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THEORETICAL APPROACH TO MECHANICAL PROPERTIES OF RESINOUS COMPOSITE

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ABSTRACT

This investigation evaluated the tensile and flexural properties of polystyrene resin reinforced with different weight fracture from random glass fibres (20%, 40%, and 60%)by using Ansys program version (11). The standard specification (ISO-R-527) and (ASTM D790) were used to fabricant the tensile and flexural test samples respectively by Ansys program. The theoretical data shows that high tensile and flexural strength value for polystyrene resin after reinforcing with random glass fibres and this strength will increase with increasing weight fracture of fibres.

Keywords: Polystyrene resin, Mechanical properties, Ansys program

INTRODUCTION

A composite is a structural material that consists of two or more constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix (Kaw, 2006). The composite material however, generally possesses characteristic properties, such as stiffness, strength, weight, high-temperature performance, corrosion resistance, hardness, and conductivity that are not possible with the individual components by themselves (DeGarmo, et al., 2008).

There are many types of composite materials and several methods of classifying them, one such method is bases on geometry and consists of three distinct families (Ali et al,2012):

1. Laminar Composites: laminar composites are those having distinct lagers of materials bonded together in some manner.
2. Particular Composites: particular composites consist of discrete particles of one material surrounded by a matrix of another material.
3. Fibre-Reinforced Composites: the most popular type of composite material is the fibre-reinforced composite geometry.

Generally, the composite material contains two elements:

1. Matrix material: it is the continuous phase; it may be metal, ceramic or polymer matrix. The polymer matrix is considered the best because of its mechanical and thermal properties, and also it can reinforce by a large fibre volume fraction compared with metal and ceramic matrix.

   In addition to the low cost and easy fabrication, as example for this materials araldite resin, polyester, and epoxy resin. Araldite resin belong to epoxy group which has excellent thermal and physical properties, and usually used in composite materials for different applications, where it distinct by excellent adhesive capability especially to fibres, also it retain constant dimensions after dryness (Dobrzański et al, 2006).

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2. Reinforcing material: The distributed phase is called reinforcement, many reinforcement materials are available in a variety of forms; continuous fibres; short fibres; whiskers, particles...etc. Reinforcements include organic fibres such as carbon and kevlar fibres, metallic fibres, ceramic fibres, and particles (Ali et al, 2012).

Polystyrene (PS) has a wide range of properties including versatility, rigidity, clarity, and brittleness. It's a poor barrier to oxygen and water vapor. But the most unique property of PS is thermoforming, the ability to form and foam. Two familiar products made of foamed PS are coffee cups and fast food clam shell containers. Used in a variety of applications because of its low cost and easy ability to be processed, PS is often used in automobiles, insulation, disposables, packaging, toys, construction, electronics, and housewares. PS is also used for sour cream and cottage cheese containers, and horticultural products such as trays, packs, and flats (Ali et al, 2012).

(G.Morom etal, 1986) studied the effect of hybrid fibres (Carbon/Kevlar) on the impact strength of epoxy resin. also (Ali,2009) investigated the effect of changing the reinforcement percentage by fibres on Mechanical properties, for composite material consists of conbextra epoxy (EP-10) resin reinforced by biaxial woven roving kevlar fibres. (Azhdar,1992) studied the impact fracture toughness of fibre reinforced epoxy resin.(Al-Jeebory et al,2009) studied effect the change of reinforcement percentage of fibres on the thermal and mechanical properties for polymeric composite material consist of conbextra epoxy (EP-10) resin reinforced by biaxial woven roving S–type glass fibres.

TENSILE STRENGTH

A tensile test is a fundamental mechanical test where a carefully prepared sample is loaded in a very controlled manner while measuring the applied load and the elongation of the sample over some distance. Tensile strength or ultimate strength is defined as the maximum load that results during the tensile test, divided by the cross-sectional area of the test sample.

