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The Effect of Inter Laminate Layer on Flexural Strength for Unsaturated Polyester Resin Reinforced Hybrid Fabric Composite

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ABSTRACT

The present study aims to examine the effects quality, sequence and direction of the layers for three types of fibers: orthogonal glass fibers, randomized glass fibers, short carbon fiber cut on the bending test using a bonding material, unsaturated polyester. The manual modulation method was used to manufacture a composite material of unsaturated polystyrene and three layers of glass fibers with 25% volume fracture a compound material of unsaturated polystyrene supported by chopped carbon fiber and fractions of 10% volume, and the manufacture of the hybrids with (glass - regular glass - random glass) and layers (regular glass - random glass - regular glass) and layers (regular glass - carbon 5% - regular glass). The results showed that the fiber orientation played an important role in determining the mechanical behavior of the composite materials. The values of the ionic coefficient increased by increasing the number of orthogonal layers of glass compared to random samples. The flexural stress for epoxy reinforcement by different kind hybrid composite according to the results, the mechanical behavior between the glass and hybrid composites may be due to the differences in the mode of load transfer at the fiber - matrix interface and, consequently, in the interfacial bond strength and who fiber can be interlaminating layers of composite.

Keywords: Hybrid Composite, Unsaturated Polyester, Glass Fiber, Carbon chopped Fiber, Flexural strength.

1. INTRODUCTION

Composite materials are a combination of two or more substances, each of which has a significantly different physical or chemical properties than the other, the purpose is to form materials with new characteristics that differ from those of each original material to achieve a coherent structure resulting from the homogeneity of two different materials in terms of composition, fragmented, particles and fibres material science, the combination of an organic phase (generally polymers) [1,2]. The mixing phase is what gives coherence between the components to form a strong composite system [3,4]. Polymers are commonly used because they have basic mechanical properties and fibres processing is dependent on the properties of the materials including viscosity, melting temperature and processing time, which mainly consist of resins [5,6]. The classification of polymers: there are many possible classifications of polymers. One is according to the general types of polymerization processes used to produce them. Two other useful classifications are the following [6-8]: classification based on structure: linear, branched and network polymers. Figure 1 shows these types of polymer schematically.

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It should be noted that the real structures are three-dimensional, which is particularly important for networks. The chemical structures of the repeat units of some common polymers are shown in figure 6,7. Classifications based on properties: thermoplastics, rubbers (elastomers) and thermosets. "Polymer-Matrix Composites" (PMCs) contain of a polymer resin as the matrix, with fibres as the reinforcement middle.

These materials are applied in the highest variety of composite applications, as well as in the biggest quantities, in light of their room-temperature properties, comfort of fabrication, and cost. The most extensively used and least exclusive polymer resins are the polyesters and epoxy, these matrix materials are used primarily for glass fibres–reinforced composites. A large number of resin formulations provide a wide range of properties for these polymers. The epoxies are more expensive and, in addition to commercial applications, are also used lengthily in PMCs for aerospace applications. They have better mechanical properties and resistance to moisture compared by metal. The surface characteristics of glass fibres are extremely important because even minute surface flaws can deleteriously affect the mechanical properties. Surface flaws are easily introduced by rubbing or abrading the surface with another hard material. Also, glass surfaces that have been exposed to the normal atmosphere for even short time periods generally have a weakened surface layer that interferes with bonding to the matrix.

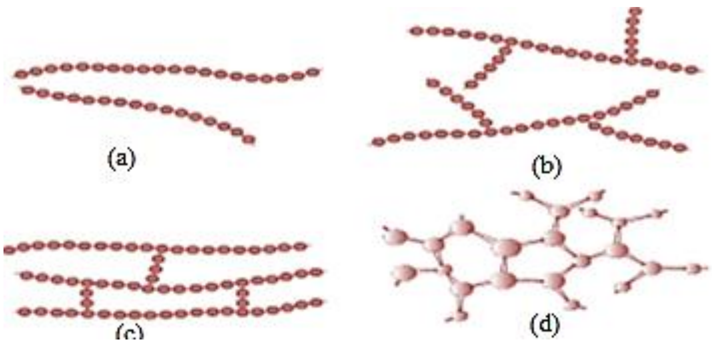


Figure 1. Graph representations of (a) linear, (b) branched, (c) cross-linked, and (d) network (3-dimensional) molecular structures. Circles designate individual repeated units [7].

