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A study on behavior of bubble deck slab using ansys

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Abstract— 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 a method of eliminating all concrete from the middle of a floor slab, which is not performing any structural function, thereby dramatically reducing structural dead weight. 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 in-effective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. By introducing the gaps leads lighter slab which reduces the loads on the columns, walls and foundations, and of course of the entire building. The advantages of the bubble deck slab are less energy consumption both in production, transport and carrying out, less emission of exhaust gases from production and transport, especially CO_2 .The aim of this paper is to discuss about various flexural behaviors of two-way Bubble Deck slab such as ultimate load capacity, service load deflection, concrete stress distribution and crack pattern by using a model in ANSYS. Along with that various properties of bubble deck slab was also discussed based on the studies carried out on abroad.

Index Terms— Biaxial Hollow core slabs, Bubble deck slab, Finite element method (FEM), Hollow plastic spheres

1.Introduction

In building constructions, the slab is a very important structural member to make a space. And the slab is one of the largest member consuming concrete. The main obstacle with concrete constructions, in case of horizontal slabs, is the high weight, which limits the span. For this reason 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. To avoid these disadvantages which were caused by increasing of self-weight of slabs, the Bubble Deck slab system, also known as void slab, was suggested. The invention of a new type of hollow core slabs was a breakthrough at the turn of 20th and 21st centuries. During the first decade there have been many studies on the feasibility of using the hollow core technology.

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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 in-effective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor.

2. MATERIAL

Bubble deck slab is a biaxial hollow core slab invented in Denmark, by Jorgen Breuning who invented a way to link air space and steel within a voided biaxial concrete slab. It is a new innovative and substainable floor systems to be used as self supporting concrete floor.it can be used for storey floors, roof floors and ground floor slabs.It is mainly composed of three materials.They are concrete,steel and HDPE bubbles.

2.1 Concrete

The concrete is made of standard Portland cement with a maximum aggregate size of 3/4 in. No plasticizers are necessary for the concrete mixture.

2.2 Steel

The steel reinforcement is of Grade Fe 500 strength or higher. The steel is fabricated in two forms- meshed layers for lateral support and diagonal girders for vertical support of the bubbles.

2.3 HDPE

The hollow spheres are made from recycled high-density polyethylene or HDPE. PVC,PVP,polyethin are usually used

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3.PROPERTIES OF BUBBLE DECK SLAB

3.1 Material And Weight Reduction.

The nominal advantage of Bubble Deck slab is that it uses 30-50% less concrete than normal solid slabs. The HDPE bubbles replace the non-effective concrete in the center of the section, thus reducing the dead load of the structure by removing unused, heavy material. Decreased concrete material and weight also leads to less structural steel since the need for reinforcement diminishes. The building foundation can be designed for smaller dead loads as well. Overall due to the lighter floor slabs, the several downstream components can be engineered for lower loads and thus save additional material.

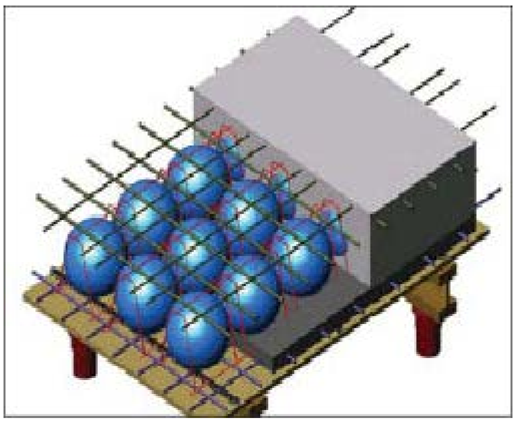

fig 1. Compenents of Bubble Deck Slab

3.2 Construction And Time Savings

Onsite constructions can be minimized since Bubble Deck slabs can be precast. Similar to modern precast concrete flooring nodules, Bubble Deck can be fully shop fabricated and transported on site for installation as well. Time savings can also be achieved through the faster erection of walls, columns due to the lack of support beams and load bearing walls for this innovative flat slab. Additional time may be saved from the quicker curing time since there is less concrete in the slab.

3.3 Cost Savings

In relation to the saving of materials and time, cost reductions are also typical with the Bubble Deck system. The decreased weight and materials mean lower transportation costs, and would by more economical to lift the components. With the less on-site construction from the full and semi-pre cast modules, labor costs will decrease as well. In addition money can be saved downstream in the design and construction of the building frame elements (columns and walls) for lower loads. There is a slight rise in population costs for the Bubble Deck slab due to the manufacturing and assembly of the HDPE spheres. However, the other savings in material, time, labor and transportation will offset this manufacturing price increase. For the same amount of steel and concrete, Bubble Deck has 40% larger span and is further rmore 15% cheaper. For the same span, Bubble Deck reduces the amount of concrete with 33%, and reduces the price with 30%. [3]

3.4 Green Design

The number of owners, designers and engineers who desire green alternative is growing exponentially. Bubble Deck is a fitting solution for lowering the embodied carbon in new buildings. According to the Bubble Deck Company, 1 kg of recycled plastic, which is an industrial waste, replaces 100kg of concrete. By using less concrete, designers can save up to 40% on embodied carbon in the slab, resulting in significant savings downstream in the design of other structural members. Carbon emissions from transportation and equipment usage will also decrease with the use of fewer materials. Additionally, the HDPE bubbles can be salvaged and reused for other projects, or can be recycled.

