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An Experimental Analysis on the Impact of the Epoxy on the Torsional Behavior of Composite Fiber-Glass

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ABSTRACT

The value of the torsion test is of particular interest to this line of investigation, which intends to explore the effects of epoxy % on fiberglass (a composite material). The practical result demonstrates that an increase in the percentage of epoxy has a clear impact; it was noticed that an increase in the percentage of fiber-glass results in an increase in the values of torque (T) and angle (Ɵ). Three samples of epoxy and fiber are ascribed, with rates of -(Epoxy) +(Fiber Glass) being (0.5%,1%,1.5%), and three samples of polyester and fiber are credited, with rates of -(polyester) +(Fiberglass) being (0.5%,1%,1.5%). Additionally, three samples of epoxy and fiber are attributed, with rates of -(Epoxy) +(Fiberglass) being (0.5%,1%,1.5%). We get the best results for the torsion test with the first specimen (0.5% fiberglass for polyester) and the best results for the shear strain with the fourth specimen (0.5% fiberglass for epoxy). Both of these results are 120 MPa for the torsion test and 2.2 for the shear strain.

1. Introduction

In order to take use of the material's one-of-a-kind mechanical and physical properties, such as its high specific stiffness and high specific strength, fiber-reinforced plastic was used extensively in the production of structural parts for airplanes [1]. Another significant usage for fiber-reinforced polymeric composites, in particular the glass-fiber-reinforced plastic, may be found in the electronics sector, where these materials are utilized in the production of printed circuit boards [2]. The matrix is continuous and surrounds the other phase, which is typically referred to as the reinforcing phase. Composite materials are composed of two phases: the matrix and the reinforcing phase. Epoxy resins are a type of thermoset material that are of particular interest to structural engineers owing to the fact that they offer a unique mix of mechanical and chemical properties combined with a wide variety of processing options [3]. This makes epoxy resins one of the most versatile types of materials available. Epoxy resins are used extensively as the matrix in a variety of fiber-reinforced composites, which are abbreviated as FRCs [4]. Because of the specific strength of its components, glass fiber is

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the type of reinforcing material that is most frequently used in the building of structural elements. The situation in which the Fiber is parallel to the direction of the tensile force, at a 45-degree angle, and less than discontinuous type strength results in the highest level of strength being achieved by the Fiber. The number of laminates that are produced has a significant bearing on the material's level of hardness. In the end, the strength is reduced whenever there is an increase in the fiber volume fraction, unless the composite material content is greater than thirty percent. Aluminum (no. 2) [5,6].

The influence of the Net (AN) on Fiber Reinforced Polymer (FRP). This material is considered to be a hybrid composite material because of its composition. On a total of four distinct types of specimens, both an impact test and a tensile test have been carried out. The samples are built of AN/FG FRCs with various volume percentages of acrylonitrile butadiene styrene (AN) and fiber glass (FG) [7,8]. Specimen 1 has one layer of AN and eight layers of FG, Specimen 2 has two layers of AN and seven levels of FG, Specimen 3 has three layers of AN and six layers of FG, and Specimen 4 has four layers of AN and five layers of FG. Both an impact test and a tensile test have been carried out, and while the composite with 3 and 4 AN layers has a lower level of toughness and strength, the composite with only 1 and 2 AN layers has a higher level of toughness and strength. Although the presence of AN in FRP demonstrates significant improvement in mechanical properties compared to polypropylene/fiber glass, fiber glass, and carbon/fiber glass reinforced composite, the toughness and strength of the composite decreased as the number of AN layers grew. This hybrid composite class has the potential to be exploited in the industry, notably for the components of automobiles like the vehicle bumpers [9]

