fib Bulletin 101:

Precast Concrete in Tall Buildings

An Introduction

by

George Jones
C.Eng., MICE, MIEI
Member of *fib* Commission 6, Convener of TG6.7

State-of-the-art Report

fib Bulletin 101: Precast Concrete in Tall Buildings-An Introduction

In collaboration with, and also published by PCI

fib Bulletin 101: Precast Concrete in Tall Buildings

<u>Background:</u>

Due to the current popularity of tall buildings several references have been written on their design in both steelwork and structural concrete, including *fib* Bulletin 73 *“Tall Buildings”,* published in 2014.

fib Commission 6 felt that a reference specifically for precast concrete in tall buildings was overdue.

fib Bulletin 101: Precast Concrete in Tall Buildings

Background:

2014: Task Group 6.7 formed from Commission 6 members- 32 TG members from 16 countries.

Aim: To bring together in a single document an up to date reference for the modern applications of precast concrete in tall building construction.

2019: Finalised draft available.

2021: Approved by both *fib* and PCI, and published.

fib Bulletin 101: Precast Concrete in Tall Buildings

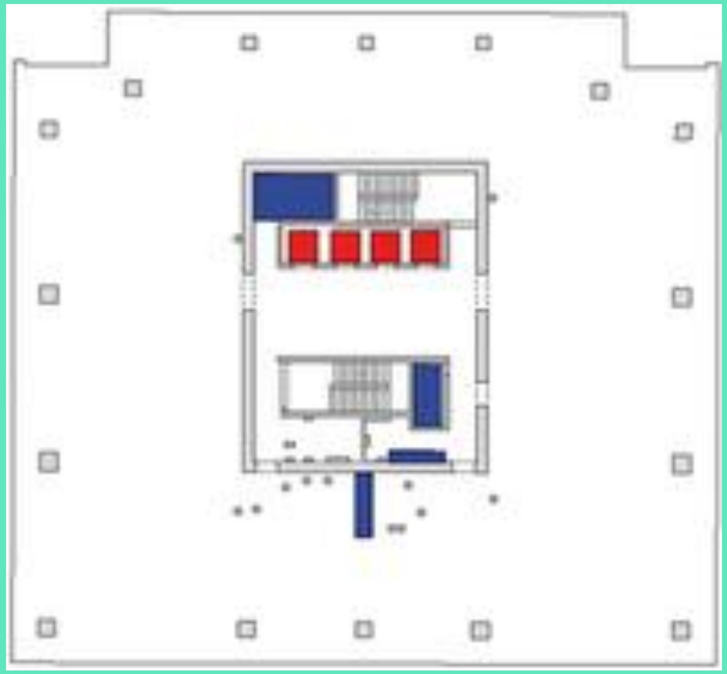
Bulletin divided into four parts:

- **Chapters 1 to 4:** How benefits can be achieved with precast concrete and how it can be integrated into any building.
- **Chapters 5 to 8:** Covers the individual “building blocks” in precast concrete-floors, columns, walls and stairs. Particular attention paid to design and detailing and production methodology.
- **Chapters 9, 10 and 11:** Areas of specific interest-building facades, precast in seismic zones and construction.
- **Chapter 12:** Case studies illustrating the applications and benefits previously described. There are 15 case studies with examples from Europe, North and South America, Australia, Japan, the Middle East and China.

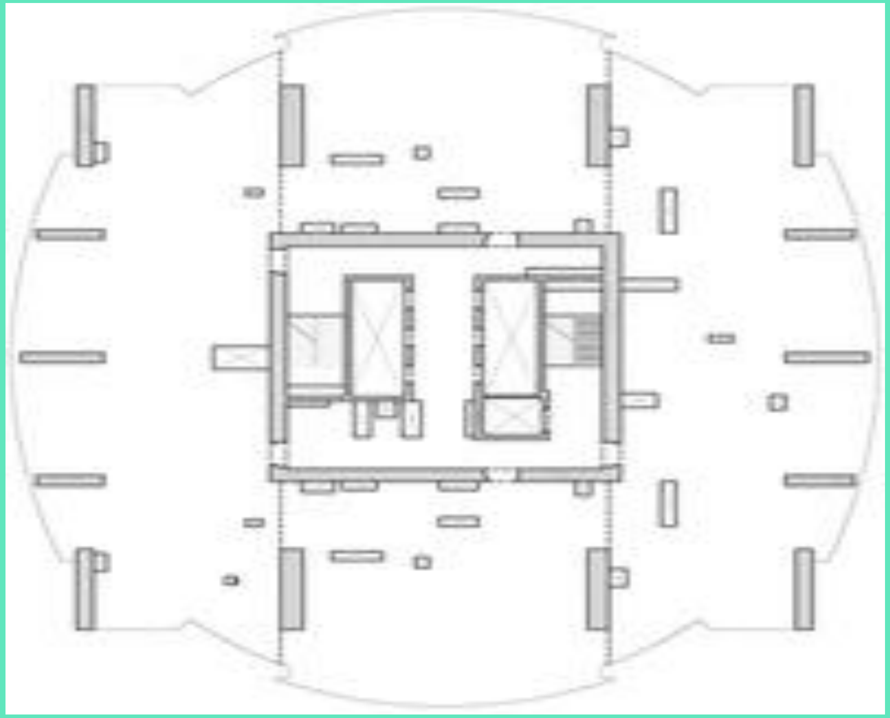
Characteristics of Tall Buildings-Chapter 1

