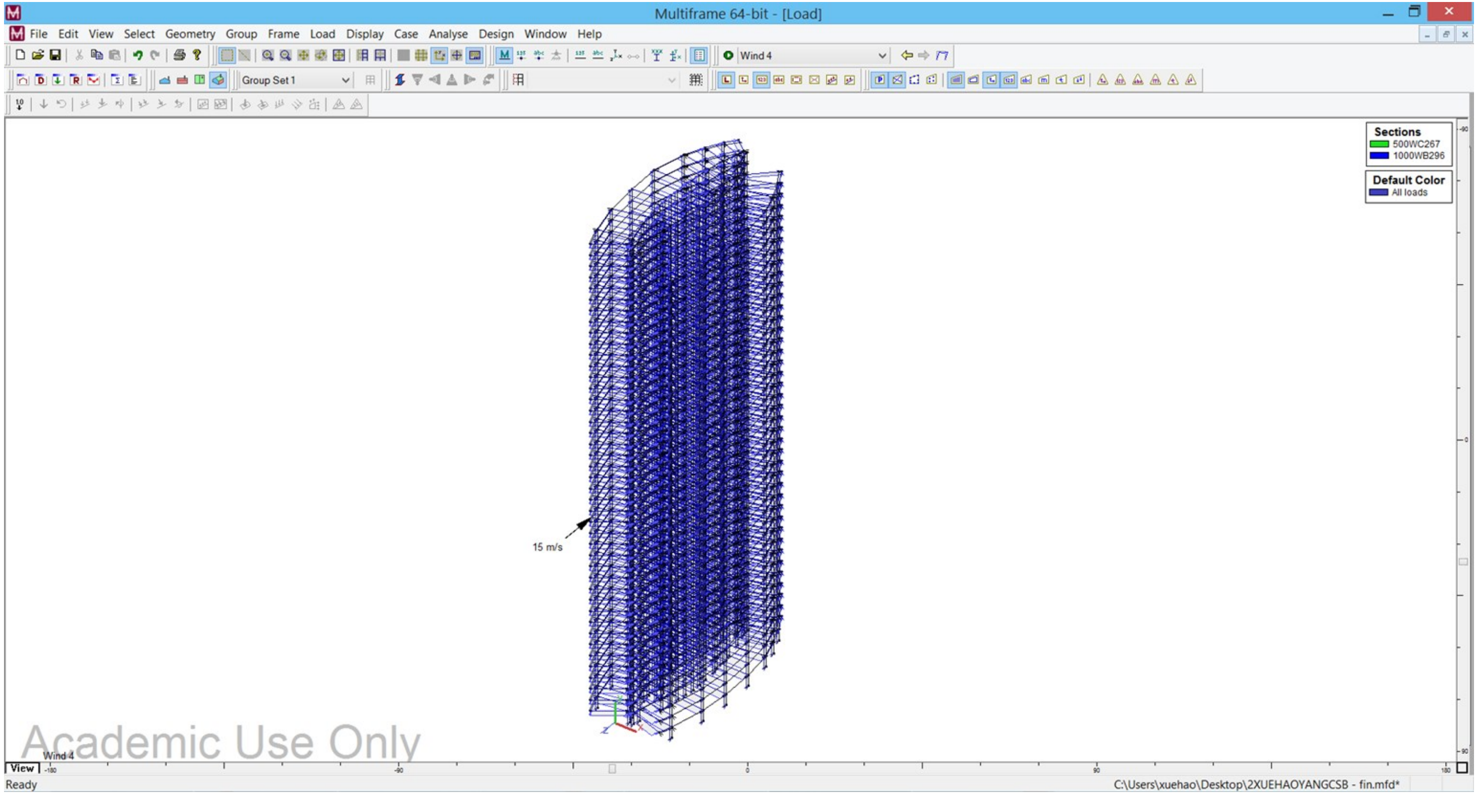
The largest bending moment and shear appears at the cantilevered beam from the core in the bottom, the largest deflection appear at the cantilevered beam in the top floor.

