Study of the effect of fiber orientation on the flexural strength of epoxy-coated glass fiber-reinforced composite materials

Hisham M. Ali *   Abdurahman R. Mohammed

Department of Physics – College of Education University of Qadisiya.

*houshammah@gmail.com

Abstract:

In this paper, a composite material was prepared with layers of glass fiber. Six layers were arranged with unidirectional angles $[0^0]_{6,}$ $[45^0]_6$, $[90^0]_6$ In addition angles with tilted layers, any symmetrical and symmetrical laminate$[\,90^0\,, 45^0\,, 0^0\,]_s$ $In\ addition$ three layers are $[\,90^0\,, 45^0\,, 0^0\,]$, $[90^0]_3$, $[45^0]_3$, $[0^0]_3$.

In Hand Lay-up¸the composite material consists of epoxy resin as a base material and layers of fiberglass as a reinforced material with weight fracture of 25% and 12%.respectivty The research was carried out in two stages: First, the synthesis of the composite material of the samples were then processed at different temperatures $(25^0\,, 50^0\,, 100^0\,, 125^0)C$.

In the second stage, the three-point bending test was performed on the samples. The results have shown that the composite material is varying with directions. In the orientation of the fibers, the strength reaches at maximum values i.e. the angles , $[0^0]_3$ $[0^0]_{6,}$ While in the direction of the angles $[90^0]_3$ $[90^0]_6$ The strength at the minimum values and the values of strength between these two extremes, i.e. angles $(0^0 - 90^0)$ As for the symmetrical ply Laminated**,** the strength increases with the presence of the(0°) layer.

Key words: epoxy, glass fiber, bending test.

Introduction:

Many modern technologies and industries demand materials having combination of properties (strength / weight) which are not exist in traditional materials such as metal alloys, ceramics and polymeric materials.so, composite materials have been produced(William *et al*., 2000) .

Composite materials can be defined as the combination of two or more substances without a chemical reaction between them to form a new material which has different properties than the properties of the single materials. The composite material depends mainly on the base material and the supporting materials, as well as the nature of the interface between them (Jack *et al*.,1975) .

Polymeric composite materials are the most common type of compound materials due to their high physical and mechanical properties. (Daniel *et al*., 2001) .The most important requirements for the use of these materials are good strength, high performance, resistance to internal and external stresses, as well as their resistance to surrounding environmental conditions like heat, humidity, pressure, etc. In addition ¸the possession of these materials better resistance to the weight of the traditional engineering metals as well as high hardness and strength(Y. K *et al*., 2005).

In 1960, the demand for the emergence of a material with the characteristics of light weight, and high resistance at the same time as in the field of space and transport to get such materials started. This requires an effort of extensive research in the field of composite materials by studying the properties of the material and how they are interrelated and the rates of addition and this led to the emergence of types of composite materials, so Polymer composite materials are the best species for their high mechanical properties due to density in addition to the easiness of their manufacturing. (Elena *et al*., 2009).

The composite material of all types has been in advanced position in industrial applications since its first appearance. Polymeric composite have a special importance in many industrial applications depending on the base material and the reinforcing materials.

Mechanical properties:

Polymeric materials, in their competition with other building materials, depend on their desired mechanical properties. They are the changes as the resistance shown by the material, or the strain of the stresses affecting it whether during operation or formation. Those who deal with polymers.

Must be aware of at least some basic information about the mechanical properties of polymers in order to know how these properties are modified to suit their specific uses. As well as knowledge of thep mechanical behavior of the material towards a group of internal and external factors, including the nature of periodic load , temperature and time when testing and chemical nature.

Another important factor is the strain rate due to its significant influence on the mechanical behavior of the material. ductile can be counted at a low rate of emotion, but at a high rate of the strain, material will have a brittle mechanical behavior. Mechanical properties can therefore be categorized depending on the rate of strain and the nature of the power distribution to static mechanical properties and dynamic mechanical properties (N. G. *et al*., 1997; David,1983; Mohamed , 2001).

