THE INFLUENCE OF NATURAL OKRA-BANANA GEOTEXTILE ON THE IMPROVEMENT OF ROAD SUBBASE BEARING CAPACITY

An Undergraduate Thesis

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College of Engineering Education
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of the Requirements for the Degree
Bachelor of Science in Civil Engineering

By

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APPROVAL SHEET

This undergraduate thesis entitled, " **THE INFLUENCE OF NATURAL OKRA-BANANA GEOTEXTILE ON THE IMPROVEMENT OF ROAD SUBBASE BEARING CAPACITY"** prepared and submitted by Cristian D. Sereño, Melany Joyce E. Aguilon, and Carlo Emmanuel C. Alcantara, has been examined, accepted, and is hereby endorsed.

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We want to express our heartfelt gratitude to a number of individuals and organizations who played crucial roles in our research:

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C.D.S

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ABSTRACT

Low bearing capacity is one of the common problems for soils, especially on-the-road soils in the Philippines. Geotextiles are made to enhance the soil's characteristics. Geosynthetics are geotextiles made of synthetic fibers and are widely available in the market, but because of environmental sustainability issues, natural geotextiles were developed over the years. The study is focused on determining the application of Okra (Abelmoschus esculentus) and Banana (Musa acuminata) natural geotextile in enhancing the California Bearing Ratio (CBR) of subbase soil. The test includes a soil compaction test, a tensile test for the geotextile, and a CBR test for the subbase soil mixed with geotextile. The geotextile was created and cut into strips using the methods of the previous studies. The subbase soil was collected based on the DPWH specifications. The samples tested for CBR include 0%, 1%, 2%, and 3% of geotextile strips mixed with the subbase soil. The result shows that the CBR value increases as the geotextile strip percentage increases. Therefore, the sub-base soil has the best bearing capacity with the 3% Okra-Banana geotextile strips added and has a significant difference compared to the control sample.

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The Influence of Natural Okra-Banana Geotextile on the Improvement of Road Subbase Bearing Capacity

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Abstract— **Low bearing capacity is one of the common problems for soils, especially on-the-road soils in the Philippines. Geotextiles are made to enhance the soil's characteristics. Geosynthetics are geotextiles made of synthetic fibers and are widely available in the market, but because of environmental sustainability issues, natural geotextiles were developed over the years. The study is focused on determining the application of Okra (Abelmoschus esculentus) and Banana (Musa acuminata) natural geotextile in enhancing the California Bearing Ratio (CBR) of subbase soil. The test includes a soil compaction test, a tensile test for the geotextile, and a CBR test for the subbase soil mixed with geotextile. The geotextile was created and cut into strips using the methods of the previous studies. The subbase soil was collected based on the DPWH specifications. The samples tested for CBR include 0%, 1%, 2%, and 3% of geotextile strips mixed with the subbase soil. The result shows that the CBR value increases as the geotextile strip percentage increases. Therefore, the sub-base soil has the best bearing capacity with the 3% Okra-Banana geotextile strips added and has a significant difference compared to the control sample.**

Keywords—**Okra (Abelmoschus esculentus), Banana (Musa acuminata), Geotextile Strips, California Bearing Ratio, Subbase Soil**

I. INTRODUCTION

Bearing capacity is the ability of the soil to carry loads from a structure. Low bearing capacity is one of the most common problems for soil's capability of infrastructures. Improving the soil conditions with the help of geotextiles is one of the technological developments designed to strengthen the soil and increase the soil-bearing capacity [1]. In the study [2], it is said that low bearing capacity is one of the reasons some places in the Philippines, specifically Manila, need help developing.

Geotextiles are used in engineering as soil fills that help the soil enhance its characteristics. It helps undernourished soils become suitable for infrastructure such as roads, harbors, landfills, drainage, and other construction projects [3]. Geotextiles can be non-woven, knitted, or woven fabrics made of synthetic or biodegradable materials [4]. Using non-woven geotextiles improves soil strength and increases flexibility compared to woven geotextiles. It has also been proven capable of thermal, sound, electrical, and filter material [5], [6]. In the study [7], geosynthetics enhanced bearing capacity and the mechanical behavior of sandy soils. Even though geosynthetics or synthetic fibers are highly recognized in the market because of their low cost yet excellent performance, synthetic materials have contributed to the environmental problems the world is facing today [8]. Due to the decreasing supply issues, it is now a trend to utilize biodegradable materials to promote a sustainable environment. Still, products made of biodegradable materials outnumbered production and efficiency [9]. Thus, natural fibers as an alternative to synthetic fibers have developed over the years. Since these natural fibers are from animals and plants, some downsides include low moisture resistance and the difference between the characteristics of fibers. Modifying its properties using chemical treatments helps address the disadvantages [8]. The study [10] proved that using epoxy resin as a binder for natural fibers enhances the efficiency of the fibers.

On the other hand, in the study [11], a non-woven geotextile was produced from Okra (Abelmoschus e.) and Banana (Musa a.) natural fibers. It shows that the 175 mL of epoxy mixture for 50% Okra and 50% Banana fiber obtained the highest tensile strength, water absorbency, and soil degradation. The ratio of the length and width to the weight of epoxy and fibers is 12:7. Furthermore, a subbase is essential for road construction. Low bearing capacity on subbase roads results in waviness, distress in the pavement, and costly maintenance or rehabilitation [12]. Infrastructures constructed on fine-grained subbase (e.g., clay) are prone to damage. The study [13]

investigated if geotextiles and their placement will influence the California Bearing Ratio (CBR) value. The findings concluded that the CBR value increases as the distance of geotextile increases and the farther its distance to the ground surface. The more soil rests above the geotextile, the more it causes friction to the soil under it and makes it denser. A study is conducted to determine how geosynthetic cutting influences road subbase. The level of bearing capacity improvement is affected by soil type and geosynthetic cutting, with a cutting size and recommended ratio of 4:1 [14].

The results of laboratory experiments examining the impact of recycled geogrid on soil-bearing capacity through a CBR test are detailed in the earlier research conducted in reference [14]. However, the study uses polyester geosynthetics that have high resistance to biodegradation, which is not much preferable for the environment. Thus, this research will utilize a natural geotextile, a mixture of 175mL resin for 50% Okra and 50% Banana fiber [11], to improve road subbase bearing capacity using a CBR test, which is an advancement to address poor road conditions in the Philippines with the help of biodegradable materials.

This paper presents the influence of Okra-Banana non-woven natural geotextile strips on the bearing capacity of soil with the help of the California Bearing Ratio (CBR) test. The following are the specific objectives: (1) to determine the strength of subbase course materials with and without Okra-Banana non-woven geotextile strips; (2) to determine the effect of geotextile content on moisture content and CBR values; and (3) to evaluate the improvement in soil bearing capacity resulting from geotextile.