Although the low elongation fiber of Woven Kenaf improves the composite modulus more in the laminate direction, the high elongation fiber of (PET) polyethylene tereph thalate plays a more significant role in increasing the strength of hybrid composites [10]. Additionally, hybrid composite laminates consisting of six different layers have been investigated. In the stacking process, symmetric angle ply with a thickness of 12 millimeters all the way through was utilized. The thermal expansion coefficient of the laminate increases significantly more than that of the individual plies. The overall analytical findings demonstrate that the tensile properties of hybrid composite have substantially improved over those of the single FRC. This improvement can be seen when comparing the two types of composites [11]. For a composite material constructed of Araldite resin and chopped glass fibers with a density of (2.6 g/cm3), evaluate the effects of increasing the fraction of fiber reinforcement on mechanical characteristics (tensile, impact, and compressive strength) [12]. This will be done using a composite material that has a density of (2.6 g/cm3). The needs of the operation and/or the environment in which the activity is carried out are often the driving force behind the utilization of composite materials in industrial settings. FRCs are commonly used in the structural components of rockets, aircraft, and automobiles due to the benefits they provide, which include being lower in weight while possessing better levels of stiffness and strength. Since the introduction of composite materials, such as fiberglass reinforced thermoset polymers, into pipe systems more than four decades have passed [13].

Impact resistant materials continue to be a concern for makers of all different kinds of equipment, including both civilian and military products. At the moment, traditional composites and metals are often used in applications that need impact resistance. When metals possess high strengths and are capable of substantial plastic deformation prior to fracture, people refer to these metals as being tough or impact resistant. Particles made of rubber or another type of elastomer are typically included in the polymer resins that are used in the production of composites [14-16]. For the purpose of improving the damping behavior of carbon fiber reinforced epoxy composites, a multi-scaled technique that makes use of flax fibers and carbon nanotubes (CNTs) has been presented [17,18].

In order to evaluate the influence of grammage layer on CFRP damping and mechanical characteristics [19], three laminate configurations were created utilizing rubbery nonwoven layers with varying thicknesses (5, 10, and 20 m)[20,21].

Epoxy resin, glass fiber reinforcement, and various filler components including ZnS and TiO2 were used to create the unique polymer composites that were the subject of the current study. Additionally, the mechanical properties of these composites were investigated. The freshly manufactured composite material stands out due to the distinctive mechanical properties it possesses. Experiments such as three-point bending, tensile test, and impact test have been undertaken out in order to determine what constitutes the Significant.

In this study, an experimental analysis on the impact of the epoxy on the torsional behavior of composite Fiber- Glass has been conducted accordingly.

2. Methodology

The use of composite materials in industry is typically based on the requirements of the operation and/or the environment where the activity is conducted. Because of their advantages in lighter weight with higher stiffness and strength characteristics, FRCs are frequently utilized in rockets, airplanes, and automobile structures. In plumbing systems, composite materials like fiberglass-reinforced thermoset plastics were utilized [22,23]. Three samples of polyester with fiber are Attributed with different rates: (polyester) + (Fiber-Glass) are (0.5%,1%,1.5%). Moreover, three samples of epoxy and Fiber are Attributed. With these rates:

(Epoxy) +(Fiber Glass) are (0.5%,1%,1.5%). As shown in Figures 7 and 8: six samples are used for this work, and the following steps are followed:

i. Weigh polyester,9.0420225 gm, and Weigh epoxy, 9.891 gm.
ii. Add (0.5%,1%, and 1.5%) of the random fiberglass for each Polyester and Epoxy.
iii. Mix the polyester with the random fiberglass and mix Epoxy with the random fiberglass.
iv. Add a hardener to the mixture in 0.5 to polyester and a hardener to the mixture in 1/3 to epoxy.
v. For 24 hours, the product is maintained in the mold to produce the following sample
vi. Verify the product by torsion test.

3. Results

After creating the sample according to standard specification torsion test was conducted on the sample, and the result was:

(Polyester +(Fiber _Glass)) with rates (0.5%,1%,1.5%)

$V_{cylinde} = \pi h r^2$ (1)
$V = \pi\ (10.5\ cm)\ (0.5\ cm)^2$
$= 8.2425\ cm^3$

Weight = V*P (2)
=8.2425 *1.097
=2.0420225 g

The amount of hardener that is added to sample (1), sample (2), and sample (3):

9.0420225*0.5 % = 4.52101125

The amount of the fiberglass that is an addition to the sample (2):

9.0420225*1% =0.090420225

The amount of the fiberglass that is an addition to the sample (3):

9.0420225 *1.5%=0.1336303375

((Epoxy) +(Fiber-Glass)) with rates (0.5%,1%,1.5%) with apply Eq. (1) above, the Volume of cylinder will be:

$V = \pi(10.5)(0.5)^2$
$= 8.2425 \text{ cm}^3$

Moreover, applying Eq. (2) above the weight will be:

