Behaviour of Bubble deck slab by model making and performing compressive strength

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ABSTRACT

In western country for a construction of high-rise building large projects the bubble deck slab is widely use to modified slab structure. This constructive system could not be brought into practice in so many projects achieved, the test that prove project that will be performed is useful in so many project, therefore tests were made concerning: bending behavior, reaction in the slab, the behavior of mountings, the reaction to fire, the achievement of economy. Bubble deck slab make the slab lighter than convectional slab of by eliminating all concrete from the middle of a floor slab, which is dormant concrete function, thereby dramatically reducing structural dead weight. Plastic hollow balls replace the in-effective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. The advantages are less energy consumption - both in production, transport and carrying out, less emission - exhaust gases from production and transport, especially CO2 and reduce the material, the load, lower the cost and it is also a green technology.

Keyword : - *Bubble deck slab , Compressive strength of bubble deck slab, Modelling of bubble deck slab*

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1. Introduction

In construction industries the column, beam, slab and other members is a very important structural member to make a space and slab is one of the largest member consuming concrete. A slab being the essential part of the structure has to be effectively designed and utilized. It tends to use more concrete than any other structural member, hence has to be optimized.

The area of slab is more and the thickness also consuming the more concrete, the deflection of the slab is also more. Therefore the slab thickness is on increasing. Increasing the slab thickness makes the slabs heavier because of dead load of slab also increase, and hence increase in column and foundations sizes. Thus, it make the building more concrete consumable member.

In western country bubble deck slab widely used to reduce CO2 emission and make the structure lighter. Bubble deck slab uses balls made by recycled plastic and therefore it is an inventory method of eliminating the inert part of dormant concrete.

Bubble deck is a two-way spanning pour deck in which recycled plastic bubbles serve the purpose of eliminating non-structural concrete, thereby reducing structural dead weight, void formers in the middle of a flat slab eliminates approx. of a slabs self weight that is dead load.

This is the geometry of the Bubble deck slab showing in Fig.1 is defined by the spheres of a certain size, placed in a precise modular grid for a particular overall deck thickness. Bubble deck that it produces floors faster with less formwork and beams, reduces construction costs by approximate 10% and agrees with the 35% reduction in concrete use.

Fig.1: Bubble Deck Slab Actual Model

I. TYPES OF BUBBLE DECK SLAB

1.1 Filigree elements : This element is casted with ¼ of total depth of slab and this precast element brought on site with the bubbles and steel reinforcement unattached in bottom of slab. The balls are then supported by temporary stands on top of the precast layer of reinforcement steel top mesh.

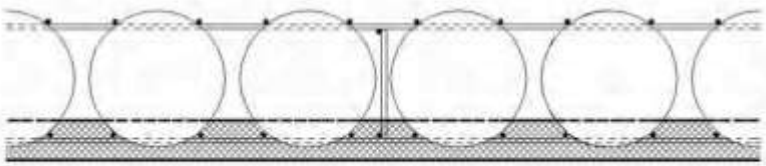


Fig. 2: Filigree elements

1.2 Reinforcement modules : This module consist of top reinforcement mesh and bottom reinforcement mesh with middle part of plastic balls lattice. This modules will be transported for concreting when we need it.

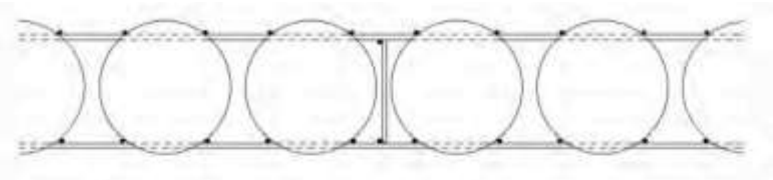


Fig. 3: Reinforcement modules

1.3 Finished planks : This is fully casted slab which is combination of filigree element and reinforcement modules. It is casted on actual site steel and balls are assemble on site and work will be executed for slab.

