

From Planar to Volumetric Prefabrication

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Characteristics of Public Housing Construction in Hong Kong

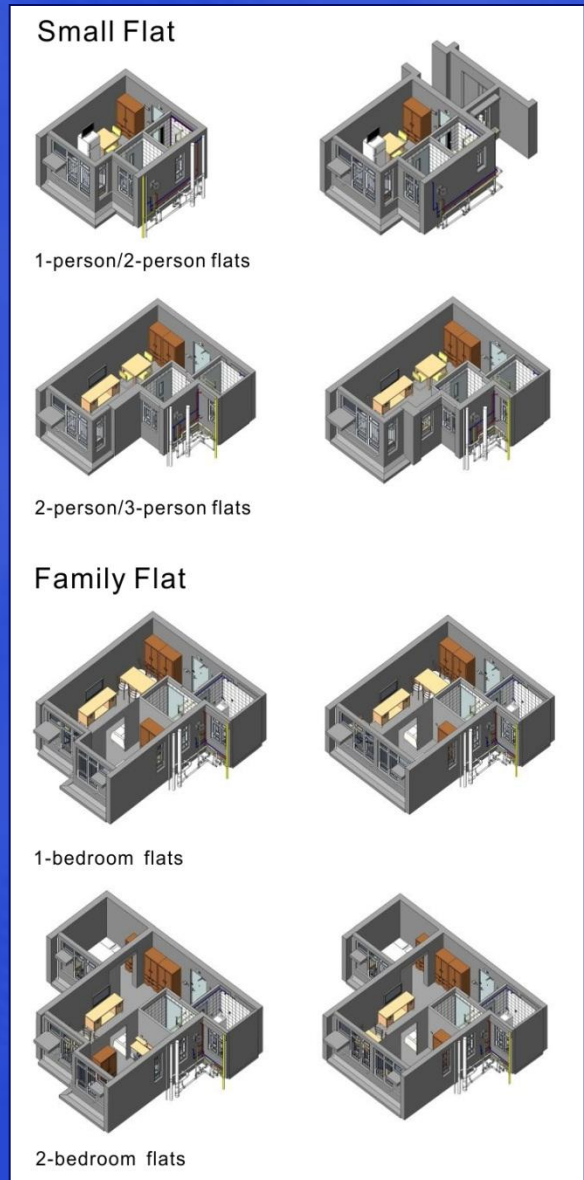
A. Standardization

B. Prefabrication



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.



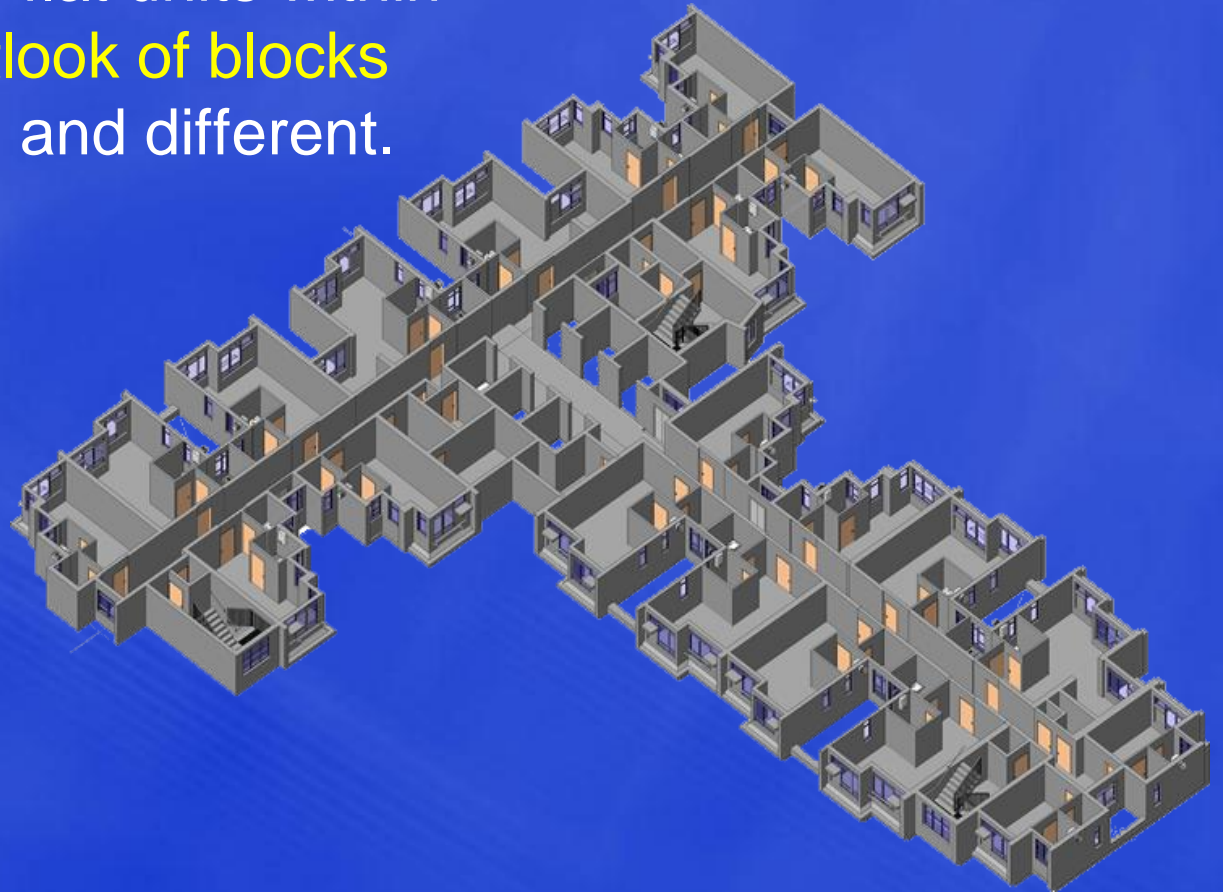
Standardization to Modular Flat Designs (cont'd)

