INTERFERENCE OF ADJOINING RECTANGULAR FOOTINGS ON REINFORCED SAND

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ABSTRACT

The influence of two adjoining rectangular footings on bearing capacity and settlement resting on reinforced sand is discussed in the paper. The parameters include sizes and spacing’s of the footing. The model tests were conducted for simulating the various conditions of footing and showing the effect on the bearing capacity and settlement. It has been observed that providing continuous geogrid reinforcement layer in the foundation soil under the closely spaced rectangular footings improved the bearing capacity.

Keywords: Bearing capacity, Geogrid, Interference effect, Rectangular footing.

1. INTRODUCTION

Many townships are developed and lot many are proposed with higher construction density. As a common practice several storied buildings are constructed in a series keeping very small spacing between adjacent corner footings. Due to heavy loads and the non availability of good construction sites, engineers are often required to place footings at close spacing’s. Therefore, the footings in the field generally interfere with each other to some extent and are rarely isolated. The general scenario is to design the footings as an isolated footing. The interfering as well as spacing effect is not considered while designing the footings. The technique of reinforcing the soil below shallow foundations with geosynthetic reinforcement is one of the fastest growing techniques in the field of geotechnical engineering. Therefore in the preset study, the influence of two adjoining rectangular footing resting on reinforced sand on bearing capacity and settlement was carried out. The effect was studied for various sizes and spacing’s of the footing on reinforced sand.
2. LITERATURE REVIEW

The study on ultimate bearing capacity of two interfering strip footings using the method of stress characteristics shows that the efficiency factor $\xi \gamma$ decreases continuously with an increase in spacing [1]. The ultimate bearing capacity of number of strip footings using the lower bound limit analysis in combination with finite elements shows that the failure load for a footing in the group becomes always greater than that of a single isolated footing [2]. The effects of multiple-footing configurations in sand on bearing capacity using field plate load tests and finite element analyses shows that the load responses of multiple footings are similar to those of the single footing at distances greater than three times the footing width [3]. The interference of surface model footings resting on sand shows that the interference between footings was observed to cause an increase in bearing capacity and decrease in settlement with reduction in spacing [4]. The interference effect on the ultimate bearing capacity of two closely spaced strip footings placed on the surface of dry sand by using small scale model tests shows that an interference of footings leads to a significant increase in their bearing capacity [5]. The numerical examination of bearing capacity ratio for rough square footings located at the surface of a homogeneous sandy soil reinforced with a geogrid was shows the bearing capacity of interfering footing increases with the use of geogrid layers depending on the distance between two footings [6]. The effect of spacing between the footings, size of reinforcement and continuous and discontinuous reinforcement layers on bearing capacity and tilt of closely spaced footings was investigated by performing total 74 tests. It shows considerable improvement in bearing capacity, settlement, and tilt of adjacent strip footings by providing continuous reinforcement layers in the foundation soil under the closely spaced strip footings [7]. The interference effect of two nearby strip footings on reinforced sand shows that the bearing capacity of single footing on the reinforced soil decreases with increase in D/B [8]. The literatures, shows work on the interfering effects of different sizes footings on unreinforced and reinforced sand. However, the interfering effect of rectangular footing on bearing capacity and settlement is not available for reinforced sand. This revels that the influence of two adjoining footings on bearing capacity and settlement for various sizes and spacing of the footings on reinforced sand is need of the future. In order to evaluate the effects of two adjacent footings on reinforced sand, laboratory experiments to simulate the various conditions of footing was performed. In each case, different sizes and spacing of footing were applied for the purposes of comparison among all of the results for development of knowledge base in this regards.

3. MATERIAL

The material used for the study is as follows.

3.1 Foundation Material

For the model tests, cohesionless dry sand was used as the foundation material. The study was carried out on Kanhan Sand as foundation material. This sand is available in Nagpur region of Vidharabha, Maharashtra. The test sand has angular shape, uniform yellow colour with small proportion of flint stone of black colour. The particle size of sand decided for the test was passing through IS sieving 2 mm and retaining on 450 micron IS sieve. The properties of sand used are as shown in Table 1.
3.2 Model Footing
Rectangular model footings of dimensions 3cm x 6cm, 4cm x 8cm and 5cm x 10cm were fabricated by using cast iron material as shown in Fig. 1. Every footing has a little groove at the center to facilitate the application of load. The footings were provided with the two flanges on two sides of footings to measure the settlement of footing under the action of load with the help of dial gauges.

