ECONOMY IN BUILDING CONSTRUCTION SYSTEMS OF PREFABRICATED STRUCTURES

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Abstract - *Prefabrication means investing in preparation, so that things proceed smoothly. Planning and organization must be intensified, interaction issues for an optimization and Co-operation in a multi-trades context has to be defined Cost studies of Buildings is about the understanding and application of costs to buildings and other structures. One of its aim is to ensure that scarce and limited resources are used to best advantage. It is about ensuring that clients receive the best value for money for the projects that they construct. In this paper I have considered Economy in the Construction system through "Pre Fabricated Structure" Building. Prefabrication is an advanced and up-to-date method of Reinforced Cement Concrete construction. The following are the detailed items dealt with this journal paper.*

,***Key Words***: *Load bearing wall, Cross walls, Longitudinal walls, Two Way Span Systems, Prefabricated, Construction*

1. INTRODUCTION

Prefabrication must come to be seen as separate from the concept of mass production. In future, industrial prefabrication must face the challenges of accepting individuality as a quality indicator and taking account of user's needs and wishes. We cannot build at the cost of the individuality of future residents by inflexible modular building systems. The interchange ability of components, for example, in systems that can later be modernized, allows for flexibility of use. The degree of industrial prefabrication must be increased in order for prices to be competitive. A higher degree of prefabrication, however, requires more work on the part of planners, which means that more time must be invested in planning processes. There is a necessity of making precise commitments in certain instances in the planning process. Optimization should be aimed for so as to transcend the trades' boundaries.

1.1 Load bearing wall type buildings

In this type, as the name indicates, the loads are carried by the walls themselves. This type can be further classified into two categories, namely, the open and the closed system.

In the open system, the components needed for a complete building are standardized, manufactured to specified tolerance and catalogued. With the use of these products, there is scope for several planning arrangements, subject to certain constraints. On the other hand, in the closed system the elements are manufactured to specific requirements for use in a known operation. For example, a wall of a room can be precast in a single piece, often referred to as large panel, instead of assembling the same from several precast standard components as in open systems. Structurally, load bearing wall type of schemes may be classified as follows:(a)**Cross walls** as load bearing and fa�de walls as non-load bearing. In this scheme, it is preferable to locate the openings, shelves, etc, in long walls as far as possible.(b)**Longitudinal walls** as load bearing and cross walls as non-load bearing. In this case the openings, cupboards, etc, may preferably be located in cross walls.

1.2 Frame type buildings

In the frame type of construction bearing and curtain wall elements can be clearly distinguished. There are two types of frames: complete frames and incomplete frames. In the buildings with complete frames, the outer enclosure takes the form of a non-bearing curtain wall with the floor loads transmitted downwards via exterior and interior columns. In buildings, where the frame is incomplete, there are no exterior columns and the outer enclosure is built in the form of a bearing wall. There are two fundamental systems of structural layout of a multi-storeyed frame building aimed at achieving skeletal rigidity, namely, the rigid frame and the diaphragm braced frame, that is, with shear walls. In the rigid joint frame both vertical and the horizontal wind thrust are taken up by a frame whose joints are rigid. In the diaphragm braced frame the vertical loads are taken up by a frame, but the joints may be either hinged or rigid, while the horizontal thrust from the wind or other sources is taken jointly by a vertical bracing diaphragm and the frame.

1.3 Buildings with load bearing walls

Precast wall panels are also used to form shear walls at the perimeter of cast-in place or precast frame structures. This "perimeter wall system" serves to resist lateral forces either alone or in combination with a cast –in place core shaft.

1.4 The Long – Wall System Buildings

In the long wall system, the main beams or load bearing walls are placed longitudinally, or parallel to the main axis of the building. One way slabs span transversely between the load bearing walls. The long-wall system applied to a building with large prefabricates has much in common with traditional brickwork techniques. Longitudinal external walls, which carry floor loads, must possess not only thermal properties, but also sufficient load bearing capacity. Thus the structural requirements influence the ratio of the widths of windows to the widths of the load-carrying bands. Longitudinal wall systems are suitable for low rise buildings.

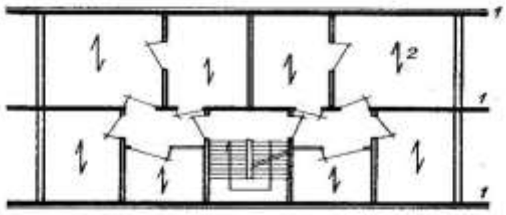

Fig -1: Long-wall system

The long – wall system of construction is typical of the “classic” large-block buildings which were the first large precast-component buildings to be erected in Poland. The special pier blocks between windows, which carry loads from lintels and from the walls above are characteristic here. The horizontal sill blocks are not loaded. When the crane used in erection is of small capacity, the pier consists of two or three smaller blocks laid one upon the other.

