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A Review on low cost Geogrid: Bamboo as a Geogrid for Improving Ground Characteristics

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ABSTRACT:

Geosynthetic materials, such as geogrids, are increasingly used in civil engineering applications for soil stability and performance improvement. Geogrids, usually from polyester or polyethylene, are widely applied to reinforce weak soils in infrastructures. The research presented here is on the possibility of using bamboo as a geogrid as a sustainable alternative to synthetic geogrids for soil reinforcement. Being very strong in tension and having rapid growth, bamboo is an effective, environment-friendly material for geotechnical applications. The present study deals with the behavior of a circular footing resting on a sand bed both with and without reinforcement by placing bamboo as geogrids at different depths and reinforcement widths of 40cm and 60cm. Experiments were conducted in a 0.6m x 0.6m x 0.6m wooden box with different layers of reinforcement: N = 1, 2, 3. This research is targeted to analyze the load-bearing capacity effect of bamboo as a grid reinforcement. The outcome reveals that the stability of footing increases with bamboo grids, thereby being a promising low-cost solution for large-scale civil engineering projects. This research has pointed out the suitability of bamboo as an eco-friendly and sustainable material, with scope for extensive utilization in soil reinforcement and other geotechnical applications.

Keywords: Geosynthetic materials, bamboo geogrids, soil reinforcement, sustainable construction, tensile strength, civil engineering, load-bearing capacity, eco-friendly, geotechnical applications, circular footing.

Introduction :

1.1 General Overview

In geotechnical and civil engineering, the upgrading of soil properties and the improvement of structural stability are a significant factor to construction projects. There is an important class of materials in this field, which is geosynthetics. In fact, the interest in geosynthetics has increased due to their enhancing effect on soil behaviour, erosion control, and safety in various infrastructural projects. Geosynthetics, which are mainly constituted by polymers such as plastic, are used to stabilize weak soil layers, regulate water flow, and prevent soil movement. These materials are used in almost every construction project, like roads, bridges, embankment, retaining walls, and tunnels, significantly enhancing the structural integrity of construction.

1.1.1 Geosynthetic Materials

Geosynthetic materials are engineered products, designed to work with the naturally occurring materials in the soil, rock, and water environments for improved performance and stability. Various types of geosynthetics include the following:
Geotextiles: Filtration, separation, and reinforcement fabric which is offered both in woven and non-woven forms.
Geogrids: Grid-like material that stabilizes the soil which is primarily applied in road construction, embankments, and slopes.
Geomembranes: Non-permeable materials intended to control the flow of liquids and gases. They are mostly used in landfills and reservoirs.
Geocomposites: Geosynthetic materials that consist of a combination of different geosynthetic materials, including geotextiles and geomembranes. They are mainly used for drainage and filtration.
Geofoam: Lightweight materials applied to reduce loads on underlying soil layers.

Geotubes: Tubular structures that are used in dewatering and sediment control.

(a) **(b)**

Fig. No. 1.1 Geogrids

1.1.2 Geogrids and Their Role in Construction

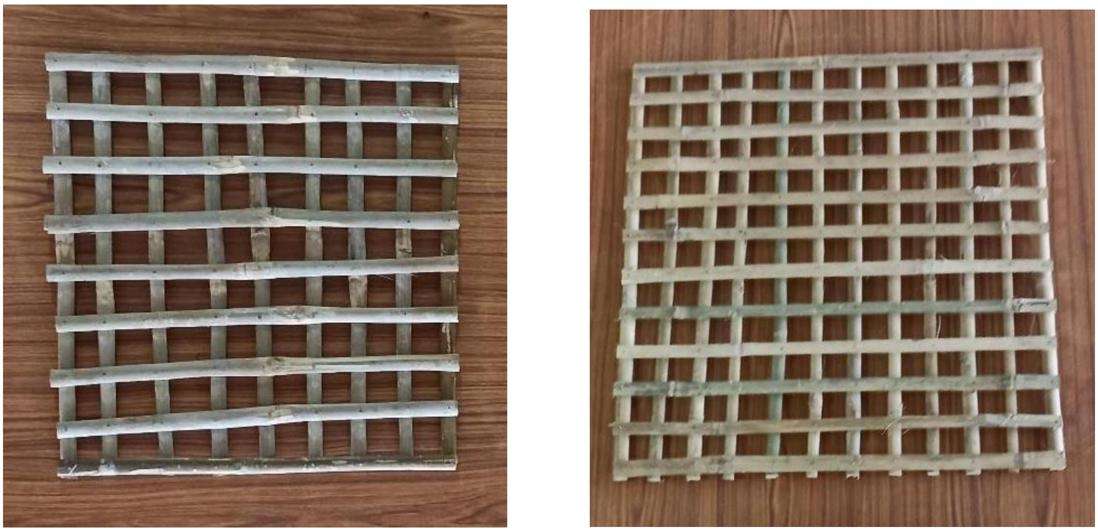
Geogrids are polymer-based materials like polyester or polyethylene, featuring a grid structure that reinforces soil and improves its strength and load-bearing capacity. These materials are essential for enhancing the stability of ground surfaces, especially in infrastructure projects like roads, embankments, and retaining walls. Geogrids function by providing lateral confinement to soil particles, allowing for better load distribution and preventing soil displacement. Their ability to stabilize weak soils and reduce settlement is crucial for maintaining structural stability in construction projects.

