Lecture 3 – Precast Concrete in Building
Precast Concrete

- Concrete elements, cast and cured in a manufacturing plant, then transported to the construction site.
• Structural elements are commonly reinforced with tightly stretched pretensioned steel strands, which provide increased structural efficiency.

• Conventional steel reinforcing is added for resistance to thermal and other secondary stresses.
• On the construction site, precast concrete elements are lifted into place and assembled into structural assemblies in a process similar to that used for structural steel.

• Compared to site cast concrete, precast concrete erection is faster and less affected by adverse weather conditions.
Advantage of Precast Concrete

• High efficiency and good quality control.
• Durability
• Very rapid speed of erection
• Entire building can be precast-walls, floors, beams
• Rapid construction on site
• High quality
• Prestressing is easily done
• Aesthetic versatility
• Low maintenance and low cost
• Sustainability
Precast vs In-Cast

**Site-cast**
- no transportation
- the size limitation is depending on the elevation capacity only
- lower quality because directly affected by weather
- proper, large free space required

**Precast at plant**
- transportation and elevation capacity limits the size
- less affected by weather
- no space requirement on the site for fabrication
- unlimited opportunities of architectural appearance
- option of standardized components
Disadvantage of Precast Concrete

• Very heavy members
• Connections may be difficult
• Somewhat limited building design flexibility
• It can not be used for two-way structural systems
• Joints between panels are complicated
• Skilled workmanship is required
• Cranes are required to lift panels
Performance in Use of Precast Concrete

- Inherent fire resistance
- Acoustics
- Air tightness
- Vibration control
Quality of Precast Concrete

- Accuracy
- High quality finishes
- Consistency of concrete supply
- Controlled environment
Design of Precast Concrete

- Long clear span
- Proven design and methodologies
- Durable
- Mouldable
Sustainability of Precast Concrete

- Thermal mass / fabric energy storage
- Less wastage
- Reused and recycled
- Reduce noise
Precast Concrete

Precast Concrete Slabs

- Used for floor and roof decks.
- Deeper elements (toward the right below) span further than those that are shallower (toward the left).
- Right: Hollow core slabs stacked at the precasting plant.
Precast Concrete

Precast hollow core Slab
• Used for long span floor that needs thin slab.
• Used for prestressed precast concrete.
Precast Concrete Beams and Girders

- Provide support for slabs.
- The projecting reinforcing bars will bond with concrete cast on site.
- Right: Inverted tee beams supported by precast columns.
Precast Concrete

Precast Concrete Columns and Wall Panels

• Provide support for beam and slab elements.

• Since these elements carry mainly axial loads with little bending force, they may be conventionally reinforced without prestressing.

• Or, long, slender multistory elements may be prestressed to provide resistance to bending forces during handling and erection (columns at right).
Precast Concrete

Precast structural shear wall for residential house in Hongkong
Precast Concrete

Other Precast Concrete Elements
• Precast concrete stairs (below)
• Uniquely shaped structural elements for a sports stadium (right)
Precast Concrete

Enhanced Precast and Prefabrication System (EPPS) for construction of public housing in Hongkong
– precast concrete bathrooms and the precast concrete bathroom-cum-kitchen units.
1. Large-panel systems
2. Frame systems
3. Slab-column systems with walls
4. Mixed systems
Large Panel System

- box-like structure.
- both vertical and horizontal elements are load-bearing.
- one-story high wall panels (cross-wall system / longitudinal wall system / two way system).
- one-way or two way slabs.
Frame System

- Components are usually linear elements.
- The beams are seated on corbels of the pillars, usually with hinged-joints (rigid connection is also an option).
- Joints are filled with concrete at the site.
Slab-Column System with Walls

- partially precast in plant (pillars) / partially precast on-site (slabs).
- one or more storey high pillars (max 5).
- up to 30 storey high constructions.
- special designed joints and temporary joints.
- slabs are casted on the ground (one on top of the other) – then lifted with crane or special elevators.
Precast Concrete Building

- Car park frame and deck
- Crosswall construction
- Volumetric construction
- Hybrid concrete construction
Car Park Frame and Deck

• Precast columns, precast beams and precast decks.
• Standard bay size is 15.6 m x 7.2 m.
• 400 mm thickness hollowcore unit and 600 mm deep double tee unites for prestressed precast decks.
• Precast spandrel panels for shorten span distance
Crosswall Construction

