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Comparative Study between RCC Structures and Prefabricated Structures

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Abstract - *Building cost in India is increasing at around 50% over the average inflation levels. It have registered amplification of up to 15 % every year, mostly due to cost of basic building materials such as steel, cement, bricks, timber and other inputs as well as cost of labor. Consequently, the cost of construction using conventional building materials and construction is becoming further away than the affordable limits particularly for low-income groups of population as well as a large division of the middle – income groups. Hence, there is an urgent need to adopt cost-effective construction methods either by up-gradation of traditional technologies using local resources or applying modern construction materials and techniques with efficient inputs leading to cost-effective solutions. This has become the most relevant aspect in the context of the large volume of housing needed in both rural and urban areas and the consideration of limitations in the availability of resources such as building materials and finance. Each state in India is currently investigating the developments in the prefabricated system and its potential to overcome the shortages of housing accommodation in this country. The Indian government, involved through its agency, the Building Materials and technology promotion council (BMTPC) and National Urban Housing and Habitat Policy (NUHHP) has been persistently pushing the construction industry to utilize the prefab method of construction since the year 2016. It is a part of an incorporated venture to further improving the aptitude, potential, efficiency and competitiveness of the industry as well as to diminish the industry's dependence on natural resources and unskilled labor. It is an attempt by the Indian construction industry to encourage positive inroads in matters related to construction-site safety concerning a working environment that is cleaner, more convenient and more organized. This paper makes an overview of the housing status in India and adoption of suitable and cost effective technologies in the country.*

Key Words: **Prefabrication; Rapidwall; GFRG; monolithic; LGSFS; Precast; SIP panels; Building; Gypsum; Glass Fibres; Prefabrication; Construction; Wall Panels; New Building System;**

1. INTRODUCTION

The Architects, engineers, contractors and planers are still unable to switch from conventional construction systems even after such a heavy and urgent demand. Its due to lack of awareness, support from authorities and distrust on the new technological advancement because of unavailability of sufficient and proper design guides and provision in IS codes and structural analysis software giants like STAAD.PRO, ETABS, Autodesk Revit, etc.

Although the Building Materials & Technology Promotion Council (BMTPC), Ministry of Housing & Urban Poverty Alleviation, Government of India has taken an initiative in this direction to provide support to Architects and engineers to adopt new building technologies. BMTPC took an initiative to study/select emerging technologies suitable to Indian geo-climatic conditions.

The conventional construction systems are primarily cast in-situ slow pace construction systems and cannot meet the present requirement of housing shortage. Therefore, it is call of the day to adopt new construction systems, which are fast track and at the same time meet functional and structural requirements, which includes Constituted Technology Advisory Group for identification, evaluation and selection of the suitable technologies/ systems, comprising of eminent experts from Government, CSIR, academic and private agencies.

It is envisaged to construct 20 million houses by 2022 in urban area and about 10 million houses in next 3 years in rural areas (urban : 2.5 million houses a year, 7000 houses per day). Such a heavy requirement puts a very massive load on the natural resources and conventional building materials, so that brings us to consider alternative new technologies for mass housing, keeping in mind Speed, Quality, Safety, Life Cycle cost, Thermal, acoustics, Fire, etc. In addition, the need of the hour suggests use of renewable resources for building materials, use of raw materials resources based on waste products, efficient use of existing conventional materials by producing factory made (pre-cast) building components, affordability and sustainability, Industrialization of housing sector.

2. OBJECTIVE

The purpose of this paper focuses on the literature review of the prefabricated system of construction methodology. The author tries to bring out the merits and demerits of prefabricated construction to its readers. For this purpose, this paper presents the five major prefabrication system approved and promoted by BMTPC

for the fast track construction in India. Aim of this paper also is to project building materials and technologies, which are less dependent on natural resources and labor and require less time in construction without compromising with the quality and esthetic value of the building.

3. NEED OF PREFABRICATED SYSTEM

Conventional building materials use bricks, cement, steel, stone, timber, glass, plastic, ceramics and other metals that exploit a huge amount of natural resources and leave a large carbon footprint on the planet. These materials have a finite resource base and the huge demand of material have its consequences. Due to larger demand and limited availability causes escalation in the cost leading to increased cost of shelter and rapid & irrationally managed utilization of finite natural resources. This causes Environmental degradation; depletion of fertile topsoil, Deforestation, Lime-quarrying, Surface working in stone belts. The factory made products like cement, steel etc. calls for high-energy inputs also liable to enhanced cost because of transportation.

There is too much of dependency on cement, aggregates and water in these conventional construction practices. In particular, the fine aggregate (sand) and water to-day are quite scarce. After the restriction from government over sand mining, the cost escalated even higher. It is also seen that, because of lack of skilled labor, these construction nowadays, in general, are not up to the mark in terms of quality. In addition, traditional buildings cannot be green buildings normally. However, green buildings are the order of the day, in view of energy scarcity and, fast depletion of precious natural materials.

