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Experimental Investigation on Soil Reinforced with Bitumen coated Bamboo

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Abstract - *when structures have to be constructed on challenging ground conditions, soil reinforcement can be an adaptable technique to improve ground. Uses of natural material in soil have more significance nowadays. Bamboo is a natural material which possesses high tensile strength. This study focuses to explore the possibility of using bamboo as a reinforcing element within soil. In this bamboo specimens were coated with bitumen. A small scale laboratory model test was conducted on unreinforced soil and soil reinforced with geogrid, bamboo grid and bamboo rods. The result indicates that soil reinforced with bamboo shows increase in bearing capacity. The performance of bamboo grid was found to be better than geogrid.*

Keywords_ *Soil reinforcement, Bamboo grid, Geogrid, Bearing Capacity, Model test.*

1. INTRODUCTION

When huge buildings and large networks of road, railway lines, airport etc have to be constructed on challenging ground conditions, soil reinforcement can be an adaptable technique to improve the performance of ground. Soil reinforcement is the process of inclusion of tensile elements like sheet, nets, strips, grids etc. in soil mass having low load carrying capacity. Nowadays environmental sustainability gains more importance in construction and hence eco-friendly natural material bamboo can be used for soil reinforcement. Bamboo has high tensile strength and high specific load bearing capacity.

Bamboo is a perennial grass which exists abundantly in tropical and subtropical zones of the world. Bamboo is fast growing plant and it matures with 2-5 years. Abang Ali (1984) found that bamboo is very strong in tension. Bamboo has desirable properties needed for geosynthetics, so bamboo can be used as tension reinforcement in soil. Durability of bamboo is a major concern in soil applications. Different preservation techniques are available to enhance the durability. From various methods coating with bituminous material is found to be easier and cost effective.

A. Hedge and T.G Seetharaman (2015) tried to explore the possibility of using naturally available bamboo as reinforcement. 3 dimensional cells were made from bamboo and are compared with commercial geocells. A model study was carried out in the laboratory in a test tank of 0.9m×0.9m×0.6m filled with soft soil reinforced with bamboo cells, geocells, bamboo grid and geogrid. The laboratory load test shows that the bearing capacity of soft soil reinforced with both bamboo grid and bamboo cells are about 1.3 times more than geocell and geogrid.

Md Asaduzzaman, Muhammad Iftial Islam (2014) proposes a soil improvement method using bamboo of 12 inch length and 0.5 inch diameter in medium dense soil. The reinforcements were placed at 0.75 inch, 1.5 inch and 2.25 inch below footing and 3 square footings of 3×3 inch, 3.5×3.5 inch and 4×4 inch were used. The bearing capacity of medium dense soil was increased up to 1.77 times that of unreinforced soil for single layer of bamboo reinforcement. Bearing capacity increased to 2.02 times for multiple reinforcement system for reinforcements placed at 0.3B as single layer the bearing capacity is maximum and settlement is minimum and bearing capacity ratio increases as number of reinforcing layer increases.

Raja J and G.L Sivakumar Babu (2013) studied the effect of bamboo as subgrade reinforcement for different sub grade strength. In the study the required thickness of base course layer was determined for unreinforced and reinforced pavements and the thickness was evaluated for different CBR values, different rut depths and for different number of passes of axles. Results indicate that the base course thickness reduces as CBR value of sub grade increases. For low allowable rut depth, the thickness of base course was more reduced for reinforced unpaved roads than unreinforced unpaved roads. It is shown that bamboo grids can be an effective reinforcement in soft soil, since it reduces base course thickness and saves material.

This study focuses to explore the use of bamboo as a reinforcing element by enhancing the durability with a bitumen coating. So a laboratory model test was conducted on soil reinforced with bamboo in the form of grids and bamboo reinforcements of 1 cm diameter. For comparison, model tests were conducted on unreinforced soil and soil reinforced with geogrid.

2. MATERIALS

A. *Soil*

Soil used in the research was collected from Pallathuruthy, Alapuzha district, Kerala, India from 1 m depth below ground level. Index properties and other basic properties were determined according to relevant IS codes.

Basic properties are given below in Table- 1

B. *Bamboo*

Bamboo was collected from local area having age more than 3 years. Water content and density were determined according to IS 6874:2008. Properties of bamboo are given in Table 2.

C. *Bitumen*

Bitumen used in the study is 80/100 grade bitumen.

D. *Geogrid*

Geogrid used was high tenacity polyester with tensile strength 40 kN/m and 23×23mm aperture size.

TABLE -1 Properties of Soil

Field moisture Content (%)	82.8
Specific Gravity	2.43
Liquid limit (%)	84.8
Plastic limit (%)	31.25
Plasticity Index	53.55
Shrinkage Limit (%)	26.11
Sand (%)	28.33
Silt (%)	49.6
Clay (%)	22.07
MDD (gm/cm^3)	1.62
OMC (%)	24
UCC (kN/m^2)	15.01
Soil Classification	Sandy Silt
Cohesion (kN/m^2)	15
Angle of internal friction	10

TABLE -2 Properties of Bamboo.

