Potentiality of Boehmeria Nivea as Alternative Material in the Production of Geotextile

Oliver C. Celis[1], Catalino Mendoza[2], Ernesto Q. Villarica[1], Ann Krischel Hipolito[1], Alfred C. Santos[1], Nichols P. Manarang[1], Mary Jane Lusung[1], Christian Ivan L. Magistrado[1], Ederick T. Songahid[1], Jefferson V. Cuellar[1], John Mark G. Evangelista[1], Ralph Allen M. Cotelo[1]
[1]Civil Engineering Department, College of Engineering
[2]Natural Science Department, College of Arts and Science
Our Lady of Fatima University, Philippines, 2000
Email: revilo.silec@gmail.com[1], catfish3789@yahoo.com[2], ernestovillarica08@gmail.com[3], annshipolito@gmail.com[4], zionengr@gmail.com[5], jeffersoncuellar143@gmail.com[6]

ABSTRACT: The study focused on the potentiality of Boehmeria Nivea as alternative material in the production of geotextile. The researchers used Ramie's bark in the production of geotextiles and series of tests were performed at the Philippine Textile Research Institute (PTRI) of the Department of Science and Technology (DOST) located at Taguig, Metro Manila, to compare ramie geotextiles and commercially available coconet geotextiles. Each test specimen was tested for their nominal thickness, mass per unit area, and tensile strength. The results were analyzed and gave presentable results. After analyzing the results, the researchers reached at acceptable findings. All the test conducted of ramie geotextile did meet the minimum tensile strength of the commercially available coconet geotextile for 400, 700, and 900 and considerably met the polyfelt specification filtration 58 for non - woven geotextile. Therefore, ramie fiber can be used as a raw material in the production of a high strength and sustainable geotextile.
Keywords: Geotextile, Boehmeria Nivea, Ramie, polyfelt.

1. INTRODUCTION

Geosynthetics have been characterized by the American Society for Testing and Materials (ASTM) committee D35 as “a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a human-made project, structure, or system” (https://www.slideshare.net/pparida/geosynthetics). They are used for purposes of separation, reinforcement, drainage, and filtration. According to Dr. Robert M. Koerner, “there are eight types of geosynthetics: geogrids, geotextiles, geonets, geomembranes, geosynthetic clay liners, geopipe, geofoam, and geocomposites.”(http://www.acegeosyntheticsecopark.com/geosynthetics#WHAT%20IS%20GEOSYNTHETIC?). Among these geosynthetic products, the commonly used product is geotextiles.

Geotextiles have been defined by the American Society of Agricultural and Biological Engineers (ASAE) as, “a fabric or synthetic material placed between the soil and a pipe, gabion, or retaining wall to enhance water movement and retard soil movement, and as a blanket to add reinforcement and separation."(http://www.apparelsearch.com/education/research/nonwoven/2001_kermit_duckett/education_research_nonwoven_geotextiles.htm). Geotextiles are commonly utilized in geotechnical engineering to reinforce soil and to construct strong bases for roads. Geotextiles are the most popular type of geosynthetic material due to their versatility and affordability compared to other types of geosynthetics.

In civil engineering applications, the geotextiles used are generally polymeric material. They offer longer life span and are not subject to biodegradability. However, synthetic geotextiles are not eco-friendly and could possibly create environmental problems in the long run. Also, the raw materials used in synthetic geotextiles are not readily accessible. Thus, prices of raw materials needed for production do not reduce resulting into expensive synthetic geotextiles. Due to the problems in relation to the use of synthetic geotextiles and with the awareness and efforts to provide sustainable development, the use of biodegradable natural geotextiles has emerged. Natural fiber-based geotextiles are widely accepted because they are eco-friendly, renewable, economically viable, abundantly available, very cost-effective and cheaper in comparison to their synthetic counterparts.

Natural fiber-based geotextiles are commonly in the form of jute, coir, and wood shavings. Ramie (Boehmeria Nivea), a plant that is vastly found in the Philippines especially in Mindanao and some parts of Batan and Babuyan Islands. It has a great potential as an alternative material for geotextile production due to the high tensile capacity of its fiber.

Ramie are subtropical bast fibers, which are obtained from their plants five to six times a year. The fibers have silky luster and have white appearance even in the unbleached condition (http://textilelearner.blogspot.com/2012/12/ selection-of-fiber-for-geotextiles.html). They consist of pure cellulose fiber which possess highest tenacity among all plant fibers”. Thus, ramie can be considered a great source of natural fiber.

