The Mechanical Properties of Laminated Composites Reinforced With Discontinuous and Continuous Different Fibers

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Abstract

In this paper we investigate how do the laminated composites behave mechanically when subjected to external stresses, when reinforced with continuous fibers (mat) and discontinuous fibers (chopped) and to find the effect of the fiber type on the mechanical properties. Laminated composites consisting of wood- wood and Ph-F resin as suitable adhesive were reinforced with different fibers(jute, glass, and carbon).However, two different methods of reinforcement namely, mat and chopped fibers were utilized. The mechanical properties such as (impact strength, compression strength, tensile strength, shear strength, bending strength, and elasticity modulus) of laminated composites were measured. Fibers reinforced laminated composite exhibited better mechanical properties than anreinforced composite. Furthermore, Carbon fibers reinforced laminated composite exhibited better mechanical properties than both jute and glass fibers reinforced composite. All used fibers of laminated composite showed that distribution as mat rather than as chopped, where the increase in the total strength of laminated composite was observed as mat.

Introduction

Layered composites are found in many familiar applications. Plywood composite is usually made from thin layers of wood with a suitable thermosetting resin as adhesive. The layers of wood provide the bulk of the strength, while the resin acts as a semi-rigid binder[1]. As a result, laminates formed from bonding layers of wood by organic adhesive exhibit distinctive properties from these of the individual ply (lamina) that its usually used for makin the composite. Laminates such as metal to metal, metal to ceramic, metal to polymer, polymer to polymer, ceramic to polymer, ceramic to ceramic are also good examples of laminated composites[2].Adhesion is the interaction between the two different substrates across an interface which may involve either physical or chemical bonding. Chemical bonding consists of direct interlinking between molecules by covalent or ionic bonds. The physical bonding may result from mechanical interlocking or from the forces of physical adsorption between adhesive molecules and substrate molecules, or by the penetration of adhesive molecules into substrate by diffusion. Thus, the mechanism of adhesive action is quite different according to the type of reaction[3].The advantage of fiber reinforcement is two-fold: i- enhancement of the mechanical properties such as strength, stiffness and heat deflection temperature, ii- increase of the toughness of the matrix, so that more energy is required to initiate and propagate fracture[4]. In the fibers reinforced materials, the stress is carried almost entirely by the fibers and the matrix is used to 1- bind the fibers together (by cohesion and adhesion),2-transmit the stress from one fiber to the other(distributes load evenly among fibers),3-provides resistance for a composite to crack propagation,4- protect the fibers from the environment,5- keep reinforcing fibers in a desired orientation[5]. However, we must consider the factors in the design of fibers reinforced composites. They are the aspect ratio, volume fraction, type of fiber(metallic, glass, carbon, ceramic, polymer, and whisker) ,critical length for chopped fibers, and the method of reinforcement. It may be classified as continuous fibers along the matrix , orthogonal fibers, mat (in which the continuous fibers are distributed equally along the matrix longitudinally and transversely to give the form of mat or net), and chopped fibers (discontinuous) [6]. Many researches studied the effect of adhesive on the mechanical properties for laminated composites[7,8,9]. The aim of using the resin as a binder among thin layers is to produce laminated composites with a high strength. So we seek to increase strength of these systems via the reinforcement with fibers and better choice of fiber type and distribution within the resin. In a previous article [10] we reported the effect of continuous fibers distribution regarding (length, width, orthogonal, and mat) method, on the mechanical properties for laminated composites by using glass fibers. It was found that fibers reinforced laminated composites exhibit better mechanical properties than anreinforced composites. Furthermore, the increase in the total strength of laminated composite was observed as mat. This paper aiming to compare the mat (continuous fibers) with chopped (discontinuous fibers) and effect of fiber type through choosing three fibers(jute, glass, and carbon) on the mechanical properties such as impact strength, compression strength, tensile strength, shear strength, bending strength, and elasticity modulus of laminated composite.

