MODEL STUDY ON VARIATION OF BEARING CAPACITY OF SQUARE FOOTING ON REINFORCED SAND WITH CEMENT INTERFACE

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***Abstract*— Geosynthetic are used for reinforcements in many problem areas of civil engineering. It is mainly used to improve the bearing capacity and reduce settlement of the soil. Geogrids, geocells and geotextile are commonly provided as soil reinforcement which improves the bearing capacity and reduces settlement of foundation. The bearing capacity of square footing on sand reinforced with single layer geotextile reinforcement at different dimensions with cement interface is studied. A cement interface zone is created on the surface of geotextile to improve the friction and adhesion of sand and geotextile. Tests are also conducted on reinforced soil without cement interface and the results are compared to find out the variation on bearing capacity. Cement treated interface improves the bearing capacity and reduces the settlement. From the literatures referred depth and dimension of reinforcement affect the bearing capacity of the reinforcement. Test on unreinforced sand, reinforced sand and reinforced sand with cement interface of size 20cm, 25cm and 30cm geotextile at 0.5B depth from the base of footing. The result shows that size of the geotextile increase the bearing capacity considerably in both cases. When ordinary geotextile was treated with cement interface 10% to 40% increase in bearing capacity was observed. The cement treated geotextile improves the bearing capacity at lower size than ordinary geotextile.**

Keywords—geotextile, cement interface,

I. INTRODUCTION

The mechanical properties of soil as a granular material depend on its friction, cohesion, interlocking, and confinement. The inclusion of geosynthetic as a mechanical stabilization method improves the mechanical properties of soil. A number of researches are carried out on theoretical and experimental studies to understand the role of reinforcement materials in improving the bearing capacity of foundation soils. Geogrids, geotextile, geocells etc. are commonly used a soil reinforcement. Soil reinforcement is provided to improve the bearing capacity and reduce the settlement of the soil. The reinforcement mechanism may depend on the depth, length, width and number of reinforcement layers. Most of the studies are conducted on geogrid or geocell used as reinforcement. In this study effect of ordinary geotextile with cement treatment on the bearing capacity of a square footing resting on sand layer has to be conducted.

The ordinary geotextile does not provide much improvement as that of geogrid or geocells. So that when the geotextile with cement interface is provided it increases the friction and adhesion between the soil and geotextile. As a result the bearing capacity of the soil can be improved and the settlement can be reduced. The test is conducted by varying the depth and dimension of the reinforcement. The main advantages of this type of reinforcement is it provide higher amount of improvement at lower length of reinforcement and only single layer reinforcement is enough ,so that multilayer reinforcement can be avoided. The geotextile with cement interface can be used as an alternative for geogrid or geocells. **Farsakh,A,M.,Chen,Q.,Sharma,R(2013)** conducted study on the effect of geosynthetics on square and rectangular footing on sandy soil. The test was conducted by varying different parameters contributing to performance of footing. The results showed that the reinforcement configuration have very important role on behavior of reinforced sand foundation. **Ouaria,A.,Mahmoudi,A (2018)** under took a study on the effect of cement treatment of the interface between geotextile and sand on the bearing capacity of a foundation built on geotextile and sand on the bearing capacity of a foundation built on geotextile reinforced sand. A cement treated zone was created on the geotextile to improve the friction and adhesion of the interface zone. Test was also conducted on reinforced soil without a cement treated zone results were compared. The cent interface has significant effect on the bearing capacity of the strip footing. From the results in the journal required length of the reinforcement was reduced by approximately 40% when the interface zone of the land and reinforcement was cement treated. The effect of the cement treated zone on the bearing capacity was more evident in low settlement levels. **Ebadi,M et al (2013)** conducted a study on non-woven geotextile to investigate the effect of cement interface on soil layer. The result shows that when cement is introduced into the interface of soil and geotextile the shear strength of sol considerably increased.

II. MATERIALS

The test material involves uniformly graded sand and Portland cement. For reinforcing the foundation medium, geotextile has to be used.

A. Sand

Natural river sand is used for the study. The sample is air dried for conducting the test. According to Indian standard

soil classification the soil is classified under well graded. Properties of sand is given in Table1

Table 1 Properties of sand

Properties of sand	*Values*
Specific gravity ,g	2.78
Coefficient of uniformity, c_u	4
Coefficient of curvature,c_c	1.02
Angle of internal friction, ϕ	34°
Relative density	50%
Maximum density, ρ_{max}	1.736 g/cc
Minimum density , ρ_{min}	1.558 g/cc
Classification	Well graded sand

B. Geotextile

Geotextile used in the study is non-woven synthetic polypropylene purchased from India mart with standard specification. The cement treated geotextile were prepared by saturating the geotextile followed by spraying 1.5kg/m^2 Portland cement on the surface with a sand layer on the top on both sides (Figure 1). The property of geotextile is represented in Table2.

