THE ART OF PRECAST CONCRETE

An Over-view

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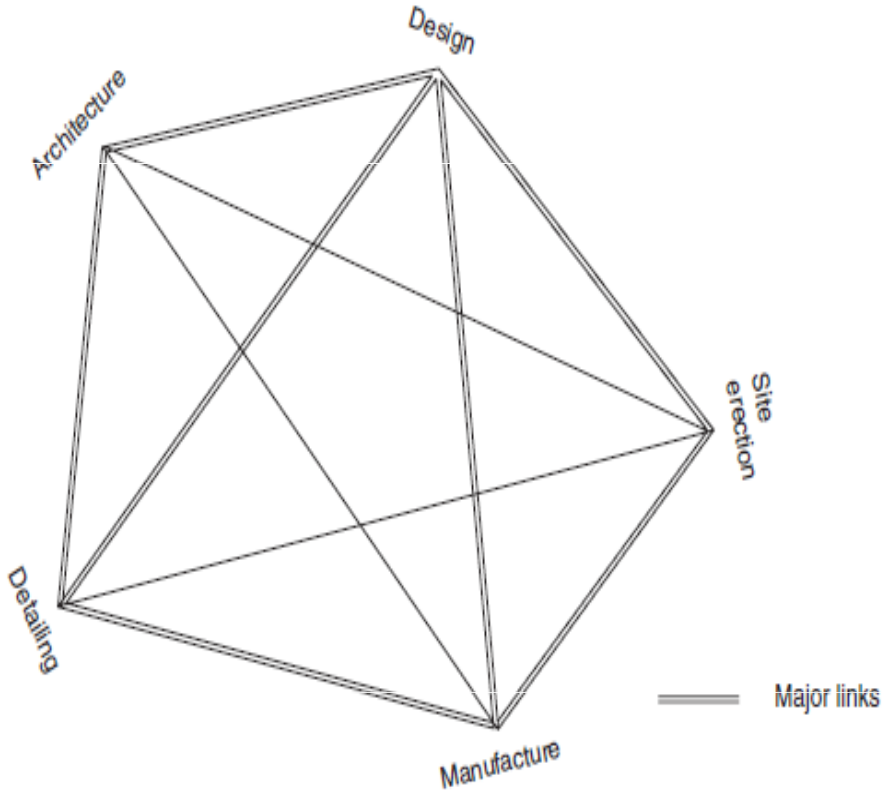
Importance of Precast Design

- 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**

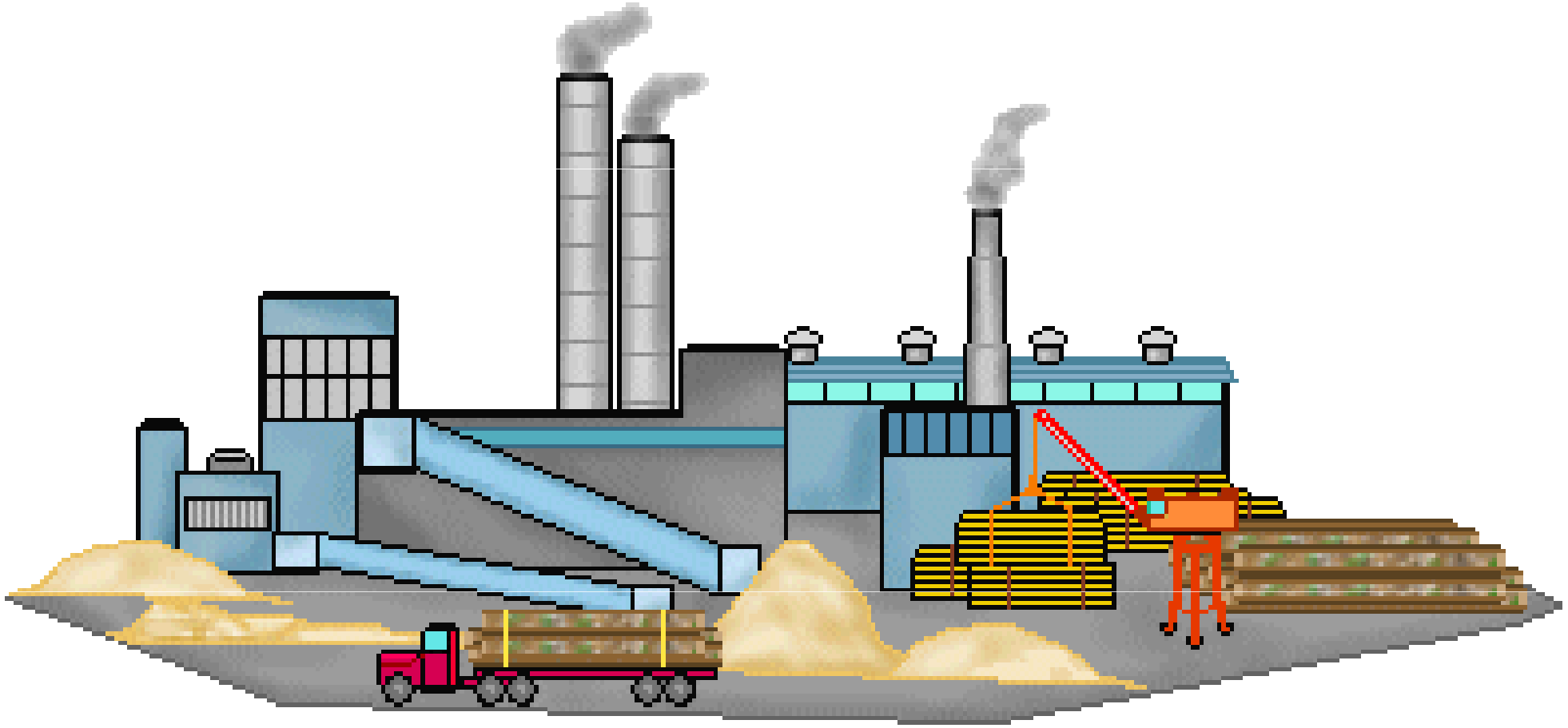


WHAT IS PRECAST?

- Precast Concrete is the concrete which has been prepared for Casting, Cast & Cured at a location which is not it's 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

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WHY PRECAST?

High Speed – up to 50% reduction in time

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WHY PRECAST?

Labor Force – up tp 75% reduction

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WHY PRECAST?

Reduction in Maintenance Cost

WHY PRECAST?

Better Health & Safety – Hygienic & Clean Work Site

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WHY PRECAST?

Green Method – Less Wastage & Suspended Particles

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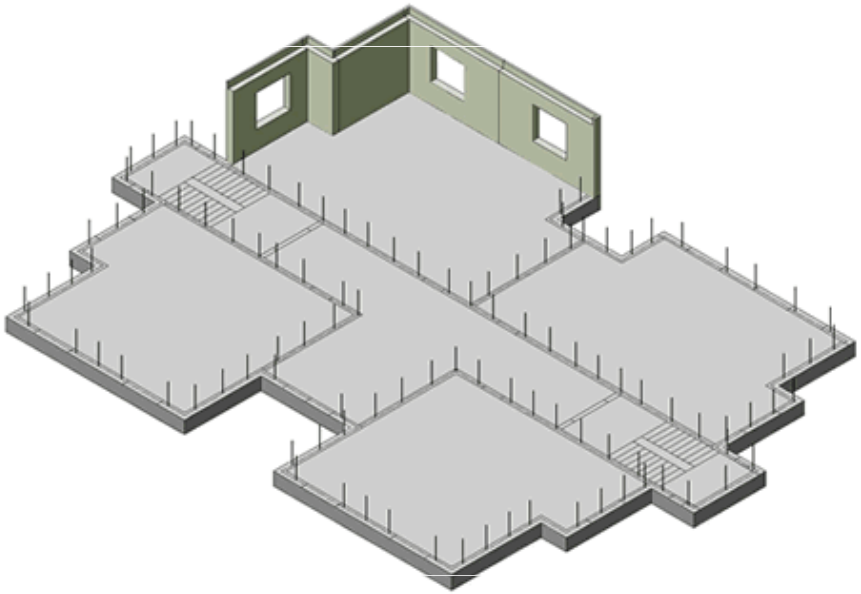
PRECAST STRUCTURE- Wall Frame



Erection of External Panels

Residential Buildings up to 20-25 floors

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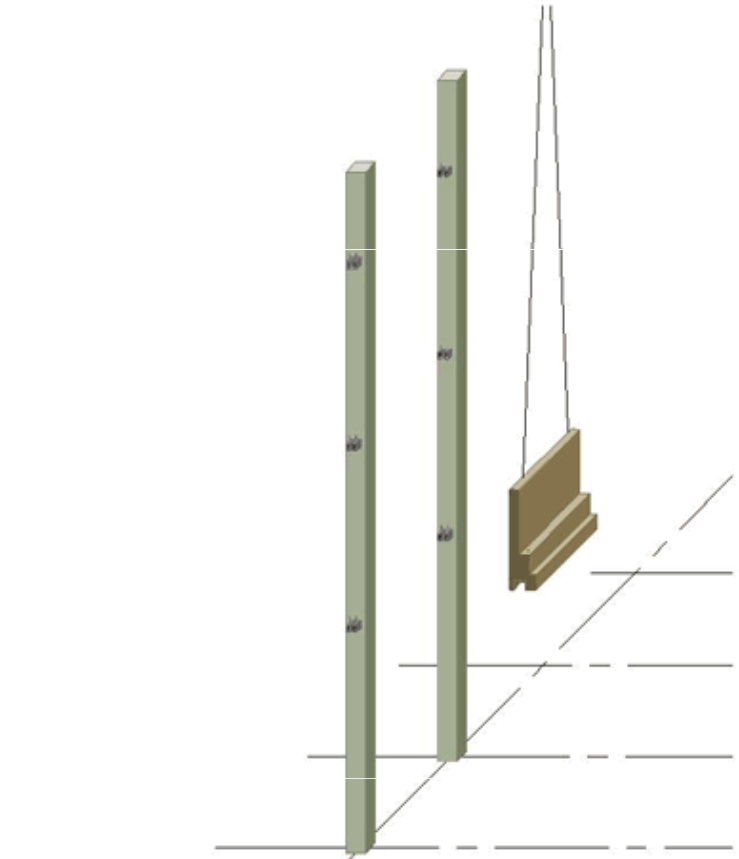
PRECAST STRUCTURE- Skeletal Frame



Multi-Storey Columns in Position
Spandrel being lifted into position

Commercial Buildings, MLCP up to 10-15 floors

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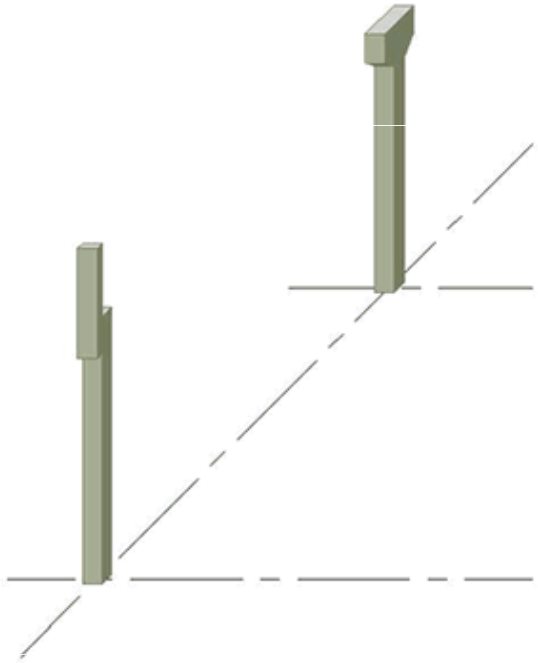
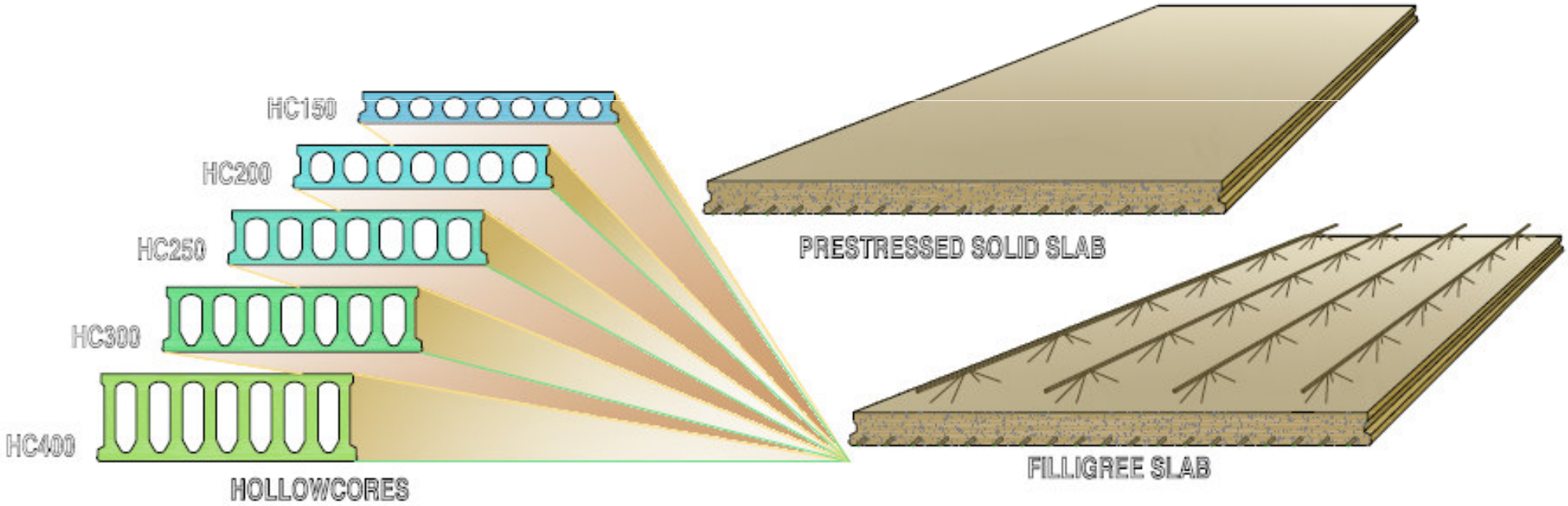
PRECAST STRUCTURE- Portal Frame



Columns in Position

Industrial, Warehouse Buildings, Retail Malls

Standard Precast Components- Flooring Slabs



In Addition to above it is possible to use Solid, Reinforced, Room size slab as Notched slab and Half Slab

