

# Pre-fabrication adopted in HA

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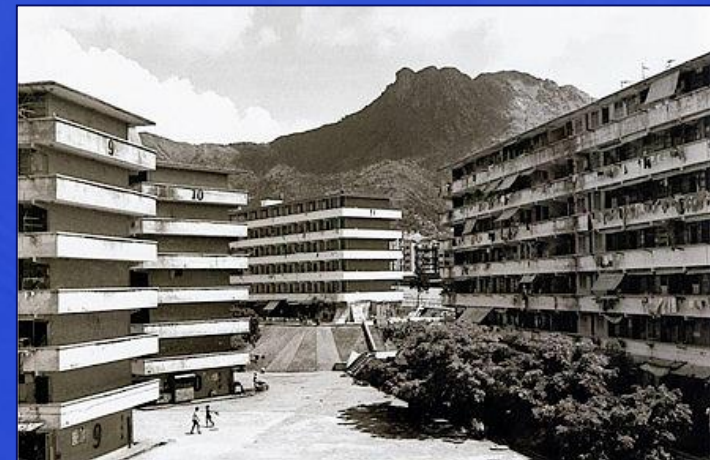
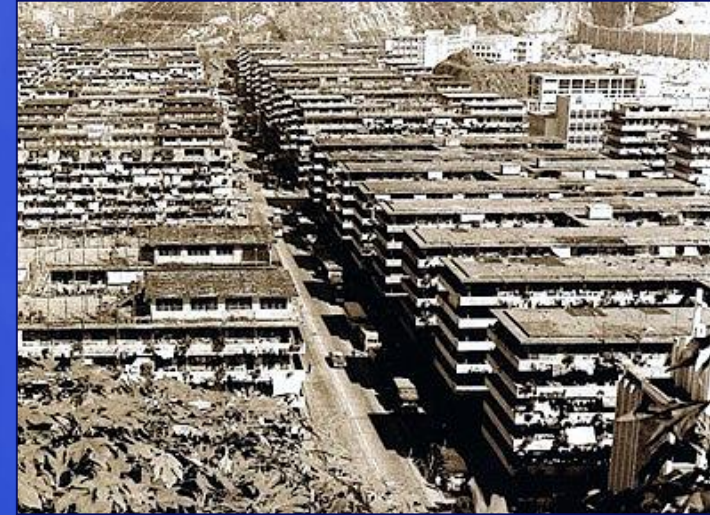
# Overview of Public Housing in Hong Kong

- High rise residential construction.
- Relatively fast speed of construction to meet waiting list demand.
- Modest cost of development for lower income sector.
- Material and labour cost are high due to high cost of living.



# Overview of Public Housing in Hong Kong (cont'd)

- Redevelopment of old existing housing blocks to modern domestic living habitat.
- Committed to quality of living in terms of environment and sustainability.
- Quality of works is not compromised to meet public expectation and to sustainably reduce future maintenance.



# Characteristics of Public Housing Construction in Hong Kong

Standardization

Prefabrication

Mechanized Construction



# Standardization to Modular Flat Designs

- Taking the benefit of **mass flat production**, but bearing in mind the impact of prototype blocks, we target for **standardization of flat units only**.
- This has replaced the **standard block designs** which we have adopted in the past three decades.



# Standardization to Modular Flat Designs (cont'd)

- Building **skeleton** components such as **facades**, **slabs**, **staircases**, **partition walls** and **beams** are standardized to form modular flat units.



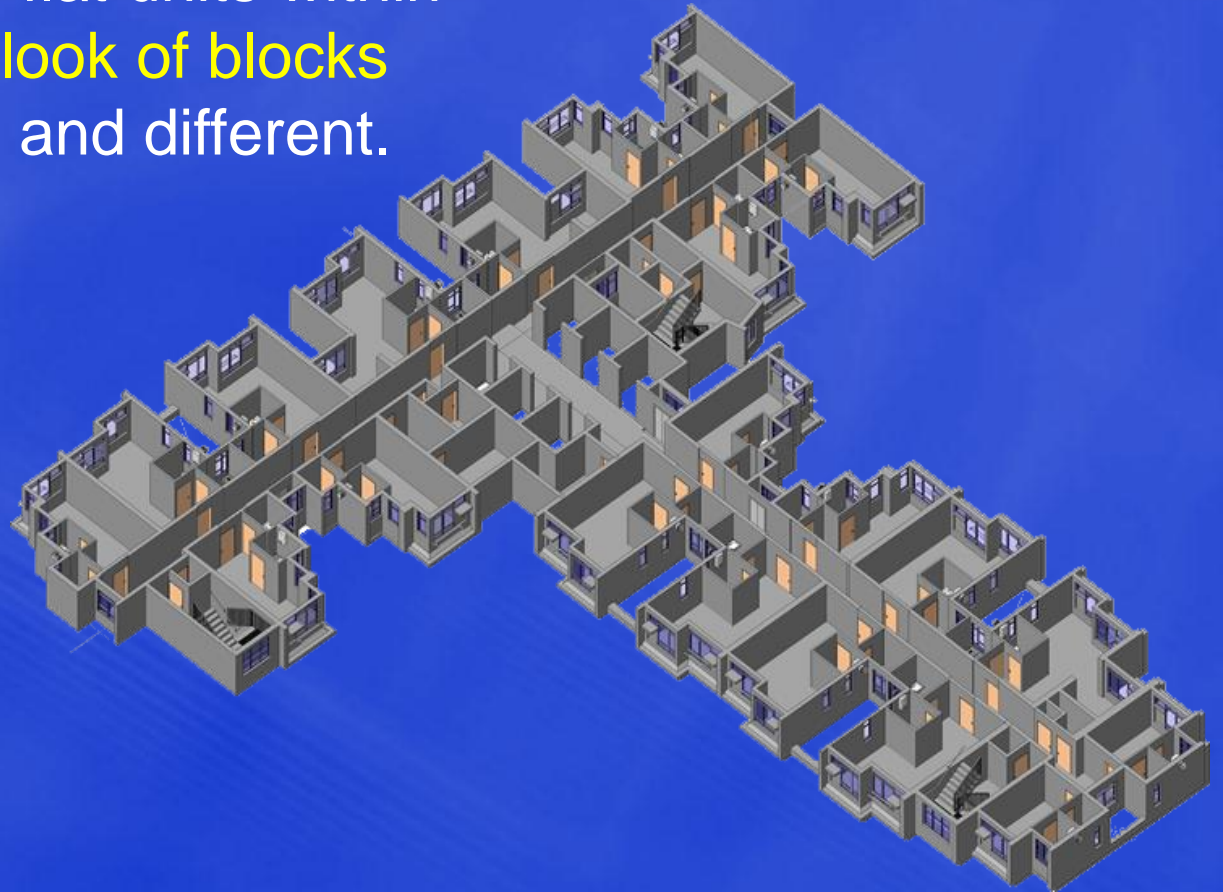
# Standardization to Modular Flat Designs (cont'd)

- Building **fabric** components such as **windows, bathroom and kitchen fittings, doors, metal gatesets** are standardized for factory manufacture.



# Standardization to Modular Flat Designs (cont'd)

- Blocks are **assembled** using these modular flat units within layout, but **outlook of blocks** can be **unique** and different.





# Prefabrication

- Prefabrication of **concrete components** is essentially the construction method which transfers some of the **difficult insitu** reinforced concrete construction from **working floor to factory**.
- The transfer is also from elevated construction on site to **construction on ground in factory**.



# Mechanized Construction

- **Mechanized construction** comprise primarily the use of **tower crane** to move around **steel formwork, concrete skips and precast components**. The transportation is **between ground and working floor and between different wings** of working floors. The Hong Kong Housing Authority (HA) has adopted this approach early in the 80's.