![Figure 1: Model Footing](image)

3.3 Geogrid
Commercially available continuous biaxial geogrid was used for reinforcing the sand bed. The size of biaxial geogrid reinforcement used was five times the size of the footing as shown in Fig. 2. The biaxial geogrid reinforcement was placed at the location of the desired layer of reinforcement i.e. D/2 or B/2 from bottom of footing. The top surface of the sand will be leveled and the biaxial geogrid reinforcement will be placed.
4. EXPERIMENTAL SETUP

The experimental setup used for studying the performance of adjacent footing on reinforced sand is shown in Fig. 3. The assembly for the model plate load test setup consist of a tank of size 0.5m x 0.5m x 0.6m. A loading frame for applying the load to the models is assembled over the tank. The load was applied with manually controlled hydraulic jack and measured with the help of proving ring. Dial gauges were placed on each flanges of each footing to measure the settlement.

5. TEST PROCEDURE

The sand was poured in the tank by rainfall technique keeping the height of fall as 35 cm to maintain the constant relative density throughout the bed. The sand was poured up to the location of the desired layer of reinforcement, then the top surface of the sand made leveled and the biaxial geogrid reinforcement was placed at depth 0.5D below footing. Again, the sand was filled over this geogrid reinforcement layer in the tank. A manually controlled hydraulic jack with activated loading piston, installed between the sliding beam and strong
reaction beam as shown in Fig. 3 was used to provide the required load on the footings. Both
the footings will be simultaneously loaded vertically. The vertical displacement of each test
footing was measured by taking the average of two dial gauges readings. By gradually
increasing the load, a series of tests was carried out so as to monitor the complete load-
deformation plots till the ultimate failure occurs. Each test was carefully controlled by
observing the displacement of each footing through dial gauge reading.

6. TEST RESULTS

Load settlements for each testing were plotted. The curves, in general, show a linear
variation in the initial portion and become non-linear thereafter. Fig. 4 shows average load
settlement curve for isolated rectangular footings.

![Figure 4: Load settlement curve for isolated footings.](image)

Load settlement curve for adjoining rectangular footings placed reinforced sand bed at
different spacing to width ratio (S/B) are shown in Fig. 5 - 7.

![Figure 5: Load Settlement curve for 3cm x 6cm rectangular footing.](image)
The ultimate bearing capacity was obtained by using tangent intersection method. Tables 2 show the bearing capacity of corresponding model footing.

**Table 2:** Ultimate bearing capacity of footing for Different S/D Ratio.

<table>
<thead>
<tr>
<th>S/B Ratio</th>
<th>Ultimate bearing capacity (KN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3cm x 6cm</td>
</tr>
<tr>
<td>1.0</td>
<td>51.11</td>
</tr>
<tr>
<td>2.0</td>
<td>42.77</td>
</tr>
<tr>
<td>3.0</td>
<td>36.66</td>
</tr>
<tr>
<td>Isolated</td>
<td>33.88</td>
</tr>
</tbody>
</table>
7. DISCUSSIONS AND INTERPRETATION OF RESULT

The bearing capacity of adjoining footing resting on reinforced sand was studied. The biaxial geogrid was kept at 0.5D below the footing. The adjoining footing was spaced to study the interference effect on reinforced sand. Fig. 5-7 shows that with increase in S/B the bearing capacity decreases and the settlement was observed to be increase. The ultimate bearing capacity was observed to be more than that for isolated footing. The increase in the ultimate bearing capacity may be due to existing footing acts as a surcharge for the adjacent footing and at wider spacing no interference takes place and each footing acts as an individual (isolated) footing.

7.1 Efficiency Factor ($\xi\gamma$)

The efficiency factor ($\xi\gamma$) is the 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. Table 3 shows the efficiency factor for different S/B ratio for 3cm x 6cm, 4cm x 8cm and 5cm x 10cm dimension rectangular footings.

<table>
<thead>
<tr>
<th>S/B Ratio</th>
<th>Efficiency Factors ($\xi\gamma$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3cm x 6cm</td>
</tr>
<tr>
<td>1.0</td>
<td>1.50</td>
</tr>
<tr>
<td>2.0</td>
<td>1.26</td>
</tr>
<tr>
<td>3.0</td>
<td>1.08</td>
</tr>
</tbody>
</table>

From Table 3, it can be seen that, the efficiency factor decreases with increase in S/B ratio. This indicates that the bearing capacity is greatly influenced by spacing between them. As the spacing decreases, the bearing capacity is observed to be increased.

8. CONCLUSIONS

From the present study following conclusions are drawn:
- Bearing capacity of rectangular footings increases as the size of footing increases.
- Bearing capacity of interfering footing is more than that of isolated footing.
- Bearing capacity of interfering footing increases as spacing between them decreases.
- The settlement was observed to be increase as spacing is decreased.
- The efficiency factor decreases with increase in S/D ratio.
REFERENCES