Short Communication

Ultimate Load Carrying Capacities of Perforated Footings

by

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Introduction

In the last few decades, extensive work has been done for the theoretical preduction of ultimate bearing capacity/load carrying capacity of solid foundations of different geometry with varying loading conditions. Studies notably of Terzaghi (1943), Meyerhof (1951), Balla (1962) and Hansen (1970) have contributed to the rational design and analysis of foundations. Many scientists (Feda 1961, Milovic 1965, Ko and Davidson 1973) have reported experimental investigations about the ultimate bearing capacity/load carrying capacity of footings. These studies were mostly carried out on solid foundations. Information about the behaviour of perforated footings is limited, though they are being used in practice to serve various aspects. According to some investigators, perforated footings may be safe and economic for different type of marine structures. Studies reported by Broms and Massarsch (1977) and Young and Turner (1981) are however, noteworthy.

Scope of the Study

Experimental investigations on shallow isolated footings of different geometry with perforations of different shapes and extents are necessary to understand the behaviour of such footings. In view of the above, following experimental investigations on wooden model footings have been undertaken here to study :

(1) The ultimate load carrying capacity of isolated circular and square solid footings of same width or diameter with varying embedment.

(2) The ultimate load carrying capacity of circular and square footings with circular, triagular and square perforations having equal perimeters and numbers, and varying embedment.

Experimental Set-Up and Testing Procedure

Model Details

Wooden footing models were prepared in two different sets having

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different type of perforations. They were prepared out of well seasoned 10-cm. thick teak wood.

Square models of 10×10 cm and circular models of 10 cm diameter with and without openings were tested for ultimate loads. For convenience circular footings are classified as group A and subdivided into sub-groups A_1—A_4 depending upon the shape of the inside openings. Similarly square footings are classified and subdivided as B_1—B_4. Model details regarding the sizes, shapes, areas etc. are given in Table 1.

Soil

Locally available dry sand yellowish in colour with reddish traces was used as foundation medium. Sand particles passing through 1 mm sieve were chosen for the tests. These particles had an uniformity co-efficient of 2.4. All the test results reported here were performed on dry sand of unit weight=1.68 g/c.c. The angle of shearing resistance of the sand corresponding to this density was 39°.

Testing Procedure

The experiments on model footings were performed in a wooden tank of size 70×70 cm and height 110cm. The sand was poured manually by a hopper by raining technique. By maintaining the height of fall it was possible to cantrol the density of sand and get the desired reproducible results. The mode of pouring and the experimental detailed procedure is given elsewhere (Ghosh, 1984). Thr dry unit weight of the sand (=1,58 gm/c.c.) was taken as the criterion for the control of placement condition of sand. The model footing was placed on the soil and the axial load was applied by the screw jack through the loading frame. Two dial gauges recorded the settlements.

Test Programme

(1) Solid model footings A_1 and B_1 are tested under the following conditions :

(*a*) Surcharge depth, $D_f = 0$

(*b*) Surcharge Depth, $D_f = 0.4\ b$

(*c*) Surcharge depth, $D_f = 0.8\ b$

where, b = width or diameter of the solid footing.

(2) Perforated model footings A_2—A_4 and B_2—B_4 were tested under the conditions as stated in (1) above, but without any sand filling in perforations.

(3) Perforated model footings A_2—A_4 and B_2—B_4 were tested under the conditions as stated in (1) above sand filling in perforations equal to the outside surcharge depth.

Analysis of the Results

From the load settlement curve, the ultimate load carrying capacity was

TABLE 1

Specifications of Models

Footings	Classification (*1*)	Type of Perforations (*2*)	No. of Perforations (*3*)	Size of Perforations (*4*)	Perimeter of Each Perforation in cm. (*5*)	Area of each Perforation in cm² (*6*)	Net contact Area in cm² (*7*)
Circular	A_1	No Perforation	—	—	—	—	78.54
	A_2	Circular	4	Diameter = 2.5 cm	7.9	4.9	58.94
	A_3	Square	4	2×2 cm	8	4	62.54
	A_4	Triangular	4	Equilateral Triangle of Side 2.67 cm	8.01	3.08	66.22
Square	B_1	No Perforation	—	—	—	—	100.00
	B_2	Circular	4	Diameter = 2.5 cm.	7.9	4.9	80.4
	B_3	Square	4	2×2 cm	8	4	84.00
	B_4	Triangular	4	Equilateral Triangle of Side 2.67 cm	8.04	3.08	87.68

TABLE 2

Load Carrying Capacities of Circular Footings

Type of Footing & Diameter (cm) (1)	Sub Group (2)	Net Contact Area (cm^2) (3)	% Area of Perforations (4)	Sand Fiilling in Perforations (cm) (5)	Outside Surcharge (cm) (6)	Ultimate Load (Kg) (7)	Ultimate Bearing Capacity (Kg/cm^2) (8)
CIRCULAR 10	A_1	78.54	—	—	0	47	0.60
					4	75	0.95
					8	105	1.34
CIRCULAR 10	A_2	58.94	24.9	0	0	33	0.56
				0	4	58	0.98
				0	8	82	1.39
				4	4	62.5	1.06
				8	8	90	1.53
CIRCULAR 10	A_3	62.54	20.4	0	0	49	0.78
				0	4	79	1.26
				0	8	112	1.79
				4	4	82	1.31
				8	8	118	1.87
CIRCULAR 10	A_4	66.22	15.7	0	0	52	0.78
				0	4	84	1.27
				0	8	120.5	1.82
				4	4	88	1.33
				8	8	124	1.87