2. EXPERIMENTAL METHOD

2.1 Materials

The matrix in composite materials is the type of unsaturated polyester resins (A-50) (UPE). hardener MEKP with accelerator cobalt naphthenate supplied by IPI Jordan were used. Typical characteristics of unsaturated polyester resin are shown in Table 1 [6]:

$$Vm= \frac{vm}{vc}\% \quad (1)$$

where: V_m is volume fraction of matrix.
V_c is volume fraction of composite.
Reinforcing material: E- Glass fibres: Uniform(GW), random (GR) and carbon chopped fibres were illustrated in Figure 1. Volume fraction of fiber calculated according to:

$$V_f= \frac{vf}{vc}\% \quad (2)$$

Table 1 Typical properties of unsaturated polyester resins (UPE)

Property	Density (gm/cm3)	Tensile strength (MPa)	Tensile modulus (GPa)	Flexural strength (MPa)	Modulus flexural (MPa)
Unsaturated Polyester (UPE)	1.05-1.4	45-90	2-4.5	110	4200

(A) Glass fiber (B) Carbon chopped fiber

Figure 2. The fibers used in this work.

2.2 Sample Preparation

The samples were prepared from unsaturated polyester as a matrix and (E-glass, carbon chopped) fibres as a reinforcement with fibres weight percentage (wt.%) were illustrated in figure 3, by using hand lay-up. The mould stage of glass plates for casting the composite sheets, were prepared from cleaned waxed glass plates of dimensions 10 × 10 cm^2. The wax was applied to prevent the adhesion of composite sheets with glass plates. Fibre sheets were cut from woven roving with orientations (0-90). Thin layer of unsaturated polyester resin as a matrix was distributed on the dried plate using a paint brush. Sheet of fibres were stick on the distributed matrix and some of resin was added again to the upper surface of the glass sheet. By using aluminium notched roller, the sheets were pressed to drive away the voids of air from the composites. The composite sheets were stored at room temperature for 72 hours, and then were post-cured for 4 hours in an oven at 50ºC to get mould sheets. The sheets of neat unsaturated polyester and their composites were cut to a certain dimensions specimens according to Three-point Bending tests was used to study the flexural of the specimens and it was carried out by using Instron universal testing machine of (5 Kn) full scale load capacity according to ASTM standard (D-790) Flexural strength of the composites was calculated according to:

$$\sigma \text{ max}=\frac{3FS}{2bd^2} \quad (3)$$

Where F: is the applied central load (N), L: support span, b and d: width and thickness of the specimen (mm). Elasticity modulus was calculated according to:

$$E=\frac{m\,L^3}{4bd^3} \quad (4)$$

Where m is the slope of the tangent to the initial straight line portion of the force deflection curve. The maximum tensile strain was calculated according to

$$\varepsilon=\frac{6Dd}{L^2} \quad (5)$$

D is the deflection beam at a given point on the load –deflection data.

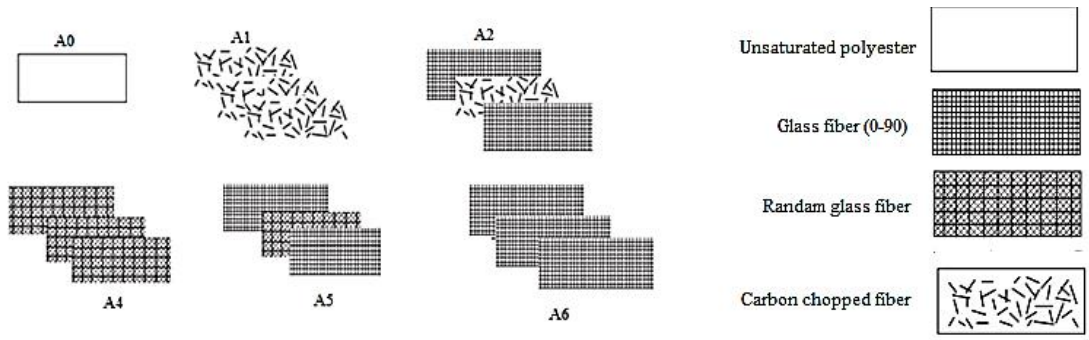


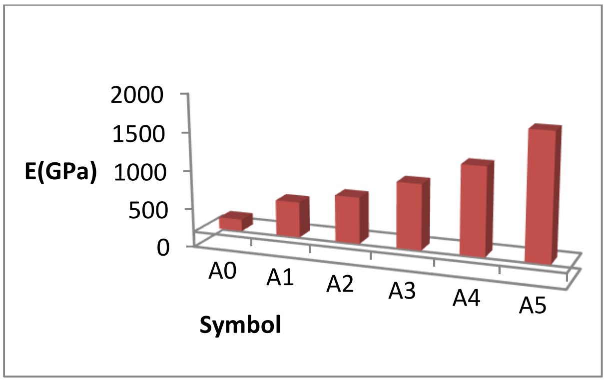
Figure 3. Types of samples prepared.