Experimental

We have prepared and tested 42 samples of laminated composites reinforced by jute, glass, and carbon fibers with 22wt% .They were manually distributed on adhesive by two methods (chopped and mat) .Laminated composites consisting of wood-wood and resin reinforced with fibers were prepared in polymer searches unit, College of Science ,University Al-mustansiriya through many steps.The first was started with putting the solvent ethanol (15ml) in flask to dissolve Ph-F(phenol-formaldehyde)resin by using water bath at controlled temperature (70^{o}C). The reaction was stirred and heated for 30min until the solution becomes turbid and then adding the bonding system (talk powder 8%), Hexamethyletetraamine(H.MTA. 10%), and resorcinol(4%). Finally we fix Ph-F resin reinforced by jute, glass, and carbon fibers between wood surface of various dimensions. The prepared samples were heated at 120 ^{o}C under pressure to obtain the final solid product .For the investigation of structure of laminated composites, we studied the microstructure of the prepared specimens by the optical microscope of the type (Olympus).The micrographs of polishing surface texture of anreinforced and reinforced laminated composites are shown in Figs.(1,2,3) by using images analysis with software of type VCIA,G,version 4.81.

Charpy impact instrument was used for impact test ,where the samples are prepared with dimensions 10x10x55mm according to (ISO-179). Hydraulic piston type Leybold Harris No.36110 was used to measure the compressive strength of samples at room temperature . ASTM-D695 method was used for the preparation of the samples with the length double the width to obtain the ratio 2:1 and the thickness was equal to its width. Bending test of rectangular samples with dimensions of (10x135mm)was carried out according to ASTM-D790. Tensile strength , modulus of elasticity ,and shear strength were determined by Zweigle instrument according to ASTM-D648, where the crosshead speed was 5mm/min at room temperature. These testes are carried out in physics laboratory, Department of Applied Sciences, University of Technology.

Results and Discussion

The resultant mechanical properties of the (standard) anreinforced and reinforced laminated composites are showed in figures(4-15). Three different types of fibers were used to study the effect of fiber type. Figs.(4-9) show the plots of impact strength, compression strength, tensile strength, shear strength, bending strength, and elasticity modulus of the (jute,glass,carbon) fibers reinforced and standard composites versus fibers distribution. Where the symbols (s, ch, m), indicates; standard, chopped, and mat respectively. It is observed that as mat gives better results compared with chopped way through increasing of impact, compression, tensile, shear strength, and elasticity modulus as shown in Figs.(4-8) due to the fibers which form mat carry and transmit the stress together to produce higher modulus and higher energy absorption for the composite while random (chopped) fibers produce lower modulus and low energy absorption for the composite . Also It is observed the decrease of deflection and then the increase of bending strength of composite are due to the reinforcing fibers, specifically as mat with carbon fibers as illustrated in Fig.(9). Moreover, Figs.(4-9) ensure that the presence of the reinforcing fibers would strengthen the composite. After choosing mat as an alternative method we have studied the effect of type of the fiber through the results showed in Figs(10-15) where the carbon fibers gave more strength of the mechanical properties of the laminated composites compared to glass and jute fibers because of the carbon fibers have higher modulus compared to glass and jute fibers .

Conclusions

The experimental results give rise to the conclusion that laminated composites reinforced with continuous fibers, as mat, exhibit better mechanical properties than discontinuous chopped fibers .Also the fiber type affects the mechanical properties of laminated composites, where carbon fibers gave better strength than others fibers (glass and jute).

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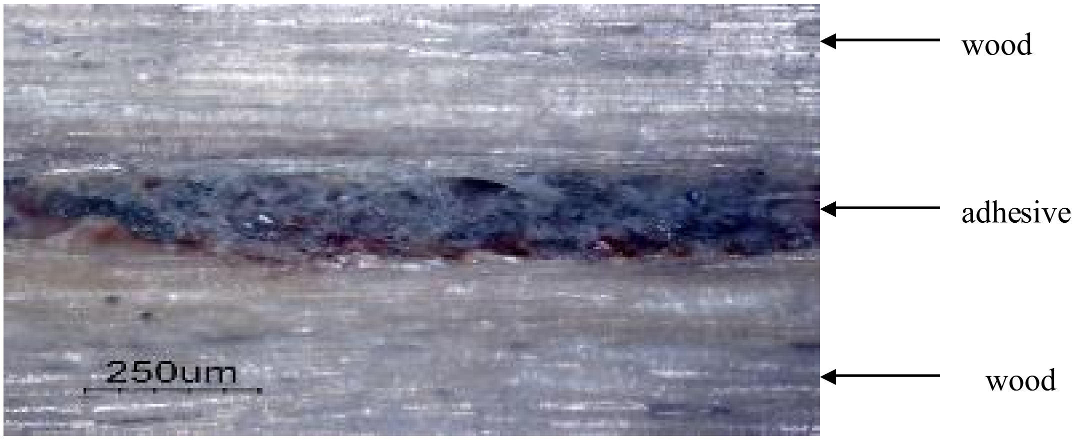