- 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**.



Prefabrication (cont'd)

- For **elevated construction**, it is often difficult to handle **complicated profiles** or locations which are **difficult to access**. **Substantial falsework** and working platforms may be required. In case **timber formwork** is used, the workmanship may be **deteriorated after repetitive construction**.



Prefabrication (cont'd)

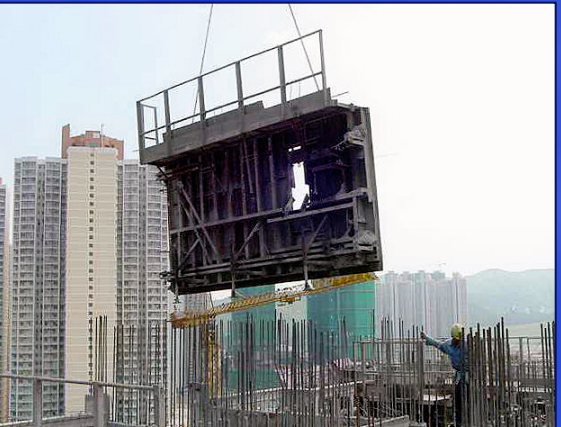
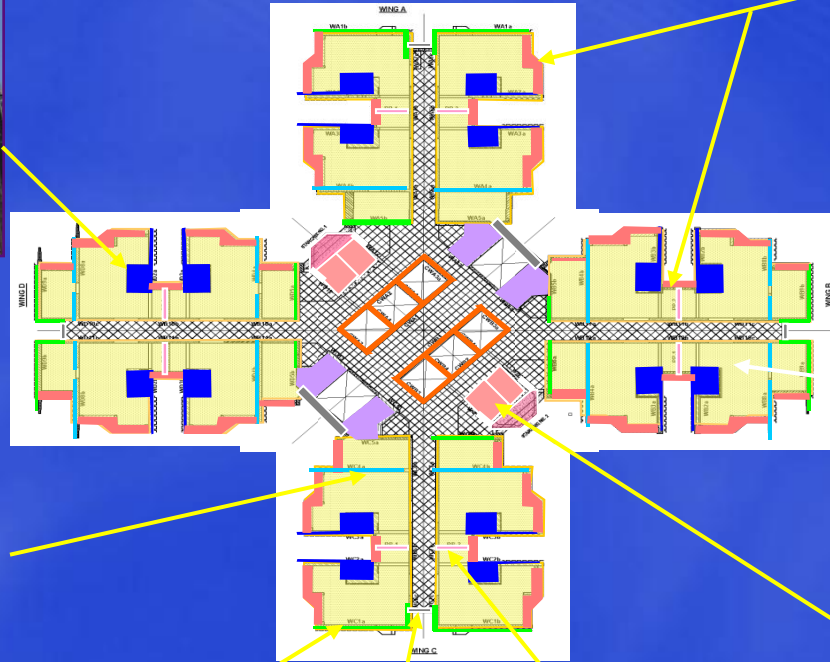
- For **factory** fabrication on ground, **steel moulds** can be used which facilitates **horizontal casting** of **concrete** and **steel** fixing.