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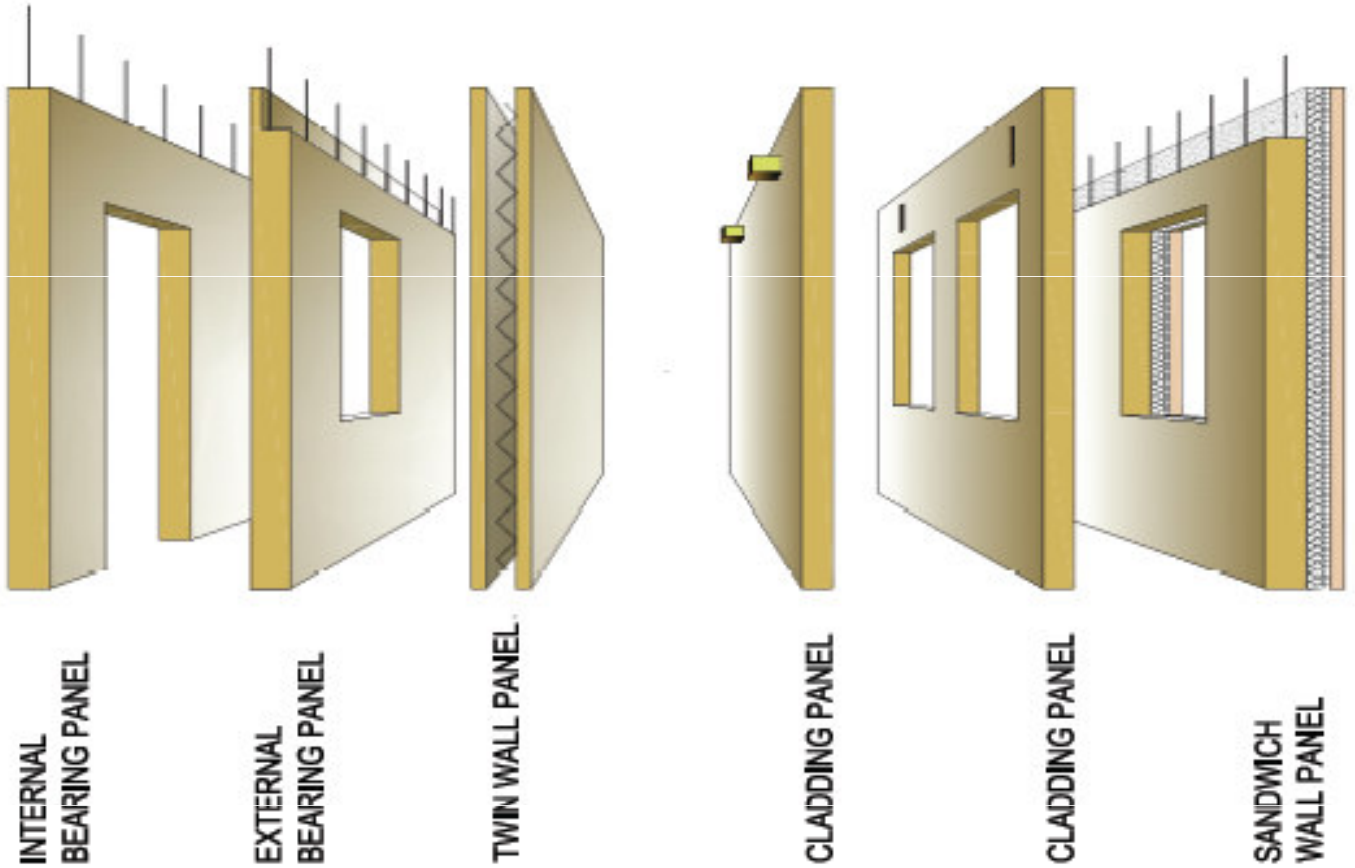
Flooring Slabs - Comparison

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

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

Parameter of Comparison	Solid Walls	Twin Walls	Sandwiched Walls	Dumbbell Shaped Walls
Capex	Moderate	High	Moderate	Moderate
Material Consumption	Moderate	High	High	Low
Irregular Architectural Grids	Yes	Yes	No	Yes
Aesthetics	Moderate	High	High	Low
Ease of Substructure Construction	Low	Low	Low	High
Ductility	Moderate	Low	Moderate	High
Ease of Production/ Erection	High	Low	Low	Moderate

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

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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.

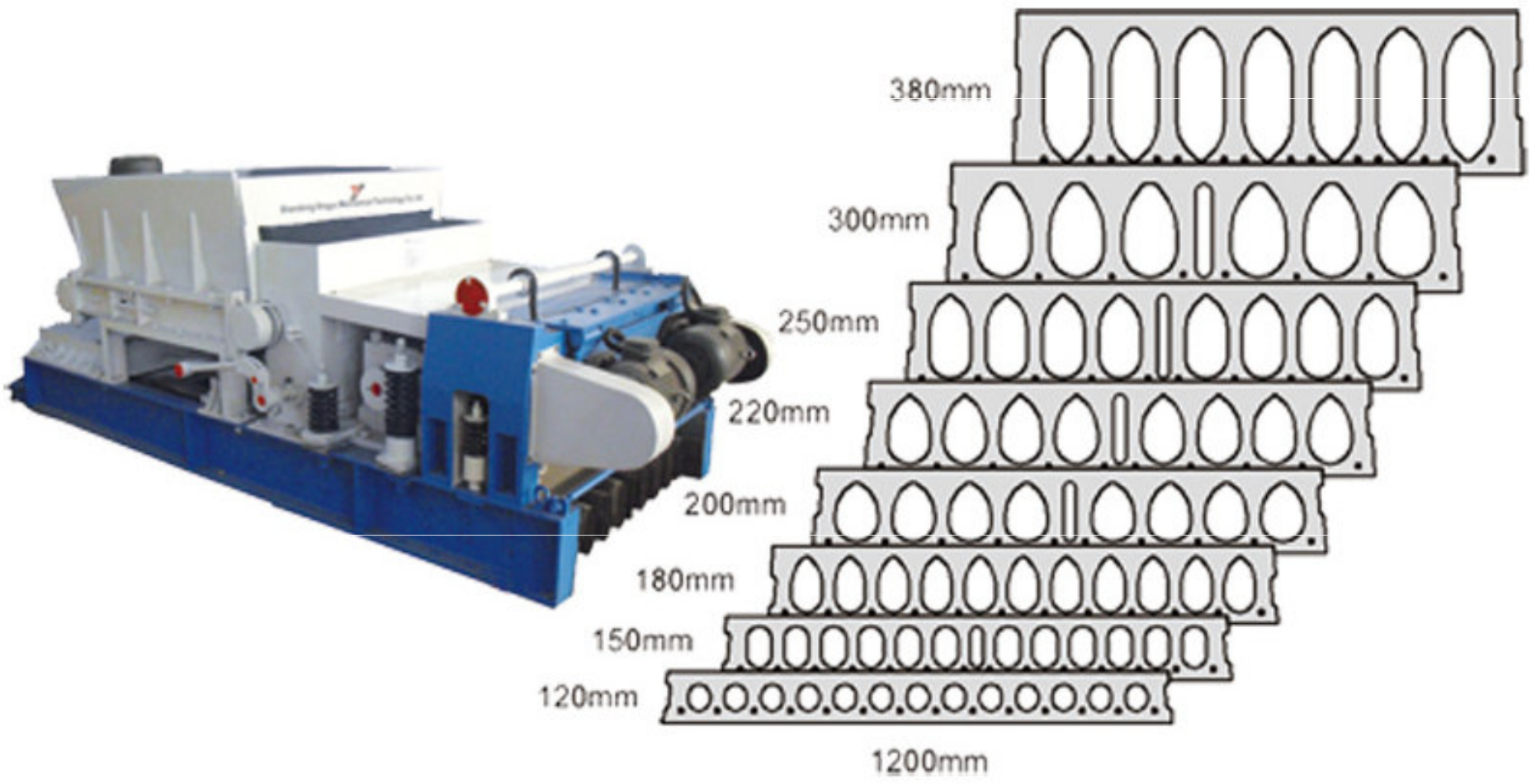
Various Cross-sections by Slip-Form Method

- ✓ Hollow core slabs
- ✓ U panel
- ✓ Lintels
- ✓ Inverted T & I beams
- ✓ Inverted double T slabs
- ✓ Solid slabs
- ✓ Vineyard posts

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



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Floor Manufacturing-Comparison

Wet-Cast	Slipform	Extrusion
Low Capex	High Capex	High Capex
High cement consumption	Moderate cement consumption	Low cement consumption
Versatile	Versatile	Only H/C
Projecting steel Possible		
Low in Quality	Moderate Quality	High Quality
Less Efficient / Turn-over time	Efficient	Highly Efficient
Labor Intensive	Moderate Labor force	Reduction in Labor
Negligible Maintenance cost	Moderate Maintenance cost	High Maintenance cost

Manufacturing of Precast Walling Units

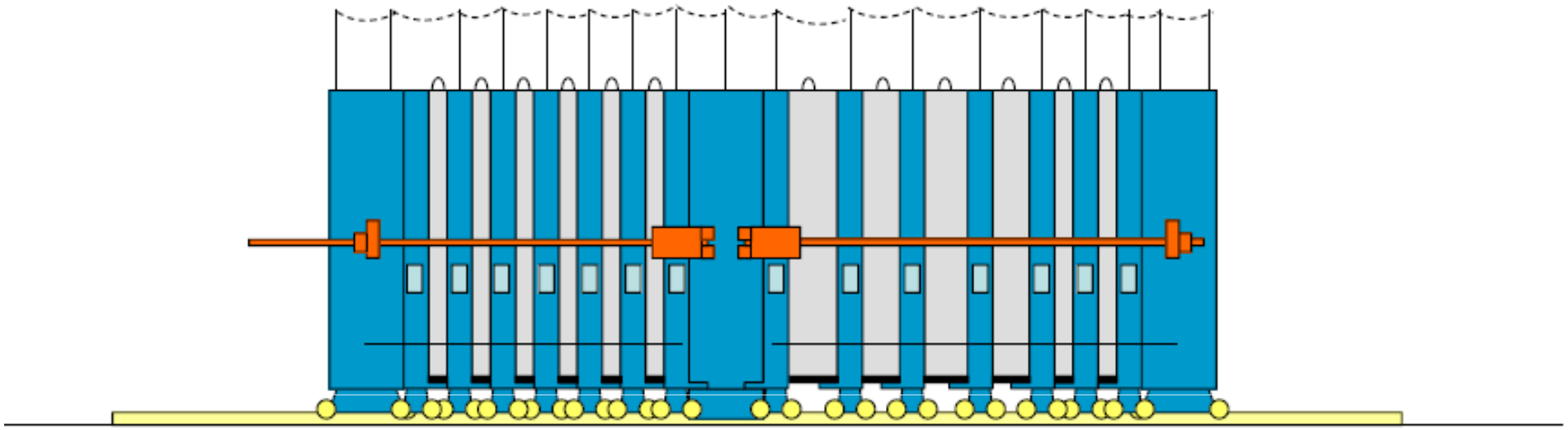
- The Precast Walls are generally manufactured in size up to 9-12 m. in length & floor to floor height (approx. 3 m.)
- Such walls can be manufactured using Battery Moulds (Vertically) or using Tilting Tables or Circulation Plant (Horizontally).

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.