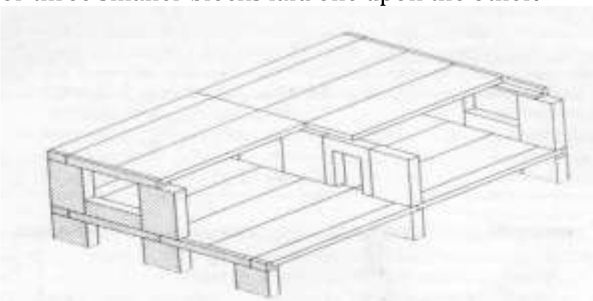

Fig - 2 Diagrammatic view of a “classic” long wall construction in a prefabricated building

1.5 Cross – Wall System Buildings

The load bearing walls in the cross-wall structures are perpendicular to the longitudinal axis of the building. One-way floor and roof slabs span between the bearing walls . In the cross-wall system the external long walls do not distribute floor loads. If these walls are required to carry their own weight down to the foundations, the elevational treatment will not differ much from that of a long-wall building. However, when normal non-structural façade walls are supported at each level, the width of windows is unrestricted. Cross wall systems are more suitable for high rise buildings.

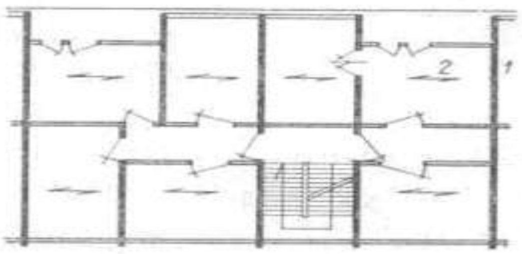

Fig -3: Cross-wall system

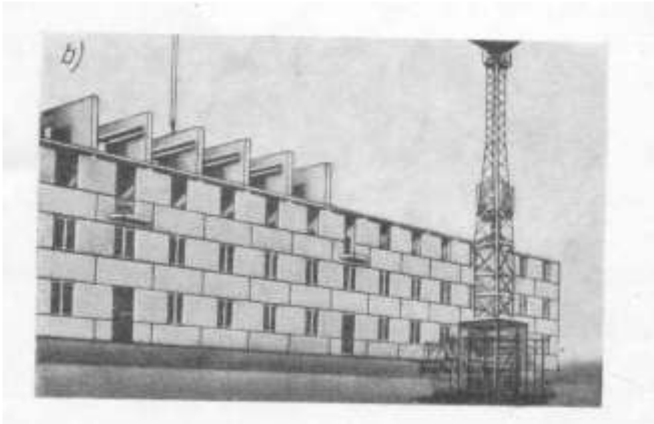

Fig – 4: Foamed concrete block building

In cross-wall buildings there is a clear distinction between the structural and the thermal insulation functions of walls, which permits the full utilization of the structural properties of ordinary concrete in the internal load bearing walls, and of the thermal properties of light concrete in the outside walls. Because of this, and of the ease with which new insulating materials can be introduced, the cross-wall system is very often adopted in buildings with prefabricated load bearing wall components. The external walls consists of two basic block units: pier block and sill block. Both blocks are of similar weights, which is of advantage both in transport and during erection.

2. TWO WAY SPAN SYSTEMS

In ring or two-way span system, the supporting members run both longitudinally and transversely. In buildings with the ring system of support, the floors are normally supported on all four edges, and span two directions. In buildings based on the ring system only part of the floor load is carried by the outside walls. Because of the close cooperation of all walls in load distribution, it is said that, the ring system of all walls, with the floors spanning in two directions Fig 8, is ideal for large-panel buildings.