Prefabricated Systems



LOCATIONS OF PRECAST ELEMENTS



Planar Prefabricated Systems



Planar Components

A. Precast Facades

a) Purpose

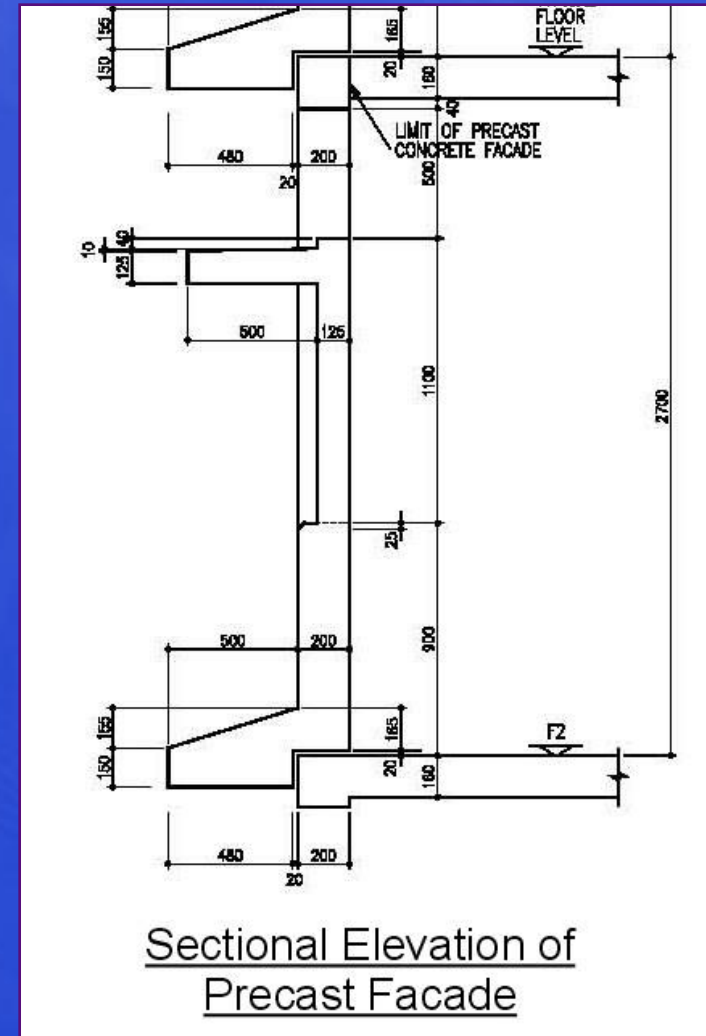
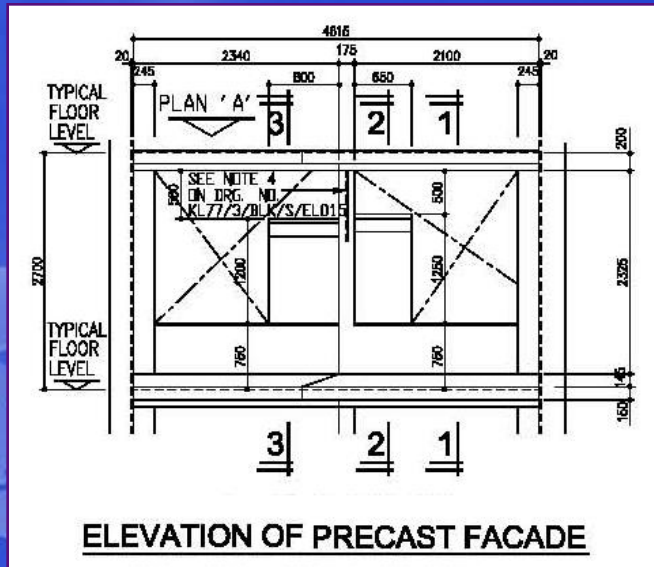
- To tackle the **complicated profile by casting on ground.**
- To **cast-in windows** to prevent **water seepage.**
- **Applying finishes in factory and on ground.**



Planar Components

b) Design

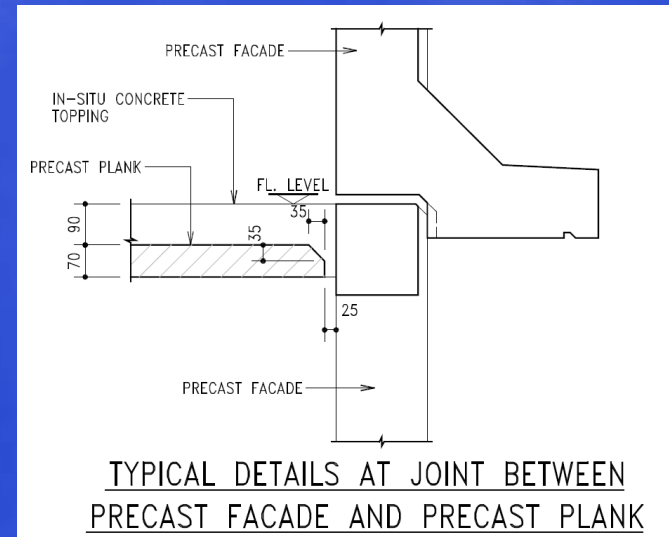
- Design to be supported on either side by structural walls; not to accumulate the loadings to lower floors.