3. RESULT AND DISCUSSION

Bending stresses are important in structure tests because of variety of loading situations in service. It determines the behavior and properties of the structure. Many factors should be worried test facts." Polymeric Composites" are vulnerable to mechanical damages when they are subjected to efforts of tension, flexural, compression which can lead to material failure [6]. The mechanical properties of the materials are affected by many factors including: fiber type, volume fraction, direction of the fiber, specimen thickness. Resins are fragile materials and their resistance to flexural strength is very low. Therefore, flexural strength is increased by increasing the added weight ratios because it occupies more space inside the resin, allowing better distribution of the load. The main purpose of the bending test is to determine the linear behaviour of the materials under the impact of vertical load installed at the surface level. The deviation is directly proportional to the updated load when disposing of the bearing effect of the material to recover the first case, and concludes that the substance is subject to law (Hook Act) [8]. The results shown in table 2 and the figure below show an increase in elasticity coefficient when carbon fiber reinforcement for unsaturated polyester resin is increased and reinforced with two different fibers (carbon fibers and glass fibers). Whether glass fiber is random or otherwise, the increase is apparent in the elastic coefficient when reinforced with two layers of fiber in different directions or three layers. Figure 4 the bending test was found to be caused by two types of stress, the first face (front) and the back tension (back) [10]. Fragile materials are known to contain a small non-existent plastic deformation area. The elasticity coefficient values are increased with the increase in the ratio of the reinforced material due to the increase in bonding density, which greatly affect the elasticity of the chains, so that the material becomes solid at low voltage rates, increasing the elasticity coefficient. As for the hardness properties of the mixtures, it is possible to say that resins are considered to be low hardness materials, but when adding fibres to them, the hardness properties of composite materials will improve clearly [15]. The results also showed an increase in resistance values to arm bending movement more than one layer in different types [9], both random and regular, and in different directions. Figure 4 shows modulus flexural is increased by increasing the added weight percentage as it occupies more space inside the resin allowing better distribution of the load. The increase in the ratio of additives increases the hardness of the material due to the generation of the pores resulting from the increase in the ratio, which in turn weakens the properties of the material hardness [11]. A decrease in the ratio of basic materials means a weakness in the strength of cohesion. The overall shock resistance of resins is reduced because of its fragility, however after mixing, it increases because the mixing materials will carry the bulk of the collision energy on the composite material and thus improve the resistance. The composite is reinforced with random fibres, the load is concentrated at the end of short fibres and the alignment of fibres is randomly distributed in the matrix which makes the control of transmission of the load from the matrix to the fibres through the interface region weak [12]. The failure of the non-reinforced resin material either results in the breakdown of the bonds or forces the polymer by the growth of the initial cracks created under the pressure of the shock. These cracks grow rapidly towards the interfaces between polymer chains because the forces between these polymer chains are the forces of Vander (Waal - Vander), which require a small amount of energy to overcome them, and the cracks are stretched in a direction perpendicular to the direction of polymer chains, which leads to break these chains during the process of proliferation. It is worth mentioning that this requires more energy to overcome the covalent bond [13]. When the resin is reinforced with carbon fibres as an intermediate layer of glass fibres, or a hybrid, the diffusion mechanism is different from the previous one. The presence of fibres inside the resin inhibits spreading of the cracks While the samples gave different behaviour in terms of deformation characteristic, the sample of unsaturated polystyrene gave the least distortion value, and the presence of fibres of all types and their multiple layers and directions gave high flexibility and thus increased resistance to deformation of the samples armed with fibres [14].

Table 2 Flexural strength, deflection at max stress and young modulus of all samples

Type of specimen	Specimen	Modulus flexural (GPa) (E)	Flexural strength (MPa) (F.S)	Deflection at Max. Stress(mm)
Unsaturated Polyester (UPE)	A0	352	1522	0.4
Carbon fiber at(10%wt) /UPE	A1	658	6181	4.2
(Glass fiber(0-90) carbon 5% wt-glass fiber(0-90))at 25% wt /UPE	A2	798	4998	15.8
(3Layers glass random) 25%wt /UPE	A3	1044	5574	20
(Glass(0-90)-glass random-glass(0-90)) at 25%wt /UPE	A4	1333	4398	19.7
(3Layeres glass (0-90)) at 25%wt/UPE	A5	1822.5	8580	18.8



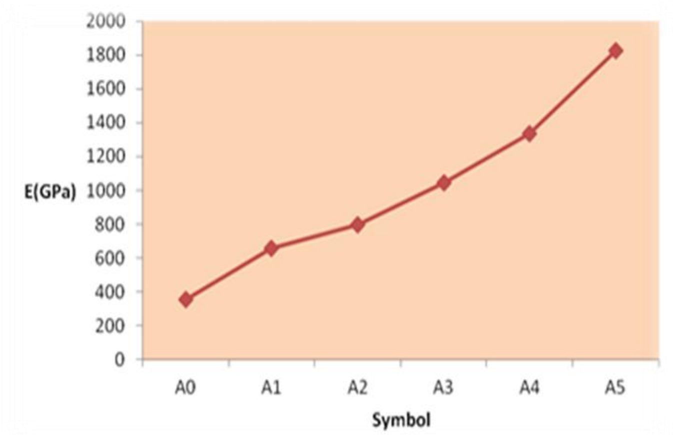


Figure 4. Effect of Modules of elasticity by number of layers, direction and type of fiber (orthogonal glass, random glass, and short carbon fibers).