Prefabrication seems to be the immediate solution for these problem as they are more manageable and quality controlled hence reducing the waste significantly reducing the environmental impact. Most of the prefabrication technologies also reduce the requirement of building material in general further reducing the impact.

It is need of the hour to use raw materials resources based on waste and other by products, which may eventually end up in landfills. This may help us to achieve affordability and sustainability.

4. TYPES OF PREFABRICATED SYSTEMS

BMTPC took an initiative to study/select promising technologies appropriate to Indian geo-climatic conditions, through Global Expression of Interest (EOI). BMTPC composed technology advisory group for identification and evaluation of the suitable technologies based on following parameters-

1. Safety of the structure against anticipated live loads and safety and stability with respect to the prevailing wind loads and with respect to the possible earthquake loads and other loads such as snow, cyclone etc.
2. Performance of the structure during its life span
   a. Thermal efficiency of the construction during summer and winter
   b. Acoustics efficiency, Damp proof-ness of the construction during rains
   c. Efficiency of the joinery systems, Fire resistance characteristics of the structure
3. Durability of the structure
   a. Deterioration of components with age
   b. Deterioration of components due to atmospheric pollutions
   c. Deterioration of foundation system due to polluted/chemically adverse soil media
   d. Life expectancy (*Our normal housing constructions are designed for a life of 60 years and above*).

The following are the recommended prefabrication technologies by BMTPC according to the Indian geographical conditions.

1. Monolithic Concrete Construction Technology-

The conventional mode of construction is RCC framed structure with infill masonry walls whereas in this system, all walls, floors/slabs, stairs together with door & window openings are cast in-situ monolithically using specifically custom designed modular formwork made up of aluminum/plastics/steel/ composite.

Fig.1 – A Typical working of a Monolithic Concrete Construction Technology

The appropriate grade of concrete and reinforcement is used as per design and the entire casting of a modular unit is done in a single pour. Being modular predesigned formwork system, it acts as an assembly line production and enables rapid construction of multiple/mass scale of units of repetitive type.

In the Monolithic concrete construction with aluminum/plastic/steel/composite forms system, Concrete walls and slabs are cast monolithically at one pour. The system allows reduction in thickness of concrete members below the minimum value than the conventional construction, thus reducing the consumption of natural resources.

A Typical plan is of a Single floor with built up area of about 300 SQ.M. can be completed in two days using the aluminum formwork system. The technology reduces the

cost of repair and maintenance compared to conventional system. Walls and slabs are cast in one operation in specially designed lightweight form/ moulds in concrete. Concrete is poured in the forms & forms are removed after the setting of concrete takes place, resulting in box like cubical structure of required architectural design. The pre-designed formwork also acts some sort of assembly line production and enables rapid construction of multiple units of repetitive type.

2. Light Gauge Steel Framed Structure (LGSFS)

Light Gauge Steel is cold form steel which has an advantage over hot rolled steel as it is lighter in weight and on thin sections of any form can be manufactured. Normally, LGSFS is factory made galvanized light gauge steel components assembled as panels at site and suitable for 3 to 4 storey structures. The infill walls can be of any material ranging from precast boards, blocks, EPS panels or an external layer of insulation material and outer leaf of CP Board or dry mix shotcrete. The floor/roof can be RCC/ Steel truss /Steel deck on joists as per the requirement.

Fig.2 – A Typical working of a LGSFS

Frame is made of cold rolled high strength steel sections and EPS panels for walling. Internal walls covered with gypsum and cementitious board. Exterior wall Sprayed with cementitious material directly onto the studs. It gives faster construction by prefabricated panels. All structural components are precisely pre-manufactured and simply assembled on site. In addition, it gets Enhanced Thermal & Acoustic insulation with Boarding/Expanded Polystyrene (EPS) /Rockwool/Vapor Barrier.

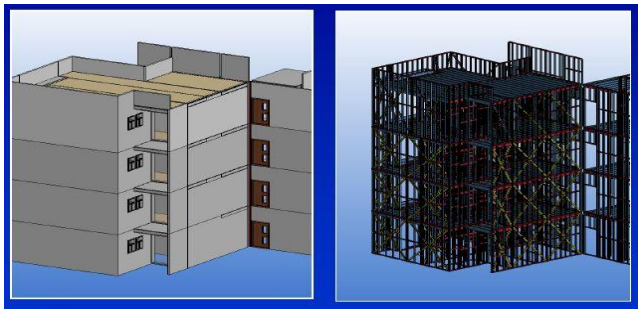

Fig.3 – A Perspective View and Framing View

3. Precast Large Concrete Panel System

Precast Large Construction Panel (PLCP) system is a structural system comprising of various precast elements such as walls, beams, slabs, columns, staircase, landing and customized elements. There are two types of precast concrete elements, namely precast reinforced concrete elements and precast pre-stressed concrete elements, prefabricated in a precast yard or site. The precast elements are installed on site and supported by temporary jacks. Shims are used to carefully align the elements and grouted after the final adjustments. A typical construction involves design, strategic yard planning, lifting, handling, transportation and assembly of precast elements.

