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ORIGINAL ARTICLE

Study pultruded Jute fabric effect on the cementitious thin composites mechanical properties with low fiber volume fraction

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KEYWORDS

Volume fraction;
Jute fiber;
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Abstract The objective of this work was to study the influence of low fiber volume fraction on the mechanical properties of the Jute fabric reinforced cementitious composites, suggesting the thin sheet of pultruded fabric instead of Jute as a suitable solution for the forming complex matrix shapes. The present work investigates the pultrusion of a Jute fabrics reinforced by the polymeric matrix material, which protects the Jute fabrics and improves the durability of fiber cement sheets. Different fiber volume fraction as well as polymeric matrix material blending ratios were investigated through the pultrusion technique and compared with the control untreated Jute fabrics reinforced cementations composites. Microstructure characteristics of the fabric–matrix interface were also explored and correlated with the mechanical properties of the pultruded Jute fabrics reinforced cementations composite. It was found that an improvement in the behavior of mechanical properties of the cement composite with pultruded Jute fabrics compared to similar composites. Acceptable correlations were found on the mechanical properties of the composite, particularly bending stiffness. Pultrusion Jute reinforced polymeric matrix material increases the tensile stress, the modulus of elasticity, and the flexure strength than in control untreated Jute fabrics reinforced cementations composites.

1. Introduction

Natural fibers, including sisal, coconut, Jute, bamboo and wood fibers, are prospective reinforcing materials and their use until now has been more empirical than technical [1–7]. They have been tried as reinforcement for cement matrixes in developing countries mainly to produce low-cost thin elements for use in housing schemes. This may be returned to that the natural fibers have some drawbacks such as they are more prone to catching fire, their quality cannot be maintained equally, and moisture causes swelling of fibers [8]. Natural fibers require only a low degree of industrialization for their processing and in comparison with an equivalent weight of the most common synthetic reinforcing fibers, the energy required for their production is small and hence the cost of fabricating these composites are low too. Jute fibers, as a natural reinforcing agent, are about seven times lighter than steel

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and high tensile strength values with a suitable low-cost [9]. Although many researchers have been conducted to study the mechanical properties of cement composites reinforced with Jute fibers, they have still not been put into much use practically. This is because of its swelling properties and degradations. The use of textile fabrics as reinforcement for cement and concrete elements is gaining increased interest in recent years for various applications such as thin elements, light weight products, repair, and strengthening, and pre-stressed concrete components [10]. An efficient production method for natural fibers reinforced composites; especially in the civil engineering applications is the pultrusion process which is based on a relatively simple set up using low-cost equipment and assuring uniform production. This method has the ability to overcome the drawback of natural fibers. Pultrusion [11,12] has been examined to produce cement composites with continuous filaments (filament winding technique) by several researches, exhibiting significantly improved performance. Prefabricated cement-bonded fiberboards are used around the world for wall panels, exterior siding, pressure pipes, and roofing and flooring tiles. Use of reinforcement in these elements is essential in order to improve the tensile and flexural performance. The reinforcements can be either short fibers or continuous reinforcement in a fabric form. Recently, several researches reported very promising results of cement based products reinforced with hand lay-up of fabrics. In addition to ease of manufacturing, fabrics provide benefits such as excellent anchorage and bond development. The penetration of cement paste in between the opening of the fabrics is a controlling factor in the performance of the cement based fabric composites and dependent on the size of the fabric opening and the viscosity of the cement matrix. Pultrusion Jute reinforced polymeric matrix material increases the tensile strength, modulus of elasticity, and the modulus of flexural rigidity and reduces the breaking elongation. Flexural strength of fiber cement sheets (FCS) has been significantly improved using pultrusion of the Jute/polymeric matrix fabric [13].

The target of this investigation is to study the influence of the fiber volume fraction on the mechanical properties of the hybrid Jute fabric reinforced cementitious composites. The characteristics of the fabric–matrix interface were also explored and correlated with the mechanical properties of the pultruded Jute fabrics reinforced cementations composite. This is by producing different fiber volume fractions with using the pultrusion technique of Jute fabrics reinforced by a polymeric material, which is the surface treatment of the textiles fabric to produce new perform for textile-reinforced mortar (TRM).

2. Experimental program

Pultruded Jute fabrics of different specifications using a pultrusion technique with altered properties of resin, were used for reinforced cementitious samples to form the cementitious composites.

2.1. Materials

2.1.1. Fabric specifications

The specifications of the Jute fabric samples used are illustrated in Table 1.

Table 1 Fabric characteristics.

Fabric number	Fabric specification	Fabric weight g/m^2	Fabric thickness (mm)
1	$\frac{1\times1/cm}{3.34\times\ 3.34\ Nm}$	64	0.38
2	$\frac{2\times2/cm}{3.34\times\ 3.34\ Nm}$	110	0.38
3	$\frac{3\times3/cm}{3.34\times\ 3.34\ Nm}$	180	0.38

2.1.2. Matrix material

Polymeric material (Concresive 1315 M) which has low viscosity polymeric as matrix material was used. Matrix consists of two chemical components. The first material depends on chemical nature hazardous ingredients prepared using Bisphenol A epoxy. The second chemical component material depends on chemical nature Hazardous ingredients prepared using Polyamide TriethyleneTetramine Content. Their chemical structure is given in Fig. 1.

2.1.3. Cement matrix

Portland cement, type "Ordinary", CIM.I (42.5 N) produced by Alex. Portland Cement Company was used. The cement matrix prepared with water to cement ratio of 0.4.

2.2. Composite manufacturing

2.2.1. Pultrusion process

Specimens were produced with the pultrusion process, in which the Jute fabrics were immersed in a small bowel through the resin material (Concresive 1315 M) applying different ratios of base to hardener (1: 0.6, 1: 0.8 and 1: 1) of the polymer, and then pulled through a set of rollers to squeeze the additional amount of polymer in the openings of the fabric, and remove excessive polymer. Composite laminates were formed on a wax sheet to dry and then cure for one week. Table 2 illustrates the different fiber volume fractions of the pultruded fabrics which were fabricated.

2.2.2. Specimen preparation

For testing the mechanical properties of the cementitious composite, here is the method of preparation of the testing specimens for mechanical measurement. At which all the specimens were fabricated using hand lay-up method by fabricating the pultruded reinforcement samples in the middle of the cement samples, and the curing of the samples were done in standard atmosphere for five days inside the water bowel and then curing also in standard atmosphere for twenty-eight days before they were subjected to the mechanical tests. The specimens for the thick cement specimens have average weight 50 g, and the specimen dimensions were 25 mm × 200 mm × 5 mm for sample width, length and thickness respectively. The specimens for the thin cement specimens have average weight 12 grams, and the specimen dimensions were 25 mm × 200 mm × 1 mm for sample width, length and thickness respectively. Table 3 gives the composite samples specifications.

2.2.3. Testing procedure

2.2.3.1. Flexural test. The data recorded during the 4-point bending test is used to evaluate the flexural strength. The