Fig(1): The optical micrograph(100x) of wood- adhesive - wood

Fig.(2): The optical micrograph(100x) of wood- adhesive - wood reinforced with mat fibers

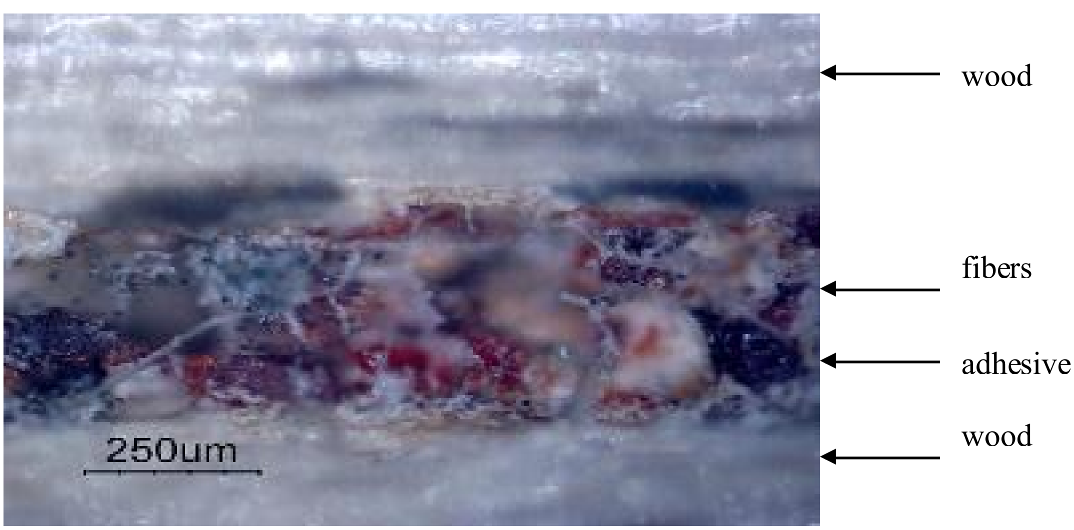

Fig.(3): The optical micrograph(100x) of wood- adhesive - wood reinforced with chopped fibers

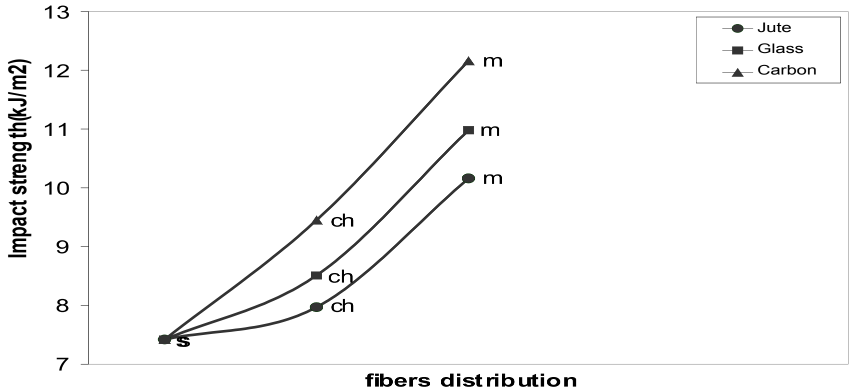

Fig.(4):Effect of fibers distribution on the impact strength.

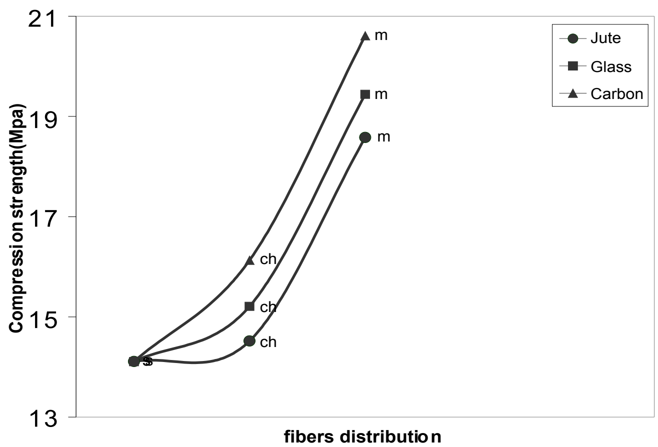

Fig.(5):Effect of fibers distribution on the compression strength.

