Analysis of Carbon-Jute Hybrid Reinforced Polyester Composite under Flexural Loading

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Abstract— Polyester composites reinforced with carbon-jute hybrid with three different orientations of 0º, 30º and 45º was fabricated by hand lay-up process. It is very important to evaluate the mechanical properties of these composite before it is subjected to the real practical application. The flexural test results obtained shows better flexural strength of hybrid composite at 30ºorientaion when compared with 0º and 45º. By Ansys, the analysis results are closing with the specimens tested data.

Key words: Carbon fiber, Composite, flexural strength, Jute, Hybrid

I. INTRODUCTION

Fiber reinforced polymer matrix composites were initially used in the aerospace industry, where critical importance is placed on the use of lightweight materials. Decades later, fibrous composites found applications in other areas such as automobiles, infrastructure and biomaterials in light of their good environmental stability, moldability and damage resistance. Carbon fibres represent a large part of the materials used in aeronautics and aerospace structures, and in the reinforcement of composites. They display a very wide range of thermal, electric and mechanical properties [1, 6]. The need for renewable fiber reinforced composites has never been as prevalent as it currently is. Natural fibers offer both cost savings and a reduction in density when compared to glass fibers.

Though the strength of natural fibers is not as great as glass, the specific properties are comparable. Currently natural fiber composites have two issues that need to be addressed: resin compatibility and water absorption. Many researchers are searching for structural materials of high strength, less weight and low cost, in general strong materials are relatively dense and light materials have less strength. In order to achieve high strength and less weight, it requires combining two or more distinct materials to get composite materials [2]. Hybrid composite material represents the newest group of various composites where more than one type of fibre is used to increase cost-performance effectiveness.

That is, in a composite system reinforced with carbon fibre, the cost can be minimized by reducing its content while maximizing the performance by optimal placement and orientation of the fibre. [5,7]. Evaluation of mechanical testing being carried out on a scientific basis in the second half of the nineteenth century when metals were the most common engineering material. The use of high performance composite materials, as distinct from 'reinforced plastics', as major load-carrying materials began almost a century later, and it follows that the test methods initially used to test composites were based very closely on 'metallic' techniques.

Testing of metals is not a difficult task, being aided by the strain hardening isotropic homogeneous nature of the material. At its simplest, a piece of stock material can be pulled in a testing machine and fail in its mid length: locally reducing the cross-section of the test piece can ensure that failure occurs away from the grips. It is important to understand that, where composite materials are concerned, there the second aim is to determine the properties, or investigate the behavior, of an existing material. This is likely to involve testing material with fibers lying at a number of angles to the principal loading direction [3].

Polymer composites have become popular due to their ability to modify the mechanical properties by incorporating different reinforcement fibers. Composites made with a polymer matrix have become more common and are widely used in various industries. Natural fibre is certainly a renewable resource that can be grown and made within a short period of time, in which the supply can be unlimited when compared with traditional glass and carbon fibre for making advanced composites [4]. Considerable effort has been made over the years to understand the behavior and the mechanisms of its failure of composite laminates. Numerous test methods and analytical models to analyze and predict the properties have been developed [9, 10].

II. EXPERIMENTAL DETAILS

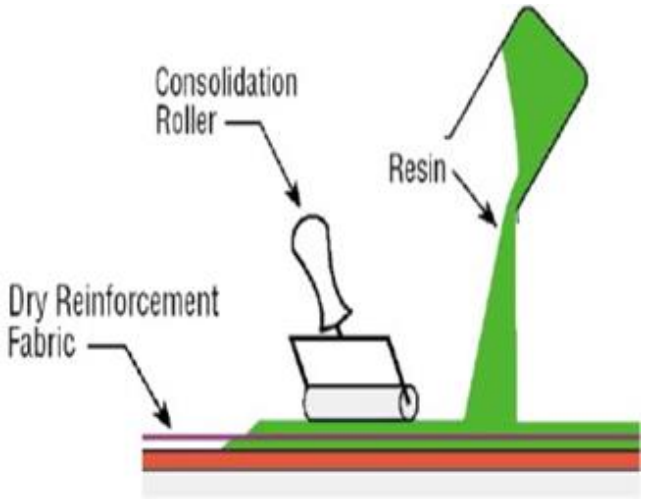

Fig. 1: Hand Lay-up Method.

