Prefabrication Construction Practices in Hong Kong

Prefabricated construction refers to construction making use of readily-assemble components which are prefabricated off site and to connect them on site into a permanent structure in a convenient and structurally strong manner. Materials suitable for prefabricated construction mainly include concrete, steel and timber. Out of the three named, prefabrication using precast concrete is the most popular in Hong Kong. Prefabrication using steel, under a more specific classification, belongs to structural steel construction, which is for the time being beyond the scope of discussion in this article. It is understandable that the use of timber as a material in prefabricated construction is very rare in Hong Kong and will not be discussed here either. This article aims to provide a brief introduction in the using of prefabricated construction based on precast concrete.

The basic principle of using prefabrication in construction is to take the advantage of allowing some of the major building elements being produced off-site in a prefabrication yard or factory where productivity, quality and cost of works can be better controlled. The finished elements can then be transported to the site for assembly and connection.
Construction using precast concrete to replace part or all of the structural members in a permanent structure has the following advantages.

a) Prefabricated elements produced in factory environment can be worked to a very high structural or architectural standards.

b) Similarly, the prefabricated elements can be more durable when compare to structure constructed in in-situ concrete.

c) Elements can be conveniently pre-stressed, or even post-tensioned to form continuous structure afterward, to produce structures of higher performance.

d) Productivity is much higher than cast in-situ works especially when standardized design is adopted.

e) The assembly and installation process carried out on site can save up a significant amount of formwork and falsework especially when the structure is of very high headroom.

f) Construction can normally be done in higher speed with easier supervision and reduced cost.
Though prefabricated construction exhibits quite a number of benefits over traditional construction methods, it is still not popularly received in the construction of buildings in Hong Kong. One very major reason is that prefabrication construction using precast concrete components cannot produce a very rigid structure. This drawback becomes more significant when used in high-rise buildings where huge lateral wind load has to be taken into account. The insufficient rigidity mainly originated from the joints of the major elements, such as in joints between columns and columns, beams and columns, or beams to paneled walls etc. Sometimes, rigid joint design can be made to improve the performance, but this will, again, complicate the connection and increase the time and cost of work. Furthermore, prefabricated construction also inherits with the following drawbacks.
a) Tighter and longer period of coordination are required to allow for structural design, construction planning, procurements and approval procedures (sometimes involves submission and approval by Buildings Department) etc.

b) More time to be allocated in advance for the production of the precast elements until they can be accumulated to sufficient numbers for delivery to site to start installation.

c) Huge working space is required for the carrying out of the fabrication works and this is particularly critical under Hong Kong situation. Though most of the fabrication works are recently carried out in casting yards scattered around the Pearl River Delta, this will unavoidably increase the transportation cost when delivery is to be arranged no matter by sea or on land.

d) Storage and pre-installation handling, again, requires extra working space.

e) Installation of precast elements on site requires careful planning and extra cranage provisions.

f) The handling and assembly of heavy precast members, sometimes up to several tons a unit, poses certain safety problems and increase the likelihood of risk both to human operatives or to the semi-completed structure itself.

g) The structure under assembly in its semi-completed state may cause difficulties in making access into the work spot.

h) Defective connections may frequently result to cracks and water leakage which will create further maintenance problems.
There are not much precedent cases of using prefabricated construction in Hong Kong, especially when compare to the huge volume of building being built every year. The most popular and renowned application is found in the Housing Authority's projects for the construction of public houses, basically under the Harmony and Concord design. However, the applications are limited to semi-fabricated structure using a certain number of precast concrete components only instead of constructing the building all in prefabricated members. In this case, the main structural members, such as the core walls, columns and main beams, are cast in-situ, often making use of some kinds of patented metal forms. While the secondary members like the flight of stairs, secondary beams, short span tie beams, slabs (or semi-slabs) and external facades etc., are constructed using precast concept. In order to improve the rigidity of the joints, most precast elements are placed in position with build-in link bars and cast at the same time together with the main structure.
Other recent examples of significance include the construction of the Headquarters Building for the Hong Kong Jockey Club (1995), Central Store for the Government Supplies Department in Chai Wan (1998), a series of school buildings in the Tseng Kwan O New Town (1999), and the 5-hectare podium extension for the Kowloon Canton Railway Corporation at Hung Hom. The Photo Essay appended in this article makes use of some of the named projects as the focus of illustration.
The Head Office Building of Hong Kong Jockey Club

