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Research Paper

Study on Behaviour of Cellular Concrete Slab

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Abstract

Generally for any construction, normal conventional concrete is used to obtain required strength as per design. In the construction industry, now a day's many construction techniques are in practice to minimise the self weight of concrete, thereby reducing the size of structural elements. One of the most widely adopting techniques is use of light weight concrete. But use of these light weight concrete do not fulfil the strength requirement as per the design of the structure. Hence it is used only as non-load bearing structural elements in the field. In view of this, in this study the attempt has been made to introduce the air voids in conventional concrete without compromising the strength. In this work the air voids are introduced in the concrete slabs and it is tested in the laboratory to know the performance. For this purpose, the slab of the size of 600mm x 600mm x 100mm is prepared with the voids of diameters 30mm, 35mm and 40mm. The voids are introduced in the concrete slab in four different configurations (line, X, I and matrix) to prepare the cellular elements. The normal and cellular slabs are tested under single point loading and the effect of various configurations is studied at the age of 28 days. From the test results, it was found that the slab with void volume of 1.59% shows the lowest stiffness and the slab with void volume of 2.28% shows the highest stiffness.

Keywords: *Conventional concrete, Cellular concrete, Stiffness and Air voids;*

1. Introduction

The world is being filled with fast growing sky scrapers. The height of these building increase, one of the major problems faced by them is the increasing dead weight primarily due to concrete. Studies have been done and this led to the development of light weight concrete. concrete of substantially lower density then that made from gravel or crushed stones usually made with light weight aggregate or by injecting air or gas into the mortar is termed as light weight concrete. Such concretes include aerated and cellular concrete. In modern construction, cellular concrete is widely used for modular and reinforced concrete structural member to lessen the weight of construction elements. cellular concrete is the light weight product consisting of Portland cement, cement silica, cement pozzalona, lime pozzalona or lime-silica paste or paste containing blends of these ingredients and having a homogeneous structure produced by gas forming chemicals or foaming agents. In this study the voids are created by introducing plastic balls into the conventional concrete and thereby reducing self weight of the structural element. The plastic balls used in the concrete are table tennis balls having specific diameters and a hollow thin wall structure. The air cavity inside these balls can reduce the weight of concrete, least affecting the strength and stiffness criteria of the concrete. The influence of ball diameter, spacing and volume of voids on the slab is studied and compared with normal concrete slab.

2. Experimental Program

2.1 Material specification

The concrete specimens are prepared using a mix proportion of 1:1.56:2.52 in Ordinary Portland Cement of Grade 53, locally available river sand as fine aggregate and well graded crushed coarse aggregate.

2.2 Specimen Details

The details of the specimen are given in the Table 1

Table 1 Specimen Details

Specimen	Slab
Dimension	600mmx600mmx100mm
Number of specimen	13
Type of ball	Table tennis ball
Diameters used	30, 35 and 40mm
Number of balls used	3, 5, 7 and 9
Diameters of steel road	6mm
Number of rods	14(8 along longer span and 6 along shorter span)
Cover of slab	20mm
Effective depth	60mm
Spacing of rods along longer span	75mm
Spacing of rods along shorter span	110mm

The plan of the slab and reinforcement details are shown in the Fig 1(a) and (b)