Textiles are primarily and traditionally used for the design and production of garments but recently natural fibers and textiles were used as an alternative to synthetic fiber to promote environmental awareness and conservation for the benefit of the generations ahead of us. Knowledge with regards to the utilization of natural-fiber geotextiles should be further encouraged and recognized.

The study aimed to determine the potentiality of Ramie (Boehmeria Nivea) as an alternative raw material in geotextile production.

2. METHODS AND MATERIALS

2.1 Preparation of Sample

The natural fiber used in this study came from Boehmeria Nivea (Ramie) a wild plant generally abundant in Barangay Manila de Bugabos, Agusan del Norte, Mindanao and other parts of the Philippines. Initially, the Ramie’s bark were taken from the stem of the plant. The collected stems were then cleaned and prepared for the succeeding processes.

The bark were removed with by means of peeling using a knife, precautions were done to avoid damages in the fibers. Cellulose layer of the bark were then removed and cleaned in preparation for drying the fiber.

Ramie’s fiber were then sun-dried to remove excess water. Oven-drying can also be performed if available to thoroughly remove excess moisture of the extracted fiber.

Figure 1 shows the process flow of ramie geotextile production.

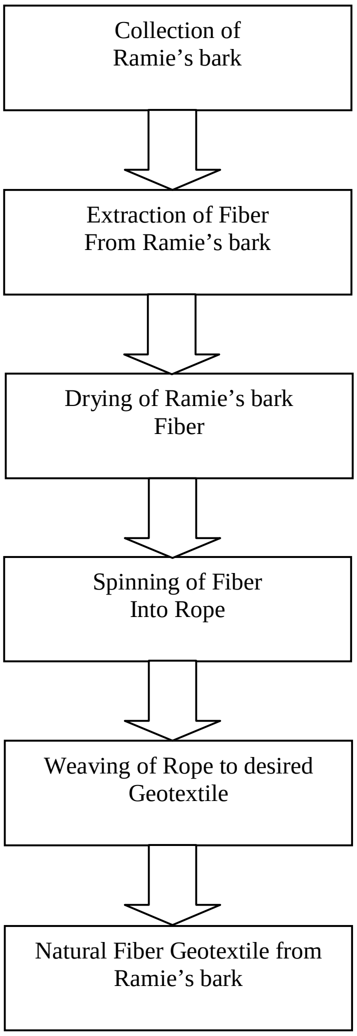

Figure 1 Process flow of ramie geotextile production

The sample specimen were made using a 8 ft x 4 ft wooden frame for weaving the geotextile into desired dimension, 3 wood nails, hammer, scale, and tape.

The dried extracted fibers were span into yarns. The procedure was done by means of wheel spinning, manually by hand or by mechanical spinning. Based on research, the latter method can produce a good quality of yarn. A good quality of yarn can be identified be means of physical and mechanical features, e.g. thickness, appearance, colour, proper twist, strength, fineness, texture, etc. In this study, hand spinning method was used by the researchers for producing of yarn. The ramie's bark fiber was tied into the wall and spanned the fiber manually by hand to produce an estimated 400 meters of fiber rope needed to produce a 2000 mm x 1000 mm ramie's geotextile samples.

After spinning and producing an estimated of 400 meters rope ramie's fiber, the next process was to weaved the fibers to form the by-product which is the ramie's geotextile. Weaving the fiber was done in normal process like any other textile. It is finished by intersecting the longitudinal strings, the twist that was tossed crosswise over with the horizontal strings. This is a common method of textile production in which two particular arrangements of yarns or strings were intertwined at right points to frame a textile and fabric. Alternate techniques are composed of weaving, bind making, felting, and meshing or plaiting. The longitudinal strings are known as the twist and the parallel strings are the weft or filling. The strategy in which these strings are interwoven influences the quality of the textile.

2.2 Equipment

Several materials and equipment were used in the preparation of sample specimen needed for testing the properties of the natural fiber geotextile.

The J.A. king pneumatic sample cutter SASD-692 was used to cut eight (8) circular test specimens that were used for the test for mass per unit area and nominal thickness. (Laroza, J.P et al. 2014).

Eight (8) test specimens were tested using the Zwick/Roell tensile strength tester Z050 (CRE) using a 50 kN full safe load with a wide-width strip method in order to determine the average tensile strength of sample.

