International Journal of Civil Engineering (IJCE)
ISSN 2278-9987
Vol. 2, Issue 3, July 2013, 123-128

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

BEHAVIOR OF BAMBOO GEOCELLS UNDER COMPRESSION LOADING CONDITION

SUSHOVAN DUTTA & JNANENDRA NATH MANDAL

Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, Maharashtra, India

ABSTRACT

In the present study, laboratory experimental investigations has been carried out on bamboo made geocells to check its efficacy as alternative encasements. A series of unconfined compression tests were carried out on single bamboo geocells filled with stone aggregates by a strain controlled Universal Testing Machine. The circular perforated cells were prepared by using easily available well finished bamboo sticks of 10 mm width. Each cell was surrounded by a multifilament woven jute geotextile from inner side to prevent the infill material from escaping out of the perforated cell. Diameters of the bamboo cells were 75 and 100 mm with varying heights of 50, 100 and 200 mm. Bamboo geogrid was prepared by sticking the bamboo sticks with adhesive to evaluate its wide width tensile strength. Opening size of the bamboo geogrid was same as that of the bamboo geocells. From the experimental investigation, it was observed that the smaller diameter geocell exhibits higher compressive strength at a particular deformation before failure. Also, the compressive strength of geocell increases with decrease in the height of geocell. The failure pattern of bamboo geocell is also reported in this paper.

KEYWORDS: Bamboo Geocell, Compressive Strength, Geogrid, Infill Material, Jute Geotextile, Opening Size

INTRODUCTION

Extensive research has been carried out on different types of geocell reinforcements. A practical construction procedure of geocell foundation mattress with basal geogrid reinforcement over soft foundation soil was reported by Bush et al. (1990). It was suggested to ensure that no cell was filled to full height before its adjacent cell was at least half filled to avoid potential distortion of the cell structure. Slip line field method was suggested for designing of geocells over thin foundation soil to support an embankment (Jenner et al., 1988).

Many authors have carried out their research on geocell mattress over sand (Dash et al., 2001; Moghaddas Tafreshi and Dawson, 2010) and soft clay (Mahiskar and Mandal, 1996; Dash et al., 2003; Emersleben and Meyer, 2010), triaxial study using geocell (Bathurst & Karpurapu, 1993; Rajagopal et al., 1999) and performance of embankment over a geocell mattress underlying soft soil (Cowland and Wong, 1993; Madhavi Latha et al., 2006). The influencing parameters considered were mostly the shape, diameter, height, infill material, tensile stiffness of the cell material and width of mattress.

From the available literature, it is evident that the extensive work has been carried out on different types of geocells. However, no attempt has been reported to prepare geocell with bamboo material. In the present study, an initiative has been taken to prepare the bamboo geocell by using locally available bamboo strips.

Multifilament woven jute geotextile was used to wrap the cells from inner side to prevent escaping of the infill material. Stone aggregates were used as infill material. The unconfined compressive strength tests were carried out on single bamboo geocells. The effect of diameter and height on the compressive strength of bamboo geocell has been studied and presented in this paper.

MATERIALS AND PROPERTIES

Bamboo Sticks

The circular perforated bamboo geocells were prepared by using easily available well finished bamboo sticks of 10 mm width. The tensile strength of the bamboo was determined according to ASTM D4595 for wide-width strip method. Wide width specimens of 200 mm width and 100 mm gauge length were prepared by attaching the narrow bamboo sticks from both directions with adhesive and tested as shown in Figure 1. The tensile strength-strain curve is shown in Figure 2. Some properties of bamboo geogrid are mentioned in Table 1.

