AN EXPERIMENTAL STUDY ON SPHERICAL VOIDED SLAB

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ABSTRACT: In India majority Structures are built in RCC. Usage of concrete increases day by day with rapid growth of Construction industries. In building constructions, the slab is a very important structural member to make a space and also 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. So an attempt has been made to reduce the weight of slab by providing plastic spherical voids in Two way RC Slab without compromising with strength and Safety. A spherical voided slab has a two-dimensional array of voids within the slabs to reduce self weight. Plastic hollow sphere balls introduce in the center of the slab. The behavior of voided slabs is influenced by the ratio of bubble diameter to slab thickness. Two-dimensional flexural tests were tested by using special loading frame. Three test specimens are used, one was a normal solid slab and two were voided slabs having void diameter of 37mm and 45 mm. The ball diameter to slab thickness ratios of voided slab (0.47 and 0.57) and same is tested under five point loading system. To verify the flexural behavior of voided slab, comparison has been carried out in form of ultimate load capacity, deflection, concrete compressive strain and stiffness reduction factor with normal solid slab.

Key words: spherical voided slab, Normal solid slab, ultimate load capacity, plastic sphere.

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. 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 Structure consumes more materials such as concrete and steel reinforcement. The self-weight of slab can reduce by replacing the middle height of the cross section of slab with void former. By introducing void former into the slab, self-weight of the slab can be reduce and this lead to reduction in overall cost of the slab. The spherical balls, which are inserted in the middle of the slabs, are manufactured from recycled plastic, which do not react chemically with concrete or steel.

MATERIAL DESCRITION

Concrete

For the concrete mix standard Portland cement is used. Self Compacted Concrete is used for current and the concrete design done as per the EFFNARC guideline. The design compressive strength of specimen after 28 days is 25 N/mm^2 and for the identification of strength of the concrete cubes was casted and average strength of 3 cubes was used. The mix design of SCC is shown in Table-1.

Table-1 SCC mix design

MATERIAL	Kg/m^3
Cement	416
Sand	820
Aggregate	820
Fly ash	104
Water	182
Super plasticizer	2.08

Steel reinforcement

Reinforcing bars of 6mm diameter of Fe415 HYSD bars is used in the specimens. Reinforcement provided at bottom face and in both direction longitudinal as well as in transverse. The detail of reinforcement is shown in Table-2.

Recycled plastic ball

Recycled plastic ball used, to reduce wastage of plastic instead of dumping of it and also it helps in reduction of environmental pollution. The cost of plastic ball is low compare the concrete material. Plastic spheres of size 37mm and 45 mm diameter were used in this research work. The purpose of the spheres is to reduce the quantity of concrete and dead load of specimens.

PROBLEM DEFINITION

Three Test specimens are designed, one is normal solid two-way R.C slab and the others two are two-way spherical voided slabs. The test parameters included the ratio of bubble diameter (B) to slab thickness (H), (B/H). The specimen dimension detail and other parameters are shown in Table-3.

The slab was simply supported at all edges by four steel beams which had a hinge in the upper surface to minimize fixed end moment and other errors from support condition during the test. Punching effect was generated due to single point load therefore 5 point load system was established beneath the hydraulic jack on slab specimen. The arrangement of specimen in loading frame is shown in fig- 1