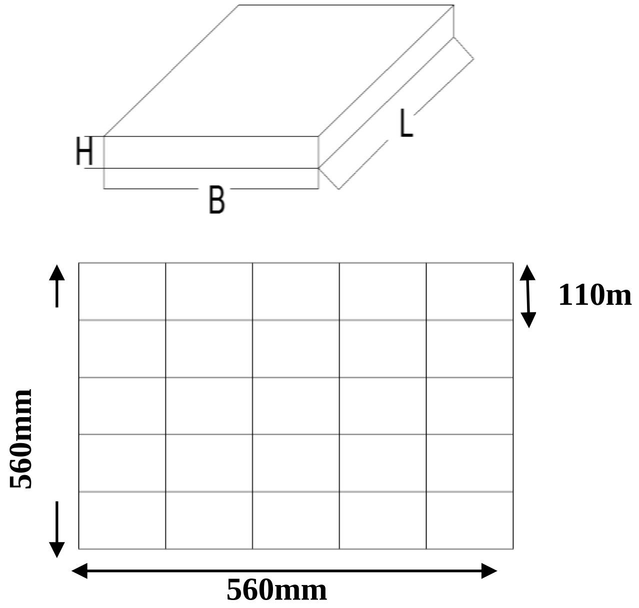


Fig 1(a) Plan of the slab and (b) Reinforcement Details

The balls with different diameters are laid in varying configurations such as line, X, I and matrix. The laying of balls slabs is shown in Fig 2. The slabs are casted with the above mentioned reinforcement detailing and is allowed to cure for 28 days. The slabs are tested under concentrated central loading. The casting and loading of the slab is shown in Fig 3(a) and 3(b) respectively. A load quantity of 250kg is provided each time until it reached its ultimate load capacity.

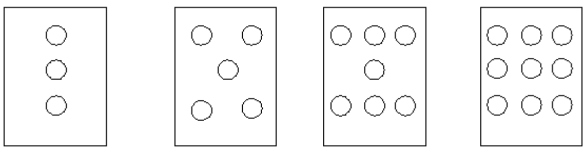


Fig 2 Laying of balls in Line, X, I and Matrix configuration

Fig 3 (a) Casting of slab and (b) Loading of slab

3. Results

3.1 Ultimate load

The ultimate load carrying capacity different void ratios is shown in the Table 2 and the variation of ultimate load for different void ratio is shown in Fig 4.

Table 2 Ultimate load for the voided slabs

Specimen Detail	% of voids	Ultimate load (ton)	Ultimate load (kN)
Conventional Slab	0	8.25	82.5
3nos 0f 30mm Φ balls	0.95	7.5	75
5nos 0f 30mm Φ balls	1.59	7	70
7nos 0f 30mm Φ balls	2.24	8	80
9nos 0f 30mm Φ balls	2.91	7.5	75
3nos 0f 35mm Φ balls	1.52	7.25	72.5
5nos 0f 35mm Φ balls	2.55	7.5	75
7nos 0f 35mm Φ balls	3.61	7.25	72.5
9nos 0f 35mm Φ balls	4.70	7.75	77.5
3nos 0f 40mm Φ balls	2.28	7	70
5nos 0f 40mm Φ balls	3.86	7.5	75
7nos 0f 40mm Φ balls	5.49	7.25	72.5
9nos 0f 40mm Φ balls	7.18	7.25	72.5

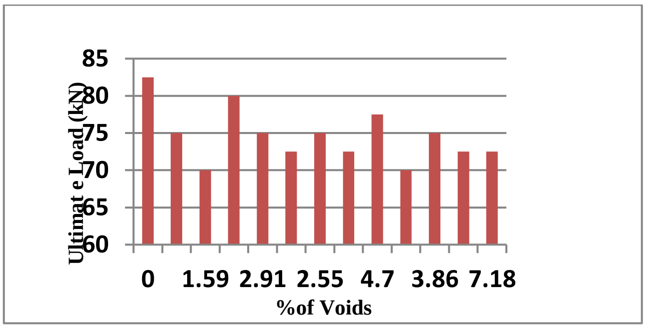


Fig 4 Variation of Ultimate load to % of voids

3.2 Load deflection characteristics of solid slab

The load is applied to each slab with varying void ratio and the deflection is found at each point of time until each reaches the ultimate load. The load deflection curve for each slab is plotted and is divided into three phases namely Phase 1, Phase 2 and Phase 3. The load deflection curve for solid slab is shown in Fig 5.

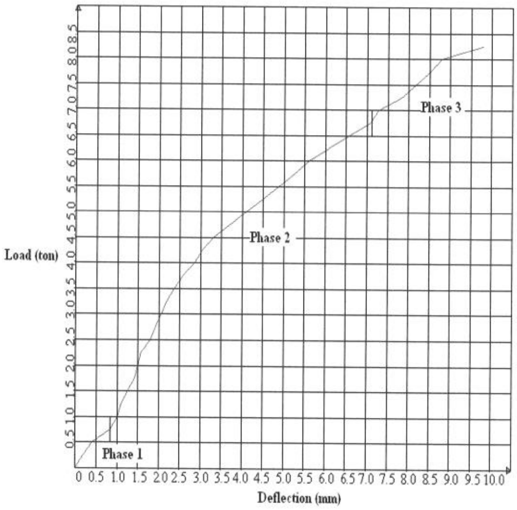


Fig 5 Load deflection curve for solid slab

From the above graph the stiffness at three phases are calculated and is given in the Table 3.

