

# Load Settlement Analysis of Basalt Fibre Geogrids in Cohesionless Soil

Jasmin Jacob, Dr. K. Balan

**Abstract**— Geogrids are more popularly used in the field of Geotechnics in improving the load bearing capacity of weak soils. The study focusses on utilization of natural fiber Geogrids obtained from basalt rock. Being light weight and ecofriendly compared to other metal and polymer Geogrids, basalt fiber Geogrids can be used more reliably in strengthening the cohesion less soils. The optimum depth of placement of Geogrids is found to be at 0.25b from the surface of footing. Both cellular and sandwich model of Geogrids with coir fiber inclusions are studied. The results show a phenomenal relation. The percentage of coir fiber is varied as 0.4%, 0.6%, 0.8%, and 1%. Variation in length (0.25b, 0.75b, 1.5b and 2b) and number of basalt fiber Geogrids cells (N=1, 5, 9) have been carried out and compared with unreinforced condition of soil. Results show that maximum benefit can be obtained with a cellular arrangement at  $l/b=1.5$  and  $N=9$ . A comparative study is done to determine the effectiveness of natural fiber Geogrids like coir and basalt.

**Index Terms**—basalt fiber Geogrids, settlement ratio, coir fiber, cellular model, sandwich model

## I. INTRODUCTION

Geogrids can be effectively used as a ground improvement technique in increasing the strength of weak soils. Being an inextensible material, it can be efficiently utilized as a reinforcement for abutments slope protection, retaining walls, and beneath the foundations placed in poor soil. In addition to compressive and shear forces the soil could take up tensile forces by the insertion of geogrids. They can be obtained from both natural and polymeric fibers which are intersected to form a rib like pattern whereby interlocking the soil particles together and distributes the load to a larger area. A good confinement of granular materials could be obtained by the stiffened ribs. These tensile elements can be biaxial geogrids which carry strength in both perpendicular directions as well as uniaxial geogrids which carry strength in one single direction. Present study focusses on utilization of biaxial geogrids obtained from basalt fibers which is an inert and ecofriendly material obtained from extrusive volcanic basalt rock by drawing and winding the natural fibers from the melt. They possess high tensile strength and resistance to fire and ultraviolet radiations. Tests are carried out to determine the settlement characteristics of square footings in sandy soils. Both cellular and sandwich model of basalt fiber geogrids were adopted with varying the percentages of coir fiber

improving the load bearing capacity of cohesion less soils. A comparative study has been carried out with different coir geogrids of 400gsm, 700gsm and 900gsm to determine its efficiency among natural fiber geogrids

## 2 MATERIALS USED

### 2.1 Cohesionless Soil

The soil collected from Attingal was washed to remove the impurities, oven dried and properly sieved by passing through IS 4.75mm sieve and retaining on 0.075mm IS sieve to obtain the required gradation. The gradation curve obtained as per IS 2720 (part-4)-1985 is shown in Fig 1.

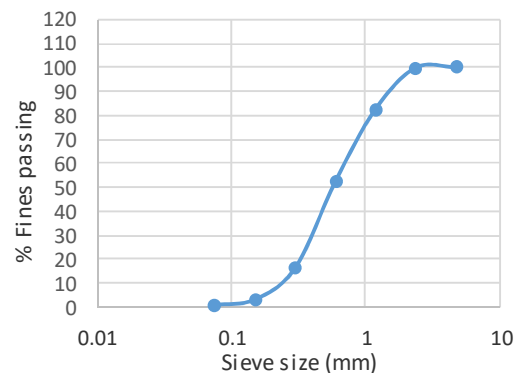


Fig. 1. Gradation curve

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The properties of the cohesionless soil obtained is discussed in Table 1.

