THE ART OF PRECAST CONCRETE
An Over-view
Importance of Precast Design

- The art of successful precast construction involves various activities like Architecture, Design, Detailing, Manufacturing & Site erection.
- The relationship between these various activities is shown in diagram below. The linkages shown with double line are critical relationships for any successful project.
- As can be seen from Figure, the Precast Design is the only activity which has major or critical link with all other remaining disciplines. As such “Precast Design” becomes focal point in any precast construction & hence the Success of any Precast Construction Project depends on the expertise, experience of Precast Design Team to a large extent.
WHAT IS PRECAST?

• Precast Concrete is the concrete which has been prepared for Casting, Cast & Cured at a location which is not its final destination.

• The Distance travelled of such concrete products may be just a few meters in case of site based precasting methods or even thousands of kilometers in case of high value added precast products.
WHY PRECAST?

Industrialized Production – Better Quality
WHY PRECAST?

High Speed – up to 50% reduction in time
WHY PRECAST?

Labor Force – up tp 75% reduction
WHY PRECAST?

Reduction in Maintenance Cost
WHY PRECAST?

Better Health & Safety – Hygienic & Clean Work Site
WHY PRECAST?

Green Method – Less Wastage & Suspended Particles
PRECAST STRUCTURE- Wall Frame

Erection of External Panels

Residential Buildings up to 20-25 floors
PRECAST STRUCTURE- Skeletal Frame

Commercial Buildings, MLCP up to 10-15 floors
PRECAST STRUCTURE- Portal Frame

Columns in Position

Industrial, Warehouse Buildings, Retail Malls
In Addition to above it is possible to use **Solid, Reinforced, Room size slab** as **Notched slab** and **Half Slab**
# Flooring Slabs - Comparison

<table>
<thead>
<tr>
<th>Parameter of Comparison</th>
<th>Pre-stressed H/C Slab (Planks)</th>
<th>Pre-stressed Solid Slab (Planks)</th>
<th>Pre-stressed Filigree Slab (Planks)</th>
<th>Notched Solid Slab (Room size)</th>
<th>Half Slab (Room size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Material Consumption</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Irregular Architectural Grids</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ceiling Aesthetics</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F/F Ht</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Load/Span Capacity</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Ease of Production/Erection</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

*Red indicates High, Green indicates Moderate, Yellow indicates Low.*
Standard Precast Components- Walls

In addition to above it is possible to use Dumbbell Shaped Wall (Column, Beam & Partition Walls cast as one piece Unit)
# Walling Units - Comparison

<table>
<thead>
<tr>
<th>Parameter of Comparison</th>
<th>Solid Walls</th>
<th>Twin Walls</th>
<th>Sandwiched Walls</th>
<th>Dumbbell Shaped Walls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Material Consumption</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Irregular Architectural Grids</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Ease of Substructure Construction</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Ductility</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Ease of Production/Erection</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Manufacturing of Precast, Pre-stressed Flooring Units

- The Precast Pre-stressed Flooring Units are generally manufactured on a long line (120-150m length) using Pre-tensioning Method.
- The Bed of the line consists of Steel Plates (1.2/2.4 m. Width) with under heating pipes for rapid curing.
- The Pre-stressing force is resisted by Foundations & Abutments cast with Mass Concrete.
- These units can be manufactured using Wet-casting, Slip-forming or Extrusion.
Manufacturing of Precast, Pre-stressed Flooring Units using Wet-Cast

- **Solid** Precast Pre-stressed Flooring Units with/without projecting reinforcement at top/sides (like filigree/half slabs or Inverted T beams) can be manufactured by Wet-Cast technique with very minimal machinery cost.

- Water-Cement ratio required in such technique is generally high (0.42-0.48) due to workability requirements which increases the cement consumption.

- The strength of concrete at release of Pre-stress (30-35 Mpa) can be achieved in 12-18 Hrs.
Solid Precast, Pre-stressed Slab with Projecting Rebars by Wet-Cast Method
Manufacturing of Precast, Pre-stressed Flooring Units using Slip-Form

- Precast Pre-stressed Flooring Units of any cross-section without projecting reinforcement at top/sides (like Solid Slab, Hollow-cored Slab or Inverted T beams etc.) can be manufactured by Slip-Form technique with moderate machinery cost.

