Bolt Connected Prefab Hollow Core Panels

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Abstract: With increase in population, providing housing to all has become a great challenge for all. Owing a house has become much difficult in now a days. The cost of constructing a build has become much costlier than it was before just few year ago. But still there is a wide use of old conventional technique which is slow and costly. This subject deals with such element in old conventional construction industry i.e. floors and roofs that takes the longest time in getting ready for use thus there must a method that could save time and money. This chapter deals with one such proposed method of using prefabricating.

Keywords: prefabrication, hollow core, bolt connection, pre-stressing.

I. INTRODUCTION

The major portion of Indian population comprises of poor and middle class persons. A dream of an own house is like something is one which would never end. India needs some new advancements in construction techniques that could result in affordable housing system. The best way to reduce cost of construction is to reduce the time consumed during the construction. Prefab is the best alternative for this slow old techniques. The most time and money consuming element of building is floors and roofs.

For a lower class person who lives in a small house can’t afford a solid roof, thus uses steel sheeting to cover their roofs but these roofs is the most to live with. These sheeting have a great disadvantage they waste the floor space which is very useful in multiple storey houses at lesser plot area. Using lesser land area reduces the cost of structure to a greater extent, because land is the expensive of all, what is required for building construction.

With the rapidly growing and evolving industries, the hour of need is to move on and work on new techniques that could reduce time and cost of construction. With the increase in population there is need of techniques that could provide fast and cheap accommodations. Now a days, with hiked prices of land people are willing to purchase it on lease or simply tend to rent it. On rented or leased land constructing a permanent structure is uneconomical.

If a temporary structure is installed it would be easy to remove whole structure easily after lease is expired or rented plot is left. The cost of creating new building and its material would be saved. Temporary structures are required at many other places like at construction site, the project that takes years to finish and there are needs of various temporary structures like site office, stores and other structure that would be required.

The conventional system can be grouped as

I. Temporary placed
II. Permanent placed

1.1 Prefabrication

The prefabricated alternative to roof construction removes the issues of timber moulds and shuttering. Prefabrication in Indian housing improves uniformity and brings unskilled labour inside where work is supervised, monitored and controlled.

I. Quick execution of work.
II. Quality control.
III. Cleaner Construction Site.
IV. The labour problem.

1.2 Hollow core slab

A hollow core slab, also known as a voided slab, prefab bolted floor plank or simply a concrete plank is a precast slab of pre-stressed concrete typically used in the construction of floors in multi-story apartment buildings. The slab has been especially popular where the emphasis of home construction has been on precast concrete. Precast concrete popularity is linked with low-seismic zones and more economical constructions because of fast building assembly lower self weight (less material), cost of construction, etc.

Hollow core plank allows longer spans, much thinner decks and greater rigidity when compared with steel or wood joist flooring systems, and is lighter than poured-in-place concrete construction. Due to the hollow core pre-stressed design, span length is increased. This eliminates obstructing interior beams and columns, thereby achieving a more flexible, more valuable space.

1.3 Prefabricated bolted panels

These slabs are modified form existing hollow core slab panel, the section of existing hollow core slab is modified as shown in figure 1, which enable panels to be attached to each
by use of bolt.

Figure 1: section of modified slab

The problem that was with solid slab and existing hollow core slab is that it can’t be removed without dismantling (topping in case of hollow core slab), if once casted it has to be broken to remove. Use these modified versions will provide flexibility to remove and modify roofs as per our requirement.

Cast in situ slabs require more labour and time as these require curing for long time before it can be put to use whereas precast slabs are ready for installation and use. Factory production provides the obvious advantages of reduced time, labour and training. The slabs is prestressed to attain more strength. This method can be used in private housing. To meet modern standards of sound proofing, the floor needs to be covered with a soft floor covering that is able to dampen the sound of footsteps or a floating floors creed should be installed. An alternative is to put a strip of rubber underneath the floor slabs. The voids of the prefab bolted floor can be used as conduit for installations. The interior of the core can be coated in order to use it as a ventilation duct.

Some of the requirements from the PREFAB BOLTED FLOOR are:
- Temporary roofing system
- Re-usable
- Bearing capacity similar to permanent concrete slabs
- Faster construction
- Water proof
- Overall reduction in expenditure for roof construction
- The system should eradicate the limitations of the sheet roofing system

II. DESIGN ELEMENTS FOR PREFAB BOLTED PANELS

2.1 General: The design requirement is as follows:

I. A prefabricated load bearing courteous elements

The element shall be an refined component. The design shall consider that the top surface is prefinished. No or minimal site work on top surface after assembly may be used as per one’s choice.

II. Design for connection between elements during and after assembly.

The design shall take into consideration ease of assembly on site, feasibility of self alignment, minimal time delays due to site work during assembly. It shall also consider structural load transfer but still stays temporary

III. Design of joints

The joint design shall be consider water tightness, load transfer bearing areas.

IV. Design for end conditions

Strategy for openings spanning of elements over openings, jamb details. Strategy at floor and wall connections, corners

V. Strategy for integration of sun shading elements into the system.

This is important from climatic perspective, as sun shading from outside are important in tropical countries. It is important to consider the means of integrating other architectural features like fins etc, from a different manufacturer into the system.

VI. Building physical properties:

The panels must have light weight. The material composition of wall shall investigate the possibility of maximum utility of fly-ash and other light weight materials.

2.2 Structural: The variables which must be established in the design of any statically determinate pre-stressed members are:-

I. Shape and size of the section,
II. The amount and location of both the pre-stressed steel and non-pre-stressed reinforcement and,
III. The magnitude of the pre-stressing force.