Carbon and jute fiber woven mat is used as a reinforcing material and matrix material of unsaturated polyester resin plus Methyl ethyl ketone peroxide (MEKP) as accelerator, plus cobalt as a catalyst were used respectively. Dry hand lay-up technique was employed to fabricate the composites. The release film was placed on the lower surface of the mould coated with anti adhesive gent. Carbon fiber woven mat is placed on it, on which a mixture of matrix system is coated with help of a brush.

The stacking procedure was followed: placing of the carbon fiber woven mat one at the bottom followed by jute and at the top again the carbon fiber thus forming a natural – polymer hybrid composite by coating with the mixture prepared well on it and covering film was again used to complete the stack. To ensure approximate thickness of the sample, a spacer was used. At the last again release film coated with anti adhesive agent was kept and on it another large granite stone was again placed over it to apply enough load on it was also coated with anti adhesive agent in order to aid the ease of separation on curing. Enough load was ensured and then it was allowed to cure for a day at room temperature. .Test samples according to ASTM D-790, were prepared from the cured sheet using cut-off machine [8].

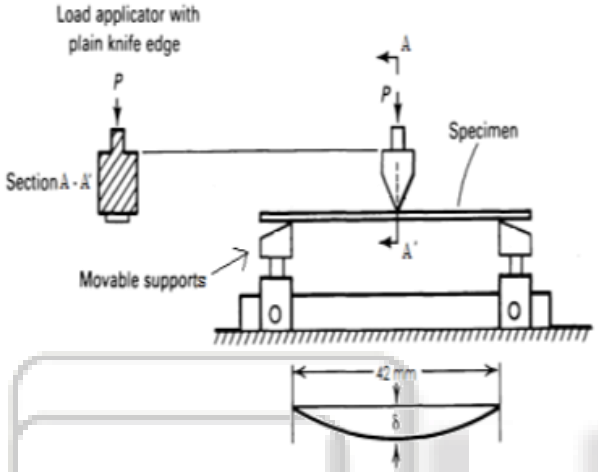

Fig. 2: Schematic diagram of 3 point bending.

A. Flexural Test:

Fig. 3: Computerized Universal testing machine.

Computerized Universal testing machine which uses modern software for material test and analysis is used. A sophisticated data gathering algorithm might be expected to adjust the rate of data collection in conjunction with varying rates of change in load or strain, and so on.

A flat rectangular specimen is simply supported close to its ends and either centrally loaded in three-point bending. The loading is done on the specimen until it breaks and finally the computer will record the necessary data. Automatically the stress– strain graph is generated which includes all the features likely to be found in a loading curve, including evidence of changes in stiffness, progressive failure and so on. [3,8].

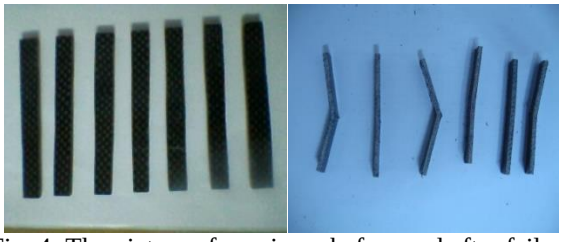

Fig. 4: The picture of specimen before and after failure specimen.

III. RESULTS AND DISCUSSION

The flexural testing is carried out by three-point bending arrangement in which the sample is simply supported close to its ends and centrally loaded. Properties such as Maximum. Flexural strength and maximum load can be determined. The specimen is loaded in three point bending with a recommended span of 50 mm. The test is conducted on the machine, by applying the speed of loading of 0.033 mm/sec is applied during the testing.