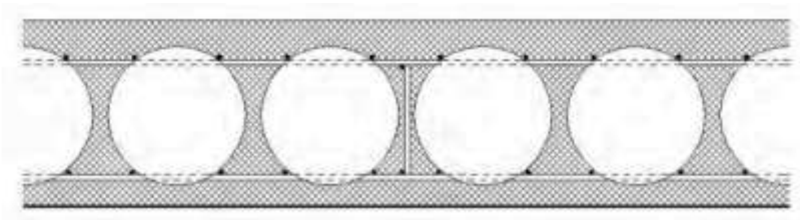


Fig. 4: Finished planks

2. SYSTEM DEVELOPMENT

A. Materials

i. Cement

The Ordinary Portland cement 53 grade were used. According to IS 456-2000 the test were performed.

ii. Aggregate

a) Fine aggregates

Those sieve fraction 4.75 mm to 150 micron are termed as fine aggregate. The crush sand is being used as fine aggregate conforming to the requirements of IS: 383.

b) Coarse aggregate

Those sieve fractions from 10 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from 10 mm, 20mm are used conforming to IS: 383 is being use.

iii. Water

Potable water free form impurities as per IS 456:2000. From durability consideration water cement ratio should be restricted as in case of normal concrete and it should preferably be less than 0.48.

iv. Concrete

The concrete used for 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 10mm & 20mm. M30 Grade should be performed.

v. 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. Grade Fy415 strength is used.

vi. Hollow bubbles

The bubbles are made using recycled plastic materials. 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 120 mm and the distance between bubbles is 80 mm. The bubbles are spherical in shape.

B. Methodology

a) **Conventional slab:** This is a slab with specifications prepared to analyse experimentally with normal concrete of grade M30 by adopting conventional methods of design according to IS 456:2000 & IS 10262:2009.

b) **Bubble deck slab:** This is a slab with specifications prepared to analyse experimentally with normal concrete of grade M30 by using recycled normal plastic balls.

C. Drawing

The Fig.5 of Plan of Bubble Deck Slab view shows the arrangement of top reinforcement meshes with bubbles, bottom reinforcements and diagonal girder edge positioning

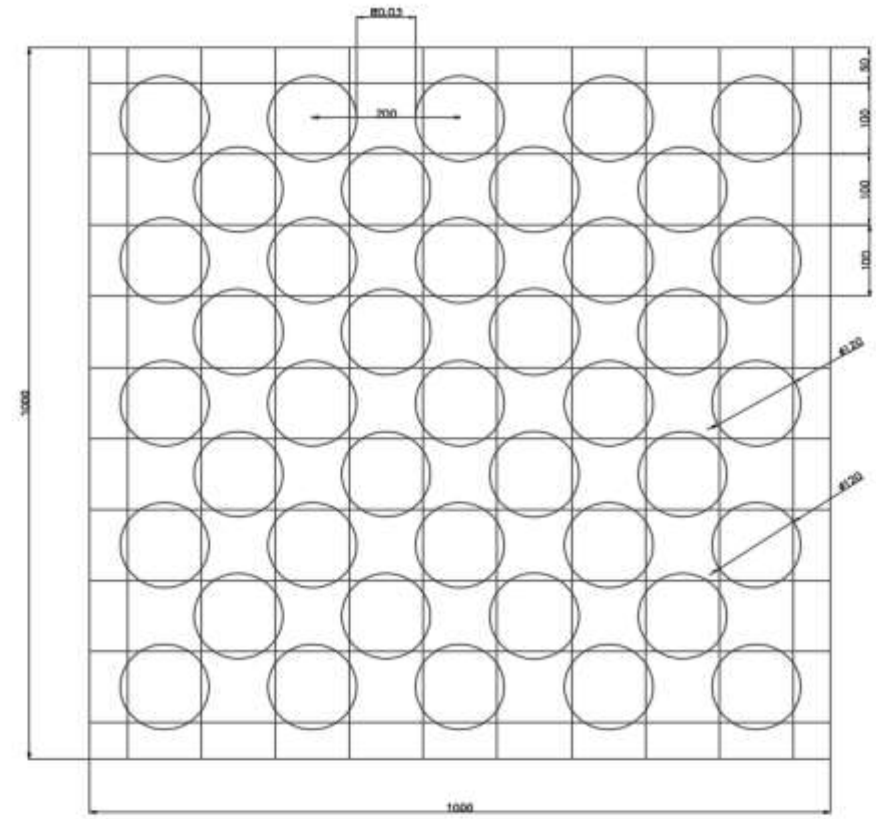


Fig.5: Plan of Bubble Deck Slab

Fig.6 of section AA passes through the slab portion only. It represents the sectional view of the slab including diagonal girder and bubbles.