The findings of this study will aid the transportation industry by providing renewable and biodegradable materials that will help weak soils enhance their characteristics for road construction. In addition, this study can serve as an additional resource for future researchers focused on geotextiles made from natural fibers.

Hence, the present study attempted to examine the enhancement of soil-bearing capacity used in road applications by reinforcing it with natural Okra-Banana non-woven geotextile strips.

II. Materials and Methods

A. Conceptual Framework

As shown in Fig. 1, the Okra-Banana natural non-woven geotextile will be cut into 40 mm by 10 mm long strips and mixed with subbase coarse aggregate. Each sample will undergo the CBR test to determine the soil-bearing capacity.

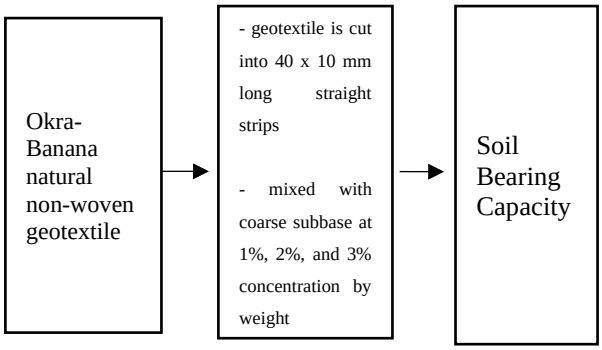

Fig 1. *Conceptual Framework*

B. Materials and Resources

The adhesive resin used in the study was a liquid epoxy resin derived from bisphenol-A and epichlorohydrin, with caustic soda serving as its catalyst. The curing agent and hardener for this resin were primarily composed of amine.

The Okra (10 kg, raw) plant was collected in the backyard of a family residence at Banaybanay, Davao Oriental. For the Banana fibers, a well-grown banana stem (10 kgs) from a banana tree was collected from a banana plantation in Banaybanay, Davao Oriental. The banana stems are about 18-24 months old [11].

C. Methods and Procedures

1. Soil and geotextile preparation

The researchers employed the Oven Drying Method, in line with ASTM D2216-19, to analyze the soil's moisture content and dry weight—the procedure initiated by weighing empty containers and documenting their weights and corresponding container numbers. Subsequently, a specific quantity of the wet soil was accurately measured and placed in each container.

Fig 2. *Weighing of soil sample*

The containers were then positioned in an oven set within a temperature range of 110 - 115°C and left undisturbed for 24 hours to ensure the soil's moisture content evaporated and the weight of the container and its contents stabilized. After adequate drying, the containers were delicately removed from the oven using tongs. The researchers then determined the weight of each container, including the dry soil sample within. The final step involved the execution of necessary calculations to determine

the moisture content of the soil, which held significant relevance for their research objectives.

Fig 3. *Drying of soil sample in the oven*

The natural geotextile made from a combination of Okra and Banana was cut into smaller pieces. This cutting process was designed to create strips with a length-to-width ratio of about 4:1 [14]. These geotextile strips were then mixed with the soil mixture until each sample weighed 28 kilograms, including subbase soil with concentrations of 1%, 2%, and 3% [14]. The 28-kilogram samples were divided into four parts, each weighing 7 kilograms. The different variations in the tested samples are outlined in Table 1.

Table 1. Variants of the tested samples

Soil + Additive%	Soil Weight (grams)	Geotextile Strips Weight (grams)
subbase soil	7000	0
subbase + 1%strips	6930	70
subbase + 2%strips	6860	140
subbase + 3%strips	6790	210

2. Sample testing

a. Measurement of Tensile Strength

In their testing procedure, the researchers prepared test specimens cut in both the machine and cross-machine directions. The test involves placing the specimen between the grips, ensuring a 75 mm (3-inch) separation between the jaw faces, as specified by the ASTM D4632 standard, which requires the jaw faces to have a minimum size of 25.4 mm x 50.8 mm. The evaluation is then carried out at a controlled speed of 300 mm/min. The key parameters being measured in this test include the load at the material failure point and the material's total elongation.

Fig 4. *Geotextile tested in ASTM D4632*

b. California Bearing Ratio Test

To assess the bearing capacity of the sample, the researchers conducted tests following the ASTM D1883 standard. The test started by placing the soil specimen mold on the penetration testing machine's lower plate, adding a 2.5 kg annular weight on the soil surface to prevent soil from entering the hole designed for extra weights, and securely attaching the penetration plunger. Afterward, they added the remaining extra weights.

Once the setup was in place, the researchers carefully positioned the penetration piston at the center of the specimen, making sure that the load didn't exceed 7 kg to ensure complete contact. They set the load and deformation gauges to zero and began applying a controlled load to the piston at a rate of about 1.25 mm per minute. Load measurements were taken at different penetration depths, ranging from 0.5 to 12.5 mm. The plunger was lifted when the test was finished, and the mold was removed from the machine for further examination.

c. Modified Proctor Compaction Test

The sample goes through the Modified Proctor Compaction Test, which follows the guidelines of ASTM D1557. Initially, 7 kg samples are obtained from the CBR test. The combined weight of the soil and mold (without the collar) is calculated for each sample. These samples are then placed in a mixer, and water is gradually added until the desired moisture content is achieved. A lubricant is applied to the collar to facilitate the soil extraction from the mold. Next, the soil is layered into the mold in five segments, each compacted using 25 blows consistently. It's essential to ensure that the soil slightly overflows into the collar, extending about 1 centimeter.

Once the compaction process is completed, the collar is removed, any excess soil above the mold is trimmed, and the weight of the mold with the soil is recorded. A metallic extruder gently removes the soil from the mold, ensuring it's properly aligned. Moisture content measurements are taken at the soil sample's top, middle, and bottom sections. The measurements from these three sections are averaged to determine the compaction water content.

III. Results and Discussions

Fig. 5 shows the Okra-Banana geotextile created by the researchers following the procedures from [11].

Fig 5. *Okra-Banana non-woven jute geotextile*

The samples designed are based on the varying percentages of Okra-Banana geotextile strips added to subbase soil. The results were analyzed comparatively to the pure subbase soil control sample without the geotextile strips.

The data provided reveals the results of an experimental study focused on investigating the effects of different additives on the California Bearing Ratio (CBR) values and optimum moisture content of subbase material. The CBR values indicate the material's strength and stiffness, while the optimum moisture content indicates the ideal moisture level for optimal performance.