W = 8.2425*1.2
= 9.891 g

The amount of hardener that is added to the sample (1):

9.891*1/3=3.298 g

The amount of Fiber - Glass that is an addition to the sample (1):

9.891*0.5%=0.049455 g

The amount of Fiber- Glass that is an addition to the sample (2):

9.891*1%=0.09891 g

The amount of Fiber-Glass that is an addition to the sample (3):

9.891*1.5%=0.148365 g

To find the relationship between the torque and angle of twist of solid and hollow shafts subjected to a torsion load. Compute shear stress and shear strain for every one of the increments. Tabulate the values of strain and stress. Draw the relationship between the torque and angle (T) and (Ɵ). Draw the relationship between the shear stress and strain (ɼ) and (Y) where Rod Diameter in millimeter (mm), Mass (kg), Torque (Nm), Angle of twist in radians = Ɵº/180

With the use of a vertical axis for shear stress and a horizontal axis for shear strain. Plot stress-strain diagram. Specify shear modulus (G) from straight line's slope. Compare result with the published value of the shear modulus (Figure 1 and Figure 2).

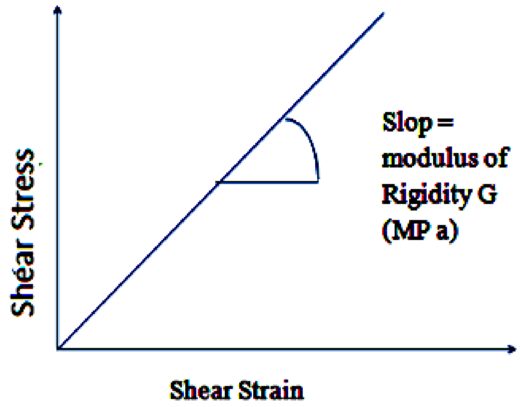

Fig. 1. Relationship between shear stress and shear strain for solid shafts

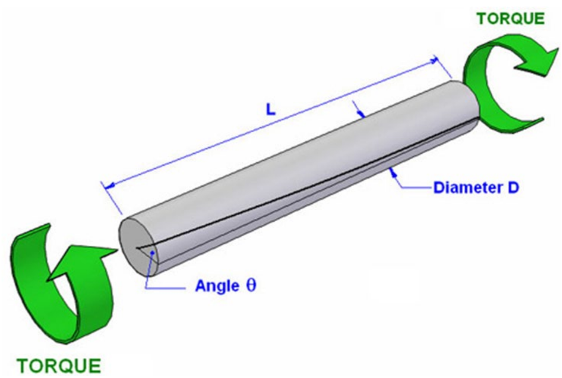

Fig. 2. The L, Ө and D

Where:
Shear Stress (Mpa)=ϒ
The angle of twist (radians)=Ө
L= Length of the Gauge (mm)
G= Shear Modulus (Mpa)
r= Radius (mm)
J= Polar Moment of Inertial (mm^4)
T= Torque (N.m)

The curve depicts the applied force, position, shear stress, and strain. The Torsion is almost linearly varied concerning Shear Strain, unit the Shear Stress maximum value, 120 Mpa, and shear strain maximum value of 3.32. Take notice that the relationship between Shear Strain and Shear Stress is proportion. So that every time Shear Strain is increased, Shear stress increases accordingly, as shown in Figure 3.

