Numerical Study of Bubble Deck Slab Using Ansys

B. Gopi Raju, P. Poluraju

Abstract: ***Construction of slab element is one of the important structural members consumes higher concrete. It is necessary to optimize the use of concrete in slabs. Bubble deck slab is an innovative technique made up of high-density polyethylene hollow spherical balls. It eliminates the inactive concrete which is present below the neutral axis by replacing hollow spherical balls. The parameters like strength, stiffness, durability and structural integrity remain unchanged when compared with the conventional slab. It has advantages in terms of economy, reducing co2 emission, earthquake damages and structural dead weight etc. Bubble deck slab diminish the load coming on the columns, walls, and foundations. In this research work, simulation work has been carried out on bubble deck slab by varying the parameters such as void ratio and thickness of bubble deck slab at different support conditions under uniformly distributed load by using ANSYS. From this simulation work, the total deformation, directional deformation, and Von-mises stresses were assessed. It is been concluded that when the void ratio percentage was varied from 30- 50% for achieving high strength.***

Index Terms: ***void ratio, size of the slab, the compressive strength of concrete, type of load.***

I. INTRODUCTION

Now a day's usage of concrete is more due to this large amount of pollution is creating, so one innovative technology was introduced it is bubble deck slab. The main use of bubble deck slab is to reduce the concrete at the middle the portion by replacing with high-density polyethylene (HDPE) hollow spherical balls. In Denmark bubble deck slab was invented it is a hollow biaxial core slab.

35% of the self-weight is decreased by replacing the concrete with high-density polyethylene hollow spherical balls compared to conventional slab or solid slab[1]. By using bubble deck slab no need of down-stand beams and large clear spans are available so finally load will be decreased, this can save the building material up to 50% [2]. Due to the decrease in the size of structural elements and floor vibrations are easily mitigated while any earthquake occurred damage is reduced[3].

Generally, in slabs, neutral axis is at centre but due to introducing of high-density polyethylene hollow spherical balls into the slab the neutral axis is shifted towards to the compression zone due to this the stress is slightly different when compared to the conventional slab shown Fig. 1. By introducing of high-density polyethylene hollow spherical balls into the slab we can reduce the concrete portion. Where the concrete is inactive under the bending condition. At top and bottom of these hollow spherical balls, mesh type reinforcement is provided to increase the bonding capacity this type of method is called reinforcement module and the slab is acting monolithic behaviour. Bubble deck slab is used for ground floors, storey floors, and roof floors. The deformation due to living load and long-term deformation of the solid flat slab and voided slab is in the range of permissible limits. The structural efficiency point of view the voided slab shows good agreement[4]. Compare to the solid slab, the maximum stress and internal force in the voided deck is reduced about 40% due to the use of HDPE spheres in the place of concrete. Due to the presence of the bubbles in the bubble deck slab the deflection was slightly higher but the stiffness is lower. The entire situation will be overcome by the reduction of overall stress in the slab [5]. To carry the shear force, the voids should not be provided at the corners of the slab [6]. The major problem faced in the bubble deck slab is the punching shear capacity because of its reduced weights.20% load carrying capacity we increased due to the strengthening of bubble deck slab with GFRP [7].

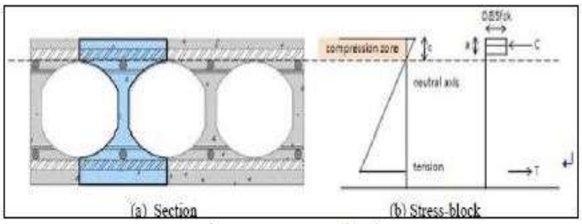

Fig. 1: Stress block of bubble deck slab

II. MATERIALS

Materials used are concrete, steel, and hollow spherical balls.

A. Concrete

The grade of concrete is M30 and the maximum size of the aggregate is 20mm and Portland cement was used. In bubble deck slab construction, more grade of concrete is recommended and no plasticizers are used.in bubble deck slab construction self-compacting concrete is most suitable when compared to the conventional concrete. Due to the usage of self-compacting concrete, the voids are filled and give high strength.