Generally for every 5,000 sq.m of Bubble Deck floor slab, the owner can save:

a) 1,000 sq.m of on-site concrete
b) 166 concrete truck trips
c) 1,798 tons of foundation load, or 19 less piles
d) 1,745 GJ 0f energy used in concrete production and transportation
e) 278 tons of Carbon di oxide emission

4. ANALYSIS OF BUBBLE DECK SLAB USING FINITE ELEMENT METHOD

A 3D solid slab and bubble deck slab were modelled in ANSYS with all the same dimension of 1 x 1 m and 125 mm thick was modeled as volume in ANSYS.The diameter for the bubble chosen for the study was 64mm. Quarter of the total dimension are modeled . Reinforcement is provided using discrete method.

Young's Modulus E=27386.128Mpa
Poison's ratio v=0.2
Density p=25kN/m^3
Characteristic Compressive Strength =30000kN/m^2

4.1 Element Types

The element types used for the modeling are

Components	Element Types
Concrete	SOLID 65
Steel Reinforcement	LINK 180
Loading plate	SOLID 185

4.2 Meshing

To obtain good results from the Solid65 element, the use of a rectangular mesh was done . Therefore, the mesh was set up such that rectangular elements were created. The meshing of the reinforcement was a special case compared to the volumes. No mesh of the reinforcement was needed because individual elements were created in the modeling through the nodes created by the mesh of the concrete volume. Mapped meshing is utilized for meshing the bubble deck slab portion.Fig. 2 shows the meshing of Bubble deck slab.

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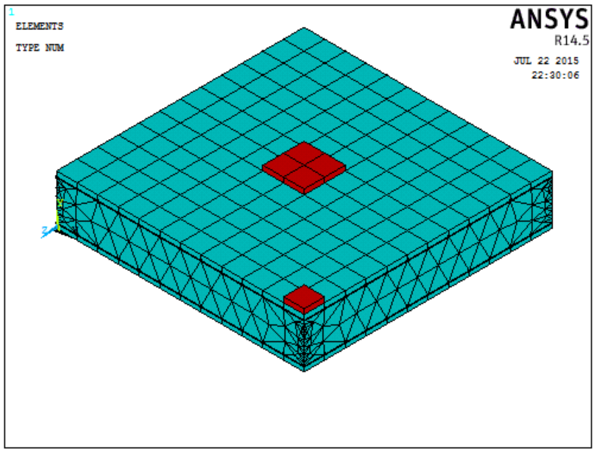

fig2.Meshed Model of Bubble Deck Slab

4.3 Boundary Conditions And Loading

Instead of modelling the total structure, quarter portion was modelled. Since the geometry and the boundary condition are symmetric ,symmetry boundary condition are applied. Slab system is loaded under five point loading system and the loading plates are established to make actual loading system. Fig.3 shows the boundary condition and loading of bubble dek slab.

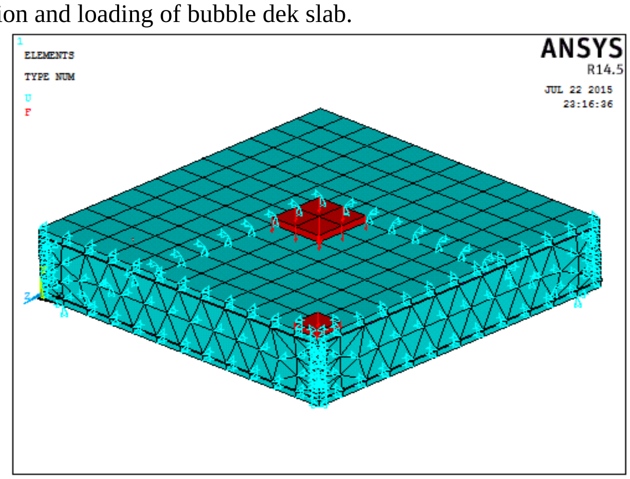

fig.3 Boundary condition and loading

5.ANALYSIS RESULTS

5.1 Deflection Diagrams

The deflected shapes due to applied loads are shown in Figures .After first cracking, the stiffness of the finite element models is again higher. There are several effects that may cause the higher stiffness in the finite element models. First, micro-cracks are present in the concrete, and could be produced by drying shrinkage in the concrete and/or handling of the slabs. On the other hand, the finite element models do not include the micro-cracks. The micro-cracks reduce the stiffness of the slabs. Next, perfect bond between the concrete and steel reinforcing is assumed in the finite element analyses, but the assumption would not be true for the actual slabs. As bond slip occurs, the composite action between the concrete and steel reinforcing is lost.

