INFLUENCE OF MODEL FOOTING DIAMETER ON SILTY SAND BEDS REINFORCED WITH GEOTEXTILE

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Abstract—This research study aims to investigate the potential benefits of using the reinforcement to improve the bearing capacity and reduce the settlement of shallow foundations with medium plasticity, resulting in low bearing capacity and/or excessive settlement problems. This can cause structural damage, reduction in the durability, and/or deterioration in the performance level. This research is performed to investigate the behavior of geosynthetic reinforced silty sand foundation and to study the effect of different parameters contributing to their performance using laboratory model plate load tests. The model circular footing of diameter 60 mm, 75 mm and 90 mm are used and the parameters investigated in this study included a number of reinforcement layers, the effect on the diameter of footing, BCR values and settlement ratio. Three tests in unreinforced and nine test in reinforced conditions with different reinforcement layers of geotextile are performed. By using the load settlement curve, the ultimate bearing capacity of foundation on soil under axial loadings has been obtained by the double tangent method, and the results are compared with Terzaghi’s method-1943, IS method, Vesic -1973. The results showed enhancement in the bearing capacity of the soil as well as a reduction in its settlement in all used configurations compared with the reference case.

Keywords—Model plate load test; silty sand; diameter of footing; geotextile; BCR; settlement ratio

1. INTRODUCTION
The shortage of available and suitable construction sites in the city center has led to the increased use of problematic areas, where the bearing capacity of the underlying deposits in very low. The reinforcement of these problematic soils with granular fill layers is one of the soil improvement techniques that are widely used.

Ahmed Elzoghby Elsaied, Nasser Mosleh Saleh, Mohi Eldeen Elmashad stated that soil confinement enhances the influence of the load-settlement behavior of circular footing resting on granular soils. The optimum depth for placing a single geogrid layer under the bottom of the cylinder was found equal to a quarter of the footing width.

P.K. Basudhar, Santanu Saha, Kousik Deb stated that substantial increase in the BCR values for each increment in the number of reinforcement layers; even though the settlement improvement is not appreciable. For three-layer reinforced case, the BC improvements have been found to be 4.5 times for 30mm diameter footing and about 3.0 times for 45 and 60mm diameter footings.

Sujit Kumar Dash, S. Sireesh, T.G. Sitharam studied The effectiveness of geocell reinforcement placed in the granular fill overlying soft clay beds has been studied by small-scale model tests in the laboratory.

Seeing the above statements given by different researchers The studies on circular footings mostly pertain to the area wherein the underlying soil is reinforced with geogrids or geocells. However, very less work has been conducted to study the behavior of circular footings resting on silty sand beds reinforced with geotextiles.

Less work has been conducted to study the effect of diameter of footing. There is a necessity to study the behavior of circular footings resting on silty sand beds reinforced with and without geotextiles.

2. MATERIAL
A. Silty sand
For the model test, silty sand was collected from Dhamidhaj Jain temple, Ahmedabad, Gujarat. For the test, the soil was collected from 1 m depth of the ground level. For the experimental work, 4.75 mm sieve passing materials were used.

B. Geotextile
Geotextile used was M-305 polypropylene multifilament fabric having a tensile strength 440 kg (50 mm* 200 mm strip) and weight of 275 g/sq.m.

### TABLE I. GEOTEXTILE PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymer</td>
<td>Polypropylene</td>
</tr>
<tr>
<td>Weight (sq.m)</td>
<td>275 g</td>
</tr>
<tr>
<td>Air permeability (cu.ft/sq.ft/s)</td>
<td>0.5</td>
</tr>
<tr>
<td>Particle retention (micron)</td>
<td>15 to 20</td>
</tr>
<tr>
<td>Tensile strength (kg)</td>
<td>440 kg*</td>
</tr>
</tbody>
</table>
3. METHODOLOGY

A. Testing Tank

As per IS 1888-1962, the minimum size of footing should be 5D, where D is the diameter of the footing to develop the full failure zone without any interference of side. Keeping these criteria in mind, tank size of 0.5 m diameter and 0.51 m height was fabricated.

B. Test apparatus, program and setup

A model plate load test was conducted on the silty sand in the laboratory. The prototype footing used is circular in shape with a diameter of 60mm, 75mm and 90mm and thickness of 15mm. The test model was prepared by a compact the sand in layers, each of 100 mm thick up to 450 mm height. The sand was compacted at a relative density of 55%. The geotextile layer was placed at the depth varying from 0.25D, 0.50D, and 1.0D.

The model footing was placed centrally on the top surface of the silty sand and the dial gauge was placed on the footing. Each load increment was maintained constant until the settlement rate reached 0.02 mm/hr. The experimental program consists of carrying out twelve load bearing tests on the circular model footing. This study investigates the effect of BCR value and settlement ratio.