A. Subbase Soil Moisture Content

The subbase soil used in the experiment undergoes the soil moisture content test through the dry-oven method, and the values obtained are presented in Fig. 6. The figure shows that the subbase soil moisture content at 80, 94, 95, 99, and 106 grams is 9.82, 9.33, 13.33, 12.82, and 9.41 %.

The subbase soil's moisture content increased as the weight increased until it reached its maximum moisture content value of 13.33% at 95 grams; after that, even if the weight continued to increase, the moisture content decreased. Meanwhile, the minimum moisture content is 9.33% at 94 grams. According to the results, the calculated mean soil moisture content is 10.95%.

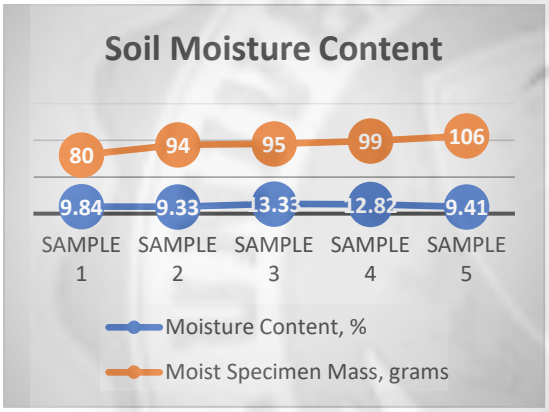

Fig 6. *Subbase Soil Moisture Content*

B. Tensile Strength

The Okra-Banana geotextile with the size of 150 mm x 300 mm was tested for tensile strength using the grab method. The test results are shown in Table 2; the average tensile strength value is in kilo-Newton per square meter (kN/m2) unit. The geotextile obtained a maximum load of 0.2 and 0.3 kN; thus, the tensile strength is 266.667 and 400 kN/m2. As computed, the average tensile strength of the Okra-Banana geotextile is 333.334 kN/m2.

Table 2. Average Tensile Strength of Okra-Banana geotextile

Sample	Maximum Load (kN)	Tensile Strength (kN/m^2)	Average Tensile Strength
1	0.2	266.667	**333.334**
2	0.3	400	

C. California Bearing Ratio

To evaluate the effect of Okra-Banana geotextile additive on subbase soil bearing capacity, the researchers conducted a test called California Bearing Ratio. The geotextile additive is cut into 10mm x 40mm strips for CBR testing. The test results show each sample's maximum moisture content (in percentage) and the CBR values.

Fig. 7 shows that the control sample, which did not contain any geotextile additive, exhibited an optimum moisture content of 10.6% and a corresponding CBR value of 33.1%. These values provide a reference point for comparison in the subsequent tests.

Introducing a 1% additive resulted in a slight decrease in the optimum moisture content to 9.8%, accompanied by a modest increase in the CBR value to 34.6%. It suggests that the 1% additive lowers the moisture content required for optimal performance while enhancing the material's strength and stiffness compared to the control sample.

In the 2% additive, a more notable decrease in the optimum moisture content to 8.2% was observed, along with a significant increase in the CBR value to 38.4%. It indicates that the 2% additive has a more pronounced effect on reducing the optimal moisture content and improving the material's strength and stiffness when compared to both the control and 1% additive scenarios.

The last sample with a 3% additive led to an optimum moisture content of 9.1%, accompanied by the highest CBR value of 39.2% among all the tested additives. It suggests that the 3% concentration decreases the optimal moisture content and substantially enhances the material's strength and stiffness.

The results show significant changes in the moisture content and the CBR values of the samples with geotextile additive. The control sample has the highest moisture content of 10.6% yet the lowest CBR value of 33.1. As the geotextile additive increased, the moisture content decreased, and the sample with 2% geotextile additive obtained the lowest moisture content of 8.2%. On the other hand, as the geotextile additive increased, the CBR value increased as well; thus, the sample with 3% geotextile additive obtained the highest CBR value of 39.2.

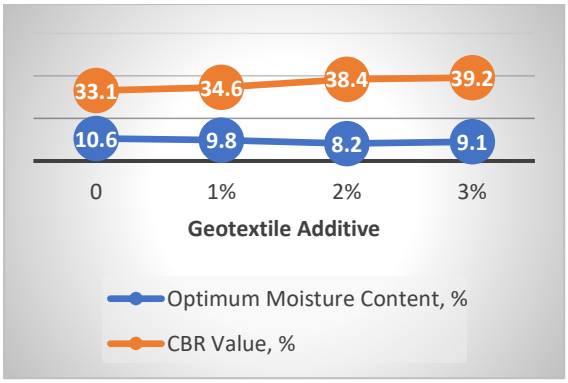

Fig 7. *Effect of Okra-Banana geotextile additive on moisture content and CBR values*

The CBR test showed that the sub-base soil has the best bearing capacity with the 3% Okra-Banana geotextile strips added and has a significant difference compared to the control sample.

IV. Conclusions and Future Works

The data illustrates that adding varying additive concentrations influences the subbase material's optimum moisture content and CBR value. Higher additive concentrations reduce optimum moisture content and improve strength and stiffness compared to the control sample. However, it is essential to consider that drawing definitive conclusions regarding the specific additive or its overall effectiveness in optimizing the material's performance becomes easier with additional context and comparative data.

For future works, these are the researchers' recommendations. First, future researchers can explore the effects of geotextile additives on different specific subbase soil moisture content. Second, the soil can be subjected to more geotextile additive percentages. Third, woven Okra-Banana geotextile can be studied to see how they differ without the epoxy resin as a bonding agent. Furthermore, additional tests can be made, and since geotextile helps in soil-bearing capacity, other applications can be studied, such as its effect on foundation footings.

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APPENDIX A
Data Sheets

1. Data for Average Moisture Content of Subbase Soil

Table 1. Soil Moisture Content

Container/Lid Number	1	2	3	4	5
Container Mass, g M_c	13	12	13	11	10
Container +Moist Specimen Mass, g M_{cms}	80	94	106	99	95
Initial Container Dry Specimen Mass, g	74	87	97	89	86
Secondary Container Dry Specimen Mass, g	74	88	98	88	85
Final Container Dry Specimen Mass, g M_{cds}	74	87	98	89	85
Mass of Water, g, $M_w = M_{cms} - M_{cds}$	6	7	8	10	10
Mass of Soilids, g, $M_s = M_{css} - M_c$	61	75	85	78	75
Soil Moisture, %, $w = (M_w / M_s) \times 100$	9.84	9.33	9.41	12.82	13.33

2. Data for Tensile Strength Testing

Mapua Malayan Colleges Mindanao
General Douglas MacArthur Highway, Matina, Davao City
www.mcm.edu.ph