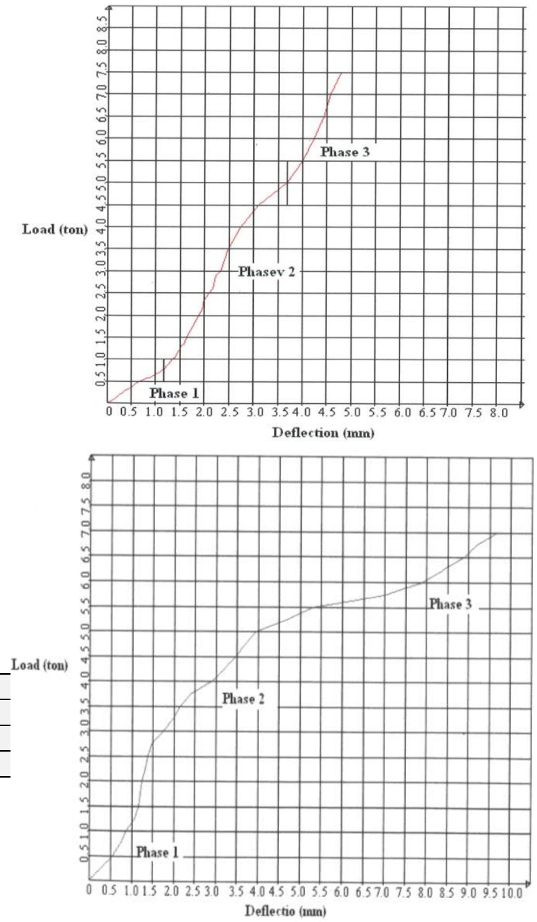
Table 3 Ultimate load for the solid slabs

% of voids	Description	Phase 1	Phase 2	Phase 3
0	Load (kN)	7.5	67.5	82.5
	Deflection(mm)	0.83	7.08	9.79
	Stiffness(kN/mm)	9.036	9.533	8.426

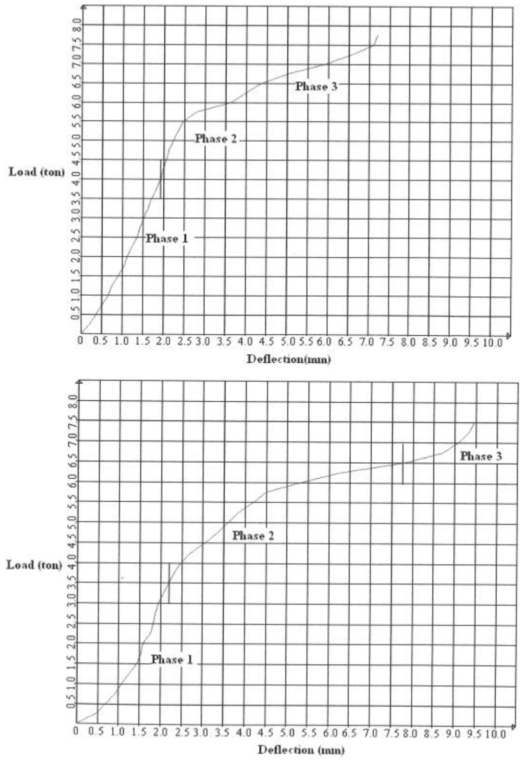
3.3 Load deflection characteristics of cellular concrete slab

The load is applied to the slabs with varying void ratio and the deflection is plotted until the slab reaches the ultimate load.

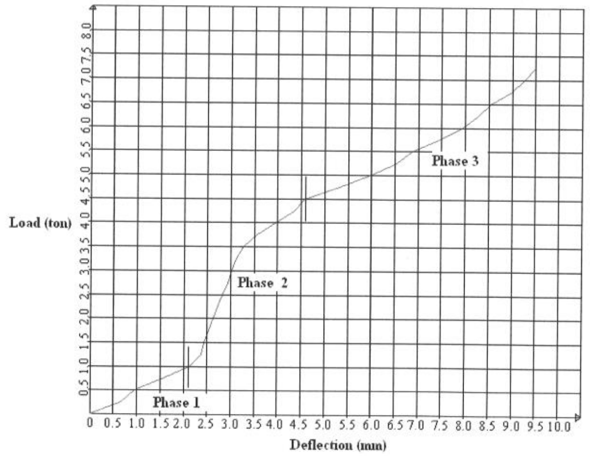
The load deflection curves of the slabs with varying void ratio are shown in Fig 6(a) to 6(l).