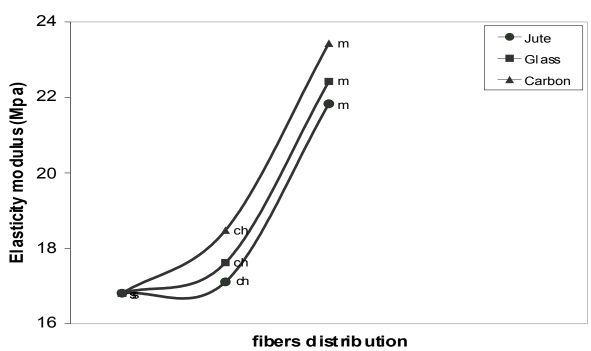

Fig.(6):Effect of fibers distribution on the elasticity modulus.

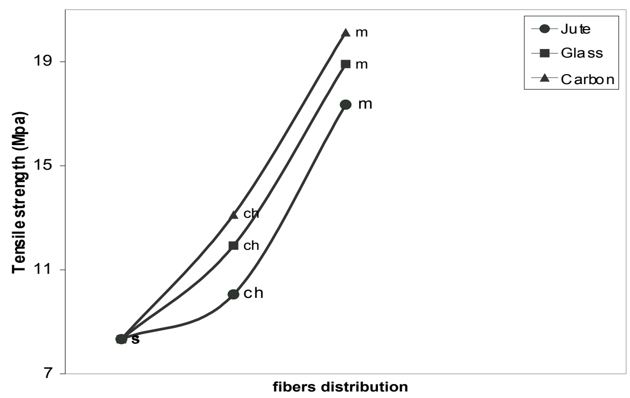

Fig.(7):Effect of fibers distribution on the tensile strength.

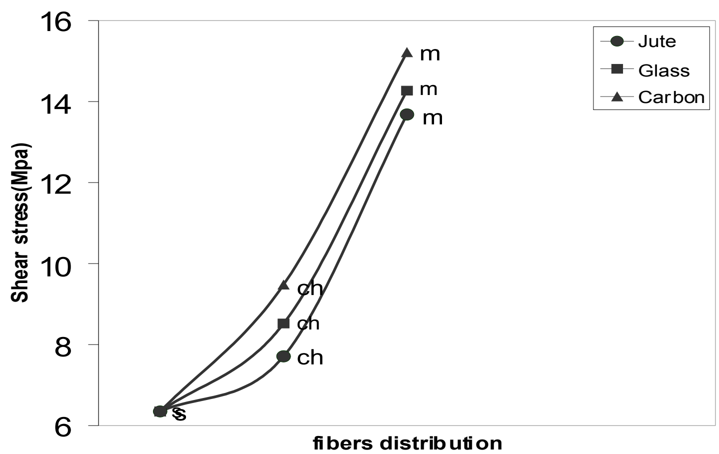

Fig.(8):Effect of fibers distribution on the shear stress.

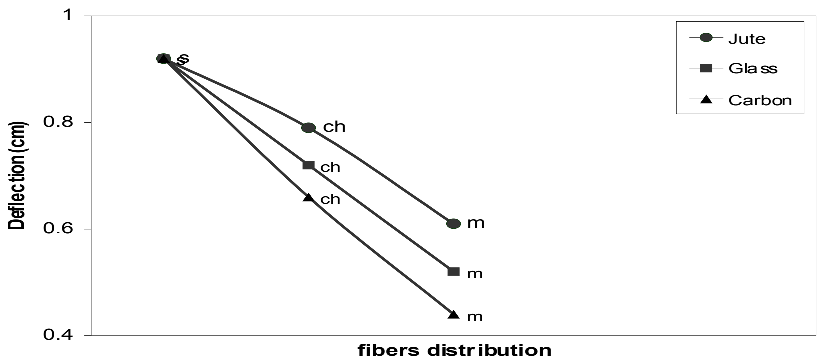

Fig.(9):Effect of fibers distribution on the deflection at load 250g.