- Small footprint due to high land values and restricted space
- Repetitive layout above lower levels
- Increase in the relative magnitude of lateral loading compared to vertical gravity loads
- Importance of vertical service cores: Structural stability and fire escape

Characteristics of Tall Buildings-Examples of small footprint, repetitive arrangement and service cores.



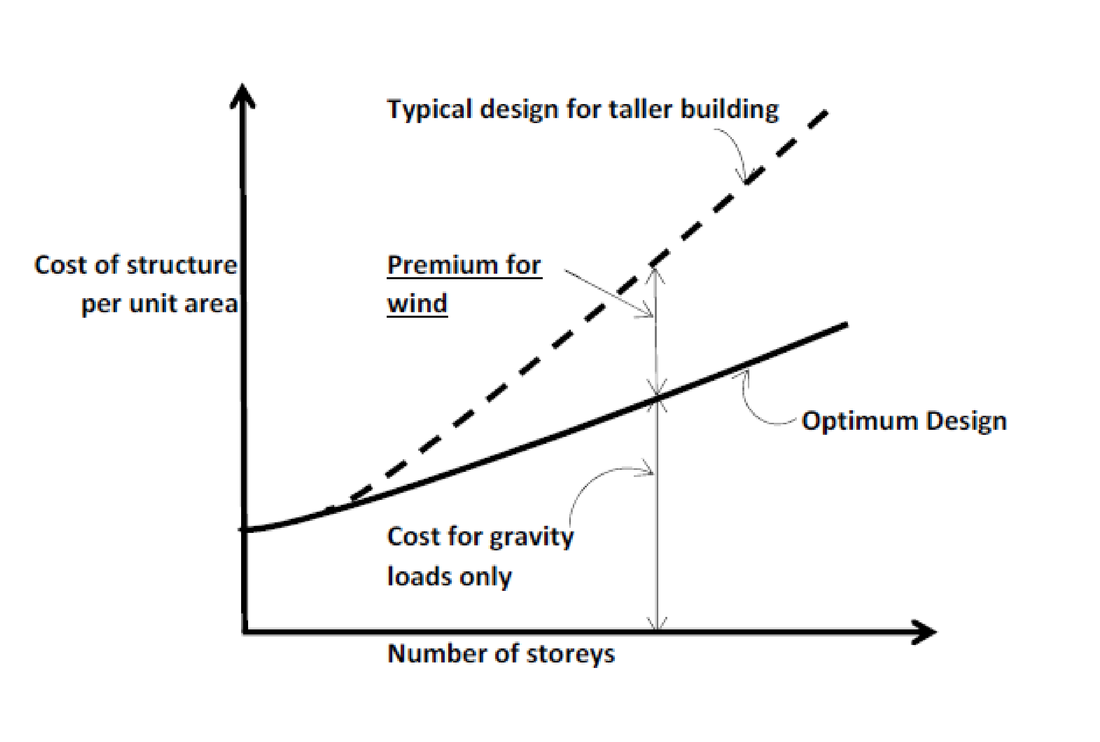
Open Plan Office Layout with Edge Columns



Residential Layout with Dividing Walls used as Part of the Structure

Characteristics of Tall Buildings-Cost Premium due to "Tallness"

The engineer's challenge is to develop efficient and innovative structural systems that minimise the cost premium arising through "tallness" but also satisfy the building's performance requirements (e.g. overall drift, inter storey drift and dynamic response).



There is a cost premium for the structure from wind and other lateral forces due to "tallness"

Characteristics of Tall Buildings-Essential Components

- ➢Cores, including stairs and landings
- ➢Floors
- ➢Other vertical components: Columns and walls
- ➢Façade

All these components can be provided in precast concrete

A solution can be delivered where the structural frame is part of the functional building, i.e. its walls, floors and facade, without the need for a separate structural frame.