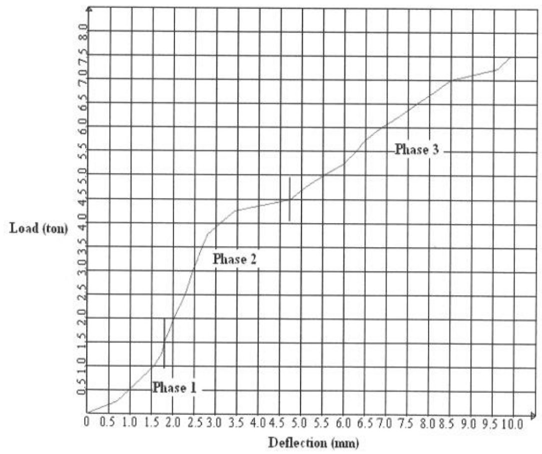


a) Load deflection curve for slab with 0.95% voids
b) Load deflection curve for slab with 1.59% voids

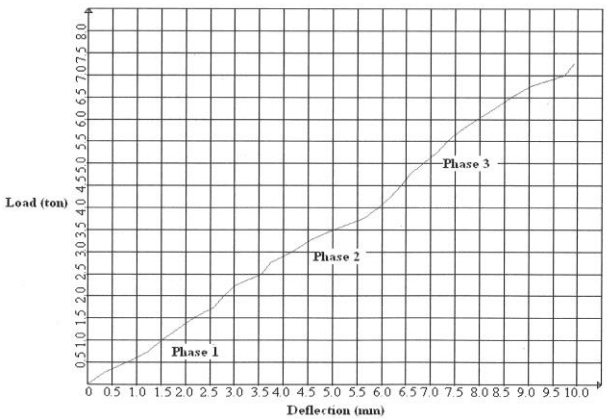


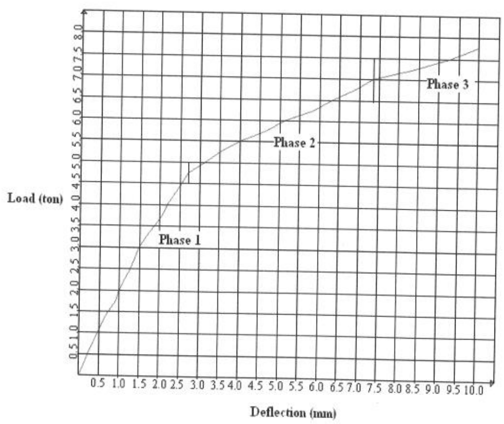
c) Load deflection curve for slab with 2.24% voids
d) Load deflection curve for slab with 2.91% voids



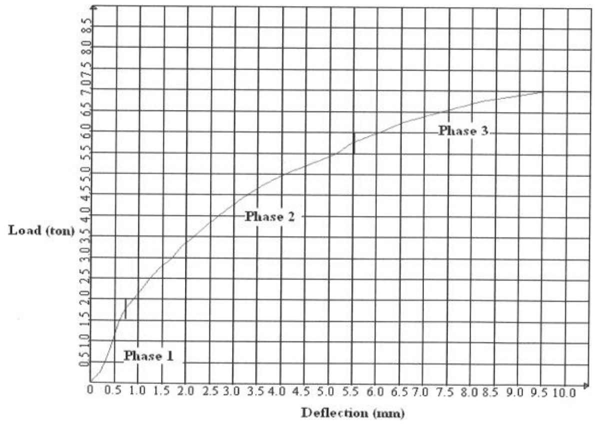


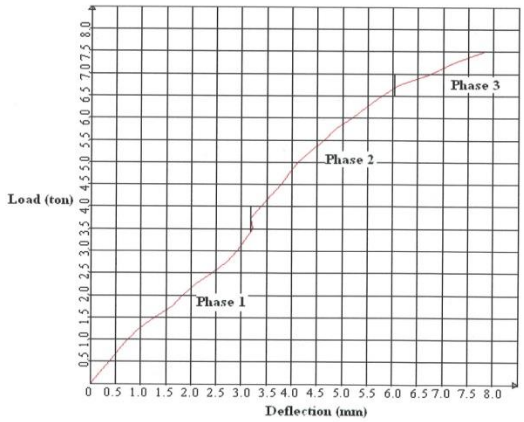
e) Load deflection curve for slab with 1.52% voids
f) Load deflection curve for slab with 2.55% voids



