Performance Analysis of Bubble Deck Slab Using Elliptical Balls

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***Abstract*: Concrete plays a major role in the construction field. In building construction slab is one of the largest and important structural member consuming concrete. Concrete slab use more concrete than requirement, hence has to be optimized. So reduce the concrete in center of the slab by using hollow recycled plastic balls. High density polyethylene (HDPE) hollow balls replace the ineffective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. Voids in the middle of a flat slab eliminate 35% of a slab's self-weight removing constraints of high dead loads and short spans. Combination of recycled plastic bubbles permits 50% longer spans between columns without any beams. This provides a wide range of cost and construction benefits. In this paper, Finite element analysis (FEA) was carried out by using ANSYS software to study the structural behavior of bubble deck slab with different arrangements of elliptical balls.**

Keywords: Bubble Deck Slab System; ANSYS; High density polyethylene hollow balls

I. INTRODUCTION

The invention of a new type of hollow core slabs was a breakthrough at the turn of 20th and 21st centuries. Bubble deck slab technology is an innovatory method of virtually eliminating all concrete from the middle of a floor slab, thereby reducing dead weight and increasing the efficiency of the floor by using recycled hollow plastic balls. Bubble deck is the invention of Jorgen Bruenig in 1990's, who developed the first biaxial hollow core slab (now known as bubble deck) in Denmark. The main obstacle with concrete constructions in case of horizontal slabs is the high weight, which limits the span. So the major developments of reinforced concrete have focused on enhancing the span reducing the weight or overcoming concrete's natural weakness in tension. In a general way, the slab was designed only to resist vertical load. However, as people are getting more interest of residential environment recently, noise and vibration of slab are getting more important, as the span is increased, the deflection of the slab is also increased. Therefore, the slab thickness should be increase. Increasing the slab thickness makes the slabs heavier, and will increased column and foundations size. Thus, it makes buildings consuming more materials such as concrete and steel reinforcement. Increase the self-weight of the slab due to increase in thickness. So many studies were conducted for to reduce the disadvantages caused by self-weight of the concrete.

For past few decades, several attempts have been made to create biaxial slabs with hollow cavities in order to reduce the self-weight. But there have a chance of stress concentration in corner of hollow cavities. Stress concentration in hollow cavities leads to severe crack generation in slabs. Most attempts have consisted of laying blocks of a less heavy material like expanded polystyrene between the bottom and top reinforcement, while other types including waffle slabs or grid slabs. These types, only waffle slabs can be regarded to have a certain use in the market. But the use will always be very limited due to reduced resistances towards shear, local punching and fire.

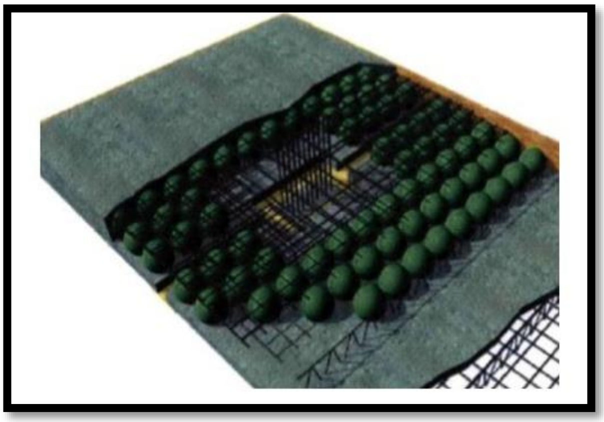

Fig.1.1 Bubble deck slab

Though many materials have been selected for the study related to this, materials like polypropylene and polyethylene were found ideal because of reduced weight and act as good crack arrester. Then materials like polypropylene and polyethylene were used for creation of hollow plastic balls. These hollow plastic balls are introduced in the middle portion of the slab between top and bottom reinforcement, thereby reducing self-weight of the slab. To avoid the disadvantages which were caused by increasing self-weight of the slabs, the bubble deck slab technology was suggested.

Behaviour of bubble deck slab is influenced by the ratio of bubble diameter to slab thickness. The reinforcements are placed as two meshes one at the bottom part and one at the upper part that can be tided or welded. The distance between the bars are kept corresponding to the dimensions of the bubbles that are to be provided between the top and bottom meshes. In this technology it locks ellipsoids between the top and bottom reinforcement meshes, thereby creating a natural cell structure, acting like a solid slab. High Density Polyethylene (HDPE) hollow spheres replace the ineffective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor.

II. OBJECTIVES

1. To validate ANSYS Soft ware.
2. To find out performance of bubble deck slab for different arrangements of elliptical balls.

III. METHODOLOGY

This chapter describes the methodology of the thesis work..The methodology includes study of bubble deck slab and ANSYS software. The whole thesis work is divided into the following sequential steps. The following flowchart represents the methodology of the thesis work to be completed.

