

# Investigation of Alternative Design Forms of Precast Beam for Low Cost Buildings

L. Mahender Goud & Mr. Ch. Prahasith

Department of CIVIL Ellenki College of engineering and technology<sup>1</sup>

Associate professor Department of CIVIL Ellenki College of engineering and technology<sup>2</sup>

## ABSTRACT

*It should not be puzzling to have 55% of the Indian population lack proper housing facilities, there is a great need to develop lower cost housing at a much faster rate so that people wouldn't have to stay in unsafe houses. This project looks at different methods of low cost housing and some case studies relating to it. This study is also an endeavor to investigate structurally safe and economical forms of precast beam. Hence a new plane truss forms of precast beam is investigated and compared to the practicing space truss form of precast beam. The new model, though it has relatively shorter length of span for the similar sizes of bar, it is found reducing the cost by around 25% and mass (weight) of the beam by 33% for relatively similar spanlengths.*

*This type beam can be used in many different types of structures, the precast fabrication allows us to reduce production costs and the ease and swiftness of installation reduces labour and time associated costs. The aim here is to develop the precast concrete beam that would reduce the cost and time in producing low cost affordable housing for all.*

## INTRODUCTION

### General

It's estimated that 40% of the urban dwellers are living in dilapidated area where proper public facilities like access to potable water, electric power supply and emergency access etc are not properly available. This compelled the government to enhance the construction of residential apartments in slum area in different cities of the country. Since construction projects demand higher investment, it's usually difficult to curb the problem with limited resources. Still many endeavors have yet been made to introduce relatively low cost design so that to build as many houses as possible. The LCH-MH[10],

which is claimed to be cost saving from the total project cost of comparable conventional building type, has put forward six integrative approaches to come up with relatively low cost houses, these are:

- Construction management consultancy system
- Phased construction system
- Modular or grid design system
- Specialized (labor based) construction system
- Manufacturing and assembling construction system
- Waste reduction system

Naturally construction industry involve many professionals of different disciplines, its known that effective implementation of one or more of the above cost reduction approaches, crystal change will be achieved.

To take part in the endeavor of making the houses more cost effective, it is intended to investigate the existing model of pre cast beam and slab block arrangements. Good experience of other countries has been taken to implement in the design and construction of grand housing development program of the country, which is still open for further investigation to enhance quality of work that meet the intended purpose.

### Logical approach for optimizing housing solutions:

There should be a logical approach for providing appropriate technology based on the availability of

options, considering its technical and economical analysis.

1. There should be optimal space in the design considering efficiency of space, minimum circulation space.

2. Economy should be considered in design of individual buildings, layouts, clusters etc.

3. While preparing the specifications it should be kept in mind that, cost effective construction systems are adopted.

#### **Non-erodible mud plaster:**

The plaster over mud walls gets eroded during rains, which necessitates costly annual repairs. This can be made non-erodible by the use of bitumen cutback emulsion containing mixture of hot bitumen and kerosene oil. The mixture is pugged along with mud mortar and wheat/ rice straw. This mortar is applied on mud wall surface in thickness of 12 mm. One or two coats of mud cow dung slurry with cutback are applied after the plaster is dry. The maintenance cost is low due to enhanced durability of mud walls

#### **CONCRETE AND STONE BLOCKS:**

This technique is suitable in areas where stones and aggregates for the blocks are available locally at cheaper rates. Innovative techniques of solid blocks with both lean concrete and stones have been developed for walls. The gang-mould is developed for semi-mechanized faster production of the blocks. In the manual process, single block moulds are used wherein the concrete is compacted with help of a plate vibrator. With the use of a portable power screw driven egg laying type machine, solid concrete blocks are made with higher productivity at low cost. Six blocks of 30 x 20 x 5 cm size are cast in single operation with an output of 120-150/hr.

#### **In Floor and Roof:**

Structural floors/roofs account for substantial cost of a building in normal situation. Therefore, any savings achieved in floor/roof considerably reduce the cost of building. Traditional Cast-in-situ concrete roof involve the use of temporary Shuttering which adds to the cost of construction and time. Use of standardized and optimized roofing components where shuttering is avoided prove to be economical, fast and better in quality. Some of the prefabricated roofing/flooring components found suitable in many low-cost housing projects are:

- i. Precast RC Planks.
- ii. Prefabricated Brick Panels
- iii. Precast RB Curved Panels.
- iv. Precast RC Channel Roofing
- v. Precast Hollow Slabs
- vi. Precast Concrete Panels
- vii. L Panel Roofing
- viii. Trapezon Panel Roofing
- ix. Un reinforced Pyramidal Brick Roof