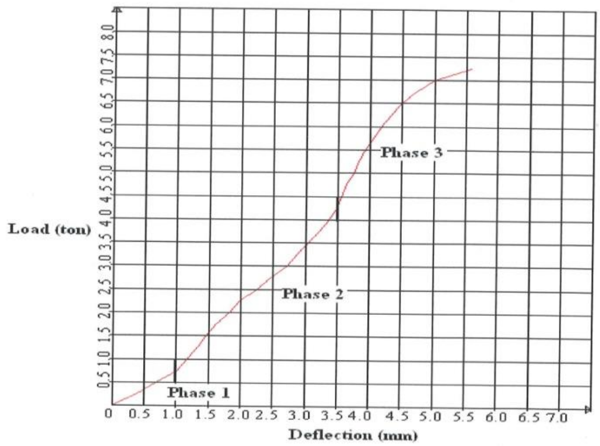


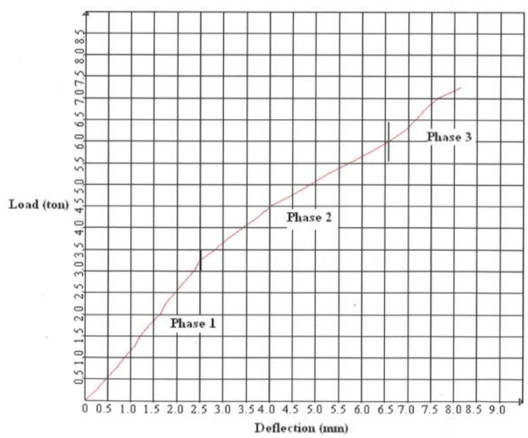
g)Load deflection curve for slab with 3.61% voids
h) Load deflection curve for slab with 4.7% voids





i)Load deflection curve for slab with 2.28% voids
j) Load deflection curve for slab with 3.86% voids





k)Load deflection curve for slab with 5.49% voids
l) Load deflection curve for slab with 7.18% voids

Fig 6 Load deflection curve of slabs with varying void ratio

The stiffness of the cellular concrete with varying void ratios at different phases of the curve are shown in the Table 4.

Table 4: Stiffness of slabs at different phases of the curve

% of voids	Description	Phase 1	Phase 2	Phase 3
0	Load (kN)	7.5	67.5	82.5
	Deflection(mm)	0.83	7.08	9.79
	Stiffness(kN/mm)	9.036	9.533	8.426
0.95	Load (kN)	7.5	50	75
	Deflection(mm)	1.12	3.68	4.79
	Stiffness(kN/mm)	6.696	13.586	15.657
1.59	Load (kN)	27.5	57.5	70
	Deflection(mm)	1.48	7	9.68
	Stiffness(kN/mm)	18.581	8.214	1.033
2.24	Load (kN)	40	60	77.5
	Deflection(mm)	1.93	3.62	7.2
	Stiffness(kN/mm)	20.725	16.574	10.763
2.91	Load (kN)	35	65	75
	Deflection(mm)	2.2	7.8	9.47
	Stiffness(kN/mm)	15.909	8.333	7.919
1.52	Load (kN)	10	45	72.5
	Deflection(mm)	2.12	4.57	9.48
	Stiffness(kN/mm)	4.716	9.846	7.647
2.55	Load (kN)	15	45	75
	Deflection(mm)	1.81	4.75	9.87
	Stiffness(kN/mm)	8.287	9.473	7.598
3.61	Load (kN)	17.5	37.5	72.5
	Deflection(mm)	2.58	5.63	9.92
	Stiffness(kN/mm)	6.782	6.660	7.308
4.7	Load (kN)	47.5	70	77.5
	Deflection(mm)	2.72	7.33	9.98
	Stiffness(kN/mm)	17.463	9.549	7.765
2.28	Load (kN)	17.5	57.5	70
	Deflection(mm)	0.71	5.48	9.55
	Stiffness(kN/mm)	24.647	10.492	7.329
3.86	Load (kN)	37.5	67.5	75
	Deflection(mm)	3.18	6.13	7.84
	Stiffness(kN/mm)	11.792	11.011	9.566
5.49	Load (kN)	7.5	42.5	72.5
	Deflection(mm)	1.01	3.64	5.58
	Stiffness(kN/mm)	7.425	11.675	12.992
7.18	Load (kN)	32.5	60	72.5
	Deflection(mm)	2.5	6.58	8.12
	Stiffness(kN/mm)	12.8	9.118	8.928