TENSILE TEST REPORT ON GEOTEXTILE

Customer : Melany Joyce Aguilon
Test Date : 30/08/2023
Type : Flat
Length (mm) : 300
Width (mm) : 150
Thickness (mm): 5

Sample	P = Maximum Load (kN)	P ÷ (l x t) = Tensile Strength (kN/m^2)
1	0.200	266.667 kN/m^2
2	0.300	400 kN/m^2
Average Tensile Strength : 333.334 kN/ m^2		
REMARKS: This report gives the results carried out on samples submitted and tested to Civil Engineering Materials and Testing Laboratory of Mapúa Malayan Colleges Mindanao, Davao City.		
Witnessed By: **Melany Joyce Aguilon** **Carlo Emmanuel Alcantara** **Cristian Sereño**	**Approved By:** **Ace Vann Cardiff T. Aleria** **Laboratory Assistant**	

3. Data for California Bearing Ratio

MEGATESTING CENTER INC.
CIVIL ENGINEERING LABORATORY
PUROK 46, KAPUNDOK, MA-A ROAD, TALOMO, DAVAO CITY
DPWH-BRS Accredited Laboratory
Telefax :(082) 282-0889
Main Office: No. 26 Congressional Ave., Brgy. Bahay Toro, Quezon City
Tel. No.: (02) 289 - 8305
Valid Until : 2024-04-06

Date: May 23, 2023
Lab. Report No.: MTCI-DVO-230504-0083

TEST REPORT ON SOIL AGGREGATES

Project	: **The Influence of Okra-Banana Natural Geotextile on Improvement of Road Base Coarse Bearing Capacity**		
Location	: UM Matina		
Contractor	: **Melany Joyce Aguilon**		
Kind of material	: Sand-Gravel		
Sample Identification	: Sand - Gravel (Control)		
Quantity Represented	: n/s		
Sampled at	: n/s		
Original source	: Davao City		
Supplied by	: n/s		
Proposed use	: Thesis		
Spec's Item No.	: n/s		
Sampled by	: **n/s**	**n/s**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Sampled)*
Submitted by	: **M.J. Aguilon**	**Student**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Submitted)*

TESTS	REQUIREMENTS	RESULTS
Sieve Analysis: Cumulative % Passing		
Sieve Size, inch		
3		
2 1/2		
2		
1 1/2		
1		
3/4		
1/2		
3/8		
No. 4		
No.10		
No.40		
No.200		
Liquid Limit, %		
Plasticity Index, %		
Abrasion Loss (LAM), %		
Moisture Density Relationship		
Max. Dry Density Kg/m³	-	2015
Optimum Moisture Content, %	-	10.6
California Bearing Ratio:		
CBR Value, %	-	33.1
Swell, % 10 Blows, 30 Blows, 65 Blows	-	- - -

REMARKS: *This report gives the results carried out on samples submitted and tested to Megatesting Center, Inc. - Davao Branch This Laboratory is Responsible for test only.*

Checked by: **Brian Ber G. Estacion** **Sr. Laboratory Technician**	**Certified By:** ENGR. CHRISTOPHER V. CASINILLO MATERIALS ENGINEER I PRC LICENSE # 0132530 DPWH-BRS ACCREDITATION # 4775
Witnessed by: **Melany Joyce Aguilon** **Carlo Alcantara** **Cristian Sereño**	**Approved By:** **Engr. Rushell Rowena D. Gelacio** **Laboratory Manager**

MEGATESTING CENTER INC.
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Tel. No.: (02) 289 - 8305
Valid Until : 2024-04-06

Date: May 23, 2023
Lab. Report No.: MTCI-DVO-230504-0084

TEST REPORT ON SOIL AGGREGATES

Project : **The Influence of Okra-Banana Natural Geotextile on Improvement of Road Base Coarse Bearing Capacity**
Location : UM Matina
Contractor : **Melany Joyce Aguilon**
Kind of material : Sand-Gravel & Natural Textile (1%)
Sample Identification : Banana - Okra Geotextile
Quantity Represented : n/s
Sampled at : n/s
Original source : Davao City
Supplied by : n/s
Proposed use : Thesis
Spec's Item No. : n/s

Sampled by	: **n/s**	**n/s**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Sampled)*
Submitted by	: **M.J. Aguilon**	**Student**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Submitted)*

TESTS	REQUIREMENTS	RESULTS
Sieve Analysis: Cumulative % Passing		
Sieve Size, inch		
3		
2 1/2		
2		
1 1/2		
1		
3/4		
1/2		
3/8		
No. 4		
No.10		
No.40		
No.200		
Liquid Limit, %		
Plasticity Index, %		
Abrasion Loss (LAM), %		
Moisture Density Relationship		
Max. Dry Density Kg/m³	-	2021
Optimum Moisture Content, %	-	9.8
California Bearing Ratio:		
CBR Value, %	-	34.6
Swell, % 10 Blows, 30 Blows, 65 Blows	-	- - -

REMARKS: *This report gives the results carried out on samples submitted and tested to Megatesting Center, Inc. - Davao Branch. This Laboratory is Responsible for test only.*

Checked by:
Brian Ber G. Estacion
Sr. Laboratory Technician

Certified By:
ENGR. CHRISTOPHER V. CASINILLO
MATERIALS ENGINEER I
PRC LICENSE # 0132530
DPWH-BRS ACCREDITATION # 4775

Witnessed by:
Melany Joyce Aguilon
Carlo Alcantara
Cristian Sereño

Approved By:
Engr. Rushell Rowena D. Gelacio
Laboratory Manager

MEGATESTING CENTER INC.
CIVIL ENGINEERING LABORATORY
PUROK 46, KAPUNDOK, MA-A ROAD, TALOMO, DAVAO CITY
DPWH-BRS Accredited Laboratory
Telefax :(082) 282-0889
Main Office: No. 26 Congressional Ave., Brgy. Bahay Toro, Quezon City
Tel. No.: (02) 289 - 8305
Valid Until : 2024-04-06

Date: May 23, 2023
Lab. Report No.: MTCI-DVO-230504-0085

TEST REPORT ON SOIL AGGREGATES

Project : **The Influence of Okra-Banana Natural Geotextile on Improvement of Road Base Coarse Bearing Capacity**
Location : UM Matina
Contractor : **Melany Joyce Aguilon**
Kind of material : Sand-Gravel & Natural Textile (2%)
Sample Identification : Banana - Okra Geotextile
Quantity Represented : n/s
Sampled at : n/s
Original source : Davao City
Supplied by : n/s
Proposed use : Thesis
Spec's Item No. : n/s

Sampled by	: **n/s**	**n/s**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Sampled)*
Submitted by	: **M.J. Aguilon**	**Student**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Submitted)*

TESTS	REQUIREMENTS	RESULTS
Sieve Analysis: Cumulative % Passing		
Sieve Size, inch		
3		
2 1/2		
2		
1 1/2		
1		
3/4		
1/2		
3/8		
No. 4		
No.10		
No.40		
No.200		
Liquid Limit, %		
Plasticity Index, %		
Abrasion Loss (LAM), %		
Moisture Density Relationship		
Max. Dry Density Kg/m³	-	2056
Optimum Moisture Content, %	-	8.2
California Bearing Ratio:		
CBR Value, %	-	38.4
Swell, % 10 Blows, 30 Blows, 65 Blows	-	- - -

REMARKS: This report gives the results carried out on samples submitted and tested to Megatesting Center, Inc. - Davao Branch. This Laboratory is Responsible for test only.