Sl. No.	Material Orientation in degrees	Maxi. Load in N	Maxi. Flexural Strength (MPa)
1	0˚	162.92	125.60
2	30˚	230	146.60
3	45˚	210	116.87

Table 1: Flexural properties of 0° orientation

The flexural strength of carbon and jute fiber reinforced with polyester composite is found to be 146.60 MPa for 30° orientation. The variation of the flexural strength of the hybrid composite has been influenced by varying the fiber orientation. Fig. 5, 6 and 7. Shows the stress Vs strain plot obtained under flexural loading for carbon and jute fiber reinforced – polyester composite with 0°, 30° & 45° orientations. For 30° orientation, it exhibited better result, then the remaining. The composite with orientations of 0° and 45° showed the decreased flexural strength. It was observed that the lowest values of flexural strength were seen with 0° and 45° orientation in carbon and jute fibers reinforced – polyester hybrid composite shown in Fig. 5 and 6 respectively. From the table 1 for different orientation with carbon and jute fiber – polyester hybrid composite.

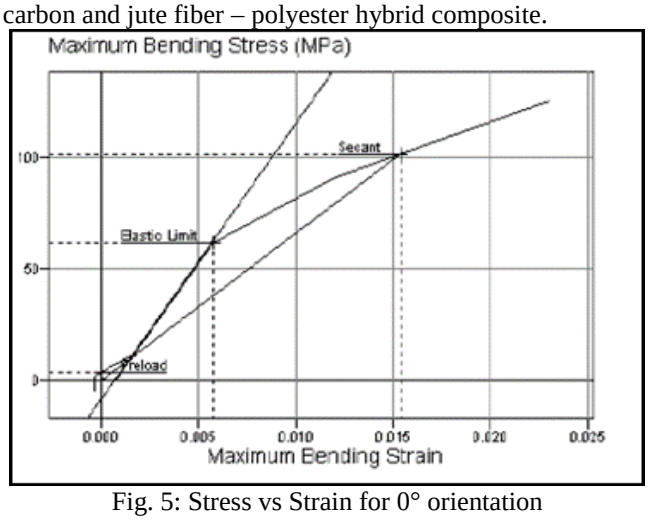

Fig. 5: Stress vs Strain for 0° orientation

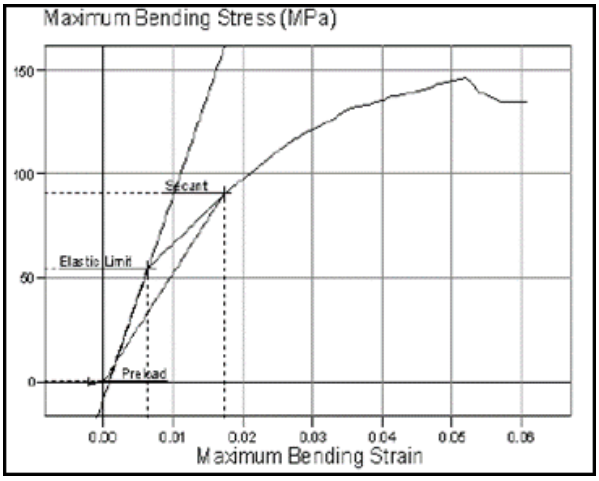

Fig. 6: Stress vs Strain for 30° orientation

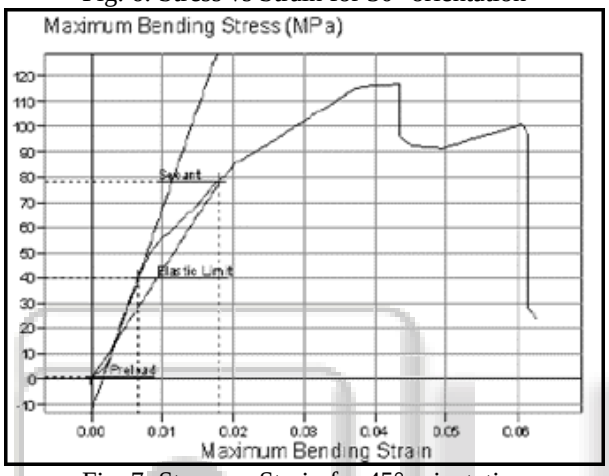

Fig. 7: Stress vs Strain for 45° orientation

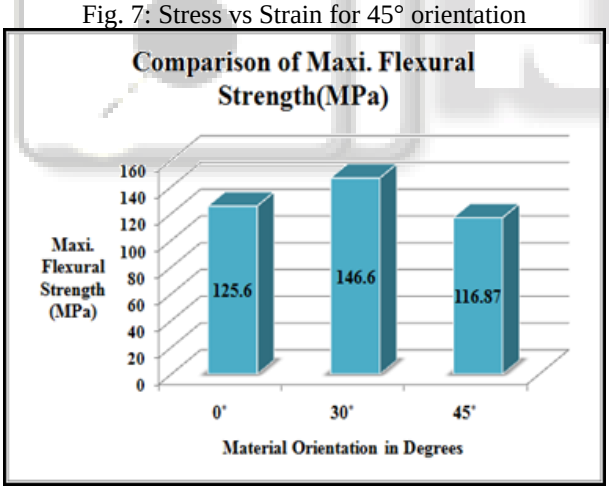

Fig. 8: Comparison of Maxi. Flexural Strength

From the Fig. 8, it indicates the comparative result of ultimate tensile stress of the developed hybrid composite. For 30° orientation, the Maximum flexural strength is high when compared with 0° and 45° orientations.

A. Fea Analysis:

