USE OF PARTIAL PREFABRICATION AND NON-TRADITIONAL TECHNOLOGY IN CONSTRUCTION OF STRUCTURE IN DISASTER PRONE AREAS

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ABSTRACT

In Prefabrication, the advance productions of standardized components of building are ready for quick assembling and erecting at the building site. The production of units is undertaken at factory away from the actual site i.e. the industrial method of house construction is the most suitable technique for mass production of houses. Building of any height can be constructed and blocks of houses can be erected in any geological and climate condition. Adoption of prefabrication technique and use of non-traditional technologies solve the problem to a great extent by achieving speed in construction and limiting the use of scarce material. Fly ash bricks replace burnt bricks which constitute 22% of the cost of the building.

INTRODUCTION

It is common practice in India to make houses with traditional practice using clay bricks for making load bearing walls, roofing with roof tiles, traditional trusses, RCC structures without following IS specification caused potential damage at the era of natural disaster like earthquake, massive floods, landslides etc. India has active faults along Himalayan belt which is capable to generate earthquake shocks in major part of country like Uttar Pradesh, Bihar and other North east part of the country. These parts are thickly populated and at every occasion of disaster mass damage to lives, houses, property occurred. For government it is a big challenge to build habitat for such a huge affected population. Looking to the problem it is necessary to make houses such that they can withstand above challenges, affordable and fit for use in high risk zone of country. The work of
construction of partial prefabricated buildings and use of nontraditional material/technology make the structure affordable and safe for design load.

**Key Words:** Earthquake, Risk Zones, Affordable House, Use of Nontraditional Material, Prefabricated Building, Design Load.

**Material useful for construction:** please refer table given below

<table>
<thead>
<tr>
<th>SN</th>
<th>PART OF HOUSE</th>
<th>TECHNICAL DETAILS</th>
<th>MATERIAL</th>
<th>REMARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Foundation</td>
<td>Spread footing,</td>
<td>Reinforcement,</td>
<td>For hilly areas above ground level fixing</td>
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<td></td>
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<td>Isolated footing,</td>
<td>cement concrete,</td>
<td>of upper part of building should be</td>
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<td></td>
<td></td>
<td>pile foundation or</td>
<td>stone masonry in</td>
<td>connected by plate and nut bolt to</td>
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<td></td>
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<td>as per site condition</td>
<td>case of load bearing</td>
<td>facilitate dismantling and shifting to new</td>
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<td></td>
<td></td>
<td></td>
<td>wall structure.</td>
<td>place in case of soil erosion.</td>
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<td>2</td>
<td>Load bearing</td>
<td>Columns, beams,</td>
<td>RCC/ steel/bamboo</td>
<td>Column, beam joints should be connected</td>
</tr>
<tr>
<td></td>
<td>structure</td>
<td>lintel, window sill</td>
<td>as per availability/</td>
<td>properly to avoid dislocation/failure of</td>
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<td></td>
<td></td>
<td>budget</td>
<td>joints. In case of brick or stone masonry</td>
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<td>as load bearing structure RCC lintel and</td>
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<td>sill band must be provided to make</td>
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<td></td>
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<td>proper bonding between walls to avoid</td>
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<td></td>
<td></td>
<td>shear failure of walls.</td>
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<td>3</td>
<td>Roof</td>
<td>For single storey</td>
<td>RCC/ Roof tiles/ roof</td>
<td>In case of single unit, entire truss unit can</td>
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<tr>
<td></td>
<td></td>
<td>roof panels, roof</td>
<td>panels as per location and budget.</td>
<td>be shifted to safe place.</td>
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<td></td>
<td></td>
<td>tiles. For multi storey intermediate roofs of RCC work</td>
<td></td>
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<td>4</td>
<td>Walls</td>
<td>Load bearing walls,</td>
<td>Wall puff panels,</td>
<td>Proper bands at sill, lintel level in case of</td>
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<tr>
<td></td>
<td></td>
<td>shear walls, in fill</td>
<td>gypsum board, wooden board, fly ash brick, stone</td>
<td>brick or stone work to avoid shear failure of</td>
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<td></td>
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<td>walls, curtain walls.</td>
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<td>walls. It should be safe during ground</td>
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<td>shaking, avoid brittle failure like in case of</td>
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<td>brick work.</td>
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**NECESSITY OF PREFABRICATION IN HOUSING:**

