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Mechanical and Simulation-Based Evaluation of Woven Bamboo-Fiber Geonets as Soil Reinforcement Materials for Unpaved Road Subgrades

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ABSTRACT: The growing demand for sustainable and cost-efficient road construction materials has encouraged the development of natural fiber-based alternatives for soil stabilization. This study evaluates the performance of a woven bamboo fiber geonet as a protective layer for unpaved roads using software-assisted analysis. Bamboo, recognized for its tensile strength and environmental benefits, was processed into a geonet structure and analyzed under vertical pressures typically experienced by unpaved road surfaces. SolidWorks Simulation was used to assess the geonet's structural response through von Mises stress, equivalent strain, and displacement outputs, providing insight into its deformation behavior and potential failure zones.Results show that although the bamboo fiber geonet offers advantages as a lightweight, renewable, and biodegradable material, it does not withstand heavy vertical pressures. Excessive stress, strain, and displacement values were observed, indicating that the geonet is unsuitable for heavily loaded sub-base applications. However, its performance suggests potential for low-intensity or light soil reinforcement uses where loading demands are minimal. The study also demonstrates the value of software-assisted simulation in evaluating natural fiber geosynthetics, reducing dependence on extensive physical testing. Overall, the research clarifies the performance limitations of bamboo fiber geonets and recommends further validation under varied loading conditions and field environments.

KEYWORDS: bamboo fiber, geonets, mechanical properties, soil reinforcement, unpaved roads, finite element simulation

CHAPTER I

THE PROBLEM AND ITS SETTINGS

Introduction

Civil engineering applications increasingly require sustainable material sources, creating a demand for alternative materials such as bamboo fibers. Bamboo (*Bambusa blumeana*) is a promising candidate due to its rapid growth, renewability, and excellent mechanical properties. These characteristics make it suitable for developing geonet systems that contribute to soil stabilization, erosion control, drainage improvement, and lateral restraint. This study focuses on evaluating the performance of bamboo fiber geonets for possible geotechnical applications. The primary objective is to assess the mechanical properties of bamboo fiber—specifically its tensile strength, flexural behavior, and durability of bamboo fiber geonets under loading conditions. By evaluating its mechanical behavior, the study seeks to assess the viability of bamboo-fiber geonets as sustainable reinforcement materials for improving soil strength.

In addition, geosynthetics also provide lateral restraint by limiting both horizontal and vertical displacement of soil particles under load. Reinforcement mobilizes shear within the geosynthetic layer, effectively shifting potential failure surfaces and increasing the overall bearing capacity of the soil (Carlos et al., 2024).

Additionally, as the need for sustainable and environmentally friendly building materials increases, scientists are searching for substitutes for the traditional geonets, which are typically made of high-density polyethylene (HDPE) resin. HDPE geonets are effective, but their manufacturing is resource-intensive and environmentally damaging. Investigating bamboo fibers as a potential alternative material for geonet production is the aim of this project. Bamboo fibers can be used to make ropes with the right properties for geonet applications since they are robust, abundant, and renewable.

Bamboo fiber's high specific strength and renewability have generated a lot of interest. For long bamboo fibers to reach their maximum strength, unidirectional reinforcing is necessary. Among all plant fibers, bamboo fiber has a comparatively higher mechanical strength. Bamboo fibers have a modulus of 46 GPa and a tensile strength of 600 MPa, respectively. On the other hand, single bamboo fiber has better elongation, tensile strength, and Young's modulus than several other plant fibers like coir, flax, and bagasse. Therefore, there are a number of potential uses for using bamboo fiber as reinforcement into cement and resin. Bamboo fiber is a sustainable and environmentally friendly fiber reinforcement that can be utilized as a good alternative to glass and polymer fiber (Gao et al., 2022).

Furthermore, researchers realized that natural goods could replace synthetic ones due to the rising expense of geosynthetics and the developing sustainability issue. Certain characteristics of natural fibers, such as sisal, jute, coir, bananas, palms, water hyacinth, rice husk, bamboo, hemp, and many more, meet the requirements to be utilized as geosynthetic materials. These geotextiles are frequently utilized to lower construction costs while enhancing the functionality and longevity of roadways. Applications for geotextiles are numerous and include drainage systems, soil stabilization, erosion prevention, and concrete and asphalt reinforcing. Because the natural fibers have a 500% water-holding capacity on dry soil, it is also utilized to improve the grass growth along riverbanks and prevent soil erosion (Badri et al., 2023).

According to Salzer et al. (2018), recent studies have been done on the importance of understanding the mechanical properties of bamboo fibers to improve their performance in geosynthetic applications. Research has shown that bamboo fibers have significant tensile strength and modulus of elasticity compared to conventional geonet materials made from synthetic polymers. Further, Sanchez et al. (2019) reported that treatments in bamboo fiber processing and hybridization with others have been pursued to obtain higher resistance against moisture and degradations. These studies contribute toward an overall growing body of knowledge on replacing conventional nonrenewable geo-net materials with more sustainable, biodegradable alternatives.

Moreover, the exploration of the mechanical properties of bamboo fibers for geo- net application is a developing research field, featuring different viewpoints on its potential and challenges. Bamboo fibers are progressively seen as a sustainable, biodegradable, and economical substitute for synthetic materials, especially in geotechnical uses such as erosion control and soil reinforcement. According to Janssen (2000), bamboo's high tensile strength, low environmental impact, and abundance in many regions make it an ideal material for geo-nets, aligning with global goals for sustainable development. Bamboo’s mechanical strength, including its tensile properties, has been widely recognized and explored in various structural applications.

Research has examined the potential of bamboo fibers in geotechnical applications, especially for soil stabilization and reinforcement in materials like geonets. While this field is still evolving compared to traditional materials, bamboo offers considerable promise due to its strength, lightweight nature, biodegradability, and renewability. These qualities make bamboo a promising choice for reinforcing soil structures, particularly in tropical areas where it's abundant. According to Doe et al. (2020), bamboo provides both economic and environmental benefits, particularly in regions where it grows. As a renewable resource, bamboo captures CO_2 during its growth, making it a carbon-negative material. Using locally sourced bamboo in construction reduces the carbon footprint from transporting conventional materials, supports local economies, creates jobs, and lowers dependency on imports, fostering sustainability and economic development.

Bamboo fiber's strength, biodegradability, and environmental friendliness make it a great candidate for geonet applications. However, there are several obstacles to its practical application. Significant challenges include worries regarding mechanical property fluctuations, microbial damage susceptibility, and durability. Additionally, weathering and moisture can impact bamboo's performance, and increasing output can be expensive. Environmental issues, such as the sustainability of bamboo harvesting and the use of chemicals in processing, raise further questions. The absence of defined testing protocols and regulations for bamboo-based geonets impedes widespread adoption. Notwithstanding these obstacles, more investigation and improvements in production techniques may make bamboo fiber a practical and sustainable option for geotechnical uses.