3.4 Comparison of stiffness

The stiffness of the slabs at to the percentage of voids present in the slab in Phase 1, Phase 2 and Phase 3 is shown in the Fig 7, Fig 8 and Fig 9 respectively.

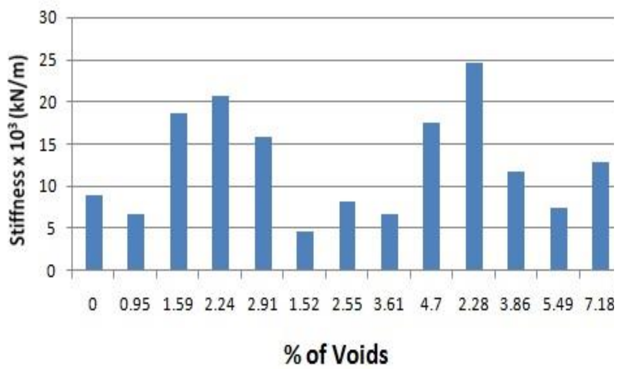


Fig 7 Stiffness to Percentage of voids in Phase 1

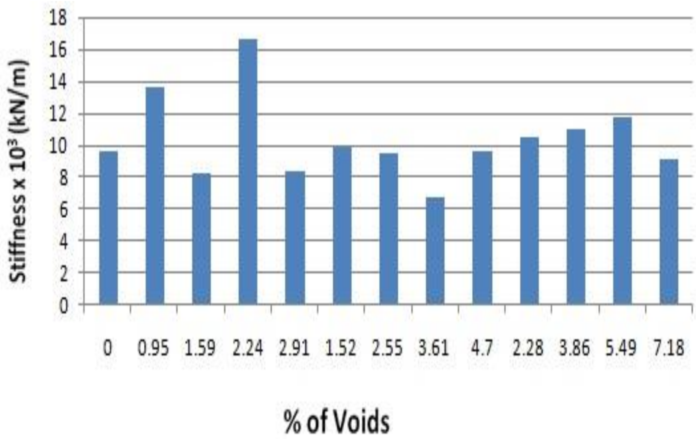


Fig 8 Stiffness to Percentage of voids in Phase 2

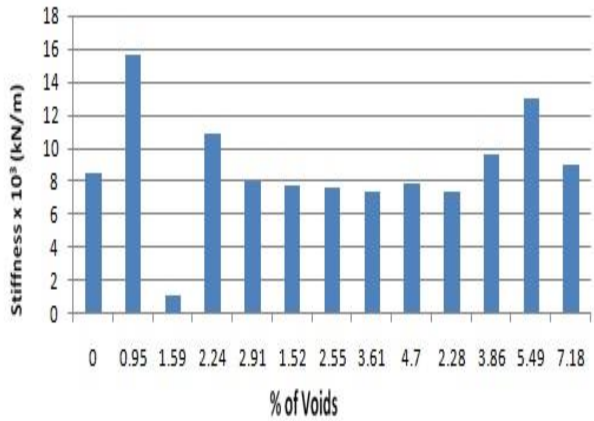


Fig 9 Stiffness to Percentage of voids in Phase 3

4. Conclusion

The slab with ball void volume of 1.59% shows the lowest stiffness value of 1.01 kN/m with a decrease of 89.19%. The slab with ball void volume of 2.28% shows the highest stiffness value of 24.2 kN/m with an increment of 61.36%. The conventional solid slab has the maximum load carrying capacity of 80.93 kN. The slab with ball void volumes of 1.59% and 2.28% shows the minimum load carrying capacity of 68.67 kN which shows a diminution of 15.14%.

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