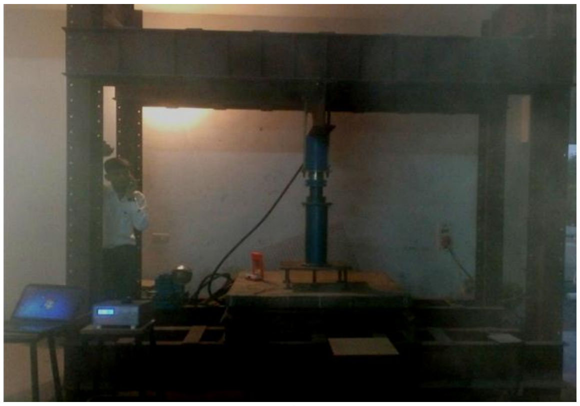


Fig-1 Specimen arrangements in loading frame

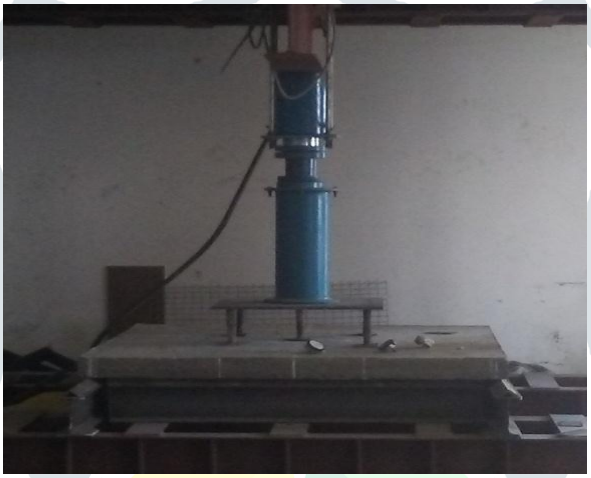


Fig.-2 Slab specimen with five point loading system

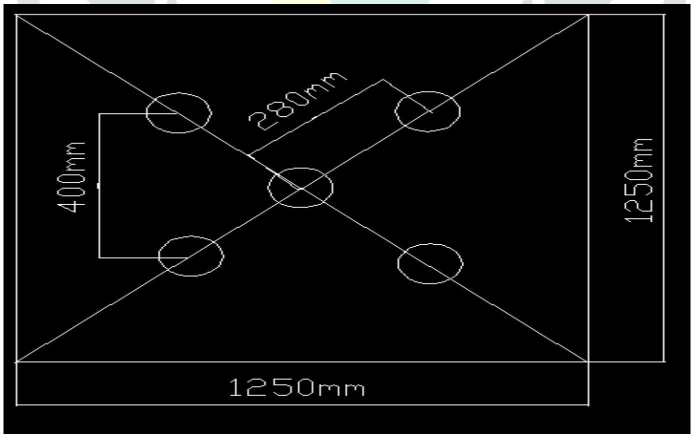


Fig.-3 Arrangement of five point loading system

The deflection of the specimens was measured at their mid-span beneath the lower face of the tested slabs with the help of dial gauge. The strain of the compressive side of the specimens was measured using strain Gages of 350 ohm of 20mm size at six points, two on horizontal axis and two on vertical axis at a distance of 150mm and 300 mm respectively and rest of two on diagonal of specimen at same distance from the center of slab. The load was increased gradually at increments of (2.5kN) to record the deflection up to failure.

EXPERIMENTAL RESULT

Ultimate load capacity

The two way spherical voided slab with the plastic sphere showed good ultimate load capacity compared with the normal solid slab. The ultimate load of normal solid slab was 51.3KN and for spherical voided slab 50kN and 41.5kN of having voids of 37mm and 45mm diameter respectively. The deflection of normal solid slab and spherical voided slab for the same ultimate load were 22.9mm, 25.3mm and 22.1mm. The result of ultimate load capacity of slab specimen shown in Table-4

Load versus Deflection Relationship

A curve showing the relationship between the load on the structure and deformation is known as load – deformation curve. It is unique for each material and is found by recording the amount of deformation at distinct intervals of tensile or compressive loading. The graph of load vs deflection for specimen shown in figure-4

Concrete Compressive Strain

The Spherical voided specimens give an increase in the concrete compressive strain over that of the reference solid specimen. This is due reduced concrete volume in the compression zone due to plastic spheres in spherical voided specimens. The graph of load vs deflection for specimen shown in figure-5

Stiffness reduction factor

The second moment of inertia is a key variable when performing structural analysis of slab. The untracked moment of inertia is dependent on the thickness and width of the slab and the contribution made by steel can be ignored since steel is not taking part prior to cracking. The stiffness reduction factor can be derived from the calculation of second moment of inertia of voided slab and solid slab. To derive the stiffness reduction factor **Iv** can be subtracted from **Is** and the answer can then be divided by **Is** (Is- moment of inertia of solid section, Iv- moment of inertia of voided section). The value of stiffness for slab specimen shown in Table-5

Crack pattern

Due to ultimate loading, cracks were developed in the specimen. Pattern of cracks of various slab specimens is shown In figure-4. During test, flexure crack were induced firstly, later on shear cracks were observed. Hence our 5 point loading system is dominant in flexure.