Name	Bambusa Bambos
Water Content (%)	24.34 %
Density (gm/cm^3)	0.967

3. LABORATORY MODEL TEST

Small scale laboratory model tests were conducted on unreinforced and reinforced soils. Foundation bed was prepared in a test tank having a size of 28cm×28 cm×30 cm in volume, made of 6 mm thick iron plates. Model foundation used was a footing of 10 cm ×10 cm × 0.6 cm made of iron plate. The applied load was measured by a precalibrated proving ring having maximum capacity of 2 kN. When load is applied to foundation, settlement of soil takes place and it was measured by dial gauge fixed at top of foundation. Model tests were conducted on

1. Unreinforced Soil
2. Soil reinforced with geogrid
3. Soil reinforced with bitumen coated bamboo grid
4. Soil reinforced with bitumen coated bamboo reinforcement

A. *Test bed Preparation*

The soil to be tested was pulverized; air dried and then mixed with OMC and was kept for 24 hours for uniform distribution of water without allowing water loss. The test tank was filled with soil in layers of 25 mm and compacted by giving 25 blows to achieve maximum dry density. Foundation model was placed at the centre of test tank and dial gauge was fixed at top of foundation.

B. *Reinforcements*

a) *Geogrid*

Geogrid made from high tenacity polyester with tensile strength 40 kN/m was used in the study.

b) *Bamboo grid*

Bamboos were cut into small pieces of 1 mm thick and 27 cm long to form the warp and weft of geogrid. The bamboo grid specimen was similar to commercially available geogrid. Bitumen coating was also provided. Fig- 1 shows bitumen coated bamboo grid placed in the test tank.

c) *Bamboo reinforcement*

Bamboo reinforcements of 1cm diameter and 27cm length were prepared and coated with bitumen. The bamboo reinforcements were placed parallel to each other at 4.5 cm centre to centre in the test tank at a depth of 4 cm below the footing. Fig-1 shows bitumen coated bamboo reinforcements placed in the test tank. All the reinforcements are placed at a depth of 0.4 times width of foundation.

Fig -2 shows test tank placed for model test.

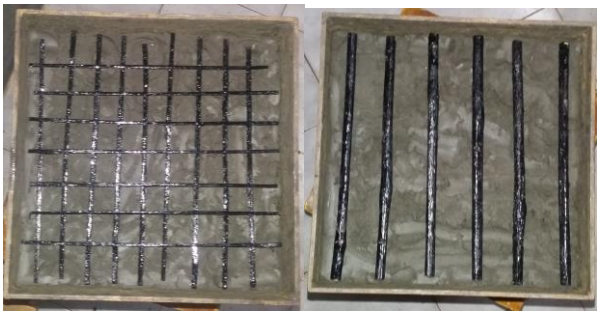

Fig -1 Bitumen coated Bamboo grid and Bamboo rods

After placing reinforcements, tank was completely filled with soil and leveled. Footing was placed at centre of leveled soil. Total axial load of 600N were applied at the centre of footing and load and corresponding settlement was measured.

4. RESULTS AND DISCUSSIONS

From model test conducted in the laboratory, loads and corresponding settlements were noted and graphs were plotted. Load versus settlement plot for unreinforced soils and reinforced soils are shown in Chart -1.

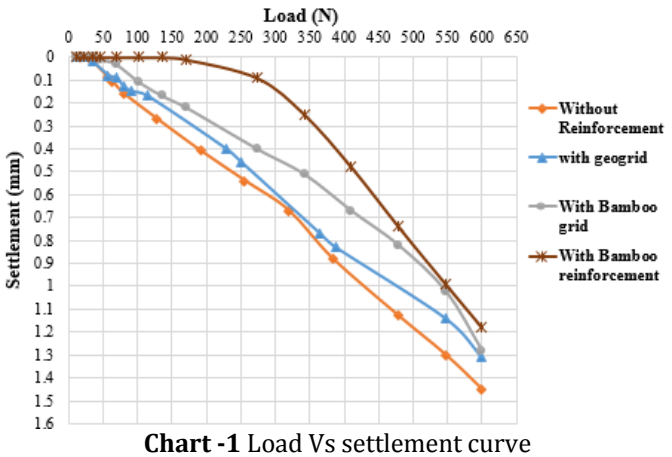

Chart -1 Load Vs settlement curve

From the laboratory model test conducted it was found that the maximum bearing capacity and minimum settlement were obtained for soil reinforced with bamboo rods. From the figure it is found that reduction in settlement was more for soil reinforced with bamboo grid than that of soil reinforced with geogrid. Settlement of soil reinforced with bamboo reinforcement of 1cm diameter was found to be reduced by 24%.

5. CONCLUSIONS

In the present study, reinforced benefits of bamboo are evaluated by conducting laboratory model tests.
The main findings are

1. Bearing capacity of soil was found to be increased when reinforced with bamboo grid, bamboo rod and geogrid than that of unreinforced soil.
2. Maximum increase in bearing capacity was observed for soil reinforced with bamboo of 1 cm diameter.
3. About 20-30% reduction in settlement was obtained for bamboo reinforced soil.
4. Considerable reduction in settlement was observed for soil reinforced with bamboo grid than that of geogrid

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