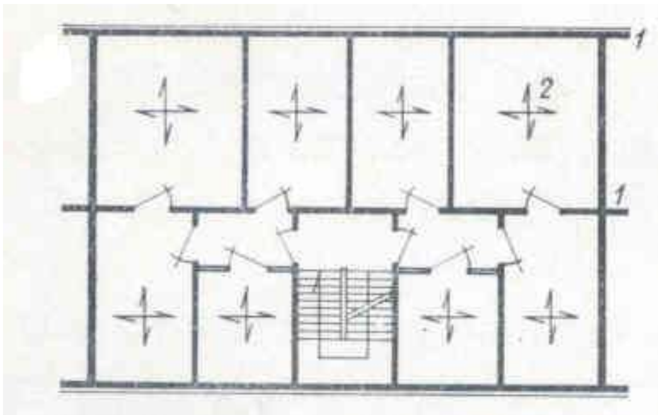

Fig -5: Two-way span system

When the overall width of the building is more than 10 m it is normally necessary to design it as a three-bay structure, which increases the number of wall components and rather restricts the flat layout. The load carrying function of the external wall restricts freedom in the design of wall prefabricates, just as in the case of the long-wall system.

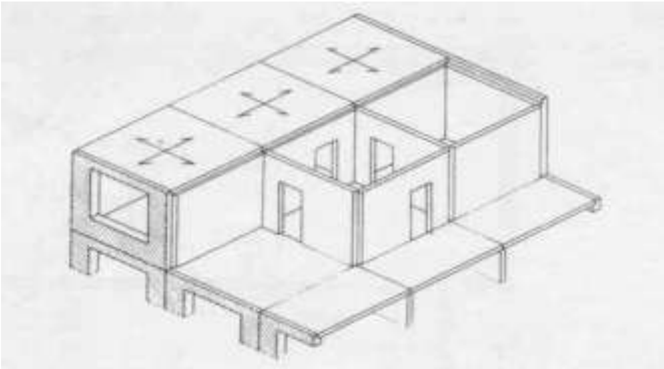

Fig-6: Diagram of the "classic" arrangement in a large-panel two-way span system building

Two–way span system allows the best utilization of the structural materials and the finished buildings are very rigid in both directions. The greatest economy of steel is obtained when the floor panels are nearly square.

2.1 Skeleton Construction

In skeleton constructions based on this system the slab units may rest directly on columns, completely eliminating beams as structural components. In a skeleton structure the outside walls may consist of panels or blocks. The orientation of floor slabs, i.e. the structural system, is less significant in skeleton construction. These may be classified as:- Prefabricated column and beam structures, eamless structures, in which floor panels bear directly on columns , and precast frames. All the walls in skeleton structures may consist of large prefabricated units, or may alternatively be laid by hand using smaller precast units.

2.2 Prefabricated Columns and Beams

A diagrammatic view of a skeleton structure consisting of prefabricated columns and beams is shown in Fig 7. This scheme employs the same structural elements as are used in a monolithic in-situ cross-frame building. One essential difference is that there are no longitudinal edge beams to support the external walls. These walls are fixed directly to the column members.

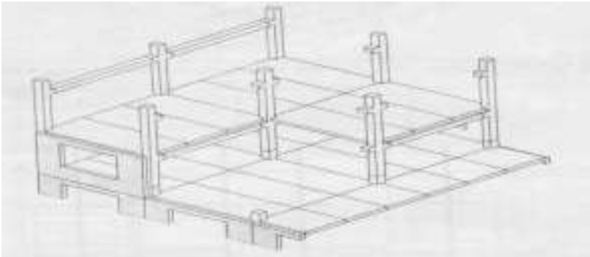

Fig -7: Diagram of a skeleton structure consisting of prefabricated columns and beams

Prefabricated skeleton members as in Fig 7 are of simple shape and easy to transport. Often, to expedite erection, beams and columns are assembled into larger units, frames, or even three dimensional units before erection.The type of construction shown in Fig 7 has been applied to many buildings erected in Moscow and other towns of the Soviet Union. Precast skeleton constructions may also be based on the long wall system as shown in Fig 8 .

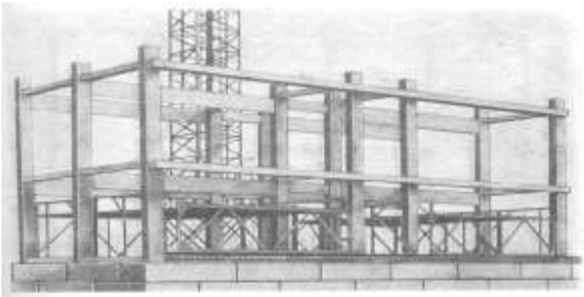

Fig -8: An erection view of a skeleton building

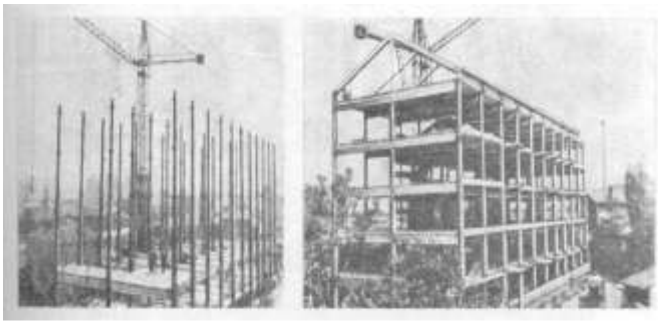

Fig-9:A skeleton building with one – piece precast spun concrete columns, views of the building in various stages of erection

3. PRECAST SKELETON STRUCTURE

A diagrammatic view of a structure consisting of prefabricated portal frames is given in Fig16. Several versions of this type of construction have been widely used in many countries.

