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Influence of Interference of Symmetrical Footings on Bearing Capacity of Soil

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Abstract:- The bearing capacity and load-settlement behavior of footings from the isolated footing condition to the interference of adjoining footing is of major concern due to increase in urbanization and industrialization of cites. In the present study, an attempt has been made to model the settlement behavior of two footings placed with varying spacing on single layered soil deposit. The study revealed the interference affect the ultimate bearing capacity of adjoining footings. The ultimate bearing capacity was found to be influenced by its spacing. The ultimate bearing capacity of footings increased with decrease in spacing between the footings. The settlement of footings due to interference was found to be increased with decrease in spacing.

Keywords:- Interaction, Footing, Interface, Settlement and Bearing Capacity

I. INTRODUCTION

The loads of a structure are transmitted to the ground through its foundation. The foundation design is aimed at providing a means of transmitting the loads from a structure to the underlying soil without causing any shear failure or excessive settlement of the soil under the imposed loads. According to the footing failure mechanism of Terzaghi, the lateral distance of the passive zone extends to approximately 3–5 times the footing width [1]. If a neighboring footing is placed sufficiently far beyond this lateral distance, the footing will behave as an individual single footing. However, if footings were placed at intervals within this lateral distance and were loaded, the failure and slip mechanism of a single footing would no longer be valid [2, 5].

On many occasions, it is unavoidable to place footings with quite close spacing. Due to close spacing, the behaviour of interfering footings becomes different from that of a single isolated footing. In such cases, the interference of failure zones could alter the bearing capacity and load-settlement behaviour of footings from the isolated footing condition. The effect of interference of footings on bearing capacity and settlement of square, circular and strip footings resting on sand of various sizes were studied [2, 4, 5, 6 and 8]. The efficiency of interfering footings was compared to that of the isolated footings having the same size from the considerations of bearing capacity and settlement characteristics. The study concluded that (i) Bearing capacity of model footings increase as the size of footing increases. (ii) Bearing capacity of interfering footing is more than that of isolated footing of the same size. (iii) Bearing capacity of interfering footing increases as spacing between them decreases. (iv) For equal settlement, the loading intensity was found to increase with decrease in spacing of the footings. (v) Settlement for a given load intensity decreases as the spacing between the footings decrease

Hence, keeping in view the variation, the study aims for the interference effect on ultimate bearing capacity of two nearby footings with the following objectives

- Effect of shapes of footing on interference of footings
- Effect of spacing of footing on interference of footings.
- Interfering effect of two footings on bearing capacity compared to that of isolated footing.

II. METHODOLOGY

The work includes plate load test to evaluate the bearing capacity and settlement. The materials used for the work was Kanhan sand and footing of various shapes i.e. square, circular and rectangular made up of cast iron having constant area of 25 cm^2. The assembly for the plate load test setup is as shown in Fig. 1 consisting of a tank of size 0.6m x 0.6m x 0.6m with a loading frame. The load is applied with the hydraulic jack and measured with the proving ring. Two dial gauges were placed on each flanges of footing to measure the anticipated settlement.

