Improvement of soil bearing capacity using geocell Reinforcement

[1]Kher Bhavanisinh Ranjitsinh, [2]Maradia Kashyap Vinodbhai, [3]Manali Pravinkumar Vaghela, [4]Pooja Bhojani
[1]Student, [2]Student, [3]Student, [4]Temporary Assistant Professor
M S University The Faculty Of Technology And Engineering , Baroda.

***Abstract* - Foundation is the base of any type of structure, may it be a single storeyed building to the heaviest structure like dams. For the foundation, the factor that plays a very important role is the bearing capacity of soil. Generally, for any type of soil, the required bearing capacity should always be more than the designed load of foundation, but it is not the same for all cases. Sometimes the bearing capacity of soil is not as good as required, which ultimately leads to settlement. There are many approaches to for improvement of bearing capacity. One of them is use of geo-synthetics materials, they are polymeric products mainly used to solve civil engineering problems. The main product categories used in civil engineering are geo-grids, geomembranes, geosynthetic clay liners, geocells, geocomposites, etc. The present study gives us the idea of increment of bearing capacity-using geocell as a reinforcing material.**

***keywords* - Bearing capacity, geo-cell , soil improvement**

I. Introduction

Recently, the combination of the limited supply of land and man's economic growth, has forced engineers to build structures where they are required, almost irrespective of soil conditions. Further for any type of foundation or any construction, in the base of foundation hard strata is required to perfectly transfer the load of structure without any failure in the soil. Soil has mainly two characteristics depending upon weathering conditions, namely low shear strength and tensile strength. The main objective of geocell reinforcement is to improve soil stability, increase bearing capacity and reduce differential and uniform foundation settlement. Geo-synthetics are synthetic products used to stabilize terrain. Geo-synthetics are available in a wide range of forms and materials. These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, geo-environmental, hydraulic and private development applications.

II. Geocell

In the late 1970's, Presto co-invented the technology known as cellular confinement with the US Army Corps of Engineers Waterways Experiment Station (WES). The early applications of cellular confinement or geocells consisted primarily of stabilized, expedient sand roads for military vehicles.

Dash et al. (2001) performed laboratory tests on strip footing supported by a sand layer with geocell of varying height as reinforcing material. He concluded that with the increase in cell thickness, load-bearing capacity also increases, in which cell thickness ranges up to twice the width of footing.

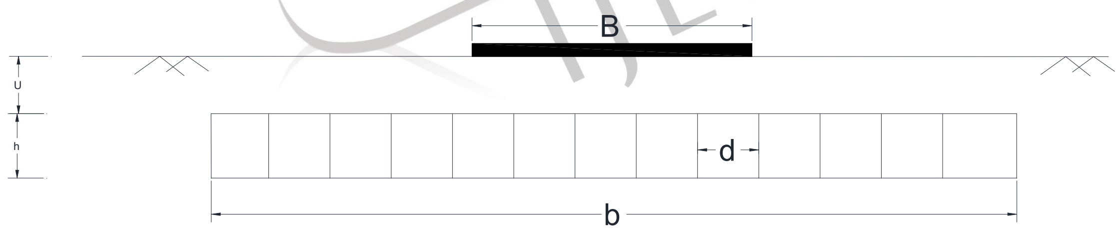
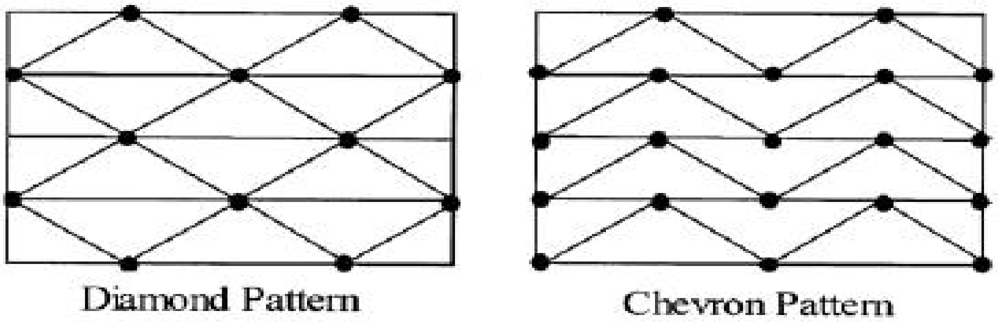


Fig.1 Schematic sketch of experimental setup used by dash et al (2001)

Dash et al. (2003) in his ensuing study, performed tests on circular footing of sand underlain by soft clay with geocell. In this case, width and height of geocell were taken as variables.