Conceptual Framework

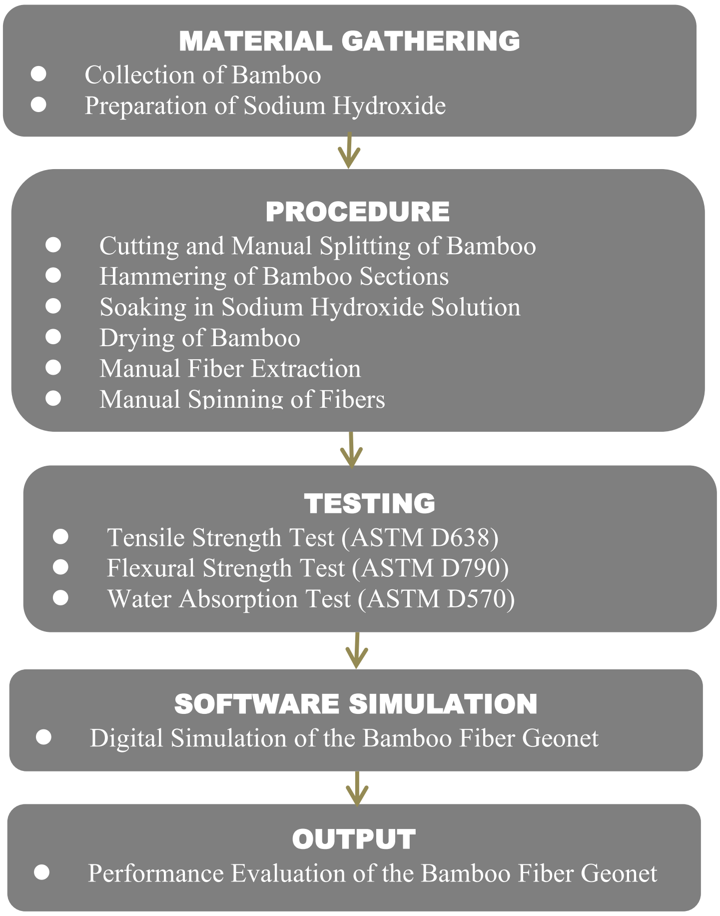

Figure 1. Research Paradigm

The conceptual framework in Figure 1 illustrates the systematic workflow involved in producing a bamboo fiber geonet, beginning from raw materials and progressing toward the tested final output. The process starts with two primary materials: bamboo and sodium hydroxide (NaOH). The bamboo is manually split into smaller parts to prepare it for chemical treatment. These pieces are then soaked in a solution containing 6% sodium hydroxide per liter of water, where the alkali treatment is maintained for eight hours to facilitate fiber separation. After soaking, the bamboo is removed from the solution and dried before undergoing manual extraction to obtain the bamboo fibers. The extracted fibers are then subjected to manual spinning, forming bamboo ropes. To increase strength and durability, two or more ropes are combined to produce a stronger braided rope, which is subsequently shaped into the final geonet structure. The bamboo geonet is evaluated through a series of standardized tests categorized into material properties, moisture behavior, and load-bearing performance. Material properties are assessed through tensile strength testing (ASTM D638), flexural strength testing (ASTM D790), and water absorption testing (ASTM D570). In addition to physical testing, software simulation is applied to predict the mechanical performance of the geonet under various load conditions, allowing assessment of its suitability for soil reinforcement without relying solely on experimental trials. The final output is a functional bamboo fiber geonet, representing a sustainable, locally sourced, and bio-based reinforcement material suitable for geotechnical and environmental applications.

Statement of the Problem

This study aims to determine the effectiveness of a geonet made up of woven bamboo fibers. It also seeks to develop an alternative geosynthetic material made up of natural fiber. Specifically, it seeks to answer the following questions:

1. In what ways does bamboo fiber rope influence the performance behavior of the bamboo-fiber geonet in terms of:
   1.1 Tensile Strength,
   1.2 and Flexural Strength?
2. What behavior will a woven bamboo-fiber geonet exhibit under vertical pressure loading in terms of:
   2.1 Stress,
   2.2 Displacement, and
   2.3 Strain?
3. What insight can simulation results provide about the suitability of bamboo-fiber geonets for soil reinforcement on unpaved roads?

Objectives

The following objectives have been formulated to guide this study:

1. To determine how the tensile and flexural strengths of bamboo fiber rope influence the overall tensile and bending performance of the bamboo fiber geonet.
2. To examine the performance of the woven bamboo fiber geonet when subjected to vertical pressure loads for soil reinforcement purposes.
3. To evaluate the suitability of bamboo fiber geonets for soil reinforcement on unpaved roads using simulation-based analysis through SolidWorks.

Significance of the Study

This study focuses on the potential of bamboo fibers as geonet. As a result, the findings of this study will benefit various sectors. By using fiber-made geonet, society can benefit from environmental sustainability and improved infrastructure. As the demand for bamboo increases, bamboo farmers can find new markets for their crops, resulting in a possible increase in their income. The growing demand not only improves the earnings of the farmers but also supports their economic stability. Lastly, this study is to acquire knowledge on the potential of bamboo fiber as a geonet and will also include the students or the researchers to have a background and additional knowledge about the topic or related to this study.

Scope and Limitations of the Study

This research explores the potential for using *Bambusa blumeana* fiber in the manufacturing process of bamboo fiber geonets, focusing on performance evaluation through software-assisted simulation. The entire process, starting with bamboo collection, NaOH treatment, fiber extraction, rope preparation, and the weaving of the bamboo fiber geonet, is covered under this research. The mechanical properties of the rope will be tested using standardized laboratory tests to determine its tensile strength according to ASTM D638, and flexural strength according to ASTM D790.

This paper simulates the woven bamboo fiber geonet using software in order to assess the behavior of the geonet under different loading conditions for soil reinforcement on unpaved roads. The simulation will look into the response of the geonet with regard to applied loads and general structural performance, thereby providing insight into its effectiveness in real-world soil reinforcement. All collected data is analyzed by means of descriptive statistical methods in order to bring out the performance trend and material behavior.

The study is limited to laboratory-scale testing, and software simulation, it does not include long-term monitoring of the geonet's durability under continuous exposure to rainfall, sunlight, microbial activity, or repeated vehicular loads. Only rope samples and one geonet sample are tested, limiting statistical generalizability. The mechanical evaluation is restricted to tensile strength, and flexural strength; other factors, such as biodegradation rate, chemical resistance, creep performance, and long-term structural integrity, are not assessed.

Since all of the fabrication is by hand, there could be some variations in fiber thickness, rope diameter, and weave consistency. Economic analyses, large-scale production feasibility, and direct comparison with commercial synthetic geonets are beyond the scope of this study.

Moreover, This study is an academic research project conducted solely for educational purposes. The analyses, simulations, and conclusions presented are based on the methodologies, material assumptions, and tools available at the time of the study. The results are intended to provide insight into the performance of bamboo fiber geonets as soil reinforcement but should not be considered final engineering design values or used as the sole basis for construction, commercial applications, or professional engineering decisions.

While all efforts were made to ensure accuracy, the authors do not guarantee absolute precision in simulation outputs or material estimations. Any errors or discrepancies identified after publication may be corrected without liability to the authors or the affiliated institution.

Definition of Terms

Alkali Treatment. A chemical process using sodium hydroxide (NaOH) to remove lignin, hemicellulose, and other impurities from natural fibers such as bamboo. This improves fiber separation, increases surface roughness, and enhances the mechanical bonding strength of the fibers (Bledzki & Gassan, 2021).

Bamboo Fiber. A natural fiber extracted from bamboo plants, known for its high tensile strength, durability, and renewability. It is used as a sustainable alternative to synthetic fibers in various engineering applications, including geo-nets. (Li et al., 2015).

Bamboo Fiber Geonet. A woven or braided network made from bamboo fiber ropes designed to provide soil reinforcement, lateral restraint, erosion control, and drainage improvement in geotechnical applications (Sharma et al., 2014).

Braided Rope. A rope produced by intertwining two or more bamboo fiber ropes to increase tensile strength, durability, and structural integrity for geonet formation. (Rahman et al., 2019).

Drainage Layer. A geosynthetic or natural-fiber layer designed to transport water horizontally to prevent water accumulation, reduce pore water pressure, and maintain soil strength (Koerner, 2012).

Erosion Control. Methods or materials used to prevent or reduce soil erosion caused by water, wind, or human activity. Bamboo-based geo-nets can serve as a sustainable solution for erosion control.(Muthu & Li, 2012)

Flexural Strength. The ability of a material—such as bamboo fiber rope—to resist deformation under bending forces (Nugroho & Ando, 2018).

Geo-net. A geosynthetic material used in civil engineering for applications such as soil stabilization, erosion control, and drainage. Typically made of synthetic polymers, geo- nets can also be manufactured using natural fibers like bamboo.(Mandal & Dhar, 2015)

Geosynthetics. Synthetic materials, typically polymers, used in geotechnical and civil engineering projects for soil reinforcement, erosion control, and drainage. Natural alternatives like bamboo-based materials are part of emerging sustainable innovations.(Shukla, 2017)

High-Density Polyethylene (HDPE). A type of synthetic polymer commonly used in conventional geo-net manufacturing. It is resource-intensive and environmentally damaging compared to biodegradable alternatives like bamboo.(Hopewell, Dvorak, & Kosior, 2009)

Mechanical Properties. Characteristics of a material that define its behavior under applied forces, including tensile strength, elasticity, and durability. These properties are central to evaluating bamboo fiber's suitability for geo-net applications.(Liese & Köhl, 2015)

Natural Fiber. A fiber obtained from plants, animals, or minerals that can be used as an alternative to synthetic fibers. Bamboo is a type of natural fiber increasingly explored for its engineering applications. (Pickering et al., 2016)

Soil Stabilization. The process of improving soil strength and durability to support construction and prevent soil erosion. Geo-nets, including bamboo-based ones, are often used in soil stabilization projects. (Muntohar & Hantoro, 2000)

Tensile Strength. The maximum stress that a material can withstand while being stretched or pulled before breaking. It is a critical property in assessing the performance of bamboo fibers in geotechnical applications.(Amada, Untao, & Ichikawa, 1997)

Water Absorption Capacity. The amount of water a material can absorb over a specified time. For bamboo fibers and bamboo geonets, this property affects durability, swelling, and long-term performance. (Li et al., 2007)

CHAPTER II
METHODS AND PROCEDURE

Research Design

The study adopted an experimental design complemented by software-assisted simulation to evaluate the performance of bamboo fiber geonet for soil reinforcement on unpaved roads. According to Creswell (2014), experimental research refers to the manipulation of one or more independent variables to observe the effect that such manipulation has on one or more dependent variables, thus the establishment of causal relationships. This is a very rare approach in assessing innovative material performance, like that of bamboo geonet, because it gives a clear view of their effectiveness in real applications.

