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NATURALLY COLORED COTTON FOR GEOCOMPOSITES

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Abstract

Aiming at developing environmentally friendly products, naturally-colored cotton and waste bagasse were used for making geocomposites. The airlaid and wetlaid nonwoven techniques were applied for geocomposite fabrication. Tensile strength of the geocomposites was evaluated using a strip test method (ASTM D5035-95). Research results exhibited that the experimental bagasse/cotton geocomposites featured lighter weight, attractive artificial grass appearance, engineered structure, and sufficient strength for handling and installation. These advantages would be highly desirable for erosion control applications such as embankment re-vegetation for highways, reservoirs/ponds, or landfill sites. Further research work was recommended to examine lifetime performance and economics of these new geocomposites, including weather sustainability, biodegradability, efficiency to promote vegetative cover, and production cost.

Introduction

According to the National Energy Policy addressed in the 2002 Farm Bill (Title IX Energy), biomass research and development has a national priority. The development of biomass technologies for producing bio-energy and biobased products, domestic natural resources such as crops, trees, and agricultural residues will be utilized more wisely and economically. Implementation of this R&D priority will make significant impacts on the nation's energy security, environmental protection, and rural economic growth [The U.S. Biomass Technical Advisory Committee, 2002].

An increasing concern for the environment has led to a worldwide consumer awareness of environmentally friendly products, including textile products without the need for bleaching, dyeing, and other finishing procedures. Naturally colored cotton is identified as a type of agricultural resource that can be used for manufacturing ecological textile products. However, the fiber characteristics of too short length and too limited range of palette makes the naturally colored cotton not favorable for modern textile processing and not competitive with traditional white cotton products. So far, there is only a niche market for the naturally-colored cotton.

Sugarcane bagasse is produced in large quantities and is an undervalued agricultural waste. The U.S. sugarcane production in 2002 is 34,245 kt [http://jan.mannlib.cornell.edu/reports/nassr/field/pcp-bban/cropan03.pdf]. It is estimated that about 80% of the sugarcane production, by weight, will be converted into wet bagasse during the refining process. However to convert the waste bagasse into value-added industrial products is a national research interest. An important research effort in previous work was extraction of sugarcane rind fiber for textile applications [Collier et al. 1992; Collier and Arrora 1994]. The extracted sugarcane rind fiber was used for making geotextile mats for soil erosion control [Thames 1994]. It was reported that the sugarcane fiber mats had higher water resistance, lower light penetration, and were less flammable than the commercial geotextile products [Collier et al. 1995; Collier et al. 1997]. The previous research also showed that the sugarcane fiber mat provided effective protection for grass seedbed and mat slope stabilization was satisfied. Production cost for the sugarcane geotextile was estimated approximately at $0.20/yd^2, in comparison with the commercial geotextiles: coconut $6.00/yd^2, wood $1.50/yd^2, and straw $0.12/yd^2. However, the previous research is limited to the use of sugarcane rind fiber and a manually wet-laid method for the geomat fabrication.

Research conducted in the Textile Processing Laboratory of the LSU School of Human Ecology has developed an approach for bagasse fiber extraction and bagasse fiber nonwoven fabrication using a carded method [Chen et al. 2001; Chen et al. 2002]. Recently, two new types of geocomposite were produced using the bagasse fiber and naturally green cotton. The airlaid and wetlaid nonwoven techniques were applied for the production of these geocomposites. This paper reports the process of converting waste bagasse and low quality naturally colored cotton into value-added geocomposite materials, and the comparison of product performance between the wetlaid and airlaid geocomposites. A major purpose of this study is to demonstrate a potential use of the low quality naturally colored cotton in erosion control applications such as embankment re-vegetation for highways, reservoirs/ponds, or landfill sites.

Experiment

Materials
Naturally colored cotton used in this study is low quality green (sticky) cotton and gray white cotton provided by the USDA Southern Regional Research Center. The green cotton cannot be processed by the cotton system for spinning and weaving. Bagasse fiber is produced in the Textile Processing Laboratory at LSU. The bagasse fiber has mean length of 1.34 inches (34 mm) and mean fineness of 58.7 tex. A polypropylene netting material is commercially available with a net size of ¾×1⅝ inch and weight of 1.4 lb/1000 ft^2.