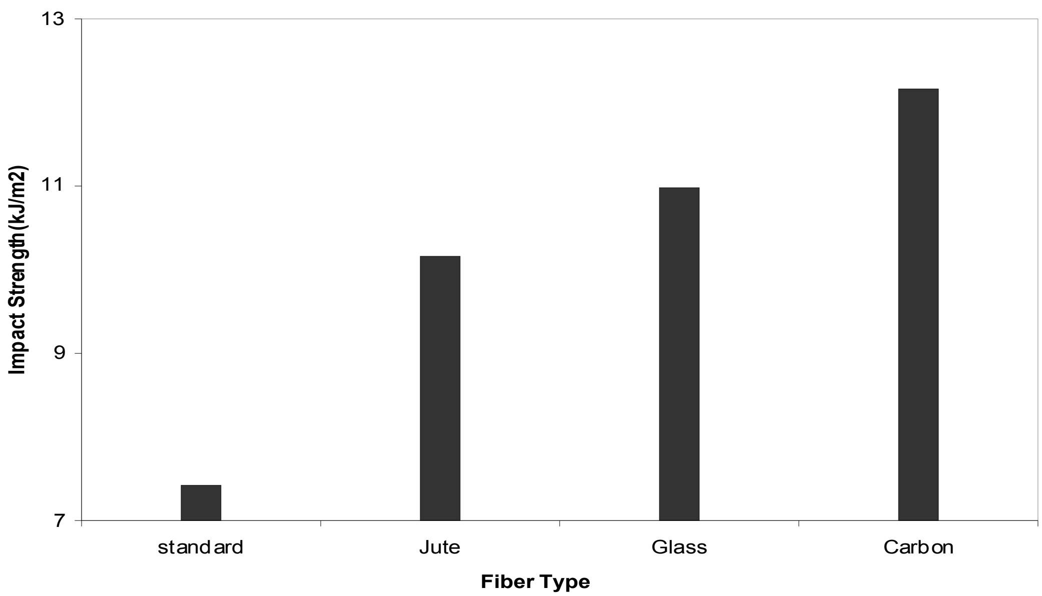

Fig.(10):Effect of fibers type reinforced with mat way on the impact strength..

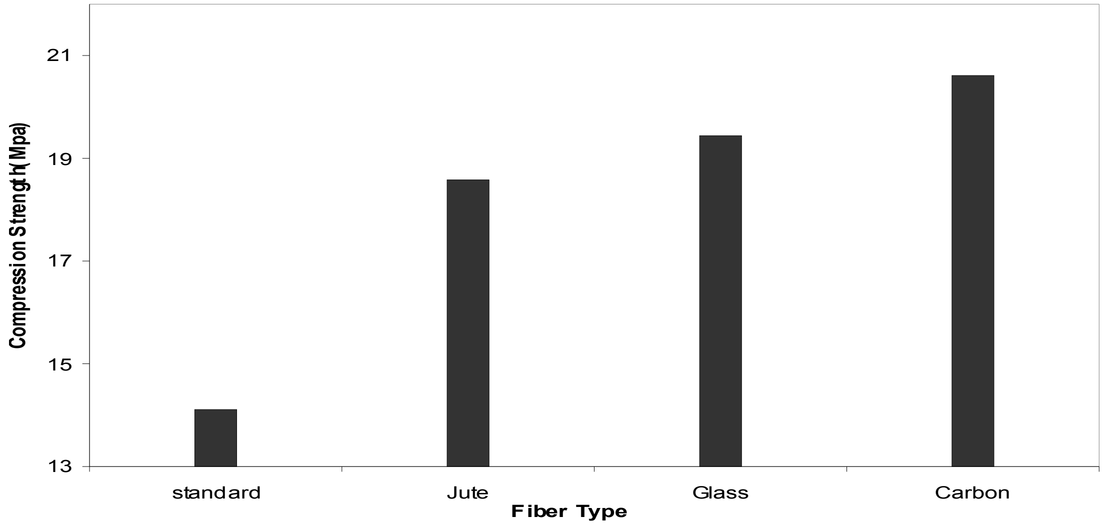

Fig.(11):Effect of fibers type reinforced with mat way on the compression strength.