Additionally, Baraceros (2019) stated that experimental research involves the subject of analysis with precision. Hence, this ensures that there will be a definite degree and results or influence of the treatment on the subject and finding the causes of such effects. Moreover, Shadish et al. (2018) further emphasize that in experimental designs, true experiments ensure good control of unwanted variables such that the effects observed can be confidently assigned to the experimental treatment by using random assignment; thus, it also ensures internal validity. In this study, controlled laboratory tests including tensile strength, and flexural strength, were conducted on bamboo fiber ropes used in the fabrication of geonets. These results were then integrated into software-assisted simulations using SolidWorks to model the mechanical behavior of the bamboo fiber geonet under applied pressure loads. The combination of laboratory testing and simulation allowed the researchers to evaluate potential failure points of the geonet in a virtual environment, complementing physical observations. This pre-test and post-test framework, together with computational modeling, ensures accurate evaluation of whether the mechanical properties of the bamboo fiber geonet contribute to the performance of the bamboo fiber geonet. Beyond measuring performance, this method also supports a deeper investigation of the material's potential role in promoting sustainable and locally sourced solutions for rural road development.

In this study, the geonet was evaluated under a single, worst-case loading condition of 550 kPa. The use of an extreme load as the initial simulation scenario aligns with established geotechnical and geosynthetic design practices, which routinely employ limit-state and conservative loading approaches to characterize structural behavior under severe service environments. According to the Federal Highway Administration (FHWA) geosynthetic design guidelines, performance evaluations commonly apply strength and serviceability limit states using upper-bound load assumptions in order to identify potential failure zones and assess structural adequacy under critical conditions (FHWA, 1998). This principle supports the use of high or extreme loads when the goal is to determine whether a system can withstand the most demanding operational scenario.

Likewise, guidance from the Geosynthetic Research Institute (GRI) reinforces the methodological validity of this approach. GRI Standard Practice GG4(a) recommends adopting worst-case or maximum credible loading conditions whenever key parameters, material behavior, or environmental conditions cannot be fully assessed through multiple tests. This practice ensures that the resulting evaluation remains conservative, safe, and structurally reliable (GRI, n.d.). Consequently, selecting a highest-load scenario is justified in cases where a bounding assessment of system performance is required.

Further support comes from recent numerical research, where extreme or upper-bound loading is frequently applied to reveal critical deformation mechanisms and evaluate the structural limits of geosynthetic-reinforced systems. Esen et al. (2023), for instance, utilized such high-intensity loads in finite-element modeling to expose failure-prone regions and guide subsequent reinforcement optimization.

Taken together, these methodological precedents demonstrate that the use of a single worst-case loading condition is not only acceptable but also consistent with recognized design philosophy, standard testing protocols, and contemporary numerical modeling practice. As a result, the present study's approach provides a conservative yet technically defensible basis for assessing the structural limits and potential performance of the woven bamboo-fiber geonet.

Research method

This study adopted a quantitative approach using an observation method to evaluate the performance of the bamboo fiber geonet. Observation will detail contextual data on installation and performance. According to Creswell (2014), quantitative observation allows researchers to capture behaviors, interactions, and environmental conditions that quantitatively might be overlooked. This corresponds with Marshall and Rossman's (2016) principles as they emphasize the role of observational techniques in quantitative research in trying to understand the complexity of the social phenomenon.

This study utilized simulation software to assess the performance and behavior of the woven bamboo fiber geonet under various loading conditions. By creating a virtual model of the geonet in a controlled environment, the simulation enabled the analysis of its mechanical response, including deformation, stress distribution, and stability characteristics. The approach provided a practical means to evaluate the material's potential for engineering applications, offering insights into its structural performance without the need for extensive physical testing. The results of the simulation serve as a basis for understanding the suitability of the woven bamboo fiber geonet as a sustainable reinforcement material and guide future experimental and field-based investigations

Locale of the study

The study will be conducted within the province of Nueva Ecija. The bamboo sourcing and fabrication of the bamboo fiber geonet will take place in Barangay San Josef (Navao), Jaen, Nueva Ecija, an area selected due to its abundant and readily available bamboo resources. This location provides suitable raw materials for producing the bamboo fiber ropes and assembling them into geonets, supporting the study's aim of utilizing locally sourced, sustainable materials.

Sampling Procedure

The testing procedures follow standardized methods to assess the performance of selected bamboo from Barangay San Josef (Nabao), Jaen, Nueva Ecija, an area known for its abundant supply of *Bambusa blumeana*. The researchers prepared three rope samples with same diameters to evaluate the mechanical properties of bamboo fiber and one sample of geonet for geotechnical applications. The bamboo stalks were manually split and subjected to chemical treatment using a 6% sodium hydroxide (NaOH) solution for eight hours to remove lignin and facilitate fiber extraction. After drying, the fibers were processed manually using bare hands to ensure the maximum strength capacity the researchers meticulously followed, the standard procedure for each rope was then woven into a geonet configuration.

The sample underwent mechanical property evaluations through standardized laboratory tests: tensile strength test (ASTM D638), and flexural strength test (ASTM D790). These parameters were then input into SolidWorks to create a virtual model of the geonet to evaluate its' performance under pressure loading conditions. This purposive approach ensured that both the physical testing and software-assisted evaluation were based on representative samples, enhancing the reliability and validity of the study's findings.

Research Instrument

To create the Bamboo Fiber for Geonet, the researchers used the following materials:

Bamboo Fibers. The fibers will be extracted from bamboo through improvised weaving equipment. Bamboo fibers have remarkable properties in geotextiles: great tensile strength, biodegradability, and excellent moisture absorption, thus making it the most effective soil stabilization and erosion control option (Devi and Jempen, 2016).

Sodium Hydroxide. The effect of sodium hydroxide (NaOH) treatment on bamboo fibers at various concentrations. The treatment improved fiber flexibility by increasing elongation at break and altering the fiber surface, while reducing diameter and causing cracks in the cell wall. Although tensile strength and modulus of elasticity decreased, higher NaOH concentrations notably enhanced ductility. These findings suggest that NaOH-treated bamboo fibers could be promising for textile applications due to their improved flexibility. On the other hand, Nirmal et al. (2013) claimed that a 6 wt.% NaOH concentration is best for treating natural fiber and capable of removing excess moisture thoroughly whilst exhibiting excellent interfacial adhesion strength. However, evidence that the NaOH concentration alone is the factor that affects the bonding between a matrix and a natural fiber is still inconsistent.

Equipment. To ensure quality and durability of Geonet.

Software. A simulation software (SolidWorks) will be employed to model the behavior of the woven bamboo fiber geonet under pressure loading conditions representative of geotechnical applications. Through computational simulation, the instrument will enable analysis of potential failure zones. This method complements the physical fiber treatment and fabrication, providing predictions on structural performance prior to extensive field tests consistent with current trends in evaluating natural fiber geosynthetics. (Harmening et al., 2020)

Data Gathering

Collecting of Bamboo

The bamboo that was collected came from Barangay San Josef (Nabao), Jaen, Nueva Ecija. The abundance of *Bambusa Blumeana* in the area led to the selection of this site as a sustainable and easily accessible source of raw materials for the research.

Cutting and Manual Splitting of Bamboo

The bamboo stalks were manually cut and split into manageable strips for processing. This process made the material easier to handle and prepared it for subsequent mechanical processing.

Struck the Bamboo

The bamboo was struck with a hammer to gradually soften the fibers.

Soaking of the Struck Bamboo in Sodium Hydroxide Solution

The crushed bamboo was soaked in a 6% NaOH solution. This chemical treatment removed lignin and other unwanted components, enhancing the flexibility, softness, and quality of the extracted fibers.

Drying of the Bamboo from the Solution

After soaking, the bamboo fibers were air-dried. This drying step was essential to prepare the fibers for manual extraction and prevent mold or premature degradation.

Extracting the Bamboo Fiber

The treated and dried bamboo was manually processed to extract the fibers. This involved carefully pulling and separating the strands by hand to ensure that long, and clean fibers were obtained, suitable for weaving into geonet sheets.

Creating of the Bamboo Fiber Geonet

The processed fiber was made into rope through a manual method and then turned it into a geonet. These geonets served as the primary test samples for evaluating the mechanical properties of bamboo fiber in geotechnical applications and assessing its performance as slope reinforcement for farm road stability.

Figure 2. Sample of Geonet

Tensile Strength Test (ASTM D638)

To determine the rope's resistance to pulling forces, which indicates how well the bamboo fiber geonet can handle tension when used as soil reinforcement.

Flexural Strength Test (ASTM D790)

To assess the rope's resistance to bending, reflecting the geonet's ability to flex and maintain integrity during installation and soil loading.

Water Absorption (ASTM D570)

To determine the water uptake capacity of the bamboo fiber geonet in relation to its operational role in soil stabilization and reinforcement.

