AN EXPERIMENTAL STUDY ON FLEXURAL STRENGTH OF BUBBLE DECK SLAB

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Abstract – *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 the load transfers from the structure only on the column portion not throughout the slab. As the volume of concrete decreases, the material cost reduces which decreases the labour cost, which in turn minimize the construction cost. So, the aim was to reduce the concrete in centre of the slab by using recycled balls. Plastic hollow spheres balls replace the in-effective concrete in the centre of the slab, thus decreasing the dead weight and increasing the efficiency of the floor this new technology is called Bubble deck slab. Hollow sphere ball is made up of recycled plastic.*

The stress and deformation results were observed and compare the bubble deck slab with conventional slab. This project focused on material optimization by introducing hollow HDPE balls in RC slabs. For this, 4 slabs of size 600x300x120 mm is casted with one conventional slab and 3 slabs with hollow HDPE balls of diameter 60mm at various spacings. M20 grade concrete with Fe415 grade steel is to be used. The slab samples will be finally tested after 28 days for flexural strength, under gradually increasing single point loading. By using cheap and light material sustainability can be achieved.

Key Words: **RCC Slab, HDPE balls, Reinforcement mesh, Flexural strength test.**

1.0 INTRODUCTION

When designing a reinforced concrete structure, a primary design limitation is the span of the slab between columns. Designing large spans between columns often requires the use of support beams and/or very thick slabs, thereby increasing the weight of the structure by requiring the use of large amounts of concrete. Heavier structures are less desirable than lighter structures in seismically active regions because a larger dead load for a building increases the magnitude of inertia forces, thus the structure must resist larger dead load and it contributes to higher seismic weight.
A new solution to reduce the weight of concrete structures and increase the spans of two-way reinforced concrete slab systems was developed in the 1990s in Europe and is gaining popularity and acceptance worldwide. Bubble deck or plastic voided slabs provide similar load carrying capacity to traditional flat plate concrete slabs but weigh significantly less. This weight reduction creates many benefits that should be considered by engineers in determining the structural system of the building.
Plastic voided slabs remove concrete from non-critical areas and replace the removed concrete with hollow plastic void formers.
Bubble deck can achieve larger spans as compared to a site cast concrete structure without the need for post-tensioning or pre-stressed sections. The total construction time for the structure was reduced.

2.0 OBJECTIVES

To cast conventional slab and 3 bubble deck slab with varying spacing between hollow HDPE ball.

- To find out the load carrying capacity of Bubble Deck Slab.
- To study the flexural strength of Bubble Deck Slab.
- To compare the strength characteristics of bubble deck slabs and conventional slab.
- To estimate the amount of concrete saved by using bubble deck slab.

3.0 MATERIALS USED

3.1 Cement

Ordinary Portland cement is the cement used for normal construction. It has adhesive and cohesive properties so that it forms a good bond with other materials. It solidifies when mix water. It is the most active binding medium. Here 43 grade cement is used.

Table -1: physical properties of 43 grade cement

Tests	Results
Specific gravity	3.14
Standard consistency	30 %
Initial setting time	30 min
Fineness of cement	6.5 %

3.2 Steel

The main purpose of inclusion of steel is to resist tensile stress in particular regions of the concrete that may cause structural failure or cracking. The steel reinforcement is of GradeFe415strength.

Fig.1: Arrangement of balls and reinforcement

3.3 Plastic spheres

The hollow spheres are made from recycled High Density Poly Ethylene (HDPE) or Poly propylene. Hollow plastic balls of 6 mm dia is used in this experiment.

3.4 Fine Aggregate

Fine aggregates are materials less than 4.75mm. M sand confirming to IS 383 - 1970 collected from local sources was used as fine aggregate.

Table -2: Physical properties of Fine aggregate

Tests	Results
Specific gravity	2.6
Fineness modulus	3.04

3.5 Coarse Aggregate

According to IS 383-1970 coarse aggregate of maximum 20mm size is suitable for concrete work. Aggregate of size of 20 mm confirming to IS 383 – 1970 and collected from local sources was used.