determined by log—log method. The values of the ultimate loads obtained from the experimental results are reported in Tables 2 and 3. The variation of load carrying capacities with D_f/b ratio, is shown in Fig. 1. It is seen that, at any D_f/b ratio, the load carrying capacity of a particular perforated footing with sand filling in perforations is marginally greater than that without it. Footings with square and triangular perforations give slightly higher values of ultimate loads as compared to solid footings. Also, the ultimate bearing capacities as calculated using the net contact area of the footings are about 20 to 30 per cent more than those of the solid footings. However, the ultimate loads of foundations with circular openings are less than the solid footings.

Conclusions

The load carrying capacity of a perforated footing with sand filling in the perforations is more than that without it.

Footings with square and triangular perforations give marginally higher values of load earrying capacities as compared to solid footings.

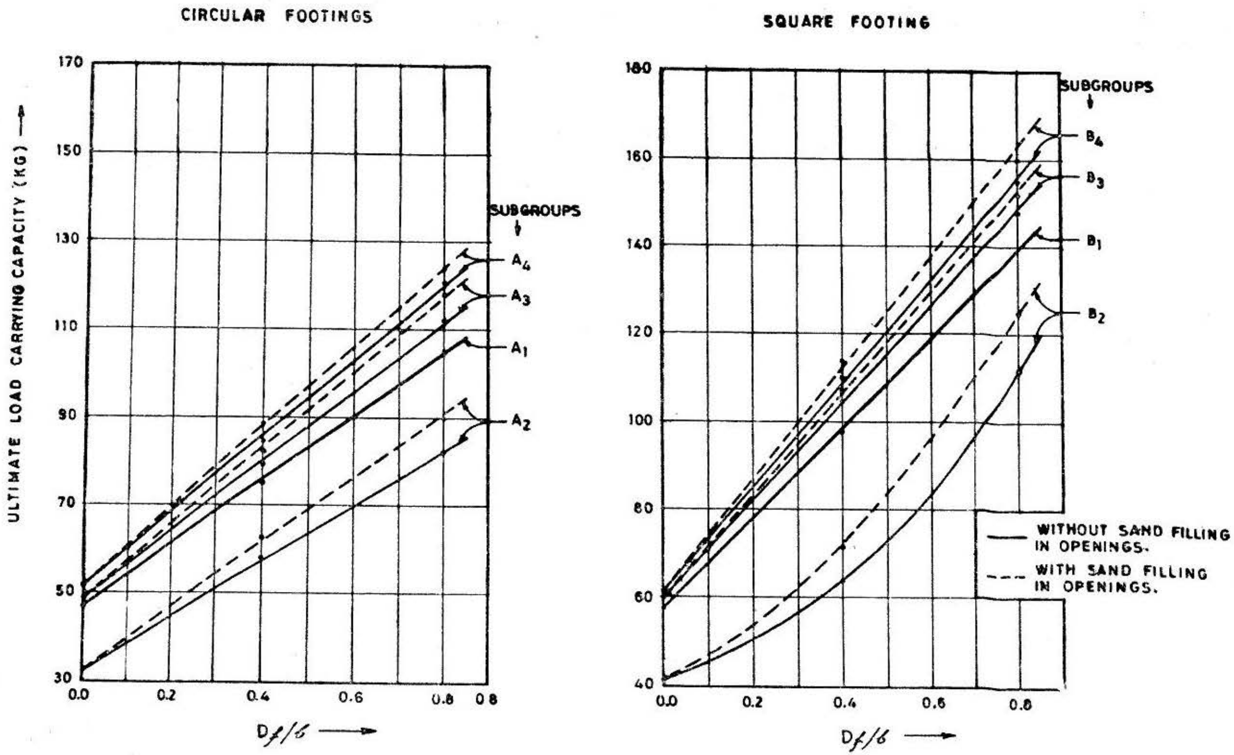

FIGURE 1 Ultimate Load Carrying Capacity Vs. D_f/b RATIO.

TABLE 3

Load Carrying Capacities of Square Footings

Type of Footing (1)	Sub Group (2)	Net Contact Area (cm^2) (3)	% Area of Perforations (4)	Sand Filling in Perforations (cm) (5)	Outside Surcharge (cm) (6)	Ultimate Load (Kg) (7)	Ultimate Bearing Capacity (Kg/cm^2) (8)
Square (10× 10cm)	B_1	100	—	—	0	58	0.58
					4	98	0.98
					8	140	1.40
	B_2	80.37	19.63	0	0	41	0.51
				0	4	64	0.80
				0	8	112	1:39
				4	4	72	0.90
				8	8	125	1.55
	B_3	84	16	0	0	60	0.71
				0	4	105	1.25
				0	8	148	1.76
				4	4	107	1.27
				8	8	152	1.80
	B_4	87.66	12.34	0	0	61	0.70
				0	4	110	1.25
				0	8	155	1.77
				4	4	114	1.30
				8	8	160	1.83

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