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A Review on Stabilization of Soil with Bamboo for Pavements

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Abstract: ***Strength of a subgrade soil, which is an important parameter in the case of pavement. The pavement transfer all the loads come on itself directly to the ground. When the soil is not suitable to withstand loads, failures such as settlement and crack may develop on the pavement. Improvement of soil is required to rectify this problem. Bamboo is used in this study to stabilize the soil. By adding bamboo into the soil, CBR values will increase while the pavement layer's thickness is reduced. Bamboo is a natural material that is easily accessible, sustainable, and economical.***

Keywords: bamboo fiber, bamboo grid, pavement, CBR

1. Introduction

The essential to the country's overall development is the growth of the transportation infrastructure. Compacted soil makes up the sub grade, the pavement's lowest layer, as well as the embankments for roads and railroads. The existence of solid soil strata along the proposed path is one of many elements that determine the road's alignment. If the available soil is not suitable for the construction of pavements, it is necessary to make the soil suitable for this purpose. In this situations soil stabilization is a remedy to strengthen the soil.

Soil stabilization or reinforcement has been used to improve geotechnical properties and meet design requirements. Many researchers have already investigated the mechanical behavior of soils with limited strength capacities and tried to strengthen them to modify their role as construction materials. Soil stabilization or reinforcement has been applied for several years to improve the geotechnical materials and to fulfill design specifications. From the past, many researchers have studied the mechanical behavior of soils with low strength capacity and tried to reinforce them in order to change the function of these soils as construction materials. In this study the effect of bamboo as a reinforcement in soil is investigated.

2. Materials Used

2.1 Bamboo

One of the rapidly growing grasses in the poaceae/graminae family is the perennial grass bamboo. Bamboo may grow organically without the use of pesticides, as is well known. Root rhizomes of bamboo are excellent soil binders that can stop erosion. The tensile properties of bamboo is higher compared to other natural materials. This property of bamboo makes it can be used as a soil reinforcement material.

3. Literature Review

Ahirwar and Mandal [2018] analyzed the behavior of a bamboo grid-reinforced soil bed. This paper shows the results of small-scale load testing on sand reinforced with bamboo grids of various aperture shapes. Effects of the location of the top reinforcement layer, size of reinforcement, number of reinforcement layers and aperture shape of the bamboo grid are the parameters studied in this paper.

Unpaved road stabilization using bamboo grid and bitumen coated bamboo cells were studied by Ravindran et al. (2019). Bamboo grid, Bamboo cell and Geotextile separator were used as reinforcement on sandy soil. Fly ash is used along with sand. The static load tests showed that inclusion of a basal bamboo grid and cellular bamboo mattress over the geotextile separator underneath the unreinforced fly ash beds improved the load carrying capacity and reduced vertical deformation as compared to the unreinforced fly ash beds with only a geotextile separator. The cyclic load test showed considerable reduction in total deformation due to inclusion of the basal bamboo grid underneath the unreinforced fly ash beds as compared to the unreinforced fly ash beds with only the geotextile separator.

Subhankar Biswas et al. [2013] studied the physical and mechanical properties of bamboo fiber. The tensile properties of bamboo fiber can be determined with varying span lengths. Scanning electron microscopic analysis was used to determine the physical properties of fibers. The result of this study shows that increasing the span length increases young's modulus of the bamboo fiber.

Dutta et al. [2021] conducted an experimental investigation on bamboo-made cellular mattresses reinforced fly ash beds overlying soft clay. This study involved testing cellular mattress-reinforced fly ash beds on top of soft clay in a lab setting. To examine the impact of mattress width on the system's overall performance in terms of footing pressure exerted over the center of the beds using a square rigid steel plate, footing settlement, and nearby surface deformation, a series of model experiments were carried out. Five distinct

materials—bamboo geogrid, bamboo-made cellular mattress, jute geotextile, fly ash, and marine clay—are used in the model study. The geocell mattress is supported at the base by the bamboo geogrid.

Experimental Investigation on Bamboo as Structural Pile was investigated by Madhubala Mayilswamy et al. [2021]. Testing was done to see whether bamboo could be used as a pile in soil. The model tank arrangement was used for a number of vertical pile load experiments, and bamboo pile were used to enter loose soil that had little cohesiveness. They were tested by adjusting the bamboo's length and diameter while maintaining a fixed relative density. According to a series of experiments, bamboo piles with greater diameter and length have higher load-bearing capacities. The pile length can, however, be extended under cases similar to friction piles.

Use of Polymer/Bamboo Reinforced Rap in Base Course of Flexible Pavement Construction was studied by Dulal Chandra Saha and Mandal [2020]. A series of laboratory model test were conducted using Wet Mix Macadam (WMM) and Reclaimed Asphalt Pavement (RAP). Unreinforced and reinforced samples subjected to laboratory test. Polymer/Bamboo geogrid and geocell were used as reinforcements to RAP. Model tests results shows that the improvement factor on load bearing capacity of bamboo (geogrid+geocell) reinforced RAP was observed to be increased in comparison to that of unreinforced WMM.

