Effect of Nature Materials Powders on Mechanical and Physical Properties of Glass Fiber / Epoxy Composite

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ABSTRACT

In the present study composites were prepared by Hand lay-up molding. The composites constituents were epoxy resin as the matrix, 6% volume fractions of Glass Fibers (G.F) as reinforcement and 3%, 6% of nature material (Rice Husk Ash, Carrot Powder, and Sawdust) as filler. Density, water absorption, hardness test, flexural strength, shear stress measurements and tests were conducted to reveal their values for each type of composite. True density results had show an incremental increase with volume fraction increasing and water absorption, hardness, flexural strength and shear stress results had shows an incremental increase with volume fraction increasing with smaller particle size.

Keywords: Density, Water absorption, Hardness, Flexural Strength, Glass fibers, Composites**.**

تأثير مساحيق اساسها مواد طبيعي على الخواص ميكانيكية وفيزياوية لمواد مركبة من ايبوكسي والياف زجاج

الخلاصة

تم في هذا البحث تحضير مواد متراكبه بواسطة طريقة القولبة اليدوية. المواد المتراكبة مكونة من راتنج الايبوكسي كماده اساس وبألياف الزجاج بكسر حجمي 6% وكذلك 3% و 6 % كحشوة من المواد الطبيعية (رماد قشور الارز , مسحوق الجزر , بودرة خشب جاوي) . تم اجراء قياسات وفحوصات الكثافة وامتصاصة الماء وفحص الصلادة, مقاومة الانحناء , اجهاد القص للكشف عن قيمها لكل نوع من المواد المتراكبة . عند اجراء اختبارات الكثافة فان النتائج اظهرت بان الكثافة تزداد مع زيادة الكسر الجحمي والنتائج اظهرت بان امتصاصية الماء والصلادة ومقاومة الانحناء واقصى اجهاد قص يزداد مع زياد الكسر الجحمي و مع اصغر حجم حبيبي .

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Symbol	*Title*	*Unit*
ρ_c, ρ_m, ρ_f	Density of composite, matrix and fiber respectively	(gm/cm^3)
v_c, v_m, v_r	Volume of composite, matrix and reinforcement respectively	(cm^3)
ρ_t	Measured density or true density	(gm/cm^3)
W_d	Dry weight of the sample	(gm)
W_s	Weight of the sample is saturated with water	(gm)
W_n	Weight of the sample when submerged with distilled water	(gm)
D	Density of distilled water	(1 gm/cm^3)
M%	Water absorption percentage	/
m_o	Mass of specimen before immersion	(gm)
m_t	Mass after immersion for seven days	(gm)
F.S	Flexural strength	(Mpa)
L	Length of the sample	(mm)
P	Force at fracture	(N)
b	Thickness of the sample	(mm)
d	Width of the sample	(mm)
τ	Maximum shear stress	(Mpa)

INTRODUCTION

Composite materials have successfully substitute the traditional materials in several light weight and high strength applications. The reasons why composites are selected for such applications are mainly their high strength-to-weight ratio, high tensile strength at elevated temperatures, high creep resistance and high toughness. By definition, composites are materials consist of two or more chemically distinct constituents on a macro scale having a distinct interface separating them and having bulk behavior which is considerably different from those of any of the constituents. The primary phase of composite material having a continuous character is called matrix. This phase is usually less hard and more ductile the matrix forms the bulk part. The secondary phase is a discontinuous form which is embedded in the matrix. The dispersed phase is generally harder as compared to the continuous phase and is called reinforcement. It serves to strengthen the matrix and improves the overall mechanical behavior of the matrix. Depending on the type of matrix materials used, composite materials can be classified into three categories such as metal matrix composites, polymer matrix composites and ceramic matrix composites each type of composite material is suitable for different applications. Most commonly used matrix material in composite materials is polymer. The reason for this is two folds [1]. Firstly, their strength and stiffness are less as compared to ceramics and metal, and these shortcomings are overcome by reinforcing other materials with polymers. Secondly, the processing of polymer matrix composite does not require high pressure and high temperature. For these reasons polymer matrix composites are developing rapidly and soon becoming popular for structural applications

there are two major classes of polymers used as matrix materials such as thermoplastics and thermosets. Thermoplastics (polypropylene, nylons, acrylics etc.) can be repeatedly softened and reformed by application of heat. However, thermosets (phenolics, epoxies, unsaturated polyester etc.) on the other hand, are materials that undergo a curing process during part fabrication, after which they are rigid and cannot be reformed. Fiber reinforced polymer composites have played a significant role for a long time in a range of applications for their high specific strength and modulus. These materials also provide lightweight, high durability and design flexibility, which make them attractive materials in comparison to others to be used in various applications. Fiber reinforced polymer matrix composites consist of reinforcing fibers embedded in a rigid polymer matrix The properties of matrix, fiber and its interface have greatly influencing the properties of composite materials [2 – 3].The objectives of the research Suggestion composites of epoxy reinforced with glass fibers and natural powder (rice husk ash, carrot powder and sawdust).Studying some physical and mechanical properties (density, water absorption), (hardness shore (D), flexural strength and shear stress) tests of the prepared composites.
There are many studies about composite materials.

Ghassan & Hilmi have studied the investigates of the properties of rice husk ash (RHA) produced by using a ferro-cement furnace. The effect of grinding on the particle size and the surface area was first investigated, then the XRD analysis was conducted to verify the presence of amorphous silica in the ash. Furthermore, the effect of RHA average particle size and percentage on concrete workability, fresh density, super plasticizer (SP) content and the compressive strength were also investigated. Although grinding RHA would reduce its average particle size (APS), it was not the main factor controlling the surface area and it is thus resulted from RHA's multilayered, angular and microporous surface. Incorporation of RHA in concrete increased water demand . RHA concrete gave excellent improvement in strength for 10% replacement (30.8% increment compared to the control mix), and up to 20% of cement could be valuably replaced with RHA without adversely affecting the strength. Increasing RHA fineness enhanced the strength of blended concrete compared to coarser RHA and control OPC mixtures [4].

Wafaa & Sewench have studied Interest has largely centered on the use of plant fibers to reinforce plastics, because these fibers are abundant and cheap. Carrot fibers (Curran) have been extracted from carrot, left over from carrot juice manufacture. The fibers of two sizes fine (50<μm) and coarse (100-150 μm) have been mixed with epoxy in four levels of loading (10, 20, 30, 40 wt %) respectively. Impact test, shore d hardness test and three point bending test of epoxy and carrot fiber-epoxy composites samples have been determined. The impact strength values of samples prepared with fine and coarse fibers increased as compared with pure epoxy sample. Hardness values increased, and the Young's modulus values decreased with fiber content of both sizes [5].