Multiframe Analysis



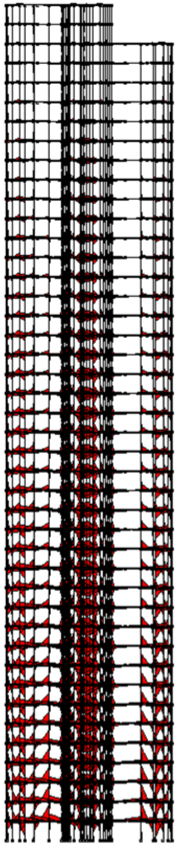
Multiframe 3D Model

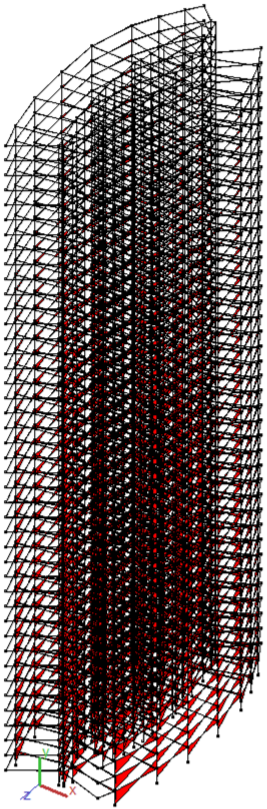
Multiframe Analysis (wind load)

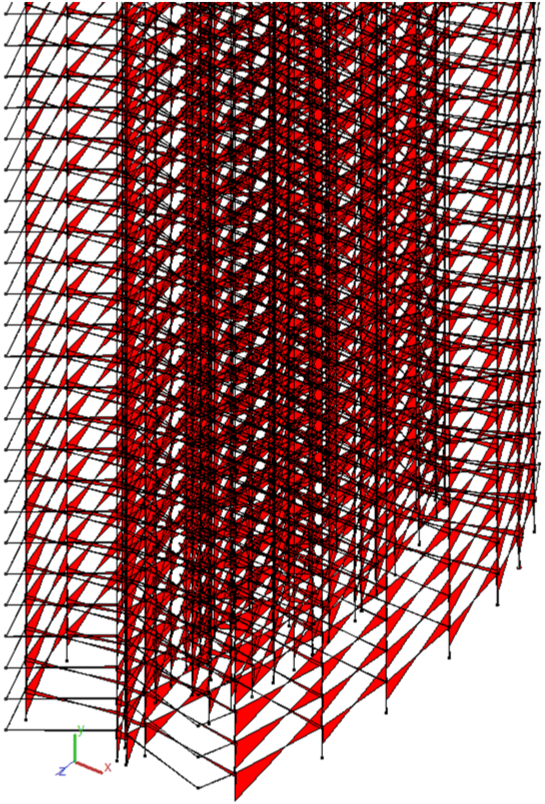


Wind velocity of 15m/s from south direction

Multiframe Analysis (wind load)

