Pre-Cast Technology: An Initial Step to Sustainable Development

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Abstract— Erection of precast construction unit is a complex mechanized process for continuous assembly of buildings and installation of prefabricated elements and components. Precast construction provides advantages over conventional practice by costing the pre definite size of the members (penal, walls, beams, columns) in the factory. In this technique the structural members specially made of concrete that has been cast into form prior being transported to its construction location for the final installation work. Precast construction technique is the first step to satisfy the demand of sustainable housing for the population in developing country. It is also one of faster construction process which also provides high quality. This Paper cover different types of precast construction system, its main features, equipment required for the construction work and its installation process for different type of components. 

Keywords: Faster method, Installation of components, Joint ceiling, Low cost, Precast construction.

I. INTRODUCTION

As the modern culture and fast growing population is increasing, it is essential to have more residential demand with lesser cost and lesser time. Cost of the construction can be reducing by several ways and one such way is to use prefabrication techniques. To reduce the overall cost and to greatly reduce the construction time for building, 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. Precast construction technology helps to save a lots of construction time and provides good quality, value of the construction. It is also helpful for quality enhancement of the final work. This technology also reduce the construction cost because none of the material get stored or waste as usually seen in on-site construction work and also reduce the labor cost because less and skill full labors are required for the installation of the components. It saves 10 to 15\% of the total construction cost. The concept of precast (also known as “prefabricated”) construction includes those buildings, where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost. Prefabrication has been used extensively and widely for many years around world. Pre-assembly, prefabrication, modularization, system building and industrialized buildings are the terms which have been frequently used to describe that the manufacture of building components are constructed either on-site or off-site in a factory covering manufactured, modular and pre-cut or pre-engineered systems. It is seen as one of the code of belief of improving construction in the 21\textsuperscript{st} century.

II. TYPES OF PRECAST BUILDING SYSTEMS

Depending on the load-bearing structure, precast systems can be divided into the following Categories:

1. Large-panel systems
2. Frame systems
3. Slab-column systems with walls
4. Mixed systems

A. LARGE PANEL SYSTEMS

The term large-panel system is used for multi-story structures which are made up with large wall and floor concrete panels connected in the vertical and horizontal directions so that the wall panels enclose appropriate spaces for the rooms within a building. The closer of those panels form a box-like structure. Both vertical and horizontal panels help to resist gravity load. Wall panels are usually one story high. Horizontal floor and roof panels span either as one-way or two-way slabs. When properly joined together, these horizontal elements act as diaphragms that transfer the lateral loads to the walls.

Fig.1: A large-panel concrete building under construction

Source: https://www.google.co.in/search?q=image+for+large+panel+systems+building&source

B. FRAME SYSTEMS

Precast frames can be constructed using either linear elements or spatial beam column Sub-assemblies. Precast beam-column sub-assemblies have the advantage that the connecting faces between the sub-assemblies can be placed away from the critical frame regions; however, linear elements are generally preferred because of the difficulties associated with forming, handling, and erecting spatial elements. The use of linear elements generally means placing the connecting faces at the beam-column junctions. The beams can be seated on corbels at the columns, for ease of construction and to aid the shear transfer from the beam to the column. The components of a precast reinforced concrete frame are shown in below figure.
C. SLAB-COLUMN SYSTEMS WITH SHEAR WALLS

These systems rely on shear walls to sustain lateral load effects, whereas the slab-column structure resists mainly gravity loads. There are two main systems in this category:

1. Lift-slab system with walls
2. Pre-stressed slab-column system

In the Lift-slab system, the load-bearing structure consists of precast reinforced concrete columns and slabs. Precast columns are usually two stories high. All precast structural elements are assembled by means of special joints. Reinforced concrete slabs are poured on the ground in forms, one on top of the other. Precast concrete floor slabs are lifted from the ground up to the final height by lifting cranes. The slab panels are lifted to the top of the column and then moved downwards to the final position. Temporary supports are used to keep the slabs in the position until the connection with the columns has been achieved. The pre-stressed slab-column system uses horizontal pre-stressing in two orthogonal directions to achieve continuity. The precast concrete column elements are 1 to 3 stories high. The reinforced concrete floor slabs fit the clear span between columns. After erecting the slabs and columns of a story, the columns and floor slabs are pre-stressed by means of pre-stressing tendons that pass through ducts in the columns at the floor level and along the gaps left between adjacent slabs. After pre-stressing, the gaps between the slabs are filled with in situ concrete and the tendons then become bonded with the spans. Seismic loads are resisted mainly by the shear walls (precast or cast-in-place) positioned between the columns at appropriate locations.