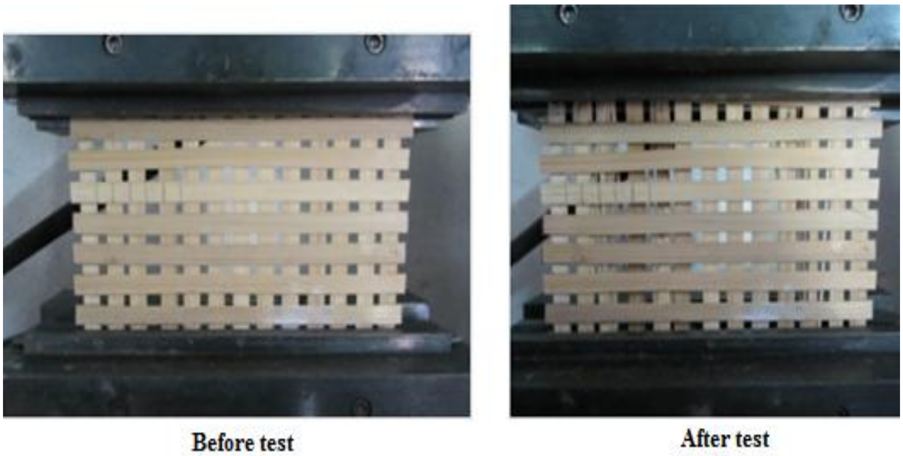

Figure 1: Wide Width Tensile Strength Test on a Bamboo Geogrid Specimen

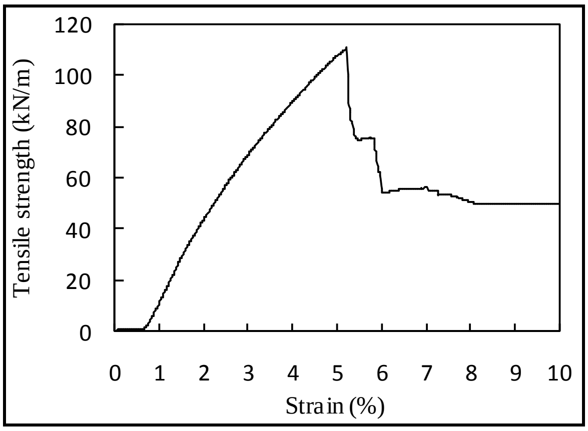

Figure 2: Tensile Strength-Strain Behaviour of Bamboo Geogrid

Table 1 Properties of Bamboo Geogrid

Materials	Properties	Value
Bamboo geogrid	Mesh size	10 mm x 10 mm
	Ultimate tensile strength	110 kN/m
	Strain at failure	5 %
	Ultimate tensile stiffness	2200 kN/m
	Thickness	1 mm

Jute Geotextile

Multifilament woven jute geotextile was used in the experimental study to wrap the bamboo cell from inner side. The tensile strength of jute geotextile is calculated as per ASTM D4595. Tensile strength in machine direction is 30 kN/m and in cross machine direction is 20 kN/m. The thickness of jute geotextile is 1.8 mm. Mass per unit area is 720 g/m^2 evaluated as per ASTM D5261. Each bamboo geocell was surrounded by a multifilament woven jute geotextile from inner side to prevent the infill material from escaping out of the perforated cell.

Stone Aggregates

Stone aggregate having size 2 to 10 mm with dry density 16 kN/m^3 and angle of internal friction 35° was used as the infill material in bamboo geocells.

PREPARATION OF THREE DIMENSIONAL BAMBOO GEOCELLS

Laboratory unconfined compression tests were performed on bamboo geocells of two different diameters 75 and 100 mm with three different heights as 50, 100 and 200 mm. The cells were prepared by sticking 10 mm wide and 1 mm thick well finished bamboo sticks with adhesive. Initially, horizontal rings of 75 mm and 100 mm outer diameter were prepared with an overlap of 40 mm. The rings were prepared by surrounding the sticks around a 98 mm diameter wooden mould. Afterwards, vertical sticks of desired heights were attached from outside of the horizontal rings with the help of adhesive maintaining an average square opening size of 10 mm × 10 mm to form the bamboo geocells. It was taken care of that the overlap portion of the horizontal rings must not be in a same vertical line to avoid quick failure. A woven multifilament jute geotextile was used to wrap around the geocells from inner side to prevent escaping of the stone aggregates. The geocells of 100 mm diameter before and after wrapping are shown in Figure 3.

