Formwork for Precast - An Overview

Mangesh Kumar Hardas
Director, Precision Precast Solutions Pvt. Ltd.

Precast concrete buildings are structures made up of numerous small individual elements of concrete cast at an off-site location. These precast elements such as beams, columns, slabs and walls are transported to the site for assemblage and erection. Wind and earthquake loads are resisted by coupling of beams to columns for moment frame resistance, and coupling of wall elements together for composite shear wall resistance. Thus generally in precast concrete buildings the individual element on its own plays no role in gravity and lateral resistance. It is the assembly of all these elements by proper connections which gives the building its stability against vertical and lateral resistance.

Precast concrete usually is either ordinary reinforced concrete or prestressed reinforced concrete. Prestressing gives advantages of reduced cross-sections and steel requirements (reduced weights). However prestressing needs additional equipments, abutments etc.

Precast Concrete is either a factory-cast (off-site) precast or site-cast (on-site) depending on the volume of work and logistics. Factory cast is typically more popular. Factory cast precast gives more control to the producer and the designer with better options for prestressing, architectural finishes and grade of concrete. A better quality can be obtained as workers and supervisors are well trained and experienced. Work does not hamper due to bad weather.

Site-cast precast is adopted when the project volume is so large that setting up a plant at site is economical. It is also adopted when the transport of precast products becomes very expensive or difficult due to large distances and adverse road conditions. Setting up of long line prestressed beds is difficult on site and may not be economical, hence most of the site-cast precast is non-prestressed.

Wet concrete is poured in forms (moulds) and stripped out when it attains certain minimum strength. It is stored in a storage area and later transported to the site for erection. Forms are basically either stationary steel plate forms or Tilting tables or battery moulds or moving Carrousel systems with production pallets. Selection of a system depends upon the volume of production of a particular element and flexibility desired in production. There are various patented systems for forms systems available in India.

Prestressed systems are usually long line systems wherein large number of elements are produced in a single bed. Typical elements produced in such a system are Hollowcore
planks, Double Tee floor elements, Spandrels and Inverted Tee girders. A prestressed bed needs stressing abutments at the ends and a long form is in between. Generally the forms for prestressing elements are either self stressing forms which take the hydrostatic forces of concrete and compressive forces from prestressing, or non-self-stressing or free forms which take only hydrostatic forces leaving the compressive forces coming from prestressing to the abutments. End abutments for stressing is a good solution but sometimes one needs setup for small quantity of elements where self stressing beds can be used. Sometimes post tensioning is also done within the factory for small number of elements.

The forms must be designed properly so that they do not deform during any of the operations of production - pouring concrete, vibrating, stressing, distressing and stripping the element out of form. The end product must comply with the specified tolerances as specified in the BIS codes.

**Material for Precast forms**

The forms for precast concrete are also called as Moulds (US: Molds). These moulds can be made up of Wood, Steel, Aluminium, Fiberglass, Plastic, Concrete or even EPS (Expanded Polystyrene) as long as it retains its shape against the hydrostatic pressure of concrete, provides product tolerances, and is able to withstand the vibrations, the impacts of placing the rebars and the forces of stripping. Generally good quality fiberglass and wood forms can be reused about 50 times. Steel forms have a very large reuse capacity. For complex shapes of elements as used in architectural precast, forms made with wood fiberglass or concrete are used. EPS forms have limited reuse and mostly used in Architectural precast where the shapes are complex. EPS is also used as sacrificial formwork.

**Comparison with Conventional Formwork**

Unlike cast in situ formwork, precast formwork can be vibrated in place using vibrating tables thereby giving excellent quality.

Cast in situ formwork needs extensive shoring/ propping which precast formwork does not.

In case of precast formwork it is very important to maintain shapes and dimensional accuracies (tolerances) or else the product may not fit at its place at the time of erection.

Precast formwork presents unlimited possibilities of architectural finishes such as brick, stone, ribbed finish sand blasted or acid itched exposed aggregates.

Steam curing and heating of the bed is possible in precast formwork which increases the rate of strength gain of concrete.

**Design Considerations**

Maximum reuse of formwork is the key to economy. The Architect must keep the number of different shapes to a minimum and design shapes which can be stripped easily, preferably cast in single pour. Even so, it should achieve the desired edges, surfaces and textures.

Typically forms should be made for standard cross sections of columns, beams etc. The Architect should try to use these standard sizes as much as possible so that new forms are not required to be made.

The form side(s) of the precast are usually on exterior of the building. When a panel is cast horizontal, the bottom side may be exposed aggregate, rubber form lined (to give desired texture) or just plain surface. The upper surface of the concrete in the mould which is not as smooth is on the interior of the building.