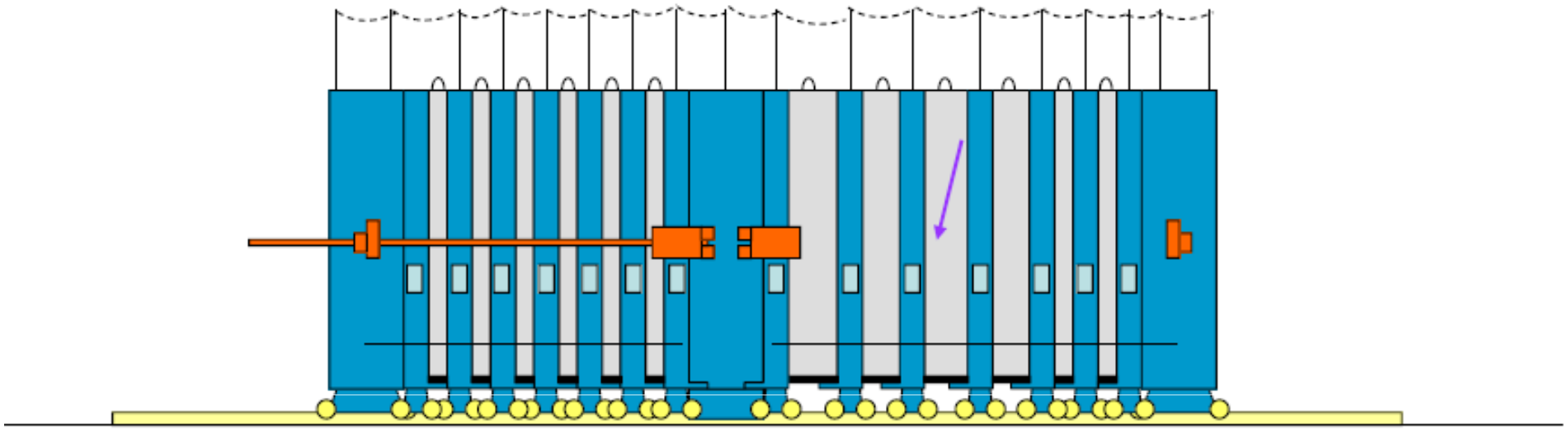
Battery Mould Operations

Production principle



Battery Mould Operations

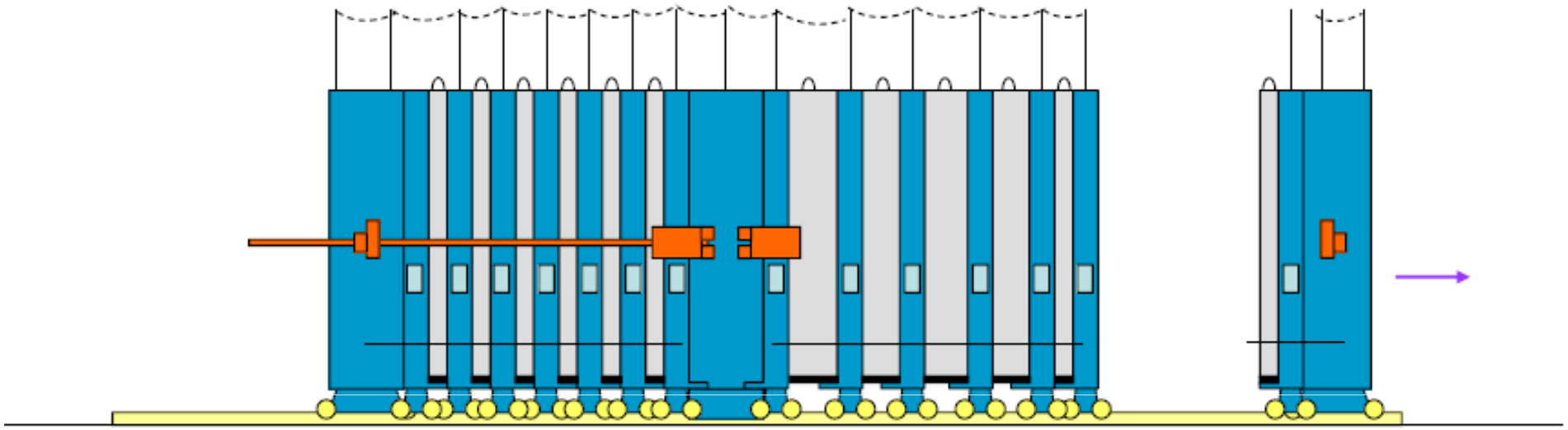
Production principle



Open (hydraulic) clamp ramps

Battery Mould Operations

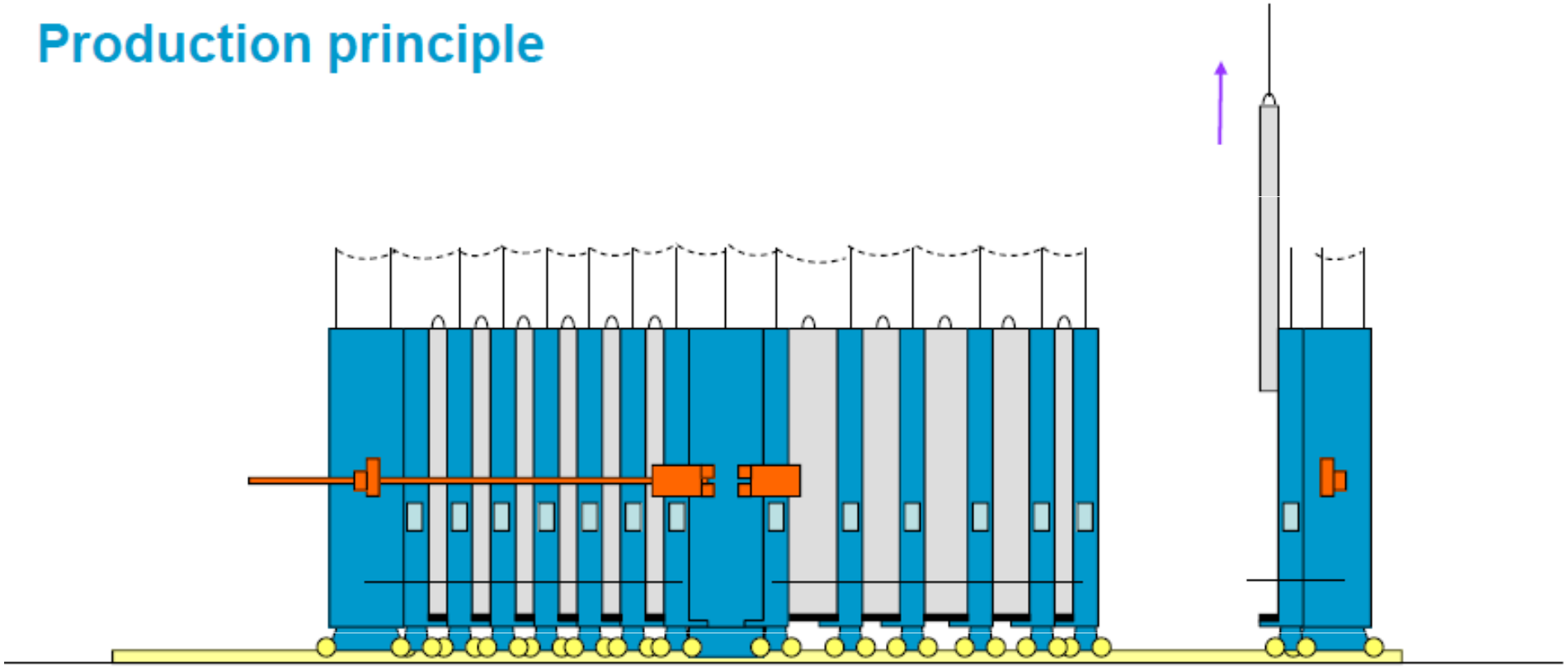
Production principle



Move end wall with first intermediate mould plate

Battery Mould Operations

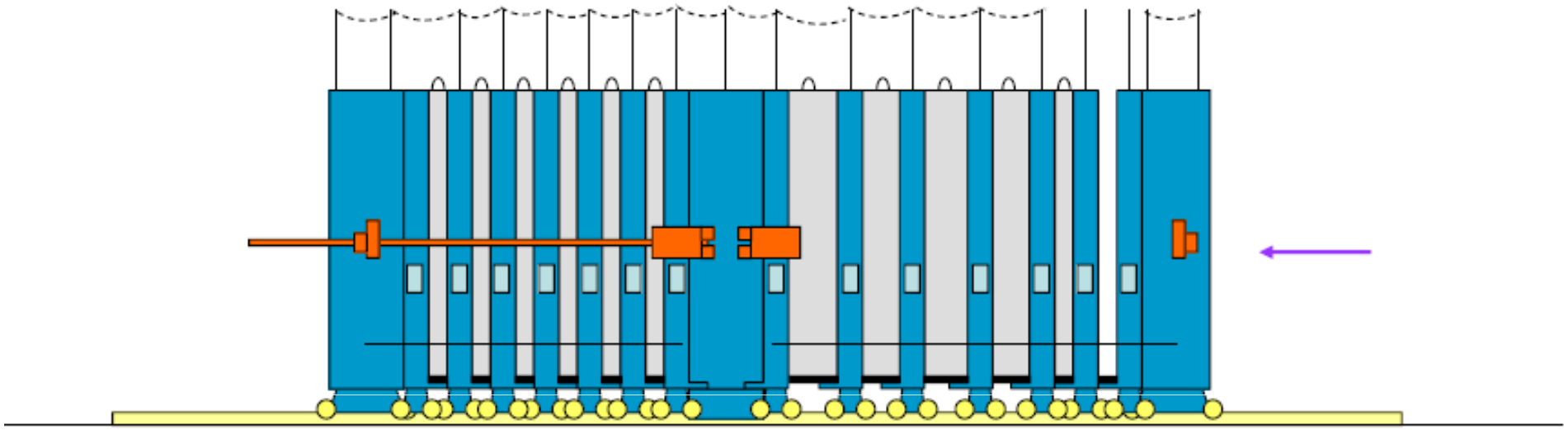
Production principle



Remove panel

Battery Mould Operations

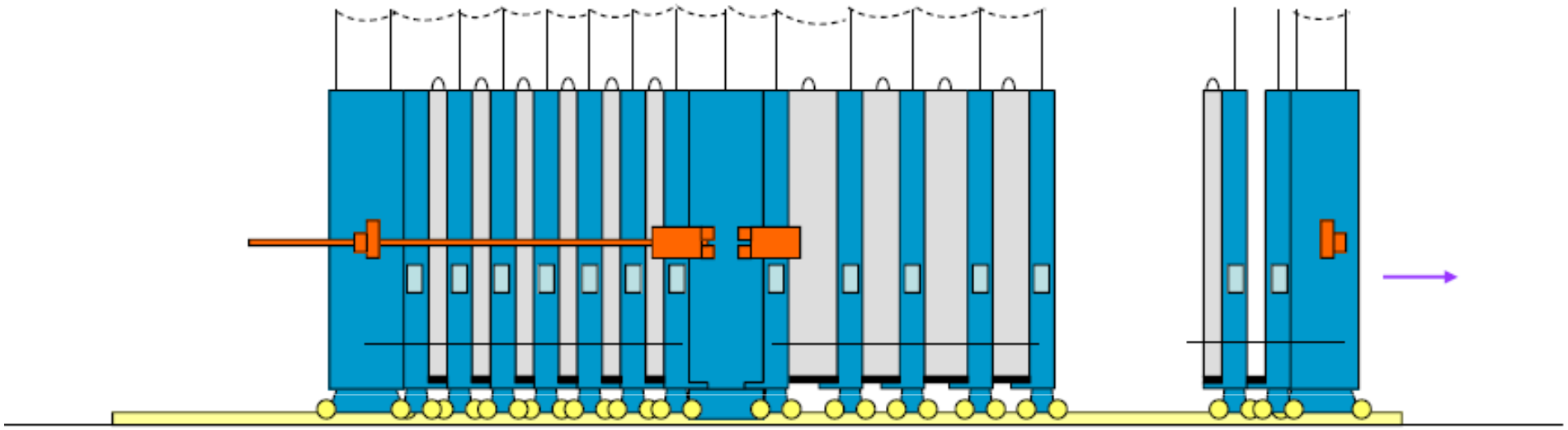
Production principle



Move end wall to catch next intermediate mould plate

Battery Mould Operations

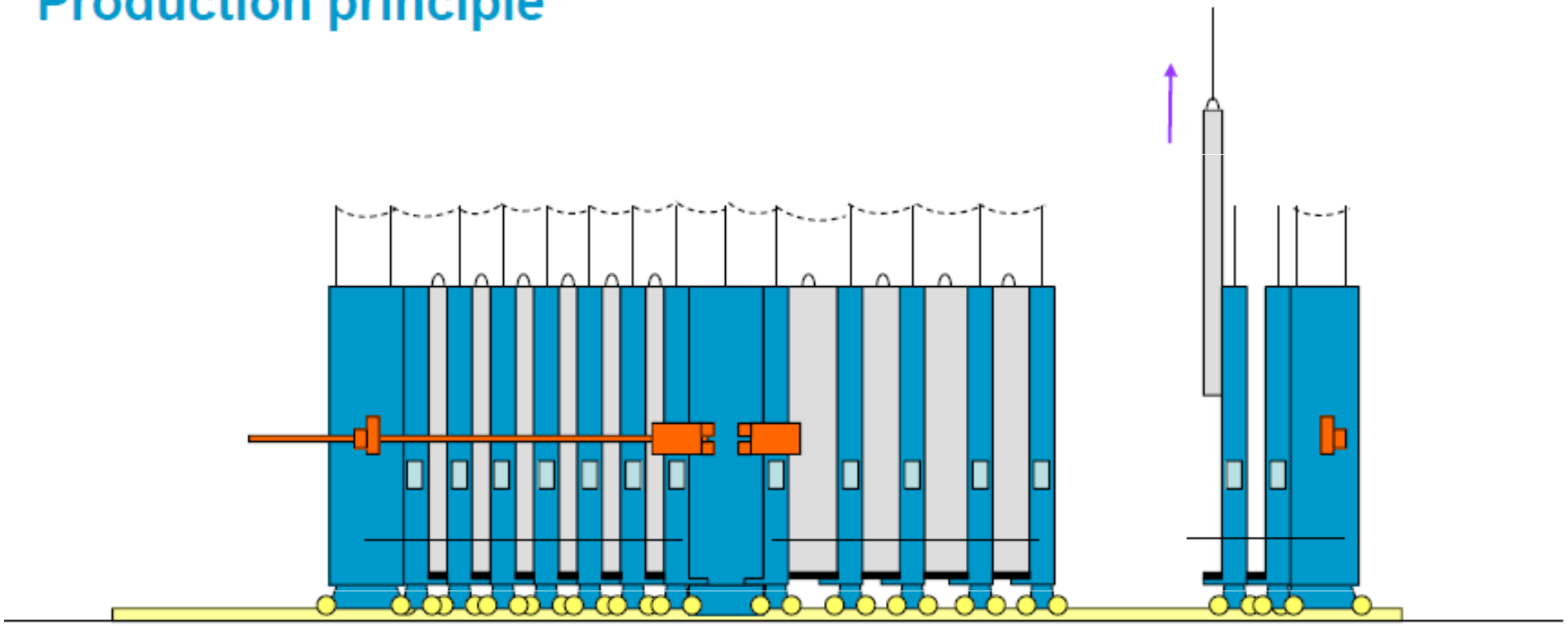
Production principle



Move end walls with next intermediate mould plate

Battery Mould Operations

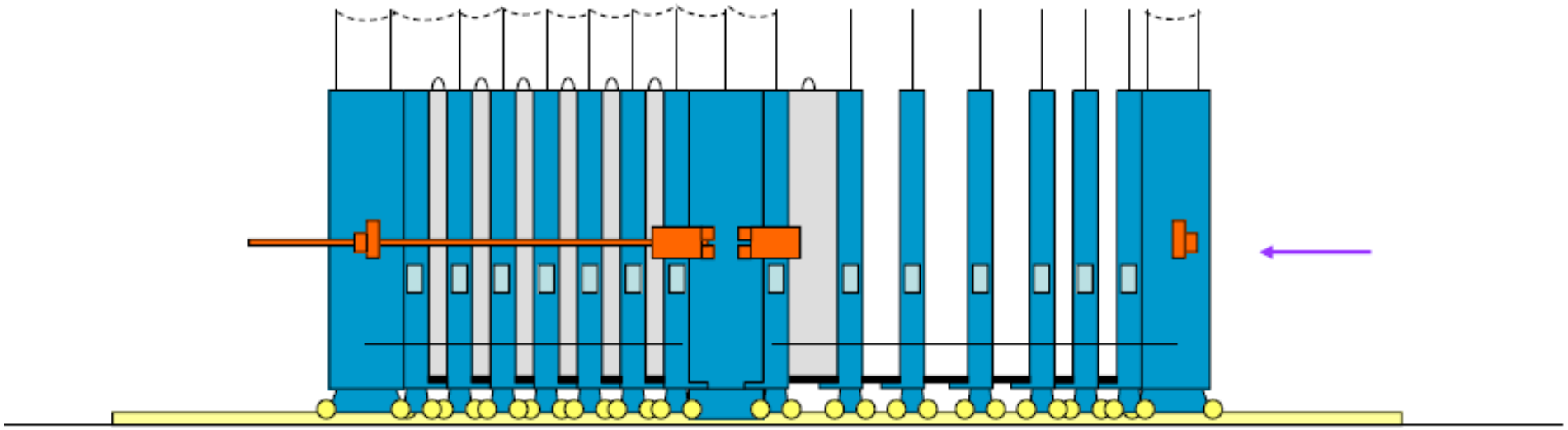
Production principle