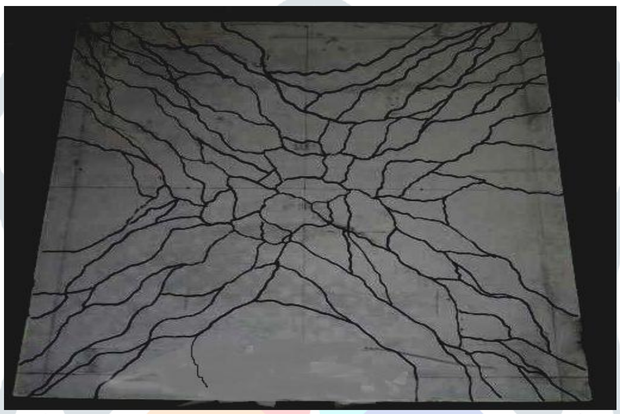


Fig.-6 Crack pattern of normal solid slab

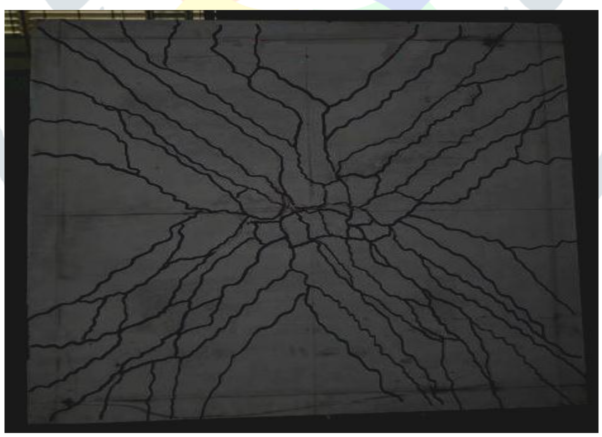
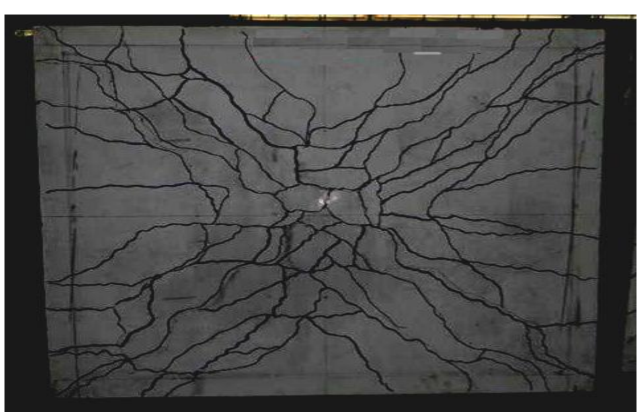


Fig.-7 Crack pattern of voided slab with 37 mm ball diameter



Fig,-8 Crack pattern of voided slab with 45 mm ball diameter

Table-2 Reinforcement detail

Slab	Thickness	Reinforcement	c/c Dis.	Clear cover
NS	` 80 mm	7-6mmφ	175mm	12 mm
VS-37		7-6mmφ	175mm	12 mm
VS-45		7-6mmφ	175mm	12 mm

Table-3 Specimen Dimension

NO	SLAB	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	BALL DIAMETER	B/H	NO. OF BALLS
1	NS				-	-	-
2	VS-37	1250	1250	80	37mm	0.47	196
3	VS-45				45mm	0.57	196

Table-4 Ultimate load capacity of specimen

SLAB	THICKNESS (mm)	LOAD AT FIRST CRACK	ULTIMATE LOAD	CAPACITY	WEIGHT (Kg)	% OF WEIGHT
NS		40.9 KN	51.3 KN	100%	319.5	100%
VS-37	80	32.5 KN	50 KN	84%	286.5	89%
VS-45		27.3 KN	41.5 KN	69%	277.5	86%

Table -5 Stiffness reduction factor

Ball diameter (mm)	Thickness (mm)	Width (mm)	Is (mm^4)	Iv (mm^4)	Stiffness reduction factor
37	80	70	$2.986*10^6$	$6.88*10^4$	0.97
45	80	70	$2.986*10^6$	$15.4*10^4$	0.94

