LOAD CARRYING MECHANISM OF GEOCELL REINFORCED EARTH SLABS SUPPORTING A STRIP FOOTING

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ABSTRACT: This paper presents the results obtained from laboratory model tests on strip footings supported by homogeneous sand bed reinforced with geocell mattress. Observations on the pattern of deformations in the sand subgrade below geocell layer have been analysed to understand the laod carrying mechanism of the geocell mattress. The geocell reinforcement inhibits the formation of failure planes just below the footing thereby, transmits the footing pressure to a deeper depth. The load spreading angle (α) is found to be governed by factors such as; geometry of geocell layer, aperture opening size of the geogrid used to make geocell and density of the fill soil.

1 INTRODUCTION

The geocell foundation mattress consists of a series of interlocking cells constructed from polymer grid reinforcement, which contains and confines the soil within its pockets. The beneficial effect of incorporating geocell in soil fills has been reported by several authors e.g. Bush et al. (1990), Cowland and Wong (1993), Krishnaswamy et al. (2000), Dash et al. (2001, 2003).

Dash et al. (2001) through model tests have observed that the pressure settlement responses of a strip footing resting on geocell reinforced sand beds are approximately liner even up to a settlement of about 50% of the footing width and a load as high as 8 times the ultimate capacity of the unreinforced sand bed. This indicates that failure has not taken place even at this high settlement and an eight-fold increase in the bearing capacity of the strip footing can be obtained by providing geocell reinforcement in the underlying sand bed.

In this paper observations through laboratory model tests on the pattern of deformations in the sand subgrade below geocell layer have been analysed to understand the mechanism of load dispersion through the geocell layer.

2 TEST PROGRAM

The model tests were conducted in a steel tank measuring 1200 mm length × 332 mm width × 700 mm height. The length sides of the tank were made of thick perspex sheet and were braced with angle iron to avoid yielding during the tests. The model foundation used was made of steel and measured 330 mm length × 100 mm width × 25 mm thickness. The footing was centered in the tank, with the length of the footing parallel to the width of the tank. Since the inside width of the tank was chosen to be almost equal to the length of the model foundation (a difference of 2mm), a plane strain condition was generally maintained.

The soil used is a uniformly graded river sand (SP) with properties C_u = 2.318, C_c = 1.03, D_{50} = 0.46mm, γ_{max} = 17.410 kN/m^3, γ_{min} = 14.30 kN/m^3. Tests were carried out at relative densities (ID) of 30%, 40%, 50%, 60% and 70%. The peak friction angle of the sand at relative densities of 30%, 50% and 70% as determined from direct shear tests are 43°, 44.6° and 46° respectively. Three types of geogrids with different aperture openings (d_a) were used for forming the geocells. The geocell mattresses were prepared by placing the geogrid strips in transverse and diagonal directions with bodkin joints (i.e. plastic strips) inserted at the connections (Bush et al.1990). To achieve uniform density in the fill soil, sand-raining technique was used.

The footing was loaded by a hand operated hydraulic jack supported against a reaction frame. The load was applied incrementally. Settlements of the footing were measured by two dial gauges placed in diagonal directions. In the absence of a clear-cut failure, the footing was driven to a maximum displacement of 50 mm. The geometry of the problem is shown in Fig.1. The pocket size (d) of the geocells is taken as the diameter of an equivalent circular area of geocell pocket opening.

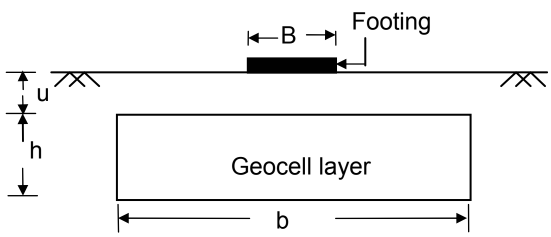

Figure 1 Geometric parameters of geocell reinforced foundation bed

The deformation pattern of subgrade soil below the geocell layer was observed by placing thin horizontal layers of white coloured sand at 50 mm vertical intervals. On completion of each test, the deformed shape of the coloured lines at different depths was recorded.

