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PERFORMANCE STUDY OF GEOCELL REINFORCED CLAY BED SUBJECTED TO STATIC LOADING

Akshaya Subadharshini R[1], Dr. Jeyapriya S.P[2]
Department of Geotechnical Engineering, Government College of technology, Coimbatore, India

Abstract: Geocells are three dimensional systems with polymeric, honeycomb like structure of filled units interconnected at joints. The interconnected filled cells form a system that acts like a large mat that spreads the load from the footing over a wider area, resulting in an overall improvement in the performance of the foundation. This study investigates the behaviour improvements in the load bearing capacity of clay soil reinforced with geocell filled with two trails with two different infill materials namely sand and aggregate. A series of model tests were conducted on a square footing of size (70mm x 70mm x 10mm) resting on the surface of clayey soil to study the behavior of geocell reinforced system. The results indicate that with the aid of geocell reinforcement, the load bearing capacity of clay bed increases and thereby a reduction in surface heaving of the foundation bed was observed. The improvement in the load carrying capacity was higher for geocell filled with aggregate compared to sand. This is attributed due to mobilization of higher passive force at the geocell walls and frictional resistance at the soil interface. The test demonstrates that provision of geocell distributes the footing load to wider area and that results in improving the load carrying capacity of clay bed.
Keywords: Geocells; infill materials; load carrying capacity; clay soil; surface heaving

I. INTRODUCTION

For any structure to last for a long time, its substructure has to stand firm and must be capable of transfering the whole load of the structure to the ground. For an effecient load transfer, the soil over which the foundation has been laid plays a very critical role. Due to space constrains many constructions has to take place over poor soil. Constructions over weak soil with high intensity loads brings a huge challenge for the civil engineers. Removing the poor soil and replacing it with stronger soil or by improvising the engineering properties of the poor soil with ground improvement techniques are adopted in this situation. Even if such soil are uneconomical to remove and replace, then ground improvement techniques are used. Reinforcement of soil is one of the most popular technique among ground improvement techniques.

The geotechnical environment was completely revolutionized with the application of geosynthetics of different kinds, starting with the humble non-woven to the more complex geo-composites. Among various geosynthetics known are two-dimensional. Lateral confinement in geocells provide an additional dimension to geosynthetics, which brings out many applications, ranging from enhancing strength to geo-systems, to protection of soil against erosion.

II. EXPERIMENTAL SETUP

The model tests were conducted in a steel framed tank of length 500mm, width 500mm and depth 300mm. The model square footing, made of steel, had sides 70 x 70 mm, and thickness of 10 mm, and the model footing was centered in the tank and the bottom surface of the test footing was roughened by a coating of thin layer of sand with epoxy glue. The test tank was prepared with a clay bed of 200 mm depth and the clay bed was cured for one full week to attain uniform properties throughout the clay bed. After leveling the clay bed, a layer of geocells was placed on top of the clay bed by cutting the geotextile from full rolls to the required length and breadth and placing them in longitudinal and diagonal directions with bodkin connections. The tensile strength properties of the geocell employed in this model tests were determined from wide width tensile strength tests and presented in Table 1.

Table 1: Tensile strength properties of geocell

Properties	Standard	Values
Mechanical Properties		
Tensile Strength	ASTM D 4595	8 kN/m
Elongation	ASTM D 4595	>50%
Grab Tensile Strength	ASTM D 4632	540 N
Grab Tensile Elongation	ASTM D 4632	>55%
Trapezoidal Tear Strength	ASTM D 4533	250 N
Puncture Strength (CBR)	ASTM D 6241	1700 N
Physical Properties		
Mass /Unit Area	ASTM D 5261	200 g/m^2
Thickness	ASTM D 5199	1.5 mm

Natural clay with specific gravity 2.72 was used to prepare the foundation bed. The liquid limit and plastic limit of the clay used were 46% and 27% respectively. As per Unified Soil Classification System (USCS), the test clay was classified as (CL). The optimum moisture content (OMC) and maximum dry density ($\gamma_{d,\ max}$) of the clay in the Standard Proctor test were 16% and 16.88 kN/m^3 respectively.

Dry sand and aggregate was used to fill the geocell pockets. Sand was having specific gravity 2.59, effective particle size (D_{10}) 0.23 mm, coefficient of uniformity (C_u) 3.48, coefficient of uniformity (C_c) 0.91, angle of internal friction (φ) 36˚. As per Unified Soil Classification System (USCS), the infill sand was classified as (SP). Aggregate has a size range of 2mm – 10mm, specific gravity 2.65, and impact value 20%, water absorption 0.67%.