Table -3: Physical properties of Coarse aggregate

Tests	Results
Specific gravity	2.63
Fineness modulus	3.24

3.6 Water

Water is an important ingredient of concrete, because hydration takes place only in the presence of water. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali, acid etc. In general the potable water is considered satisfactory.

4.0 METHODOLOGY

The various works done are given below:

1. M20 grade concrete is selected
2. Carryout mix design of M20 concrete
3. Conventional slab and slabs with varying numbers of hollow balls are casted.
4. Using Universal testing machine (UTM) single point load test is conducted.
5. Result analysis of conventional slab and bubble deck slabs.

5.0 TEST RESULTS AND DISCUSSIONS

5.1 Discussion on Load Carrying Capacity

The load carrying capacity of the conventional slab and bubble deck slabs with varying number of HDPE balls is found out by conducting flexural strength test using Universal testing machine (UTM) apparatus. It is found that the load carrying capacity of the bubble deck slabs are in same range that of conventional slab.

Table -4: Load carrying capacity value

Specimen	Number of Balls	load in KN
Normal Slab(NS)	-	81
Bubble Deck slab (B)	9	80
Bubble Deck slab (B+)	12 24	78
Bubble Deck slab(B++)	24	78.2

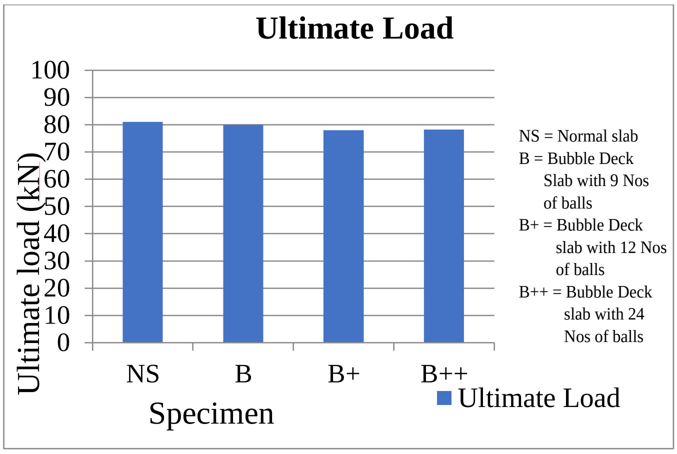

Fig.2: Ultimate Load Variation Graph

5.2 Discussion on Load vs. Deflection

Table -5: Load deflection test results

Load kN	Deflection (mm)			
	Normal slab	Bubble deck slab with 9 no's of balls	Bubble deck slab with 12 no's of balls	Bubble deck slab with 24 no's of balls
5	0.205	0.485	0.26	0.37
10	0.20	0.58	0.45	0.735
15	0.19	0.805	0.60	1.007
20	0.16	1.01	0.785	1.305
25	0.88	1.275	1.06	1.3025
30	1.10	1.50	1.285	1.81
35	1.345	1.68	1.53	2.0325
40	1.685	1.87	1.72	2.265
45	1.82	2.075	1.95	2.475
50	2.05	2.305	2.145	2.695
55	2.50	2.53	2.385	2.95
60	3.09	2.74	4.23	3.375

The Load deflection analysis helps to analyse the behavious of slabs subjecting to 3 point loading. The load values and corresponding deflection values of conventional slab and bubble deck slabs are shown in table 5.

The variation of load and deflection is shown in the fig 2.

