Study on Voided Slab with High Volume Fly Ash Concrete

Saranya P, Sankaranarayanan KM

Abstract- A traditional method of building a structure is through concreting. It is not considered as environmental friendly due to the consumption of large amount of cement. The complex design of structures can be made simpler by reducing the dead weight of structural elements. This also reduces the overall cost of construction as well as reduces the use of cement. Such an approach is done through HVFA concrete bubble deck slab. This thesis presents the ultimate load carrying capacity of slabs with high volume fly ash replacement and also incorporation of plastic balls in it. The load at which first crack in the slab appeared is included. The high volume fly ash concrete has a reduced weight compared to normal concrete and again in the slab plastic balls are used as spacers which in turn reduces the dead weight of the slab. The replacement of cement by fly ash is by 50% and curing is done for 56 days. Four different slab samples are tested with different arrangement of the balls and one without balls after curing for 56 days. The ultimate load capacities and load at first crack is compared with each other.

Key words- Bubble deck slab, plastic balls, ultimate load, HVFA concrete

1. INTRODUCTION

Most commonly used building material for bridges, buildings, dams etc is concrete. Due to increasing environmental issues Engineers are focusing on green concreting which is a way to reduce emission of carbon dioxide. Utilization of industrial waste products in concrete has attracted attention all over the world. The slabs being important component of a structure that contributes a large amount of dead load to the structure is a point of attraction. Ways have been invented in the past to reduce the dead weight of slabs like U boot beton, waffle slab technique, cobiax slabs, bubble deck slab etc. In a bubble deck slab high density polyethylene balls are used to create the void.

The voids are provided between meshes of reinforcement bars at top and bottom of slab. The concrete between upper and lower mesh acts as spacers who do not have a specific role in the strength or durability aspects of the slab. When this concrete is replaced by balls the dead load of the slab is reduced to a great extend. This in turn reduces the requirement of heavy beams and columns. Thus reducing overall weight of structure which requires only a smaller foundation and a much lower construction cost.

High volume fly ash concrete is a substitute for ordinary concrete which uses much lesser cement without much compromise in strength. When the amount of fly ash is more than 35% as said in Indian Standard code, it can be considered as high volume fly ash concrete. The fly ash concrete is a waste product of coal industry which is toxic in nature. Its safe disposal is a challenge to the government. When such a material is used in construction it becomes eco friendly and economical. It also has a reduced dead weight in comparison with conventional. But HVFA concrete requires a longer period of curing to attain its potential strength.

Author 1 is a PG Scholar from Sreepathy institute of management and technology, saranyaperikamana@gmail.com
Author 2 is Assistant Professor of Sreepathy institute of management and technology, Civil department, Sankaranarayanankm@simat.ac.in

2. LITERATURE REVIEW

David A. Fanella, Mustafa Mahamid and Michael Mota (2017) presented the design, serviceability, fire resistance and construction sequence of flat plate voided concrete slab system. The flexural strength requirements as well as the method to determine the flexural strength by considering the spacing between voids is explained. The shear design both for one way shear and punching shear is explained which include the cost effective headed shear stud reinforcement. Fire resistance for the slab at least for two hours is obtained by provided with 20 mm cover. Typical site installation of cast in place voided concrete slab is explained. It serves minimum conditions for vibration control. The benefits of voided slab that is reduction in 35% of dead load, reduced seismic forces on structure, easier design avoiding congestions of reinforcements especially in joint regions, supporting large superimposed loads in a given span, mitigation of floor vibration, accelerated construction schedules make them advantageous over conventional slabs.

K.R.Dheepan, S.Saranya, S.Aswini (2017) presented experimental study on bubble deck slab using polypropylene balls. In this work polypropylene balls of 60mm and 75mm diameters are used. The balls are arranged at 20mm and 30 mm spacing which are continuously arranged. The lateral support is provided by fabricating steel in meshes at top and bottom and vertical support provided by diagonal girders. As the spacing between ball increases, diameter decreases and flexural strength of slabs increases. Optimum diameter obtained is 60mm and optimum spacing is 30 mm. The maximum flexural strength obtained for the slab with 100mm depth 60 mm diameter and 30 mm spacing.