TABLE I. PROPERTIES OF COHESIONLESS SOIL

Properties	Values
Specific gravity, G	2.62
Effective size, D10 (mm)	0.25
D60 (mm)	0.70
Uniformity coefficient, Cu	2.80
Coefficient of curvature, Cc	0.91
Maximum dry density (g/ cm3)	1.63
Minimum dry density (g/ cm3)	1.32
E <sub>max</sub>	0.59
E <sub>min</sub>	0.98

## 2.2 Basalt Fibre Geogrid

Basalt fiber geogrid of 350gsm is used as shown in Fig 2 and Fig 3.

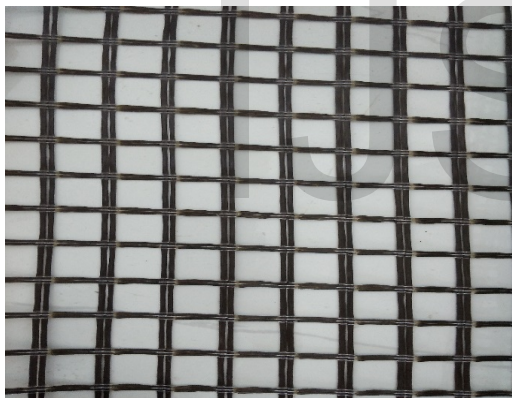


Fig. 2. Basalt fibre geogrid

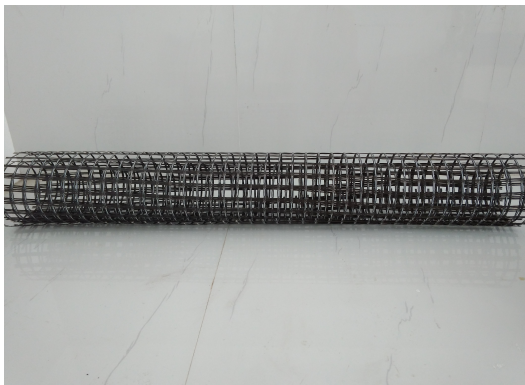


Fig. 3. Basalt fibre geogrid roll

The properties of basalt fiber geogrids are discussed in Table II.

TABLE II. BASALT FIBRE GEOGRID

Properties	Values
Opening size (mm)	25
Thickness (mm)	0.08
Weight (g/m <sup>2</sup> )	350
Max load –warp (N/m)	80780
Max load –weft (N/m)	78900
Elongation at break –warp (%)	6.67

## 3 METHODOLOGY

A test tank of size 600x600x600mm was used for conducting the settlement analysis and the sides of the tank are properly braced to overcome lateral yielding. A mild steel plate of size 100x100x20mm was used as square footing. The experimental setup used is shown in Fig 4.



Fig. 4. Experimental setup

The cohesion less soil was filled in the tank at relative densities of 85% and 35% respectively with geogrids placed at the required positions. The footing is placed on the top surface of the sand so that its center coincided with the center of the tank. Load is then applied at equal increments after applying the balancing load. The settlement occurred was noted by using two dial gauges of range 50mm. The required settlement is calculated by taking the average of the two values. Loading was continued till the footing failed due to excessive settlement caused by failure load.

## 4 RESULTS AND DISCUSSION

Load settlement analysis have been carried out to determine the effectiveness of basalt fiber geogrids in cohesion less soil. Following results have been obtained.

### 4.1 Variation in d/b Ratio for Single Layer of Geogrid

Settlement characteristics of basalt fiber geogrid are studied by varying the d/b ratios at 0.25, 0.75 and 1.5 where 'd' is the depth of placement of geogrid from the surface of the footing and 'b' is the size of the footing. Maximum benefit can be obtained at d/b=0.25 due to the interlocking action of the geogrid as shown in Fig 5.

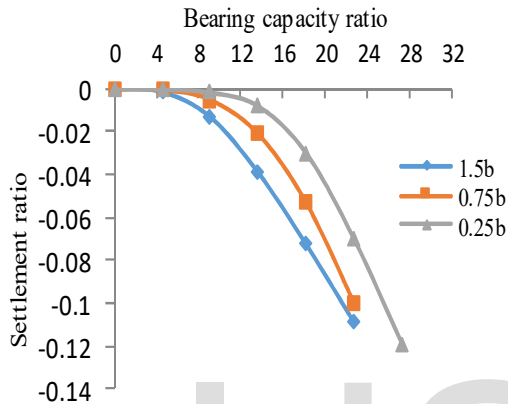


Fig. 5. Load settlement curve for single layer of geogrid placed at different depth

### 4.2 Variation in Arrangement of Geogrid

Sandwich model: Basalt fibre geogrid are placed in two layers with an intermediate layer of soil and coir fibres as shown in Fig 6.

