Structural Behaviour of Bubble Deck Slab Using Epoxy Spherical Balls: A Review

Anshulika Bansal[1], Neeti Mishra[2]
[1]Dept of Civil Department
[2]Assistant Professor, Dept of Civil Department
[1, 2] Babu Banarsi Das university, Lucknow (U.P.), India

Abstract- *Bubble deck slab is a revolutionary floor system of reinforced concrete which has spherical hollow balls of certain material in order to reduce the concrete concentration in the middle portion of the slab. It reduces the structural dead weight in the middle portion as it does not perform any structural function. Introduction of these epoxy spherical balls replaces the in-effective concrete present in the centre portion of the slab. The presence of voids provides thermal insulation which in return gives 30%-50% lighter slabs as compared to traditional concrete slabs. It is seen that bubble deck slab is known for long spans between the column supports. In this paper, a reinforcement mesh is made of specified width and geometry of epoxy spherical balls to obtain a unique and optimized concrete construction. The reinforcement mesh catches, distributes and fixes the spheres at exact position, while the spheres take care of the air volume.*

Keywords- bubble deck, lighter slab, epoxy spherical balls, reinforcement mesh

I. INTRODUCTION

The bubble deck slab is also known as voided slab. It is a new technique of construction using recycled spherical balls in slab to reduce the self-weight of the structure. Use of spherical balls to fill the voids in the middle of a slab eliminates 35% of a slab self-weight compared to solid slab having same thickness without affecting its deflection behaviour and bending strength. Concrete plays a major role in the construction field. The usage of concrete is high in slab construction. It leads to loss of concrete because load transfers from the structure only to the columns not throughout the slab. So, we reduce the concrete in center of the slab by using recycled balls. High density epoxy resins hollow plastic spheres replace the in-effective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. According to the manufacturer, Bubble deck slab can reduce total project costs by three percent. Bubble deck slab is a new innovative and sustainable floor system to be used as a self-supporting concrete floor. Bubble deck slab floor can provide the required load-bearing capacity at a smaller thickness this leads to a further advantage, resulting in a saving of 40 to 50 % of the material consumption in the floor construction. This is not the last of the advantages of the Bubble deck slab floor system: because of the lower weight of thefloor system itself, also the supporting constructions such as columns and foundations can be less heavy. This can result eventually in a total weight or material saving on the building construction of up to 50 %. Since the weight of the structure reduced, this type of structure can useful to reduce earthquake damage.

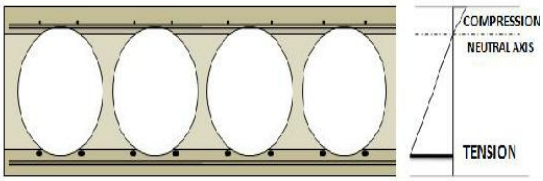

Fig 1. Stress Diagram of Bubble Deck Slab

Objective:

- The main objective of this paper is to perform the analysis of bubble deck slab on the software 'ANSYS' by using plastic hollow spheres in the slab.
- To study the deflection of the slab bubble deck slab
- To study the behaviour of bubble deck slab
- The main objective of this study is using Hollow plastic ball (epoxy resins) in the reinforced concrete slab and its effects.

II. TYPES OF BUBBLE DECK SLAB

Bubble deck slab is composed of three materials: steel, plastic (epoxy) hollow spheres and concrete. The bubble deck slab comes in three forms: filigree elements, reinforcement modules, and finished planks.

FILIGREE ELEMNTS:

This type of deck slab is a combination of constructed and unconstructed elements. For making these elements, a 60mm thick concrete layer is precast and brought

on site with bubbles and steel reinforcement unattached. The bubbles are supported by temporary stand on precast layer and held in position by a honeycomb of interconnected steel mesh. Some additional reinforcement may be inserted according to the design requirement. After placing reinforcement, full depth of slab is reached by common concreting technique.

REINFORCEMENT MODULES:

A reinforcement module consists of a pre- assembled sandwich of steel mesh and plastic bubbles. These components are bedded on the traditional formwork, connected to any additional reinforcement and then concreted. This category of Deck slab is used for construction area with tight spaces.

FINISHED PLANKS:

This type is a shop-fabricated module that includes the plastic spheres, reinforcement mesh and concrete in finished state. These modules are manufactured in the form of a plank and delivered to the site.

The arrangement of bubble deck slab is shown below in Fig. 2.