An external view of the Head Office Building of Hong Kong Jockey Club
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The Head Office Building under construction dating back to March 1994. The central core and the main structural frame, including the columns and the primary beams, were constructed using steel forms, all cast in-situ. The minor elements such as the secondary beams, sub-slabs and stairs, were precast and connected to the main structure by rigid joints.
The forming of the main beam using a type of easy-assemble steel form with slots for insertion of precast secondary beams.
A typical location on floor slab where the precast beams join to the main beams. The precast panel on the foreground is the semi-slab. With the link bars provided, the beams and slab will connected rigidly after the placing of concrete and form a strong monolithic floor system.
Forming the floor with the precast beams/semi-slab arrangement as seen from the underside. The structure under construction at the background is the central core of the building.
The side building used as club house facilities, is constructed using similar fabricating system. However, instead of resting onto the main beams, the precast beams are rested on slots position of load bearing wall due to lighter loading requirement at this part of the building.
Close up seeing the edging detail of the precast beam, semi-slab and the formwork of the primary beam.
Junction detail at column head before the placing of concrete. Note the tendons placed within build-in metal hose for post-tensioning. Prefabrication Works employed in Public and Private Housing Construction.
The construction of Harmony and Concord blocks under Housing Authority's project is by now the most popular form of construction employing the largest amount of prefabrication in a single building. The one shows in this photo is the latest version of this kind for a project at Yau Tong area.
Buildings under the Harmony or Concord design at present are basically all in 40-storey high. This makes a fully fabricated construction with all major elements precast almost impossible due to insufficient rigidity. Therefore, prefabrication is limited only to the external facade, semi-slab, stairs and some of the tie beams etc. The precast facades, as shown in the photo, are already in position pending for the erection of the inner wall forms.
One critical factor in securing the precast facade rigidly and seamlessly to the main structure is in the design of the wall form. The magic is to provide a flapped end in the steel form so that the sides of the facade can be anchored into the form with concrete completely embedded to produce a somewhat monolithic connection.
Another advanced method of casting the inner wall in the Harmony or Concord construction is by the use of a self-lifting formwork system known as the Jump Form. This photo shows the set-up arrangement of the formwork and how the precast facades are to be articulated into the system.
Semi-slab or sometimes called sub-slab, is not exactly part of the structural slab system in usual design but serves only as a permanent shutter to form the floor slab. By the use of semi-slab panel, a great number of falsework can be saved and so does to the labour erecting the falsework. The photo shows the layout of the inner walls and the prop arrangement before the placing in of the semi-slabs.
Workers adjusting the final position of the semi-slab panel. Note that the panel is at this stage supported by props but not rested on the top of cross walls. Besides using as the permanent shutter, they may so designed to form a composite floor system after the fixing of the top reinforcing bar and the placing of concrete.
A 2.1m-span precast tie beam occasionally being used in the construction of public houses. The beam is located on the external face of the light well of a typical wing in a clear suspended manner making prefabrication in this case an appropriate choice.
The flight of stair is another common element that prefabrication concept often applied. These precast stair flight units are for a private residential housing project in Hung Hom area.
The shaft inside the building core as seen in a private residential housing project. The forming of the shaft in a 2-phased manner, that is, to cast the walls using large-sized panel form continually, and add in the inner members such as for lobby slab, lift and staircase wall at a later stage, can accelerate the construction process significantly. In this project, the stairs are formed using precast flights.
Detail showing the connection of the stair flights at the landing location. Additional rebars will be fixed before the landing is to be concreted. Extension to the podium at KCR Hung Hom Terminal.
The overall view of the podium extension at the beginning of the project. The space below the podium will be used as freight cargo handling bays while on top is a 5-hectare residential development jointly developed by Chueng Kong Holdings and the Kowloon Canton Railway Corporation.
Overall layout seeing the neighbouring relationship of the podium and the Hung Hom By-pass, which was constructed almost at the same pace with the podium extension.
The podium construction is basically sub-divided into 4 major work operations, that is, the construction of the column and main beam structures, the erection of the precast secondary beams and the forming of the main deck structure. The photo shows a critical location where the mentioned operations meet.
The main beam with the reinforcing bars being fixed in position. Note the boxing out to form the slot position for the placing in of the precast secondary beams and the cambered beam soffit arrangement.
A section of the main beam between two independent columns with side panel forms secured ready for the placing of concrete.
A continual section of main beams before the placing in of the secondary beams.
The podium deck taking shape and eventually it will join to the existing podium on which the Hong Kong Coliseum stands.
The gradual forming of the podium deck with the placing in of the precast beams and the covering up of the semi-slab panels. Note the services tough (only one section being placed as seen in the photo) located between two rows of secondary beams.
Close up showing the junctioning detail between the main and secondary beams. The looped bars on top of the beams will form a very strong structural linkage to tie up with the final deck system.
The Head Office Building of Hong Kong Jockey Club

Placing in of the semi-slab.
Close up to see the reinforcing bars that form the upper section of the main and secondary beams. This section of beam will accommodate the thickness of the slab structure, and after concreted, will become a very rigid horizontal plate strong enough to form the structure of the podium. Note also the evenly-space looped bars on top of the semi-slab panels for linking into the slab bars.
Slab rebars details. Note the PVC water stop which will provide a water-tight construction join between phased sections of deck.
The storage area for precast members. Semi-slab, beam sections, and a piece of service tough can be seen here.
The delivery of a 15m long precast services tough that weighs about 28 tons.
The joining of the new podium to the existing at the north-eastern corner. Complicated interfacing arrangement to allow for the diversion of the existing pedestrian footbridge (at lower-right corner) is to be carried out.
The completed podium as seen on March 1999.