In case of forms with fixed sides, the vertical faces should have draft (slope) of about 1:5 to 1:12 depending upon the width of the section - this would make it easy to remove.

The interior edges of the form should be radiused or chamfered at least 10mm to avoid edge damage during stripping. This can be done using chamfer strips made up of wood or steel.
In long line - prestressed method of casting during detensioning of strands concrete shortens, and so the inside forms need to be removed before detensioning. The design should be such that these inside forms can be removed without disturbing the strands.

The form surface against which concrete is cast should be smooth. These are cleaned by wirebrush, scrapping, scrubbing and even chipping. The form sheet should be thick and strong enough to maintain its smooth surface. The plywood used is raisin coated.

If steel bed is chosen, which normally is the case, magnetic systems can be used to fix side forms. Side forms are needed for not only defining the boundaries of the panel but also for door and window openings.

Formwork construction techniques vary, but generally heavier construction gives more dimensional stability and helps reduce transmission of vibration and results in longer life. Fabrication tolerances are typically half the product tolerances. The surface roughness of the steel used is about 0.15 micron. The steel forms have thickness of plates of about 5mm to 8mm and have gussets at every 200mm to 500mm depending upon the forces. Sometimes the Steel plates are made of Chrome Molybdenum Steel.

Sometimes accelerated curing is achieved by heating. To do so, elaborate piping is done under the form bed and hot water or steam is passed through it. To reduce heat loss, insulation should be installed under the beds. The pipe for heating is above the insulation.

Long forms usually have slopes and drainage should be provided.

**Formwork for precast wall panels**

Wall panels are cast individually or on a long bed when prestressed. Generally the bottom platform is a steel plate of at least 5mm thick mounted on a concrete. The side forms are usually are fixed rail/channel or wooden. The blockouts are also wooden.

In a long line method, there is a long form of about 50 to 100m with side fixed rail on one side which makes the common side for all the panels. The second rail is usually movable and is kept such that it is on the largest width in the pack. Others in between are wooden. Sometimes the bed is capable of vibrating.

![Figure 2 - Tilting Table](image1)

Tilting tables are used to cast wall panels. These tables are equipped with heating and vibrating bed as well. Tilting tables are hydraulically operated and are horizontal at the time of casting. At the time of stripping, tilting tables tilt to almost vertical – thus need lifting inserts only on the edges. They also reduce the steel required or can be stripped quickly.

Battery moulds are designed for the vertical fabrication wall panels. Each layer can have a variable area and reinforcement. They consist of bulkheads between which 5 to 10 panels can be simultaneously formed. Vibrators facilitate the effective compacting of concrete. Battery moulds offer to produce architectural wall panels with both inside and outside surfaces as smooth.

Another system is based on production pallets (a steel table) which pass through various workstations manually over a set off protruding wheels before concrete products are complete. Various transport systems (such as central shifter, side shifters, and rollers) transport the pallets from workstation to workstation. Each workstation has a role – preparing, concreting, curing and stripping. This system offers the flexibility of horizontal casting and economizes on tilting table.

![Figure 3 - Battery Mould](image2)
Strong magnetic systems are available which help in fixing the side forms. The force is more that 500kgs and th

A fully automated system called carousal system is also available. It is computer controlled and gives a very rate of production. Lattice Girder Slabs can be made with such a system.

Double wall formwork is essentially the same but it additionally needs a system to rotate one half of the already cast and set slab all around and keep it on the one which is recently concreted.

**Formwork for Columns and beams**

Usually precasters keep standard width and height forms. Column forms are usually non prestressed and can be made up of steel or wood. These can also be made in specially fabricated battery moulds. Rectangular beams can be cast in similar way but special forms are needed for Inverted Tee beams. The sides of these forms can be detached. Long line prestressed forms have arrangements for prestressing steel. They need permanent abutments and hence are fixed in place.

**Formwork for Hollowcore slabs**

Formwork for Hollowcore beds need steel plates firmly mounted on a foundation and abutments at both ends to take prestressing force. Manufacture of hollowcore is a propriety system and a hollowcore machine manufacturer normally provides the beds as well. No side forms are required as hollowcore production needs a very dry mix concrete and remains their on its own. Some machine manufacturers recommend concrete beds to cast the hollowcores on.

**Conclusions**

Formwork or precast is needed more in the plant and less at the construction site. The principles of structural design of formwork remain the same. Tolerances required for the finished product and the forces coming on it govern the design of formwork. Precast concrete products do not need any finishing (such as plastering) on site. By using coloured aggregates and formliners beautiful patters can be achieved. Companies can fabricate their own formwork or choose from the various systems available in the market based on the production needs.

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