- Slip-forming requires zero-slump concrete with moderate w/c ratio (0.37-0.42) in order to maintain the cross-section of wet concrete without collapse.

- The maintenance cost of Slip-forming machines are lower due to less wear and tear of moving parts.

- The strength of concrete at release of Pre-stress (30-35 Mpa) can be achieved in 8-12 Hrs.
Various Cross-sections by Slip-Form Method

✓ Hollow core slabs
✓ Inverted T & I beams
✓ Vineyard posts
✓ U panel
✓ Inverted double T slabs
✓ Solid slabs
✓ Lintels
Manufacturing of Precast, Pre-stressed Flooring Units using Extrusion

- With Extrusion Technique, it is possible to manufacture only & only Hollow-cored Slab Flooring Units.
- The Cores in the slab are formed due to rotating augers.
- Extrusion requires zero-slump concrete with less w/c ratio (0.34-0.38) in order for extruder to move ahead by reaction from cast slab.
- The Highest Quality of Hollow-core Slab units can be manufactured using extrusion with relative ease.
- The maintenance cost of Extrusion machines are higher due to wear and tear of rotating augers.
- The strength of concrete at release of Pre-stress (30-35 Mpa) can be achieved in 6-8 Hrs.
Hollow-Cored Slab by Extrusion
# Floor Manufacturing-Comparison

<table>
<thead>
<tr>
<th>Wet-Cast</th>
<th>Slipform</th>
<th>Extrusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Capex</td>
<td>High Capex</td>
<td>High Capex</td>
</tr>
<tr>
<td>High cement consumption</td>
<td>Moderate cement consumption</td>
<td>Low cement consumption</td>
</tr>
<tr>
<td>Versatile</td>
<td>Versatile</td>
<td>Only H/C</td>
</tr>
<tr>
<td>Projecting steel Possible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low in Quality</td>
<td>Moderate Quality</td>
<td>High Quality</td>
</tr>
<tr>
<td>Less Efficient / Turn-over time</td>
<td>Efficient</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>Labor Intensive</td>
<td>Moderate Labor force</td>
<td>Reduction in Labor</td>
</tr>
<tr>
<td>Negligible Maintenance cost</td>
<td>Moderate Maintenance cost</td>
<td>High Maintenance cost</td>
</tr>
</tbody>
</table>
Manufacturing of Precast Walling Units

• The Precast Walls are generally manufactured in size up to 9-12 m. in length & floor to floor height (approx. 3 m.)

• Such walls can be manufactured using Battery Moulds (Vertically) or using Tilting Tables or Circulation Plant (Horizontally).
Manufacturing of Precast Wall Units using Battery Mould.

- The battery mould is a space saving and productive cassette method of producing solid panels and boundary walls and other solid components.
- Battery moulds produce a very precise, smooth and ready-to-paint finish on both sides. Also, it is the best system if the electric sockets are on both sides of walls.
- There is less need for after handling as the elements are stripped in a vertical position, removing the need for tilting.
- The moulds are extremely durable, easy to handle and operate, safe from damage and dirt, and provide an even curing.
Battery Mould Operations