Planar Components

b) Design

- **Horizontal water proof joint** to prevent water seepage.



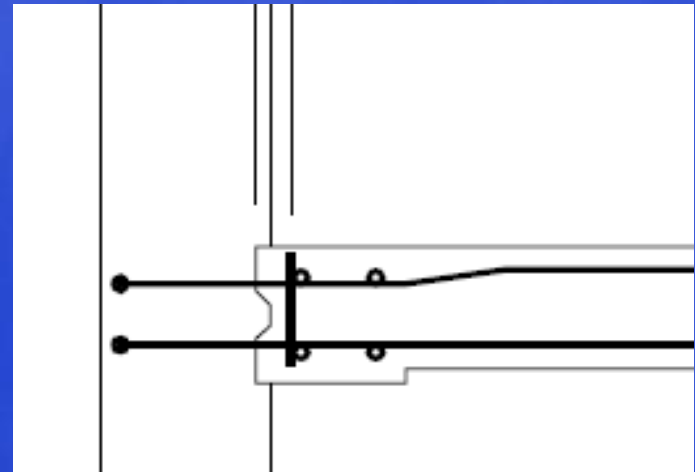
HORIZONTAL JOINT
BETWEEN UPPER &
LOWER FACADES



Planar Components

b) Design

- **Vertical insitu joint**, to ensure no structural movement.



VERTICAL JOINT
BETWEEN FACADE AND
WALL



Planar Components

c) Manufacture

- Fixing of reinforcement and cast-in windows
- Horizontal cast (**wall as slab**)



Planar Components

c) Manufacture

- Two types of steel moulds, one by lifting and the other by tilting.



Planar Components

B. Semi-precast Slab

a) Purpose

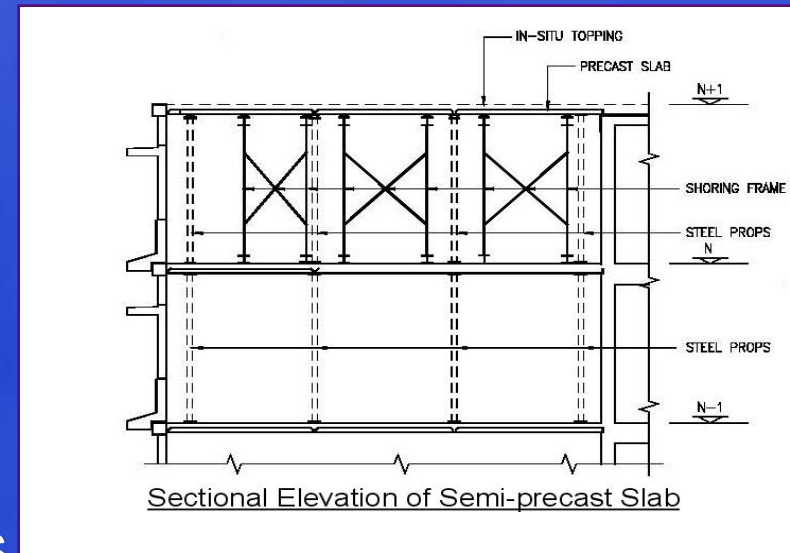
- To **avoid** using **substantial insitu formwork** and **falsework**, hence **neater** construction.
- To provide **quality** surface finish at **soffit** of slab.
- To **house concealed conduits** within slab thickness.



