

# Static and Dynamic Mechanical Behavior of Hybrid Fibers Composites

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**Abstract:** Fiber reinforced polymer composites demonstrate essentially better execution over many regular metallic materials in light of their prevalent quality than weight proportion and greater stiffness. Improvement of properties of FRP composites can be conceivable by the alteration of matrix properties. After the construction work, The static mechanical properties like Inter laminar shear strength and impact strength and dynamic mechanical properties are the viscoelastic properties such as storage modulus, loss modulus, and tan delta (Damping Behavior) of the materials were deliberated by the Dynamic Mechanical Analysis as a part of temperature of these laminates were experimentally estimated as per ASTM standards for investigate the mechanical behavior of the hybrid fabric reinforced vinyl ester composites are behaved differently on different combination of hybrid fibers and described in detail.

## 1. Introduction

Composites have numerous attractive properties that can't be accomplished by the complete segments alone. Be that as it may, the execution of such materials is all the time controlled by the properties of an interfacial district, a two-dimensional (interface) or a three dimensional (interphase) territory in composites. A decent interface holding, to guarantee the heap exchange from grid to support is an essential prerequisite for the viable utilization of reinforcement properties.

Vinyl ester resins are extensively utilized as thermoset matrix to build a variety of strengthened structures [1– 4] including funnels, tanks, scrubber and pipes. They are the prime contender for use in composite for transportation, foundation, basic overlays and electrical applications, and so forth. Vinyl ester resins associate the best properties of epoxies and unsaturated polyesters [5].

Hybrid composites are one of the rising fields in polymer composite that are thought for application in an variety of divisions, for example, construction, aeronautical and vehicles [6]. The idea of hybridization gives adaptability to the plan designer to tailor the material properties as indicated by specific necessities [7]. In the present article, an effort was made to create composites in view of hybrid fibres (Glass, Carbon and Kevlar fibres) and vinyl ester resin to assess the static and dynamic mechanical properties of hybrid fibre polymer composites.

## 2. Materials

The selection of materials for the experimental work was both glass fiber & Carbon Fiber in single mat, both Kevlar Fiber & Carbon fiber in another single mat as reinforced and vinyl ester resin with accelerator (cobalt naphthenate- for speed the chemical reaction), catalyst (methyl ethyl ketone peroxide – for speed the curing of the compound), were used as matrix components.

## 3. Experimental Method

There are many papers focusing on the manufacture of laminated composites using the hand lay-up techniques and their characterization [8]. In the present study the composite laminate specimens are



prepared using the hand layup technique and the specimens are subjected to the investigation as per the ASTM standards. As the laminate is prepared, it has to be subjected to post curative so the all the layers of the lamina link together. This can be achieved by keeping the laminate in oven and set the oven to the temperature 30°C for 3 hours then let the oven cool down slowly to room temperature.

**Table1.** Sample and Orientation of Hybrid Fiber Laminates

Name of the Sample	Orientation of Fibers	
	0°	90°
Hybrid 1(H1)	Glass	Carbon
Hybrid 2(H2)	Carbon	Glass
Hybrid 3(H3)	Kevlar	Carbon
Hybrid 4(H4)	Carbon	Kevlar
Hybrid 5(H5)	Kevlar & Carbon	Glass & Carbon
Hybrid 6(H6)	Glass & Carbon	Kevlar & Carbon

#### 4. Results & Discussions

##### 4.1 Inter Laminar Shear Strength Test:



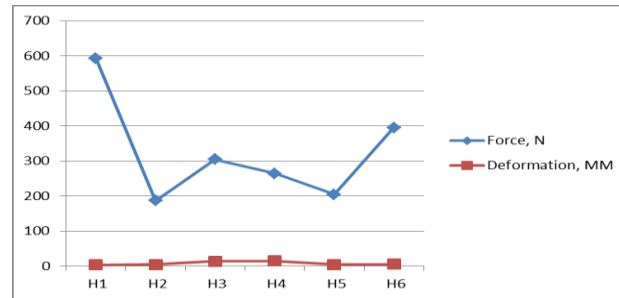
**Figure 1.** Performing Experimental Test

The ILSS is one of the basically fundamental parameters in finding the capacity of a composite to resist delamination destruction. It is valuable to test for composites where the probabilities for failure of lamina in layered composite is more significant to start when subjected to shearing stresses. Above Figure demonstrates the Experimental set up as per ASTM D790.

