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# ADVANCES IN CONCRETE SLABS: A REVIEW

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**ABSTRACT— Conventional slab is a simple method of construction in which top and bottom reinforcement has been provided & concrete has been poured. The pre-stress slabs are the method of construction in which the tendons have been provided with their curved profile and internal stresses have been developed. Bubble deck slab is a method of producing the gaps between concrete portions, so as to reduce the overall weight of slab. HDPE hollow spheres replace the concrete portion in the center of the slab, which decreases the weight of slab and increases the efficiency of the floor. By introducing the gaps in the middle floor of slab , it reduces 30 to 50% lighter slab as compared to solid conventional slab, which reduces the loads on the columns, walls and foundations and of course of the entire building. The aim of this paper is to discuss about the various properties of various types of slab. The current study gives a brief idea about the different types of slabs, their production and advantages. There are a number of green attributes of bubble deck slab and pre-stress slab over solid conventional slab including; reduction in total construction materials, use of recycled materials, lower energy consumption and reduces $CO_2$ emissions, less transportation and crane lifts which make Bubble deck & Pre-stress are more environmental friendly than other concrete construction techniques. They can achieve larger spans as compared to a site cast concrete structure. The total construction time for the structure has been reduced and allowed the consultants to fast track the design without the finalization of interior design.**

**Keywords—Bubble deck slab, LDPE, Pre-tensioning, Post-tensioning.**

## I. INTRODUCTION

The conventional solid slab is simple method of construction in which the top and bottom reinforcement has been provided & concrete has been poured.

The Pre-tensioning slab is a method of introducing the internal stresses inside of the slab before pouring of concrete & after the hardening of concrete, the stressed cables has been released.

The Post-tensioning is a method of introducing the stresses after hardening of concrete.

The Bubble deck is an advanced method of slab construction which eliminates all concrete from the middle of floor slab & not performing any structural functions. By introducing the gaps between the top and bottom reinforcement, it reduces the overall structural load on columns, footings and ultimately on ground strata (where overall structure rests). In this technology LDPE bubbles are fixed in the effective depth of slab by providing top and bottom reinforcement and their horizontal movement is avoided by providing the lacing girders. The Bubble deck creates a cushion of air between layers of concrete with the reinforcement of both the metal grid and the weight distribution across the plastic spheres. Bubble deck does not have the earlier problems with reduced resistances towards shear, local punching and fire.

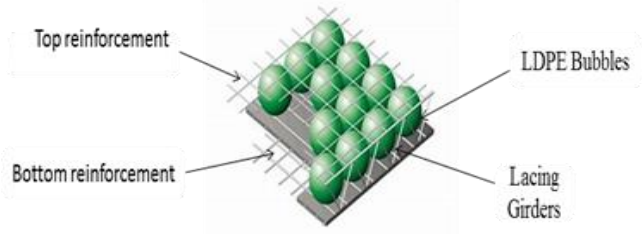



**Fig – 1 Bubble Deck slab[2]**

As it is possible to achieve larger span as compared to conventional solid span. For cantilever span, it is more convenient. By using post-tensioning or pre-tensioning, it can be more enhanced. This technology can be used to manufacture lighter weight bridge deck. For Precast construction technology, Bubble deck technique is more suitable as compared to solid conventional slab as it reduces the overall dead weight of specimen.

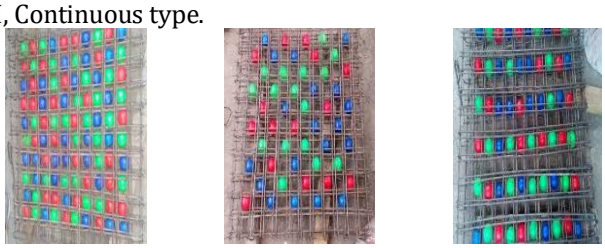
## II. LITERATURE SURVEY

The detailed comparison between bubble deck slab and conventional solid slab has been done i.e. dead weight of slab, time, cost, eco-friendly etc. by Bhagyashri G. Bhade, S.M. Barelikar, Raj.R.Vakil, Dr. Mangulkar Madhuri Nilesh[1,2].

The various design parameters required for design of solid conventional slab, pre-stressed slab has been given in IS 456, IS 1343 & the design parameter for bubble deck slab has been given by Ashish Kumar Dwivedi, Prof. H. J Joshi, Er. Immanuel Joseph Chacko, Er.Sneha M. Varghese[3,8].