Procedures
The proposed research includes these phases: extraction and dyeing of bagasse fiber, formation of the bagasse/green cotton geomats, bonding of the geocomposites, and property testing. Figure 1 illustrates a work flowchart for these research procedures.

Bagasse Fiber Extraction. Waste bagasse was obtained from a local sugar mill. The first step of process was to clean waste bagasse by manually sifting. After cleaning, the bagasse was treated with a sodium hydroxide solution at 212 F (100 C). Bagasse/liquid ratio (weight/volume) was 1:10. After the alkaline treatment, bagasse fiber was washed thoroughly by running water. Then the rinsed bagasse fiber was dried in an oven (Blue M Electric Company).

Bleaching and Dyeing. Extracted bagasse fiber was bleached using 10-time diluted Clorox liquid at a bagasse/liquid ratio of 1:10. After bleaching, the bagasse fiber was rinsed with cold water. The wet bagasse was put in a dye bath for dyeing using a direct green pigment.

Web Formation. Two methods were used for making bagasse/green cotton fiber webs. One was the wetlaid method and the other was the airlaid method. When using the wetlaid method, wet bagasse fiber after dyeing and rinsing was laid on a metal screen evenly and dried in the oven. A cohesive mat was formed after drying. In the airlaid process, the wet bagasse fiber after dyeing and rinsing was dried first and then opened and cleaned mechanically by an Opener/Blender. The cleaned bagasse fiber was blended with green cotton and fed into a Rando-Webber machine to form a bagasse/cotton blended web.

Geocomposite Fabrication. Two types of geocomposites were produced. The wetlaid bagasse web was stacked with a layer of cotton web and a layer of polypropylene net and needle-punched to form a three-layer geocomposite. The airlaid bagasse web was backed by the polypropylene net and thermal-bonded to form a two-layer geocomposite.

Property Testing. Tensile strength of the two geocomposites was measured using an Instron tensile tester. The testing procedure was in accordance with the ASTM D5035-95 (strip method).

Results and Discussion

Geocomposite Structure
Figures 2 and 3 illustrate the structure of the airlaid and wetlaid geocomposite samples. Their structural parameters are listed in Table I. Three commercial geocomposite products are also listed in the table for comparison. The experimental nonwoven geocomposites have lighter weight than the commercial geocomposites. This may help reduce production cost.

Tensile Strength
Measured tensile strengths for the two geocomposites are listed in Table II. Tensile load-extension curves are plotted in Figures 4 and 5. The tested results reveal that there is no substantial difference in the tensile strength and modulus between the wetlaid and airlaid geocomposites, although the airlaid web is much weaker than the wetlaid web in tensile strength. This indicates that the PP netting material plays a key role in determining the tensile strength of the geocomposites.

Summary and Further Work

Naturally-green cotton and waste bagasse could be used for making geocomposites, although the carding process was very difficult because of their too short or too stiff fiber quality. Two types of geocomposites were produced using the wetlaid and airlaid techniques. The wetlaid web had a smooth surface and good tensile strength and the airlaid web exhibited a bulky surface and weak tensile strength. In general, these geocomposite products featured lighter weight, attractive artificial grass appearance, engineered structure, and sufficient strength for handling and installation. These advantages are highly desirable for erosion control applications such as embankment re-vegetation for highways, reservoirs/ponds, or landfill sites.

Compared to the sugarcane rind fiber geomats developed in the previous research, the bagasse/green cotton geocomposites can be more cost-effective, because its raw material is waste bagasse and its weight is reduced. In addition, this product has a potential use in steeper slope areas because of a web+net structure. However, further research is needed to evaluate lifetime performance and economics of these new geocomposites, including ease of installation, slope stabilization, weather sustainability, biodegradability, efficiency to promote vegetative cover, and production cost.

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Table 1. Product Physical Properties.