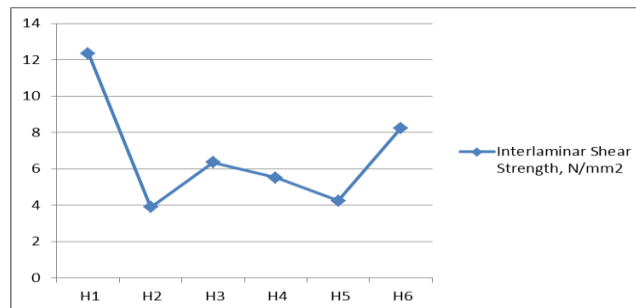
**Table 2.** ILSS Test Results

Name of the Sample	Force, N	Deformation. @Max.Load, MM	ILSS, N/mm2
H1	592.8	4.216	12.35
H2	186.8	4.485	3.89
H3	305.1	14.03	6.35
H4	264.93	15.47	5.51
H5	204.366	4.488	4.25
H6	394.833	5.409	8.22

The ILSS value of Different hybrid composites were also evaluated to know the influence of different fibers. From the table result shows more inter laminar shear strength on H1 with more force sustained and less on H2 with less force sustained. Maximum deformation was shown on H4 hybrid laminate. This result indicates that the ILSS value predominantly depends on the fibre and matrix composite materials. The graphical demonstration is also shown in the fig 2& fig 3.



**Figure 2.** Variances in Force and Deformation



**Figure 3.** Variances in Inter Laminar Shear Strength

#### 4.2 Impact Strength Test:



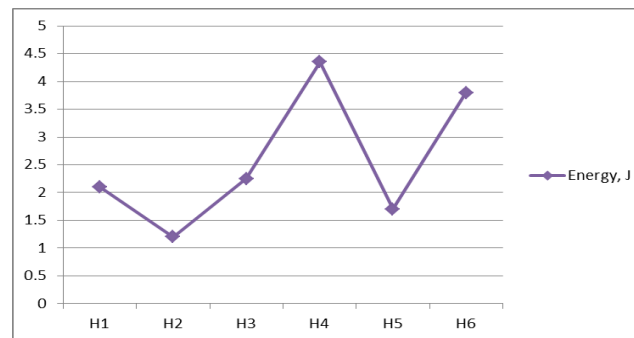
**Figure 4.** Performing Experimental Test

The Izod impact quality of composites was tried according to ASTM D256. Each test was conducted thrice and the average approvals were taken for calculation. The test is completed in Izod setup, the specimen must be stacked in testing machine and permits the pendulum until the point that it cracks. Utilizing the impact test, the energy required to break the material can be measured certainly. It would be in Joules.

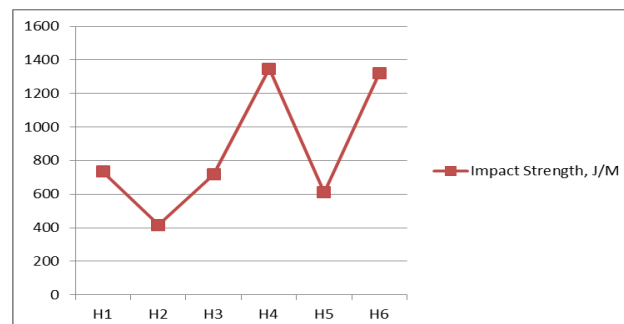
**Table 3.** Impact Strength Test Results

Name of the Sample	Energy, J	Impact strength J/M
<b>H1</b>	<b>2.1000</b>	<b>734.2000</b>
<b>H2</b>	<b>1.2000</b>	<b>416.0500</b>
<b>H3</b>	<b>2.2500</b>	<b>718.7000</b>
<b>H4</b>	<b>4.3500</b>	<b>1348.0500</b>
<b>H5</b>	<b>1.7000</b>	<b>611.5000</b>
<b>H6</b>	<b>3.8000</b>	<b>1320.55</b>

From the above table outcomes are demonstrated that, the arrangement of H4 hybrid composite has high impact strength. The reason for such high strength is because of good holding power amongst matrix and fibres and adaptability of the interface atomic chain following in keeps and throws the more energy, and keeps the breaks initiator proficiently. The energy consumed by every specimen when it is affected by a substantial blow from pendulum break is formed. The break for the most part moves through the fiber and resin of the composite. So once split spreads through the composite preservation of energy will be high. The graphical representation is appeared in the fig 5 and fig 6.