Table 2.Properties of geotextile

Properties	*Value*
Thickness	2mm
Unit mass	0.3kg/m^2
Extension at failure	75%
Bursting strength	17.15kg/cm^2
Tensile strength	12kN/m^2

Figure 1.Geotextile with cement interface

III. METHODOLOGY

A model tank with required dimensions and loading has to be fabricated for the present study. The test material involves sand, geotextile, cement and model plate. Model plate load tests were performed on square footing. The foundation soil consists of sand layer. The model tank is rigid in nature, so that it won't undergo any deformation during filling. The side walls of the tank are made frictionless. Geotextile and geotextile with cement treatment of varying dimension are considered for the study. After filling the tank, the test plate is placed and loading is given. The test is conducted on unreinforced, reinforced and reinforced The load is given until the plate fails. The dial gauge has to be attached to the plate to measure the settlement and load. The test is repeated by varying the size of geotextile and depth of the reinforcement layer. The experimental model is shown in figure 2.

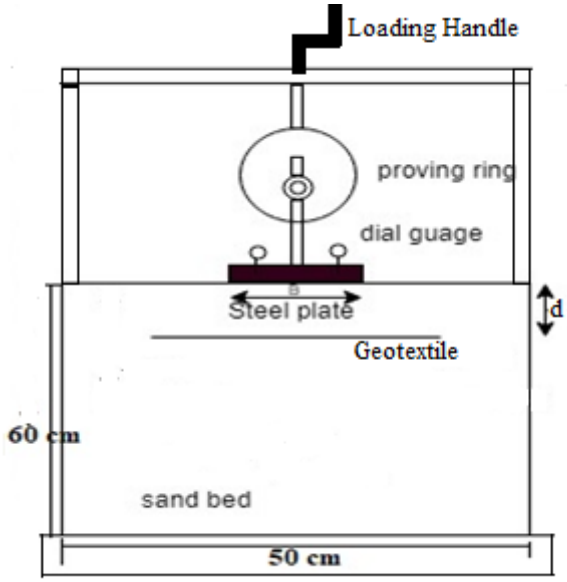

Figure 2.Experimental model

A. Laboratory Model Testing

The dimension of testing tank is 600mm x 600mm x500mm.The sand is filled at the relative density of 50%. The sides of the tank are smoothened for avoiding friction effect. The tank is made of metal sheet. Tank is filled with sand as shown in figure 3.

Figure 3.Testing tank

B. Model Footing

Model square footing made of mild steel is used. The width of the footing is 10 cm. The dimension of the footing is selected according to the model tank dimension. Lateral dimension of tank should be 5 to 9 times the width of the footing (B). (16).

C. Loading Setup

The tank was made of mild steel and has adequate stiffeners provided at required positions, in order to withstand enough load acting on it. A strong base is also provided for the tank (Figure4) In order to apply the load; a frame is constructed and fixed on the top of the tank using proper fixing mechanisms. A proving ring is also attached to it, so as to measure the applied load. The load was applied manually. The applied load is distributed equally to both the adjacent footings and settlement corresponding to each load is noted. The settlement is measured by means of dial gauges of least count 0.01 mm. In order to maintain a constant loading result, the footings are loaded to a settlement value equal to 10% of footing width.

Figure 4.Loading mechanism

IV. Results and Discussions

A. Study on Unreinforced Sand

The bearing capacity is found out by conducing plate load test on testing tank filled with sand at a density of 15 kN/m ^{3} in four equal layers. The footing of size 10 cm X 10cm was placed over the sand provided with loading setup. The load corresponding to 10mm settlement of footing is noted. Unreinforced sand gives a bearing pressure of 82 kN/m ^{2} for 10mm settlement of footing. The load intensity- settlement graph is shown in figure 5.

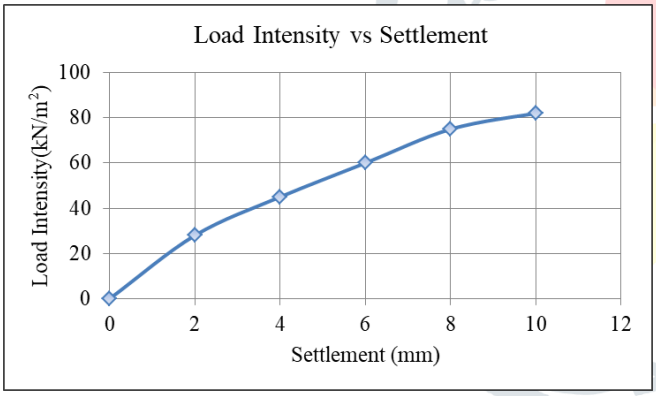

Figure 5.Load settlement graph for unreinforced sand

B. Study on Geotextile Reinforced Sand

Test conducted on 20cm, 25cm and 30 cm geotextile at different depth varying from 0.5B To 1.25B were B is the width of the footing. The load corresponding to 10 cm settlement is noted. As the size of the geotextile increases the bearing capacity of the sand increases. When 20 cm geotextile was provided the bearing capacity increases to 107kN/m^2. 20 cm geotextile provide 30% increase, 25cm shows 65% increase and 30 cm shows 100% increase in bearing capacity than unreinforced sand. Increase in size of geotextile provides 1.25 fold improvement in bearing capacity than previous size. The load intensity – settlement graph is shown in figure 6.