Fig.4 – A Typical working of a Precast Large Concrete Panel System

The industrialized total open prefabricated construction technology is based on factory mass manufactured structural prefab components conforming to norms of IS standards and BIS Certification mark. In this Patented system, precast dense concrete hollow column shell of appropriate size are used in combination with precast dense concrete rectangular T Shape/ L shape beams and lightweight reinforced autoclaved cellular concretes labs for floors and roofs. The hollow columns are grouted with appropriate grade of in–situ concrete. All the connections and jointing of various structures are accomplished through in situ concreting along with secured embedded reinforcement of appropriate size, length and configuration to ensure monolithic continuous resilient ductile behavior.

4. SIP Panel - Building System using Steel Mesh, Polystyrene Core and Chipping Concrete (evaluated through PACS)

EMMEDUE Advanced Building System (patented) is based on factory made panels consisting of self-extinguishing expanded polystyrene core (generally corrugated) sandwiched between two-welded wire fabric mesh made of high strength galvanized wire. A galvanized steel truss wire is pierced completely through the core at an offset angle for superior strength and welded to each of outer layer welded wire fabric mesh.

The panels are finished at site using shotcrete of mix of cement and coarse aggregate of required thickness on both sides. The panels are used for load bearing walls and floors and suitable for 3 to 4 storey buildings.

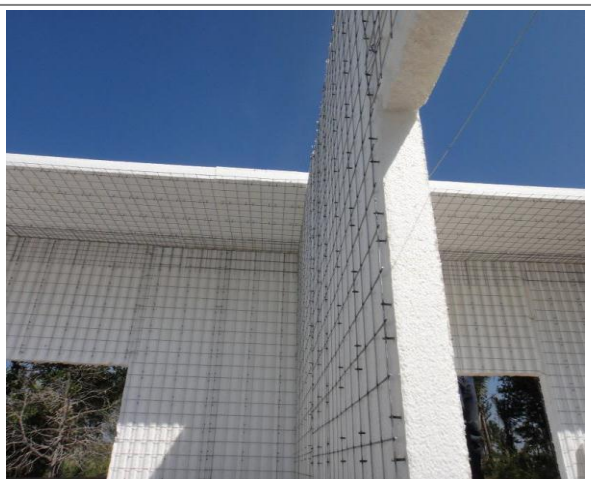

Fig.5 – A Typical working of a SIP panels

5. Glass Fiber Reinforced Gypsum (GFRG) Panel System

GFRG is an integrated composite building system-using factory made prefabricated load bearing cage panels and monolithic cast in-situ RC in filled for walling and floor/roof slabs, suitable for single storey to ten-storey building. It is made of calcined gypsum plaster, reinforced with glass fibers and panels manufactured to a thickness of 124 mm under carefully controlled conditions to a length of 12 m and height of 3m, contains cavities. The panels are being produced at FRBL Kochi and RCF Mumbai and being promoted by IIT Madras.

Fig.6 – A Typical GFRG panels

Glass Fiber Reinforced Gypsum (GFRG)/ Rapid wall is a building panel product, made essentially of gypsum plaster, reinforced with glass fibers. Used since 1990 in Australia. Although its main application is in the construction of walls, it can also be used in floor and roof slabs in combination with reinforced concrete. The panels may be unfilled, partially filled or fully filled with reinforced concrete as per the structural requirement.

5. RESULT AND CONCLUSION

After comparing the above available construction techniques for the pros and cons, author finds Glass Fiber Reinforced Gypsum (GFRG) Panel System most suitable for the desired outcome of the work. The reason being, from all the types of construction technologies, GFRG prove to be giving most economic outcome by saving lots of building material, time and labor. In addition, GFRG panels had the thinnest wall space requirement, providing most usable space. Hence, GFRG panels were shortlisted and chosen for the comparison from the prefabricated structures.

GFRG is of exceptional relevance to India, where there is a massive need for cost-effective mass-scale affordable housing, and here gypsum is available in plentiful amount as an industrial by-product waste. The product not only proves to be environmental friendly or green, but also resistant to damage by water and fire. GFRG panels are currently manufactured in a panel size of length of 12m, a height of 3m and a thickness of 124 mm. Although its main function is in the construction of walls, it was found to be effective to be used in floor and roof slabs in combination with reinforced concrete. IIT Madras and BMTPC have been involved, since 2003, in the development of prefabricated building systems (especially with respect to use of GFRG panels as floor slabs and earthquake resistant design) for utilization in India.

The panel contains cavities that can be filled with concrete and reinforced with steel bars to provide additional strength and ductility, if required. Experimental researches and studies have shown that GFRG panels, when properly filled with reinforced concrete, acquires significant strength to act not only as load-bearing elements, but also as shear walls, able of resisting lateral forces due to earthquake and wind. It is possible to design such buildings up to ten storeys in low seismic zones (and to smaller elevation in high seismic zones). However, such building needs to be suitably calculated by a qualified structural engineer for safety.

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