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A Comparative Study on Tensile Behavior of Plant and Animal Fiber Reinforced Composites

B. Nagaraja Ganesh[1] and B. Rekha[2]

[1]Department of Mechanical Engineering,
Madurai Institute of Engineering and Technology,
Sivagangai District, Tamilnadu, India

[2]Department of Physics,
SACS MAVMM Engineering College,
Madurai District, Tamilnadu, India

ABSTRACT: The potential applications of natural products which are commonly used in the preparation of natural fiber reinforced composites are explored. The increasing demand for environmentally friendly materials and the need for cheaper fibers which increase the desirable mechanical properties forces to search for the natural products. The products that are abundantly available and are not efficiently used are taken in the study. Rice straw and chicken feather are one among the commonly available natural products of agricultural industry and poultry industry respectively which are considered as waste. These materials are disposed causing negative impact to the environment. Composite samples are prepared using untreated, uneven rice straw and chicken feather fibers using general purpose polyester resin matrix. The tensile behavior of the samples prepared with different volumetric proportions of the matrix and fiber were analyzed. The studies show an increase in the fiber loading decreases the tensile strength till an optimum fiber proportion. The tensile strength of rice straw fiber reinforced composites shows a decreasing trend till 40% of fiber volume and then increases. Similar behavior is observed in chicken feather fiber reinforced composites. The hybrid composites (rice straw and chicken feather combination) show an increasing trend till 30% of fiber volume and then decreases for 40% and again it increases.

KEYWORDS: Plant Fiber, Animal Fiber, Hybrid composites, Tensile strength, Polyester Resin.

1. INTRODUCTION

Rice (Oryza sativa L.) is one of the oldest cultivated crops [1] and ranks as the most widely grown food grain crop that serves as the most staple food for more than 60% of the Indian population. According to International Rice Research Institute, Manila, India‘s rice production crossed 100 million metric tons, which implies its importance as a basic food crop. The crop leaves several million tons of straw annually and which of them are mainly used for burning purposes and as cattle feed. These are considered as agricultural waste. But, there is growing interests on agricultural waste as a substitute for wood-based raw materials and recently many studies and researches are going on to tap the potential uses of the rice straw as they prove to exhibit appreciable mechanical properties. Similarly chicken feather is an important waste product of poultry industry. Poultry feather fiber is predominantly keratin protein in α-helix structure with a crystalline melting point of about 240 ºC [2, 3]. As per the reports, US alone generate about 2x109 kg of chicken feather fiber annually. The feathers are considered as waste because their current uses are economically marginal and their disposal is difficult. Disposal methods of chicken feather are done either by burning or burying occasionally. Hence they are environmentally unfriendly. Burning feathers causes air pollution and a landfill feather decomposes very slowly and requires a lot of land for decomposition. Natural based bio-fibers are nowadays a promising area for researchers. Unsaturated polyester resin has been chosen as the matrix material because it is relatively cheap, low shrinkage and can be molded at room temperature. In order to use these waste products into a useful one, various percentage volume of rice straw and chicken feather fibre has been combined with an unsaturated polyester resin to produce the composites. This paper focuses on the tensile behaviour of the natural fibres composites (plant and animal fibre). Untreated natural fibers are taken for the present study. the mechanical property of the

Corresponding Author: B. Nagaraja Ganesh (bng9@ymail.com)

resin can be improved by the addition of fibre. The rice straw and chicken feather fibres are combined to form hybrid composite [4].

2. MATERIALS AND METHODS

2.1 TEST MATERIALS

General purpose Polyester Resin (PE) was supplied by GVR Enterprises (India) and used as received. The Rice Straw (RS) agricultural waste was taken from the rice-producing region, Madurai, India. The Chicken Feather Fiber (CFF) was obtained from nearby poultry farms in Madurai. Prior to the preparation of the composites, rice straw and chicken feather was dried for 48 hours under direct sunlight to remove the moisture content.

2.2 COMPOSITE PREPARATION

Initially, the materials were cleaned with water and cut into small pieces manually. The composite fabrication is done by hand layup method, the simplest and oldest open molding method [5]. It is a low volume, labor intensive method suited especially for large components such as boat hulls, etc. A wooden mold of dimension 150 x 150 x 5 mm respectively was prepared. A thin film of polyvinyl acetate was coated on the inner surface of the mold which aided in the easy removal of the sample from the mold after curing. Resin was poured along with fibers of definite proportion in the mold. Entrapped air was removed manually with rollers to complete the laminated structure. Curing was initiated by a catalyst namely methyl ethyl ketone peroxide and cobalt as an accelerator in the resin system, which hardened the fiber reinforced resin composite without external heat. The composites were prepared with different fiber loadings (10, 20, 30, 40 and 50%) by volume proportion. The tortuous nature of the chicken fibers posed practical problems in preparing the samples.

3. RESULTS AND DISCUSSION

The mechanical property namely the tensile strength of the fibers was determined in accordance with ASTM D638-03 and its results are discussed below. Tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates up to that breaking point.

3.1 TENSILE STRENGTH

Studies about composites show that there is a relationship between the fiber loading and tensile strength and the tensile strength of the composites always exceeds that of the resin. This test method covers the determination of the tensile properties in the form of standard dumbbell-shaped test specimens. This test method can be used to test materials of any thickness up to 14mm (0.55 inch), [6] since the sample thickness is less than 5mm.

