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## Experimental Investigation of Static Mechanical Properties of Epoxy Based Glass, Carbon & Sisal Woven Fabric Hybrid Composites

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**Keywords:** synthetic fiber, natural fiber, Epoxy, biodegradable, hand layup method, ASTM standards.

**ABSTRACT.** In recent years, composite materials widely involved replacing the metals to increase the strength at minimal weight. Synthetic fiber reinforced polymer composites are widely used many application like aircraft, automobile etc. Due to increasing demand for the synthetic fiber, because of its light weight and easily biodegradable, Natural fiber are involved in achieving good strength to weight ratio. In present work sisal fiber reinforced polymer composite SFRP was used to replacing the two synthetic composite such as carbon fiber reinforced polymer composite CFRP and glass reinforced polymer composite GFRP. All laminates are fabricated by using hand layup method. The static mechanical properties of epoxy based SFRP, GFRP, CFRP and their hybrids laminates are experimentally evaluated as per ASTM standards and reported.

**Introduction.** Investigated the mechanical properties of sisal, jute and glass fiber reinforced polyester composites observed that the addition of glass fiber into jute fiber composite resulted in maximum tensile strength and that jute and sisal mixture composites sample is capable having maximum flexural strength and maximum impact strength was obtained. [4]. The variation of tensile strength, flexural strength and compressive strength of epoxy based sisal-glass hybrid composites have observed that 2 cm fiber length hybrid composites showed maximum optimal tensile, flexural and compressive strength than 1 and 3 cm. The effect of alkali treated hybrid composites showed higher strength than untreated composites [2]. Increase in NaOH concentration worsens the tensile properties of the natural fiber and also higher concentration enhances the surface characteristics of the fiber by removing the waxy layer from the surface and the fiber matrix interfacial adhesion. So 6% NaOH is the optimum concentration which provides acceptable fiber strength and surface characteristics [8]. The application of composites in structural facilities is mostly concentrated on increasing the strength of the structure with the help of artificial fibers and does not address the issue of sustainability of these raw materials used for strengthening purposes [6].

The composite with 50% sisal-glass fibre and 50% resin combination has maximum tensile strength and that the breaking load of sisal-glass fibre reinforced composite is 1.10 times higher than sisal-coir-glass fibre reinforced composite and 1.33 times higher than coir-glass fiber reinforced composite. The percentage elongation of coir-glass fiber reinforced composite is found as higher than the other composites and hence it may have more ductile property in nature [1].

In the present work we are going compare the static mechanical properties of glass fiber, carbon fiber and sisal fiber in the form reinforced polymer composite laminates. We made the laminates in stacking sequence form of glass- sisal- glass sisal –glass (GSGSG), sisal- glass- sisal- glass- sisal (SGSGS), carbon- sisal- carbon- sisal- carbon (CSCSC) and carbon- sisal- glass- sisal- carbon (CSGSC). Four different combination hybrid composite laminates were prepared through hand lay-

up techniques. Then the laminates are tested as per ASTM standards for polymer composites. The results of various mechanical properties are reported and tabulated.

**Fabrication of Composite Laminates.** E-glass, Carbon and Sisal are taken in the form of woven fabric. Sisal is natural fiber it undergoes alkali treatment to increase the bonding characteristics.

**Alkali treatment.** Woven fabric sisal layers of size 300 X 300 mm are taken. Total seven layers of sisal used for entire study. It can be immersed in 6.25% NAOH solution over 24 hours at room temperature. Then after the completion of the process, the sisal layers mats washed with distilled water. After washing woven fabric sisal layers can be dried in room temperature for 24 hours.