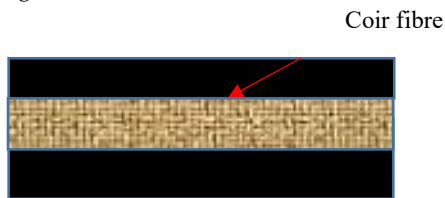


Fig. 6. Sandwich model

Cellular model: Geogrids are placed in the form of cells encasing soil and coir fibres as shown in Fig 7.

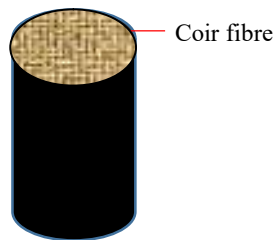


Fig. 7. Cellular model

A phenomenal relation is observed between cellular and sandwich model but performs better than single layer of geogrid due to the all-round confining action of the geogrid and the infill action of the coir fibres as shown in Fig 8.

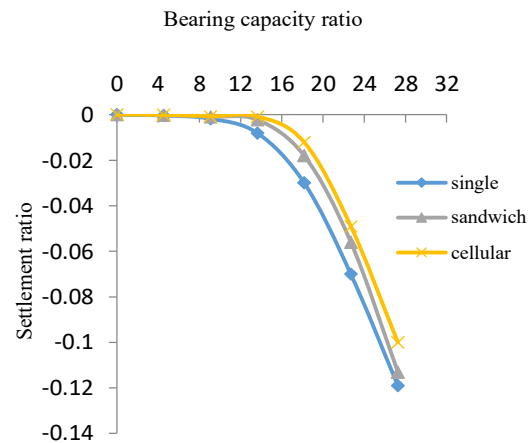


Fig. 8. Comparison among Cellular and sandwich model

### 4.3 Variation in Coir Fibre Percentage

The percentage of coir fibres are varied from 0.4% to 1% and optimum fibre content was obtained at 0.8% with minimum settlement in both sandwich model as the fibre content exceeds the percentage of soil particles at 1% coir fibre as shown in Fig 9.

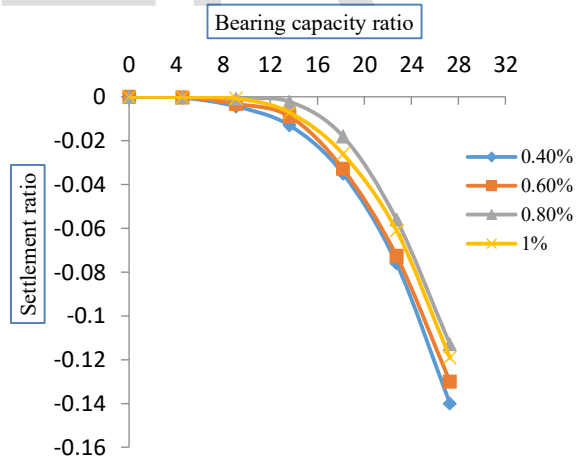


Fig. 9. Variation in percentage of coir fibre in sandwich model

Variation in percentage of coir fibres for cellular model is shown in Fig 10. The graph shows a maximum value at 0.8% of coir fibre.