Therefore, tensile strength, like yield strength, is expressed in Mpa. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties [9]. Tensile strength can be obtained from the following formula:

$$\sigma = P/A \qquad \text{.......................................(1)}$$

where :

σ = tensile strength (N/m^2)

P = test load (N)

A = cross section area of sample (m^2)

FLEXURAL STRENGTH

The flexural strength of a material is defined as its ability to resist deformation under load. For materials that deform significantly but do not break, the load at yield, typically measured at 5% deformation/strain of the outer surface, is reported as the flexural strength or flexural yield strength. The test beam is under compressive stress at the concave surface and tensile stress at the convex surface (see Fig.1) (Sharafeddin et al, 2013). Then another object applies load on the central part of the concrete, between the platforms, and gradually increases pressure until the concrete breaks. The flexural strength of concrete is estimated based on the weight of the load that collapses the concrete, the distance between the platforms and the width and thickness of the object being tested. An object's flexural strength also correlates with its tensile strength, or the object's ability to be stretched without significantly changing its shape (Schlichting et al, 2010).

When an object is made to bend, it is also somehow stretched, although only in a localized area. In occupational fields such as construction and engineering, knowing a material's flexural and tensile strengths is important in order to make sure that the material is strong enough to use in structures. Hard but brittle objects, such as wood concrete, alloys and plastic, are used more often in construction than elastic and ductile objects such as rubber, gold or silver, so it is more important to evaluate the formers flexural and tensile strengths (Schlichting et al, 2010). Flexural strength can be obtained from the following formula:

$$\sigma = F \times S = \frac{3PS}{2bt^2} \quad \text{.......................................} \ (2)$$

Where:

F = Maximum load (N)

S = Distance between loading points (mm)

b = Sample width (mm)

t = Sample thickness (mm)

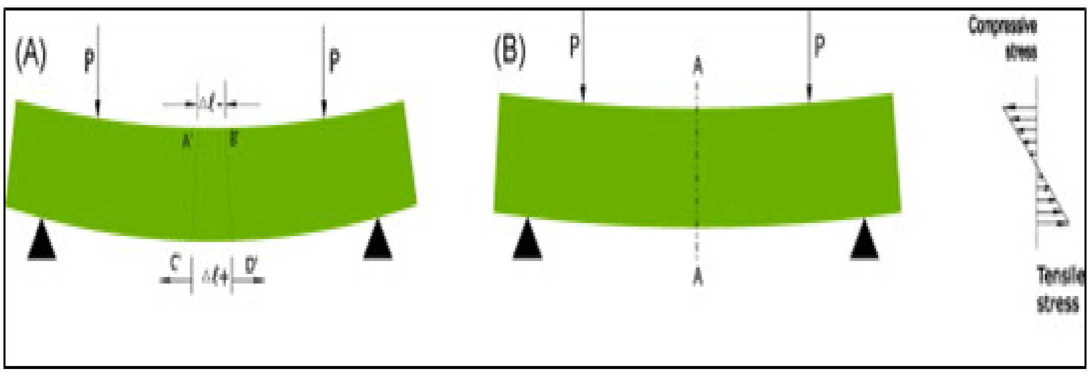

Figure 1. (A) Under flexure, any beam will experience compressive (load side, $\Delta l < 0$) and tensile (opposite side, $\Delta l > 0$) stresses. (B) Under load, half of section AA will be compressed while the other half will be subject to tensile efforts.

In theory, an object's flexural and tensile strengths would be in similar ranges if there is homogeneity in the materials used, meaning that the substances used are mixed in equally. If the substances are not uniformly mixed, then the flexure and tensile strengths might drastically vary in different areas of the object. Another factor that can change an object's flexural and tensile strengths are defects. For example, a rope with torn fibres might increase its tensile strength, as the fibres can stretch longer, but it might decrease its flexural strength, especially when load is applied on the area where the fibres are weakest (Gomec et al, 2005).

MATERIALS AND METHODS

In this study, Ansys program version (11) was used to estimated tensile and flexural strength for polystyrene resin before and after reinforced with different weight fracture random glass fibres (20%, 40%, and 60%). Specific Properties for both resin and fibres was input in database of Ansys program, as well as standard shape of samples, and applied different amount of loads to make a theoretical emulation to experimental tensile and flexural test, and

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then draw the obtained data after applied the loads. Table 1 shows the specifications used to draw test samples.

Following a short description to materials used:

1. Polystyrene Resin with (1.05 g/cm^3) density.
2. Random glass fibres E-type with (2.6g/cm^3) density.
3. Test samples: standard specification (ISO-R-527) was used with rectangular section.
4. Flexural Strength Samples: (ASTM-D790) was used as a rectangular shape (10mm×135mm).