#### **Other uses of prefabrication**

The use of prefabrication for other materials can be made like lintels, sun shades, cupboard shelves, kitchen working slab and shelves, precast Ferro cement tanks, precast staircase steps, precast Ferro cement drains

#### **MATERIALS USED:-**

##### **(BMTPC- Building Materials & Technology Promotion Council, Govt. of India)**

By and large, conventional building materials like burnt bricks, steel and cement are higher in cost, utilize large amount of non-renewable natural resources like energy, minerals, top soil, forest cover, etc.,. The continued use of such conventional materials has adverse impact on economy and environment. Environment friendly materials and technologies with cost effectiveness are, therefore, required to be adopted for sustainable constructions which must fulfill some or more of the following criterion :-

- Not endanger bio-reserves and be non-polluting.
- Be self sustaining and promote self reliance.

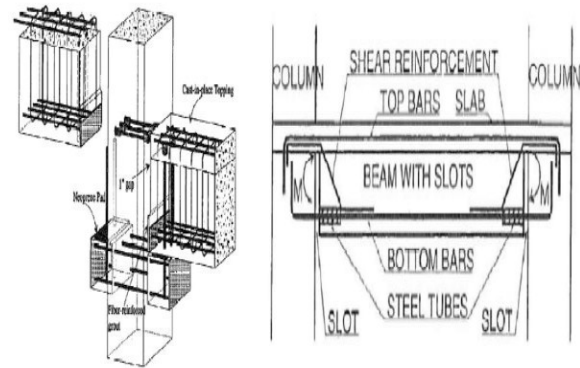
- Recycle polluting waste into usable materials.
- Utilize locally available materials.

### Case histories in India Demonstrations Construction Using Cost- Effective & Disaster Resistant Technologies – BMTPC’s Initiatives

BMTPC has been promoting cost-effective & environment- friendly building materials & construction techniques in different regions of the country. During recent past the council has been laying emphasis on putting up demonstration structures utilising region specific technologies . Such efforts for demonstrating innovative technologies have created a much better impact and helped in building up confidence and acceptability in private & public construction agencies, professional & contractors. Details of the major projects handled by them are given as under:

#### PRECAST BEAM

Structural damage within a monolithic concrete moment resisting frame primarily stems from plastic hinge zones. In a traditional monolithic structure the energy is dissipated through alternative tensile and compressive yielding of the top and bottom longitudinal reinforcement over loading reversals. This mechanism results in there being an offset in the neutral axes at the beam ends, this geometry results in beam elongation. Shear transfer through a plastic hinge zone is by way of equivalent truss mechanism. The horizontal component of the diagonal shear strut causes tensile forces, and hence strains, to be larger than compressive. These accumulating tensile strains cause a further material contribution to beam elongation. The cumulative effect of combined geometric and material contributions to beam elongation is the potential to form an unintended inelastic mechanism and tearing of the floor diaphragm. Floor diaphragm damage has been shown to inhibit lateral force transfer and in extreme cases cause floor collapse (Bull, 2004; Matthews, 2004).

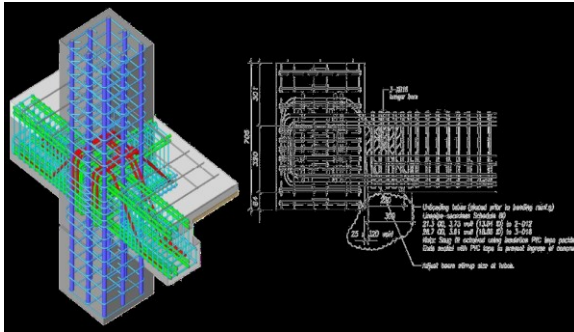


The slotted beam for insitu reinforced concrete was proposed at a similar time in Japan (Matsuoka & Ohkubo, 1996). An early schematic of the system is shown in Figure 2.1 (b). A slot extending approximately  $\frac{3}{4}$  up the column face is provided which constrains rotation to occur about the top concrete hinge for both positive and negative flexure. The top longitudinal reinforcement is stronger than the lower to limit strain, and hence cracks and elongation at the top concrete hinge. Moment resistance and energy dissipation is provided by tension and compression yielding of the bottom longitudinal reinforcement. A portion of the lower longitudinal reinforcement is unbonded to spread the plastic strains over the length of the bar, rather than accumulating potentially excessive strain over the short length of bar spanning the gap. Shear transfer is facilitated via diagonal hanger bars anchored in the columns.

#### Specimen Design

Research to date has focussed on the connection mechanics. This has been investigated parametrically, numerically and experimentally using beam-column joint subassemblies or two-dimensional frame systems. These types of specimens are purposefully simplified to prevent the data being influenced by outside factors that are not being examined. This configuration lends itself well to trialling many details in a time and cost effective manner in order to develop satisfactory performance

and refine design recommendations. However, to be able to fully evaluate the performance of the reinforced concrete slotted beam system, complex three-dimensional interactions between the lateral load resisting system and the floor diaphragm need to be assessed.