Product	Material Content	Netting	Weight g/m^2 (oz/yd^2)	Thickness mm (inch)
Wetlaid (LSU)	90% bagasse, 10% Green Cotton	One side polypropylene	202.4	0.70
Airlaid (LSU)	90% bagasse, 10% Green Cotton	One side polypropylene	217.4	0.70
Curlex I (American Excelsior Co.)	100% aspen wood	One side photodegradable	396 (11.68)	–
Premier Straw (American Excelsior Co.)	100% straw	One side photodegradable	270 (8)	–
BioMac (Maccaferri Inc.)	100% coconut	Both sides biodegradable	270 – 380 (8 – 11)	–

Table 2. Mean Values for Tensile Strength.

Direction	Structure	Stress (MPa)	Strain (mm/mm)	Modulus (MPa)
Along machine	Wetlaid	1.932	0.497	8.450
	Airlaid	1.810	0.495	8.107
Cross machine	Wetlaid	1.133	0.340	7.034
	Airlaid	1.222	0.325	7.380

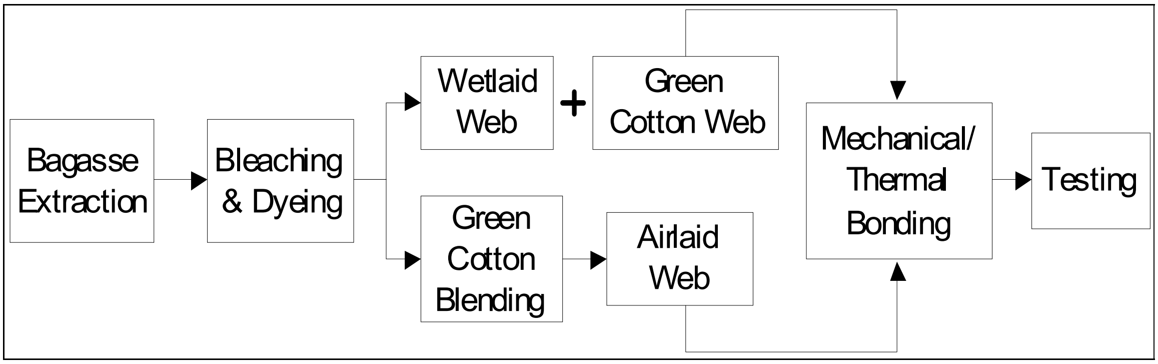

Figure 1. Flowchart of Experimental Procedures.

Figure 2. Airlaid bagasse/green cotton geocomposite.

Figure 3. Wetlaid bagasse/gray cotton geocomposite.

