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STUDY ON PREFABRICATION CONSTRUCTION

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ABSTRACT

The construction boom in India is developing at a fast rate of growth. It provides wide opportunity in India for a new entrant in prefab sector. At present precast concrete buildings are the advanced construction techniques available over worldwide. Being its wide applicability, the total precast concrete buildings systems are becoming a popular choice for many construction. Precast concrete available in many shape, sizes, including structural elements and unreinforced pieces. The prefab industry is the backbone for the development of new ideas in construction business of any country; Factory buildings, residential buildings and the industrial township are needed practically by all the sectors, either to support the manufacturing or services of any industry.

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. A modular structure however, is not a mobile structure; it is simply a structure that is built off-site as opposed to on-site. These structures are often called factory-built structures, system-built or pre-fab. structures. Modular and manufactured structures however, are not the same. Manufactured buildings are not placed on permanent foundations. Manufactured homes, sometimes referred to as mobile homes can be moved from one location to another. Prefabrication has been used extensively and widely for many years around the 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. Although the terms, are often interchangeably used, their precise definitions depend heavily on the users' experience and understanding, which vary from country to country

Prefabrication is preferred with special emphasis on the building components are made off-site in a factory. Off-site fabrication is a topic of international interest and provides an effective construction technique in term s of quality, time, cost, function, productivity and safety. It is adopted worldwide as the ideal means of producing an immense array of elements from structural members, cladding units, and bathrooms to fully-finished modular buildings.

Architects are incorporating modern designs into the prefabricated houses of today. Prefab housing should no longer be compared to a mobile home in terms of appearance, but to that of a complex modernist design.

There has also been an increase in the use of "green" materials in the construction of these prefab houses. Consumers can easily select between different environmentally friendly finishes and wall systems. Since these homes are built in parts, it is easy for a home owner to add additional rooms or even solar panels to the roofs.

The main objective of this paper is to Investigate the current level of utilization of prefabrication technology in the building sector of the construction industry,examine the advantages and disadvantages of prefabrication technology in the building industry examine the advantages and challenges of conventional building practices in the current industry and formulate construction techniques that will integrate prefabrication in the current conventional building practices.

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Keywords: Prefabrication, Systems, Standardization, Assembling, Construction

1. INTRODUCTION

It is essential to have more residential with lesser cost and lesser time in this modem culture, and fast growing population. 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. In Prefabricated structure the component member 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.

Prefabrication is a development industry term used to depict assemblies that are fabricated under processing factory conditions and afterward transported to the construction site. The work with this manuscript was initiated with a general literature study to get an overview of construction methodologies of prefabrication systems. Prefabrication systems could be divided according to materials, methods, structural configuration etc. In this article, prefabrication systems are divided according to their configuration. Although there are numerous advantages connected with developing and assembling buildings utilizing prefabrication construction frameworks, a few constraints might likewise exist. The goal of prefabrication systems is to offer a way to get a well-designed building that is at least roughly tailored to resident's needs. It could be stated that prefabrication systems in building construction have the most effect on time and cost reduction.

It is understood that, prefabrication systems could be used more in building construction if the disadvantages of prefabrication are solved and It is possible to say that further improvement of prefabrication systems will prompt a closer joining between building construction and future potential of prefabrication.

Introduction

There are various technologies available worldwide for using prefabricated construction methods, almost all technologies try to reduce costs and time, prefabrication method gives possibility to the designers for assembling their structures in a short period of time.

Although designers are allowed to use different kinds of materials, they mostly prefer to choose light weight ones. Wood and steel are the most practical materials in prefabrication construction. Designers should carry out prefabricated buildings by the usage of different technologies and systems, however these technologies need high level of knowledge and experience and high quality of application on site, so prefabricated construction technologies are preferred in many developed countries. Lack of knowledge and experience has caused decreasing in prefabrication construction technologies in many developing countries. In the other hand many countries encounter earthquake risk and it is one of the important reasons which prefabrication is not such an appropriate choice for countries in disaster prone areas. However, several developing countries start using prefabrication by importing its knowledge and techniques. Nowadays prefabrication technologies play an important role in multiple developing countries and its usage has been increasing every day) .

This paper is initiated with a general literature study to get an overview of construction methodologies of prefabrication systems to acquire some background knowledge of these kinds of constructions.

The focus of this paper is to study the various methods that are used today when constructing prefabricated buildings. The aim of this research is to examine various prefabrication systems according to their structural elements. Additionally, to discuss the way of using prefabrication systems in architectural design such as: sustainability and project management. This paper will discuss the future market of prefabrication. Besides, the study will show the possibility of decrease the time and costs of construction projects by prefabrication.