B. Steel

High yield strength deformed bars of grade Fe415, Fe500 and Fe550 grade steel is used. In slabs, reinforcement is provided in two directions both longitudinal and transverse

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direction. Here a 12mm diameter steel bar is used as main reinforcement and 10mm diameter steel bar is used distribution reinforcement. In bubble deck slab top and bottom steel mesh is used and in between high-density polyethylene hollow spherical balls.

C. Hollow spherical balls

In general, recycled plastic balls are used instead of burning the plastic and also to reduce the wastage of plastic due to this we can reduce the environmental pollution.

The recycled hollow spherical balls are made up of high-density polyethylene (HDPE). Reinforcement is concrete does not chemically react with the hollow spherical balls. The thickness of the shell is 2mm and the size of the HDPE ball is 150mm. it is having rigidity and has enough strength to take more loading while pouring the concrete.

III. MATERIAL PROPERTIES

Material properties are described in Table I.

Table. I:Material properties

S. No	Name of material	Property	Value
1.	concrete	Modules of elasticity(E)	27386MPa
		Density(P)	2400kg/m^3
		Poisson's ratio(μ)	0.18
2.	steel	Modules of elasticity(E)	200000MPa
		Density(P)	7850kg/m^3
		Poisson's ratio(μ)	0.3
3.	HDPE	Modules of elasticity(E)	1035MPa
		Density(P)	970kg/m^3
		Poisson's ratio(μ)	0.4

IV. NUMERICAL INVESTIGATION

Numerical study of bubble deck slab with hollow spherical balls was investigated by using finite element ANSYS. The finite element method is used to numerical study of bubble deck slab such directional deformation, total deformation, and equivalent stress. The varying parameters in bubble deck slab are the thickness of the shell, the diameter of the hollow spherical ball and thickness of the bubble deck slab.

A. Numerical Modeling

3D bubble deck slab with hollow spherical balls was modeled in ANSYS having dimensions of 1000*1000*230mm. The shell thickness 2mm and diameter of the hollow spherical balls is 150mmand hollow spherical ball center to center spacing is 210mm and concrete cover top and bottom of the slab is 25mm. Fig. 2 indicates the modellig of bubble deck slab

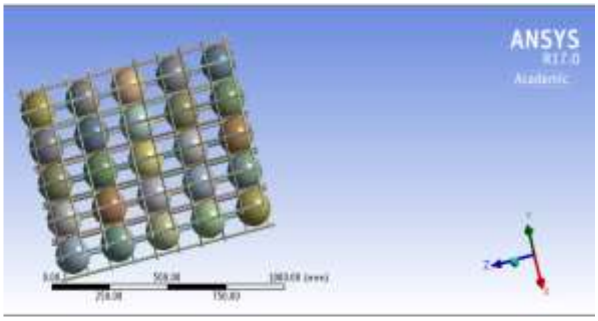

Fig. 2: Modeling of bubble deck slab

B. Meshing

By using TETRA mesh in bubble deck slab with hollow spherical balls were modeled in ANSYS.Meshing of bubble deck slab is shown in Fig. 3.

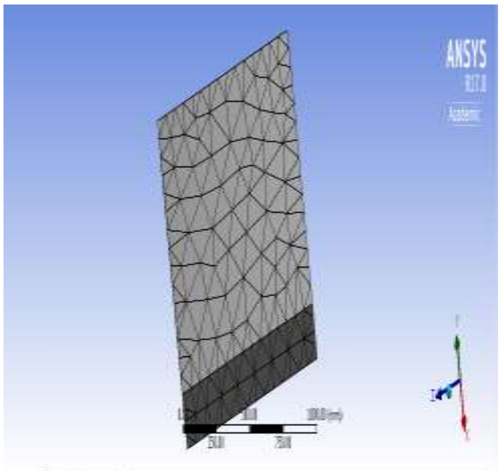

Fig. 3: Meshing of bubble deck slab

C. Boundary Conditions and Loading

Boundary conditions of the bubble deck slab are fixed supports at both ends. The uniform distributed load is applied on the top surface of the slab. Fig. 4, 5 indicates Boundary conditions and loading.