1.1.3 Types and Functions of Geogrids

Geogrids come in various forms, each suited for specific applications. Uniaxial geogrids provide strength in a single direction, while biaxial and triaxial geogrids offer reinforcement in two or three directions, respectively. Composite geogrids combine geotextiles and geogrids to perform multiple functions, such as separation, filtration, and reinforcement. Geogrids are used for the following critical applications: soil reinforcement, load distribution, slope stabilization, base and subgrade stabilization, and drainage. These functions make them a vital part of the success of many civil engineering projects.

1.2 Bamboo in Construction

Bamboo has been a material of choice in construction for centuries due to its rapid growth, strength, and sustainability. Widely used in tropical and subtropical regions, bamboo's high tensile strength, lightweight properties, and fast regeneration make it a valuable resource for various construction applications, especially in housing. Beyond its physical benefits, bamboo contributes to environmental conservation by reducing soil erosion and supporting reforestation initiatives.



(a) 40 x 40 cm **(b) 60 x 60 cm**

Fig. No. 1.2 Bamboo as a Geogrid of size 40x40cm, 60x60cm

1.2.1 Bamboo Grid for Sustainable Construction

Bamboo grids, based on the natural strength and flexibility of bamboo, are an innovative and sustainable alternative for soil reinforcement in construction. Bamboo grids are lightweight, modular, and adaptable for various applications, including housing, temporary infrastructure, and interior design. Due to their eco-friendly nature and resilience, bamboo grids are gaining recognition in sustainable architecture, particularly in earthquake-prone areas. However, they remain vulnerable to pest attacks and are yet to undergo long-term performance studies for further investigation before realizing their complete potential in construction works.

Methodology :

2.1 General Overview

This chapter outlines the materials, experimental setup, and methodology used to evaluate the performance of foundations supported by sand beds reinforced with bamboo grids. The experiment investigates how varying the number of reinforcement layers and grid dimensions impacts the load-bearing capacity and settlement behaviour of circular footings. Additionally, this study includes an assessment of the engineering properties and index of the sand to analyse its behaviour under applied loads.

2.2 Materials Used

The materials used in this experiment include sand, Moso bamboo for grid preparation, boric acid solution for bamboo treatment, and other necessary testing equipment. The materials are described in detail as follows:

2.2.1 Sand

The sand used in the study was sourced from a nearby river. Laboratory tests were conducted to determine the physical properties of the sand in accordance with the Indian Standard (IS) codes. Key properties measured include:

- Effective size
- Uniformity coefficient
- Specific gravity
- Relative density
- Angle of internal friction

These results provide an understanding of the sand's behaviour as a foundation medium. After characterization, the sand was poured into the test tank to create the foundation bed.

2.2.2 Bamboo as Geogrid

Moso bamboo was chosen for its strength and suitability as a natural reinforcement material. The bamboo was processed into grid-like structures resembling traditional geogrids. Two grid sizes were used for the experiment: 40x40 cm and 60x60 cm. To ensure longevity and resistance to termite damage, the bamboo grids were pre-soaked in a boric acid solution for 24 hours before being incorporated into the tests.

2.2.3 Test Tank

The test tank used in the experiments adhered to the specifications outlined in IS 1888:1982. The dimensions of the test tank were 60 cm x 60 cm x 60 cm, allowing for an ideal development of the failure zone without side interference during testing.

2.2.4 Metallic Ball with Model Footing

A circular model footing with a diameter of 10 cm was used in the experiments. The footing was made from mild steel, with one face featuring a circular groove to accommodate a metallic ball. On the other face, a sand bed was glued using Fevicol glue, ensuring that friction developed between the footing and the sand bed during loading.

2.2.5 Dial Gauge

A dial gauge (or dial indicator) was employed to accurately measure the vertical settlement of the footing. This instrument provided precise readings of the footing's settlement due to applied loads.

2.2.6 Screw Jack

A screw jack with a lifting capacity of 3 tons was used to apply a vertical load to the model footing. The screw jack operates by converting rotational motion into vertical force, which is applied steadily to the footing.

2.2.7 Proving Ring

A proving ring with a 2 kN capacity was used to measure the applied load during the experiment. The proving ring ensures that the load is applied uniformly and accurately measures any deformation resulting from the applied load.

2.2.8 Boric Acid

The boric acid solution was applied to the bamboo grids to prevent them from being destroyed by termites and other wood-destroying insects. The grids were immersed for 24 hours to ensure effective treatment and protection.