Software-Assisted Simulation

A detailed virtual model of the woven bamboo fiber geonet was created in SolidWorks. Using the mechanical properties obtained from laboratory tests, the model was analyzed under pressure loading conditions. This simulation allowed the researchers to predict the geonet's behavior in real-world geotechnical applications, such as soil reinforcement and slope stabilization, while minimizing the need for extensive physical prototyping.

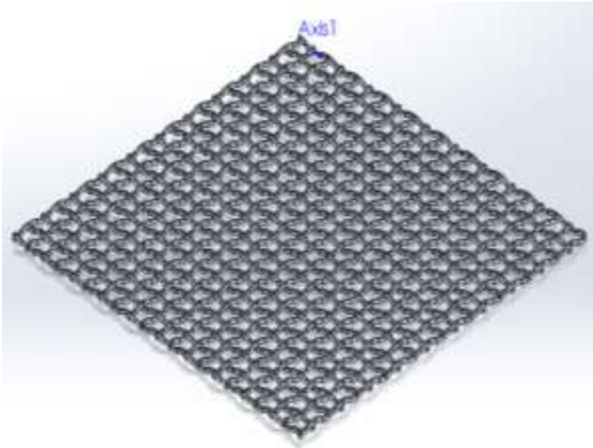

Figure 3. Sample of software simulated geonet

Data Analysis and Technique

The data gathered in this study were analyzed using a combination of descriptive statistical methods, engineering interpretation, and simulation-based evaluation to determine the mechanical and performance behavior of the bamboo fiber geonet. All numerical results from tensile strength and flexural strength were first organized and converted into their corresponding engineering units, such as tensile stress (MPa), flexural resistance (N), and simulated stress and strain values obtained from SolidWorks.

The mechanical and performance data of the bamboo fiber geonet were analyzed using descriptive statistical methods to summarize the central tendency and variability of the measurements. These methods include calculating the mean, range, and standard deviation, which provide insight into the typical performance of the bamboo fiber ropes and the geonet.

The following formulas were used:

Mean (Average) – represents the central tendency of the data:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Where:

$\bar{x}$ = mean value

x_i = individual measurement (e.g., tensile strength, flexural strength, CBR value)

n = number of trials or samples

Range – represents the spread between the minimum and maximum values:

$$\text{Range} = x_{\max} - x_{\min}$$

Standard Deviation (SD) – represents the variability or dispersion of the data around the mean:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

These methods include calculating the mean, range, and standard deviation, which are essential in summarizing the central tendency and variability of the data. Given the limited number of trials per sample and the intentional variation in rope diameters (1.1 cm, 1.2 cm, and 1.5 cm), descriptive statistics are the most appropriate tools to highlight trends and performance patterns without the need for complex inferential analysis.

Additionally, this study applied finite element analysis through SolidWorks, where the experimentally obtained material properties were encoded into a virtual geonet model to evaluate its response under pressure loads. Through this simulation, the researchers examined stress distribution, displacement, and strain patterns to determine whether the geonet remained within its elastic range and whether deformation levels were acceptable for soil reinforcement applications. The simulation outputs were compared with laboratory findings and published literature, creating a triangulated assessment that strengthened the validity of the performance interpretations.

CHAPTER III
PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter aims to present the data collected by the researchers in an organized and systematic way with a view to answering the given research problems. The data collected during the experimental process form the foundation upon which the performance of the bamboo fiber geonet in software assisted analysis are evaluated for soil reinforcement on unpaved roads. The data obtained are documented in tables and accompanied by adequate analysis and interpretation.

1. Contribution of Bamboo Fiber Rope to the Performance of Bamboo Fiber Geonet

To evaluate how the mechanical properties of bamboo fiber ropes contribute to the overall performance of the bamboo fiber geonet, a single rope sample was tested. The tensile strength, and flexural strength results obtained from the rope sample are presented below.

1.1 Tensile Strength (ASTM D638)

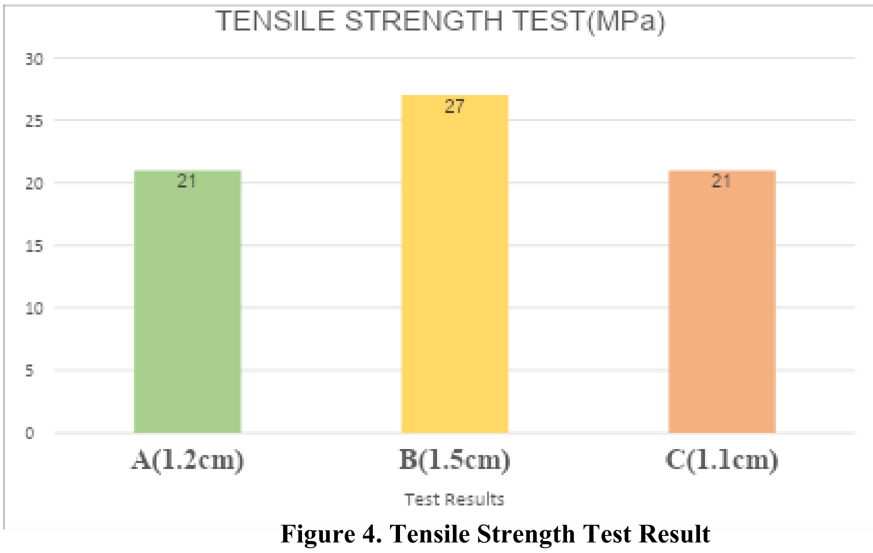

Figure 4. Tensile Strength Test Result

This graph shows the tensile strength (measured in MPa) of three samples of bamboo fiber rope with different diameters. Sample A, with a diameter of 1.2 cm attained 21 MPa. Sample B, with the thickest diameter at 1.5 cm got 27 MPa. Sample C, with 1.1cm diameter also attained 21 MPa. From the values, the following descriptive statistics were computed:

Mean tensile strength:

$$x=\frac{21+27+21}{3}=23\ MPa$$

Standard Deviation (SD):

$$s=\sqrt{\frac{(21-23)^2+(27-23)^2+(21-23)^2}{3-1}} \approx 3.46 \text{ MPa}$$

Range: Range= 27 - 21= 6MPa

Although Sample B (1.5 cm diameter) exhibited the highest tensile strength at 27 MPa, Sample C (1.1 cm diameter), which attained 21 MPa, was selected for further application due to its significantly lower water absorption. This selection reflects a functional trade-off wherein Sample B demonstrates superior strength under dry laboratory conditions, whereas Sample C is expected to maintain more stable mechanical performance under moisture-exposed environments. Given that the intended application involves potential exposure to water and varying humidity levels, the lower water absorption of Sample C renders it the more suitable and durable option despite its comparatively lower tensile strength.

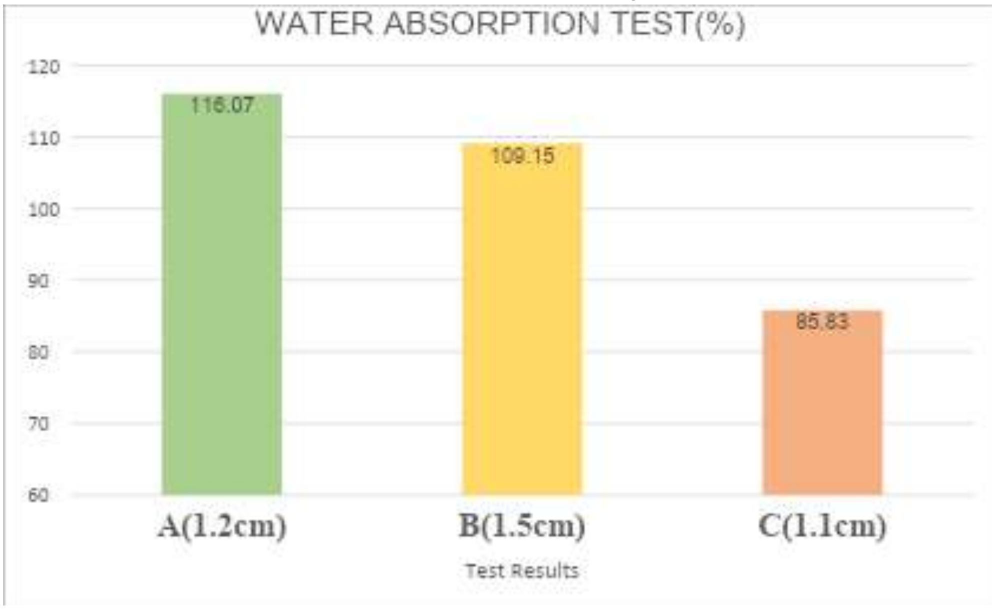

Figure 5. Water Absorption Test Result

Although Sample B (1.5 cm diameter) exhibited the highest tensile strength at 27 MPa, Sample C (1.1 cm diameter), which attained 21 MPa, was selected for further application due to its significantly lower water absorption. This selection reflects a functional trade-off wherein Sample B demonstrates superior strength under dry laboratory

conditions, whereas Sample C is expected to maintain more stable mechanical performance under moisture-exposed environments. Given that the intended application involves potential exposure to water and varying humidity levels, the lower water absorption of Sample C renders it the more suitable and durable option despite its comparatively lower tensile strength. As stated by Pavlovic et al. (2025),water absorption leads to swelling of the fiber cell walls, internal softening, and weakening of the interfiber and fiber-matrix interface. This swelling and softening undermine the ability of the fibers to bear tensile loads.