Production principle
Battery Mould Operations

Production principle

Open (hydraulic) clamp ramps
Battery Mould Operations

Production principle

Move end wall with first intermediate mould plate
Battery Mould Operations

Production principle

Remove panel
Battery Mould Operations

Production principle

Move end wall to catch next intermediate mould plate
Battery Mould Operations

Production principle

Move end walls with next intermediate mould plate
Battery Mould Operations

Production principle

Remove panel
Battery Mould Operations

Production principle

Move end wall to catch last intermediate mould plate
Battery Mould Operations

Production principle

Move end wall with last intermediate mould plate
Battery Mould Operations

Production principle

Remove panel
Battery Mould Operations

Production principle

Clean walls
Oil walls
Battery Mould Operations

Production principle

Assemble panel
Battery Mould Operations

Production principle

Move end wall with intermediate mould plates
Battery Mould Operations

Production principle

Move end wall with intermediate mould plates
Battery Mould Operations

Production principle

Clean walls
Oil walls
Battery Mould Operations

Production principle

Assemble panel
Battery Mould Operations

Production principle

Move end wall with intermediate mould plates
Battery Mould Operations

Production principle

Move end wall with last intermediate mould plate
Battery Mould Operations

Production principle

Clean last walls
Oil last walls
Battery Mould Operations

Production principle

Assemble panel
Battery Mould Operations

Production principle

Move end wall with last intermediate panel
Battery Mould Operations

Production principle

- Close (hydraulic) clamp ramps
- Save platform
- Inspect cells
Battery Mould Operations

Production principle

Fill in concrete
Battery Mould Operations

Production principle

Fill in concrete
Battery Mould Operations

Production principle
Battery Mould
Manufacturing of Precast Wall Units using Circulation Plant

• Reduces the need for skilled labor and reduces the total number of workers to a fraction of the number required in a manual plant.

• Problems in the production process are more easily identified because each step in the process is timed and monitored separately.

• The placement of concrete takes place at only one station in the work circuit, which allows for a much cleaner total operation.

• All custom and standard pieces are produced on the same production line and the quality of the products is increased.

• As this is casting on the flat plate, it offers variety of products like solid walls, sandwich panels, double walls, retaining walls, columns, beams, solid slabs, landings, balconies, filigree slabs.
Circulation Plant
Circulation Plant
Manufacturing of Precast Wall Units using Tilting Tables

• Tilting tables refer to the type of process in which stationary precast molds consisting of a robust welded profile structure are horizontally mounted on the floor, and then, after casting and curing, hydraulically or mechanically tilted vertically up about 80 degrees to facilitate product removal in the correct position for transportation.

• Tilting tables are designed for the fabrication of reinforced large area concrete products of varying dimensions and configurations. High-frequency vibrators ensure excellent compacting of the freshly-cast concrete. Depending on local conditions or customers' specific requirements the tilting table can be equipped with a heating system.
Manufacturing of Precast Wall Units using Tilting Tables

- Tilting tables are used to make many different solid elements such as bearing and non-bearing internal and external walls, boundary walls and special elements. The extremely high mold quality and accuracy of tilting table systems ensures perfect end products while allowing for lots of variation in size and shape. Substantial output is also possible in certain cases.
## Wall manufacturing-Comparison

<table>
<thead>
<tr>
<th>Battery Mould</th>
<th>Tilting Table</th>
<th>Circulation Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Saving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due to fall of 3.0m. concreting needs care.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid Walls only</td>
<td>Solid, Sandwich, Rendered Walls, Solid Slabs.</td>
<td>Solid, Sandwich, Double walls &amp; Solid, Filigree slabs.</td>
</tr>
<tr>
<td>Both Side Mould finish</td>
<td>One side Mould finish</td>
<td>One side Mould finish</td>
</tr>
<tr>
<td>Easy fixing of inserts on both sides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Even Curing</td>
<td>Equipped with heating System</td>
<td>Curing Chamber, central shifter Reqd.</td>
</tr>
<tr>
<td>Labor Intensive</td>
<td>Moderate Labor force</td>
<td>Reduction in Labor</td>
</tr>
<tr>
<td>Can be operated in single shift only</td>
<td>Can be operated in single shift only</td>
<td>Can be operated in two shifts easily.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Systematic &amp; Efficient Production</td>
</tr>
</tbody>
</table>
Project Management & Supervision (QA/QC)
For Precast Production & Erection
Flowchart of Precast Production

1. Receive Reinforcement
2. QC inspection
3. Cut and Bend
4. QC inspection
5. Fix insets for lifting, propping, blockouts, and conduits
6. Assemble rebar cage
7. QC Inspection
8. Preparation of moulds and check the dimensions
9. Pour concrete finish and cure
10. Check the cube strength for demoulding
11. QC inspection
12. Demoulding and lifting the panel to stock yard
Guidelines for Stacking of Precast Elements

Stacking method and packers (or support spacers) vary according to the types of precast elements. Horizontal stacking of slab/beam or column units was done with suitable packers or support spacers. As a guide, the storage support position for beams and planks should be within 300mm from the lifting points.