Benefits of Precast Concrete in Tall Buildings-Chapter 2

<u>The Benefits of Concrete:</u>

- ➢High quality and low maintenance
- ➢Fire resistance
- ➢Strength
- ➢Temperature control and insulation
- ➢Acoustic separation
- ➢Durability
- ➢Visual flexibility
- ➢Sustainability

Benefits of Precast Concrete in Tall Buildings

Extra Benefits through Use of Precast Concrete in Tall Buildings:

- Reduction in floor cycle time (Time taken to construct single floor and supporting vertical elements).
- Increased time certainty and improved completion dates
- Less congestion at jobsite, fewer people and materials
- Budget certainty and value for money: Not generally affected by site based risks.
- Quality certainty as elements produced in advance of construction.
- Providing complex components, often in relatively inaccessible locations

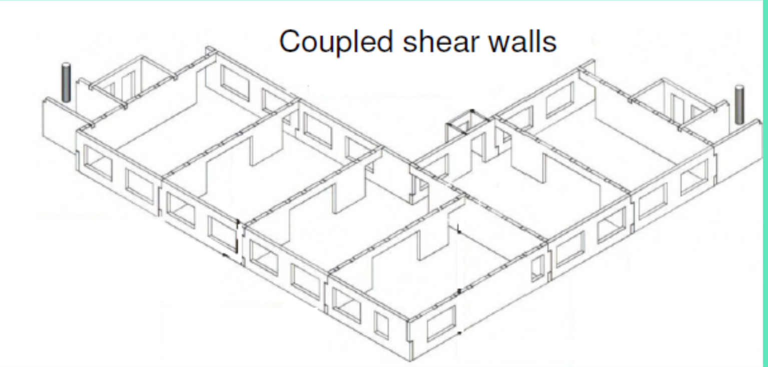
Integration of Precast Concrete into Mixed Construction-Chapter 3

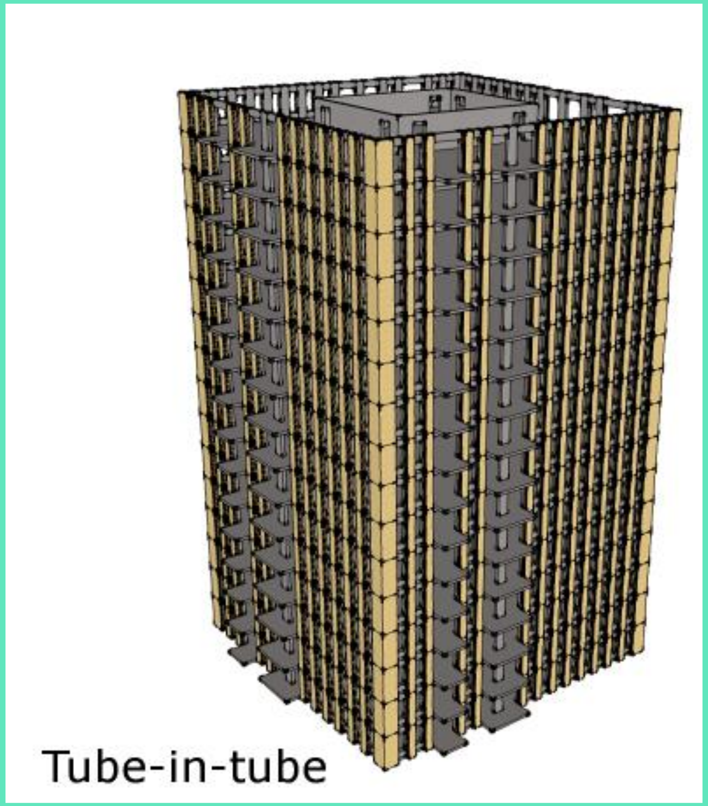
<u>Possible Combinations:</u>

- Slipformed cores with precast concrete stairs and landings
- Insitu cores with precast concrete columns, beams and slabs
- Precast columns and walls with insitu concrete floors
- Precast cores with insitu concrete floors
- Composite precast and insitu concrete floors
- Precast floor slabs with steel beams
- Insitu concrete or steel frames with precast concrete facades
- Precast concrete balconies with insitu and composite floors

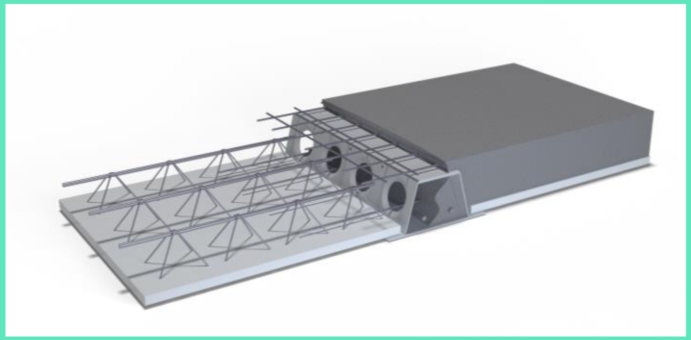
Precast Concrete Structural Systems-Chapter 4