The tensile strength of bamboo fiber rope plays a critical role in determining the overall tensile behavior of a bamboo fiber geonet, as the geonet's load-carrying capacity depends on the mechanical performance of its woven components. According to Zhang et al. (2021), individual bamboo fibers exhibit tensile strengths ranging from 1400 to 1700 MPa, however, when fibers are combined into bundles, strips, or ropes, the tensile capacity decreases significantly due to internal defects, misalignment, and reduced fiber-to-fiber bonding. This phenomenon is consistent with geotextile studies wherein the mechanical behavior of bamboo-based fabrics is dictated largely by the quality and strength of the woven strands rather than isolated fiber properties. Topacio (2018) emphasized that the performance of bamboo geotextiles is directly influenced by the tensile behavior of their constituent fiber elements. The tensile strength of 21 MPa recorded for the bamboo fiber rope aligns with typical values reported for natural-fiber ropes, which often fall within the 20–80 MPa range because of structural imperfections that develop during rope fabrication. Rope diameter also significantly affects tensile behavior. Moreover, Ali et al. (2013) demonstrated that natural-fiber ropes exhibit diameter-dependent strength, where larger diameters tend to show reduced specific tensile strength due to increased internal voids and non-uniform stress distribution. With a diameter of 1.1 cm, the tensile performance of the bamboo rope is consistent with these observations, indicating that rope geometry and fiber arrangement are major determinants of the geonet's tensile response under applied loads.

1.2 Flexural Strength (ASTM D790)

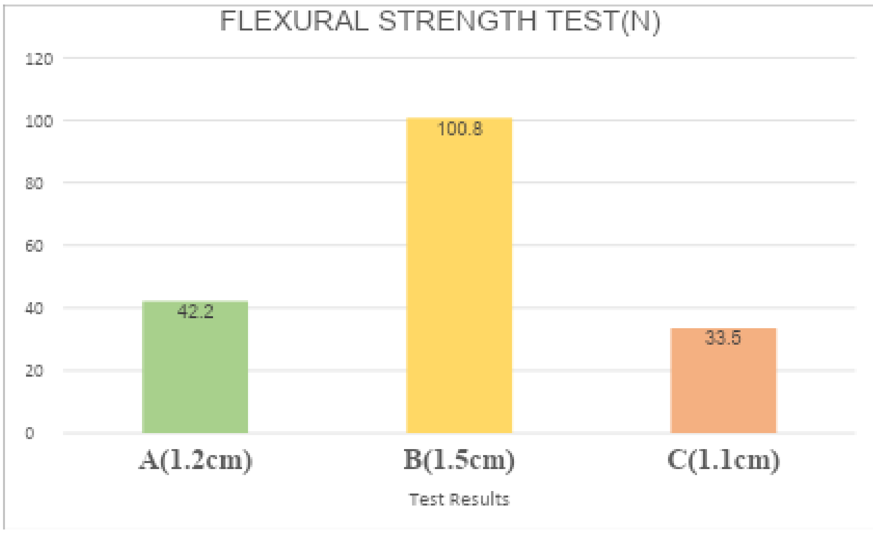

Figure 6. Flexural Strength Test

This graph shows the Flexural Strength Test of the bamboo fiber rope. Although Sample B obtained the highest flexural strength at 100.8 N, Sample C (33.5 N) was chosen for further application because it exhibited the lowest water absorption among all samples. This selection reflects a practical consideration of performance under real environmental conditions: while Sample B performs best under dry laboratory testing, Sample C is expected to retain its mechanical integrity more effectively in moisture-exposed settings. Dhakal, Zhang, and Richardson (2007) reported that water absorption causes reductions in flexural strength and stiffness due to micro-cracking and interfacial degradation. These findings indicate that materials with lower water absorption, such as Sample C, are more suitable for applications where durability under fluctuating moisture conditions is required.

Natural bamboo fiber, and by extension bamboo fiber rope can substantially contribute to the flexural strength of a geonet through effective load transfer and crackbridging under bending stress. According to Sudarisman, Muhammad, & Aziz (2015), bamboo fiber/epoxy composites showed that flexural strength and modulus increased with higher fiber volume fractions, with failure under bending largely by fiber/matrix debonding followed by fiber breakage or pullout indicating that the bamboo fibers actively carry tensile loads on the tension side during flexure. Moreover, in a study where bamboo rope fiber was used as reinforcement in polymer composites, the bending (flexural) strength reached about 95.32 MPa demonstrating that even ropeform bamboo reinforcement can yield significant flexural capacity under favorable orientation and matrix bonding. Therefore, given the measured flexural strength of 33.5 N for a geonet reinforced with a 1.1 cm-diameter bamboo fiber rope, these studies support that the rope enhances the geonet’s performance by transmitting tensile loads across the network, resisting bending, and bridging potential cracks, thereby improving its overall structural stability in flexure.

Lastly, for bamboo-based reinforcement and bamboo-fiber composites, the literature likewise treats tensile strength as a fundamental indicator of mechanical performance. Multiple studies on bamboo strips, bamboo-fiber composites, and bamboo-reinforced elements report tensile testing (and, where relevant, flexural testing) as primary experimental methods to characterize fiber strength, bonding behaviour, and bending performance; flexural tests are particularly important where bending or plate-type deformation may occur in application. In the context of geonets and other geosynthetic-type uses, researchers similarly rely on tensile and flexural tests as core metrics for evaluating the load-carrying capacity and deformation resistance of natural-fiber nets intended for soil stabilization. According to Hu et al. (2022), tensile and flexural properties are among the most reliable predictors of the mechanical stability and reinforcement capability of bamboo-derived materials, especially when these materials are subjected to combined loading conditions. For geonets used in sub-base soil reinforcement—where the material must primarily withstand in-plane tensile stresses from lateral soil movement and bending stresses caused by traffic-induced deformation—these two tests are widely viewed as sufficient to represent the dominant failure modes. The combined tensile and flexural results therefore provide critical insight into the geonet’s ability to resist fiber rupture, crack initiation, and bending-induced deformation, which are the most common stresses encountered in geonet applications for unpaved road sub-bases.

2. Behavior of woven bamboo fiber under vertical pressure load conditions.

2.1 Stress

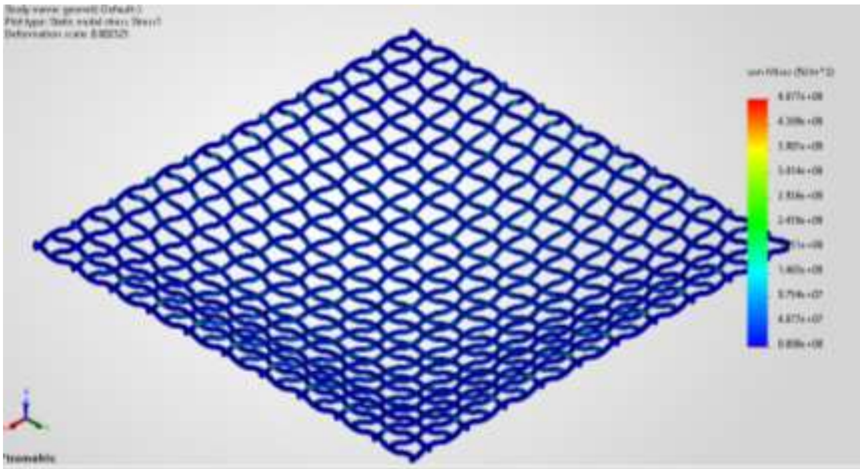

Figure 7. Result of Stress

The simulation results clearly demonstrate how the woven bamboo-fiber geonet responds under the applied loading condition. The von Mises stress field shows strong concentration of stresses at the rib intersections and central regions, which is consistent with how open-grid reinforcement structures naturally carry load. Under the imposed pressure, peak stress reaches approximately 4.88×10^8 N/m² (≈487.7 MPa), indicating that the material experiences extreme tension and bending at these critical nodes. This result shows the structural limitation of the bamboo-fiber geonet. If subjected to such a high-pressure environment in real-world conditions, the material would indeed be unable to withstand the load and would be expected to fail at these overstressed areas. Thus, the simulation effectively reveals the failure-prone regions and the sequence of structural response the geonet would undergo when overloaded. The gradual decrease of stress toward the edges further confirms that the woven pattern transfers load inward before failure occurs.