At the moment of natural disaster it is necessary to provide shelter to make roof over the victims, the main challenge is construction speed and to meet required target to of safety, serviceability and economy in construction of structure. By making partial prefabrication structure all above targets can be achieved.
ADVANTAGES AND DISADVANTAGES OF PREFABRICATION

ADVANTAGES: The main advantages of prefabrication are given below:
I. **Speed:**
   The construction period could be reduced by about 40% for single storey building and 25 to 40% for multi-storied buildings.

II. **Reduction in cost:**
   With an assured demand, the cost could be reduced by 15 to 20%, if not more. Economy lies in the framework, shuttering, labor, materials etc.

III. **Disciplined of scarce materials:**
   By adopting design methods involving optimization theories etc., the consumption of scarce materials like cement and steel could be reduced to minimum.

IV. **Good Technical Control:**
   The units are manufactured under good technical control over various factors such as storage, grading of materials, proportioning and mixing, curing of concrete, accurate dimensioning of members and proper position of reinforcement etc.

V. **Strength and quality of concrete:**
   With effective control over the process of manufacture, it becomes possible to improve upon the strength and quantity of concrete.

DISADVANTAGES
I. Owning the difficulty of ensuring monolithic continuity in the finished products, precast concrete members may often need to be made larger or more heavily reinforced that in situ equivalent because of the free ends condition involved.

II. Adequate care and provisions for extra stresses due to transporting, erecting and handling must be taken.

III. The prefabricated systems need much larger initial capital investment for installation and operation.

IV. Sufficient care has to be taken for joining the components in prefabricated system.

DESIGN PRINCIPLES OF PREFABRICATED SYSTEM

Normally the method of analysis and design of prefabricated structural components are the same as in the case of conventional construction. But the following main points of system approach will have to be further considered in the prefabricated construction:

A) **Standardisation**
   Prefabrication calls for repetitive use of building elements and universal forms for speedy and easy construction. Thus standardization of prefabricated elements becomes essential. Standardization will facilitate quicker construction of similar structures avoid duplication of manufacture a number of components on mass scale without fear of accumulation of stocks. The consumers are also sure of obtaining building elements of certain minimum standard and thus avoid his expenditure on supervision and other overheads.
   To adopt prefabrication in actual practice, it is necessary that the main parameters of the whole building are standardized. The dimensions which have proved most rational and useful in
service are selected for the purpose. Then each and every component that forms the building can be standardized. For each standard element, a limited number of types and sizes are established with a definite gradation in geometrical dimensions and reinforcement ratio.

The experience gained in standardization shows that it is good practice that the flexural elements should retain their cross-sectional dimensions and with changes in length and/or load only section of reinforcement should be increased. As regards the columns of multi-storied residential buildings, it is rational to retain constant cross-sectional dimension and change only the section of reinforcement or where necessary the grade of concrete is made in columns of upper storey but the total cost of construction will be reduced through repeated use of the forms and unification of reinforcement mats and cages. Another favorable factor is that with unchanging dimensions of columns from storey to storey, one type of floor beam or girder supported by columns can be made.

The standardization can be possible only by use of modular coordination in the planning and design of building elements.

B) Principle of Structure Design

Though is board principle, the method of analysis and design of prefabricated structural components are the same as in the case of conventional construction, the following main points will have to be further considered in the prefabricated construction. The units are structurally designed for the following two stages;

I. Stage I Loading

At the time of laying out the units, the load comprises of self weight of the units and the weight of concrete in joints between two units and the incidental live load. The units should be able to withstand this loading as simply supported beam. Further the units should be checked for handling stresses considering the permissible stress in concrete at the time of handling. The location of the points at which the components can be lifted should be analysed technically and the proper design of the members to withstand the extra stresses should be made.

II. Stage II Loading

It is designed as the full road acting on the unit under appropriate end conditions i.e. simply supported, partially fixed or continuous support. Maximum positive bending moment, maximum negative bending moment and maximum share force should be calculated and elements should be designed as per IS 456 code provisions accordingly.