Prasad V. V. S.,(*2012),* has studied the Palm fibre reinforced plastic composites (PFRP) are prepared by using "hand lay-up technique" and tested. The composites are tested for tensile strength, thermal conductivity and electrical conductivity. Composites made of Palm fibre less thermal conductivity and hence these can be used as insulators. Thermal conductivity is found to be increasing with increasing palm contents in the

composite. Tensile strength of the composite increases with increases in the fibre volume fraction [6].

Experimental Work

The basic materials used in the preparation of research samples consisting of glass fibers (Woven E- Glass Fiber) from the Tenax company, England, and epoxy resin Quickmast (105) base as the matrix from the (Don Construction products) Made in Jordan in the form of transparent viscous liquid at room temperature which is a thermally hardened polymers (Thermosets) with a density of (1.2 gm / cm^3). The powder was used for RHA (61.6µm), Carrot powder (95.5µm), and wood powder (sawdust) (149.4µm) as shown in figure (1). All the required moulds for preparing the specimens were made from glass with dimensions of (150×150×5) mm. The inner face of the mould was covered with a layer of nylon (thermal paper) made from polyvinyl alcohol (PVA) so as to ensure no-adhesion of the resin with the mould.

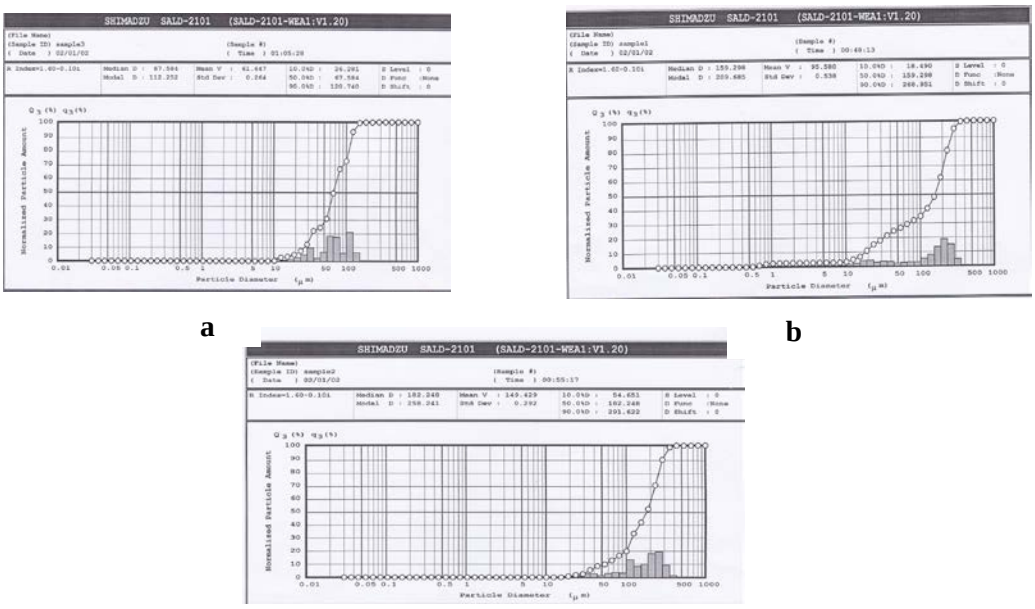


Figure (1): (a) Particle size analyzer of RHA, (b) particle size analyzer of Carrot powder, (c) particle size analyzer of Wood powder (sawdust)

Preparation of Natural Materials.

A- Carrot Powder

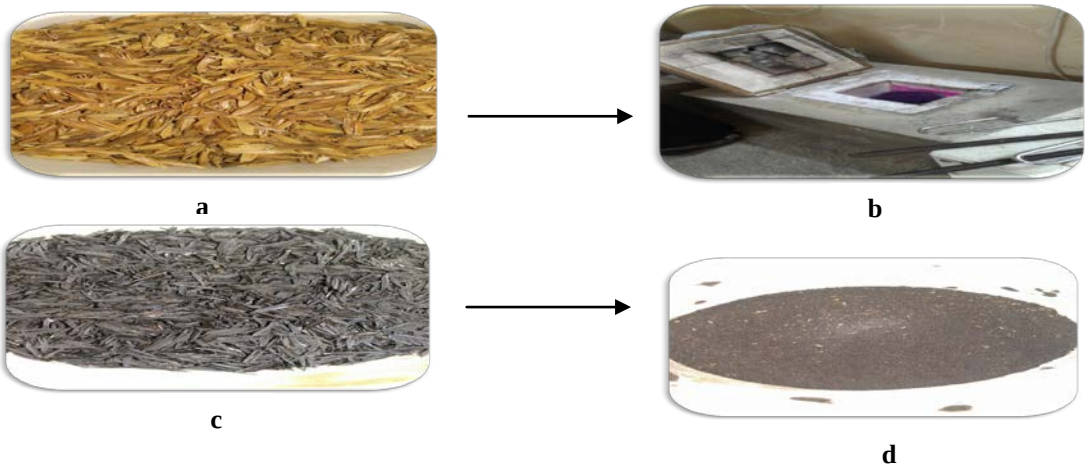
The carrot seeds were cleaned to remove all foreign matter such as dust, dirt, and sand clay. The juice was removed from carrot seeds the solid waste from carrot juice is rich in fiber which regarded as a functional fiber source. The waste was dried to a

constant weight and then grounded by using a grinder and sieved. Two sizes were obtained, Once (fine fiber) is less than 50 µm and the other (coarse fiber) is between 100-150 µm which represent as accumulated fibers [7] as shown in Figure (2).