Remove panel

Battery Mould Operations

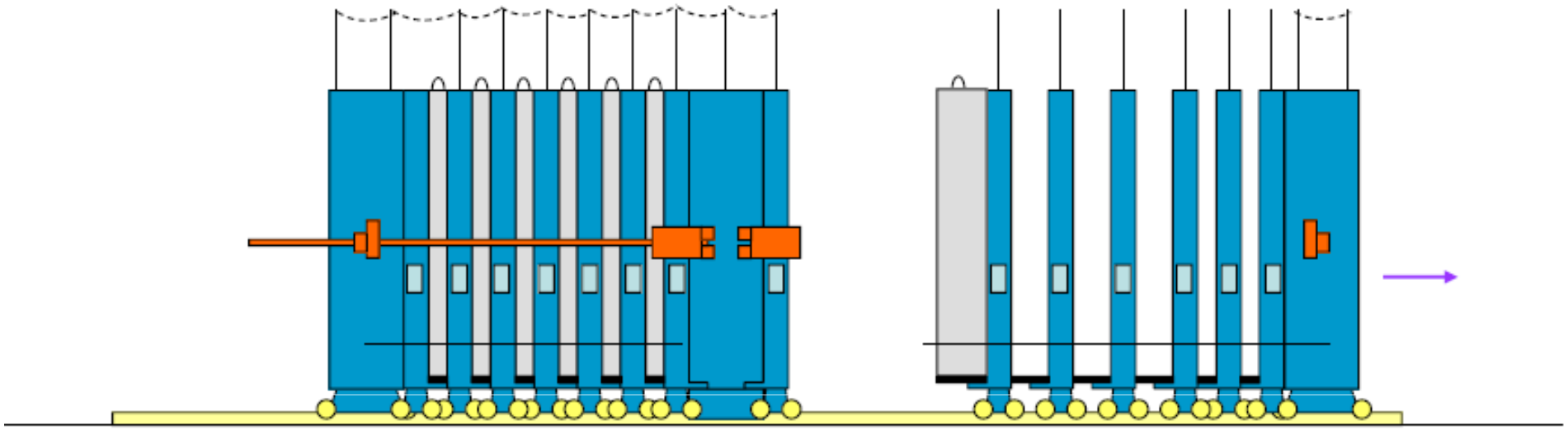
Production principle



Move end wall to catch last intermediate mould plate

Battery Mould Operations

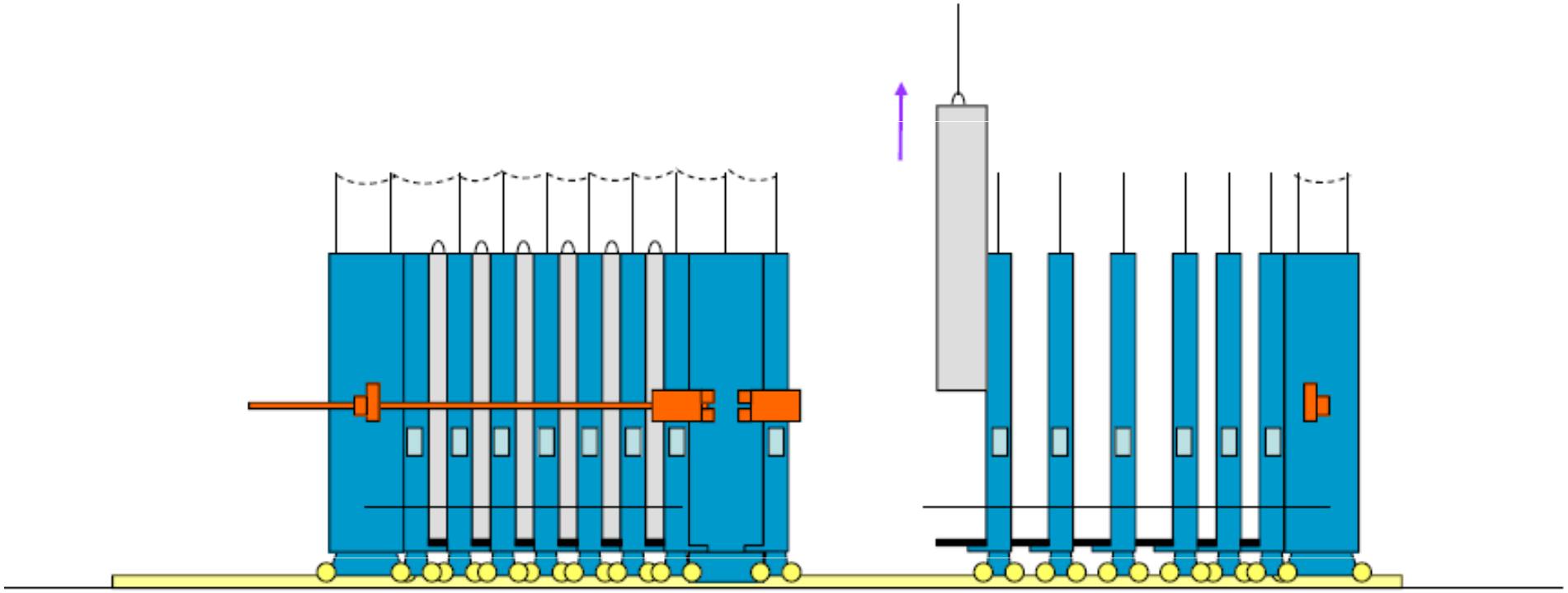
Production principle



Move end wall with last intermediate mould plate

Battery Mould Operations

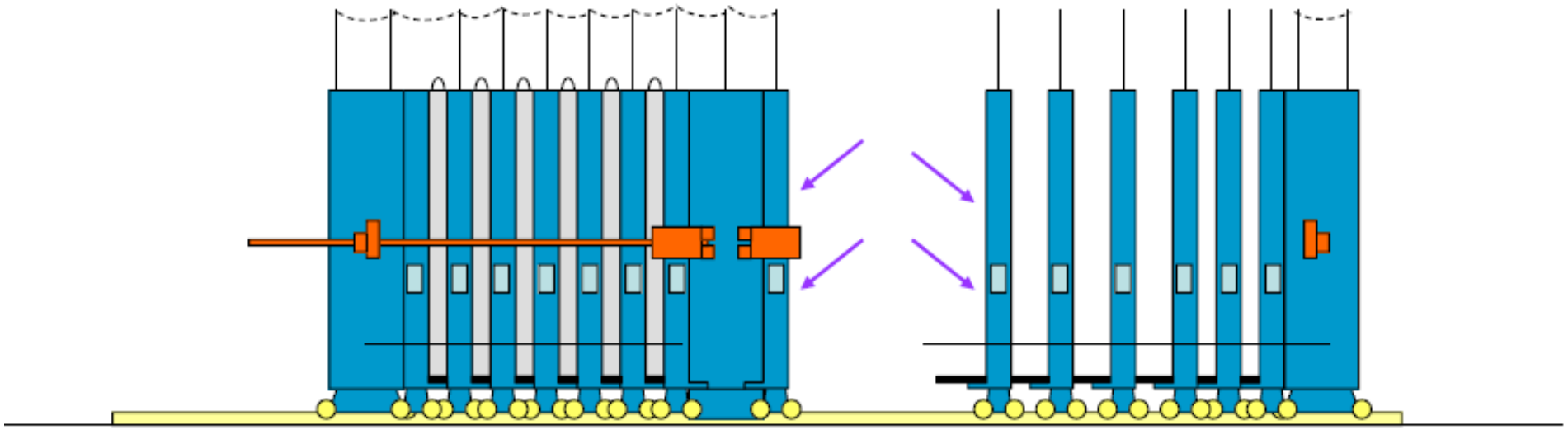
Production principle



Remove panel

Battery Mould Operations

Production principle

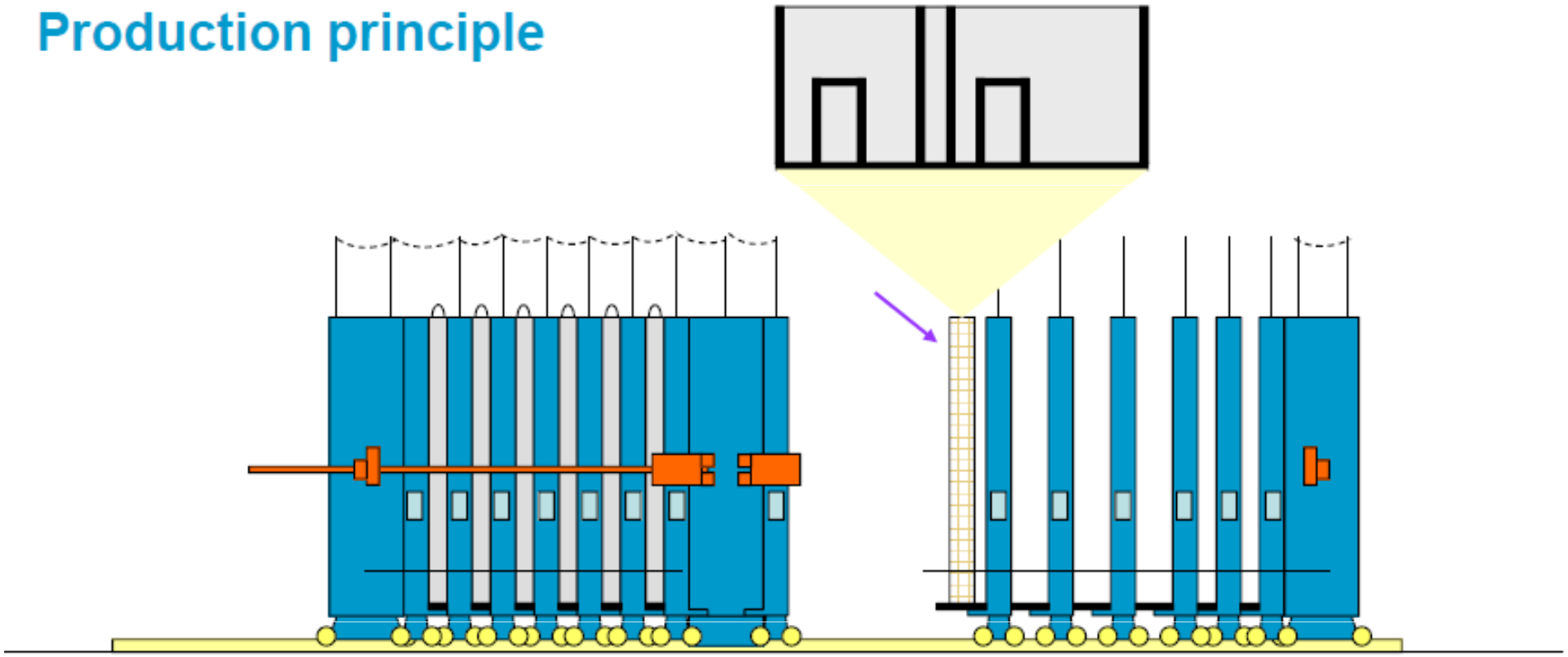


Clean walls

Oil walls

Battery Mould Operations

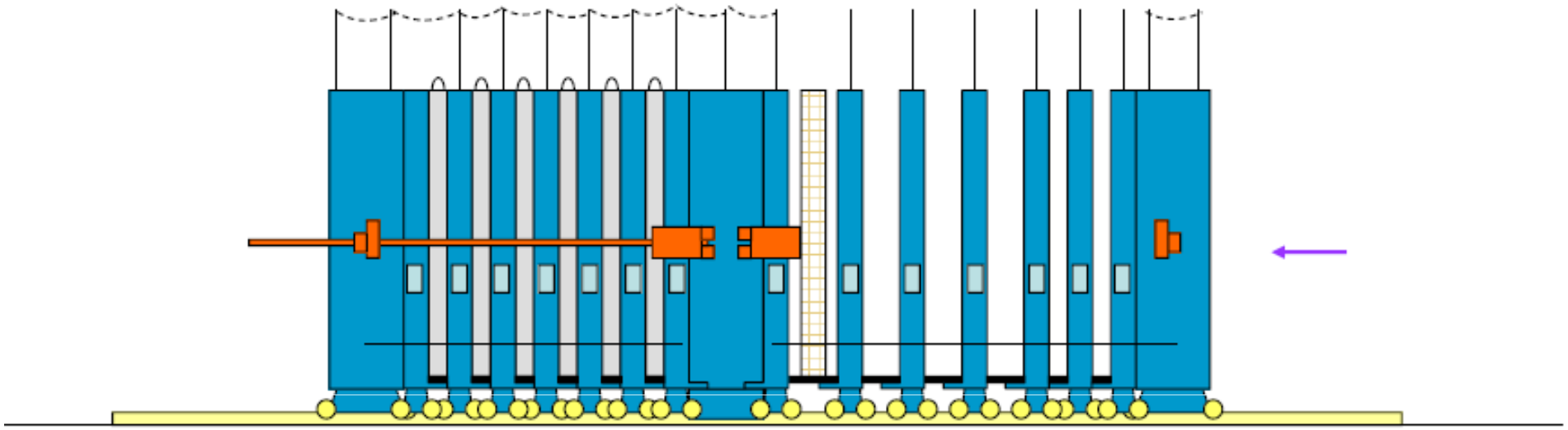
Production principle



Assemble panel

Battery Mould Operations

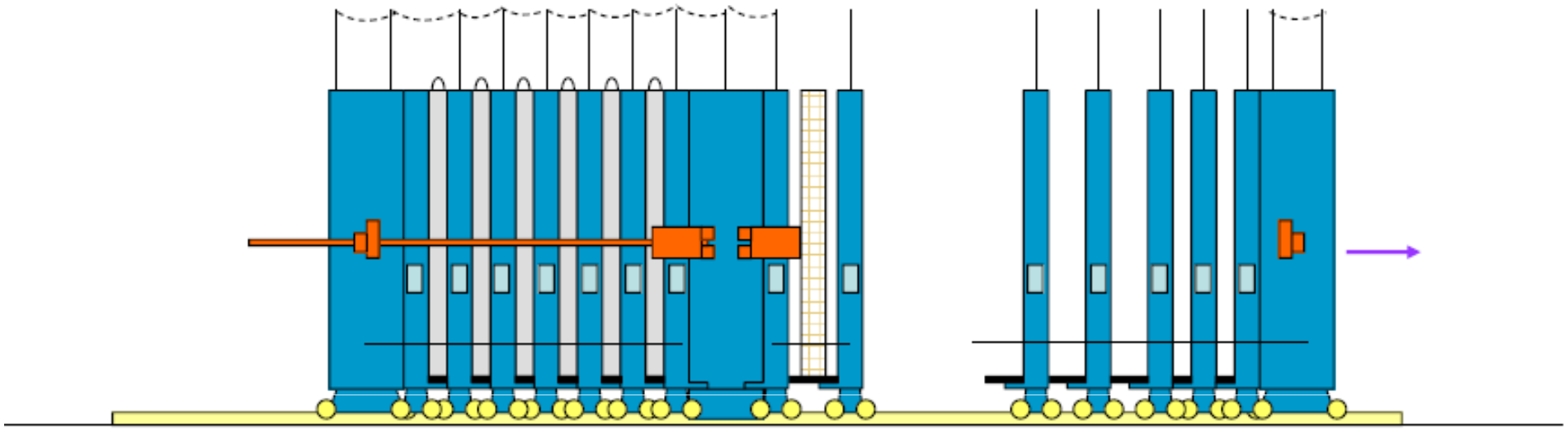
Production principle



Move end wall with intermediate mould plates

Battery Mould Operations

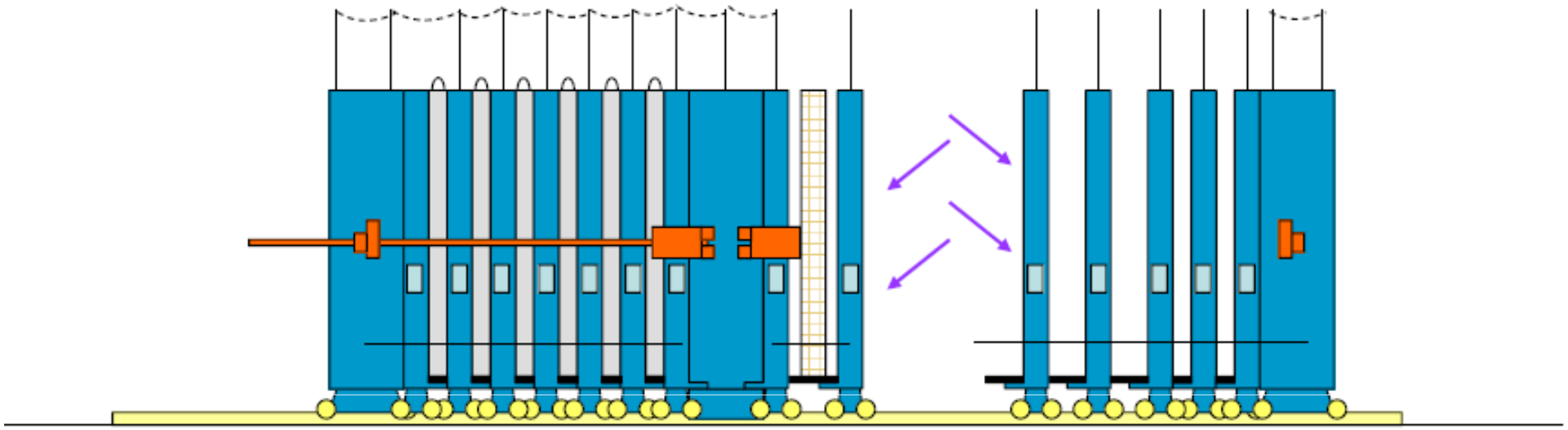