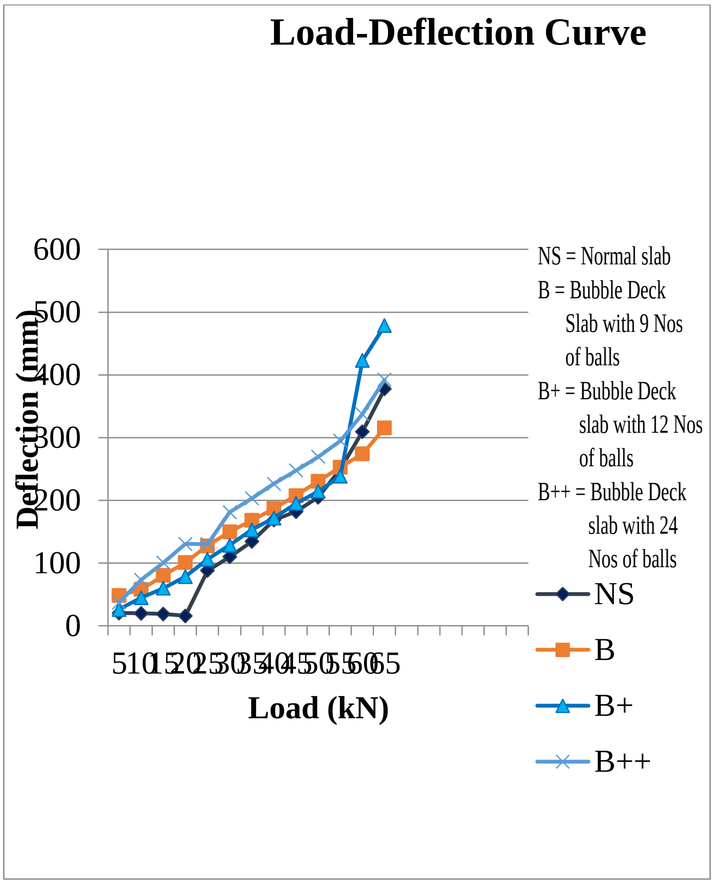

Fig.3: Load deflection curve

5.3 Discussion on flexural strength results

Table -6: Flexural strength test result

Specimen	Ultimate load in KN	Flexural Strength in N/mm²
Normal Slab(NS)	81	14.06
Bubble deck slab with 9 nos of balls	80	13.88
Bubble deck slab with 12 nos of balls	78	13.54
Bubble deck slab with 24 nos of balls	78.2	13.57

Flexural strength is measure of the tensile strength of concrete. It is the ability of structural member to resist against bending. The flexural strength of conventional and bubble deck slabs calculated are given in table 6. Results shows that flexural strength of normal slabs and bubble deck slabs with varying number of balls are in same range.

5.4 Discussion on Crack Pattern

Loading of slabs are carried by univeral testing machine. As the loading progress cracks are developed on the slabs when the loading reaches the rupture strength of the concrete. As the loading increases intensity of cracking also increases. The crack patterns developed on all slabs are identified. Crack patterns of conventional slab and that of bubble deck slabs are shown in fig 3.

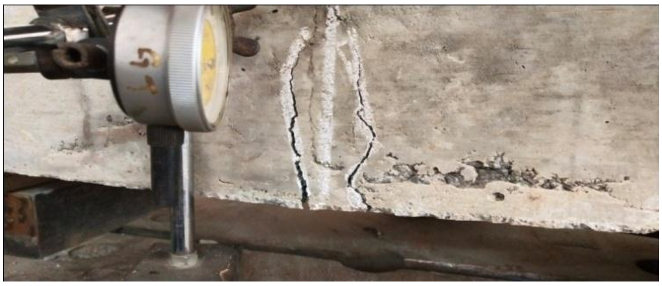

Fig.4: Cracks developed in conventional slab

Fig.5: Cracks developed in bubble deck slab with 9 Nos balls

Fig.6: Cracks developed in bubble deck slab with 12 numbers of balls

Fig.7: Cracks developed in bubble deck slab with 24 numbers of balls

5.5 Concrete saving and self weight reduction

If we consider the slab in this study, the dimensions are of length = 60cm, breadth = 30cm and depth = 12cm with balls having 3 cm radius. By calculating the volume, we can know the percentage reduction in concrete volume.