Figure (2): Carrot powder after Milling

B- Rice Husk Ash

Rice-husk contains about 50% cellulose, 25–30% lignin, and 15–20% of silica. On burning, cellulose and lignin are removed leaving behind silica ash. The controlled temperature and environment of burning yields better quality of rice-husk ash as its particle size and specific surface area are dependent on burning condition [8-9]. Figure (3-a) shows the Rice Husk before Combustion. To produce the best pozzolanas, the burning of the husk must be carefully controlled to keep the temperature below 700°C and to ensure that the creation of carbon is kept to a minimum by supplying an adequate quantity of air. At burning temperatures below 700°C an ash rich in amorphous silica is formed which is highly reactive. Temperatures above 700°C produce crystalline silica which is far less reactive**.** Figure (3-b) shows the Furnace used for Combustion. Figure (3-c) shows Rice Husk after Combustion. The second step in processing is milling the RHA to a fine powder, and ball or hammer mills are usually used for this purpose. Crystalline ash is harder and will require more milling in order to achieve the desired fineness [10] Figure (3-d) shows Rice Husk Ash after milling**.** Suitability of RHA mainly depends on the chemical composition of ash, predominantly silica content in it. RHA is found to be superior to other supplementary materials like slag, silica fume and fly ash [11-12].



a **b**

c **d**

Figure (3): Preparationof Rice Husk Ash (a) Rice Husk before Combustion, (b) Furnace used for Combustion, (c) Rice Husk after Combustion, (d) Rice Husk Ash after millin

C- Wood powder (Sawdust)

Wood powder is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. It is also the byproduct of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. It can present a hazard in manufacturing industries, especially in terms of its flammability. Sawdust is the main component of particleboard [13]. As shown in figure (4)

Figure: (4) Wood powder (sawdust)

A(Carrot powder)	**B (RHA)**	C **(Wood powder) Sawdust**

Table (1): (a) Chemical composition of the Carrot Powder, (b) Chemical composition of the RHA, (c) Chemical composition of the Wood Powder.

Chemical Composition	**(Content %)**	**Chemical Composition**	**(Content %)**	**Chemical Composition**	**(Content %)**
Al	3.82%	SiO_2	94.41%	Cellulose	47%
B	0.30%	Al_2O_3	0.15%	Lignin	21%
Ca	31.27%	Fe_2O_3	0.99%	Hemi-Cellulose and other compounds	30%
Cr	0.086%	CaO	0.52%	Extractives	2%
Cu	0.06%	MgO	0.70%	Ash	0.4%
Fe	6.05%	K_2O	2.27%		
K	35.55%	Na_2O	0.26%		
Mg	3.87%	P_2O_5	0.62%		
Mn	0.403%	TiO_2	<0.01%		
Na	6.08%	MnO	0.08%		
Ni	0.059%				
P	12.85%				
Se	0.005%				
V	0.184%				
Zn	0.281				

Using chemical composition analyzer to find the element of the natural material. As shown in table (1)

The X-Ray Diffraction (XRD) used to find crystalline phases for the nature materials as shown in figure (5)

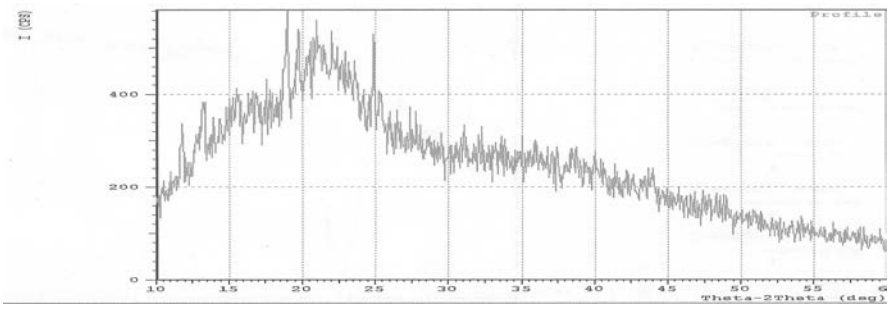


Figure (5) :(a) the X- Ray Diffraction of Carrot Powder

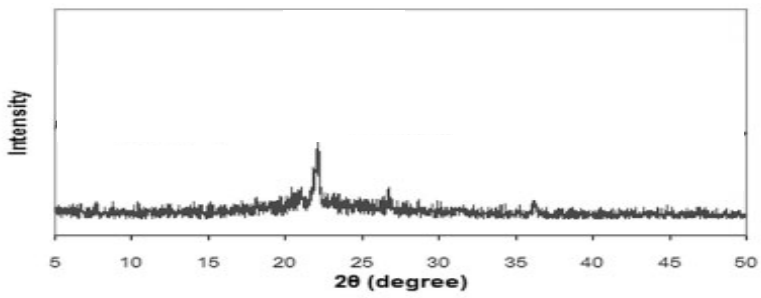


Figure (5): (b) X- Ray Diffraction of RHA

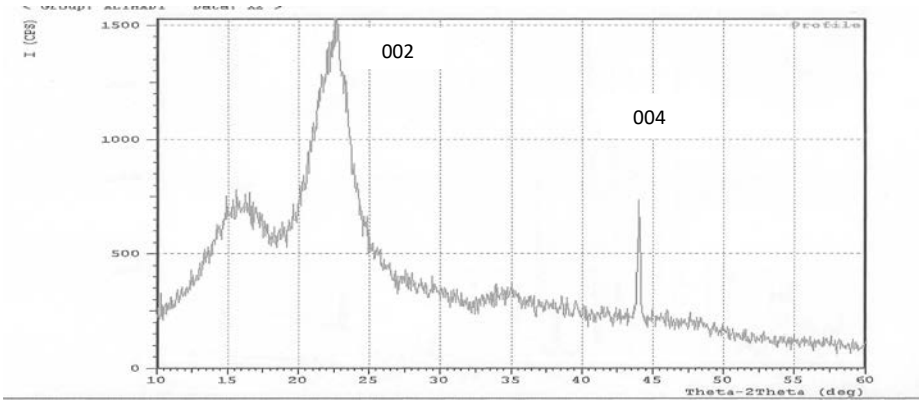


Figure (5): (C) X- Ray Diffraction of Wood Powder (Sawdust)

Figure (5-a) shows the X-Ray Diffraction pattern confirmed that (carrot powder) is mainly (amorphous calcium and potassium) this agree with [14] .Figure (5-b) shows the X- Ray Diffraction pattern confirmed that (RHA) Sharp XRD peaks of RHA at 2θ values of 20.9, 21.9, 26.6, 31.4 and 36.0˚ indicate presence of silica in crystalline form (figure 5-b). These reflections would give corresponding d-values of 4.06, 3.35, 2.85, and 2.49 as estimated from Bragg's law in agreement with the values from ICDD of tridymite (4.06, 3.33, and 10.9) and cristobalite (4.04, 2.49, and 2.84) phases.[15] These XRD peaks, therefore, suggest that the RHA has mixed phases of both forms of crystalline silica. At calcination temperatures above 900℃, the SiO_2 in RHA would consist of cristobalite and some tridymite phases due to melting of the surfaces of ash silica particles and bonding of particles together. [15] It is observed that at temperature around 1000℃ the RH turns into ash with predominant crystalline silica. At 1350℃ 83% of the RH turns into crystalline silica. It is worth mentioning that in the temperature range 450 – 700℃, the contained silica exhibits an amorphous nature in the RH with less than 5% of crystalline. Figure (5-C) shows the X-Ray Diffraction of wood powder, from the results, it is obviously that cellulose has crystalline nature with an intensive peak at (2Θ= 22°) corresponding to 002 lattice plane and the second in the region (2Θ= 44°) corresponding to 004 lattice plan [16-17].