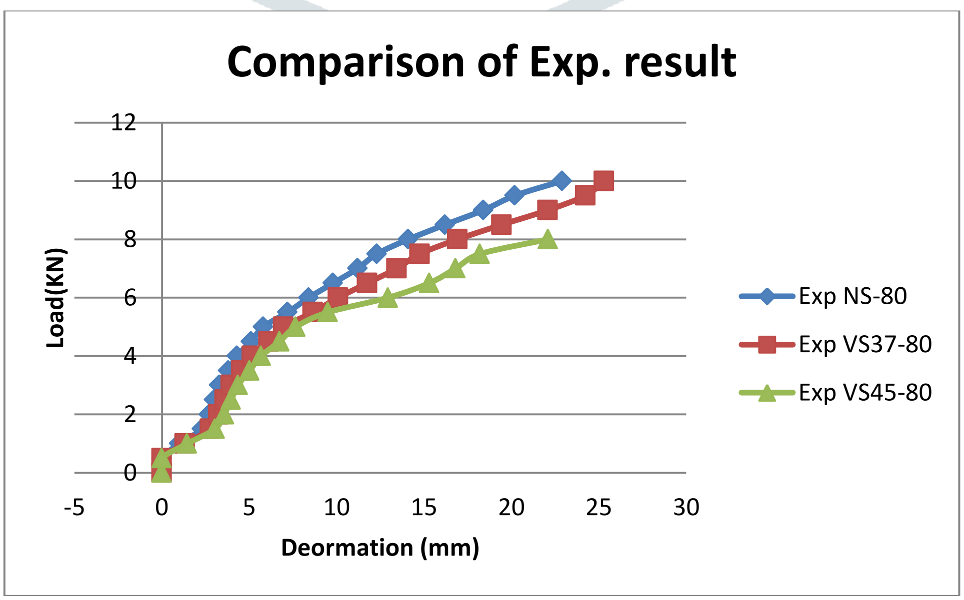


Fig.-4 Comparison of load vs deformation curve of normal slab and voided slab

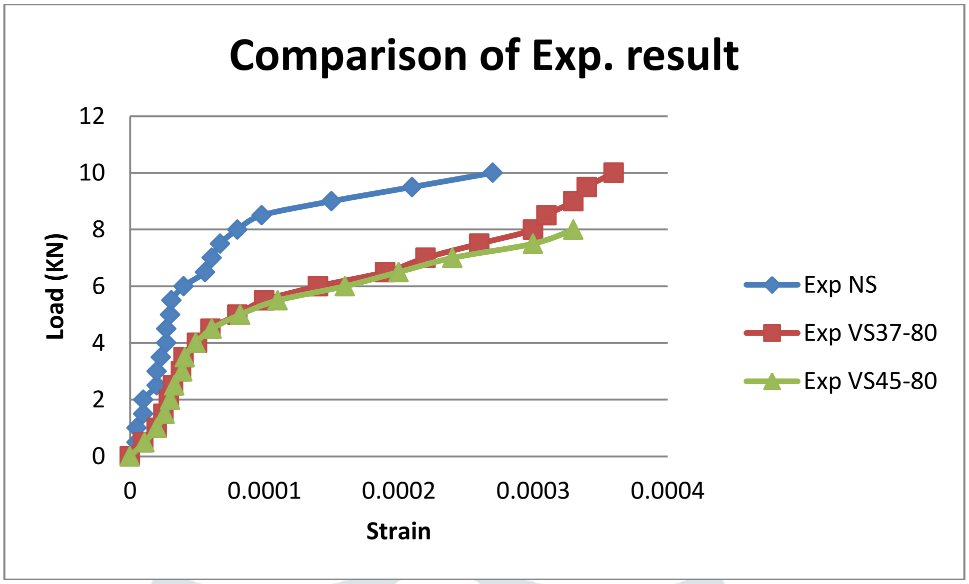


Fig.- 5 Comparison of load vs strain curve of normal slab and voided slab

CONCLUSION

The stiffness values of spherical voided slab were little different from solid slab. In view of the results so far achieved, two-way spherical voided slab act like general solid R.C slabs basically

The use of plastic spheres in reinforced concrete slabs (B/H=0.47, 0.57), had a result in comparison with reference solid slabs (without plastic spheres), voided slab has (100%) of the ultimate load of a similar reference solid slab but only (84%, 69%) of the concrete volume due to plastic spheres, respectively.

The deflections under service load of voided specimens were a little higher than those of an equivalent solid slab.

The concrete compressive strain of voided specimens is greater than that of an equivalent solid specimen

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