Table 1. Specifications used to draw test samples

	Model	Type of Element	Element No.	Nodes No.
Tensile	Linear	Solid 185 Geometry , 8 Nods ,3-D Modeling	3922	10961
Flexural	Linear	Solid 185 Geometry , 8 Nods ,3-D Modeling	5145	10290

RESULTS & DISCUSSION

Tensile strength of polystyrene resin before reinforcement was shown in Figure 2, where we observed that, low tensile strength for this resin when exposed to loads, because of in general the resins considered a brittle materials, which accepted with experimental results obtained by (Ali et al, 2012).

After reinforcing by fibres this property will be improved greatly as shown in Figure 3 which represent the tensile strength to polystyrene resin after reinforcing with (20%) glass fibres, where the strength of resin will increased due to the fibres will withstand the maximum part of loads and by consequence will raise the strength of composite material and this also accepted with experimental results obtained by (Al-Jeebory et al, 2009).

The tensile strength will be increased as the fibres percentage addition increased as illustrated in Fig.4 and Fig.5 which represent tensile strength to polystyrene resin after reinforcing with (40%) and (60%) from glass fibres respectively . These fibres will be distributed on large area in the resin which will be improved tensile strength greatly (Kiichi et al, 2009).

Flexural Strength: as mentioned above, the resin is brittle; therefore its flexural strength is low before reinforcement as shown in Fig .6. But after added the fibres to this resin the flexural strength will be raise to the producing material because the high modulus of elasticity of these fibres will helps to carry a large amount of loads and raise this strength as illustrated in Fig.7, Fig.8 and Fig.9 which represent tensile strength to polystyrene resin after reinforcing with (20%), (40%) and (60%) from glass fibres respectively (Schlichting et al, 2010).

CONCLUSIONS

From the obtained results we get: Improvement of mechanical properties after reinforcement by glass fibres .Increased tensile and impact strength with increasing fibres weight fracture.