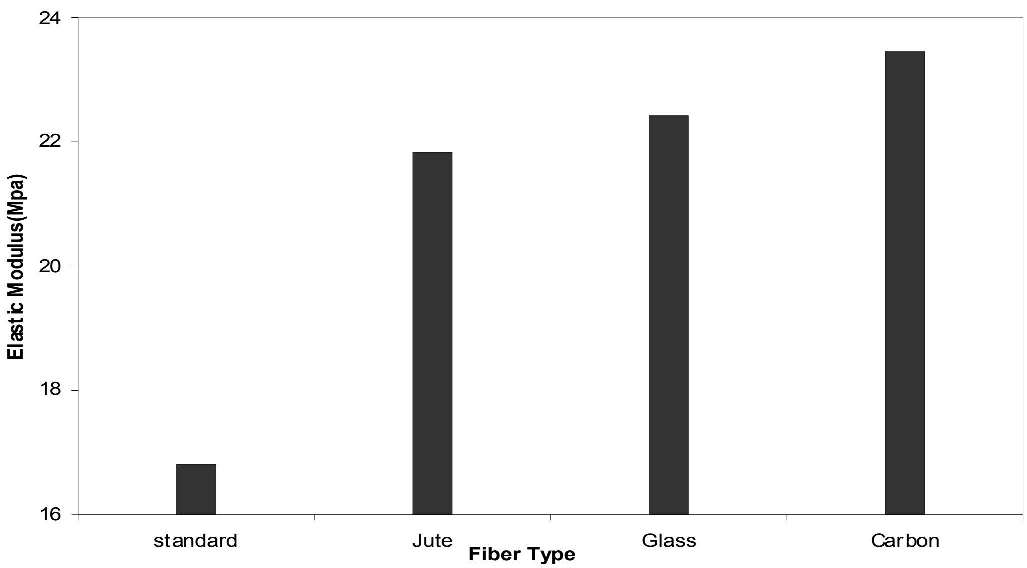

Fig.(12):Effect of fibers type reinforced with mat way on the elasticity modulus.

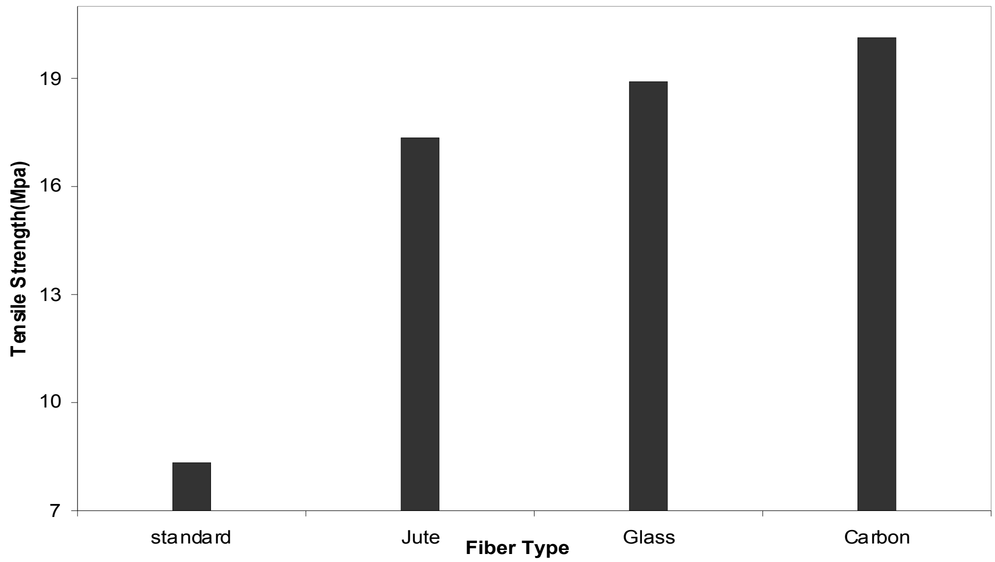

Fig.(13):Effect of fibers type reinforced with mat way on the tensile strength.