Volume of slab,

V_1= l x b x h= 0.60x0.30x0.12= 0.0216 m^3

Volume of the ball,

$V_2 = \frac{4\,\pi\, r^3}{3} = \frac{4 \times \pi \times 0.03^3}{3} = 0.0001131\ m^3$

% reduction in concrete for bubble deck slab with 9 numbers of balls = [(V_2)/ (V_1)] x 100

= [(0.000113x 9)/0.0216] x 100 =4.712 %

% reduction in concrete for bubble deck slab with 12 numbers of balls = [(V_2)/ (V_1)] x 100

= [(0.00013x 12)/0.0216] x 100 =7.22 %

% reduction in concrete for bubble deck slab with 24 numbers of balls= [(V_2)/ (V_1)] x 100

= [(0.00013x 24)/0.0216] x 100= 14.44%

Since we have assumed a small slab, the percentage reduction is also small. When we assume this for a larger section, the percentage reduction will be larger.

Dead load shall include weight of all structural and architectural components which are permanent in nature. It includes self-weight of the structure. The unit weight of concrete is 25kN/m^3. If we can reduce the volume of concrete then the self-weight of the slab also get reduced.

Weight of 1m^3 concrete = 2400kg

Considering slab of dimensions: length= 0.60 m;

Breadth = 0.30m; depth= 0.12m

Volume of slab, V_1 = l × b × h= 0.60x0.30x0.12= 0.0216m3

Weight of slab, W_1 = 2500x0.0216= 54kg

Considering HDPE hollow ball of radius 3 cm.

Volume of 9 balls,

$V_2 = 9 \times \frac{4\,\pi\, r^3}{3} = 9 \times \frac{4 \times \pi \times 0.03^3}{3} = 0.001017 m^3$.

Weight of concrete saved, W_2 = 0.001017x 2500 = 2.54 kg

Weight of hollow slabs $=W_1-W_2 = 54-2.54= 51.46$ kg

Volume of 12 balls,

$V_2= 12x\frac{4\,\pi\, r^3}{3}= 12 \times \frac{4 \text{ x } \pi \text{ x } 0.03^3}{3} = 0.00135$m3.

Weight of concrete saved, $W_2 = 0.00135x\ 2500 = 3.3925$ kg

Weight of hollow slabs$=W_1-W_2 = 54- 3.392= 50.61$ kg

Volume of 24 balls,

$V_2= 24x\frac{4\,\pi\, r^3}{3}= 24 \times \frac{4 \text{ x } \pi \text{ x } 0.03^3}{3} = 0.00271\ m^3$.

Weight of concrete saved, $W_2 = 0.00271x\ 2500 = 6.78$kg

Weight of hollow slab$=W_1-W_2 = 54-6.78= 47.22$kg

Since we have assumed a small slab, the self-weight reduction is also small. When we assume this for a larger section, the weight reduction will be larger.

6.0 CONCLUSIONS

From this study it was evident that though the bubble deck slabs were efficient as the conventional slab, (having similar load bearing capacity), they are very much satisfactory in slab construction considering the negligible difference in load bearing capacity between them and the conventional. It is however interesting to note a weight reduction in the bubble deck slabs compared to the conventional slab which is an added advantage for the bubble deck slabs especially in structures where load is an issue.

1. The Bubble Deck configuration gives comparatively similar flexural capacity comparing to that of conventional slab.

2. The Bubble Deck slab reduces amount of concrete with the same reinforcement as used in the solid slab, realizing an average reduction of 4.712 % concrete mass in bubble deck slab with 9 numbers of balls, an average reduction of 7.22 % concrete mass in bubble deck slab with 12 numbers of balls, an average reduction of 14.44 % concrete mass in bubble deck slab with 24 numbers of balls on comparing with conventional slab.

3. Advantage of Bubble Deck system is the significant selfweight reduction. The weight of concrete saved for Bubble Deck slabs with 9 number of balls, 12 numbers of balls and 24 numbers of balls are 2.54 kg, 3.3925 kg and 6.78 kg respectively, which intern leads to less foundation costs and which allow to creating foundation sizes smaller.

4. Concrete usage is reduced as 1 kg of recycled plastic replaces 100 kg of concrete. This avoids the cement production and allows reduction in global CO_2 emissions. Hence this technology is environmentally green and sustainable.

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