Mr. Muhammad Shafiq Mushfiq, Shikha Saini and Nishant Rajoria(2017) did experimental study on bubble deck slab. The load carrying capacity of bubble deck slabs with two different B/H ratio and the conventional slab is compared. 70mm x 70mm x 150mm was the specimen size used. Bubble diameter B of two different sizes that is 90mm and 120 mm with a fixed slab depth of 150 mm was used. The load carrying capacity of conventional slab is greater than bubble deck slab. As the B/H value increases the load carrying capacity increases. Deformation obtained is almost similar for both bubble deck slabs. It is slightly greater for conventional slab. The weight reduction of 10.55% & 17% in the bubble deck slabs was found compared to the conventional slab which is an added advantage for the bubble deck slabs especially in tall and large structures.

Jasna Jamal, Jiji Jolly conducted study on bubble deck slab with two different mixes such as M30 and M25, also in elliptical and spherical balls. The finite element analysis of the above structures was done with software Ansys workbench. The slab was of size 1.25 x 1.25 x 0.23 m for 150mm diameter spherical slab, whereas the slab with elliptical ball of 180 x 240 mm dimensions had a size of 1.730 x 1.350 x 0.23 m. The balls were high density polyethylene balls with Poisson's ratio 0.4 and modulus of elasticity 1030MPa. The loading provided was uniformly distributed load with simply support on both ends. It was found that the load carrying capacity was greater for slab with elliptical balls than spherical. The weight reduction was also better for elliptical than spherical that is 35% and 33% respectively. M30 grade showed better performance than M25 grade for both type of slabs.

3. MATERIALS USED

The materials used for the present work are as follows;

Steel: Fe 500 steel reinforcement bars of 8mm diameter are used for creating mesh in the slab. The reinforcement bars are placed at a spacing of 150mm. the meshes are provided at top and bottom of the slab after a cover of 20mm.

Plastic balls: The balls used for creating void space in the slabs are recycled plastic balls. Each ball is of 65 mm in diameter. They are high density hollow spheres each of which weighs about 18g.

Fig 1: Plastic balls

Concrete: High volume fly ash concrete is used in this work. HVFA concrete with 53 grade OPC and class C category fly ash is used.

Table 1

Properties Of Concrete

Physical properties	Results
Compressive strength for 56days	56.3 MPa
Slump value	82mm
Water binder ratio	0.275

4. METHODOLOGY

I. Materials are tested and confirmed ready to use.
II. Mix design for HVFA concrete for 40 Mpa is done.
III. Compressive strengths for 28 days and 56 days are found out.

IV. Four slab samples are constructed and cured for 56 days.
V. Ultimate load carrying capacity is found for each slab using loading frame.
VI. The flexural strength of the slab is found out.

5. MIX DESIGN

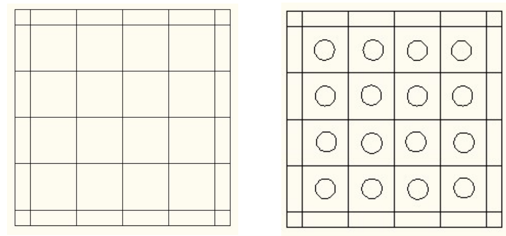
Mix design is done according to IS 10262; 2009. M40 mix is designed with high volume fly ash replacement. In this mix 45% excess cementitious material is added in which 50% is cement and rest 50% is fly ash.