Krishnaswamy et al. (2000) performed test over soft clay reinforced with geocell. For the construction of foundation over soft clay, diamond and chevron patterned geocell of uniaxial and biaxial geogrids were used. The performance of chevron and diamond patterns came out to be identical.

(a) (b)



(c) (d)

Fig.2 The typical configurations of geocell reinforcement elements (a)Perforated geocell (Bathurst and Jarrett, 1998) (b)Handmade geocell (Dash et al., 2003[6]) (c)Handmade geocell diamond pattern (Dash et al., 2003) (d)Handmade geocell chevron pattern (Dash et al., 2003)

III. Material properties

The backfill material used was expansive soil of CL type which was obtained from Virod was tested for various geotechnical engineering properties such as particle size distribution, Atterberg limits, Triaxial test, Free swell index, etc.

Table 1 Properties of soil

Sr. No.	Soil properties	Results
1	In-situ density (gm/cc)	1.885
2	Natural moisture content (%)	20.33
3	Gravel fraction (%)	0
4	Clay and silt fraction (%)	68
6	Sand fraction (%)	32
7	Liquid limit (%)	33.91
8	Plastic limit (%)	16.89
9	Plasticity index (%)	17.02
10	Maximum Dry Density (gm/cc)	1.735
11	Optimum moisture content (%)	17.33
12	Free swell index (%)	27.27
13	Triaxial test	C=0.253
		Ø=6°

IV. Origin and characteristics of Geocell

Geocells (also known as Cellular Confinement Systems) are three-dimensional, expandable panels made from high-density polyethylene (HDPE), polyester or another polymer material. When expanded during installation, the interconnected strips form the walls of a flexible, three-dimensional cellular structure into which specified infill materials are placed and compacted. This creates a free-draining system that holds infill materials in place and prevents mass movements by providing confinement through tensile reinforcement. Cellular confinement systems improve the structural and functional behavior of soils and aggregate infill materials. Geocells are used for erosion control, ground stabilization, retaining walls, slope and channel protection, reservoirs and landfills. Geocells with different aspect ratio and heights corresponding to their varying shapes, sizes and material are used.

