Effect of Geocell on the behaviour of Soil

Dharmesh Lal^1, K. Laxmi Prasanna^2, K. Rohith Rao^3, Prithhe Kamalekkar^4, J. Bajrang^5

^1Assistant Professor, Department of Civil, Vardhaman College of Engineering, Hyderabad, India
^2,^3,^4^,^5 B.Tech Student, Department of Civil, Vardhaman College of Engineering, Hyderabad, India

E-mail: dharmeshlal34@gmail.com

Abstract. As the use of plastic has rapidly increased in past few years, attempts are made to use it as reinforcement material to escalate the soil properties. For the present study, plastic bottles are cut and made into geocell to use it as the reinforcement to the soil. Use of plastic as reinforcement has great advantages, as it is low cost and easily available. Results of plate load tests on soil and plastic bottle reinforced soil are presented and compared. Finally, it is observed that plastic bottle reinforced soil provides improved performance when compared to that of unreinforced one. An improvement of 1.86 times the plain sand is attained when plastic bottle reinforcement was used.

1. Introduction

Reinforced earth is relatively new construction technique, which has only been used commercially for past 40 years or so for Bearing capacity Improvement. Engineers effectively use soil as a reliable construction material in civil engineering application by introduction of the sand reinforcing techniques.

In this present study, an attempt is made to stabilize natural sand with the use of plastic geocell. The term geocell has two parts, first is “geo” which means earth or soil and second is “cell” which means cellular type of shape for infill material such as soil. Geocell confinement effectively increases stiffness and strength of soil, while reducing vertical settlement and lateral spreading of stress. Use of geosynthetics as reinforcement for improving the performance of shallow foundations has been studied by engineers over the past two decades. But most developed and developing countries all over the world have huge resources of waste materials. They should be banned for the better good of the environment for a sustainable world.

The current work deals with the plate load test data of plain sand and plastic bottle geocell reinforced sand. The results obtained for the unreinforced and reinforced sand with plastic geocell are compared. It was observed that reinforced sand has more bearing capacity than unreinforced sand. The confinement effect of geocell on reinforced sand beds were studied by [1]. The occurrence of an apparent cohesion was observed by [2-5]. Effect of plastic as soil reinforcements was studied by [4]. The tensile strength was the sole reason for the additional strength. Similar remarks were made by [6,7]. The studies revealed an escalation is soil strength with the addition of plastic.

2. Test materials
2.1 Sand
Sand was collected from a nearby river source. The size distribution and properties of the collected sand is shown in Fig.1 and Table 1 respectively. The properties of soil were calculated according to the standard Indian codes.

![Figure 1 Grain size distribution of sand](image_url)

**Table 1. Properties of soil**

| Property value                          | Value   |
|----------------------------------------|---------|
| Specific gravity                       | 2.37    |
| Effective size ($D_{10}$)              | 0.30    |
| Uniformity coefficient ($C_u$)         | 2       |
| Coefficient of curvature ($C_c$)       | 1.02    |
| Dry density (Max) kN/m$^3$              | 17.8    |
| Dry density (Min) kN/m$^3$              | 15.63   |
| Angle of friction from direct shear test | 25°     |

2.2 Plastic bottles
Plastic bottles used in this study is locally available in the stores (Bisleri bottle).
The bottles were cut and made into geocells (Figure 2). Plastic bottle dimensions are: Height – 8cm; Length: - 20cm; Width: - 20cm. A similar process was done by [8,9].

3 Test set up and procedure
Tests were conducted on a 900mm x 900 mm x 900mm test tank (Figure 3). For model circular footing (Figure 4), the dimensions were 150 mm diameter and 25 m height.
Figure 4 Circular footing

The layout the test tank and reinforcement is shown in the figure 5. The parameters u, b & B are explained in the figure. The depth and width are standardized by dividing with the foundation width for wider applicability [10, 11].

Figure 5 Layout of Reinforcement

Relative density of 55% was adopted because medium dense is the most common condition in the field. Weight of the sand required to achieve this condition was found out mathematically. Sand was emptied in the test tank and vibrated with the electric vibrator as shown in the figure 6 to get the required relative density. Plastic bottle geocell was then placed in the test tank after proper levelling. After proper placement of geocell reinforcement as shown in figure 7, sand was put up to the footing.
Circular footing was placed centrally after filling the sand till the top such that distribution of load is homogeneous throughout. Above the footing, hydraulic jack was carefully placed as shown in figure 8. The load values are noted for regular interval of time and bearing capacity is calculated by plotting a graph between Settlement and bearing pressure.
4 Results and Discussion

4.1 Comparison between reinforced and unreinforced soil

Figure 9 shows the Results of plate load tests on plain soil and plastic bottle reinforced soil placed at different levels. Plastic geocell escalates the performance of sand through the reinforcement effect provided. It shows that optimum depth of placement is at 0.3 since the maximum settlement occurs at the top but further at u/B = 0.1 the reinforcement gets damaged due to foundation. Therefore, overburden sand is required, which prevents contact with footing and the reinforcement.
As soil generally fails with lateral spreading, however the reinforcement prevents this spreading and hence enhances the bearing capacity of soil. Figure 11 shows that improvement factor increases up to \( u/B = 0.3 \), and thereafter, a decrease was indicated. Table 2 shows the list of bearing capacities of both unreinforced and reinforced sand.