Table 1. Tensile Properties of PE/RS, PE/CFF, PE/RS/CFF* Composites

S.No	Sample $^{Vol}/_{Vol}$	Tensile Strength MPa
A1	PE/RS, 90/10	17.62
A2	PE/RS, 80/20	17.36
A3	PE/RS, 70/30	15.19
A4	PE/RS, 60/40	13.28
A5	PE/RS, 50/50	14.97
B1	PE/CFF, 90/10	17.50
B2	PE/CFF, 80/20	16.25
B3	PE/CFF, 70/30	15.83
B4	PE/CFF, 60/40	9.60
B5	PE/CFF, 50/50	10.32
C1	PE/RS/CFF, 90/5/5	12.28
C2	PE/RS/CFF, 80/10/10	14.67
C3	PE/RS/CFF, 70/15/15	17.16
C4	PE/RS/CFF, 60/20/20	15.16
C5	PE/RS/CFF, 50/25/25	19.09

*** PE- polyester, RS – rice straw, CFF – chicken feather fiber A – Rice Straw composites, B-Chicken Feather composites, C-Hybrid composites**

Table 1 shows the values of tensile strength of the composites of various volume proportions. Fig 1 shows the variation of tensile strength with varying volume proportion of the resin and the natural fibers. The figure reveals that the rice straw based composites show a decreasing trend in tensile strength for increase in volume proportion of fiber loading till 40%, and then it starts increasing. Similar behavior is observed in chicken feather fiber composites too. But, for the hybrid combination of rice straw and chicken feather fiber, the tensile strength increases gradually till 30% and then decreases for 40% volume proportion and again increases abruptly for 50% fiber loading. For a fiber loading of 30%, the tensile strength of the rice straw and chicken feather composites are 15.19 MPa and 15.83 MPa which is nearer to the tensile strength of the hybrid composites i.e. 15.16MPa at 40% fiber loading. Least values of tensile strength are found in rice straw and chicken feather composites at 40% fiber loading. Hybrid composites are found to possess better tensile strength than individual composites [7]. Fig 2 shows the decrease in tensile strength of hybrid composites initially, followed by increase after 30% of fiber loading than individual composites. At 50% fiber loading, tensile strength of hybrid composite is 28% and 85% higher than rice straw and chicken feather composites respectively. A nonlinear behavior of tensile strength is obtained on varying fiber loading and resin.

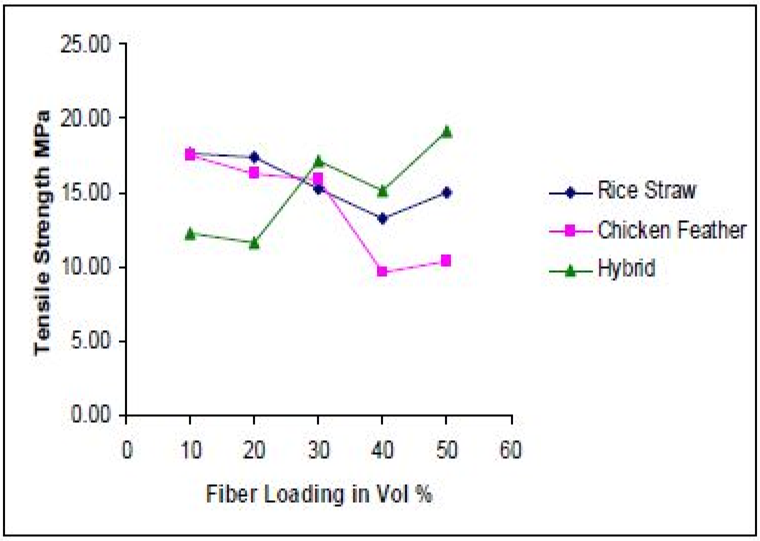

Fig. 1. Variation of Tensile Strength with Volume Proportion.

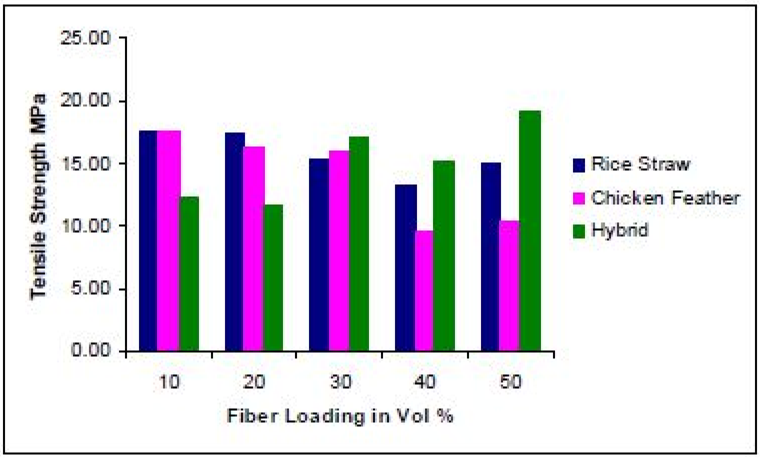

Fig. 2. Tensile Behavior of Rice Straw, Chicken Feather and Hybrid composites.

4. Conclusion

While agricultural production has been rising at the rate around 2 percent per annum over the past two to three decades and the poultry production has been rising at the rate of around 8 percent per annum with an annual turnover of US$ 7500 million there is an abundant availability of the agricultural and the poultry waste such as rice straw and chicken feather respectively which could be used efficiently in the preparation of composites. The study shows the tensile property of hybrid composites exhibit a higher value than the individual composites. The fibers in this study are untreated and they are randomly oriented. Proper fiber orientation of the fibers may yield still better tensile strengths. Chemical modifications may be employed to improve the interfacial matrix-fiber bonding resulting in the enhancement of tensile properties of the composites [8]. Increased fiber length causes improper bonding between fibers and matrix leading to agglomeration and fiber clamping [9]. The increase in high percentage of tensile strength namely 28% and 85% of hybrid composites makes it to be suitable composite in the manufacture of automotive components.

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