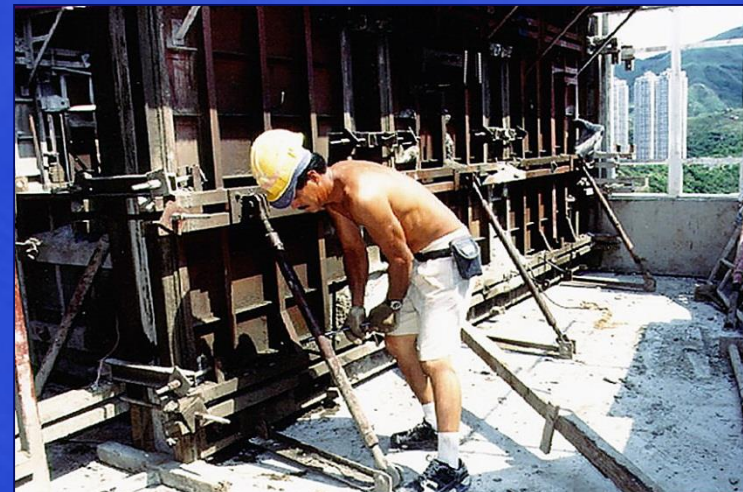
# Mechanized Construction

- For **elevated construction** using traditional methods, it is often difficult to construct at locations which are **difficult to access**.
- **Substantial falsework and working platforms** may be required. In case **timber formwork** is used, the **workmanship may deteriorate** after repetitive construction.



# Mechanized Construction

- Large panel steel wallforms are used in HA which replace timber formwork.
- Large panel formwork was mandatorily introduced in the mid 80's.
- It was a pioneer environmental initiative to reduce the use of timber.



# Prefabricated Systems



# Prefabricated Components

## Precast Facades

### Purpose

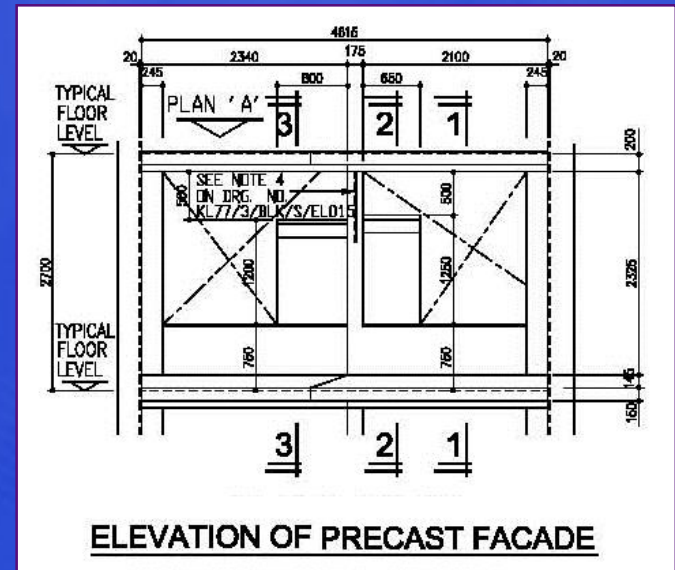
- To tackle the **complicated profile by casting on ground.**
- To **cast-in windows** to prevent **water seepage.**



# Prefabricated Components (cont'd)

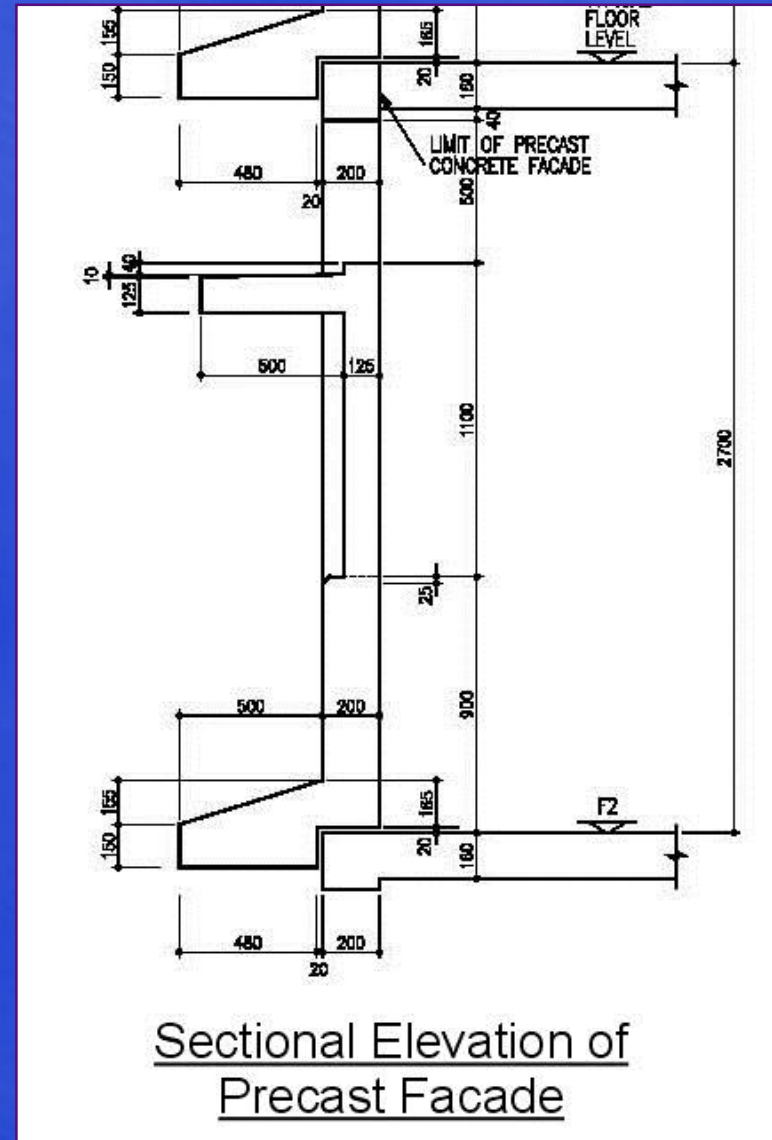
## Technical Considerations

- Horizontal cast (**wall as slab**)
- **Sophisticated steel mould** with removable mechanism.
- **Applying finishes in factory and on ground.**