Planar Components

b) Design

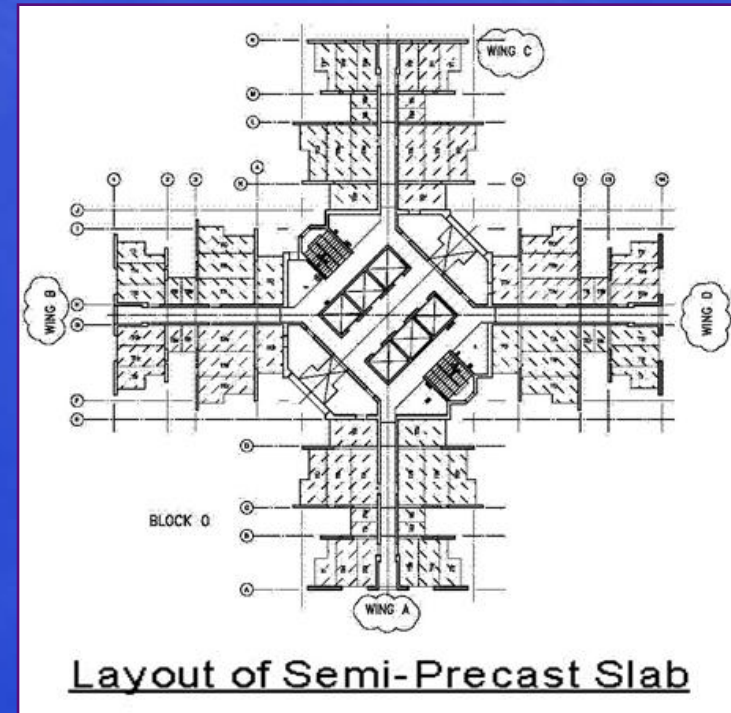
- By 'composite' construction, i.e. **precast plus insitu**.
- **Precast portion at lower part avoids the use of extensive formwork and falsework.** Only a minimum amount of props is required.

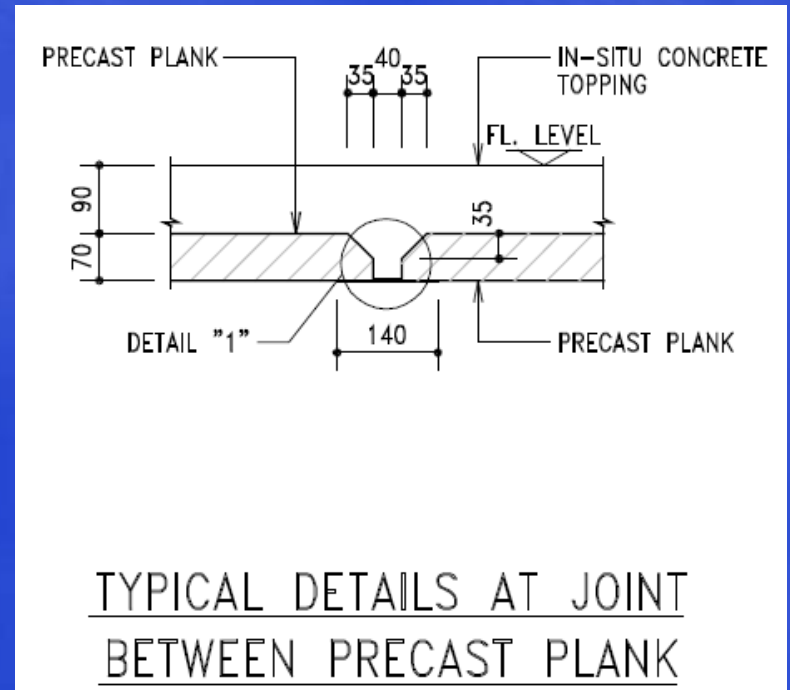
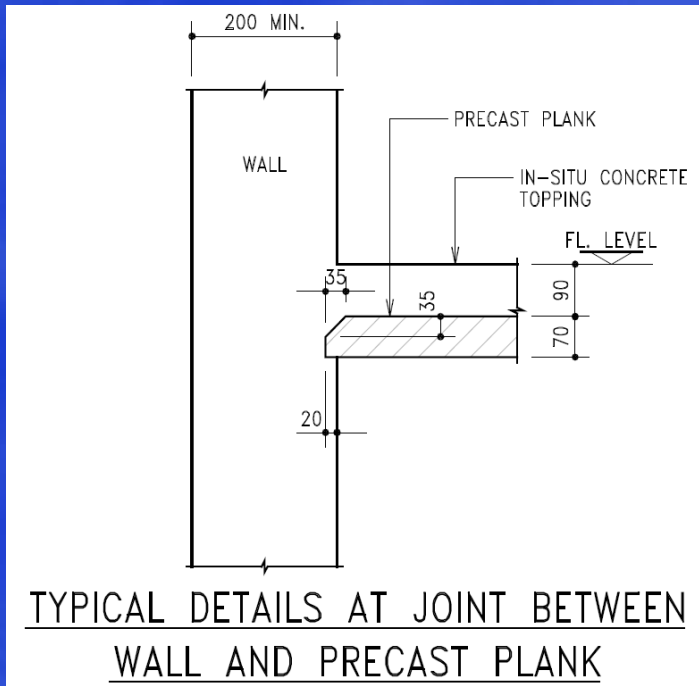


Planar Components

b) Design

- 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.





Planar Components

b) Manufacture

- Manufacture of semi-precast slab can now be **semi-automated**.
- The mould table can be **moved horizontally along rollers** and transported to **concreting room** one by one after steel fixing.



