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ABSTRACT

This paper deals with the prefabrication techniques for residential building using a system of Precast units for columns, beams, roof and walls. Precast R.C.C. planks and partially Precast R.C. joists are considered for flooring / roofing system in this paper and special types of Precast wall panels are recommended. Prefabricated columns with a specific configuration, beams and staircase units are considered in this paper. Special emphasis has been made with respect to the various joints and connections and the details of these are discussed. A comparison of the cost of construction of Precast system with that of a conventional construction unit has also been made. Finally, identified that large scale adopting of such a Precast systems will eventually result in considerable cost reduction with the added advantages of execution speed.

1. INTRODUCTION

In this modern culture, and fast growing population it is essential to have more residential with lesser cost and lesser time. Cost reduction is made by several ways and one such way is to use prefabrication techniques. To reduce the overall cost and to greatly reduce the construction time. Of buildings, prefabricated units are adopted. Prefabricated structure is one, the component member of which is precast, either in factories or in temporary plants established on the site. These precast members are transported to the site and then they are hoisted, set into complete structure.

2. PREFABRICATION TECHNIQUES

"Prefabrication" is an industrialized. Construction method whereby mass-produced components are assembled into buildings with the aid of cranes and other lifting and handling appliances. The work of building is carried out in two stages manufacture of the components in the factory or workshop, and erection on the site. Prefabricated structural components made of concrete are referred to as "Precast units" ("Precast members" or precast elements" are terms alternatively used), signifying that they are cast in advance and given time to harden and acquire strength before being taken to the actual construction site for erection. Construction methods which make use of prefabricated components are collectively referred to as "Prefabricated construction".

The precast structural components may, alternatively, be produced on the building site itself. However the trend is definitely towards "factory made" components, (i.e) produced in a permanent factory or workshop. The series of precast units produced on the site are generally smaller. The units themselves can be manufactured to larger dimensions, as transport difficulties are obviated. The units are concreted in stationary moulds: they are provided with ordinary reinforcement or prestressed with cables or wires.

The object of factory production is to turn out large series of precast units. The size and weight of the individual units are, however, limited by the possibilities of handling and transport. They may be manufactured in stationary moulds, which in the case of pre-tensioned prestressed
concrete components are, arranged on prestressing beds with tendons consisting of strands or individual wires which are anchored by being embedded in, and thus being directly bonded to, the concrete. Alternatively, the moulds and the units may be moved along during the manufacture operations; in this way a kind of production line process is obtained. Another significant feature of prefabricated construction is that the precast units, i.e. the structural concrete components manufactured in advance, have to be erected by appropriately assembling them together. The prefabricated components should already comprise the various finishes, surfacing, doors and windows.

These items of finish are of great importance more particularly in housing construction. This will be readily understood when it is considered that the walls represent only about one fifth of the total cost of a house.

2.1 Advantages of Prefabricate Construction

a. The construction time is shortened, since structural work on the site is confined to constructing the foundations and erecting the pre fabricated components. Because of the low moisture content the building dries out more rapidly than a building of conventional construction and is sooner ready for service.

b. The quantities of materials required are reduced, as formwork and scaffolding are largely eliminated. Favorable weight-saving structural sections can be used, so that less concrete and steel is needed and the weight of the building as a whole is reduced.

c. Production of precast units in large series makes it practicable to use machines whereby the required amount of manual labor is substantially reduced. Besides the units can be manufactured in the most convenient position on the casting bed.

d. Less man power is needed, since the precast units are manufactured in a factory or, at any rate, under factory conditions on the building site. Instead of skilled labor, unskilled workmen can be used, who do not have to travel around from site to site.

e. Better quality of the products is obtained as a result of manufacture under factory conditions with constant Quality control, the use of machines, and the better Working environment provided by the factory.

f. Construction can proceed almost independently of weather conditions, since the units can be manufactured in covered buildings which can be heated and erection of the units can also carried out in winter.

2.2 Problems in Prefabricated Construction

There is the problem of transporting the prefabricated components from the factory to the site which is not more difficult than the transport of materials and of erecting and interconnecting them to form the final structure. These operations associated with prefabrication entail additional costs and technical problems. To justify the choice of prefabricated construction in any particular case, the advantages must of course out weigh the disadvantages.

2.3 Classification

The prefabrication is classified as follows from the view of degree of precast construction.

1. Small prefabrication
2. Medium prefabrication
3. Large prefabrication
4. Cast-in-site prefabrication
5. OFF site (or) factory prefabrication
6. Open system of prefabrication
7. Closed system of prefabrication
8. Partial prefabrication
9. Total prefabrication
3. PREFABRICATION ELEMENTS.

