Effect of Water on Some Mechanical Properties for Sawdust and Chopped Reeds /UPE composites

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Abstract:

In this study, composite materials were prepared using unsaturated polyester resin as binder with two types of fillers (sawdust and chopped reeds).
The molding method is used to prepare sheets of UPE / sawdust composite and UPE / chopped reeds composite.

The mechanical properties were studied including flexural strength and Young's modulus for the samples at normal conditions (N.C). The Commercial wood, UPE and its composite samples were immersed in water for about 30 days to find the weight gain (M_t%) of water for the samples, also to find the effect of water on their flexural strength and Young's modulus.

The results showed that the samples of UPE / chopped reeds composite gained highest values of flexural strength (24.5 MPa) and Young's modulus (5.1 GPa) as compared with other composites at (N.C).

The results showed that the wet samples of sawdust composite have lowest values of weight gain (M_t %) of water (0.043%) as compared with other composites after immersion. Also it's showed a slight decrease in values of Young's modulus for all the samples after immersion as compared with the samples at (N.C).

Finally it's showed a slight decrease in values of flexural strength for all the samples except for the composite material formed from UPE / chopped reeds which showed an increase in the value of flexural strength after immersion, where the wet samples of UPE / chopped reeds composite gained (29 MPa) as compared with the samples at (N.C).

Key words : Composite, Sawdust, Chopped reeds, Commercial wood

Introduction :

Composite materials are defined as a materials consisting of two or more physically distinct phases, suitably arranged or distributed, the continues phase is referred to as the matrix, while the distributed phase is called the fillers. Three things determine the characteristics of a composite: the matrix, the fillers and the interface between them [1, 2].

Over the past two decades, natural plant fibers have been receiving considerable attention as the substitute for synthetic fiber reinforcement such as glass in plastics [3,4].

There are environmental and economical reasons for replacing part of the plastics with wood but the wood could also work as reinforcement of the plastics. The elastic modulus of wood fibers is approximately 40 times higher than that of polyethylene and the strength about 20 times higher [5].

Fillers are most widely used additives in polymer composition. They are used in all plastics, natural and synthetic rubber, and in coating. The main reason for their use is the need for cheaper materials or for significant improvement in some

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properties (rigidity, strength, toughness resistance to temperature, etc.) of the polymer matrix [6, 7].

The environmental awareness of people today is forcing the industries to choose natural materials as substitutes for non-renewable materials. Wood has been used as building and engineering material since early times and offers the advantages of not just being aesthetically pleasing but also renewable, recyclable and biodegradable [8].

Wood fiber and polymer composites (WFPC) are normally produced by mixing wood fiber with polymer, or by adding wood fiber as filler in a polymer matrix, and pressing or molding under high pressure and temperature [9].

Diffusion is the process which matter is transfer from one part of the system to another as a result of random molecular motion of a single molecule that can be described in terms of the "random walk". The solution penetration into polymer matrix composites involves three mechanisms:-

1. Diffusion of solution into the matrix directly and to a much lesser extend, in to the filler material.
2. Flow the solution molecules along the filler-matrix interface, followed by diffusion into the bulk matrix.
3. Transport of solution through micro cracks or other forms such as pores or small channels [10].

The aim of this work is to:-

1. Fabrication of UPE / sawdust and UPE / chopped reeds composites.
2. Evaluation of mechanical properties of the composites such as flexural strength and Young's modulus.
3. A many countries, which have suffered for rain and high humidity, some type of wood absorbed water and swell, absorbed water will reduction the mechanical property for woods. In this research sawdust and reeds will be used to prepare composites resistance to water, and have good mechanical properties.
4. Besides all these the main objective is to develop a low cost natural fillers based composite that can be used for commercial usage.

Materials and Methods:

(A) Raw Materials

The materials used to prepare the composites are unsaturated polyester (UPE) resin type (A-50) with the hardener MEKP and with accelerator cobalt naphthenate (having a symbol SIR SIROPOL) which was supplied from Saudi industrial resin CO. LTD, p.o.box 7764, Jeddah 21472, kingdom of Saudi Arabia, commercial wood blocks were supplied by wood co. (Iraq-Baghdad), which were used as standard samples and two types of fillers materials were used:

1- Sawdust (S.D) was obtained from carpentry and wood- working processes and supplied by wood co. (Iraq-Baghdad). The average lengths of sawdust used in this work were in the range of (5–20 mm) as shown in Figure (1-a).