Do not use more than two support points in particular for pre-stressed element such as hollow core slab.

The packers or support spacers should not be misaligned.

Column-wall-beam & Wall Panels should be stored vertically and braced in position by A-frames or a racking system.
### Guidelines for Transportation of Precast Elements

<table>
<thead>
<tr>
<th>Use of polythene wrapping as a form of protection against stain and damages</th>
<th>Use of styrofoam to minimise damages to precast elements at support end</th>
<th>Cushion packing should be provided to prevent damage to the edges of precast elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of timber packer to secure the precast elements</td>
<td>Damages can be commonly found at the contact areas between the precast elements and supporting frames</td>
<td>Protection of the critical connection details such as the threaded parts of bolt connection against rust and thread loss</td>
</tr>
</tbody>
</table>
Erection Guidelines

Temporary Strengthening of Panels with openings
Erection Guidelines

Note: The lifting points are designed and located to limit the bending moments within the beam element. As a general guide they should be located at about one fifth of the beam length measured from the edge.
Erection Guidelines

For wall panel, it is recommended to lift the wall panel in vertical position for installation so that turning is not required.

Hoisting method adopted for de-moulding of wall panels that are cast horizontally.
Erection Guidelines

Precast slabs

InNovela
Building Solutions
Complexity simplified
Typical Erection Sequence

For Precast Wall Frame
<table>
<thead>
<tr>
<th>PRECAST ELEMENTS &amp; FINAL STRENGTH</th>
<th>REQUIRED CONCRETE STRENGTHS AT DIFFERENT STAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FOR STRIPPING</td>
</tr>
<tr>
<td>PRECAST WALLS</td>
<td></td>
</tr>
<tr>
<td>40 N/mm²</td>
<td>16 N/mm²</td>
</tr>
<tr>
<td>PRECAST SLABS</td>
<td></td>
</tr>
<tr>
<td>40 N/mm²</td>
<td>16 N/mm²</td>
</tr>
</tbody>
</table>

STAGE 1

PROJECTING DOWEL BARS FROM IN-SITU STRUCTURE

S.S.L.

GR. FLOOR
STAGE 2

LEVELLING, SHimming AND WALL POSITIONING AND FIXING

PROJECTING Dowel bar FROM WALL

TB BAR PROJECTING FROM WALL

PRECAST WALL PANEL

TEMPORARY PROPPING (PUSH & PULL) TO BE REMOVED AFTER GROUT IN VERTICAL JOINTS AND DOWEL TUBES HAS ACHIEVED AT LEAST 50% OF TARGET STRENGTH OF GROUT OR 3 DAYS WHICHEVER IS THE LONGEST DURATION.

SHIMS AND GROUT

S.S.L. GR. FLOOR
PLAN

PROJECTING DOWEL BAR FROM WALL

T3 BAR PROJECTING FROM WALL

PRECAST WALL PANEL

TEMPORARY PROPING (PUSH & PULL) TO BE REMOVED AFTER GROUT IN VERTICAL JOINTS AND DOWEL TUBES HAS ACHIEVED AT LEAST 50% OF TARGET STRENGTH OF GROUT OR 3 DAYS WHICHEVER IS THE LONGEST DURATION.

SHIMS AND GROUT TO BE FILLED IN THE DOWEL TUBE CAST-IN THE WALL

S.S.L. GR, FLOOR

STAGE 3

GROUT THE TUBES
1. Loops to be taken out from box
2. Loose bar to be inserted
3. 20mm vertical joint to be grouted

Precast wall panel

Non shrink non metallic grout to be filled in the dowel tube cast-in the wall

Projecting dowel bar from wall

T6 bar projecting from wall

Precast wall panel

Temporary proping (push & pull) to be removed after grout in vertical joints and dowel tubes has achieved at least 50% of target strength of grout or 3 days whichever is the longest duration.