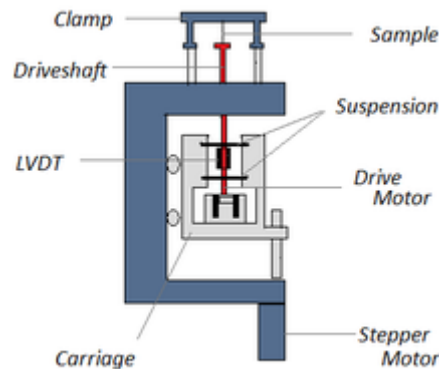


**Figure 5.** Variances in Energy



**Figure 6.** Variances in Impact Strength

### 4.3 Dynamic Mechanical Analysis Test:



**Figure 7 .**General schematic of a DMA instrument

DMA was carried out as per the standard ASTM D4065-01 using test setup DMA Q800 V 20.6 (TA Instruments, USA)[9]. From every material, three specimens were arranged. The DMA test was directed for all specimens and values were recorded and exposed.

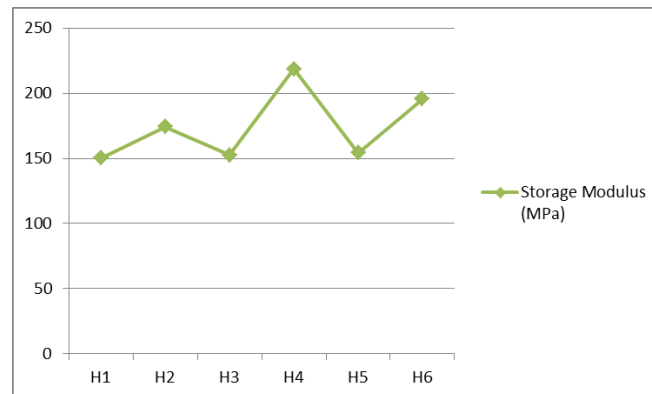
**Table 4.**Dynamic Mechanical Analysis Test Results

Name of the Sample	Time (min)	Storage Modulus (MPa)	Loss Modulus (MPa)	Tan Delta	Glass Transition Temperature (°C)
H1	14.759	150.2246	10.35581	0.068935	165.9137
H2	14.759	174.0953	14.24817	0.081841	164.8206
H3	14.759	152.3701	14.07045	0.092344	167.9671
H4	14.759	218.4205	19.90262	0.091121	169.5222
H5	14.759	154.2527	15.51041	0.110812	167.9671
H6	14.759	195.6065	14.06294	0.089862	164.8206

DMA is a procedure, which is utilized to consider the stress, temperature, and frequency of the material, when it is subjected to little deformation by sinusoidal load. In polymers, the DMA is delicate strategy to gauge the fine changes. The description of the dynamic mechanical properties such as storage modulus, loss modulus, and  $\tan \delta$  with the response of temperature of the specimens were described.

#### 4.3.1 Storage Modulus:

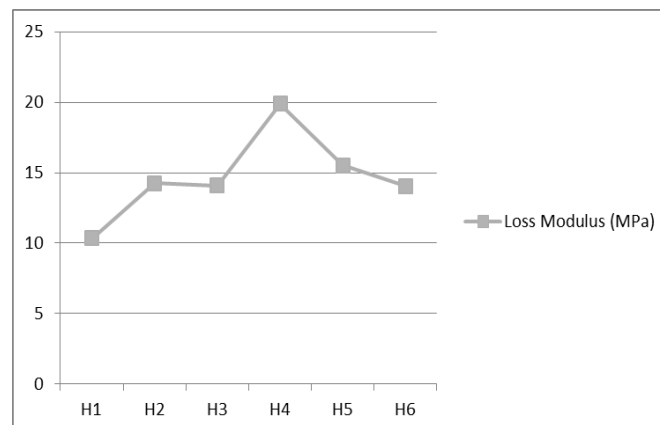
It speaks to the stiffness of a viscoelastic material and is relative to the energy consuming in the midst of loading cycle [10]. H4 hybrid laminate having more value and H1 hybrid laminate having the lesser value in storage modulus. The graphical illustration is also shown in the fig 8.