Checked by:
Brian Ber G. Estacion
Sr. Laboratory Technician

Certified By:
ENGR. CHRISTOPHER V. CASINILLO
MATERIALS ENGINEER I
PRC LICENSE # 0132530
DPWH-BRS ACCREDITATION # 4775

Witnessed by:
Melany Joyce Aguilon
Carlo Alcantara
Cristian Sereño

Approved By:
Engr. Rushell Rowena D. Gelacio
Laboratory Manager

MEGATESTING CENTER INC.
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PUROK 46, KAPUNDOK, MA-A ROAD, TALOMO, DAVAO CITY
DPWH-BRS Accredited Laboratory
Telefax :(082) 282-0889
Main Office: No. 25 Congressional Ave., Brgy. Bahay Toro, Quezon City
Tel. No.: (02) 289 - 8305
Valid Until : 2024-04-06

Date: May 23, 2023
Lab. Report No.: MTCI-DVO-230504-0086

TEST REPORT ON SOIL AGGREGATES

Project	: **The Influence of Okra-Banana Natural Geotextile on Improvement of Road Base Coarse Bearing Capacity**		
Location	: UM Matina		
Contractor	: **Melany Joyce Aguilon**		
Kind of material	: Sand-Gravel & Natural Textile (3%)		
Sample Identification	: Banana - Okra Geotextile		
Quantity Represented	: n/s		
Sampled at	: n/s		
Original source	: Davao City		
Supplied by	: n/s		
Proposed use	: Thesis		
Spec's Item No.	: n/s		
Sampled by	: **n/s**	**n/s**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Sampled)*
Submitted by	: **M.J. Aguilon**	**Student**	05/04/2023
	(Name & designation)	*(Office)*	*(Date Submitted)*

TESTS	REQUIREMENTS	RESULTS
Sieve Analysis: Cumulative % Passing		
Sieve Size, inch		
3		
2 1/2		
2		
1 1/2		
1		
3/4		
1/2		
3/8		
No. 4		
No.10		
No.40		
No.200		
Liquid Limit, %		
Plasticity Index, %		
Abrasion Loss (LAM), %		
Moisture Density Relationship		
Max. Dry Density Kg/m^3	-	2062
Optimum Moisture Content, %	-	9.1
California Bearing Ratio:		
CBR Value, %	-	39.2
Swell, % 10 Blows, 30 Blows, 65 Blows	-	- - -

REMARKS: *This report gives the results carried out on samples submitted and tested to Megatesting Center, Inc. - Davao Branch This Laboratory is Responsible for test only.*

Checked by: **Brian Ber G. Estacion** **Sr. Laboratory Technician**	**Certified By:** ENGR. CHRISTOPHER V. CASINILLO MATERIALS ENGINEER I PRC LICENSE # 0132530 DPWH-BRS ACCREDITATION # 4775
Witnessed by: **Melany Joyce Aguilon** **Carlo Alcantara** **Cristian Sereño**	**Approved By:** **Engr. Rushell Rowena D. Gelacio** **Laboratory Manager**

APPENDIX B
Design Plan

1. Collection of Stems

Collection of Okra and Banana Stems



2. Washing of Stems


3. Fiber Extraction





4. Mold Preparation

5. Bonding of Fibers through Epoxy Resin Treatment

6. Average Moisture Content Test of Subbase Soil



7. Tensile Strength Testing


8. California Bearing Ratio Test


APPENDIX C
Research Documents

As a research student, I hereby declare my acceptance and adherence to the policies, rules, and guidelines in the conduct of my thesis/capstone/FS/creative work as follows:

1. The researcher/s shall be required to attend the research orientation and shall submit this signed agreement to the subject teacher. Failure to do so shall render the researcher/s ineligible for title defense.

2. The researcher/s shall group themselves by three, of their own choice and at their own risk. They shall work as a team from the initiation to completion of the project. They shall choose a research topic/theme/subject that is aligned with the agenda of the College and the University.

3. With advisement from the Research Coordinator(RC) and approval of the Dean of College, the researcher/s shall be provided with qualified research personnel (adviser and statistician) to help them out in the conduct of the project.

4. The researcher/s shall exercise due diligence and adhere to established standards/rules of data gathering, experimentation, field work that ensure safety, security and ethical practice. Research activities in remote and secluded areas are highly prohibited.

5. The researcher/s shall seek guidance, assistance and approval from their adviser in all research-related activities, documented in a journal/record book which is to be inspected by the subject teacher from time to time for purposes of monitoring.

6. The researcher/s shall always secure the endorsement of the adviser before submitting the outline/final manuscripts for defense to the RC.

7. The researcher/s shall be responsible to get updates about schedules for outline/final defense (one month before finals) and on thesis binding as announced/posted. Two (2) copies of the outlines/manuscripts shall be submitted to the RC one week before the scheduled defense.

8. The researcher/s shall pay P2700 per group as defense fee. Lone-research or two-member group are allowed only when there is no other possible way to divide the class. Anything beyond, needs to obtain RPC consent through writing. No additional payment shall be made to panel members. Researcher/s are strongly enjoined to report to the Dean/RPC any extra fee solicited by any party.

9. The researcher/s shall deliver oral defense as scheduled by the RC before the final exam. Failure to submit themselves for oral examination forfeits their right to obtain a passing grade. Likewise, failure to submit bounded duly approved final manuscript on time shall cause a grade of 7.2 which should be completed within the standard completion days as prescribed by the UM registrar. No extension shall be entertained.

10. In the event that the researcher/s failed to meet and/or satisfy the requirements and criteria for title, outline and final defenses, they shall be given another chance through redefense. This redefense is granted only once. Should the researcher/s failed during the redefense, they shall be given a failing grade and are required to reenroll the course.

11. The researcher/s shall bring all the raw data and evidences of data gathering procedures during the oral defense as indicator of data trustworthiness and reliability.