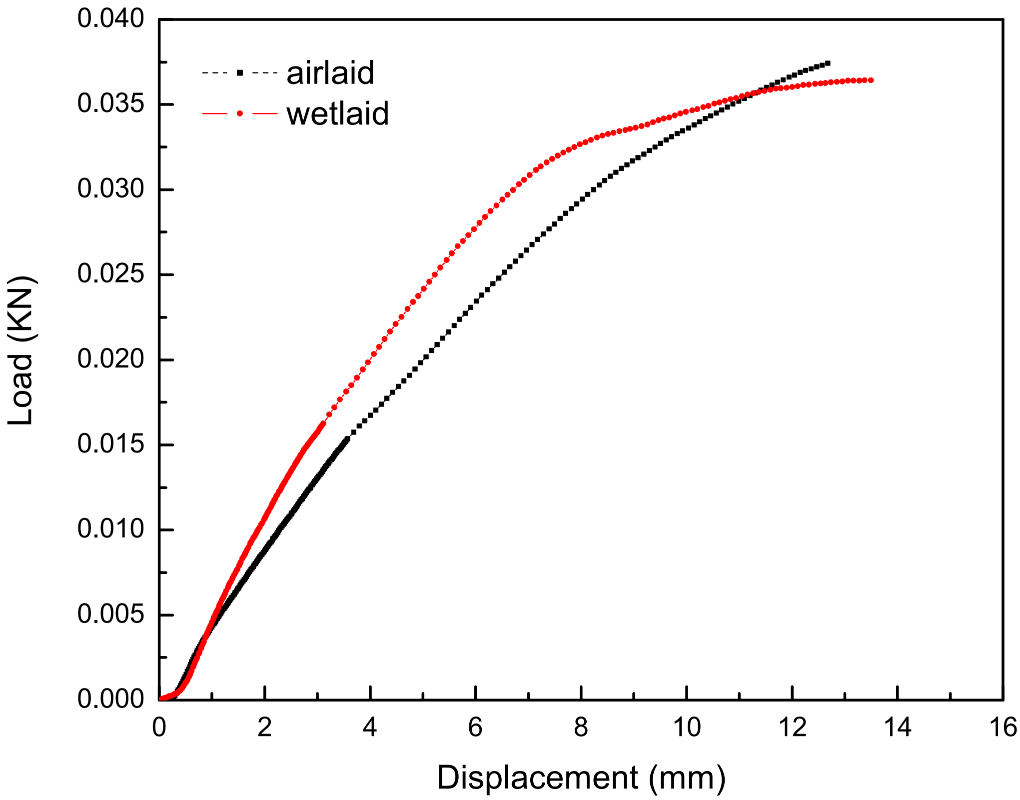

Figure 4. Tensile Load-Extension Curve (Along machine direction).

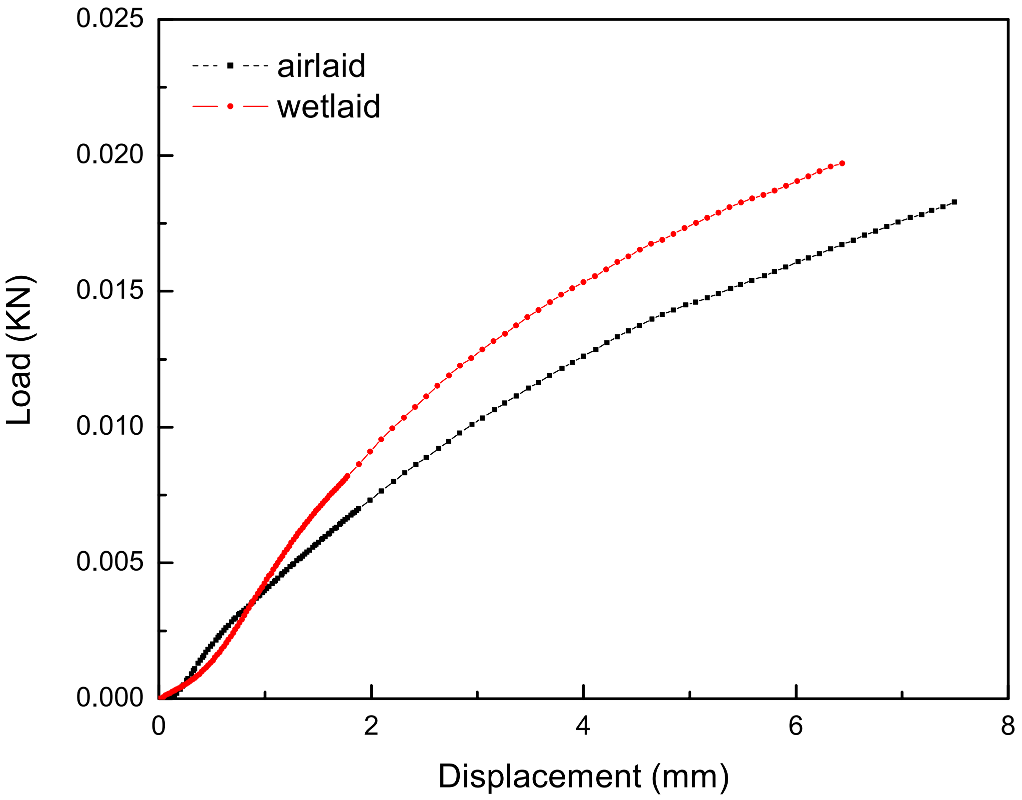

Figure 5. Tensile Load-Extension Curve (Cross machine direction).