Finite Elemental analysis is carried out to investigate the various parameter of Natural – polymer hybrid composite material. For the tested specimen of 30° orientation, the von misses' stresses developed in the natural polymer hybrid composite under flexural load is analyzed, its values indicated 122.6 MPa as a closer value with the results obtained from the tested once as shown in the Fig. 9.

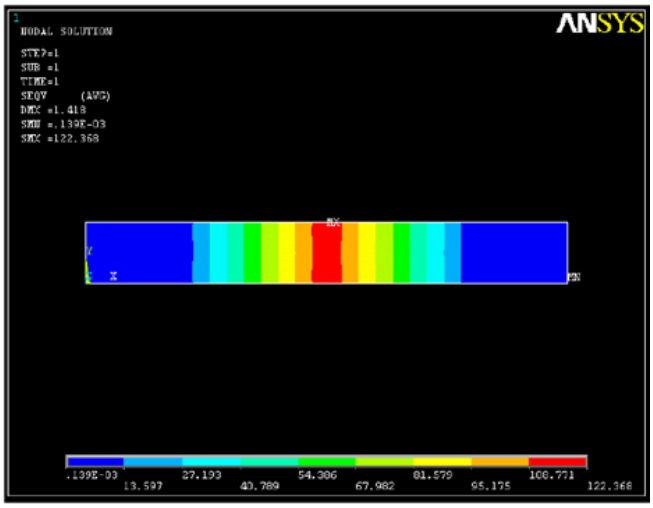

Fig. 9: Contour plot Von-Mises stress for 30º orientation.

IV. Conclusion

The Natural – polymer hybrid composite consists of carbon and jute fiber reinforced with polyester hybrid composite have been experimentally evaluated and studied for varying orientation and the same is analyzed using Ansys software and the following conclusions were drawn:

- The hybrid composite consisting of carbon – jute fiber reinforced with polyester hybrid composite for 30° orientation showed a better flexural strength and can withstand the strength of 146.60 MPa.
- Flexural test results of hybrid composite with 30° orientation showed a better maximum flexural strength, compared to 0° and 45°.
- It can be seen that there is only a marginal decrease in maximum flexural strength when compared with 0° & 45° orientation.
- Finally the natural – polymer hybrid composite with 30° orientation resulted in optimal.
- By the data obtained from the result of analysis, which is carried out by ansys software. For 30° orientation the stresses developed is 122.6 MPa, which is more than the experimental result. This shows that the values are closing to each other and resulted in optimality.

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