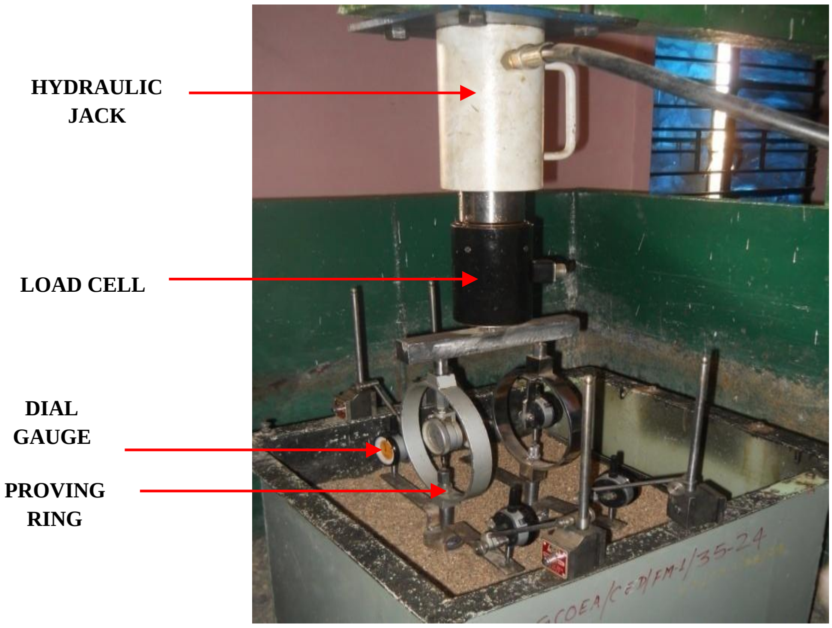


Figure 1: Assembly of Laboratory Plate Load Test

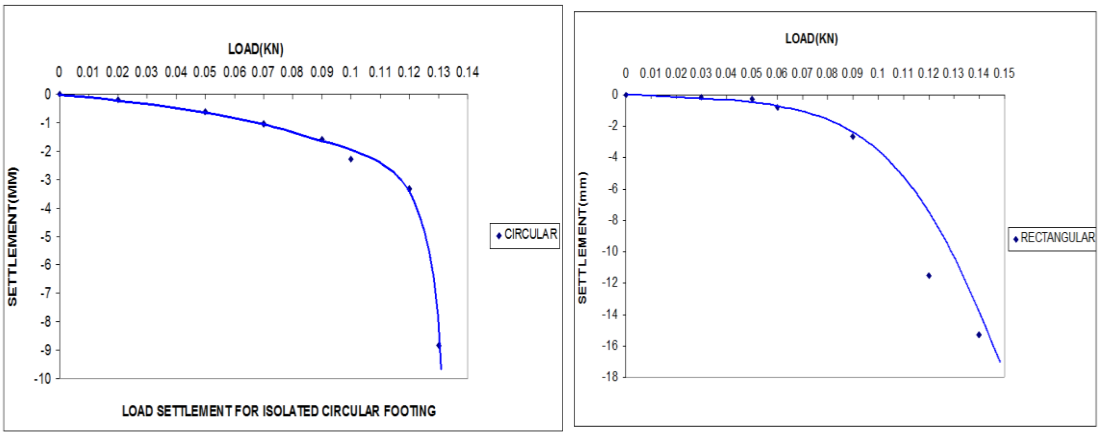
III. RESULTS AND DISCUSSIONS

The geotechnical properties of sand were obtained by conducting different tests on [3]. The specific gravity of the sand was found to be 2.81 by pycnometer method. The dry density of sand by rainfall method is found to be 14.63kN/m^3. The angle of internal friction, Φ of the dry sand was found to be 20°.

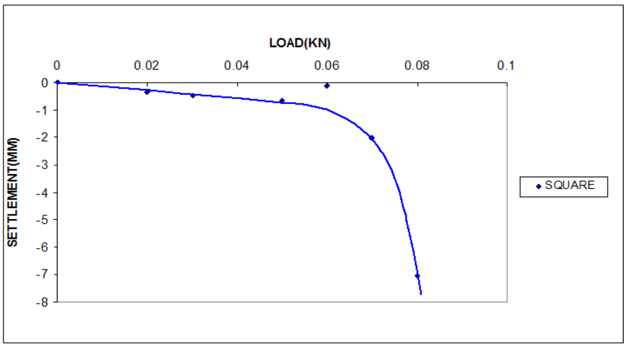
The plate load tests were conducted on square, circular and rectangular footing having same area of 25 cm^2. The tests were conducted on isolated footing and twin footing with spacing of 15 cm and 20 cm. The results of plate load test were plotted and load settlement characteristic was studied.

3.1 Load Settlement Behavior of Footings

The load settlement curve for circular, square and rectangular isolated footings are shown in Fig 2. The ultimate failure load was determined and ultimate bearing capacity was calculated from plot.



