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Mechanical Properties of Natural Fiber Braided Yarn Woven Composite: Comparison with Conventional Yarn Woven Composite

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Abstract

The effect of reinforcing natural fiber in the form of braided yarn woven fabric on mechanical properties of polymer composite was investigated. The results of braided yarn fabric composites were compared with the conventional yarn fabric composite and random oriented intimately mixed short fiber composites for the same percentage of fiber weight. The effect of intra-ply hybridization, by keeping two different natural fiber yarns along two different directions of a woven fabric, on mechanical properties of the woven fabric composite was also analyzed. Natural fiber braided yarn fabric reinforcement significantly increased the mechanical properties of the composites compared with that of the conventional woven fabric and short fiber reinforcements. Intra-ply hybridization of two different natural fibers improved the mechanical properties of the conventional woven fabric composite while it could not enhance the properties of the braided fabric composite. The improvement in impact property is very high compared to tensile and flexural properties due to the braided yarn fabric reinforcement.

Keywords: braided yarn, fabric, natural fiber, mechanical properties

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1 Introduction

Usage of petroleum based product creates the environmental problems during disposal and emission which increases interest in development of natural fiber composites for low and medium load applications[1]. Several advantages associated with natural fibers such as use of plant waste, environmental friendly, high strength to weight ratio, requirement of less energy to fabricate their composites make them as an alternative material to conventional metals and synthetic fiber reinforced polymer composites in several engineering applications where load-sharing requirement of the structural component is not vital. The proposed natural fiber composite material can be successfully used to replace several household components made of wood and plywood materials[2–5]. For example, telephone stand, window frame and door panels. In automobile, the natural fiber can be used along with synthetic fiber to reduce the weight of the final product such as outer body and door. With enhanced mechanical properties due to the woven fabric form reinforcement, natural fiber composites can be used to replace the synthetic fiber polymer composites in structural applications where the tensile and flexural load is less than 100 MPa[6–9].

Exhaustive amount of research has been carried out on the characterization of mechanical properties of different kinds of natural fiber reinforced polymer composites by reinforcing the natural fiber in short and random orientation form. In general, jute, sisal, flax, hemp, coir and bamboo natural fibers are used as reinforcement in the polymer matrix to enhance the properties of composite material for low and medium load applications[10,11]. Monteiro *et al*.[12] studied the mechanical performance of coir fiber reinforced polyester composites and found that 50 wt % fiber loading gives better mechanical properties. Venkateshwaran *et al*.[13] investigated the mechanical properties of short and random oriented banana/sisal/epoxy hybrid composites. Results revealed that the tensile strength, flexural strength and impact strength of sisal composites increased by 16%, 4% and 35% respectively in comparison to hybrid composites. Boopalan *et al*.[14] analyzed the mechanical properties of banana-jute hybrid com-

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posite and found that, in comparison with individual jute composites, the tensile, flexural and impact strengths of the composite reinforced with banana fiber increased by 17%, 4.3% and 35.5% respectively. Jawaid *et al*.[15] analyzed the tensile properties of jute-oil palm hybrid composites and found that 1:4 ratio of oil palm-jute resulted in higher tensile property. Mayandi *et al*.[16] analyzed the influence of fiber length and fiber loading on mechanical properties of veldt grape bast fiber/polyester composite and found that fiber with a length of 40 mm and a loading of 40 wt% enhanced the properties of composite.

Advancements in the weaving architecture of tensile fabric have been used by several researchers to enhance the mechanical properties of natural fiber woven fabric composites. Sapuan and Maleque[17] fabricated banana fiber woven fabric epoxy composite household telephone stand. Sastra *et al*.[18] analyzed the influence of reinforcing drenga pinnata fiber in long random, short random and woven roving form on the tensile properties of epoxy composites. They found that woven roving form reinforcement resulted in higher tensile properties. Sapuan *et al*.[19] compared the mechanical behavior of woven banana/epoxy composite by Analysis of Variance (ANOVA) statistical analysis tool and concluded that composite had stable average mechanical properties. John *et al*.[20] theoretically proposed different weaving patterns such as plain, basket, twill and stain to enhance the mechanical properties of the woven fabric composites. Venkateshwaran *et al*.[21] investigated the mechanical properties of banana-epoxy composite made of fabric with three different weaving patterns such as plain, twill and basket. They found that plain type weaving pattern improved the mechanical properties of the composite compared with the other patterns.

To improve the performance of natural fiber polymer composite researchers proposed hybridization of two different natural fibers. Jawaid *et al*.[22] found that the oil-palm and jute fiber fabric epoxy hybrid composite had higher tensile and flexural properties compared with the composites made of individual oil-palm and jute fibers. Jawaid *et al*.[23] analyzed the impact properties of woven jute-oil-palm fibers reinforced composite and found that the hybridization of the fibers enhanced the impact strength of the composite. Alavudeen *et al*.[24] compared the plain type woven fabric banana/kenaf polyester composites with twill type woven fabric and short fiber reinforced composites and found that higher mechanical properties of plain type woven composites can be achieved. Santulli *et al*.[25] investigated the tensile and flexural properties of wool-jute-epoxy composites and found that the addition of wool in the jute reinforced epoxy composite enhanced the tensile and flexural strengths by 92% and 50% respectively. Kumar *et al*.[26] investigated the mechanical properties of sisal-cotton hybrid woven polyester composite and found that increasing the number of layers of fabric enhanced the mechanical properties of composite material.

Mechanical properties of braided yarn fabric reinforced composite and comparing it with conventional simply twisted yarn fabric. Similar investigations on the intra-ply hybridization effect of two-different natural fiber by keeping them along the two different directions of a fabric on mechanical properties are also explored by researchers. Present work focuses on the investigation of mechanical properties of jute braided yarn fabric and jute-banana intra-ply fabric composites. The mechanical properties of braided yarn fabric composites are compared with that of conventional yarn fabric composite and short fiber composites. Composites with braided woven fabric reinforcement are used in several engineering applications such as aircraft structural parts, air ducts and rocket launch tubes. Ayranci *et al*.[27] reviewed the application of braided composites in various fields and concluded that braided woven fabric composite can be successfully used to replace conventional material for structural columns, rods, shafts, pressure vessels and plates. Sun and Qiao[28] compared the mechanical properties of braided composite using theoretical and experimental methods and found that braided angle influenced the mechanical properties of the composite material. Sun *et al*.[29] analyzed the mechanical properties of 3D braided composites using volume-average-compliance method and found that the mechanical properties of braided composites had a significant improvement compared with that of straight yarn composite. Goyal *et al*.[30] analyzed the mechanical properties of braided composites and found that braid angle, waviness ratio and cross-sectional shape influenced the mechanical properties of the composite material. It should be noted that these studies on braided composites are related to synthetic fibers and most of the work are carried out based on analytical and numerical investigations.