In addition, the published experimental data for bamboo-fiber–polyester composites report tensile strengths in the range of 30–40 MPa for randomly oriented fiber laminates (Manalo, Karunasena & Lau, 2013), and up to approximately 119 MPa for optimized treated–fiber composites with 40 wt.% fiber content (Chin et al., 2020). In contrast, the finite-element simulation of the woven bamboo geonet predicts a peak von Mises stress of ~ 487.7 MPa under the applied load, which substantially exceeds these empirical strength limits; thus, the model indicates that the structure would likely fail at overstressed regions under equivalent real-world loading.

Overall, the simulation provides a valid representation of the geonet’s behavior under extreme loading and offers valuable insight into its structural limits, guiding the design toward safer allowable loads and potential reinforcement strategies.

2.2 Displacement

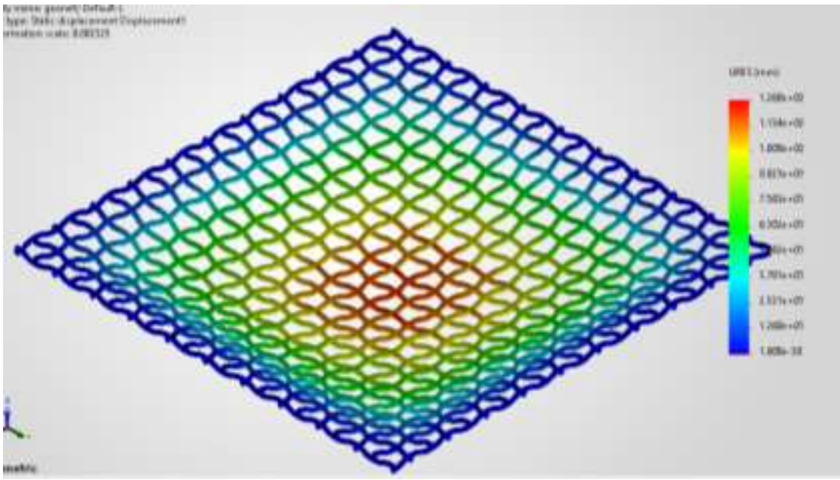

Figure 8. Result of Displacement

The finite-element simulation indicates that the geonet undergoes a deformation response characterized by pronounced downward sagging at its central region, consistent with membrane-type behavior under uniform loading. The maximum vertical displacement is concentrated at the mid-span and reaches approximately 1.26×10^{2} mm (≈126 mm), resulting in a distinct bowl-shaped deflection profile. In contrast, the boundary regions—constrained by fixed supports—exhibit negligible movement, confirming effective edge confinement within the model.

While no established standards currently define allowable deflection for woven natural-fiber geonets, serviceability guidance for geosynthetic–soil systems generally limits vertical strain to approximately 0.5 percent or restricts settlement to relatively small values under operational loads (FHWA, 2013). When viewed against these conventional service-limit benchmarks, the simulated displacement magnitude is substantially larger, suggesting that the bamboo-fiber geonet, under the applied loading scenario, would be operating beyond typical acceptable deformation thresholds.

The magnitude and distribution of the displacement further indicate that the geonet behaves as a highly compliant structural system, accommodating load primarily through out-of-plane bending and complementary in-plane stretching of the woven fibers. This response underscores the necessity of incorporating geometric nonlinearity and potential material stiffening effects in the evaluation of natural-fiber geonet performance. Moreover, it raises important considerations regarding the suitability of the current geonet configuration for reinforcement applications without modifications to either its structural design or the loading conditions.

2.3 Strain

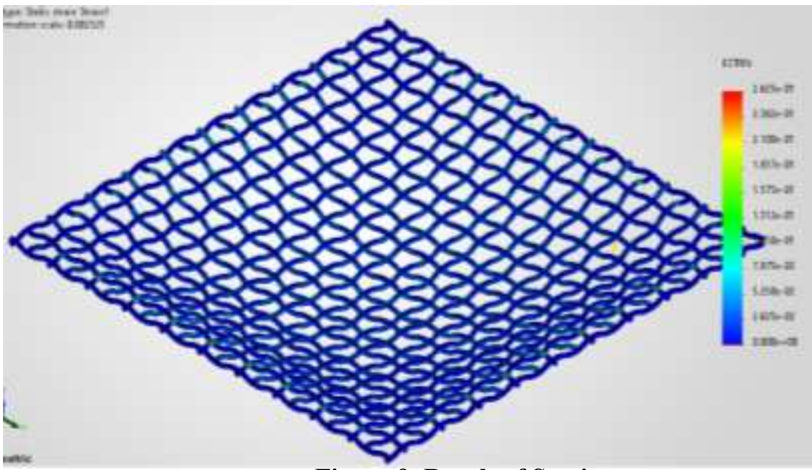

Figure 9. Result of Strain

The strain distribution indicates that the highest equivalent strain develops at the rib intersections and curved segments, where bending and tensile actions converge. The simulation predicts a maximum strain of approximately 2.63×10^{-1} (≈0.263), while the surrounding regions exhibit substantially lower strain values. This localized concentration reflects the structural behavior of open-grid systems, wherein load is transferred through critical nodes rather than uniformly distributed across the entire mesh. A strain level of 0.263 is exceptionally high and suggests that the geonet, under the simulated loading scenario, is deforming far beyond the range typically associated with elastic behavior. Consequently, the structure would not be expected to fully recover once the load is removed.

In addition, empirical studies on bamboo-fiber composites further support this assessment. According to Manalo, Karunasena, and Lau (2013) and Tran, Fuentes, Verpoest, and Van Vuure (2019), tensile failure strains for bamboo-based composites generally fall within approximately 0.9% to 2.2%, depending on fiber type, matrix characteristics, and lay-up configuration. When compared to these experimental benchmarks, the simulated maximum strain of ~0.263 (≈26.3%) is an order of magnitude higher than documented failure strains. This substantial discrepancy implies that, under the modeled loading condition, the woven bamboo geonet would likely experience material failure mechanisms such as fiber rupture, matrix cracking, or interfacial debonding rather than maintain elasticity. Nonetheless, the observed strain pattern remains valuable for identifying critical stress-carrying regions and can inform potential design improvements, including rib thickening or node reinforcement.

3. **Simulation of the Suitability of Bamboo Fiber Geonets for Soil reinforcement on Unpaved Roads**

SolidWorks is a computer-aided design and simulation software that can be used to predict the suitability of bamboo fiber geonets for soil reinforcement on unpaved roads by modeling the geometry, material properties, and loading conditions to simulate its mechanical behavior under field-representative stresses. By creating a three-dimensional model of the geonet, SolidWorks enables the application of tensile and flexural loads, thus allowing the analysis of stress distribution, strain, displacement, and potential failure points within the structure of the geonet. Chen et al. (2022), have used this simulation by inputting material properties that were experimentally determined, such as tensile strength and flexural rigidity from laboratory tests, and the simulations properly reflect real mechanical performance.

The woven bamboo fiber geonet subjected to vertical pressure loads that simulate the condition of an unpaved road was predicted for its suitability using the finite element simulation as an analytical tool. This research paper has identified three critical outputs in SolidWorks Simulation: von Mises stress, equivalent strain, and resultant displacement, which give insight into structural integrity and deformation behavior. Stress analysis identifies whether the peak von Mises stresses approach or exceed the tensile strength of the bamboo fiber rope; if the simulated stress distribution is below the material's allowable limits, then the geonet will bear the imposed soil and traffic loads without structurally failing. This is in agreement with Chen and Abu-Farsakh (2015), who identified that the performance of geosynthetics under roadway loading can be reliably estimated by comparing induced stress against material capacity. Equivalent strain results have further identified the localized deformation zone, a crucial issue in the evaluation of ductility and service life. Mahmud et al. (2020) identified that strain concentration is a key predictor of premature deformation in natural-fiber composites due to slippage at the microfibril and degradation at the fiber-matrix interface.

The displacement plot provides the final criterion for suitability by quantifying the vertical deformation of the geonet under load. xcessive displacement in applications for soil reinforcement may induce rutting, soil particle migration, or loss of interlock. Bathurst and Jarrett (2019) noted that the serviceability of geosynthetic layers in unpaved roads depends not just on strength but also on their ability to limit vertical deflection under repeated loads. In the current simulation, maximum values of displacement indicate whether the geonet possesses structural stiffness capable of distributing the loads such that surface deformations are minimized. A geonet maintains structural suitability when displacements remain within acceptable limits relative to typical geosynthetic reinforcement behavior.

Lastly, the overall output from the simulation, in terms of combined stress, strain, and displacement, provides a comprehensive assessment of geonet performance. If peak stresses remain below the strength of bamboo material, strain concentrations are within safe limits, and displacements are minimal, then the geonet can be predicted to perform effectively in stabilizing the soil of unpaved roads. This simulation-based evaluation agrees with earlier results by Rao and Prasad (2017), who stated that numerical analysis gives a reliable method of prediction for geosynthetic behavior before field validation. Therefore, SolidWorks finite element simulation serves as a robust predictive tool for establishing the structural suitability and performance behavior of bamboo fiber geonets for real-to-life applications in soil reinforcement.