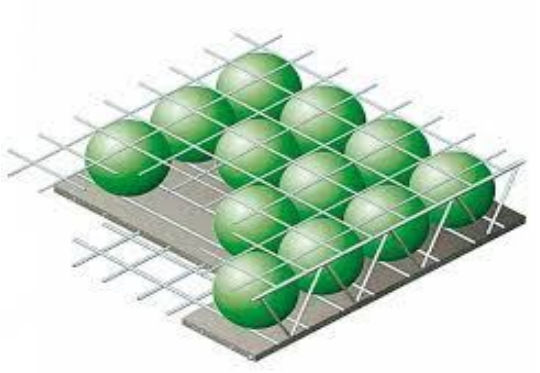

Fig2. Arrangment of bubble deck slab

III. LITERATURE REVIEW

Numerical and Experimental Study on Bubble deck slab **(M. Surendar, M. Ranjitham,2016)** presented the paper conducting the test and evaluating the structural behavior of the conventional slab and bubble deck slab. The experiment was carried out using load frame by applying UDL over the slab to know the ultimate load carrying capacity and deflection. Also, finite element analysis was carried by using ANSYS software to study the ultimate load carrying capacity, stresses and deflection. From the evaluation of these results, Bubble Deck slab gives better performance than that of conventional slab.

An Experimental Study on two-way Bubble deck slab with spherical hollow balls **(Bhagyashri G. Bhade and S.M. Barellikar;2016**) presented the paper by trying different arrangements in placing high density polythene balls. In that experiment it was found that the bubble deck is reduced the volume of concrete so that the weight of the slab ultimately decreases. Simultaneously the load carrying capacity has also increased as compare to conventional slab. But the arrangement of the bubbles is effect on the load carrying capacity of the slab, in alternative arrangement of bubbles increases the load carrying capacity than conventional slab but less than continuous bubble deck slab.

Structural Behavior of bubble deck slab by **P. Prabhu Teja, P. Vijay Kumar, S. Anusha, CR. Mounika, Purnachandra Saha, 2012,** this paper discusses the type of materials used for casting the slab and more importantly different properties like flexural strength, shear strength, durability, deflection, fire resistance, sound insulation, etc. The finite element models of the office slabs created for the study in SAP2ooo verify the prior analysis and experiments and obtained significant results in comparing bending stresses, deflection, shear strength and weight reduction of conventional and bubble deck slab.

Arati Shetkar & Nagesh Hanche (2015) did an experimental study on Bubble Deck Slab System with Elliptical Balls, the behaviour of Bubble Deck slabs is influenced by the ratio of bubble diameter to slab thickness. The bubbles were made using high density polypropylene materials. Bubble diameter varies between 180mm to 450mm and the slab depth is 230mm to 600mm. The nominal diameters of the gaps are of sizes: 180, 225, 270, 315. In this experiment, the applied force is from the bottom to the top of the slab, until the cracks occur in the slabs and the failure modes were recorded. Results obtain ned shows the better load bearing capacity in Bubble Deck can be achieved using the hollow elliptical balls, thereby Reducing material consumption make the construction time faster, and to reduce the overall costs. Besides that, result of the study also shows a reduction in deadweight up to 50%, which allow creating foundation sizes smaller.

Guðmundur B, (2003 studied the Bubble Deck based upon the patented integration technique. The direct way of linking air and steel The Bubble Deck is a two-way hollow deck in which plastic balls serves the purpose of eliminating g concrete that has no carrying effect by adapting the geometry of the ball and the mesh width, an optimized concrete construction is obtained, with simultaneous maximum utility of both moment and shear zones. Results obtained showed the basic effect of the bubbles in the

weight reduction of the deck. Results also show the dead load of the Bubble Deck to be 1/3 lesser than a solid deck with the same thickness – and that without effecting the bending strength and the deflection behaviour of the deck.

Diyala Journal of Engineering Sciences Volume 6 No.2, June (2013) studied the stiffness values of Bubble Deck slabs in comparison with solid slabs. The (BD2-bu80 and BD3- bu100) plastic spheres in reinforced concrete slabs of size (B/H=0.51, 0.64 and 0.80), were subjected to a flexure test in which they result show some one-way flexural cracks and lower stiffness indicating that their flexural capacities were good enough to use. The results were compared with reference solid slabs (without plastic spheres), (100%, 100% and 90%) applying the ultimate load of a similar reference solid slab but only (76%, 75% and 70%) of the concrete volume due to plastic spheres, respectively. Results obtained gives the deflections under service load of Bubble Deck specimens to be a little higher than those of an equivalent solid slab. The concrete compressive strain of Bubble Deck specimens is greater than that of an equivalent solid specimen.