Planar Components

b) Manufacture

- Concreting room with concrete delivered from **outside batching plant.**



Planar Components

C. Precast Staircase

a) Purpose

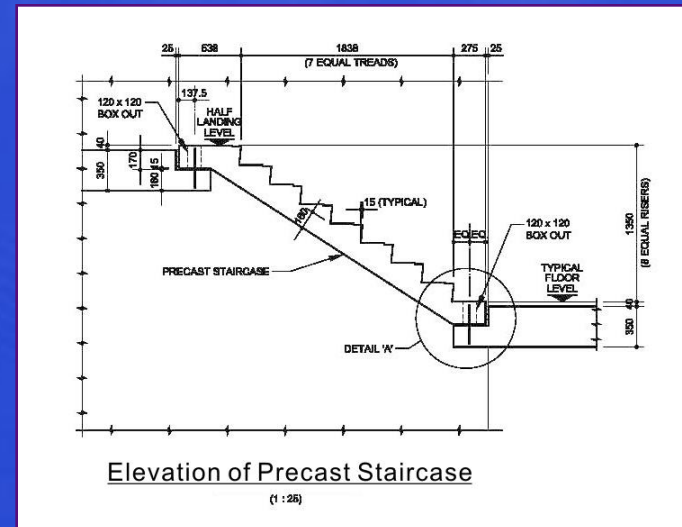
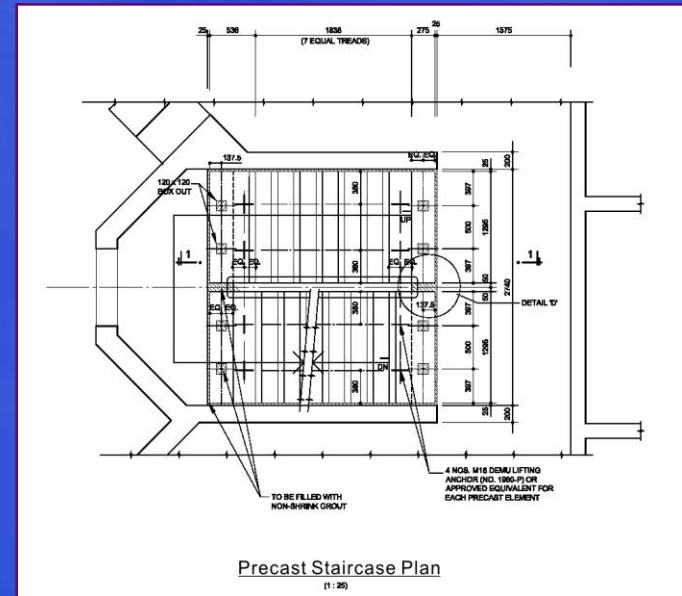
- Staircase is normally **confined** in a **limited space** within the staircore. **In situ construction** is **difficult** and sometimes **dangerous** due to possible **movement of falsework**.
- Precast staircase is **simple to produce** in factory and **easy to install** on site.



Planar Components

b) Design

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



Planar Components

D. Precast Partitions

a) Purpose

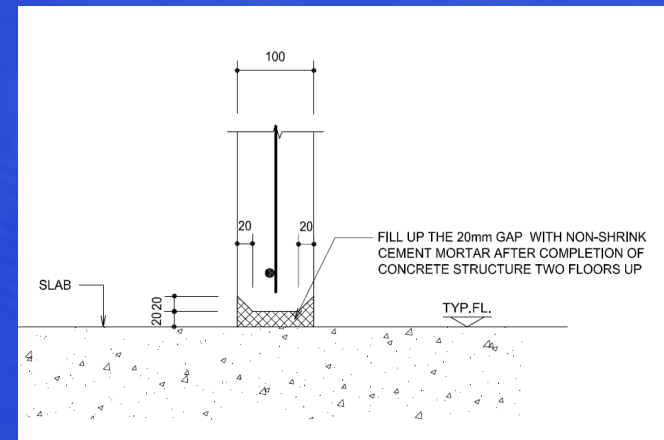
- Two types of precast partitions
:-
 - (i) Lightweight partitions
 - (ii) R.C. partitions



Planar Components

b) Design

- 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).