3 RESULTS AND DISCUSSION

For smaller height of geocell mattress (i.e. h/B ≤ 1.2) a classical general shear failure type rupture surface was noticed in the subgrade soil. But for higher heights of geocell mattress (h/B ≥ 1.6) shearing of the underlying sand layer did not take place even with footing settlement equal to about 50% of its width. The photographic view of the pattern of movement of soil below the geocell layer for (d/B = 1.2, h/B = 2, b/B = 8, u/B = 0.1, ID = 70%), at 50 mm footing settlement is shown in Fig. 2. The pattern of displacement of soil, were traced out on a transparent paper at the end of the tests for this case it has been observed that at a depth of about 2.85B, displacement of soil along the footing center line, is of the order of 8% of footing width and at a depth of 4B is around 2% of footing width. Whereas, in the case of strip footing on unreinforced sand bed, the maximum depth of failure wedge has been observed to be in the range of 0.9 to 1.1B. This establishes that the geocell mattress intercepts the potential failure planes and its rigidity forces them deeper into the underlying soil layer.

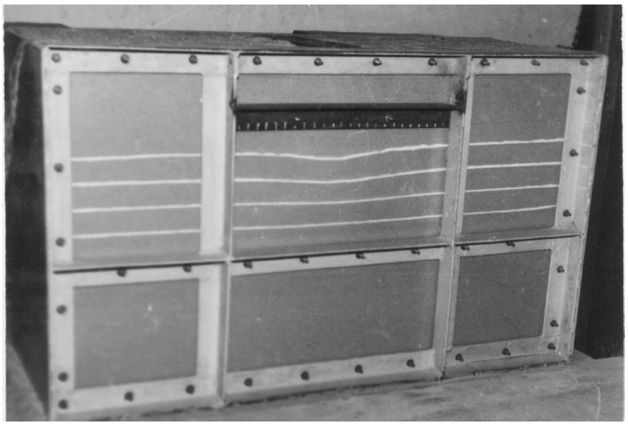

Figure 2 Photographic view of displacement pattern of soil particles below geocell mattress (d/B = 1.2, h/B = 2, b/B = 8, u/B = 0.1, ID = 70%)

Making use of the delineated rupture surface in the sand subgrade, the angle of load dispersion within the geocell layer was back calculated. The load dispersion angles for different cases are presented in Table 1.

Table 1 Summary of load dispersion angles (α)

d/B α°	1.2 41.6	1.5 38.8	2.7 33.6	- -	- -	- -
h/B α°	0.8 41.6	1.2 52.6	1.6 39.4	2.0 30.9	2.75 22.5	3.14 21.8
b/B α°	1 4.0	2 10.8	4 19.7	6 19.8	8 20.6	10 21.9
d_a/D_{50} α°	122.6 42.7	85.8 45.0	18.4 46.1	- -	- -	- -
ID% α°	30 29.1	40 30.4	50 32.9	60 35.7	70 36.8	- -

It could be observed that the load dispersion angle decreases with increase in size of geocell pocket opening (d). The rigidity of the geocell layer reduces with the increase in the size of the geocell pocket opening. Because of this, the footing load is transferred to the soil locally around the footing and hence a lower dispersion angle is obtained. The load dispersion angle (α) increases with increase in the width of the geocell mattress up to b/B ratio of 4 beyond which the increase in load dispersion angle is marginal. This shows that the geocell layer beyond a b/B of 4 does not significantly contribute to the improvement in the performance. The angle of load dispersion (α) is found to increase with decrease in the size of the aperture opening of geogrid because of the better confinement offered to the soil. The increase in the load dispersion angle with the increase in relative density of sand is believed to be due to better interaction between the geocell and the soil resulting from dilation of soil.

3 CONCLUSION

This paper has presented the results obtained from a series of laboratory sale model load tests carried out on strip footing supported by homogeneous sand beds reinforced with geocell mattress.

The test results indicate that the geocell reinforcement because of its rigidity intercepts the potential failure planes thereby transmits the footing pressure into a deeper depth, giving rise to an improved performance improvement. The load dispersion angle (α) that represents the quasi-rigid nature of the geocell mattress is found to be governed by factors such as geometry of geocell layer, aperture opening of the geogrid used to make geocell and density of the fill soil.

The findings from this study are useful in understanding the mechanism of the geocell reinforcement and will provide general guidelines for conducting large-scale tests and simulating through numerical models. The results from this study can be extrapolated to prototype cases using standard scaling laws (Butterfield 1999) with careful consideration of different parameters.

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