Compression, Bending, and Creep are static tests, and the Impact test is a kinetic test. (Rasan *et al*., 2004) . One of the characteristics studied in this research is the three-point flexural strength test.

Flexural strength:

This test is one of the basic tests of composite materials to determine the properties of flexibility and elasticity. The bending resistance of the material is the tolerance of the material to the bending force vertically on its longitudinal axis.

It is also a complex test because it involves more stress types such as tensile stress in the lower section layers and compressive stress in the upper section layers. sometimes overcoming one another and causing the material to fail as a whole.

The three-point bending test is one of the most common tests in the calculation of bending strength and is the easiest and the test is done according to ASTM (William *et al.*, 2000) The greatest stress in conditions of the three-point bending test in mid-distance between the supports can be calculated for any point on the curve (load-bending) by the following relationship (Awham, 2017).

$$F.S = \frac{3FL}{2bd^2} ------------------(*)$$

Flexural strength: bending strength and units (Newton / square mm).

F: Load (Newton).

L: the distance between the two points of loading (mm).

b: Sample width (mm).

d: Sample thickness (mm).

Materials and methods:

The research section includes the following points:

First: Materials used in research

1- epoxy type sikadur52 resin
Sikadur52 epoxy resins have been used as a base material they are non-heat resistant resins.

2- Glass fiber:
In this research layers of fiberglass were used to reinforce the epoxy resins.

Second: Preparing the Models:

The hand lay-up method was used in the preparation of the test models in which the standard ASTM-D 790 was adopted. It was in the form of rectangular models (135 × 10 mm) where the glass fiber was prepared with a diameter of 13 μm. The glass mold, (30 x 30 cm) with insulating vaplon paper and insulating glass rulers with transparent paper to prevent resin adhesion to the mold. The resin has been added to the resin by 3: 1, where the reaction occurs at room temperature. The amount of resin is placed on the surface of the inner mold and spread with a brush to ensure that it is distributed regularly on the surface of the mold. The first layer of fiber is then placed, And then to the rest of the layers to form a compound thickness required (3mm) and then clamped these models with glass cover and then left to harden for 24 hours after it was removed from the mold and ready to be cut where the samples were cut according to the required dimensions. Where the examination was carried out in the general mechanical inspection system.

Results and discussion:

The results obtained for the samples from the three-point bending test were applied in the bending strength. The tables (4,3,2,1), which show the bending strength values, were increased after reinforcing the resin with more layers of fiber Glass and also decreased direction change angles (0°-90°) because the composite material is different in different directions. In the direction taken by the fibers, the strength reaches the maximum values i.e. the direction with the angle (0°) parallel to the axis x while in the vertical direction on the fiber with the angle (90°) Between these two extremes means when the angle changes between (0°-90°) this gets for all samples and all temperatures