3.1 Flooring/Roofing system

This system consists of R.C. planks supported over a partially precast R.C. Joist. The joists are supported with the main beam through channels which are provided at the necessary spacing. To provide 'Tee' beam effect with the joist, the planks are made partly 3cm and partly 6cm thick. Remaining thickness of planks is filled with insitu concrete with necessary anchorage reinforcements.

3.2 Precast Beams

Faces of columns. The reinforcements are papered for 300mm on either side to provide better connection with another beam. Shear keys are provided on either face of the column to get better anchorage. The top corners of the beam on either side are haunched to provide good accessibility to the insitu concrete at the connections. Channel sections are provided at a regular spacing to connect the joists.

3.3 Precast Columns

Newly innovated shapes of columns are tried in this paper. The special types of columns are used to hold the wall panel in position. These types of special columns having high load carrying capacity and moment carrying capacity than the conventional types of columns. The ribs will act as a temporary support for the beam having erection.

3.4 Precast wall panels

Special types of wall panels are used in this paper. Cellular concrete of 75mm thick blocks are sandwich by a layer M25 grade concrete for thickness of 37.5mm on either face. A minimum area of reinforcements is provided on the side face concrete. To withstand the handling and erection stresses R.C.C. ribs are provided around the wall panel. Door and window frames are simultaneously while casting the wall panels.

3.5 Highlights

1. This R.C. plank and joist system provides good Tee beam effect, because of the insitu concrete and anchorage reinforcements.
2. In this system triangular shaped stirrups are used to provide better anchorages between the insitu concrete and joist.
3. In this system slender sections are used for planks and joists, for the same loading condition as in the conventional buildings, so considerably the quantity of steel and concrete is reduced. Dead weight of the roof/floor system also considerably reduced.
4. Because of the less weight, the plank and joist can be transported and erected easily.
5. The bottom surface of the planks is very smooth due to precasting. So, no need of special ceiling plastering.

3.6 High Lights

Cellular concrete is used as a filler material in the middle core of the wall panel. This cellular concrete having number of advantages as described in the relevant chapter. The subjects of the wall panels are smooth due to precasting with M25, grade concrete. No need for special plastering.

To take care of the handling stresses, special ribs are provided in the panels with the use of
cellular concrete the weight of wall panel is considerably reduced, and it is easy to transport and erect in position. Because of the special type of columns, the erection work of the wall panels is simplified.

4. CONNECTION DETAILS

4.1 Choice of connections

In precast concrete construction the connections between the elements are of utmost importance. There are two types of connections, one "Wet" connections (with motor or in-site concrete), second is 'Dry' connections (with welding on bolting). While choosing a connection, so many factors we have to consider. The connection should satisfy in technical, economical, and if required - aesthetical respect, the following considerations shall be taken into account.

4.2 Structural requirements:

The connection must comply with all requirements regarding the transmission of forces and moments, and permissible deformation or rotation.

4.3 Tolerances:

The measure to which deviations must be taken up in the connection.

4.4 Aesthetical requirements:

The connection remains completely or in part exposed.

4.5 Mode of erection:

With regard to available erection equipment (cranes etc.) fastest possible erection (short crane times), and avoidance or minimizing of bracing, supporting etc.

4.6 Necessity of checking and adjusting:

The connection and/or the elements.

4.7 Finishing requirements:

With regard to corrosion protection, fire resistance, appearance and maintenance.

4.8 Manufacture:

Manufacture of the elements and the connecting parts should be technically and economically justifiable.

4.9 Transportation and storage:

The shape of the elements (including the provisions for the connection) as related to problems during transportation or storage at plant and/or building site.
4.10 Costs:

These are mainly determined by the structural requirements and the number of connections. For an economic choice, the costs of the connection proper (incl. its finishing) should be weighed against the costs of manufacturing, transportation, storage and the erection of the elements.

4.11 Designing the connection

While designing the connection following points must be considered. Design of connection must be based on the relevant standard specifications, codes of practice, rules or by-laws and any other special requirement or recommendation which might be relevant.

4.12 Loading under working conditions

The entire structure, as well as each unit units own, must be designed to resist all loads, forces and moments, acting there on when the structure is in use. Eccentric load on an internal column, torsion of main beam.

4.13 Stability of the structure

The overall stability of the structure must be warranted during each phase of construction. This might require special provisions.

4.14 Load conditions during construction

Load conditions during construction may cause higher stresses than those through normal usage. Temporary eccentric loading of an internal column, temporary additional loads due to erection materials and temporary supports.