Production principle



Move end wall with intermediate mould plates

Battery Mould Operations

Production principle



Clean walls

Oil walls

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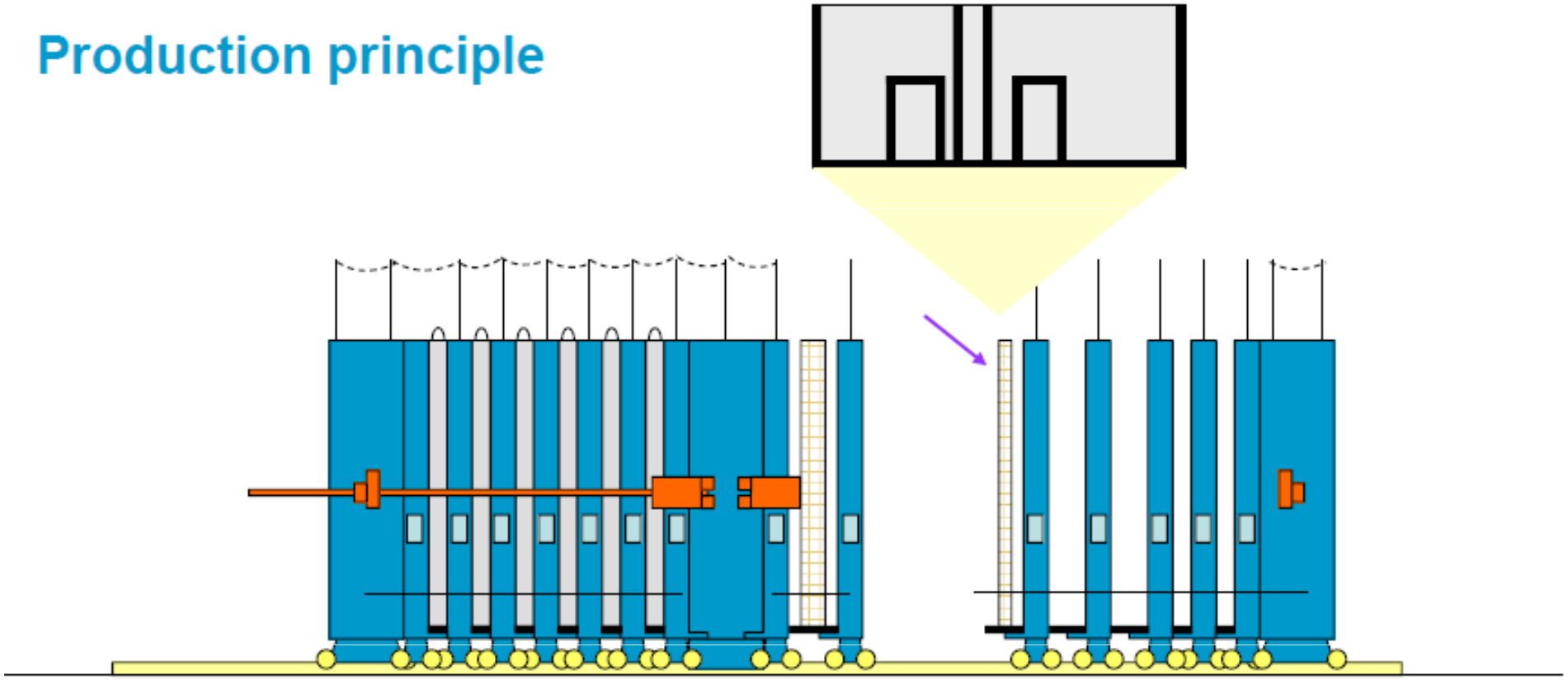
Battery Mould Operations

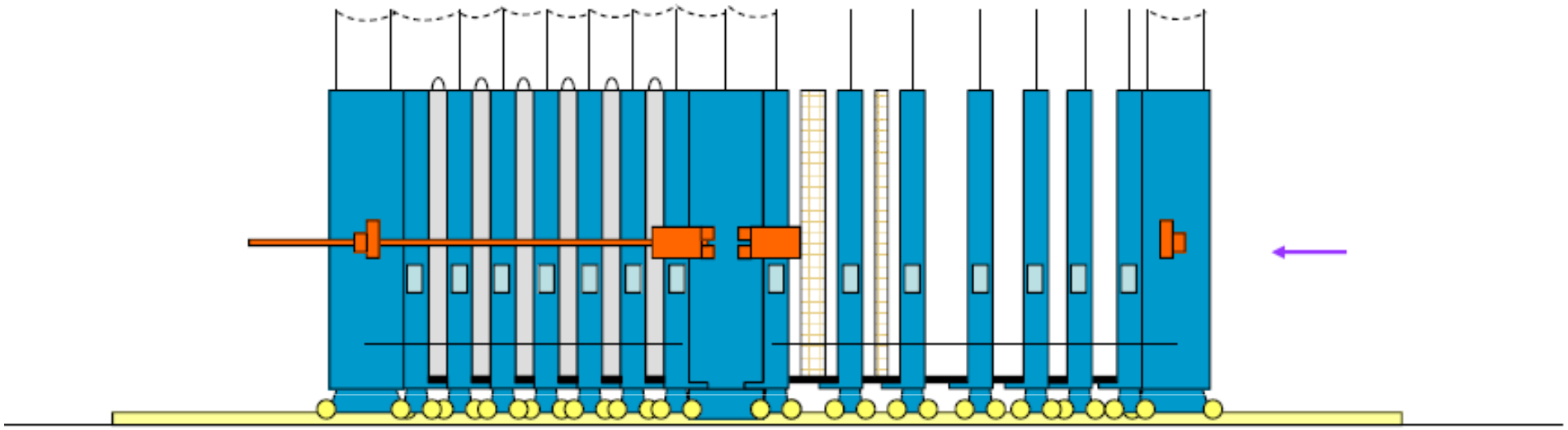
Production principle



Assemble panel

Battery Mould Operations

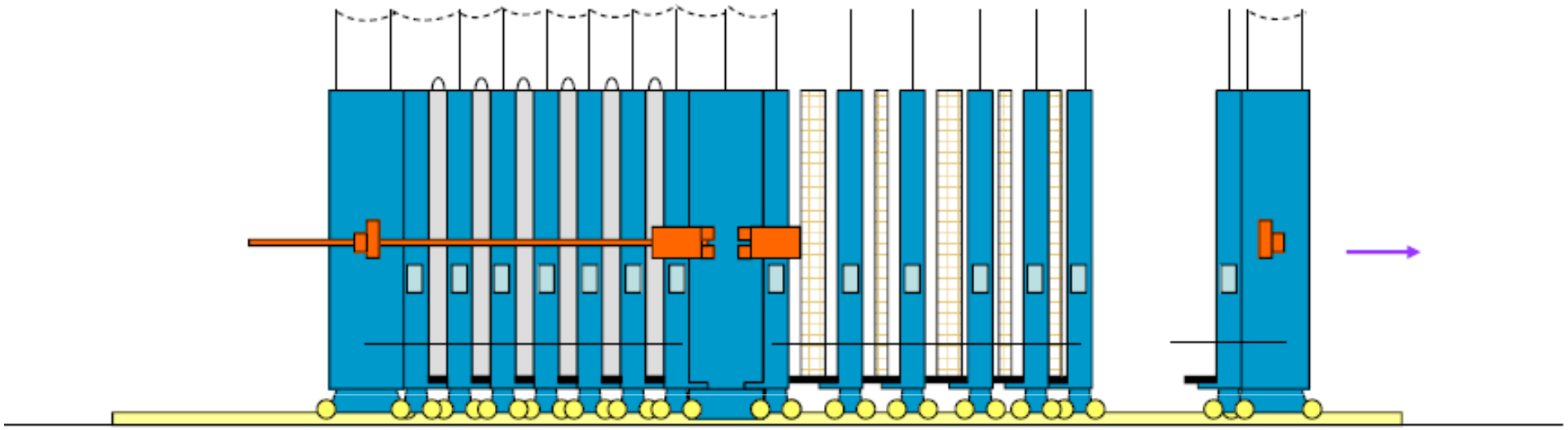
Production principle



Move end wall with intermediate mould plates

Battery Mould Operations

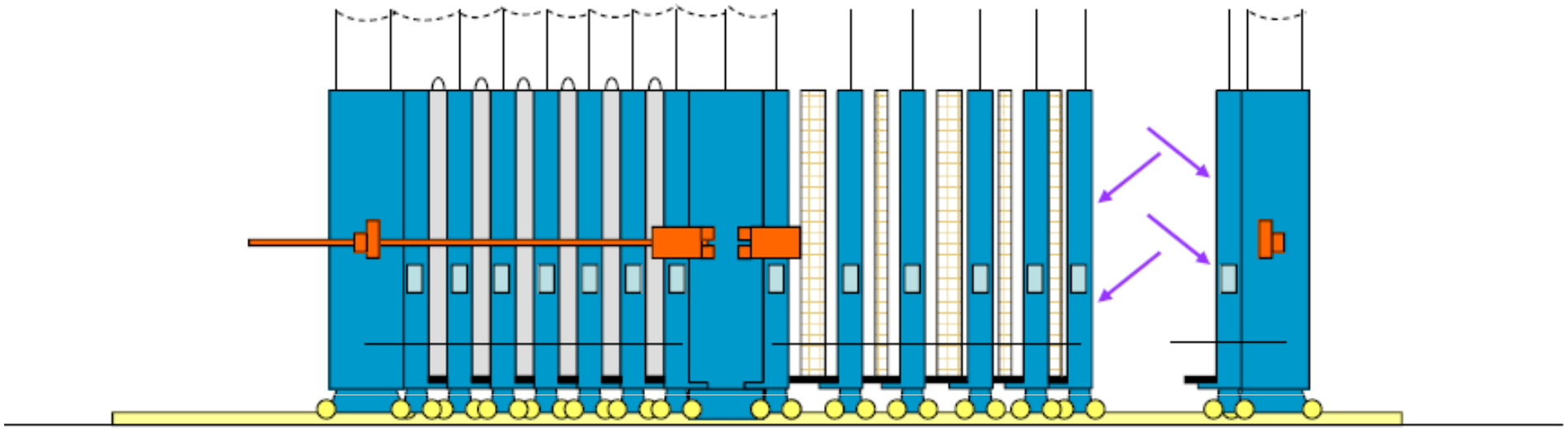
Production principle



Move end wall with last intermediate mould plate

Battery Mould Operations

Production principle



Clean last walls

Oil last walls

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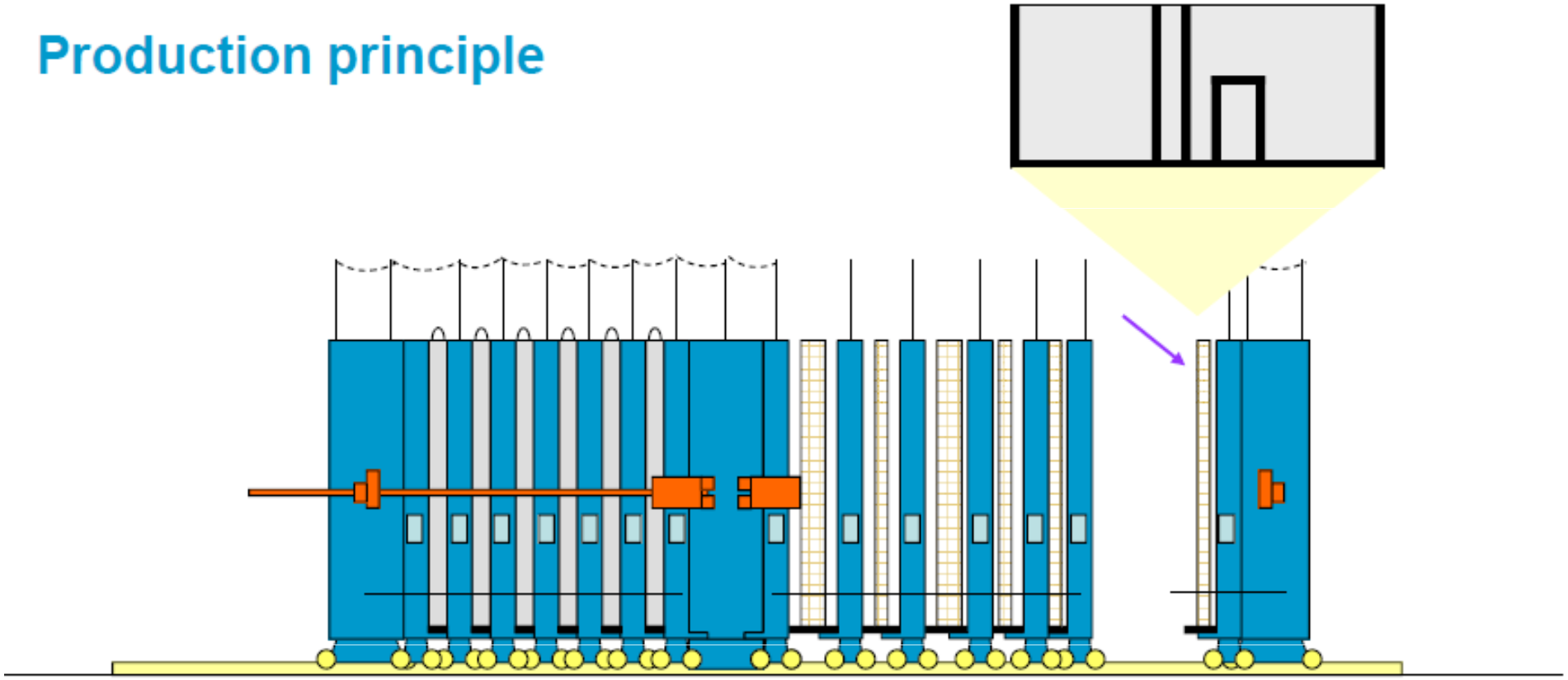
Battery Mould Operations