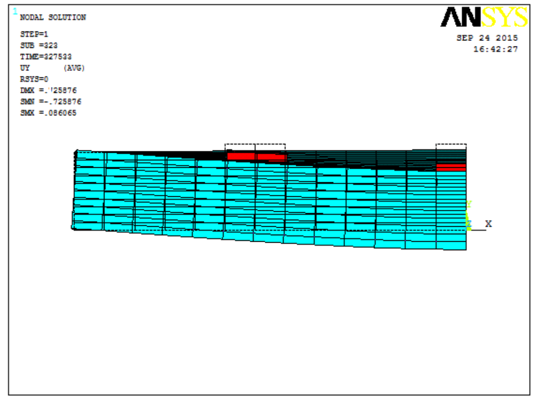

fig .4 Displacement on Reinforcement

5.2 Loads At Failure

The final load for the finite element model at the last applied load step before the solution diverges due to numerous cracks and large deflections. It is seen that the ANSYS models underestimate the strengths of the slabs. One explanation is that the toughening mechanisms at the crack faces, i.e. the grain bridging process, interlocking between the cracked faces, crack tips blunted by voids, and the crack branching process, may also slightly extend the failures of the slabs before complete collapse. The finite element models do not have these mechanisms.

5.3 Crack Pattern

The ANSYS program records a crack pattern at each applied load step. Figures shows crack patterns finite element at load failure. In general, flexural cracks occur early at mid-span. Finally, compressive cracks appear at nearly the last applied load steps. ANSYS program displays circles at locations of cracking in concrete elements. Cracking is shown with a circle outline in the plane of the crack. The first crack at an integration point is shown with a red circle outline and the third crack with a blue outline**.**

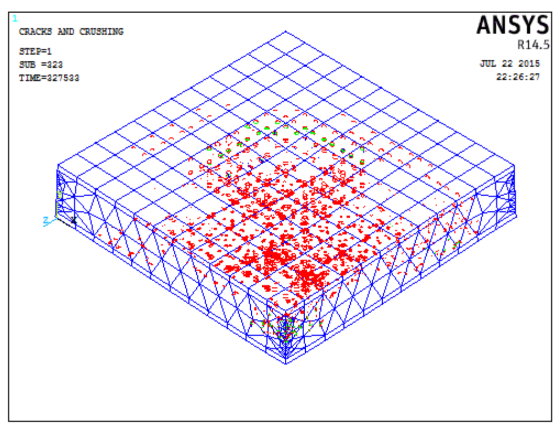

fig 5 Crack Pattern Isometric View

5.4 Von Mises Stress

The von Mises yield criterion predicts that yielding will occur whenever the distortion energy in a unit volume equals the distortion energy in the same volume when uniaxially stressed to the yield strength. When von Mises equivalent stress exceeds the uniaxial material yield strength, general yielding will occur. The von mises stress diagram for steel reinforcement is shown below.

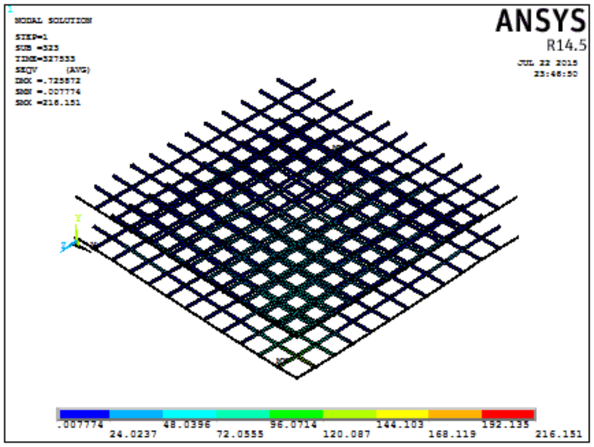

fig .6 Von mises stress on Reinforcement

6. CONCLUSION

To investigate and identify the methods for reducing the weight of the slab system is the need of the present**.** Bubble deck Technology is the innovative system that eliminates secondary supporting structure such as beams reinforced concrete columns or structural walls. Bubble Deck will distribute the forces in a better way (an absolute optimum) than any other hollow floor structures. Because of the three dimensional structure and the gentle graduated force flow the hollow areas will have no negative influence and cause no loss of strength. Bubble Deck behaves like a spatial structure as the only known hollow concrete floor structure, the tests reveal that the shear strength is even higher than presupposed, this indicates a positive influence of the balls.

The finite model of the bubble deck slab was modeled for the study using ANSYS.FEM modeling, theory related to the ANSYS, material modeling and the material behavior of concrete, HDPE Bubbles were studied**.**

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