2- Chopped reeds (C.R) were obtained from the marshes in south of Iraq, the average lengths of chopped reeds used in this work was in the range of (5–30 mm) as shown in Figure (1-b).

Fig. (1) (a) Photograph shows sawdust (S.D) (b) Photograph shows Chopped reeds (C.R)

(B) Cast Mould

The cast mould used for casting the polymeric specimens and composites, which was shown in Figure (2) made of iron which consist of two plates, the first one acts as a base with (300 mm × 300 mm × 10 mm) dimension. This plate should polish without any defect. The second plate used as a cover putting on the first plate to make symbols thickness uniform. This plate has dimension (200 mm × 200 mm × 10 mm) fixed with Compression machine to press the symbol. The four sides of the base were made of iron that connected to the base strips. These sides were removable, so that the symbol was easy to move, when it dries. Before casting, the iron plates were cleaned to remove the dirt and dust that were presented on the surfaces. The plates were dried in an oven, the base and the cover of the iron plates were coated with wax.

(a) (b)

Fig. (2): (a) Photograph of cast mould. (b) Photograph of press apparatus.(C) Composites Preparation

The sawdust fillers and chopped reeds fibers were passed to heat treatment in an oven at 100 ˚C for 24 h until the weight of the sawdust and reeds were constant. It was necessary to remove the residual moisture in the sawdust fillers and reeds fibers, which could greatly affect the mechanical properties of the composites.The composites were prepared from UPE resin (as a matrix) with weight (210 gm) was added to sawdust with weight (50 gm) [or to chopped reeds with weight (75 gm)] by molding method which can be summarized by the following steps:

1.Determine the Weight sawdust (or chopped reeds) by using a sensitive balance (Four digits). Determine the weight of resin and its hardener and mix them carefully.Mix the content thoroughly in a clean disposable container by a fan type stirrer before casting it as sheets (of dimensions 200 mm × 200 mm × 10 mm) by using iron mould.Leave the composite at room temperature about 24 hours and then for post-curing, the sheets were left for 4 hours in an oven at temperature 70C˚.

(D) Bending Test sample cutting

The sheets of the composites are cutting into specimens, by using a circular iron saw, pluses from the samples were removed by using the iron rasp, the samples were polished by using abrasive emery papers of grade 400.The shape and dimension of the samples cut for bending test according to [ASTM-D790-84] shown at Figure (3) and Figure (4).

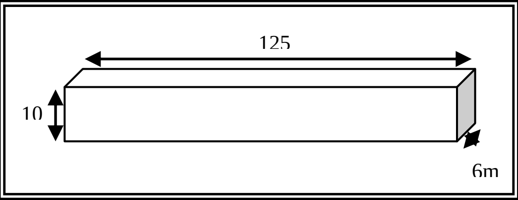

Fig. (3) Dimensions of Flexure Test Specimens(in mm) [ASTM-D790-84]

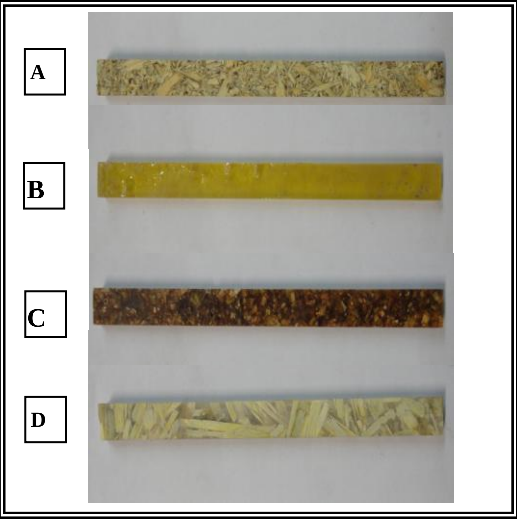

Fig. (4) Photograph of Flexure Test Specimens before Testing. (A) Commercial wood (B) Pure UPE resin (C) Sawdust composite and (D) Chopped reeds composite.

Three – Point Bending Test

Bending tests were carried out by using an Instron universal testing machine of (5KN) full scale load capacity, accords to ASTM standard (D-790), this test method covers the determination of flexural properties of unreinforced and reinforced plastics in the form of rectangular bars molded directly or cut from sheets, plates or molded shapes. In this method the bar tests on two supports and is loaded by means of a loading nose midway between the supports [11].