III. INSTALLATION SEQUENCE

1. Set reference line and offset line to determine the position of the precast elements to be installed.
2. Level pads should be provided for setting the level of the element.
3. For precast external wall/column, fix the compressible form or breaker rod on the outer perimeter of wall and for horizontal members put up temporary props to support the pre-cast slab/beam elements
4. Lift and rig the panel to its designated location with the use of wire rope.
   1) Check the hoisting condition of the pre-cast elements.
   2) Check alignment and verticality of the penal.
5. Adjust the panel to position and secure it with diagonal props.
   1) Check stability of the erected props before releasing the hoisting cable.
6. Prepare and apply non-shrink mortar to seal the gap along the bottom edge of the inner side panel.
7. For corrugated pipe sleeve or splice sleeve connection, proper and pour non shrink grout into the pipe inlets provided.
8. Keep the installation panels undisturbed for at least 24 hours.
9. Joints casting & sealing
   1) For panels with cast in site joints install the joints rebar as required
   2) Set up forms for the casting of vertical as well as horizontal joints
   3) Carry out concrete casting.
   4) Remove forms after sufficient concrete strength has been achieved
   5) For joints between faced walls or between external columns with walls elements approved sealant and grout will be installed at large stage.

IV. CRANES REQUIRED

Different types of cranes are used for the erection work depending upon type of construction and weight of the components. Some cranes which are frequently used for the installation are:

1. Crawler crane
2. Lynx –mobile crane
3. Truck mounted crane
4. Caterpillar-mounted crane
5. Tower crane
6. Gantry crane
7. Guy derrick crane
8. Rough-terrain crane

V. ADVANTAGES

1. Self-supporting ready-made components are used, so the need for formwork, shuttering and scaffolding is greatly reduced.
2. Construction time is reduced and buildings are completed sooner, allowing an earlier return of the capital invested.
3. On-site construction and congestion is minimized.
4. Quality control can be easier in a factory assembly line

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5 Prefabrication can be located where skilled labor is more readily available and costs of labor, power, materials, space, and overheads are lower.
6 Time spent in bad weather or hazardous environments at the construction site is minimized.
7 Less waste may occur.
8 Advanced materials such as sandwich-structured composite can be easily used, improving thermal and sound insulation and airtightness.

VI. DISADVANTAGES
1 Careful handling of prefabricated components such as concrete panels or steel and glass panels is required.
2 Attention has to be paid to the strength and corrosion-resistance of the joining of prefabricated sections to avoid failure of the joint.
3 Transportation costs may be higher for voluminous prefabricated sections than for the materials of which they are made, which can often be packed more efficiently.
4 Skilled labor is as less as skilled supervisor is needed for superior performance of erection.
5 Large prefabricated sections require heavy-duty cranes and precision measurement and handling to place in position.
6 Larger groups of buildings from the same type of prefabricated elements tend to look drab and monotonous. Using materials boxes which are fully sheeted to enclose the load.

VII. CONCLUSION
1 The demand of mass housing targets can be achieved by replacing conventional method by precast construction technique.
2 None of the other solution is available to meet the requirement of mass community at large scale so a system which can provide choice for people and also appropriate techniques to meet the situation.
3 Precast construction helps to reduce the cost of construction, to improve structural performance as well as to maintain quality of the work.
4 It is only solution for developing country’s to meet the requirement of sustainable construction on faster way.
5 Prefabrication is an approach towards the above operation under controlled conditions.

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