A. Modelling

In this project work, Bubble deck slab using spherical balls, different arrangement of elliptical balls and using combination of elliptical and spherical balls are modeled using Finite Element Software ANSYS. M25 grade concrete and high density polyethylene balls are used for the study. Four Bubble deck slabs were modelled

- Bubble deck slab using elliptical balls longitudinally shuffled (type I)
- Bubble deck slab using elliptical balls transversally shuffled (type II)
- Bubble deck slab using staggered arrangement of elliptical balls(type III)

B. Dimensional Details

Three dimensional bubble deck slab was modelled in ANSYS with dimension of (1900x800x230) mm. The void is of elliptical shape with dimension of (180x240) mm and is made of High Density Polyethylene (HDPE) elliptical balls. Reinforcing rebar at the top and bottom layers is 8mm dia and the concrete cover is 25mm. Reinforcement provided for vertical support is having diameter of 12mm

C. Material Properties

Bubble deck mainly composed of three main materials concrete, steel and HDPE balls. The material properties are given below

TABLE I MATERIAL PROPERTIES

Concrete	Young's modulus = 25000MPa
	Poisons ratio = 0.2
	Compressive strength = 25 MPa
	Density = 2400kg/m^3
Steel	Young's modulus = 2×10^5 N/mm2
	Poisons ratio = 0.3
	Tensile yield stress= 415 MPa
	Density = 7850 kg/m^3
HDPE	Young's modulus =1030 MPa
	Poisson's ratio = 0.4
	Density = 970 kg/m^3

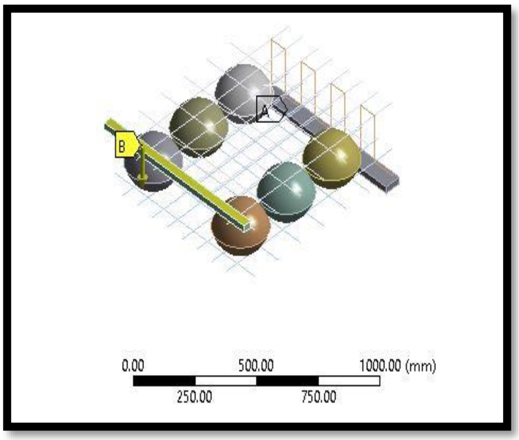

Fig.4.2 Bubble deck slab with longitudinally shuffled elliptical balls

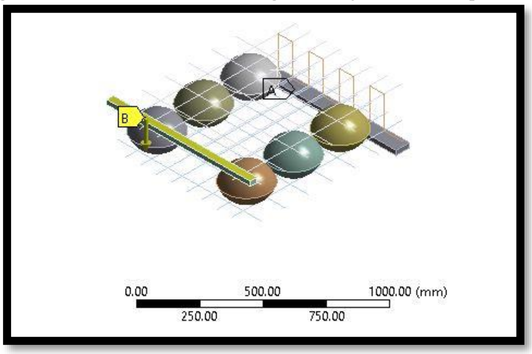

Fig.4.3 Bubble deck slab with transversely shuffled elliptical ball

D. Meshing and Loading

The bubble deck slab is modeled using a tetrahedral mesh which is a 4-node mesh. The loading is given by point load with with fixed end support.

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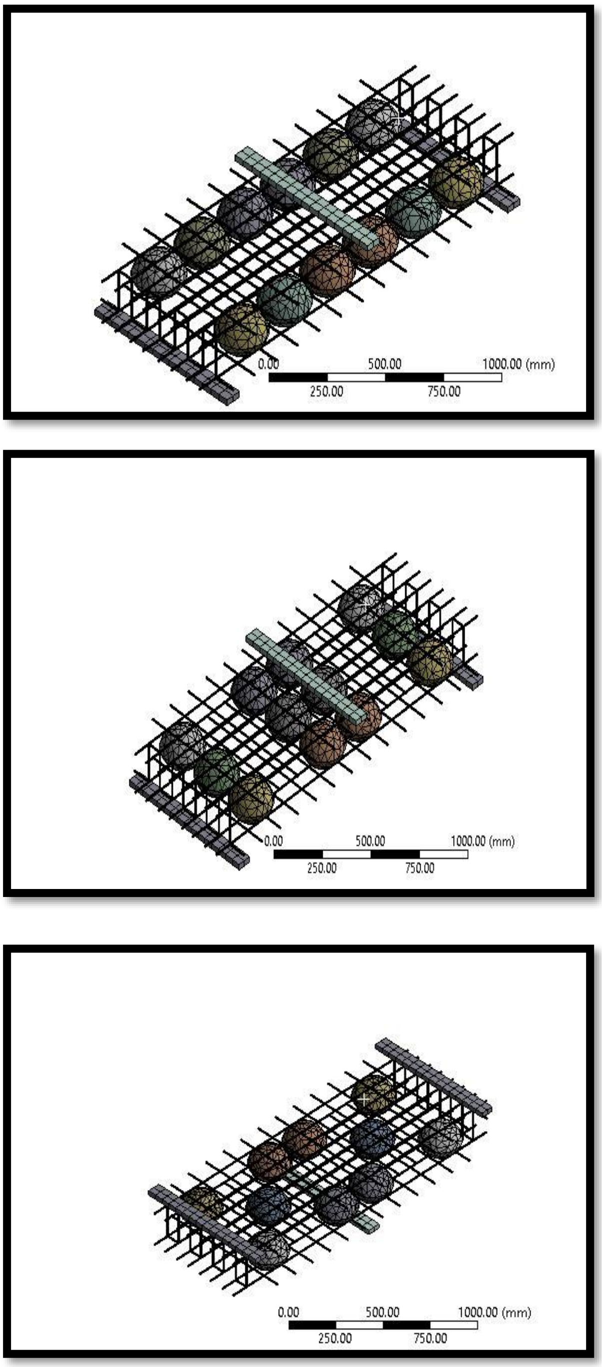