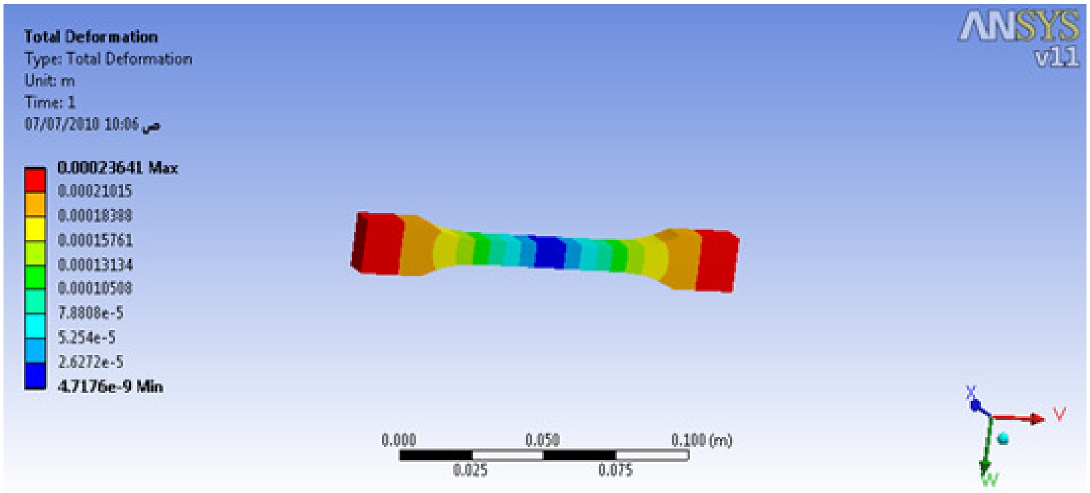

Figure 2. Tensile strength to polystyrene resin before reinforcement

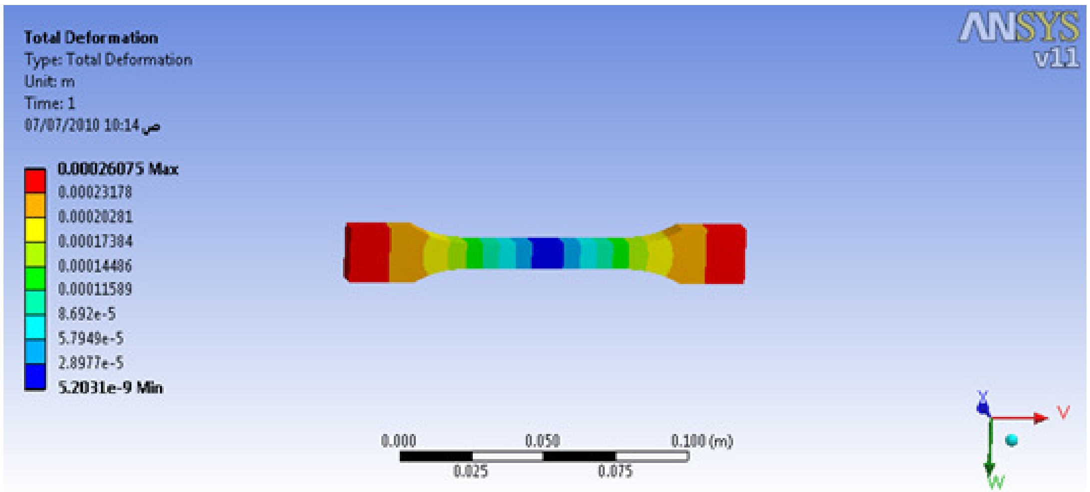

Figure 3. Tensile strength to polystyrene resin after reinforcing with (20%) glass fibres

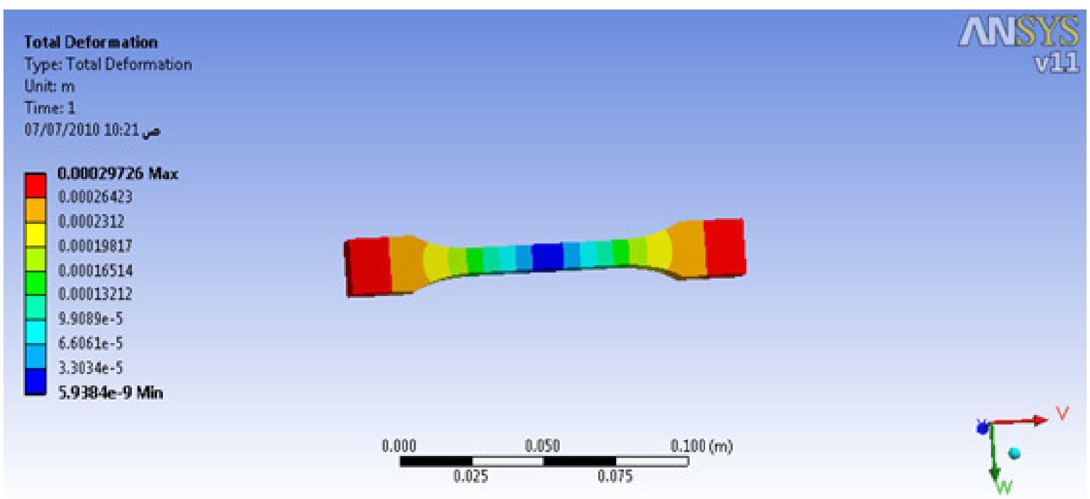

Figure 4. Tensile strength to polystyrene resin after reinforcing with (40%) glass fibres