2. *ADVANTAGES* OF *PREFABRICATE CONSTRUCTION*

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

b. Formwork and scaffolding are largely eliminated so the quantities of materials required are reduced. For saving concrete and steel favorable weight - saving structural sections can be used so the weight of the building as a whole is reduced.

c. The required amount of manual labor is substantially reduced by the production of precast units in large series makes it practicable to use machines.

d. Less man power is needed since the precast units are manufactured in a factory, 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. Units can be manufactured in covered buildings which can be heated and erection of the units can also carried out in winter and construction can proceed almost independently of weather conditions.

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 erection and interconnecting them to form the final structure.

3. CLASSIFICATION

3.1 MONOLITHIC CONCRETE CONSTRUCTION SYSTEM USING ALUMINIUM FORMWORK

(Suitable for Low Rise to High Rise Structures)

In this system, in place of traditional RCC framed construction of columns and beams; all walls, floors, slabs, columns, beams, stairs, together with door and window openings are cast-in-place monolithically using appropriate grade of concrete in one operation. The specially custom designed modular formwork made up of Aluminium/Plastic/Aluminium-Plastic Composite is easy to handle with minimum labour & without use of any equipment. Being modular formwork system, it facilitates in rapid construction of multiple/mass unit scale.

Basic Material Requirements

Concrete

Shall be of appropriate grade based on environment condition as per IS 456:2000

Reinforcement

Shall conform to IS 1786:2008

Details of Formwork

The formwork systems used are made of light weight Aluminium. The recommended concrete forms generally use robotics welding system for manufacturing. A soft alloy weld wire is utilized in the concrete form weld process. Fixing of the formwork is done using tie, pin & wedges system. Does not require very skilled labour to do the job. The formwork can be designed based on requirements of dwelling unit and the project.

Structural Requirements of the Construction The maximum spacing between cross wall shall be limited to 1.5 times the floor height if supported on two edges and 2.0 times the floor height, when supported on all four edges. The walls are designed primarily for loading and also for in-plane lateral load (shear) and out of plane (bending) due to wind load and earthquake forces as per relevant Indian Standard Code IS 875(Pt.3):1987 and IS1893(Pt.1):2002 respectively. For out of plane loading, the plate can be assumed to be supported by floor slabs / diaphragm and cross

walls and continuity can be assumed, wherever applicable. The structural design of plain & RCC shall be as per IS 456:2000 while IS 13920:1993 is referred for ductile detailing of reinforced concrete structure. Thickness of wall below plinth level should be minimum 200 mm with double layers reinforcement. Guidelines on Monolithic Concrete Construction prepared by BMTPC may be referred for material requirements & design aspects of this system.

Durability

Since concrete is main constituent material in this system, durability of the structure can be achieved by using proper ingredient, Grade of concrete as per IS 456:2000 and mix design in accordance with IS 10262:2009.

Thickness of the wall is generally 100 mm with the centrally placed reinforcement. Therefore, adequate cover is likely to be maintained , as a result high durability is achieved.

Thermal Behavior of Structure

100 mm thick RCC walls and slab has thermal transmittance (*U*) value as 3.59 W/m2K) (as per IS 3792:1978). As, it is more than the normal plastered brick masonry walls (thermal transmittance (*U*) 2.13 W/m2K), it is advised that implementing agency shall ensure proper planning for heat insulation and air ventilation in the housing units through proper orientation, shedding etc. (*see* IS 3792:1978 for guidance).

Acoustic

Average sound reduction for 100 mm concrete is ≥ 45db (IS 1950:1962), which refers reasonable acoustic insulation.

Ease of fixing services

All electric and plumbing fixtures, lines have to be pre-planned and placed appropriately before pouring concrete in RC walls & slabs. Post construction alternation is not desirable.

Economy of Scale

Economy of scale depends upon the volume of work and number of repetition of the formwork. To achieve economy, minimum 100 repetitions are desirable. Compendium of Prospective Emerging Technologies for Mass Housing 9

For very small project of less than 500 units, this system may not prove to be economical.

Limitation

A lead time of about 3 months is required for initiation of work, as the formwork are custom designed,

1) manufactured and prototype approved before manufacturing required number of sets of formwork.

Capital cost to initiate construction is high and may require regular flow of funds

.2) Post construction alterations are difficult.

3) All the service lines are to be pre-planned in advance.

4) Not much saving in construction in one storey structure.