### Specimen Construction

Specimen SA1 was designed to be largely precast to reduce erection time and labour requirements. Furthermore, it was important to the project to assess the practicality of construction using the slotted beam detail, especially when compared to a traditional detail. Hence, the manufacture of the precast units was undertaken by a reputable commercial precast company.

### OBJECTIVES

This thesis research has the following objectives:  
To search for other alternative for the existing pre-cast ribbed beam and floor system to make the design more cost effective and increase efficiency.

- To introduce simple and light weight pre-cast beam and slab block types so that to increase quality of work and speed of construction;
- To increase productivity and minimize waste during production and construction of pre-cast beam and slab block floorsystem.
- To check effectiveness of the current practice of pre-cast beam and floor system design and construction;

- To examine the structural designs of the practicing LCH-MH approaches for the existing projects and devise the mechanism to bring about a better alternative.
- To have more methods of achieving low cost housing for all.

### LITERATURE REVIEW

1) Alpa Seth, 2) Sudhir K. Jain, 3) THIRUPPUGAZH V. Earthquake Capacity Building and Risk reduction Majores in Gujarat Post 2001 Earthquake. 13th WCEE Aug., 2004 P. No. 2018. In this paper the authors have pointed the reasons of large scale disaster effects of Bhuj earthquake of 26th Jan. 2001 as lack of awareness, negligence in following the IS code provisions, amongst the owners, engineers, executors, and implementers. Hence, they state the line of rectification of identified lacunas were to spread knowledge about the causes of disastrous effects in public domain through all types of medias, educate the engineers in the field of methodology of seismic resistivity techniques and rigorous implementation of specifications by concern authorities. They have taken the stock of situation.

2) Dinesh Dhanji Patel, Deviji Kuverji Patel, Khimji Lalji Pindoria. ( web site: <http://www.sklpconline.co.uk>.) [www.arup.com](http://www.arup.com). Authors have listed the causes of damages that occurred in Bhuj earthquake, Gujrat, India, of 2001. The distinct reason out of all others is, old structures predating modern construction practices. Photographs are produced, showing respective details under different categories of failures and is therefore a very good documentation of the sort, and last but not the least have detailed the guide lines for the benefit of public at large, owners, and engineers about dealing with rehabilitation of different types of structures, as well as for new structures.

### INVESTIGATION OF ALTERNATIVE PRECAST BEAM



In previous studies and current practice in design of precast beam is modeled and analyzed as space truss, where as in this studies alternative precast beam design it is investigated to model and analyze a precast beam as a plan truss. The plane truss is comprised by two horizontal longitudinal main bar connected by diagonally laid stirrups at an equal interval (spacing)

## **CONCLUSIONS AND RECOMMENDATIONS**

### **Conclusions**

The main objective of this research is to investigate a simple and light weight precast beam and slab block types to increase quality of work and speed of construction f low cost housing.

The result of the new model, which produce maximum of 4.5m span beam. Thought it looks shorter compared to the truss model, it is appropriate for the low-cost houses, which, usually do not have a span more than this. The result also shows a space truss model of longer span are not economical.

More over the result shows the total mass of the beam is 55kg, since it is significantly, lighter weight, enhance speed of construction and save material and labor costs.

Therefore:

ii. Using similar reinforcement bar, space truss model produces relatively longer span beams than plane truss model.

iii. Plane truss models, in spite of producing smaller span beams, has lighter mass per unit length of the span.

iv. The relative difference of costs – span (i.e. the slope of the cost Vs span graph) is smaller for plane truss models, while the cost –span relationship is larger for space truss models.

v. Smaller change in span will produce larger cost in case of space truss models, that is shorter span beams are more economical than the longer ones.

production quality system, since the material/element is made lighter; the heavier will be the risk in case of any quality compromises.

o Effectiveness on the new model has to be checked based on the cost of the whole structure, materials and labor, not only on a single element of precast beam.

o The new model introduced a reduced contact area between the slab block and the precast beam this requires a further investigation to check sufficiency and nature of failure of slab block.

### **Recommendations**

Based on the study the following recommendations are made:

o This research is made based on theoretical basis, but it has to be checked by laboratory works before implementation.

o There must be a relatively controlled production quality system, since the material/element is made lighter; the heavier will be the risk in case of any quality compromises.

o Effectiveness on the new model has to be checked based on the cost of the whole structure, materials and labor, not only on a single element of precast beam.

o The new model introduced a reduced contact area between the slab block and the precast beam this requires a further investigation to check sufficiency and nature of failure of slab block.

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