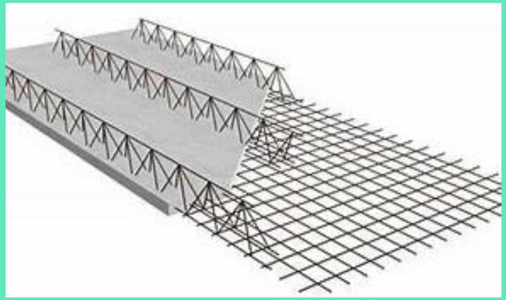
- Frame Systems
- Shear Wall Systems
- Tube Systems

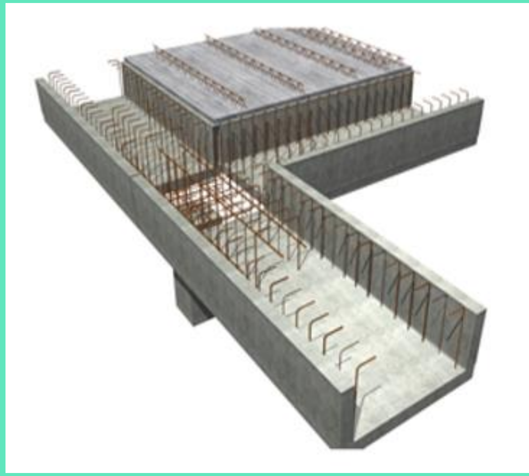


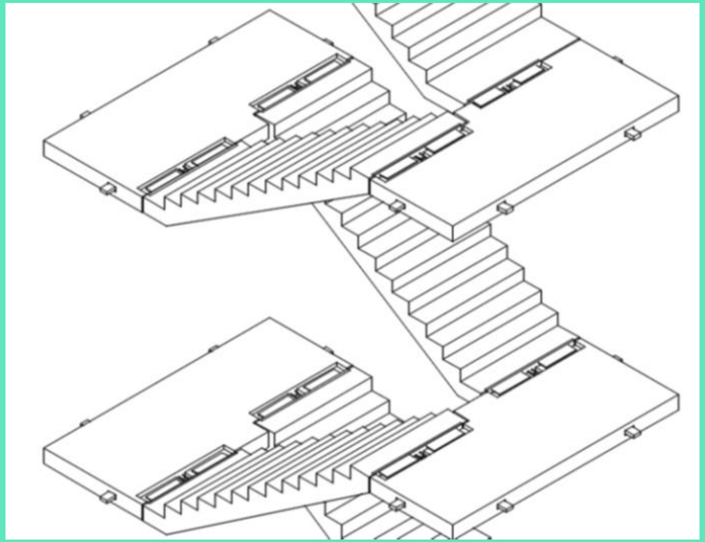


“The Building Blocks”-Chapters 5 to 8



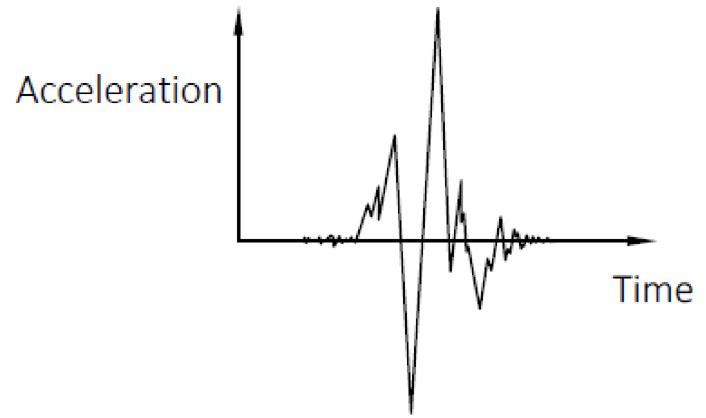






Special Topics-
Chapters 9, 10 and 11

- Facades and Cladding
- Precast in Seismic Zones
- Construction



Time history plot of earthquake

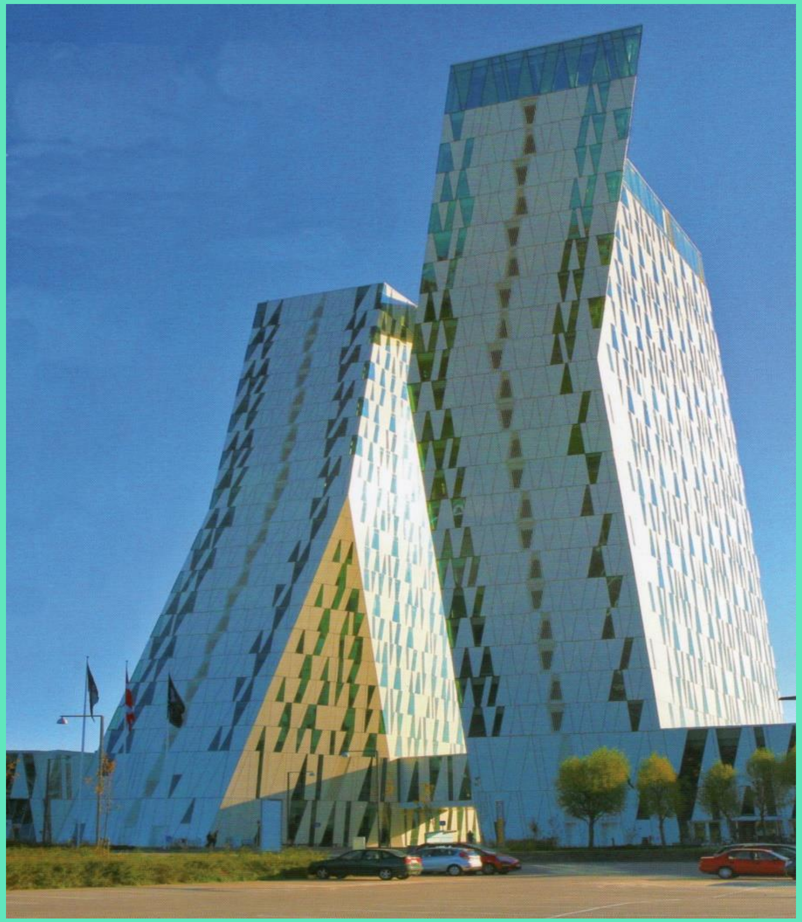
Double shaft segments with horizontal jointing only

External cladding covering the structural frame at The Carlyle, Los Angeles, USA

Case Studies-Chapter 12