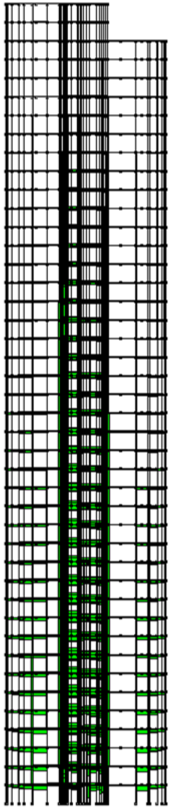


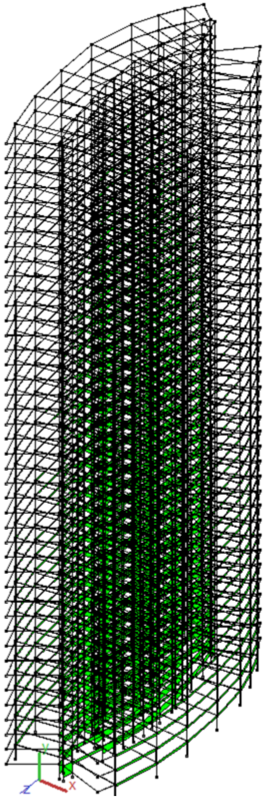


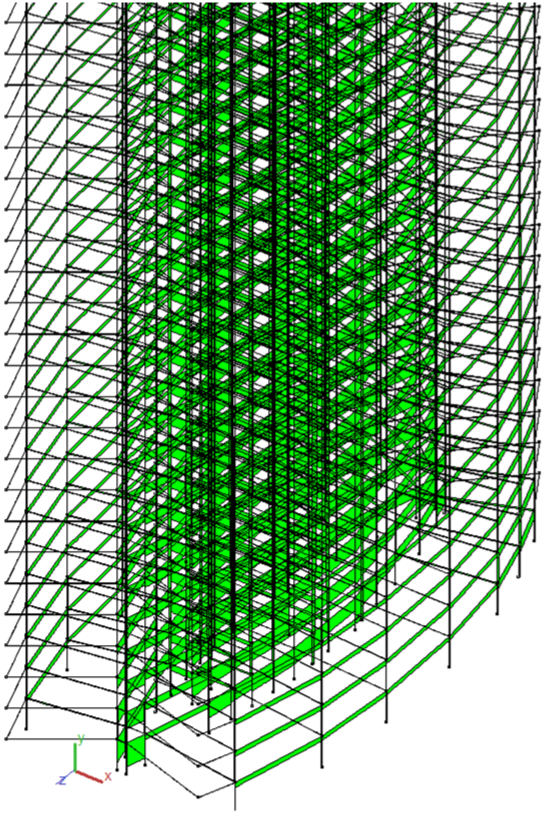


Mz

Multiframe Analysis (wind load)

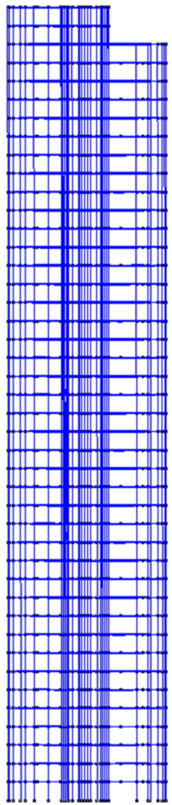


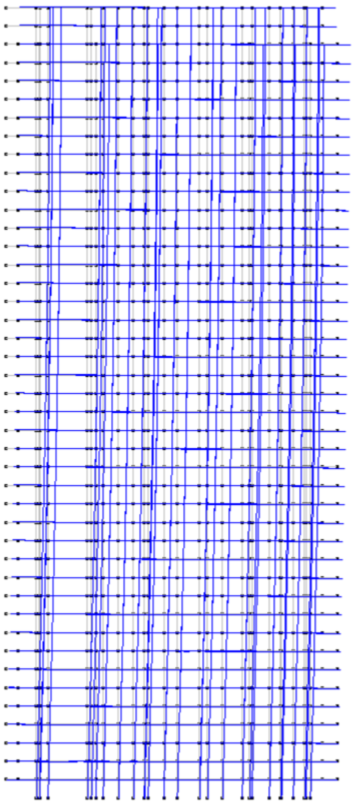


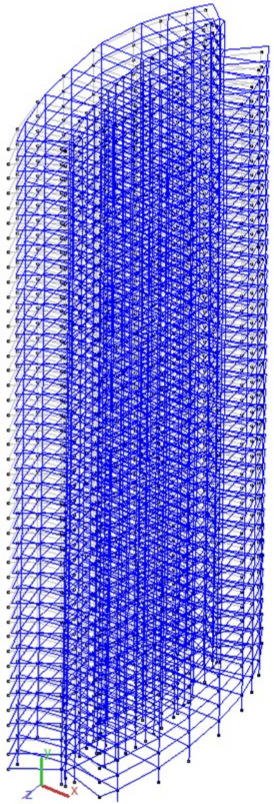


V_y

Multiframe Analysis (wind load)







Deflection

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THANKS!