CHAPTER IV
SUMMARY, CONCLUSION, RECOMMENDATION

This chapter presents the summary of findings, conclusions, and recommendations derived from the study. It highlights the key results obtained through data analysis and interpretation. Based on these findings, relevant conclusions are drawn, and practical recommendations are provided to guide future actions or research.

Summary

Bamboo fiber ropes play a crucial role in enhancing the mechanical performance of bamboo fiber geonets. Experimental testing of a 1.1 cm-diameter rope showed a tensile strength of 21 MPa, a flexural strength of 33.5 N, and water absorption of 85.83%. These results align with typical values for natural-fiber ropes, indicating that rope geometry, fiber arrangement, and internal defects significantly influence the geonet's ability to carry loads, resist bending, and maintain structural stability.

Moreover, to evaluate practical applications, a SolidWorks computational model simulated the geonet's behavior under tensile and flexural loads. By incorporating the experimentally determined material properties, the simulation analyzed stress distribution, strain, displacement, and potential failure points. However, the results showed that the woven bamboo fiber geonet did not withstand the high loading condition applied in the simulation. Excessive stress, large displacement, and critical strain values indicated structural insufficiency and potential failure under heavy loads. Therefore, while bamboo fiber geonets may still offer reinforcement benefits under light to moderate loading, the findings suggest that they are not suitable for heavy loading conditions representative of the extreme scenario tested in this study.

Overall, the stress, displacement, and strain results indicate that the woven bamboo fiber geonet does not perform adequately under the applied vertical pressure. The simulation showed that the geonet experienced stress levels, deformations, and strain values that exceeded acceptable structural limits, demonstrating that the material enters a critical state under high loading. Because the geonet is unable to maintain its structural integrity at 550 kPa, it cannot safely carry the imposed load and exhibits deformation patterns that signify potential failure. These outcomes suggest that the geonet is not suitable for heavy loading conditions, such as the extreme scenario simulated in this study. While the material may still be viable for light soil reinforcement or low-intensity applications, it is not recommended for high-stress environments typical of heavily loaded unpaved road sections.

CONCLUSION

As a result of the conducted tests and interpretation of results, the researchers have determined the following conclusions:

1. Bamboo fiber ropes play a critical role in enhancing the mechanical performance of bamboo fiber geonets. Experimental testing of a 1.1 cm-diameter rope revealed a tensile strength of 21 MPa and a flexural strength of 33.5 N, demonstrating that the geometry, fiber arrangement, and presence of internal defects significantly influence the geonet’s ability to carry loads, resist bending, and maintain structural stability.
2. The SolidWorks computational model effectively simulated the geonet’s behavior under tensile and flexural loads, incorporating the experimentally derived material properties. The simulation provided detailed insights into stress distribution, strain, displacement, and potential failure points, allowing prediction of the geonet’s performance under field-representative conditions.
3. Analysis of stress, displacement, and strain results indicates that the woven bamboo fiber geonet does not perform adequately under vertical pressure. The simulation showed that the applied load caused stress, displacement, and strain values that exceeded acceptable limits, demonstrating that the material cannot maintain elastic behavior under heavy static loading. Instead of remaining stable, the geonet experiences significant deformation and approaches structural failure. These results confirm that the geonet is not mechanically reliable for high-load structural applications, particularly those involving heavy vertical pressure.
4. The combined experimental and simulation results indicate that bamboo fiber geonets are not suitable for soil reinforcement and stabilization on unpaved roads when subjected to heavy loading conditions. Although the material demonstrates potential as a sustainable reinforcement option, the simulation results revealed excessive stress, strain, and displacement values under high vertical pressure, indicating structural insufficiency and a high likelihood of failure. These findings suggest that while bamboo fiber geonets may still offer benefits for light soil reinforcement or low-intensity applications, they cannot reliably prevent localized settlement or maintain surface stability under heavy loads, limiting their viability as an alternative to conventional geosynthetics in demanding road environments.

RECOMMENDATION

1. Extract the fibers immediately after cutting the bamboo from its source. This makes the extraction process easier and more efficient, as it becomes significantly harder to extract the fibers once the crushed bamboo has dried.
2. Ensure that the manufacturing process has consistent fiber distribution to produce uniform strength and performance throughout the geonet.
3. Look for contributing factors that affect its tensile strength such as bamboo fiber bonding and its fiber treatment.
4. Perform advanced laboratory tests to further understand the mechanical properties of bamboo fiber geonets, such as puncture resistance, creep behavior, and resilience under cyclic loading. These tests will help determine suitability for diverse geotechnical applications and improve product design.
5. Advanced software simulations, such as those conducted in SolidWorks, should be further utilized to model complex loading conditions, predict potential failure points, and optimize geonet design before physical implementation.
6. Additional research could explore hybrid designs combining bamboo fibers with other natural or synthetic materials to improve performance while maintaining eco-friendly characteristics.
7. Simulate the bamboo fiber geonet under minimal, moderate, and worst-case loads to identify the specific geotechnical applications where it performs best and determine its safe loading limits.

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APPENDICES

Photo Documentation

Collection of Bamboo

The collected Bamboo were gathered from Barangay San Josef(Nabao), Jaen, Nueva Ecija.

Cutting and manual splitting of bamboo

The bamboo stalks were manually cut and split into manageable strips for processing.

Crushing of the bamboo

The split bamboo pieces were crushed with a hammer to loosen and separate the fibers.

Soaking of the crushed Bamboo in Sodium Hydroxide Solution

The crushed bamboo was soaked in a 6% NaOH solution to remove lignin and enhance fiber quality.

Drying of the Bamboo from the solution

After soaking, the bamboo fibers were air-dried for 24 hours to prepare them for extracting and spinning

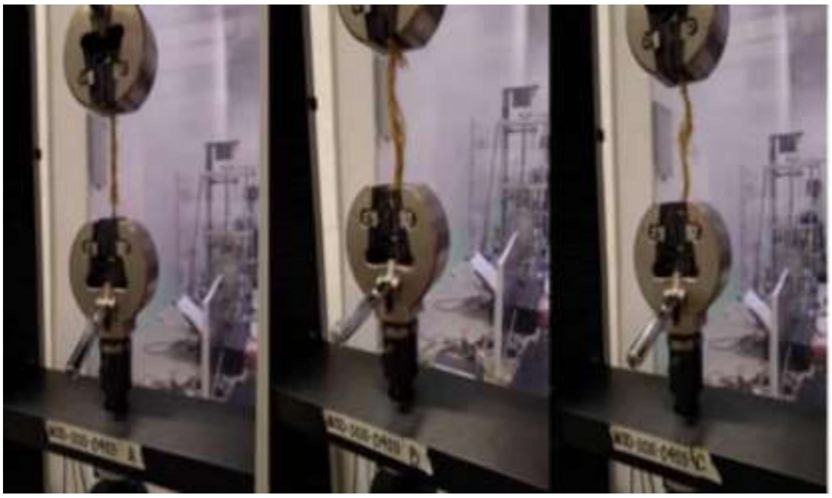
Extracting the Bamboo Fiber
The treated and dried bamboo was manually processed to extract clean, long fibers suitable for weaving.



Manual Spinning
The dried bamboo fibers were manually spun to align and refine the strands.

Making of the Bamboo Fiber Geonet
The spun fibers were woven into geonet sheets.

Testing for Tensile Strength Test
The bamboo rope samples were tested to determine their resistance to pulling or stretching forces.

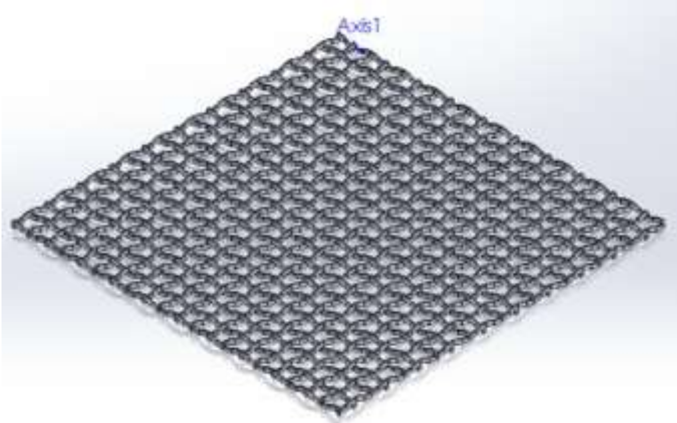


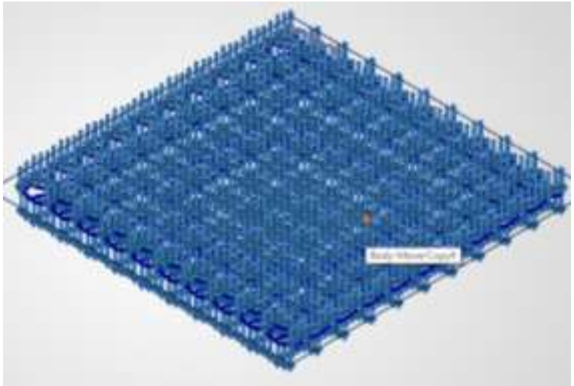
Testing for Flexural Strength Test
Flexural testing measured the bamboo fiber's ability to resist bending under applied force.