Full Precast Frame: 76m tall

Bella Sky Hotel, Copenhagen, Denmark



Winner of *fib* award for Outstanding Concrete Structures, 2014

Case Studies-Chapter 12

Full Precast Frame: 165m tall

Breaker Tower, Bahrain

Case Studies-Chapter 12

Full Precast Frame: 120m tall

Erasmus Medical Centre, The Netherlands

Climbing shed allowed installation of all precast elements without tower cranes.

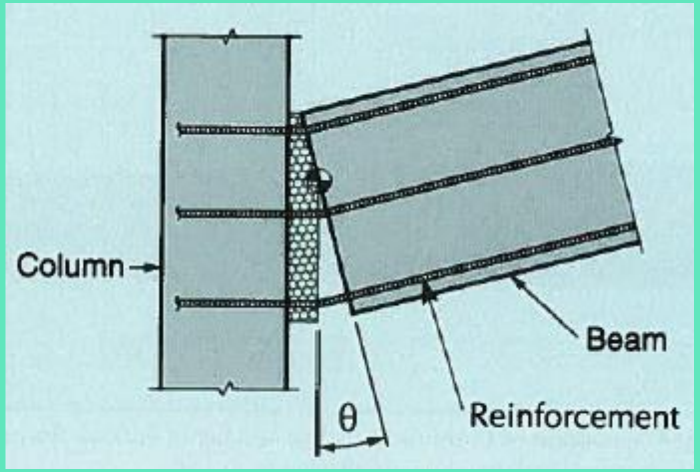
Case Studies-Chapter 12

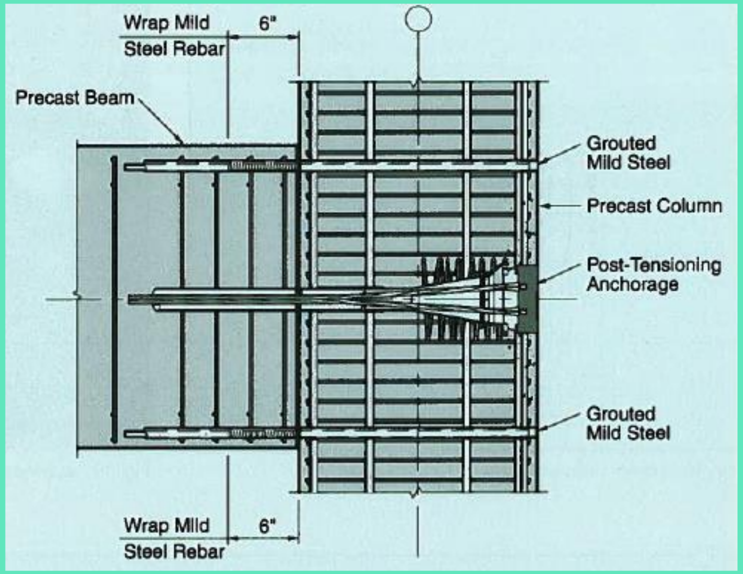
Seismic Resistant Precast Frames: 180m tall Urban Dock Park City and Deux Tours, Japan