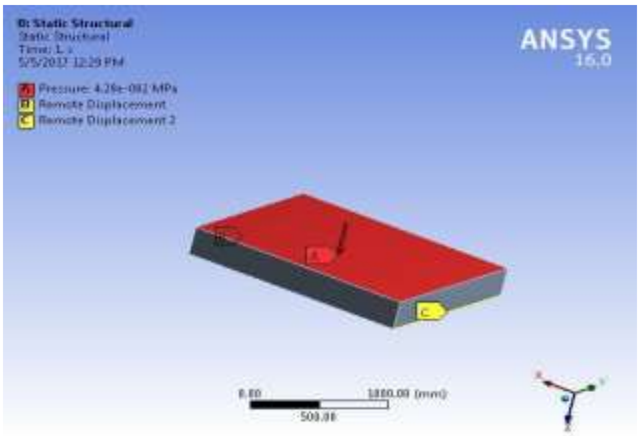

Fig. 4: Boundary conditions and loading[8]

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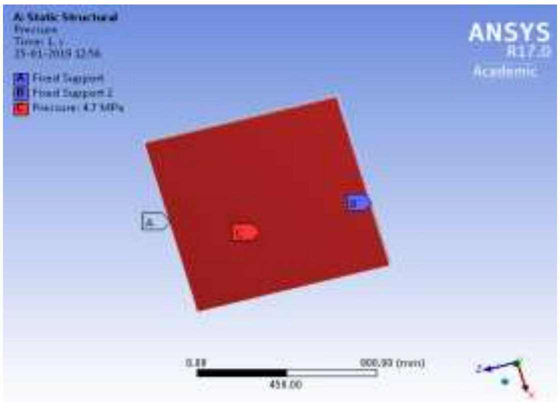

Fig. 5: Boundary conditions and loading

V. BEHAVIOUR OF THE BUBBLE DECK SLAB

A. Shear Strength

shear resistance is critical at columns in flat slabs the difference between voided biaxial slab and solid slab refer to shear resistance due to the loss of concrete volume there will be a reduction in shear resistance. In columns, if more concrete is there then shear resistance is increased. when compared to the solid slab the shear resistance of the bubble deck slab is 0.6 times more [1]. If hollow spherical balls are there in the column then it is difficult to design the bubble deck slab so we have to see that in columns hollow spherical balls should not be there than sheer will automatically increase. No check is required if there is less than the unreinforced hollow slab. If the hollow slab resistance is less than the applied shear we omit balls. By two ratios we can measure the shear capacity that is a/d(distance from imposed force to support divided by deck thickness)[1].

B. Flexural Strength

The elements which are on the outer shell is concrete under the compression side and the steel is on the tension side. There is a small difference in the behavior of the bubble deck slab. Compressed concrete depth is small in the slab portion and this means the concrete between the surfaces and ball is small.

C. Durability

The solid slab is fundamentally different from the bubble deck slab durability. Bubble deck slab does not allow a direct route to the air from the rebar surface because the bubble deck slab joint have a chamfer on the in the side to ensure that surround each bar this is the primary function of the fire resistance, durability is also relevancies.

D. Bending Strength

The stiffness of the bubble deck slab is slightly lower when compared to the conventional slab. The bubble deck slab and the solid deck have the same bending strength.

E. Fire Resistance

Fire resistance is always depending on the strength of the steel to resist the failure. When the temperature increases the slab lost its strength. Nearly 60-180minconcrete cover resist from the fire. Fire resistance is 1.5times less than the smoke resistance.

F. Punching Shear

In structural members punching shear occurred at slab and foundation due to shear because of high forces acting at one point. Punching shear mainly occurs at slab-column connection and footing column connections because of high localized forces are acted at the point. The crack pattern is comparable to the solid slab and bubble deck is same slab as shown in Fig.6.