- Precast walls and load bearing walls
- For multistorey building
- Suitable for building with cellular nature, i.e. hotel, student accommodation, apartment
- Longitudinal stability using external wall panels
Advantages of Crosswall Construction

- High quality finishes
- Thermal mass
- Bathroom pods
- Acoustic performance
Volumetric Construction

• Modular precast construction
• For prison cell blocks, student hostel, apartment
• Benefit: robustness, off-site fitting out, rapid assembly on-site
• Independence from extremes of weather
Hybrid Concrete Construction

• Combination of precast and in-cast concrete
• Reduce the overall construction time
• Reduce the amount of traditional formwork
• Thermal mass and fire resistance
• Durability
Assembly Concepts

- Vertical support can be provided by precast columns and beams (above), wall panels (below), or a combination of all three.
- The choice of roof and floor slab elements depends mainly on span requirements.
- Precast slab elements are frequently also used with other vertical loadbearing systems such as sitecast concrete, reinforced masonry, or steel.
Assembly Concepts

- Above: Precast concrete structure consisting of solid wall panels and hollow core slabs.
- Below: A single story warehouse consisting of double tees supported by insulated sandwich wall panels.
Assembly Concepts

• A parking garage structure consisting of precast double tees supported by inverted tee beams on haunched columns.
Precast Concrete Floors

- Hollowcore floors
- Termodeck
- Solid prestressed floors
- Cofferied floor units
- Lattice girder slabs
- Beam and block flooring
- Double-tee floor units
Hollowcore Floors

- The core can function as service ducts
- Reduce the self-weight of the slabs
- Maximize structural efficiency
- Typical: 1200 mm widths and 110-400 mm depths
• Specialist application of hollowcore slabs.
• The voids within the slab are used as part of ventilation system.
• Maximize the benefits of thermal mass
Solid Prestressed Floors

- Typical 75 mm or 100 mm thick
- Designed to be used compositely with an in-situ concrete structural topping
Coffered Floor Units

- For aesthetic purpose
- For services
Lattice Girder Slabs

• Thin precast concrete ‘biscuit’ with a lattice girder for reinforcement
• Typical depth: 150 mm – 300 mm
• Act continuously across several spans
Beam and Block Flooring

• Wet-cast prestressed beams
• Typical depth: 150 – 225 mm
• Provide high degree of insulation for ground floors
• Beam may be placed in pairs to accommodate loading from partitions
Double Tee Floor Units

- Ribbed precast prestressed concrete units
- Typical depth: 300 – 800 mm
- Carry load up to 16 m
- Standard width: 2400 mm
Precast Concrete Elements

- Column
- Beams
- Twinwall
- Stairs
- Bathroom pods
- Balconies
- Terracing
• Square, rectangular → cast horizontally

• Circular → cast vertically
Beam

- Reinforced with steel (prestressed with steel strand)
- Act compositely with floor or monolithic with columns
Twinwall

- Two precast concrete panels held apart by a lattice girder manufactured from steel reinforcement.
• Basement walls
• In combination with lattice girder slabs to form cellular structures
• Core walls of lift shafts
• Residential structures with load-bearing party walls
Stairs

• Offer a quick method for providing safe access routes during construction
• Cost effective
Bathroom Pods

• Consists of thin concrete walls and floor with a single layer of reinforcing mesh
• Services (electrical conduits and pipework) can be incorporated into the concrete structure
Balconies

- For apartment complexes
- Have integral drainage slots
Terracing

• For terracing in grandstand, stadium and auditorium.
• Strong, durable and easy to install.
• Protection form vibration.
Precast Concrete Cladding Panels

- Self-finished panels
- Applied-finish panels
- Individually supported panels
- Self-supporting panels (stacked facades)
- Load-bearing structural panels
- Insulation
Precast Concrete Cladding Panels

Advantages:
• High quality
• High accuracy
• On-time delivery
• Safety
• Sustainability
• Flexible
Self-Finished Panels

- To mimic a natural stone
- Typical 150 mm thick
- Surface treatment include: bush hammering, abrasive blasting, acid etching, mechanical grinding & polishing, surface retarding, rubbing
Applied-Finished Panels

• Typical material: terracota, glazed bricks, brick-slips, tiles and stone facings

• Typical thickness: 30 – 50 mm
Individually Supported Panels

- Designed to span either from column to column or floor to floor
- Enclose large areas of the structure
- The panels are fixed to the frame with brackets for adjustments in 3 directions
Self-Supporting Panels