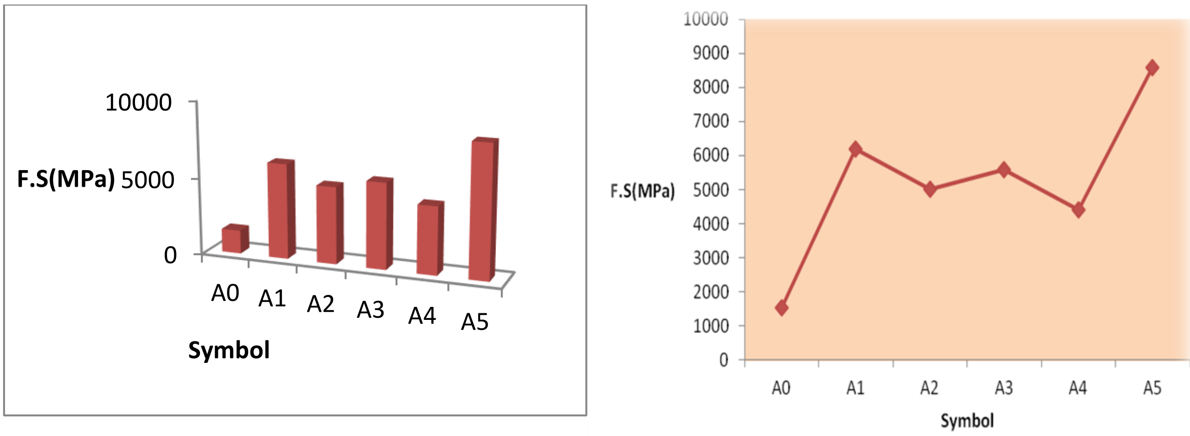


Figure 5. Effect of Flexural Strength by number of layers, direction and type of fiber (orthogonal glass, random glass, and short carbon fibers).

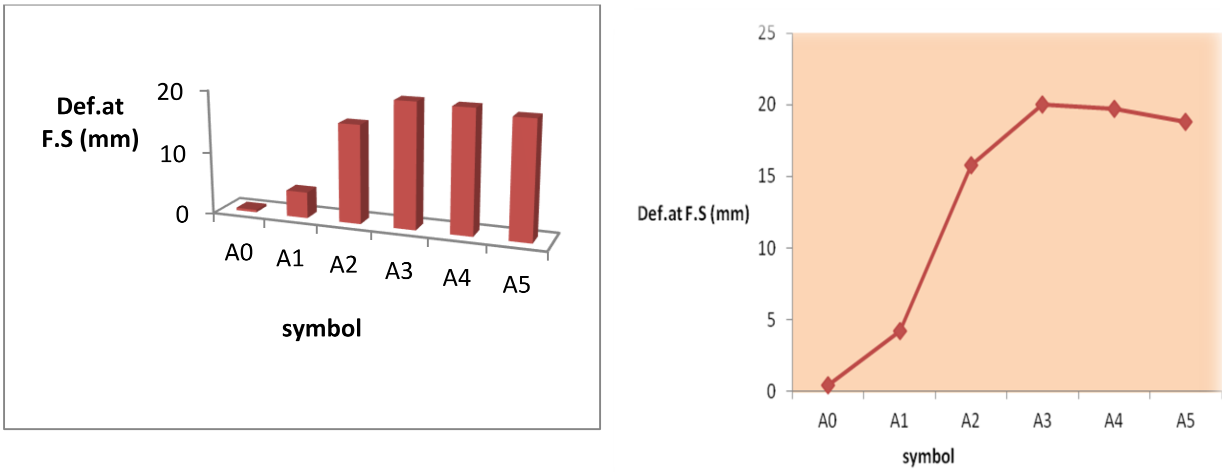


Figure 6. Effect of Deformation by number of layers, direction and type of fiber (orthogonal glass, random glass, and short carbon fibers).

4. CONCLUSIONS

Fiber reinforcement of composite material confirms its positive effect in improving the resistance to flexion. Glass-reinforced samples have more curvature and elasticity than those supported by short and cut carbon fibres. Sandwich samples have intermediate values of bending resistance and elasticity coefficients between samples supported by glass fibres and carbon. The regularity and direction of fibres (0-90) gives the best resistance to folds random guidance. The hybrid sample gave good behavior due to the different stress distribution.

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