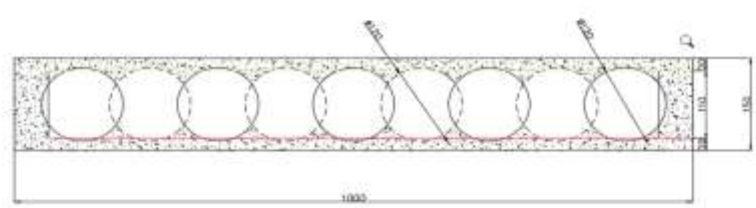


Fig.6: Section of Bubble Deck Slab

D. Mix design of concrete used

1. Stipulations for proportioning

a) Grade designation : M30
b) Type of cement : OPC 53 Grade
c) Maximum nominal size of aggregate : 20mm

d) Minimum cement content : 320 kg/m3 (IS 456:2000)
e) Maximum water-cement ratio : 0.48 (Table 5 of IS 456:2000)
f) Workability : 100-120mm slump
g) Exposure condition : Moderate
h) Type of aggregate : Crushed Angular Aggregates
i) Maximum cement content : 390 kg/m3
j) Chemical admixture type : Plasticizer Sikament 112

2. Test data for materials
a) Cement used : OPC 53
b) Specific gravity of cement : 3.15
c) Chemical admixture : Plasticizer Sikament 112
d) Specific gravity of
1) Coarse aggregate 20mm : 2.67
2) Fine aggregate : 2.65

3. Target strength for mix proportioning
f'ck = fck + 1.65 s
where
f'ck = target average compressive strength at 28 days,
fck = characteristics compressive strength at 28 days, and
s = standard deviation.
From Table I of IS 10262:2009, Standard Deviation, s = 5 N/mm2.
Therefore, target strength = 30 + 1.65 x 5 = 38.25 N/mm2.

4. SELECTION OF W/C RATIO

Maximum W/C ratio = 0.55
Water / cement ratio is taken from the experience of the mix designer based on this experience of similar work elsewhere Adopt W/C ratio = 0.48

5. Selection of water content
From Table 2 of IS 10262:2009, maximum water content for 20 mm aggregate = 186 litre (for 25 to 50 mm slump range)
Estimated water content for 100 mm slump = 186+ (6/186) = 197 litre.
(Note: If Sikament 112 plasticizer is used, the water content can be reduced upto 5-15 % and above.)
Based on trials with Super plasticizer water content reduction of 20% has been achieved, Hence the arrived water content = 197-[197 x (08/100)] = 182 litre.
Calculation of cement content
Adopted w/c Ratio = 0.48
Cement Content = 182/0.48 = 380 kg/m3
From Table 5 of IS 456, Minimum cement content for 'Moderate' exposure conditions 320kg/m3
= 380 kg/m3 > 340 kg/m3 hence ok.

6. Mix proportions
Cement = 390 kg/m3
Water = 182 l/m3
Fine aggregate 10mm = 290 kg/m3
Coarse aggregate 20mm = 850 kg/m3
Chemical admixture = 3.5 kg/m3
Density of concrete = 2621 kg/m3
Water-cement ratio = 0.48

Fig.7: The material used for shuttering are boards (Formwork)

Shuttering : Formwork is a temporary construction used to hold concrete in place while it sets. As concrete is very heavy, formwork must be solidly constructed and firmly braced and supported.. The material used for shuttering are boards, which have a thickness of 25 mm.

Oiling : Before concreting oiling will be done for all shuttering work where concrete is to be placed

Fig.8: Hollow Balls/Bubbles

Hollow Balls/Bubbles : The hollow plastic balls are made using low density polyethylene, polypropylene plastic which is a nonporous material that does not react chemically with the concrete or reinforcement bars. The bubbles have enough strength and stiffness to safely support the applied loads. The distance between bubbles must be greater than 1/9th of bubble diameter. The shape of balls must be spherical

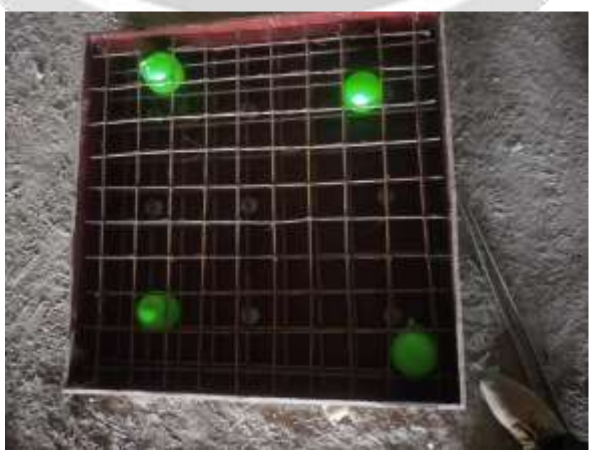


Fig. 9: Top mesh and Bottom mesh fitted in shuttering

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 or welded. The steel is fabricated in two forms- the meshed layers and diagonal girders for vertical support of the bubbles. The distance between the bars correspond to the diameter of the bubbles that are to be used and the quantity of reinforcement from transverse ribs of the slab as show in above fig.9