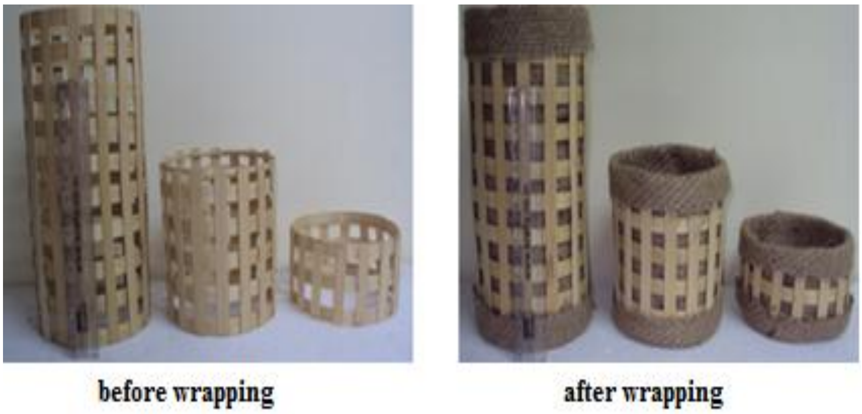

Figure 3: Bamboo Geocells before and after Wrapping (Heights 200 mm, 100 mm and 50 mm from Left to Right)

EXPERIMENTAL INVESTIGATION

Unconfined compression tests were carried out on the geocells with different diameter and heights filled with stone aggregates by Universal Testing Machine. The compressive load was applied at a constant strain rate of 1.2 mm/min till the specimen failed. The compressive strength test on bamboo geocell of 75 mm diameter before, during and after the test is shown in Figure 4. The failure load was recorded and expressed as the compressive strength.

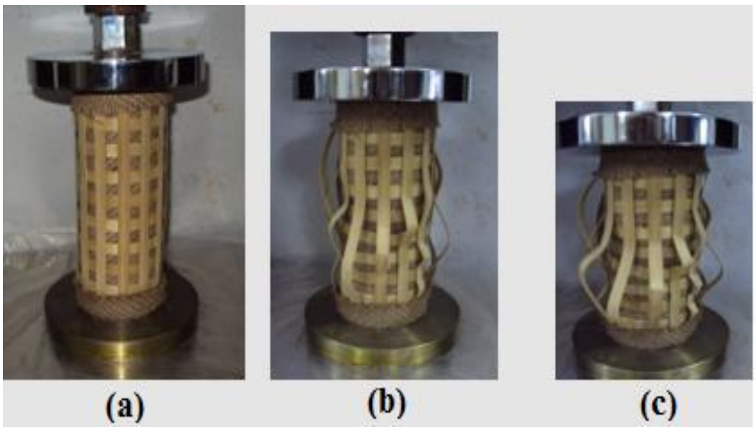

Figure 4: Unconfined Compressive Strength Test on Bamboo Geocell (a) before, (b) during, and (c) after Test

RESULTS AND DISCUSSIONS

From the experimental investigation it is found that the compressive strength of bamboo geocell varies with the variation in diameter and height. The failure pattern of the bamboo geocells is same for all the cases.

Failure Pattern

During compression, the vertical ribs got detached from the horizontal ribs at connections followed by buckling of the vertical ribs. Thereafter, breaking of the horizontal ribs took place under high compressive load. Similar failure patterns were observed for all the bamboo geocells.

Effect of Diameter (D)

For a particular deformation before failure, the 75 mm diameter geocell exhibits higher compressive strength. However, the 100 mm diameter geocell has undergone higher deformation before failure. Figures 5(a), (b) and (c) show the stress - deformation behavior of bamboo geocell with different diameters under compressive loading condition for heights 50 mm, 100 mm and 200 mm respectively.