3.2 EXPANDED POLYSTYRENE CORE PANEL SYSTEM

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

Expanded Polystyrene (EPS) Core Panel System is based on factory made panels, consisting of self extinguishing expanded polystyrene sheet (generally corrugated) with minimum density of 15Kg/m3, thickness not less than 60 mm, sandwitched between two engineered sheet of welded wire fabric mesh, made of high strength galvanized wire of 2.5 mm to 3 mm dia. A 3 mm to 4 mm dia galvanized steel truss wire is pierced completely through the polystyrene core at the offset angle for superior strength and welded to each of the outer layer sheet of steel welded wire fabric mesh. The panels are finished at the site using minimum 30 mm thick shotcrete of cement & coarse sand in the ratio of 1:4 applied under pressure. The shotcrete coat encases the EPS Core with centrally placed streel welded wire fabric mesh.

PanelTypes

The Panels being manufactured are of different types depending upon the application. The details of different types of typical panels are given below:

Single Panel for structural uses

Longitudinal wire	2.5 mm / 3.5 mm ø spaced @ 65 mm
Transverse Wire	2.5 mm ø spaced @ 65 mm
Cross Steel Wire	3.0 mm ø approx 68 nos. / m2
Polystyrene Core	Density >15 Kg/m3, Thickness not less than 60 mm
Finished Masonry	Not less than 130 mm thick

Features of Panel System

Load carrying capacity

Numerous lab tests, performed in different parts of the world, have highlighted the high load resistance of the panels which after compression testing with centred load performed on a single finished panel, 2700mm high, have shown that they withstand a maximum load of up to 1530 kN/m ≈ 153 ton/m. The Monolithic joints of the building system provide a high level of structural strength to buildings.

Thermal Behaviour

The thickness and density of the panel can be customised to deliver specific thermal insulation requirements. Furthermore, the EPS core extends throughout the surface which makes up the building envelope eliminating thermal bridging.

For example, a wall with a 80 mm core and finished thickness of about 150mm provides the same thermal insulation as an insulated solid masonry wall of about 400mm, with obvious advantages in terms of additional space.

Acoustic Behaviour

The panel has good acoustic behaviour, coupling with sound-absorbing materials (such as plasterboard, cork, coconut fibre, rock wool, etc.), further optimizes the acoustic insulation of walls.

Sustainability and Energy Efficiency

The insulating envelope provided by polystyrene core eliminates thermal bridges and ducts within the panel. This brings high level of energy efficiency. The system provides significant improvements in indoor thermal comfort by greatly reducing energy consumption and promoting strategies aimed at sustainable development.

Fire Resistivity

The expanded foam polystyrene used for panels is self-extinguishing and is perfectly encased by layers of reinforced concrete as external coat to sides of the panel and inhibit combustion. Fire resistance has also been verified in tests performed in various laboratories. For instance, a wall erected using a 80 mm core single

Cost Effectiveness

Compared to traditional products, panels achieve far better results, at considerably reduced cost. The speedy construction represent additional savings.

Rapid Installation

The system has been used in many countries worldwide. The construction experiences using the system show a marked reduction in construction time compared to traditional building methods. Panels are industrialized, and for this reason, assembly processes are optimized, labor is significantly reduced, and construction time decreased by roughly 40%.

Lightness, Ease of Transport and Handling

Being light weight and rigid, panels are both easy to handle and transport even in the most adverse conditions. Prior to an application of shortcrete, a panel weighs between 3.5kg/m2 to 5 kg/m2 which means that a single worker can easily handle a 3 m2 wall, that is, a panel as high as the storey height.

Versatility

The building system gives full design flexibility as it offers a complete range of building elements such as load-bearing walls, curtain walls, floors and stairs.

The panels are easy to use in the construction of any type of structure, and can be shaped to any geometric requirement i.e. flat or curved by simple cutting the panels at site.

Compatibility with Other Existing System

It is an extremely versatile building system which is completely compatible with all other existing construction systems; in fact, panels are even suitable for completing reinforced concrete or steel structures. In addition, panels can be easily anchored to other construction elements, such as steel, wood, and pre-stressed concrete.Compendium of Prospective Emerging Technologies for Mass Housing 15

Blast Resistance

A series of tests has been carried out on a variety of panels finished with different types of high strength concrete. These tests were conducted using a powerful explosive, in a test chamber optimized to produce a uniform shock waves on the face of the panels.The panels performed excellently withstanding explosions of 29.5 tons/m2.

Wide Choice of Finishes

Buildings constructed using panels can be completed in a variety of finishes, or can be painted traditionally on smoothed plaster.

The surface of the walls has the appearance of a thin sheet of reinforced plaster that can easily accommodate all types of wall coverings including stone tiles and rain screen cladding.

Cyclone Resistant

Laboratory tests conducted on buildings, to determine the resistance of cyclone impact and damage caused by wind- borne debris confirm the strength of the building system against such loads. Building constructed in cyclone prone area have shown very high resistance to cyclonic wind.