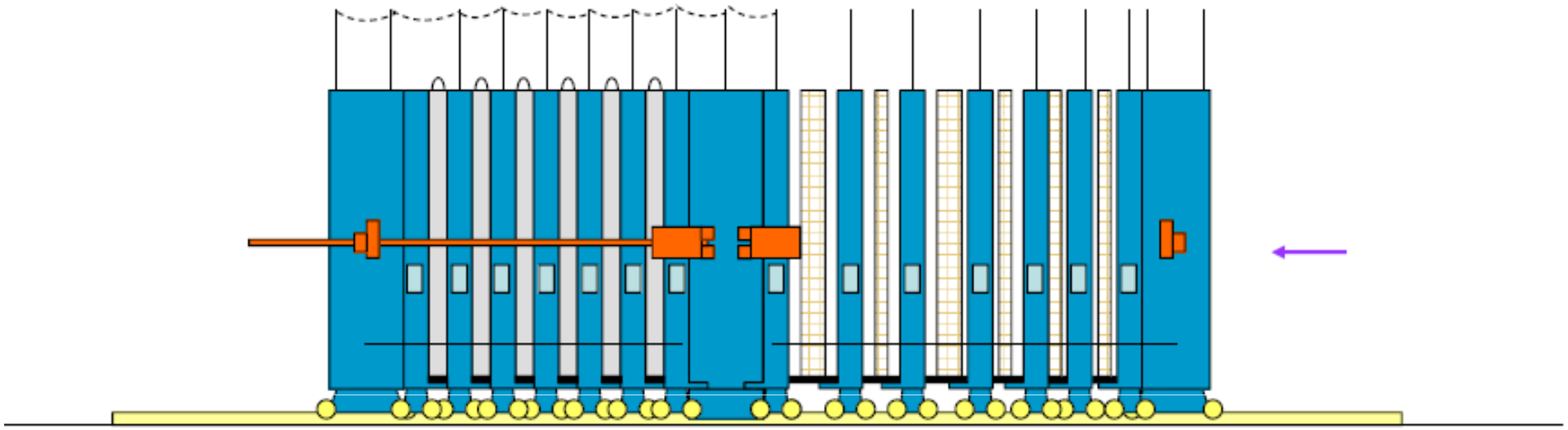
Production principle



Assemble panel

Battery Mould Operations

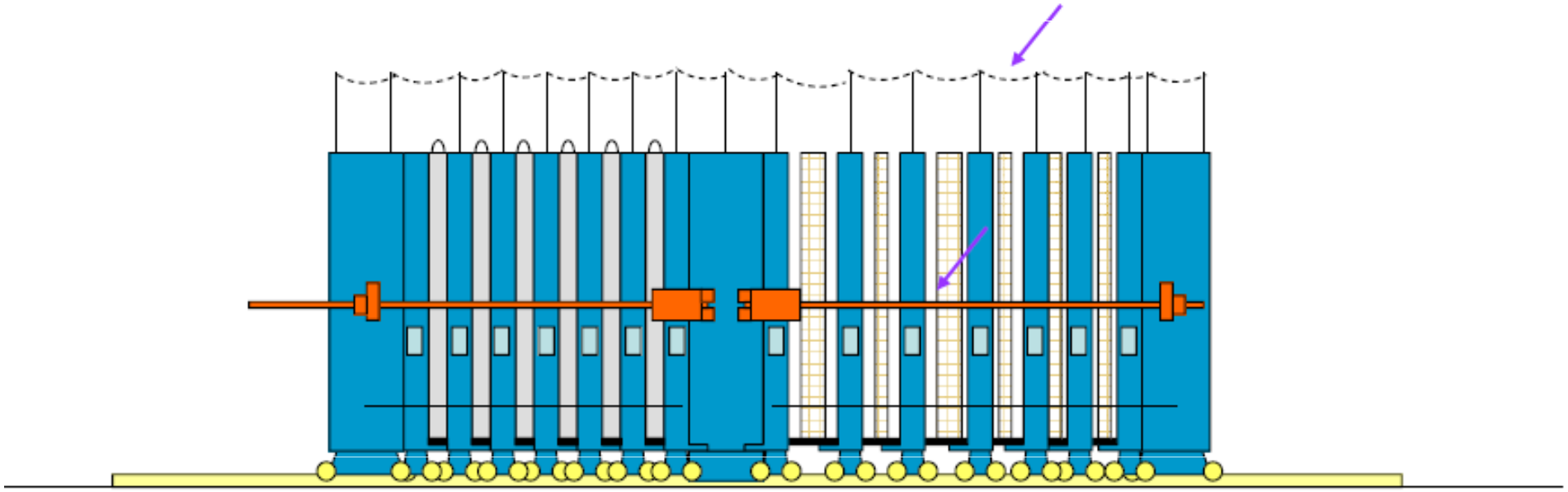
Production principle



Move end wall with last intermediate panel

Battery Mould Operations

Production principle



Close (hydraulic) clamp ramps

Save platform

Inspect cells

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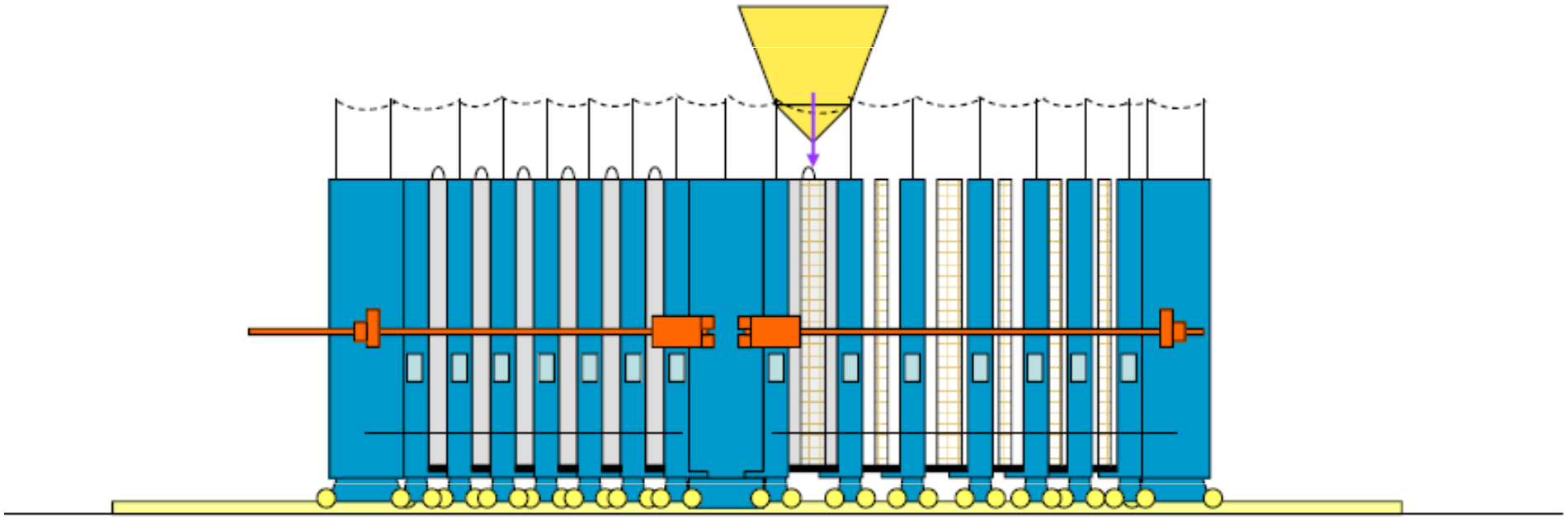
Battery Mould Operations

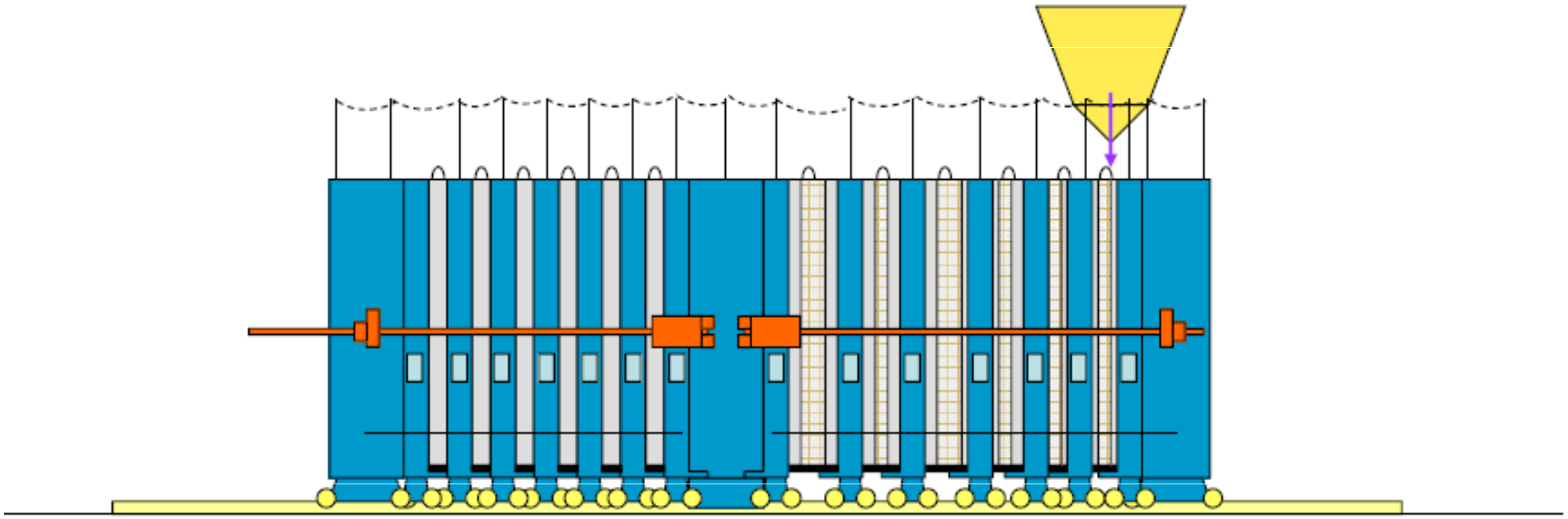
Production principle



Fill in concrete

Battery Mould Operations

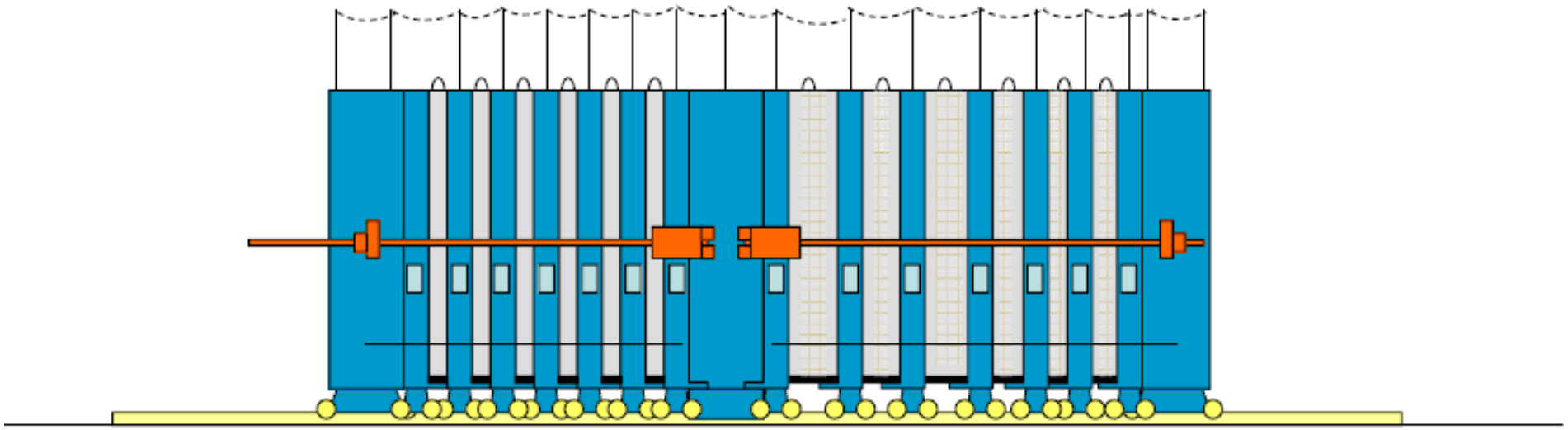
Production principle



Fill in concrete

Battery Mould Operations

Production principle



Curing

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.

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Wall manufacturing-Comparison

Battery Mould	Tilting Table	Circulation Plant
Space Saving		
Due to fall of 3.0m. concreting needs care.		
Solid Walls only	Solid, Sandwich, Rendered Walls, Solid Slabs.	Solid, Sandwich, Double walls & Solid, Filigree slabs.
Both Side Mould finish	One side Mould finish	One side Mould finish
Easy fixing of inserts on both sides		
Even Curing	Equipped with heating System	Curing Chamber, central shifter Reqd.
Labor Intensive	Moderate Labor force	Reduction in Labor
Can be operated in single shift only	Can be operated in single shift only	Can be operated in two shifts easily.
		Systematic & Efficient Production

Project Management & Supervision (QA/QC)

For Precast Production & Erection

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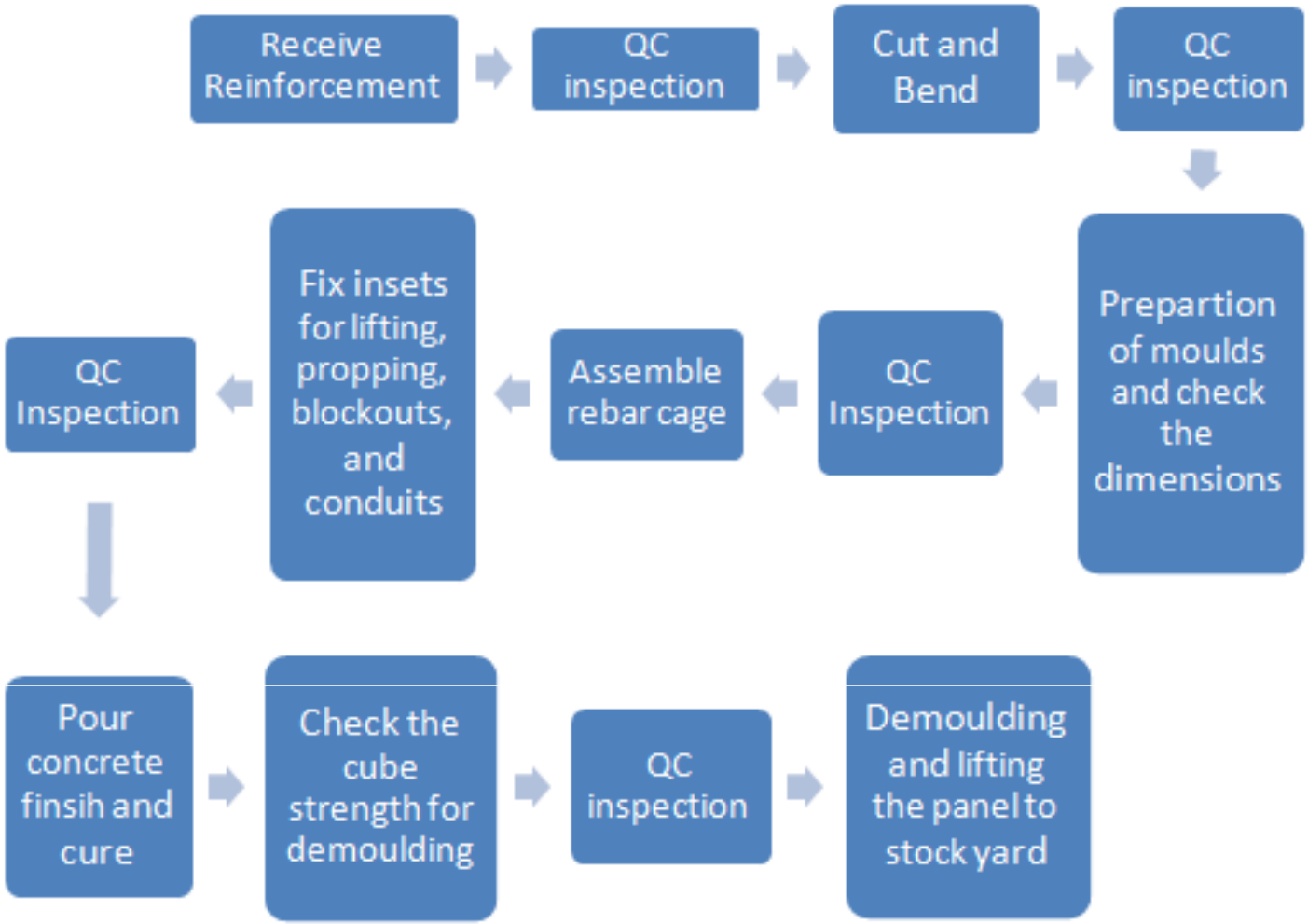
Flowchart of Precast Production



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.