Water Immersion

The test samples of polyester resin and its composites were immersed in distilled water for (30 days), the immersion test was performed under ambient temperature. The samples removed from water every 24 hours and weighted by using analytical balance (type: Sartorius, H51, made in Germany) of accuracy 10^{-4} gm. For every measurement, the specimens were wiped to remove surface condensation. In addition, the weighting process was carried out in a very short time period to minimize the effects of discontinuity in the moisture absorption process. The weight gain percentage (M_t %) was calculated by using the following equation [12] :

$$M_t \ \% = \frac{W(t) - W_0}{W_0} \quad \ldots\ldots\ldots\ldots \ (1)$$

Here, W (t) is the total weight at time (t) and W_0 is the reference dry weight of the specimen.

Results and Discussion:

(A) Flexural Strength and Young's modulus of UPE Resin

Flexural strength is a measure of the resistance of material to be bend, when it goes under bending moment. During bending, the material undergoes gross flexural deformation before fracture, because the material is exposed to three types of stresses. The convex side of the material is extended (in Tension mode), while the concave side is compressed (in compression mode) and at the same time, the internal layers of the material shear each other [13].

According to the results, figure (5) shows the flexural stress – flexural strain curve for polyester resin, the curve almost predicts two regions, linear (elastic) and non linear (plastic) regions [14]. The linear region of the curve, shows that the applied stress on the specimen is distributed on the backbone of the polymer, because of the UPE has cross-linking between the backbone chains restrict the movement of these chains under bending stresses [15].

On the nonlinear region the specimen is deformed, this can be explained because of the concentration of the stresses at the lower region of the specimen (the convex side) where the specimen is extended, the stress will be constricted at the ends of crazes, which is grown to form the micro cracks, these micro cracks will be accumulated together to form the main crack, which pass through the specimen until the fracture occurs [16].

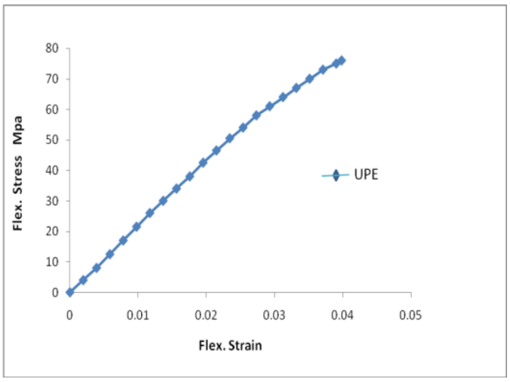

Fig. (5) Flex. Stress – Flex. Strain curve strain for UPE.

B) Flexural Strength and Young's modulus of Composites

From the obtained results the behavior of curves show different characteristics according to the filling material and its properties (weight percentage, particles size, shape, density, etc). During the flexural test for composites, there are three factors dominate the resulting flexural strength of a specimen; the flexural strength of the matrix, the adhesion between fillers and matrix and the adhesion between the shape and the characterization of filling materials. This means that, the last two factors are effect on the original strength of the matrix, and these two factors would lead to distribute the applied force on the cross-sectional area of the composite under test.

According to the results shown in Table (1) and Figure (6) which show the flexural stress – flexural strain curves of Commercial wood, UPE / Sawdust and UPE / chopped reeds composites. It is shown that values of flexural strength and Young's modulus (E) for Commercial wood are lesser than other composites. The flexural stress for commercial wood decreases due to others properties. The decreasing of adhesion between the binder and fillers leads to increase the slip between fillers, then applied stress will increase the propagated cracks among fillers. Figure (7) shows photographic image for fracture regions of Commercial wood sample.

Also according to the results shown in Table (1) for chopped reeds composite have the values of flexural strength higher than other composites due to UPE resin which is a good binder with chopped reeds, this reason will reflect to give high values of fracture strength. The applied stress at sample will distribute between matrix and reeds. This means that flexural strength will increase. It has high value of Young's modulus due to the density and stiffness (rigidity) of reeds. Figure (8) photographic image for fracture regions of chopped reeds composite shows pullout reeds on matrix.