3.3 INDUSTRIALIZED 3-S SYSTEM USING PRECAST RCC COLUMNS, BEAMS & CELLULAR LIGHT WEIGHT CONCRETE PRECAST RCC SLABS

(Suitable for Low Rise to High Rise Structures)

About the technology

The industrialized total prefab construction technology, being used since 1972, is based on factory mass manufactured structural prefab components conforming to provisions of relevant Indian Standards. The major precast elements are:

RCC hollow columns with notches •
RCC solid beams (T/L/Square Shape)•
Staircase•
RCC precast slab•
AAC precast slab•
AAC precast block•

In the system, precast dense concrete hollow column shell of appropriate sizes are used in combination with precast dense concrete rectangular / 'T' shape / 'L' Shape beams with light weight reinforced autoclaved cellular concrete/Precast RCC slabs for floors and roofs. The hollow columns are grouted with appropriate grade of in situ concrete. All the components and jointing

of various structures are accomplished through on-site concerting along with secured embedded reinforcement of appropriate size, length and configuration to ensure monolithic continuous resilient, ductile and durable behaviour. Autoclaved Aerated Concrete (AAC) slabs can be used as floor / roof slabs. Joints are filled with reinforced screed concrete (minimum 40 mm thick) of M20 grade minimum. RCC screed is laid over entire area of slab before flooring / water proofing.

Basic Material Requirements

RCC hollow columns & Beam

Concrete

Shall conform to appropriate grade based on environmental and structural requirements condition as per IS 456 : 2000

Reinforcement

Shall be of Fe 415 Grade or Fe 500 Grade as per
IS 1786:2008

AAC Precast Slab

Grade 1 of Density 551 – 650 Kg/m3 of IS 6073:2006

AAC Precast Block

Density 451-550 Kg/m3 for internal wall, 551-650 Kg/m3 for external wall as per IS 2185 (Pt. 3) :1984

Against seismic and wind load

A Test was performed by CBRI on full-scale building to establish behaviour of various joints under all design loads including seismic Zone IV. The experimental results on Full Scale Building Structure demonstrated the desired performance and behaviour of the 3S system under all loading condition as envisaged.

When designed for use in Zone V, independent verification may be needed.

Durability

Anti corrosive treatment given to reinforcement used in AAC slab • panels for durability, was evaluated by CBRI, Roorkee with satisfactory results.

Concrete and cover requirement are as per durability clause of IS 456 : • 2000, to ensure adequate durability.

Fire Resistance property of block / slab as dwelling unit

AAC blocks / Slabs used will have fire rating as per the NBC norms for dwelling units.

Thermal Behaviour

K value – 0.122 k cal/h/moc of AAC blocks*****.

Acoustic Comfort Test

For 100 mm ACC Wall, Sound absorption is 38 – 40 db*****

Ease of Fixing services (Electricity& Plumbing)

With pre-planning, electricity & plumbing services can easily be placed.

Availability of Plants & Machinery

Plants & Machineries for production of Components available in Pune, Mumbai, Bangalore and Delhi Ministry of Housing & Urban Poverty Alleviation 18

Economy of Scale

For a new plant to be setup, a minimum project of 5000 dwelling units may be needed.
In places, where plant is already set up, smaller project may also be viable.

Essential Requirements

Precasting yard / factory set up is required with facilities such as • Casting Yard, Computerized batching plant, Moulds, Transportation facility, Stacking yard for materials & components, Lifting and loading facility, Laboratory to test raw material & finished products, Water tank of enough holding capacity as required for 2 – 3 days, Service road, etc.

Utmost attention is required for process engineering before taking • up any field work. Close co-ordination between design crew, field staff and quality crew is essential.

CONCLUSION

Prefabrication will keep on growing in many different countries as the interest for quick reasonable building increments. Innovation exchange of construction procedure, including materials and advanced instruments, can influence nature, economy and society of the accepting nation contrarily. Therefore, the future of prefabrication can be seen as the improvement of the current market and the new development pattern market. At first, the construction's idea was a technique for building quicker and all the more monetarily. The early construction extends basically were moderate tasks; reasonable buildings on site that early engineers attempted to get up to speed with a profoundly productive method for construction. Today, prefabrication is not just being seen as a development strategy for moderate activities however it has additionally ventured into the extravagance market. Creating top notch building parts from a processing factory will exceptionally basic in near future.

Since the innovations of large scale manufacturing for customer items will grow quick, these advances can help build the nature of building components to a higher standard. Prefabrication systems might have some potential of increased use in future because of their characteristics.

Special types of precast wall panels are recommended andprecast R.C.C. planks and partially precast R.C. Joists are considered for flooring/roofing system in this paper. 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
encounted 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. lf 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 within 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 labor cost due to inflection 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 apaper area.

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