The packers or support spacers should not be misaligned.

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

Column-wall-beam & Wall Panels should be stored vertically and braced in position by A- frames or a racking system.

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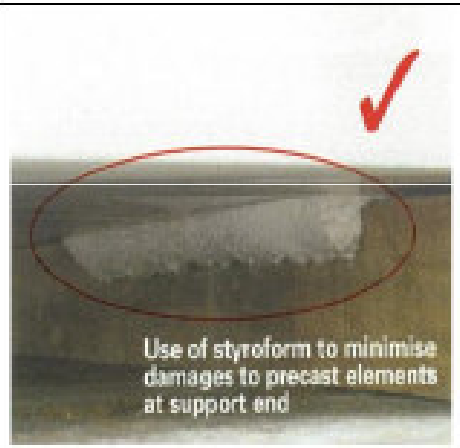
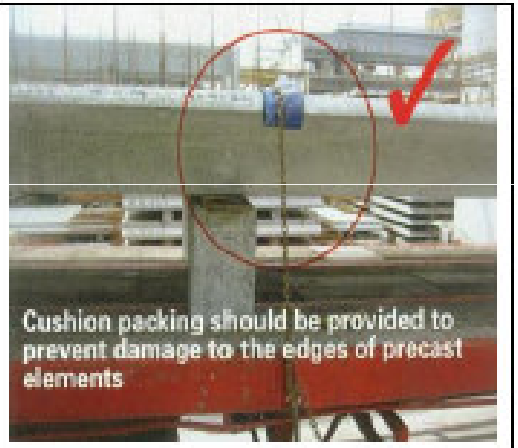
Guidelines for Transportation of Precast Elements





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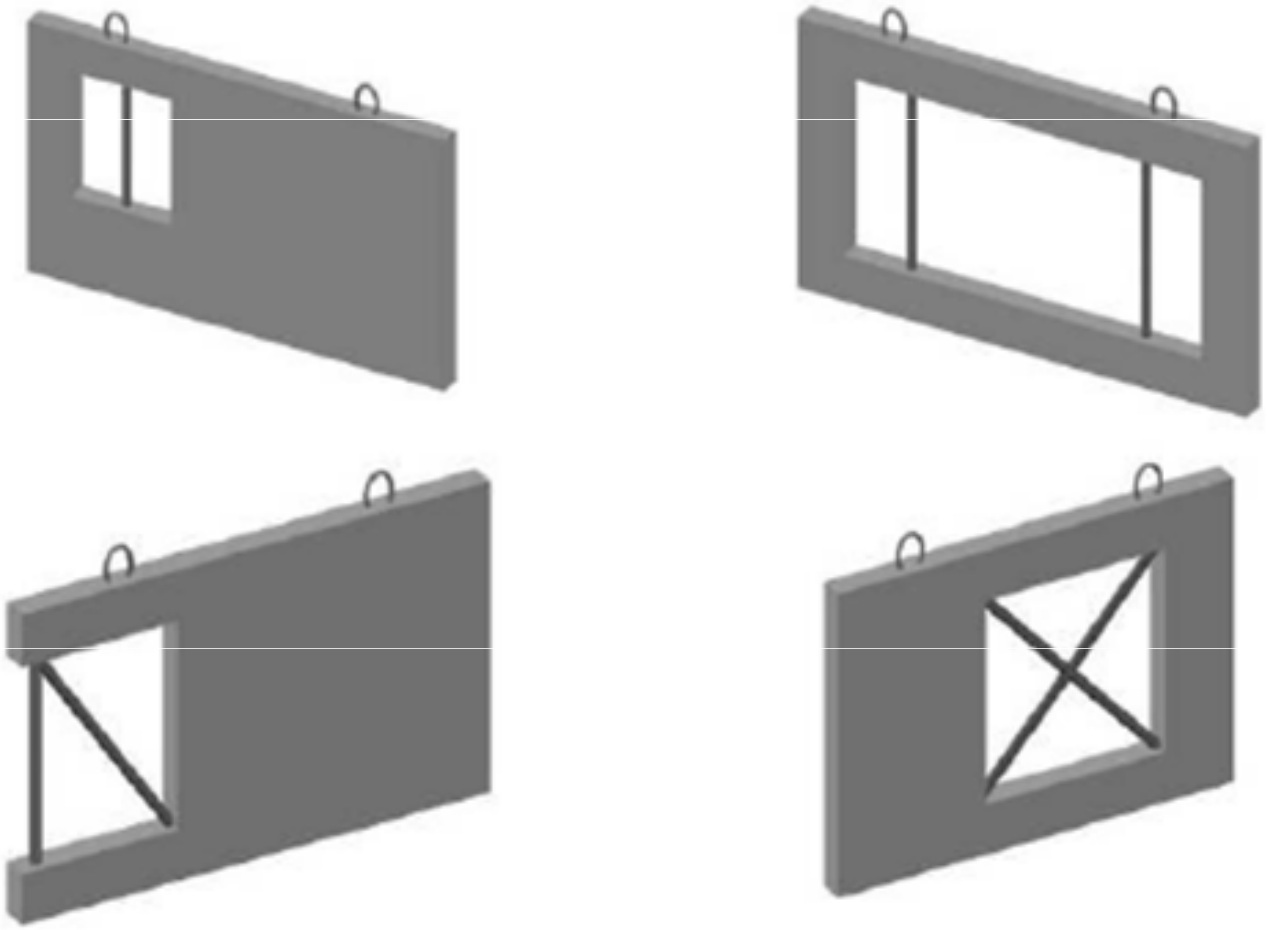
Erection Guidelines

Temporary Strengthening of Panels with openings



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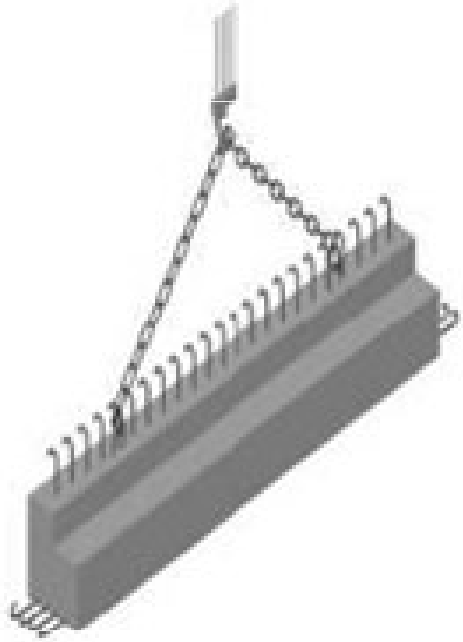
Erection Guidelines

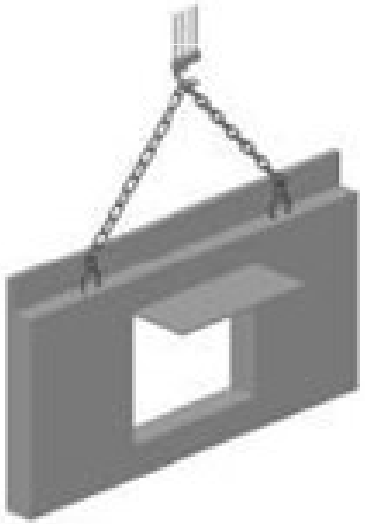
Precast Beam



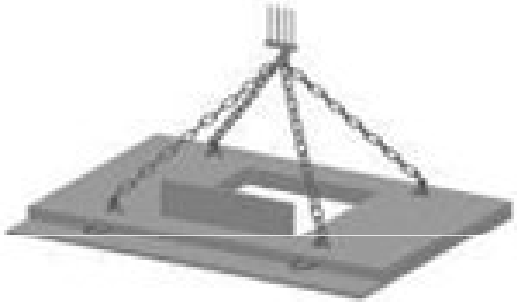
Note: The lifting points are designed and located to limit the bending moments within the beam element. As a general guide they should be located at about one fifth of the beam length measured from the edge.

Erection Guidelines

Precast Wall Panels



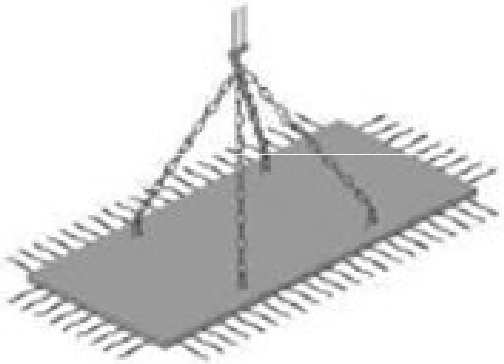
For wall panel, it is recommended to lift the wall panel in vertical position for installation so that turning is not required



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

Erection Guidelines

Precast slabs



Typical Erection Sequence

For Precast Wall Frame

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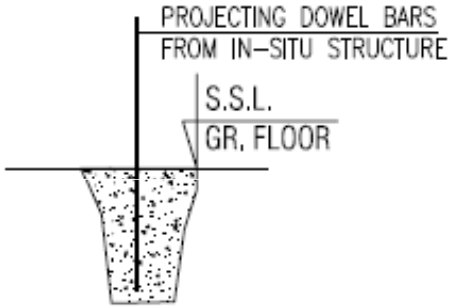
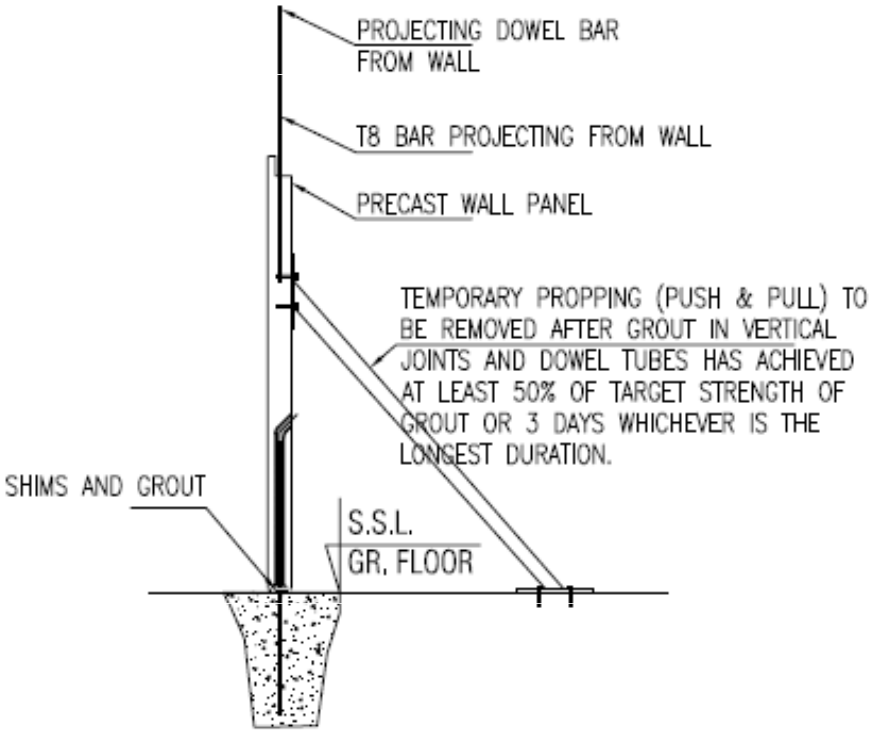
PRECAST ELEMENTS & FINAL STRENGHT	REQUIRED CONCRETE STRENGTHS AT DIFFERENT STAGES		
	FOR STRIPPING	FOR TRANSPORT	FOR ERECTION
PRECAST WALLS 40 N/mm^2	16 N/mm^2	20 N/mm^2	20 N/mm^2
PRECAST SLABS 40 N/mm^2	16 N/mm^2	20 N/mm^2	20 N/mm^2