*Fig. 1. Surface Treatment for Sisal fibers.*



*Fig. 2. Hand layup technique.*

**Hand layup method.** Woven fabric hybrid composite laminates considered for investigation were fabricated by hand layup technique. Epoxy resin LY556 premixed and homogenized with hardener HY951 in the ratio of 9:1 by volume was used as matrix. To ensure a uniform thickness for all

laminates, an aluminum dam of size of 300 x 300 x 3 mm<sup>3</sup> was used between the match plates. To avoid sticking of epoxy with aluminum dam polyethylene sheets were used. In silicon spray were to make easy separation of laminates with polyethylene sheets and aluminum dam. The various steps involved to fabricate the hybrid composite laminates are, An aluminum dam of size of 300 x 300 x 3 mm<sup>3</sup> was taken. The polyethylene sheet placed over the aluminum dam as size more than that of aluminum dam for easy separation. Silicon spray is sprayed over the polyethylene sheet for easy separation of composite laminates from the dam. Mixed matrix can be brushed over the silicon sprayed polyethylene sheet. First layer of hybrid composite can be placed over the matrix filled dam. Then roller was used to make equal distribution of matrix in the layers. Again the mixed matrix can be brushed over the surface of first layer. Second layer of hybrid composite can be placed over matrix filled first layer. Then roller was used to make equal distribution of matrix in the layers. Repeat the same steps until the completion required laminates size or combination. Final step place the silicon sprayed polyethylene sheet over final layer surface of composite laminates. Then aluminum dam placed over the sheet. Then composite laminates placed over compression molding machine for 24 hours at a pressure of 350psi. The process was repeated for all four combination of hybrid composite laminates.

**Evaluation of Mechanical Properties.** Prepared hybrid composite laminates of different combination were taken evaluation of mechanical properties. The mechanical properties are evaluated as per the ASTM standards. Specimen prepared for different mechanical test like tensile test, flexural test and impact test.

**Tensile test.** The standard for tensile testing is ASTM D638. The prepared specimen is loaded onto the machine and fixed into the cross heads and the load is applied gradually applied.



*Fig. 3. Tensile test specimen.*

**Flexural test.** The ASTM standard for flexural testing is D790, it is to have a rectangular piece of dimensions 12.7mm x 64mm.



*Fig. 4. Flexural test specimen.*

**Impact test.** The ASTM standard for impact testing is ASTM D256, the dimensions of the specimen being, 12.7mm x 63.5mm with a Vee notch at a distance from 31.8 mm from one of the ends. The Vee notch is to be at depth of 2.54 mm.



Fig. 5. Impact test specimen.

**Result and Discussion.** After the specimens were prepared as per the ASTM standards various mechanical test are done to evaluate their properties.

**Tensile test results.** It shows that the CSCSC have more tensile strength when compared to other combination. This because of implies of more carbon fiber in this combination gives more tensile strength. Interplay of glass in between the sisal and outer layer of carbon in form of CSGSC gives more strength when to other two hybrid forms of GSGSG and SGSGS.

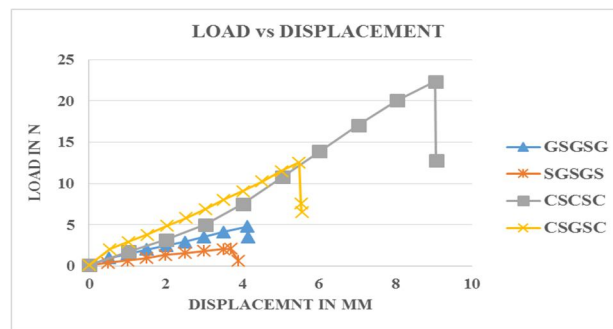


Fig. 6. Load vs displacement for tensile test.

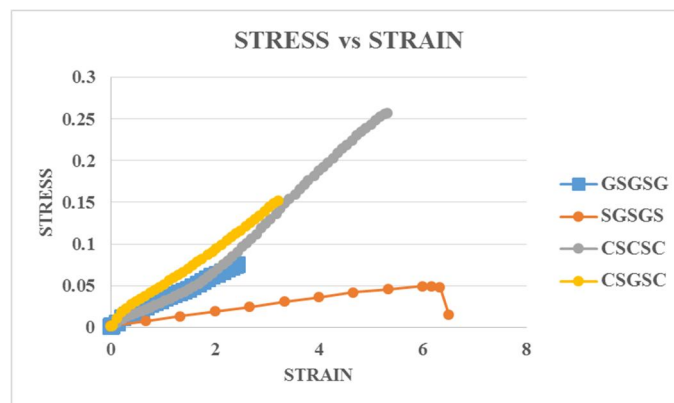


Fig. 7. Stress vs strain for tensile test.