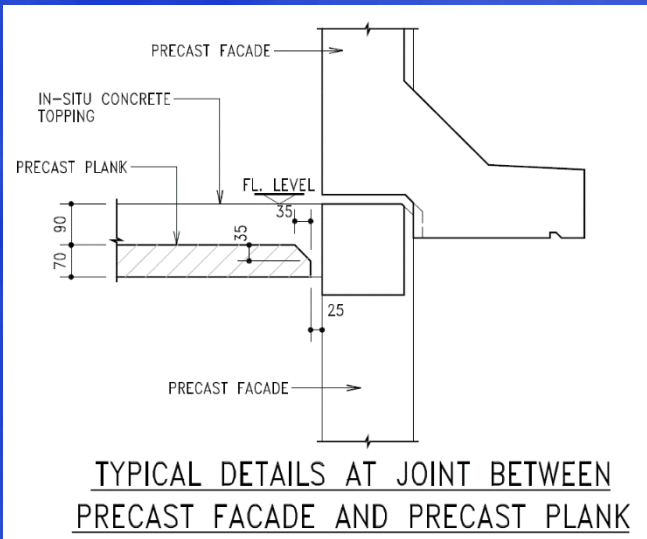


# Prefabricated Components (cont'd)

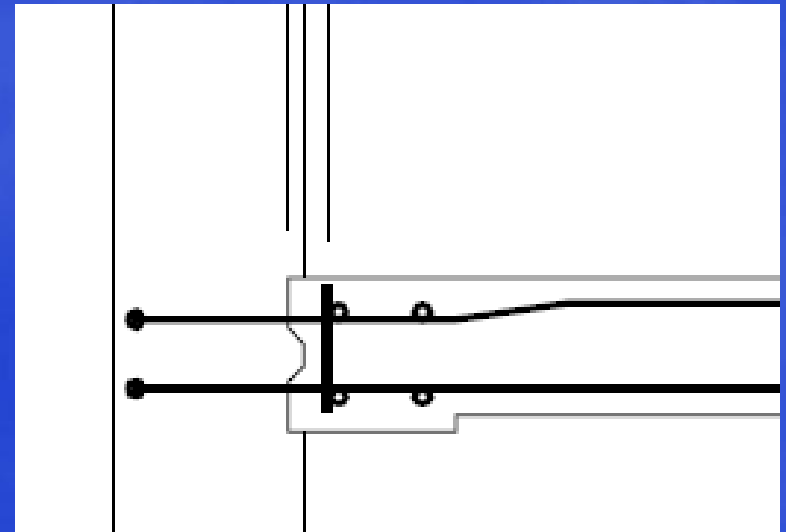
- Design to be supported on either side by structural walls; not to accumulate the loadings to lower floors.
- Horizontal water proof joint.
- Vertical insitu joint, to ensure no structural movement.







**HORIZONTAL JOINT**  
BETWEEN UPPER &  
LOWER FACADES



**VERTICAL JOINT**  
BETWEEN FACADE AND  
WALL



# Prefabricated Components (cont'd)

## Semi-precast Slab

### Purpose

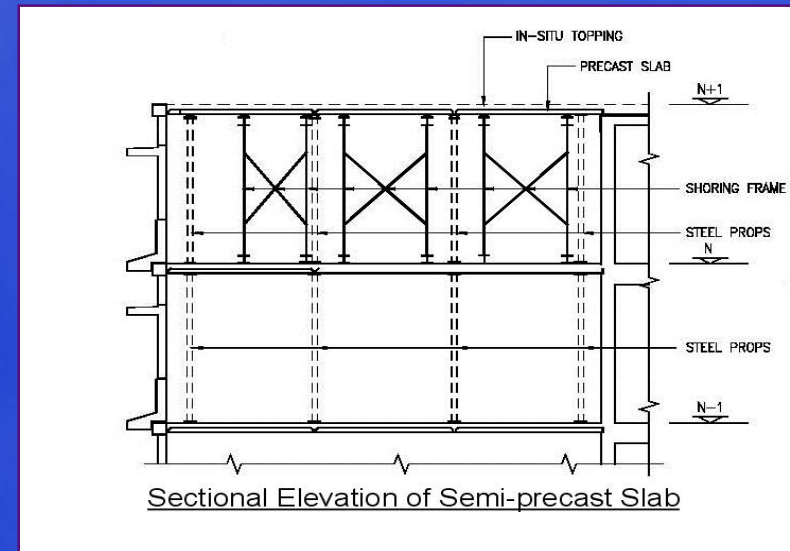
- To **avoid** using **substantial insitu formwork** and **falsework**, hence **neater** construction.
- To provide **quality** surface finish at **soffit** of slab.
- To **house concealed conduits** within slab thickness.



# Prefabricated Components (cont'd)

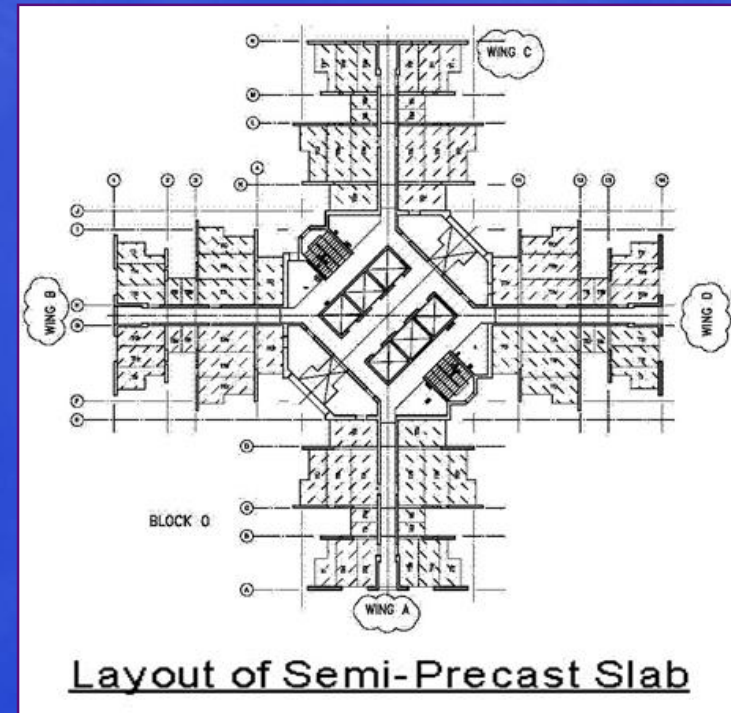
## Technical considerations

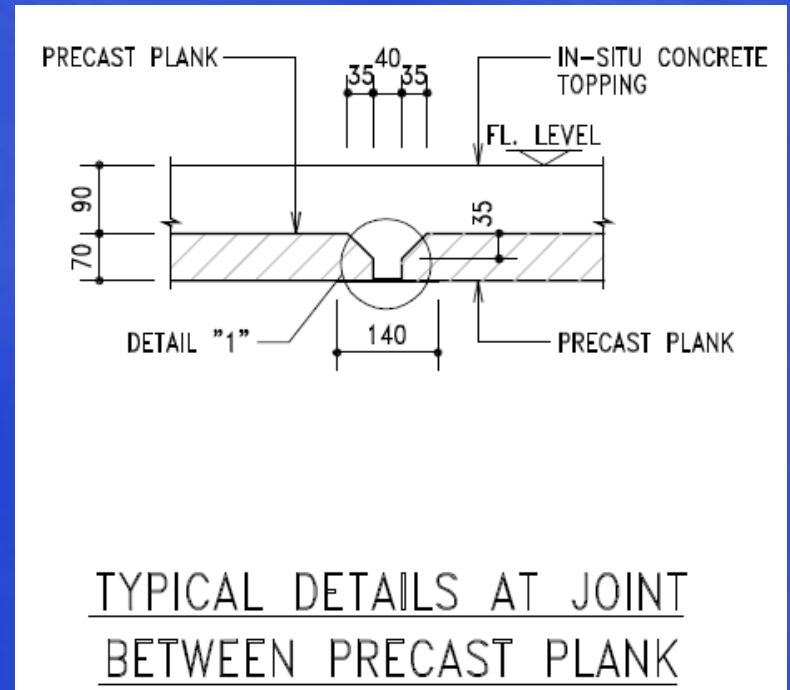
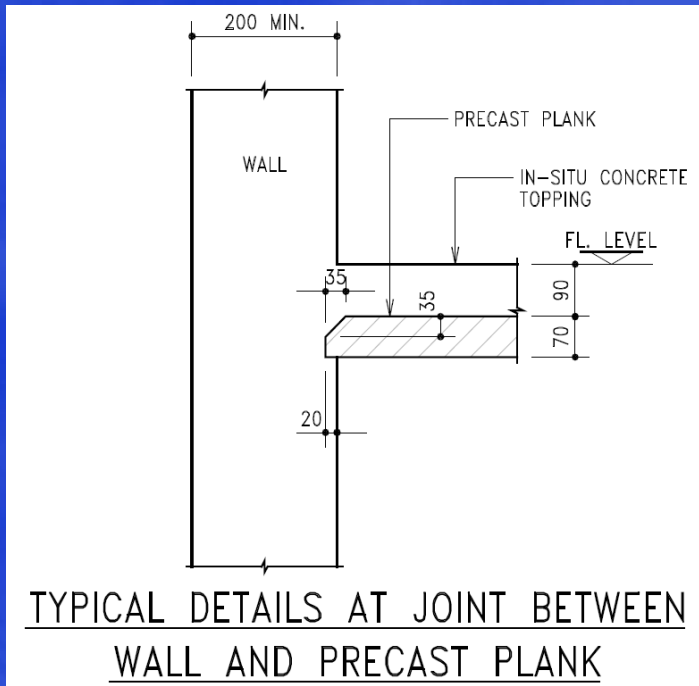
- By 'composite' construction, i.e. **precast plus insitu**.
- **Formwork at slab soffit is hence not required, only vertical props** for supporting the semi-precast slabs.