IV. MATERIALS AND METHOLODY

Materials

Concrete

The concrete used for joint filling in the Bubble Deck floor system. Usually conventional concrete is used, for the casting of bubble deck slab. The nominal maximum size of the aggregate is the function of thickness of the slab. The size should be less than12mm. M30 Grade should be used.

Reinforcement bars

The reinforcement of the plates is made of two meshes, one at the bottom part and one at the upper part that can be tied by binding wire. The distance between the bars is corresponding to the dimensions of the bubbles that are to be used in the slab is 100 mm. Grade FY 415 strength is used and diameter of the bars is 8 mm.

Epoxy Resin

The bubbles are made using high density polyethylene materials (epoxy resins). These are usually made with nonporous material that does not react chemically with the concrete or reinforcement bars. The bubbles have enough strength and stiffness to support safely the applied loads in the phases before and during concrete pouring. The diameter of bubble is 100 mm. The bubbles are spherical in shape.

Methodology

ANSYS

Ansys works on the principle of finite element analysis software which is used to solve engineering problems. The software creates simulated computer models of structures, electronics, or machine components to simulate strength, toughness, elasticity, temperature, distribution, electromagnetism, fluid flow, and other attributes. Ansys is used to determine how a product will function with different specifications, without building test products or conducting crash tests. For example, Ansys software may calculate the deflection and deformation of a bridge, a slab of the building and also the durability of the structure.

Most Ansys calculations are performed using the Ansys Workbench software, which is one of the company's main products. Typically, Ansys users break down larger structures into small components that are each modelled and tested individually. A user may start by defining the dimensions of an object, and then adding weight, pressure, temperature and other physical properties. Finally, the Ansys software simulates and analyses movement, fatigue, fractures, fluid flow, temperature distribution, electromagnetic efficiency and other effects over time.

Traditional concrete slab:

The conventional concrete i.e. M30 grade concrete is having mix design according to the IS 456:2000 & IS10262:2009 is explained in this section.

Bubble Deck slab:

In that slab continuous arrangement of bubbles are placed. In the bubble deck slab only 10mm aggregates are used. Alternative spacing for bubbles is 100mm. In that slab bubbles volume are large than the alternative bubble deck. The reinforcement mesh is placed both side of the bubbles and bubbles are arranged in continuous manner. Requirement of reinforcement is only straight shape of bar in the slab as per the design. Reinforcement is 8mm @ 100mm c/c spacing provided in alternative manner. Total length of bars is 960mm. In the bubble deck slab only 10mm aggregate is used because 12mm alternative spacing is provided. Reinforcement mesh is placed in the formwork and maintains the cover by cover block.

The arrangement of the bars in bubble deck slab is shown below in Fig 3 & Fig 4. The arrangement of bubbles in the slab is shown in Fig. 5.

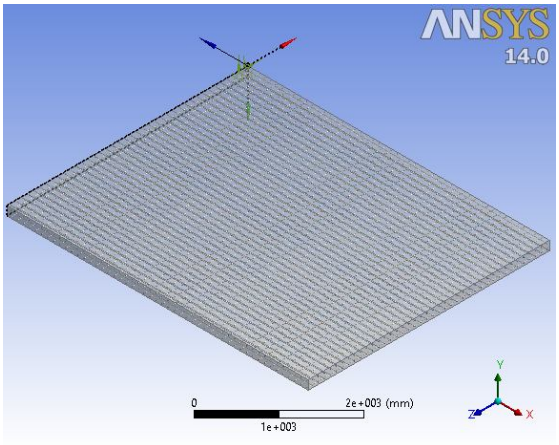

Fig. 3 Arrangement of bars in bubble deck slab (isometric view)

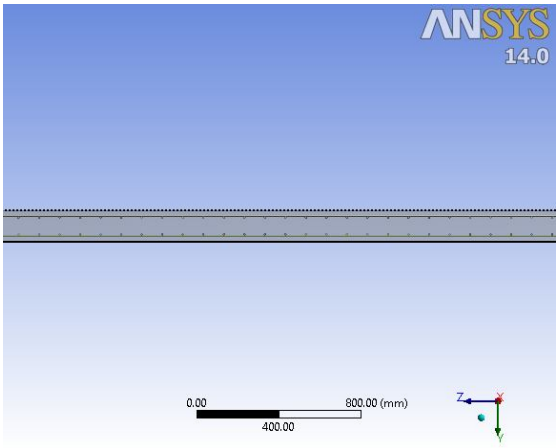

Fig. 4 Arrangement of bars in bubble deck slab (side view)