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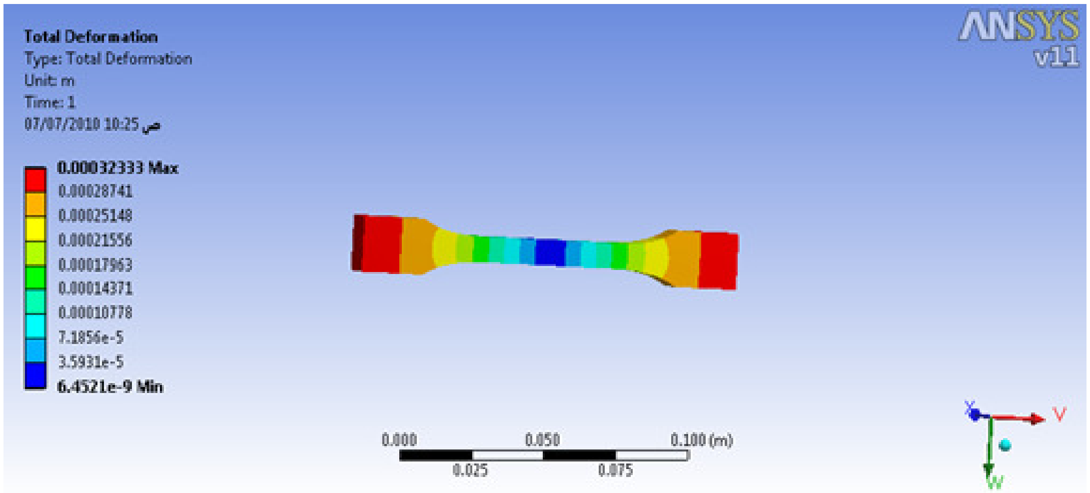

Figure 5. Tensile strength to polystyrene resin after reinforcing with (60%) glass fibres

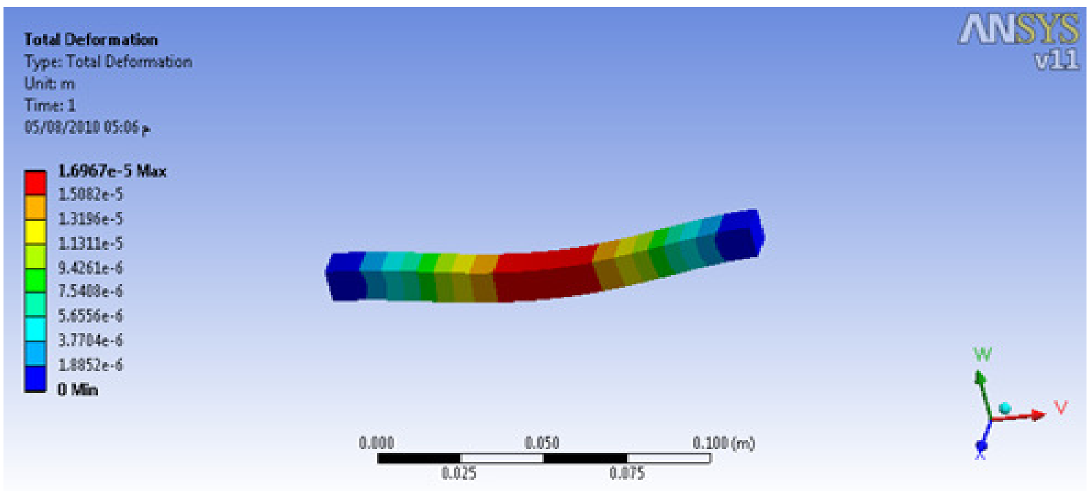

Figure 6. Flexural strength to polystyrene resin before reinforcement

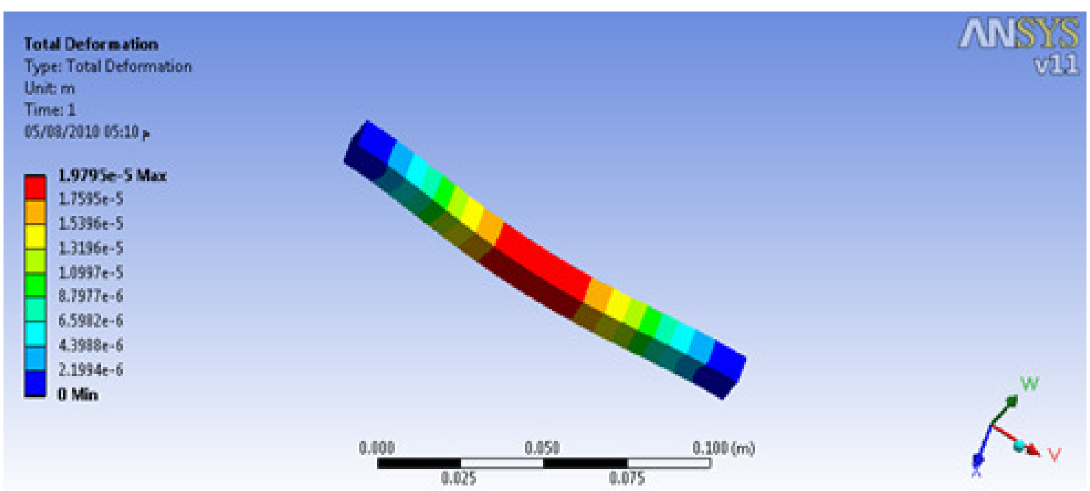

Figure 7. Flexural strength to polystyrene resin after reinforcing with (20%) glass fibres