12. All transactions with research personnel during the processing/critiquing of the final manuscript shall require the use of the standard routing form. This routing form is to be submitted to the RC for documentation and future reference.

13. The researcher/s shall maintain the right for three (3) free plagiarism checks: one during Methods of Research or its equivalent, and two during Research Proper after final oral presentation. Five hundred pesos shall be charged for the fourth and succeeding checks. Threshold of similarity is 25% and lower.

14. Manuscripts shall follow the institutional format and referencing style; the study must be a product of exercise of intellect, free of dishonesty and fraud. Also, the papers shall be subjected for Grammarly check to ensure adherence to rules of language and writing conventions. Threshold of grammar accuracy is 95% and above.

15. The researcher/s shall acknowledge the right of the College to disallow or reject researches found to be deficient, unsatisfactory or plagiarized in form or substance.

16. The researcher/s shall take precautionary measures to ensure that their paper will not be copied, replicated or duplicated by others.

17. The researcher/s shall transfer the ownership of the study to the College once the paper has been successfully defended and bound. After which no paper shall be published or presented without consent/approval from the College. Sharing and/or furnishing copies of the research paper to pertinent offices or parties is subject to the approval of the College and shall require a signed Non-Disclosure Agreement from the receiving parties.

18. The researcher/s shall present their research projects strictly during their scheduled oral defense. Failure to present as scheduled, the researcher/s will have to wait for another cycle of defense.

I affix my signature to signify that I read, understand, and conform to the items enumerated above.

Conformed:

CARLO EMMANUEL ALCANTARA
Signature over printed name of student

JERALD LUCERNAS
Signature over printed name of parent/guardian

ENGR. DANIELYN PLAZOS
Signature over printed name of adviser

As a research student, I hereby declare my acceptance and adherence to the policies, rules, and guidelines in the conduct of my thesis/capstone/FS/creative work as follows:

1. The researcher/s shall be required to attend the research orientation and shall submit this signed agreement to the subject teacher. Failure to do so shall render the researcher/s ineligible for title defense.

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18. The researcher/s shall present their research projects strictly during their scheduled oral defense. Failure to present as scheduled, the researcher/s will have to wait for another cycle of defense.

I affix my signature to signify that I read, understand, and conform to the items enumerated above.

Conformed:

MELANY JOYCE AGUILON
Signature over printed name of student

DEVINE KAYE TAN
Signature over printed name of parent/guardian

ENGR. DANIELYN PLAZOS
Signature over printed name of adviser

As a research student, I hereby declare my acceptance and adherence to the policies, rules, and guidelines in the conduct of my thesis/capstone/FS/creative work as follows:

1. The researcher/s shall be required to attend the research orientation and shall submit this signed agreement to the subject teacher. Failure to do so shall render the researcher/s ineligible for title defense.

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9. The researcher/s shall deliver oral defense as scheduled by the RC before the final exam. Failure to submit themselves for oral examination forfeits their right to obtain a passing grade. Likewise, failure to submit bounded duly approved final manuscript on time shall cause a grade of 7.2 which should be completed within the standard completion days as prescribed by the UM registrar. No extension shall be entertained.

10. In the event that the researcher/s failed to meet and/or satisfy the requirements and criteria for title, outline and final defenses, they shall be given another chance through redefense. This redefense is granted only once. Should the researcher/s failed during the redefense, they shall be given a failing grade and are required to reenroll the course.

11. The researcher/s shall bring all the raw data and evidences of data gathering procedures during the oral defense as indicator of data trustworthiness and reliability.

12. All transactions with research personnel during the processing/critiquing of the final manuscript shall require the use of the standard routing form. This routing form is to be submitted to the RC for documentation and future reference.

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14. Manuscripts shall follow the institutional format and referencing style; the study must be a product of exercise of intellect, free of dishonesty and fraud. Also, the papers shall be subjected for Grammarly check to ensure adherence to rules of language and writing conventions. Threshold of grammar accuracy is 95% and above.

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16. The researcher/s shall take precautionary measures to ensure that their paper will not be copied, replicated or duplicated by others.

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18. The researcher/s shall present their research projects strictly during their scheduled oral defense. Failure to present as scheduled, the researcher/s will have to wait for another cycle of defense.

I affix my signature to signify that I read, understand, and conform to the items enumerated above.

Conformed:

CRISTIAN D. SERENO
Signature over printed name of student

CAROLINA D. SERENO
Signature over printed name of parent/guardian

ENGR. DANIELAN PLAZOS
Signature over printed name of adviser

The University of Mindanao

College of Engineering Education
2nd Floor, BE Building
Matina Campus, Davao City
Telefax: (082)296-1084
Phone No.: (082)300-5456/300-0647 Local 131

October 26, 2022

ENGR. DANIELYN F. PLAZOS
Faculty Member, BSCE Program
College of Engineering Education

Dear **Engr. Danielyn Plazos**:

Greetings!

I am pleased to appoint you as the adviser of **Cristian Sereño, Melany Joyce Aguilon** and **Carlo Emmanuel Alcantara** of the undergraduate thesis entitled **"An experimental evaluation of size effect and bearing capacity of footing on Okra (Abelmoschus Esculentus) and Banana (Musa Acuminata) natural non-woven geotextile-reinforced sand"** of the **Bachelor of Science in Civil Engineering** program of the College of Engineering Education. This appointment is in reference to your field of specialization and your qualification as a thesis adviser reflected in OPM 14.03 (Conduct of Undergraduate Thesis).

Please affix your signature hereunder to signify your acceptance of the appointment. Looking forward to your continued support in the research endeavor of the college.

Thank you, and have a nice day ahead!

Sincerely yours,

JETRON T. ADTOON
College Research Coordinator

Noted:

Dr. CHARLITO L. CAÑESARES
Dean of College

Accepted by:

ENGR. DANIELYN F. PLAZOS

The University of Mindanao

College of Engineering Education
2nd Floor, BE Building
Matina Campus, Davao City
Telefax: (082)296-1084
Phone No.: (082)300-5456/300-0647 Local 131

November 4, 2022

ENGR. MARIE FE LACSADO
Faculty Member, BSCE Program
College of Engineering Education

Dear **Engr. Lacsado**:

Greetings!

I am pleased to appoint you as the statistician of **Christian D. Sereño, Melany Joyce E. Aguilon, and Carlo Emmanuel C. Alcantara** of the undergraduate thesis entitled **The Influence of Natural Okra-Banana Geotextile on the Improvement of Road Base Coarse Bearing Capacity** of the **BS Civil Engineering** program of the College of Engineering Education. This appointment is in reference to your field of specialization and your qualification as a thesis statistician reflected in OPM 14.03 (Conduct of Undergraduate Thesis).