### Table 2. Bearing capacities of reinforced and unreinforced sand

| REINFORCEMENT DEPTH | BEARING CAPACITY (kPa) |
|----------------------|------------------------|
| Plain sand           | 320                    |
| 0.1                  | 530                    |
| 0.3                  | 597.64                 |
| 0.5                  | 463.52                 |
| 1                    | 376.47                 |

### 5 Improvement factor

Improvement factor can be calculated by eq (1). Table 3 shows the list of improvement factors of reinforced sand and Figure 11 shows the graph between placement of geocell vs Improvement factor. This factor gives an idea of how much enhancement has taken place in soil.
Improvement Factor = Bearing capacity of plastic bottle reinforced/ Bearing capacity of unreinforced

\[ \text{eq (1)} \]

![Figure 10 Placement of geocell vs Improvement factor](image)

6. Conclusion
In the present study, plastic bottles were cut and made into geocells. The major observations that can be seen from the study are:

1. Placing of plastic geocell have increased the soil strength
2. It was found that optimum depth was at \( u/B = 0.3 \) i.e. at 4.5cm from the surface of the sand.
3. An improvement of 1.86 times the plain sand is attained when plastic bottle reinforcement was used.

Acknowledgement

The authors would like to thank Dr. HariprasadChennarapu for his invaluable support and Mahindra Ecole Centrale for giving permission to conduct the experimental study in the college.

References

[1] AdemIsik, AyhanGurbuz, 2019. Pullout behavior of geocell reinforcement in the cohesionless soils. Geotextiles and Geomembranes, 48 (1), 71-81.
[2] GhotbiSiabil M, S N MoghaddasTafreshi, A R Dawson, 2020. Response of pavement foundations incorporating both geocellsnd expanded polystyrene geofoam, Geotextiles and Geomembranes, 48 (1), 1-23.

[3] KoushikHalder, Debarghya Chakraborty, 2020. Influence of soil spatial variability on the response of strip footing on the geocell-reinforced slope, Geotechnics, 122, 103533

[4] Dash, S.K., Rajagopal, K., Krishnaswamy, N.R., 2004. Performance of different geosynthetic reinforcement materials in sand foundations. Geosynth. Int. 11 (1), 35–42.

[5] Mehrjardi G T ,Behrad R, MoghaddasTafreshi S N, 2019. Scale effect on the behaviour of geocell-reinforced soil, Geotexlites and Geomembranes, 47 (2), 154-163.

[6] Lal D, Sankar N, Chandrakaran S 2017. Effect of reinforcement form on the behaviour of coir geotextile reinforced sand beds. Soils and Foundations, 57(2), 227–236.

[7] Lal D, Sankar N, Chandrakaran S 2018. Effect of reinforcement form on the behaviour of coir geotextile-reinforced sand through laboratory triaxial compression tests, International Journal of Geotechnical Engineering, 12 (3), 309-315.

[8] Lal D, Sankar N, Chandrakaran S 201. Behaviour of square footing on sand reinforced with geocell. Arabian Journal of Geosciences, 10(15), 345.

[9] Lal D, Sankar N, Chandrakaran S 2017. Surface heave behaviour of coir geotextile reinforced sand beds. J InstEng India SerA, 98(1–2), 121–125.

[10] Lal D, Sankar N, Chandrakaran S 2017. Performance of shallow foundations resting on coir geotextile reinforced sand bed. Soil Mechanics and FoundationEngineering, 54(1), 60–64.

[11] GholamhoseinTavakoliMehrjardi, FaribaMotarjemi, 2018. Interfacial properties of geocell-reinforced granular soils, Geotextiles and Geomembranes, 46 (4), 384-395.

[12] Khing K H , Das B M, Puri V K, Cook E, Yen S C, 1993. The bearing capacity of a strip foundation on geogrid reinforced sand, Geotext. Geomembr,12, 351–361.

[13] Krishnaswamy N R, Rajagopal K, Latha G M, 2000. Model studies on geocell supported embankments constructed over soft clay foundation. Geotech. Test. J, ASTM 23, 45–54.

[14] Latha G M, Murthy V S, 2007. Effects of reinforcement form on the behavior of geosynthetic reinforced sand., Geotex. Geomembr. 25 (1), 23–32.

[15] Latha, G.M., Somwanshi, A., 2009a. Bearing capacity of square footings on geosynthetic reinforced sand. Geotext. Geomembr. 27 (4), 281–294.

[16] Latha G M, Somwanshi A, 2009. Effect of reinforcement form on the bearing capacity of square footings on sand. Geotext. Geomembr. 27 (6), 409–422.

[17] Sanat k. Pokharel, Robert L. Parsons (2018), “Experimental evaluation of geocell-reinforced bases under repeated loading”, ijprt.2017.03.007, Volume 11, Issue 2, pages 114-127.

[18] Benson C H and KhireM, 1994. Reinforcing Sand with Strips of Reclaimed High-Density Polyethylene, Journal of Geotechnical Engineering, 121,838-855.

[19] Bueno, Benedito de Souza, 1997. The Mechanical Response of Reinforced Soils Using Short Randomly Distributed Plastic Strips, Recent Developments in Soil and Pavement Mechanics, Almeida (ed.) Balkema, Rotterdam, 401-407.

[20] Anas Ashraf, A Sunil, J Dhanya, M Joseph, M Verghese, M Veena, 2011. Soil Stabilization Using Raw Plastic Bottles,Proceedings of Indian Geotechnical Conference December, 15-17, Kochi (paper no. H-304).

[21] Akinmusuru J O, Akinbolade J A, 1981. Stability of loaded footings on reinforced soil, J. Geotech. Eng. Div, ASCE, 107, 819–827.

[22] Dash, S K, Krishnaswamy NR, Rajagopal K, 2001. Strip footing on geocell reinforced sand beds with additional planar reinforcement, Geotext. Geomembr, 19, 529–538.

[23] Sitharam TG and Sireesh S, 2004. Model studies of embedded circular footing on geogrid-reinforced sand beds, Ground Improvement, 28, No.2, 69-75.