III. DESIGN OF PREFAB BOLTED PANELS

In practice, standard cross sections and reinforcements are designed to provide for all combinations of floor loading and spans. Section sizes are selected at incremental depths, usually 50mm, and a set of reinforcement patterns are selected.
Moment resistance, shear force resistance and flexural stiffness (i.e. deflection limit) are first calculated and then compared with design requirements. Most of the time, the floor units are partially pre-stressed.

3.1 Design procedure

I. Determine the design loads, moment and shear by choosing one trial section that fits from the standard cross-sections and reinforcements.

II. Determine the compressive and tensile stress limit both at transfer and working conditions.

III. Determine both the immediate and time-dependent pre-stress losses.

IV. Check for flexural capacity.
   - Compute the serviceability moment of resistance of the partially pre-stressed member, and check for serviceability limit state of flexure.
   - Compute the ultimate moment of resistance, and check for serviceability limit state of flexure.

V. Check for deflection limits.

VI. Check for shear capacity
   - Check for the shear capacity in the flexurally uncracked region.
   - Check for the shear capacity in the flexurally cracked region.

VII. Check the bearing capacity.

VIII. Repeat the above steps if the selected section does not fulfill one of the checks given above by revising the section.

3.2 Materials to be used for fabrication panels

I. Concrete: The grade of concrete that is used for post tension members is M30 grade. Use of higher grade can be used.

II. Prestressing steel: From design consideration the pre-stressing steel wires used is 4 bars of 5 mm pre-stressing diameter strand. With minimum pre-stressing force of 91.39 KN.

III. Method of Prestressing: post tensioning is chosen as method of prestressing, to facilitate manufacturing at local industries and avoid confusion regarding design grade of concrete at different places, occurring due lack of special materials.

IV. Non pre-stressed steel: The steel provided for tensile stresses is provided according to IS 456: 2000 i.e. 4% of gross area equal to 10 no. 6mm dia bars or wire mesh of 25 mm gauge can be used.

V. The Mould: The mould shall conform to IS 10297:1982

VI. Bolts: Two bolts of 16mm diameter is sufficient to hold the panels together

IV. RESULTS

4.1 From design calculations

The design calculation is carried out to find out the dimension, section, loads, specifications of steel reinforcements, area of steel required both pre-stressing as well as regular steel reinforcement.

The summary of design is tabulated below:

<table>
<thead>
<tr>
<th>s. no.</th>
<th>Particulars</th>
<th>Values</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Dimensions of slab</td>
<td>1.83x1.219x.1016 m³</td>
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<tr>
<td>2</td>
<td>Dimensions of prefab bolted floors</td>
<td>228.6x50.8 mm²</td>
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<tr>
<td>3</td>
<td>Area of section</td>
<td>77398.88 mm²</td>
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<td>4</td>
<td>Moment of inertia</td>
<td>96584211.2 mm³</td>
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<td>5</td>
<td>Section modulus</td>
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<td>6</td>
<td>Self weight</td>
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<td>7</td>
<td>Design flexural moment</td>
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<td>8</td>
<td>Net deflection</td>
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<td>9</td>
<td>Design shear strength</td>
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<td>10</td>
<td>Ultimate flexural strength</td>
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<td>11</td>
<td>Shear capacity</td>
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<td>12</td>
<td>Strength of concrete in rupture</td>
<td>13.768 KN</td>
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<td>13</td>
<td>Strength of bolt</td>
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<tr>
<td>14</td>
<td>No of bolts provided</td>
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<tr>
<td>15</td>
<td>Pitch min</td>
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<td>16</td>
<td>Edge distance min</td>
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<tr>
<td>17</td>
<td>Strength of projections</td>
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</tbody>
</table>

4.2 Analysis by using staad pro:

According to IS 456: 2000 the hollow core slabs can be analysed assuming slabs is made of series of I beams. The analysis was done on staad pro,

The output result shows:

I. Maximum slope in beams is 0.750 rad (3.15°), at node 6&5

II. Beam displacement max is 28.768 mm

III. maximum resultant end displacement is 76.2mm

IV. maximum bending moment 4.46x10⁶ N/mm²

V. 8.63 KN is the max shear force in beam

VI. Deflected shape
4.3 Results on the basis of Cost Analysis

The cost comparison of one panel with respect to analogous solid slab construction, gives a positive result i.e. the cost of erecting one panel that to casting solid slab of same area differs by approx rupees 10,000 or 154 US $.

V. CONCLUSIONS

Precast pre-stressed prefab bolted floor slab system of construction is a system, which does not need very heavy equipment for erection, and the component members can be produced with locally available construction materials. In addition it is a precast, pre-stressed concrete slab system with continuous voids provided to reduce weight and, therefore, cost and, as a side benefit, to use for electrical or mechanical runs.

Based on the theoretical investigation and the cost comparison the following conclusions and recommendations may be drawn.

I. The cost comparison shown that the prefab bolted floor slab system of construction is faster and less expensive than the cast in slab system.

II. In addition to the economical benefits gained the application of this system is believed to solve problems associated with delays in the construction industry, since construction delays are one of the main causes of disputes.

III. The top surface is generally prepared to receive a screed or structural topping. Because they are cast against a steel surface, the soffits are smooth and ready to receive a decorating finish direct without the need for plastering.

Finally, it is believed that the result of this study are encouraging and have some scope in distant future, into the introduction of temporary precast pre-stressed slab systems (prefab bolted panels) in the construction industry. However, this research will be most helpful for the proper utilization of the system. It is hoped that the present study serve as an aid for further developments and other related studies.

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