As for sawdust composite samples, it have value of flexural strength lower than chopped reeds composite due to the sizes of sawdust less than chopped reeds that lead to decrease the adhesion between matrix and sawdust. Figure (9) shows photographic image for fracture regions of sawdust composite.

Table (1) Values of Flexure Stress and Bending Modulus for Commercial wood, UPE and its Composites.

Materials	S_f(MPa)	E(GPa)
UPE	76	2.1
C .W	12	1.4
UPE + S.D	21.5	2.6
UPE + C.R	24.5	5.1

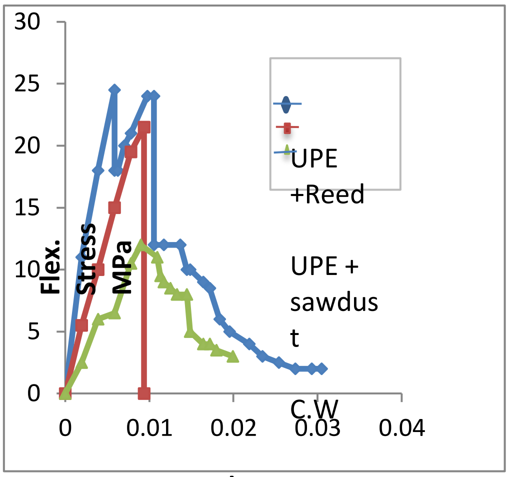

Fig. (6): Flex. Stress – Flex. Strain curves for commercial wood and polyester composites

Fig. (7) photographic image shows for fracture regions for commercial wood sample.

Fig. (8) photographic image for fracture regions for reeds composite sample.

Fig. (9) photographic image for fracture regions of sawdust composite.

(C) Effect of water

The Commercial wood, UPE and its composites samples were immersed in water about (30 days) to find the effect of water on their flexural strength and Young's Modulus.

Weight gain (M_t%) of water has been calculated from equation (1), and the values are listed in Table (2), it was showed that the samples of commercial wood have relatively high values of weight gain (M_t%) of water as compared with sawdust and reeds composites. The reason behind this was ascribed to the degradation of the binder or weakening of the interaction between fillers lead to penetration of water to the fillers of commercial wood, this would swell and plasticize that samples. The swelling causes changing in dimension and weight of samples. This changing depended on percentage of weight gain (M_t%) of water for sample.

In the same Table, it is shown that the samples of UPE \ sawdust composite have a lowest value of weight gain (M_t%) of water due to the adhesion between matrix and sawdust reduction penetration of water to the material. Also UPE resin has absorption of water lesser than binder in commercial wood. The changing in dimension and weight was little. Figure (10) shows the comparison values of weight gain (M_t%) of water for composites.

While samples of UPE \ chopped reeds composite have amidst value of weight gain (M_t%) of water between above value of commercial wood and UPE / sawdust composite. Figure (11) shows changing the values of weight gain (M_t%) of water of the samples after immersion time.

Table (2) Values of Weight Gain (Mt %) for Commercial wood, UPE and Its Composites after immersion.

Materials	Weight Gain (M_t %)
C .W	0.941373534
UPE + S.D	0.043316832
UPE + C.R	0.144196952
UPE	0.004149

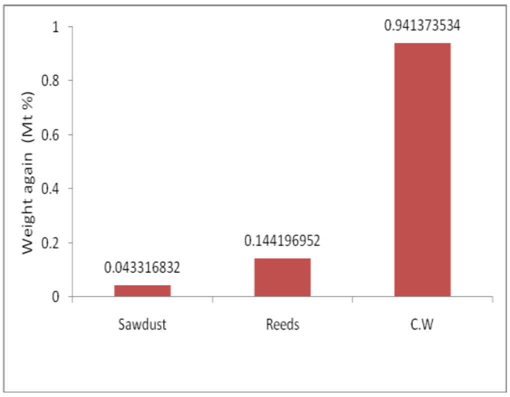

Fig. (10) Shows the comparison values of weight gain (M_t%) of water for composites after immersion.