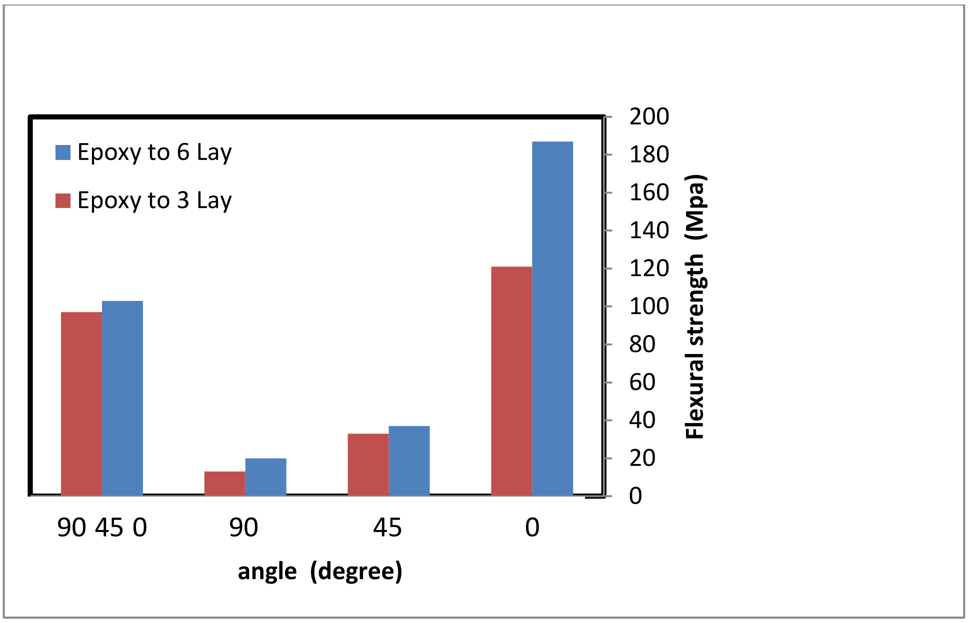

Figure (1): Change the direction of angles with changing flexural strength of epoxy glass fiber samples at (25 ° C).

Table (1) The flexural strength values of all angles at (25 ° C).

Composite material	0°	45°	90°	0° 45° 90°
Epoxy Glass Fiber for 6 Layers	187	37	20	103
Epoxy Glass Fiber for 3 Layers	121	33	13	97

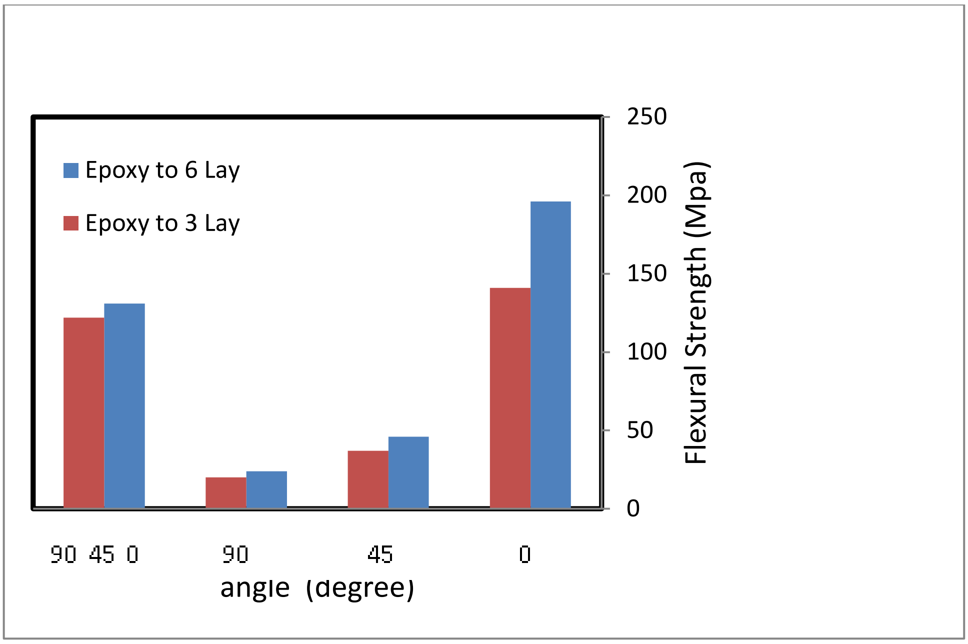

Figure (2): Change the direction of angles with changing flexural strength of epoxy glass fiber samples at (50 ° C).

Table (2) The flexural strength values of all angles at (50 ° C).

Composite material	0°	45°	90°	0° 45° 90°
Epoxy Glass Fiber for 6 Layers	196	46	24	131
Epoxy Glass Fiber for 3 Layers	141	37	20	122