Planar Components

b) Design

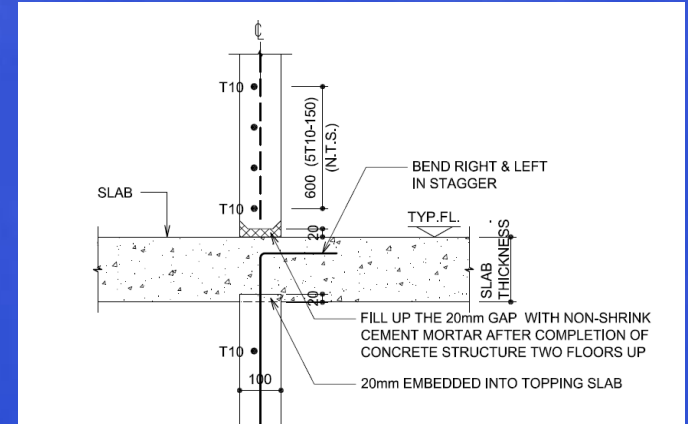
- R.C. partitions are thin partitions which are difficult to construct vertically by insitu method.
- R.C. partitions often for FRP reasons or for sound insulation, are better cast in factory and horizontally.



Planar Components

b) Design

- **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)

E. Precast Tie Beams

a) 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)

b) Design

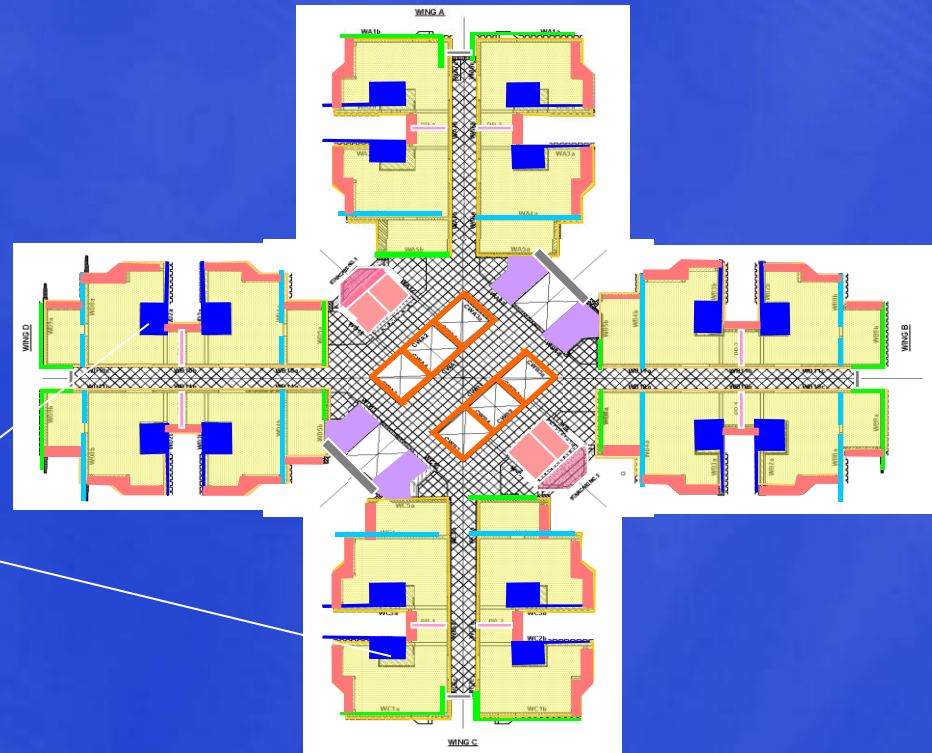
- **Relatively simple**, since these tie beams are normally **short span**.



Volumetric Prefabricated Bathroom



Prefabricated Bathroom



Prefabricated Bathroom

Volumetric precast bathroom

- 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 Bathroom

- The manufacturing process starts with the **fixing of reinforcement** at the **base slab**.
- Afterwards, the **four side walls reinforcement** are installed together with the **vertical conduits and socket boxes**.



Prefabricated Bathroom

- The **aluminium window frame** of the bathroom is also installed such that it will be **cast into** the precast bathroom.



Prefabricated Bathroom

- The partition wall steel moulds are pulled together on rails enclosing the bathroom four side walls.



Prefabricated Bathroom

- The **inner steel moulds** for the four side walls adopt the **collapsible** mould similar to that of the **lift core walls**.
- The mould could be collapsed and **extracted** after the concrete is cast and attains adequate strength.



Prefabricated Bathroom

- **Concreting** is carried out at the **working platform** at top of the bathroom.



Prefabricated Bathroom

- **Demoulding** of partition steel moulds is performing the **reverse process by pulling out the external moulds** away from the walls.
- For the inner walls, the **collapsible moulds will be contracted and lifted up at the centre.**



Prefabricated Bathroom

- After demoulding, the precast bathroom is lifted to an elevated frame for further processing.
- Meanwhile, the bathroom is also sprayed with water periodically for curing.



Prefabricated Bathroom

- Out of the **four side walls** of the bathroom, **one** of them is a **structural wall** and **reinforcement** in this wall need to be **connected to the wall below**. The **other three** side walls are **non-structural** partition walls and no connection is required.