Preparation of Composites

The method used in the preparation of the samples, in this research is the (Hand lay-Up Molding) composites are prepared according to the following steps:

1- Preparation of glass fibers woven of dimensions (150 × 150) mm according to the dimensions of the mould. The used volume fractions are (6%).

2- Weighing the reinforcing powder to specify a volume fraction of (3% and 6%).

3- Weighing the epoxy depending on the volume fraction of reinforcement materials (fiber and powder), while taking into consideration the weight of hardener.

4- Mixing the epoxy with the hardener continuously and slowly by using a glass rod so as to avoid bubbles. The mixing is carried out at room temperature.

5- Adding the powder intermittently into the mixture and stirring it for a period of (10-15) minutes to obtain homogeneity. A rise in the temperature of the mixture will result as an indication to the beginning of the interaction process. It is very important that the mixture must have a good viscosity for the purpose of protecting the particles from precipitation which may result in the heterogeneity of the mixture that leads to the agglomeration after hardening.

6- Pouring the mixture into the mould, then putting the glass fiber mat into the mould and continuing of mixture pouring until it covers the entire mat.

7- Pressing the mixture with an appropriate load.

8- For the purpose of completing the process of hardening, finally is leaving the sample in the mould for a period of (24) hour at room temperature. Samples are then extracted from the mould and then heat treated in an oven at (60Ċ) for a period of (60) minutes. This process is very important for the purpose of obtaining the best cross linking between polymeric chains, and to remove the stresses generated from the preparation process and complete the full hardening of the samples.[18]

Physical Tests

Density

Theoretical Density

The following role of mixture (ROM) formula is used to calculate the theoretical density of the composite.

$$\rho_c = \rho_m v_m + \rho_r v_r \quad \ldots.(1)$$

True Density

This test is performed according to (ASTM-D792) standard at the room temperature [19]. The samples were cut into a diameter of 40 mm and a thickness of 5 mm the Measured density (ρ_t) is calculated from the method of immersion in water (Archimedes base) using the following relationship.

$$\rho t = (Wd / Ws - Wn) * D \quad \ldots(2)$$

Where:

ρt: Measured density or bulk density (gm/cm^3).

D: Density of distilled water (1 gm/cm^3).

Wd: Dry weight of sample (gm).
Wn:Weight of the sample, a commentator and submerged with water (gm).
Ws: Weight of the sample is saturated with water (gm).

Water Absorption

This test is performed according to (ASTM D 570) standard at room temperature [20]. Samples have been cut into a diameter of (40mm) and a thickness of (5mm). The mechanism of water absorption is explained to be the direct uptake and flow of water by capillary and transport along the reinforcement-matrix interface [21]. Water absorption percentage is calculated using (Archimedes base) according the following formula [20-22].

$$M\ (\%) = \frac{(mt - m_o)}{m_o} \times 100 \quad \ldots (3)$$

Where
M (%): water absorption percentage.
m_o : mass of specimen before immersion (g).
m_t: mass of specimen after immersion for seven days (g).

Mechanical Test

Hardness Test (Shore D)

This test is performed by using hardness (Shore D) and according to (ASTM D-2240) standard at room temperature [23]. Samples have been cut into a disk with (40mm) and a thickness of (5mm). Figure (6) shows hardness device used in this research. For each specimen five hardness measurements were taken and the average hardness is calculated.

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Figure (6): Hardness device

Flexural Strength and Shear Stress Test

This test is performed according to (ASTM D 790) at room temperature [24]. Samples have been cut into the dimensions (100*13*5) mm. Figure (7) shows flexural strength

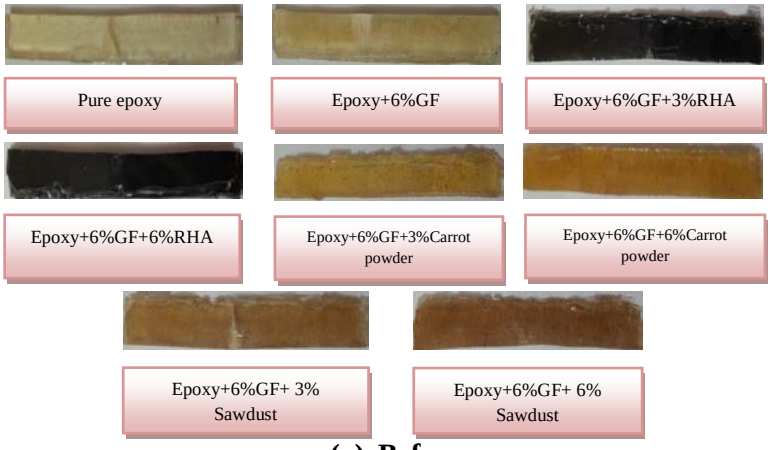
and shear stress device used in this research. The flexural strength & maximum shear stress are calculated according to the equations [25- 26].

$$F.S = \frac{3PL}{2bd^2} \quad \text{.... (4)}$$

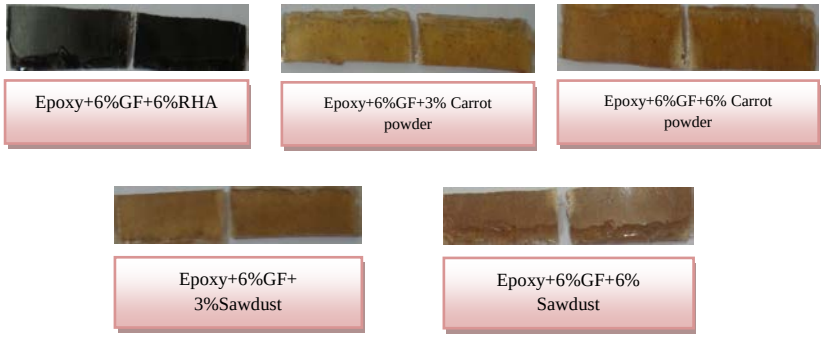
$$\tau = \frac{3P}{4bd} \quad \text{.... (5)}$$

Where

F.S: flexural strength (MPa).
P: force at fracture (N).
L: length of the sample between Predicate (mm).
b:thikness(mm).
d:width(mm).
τ:maximum shear stress (MPa)
P: force at fracture (N).
b:thikness (mm).
d:width (mm).