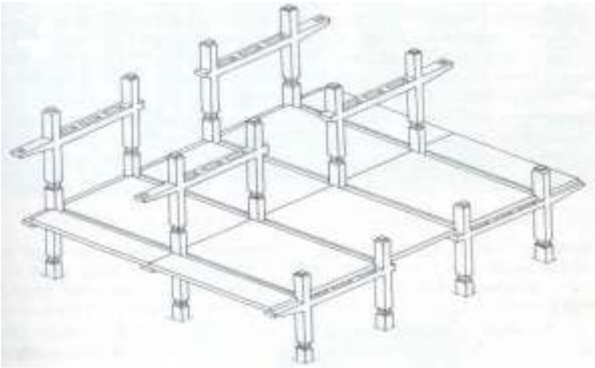

Fig -10: A Skeleton construction

A prefabricated skeleton construction was used in Poland in the erection of the new 11 storey university library in Lodz. The structural skeleton (Fig 11) consists of prefabricated double – cantilever H – frames and hinge – connected beams in the central span. The legs of the frames are welded together to form columns. The external wall panels rest on frame cantilevers.

Fig - 11: The structural scheme of the university library at Lodz

3.1 Advantages of Skeleton Construction

- Prefabricated skeleton members are of simple shape and easy to transport.
- To expedite erection, beams and columns are assembled into larger units, frames or even three- dimensional units before erection.
- Panels in conjunction with precast beams and columns are much more often used, as they are more suitable for industrialized production and long distance transport
- It may be advantageous to use materials other than concrete in the construction of light external walls in skeleton structures.

4. ERECTION OF BUILDINGS

Before commencing erection, the setting – out at the level concerned must be carefully checked with surveying instruments. At the same time, the working of the crane and the correct layout of the crane track must be checked. Any unevenness of the ground often makes it difficult to lay a horizontal crane track. With fairly steep slopes, a rather high embankment is required, and this is both costly and technically difficult. In such cases, dry staging is built out of large prefabricated blocks specially made for this purpose. Prefabricated buildings are erected in convenient sections, which, when correctly fixed, should be sufficiently rigid in all directions.The normal sequence of erection is:

(a) structural wall units;
(b) Non-structural wall units (partitions.);
(c) floor panels , balconies , stair units;
(d) Specialized prefabricates (chimney flues, ventilation ducts, sanitary installations).

If the external walls are hand – laid from small blocks or bricks, all necessary materials should be hoisted by crane and stacked on the floor near to their ultimate position. The masonry work is begun after the floor immediately above is laid. The erection schedules of two prefabricated buildings in Warsaw are shown in Fig 12 and Fig 13.

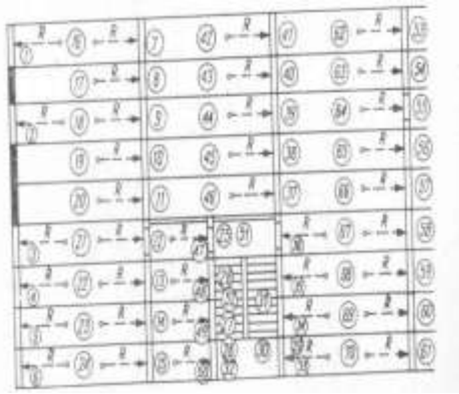

Fig 12 Erection schedule of a large-block

Numbers in circles give the sequence of prefabricate erection , R = stays

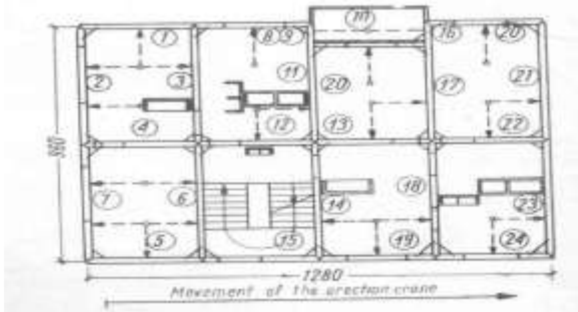

Fig 13 Erection schedule of a PBU type large-panel building, numbers in circles denote the sequence of assembly, R = stays

5. TYPES OF PREFABRICATION

With regard to the place where the work is done, two types of prefabrication can be distinguished: Plant prefabrication and site prefabrication.