# Prefabricated Components (cont'd)

- Insitu portion at upper part allows incorporation of concealed conduit runs before adding top reinforcement.
- Slab width within 2.5m to facilitate transportation by trucks.





# Prefabricated Components (cont'd)

## Precast Staircase

### Purpose

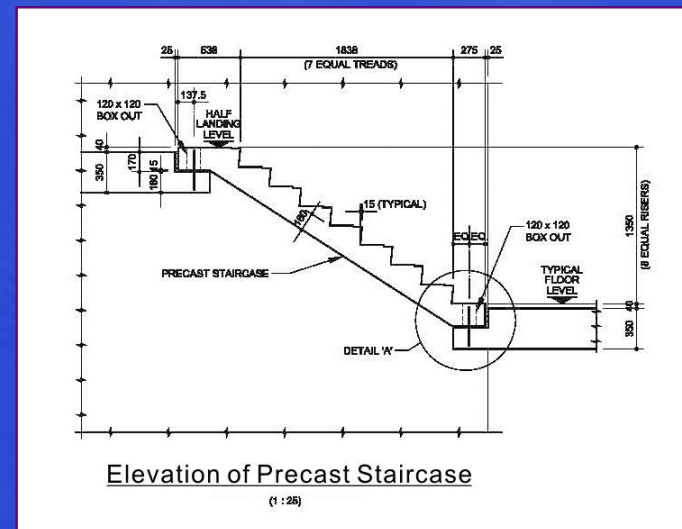
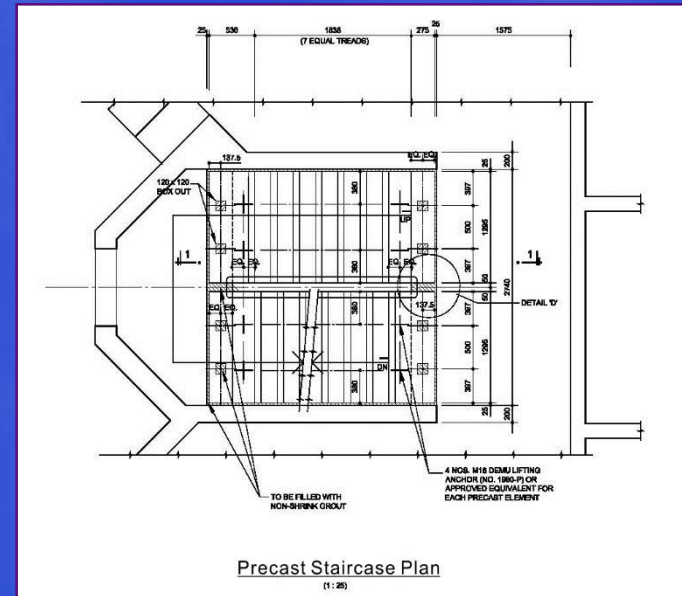
- Staircase is normally **confined** in a **limited space** within the staircore. **In situ construction** is **difficult** and sometimes **dangerous** due to possible **movement of falsework**.
- Precast staircase is **simple to produce** in factory and **easy to install** on site.



# Prefabricated Components (cont'd)

## Technical considerations

- **Connection** at supports by **dowel bars** and **box-outs**, to be **grout filled** afterwards.
- **Early completion** to allow **passage** during construction period.



# Prefabricated Components (cont'd)

## Precast Partitions

### Purpose

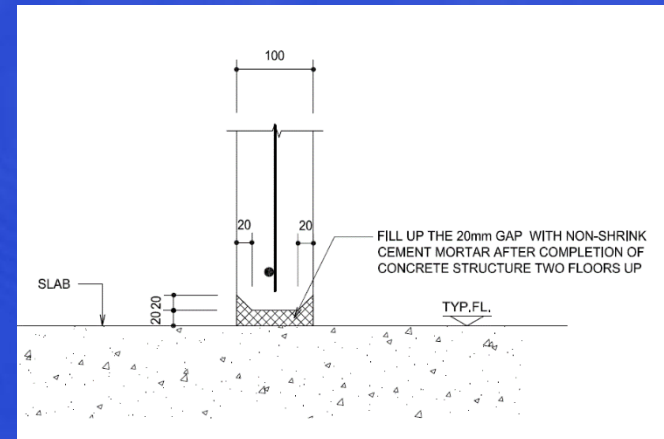
- Two types of precast partitions :-
  - (i) Lightweight partitions
  - (ii) R.C. partitions





# Prefabricated Components (cont'd)

- Lightweight partitions are either by **aerated concrete** or **hollow tube panel**.
- Lightweight partitions are to be **erected after construction of structural frame**, to serve as partitions but **eliminate wet trade** (previously by **blockworks**).



# Prefabricated Components (cont'd)

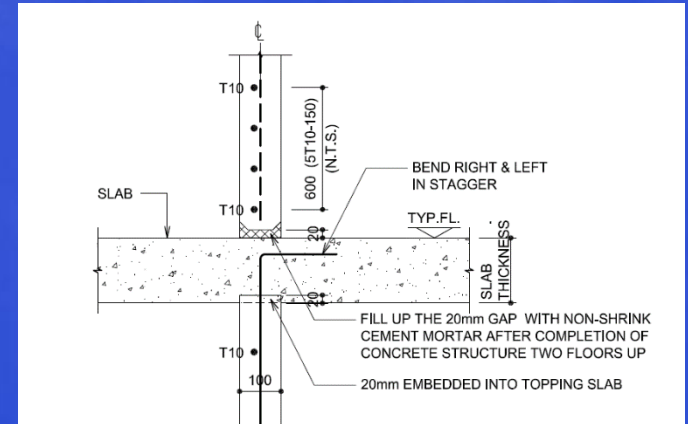
## Technical considerations

- R.C. partitions are thin partitions which is difficult to construct vertically by insitu method.
- R.C. partitions often for FRP reasons or for sound insulation, are better cast in factory and horizontally.



# Prefabricated Components (cont'd)

- **Concealed conduits** could be installed within panels or incorporated on site.
- **Panels** placed into position, **jacked up** and **mortar filled** at bottom.



# Prefabricated Components (cont'd)

## Precast Tie Beams

### Purpose

- These **tie beams** are located in elevated positions **unsupported by floor slabs**. Construction is **difficult** in terms of **erection of falsework**.
- **Precast tie beams** are **easier to install**, mainly to make the connections at supports.



# Prefabricated Components (cont'd)

## Technical considerations

- **Relatively simple**, since these tie beams are normally **short span**.



# Prefabricated Components (cont'd)

## E. Volumetric precast bathroom

### a) Purpose

- To precast a **box-type structure** to embody numerous pipe ducts, fittings, tiles, waterproofing membranes etc.
- A lot of **wet trade** could be transferred to the factory which is a better controlled working environment.



# Prefabricated Components (cont'd)

- From past experience, **bathrooms and kitchen** areas are locations which call for **frequent maintenance** throughout their life spans.



# Prefabricated Components (cont'd)

- Precast bathroom placed in storage area.
- **Waterproofing** is applied on the **bottom slab** with certain **upstand at the four edges**.