- Buildings designed and constructed using *Sumitomo Mitsui Quick RC Integration Method (SQRIM).*
- All frame elements utilised to resist seismic loads.
- Over 24,000 precast elements in each building.

Case Studies-Chapter 12

Seismic Resistant Precast Frame: 128m tall
The Paramount, San Francisco, USA

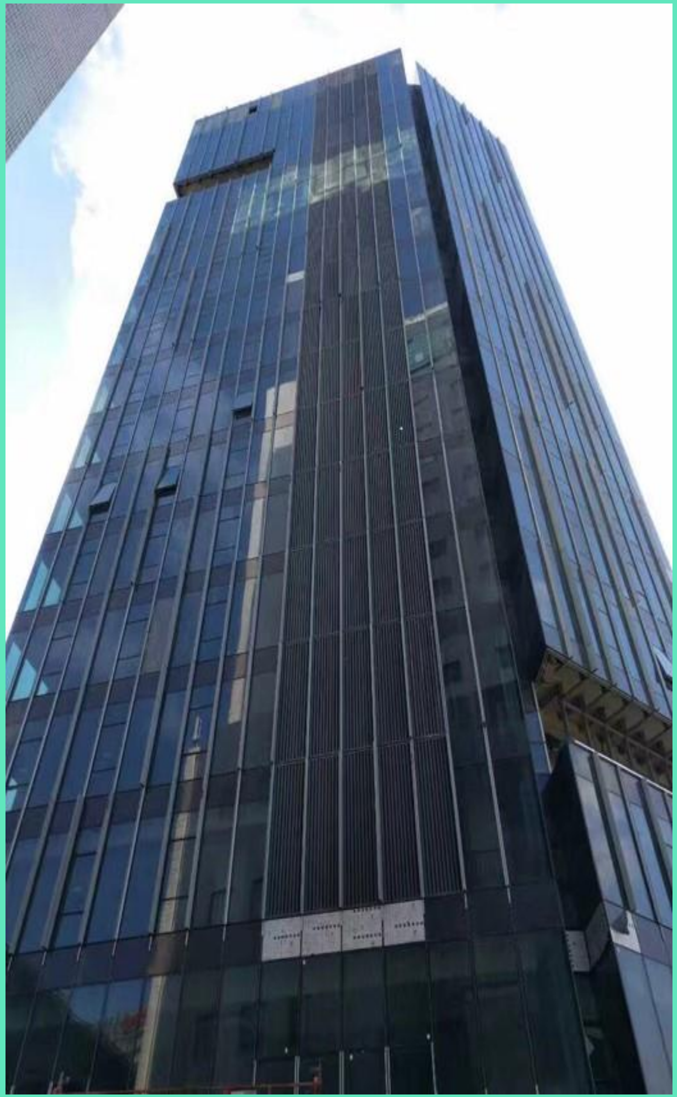




Uses *Precast Seismic Structural System (PRESSS)* technology in its seismic force resisting system: a technology that combines post tensioning and ductile connections.

Case Studies-Chapter 12

Seismic Resistant Precast Frames: 80m tall
Office Development of five buildings, Shanghai, China