5.1 Plant Prefabrication

This kind of prefabrication is done in permanent plants or factories, established particularly for this purpose. Its advantage is that the work can be performed in covered rooms irrespective of the hardships of weather and outer temperature, with a constant team of workmen, and the work itself can be organized factory-like. The plant can be furnished to the highest degree with mechanization and automation. The permanent laboratory allows continual control; and so the materials to be used always have similar properties. Owing to these advantageous conditions prefabrication plants or factories produce in serial manufacturing, in general, cheap and reliable structures of good quality. But a drawback of plant prefabrication is that the members must be transported to places where they are to be used. The transportation cost of a precast member to the site amounts, in general, to about 10 – 15 % of the total cost required for the production and assembly of same. For the sake of transportability the dimensions of the members must be held within certain limits so increasing the number of joints in the structures.The above mentioned limitation of the dimensions of the members entails a certain restraint on design , as well as on the further development of prefabrication.Plant prefabrication is appropriate for mass production, chiefly for the manufacture of standardized members. Plant prefabrication might be performed either in a large building component factory of country-wide character or in smaller prefabrication plants operated by the individual building firms. In the field of industrial structures the development markedly point towards the production of precast members in centralized prefabrication plants set up and run by the individual building firms.

5.2 Site Prefabrication

When using this kind of prefabrication , the reinforced – concrete members are produced on the site , chiefly in the open air, and most members of smaller size are precast in temporary covered sheds established for this purpose. Difficulties occurring in construction work, in general , cannot be avoided here either .Each new building site entails ,in most cases, the employment of new labourers , and the use of different building materials ,the properties of which are often not sufficiently known . Mechanization cannot be such a high degree as in a permanent plant , because of the temporary nature of the work, its duration being generally short, at most one or two years; so a high degree of mechanization similar to that applied in the permanent workshop would not be profitable.The laboratories on sites are , in general not so well equipped as in a permanent factory for building members.

6. IMPROPER DESIGN AND DETAILING OF DUCTILE ELEMENTS

For low-rise precast concrete structures the columns or wall panels are the ductile elements, with the floor and /or roof elements designed to be stronger than these ductile energy-dissipating elements in accordance with accepted capacity design principles. It is of interest that older moment resisting frames and structural walls incorporating precast concrete often have been observed to perform badly during earthquakes. The observed failures have been mainly due to brittle (non-brittle) behaviour of poor connection details between the precast elements , poor detailing of the elements and poor design concepts. Fig14 show examples of major damage to precast concrete structures as a result of severe earthquakes. As a result the use of precast concrete was shunned in some countries in seismic zones for many years.

Fig 14 Collapse of precast buildings

Fig - 15: Failure of poorly detailed precast concrete column

Fig -16: Close-up of poor column details

A close – up of the region of distress shown in Fig 16 indicates that twelve 15 mm diameter bars were continuous over the height of the column while four 20 mm diameter bars were cut-off at the region of distress. The transverse reinforcement consisted of 6 mm diameter plain bars at a spacing of 175 mm. Bond and shear failure occurred at this critical section where the vertical bars were curtailed.

7. CONCLUSION

Prefabrication is an advanced and up-to-date method of reinforced-concrete construction. Various prefabrication construction methods, its advantages and disadvantages have been discussed in this project report. The desire of the construction industry to minimize on-site labor and reduce construction time has resulted in the prefabrication of building components.

"Prefabrication" is the practice of manufacturing the parts of an assembly in one location, ready for them to be assembled in another place. Industrialization, such as the prefabrication of building deliver a better product because building is done in a quality controlled, sheltered environment. Thus Economy of the Construction system through Prefabricated Structure is attained by the various factors in which the following are the important aspects,

- Increased site productivity
- Improved quality of installation
- Reduced site waste.
- Use of lesser Labour at site
- Timely completion of construction
- Space required for construction activity / stacking of materials will be lesser compared to conventional type.

Builders will have to develop new construction methods and adopt existing methods from other industries and countries. An awareness of the current trends and latest innovations in prefabrication and industrialized construction is essential. New building systems and construction methods are also appearing in the move towards prefabrication.

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