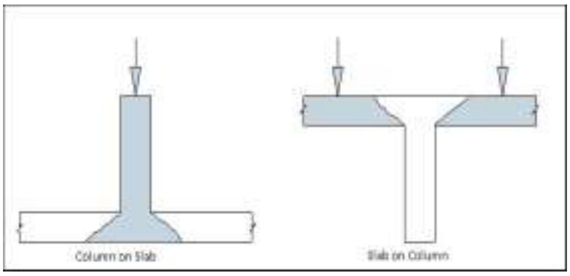

Fig. 6: Punching shear failure

G. Sound Installation

Netherlands according to ISO:140-4:1998. The sound installation was measured impact and airborne sound test are conducted.

H. Vibrations

Where compressed to the lightweight structures, steel framed structures are more susceptible then RC slab structures. When compared to the solid slab, bubble deck slab is lightweight or less weight.

Concrete cover resists from the fire. Fire resistance is 1.5times less than the smoke resistance.

VI. RESULTS AND DISCUSSIONS

The finite element analysis is carried out to analyze the bubble deck slab with spherical balls of M30 grade of concrete and 1000×1000×230mm size of the slab are same. The thickness of the ball and voided spacing are varied. Throughout the analysis structural behavior of bubble deck slab with spherical balls were studied. Results obtained from the analysis are given below. Fig. 7 is total deformation of bubble deck slab with spherical balls of M30 grade concrete 1.5mm ball thickness.

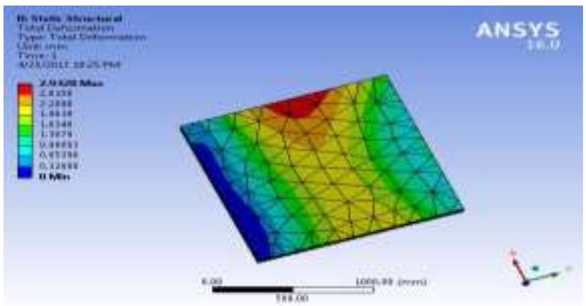

Fig. 7: Total deformation of bubble deck slab with spherical balls of M30 grade concrete 1.5mm ball thickness[8].

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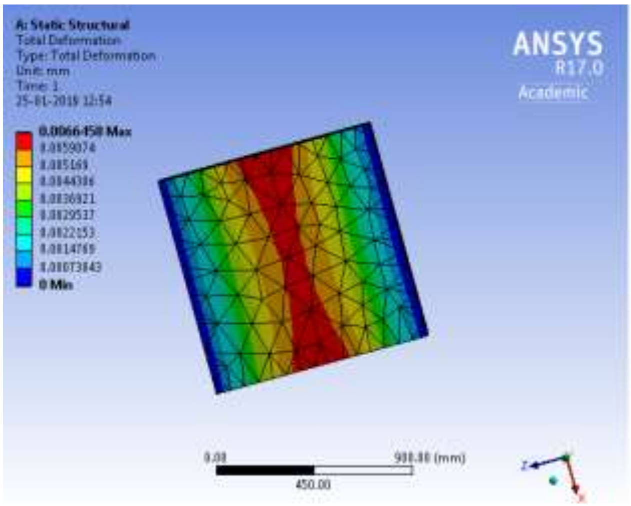

Fig. 8: Total deformation of bubble deck slab with Spherical balls of M30 grade concrete 2mm ball thickness

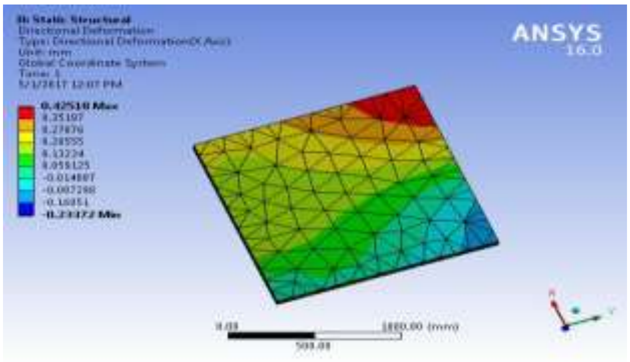

Fig. 9: Directional deformation of bubble deck slab with spherical balls of M30 grade concrete 1.5mm thickness[8].