Table 2
Mix design

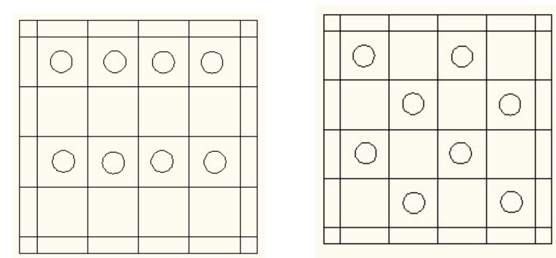
Mix	Cement kg/ m^3	Fly ash kg/ m^3	Fine aggregate kg/ m^3	Coarse aggregate liters/ m^3	Water	Admixture liters/ m^3
M	290	290	605	1091	160	5.6
Ratio	1	1	2.08	3.76	0.275	

6. EXPERIMENTAL INVESTIGATION

The compressive strength of the mix is found out for 28 days and 56 days using standard cubes in compression testing machine. Four slabs are constructed with different arrangements of the balls. S1 represents the slab with no plastic balls in it. S2 represents the slab with 16 balls in it placed in between the reinforcement bars. S3 slab represents the slab with balls arranged in horizontal pattern alternatively. S4 is the slab sample with balls placed alternative diagonal rows. Two meshes of 8mm reinforcement bar at 150mm spacing are provided at top and bottom of the slab after providing a cover of 20 mm. The balls are placed in between the meshes as shown in the figures. In order to construct the slab wooden frames are used with polythene sheets at the bottom. The balls are placed in position using thin strings. Cover blocks are used below the reinforcement bars in order to provide the cover to the slab.



(a) (b)



(c) (d)

Fig 2: a) S1 b) S2 c) S3 d) S4

The slabs are constructed according to the figure 1. Since the concrete used in the four slabs are HVFA concrete the setting time is more than that of conventional mix. The conventional method of ponding is used for curing the slabs for 56 days. Greater period of curing is done because the HVFA concrete gets more strength as the days of curing increases.

Fig 3: S3 construction

Fig 4: Curing of slabs

Fig 5: Testing with reaction frame

The slabs are tested in reaction frame. It has a capacity of 100 T. The slabs are two way slabs with l/b ratio equal to one. The support condition provided are simply support in four sides. The loading provided is uniformly distributed load in an area of 400 x 400 mm using thick plates. Hydraulic jacking is used for providing load in the samples. The load is given till the sample stops taking load. Cracks starts appearing before the slab reaches ultimate load. The load at first crack is observed. The ultimate load of sample is noted from the digital output in tonnes.

7. RESULTS AND DISCUSSIONS

The compressive strength of the mix is given in the table 3. It was seen that the strength of HVFA concrete increases with curing. The strength seemed to be almost proportional to curing period. For conventional concrete the strength gain does not happen much after 28 days curing since it achieves 95% strength in 28 days curing.

Table 3

Compressive strength

Sample	Average stress for 28 days (MPa)	Average stress for 56 days (MPa)
M2	40	56.29

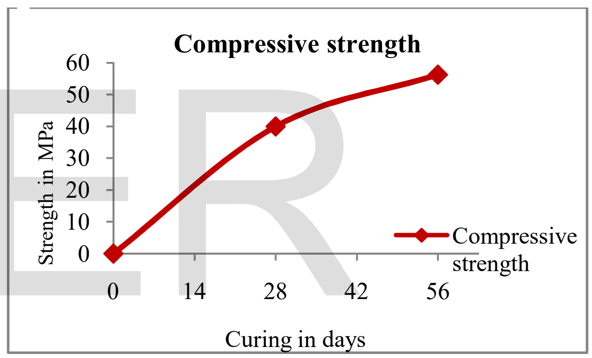


Fig 6: Graph showing compressive strength with time

The ultimate load carrying capacity of the slab samples are given in the table 4.

Table 4

Ultimate load carrying capacity

Sample	Load (T)
S1	37.1
S2	36.5
S3	32.5
S4	33.55

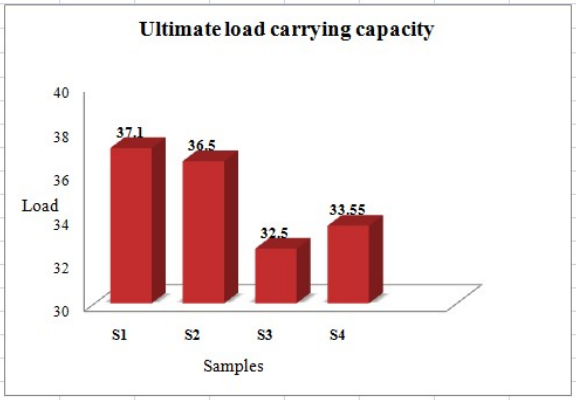


Fig 7: Graph showing variations in ultimate load carrying capacity in ton

The ultimate load of S1 is observed to be highest but S2 has almost the same ultimate load carrying capacity. S3 and S4 have almost same amount of loads. The appearance of first crack for different slab samples is observed to be different. The values are provided in table 5.