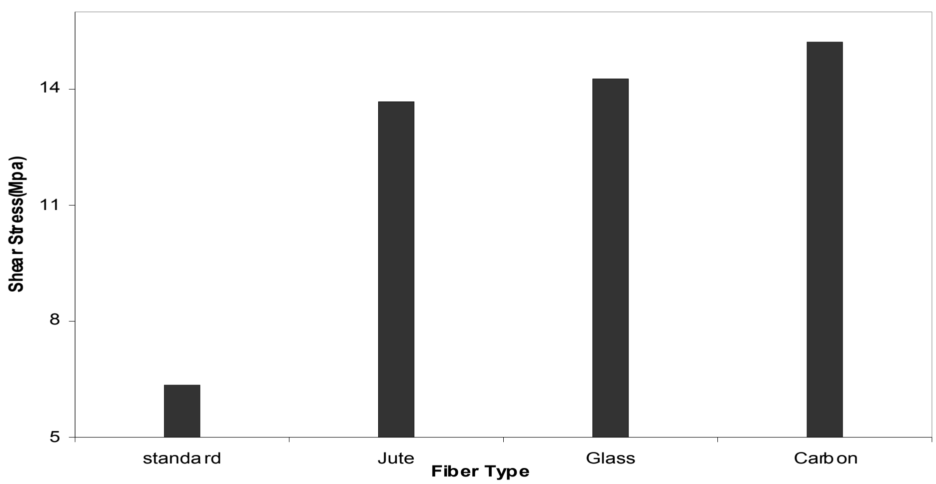

Fig.(14):Effect of fibers type reinforced with mat way on the shear stress.

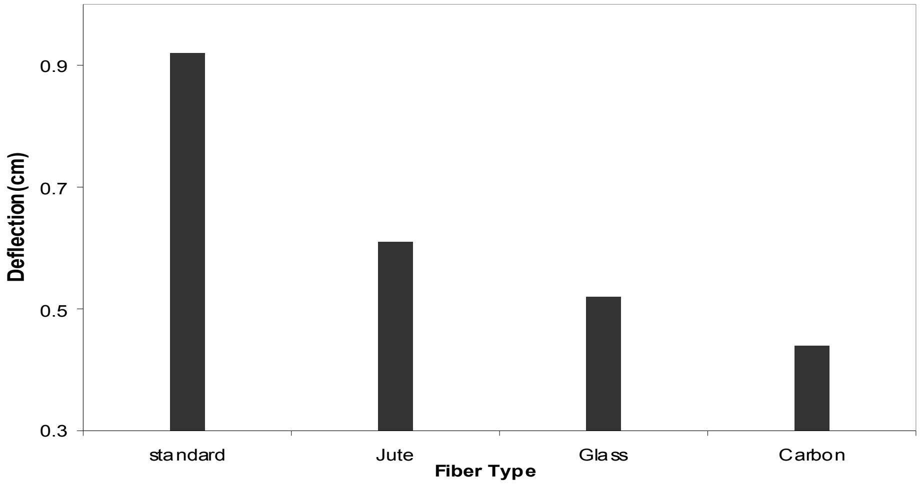

Fig.(15):Effect of fibers type reinforced with mat way on the deflection at load 250g.

الخواص الميكانيكية للمواد المتراكبة الطبقية المعززة بألياف مختلفة مستمرة وغير مستمرة

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الخلاصة

نتحرى في هذا البحث عن التصرف الميكانيكي للمواد المتراكبة الطبقية المعززة بألياف مستمرة بطريقة الحصيرة و ألياف متقطعة عندما تخضع للجهود الخارجية. و ما تأثير نوع الليف على الخواص الميكانيكية.

عززت المواد المتراكبة الطبقية المكونة من خشب–خشب و الراتينج hP–F لاصقا مناسبا بألياف مختلفة مثل:(ألياف الجوت ،و الزجاج ،و الكاربون).عززت هذه الألياف بطريقتي الحصيرة و الألياف المتقطعة، قيست الخواص الميكانيكية (مقاومة الصدمة و مقاومة الانضغاط ومقاومة الشد و مقاومة القص و مقاومة الانحناء و معامل المرونة) للمواد المتراكبة الطبقية وظهر أن الخواص الميكانيكية للمواد المتراكبة الطبقية المعززة بألالياف أفضل مما للمواد المتراكبة الطبقية غير المعززة، فضلا عن ذلك المواد المتراكبة الطبقية المعززة بألياف الكاربون أظهرت خواصا ميكانيكية أفضل من المواد المتراكبة الطبقية المعززة بألياف الجوت و الزجاج.جميع الألياف المستعملة قي تعزيز المواد المتراكبة بينت أن طريقة الحصيرة أفضل من طريقة الألياف المتقطعة، من خلال الزيادة الملحوظة في المقاومة الكلية للمواد المتراكبة الطبقية عند استخدام طريقة الحصيرة