Design maximum drift angle of 1/837,
design base shear force of 13,000 kN

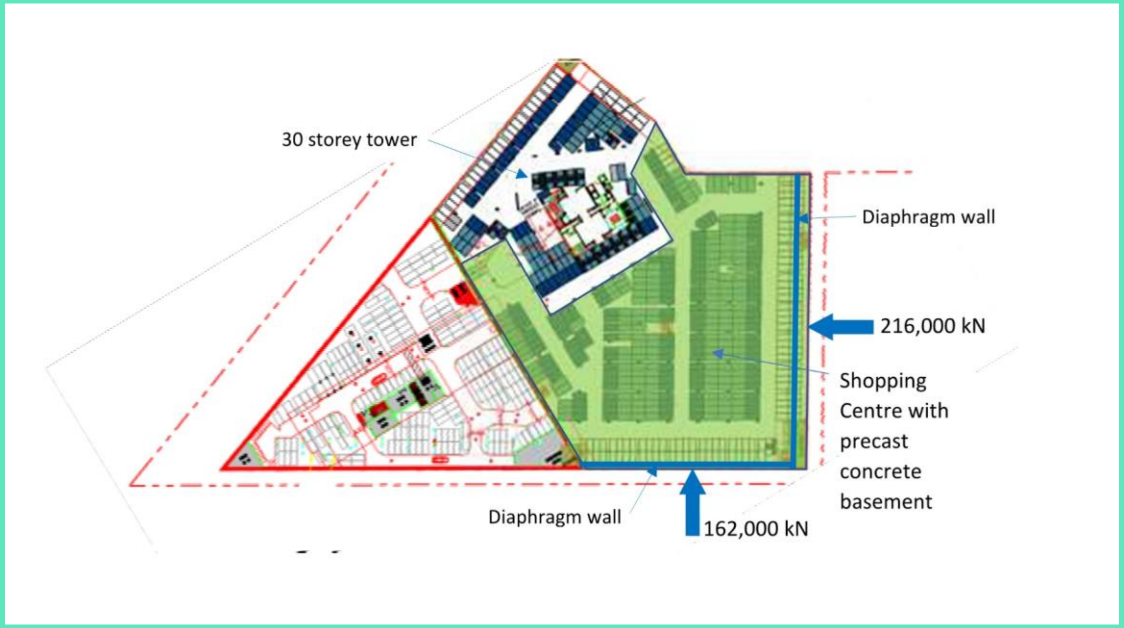
Case Studies-Chapter 12

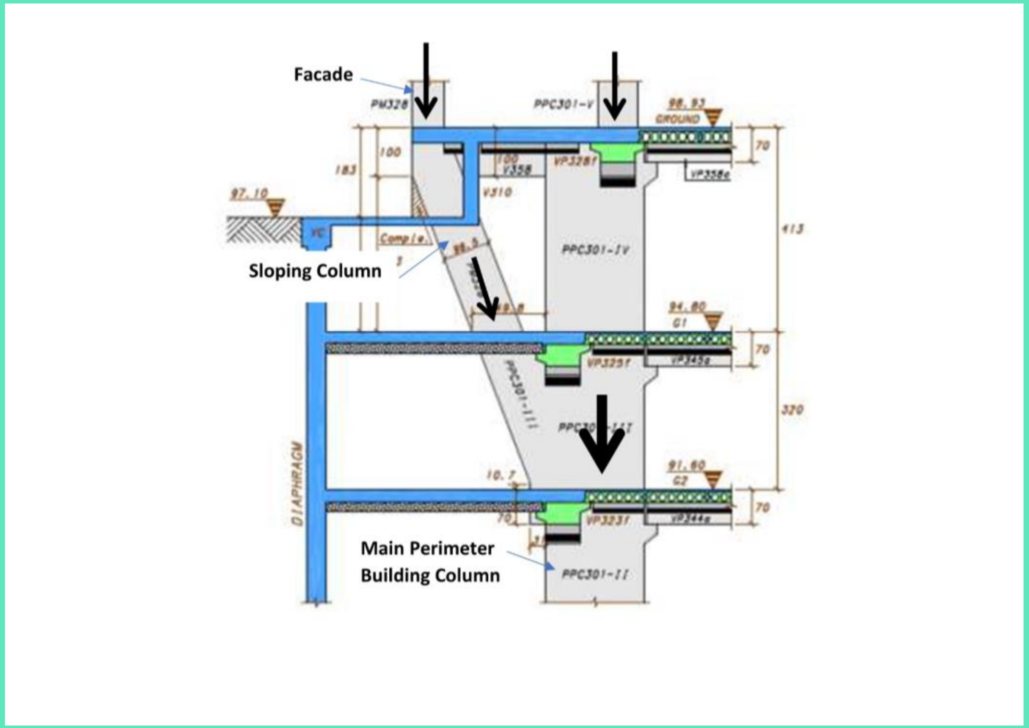
Mixed Construction: 150m tall
Dexia Tower, Brussels, Belgium

Precast columns, beams and slabs integrated with insitu concrete stability cores.