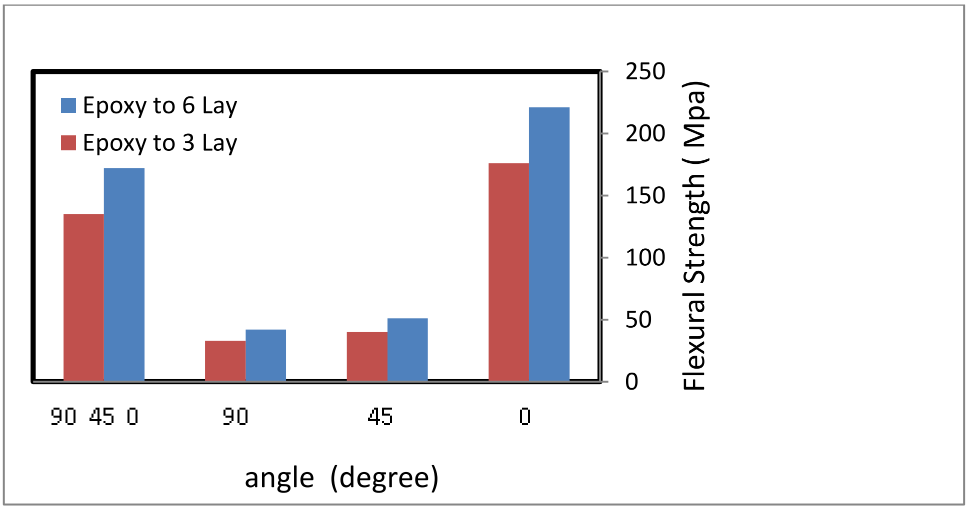

Figure (3): Change the direction of angles with changing flexural strength of epoxy glass fiber samples at (100 ° C).

Table (3) The flexural strength values of all angles at (100 ° C).

Composite material	0°	45°	90°	0° 45° 90°
Epoxy Glass Fiber for 6 Layers	221	51	42	172
Epoxy Glass Fiber for 3 Layers	176	40	33	135

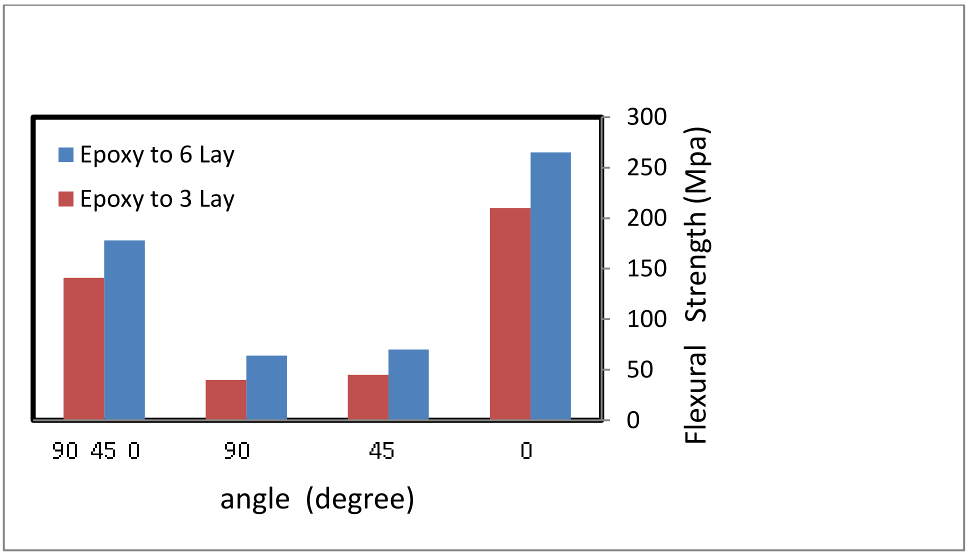

Figure (4): Change the direction of angles with changing flexural strength of epoxy glass fiber samples at (125 ° C).

Table (4) The flexural strength values of all angles at (125 ° C).

Composite material	0°	45°	90°	0° 45° 90°
Epoxy Glass Fiber for 6 Layers	265	70	64	178
Epoxy Glass Fiber for 3 Layers	210	45	40	141

Conclusions:

We conclude that the composite materials are different in strength according to the direction of angles. The maximum strength obtained was at the angle (0°),but Minimum strength obtained at angle (90°) and the strength of the material increases by increasing the number of layers.

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