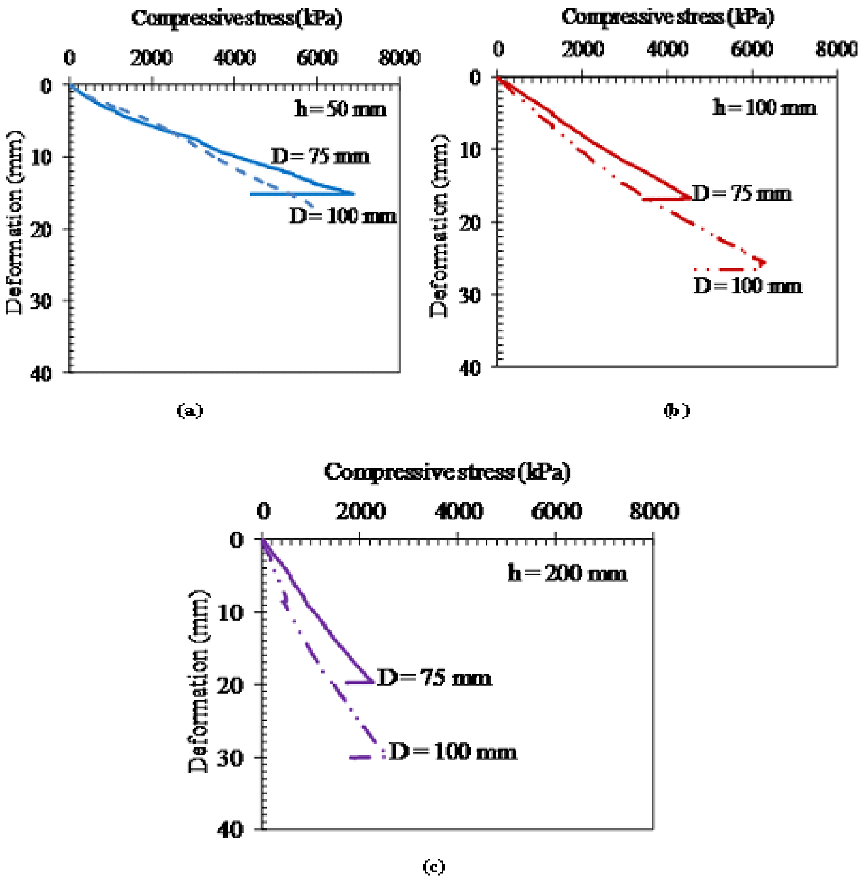

Figure 5: Stress - Deformation Behavior of Bamboo Geocell for Different Diameters under Compressive Loading Condition for Heights (a) 50 mm, (b) 100 mm, and (c) 200 mm

Effect of Height (h)

Compressive strength of bamboo geocell decreases with the increase in the height. Figures 6 (a) and (b) show the stress - deformation behavior of bamboo geocell with different heights under compressive loading condition for diameters 75 mm and 100 mm respectively. It is evident from the stress - deformation curve that geocell with lesser height has the higher compressive strength though it fails at a lesser deformation. As the height of the cell increases, it undergoes higher deformation.

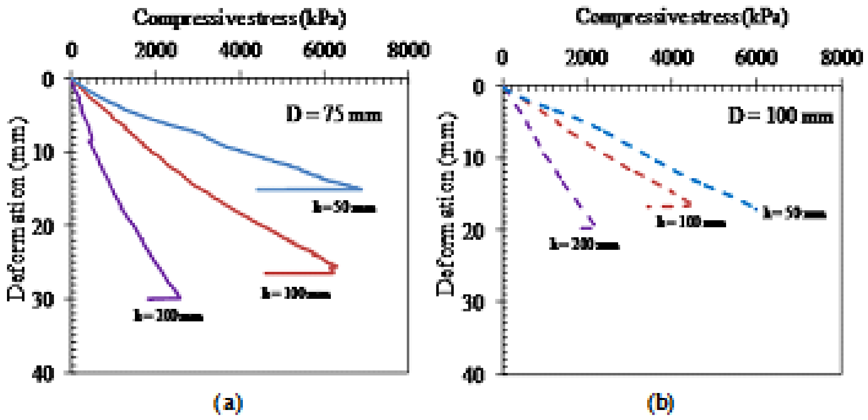

Figure 6: Stress - Deformation Behavior of Bamboo Geocell with Different Heights under Compressive Loading Condition for Diameters (a) 75 mm, and (b) 100 mm

CONCLUSIONS

Unconfined compression tests have been carried out on bamboo geocells filled with stone aggregates with two different diameters and three different heights. From the experimental study, the following conclusions are drawn.