Case Studies-Chapter 12

Mixed Construction: 10 storeys of basement and retail precast structure supporting 30 storey steel framed tower
Parque de Cidade, Sao Paulo, Brazil



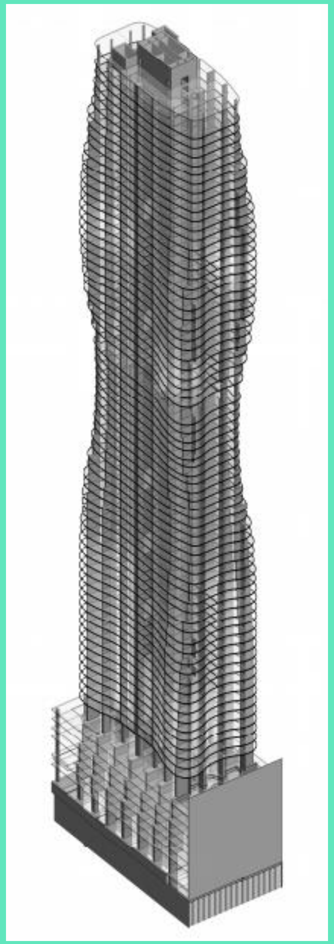


Precast basement frames resist large lateral forces from diaphragm walls.

Case Studies-Chapter 12

Mixed Construction in Australia: Precast vertical elements with insitu concrete post tensioned floors.

Precast Mega Columns



Premier Tower, Melbourne: 249m tall.

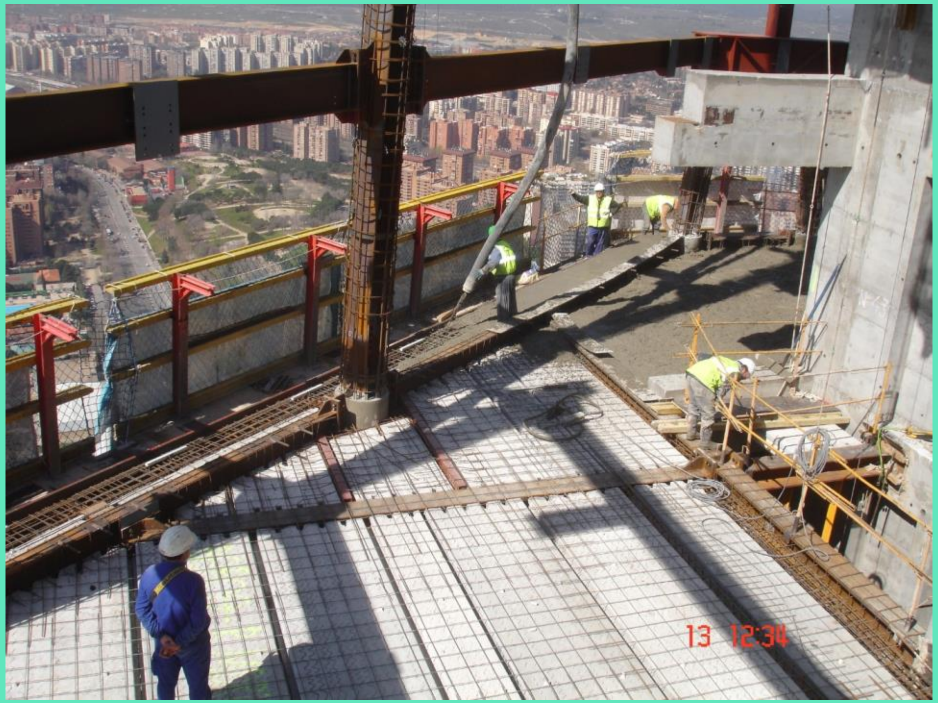
Australia 108, Melbourne: 320m tall.

Case Studies-Chapter 12

Mixed Construction: 240m tall.

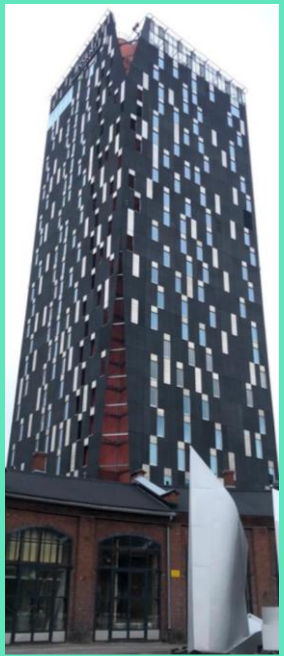
Hollowcore slabs supported by insitu concrete and steel framework.

Torre de Cristal, Madrid, Spain



Case Studies-Chapter 12

Architectural Concrete



Tampere Tower Hotel, Helsinki, Finland: 25 storeys. Black concrete sandwich panels mixed with steel accent panels to suit industrial surroundings.

Northwestern Memorial Hospital, Chicago, USA: 25 storeys with precast insulated sandwich panels.

Conjunto Paragon Hotel, Santa Fe, Mexico: 29 storeys above ground level. Undulating design with winding “S” shape.

Thank You For Your Attention