(a) Before



(b) After

Figure (7): Experimental specimens before and after test

Figure (8): Flexural strength and shear stress device

Results and Discussion

Density

Table (2) shows the values of density for the prepared composites (pure epoxy, epoxy +6% glass fiber and natural powder) composites. From the table (2) it may be noted in the all value of the composites density values are calculated theoretically from volume fraction using rule of mixtures by Eq. (1) and are not equal to the experimentally true

density values. This difference is due to presence of voids and pores in the composites. The observation shows that more voids are found in the composites with the addition of fiber as well as filler material [27]. Figures (9) and (10) show the true and theoretical densities for specimens (pure epoxy and epoxy +6%glass fiber). In figure (9) can be seen the higher density has been found to be for the specimen (epoxy +6% glass fiber) then specimen (pure epoxy) , density of composites material increases when the reinforcement is increases due to the density of glass fiber is more when compared to density pure epoxy [28,29]. Figure (11) and (12) show the true and theoretical densities for natural composites. In figure (11) can be seen the higher density has been found to be for the specimen (epoxy+6% glass fiber +6%RHA) due the RHA have the higher individual density when compared with composite natural-based materials (carrot powder and sawdust) where the density of RHA (0.49) gm/cm^3, carrot powder (0.31) gm/cm^3, sawdust (0.23) gm/cm^3. When comparing the value of true density of natural with true density of (pure epoxy) can be seen lower than because the additions of reinforcement (RHA, carrot powder and sawdust) that have lower density than matrix (pure epoxy) where the density of pure epoxy (1.2 gm/ cm^3).

Table (2): Density of the prepared composites

Type of composite	True density (gm/cm^3)	Theoretical density(gm/cm^3)
Pure Epoxy	1.2	1.2
Epoxy +6% Glass fiber	1.226	1.376
(Natural Composites)		
Epoxy+6%GF+3% RHA	1.150	1.352
Epoxy+6%GF+6% RHA	1.189	1.328
Epoxy+6%GF+3% Carrot powder	1.135	1.347
Epoxy+6%GF+6% Carrot powder	1.172	1.317
Epoxy+6%GF+3%Sawdust	1.127	1.344
Epoxy+6%GF+6% Sawdust	1.154	1.312