Please affix your signature hereunder to signify your acceptance of the appointment. Looking forward to your continued support in the research endeavor of the college.

Thank you, and have a nice day ahead!

Sincerely yours,

JETRONIX ADTOON
College Research Coordinator

Noted:

Dr. CHARLITO L. CAÑESARES
Dean of College

Accepted by:

ENGR. MARIE FE LACSADO

The University of Mindanao

College of Engineering Education
2nd Floor, BE Building
Matina Campus, Davao City
Telefax: (082)296-1084
Phone No.: (082)300-5456/300-0647 Local 131

LETTER OF REQUEST TO GATHER MATERIALS FOR RESEARCH

Date: February 7, 2023

To **Visto Household,**

We, Cristian D. Sereño, Melany Joyce E. Aguilon, & Carlo Emmanuel C. Alcantara, students at the University of Mindanao taking Bachelor of Science in Civil Engineering Major in Structural. We are conducting a study entitled "**THE INFLUENCE OF OKRA-BANANA GEOTEXTILE ON THE IMPROVEMENT OF ROAD SUBGRADE BEARING CAPACITY**". One of the necessary materials needed in our research is the Okra stem that is plenteous in your land.

We are asking for permission if we can have at least **3 to 5 kilograms** worth of Okra stem. The information gathered will be used for academic purposes only.

Should you require any further information, please contact **09209878529**.

Your assistance will be greatly appreciated.

Endorsed by:

Engr. Danielyn Plazos
Research Adviser
Date Signed: 3-8-2023

Engr. Jetron J. Adtoon
Research Coordinator
Date Signed: _____

Dr. Charlito L. Cañesares
Dean of College of Engineering Education
Date Signed: _____

The University of Mindanao

College of Engineering Education
2nd Floor, BE Building
Matina Campus, Davao City
Telefax: (082)296-1084
Phone No.: (082)300-5456/300-0647 Local 131

LETTER OF REQUEST TO GATHER MATERIALS FOR RESEARCH

Date: February 7, 2023

To **Coma Banana Plantation**,

We, Cristian D. Sereño, Melany Joyce E. Aguilon, & Carlo Emmanuel C. Alcantara, students at the University of Mindanao taking Bachelor of Science in Civil Engineering Major in Structural. We are conducting a study entitled "**THE INFLUENCE OF OKRA-BANANA GEOTEXTILE ON THE IMPROVEMENT OF ROAD SUBGRADE BEARING CAPACITY**". One of the necessary materials needed in our research is the Banana stem that is plenteous in your plantation.

We are asking for permission if we can have at least **3 to 5 kilograms** worth of Banana stem to be used in our study. The information gathered will be used for academic purposes only.

Should you require any further information, please contact **09209878529.**.

Your assistance will be greatly appreciated.

Endorsed by:

Engr. Danielyn Plazos
Research Adviser

Date Signed: 3-8-2023

Engr. Jetron J. Adtoon
Research Coordinator

Date Signed: _____

Dr. Charlito L. Cañesares
Dean of College of Engineering Education

Date Signed: _____

The University of Mindanao

RESEARCH AND PUBLICATION CENTER

[✓] Main [ ] Branch _____

ASSIGNMENT OF RESEARCH PERSONNEL

Course Code: BCE 415L

Program: CEE - BSCE

This is to acknowledge acceptance of assignment as Research Personnel for the thesis entitled:

AN EXPERIMENTAL EVALUATION OF SIZE EFFECT AND BEARING CAPACITY OF FOOTING ON OKRA (ABELMOSCHUS ESCULENTUS) AND BANANA (MUSA ACUMINATA) NATURAL NON-WOVEN GEOTEXTILE - REINFORCED SAND

	Name	Signature	Date
Adviser	ENGR. DANIELYN PLAZOS		10-27-22
Statistician/Data Analyst	ENGR. MARIE FE LACSADO		11-04-22
Editor	ENGR. DANIELYN PLAZOS		10-27-22
Panel Members	ENGR. JETRON ADTOON		11-04-22

Endorsed by: ENGR. JETRON ADTOON
Research Coordinator/Asst. Research Coordinator

Approved by: DR. CHARLITO L. CAÑESARES
Dean of College

F-13100-019 /Rev. # 0 /Effectivity: January 25, 2018

The University of Mindanao

College of Engineering Education
2nd Floor, BE Building
Matina Campus, Davao City
Telefax: (082)296-1084
Phone No.: (082)300-5456/300-0647 Local 131

ENDORSEMENT FOR FINAL DEFENSE

Date: **September 22, 2023**

This is to endorse the research manuscript entitled: "**The Influence of Natural Okra-Banana Geotextile on the Improvement of Road Subbase Bearing Capacity**" prepared and submitted by **Cristian Sereño, Melany Joyce Aguilon,** and **Carlo Emmanuel Alcantara,** for Final Defense. The manuscript has been evaluated by the research personnel listed below and was found to be compliant with the quality standards as provided in the UM Research Manual.

NAME OF RESEARCH PERSONNEL		SIGNATURE
Adviser	**Engr. Danielyn Plazos**	
Statistician	**Engr. Marie Fe Lacsado**	

Endorsed by:

ENGR. DANIELYN PLAZOS
Research Adviser

Noted by:

ENGR. JETRON J. ADTOON
College Research Coordinator

Approved by:

DR. CHARLITO L. CAÑESARES, PME
Dean, College of Engineering Education

The University of Mindanao

College of Engineering Education
2nd Floor, BE Building
Matina Campus, Davao City
Telefax: (082)296-1084
Phone No.: (082)300-5456/300-0647 Local 131

UNDERGRADUATE THESIS / RESEARCH / CAPSTONE APPROVAL OF FINAL MANUSCRIPT

Date : November 6, 2023

Title : **The Influence of Natural Okra-Banana Geotextile on the Improvement of Road Subbase Bearing Capacity**

Student-Proponents	Program
1. Cristian D. Sereño	BSCE - Structural
2. Melany Joyce E. Aguilon	BSCE - Structural
3. Carlo Emmanuel C. Alcantara	BSCE - Structural