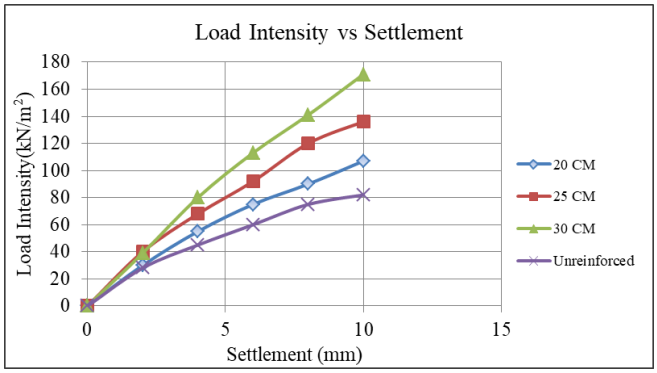

Figure 6.Load settlement graph for geotextile at 0.5B depth

C. Study on Geotextile Reinforced Sand with Cement Interface

To improve the bearing capacity of the geotextile the geotextile is treated with cement interface. Both sides of the geotextile are treated with cement at 2mm to 3mm thickness. Tests are conducted on 20cm, 25cm and 30cm with cement treated geotextile at 0.5B. Cement treated geotextile was tested at 5cm depth from the base of the footing. The load corresponding to 10mm settlement is noted. The bearing capacity increases with increase in the size of the geotextile. The 20 cm cement treated geotextile provides 86%, 25 cm size provides 126% and 30cm size provides 135% increase in bearing capacity than unreinforced sand. Increase in size of geotextile provides 1 to1.2 times improvement in bearing capacity than previous size. Comparing with the ordinary geotextile the cement treated geotextile provides better improvement for reduced size than ordinary geotextile. The load intensity – settlement graph is shown in figure 7.

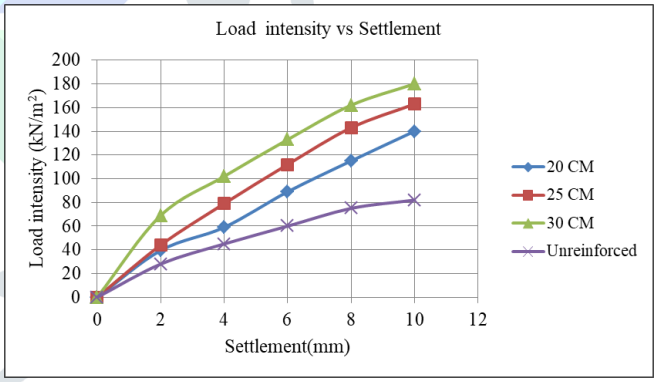

Figure7.Load settlement graph for geotextile with cement interface at 0.5B depth

When the cement interface was provided for ordinary geotextile the bearing capacity values increases. The cement treated geotextile provides higher bearing capacity for lower size than ordinary geotextile. The bearing capacities of the different size geotextile at different depth are summarized in the table 3.

Table 3 Bearing capacity of geotextile

Size/Depth	***20 CM***	***25 CM***	***30 CM***
0.5B	107 kN/m^2	136 kN/m^2	171 kN/m^2
0.5B (geotextile with cement interface)	153kN/m^2	181kN/m^2	193kN/m^2

V. CONCLUSION

A laboratory model study were conducted to evaluate the effect of cement interface on sand and geotextile on the bearing capacity of square footing on geotextile reinforced sand at 0.5B depth by varying size of geotextile.

- The size of the geotextile increases the bearing capacity increases in both cases and 30 cm sized geotextile gives higher value.
- By inclusion of ordinary geotextile the bearing capacity of sand increases by 1 to 2 times than unreinforced sand.
- When cement treated geotextile was used the bearing capacity of sand increases 1.8 to 2.3 times than unreinforced sand.
- Comparing bearing capacity values reinforced sand with geotextile and geotextile with cement interface, cement treated geotextile provided better improvement of about 10% to 45% increase in bearing capacity than ordinary geotextile.
- The cement treated geotextile provide more improvement than ordinary geotextile at smaller size.

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