Prefabricated Bathroom

- **Circular tubes** are pre-installed inside that side wall before concreting and the **tubes are extracted** after demoulding.
- As a result, **circular slots** are formed inside that side wall which **allows the reinforcement from lower floor to slot into**. **Grouting** will be introduced afterwards to **complete the connection**.



Prefabricated Bathroom

- The **top slab** of the bathroom is normally **constructed at the factory** for the purpose of **protecting the inside finishes and fittings** during the transportation from factory to site.
- The formwork used this time is **aluminium formwork** which is **more flexible** and can be **handled manually**.



Prefabricated Bathroom

- **Reinforcement** of the top slab are fixed in the usual manner together with the **electrical conduits** for lighting, etc at the **bathroom ceiling**.
- **Concreting** is then carried out afterwards.



Prefabricated Bathroom

- Aluminium formwork can be dismantled and demoulded at the underside of the top slab.



Prefabricated Bathroom

- After all the concreting works have been completed, the precast bathroom is **lifted to the storage area for applying waterproofing membrane and laying floor and wall tiles.**



Prefabricated Bathroom

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



Prefabricated Bathroom

- The **wall tiles** are layed first, **covering** the **upstand** waterproofing.
- **Tile adhesive** is normally used **instead of** using **cement mortar**.



Prefabricated Bathroom

- The **floor tiles** are layed subsequently, with **attention to drain and fall.**

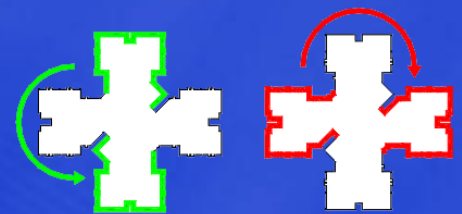
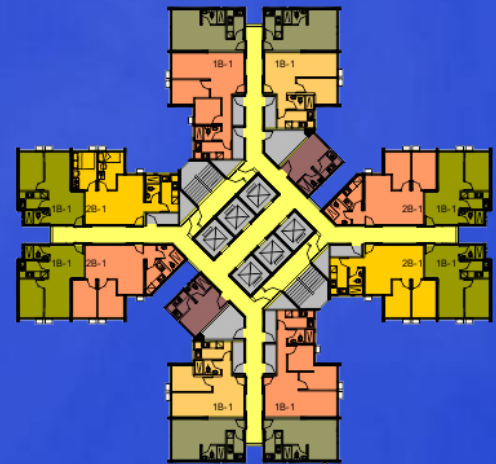


Precast in High Rise Buildings



Prefabrication for High Rise Construction

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

- Use of Tower Crane
 - a) Tower crane contributes a **significant cost** to construction. If the **crane capacity** could be **reduced**, it **saves** the overall construction **cost**.
 - b) If the weight of precast components could be minimized, such as the use of **planar facades** or facades with **less complicated profiles**, the capacity of tower cranes could be smaller.



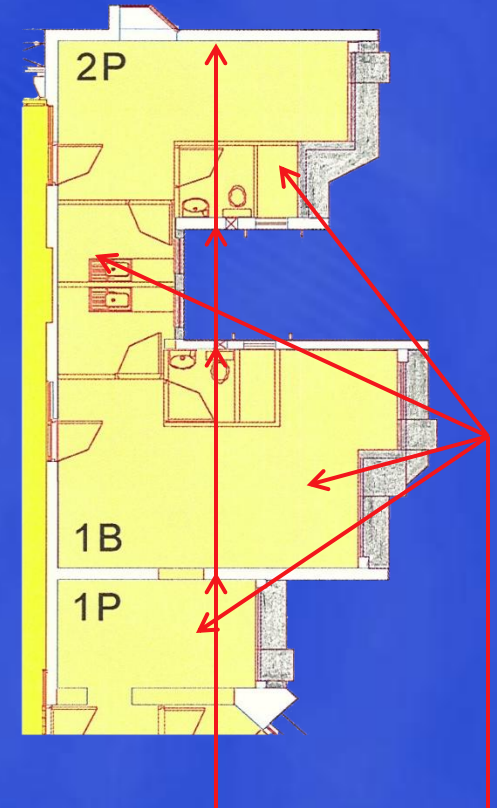
Prefabrication for High Rise Construction (cont'd)

- c) **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
 - a) **Precast** construction calls for **high precision**; otherwise it cannot fit into and interface with **insitu construction** as formwork is also **prefabricated**.
 - b) Where **precast is connecting to precast**, such as non-wind resisting elements like the slabs, **accuracy** is also vital.
 - c) 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
 - a) **Width of precast element** has to be limited to less than **2.5m** for truck transportation.
 - b) **Transportation is preferably by road**, and **'just in time'** to **minimize storage** on site.



The End

Thank You