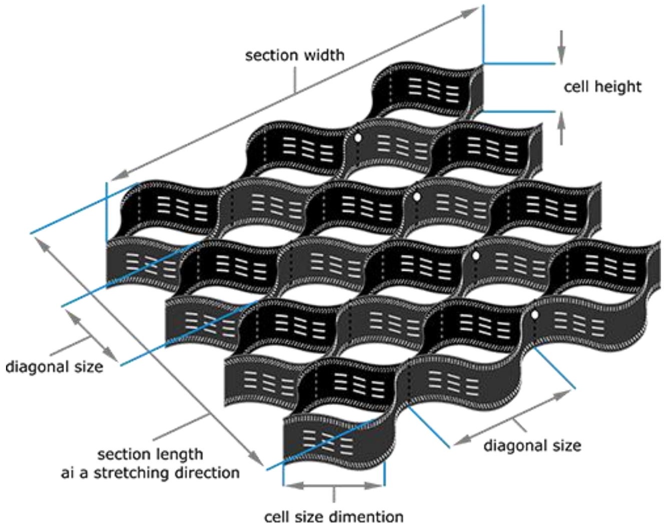


Fig. 3 Schematic diagram of geocell

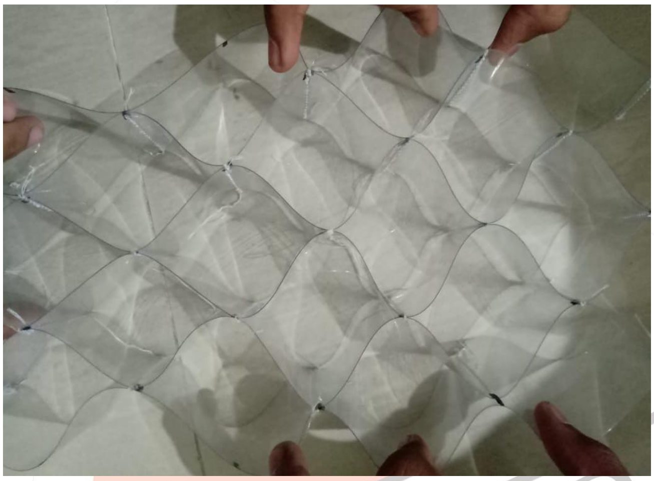


Fig.4 Photograph of geocell used in tests

Table 2 Properties of geocell

Sr. No.	Soil properties	Values
1	Polymer	Polyvinyl Chloride
2	Cell dimensions (mm)	
	Diagonal size (along length)	65
	Diagonal size (along width)	60
3	Number of cells (/m²)	270
4	Mass per unit area (gm/cm²)	0.035
5	Cell depth (cm)	3
		5
6	Strip thickness (micron)	250
7	% Open area	16

V. Experimental Investigation

All tests are performed in model tank 0.84 m x 0.2 m x 0.5 m size. The model tank was placed in a reaction frame fabricated from mild steel pipe and mild steel channel section. For backfilling with soil firstly, the wooden panel was placed as facing, after that one-fourth part of backfill material i.e., soil was thoroughly mixed with water at optimum moisture content 17.33% in a tray and was laid as first layer. Laying each layer a container was kept in order compacted using a rammer of size 10cm x 10cm and weighing 4.68 kg to achieve desired dry density. To achieve the dry density of 1.735 gm/cc soil was divided in four equal part laid in 10cm layers and was compacted to its desired density, and geocell was placed at varying heights from top. Loading surface of reinforced earth at the top was made fully leveled using level tube. The mild steel strip footing (test plate) size 10 cm x 20 cm x 2 cm thick as shown in Fig. 6 was firmly seated at the center inside the tank. Geocell of height 3cm or 5cm was placed at center of footing, one at the top and other at depth 5cm from the top face.

Fig. 5 Placement of geocell

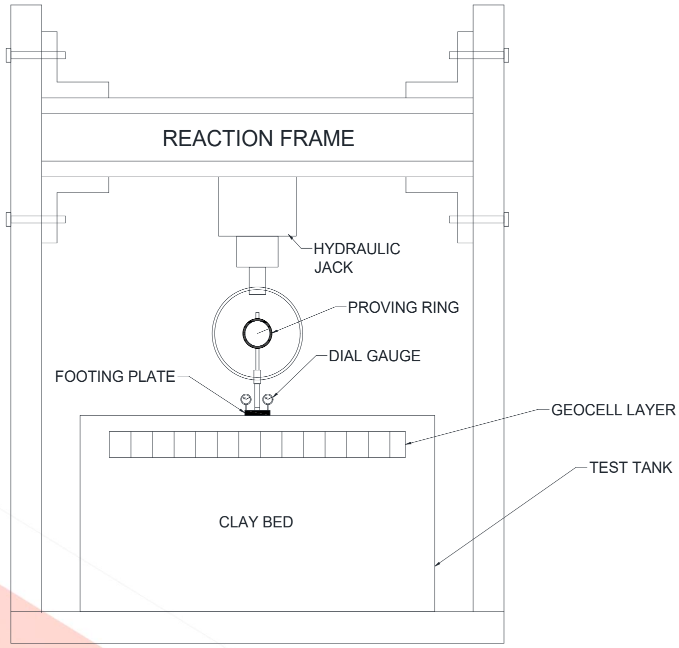


Fig. 6 Loading mechanism for load test

Mechanical screw jack was used for axial loading. Settlement was recorded with two dial gauges each one placed at the opposite corners with sensitivity 0.05mm. After completion of all arrangements, initially a seating load equivalent to 70kPa contact pressure was applied until there was no further settlement of plate. After that, the increments of load equivalent to 100 kPa were applied until the rate of settlement was negligible. The process of load increment was continued until reinforced earth failed or it reaches maximum settlement of 25mm, whichever is earlier.