The commercially available geotextile were used to form geocells as the reinforcements and the Geocell system was placed on top of the prepared clay bed. The geocell layer was prepared by cutting the geotextile to required length and height from full rolls and placing them in transverse and diagonal directions by sewing them. All the geocell layers in the present investigation are prepared in diamond pattern.

Dimensions of the geocells are 106 x 106 x 100mm. After placing of geocell; the geocell pockets were filled with sand by employing Sand raining technique and another trail was done by filling the pockets of geocell formation with Aggregates. The free-fall height from Sand raining technique was obtained by conducting a series of trials with different heights of fall.

III. TEST PROCEDURE

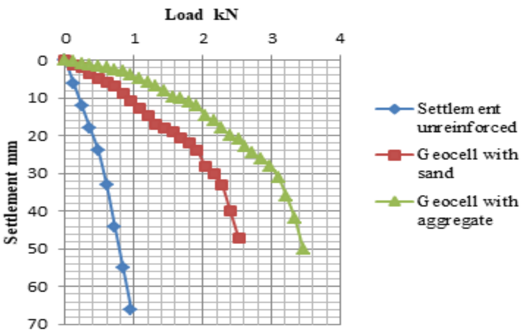
The model tests were performed on unreinforced and reinforced geocell system rested over soft clay bed in a square steel tank of inner dimensions as 500 x 500 x 300mm. A steel plate with sides 70 x 70 mm, and thickness of 10 mm was used as model footing.

A setup was arranged to transfer the vertical loads to the model footing. The footing was pushed into the soil at a rate of nearly 2mm/min and the load given to the model footing was checked with the help of a proving ring of capacity 50kN placed between the ball bearing and the loading frame. A setup with Linear variable differential transformers (LVDTs) were employed to measure the settlement as well as to note surface deformation in the clay bed. Two LVDTs (front movable spindle) were placed at a diagonally opposite side of the centerline of the loading plate to measure its vertical settlement during loading. The loading was continued up to maximum 40-mm footing settlement considering the maximum capacity of the LVDTs. The footing settlements data reported here are the average of the readings taken at two exactly opposite points.

IV. RESULTS AND DISCUSSIONS

The bearing pressure versus settlement responses of the footing for geocell reinforcement in the foundation bed with two different infill materials are shown in the figure 1.

As the vertical load in the present tests were transferred through a hydraulic jack and the data were recorded manually at certain intervals. A dense sand system tends to expand in volume under footing load, thereby mobilizing higher strength in geocell reinforcement, resulting in higher performance improvement. From the graph showing, Bearing pressure versus settlement responses for unreinforced soil; settlement in the clay bed increases with load and there is a large settlement even with a slight increase in load. Settlement increases linearly with load and no definite failure point was observed in the curve. The failure load recorded for unreinforced clay bed was 0.8kN.



The geocell-reinforced soil beds without showing any much failure continue to sustain increased footing loading. The geocell-reinforced bed with sand as an infill material showed no pronounced peak even up to a settlement as high as 40mm. The failure load recorded for this case was found to be 2.5kN. The increase in value is attributed due to placing of geocell with sand that has more relative density, angle of internal friction and weight compared to the clay soil. In the case of clay bed reinforced with the provision of geocell filled with Aggregate on top of clay bed, the failure load increased to a magnitude of about 3.5kN, this is because of geocell filled with aggregate, has more stiffness and weight compared to that of unreinforced clay. The load carrying capacity of the geocell-reinforced clay bed has significantly increased when compared to unreinforced clay bed.

The load settlement response with geocell reinforcement is found to be much stiffer than those of the unreinforced one indicating that the geocell reinforcement can reduce the footing settlement substantially. This comparison analysis is made keeping the quantity of geocell material same in both cases of test. From the load-settlement response it is seen that the unreinforced clay bed is lower stiffer than the geocell reinforced clay bed.

V. CONCLUSION

Based on results obtained from the present investigation, the load settlement behavior of square footing resting on Geocell reinforced sand and geocell reinforced aggregate underlain by soft clay were studied and the following conclusions were made.

- Load carrying capacity of square footing resting on geocell filled with sand was found to be 3.125 times that of the unreinforced soil.
- The geocell filled with Aggregate offered an improvement of 4.375 times than that of unreinforced clay.
- It was observed that geocell filled with aggregates increase the load carrying capacity than that of Sand because of its higher stiffness and strength.
- The higher performance due to the geocell reinforcement with that of unreinforced soft clay bed is due to the mobilization of higher passive force at the walls of the geocell and frictional resistance at the geotextile soil interface.
- The test results demonstrate that provision of geocell will distribute the footing load to wider area that results in improving the load carrying capacity of clay bed.
- The Load-settlement behavior and reduction in surface heaving of clay bed were significantly improved with the aid of Geocells.

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