Table 5
Load at first crack

Sample	Load
S1	162
S2	156
S3	136.5
S4	145.5

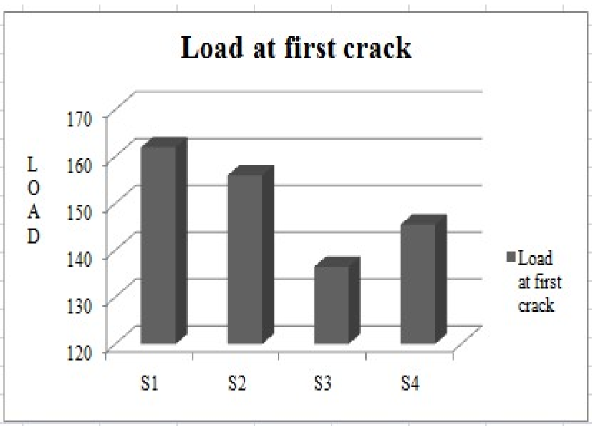


Fig 8: Graph showing variations in loads showing first crack (load in KN)

Fig 9: Appearance of crack near support

CONCLUSIONS

The ultimate load carrying capacity of slab without balls S1 and slab with 16 balls S2 are seen to be almost the same. There is only 1.6% reduction in the load carrying capacity for S2 in comparison with S1. The slabs with 8 balls each seem to have almost same ultimate load capacity. S3 has a reduction of 12.3 % and S4 has a reduction of 9.5% load carrying capacity. The first crack appeared for S1 at a load of 162 KN. For S2,S3 and S4 156,136.5 and 145.5 respectively. The slabs with balls the crack appeared sooner than that of without balls. Among the four samples S2 shows a better performance when considering the weight loss due to 16 balls and the ultimate load.

REFERENCES

[1] Putte Gowda.B.S., Aswath.M.U, Muthu.K.U., “Behaviour of fly ash concrete slabs containing higher levels of fly ash” *International journal of innovative research & development*, vol 2 issue 4, April 2013

[2] Bhagyashri G. Bhade and S.M Barelikar, “An experimental study on two way bubble deck slab with spherical hollow balls,” *International Journal of Recent Scientific Research*, Vol. 7, Issue, 6, pp. 11621-11626, June, 2016.

[3] Er. Immanuel Joseph Chacko,Er.Sneha M. Varghese, “Study on structural behaviour of bubble deck slab using indian standards” , *International journal of innovative research in technology*, Volume 3, Issue 4, September 2016

[4]Mr. Muhammad Shafiq Mushfiq, PG Student, Asst. Prof .Shikha Saini and Asst. Prof. Nishant Rajoria, “Experimental study on bubble deck slab,” *International Research Journal of Engineering and Technology*, Volume: 04 Issue: 05, may 2017

[5]David A. Fanella, F.ASCE; Mustafa Mahamid, F.ASCE; and Michael Mota, F.ASCE, "Flat Plate–Voided Concrete Slab Systems: Design, Serviceability, Fire Resistance, and Construction" Practice Periodical on Structural Design and Construction, march 2017

[6] Jasna Jamal, Jiji Jolly, "A study on structural behaviour of bubble deck slab using spherical and elliptical balls", International Research Journal of Engineering and Technology (IRJET), vol.4 issue 05, may 2017

[7] K.R.Dheepan, S.Saranya, S.Aswini, asst. Professors, SA Engineering college, Ponmalle "Experimental Study on Bubble Deck Slab using Polypropylene balls", International Journal of Engineering Development and Research, vol. 5 issue 4, march 2017