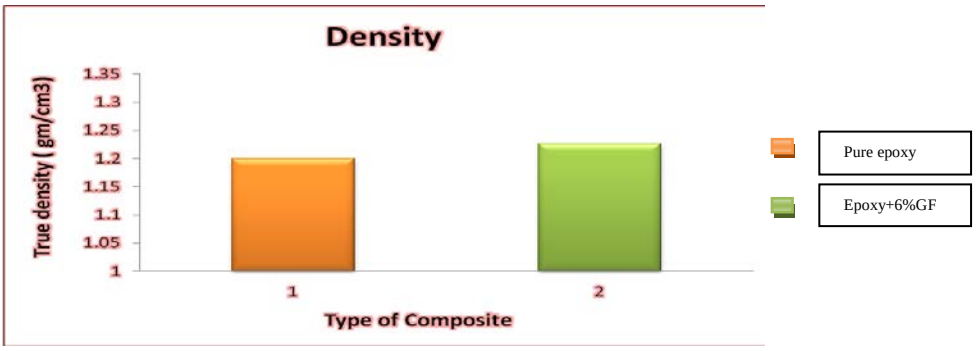


Figure (9) True density of pure epoxy and epoxy +6% glass fiber

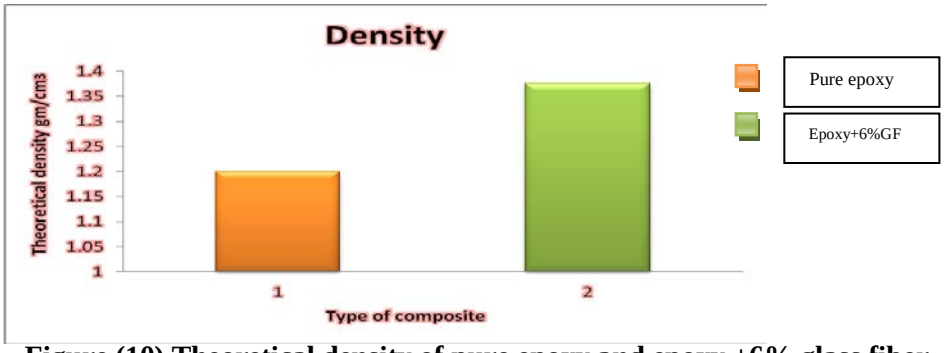


Figure (10) Theoretical density of pure epoxy and epoxy +6% glass fiber

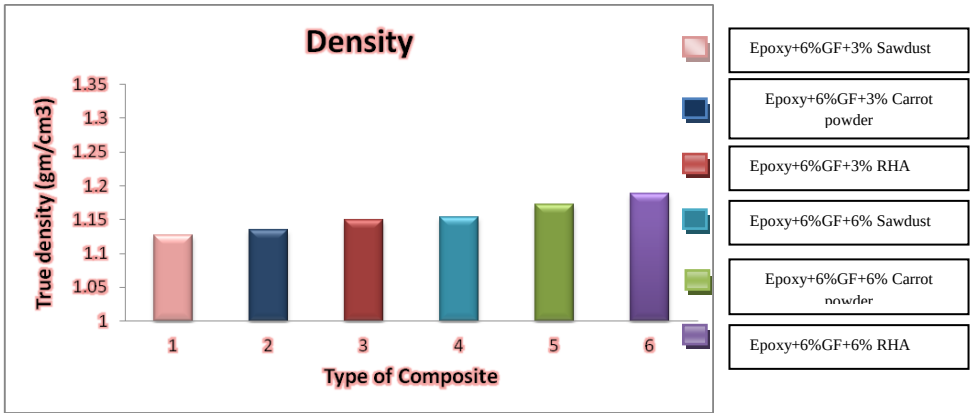


Figure (11) True density of natural composites

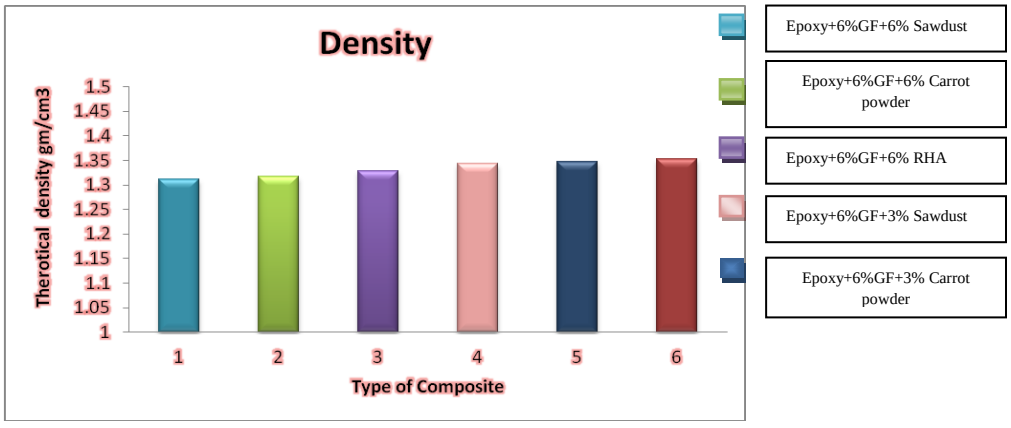


Figure (12) Theoretical density of natural composites

Water Absorption

Table (3) shows the values of water absorption for the prepared specimens (pure epoxy, epoxy +6% glass fiber and natural powder) composites. In figure (13) can be seen the specimen (epoxy +6% glass fiber) have higher water absorption than specimen (pure epoxy), the increasing water absorption percentage with increasing volume fraction (6%) of fiber depends on the rule of mixture theory where fiber have a higher water absorption percentage than the matrix. The water absorption attacked the fiber-matrix interface, causing de-bonding of the fiber and the matrix. The failures of the composite materials were due to voids and the porosity [30]. Figures (14) show the water absorption for natural composites. When comparing the values of water absorption for all of the prepared specimens composites, it can be seen that the natural composites had gave higher water absorption percentage than specimen pure epoxy and specimen epoxy +6% glass fiber composites, the increasing water absorption percentage with increasing volume fraction (6%) of fiber with filler powder . From figure (15), higher water absorption percentage of natural composite has been found (epoxy +6% glass fiber +6% sawdust) while (epoxy + 6% glass fiber +6% RHA) have lower than (carrot powder , sawdust) at a volume fraction of (6%) of glass fiber and (6%) volume fraction of filler natural powder .In this work the composite material filled with larger particles show a higher water absorption percentage when compared with composite material filled with small particles because the saturation level of fillers matrix composition influenced by agglomeration that will affect the water absorption percentage of the composite material, where mean particle size of the sawdust is (149.42 μm) while mean particle size of the RHA is (61.64 μm) and mean particle size of the carrot powder is (95.58 μm).

Table (3): water absorption of the prepared composites

Type of composite	Water absorption (%)
Pure Epoxy	0.128
Epoxy +6% Glass fiber	0.201
(Natural Composites)	
Epoxy+6%GF+3% RHA	0.320
Epoxy+6%GF+6% RHA	0.380
Epoxy+6%GF+3% Carrot powder	0.350

Epoxy+6%GF+6% Carrot powder	0.410
Epoxy+6%GF+3%Sawdust	0.370
Epoxy+6%GF+6% Sawdust	0.5

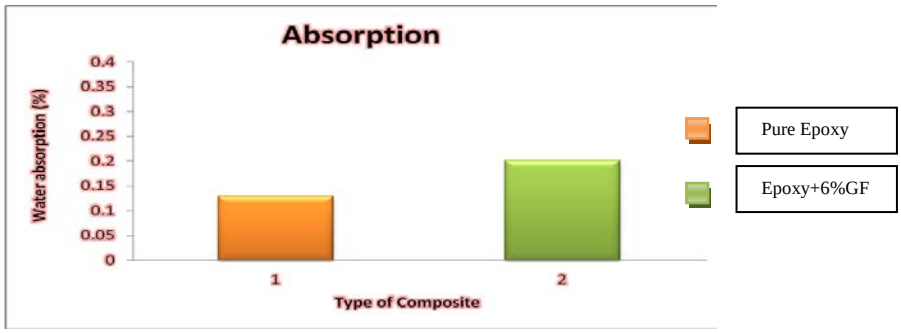


Figure (13) Water absorption of pure epoxy and epoxy +6% glass fiber

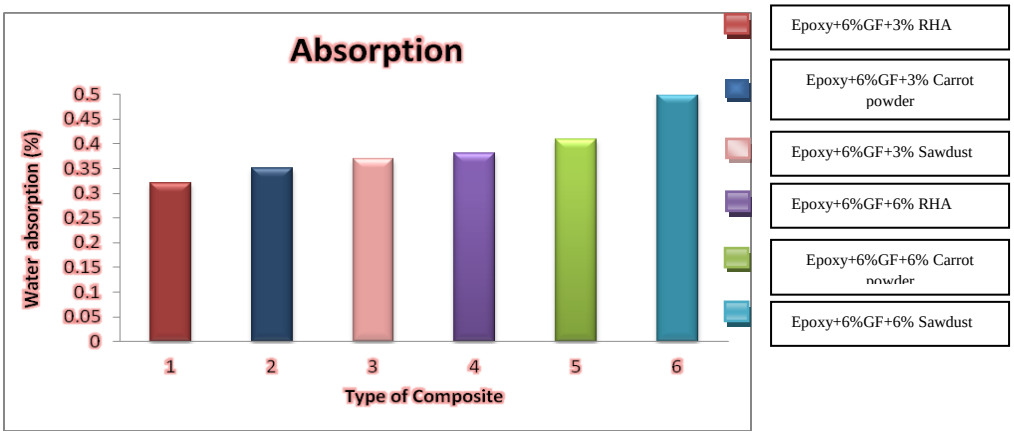


Figure (14) Water absorption of natural composites

Hardness shore (D)

Hardness test type shore (D) has been carried out on pure epoxy before and after glass fiber and powder fillers were added and the average of five readings in each case was taken to obtain higher accuracy results. Table (4) shows the values of hardness shore (D) for the prepared specimens (pure epoxy, epoxy +6% glass fiber and natural powder) composites. From figure (15), it is clear that there is a pronounced effect of the addition

of 6% glass fiber volume fraction percents on the hardness of the material. Increase in fiber content leads to a increase in the hardness, this may be due to the fact that the hardness is generally considered to be a property of the surface therefore this behavior of hardness is expected. The addition of the fiber leads to an increase in the elasticity and a decrease in the matrix surface resistance to the indentation [31], thus specimen (epoxy +6% glass fiber) have higher hardness than specimen (pure epoxy).