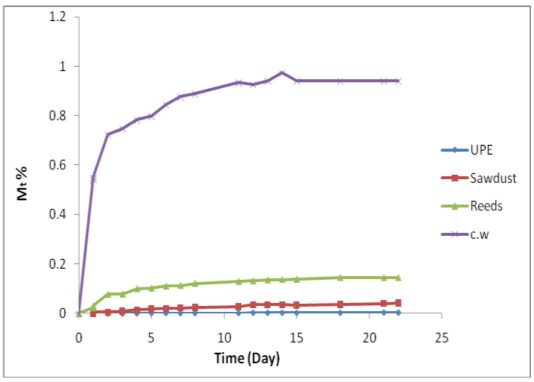

Fig. (11) Changing the values of weight gain (M_t%) of water of the samples after immersion time.

However the reason behind, this test is that water causes degradation in the properties of most composite material with polymeric matrixes [17].

Many of the polymers used in composites; (including UPE) take some percentages of water if they are immersed in it for some time. This would swell and plasticize them, causing a reduction in (E) [18]. Table (3) and Figure (12) showed the flexural stress – flexural strain curves of Commercial wood, UPE / sawdust and UPE / chopped reeds composites after immersion in water for (30 days).

Table (3) showed a slight decrease in values of Young's Modulus for all the samples after immersion. The reduction in the value of Young's Modulus for the samples after being subjected to water was due to the plasticization effect and reduced interfacial adhesion between the fillers and the matrix.

Also Table (3) showed a slight decrease in values of flexural strength for all the samples except for the composite material formed from UPE / chopped reeds which showed an increase in the value of flexural strength after immersion for (30 days).

As for commercial wood, the reason behind the reduction in the flexural strength values after immersion is ascribed to the degradation of the binder or weakening of the interaction between fillers. Another reason is penetration of water to the voids and cracks that lead to growth a big cracks reduction the mechanical properties of material. Figure (13) shows photographic image for fracture regions for commercial wood sample. As for chopped reeds composite, the increase in values of flexural strength after immersion is due to penetration of water to matrix was little whereof helped the chain to move pass each other. Figure (14) photographic image for fracture regions shows pullout of fiber after fracture for UPE / reeds composite sample. While sawdust composite, has amidst value of flexural strength after immersion in comparison other composites. Figure (15) photographic image for fracture regions of sawdust composite.

Table (3) Values of Flexure Stress and Bending Modulus for Commercial wood, UPE and Its Composites after immersion

Materials	S_f(MPa)	E(GPa)
UPE	90	2.5
C .W	3	0.28
UPE + S.D	19	0.19
UPE + C.R	29	0.96

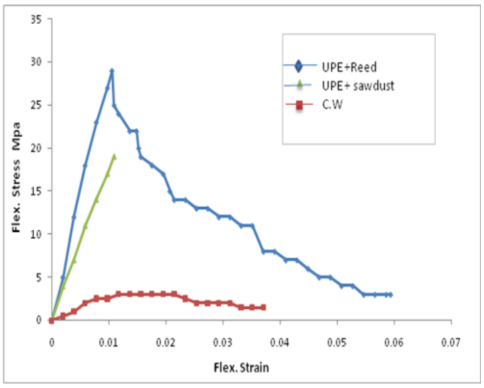

Fig. (12): Flex. Stress – Flex. Strain curves for commercial wood and polyester composites after immersion

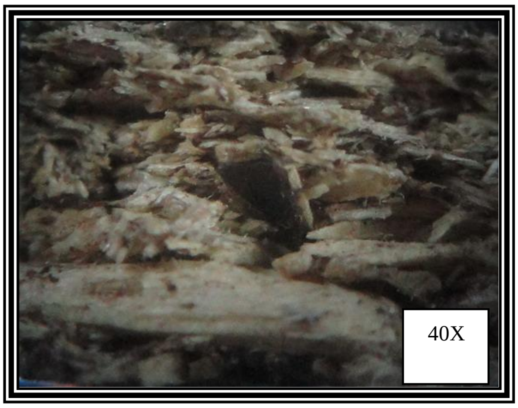

Fig. (13) photographic image shows for fracture regions for commercial wood sample.