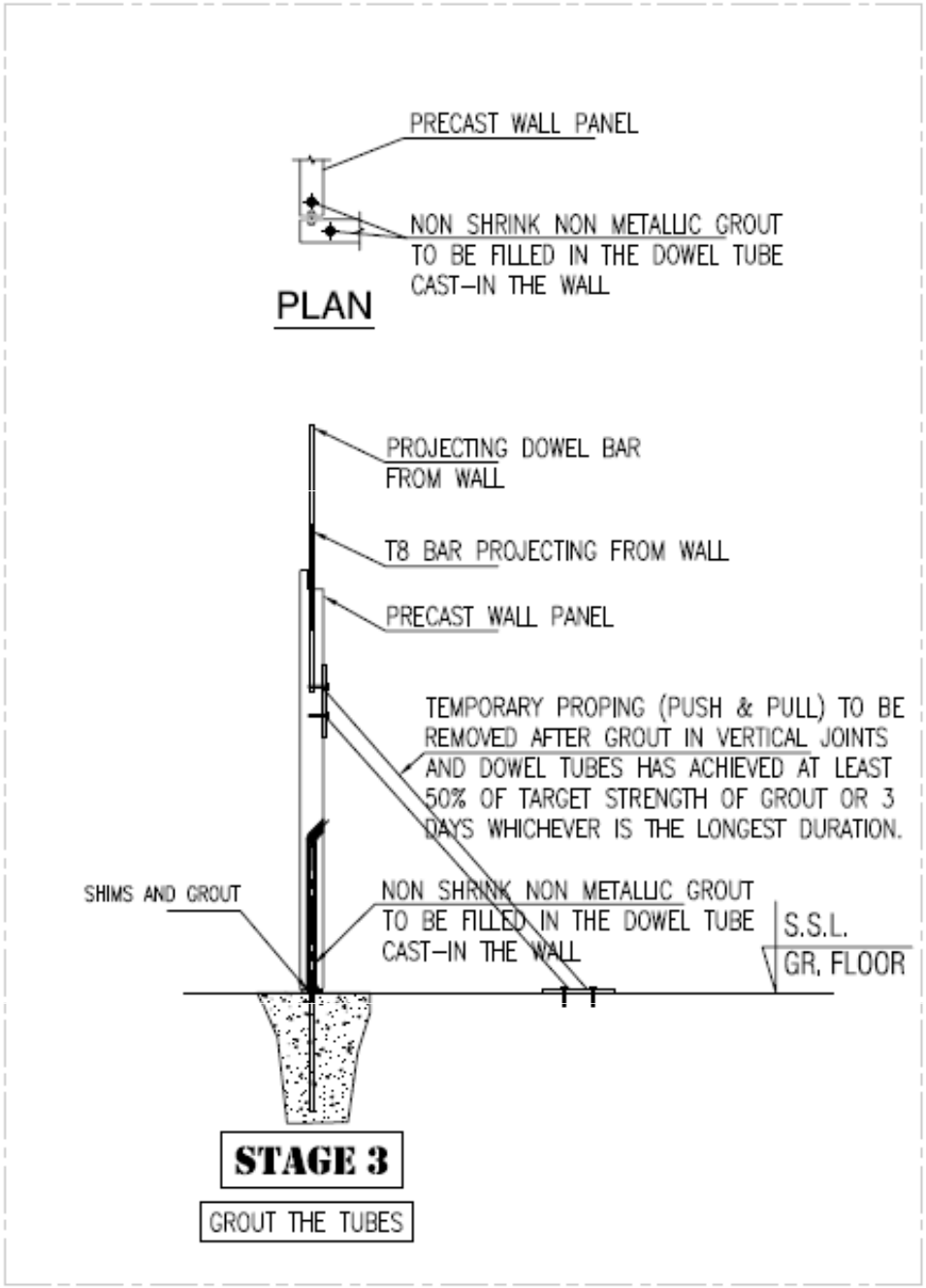


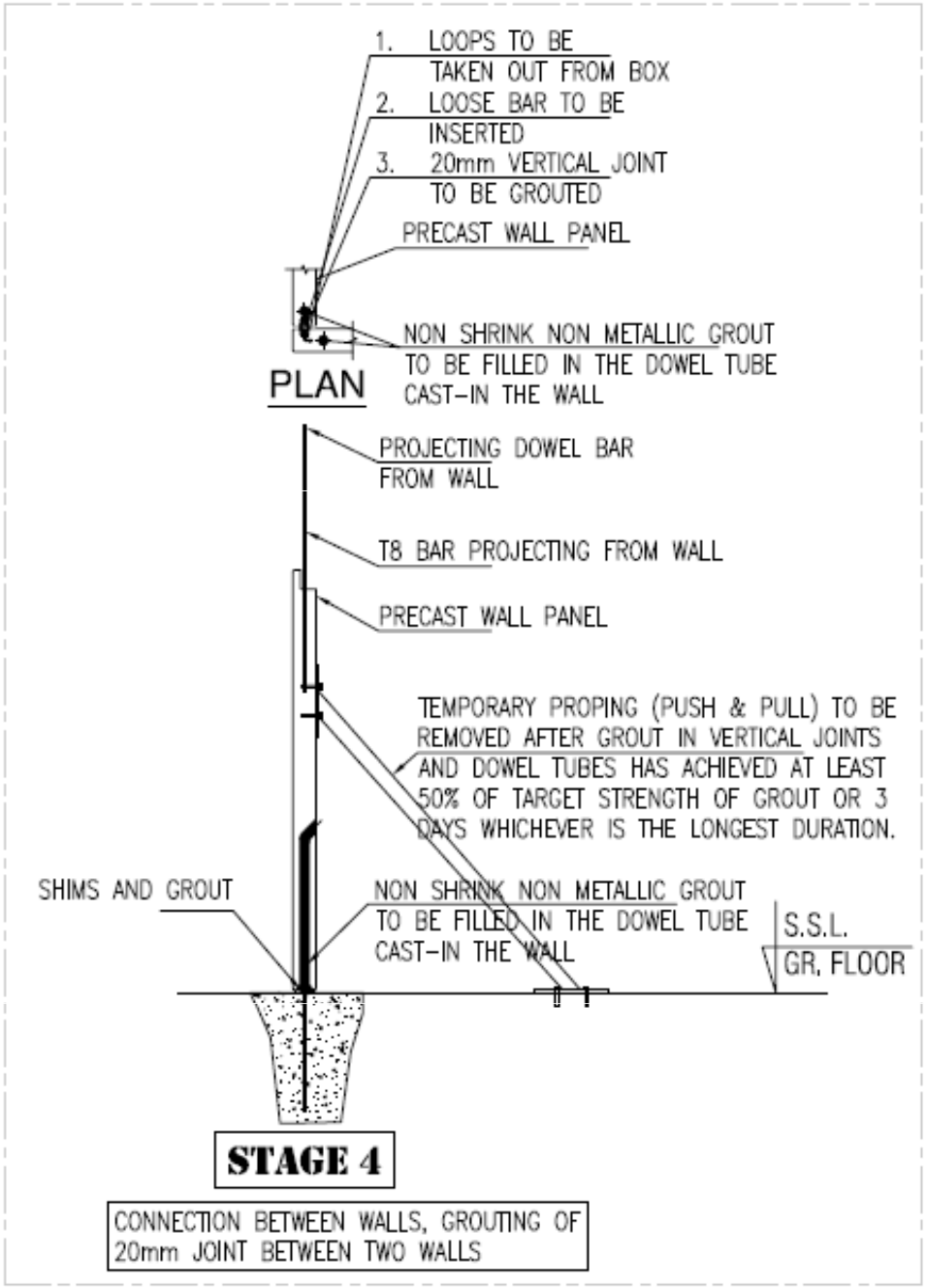
STAGE 1

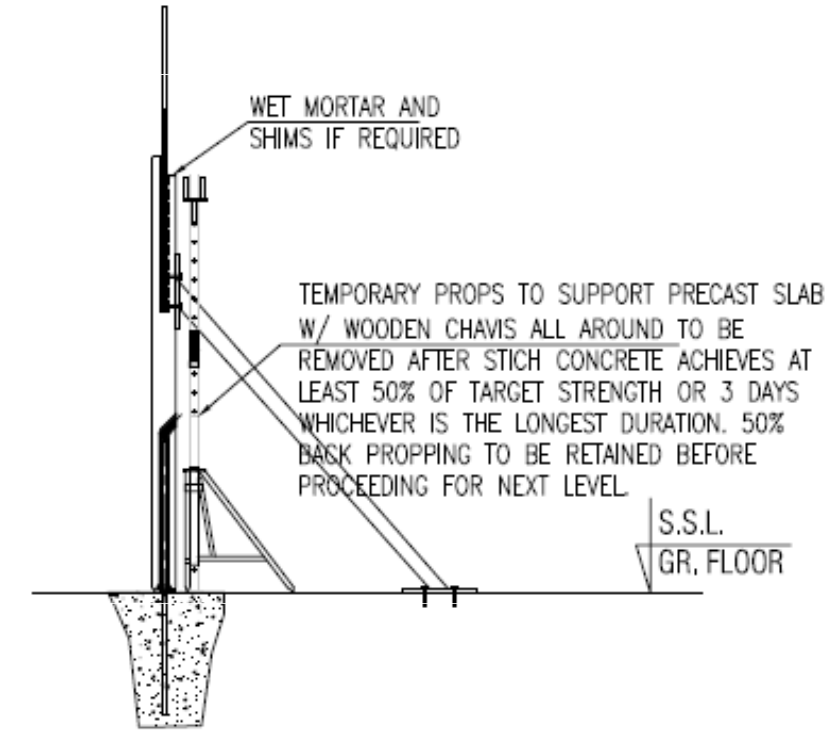


STAGE 2

LEVELLING,SHIMMING AND WALL POSITIONING AND FIXING

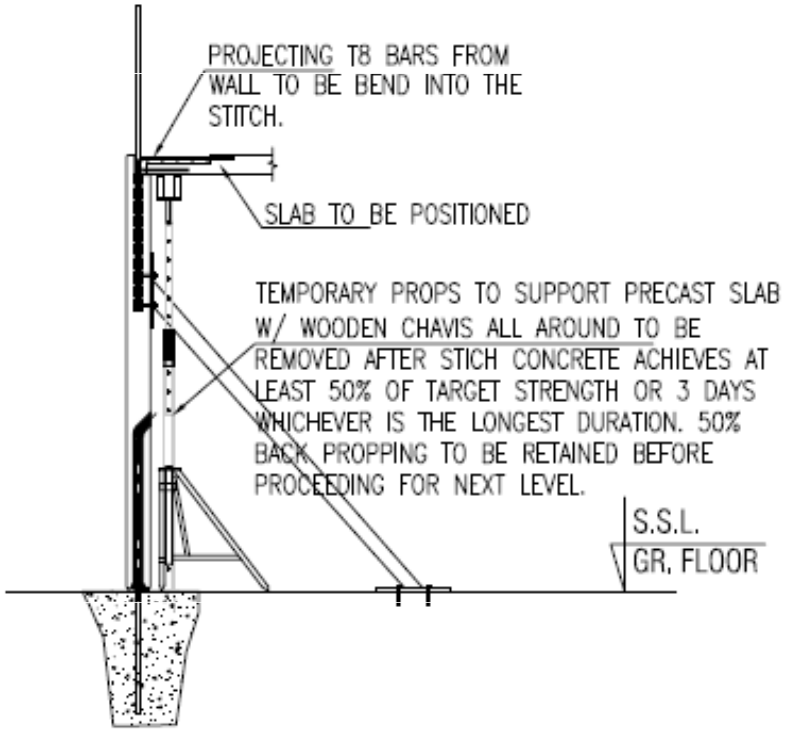






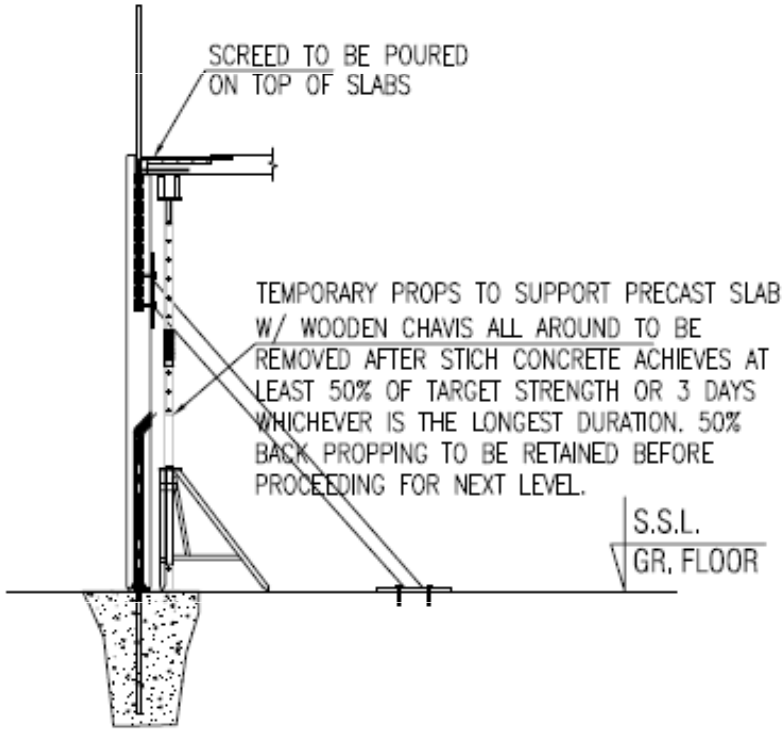
STAGE 5

PROPS TO BE SET FOR SLAB RESTING



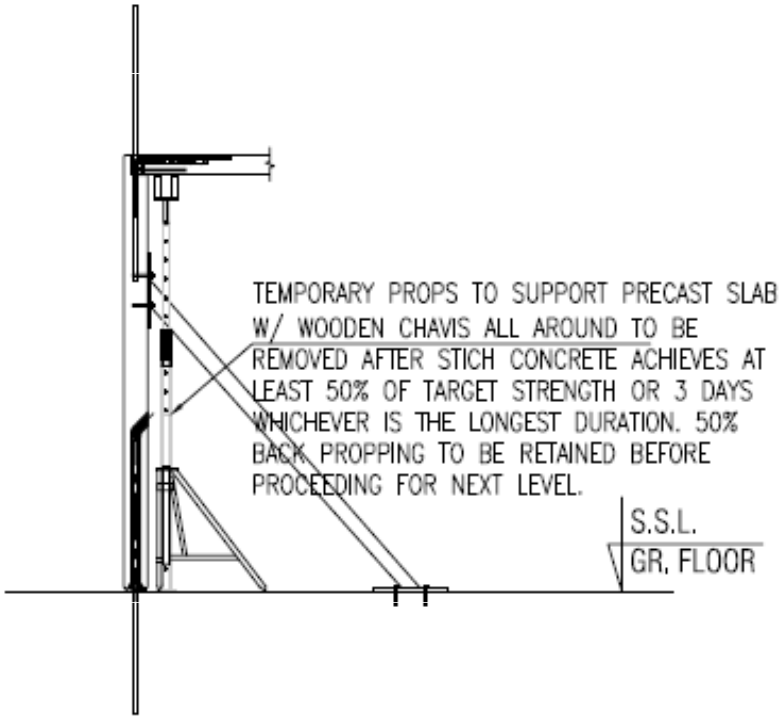
STAGE 6

SLAB POSITIONING



STAGE 7

STITCH CONCRETING



STAGE 8

READY FOR THE UPPER WALL TO BE ERECTED

Plant & Site Inspection

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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 or1/750 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

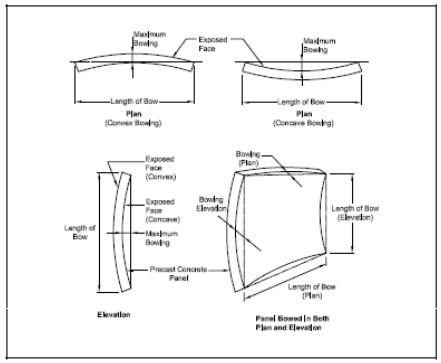
Twist:

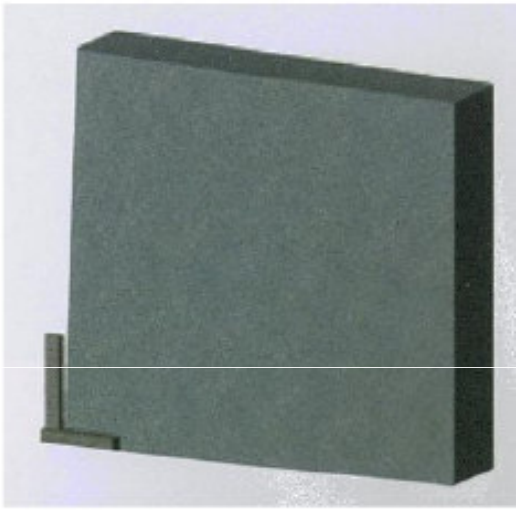
Any corner shall not be more than the tolerance given below from the plane containing the other corners:

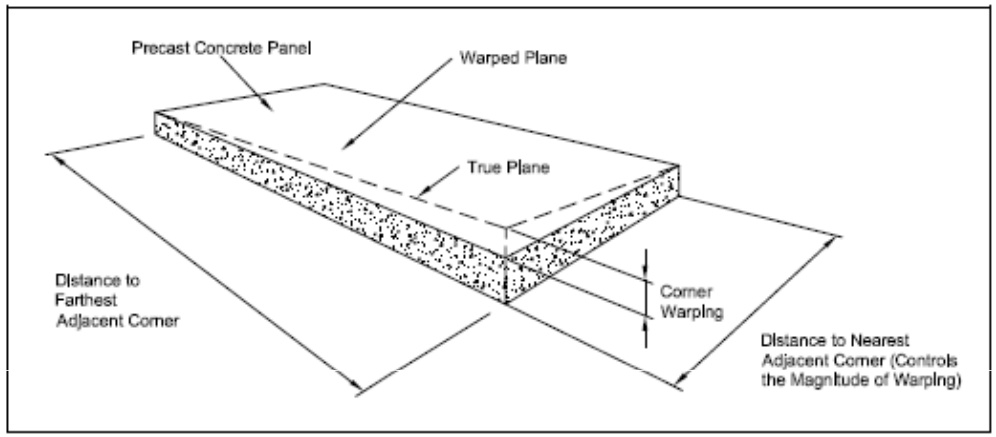
+/- 1/1500 of dimensions or +/- 5mm which ever is less

Flatness:

The maximum deviation from 1.5 m straight edge placed in any position on a nominal plane surface shall not exceed + / - 3mm







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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

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