# Prefabricated Components (cont'd)

- The **floor tiles** are layed subsequently, with **attention to drain and fall.**
- All precast bathroom are water test by ponding and the bathroom is only accepted for delivery if there is no leakage from the underside of floor slab.



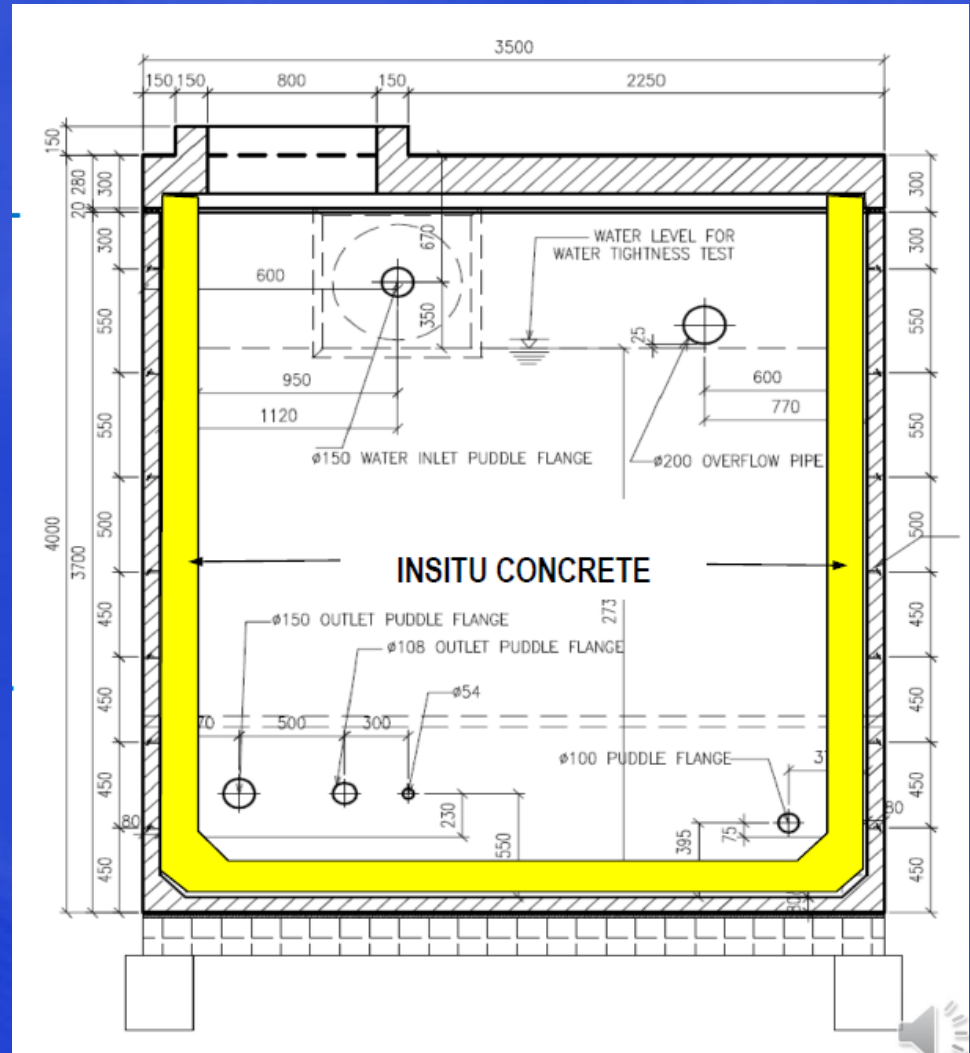
# Precast Roof Water Tanks



# Prefabricated components (cont'd)

## F. Prefabricated Roof Water Tank

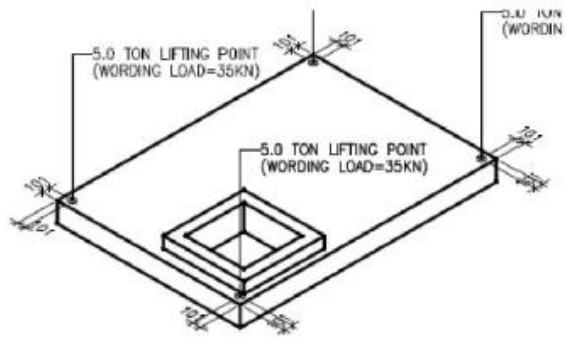
- A semi-precast water tank was first prefabricated in the factory, then delivered to site and insitu cast the inner portion (yellow)
- The purpose is to reduce the weight for delivery and for saving the setting up formwork and falsework at roof.



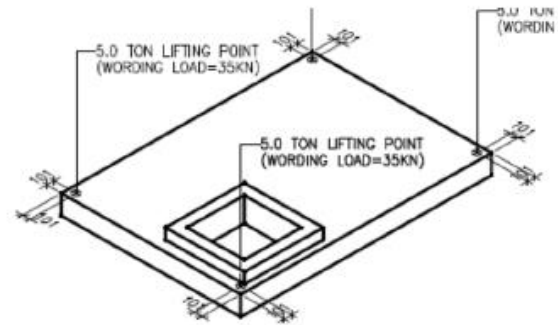
## F. Prefabricated Roof Water Tank

- Semi-precaster tank comprise of two types, mainly differentiated by weight. The first type is a smaller tank capacity, which can be cast totally semi-precaster. The second type has a larger capacity, which cannot be fully semi-precaster, but has to be cast in two portions, then insitu connected on site.
- In addition, for both types of water tanks, the top of the tanks will be fully precaster.

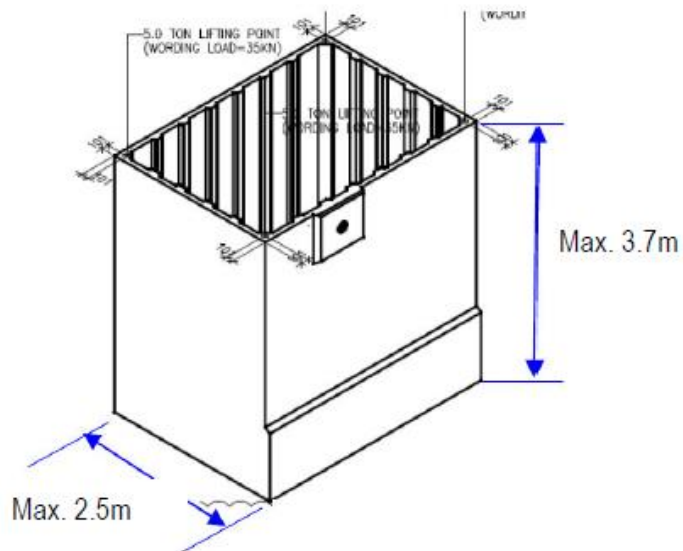




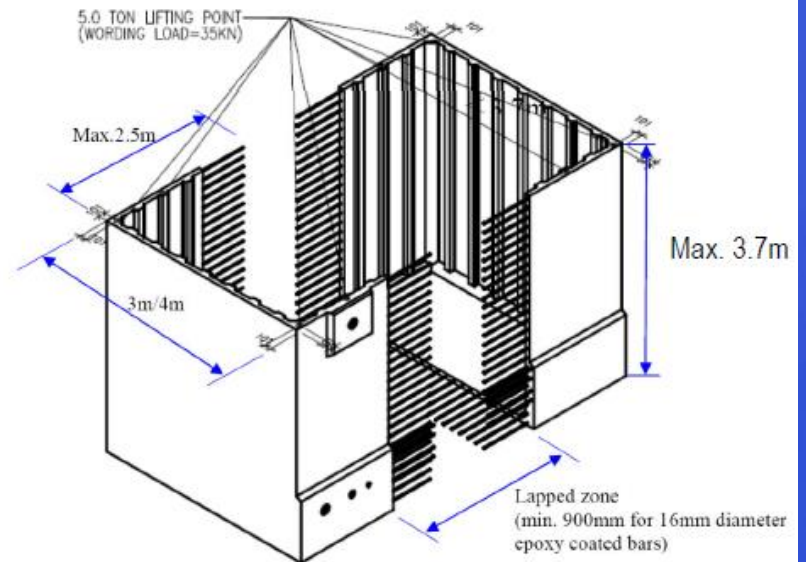
**PRECAST TOP SLAB COMPONENT**



**PRECAST TOP SLAB UNIT**



**VOLUMETRIC PRECAST SHELL COMPONENT**



**TWO C-SHAPED SEMI-PRECAST SHELLS**



## F. Prefabricated Roof Water Tank

- Reinforcement of water tank was fixed in factory and then cast with concrete.
- Tank completed with adequate concrete strength will then be delivered to site.
- The benefit of casting in factory is to allow the tank be inspected for defects before delivery.