The SDL digital thickness gauge M034A with 25 cm^2 pressure foot area subjected to 2 kPa was used to find the nominal thickness of the eight (8) circular test specimens by the J.A. king pneumatic sample cutter.

2.3 Experimental Procedure

The experimental procedure was conducted by Engr. Jun Cometa at Philippine Textile Research Institute (PTRI) under the Department of science and Technology (DOST) Philippines. One (1) test samples of Ramie's bark geotextile 2000 mm x 1000 mm. From 2000 mm x 1000 mm ramie geotextile, eight (8) circular specimen is required for the test for mass per unit area and nominal thickness test using the J.A king pneumatic sample cutter SASD – 692 and SDL digital thickness gauge M034A with 25 cm^2 pressure foot area subjected to 2 kPa pressure respectively. Eight (8) specimens were subjected to tensile strength test using the zwick/roell tensile strength tester Z050 (CRE) with 50 kN full scale load

Nominal thickness is one of the considerations in measuring how good and reliable one fiber to be a geotextile material. It provides the results needed for the variation of the tensile strength test. It is also one of the basic properties used to control the quality of geosynthetics.

The nominal thickness is determined by placing a sample of the geotextile on a plane reference plate and applying a pressure of 2 kN/m^2 through a circular pressure plate with a cross-sectional area of 2500 mm^2. A vernier gauge measures the distance between the reference plate and pressure plate. The test is useful for quality control and classification of geotextiles.

This test method is used to determine if the geotextile material meets specifications for mass per unit area. This test method can be used for quality control to determine specimen conformance to standard specifications. This measurement allows for a simple control of the delivered material by a comparison of the mass per unit area of the delivered material and the specified mass per unit area.

Furthermore, the mass per unit area of a geotextile is determined by weighing test specimens of known dimensions, cut from various locations over the full width of the laboratory sample. The calculated values are then averaged to obtain the mean mass per unit area of the laboratory sample.

Tensile strength is also one of the considerations needed to measure how good and reliable one fiber to be a geotextile material. It also measures the greatest longitudinal stress substances (geotextile) can bear without tearing apart.

In this study, width wide tensile strength test is used. A specimen of the geotextile, at least 200 mm wide, is clamped within the compressive jaws of a tensile testing machine which is capable of applying the load at a constant rate of strain. During loading, a load-strain curve is plotted and, from this, the maximum load, breaking load and the secant modulus at any specified strain may be determined.

The tensile strength of geotextiles and related materials is a very important property as virtually all applications rely on it either as the primary or secondary function. This test is useful for quality control and can also be used for design purposes

Table 1. Shows the number of specimens required for every test.

Table 1. Number of Test Specimens

Geotextile sample	Nominal thickness test/Mass per unit area	Tensile strength test		Number of test specimens
		MD	CMD	
Ramie	8	4		8

It can be seen from the table that the total number of specimens for testing was eight (8). This specimens were divided according to the test performed namely the nominal thickness test, mass per unit area and tensile strength test.

3. RESULTS AND DISCUSSION

This section presents the data collected from the test results. The data were used to create tabulations, graphical diagrams, analysis and interpretation of data gathered to determine the viability of ramie as alternative geotextile for slope protection.

3.1 Properties of Ramie Geotextile

3.1.1 Nominal Thickness

Figure 2 presents the graphical representation of the nominal thickness of Ramie Geotextile based on the test results.

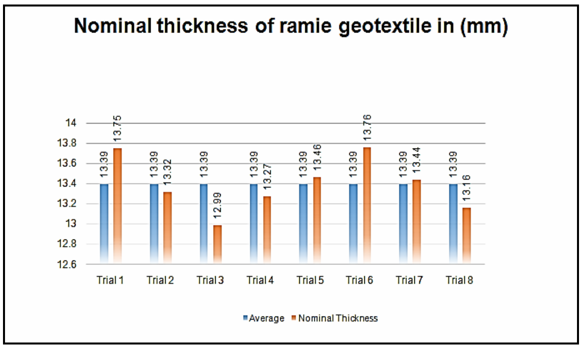

Figure 2 Nominal Thickness of Ramie Geotextile

The above figure presents the average nominal thickness of ramie geotextile which is about 13.39 mm (blue bar) and comparing to no. of trials (8 trials) done in test specimens (orange bar). Based on results, Ramie Geotextile has larger cross sectional area compared to the commercially available Coconet Geotextile.