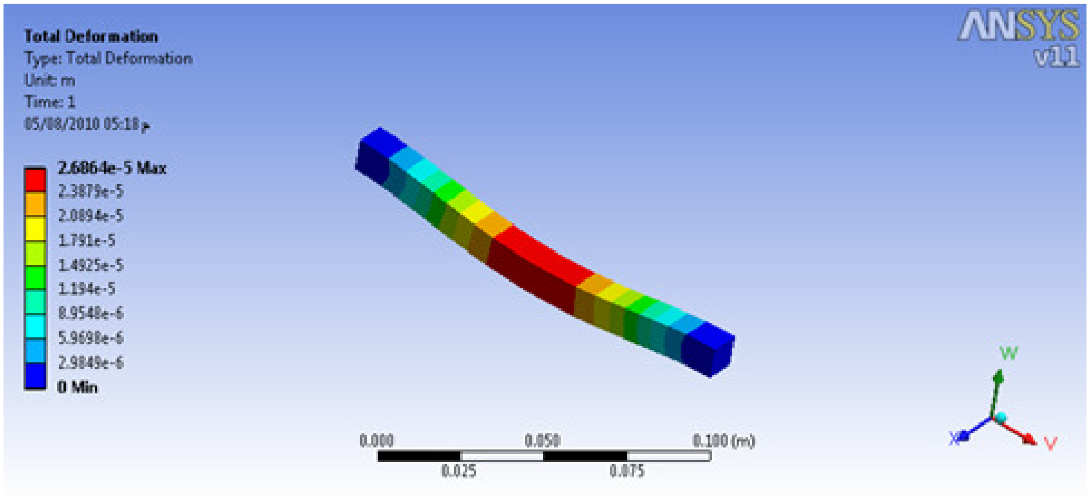

Figure 8. Flexural strength to polystyrene resin after reinforcing with (40%) glass fibres

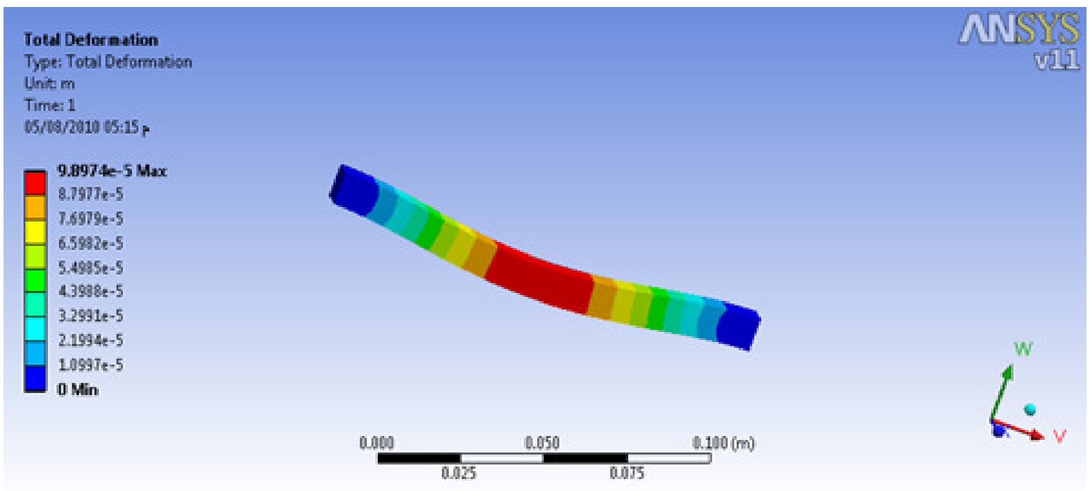

Figure 9. Flexural strength to polystyrene resin after reinforcing with (60%) glass fibres

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