From the figure (16), it is clear that there is a pronounced effect of the addition of 6% glass fiber with 3% and 6% volume fraction from natural powder percents on the hardness of the material. It can be seen that the hardness increases with increasing volume fraction (6%) . Result had revealed that the hardness of pure epoxy alone was (76.4 shore D) compared to maximum value (82.7) at volume fraction of (6%) RHA with particle size is (61.64µm), the reason of the increase in hardness is that RHA contains an elements harder than the pure epoxy that lead to an increase in hardness. These results become match with our work because the RHA have particle size smaller than (carrot powder and sawdust).

Table (4): Hardness of the prepared composites

Type of composite	Hardness Shore(D)
Pure Epoxy	76.4
Epoxy +6% Glass fiber	78
(Natural Composites)	
Epoxy+6%GF+3% RHA	81
Epoxy+6%GF+6% RHA	82.7
Epoxy+6%GF+3% Carrot powder	79.5
Epoxy+6%GF+6% Carrot powder	81.5
Epoxy+6%GF+3%Sawdust	79.2
Epoxy+6%GF+6% Sawdust	81.2

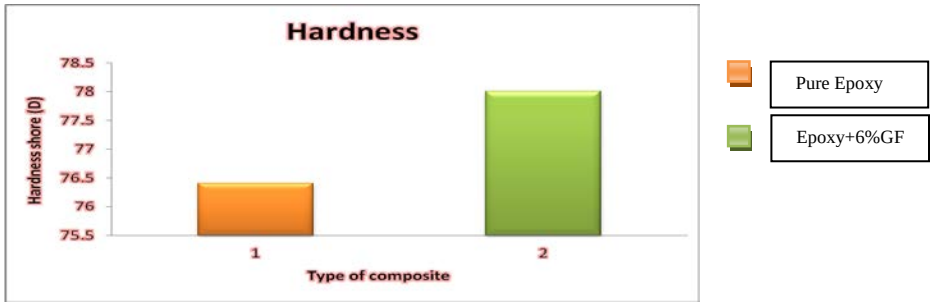


Figure (15) Hardness shore (D) of pure epoxy and epoxy +6% glass fiber

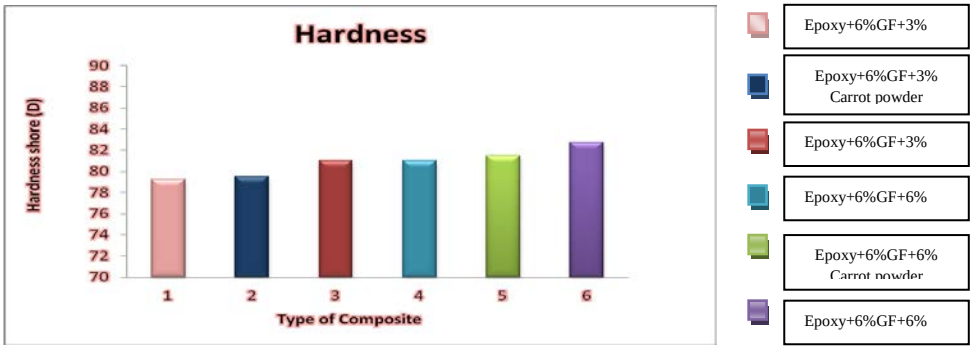


Figure (16) Hardness shore (D) of natural composites

Flexural Strength

Table (5) shows the values of flexural strength for the prepared specimens (pure epoxy, epoxy +6% glass fiber and natural powder) composites. From figure (17), it is clear that there is a pronounced effect of the addition of 6% glass fiber volume fraction percents on the flexural strength. Where specimen (epoxy +6%glass fiber) has higher flexural strength than specimen (pure epoxy) due the addition of 6% volume fraction of glass fiber and specimen (epoxy +6%glass fiber) has value hardness higher than specimen pure epoxy. From figure (18), it is clear that there is a pronounced effect of the addition of 6% glass fiber with 3% and 6% volume fraction from natural powder percents on the flexural strength of the composite material. It can be seen that the flexural strength increases with increasing volume fraction (6%) and decreasing of the particle size. Flexural strength of pure epoxy reference was (149 MPa) then an increasing had observed with increasing in volume fraction till it reached to its maximum value of (225 MPa.) by the addition of (6% glass fiber) and volume fraction of (6% RHA) with particle size is (61.64µm) these results become match with our work because the RHA has particle size smaller than (carrot powder and sawdust), this can be attributed to ductility of RHA which reducing the brittleness of composite.

Table (5): flexural strength of the prepared composites

Type of composite	**Flexural strength MPa**
Pure Epoxy	149
Epoxy +6% Glass fiber	170
(Natural Composites)	
Epoxy+6%GF+3% RHA	197
Epoxy+6%GF+6% RHA	225
Epoxy+6%GF+3% Carrot powder	186

Epoxy+6%GF+6% Carrot powder	215
Epoxy+6%GF+3%Sawdust	175
Epoxy+6%GF+6% Sawdust	205