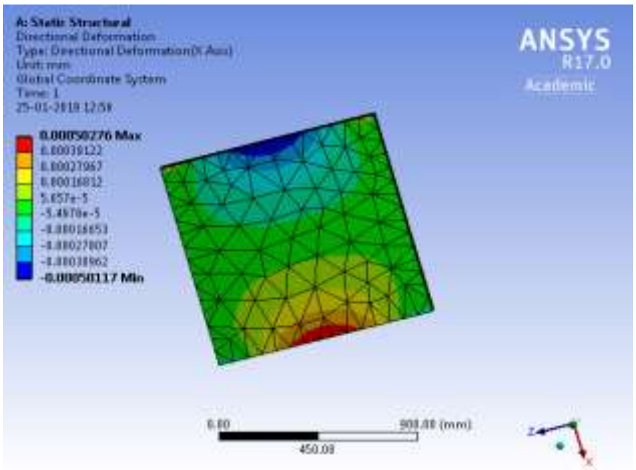

Fig. 10: Directional deformation of bubble deck slab with spherical balls of M30 grade concrete 2mm thickness

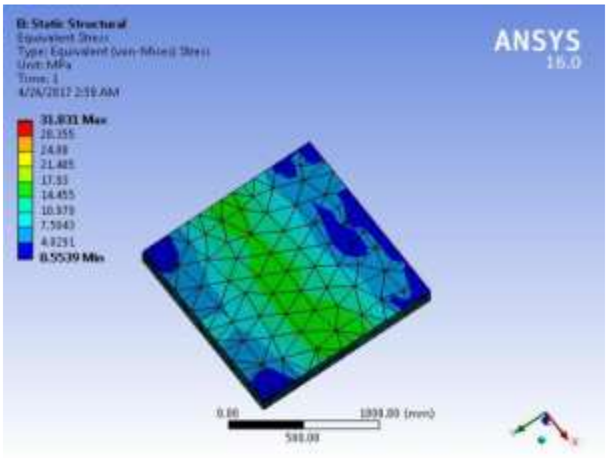

Fig. 11: Equivalent stress of bubble deck slab with spherical balls of M30 grade concrete 1.5mm ball thickness[8].

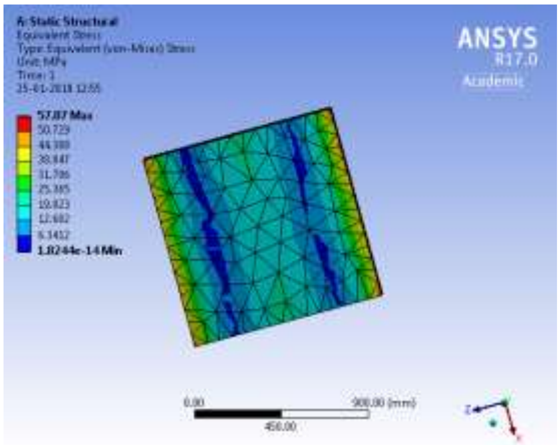

Fig. 12: Equivalent stress of bubble deck slab withspherical balls of M30 grade concrete 2mm ball thickness

VII. CONCLUSION

1. **B**ubble deck slab with a 2mm thickness of a ball and 210mm voided spacing gives better results compared to the bubble deck slab 1.5mm thickness of the ball and 200mm voided spacing.
2. Total deformation and directional deformation are decreased for the 2mm thickness of the ball and 210 voided spacing slab.
3. Von-mises stress is increased for the 2mm thickness of the ball and 210mm voided spacing.

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