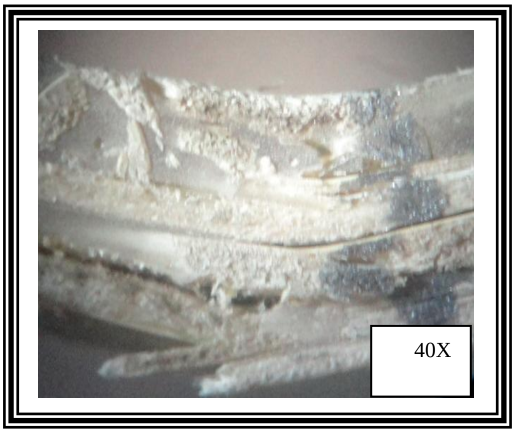

Fig. (14) photographic image for fracture regions shows the pull out of fiber after fracture for reeds \ polyester composite sample.

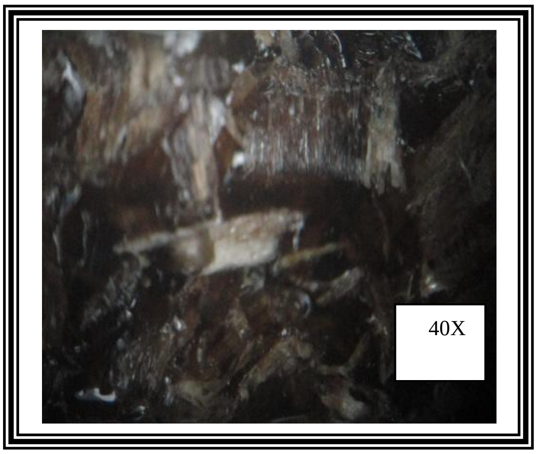

Fig. (15) photographic image for fracture regions of sawdust composite.

Conclusion:

This experimental investigation of mechanical behaviour of sawdust fillers and chopped reeds fibers filled polyester composites leads to the following conclusions:

- The polyester resin is a good adhesive material which can use as amatrix.
- This work shows that successful fabrication of wood fillers filled UPE composites with two types of wood fillers is possible by molding method.
- It has been noticed that the bending properties of the composites such as strength and young's modulus of the composites are also greatly influenced by the wood types.
- Reinforcing by chopped reeds fillers reduces the brittle nature of the UPE resin as that its flexural strength behavior is improved drastically.
- Water has limited effect on sawdust and chopped reeds composites comparing to commercial wood, so these materials can be used in humid environments.
- The chopped reeds and sawdust composites gave higher young's modulus, flexural strength before and after immersed them in water relatively than commercial wood.

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تأثيرالماءعلى بعض الخصائص الميكانيكية لمتراكبات نشارة الخشب والقصب المقطع \ بولي استر

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الخلاصة:

في هذه الدراسة حضرت المادة المتراكبة من إضافة نوعين من الحشو (نشارة الخشب, القصب المقطع) إلى راتنج البولي أستر غير المشبع الذي استعمل كرابط لمادة الحشو. استخدمت طريقة الصب لتحضير عينات البولي استر النقي , عينات متراكب البولي استر \ نشارة الخشب وعينات البولي استر \ القصب المقطع الخاصة لاختبارالثني عند الظروف الطبيعية وتم دراسة خواصها الميكانيكية التي تتضمن معامل يونك ومتانة الثني. كذلك تم غمر العينات في الماء لمدة (30 يوم) لمعرفة كتلة الماء المكتسب كذلك لمعرفة تأثير الماء على متانة الثني ومعامل يونك. بينت النتائج الخاصة بهذه الدراسة أن عينات متراكب البولي استر \ قصب مقطع اكتسبت اعلى قيمة في متانة الثني (24.5 MPa) ومعامل يونك (5.1 GPa) مقارنة مع العينات الاخرى عند الظروف الطبيعية. بينما بينت النتائج الخاصة بهذه الدراسة أن عينات متراكب نشارة الخشب الرطبة امتلكت اقل قيمة من كتلة الماء المكتسب (M_t%) = (0.043%) بعد الغمرمقارنة مع العينات الاخرى.

كذلك بينت النتائج تناقص في قيمة معامل يونك لجميع العينات بعد الغمر مقارنة مع العينات الاخرى عند الظروف الطبيعية. في حين بينت النتائج تناقص في قيمة متانة الثني بعد الغمر لجميع العينات ما عدا عينات المتراكب المصنع من البولي استر مع القصبات المقطعة الرطبة أمتلكت زيادة في قيمة متانة الثني حيث اكتسبت قيمة في متانة الثني (29 MPa) بعد الغمر مقارنة مع عينات متراكب البولي استر \ قصب مقطع عند الظروف الطبيعية.