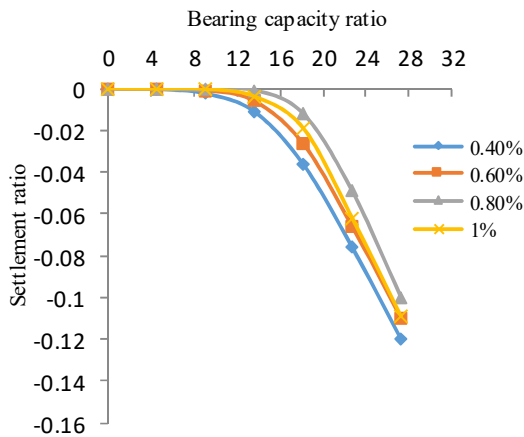


Fig. 10. Variation in percentage of coir fibre in cellular model

**4.4 Variation in Number of Geogrid Cells**

In cellular model, the no of geogrid cells are varied from N=1, 5 and 9 at 0.8% coir fibre as shown in Fig 11. The curve shows maximum load carrying capacity at N=9 as the confining effect of the geogrid increases with increase in the number of cells.

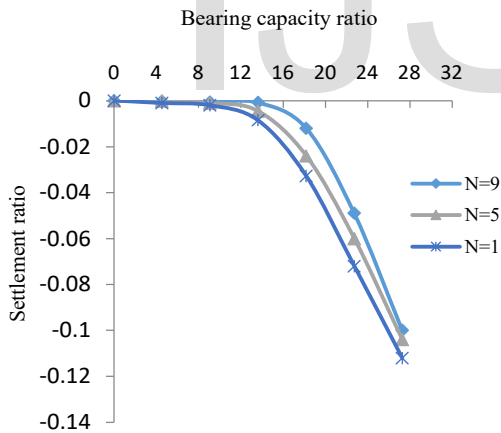


Fig. 11. Load settlement bearing curve for cellular model at N=1, 5, 9 at 0.8% coir fibre

**4.5 Variation in h/b Ratio for Cellular Arrangement of Geogrid**

Settlement curve is plotted by vaying the l/b ratio of geogrid cells as shown in Fig 12. It is noted that the settlement does not show variation beyond h/b=2 and maximum settlement is observed at h/b=0.25 due to decrease in the stiffness of geogrid cells.

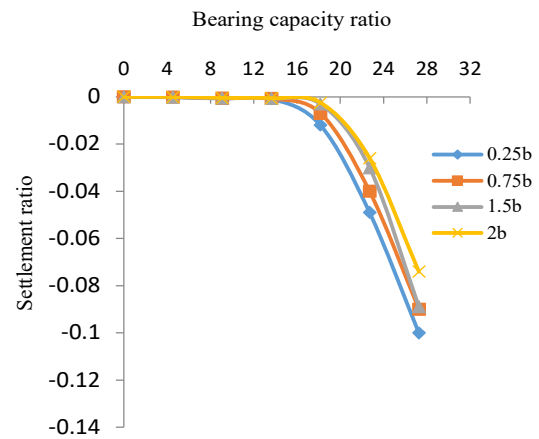


Fig. 12. Load settlement curve for cellular model at l/b=0.25, 0.75, 1.5 and 2 at 0.8% of coir fibre

**4.6 Comparison of Basalt Fibre Geogrid with Coir Fibre Geogrids**

Settlement curve for coir geogrids of grade 400gsm, 700gsm and 900gsm are plotted and compared with basalt fibre geogrid of grade 350gsm. It was noted that basalt fibre geogrids of lower grade can effectively replace coir geogrid of higher grade as shown in Fig 13.