Testing for Water Absorption Test
Water absorption tests evaluated the bamboo fiber's moisture retention capacity and its effect on durability.

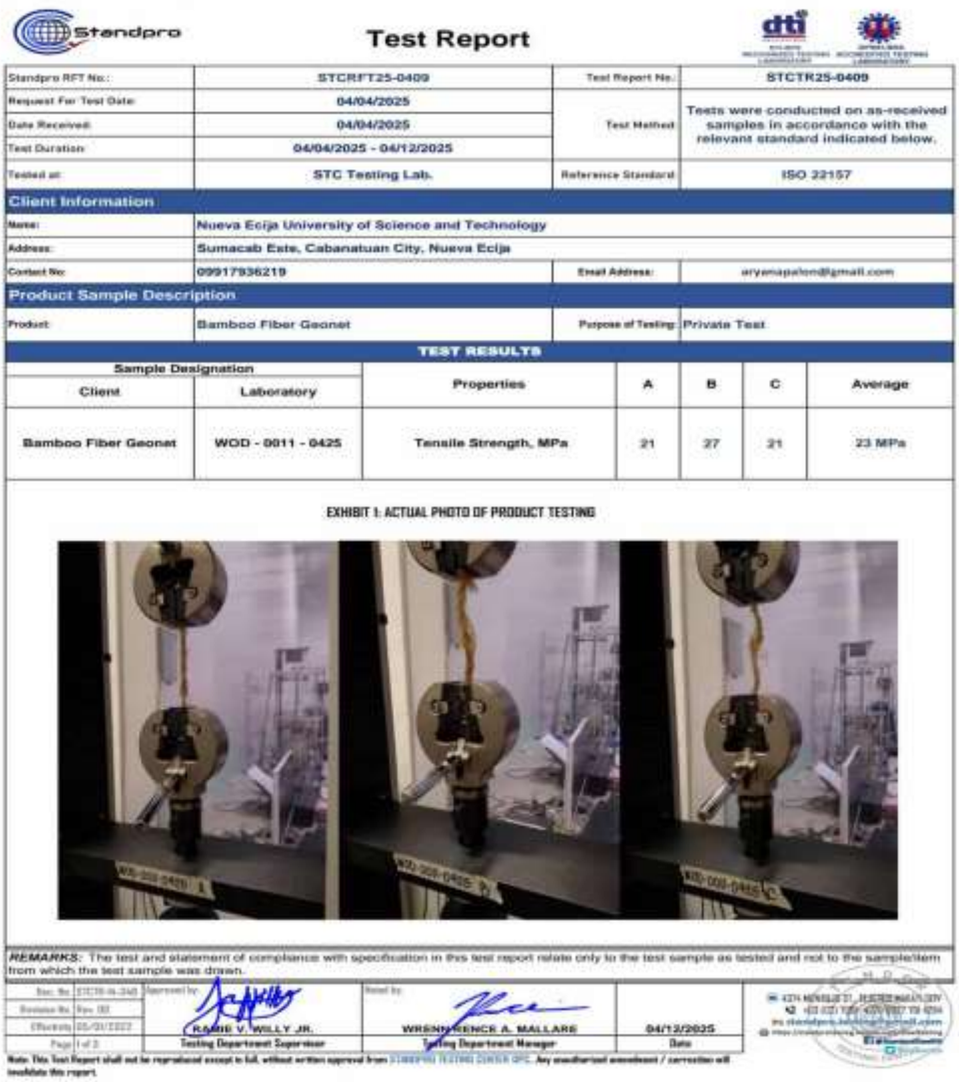
Digital Simulation of the Bamboo Fiber Geonet

The simulation predicts the geonet's structural performance and its suitability for soil reinforcement applications, particularly on unpaved roads.





Result of Tensile Strength Test for Bamboo Fiber Geonet



Standpro

Test Report

Standpro RFT No.:	STCRFT25-0409	Test Report No.:	STCTR25-0409
Request For Test Date:	04/04/2025	Test Method	Tests were conducted on as-received samples in accordance with the relevant standard indicated below.
Date Received:	04/04/2025		
Test Duration:	04/04/2025 - 04/12/2025		
Tested at:	STC Testing Lab.	Reference Standard	ISO 22157
Client Information			
Name:	Nueva Ecija University of Science and Technology		
Address:	Sumacab Este, Cabanatuan City, Nueva Ecija		
Contact No:	09917936219	Email Address:	aryanapalon@gmail.com
Product Sample Description			
Product:	Bamboo Fiber Geonet	Purpose of Testing:	Private Test

TEST RESULTS

Sample Designation		Properties	A	B	C	Average
Client	Laboratory					
Bamboo Fiber Geonet	WOD - 0011 - 0425	Tensile Strength, MPa	21	27	21	23 MPa

EXHIBIT 1: ACTUAL PHOTO OF PRODUCT TESTING

REMARKS: The test and statement of compliance with specification in this test report relate only to the test sample as tested and not to the sample/item from which the test sample was drawn.

Approved by:	Noted by:	
RAMIE V. WILLY JR.	WRENN RENCE A. MALLARE	04/12/2025
Testing Department Supervisor	Testing Department Manager	Date

Note: This Test Report shall not be reproduced except in full, without written approval from STANDPRO TESTING CENTER OPC. Any unauthorized amendment / correction will invalidate this report.

Result of Flexural Strength Test for Bamboo Fiber Geonet

Standpro

Test Report

Standpro RFT No.:	STCRFT25-0409	Test Report No.:	STCTR25-0409
Request For Test Date:	04/04/2025	Test Method:	Tests were conducted on as-received samples in accordance with the relevant standard indicated below.
Date Received:	04/04/2025		
Test Duration:	04/04/2025 - 04/12/2025		
Tested at:	STC Testing Lab.	Reference Standard:	ASTM D790

Client Information

Name:	Nueva Ecija University of Science and Technology		
Address:	Sumacab Este, Cabanatuan City, Nueva Ecija		
Contact No:	09917936219	Email Address:	aryanapalon@gmail.com

Product Sample Description

Product:	Bamboo Fiber Geonet	Purpose of Testing:	Private Test

TEST RESULTS

Sample Designation		Properties	A	B	C	Average
Client	Laboratory					
Bamboo Fiber Geonet	WOD - 0012 - 0425	Flexural Strength, N	42.2	100.8	33.5	58.83 N

EXHIBIT 1: ACTUAL PHOTO OF PRODUCT TESTING

REMARKS: The test and statement of compliance with specification in this test report relate only to the test sample as tested and not to the sample/item from which the test sample was drawn.

Doc. No. [illegible]	Approved by:	Noted by:		
Revision No. Rev. 00				
Effectivity [illegible]	RAMIE V. WILLY JR.	WRENN RENCE A. MALLARE	04/12/2025	
Page 2 of 3	Testing Department Supervisor	Testing Department Manager	Date	

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Result of Water Absorption Test for Bamboo Fiber Geonet

Standpro

Test Report

Standpro RFT No.:	STCRFT25-0409	Test Report No.:	STCTR25-0409
Request For Test Date:	04/04/2025	Test Method:	Tests were conducted on as-received samples in accordance with the relevant standard indicated below.
Date Received:	04/04/2025		
Test Duration:	04/04/2025 - 04/12/2025		
Tested at:	STC Testing Lab.	Reference Standard:	ASTM D570

Client Information

Name:	Nueva Ecija University of Science and Technology		
Address:	Sumacab Este, Cabanatuan City, Nueva Ecija		
Contact No:	09917936219	Email Address:	aryanapalon@gmail.com

Product Sample Description

Product:	Bamboo Fiber Geonet	Purpose of Testing:	Private Test

TEST RESULTS

Sample Designation		Properties	A	B	C	Average
Client	Laboratory					
Bamboo Fiber Geonet	WOD - 0013 - 0425	Water Absorption, %	116.07	109.15	85.83	103.68%

EXHIBIT 1: ACTUAL PHOTO OF PRODUCT TESTING

REMARKS: The test and statement of compliance with specification in this test report relate only to the test sample as tested and not to the sample/item from which the test sample was drawn.

Doc. No. [illegible]	Approved by:	Noted by:		
Revision No. Rev. 03				
Effectivity 05/01/2022	RAMIE V. WILLY JR.	WRENNRENCE A. MALLARE	04/12/2025	
Page 2 of 3	Testing Department Supervisor	Testing Department Manager	Date	

standpro.testing@gmail.com

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