The various test have been conducted on both bubble deck & solid conventional slab i.e. shear, flexural & compression test. The various properties of bubbles has been explained i.e. porosity, rigidity etc. and load vs deflection test have been carried out by Rittik Bhowmik, Mahalakshmi Nanthini[4,5].

The various methodologies have been given and types of bubble deck slab have been explained i.e. alternative type I&II, Continuous type.



**Continous type** **Alternative-I** **Alternative-II**

**Fig-2 Types of Bubble deck slab[4]**

The behaviour of various types of slabs under seismic load has been given by Rohit Raj, Prem Prakash Mishra, Mamta Kadhane, Bharati Mohabey[3]. The required curing methods & periods for slabs has been given by Devyanshu Jain, Nidhi Gupta[10] i.e. Water curing, Membrane curing, Application of Heat etc. The standard testing procedure has been adopted as per Indian standard i.e. slabs were simply supported & single point load was applied at the 28 days age of slab. During testing deflections were measured at a certain interval with the help of dial gauge & applied load was recorded. At the end, load vs deflection graph had been prepared.

Sourish Mukherjee, Aparna Das & Sulagno Banerjee[4] have carried out a study on preparation and construction procedure for bubble deck slab and conventional slab. The various zones have been given by them such as hollow sphere bubbles have provided at centre portion of the slab where shear force is minimum. But where the S.F. is maximum, Bubbles have not been provided in their effective depth, only top and bottom reinforcement is provided with chair fitting. They have concluded that, during pouring there are chances of movement of bubbles so they have provided lacing girders surrounding the bubbles.

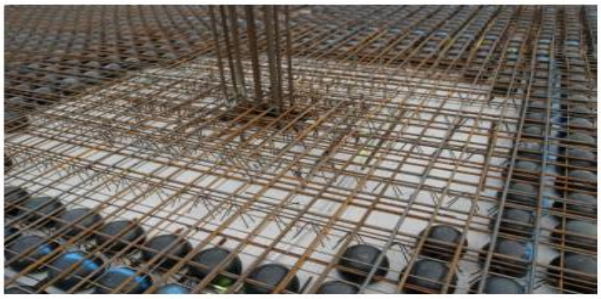


**Fig-3 Placing of Bubble [4]**

## III. METHODOLOGY ADOPTED

Conventional slab: This is a slab with specifications prepared to analyze experimentally with normal concrete of grade M30 by adopting conventional methods of design according to IS 456:2000 & IS 10262:2009. There are two types of conventional slab such as one way and two ways. If Ly/Lx ratio is greater than two then it is considered as one way slab and Ly/Lx is less than or equal to two then it is considered as two way slab. In this type of slab only bottom mate reinforcement is provided at the middle of the slab (where the maximum bending moment occurs). And top and bottom mate reinforcement is provided at support (where the maximum shear force occurs).

Pre-stressed slab: Pre-stressed is a modern technology in the construction field which is rapidly used by structural designers. This type of slab is constructed by higher grade of concrete i.e. more than M35 with the help of IS 1343. There are two types of pre-stress slab such as pre-tensioning and post-tensioning. Pre-tensioning slabs are designed only for one way slab (not for two way slab). And post-tensioning slabs are designed for both one as well as two way slab. In the pre-tensioning slab, tendon's one end is fixed and other end is stressed by hydraulic jack and fixed. Then the concrete is poured. After getting the 7 days strength (i.e. 67%), the stressed tendons are released. In the post-tensioning slab, tendons are placed in the effective depth of slab with their curved profile. Then concrete is poured and stressing is done after getting 7 days strength. But now a days, pre-stressed is used in bridge deck girders.

Bubble deck slab: This is a slab with specifications prepared to analyze experimentally with normal concrete of grade M30 by using Hollow strong plastic balls (HDPE- High density polyethylene) with the help of design according to modified DIN 1045 (1988) or DIN 1045 (2001) code (German code). This type of slab can be designed for one as well as two way slab. The main difference between bubble deck slab and conventional slab is that, the hollow sphere bubbles are provided between top and bottom reinforcement and lacing girders are provided to avoid horizontal movement during pouring of concrete. The initial cost of bubble deck slab is more but the overall construction cost is less as compared to solid conventional slab.