2.3 Experimental Setup and Procedure

The experiments were conducted in the Geotechnical Engineering Laboratory at S.G. Balekundri Institute of Technology, Belagavi, Karnataka, India. The setup included the test tank, model footing, loading frame, dial gauge, screw jack, and proving ring. The following steps outline the experimental procedure:

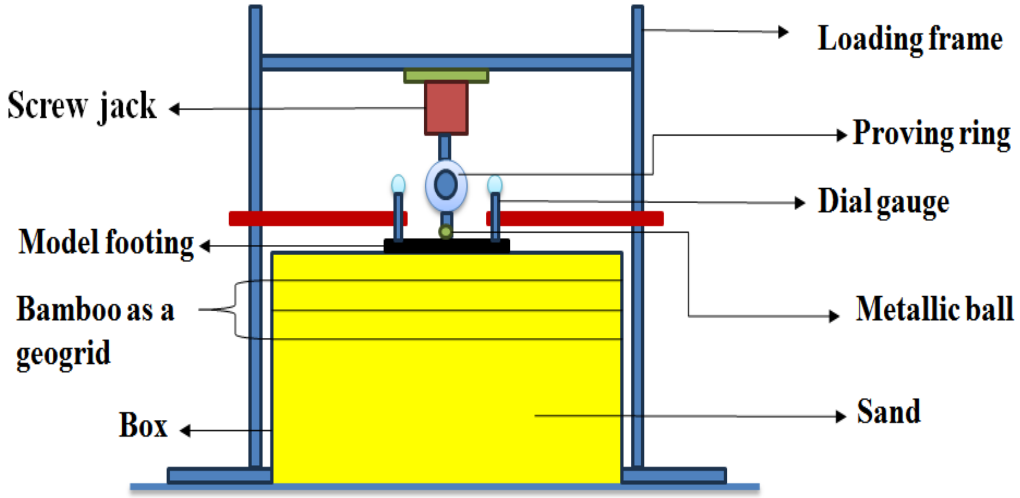


Fig. No. 2.1 Line diagram of experimental setup

2.3.1 Preparation of Sand Bed

The sand bed was prepared using the rainfall technique, which ensures uniform distribution of sand layers in the test tank. Sand was carefully poured in layers, simulating the conditions of a natural foundation medium.

2.3.2 Placement of Bamboo Grid as Geogrid

Different depths of bamboo grids were placed under the model footing to observe the effect on load-bearing capacity and settlement. The grids used had dimensions of 40x40 cm and 60x60 cm. The placement configuration was as follows:

- First layer: At a depth of 3.3 cm.
- Second layer: At a depth of 6.6 cm.
- Third layer: At a depth of 9.9 cm.

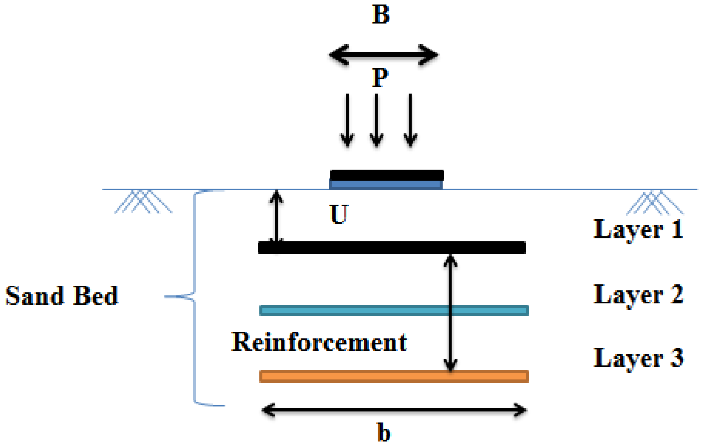


Fig. No. 2.2 Line diagram of placing of bamboo as a geogrid for different no. of layers

2.3.3 Test Procedure

For every test, the screw jack applied vertical loads on the model footing. The settlement was recorded by the dial gauge as the load was applied. The tests were conducted in various conditions:

- Unreinforced sand bed
- Sand bed reinforced with varying numbers of bamboo grid layers

Load was applied incrementally, and the corresponding settlement values were recorded. The proving ring was used to monitor the applied load, ensuring accurate measurement of the force.

2.3.4 Data Collection and Analysis

Key parameters recorded during the experiments include:

- Load-carrying capacity: The load at the point of failure or significant settlement.
- Settlement: Vertical deformation of the footing as a function of applied load.
- Effect of bamboo grid reinforcement: Comparison of settlement and load-carrying capacity for sand beds with and without bamboo grid reinforcement.

The experiments were repeated for different reinforcement layer counts and grid sizes. The collected data were analysed to evaluate the effects of bamboo grid reinforcement on the load-carrying capacity and settlement behaviour of the sand bed.

Conclusion :

The study shows that bamboo grid reinforcement improves soil foundation performance. Increasing the number of reinforcement layers and using wider grids (from 40 cm to 60 cm) both enhance the soil's load-bearing capacity and reduce settlement. This leads to more stable and efficient foundations, making bamboo grid reinforcement a valuable and sustainable solution for improving soil strength and stability in construction.

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