E. Experimental Procedure

Bubble Deck slab

The Bubble deck slab is prepared with M30 grade of concrete. It's dimension is 1m x1m x 0.150m. Reinforcement used is top 6mm@100 bar longitudinal, bottom bar on four sides of slab. Diameter of that reinforcement bars used is 8mm @ 100 c/c spacing. Total length of the bars are 1000 mm, straight portion of that bar is about 1000 mm

Fig.10: Partially Casted Model Bubble Deck Slab

3. Test on slab sample cube

A) Test on slab unit:- CTM test on cube with inert with ball in casted cube
Compressive strength for 7 days
After curing of cubes for 7days, the concrete moulds of 150x150x150 mm is tested with a compressive testing machine (CTM). Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the samples fails. The result is shown below for M30/M35

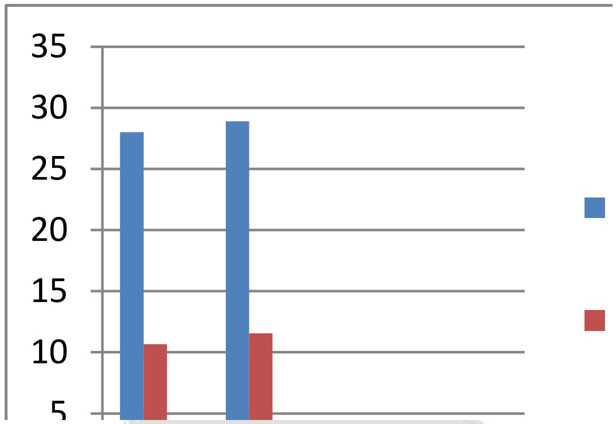
Table -1 showing the result from practically test on cubes of bubble deck slab inert with plastic ball

Bubble deck slab cube sample			
Grade	Weight of cube	Load on cube sample	Strength
M30	6.885	240	10.67
M30	6.78	235	10.44
M30	6.935	260	11.55
M35	6.94	280	12.45
M35	6.79	250	11.11
M35	6.82	260	11.56

Fig.11: Weight of different specimen of concrete cube for seven days

Table -2 showing the result from practically test on cubes of convectional slab without ball

Convectional slab cube sample			
Grade	Weight of cube	Load on cube sample	Strength
M30	8.965	610	27.11
M30	9.01	620	27.55
M30	8.91	640	28.44
M35	8.855	620	27.55
M35	8.965	670	29.78
M35	9.23	650	28.89



Graph 1: showing compressive strength between bubble deck slab and convectional slab

Based on the performance, the following result have been arrived. The cubes of concrete have been cast at 100 percentage with concrete the strength will achieved. If cube casted with spherical plastic ball then strength will be half of 100 percentage of casted cubes were tested for 7 days to resolve M30 and M35 concrete's compressive strength drawn from the current investigation.

- The replacement of Concrete with Spherical Ball is less weight of concrete cube.
- The strength will good for non live load structure. E.g. Petrol pump roof, parking, etc.
- The slab will reduce its own weight that is good in economy

Fig.12: Ball shape forming inside of casted cube

Comparison in Weight between the Bubble and the same Sphere of Concrete.

Considering the plastic ball Thickness to be 120mm in diameter and it replaces the middle concrete sphere of the same diameter. So the concrete sphere is of 120 mm in diameter. The weight of the plastic ball weighs 25 grams as shown in fig.13

Fig.13: Measuring Weight of Hollow HDPE ball on Weighing Machine

Calculation of the weight of the Concrete sphere.
Unit Weight (Density) of Concrete = 2621 kg/m3
Density = Mass/Volume
So we need Mass, i.e. formula is Mass=Density X Volume
Volume of Sphere of 120mm diameter = (4/3)πr 3
Radius = 0.060m, π = 3.14.
Volume of Sphere = (4/3)X3.14X(0.060)3 = 0.00090432 m3
Mass = 2621kg/m3 X 0.00090432 m3
Mass of 120mm Diameter Concrete Sphere = 2.370 kg.
The Difference between the weight of ball and weight of Concrete sphere = 2.370 Kg.

4. CONCLUSIONS

We found in experiment that bubble deck slab is reduced the volume of concrete so that weight of slab decrease ultimately. Also the load carrying capacity has also good simultaneously as compare to conventional slab. Simultaneously, bubble deck slab has improve the elasticity property of slab. Weight reduction is important factor in bubble deck slab. Weight of the conventional slab is more than the bubble deck slab.

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