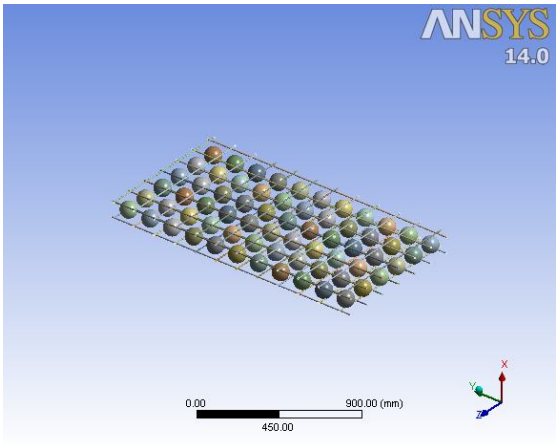

Fig. 5 Arrangement of bubbles in bubble deck slab

V. RESULTS AND DISCUSSION

Results:

The comparison is done between the traditional concrete slab and the bubble deck slab of the material epoxy resin.

Deflection in bubble deck slab of epoxy resin material is shown in Fig. 6.

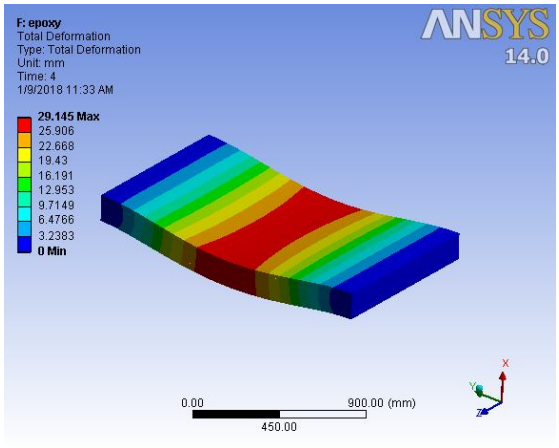

Fig. 6 Deflection in conventional slab

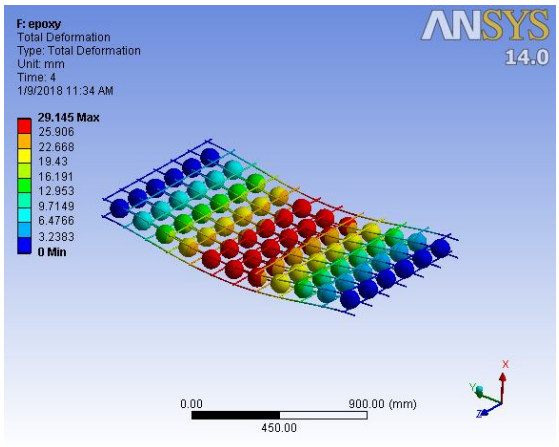

Fig. 7 Deflection of bubble deck slab (epoxy resin material)

Table of Comparison between conventional slab and bubble deck slab:

comparison between traditional concrete slab and bubble deck slab

Load (KN)	Concrete Slab (deformation)	Bubble Deck slab (deformation
3	7.3 mm	7.04 mm
6	14.68 mm	14.54 mm
9	22.01 mm	21.89 mm
12	29.33 mm	29.14 mm

Discussion:

In that experiment found that the bubble deck slab reduces the volume of concrete so that weight of slab occurs ultimate decrease. Simultaneously, the load carrying capacity has also increases as compared to conventional slab. But the arrangement of the bubbles effects on the load carrying capacity of the slab, if arrangement of bubbles is increased the load carrying capacity in conventional slab is more but less than bubble deck slab.

Simultaneously, bubble deck slab has improved the elasticity property of slab, such as conventional slab is less deflected than bubble deck slab, and quantity of bubbles in slab also effect on the elasticity property.

Weight reduction is the important factor is found in bubble deck slab. Weight of the conventional slab is more than the bubble deck slab.

VI. CONCLUSION

Weight reduction is 25% compared to solid slab. B. The bubble deck technology is environmentally green and sustainable; avoiding the cement production allows reducing global CO2 emissions. C. In comparative of conventional slab the volume of concrete in bubble deck (continuous) are less required, that is 25% approximately. D. In bubble deck slab volume of concrete is reduced, so that the weight of slab is decrease, comparative to Conventional slab. E. Cost and time saving by using bubbles in the slab like weight of slab, concrete volume indirectly load on the beam and walls also decrease/ less so that building foundations can be designed for smaller dead load.

VII. ACKNOWLEDGEMENT

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