## F. Prefabricated Roof Water Tank

- For larger sized water semi-precast tank, it can be fabricated in two portions in factory, then in-situ connected on site.
- Since the two semi-precast portions has set the framework, the formwork can be easily erected on site.
- In addition, the water pipings can be installed with better accuracy.



## Prefabricated Roof Water Tank

- Water tank top cover was precast in the factory and on ground, which is much easier to cast than insitu on site.
- In addition, the joint between the water tank and the top cover is above the top water level, hence no problem of leakage at the joint.



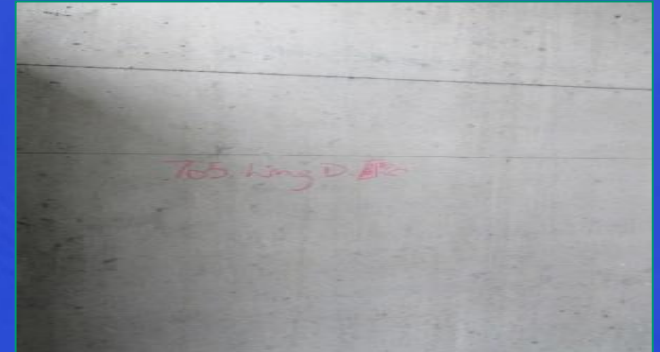


# Formwork Systems



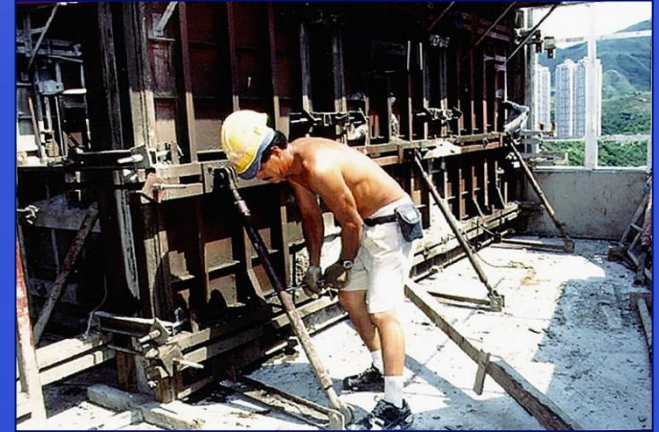
# Large Panel Steel Formwork

- Large panel steel formwork is **robust** and in **one single piece**, **without vertical joints** within the panel. As a result, **no vertical marks** due to **grout leakage** on wall face after dismantled.
- **Off-form wall surface** are **smooth** and **no undulating profile**.



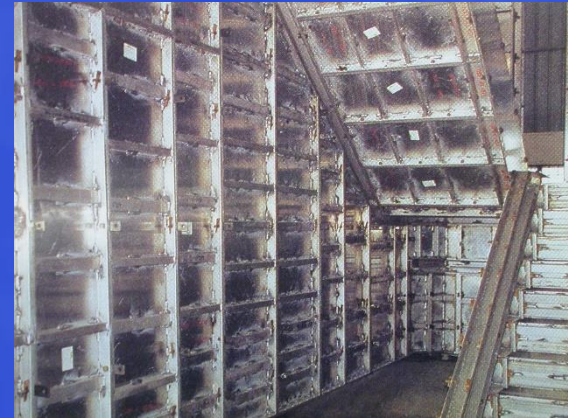
# Large Panel Steel Formwork

- Large panel steel formwork saves the need for **carpentry** which are **expensive** skilled labourers nowadays.
- It can be **used when the flat units** are relatively **standardized** in residential buildings.



# Aluminium Formwork

- Aluminium formwork panels are smaller in size, normally 600 mm in width. They are assembled into one big panel piece by connecting with bolt joints.
- As a result, they are more flexible in fitting different shapes and dimensions.
- They are transported and assembled by manual labours because of their smaller sizes.



# Aluminium Formwork

- Aluminium formwork panels have still the **drawback of possible vertical joint marks**, though **far less** significant than those produced by **timber formwork**.
- Compared with large panel formwork, it is **more expensive** because of the cost of material, i.e. **aluminium is more costly than steel**.



# Construction Cycle

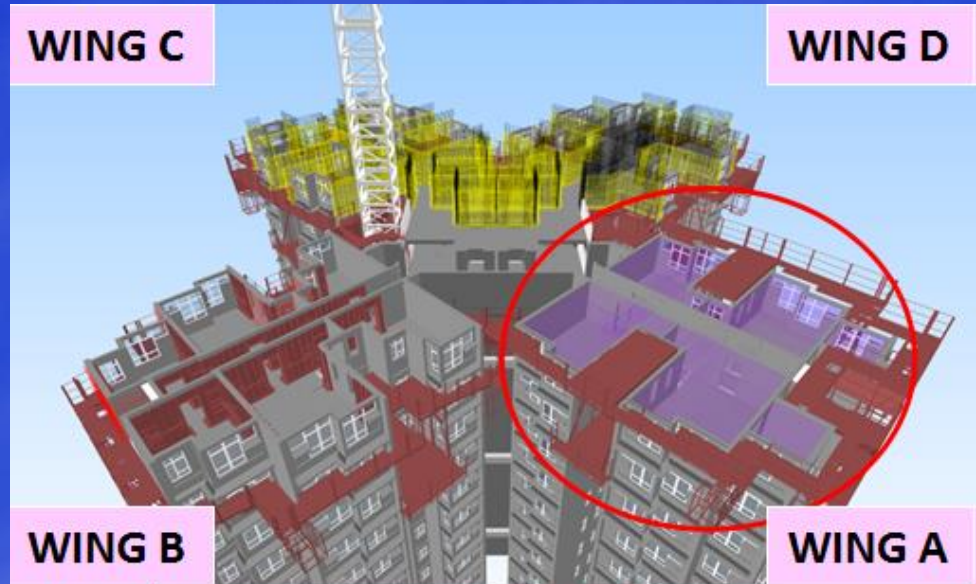


# Construction Cycle

- HA adopts **6 days cycle**, with **one tower crane per block**.
- **Design** facilitates **rotation symmetry**, allowing large panel **steel formwork for one half floor** to be rotated such that no formwork needs to be **transferred to ground level**.
- **Major activities** include:-
  - (a) **Dismantling and erection** of large panel **formwork**
  - (b) Installation of **precast facades**
  - (c) Laying of **semi-precast slab** on falsework
  - (d) Fixing of **wall reinforcement** and laying of **steel fabric** on top of semi-precast slab
  - (e) **Concreting** to walls and slabs