3.1.2. Mass Per Unit Area

Table 2 presents the mass per unit area of Ramie Geotextile.

Formula:

$$M = \frac{mx\ 10^{4}}{A} \qquad (1)$$

Based from the data drawn, Table 3 shows the average mass per unit area of Ramie Geotextile was 1684.73 g/m2 after 8 trials were made.

3.1.3 Tensile Strength of Ramie Geotextile (Machine Direction and Cross-Machine Direction)

Figure 3 presents the graphical representation of the Tensile Strength Machine Direction (MD) of Ramie Geotextile based on the test results.

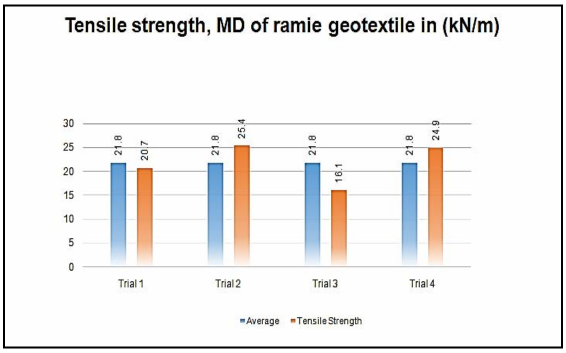

Figure 3 Tensile Strength, MD of Ramie Geotextile (kN/m)

Figure 3 presents a graphical comparison of the average tensile strength of Ramie Geotextile which is about 21.8 KN/m (blue bar) after 4 trials were made.

Figure 4 presents the graphical representation of the tensile strength CMD of ramie geotextile based on the test results.

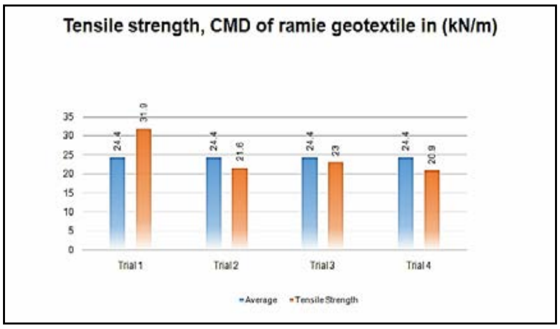

Figure 4 Tensile Strength, CMD of Ramie Geotextile (kN/m)

Figure 4 presents the comparison of the average tensile strength of Ramie Geotextile Cross Machine Direction which is about 24.4 KN/m (blue bar) after four (4) trials were made.

3.2 Comparison of Properties of Ramie Geotextile and Coconet Based on Test Results.

3.2.1 Nominal Thickness of Ramie Geotextile and Coconet Geotextile.

For verification of the strength and potentiality of Ramie Geotextile, comparisons were made against commercially available geotextile Coconet. Figure 5 presents the graphical comparison between the average nominal thickness of ramie geotextile and coconet geotextile.

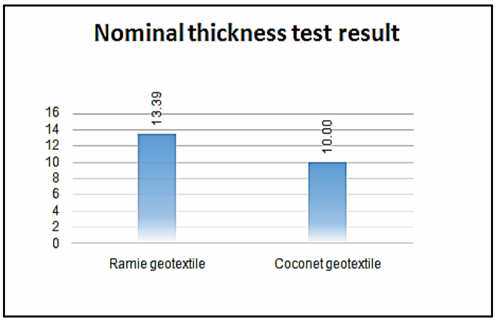

Figure 5 Nominal Thickness Test Result

The above figure shows that the average nominal thickness of Ramie Geotextile is larger than the Coconet Geotextile which is about 13.39 mm and 10.00 mm respectively.

3.2.2 Mass Per Unit Area of Ramie Geotextile and Coconet Geotextile.

The mass per unit area of Ramie Geotextile and Coconet Geotextile were also compared. The value for Ramie Geotextile was affected since it has a larger cross sectional area than the Coconet. The value signifies that the geotextile can cover more area and hold more soil in place than the Coconet Geotextile.

