Structural Behaviour of Bubble Deck Slabs and Its Application: An Overview

Neeraj Tiwari¹ Sana Zafar²
1,2 Madan Mohan Malviya University of Technology, Gorakhpur

Abstract—The Bubble Deck slab is a newly designed biaxial concrete floor slab system. High density polythene (HDPE) hollow spheres are placed in the center of slab by replacing the ineffective concrete it decreases the dead weight so increases the efficiency of floor. It have many advantages over normal solid conventional concrete slabs it decreases the cost and reduces material used and also enhances the structural efficiency of the slab it decreases the time of concentration and is a green technology. Through the test performed on models, Bubble deck was proved as better slab in comparison to solid concrete slab. The reduced dead load gives better response and more economical for the structure while offsetting the slight increase in deflection of slab. The punching shear & shear resistance of bubble deck floor is low in comparison to conventional solid slab since it is directly related to depth of concrete. for reduction of these differences in strength, the reduction factors have been suggested.

Key words: Structural Behaviour, Bubble Deck Slab, Steel Mesh, HDPE Spheres

I. INTRODUCTION

Bubble deck slab is the slab in which some amount of the concrete is replaced by the plastic hollow bubbles which are made by the waste plastic material, which reduces the self-weight of the structure. In the 1990's, a new technology was invented, eliminating the some of the problems. It is used in Dutch. German invented by JORGEN BREUNING. He locks spheres between the top and bottom reinforcement meshes, thereby creating a natural cell structure, acts like a solid slab. The slab is cast with the same capabilities as a solid slab, but with considerably lesser weight due to elimination of excessive concrete. Currently, this innovation technology has been applied to a few hundred residential high rise buildings, and industrial floor slab due to limited understandings. For this investigation, the structural behaviour of Bubble Deck under various condition will be studied in order to gain an understanding on this few technique and to compare it to the current slab system. This technology will then be applied to create lightweight bridge deck since a significant portion of the stress applied to a bridge comes from its own self-weight. By applying the knowledge gathered during the behavioral analysis. Modular deck components for pedestrian bridges that is notably lighter but comparable in strength to typical reinforcement concrete section will be designed. This floor system is designed to reduce the strength to weight ratio of typical concrete slab, it replaces or removes concrete from center of slab, where not or less useful in place of that concrete, this design system uses hollow HDPE spheres to decrease the dead load of concrete floor, however, it also reduces the slab resistance to fire and shear.

II. SCHEMATIC DESIGN

BubbleDeck is intended to be a flat slab, two way spanning slab supported by columns. It generally regulates to allow maximum deflection during service loading.

It consist of plastic spheres that is sandwich between two steel meshes. These members are brought to site, placed on formwork and concreting is done by technical methods. This type of slab is optimal for construction area with compact spacing because these modules can be stacked on top of one another for storage until required.

Fig. 1: Types of Bubble deck

A. Material Used

Bubble Deck slab is made up of three materials-plastic spheres, concrete and steel, as seen in “Figure, 1.”
- STEEL-Steel reinforcement having grade Fe60 strength or more is used. Two steel meshes for lateral supports are used.
- PLASTIC HOLLOW SPHERE-It is a hollow sphere made up of high density polythene or HDPE.
- CONCRETE-Concrete is made up of standard portland cement, sand and fine aggregates.

Fig. 2: Benefits and Advantages of Bubble Deck

1) Material and Reduced Weight

Its main advantage is that it uses 30-50% less concrete than other conventional, normal slab.
- Plastic spheres replaces the ineffective concrete in the centre of the section.
- Since it reduces the overall dead load of structure by deducing unused heavy material.
2) **Structural Properties**
   - Because of lesser dead weight of slab and its two way spanning action load bearing walls become unrequired.
   - It is also designed as flat slab, which neglects the requirement for girder members and support beams.
   - These properties reduces some of the structural needs for the foundation and column.
   - Bubble deck slabs can be analyzed and designed as a standard concrete flab slab on behalf of its ductility and strength.

3) **Time and Construction Savings**
   - These slabs can be precast at site, so reduces on site construction time.
   - Less time consumption can also be achieved by faster erection of columns, walls & MEPs because of lack of load bearing walls & support beams for this new flab slab.
   - Lesser curing time also save time since there is less concrete in bubble deck slab.

4) **Cost Savings**
   - Due to reduction in time & material, cost also reduces.
   - Reduced material and weight, lowers the cost of transportation & more economical to lift the material.
   - Cost also reduces in construction & design of frame elements like columns & walls.
   - There is slight increase in cost of production due to assembly & manufacturing of HDPE spheres.

5) **Deflection & Bending Stiffness**
   The bottom reinforcement steel and the top compressive portion of stress block contributes to flexural stiffness in bending.

6) **Shear Strength**
   Shear strength of slab mainly depends on effective mass of concrete. Due to use of plastic bubbles, the shear resistance of bubble Deck greatly reduces in comparison of solid slabs.

7) **Punching Shear**
   It must be firstly analysed that whether the applied shear is lesser or greater than the shear capacity of bubble Deck slab. Firstly, it is determined by the designer whether the applied shear is greater or less than the bubble Deck capacity. If it is found to be lesser than no further check is required. But if its founds to be greater, the spheres should be omitted surrounding the column & then check the shear in newly solid section. then if shear resistance of solid concrete portion is lesser than applied shear, then shear reinforcement is required.
Fig. 8: Floor to Column connection modification

B. Application in Pedestrian Bridge Decks
- Since the bubble deck slab has significantly less shear capacity in comparison to solid slabs, a pedestrian bridge is chosen over a vehicular bridge.
- Punching shear is also another important matter for bridge deck with HDPE spheres.
- In case of floor slab, if shear is too large near to column, spheres may be left out & that space filled with concrete.
- The vehicles wheel applies point load during travel along deck with varying speed instead of being stationary, distributed load as in building

III. RESULT DISCUSSION
- BubbleDeck performs better than normal conventional solid slabs.
- The internal forces & maximum stresses in the voided deck were up to 40% lesser than solid slab due to reduced dead weight by use of HDPE spheres.
- The deflection was little greater by 10% since the stiffness reduces from presence of bubbles.
- These results say that this type of slab will provide better long durable floor slab with better long term result under a dominant gravity and uniform load.

IV. CONCLUSION
This analysis proves that BubbleDeck technology is more useful and efficient than a solid conventional slab in office floor system. The models of the slabs created for the analysis verifies the prior analysis & experiments. However, the performance of bubble slab is not as successful in pedestrian deck. This does not reduce the use of bubble deck in bridge deck, but requires more studies to completely analyse the feasibility of slab in bridge.

ACKNOWLEDGEMENT
This work has been carried out in civil engineering department of Madan Mohan Malaviya University of Technology, Gorakhpur, India. The author presents its heartiest gratitude towards Sana Zafar, Mrinank Pandey for constant encouragement, guidance and support.

REFERENCES