Fig.4.6 Meshing of bubble deck slab

E. Analysis of Bubble Deck Slab

Analysis was done using ANSYS software. Finite element analysis will provide indepth knowledge about the behavior of the member; it performed with proper boundary conditions and material properties. There are different analyses performed in this study.

IV. RESULTS AND DISSCUSSION

DEFORMATION

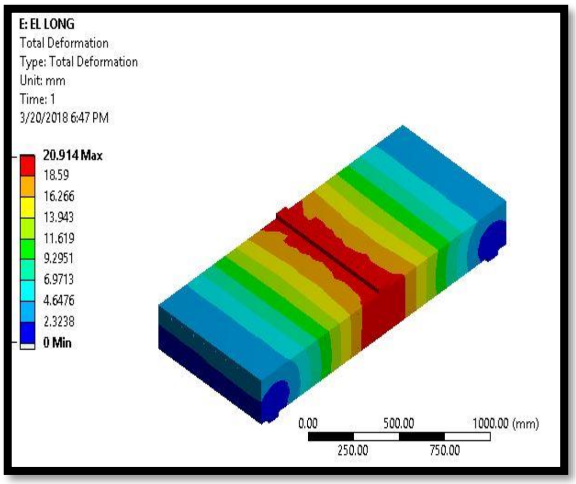

Fig.4.9 Deformation Diagram of Bubble deck slab with longitudinally shuffled elliptical balls

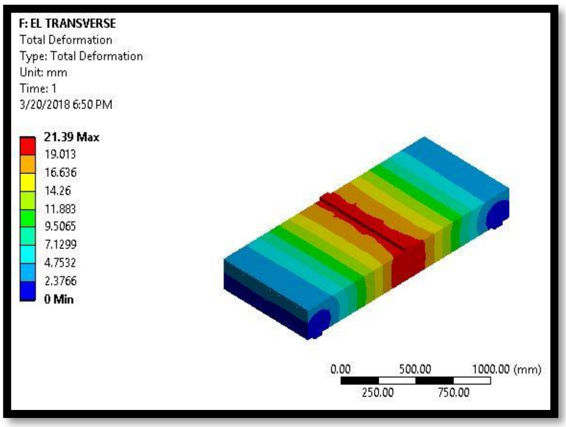

Fig.4.9 Deformation Diagram of Bubble deck slab with transversely shuffled elliptical balls

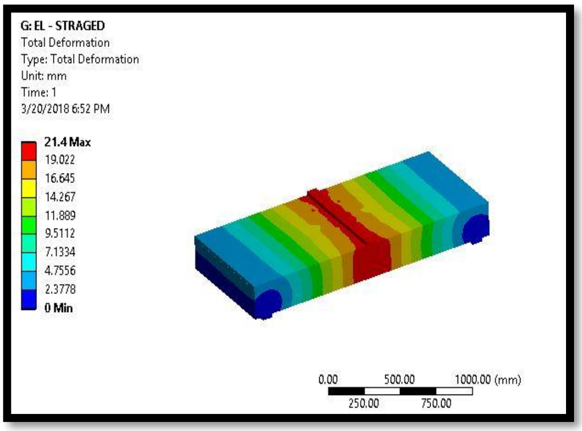

Fig.4.9 Deformation Diagram of Bubble deck slab with staggered arrangement of elliptical balls

TABLE II DEFORMATION

MODELS	DEFORMATIONS (mm)	LOAD(kN)
Type I	20.914	220
Type II	21.39	216
Type III	21.4	212

IV.CONCLUSIONS

Bubble deck slab is analysed in ANSYS software and the results where compared. Analysis was performed on the bubble deck slab with elliptical balls of different arrangements. Type I bubble deck slab has better load carrying capacity as compare to type II and type III. Deformation is comparatively less for type I bubble deck slab than the other two types of bubble deck slab.

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