C) Connections

In monolithic construction, all structural parts are rigidly joined together and hence forces are to be achieved through connections. Therefore, connections determine whether the structure will act as a unit or a series of individual members.
TYPES OF LOADING APPLIED ON STRUCTURE

STRUCTURAL DETAILS

The partial prefabricated building is constructed as framed structure i.e. columns and beam made of RCC/Steel, or other available material are tied together to perfume well in earthquake, winds, snow or lateral forces. The structure and foundation is originally designed for design load as per IS codes. The reinforcement details are based on latest IS codes to make structure Earthquake proof.
ACTUAL PHOTOGRAPHS OF PARTIAL PREFABRICATED BUILDING

LOCATION: Maulana Azad National Institute of Technology, Bhopal
In above building framed structure is made up of RCC work. Walls are constructed with 50 mm thick wall panels for wall cladding with two numbers of GI metal sheets 0.50mm thick each with 50mm polyurethane foam insulation in place of conventional brick work to alter the size as per future requirement. The roof is consisting of roof panels fixed on truss. The windows are made with iron frame and having glazed panels to provide sufficient light. The Passages are open from one side to facilitate enough light and air. Due to use of wall panels in place of brick work about 25% cost saving is achieved due to difference in cost. Also wall cladding facilitates more space as compared to traditional brick or stone work. The technical detail of roof panels is “Leak proof roofing of mechanically prefabricated sandwich panel 30mm comprising of followings:

The outer sheet shall be profiled Zinclaune steel sheet of 0.5mm (Total coated thickness), high-tensile steel 345Mpa having a coating, mass of 150 gm/sqm (Zinc aluminum coating, total of both sides as per AS : 1397) and finished with 20 microns color coating of super polyester color bond XRW quality paint as per AS/NZS -2728 : 1997 (Category 3) over a 5 microns primer on exposed side and a neutral alkyd back coat of 5 micron on inner side over a 5 micron primer. The Prof Depth shall be 29.5 mm at a pitch distance 200mm.

The inner sheet shall be 0.50 mm (Total coated thickness) galvanized steel sheet having minimum 175 gm/sqm Zinc coating mass (total of both sides) of 240Mpa conforming to IS : 277 & IS : 513. The inner liner sheet shall be in the form of a tray, having small notches in between. The core between outer profile sheet and the inner liner tray shall be of CFC free close cell high density rigid polyurethane foam 40 - 45 kg/cum having a thermal conductivity value of 0.020 w/mk at 10 deg. C. mean temperature conforming to IS: 12436. The core shall be 30mm thick average polyurethane foam insulation (58mm insulation at the profiles).

The panels shall be of required length & width with male and female edges on sides and shall be fixed through specialized agency prescribed by the manufacturer directly to the purlins using hot dip zinc coated self drilling fasteners of required size at required spacing with neoprene washers, butyle rubber sealing tape mechanically with the help of machines etc. complete as per
manufacturer's specifications. Portion of roof covering over lapping the ridge or hip etc. shall be included in the measurements of the roof). Both the wall and roof panels can be reused if extension of floor desires in future to solve the space shortage problem. Hence it saves national money and cause economy in construction. Brick work with FPS bricks has been carried out in toilet blocks only, rest of the places wall panels are used which saves cement, sand stone aggregate and water for concrete, plaster and curing.

CONCLUSION

Looking to the accelerated rates of natural disasters in our country in Himalayan areas (Uttarakhand, Bihar, Uttar Pradesh) where always proximity of landslides, floods, earthquake causes thousands to need of re habitat for survival, Prefabricated housing is affordable, quick in construction and safe to withstand design load. Structure may be single or multi storied as per requirement of condition of site. By using nontraditional material like fly ash bricks we can use waste from power station to make bricks it also save use of soil in making brick. By using it we can save environment and upper soil cover for cultivation only.

REFERENCES

1. Pankaj Agarwal & Manish Shrikhande, “Earthquake Resistant Design of Structures”.
2. T.S. Thandavamoorthy, “Analysis of Structural Strength and Behavior”.