Panel Comments/ Recommendations	Previous Status	Actions Taken / Revisions	Page Reflected
Include in the Abstract the conclusion that presents what percentage of the sample gives the best result.	The Abstract does not include the conclusion that presents what percentage of the sample gives the best result.	The conclusion that presents what percentage of the sample gives the best result is added to the Abstract.	1
Do not enumerate the Materials in Chapter 2. Discuss it in 1-2 paragraphs only.	The Materials in Chapter 2 are detailed and it is 4 paragraphs long.	The Materials is summarized into 2 paragraphs only.	2
Transfer Fig 2 (Okra-Banana non-woven jute geotextile) from Chapter 2 to Results in Chapter 3.	Fig 2 (Okra-Banana non-woven jute geotextile) is included in Chapter 2.	Fig 2 (Okra-Banana non-woven jute geotextile) is transferred to Chapter 3 and the new label is Fig 5. (Okra-Banana non-woven jute geotextile).	3
The Methods should be in order of the experimental process. Discuss the "preparation" first then next is the "testing". Under testing, discuss the "Tensile Testing" as (a), then "CBR Testing" as (b), and Modified Proctor Compaction Test as (c).	The Methods discussed are (1) Soil testing, (2) Geotextile testing, (3) Sample preparation, and (4) Sample testing. Under (4) is (a) California Bearing Ratio test and (b) Modified Proctor Compaction Test.	The Methods discussion flow is (1) Soil and geotextile preparation and (2) Sample testing. Under (2) is (a) Measurement of Tensile Strength, (b) California Bearing Ratio test, and (c) Modified Proctor Compaction Test.	3
For Fig. 9 (Subbase Soil Moisture Content), include subsections and discuss thoroughly.	Fig. 9 (Subbase Soil Moisture Content) discussed the minimum, maximum, and mean soil moisture content only.	The label is changed to Fig 6. (Subbase Soil Moisture Content). The discussion includes the results of all the samples and the interpretation of the data.	4
For the results of CBR testing, discuss the results per sample and its findings.	The CBR testing result is not thoroughly discussed for each sample and the overall CBR test result is not interpreted.	The CBR testing result is thoroughly discussed for each sample and the overall CBR test result is interpreted.	4
Thoroughly discuss the results. Include in the discussion why the findings are related. Also, discuss if the findings of the 2% and 3% samples are significantly different.	Chapter 3 did not include the overall discussion about the interpretation of the results of the testing that has been conducted.	Chapter 3 included the overall discussion about the interpretation of the results of the testing that has been conducted and what sample gave the best results.	5
Remove standards in the References.	References 15 – 20 are for ASTM Standards.	References 15 – 20 for ASTM Standards were removed.	5

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The Influence of Natural Okra-Banana Geotextile on the Improvement of Road Subbase Bearing Capacity

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Abstract— **Low bearing capacity is one of the common problems for soils, especially on-the-road soils in the Philippines. To address this issue, geotextiles are made to enhance the soil's characteristics. Geosynthetics are geotextiles made of synthetic fibers and are widely available in the market, but because of environmental sustainability issues, natural geotextiles were developed over the years. The study is focused on determining the application of Okra (Abelmoschus esculentus) and Banana (Musa acuminata) natural geotextile in enhancing the California Bearing Ratio (CBR) of subbase soil. The test includes a soil compaction test, a tensile test for the geotextile, and a CBR test for the subbase soil mixed with geotextile. The geotextile was created and cut into strips using the methods of the previous studies. The subbase soil was collected based on the DPWH specifications. The samples tested for CBR include 0%, 1%, 3%, and 3% of geotextile strips mixed with the subbase soil. The result shows that the CBR value also increases as the geotextile strip percentage increases. Therefore, the subbase soil has the best bearing capacity with the 3% Okra-Banana geotextile strips added, and has a significant difference compared to the control sample.**

Keywords— **Okra (Abelmoschus esculentus), Banana (Musa acuminata), Geotextile Strips, California Bearing Ratio, Subbase Soil**

I. Introduction

Bearing capacity is the ability of the soil to carry loads from a structure. Low bearing capacity is one of the most common problems for soil's capability of infrastructures. Improving the soil conditions with the help of geotextiles is one of the technological developments designed to strengthen the soil and increase the soil-bearing capacity [1]. In the study [2], it is said that low bearing capacity is one of the reasons some places in the Philippines, specifically Manila, need help developing.

Geotextiles are used in engineering as soil fills that help the soil enhance its characteristics. This helps undernourished soils become suitable for infrastructure such as roads, harbors, landfills, drainage, and other construction projects [3]. Geotextiles can be non-woven, knitted, or woven fabrics made of synthetic or biodegradable materials [4]. Using non-woven geotextiles improves soil strength and increases flexibility compared to woven geotextiles. It has also been proven capable of thermal, sound, electrical, and filter material [5], [6]. In the study [7], geosynthetics enhanced bearing capacity and the mechanical behavior of sandy soils. Even though geosynthetics or synthetic fibers are highly recognized in the market because of their low cost yet excellent performance, synthetic materials have contributed to the environmental problems the world is facing today [8]. Due to the decreasing supply issues, it is now a trend to utilize biodegradable materials to promote a sustainable environment. Still, products made of biodegradable materials outnumbered production and efficiency [9]. Thus, natural fibers as an alternative to synthetic fibers have developed over the years. Since these natural fibers are from animals and plants, some downsides include low moisture resistance and the difference between the characteristics of fibers. Modifying its properties using chemical treatments helps address the disadvantages [8]. The study [10] proved that using epoxy resin as a binder for natural fibers enhances the efficiency of the fibers.

On the other hand, in the study [11], a non-woven geotextile was produced from Okra (Abelmoschus e.) and Banana (Musa a.) natural fibers. It shows that the 175 mL of epoxy mixture for 50% Okra and 50% Banana fiber obtained the highest tensile strength, water absorbency, and soil degradation. The ratio of the length and width to the weight of epoxy and fibers is 12:7. Furthermore, a subbase is essential for road construction. Low bearing capacity on subbase roads results in waviness, distress in the pavement, and costly maintenance or rehabilitation [12]. Infrastructures constructed on fine-grained subbase (e.g., clay) are prone to damage. The study [13] investigated if geotextiles and their placement will influence the California Bearing Ratio (CBR) value. The findings concluded that the CBR value increases as the distance of geotextile increases and the farther its distance to the ground surface. This is because the more soil is resting above the geotextile, the more it is causing friction to the soil under the geotextile and making it denser. A study is conducted to determine how geosynthetic cutting influences road subbase. The level of bearing capacity improvement is affected by soil type and geosynthetic cutting, with a cutting size and recommended ratio of 4:1 [14].

The results of laboratory experiments examining the impact of recycled geogrid on soil bearing capacity through a CBR test are detailed in the earlier research conducted in reference [14]. However, the study uses polyester geosynthetics that have high resistance to biodegradation, which is not much preferable for the environment. Thus, this research will utilize a natural geotextile, a mixture of 175mL resin for 50% Okra and 50% Banana fiber [11], to improve road subbase bearing capacity using a CBR test, which is an advancement to address poor road conditions in the Philippines with the help of biodegradable materials.

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APPENDIX D
Curriculum Vitae

APPENDIX D
CURRICULUM VITAE

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