4. RESULTS AND DISCUSSION

A. Material property

The index and engineering properties of silty sand used for the study are shown below:

<table>
<thead>
<tr>
<th>Test</th>
<th>Symbol</th>
<th>Determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>G</td>
<td>G= 2.63</td>
</tr>
<tr>
<td>Standard Proctor</td>
<td>---</td>
<td>OMC =12.5% &amp; MDD = 18.8 KN/m³</td>
</tr>
<tr>
<td>Relative density</td>
<td>I_d</td>
<td>ρ_dmax=19.81 KN/m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ρ_dmin=13.40 KN/m³</td>
</tr>
<tr>
<td>Direct Box Shear</td>
<td>---</td>
<td>c = 8 KN/m² and Φ= 34º</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>LL</td>
<td>25.47%</td>
</tr>
<tr>
<td>Plastic Limit</td>
<td>PL</td>
<td>21.52%</td>
</tr>
</tbody>
</table>

B. Laboratory test result

Load-settlement curves from twelve tests carried out on centrally loaded circular footings in both reinforced and unreinforced conditions. The ultimate bearing capacity of foundation on soil under axial loadings was obtained from the load-settlement curves. In curves with the double tangent method, the ultimate bearing capacity and settlement at failure load are taken at the peak point. In the present research, a dimensionless parameter called bearing capacity ratio (BCR), is used to measure the effect of improvement utilizing reinforcement layers on increasing the bearing capacity. This parameter is defined as the ratio of the ultimate bearing capacity in reinforced soil to that in unreinforced soil condition. To analyze the footing settlement, the settlement ratio (SR) is proposed and defined as the ratio of footing settlement in reinforced soil to that in unreinforced soil condition.

$$BCR = \frac{qu_{\text{reinforced}}}{qu_{\text{unreinforced}}}$$

$$SR = \frac{su_{\text{reinforced}}}{su_{\text{unreinforced}}}$$

Where $qu$ is the ultimate bearing capacity and $su$ is the footing settlement.
As seen from the above fig. For 90 mm footing with one layer, two layers and three layers reinforced case, the bearing capacity improvements have been found to be 1.29, 1.94 and 2.13 times respectively.

Each increment in the number of reinforcement layers; settlement ratio of 90 mm footing is increased by 1.42, 2.80 and 3.77 times for one layer, two and three layers respectively.

As seen from the above fig. For 75 mm footing with one layer, two layers and three layers reinforced case, the bearing capacity improvements have been found to be 1.93, 2.50 and 2.74 times respectively.

Each increment in the number of reinforcement layers; settlement ratio of 75 mm footing is increased by 2.77, 4.16 and 4.16 times for one layer, two and three layers respectively.

As seen from the above fig. For 60 mm footing with one layer, two layers and three layers reinforced case, the bearing capacity improvements have been found to be 1.45, 2.47 and 2.85 times respectively.

Each increment in the number of reinforcement layers; settlement ratio of 60 mm footing is increased by 2.38, 3.74 and 5.76 times for one layer, two and three layers respectively.

As seen from above figure; bearing capacity improvements of 75mm footing have been found to be 1.32 times than 60 mm footing.

For 90 mm footing: the bearing capacity improvements have been found to be 1.98 times than 60 mm footing.

For 75 mm footing; the settlement ratio is increased by 1.31 times than 60 mm footing.

For 90 mm footing; the settlement ratio is increased by 2.07 times than 60 mm footing.

<table>
<thead>
<tr>
<th>Diameter of footing (mm)</th>
<th>IS Method (kN)</th>
<th>Terzaghi’s Method (kN)</th>
<th>Vesic’s Method (kN)</th>
<th>Practical load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>12.65</td>
<td>14.52</td>
<td>16.18</td>
<td>10.20</td>
</tr>
<tr>
<td>75</td>
<td>20.0</td>
<td>22.86</td>
<td>25.41</td>
<td>17.85</td>
</tr>
<tr>
<td>90</td>
<td>29.0</td>
<td>33.16</td>
<td>36.88</td>
<td>40.81</td>
</tr>
</tbody>
</table>

5. CONCLUSION
Considerable improvement in load carrying capacity of silty sand when reinforced with geotextile circular disc with varying space.

For 90 mm footing with one layer, two layers and three layers reinforced case, the bearing capacity improvements have been found to be 1.29, 1.94 and 2.13 times respectively.

For 75 mm footing, the bearing capacity improvement has been found to be 1.93, 2.50, and 2.74 respectively, and for 60 mm footing, the bearing capacity improvement has been found to be 1.45, 2.47 and 2.85 respectively.
Each increment in the number of reinforcement layers; settlement ratio of 90 mm footing is increased by 1.42, 2.80 and 3.77 times for one layer, two and three layers respectively.

And for 75 mm footing is increased by 2.77, 4.16 and 4.16 times for one layer, two and three layers respectively, and for 60 mm footing is increased by 2.38, 3.84 and 5.75 times for one layer, two and three layers respectively.

For 75 mm and 90 mm footing in unreinforced condition; the bearing capacity improvements have been found to be 1.31 and 2.07 times than 60 mm footing.

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REFERENCES