VI. Result, analysis and discussion

The reading of loading intensity and settlement of footing was plotted on graph to obtain ultimate bearing capacity of the footing. The main objectives of the study were to perform plate load test on footing as follows:

A. To examine load settlement characteristics of footing on the top surface of soil
B. To study the behavior of reinforced earth with geocell at center of each layer of heights 3cm or 5cm
C. To study the behavior of reinforced earth with geocell at center of each layer of heights 3cm or 5cm with depths varying, one at the top and other at 5cm from the top face.

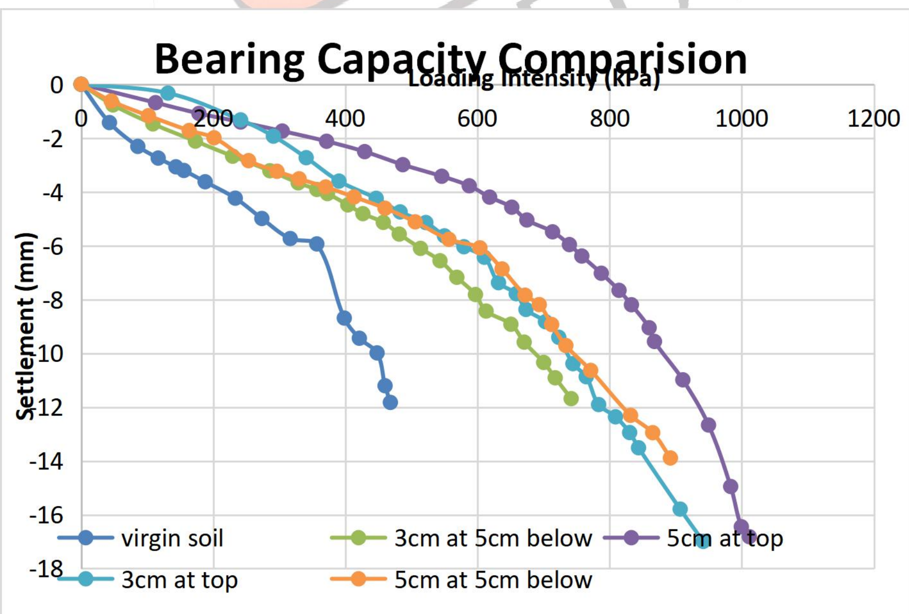


Fig. 7 settlement vs loading intensity for variation of geocell

Figure 7 shows the loading intensity v/s settlement characteristics. On comparing the magnitude of settlement of unreinforced and reinforced soil, the latter comes out to be very less, under same loading intensity. Due to geocell, foundation soil gets confined and rigidity increases which causes reduction in settlement.

From the loading intensity v/s settlement curve it can be seen that the behavior is almost linear till it reaches ultimate bearing capacity, then it turns to curvilinear with concave downwards. Due to the provision of geocell mattress there is increase in the bearing capacity of footing and it stabilizes against rotation.

After performing the tests on properties of soil, using these properties test for bearing capacity were performed by applying different variations of placement of geocell layer. Results obtained for ultimate bearing capacity are as below:

Table 3 Ultimate bearing capacities for various combinations

Sr. No.	Variations	Ultimate Bearing Capacity(kPa)
1	Virgin soil	441.20
2	Virgin soil + 3cm geocell at top	683.02
3	Virgin soil + 3cm geocell at 5cm depth	617.50
4	Virgin soil + 5cm geocell at top	851.70
5	Virgin soil + 5cm geocell at 5cm depth	736.36

From the above results of ultimate bearing capacity, maximum increment comes out to be 93.04% for virgin soil with 5cm geocell on top surface.

VII. Conclusion

From the result of the present study, it is concluded that the soil stabilization using geocell as reinforcement is a very effective process to strengthen the soil and to improve the bearing capacity. In addition, it can be concluded that:

A. As the height of geocell increases the load carrying capacity increases
B. As the depth of the reinforcement in the tank increases, bearing capacity decreases.
C. By the use of geocell, the failure takes place due to settlement and not due to rupture.

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