- Stacking one panel on top each other
- Carry vertical load
- Typical thickness: 150 mm
- Using frame to tie two panels in lateral direction
- Frame is light due to less load
Load-Bearing Structural Panels

- Part of structural frame
- Can support the floors, slabs and beams
- No requirement for perimeter column which increases the floor area
Insulation

- Fixed to the back of the panel
- Fixed between concrete and the applied finishes in the factory
- Fixed between two layers of concrete (sandwich panels) in the factory
Joints and Connections (Beam to Column)

- Steel billets with a socketed beam-end
- Corbels with recessed beam-end
- Connection between beams and single-story height columns
Joints and Connections
(Column to Foundation)

Bolted or baseplate connection

Projecting starter-bars

In-situ pocket foundation
Joints and Connections (Column to Column)

- Metal bearing plates and embedded anchor bolts are cast into the ends of the columns.
- After the columns are mechanically joined, the connection is grouted to provide full bearing between elements and protect the metal components from fire and corrosion.
Hollow core slabs are set on bearing pads on precast beams.
Steel reinforcing bars are inserted into the slab keyways to span the joint.
The joint is grouted solid.
The slab may remain untopped as shown, or topped with several inches of cast in place concrete.
Joints and Connections
(Wall to Slab)

• Precast concrete structure consisting of solid wall panels and hollow core slabs.
Sitecast Concrete Toppings over Precast Slabs

- Greater floor strength and stiffness
- Greater fire resistance
- Greater acoustic isolation
- Allow easy integration of electrical services into floor system
- Create a smoother, flatter floor surface.
Manufacture of Precast Concrete

Casting hollow core plank

• Precast elements are manufactured in casting beds, 800 ft or more in length.

• High-strength steel strands are strung the length of the bed and tensioned.

• Conventional reinforcing, weld plates, blockouts, lifting loops, and other embedded items are added as needed.

• Concrete is placed.
Casting hollow core plank

- Once the concrete has cured to sufficient strength, the castings are cut into sections of desired length (above).
- In some cases, transverse bulkheads are inserted to divide the casting bed into sections before concrete is placed. In this case, only the prestressing strands need to be cut to separate the sections (below).
Casting hollow core plank

- Individual sections are lifted from the casting bed (right) and stockpiled to await shipping to the construction site.
Casting hollow core plank

- Precast concrete elements are shipped to the construction site by truck and erected on site by crane.
Manufacture of Precast Concrete

Casting hollow core plank

• Sample hollow core slab sections of varying depths.

• At bottom left, note the insulated sandwich floor panel.
Prestressing and Reinforcing Steel

- Many precast elements contain both prestressing strands and conventional reinforcing.
- Right: The prestressing strands for an AASHTO girder are depressed into a shallow v-shape to most efficiently resist tensile forces in the beam. Shear stirrups are formed from conventional steel reinforcing.
Mould for Precast Concrete

Adjustable long-line mould systems

Flat table mould
Mould for Precast Concrete

Tilting table mould

Battery mould
Quality Control

• Precast concrete must be manufactured according to ISO 9001 standard

• Key areas of quality control include:
  – Test certificate for materials
  – Compressive strength testing
  – Consistence (workability) testing
  – Mould standard and quality checks
  – Correct preparation of reinforcement cages/strands check
  – Cast-in components and fitting checks
  – Dimensional checks – both before and after casting
  – Quality of finish inspection
Factors to be considered before preparing the method of statement:

- Safety
- Handling/cranage and transportation
- Site erection (procedure, programme, sequence)
Factors to be considered for choosing a crane and finalizing the construction sequence:

- Public and on-site safety
- Component sizes and weights
- Maximum reach of the crane from set-up position to final component installation
- Any constraints such as overhead power lines
- Availability of secure standing areas for cranage
- Ground bearing pressures for crane loads
# Cost Analyses

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<tr>
<th>Material</th>
<th>In-situ</th>
<th>Precast</th>
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<tbody>
<tr>
<td>• Girders</td>
<td>S$ 21,463.00</td>
<td>S$ 50,765.00</td>
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<tr>
<td>• Deck panels</td>
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<tr>
<td>• Reinf steel</td>
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<td>S$ 724.00</td>
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<tr>
<td>• Concrete</td>
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<tr>
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<tr>
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<tr>
<td>Total cost</td>
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<tr>
<td>Cost per sq ft</td>
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<td>S$ 53.80</td>
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Cost saving = \( \frac{53.80 - 37.54}{37.54} = 43.31\% \)
THANK YOU