**Flexural test results.** It shows that the sisal glass combination GSGSG and SGSGS have increased displacement at low load where else carbon sisal glass CSCSC and CSGSC combination shows less displacement at maximum load.

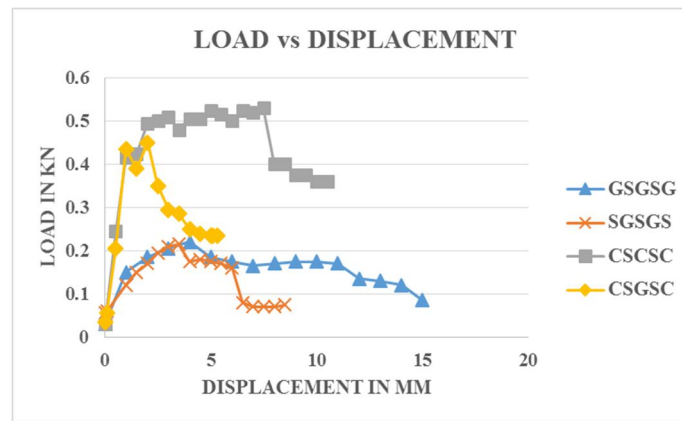


Fig. 8. Load vs displacement for flexural test.

**Impact test results.** It shows that adding more sisal layer GSGSG and SGSGS shows that maximum impact strength when compare other two combinations CSCSC and CSGSC. It clearly state adding of more natural fiber over synthetic gives more impact strength. And that impact energy of maximum content of natural fiber shows high when to least addiction of natural fiber. Interplay of glass in between the sisal and outer layer of carbon in form of CSGSC gives more strength when to other two hybrid forms of GSGSG and SGSGS.

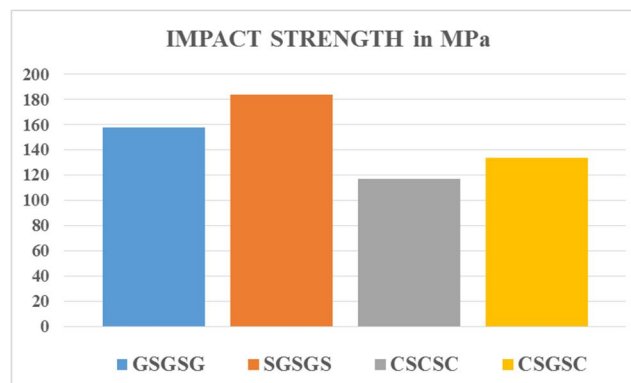


Fig. 9. Impact strength.

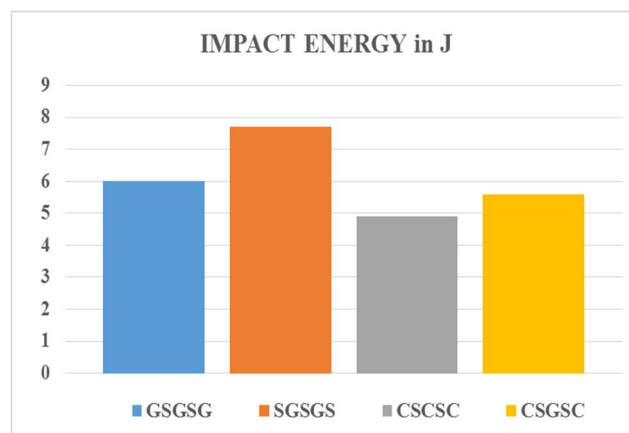


Fig. 10. Impact energy.

**Summary.** This work shows that successful fabrication of Carbon- Sisal - Glass Fiber Reinforced composites with different fiber composition is possible by using simple hand lay-up technique. It has been noticed that the mechanical properties of the various hybrid composites laminates such as tensile strength, flexural strength, and impact strength of the composites are greatly influenced by the fiber composition. In Tensile Test, CSCSC composition yielded the highest tensile strength then the other composition. In Flexural Test, CSCSC composition yielded the highest flexural strength and flexural modulus. In Impact Test, SGSGS composition yielded the highest impact energy in Joules and highest impact strength.

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