**Figure 8.** Variances in Storage Modulus

#### 4.3.2 Loss Modulus:

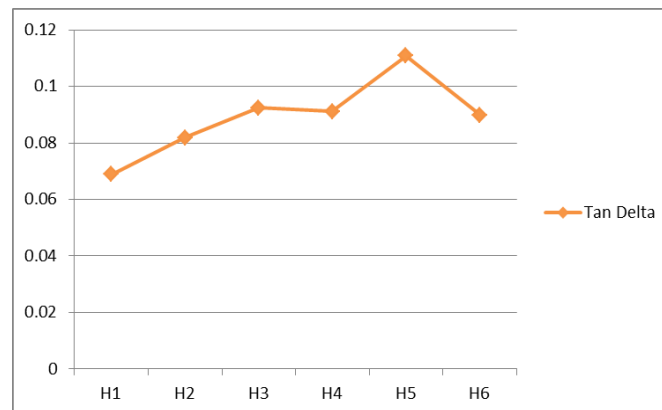
It's defined as being proportionate to the energy dissipated for the period of one loading cycle. H4 hybrid laminate having more value and H1 hybrid laminate having the lesser value. The genuine piece of the modulus might be utilized for surveying the flexible properties, and the fictional part for the viscous properties. The graphical outline is likewise appeared in the fig 9.



**Figure 9.** Variances in Loss Modulus

#### 4.3.3 Tan Delta:

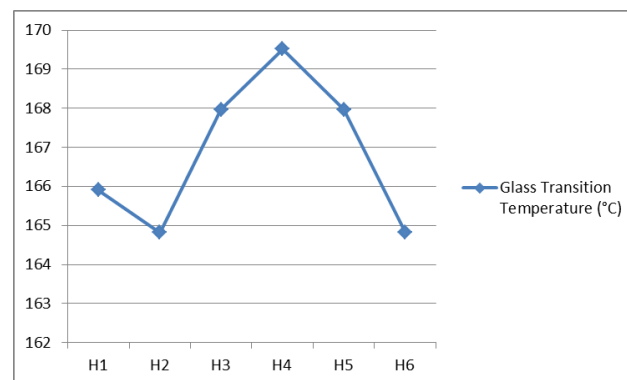
The loss factor  $\tan \delta$  is the proportion of loss modulus to storage modulus. It is a measure of the energy lost, and speaks to mechanical damping or internal friction in a viscoelastic structure. The  $\tan \delta$  is communicated as a dimensionless number. H5 hybrid fibre indicates higher esteem and H1 hybrid fibre demonstrates lesser esteem. A high  $\tan \delta$  esteem is characteristic of a material that has a high, nonelastic strain segment, while a low esteem demonstrates one that is more versatile. The graphical outline is additionally appeared in the fig 10.



**Figure 10.** Variances in Tan Delta

#### 4.3.4 Glass Transition Temperature

It is the most enormous properties in a polymer and specifically related to the mechanical properties. Tg is defined as the temperature at which the mechanical properties of a reinforce basically changed because of the internal movement of the polymer chains that shape the adhesive. The Tg is otherwise called the working temperature and the information of its esteem is essential in the design stage. In this work minimum change has been occurred in Tg so H4 hybrid laminate has highest value among other hybrid laminates. The graphical illustration is also shown in the fig 11.



**Figure 11.** Variances in Temperature

## 5. Conclusion

In view of the examination of experimental outcomes and discoveries, the subsequent conclusions can be drawn: This work demonstrates that effective construction of a multi layer of hybrid composite (utilizing vinylester as lattice, carbonfiber, glass fiber, kevlar fiber as support material) was fabricated by hand lay-up technique and Laminates were prepared by using twelve layers of fibres. Static and dynamic mechanical behavior was done on hybrid composites. H4 Hybrid fibre was higher impact strengths than other hybrid fibre except for inter laminar shear strength. H1 hybrid fibre shows more value on ILSS than other hybrid fibres. Storage modulus, loss modulus and Tg of hybrid fibre H4 is greater than other hybrid fibres.

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