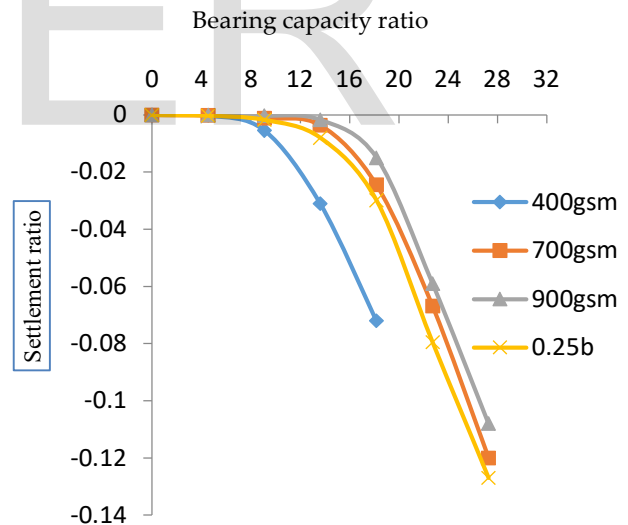


Fig. 13. Comparison with coir geogrids

**4.7 Variation in gradation of soil**

Load settlement curve is plotted by vaying the gradation of soil and it was noted that lesser settlements are observed in well graded soil than poorly graded soils shown in Fig 14.

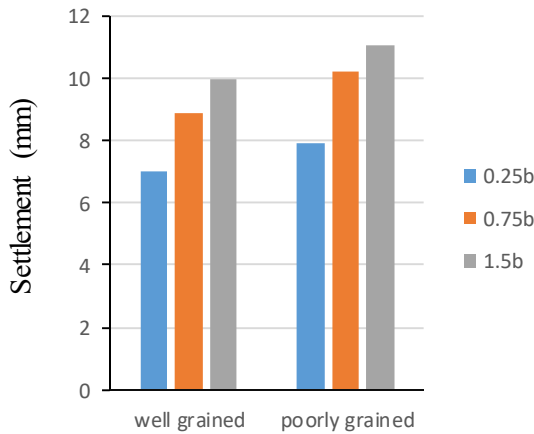


Fig 14. Load settlement curve for single layer of geogrid at different depth and gradation of soil

Minimum settlements are observed for N=9 cells in cellular model for both well graded and poorly graded soils as shown in Fig 15.

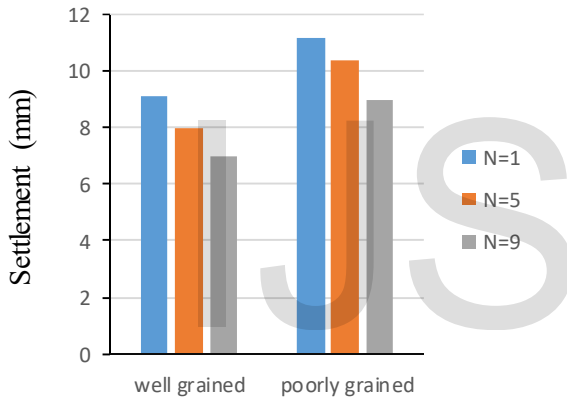


Fig 15. Load settlement curve for cellular model with varying number of cells and gradation of soil

But well graded soils perform better when compared to poorly graded soils due to presence of large sized particles in it which could easily dissipate the load acting on it. Optimum coir content added also decreases from 0.8% for poorly graded soil to 0.6% for well graded soil as shown in Fig 16.

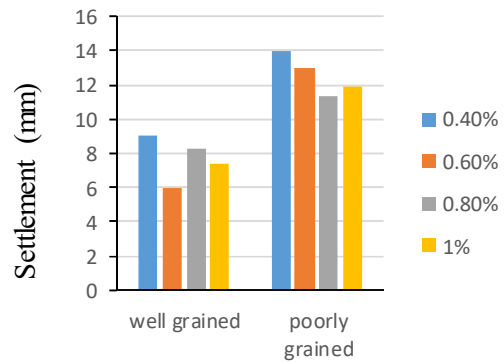


Fig 16. Load settlement curve for cellular model with varying percentage of coir fibre

## 5 CONCLUSION

From the above results it can be concluded that,

- Optimum depth of placement of geogrid was found to be at 0.25b
- Sandwich and cellular model shows better results than single layer of geogrid
- The relation between horizontal and vertical confinement of geogrid is phenomenal
- Settlement reduces with increase in geogrid cells from N=1,5,9.
- Maximum benefit can be achieved in cellular model at d/b=0.25 depth and N=9.
- Lesser settlement is observed at l/b=1.5 beyond which there is less influence of the confining action of geogrid
- Optimum percentage of coir fibre added is at 0.8%

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