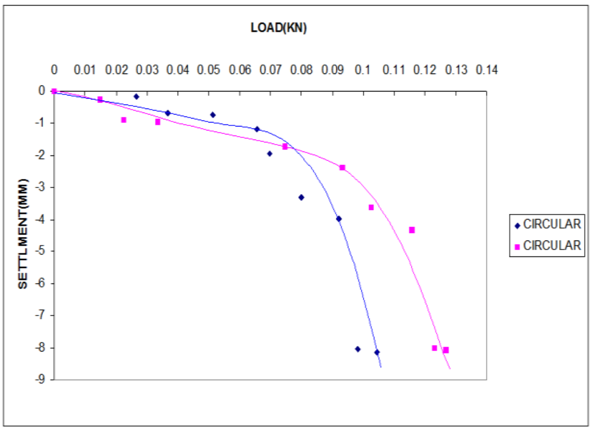
(a) Circular Footing **(b) Rectangular Footing**

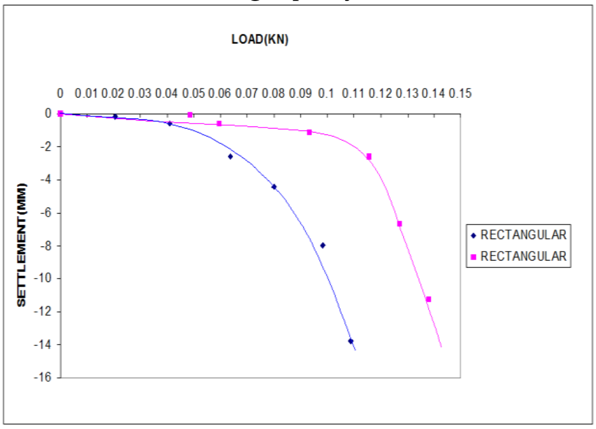


(c) Square Footing

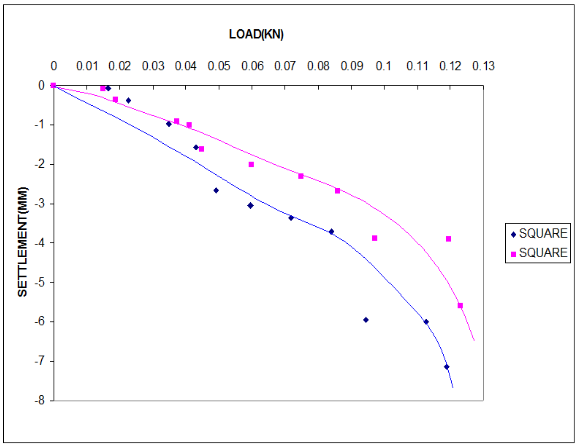
Figure 2: Load Settlement Behavior of Isolated Footings

The effect of adjoining footing with 15 cm spacing between them was studied by recording the load on each proving ring and settlement by dial gauges separately. The load settlement curve was plotted as shown in Fig. 3 from which the ultimate failure load was determined and ultimate bearing capacity was calculated.





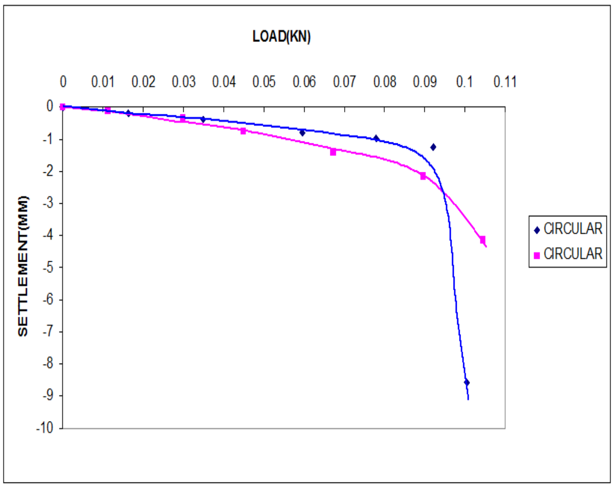
(a) Circular Footing **b) Rectangular Footing**