Experimental Studies on Strength Performance of Subgrade Soil Mixed with Bottom Ash and Coir Fiber was studied by Karthikeyan et al. [2018]. The purpose of this study is to assess the potential for using natural coir fiber and bottom ash (BA), a by-product of thermal power plants, as reinforcing agents for locally accessible weak clayey soil. Numerous strength parameters, including split tensile strength, unconfined compression strength, and California Bearing ratio (CBR), were evaluated. To encourage pozzolanic reaction, a little quantity of cement (5%) is also added. Experimental findings are presented, and a thorough discussion of the applicability of using bottom ash and coir fiber follows.

Brahmachary and Rokonuzzaman [2018] investigate the random inclusion of bamboo fiber on ordinary soil and its effect on CBR value. Both virgin soil and soil that has been reinforced with fibers were used for a number of tests. Natural bamboo fibers with diameters of 3 and 6 mm and lengths of 10 and 20 mm, respectively, were used as the reinforcing material in this investigation. The study found that an increase in bamboo fiber length correlates with an increase in both the unsoaked and soaked CBR value of soil. The unsoaked and soaked CBR values of reinforced soil rise to 17.37 and 7.33 percent, respectively, when the fiber diameter is raised from 3 to 6 mm. The inclusion of bamboo fiber raises the value of the soil's-soaked California Bearing Ratio (CBR).

Soundara et al. [2017] conducted an experimental study on bamboo-jute composite reinforced soft clay. Through a series of tests, the impact of the bamboo grid's size and the quantity of composites on the system's overall performance in terms of footing pressure and settlement has been thoroughly studied. According to test data, covering unreinforced soft clay with a bamboo grid and jute geotextile composite increases bearing pressure by around a factor of two. Additionally, it has been found that the load carrying capacity of bamboo grid-jute textile composite increases with both the number of inclusions and grid size.

Model Studies on Bamboo-Geogrid Reinforced Fly Ash Walls under Uniformly Distributed Load was done by Mekonnen and Mandal [2017]. The laboratory model studies on unreinforced and bamboo-geogrid reinforced fly ash walls under uniformly distributed load are presented in this work. A series of model tests were used to thoroughly examine the impact of bamboo-geogrid reinforcement's length to height, vertical spacing to height, and coverage ratios on backfill settlement, facing horizontal displacement, and failure surcharge pressure. Results showed that when compared to unreinforced fly ash walls, the introduction of bamboo geogrid (mattresses and strips) generally improved the behavior of the reinforced fly ash walls.

Arif Ali Baig Moghal et al. [2016] studied effect of Fiber Reinforcement on CBR Behavior of Lime Blended Expansive Soils. Two types of fibers, Fiber Cast and Fiber Mesh, on the performance of natural and lime stabilized soils as pavement sub grade were studied. California Bearing Ratio (CBR) is chosen as a performance indicator as it is a good pointer towards pavement effectiveness. Variables such as length and amount of the fibers as well as curing period were studied. Both deterministic and probabilistic (or reliability) analysis is presented in this paper. The results showed that the improvement in CBR increased with higher fiber contents and longer lengths and the effect was prominent when lime was used as a stabilizer.

Hegde and Sitharam [2014] reported experimental studies on the use of bamboo in soft-ground engineering and performance comparisons with geosynthetic. Clay beds reinforced with bamboo and geosynthetic reinforcing materials were studied in the lab. Bamboo is converted into two-dimensional grids and three-dimensional cells for efficient utilization. The final analysis reveals that clay bed reinforced with bamboo cell and grid has a bearing capacity that is 1.3 times more than clay bed reinforced with geocell and geogrid. The addition of bamboo results in less settling and deformation.

CBR strength of reinforced soil with natural fibers and taking environmental factors were studied by Hossein Sarbaz et al. in [2013]. This study examines the impact of palm fibers distributed erratically within a soil matrix. CBR experiments were run in both dry and submerged environments. Utilizing both plain and bitumen-coated fibers, the durability of fibers was also studied. The findings demonstrate that adding palm fibers greatly boosts the CBR strength of the sand sample. Additionally, it is seen that sliding strength, and rupture strength, controls the specimens' failure.

High soil compressibility and poor soil shear strength are the main causes of stability issues for embankments on soft clay. The Potential Use of Bamboo as Green Material for Soft Clay Reinforcement System was studied by Marto and Othman [2011]. Inclinometer and Hydrostatic Profiler (settlement) data were used to monitor trial embankments on soft clay, and the results are presented in this work (lateral movement). Three embankments had been built and were being monitored: (i) an embankment reinforced with bamboo-geotextile composite (BGC); (ii) an embankment reinforced with high-strength geotextile (HSG); and (iii) a control or unreinforced (UR) embankment, which had been built without adding any additional support to the clay's softness. The findings indicate that after the conclusion of the monitoring works, the BGC performed better than both the HSG embankment and the UR embankment.

4. Conclusion

Based on the paper reviewed, the following conclusions can be made

- Natural materials play a vital role in the reinforcement of soils. Bamboo is such a natural material having higher tensile strength and can be used as a structural material
- Bamboo can be used in different forms like grid, fibers, and bamboo cells
- The influence of length and amounts of fibers on the performance of natural stabilized soils as pavement subgrade were studied. CBR was used as a performance indicator
- Both unsoaked and soaked California Bearing Ratio (CBR) value of soil increases due to the addition of bamboo. When bamboo content increases, unsoaked and soaked CBR value of soil increases
- Samples with longer specimen have higher CBR strength than samples with shorter specimens
- The load carrying capacity is increased with increase in the size of bamboo

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