Before the design mix, various tests on row material should be conducted and should get a required result with the reference to Indian standard. Then Mix design of M25 have been prepared with the help of IS:456 (2000). For M25, the 28 days strength should be 25 N/mm$^2$. Proper curing should be done for 28 days to achieve a proper strength.

The required stages for manufacture of concrete are:-
1. Batching 2.Mixing 3.Transporting 4.Placing
5. Compacting 6.Curing
There are two types of batching i.e. Volume & Weigh batching.

After 28 days casting of slab specimen, the various tests can be conducted on each slab such as flexural, shear & compression. The simple test can be conducted on each slab for comparison i.e. load carrying test. In this test, load is applied on the slab and their deflection is measured at various interval of time. And load vs deflection graph can be prepared & comparison can be easily understood.

## IV. MATERIAL

Cement: The cement used for the construction of slab should satisfy the requirements of IS: 456 & OPC 53 grade should be used. The various tests should be done on cement with the reference to Indian standard i.e. fineness, standard consistency, initial & final setting time, soundness, compressive strength etc.

Aggregate: The aggregate used in concreting should satisfy all the requirements which have been mentioned in Indian standard. There are two types of aggregate used in concreting i.e. course aggregate and fine aggregate. The test should be conducted on aggregate (before use) are fineness modulus, Specific gravity, water absorption, Flakiness & elongation index, abrasion, crushing tests etc.

Steel: The grade of steel used for the slab construction should be as per Indian standard specification. For normal conventional & bubble deck slab Fe415 & Fe500 can be used. But for Prestressed slabs, Fe500should be used.

Pre-stressing steel: The pre-stressing steel i.e. Tendons, used for pre-stressed slab, should be as per market standard such as fpu 1860. The pre-stressing tendons in pre-tensioning slab can stressed up to a 76% of their standard design force and for post-tensioning; it can be stressed up to a 60% of their standard design force.

Plastic Hollow Sphere: The hollow sphere, used for the construction of bubble deck slab, is made from recycled high density polyethylene. The various sizes of the sphere are available. The hollow bubbles used for the construction of bubble deck slab can be recycled which contributes to the green properties.
The various types of hollow sphere are:

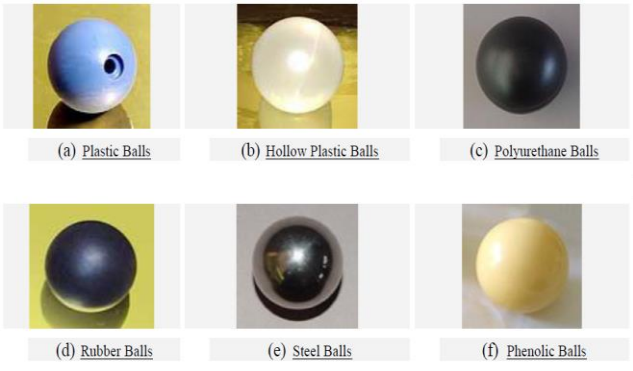



**Fig-4 Types of hollow sphere [7]**

## V. CONCLUSION FROM LITERATURE

From the study of all literature review it is observed that there is no any specific design code for design of bubble deck slab. It is also observed that these slab have been casted for two way slab, so further studies are required on one way slab. As a future scope further research on post-tensioning the bubble deck slabs can be carried out. The Advantages of Pre-stressed slabs over conventional slab are Long span can be achieved as compared to conventional slab, Slabs can be precast in factory and transported to a site, so the construction time can be improved, Minimum area of steel can be used. The Advantages of bubble deck slab over conventional slab are as follows:
a) Material and weight reduction: The main advantage is that for bubble deck slab 30-50% less concrete is required as compared to conventional solid slabs as the bubble replaces the non-effective concrete portion in centre of the section, which reduces the overall structural dead load
b) Construction and time saving: This type of slab can be fully fabricated at shop and transported on site for installation. So the time required for the casting and de-shuttering can be eliminated. Hence, the overall construction time required is less as compared to conventional slab.
c) Cost saving: The initial cost, which is required for hollow bubbles, is high. But the overall construction cost is less as compared to conventional slab.
d) Green design: In bubble deck slab, 1kg of recycled hollow plastic replaces the 100kg of concrete. So it contributes to green design.

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