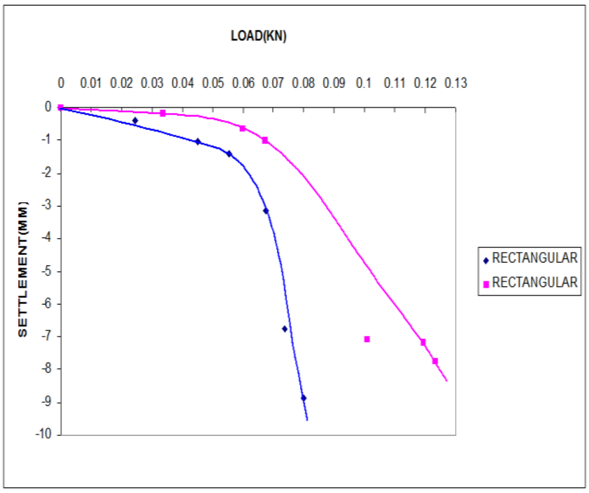
(c) Square Footing

Figure 3: Load Settlement Behavior of Footings Spaced at 15 Cm

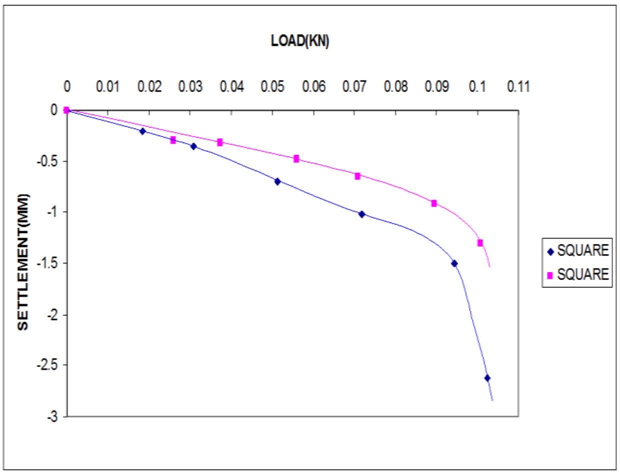
For footings with 20 cm spacing, the loads for each proving ring were recorded and settlement by dial gauges. The load settlement curve was plotted as shown in Fig. 4 from which the ultimate failure load was determined and ultimate bearing capacity was calculated.



(a) **Circular Footing**



(b) **Rectangular Footing**



(c) Square Footing

Figure 4: Load Settlement Behavior of Footings Spaced at 20 cm

3.2 Ultimate Bearing Capacities

The ultimate bearing capacity for various shapes of footings of isolated footing and adjoining footing with different spacing are computed form load settlement plot by tangent method and are shown in Table 1. The efficiency factor ($\xi\gamma$) which is defined as ratio of average pressure on an interfering footing of a given size associated with either an ultimate shear failure or a given magnitude of settlement to the average pressure on an isolated footing of a given size associated again with either an ultimate shear failure or the same magnitude of settlement is also shown in Table 1.

Table 1: Ultimate Bearing Capacities and Efficiency Factor for Single Isolated Footings

S. No.	Type of Footing	Isolated Footing UBC, kN/m^2	Spacing, cm	Ultimate Bearing Capacity kN/m^2		Efficiency Factor
				Footing 1	Footing 2	
1	Circular	51.02	15	33.6	38	0.702
			20	36.2	35.4	0.702
2	Rectangular	34.80	15	39.2	44.8	1.207
			20	27.4	26.8	0.779
3	Square	46.90	15	43.2	44	0.930
			20	36.6	38	0.795

The efficiency factor $\xi\gamma$ varies between the minimum values of 0.702 to maximum value of 1.207 as shown in Table 1. These efficiency factors $\xi\gamma$ are low compared to as predicted by Kumar and Bhoi (2009) [7] due to low density sand of density. Hence, the prediction that $\xi\gamma$ increases with increase in test density of sand found to be correct. As observed from Table 1, that the ultimate bearing capacity of symmetrical adjoining footing increases with decrease in spacing between the footings. Also, the settlement increases or remains same compared to isolated footing. After reaching the maximum value, the load generally decreases but the settlement goes on increasing. It was found that the efficiency factors decreases with increase in spacing between the footings.

IV. CONCLUSIONS

The symmetrical footings interface is more common in present practice of construction. The ultimate bearing capacities of symmetrical shape footings for different shapes of footing and spacing was studied. The study reveals that ultimate bearing capacity of isolated footing was affected by the footing under interference. It was found that the ultimate bearing capacities were reduced irrespective of spacing between two footings due to interference. The settlement was observed to be same in symmetrical footing combinations.

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