# Construction Cycle ( Day 1 )



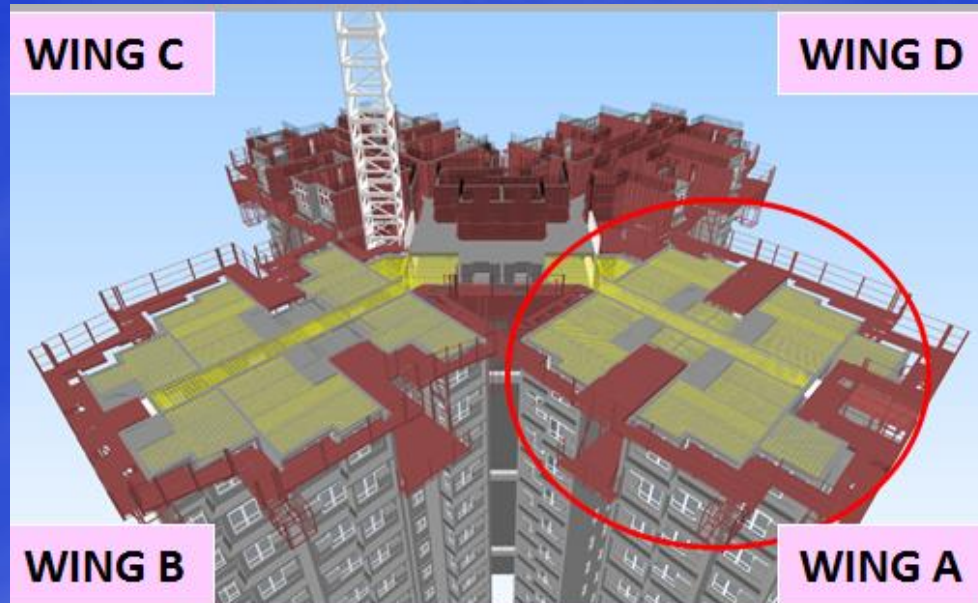
Wing	6 Day Cycle
Wing A	Wallform Dismantling ( 10% →100% ) & Semi- Precast Slab Placing ( 100% )
Wing B	Wallform Dismantling ( 33% )
Wing C	Precast Façade Installation ( 100% ); Wall Rebar Fixing ( 100% ) & Wallform Erection ( 100 % )
Wing D	Precast Façade Installation ( 100% ); Wall Rebar Fixing ( 100% ) & Wallform Erection ( 33 % )

TOWER CRANE : 10 HR





# Construction Cycle ( Day 2 )

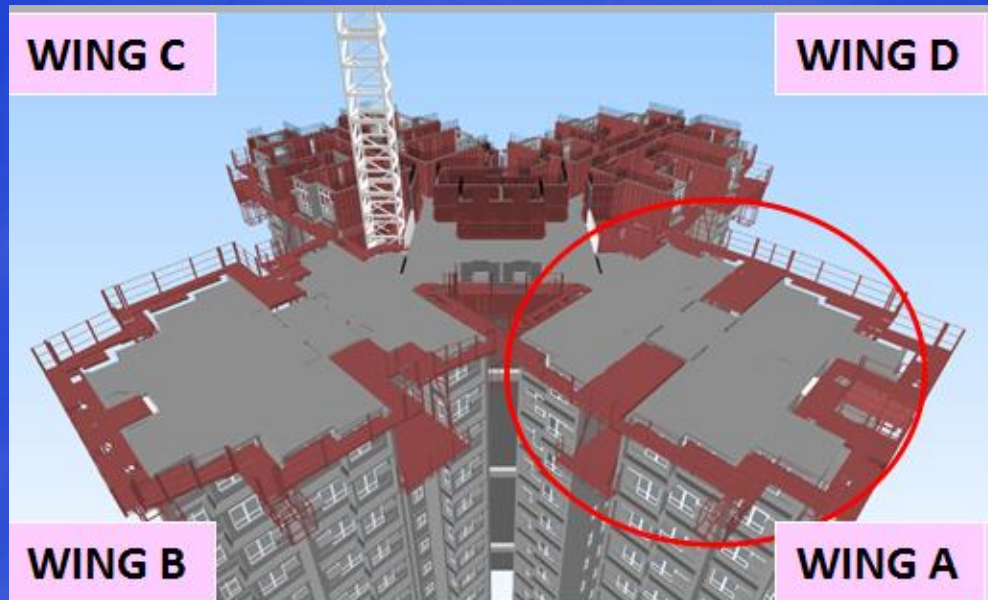


Wing	6 Day Cycle
Wing A	Slab Rebar Fixing ( 70% )
Wing B	Wallform Dismantling ( 33% → 100% ) ; Semi- Precast Slab Placing ( 100% ) & Slab Rebar Fixing ( 20% )
Wing C	Wall Concrete Casting ( 100% )
Wing D	Wallform Erection ( 33% → 100% )

TOWER CRANE : 9 HR



# Construction Cycle ( Day 3 )



Wing	6 Day Cycle
Wing A	Slab Rebar Fixing ( 70% → 100% ) & Slab Concrete Casting ( 100% )
Wing B	Slab Rebar Fixing ( 20% → 100% ) & Slab Concrete Casting ( 100% )
Wing C	Wallform Dismantling ( 10% )
Wing D	Wall Concrete Casting ( 100% )

TOWER CRANE : 8 HR



# Construction Cycle ( Day 4 )



Wing	6 Day Cycle
Wing A	Precast Façade installation ( 100% ); Wall Rebar Fixing ( 100% ) & Wallform Erection ( 100% )
Wing B	Precast Façade installation ( 100% ); Wall Rebar Fixing ( 100% ) & Wallform Erection ( 33% )
Wing C	Wallform Dismantling ( 10% → 100% ) & Semi - Precast Slab Placing ( 100% )
Wing D	Wallform Dismantling ( 33% )

TOWER CRANE : 10 HR



# Construction cycle ( Day 5 )



Wing	6 Day Cycle
Wing A	Wall Concrete Casting ( 100% )
Wing B	Wallform Erection ( 33% → 100 % )
Wing C	Slab Rebar Fixing ( 60% )
Wing D	Wallform Dismantling ( 33% → 100% ) ;
	Semi-Precast Slab Placing (100%) &
	Slab Rebar Fixing ( 40% )

TOWER CRANE : 9 HR



# Construction cycle ( Day 6 )



Wing	6 Day Cycle
Wing A	Wallform Dismantling ( 10 % )
Wing B	Wall Concrete Casting ( 100% )
Wing C	Slab Rebar Fixing ( 60% → 100 % ) & Slab Concrete Casting ( 100% )
Wing D	Slab Rebar Fixing ( 40% → 100 % ) & Slab Concrete Casting ( 100% )



# Precast in High Rise Buildings

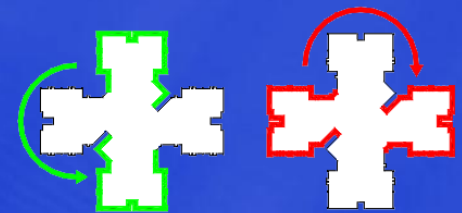
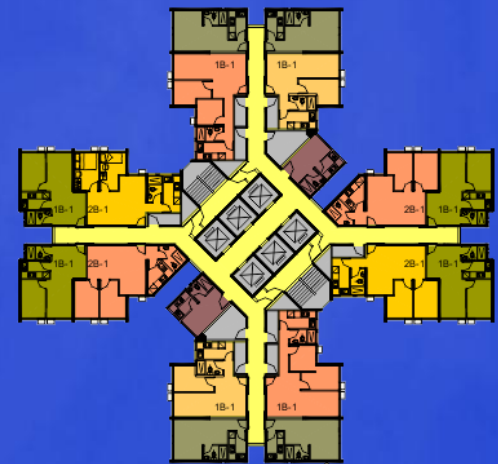


# Prefabrication for High Rise Construction

- There are several important considerations to facilitate use of prefabrication in **high rise construction**:-
- **Symmetry in Layout Design**

If the layout can be designed to be symmetric, or as far as possible symmetric, the **prefabricated steel formwork** can be rotated from one wing to another, thus **avoiding the transfer** of formwork to ground level.