Shims and grout

Non shrink non metallic grout to be filled in the dowel tube cast-in the wall

wow, s.s.l.

Gr, floor

Stage 4

Connection between walls, grouting of 20mm joint between two walls
WET MORTAR AND
SHIMS IF REQUIRED

TEMPORARY PROPS TO SUPPORT PRECAST SLAB
W/ WOODEN CHAVIS ALL AROUND TO BE
REMOVED AFTER STICH CONCRETE ACHIEVES AT
LEAST 50% OF TARGET STRENGTH OR 3 DAYS
WHICHEVER IS THE LONGEST DURATION. 50%
BACK PROPPING TO BE RETAINED BEFORE
PROCEEDING FOR NEXT LEVEL

S.S.L.
GR. FLOOR

STAGE 5

PROPS TO BE SET FOR SLAB RESTING
STAGE 7
STITCH CONCRETING

SCREED TO BE POURED ON TOP OF SLABS

TEMPORARY PROPS TO SUPPORT PRECAST SLAB W/ WOODEN CHAVIS ALL AROUND TO BE REMOVED AFTER STITCH CONCRETE ACHIEVES AT LEAST 50% OF TARGET STRENGTH OR 3 DAYS WHICHEVER IS THE LONGEST DURATION. 50% BACK PROPPING TO BE RETAINED BEFORE PROCEEDING FOR NEXT LEVEL.

S.S.L.
GR. FLOOR
TEMPORARY PROPS TO SUPPORT PRECAST SLAB
W/ WOODEN CHAIVS ALL AROUND TO BE
REMOVED AFTER STICH CONCRETE ACHIEVES AT
LEAST 50% OF TARGET STRENGTH OR 3 DAYS
WHICHEVER IS THE LONGEST DURATION. 50%
BACK PROPPING TO BE RETAINED BEFORE
PROCEEDING FOR NEXT LEVEL.

STAGE 8
READY FOR THE UPPER
WALL TO BE ERECTED
Plant & Site Inspection
Inspection of Precast Elements

• This finished precast concrete elements and works should be inspected to ensure they meet the design requirement and standards. There will be pre-pour and post-pour checklist during and after production, as well as stocking and transportation and also for erection including temporary supports.

• Quality assurance and control is achieved with good planning and management. Records are maintained for inspection and Test Plan, ITP which summarizes the projects inspection, acceptance criteria and frequency of inspection. Checklists for the in-process and final inspection of precast concrete elements are prepared to detail the checks required at critical stages.

• The produced & erected elements will be checked against tolerance parameters as per IS15916.
Allowable Tolerance for Precast Elements manufacture

**Length:**
+/- 0.1 percent subject to maximum of +5 / -10mm

**Thickness / Cross sectional dimensions:**
+/- 2mm up to 300mm wide
+/- 3mm for greater than 300mm wide

**Straightness / bow:**
+/- 5mm or 1/750 of length, which ever is greater

**Square-ness:**
When considering the squareness of the corner, the longer of two adjacent sides being checked shall be taken as the base line
The shorter side shall not be out of square line for more than +2 / -5mm

**Twist:**
Any corner shall not be more than the tolerance given below from the plane containing the other corners:
+/- 1/1500 of dimensions or +/- 5mm which ever is less

**Flatness:**
The maximum deviation from 1.5 m straight edge placed in any position on a nominal plane surface shall not exceed + / - 3mm
Allowable Erection Tolerance for Precast Elements

Walls:
- Length wise = + / - 10 mm.
- Height wise = + / - 10 mm at bottom,
  + / -2.5 mm at Top
- Width wise = + / - 5 mm

Slabs / Stairs:
- Length / width wise = + / - 5 mm
- Vertically = + / - 2.5 mm

Plumb Lines: +/- 5mm
Bearing Width: +/- 5mm
Joint Dimension: +/- 5mm
Max Accumulated Deviation: Smaller of 1/1250 of Height or 20mm
Thank You