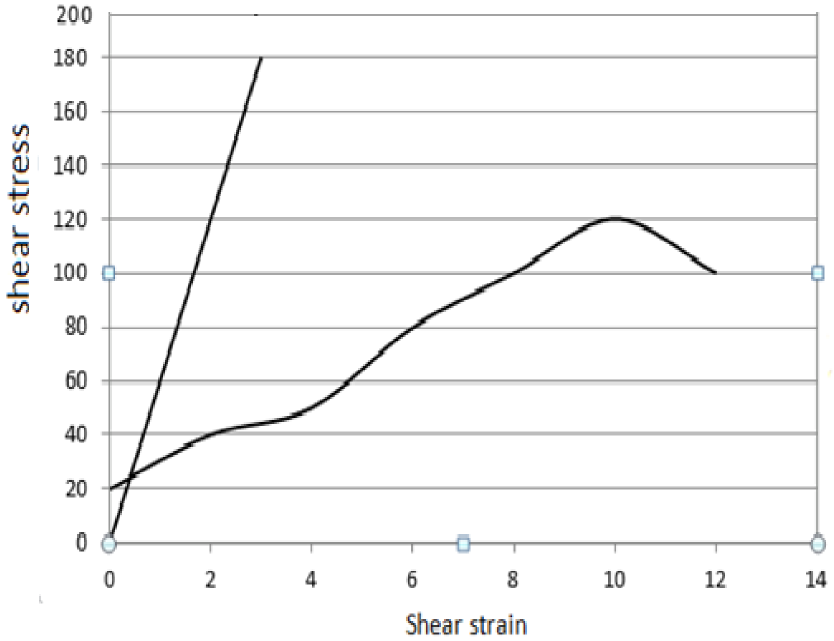

Fig. 3. Relationship between Shear Stress and Shear Strain.

The curve provides a visual representation of the applied force as well as the location, shear strain, and shear stress. In relation to the shear strain unit, the Torsion almost always varies in a linear fashion. It is important to take note that the proportional relationship between shear stress and shear strain should be considered. The highest possible value for shear stress is 160 MPa, while the highest possible value for shear strain is 2.93. As a result, whenever there is a rise in the shear strain, there is a corresponding increase in the shear stress, as can be seen in Figure 4.

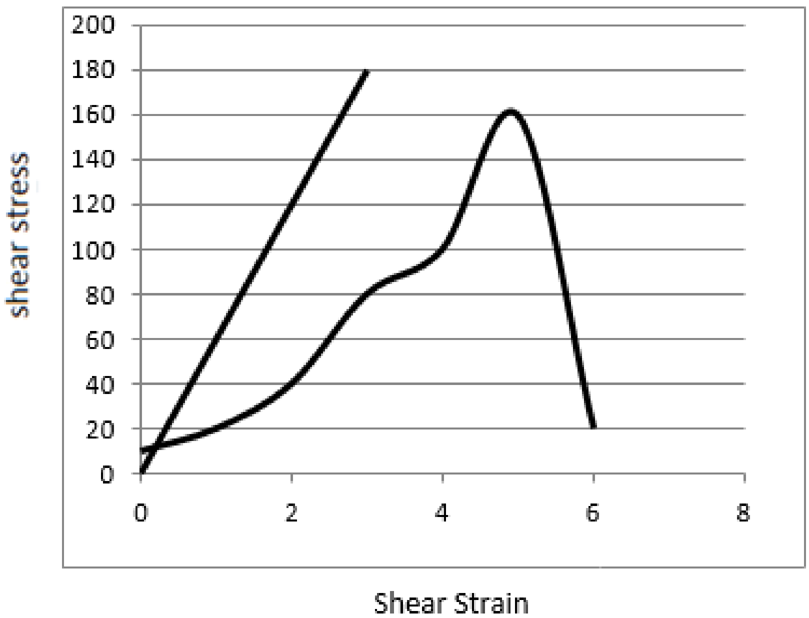

Fig. 4. Relationship between Shear Stress and Shear Strain

The graph illustrates the amount of force that was applied to sample (3), as well as its location, shear strain, and stress. The variation in torsion with respect to shear strain is practically linear, with the greatest value of shear stress coming in at 210 MPa and the maximum value of shear strain coming in at 2.98. It is important to take note that the proportional relationship between shear stress and shear strain should be considered. As a result, the shear stress will continue to rise proportionally whenever the shear strain is raised, as seen in Figure 5.