- Diameter and height of bamboo geocell are found to be the significant parameters for compressive strength.
- For a particular deformation before failure, the smaller diameter geocell exhibits higher compressive strength. However, the larger diameter geocell has undergone higher deformation.
- For both diameters, the compressive strength of geocell increases with decreases in the height of geocell.
- Due to very high stiffness of the bamboo strips, the failure occurs at lower deformation. However it carries significant compressive load.
- This study shows that geocell reinforcements can effectively be prepared with natural bamboo sticks which are easily available and cheaper in India and also environment friendly.

REFERENCES

1. ASTM D 4595 (2011). "Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method,"*ASTM*, Philadelphia, PA, U.S.A.
2. ASTM D5261 (2010). "Standard Test Method for Measuring Mass Per Unit Area of Geotextiles," *ASTM*, Philadelphia, PA, U.S.A.
3. Bathurst, R. J. and Karpurapu, R. (1993). "Large-Scale Triaxial Compression Testing of Geocell- Reinforced Granular Soils," *Geotechnical Testing Journal*, GTJODJ, ASTM, 16(**3**), pp. 296-303.
4. Bush, D. I., Jenner, C. G. and Bassett, R. H. (1990). "The design and construction of geocell foundation mattresses supporting embankments over soft ground," *Geotextiles and Geomembranes Journal*, 9, pp. 83-98.
5. Cowland, J. W. and Wong, S. C. K. (1993). "Performance of a road embankment on soft clay supported on a geocell mattress foundation," *Geotextiles and Geomembranes*, 12(**8**), pp. 687–705.
6. Dash, S. K., Krishnaswamy, N. R. and Rajagopal, K. (2001). "Bearing capacity of strip footings supported on geocell-reinforced sand," *J. Geotextiles and Geomembranes*, 19(**4**), pp. 235-256.

7. Dash, S. K., Sireesh, S. and Sitharam, T. G. (2003). "Model studies on circular footing supported on geocell reinforced sand underlain by soft clay," *J. Geotextiles and Geomembranes*, 21(**4**), pp.197-219.

8. Emersleben, A. and Meyer, N. (2010). "Bypass of Soft by the Use of Vertical Columns in Combination with Geocell Reinforced Load Transfer Platforms," *Proc. 6th Int. Congress on Environmental Geotechnics*, ICEG, New Delhi, India, II, pp. 891-896.

9. Jenner, C. G., Bassett, R. H. and Bush, D. I. (1988). "The use of slip line fields to assess improvement in bearing capacity of soft ground given by a cellular foundation mattress installed at the base of an embankment," *Proc. Int. Geotech. Symp. Theory and Practice of Earth Reinforcement*, Balkema, Rotterdam, pp. 209-214.

10. Madhavi Latha, G., Rajagopal, K. and Krishnaswamy, N. R. (2006). "Experimental and theoretical investigations on geocell supported embankments," *Int. J. Geomechanics*, ASCE, 6(**1**), pp. 30-35.

11. Mahiskar, S. Y. and Mandal, J. N. (1996). "Investigations on soft clay subgrade strengthening using geocells," *Construction and Building Materials*, 10(**4**), pp. 281-286.

12. Rajagopal, K., Krishnaswamy, N. R. and Madhavi Latha, G. (1999). "Behavior of sand confined with single and multiple geocells," *J. Geotextiles and Geomembranes*, 17(**3**), pp. 171-184.

13. S.N. Moghaddas Tafreshi, S. N. and Dawson, A. R. (2010). "Comparison of bearing capacity of a strip footing on sand with geocell and with planar forms of geotextile reinforcement," *Geotextiles and Geomembranes*, 2(**1**), February 2010, pp. 72-84.