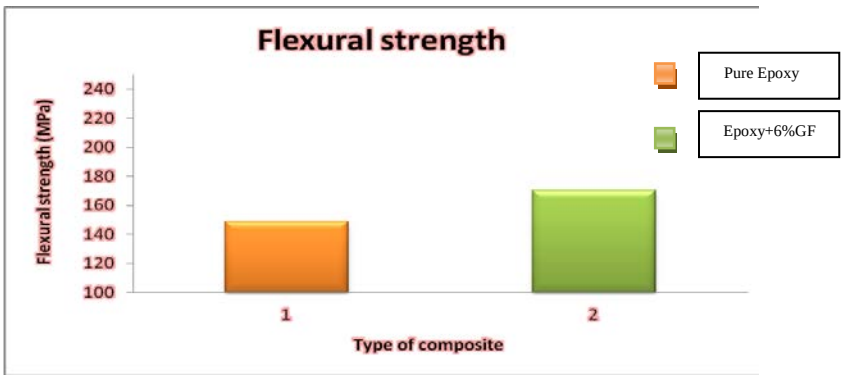


Figure (17)Flexural strength of pure epoxy and epoxy+6%glass fiber

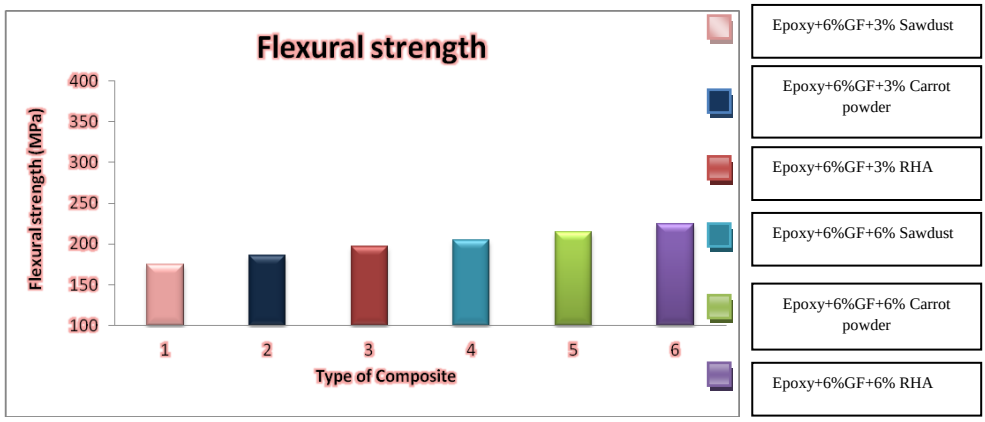


Figure (18) Flexural strength of natural composites

Shear Stress

Table (6) shows the values of shear stress for the prepared specimens (pure epoxy, epoxy +6% glass fiber and natural powder) composites. Adhesive between matrix and reinforcing material has a large effect in giving the maximum shear stress specimen that load to increase shear stress of powder/fiber reinforced epoxy to a higher amount than that of epoxy specimen alone as shown in figure (19).The specimen (epoxy +6% glass fiber + 6%RHA) composite material had a maximum shear stress of (6.20MPa.) by the addition of (6% glass fiber) and volume fraction (6%) of RHA with particle size is

(61.64µm) these results become match with our work because the RHA have particle size smaller than (carrot powder and sawdust), as shown in figure (20).

Table (6): Shear Stress of the prepared composite

Type of composite	Shear Stress Mpa
Pure Epoxy	4.65
Epoxy +6% Glass fiber	5.76
(Natural Composites)	
Epoxy+6%GF+3% RHA	5.93
Epoxy+6%GF+6% RHA	6.20
Epoxy+6%GF+3% Carrot powder	5.84
Epoxy+6%GF+6% Carrot powder	6.07
Epoxy+6%GF+3%Sawdust	5.79
Epoxy+6%GF+6% Sawdust	5.99

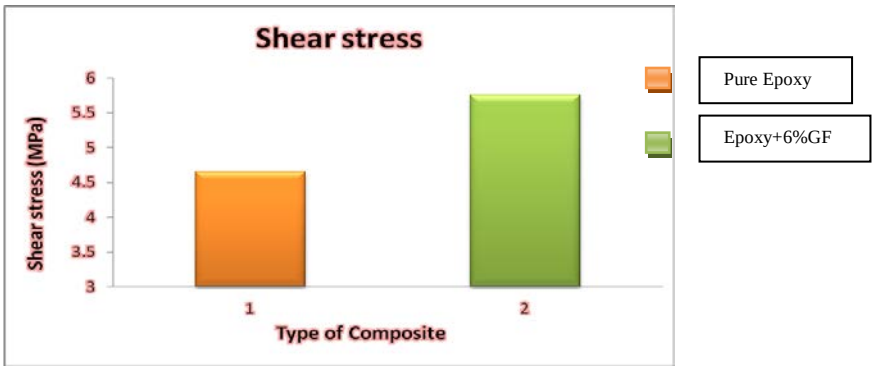


Figure (19) Shear Stress of pure epoxy and epoxy+6%glass fiber

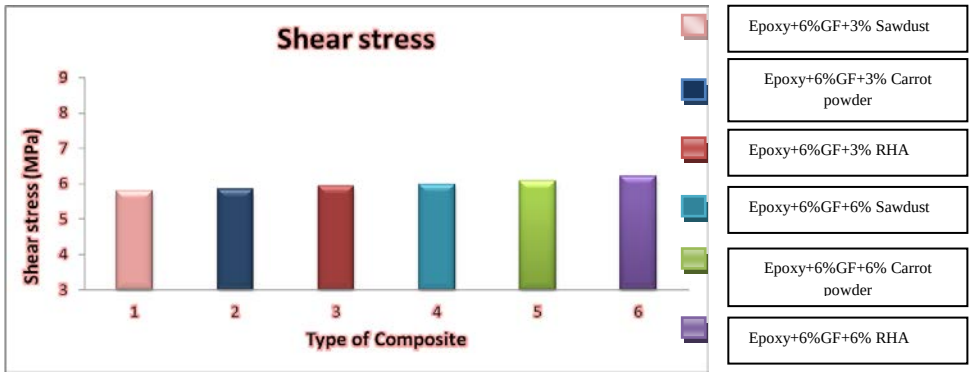


Figure (20) Shear Stress of Natural Composites

Conclusions

1. The values of true density are lower than that of the theoretical ones. Natural composite with 6% glass fiber and 6% natural powder have the higher density when compared with other composites. Natural composite with (epoxy +6% glass fiber +6%RHA) has the maximum density of (1.189) (gm/cm3) when compared with other composites.
2. The values of water absorption of specimen (pure epoxy) lower than specimen (epoxy +6% glass fibers). Natural composite with 6% glass fiber and 6% natural powder have the higher water absorption when compared with specimen (pure epoxy) and specimen (epoxy +6% glass fibers) composites. Natural composite with (epoxy +6% glass fibers +6% sawdust) has the maximum water absorption of (0.5 %)
3. Result shows that the best hardness value for (epoxy +6% glass fibers +6%RHA) was (82.7 shore D), Flexural strength value for (epoxy +6% glass fibers +6%RHA) was (225MPa) and maximum shear stress value for (epoxy +6% glass fibers +6%RHA) was (6.20MPa) at volume fraction of (6%glass fiber) with (6% RHA).

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