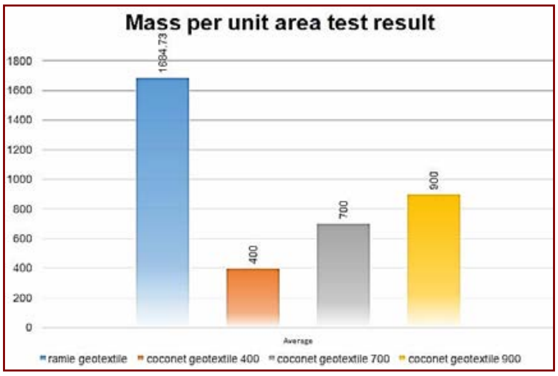

Figure 6 Mass Per Unit Area Test Result

Figure 6 shows the comparisons of the average mass per unit area of Ramie Geotextile and Coconet Geotextile. Based on the results, the average mass per unit area of Ramie Geotextile exceeded the mass per unit area of three types of Coconet Geotextiles with a value of 1684.73 g/m^2 against Coconet 400, 700 and 900 with a mass per unit area of 1284.73, 984.73 and 784.73 respectively.

3.2.3 Tensile Strength of Ramie Geotextile and Coconet Geotextile.

Tensile Strength Test were conducted to evaluate the capacity of the Ramie Geotextile and compared it with the tensile strength of the commercially available Coconet Geotextile.

Figure 7 presents a comparison between the average tensile strength of Ramie Geotextile against Coconet 400, 700, 900 Geotextiles (MD and CMD). Based on the results, the average tensile strength of Ramie Geotextile for both Machine Direction and Cross Machine Direction was higher than the tensile strength of Coconet 400, 700, and 900 Geotextiles. The average tensile strengths of Ramie Geotextile MD and CMD were 21.8 and 24.4 kN/m respectively.

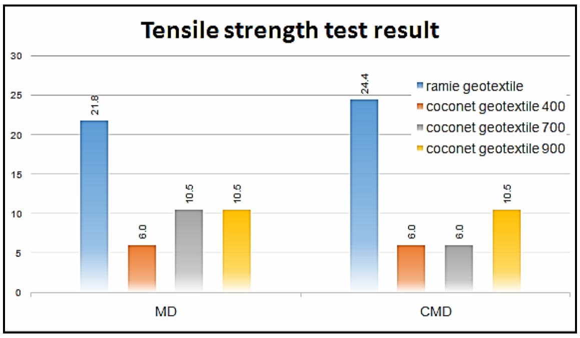

Figure 7 Tensile Strength Test Results

3.3 Comparison of Average Tensile Strength of Ramie Geotextile to Polyfelt Specifications for Non–Woven Geotextiles.

The Ramie Geotextile filtation capacity was also compared with the Polyfet Specification for non - woven geotextile.

Figure 8 presents the average tensile strength of ramie geotextile as compared to Polyfelt Specification for Non – Woven Geotextile. Ramie Geotextile passed the specification for Polyfelt F58 especially in CMD, considering that F58 is the rearmost value of Polyfelt Specification for Non – Woven Geotextile with 24.0 KN/m tensile strength. Based on Figure 8, it can be concluded that Ramie Geotextile is classified as F-58 based on the Polyfelt Specification for Non-Woven Geotextile CMD.

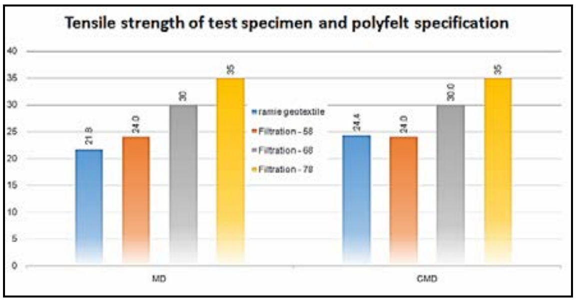

Figure 8 Comparison of the Average Tensile Strength of Ramie Geotextile

4. CONCLUSIONS

Based on the results of experiments and investigations, the researchers arrived at the following conclusions.

The average nominal thickness of geotextile is 13.3 mm and the average tensile strength of ramie geotextile MD, CMD was 21.8 and 24.4 kN/m respectively. This outcome will be of help in calculating the cost appropriation of the finished product.

Based on test results, the average tensile strength of ramie geotextileis higher than average tensile of coconet geotextile. In addition, Ramie Geotextile is more capable of resisting greater tensile force for a thinner sample than that of coconet geotextile.

Lastly, Ramie Geotextile meet the category of Filtration 58 of Polyfelt Specification for Non-woven Geotextile, thus can be concluded that it can be utilized in different geotechnical engineering application such as slope protection.

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