The **no. of types of precast elements** could also be largely **reduced**, hence more **repetitive use of steel moulds** and **simplify logistics**.



# Prefabrication for High Rise Construction (cont'd)

**Symmetry** of layout could also greatly enhance the tower crane capacity as the **reach of the crane can be optimized**. Sometimes, if the block is very **asymmetric**, **two** instead of one **tower crane** may be required.





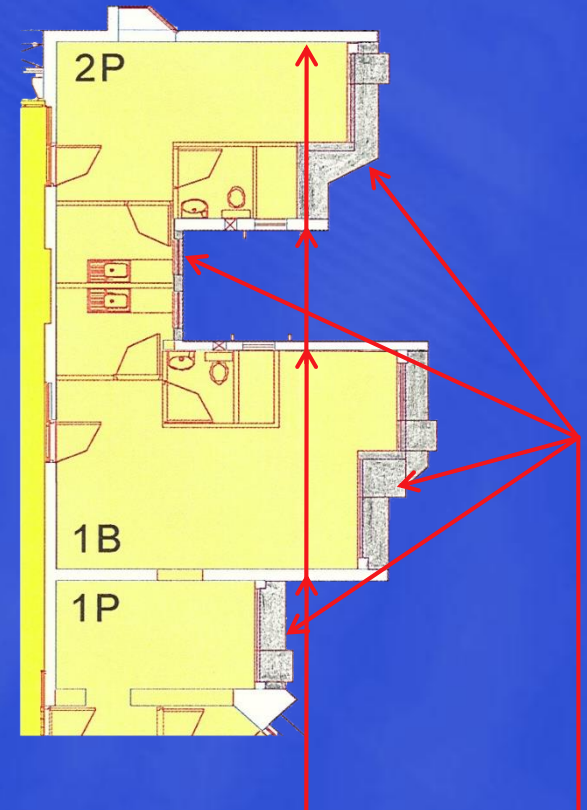
# Prefabrication for High Rise Construction (cont'd)

- **Dimensional Accuracy** of precast elements

**Precast** construction calls for **high precision**; otherwise it **cannot fit into and interface with insitu construction** as **formwork** is also **prefabricated**.

Where **precast is connecting to precast**, such as non-wind resisting elements, **accuracy** is also vital.

Generally, a maximum of **4mm tolerance** between each connection is allowed.



Insitu concrete walls

Precast Façade  
(Dimensional accuracies are very important as very tight tolerances could be allowed)



# Prefabrication for High Rise Construction (cont'd)

- Transportation from Factory to Site

Width of precast element has to be limited to less than 2.5m for truck transportation.

Transportation is preferably by road, and 'just in time' to minimize storage on site.



# Prefabrication in Factory



Semi-automatic  
Production Line

Steel Cut &  
Bend Yard



Ready-  
mix  
Concrete  
Plant

Transportati-  
on Route

Production  
Line



# Factory Layout

## A. Transportation Route

- Transportation route **between production lines** must have **adequate width**, allowing **large trailers** to move, and facilitating the **gantry** to lift the components onto the trailers.



# Factory Layout

## B. Production Line

- Production line should as far as possible be carried out in **covered factory, particularly for concreting** which will not be affected by rain.
- If the works involved **can be carried out under the sun and time is not a constraint, such as applying finishes,** production line can also be **not covered.**



# Factory Layout

## C. Cut and bend and cage fabrication yard

- If **steel cut and bend** and can be carried out **in covered factory**, the **working condition** is much better and **quality can be better assured**.
- For **cage fabrication** like that used for **precast bathroom**, reinforcement cage can be carried out in a **steel frame**.



# Factory Layout

## D. Ready-mix plant

- Concrete mixing and batching plant is set up in factory, supplying all precast concrete production.
- All the raw materials and ready mix concrete are under stringent quality control.





# Factory Layout

## D. Ready-mix plant

- The **transportation** of ready-mix concrete **within the factory** is by way of **ready-mix trucks**. Upon arrival to the covered factory, the **concrete is delivered** to the **casting point** using **concrete skip**.



# Factory Layout

## E. Lifting Gantry

- Lifting gantry is essential for both covered or uncovered production lines. It runs on rails either on ground or overhead, to lift up heavy precast components, steel moulds and raw materials.
- At the same time, it can transfer materials from covered factory to external yard and then in turn to the trailers and trucks for delivery.



# Factory Layout

## F. Factory Storage

- **Stacking and storage** of precast units need to be done **systematically** in order to **protect the components from damage**. At the same time, the **units after off-formed** needs to be regularly **sprayed with water and/or covered with plastic sheet** to ensure proper **curing**.



# Factory Layout

## G. Semi-automatic production line

- For **semi-precast slab** production, it can be done **semi-automatically**.
- The **steel mould** together with the **fixed reinforcement** can be **transferred via rollers** to the **concreting room** for concreting, as different from the **conventional method of casting each individual piece on spot**.
- It **saves** the procedure of **delivering concrete and moving labourers** to every spots for concreting.



# Factory Layout

## G. Semi-automatic production line

- Semi-precast slabs can be cast in the same concreting room, with the workers and vibrating table all stationed at the same point.
- It saves both labours and equipment.



# Factory Layout

## G. Semi-automatic production line

- Ready mix concrete can be transferred directly from the batching plant via conveyor belt to the concreting room, without the use of ready mix trucks.
- If necessary in winter or for meeting tight schedule, the slab can be put into enclosed tank for steam curing.



# Factory Layout

## H. Steel moulds

- **Steel mould** in precasting is a **significant investment**. For the case of **facades**, if the design of facades can be **standardized as far as possible**, the **steel mould can be reused** many times.
- One type of facade moulds is the **lift up type** whereby the **vertical returns** are made to be **inclined** to facilitate the **lifting operation**.



# Factory Layout

## H. Steel moulds

- Another type of facade mould is the rotating steel mould, turning 90° from horizontal to vertical.
- When the mould is vertical, it can be demoulded like a wall formwork.





# Factory Layout

## H. Steel moulds

- The advantage of the **lifting type of facade mould** is that it **saves the rotating frame**, thus **reducing the cost of the mould system**. However, it has to wait for the **concrete to gain strength** before the concrete can be **lifted and demoulded**.
- For the **rotating mould**, the facade **can be demoulded earlier**, allowing the mould to be **reused**, hence **speeding up the production cycle**.



How should young professionals  
prepare for DfMA



# Training

Whilst the **MIC** are now undergoing in various **pilot projects** in Hong Kong, pushing the **construction methodology** to a new era, it is considered necessary to **educate and train up** majority of **engineers** at the **professional and working level** who **have not** the opportunity to **participate in prefabrication construction**. In the building construction industry in Hong Kong, except those who have been involved in public housing, those **working in other government building projects and in the private sector** may not have the chance to experience the prefabrication technology.



# Training

CIC would like to **organize a series of training seminars** on same targeted to :

- (a) **design and project engineers of consultants**
- (b) **design and site engineers of contractors and**
- (c) **project and construction managers of clients and contractors.**

It is hoped that after these working level training, the industry can **pick up the technology and practice** when the **MIC is widely adopted** both in public and private sector.



# Training

Day 1

AM Session 1 - Design of Precast Concrete Components

Session 2 – Manufacture in Factory

PM Session 3 - Delivery and Erection on Site

Session 4 – Quality Assurance



Day 2

# Training

Day 2

AM Session 1 - **Precast Construction in Japan**

Session 2 – **Precast Construction in Singapore**



The End