4.15 Effects of shrinkage, creep and temperature

With fixed-end beam connections the stresses and moments due to shrinkage, creep and temperature drop of the beams must be considered for the connection proper and for the structure as a whole. To minimize these effects, it is desirable for the greater part of the shrinkage and creep shortening to have taken place prior to the installation of the beams.

4.16 Unequal settlement

In the case of fixed-end connections the possibility of settlement at the supports should be investigated.

5. RECOMMENDATIONS FOR THE ERECTION

5.1 Setting out and marking

Prior to erection, all measurements must be checked and sufficient marks set out to enable fast and accurate erecting.

5.2 Anchor bolts and dowel bars

In placing groups of bolts or dowel bars, one bolt (dowel bar) in each group should be getting out to facilitate location of the member, or even better the tops of all bolts (dowel bars) should be so defined that even the shortest bolt is sufficiently long to allow minor adjustments.
5.3 Mortar or Cast-in-place Joints

The performance of these joints depends on the strength of the hardened mortar or in-situ concrete. The mix should be aimed at achieving full compaction with the available means, and on the other hand at keeping shrinkage to a minimum. This latter requirement also called for extensive curing. Since hardening of the mortar (concrete) is influenced by the ambient temperature, such measures as the use of rapid hardening or Ultra rapid hardening cement, heating of the mortar or the concrete and even heating of the adjacent precast concrete might be required during the cold season.

5.4 Dowel holes

For grouting dowel holes the following possibilities may be considered.

5.5 Upward dowel holes

can be grouted either by injecting or by pouring a sand-cement grout containing a cement grout containing a cement not susceptible to bleeding, or by a pure cement grout with an injection agent.

5.6 Downward dowel holes

which are cast in, can be grouted similarly. If they are drilled, these should be filled either with a grout to which a synthetic resin dispersion agent is added, or with a synthetic resin with a quartz filler. In any case these holes must be filled just prior to placing the dowel bars and must then be clean and air-dry.

5.7 Recesses, pockets

Depending on the size, these should be filled with a dry to half plastic sand-cement mortar or in-situ concrete to which a synthetic resin dispersion agent might be added for better bonding.

5.8 Welding of reinforcing bars

Welds between reinforcing bars, pertaining to the same joint, should be as nearly identical as possible. To attain this each pair of bars to be welded in the same joint should be so bent, and if necessary cut, that the distance between the welding faces are equal to that of the other pairs. Further more there must be sufficient room between the concrete faces for laying the welds, and the bars should have sufficient projection to prevent overheating of the concrete. A minimum distance of five times the bar diameter between the edge of the weld nearest to the concrete and the concrete face is in this respect considered to sufficient. Moreover, welding operations should confirm to the relevant standard specifications, codes of practice etc.

5.9 Stability measures during erection

The overall stability of the structure as well as the stability of each element should be ensured by temporary supports, struts, braces etc. Until the connections are load transferring. Erection equipment (cranes etc.) Should there by not be obstructed. This may influence the order of erection.

5.10 Corrosion protection

Projecting reinforcing bars are for the same reason liable to corrosion at the interface between the precast element and the in-situ concrete or mortar fill. For this reason these bars should also be corrosion protected over a short distance from both sides of the interface with a
coating of epoxy, rustproof point. If they are welded the same applies as set out for steel parts.

CONCLUSION

An attempt has been made in this paper to plan, analyse and design a multistoreyed residential building using prefabricated techniques, bearing in mind, the cost of total construction and planning of the building are done in such a way that the maximum area utilisation is achieved for minimum space and cost. The maximum carpet area for the same plinth area is achieved by the use of lesser thickness of wall panels. The detailed drawings expressing the ideas of planning and details of structural components makes the construction work simple.

Precast R.C.C. planks and partially precast R.C. Joists are considered for flooring/roofing system in this paper and special types of precast wall panels are recommended. Prefabricated columns with a specific configuration beams and stair case units are considered in this paper.

The increase in the cost is noticed mainly due to the erection charges, which is not encountered in the conventional construction. These charges are arrived on an adhoc basis based on the limited availability of data with respect to the erection of prefabricated elements. If the number of units are more the cost of erection will lowered due to optimized utilization of erection machinery. The complete construction of prefabricated building can be done with in one-fourth of the time that is required for conventional construction.

This saving in time will give more gain in the following ways.

1. Escalation in material and labour cost due to inflation over a large construction period are avoided.
2. Earliest occupancy time.

In conclusion, it may be observed that the prefabricated construction can be easier, cheaper and great time saver in the construction of large number of similar buildings within a paper area.

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