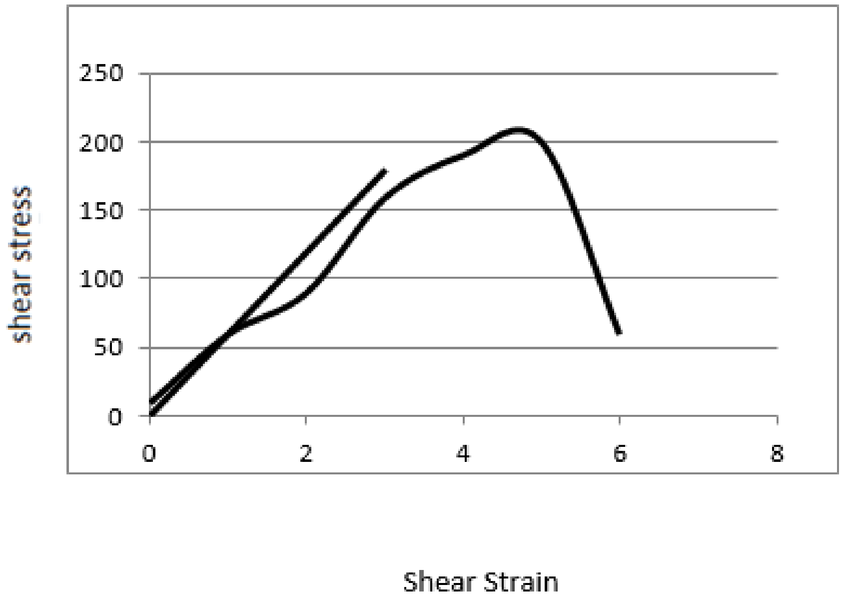

Fig. 5. Relationship between Shear Stress and Shear Strain

Regarding Example (4). The curve illustrates the amount of force that was applied in addition to the position, shear strain, and stress. The Torsion is virtually linearly modulated with regard to the Shear Strain, with the greatest value of the Shear Stress coming in at 158 MPa and the maximum value of the Shear Strain coming in at 2.2. It is important to take note that the proportional relationship between shear stress and shear strain should be considered. As a result, the shear stress will increase proportionally each time the shear strain is raised, as seen in Figure 6.

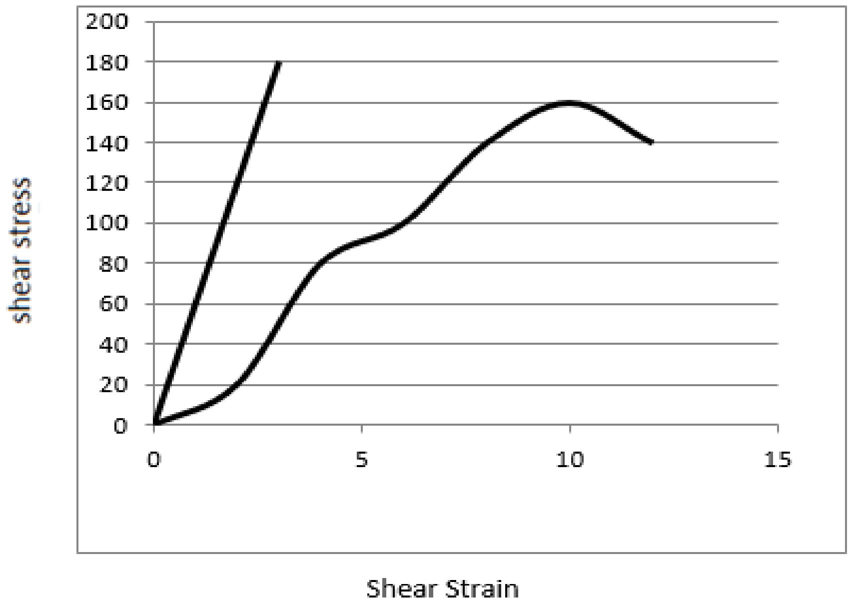

Fig. 6. Relationship between Shear Stress and Shear Strain

For sample (5), the curve depicts the amount of applied force, position, shear strain, and stress. The Torsion is almost linearly varied concerning Shear Strain, unit the Shear Stress maximum value, 148 Mpa, and shear strain maximum value 2.34. Take notice that the correlation between Shear Stress and Shear Strain is proportion. So that every time Shear Strain is increased, Shear stress increases accordingly, as shown in Figure 7.

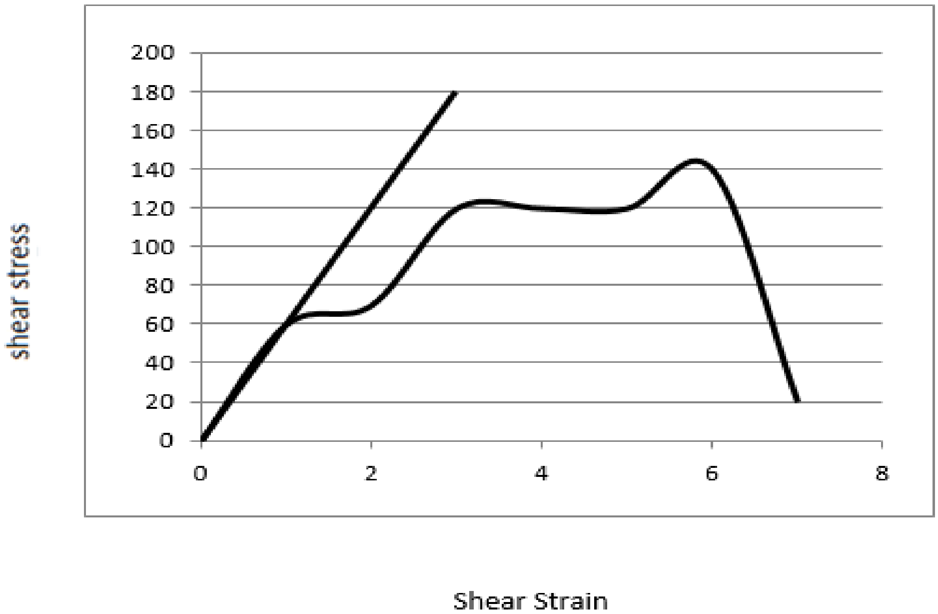

Fig. 7. Relationship between Shear Stress and Shear Strain

For sample (6), the curve depicts the amount of applied force, position, shear strain, and shear stress. The Torsion is almost linearly varied concerning Shear Strain, unit the Shear Stress maximum value, 170 Mpa, and shear strain maximum value of 3.34, the correlation between the Shear Stress and Shear Strain is proportion. So that every time Shear Strain is increased, Shear stress increase accordingly, as shown in Figure 8.

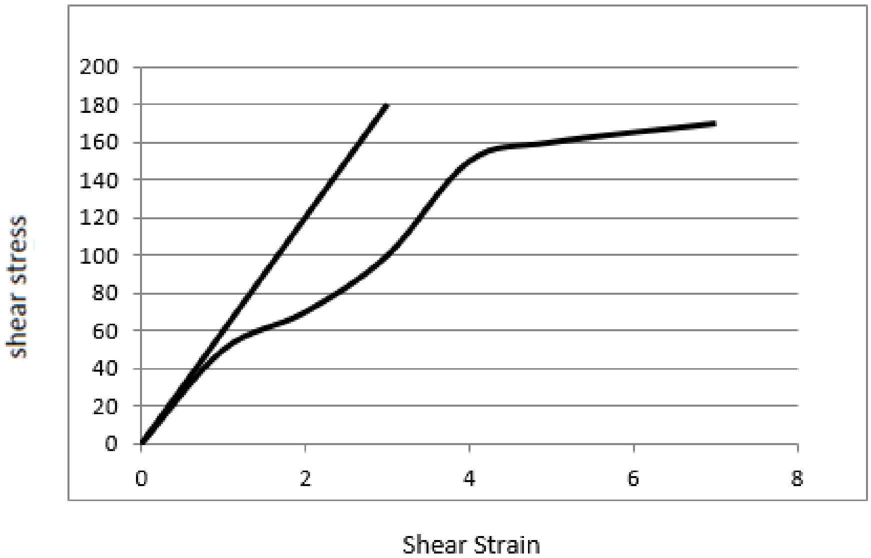

Fig. 8. Relationship between Shear Stress and Shear Strain

Figure 9 show the mold for three sample of polyester and fiber glass while Figure 10 show the Torsion Test Device.

Fig. 9. Mold for three sample of polyester and fiber glass

Fig. 10. Torsion Test Device

4. Conclusions

In conclusion, the investigation of the effects of epoxy percentage on the Fiberglass (Composite Material), especially the value of the Torsion Test has been performed. The practical result shows the evident influence of increasing Epoxy Percentage; it was observed that the increase in Fiber –glass% increases the Values of Torque (T) and Angle(Θ). From the result, we obtain the best torsion test, 120 MPa for the first specimen (0.5% fiberglass for polyester). The best shear stress is 210 MPa for the third specimen (1.5% fiberglass for polyester). For the fourth specimen (0.5% fiberglass for epoxy),it was found that the shear strain equal 2.2 and it was the best strain.

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