EasyChair Preprint

№ 304

Water Absorption and Fatigue Life of an Epoxy Composite Reinforced by Glass Fiber

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June 26, 2018

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Abstract: In the current paper, the influence of absorbed water amount on fatigue life and some mechanical properties was investigated. The epoxy-10 resin was used as a matrix and glass fiber was used as a reinforced material. Two percentage of glass fiber (25 and 35%) was performed. Woven Roven method was performed to arrange the glass fiber inside the matrix. Two types of solutions were used to immerse the samples which were distilled water and salt water. The experimental results showed the lower amount of absorbed water was observed by using salt water solution compare with distilled water due to that the salt water has higher density compare with the other. On the other hand, when the reinforced material was a large percentage, the absorbed water amount was the big amount due to a big probability of cavities were found. Consequently, when the big amount of glass fiber was used, then higher hardness value was obtained.

1. Introduction

The small part of the polymer is called monomer [1]. Many of similar series of monomer is joined end to end to create polymer [2]. Two groups are classified according to solidification properties; thermoplastics and thermoset polymers [3]. Polymer has light weight, good corrosion resistance and flexibility machining [4], but it has lower strength compare with steel and some metals [5]. Some reinforced materials were used to strength the polymer by using composite technique. These techniques are significantly improved the mechanical properties according to relative proportional (strength to mass). Glass, PVC, Kevlar and carbon fibers are used as reinforced materials [6, 7]. These material are used a wide range with civil engineering and building instructions.

Composite materials are produced by mixing two or more materials. The first is called matrix while the other is called reinforced material [8]. The fibers are bonded by the matrix, therefore the stress distributed between them. In addition, the matrix is provided the protection from environmental [9]. In the last decade, some applications of polymer composite were found such as structural strengthening, mooring cables and some car spare parts. In recent years, the corrosion problems were found with steel, therefore it was replaced by polymer composite especially with concrete. In the current paper, epoxy resin is reinforced with glass fiber. Two percentage of glass fiber are performed. The effect of immersing solution and percentage amount of glass fiber are investigated [10].

2. Experimental procedure

2.1. Material

Epoxy resin type 10 and hardener material were used to provide the samples. Epoxy resin was used as a matrix. Glass fiber was used as a reinforced material. The density of glass fiber is 2.58 g/mm^3, yongs modulus is 35 GPa, ultimate tensile strength is 100 MPa, while The density of epoxy resin is 1.3 g/mm^3, yongs modulus is 3 GPa, ultimate tensile strength is 30-120 MPa. Woven Roven method was performed to set up the fiber.

2.2. Slates preparation

The glass slates were cut with dimensions of (30x30 cm) thickness (6 mm), distilled water was used to clean the sample to remove the dirt and dust. Dry process was performed by a furnace using suitable temperature. Wax material was used to avoid adhesion with die

2.3. Sample preparation

Hand lay-up procedure was used to prepare the samples due to its simple. The dimension of glass fiber was 15 x 15 cm. Then, the fiber was weighted by sensitive balance with accuracy 0.0001. Volume fraction was calculated by the following equation:

$$V.F = \frac{mass\ of\ fiber}{total\ mass\ of\ composite} \quad (1)$$

Two percentages of fibers (25 and 35%) were performed. Table 1 shows the details of the samples contents.

Table 1. Details of the samples contents

Symbols Type	Epoxy only	Epoxy + 25% glass	Epoxy + 35% glass
Fiber weight (g)	0	7.5	10.5
Epoxy Resin (g)	30	22.5	19.5
Total Weight	30	30	30
Volume Fraction of fiber	0	25%	35%

2.4. Sample immersion in the solution

Two types of solutions were utilized, which were distilled water and salt water. At the first three days, the samples were weighted each 4hrs. After that it was weighted after 24hrs until 50 days. All samples were performed at room temperature.

3. Results and discussion

In this section, the results are showed and discussed. Epoxy resin was strengthened by using glass fiber as a reinforced material. Two percentage of glass fiber were performed, which were 25 and 35%. The efficiency of epoxy resin was improved by using glass fiber. Thereby hardness test and fatigue test were inspected. On the other hand, water absorbed amount was measured to evaluate the efficiency process.

3.1. The absorption of the composite materials

Water absorbed amount was followed by Fick's law. At this law, mass absorbed of solution is increased gradually with square root of time. Then, the absorption was limited with saturation state**.** The humidity was higher absorbed with using reinforced material. The absorbed water amount was affected with the type of solution. Figure 1 illustrates the relation between water absorbed amount and the time.

It can be seen, that the results of absorbed water amount of epoxy only in salt water was less than the amount of epoxy only in distilled water. These results were attributed to the density of the solutions. The density of the salt water has been observed higher than the density of distilled water. Then, the Permeability of the distilled water was higher than the salt water. Figure 2 shows the relation between each type of solution and the percentage of reinforced material. It can be seen that the absorbed water amount was affected with the percentage of reinforced material. When the percentage of reinforced material increased, the absorbed water amount increased. Then, the relation between them was direct proportional. The increasing of absorbed water amount was gradually increased until 3 days (saturation state). After that the water absorbed amount was gradually decreased until 7 days. Then, steady state was observed until 50 days.

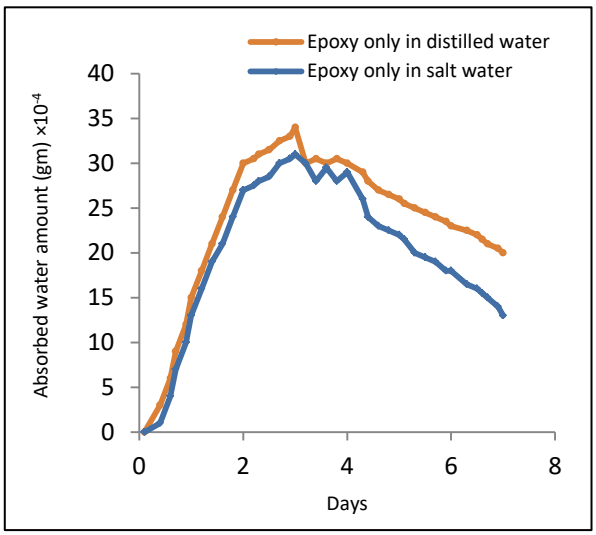

Figure 1. Relation between water absorbed amount and the time for various media

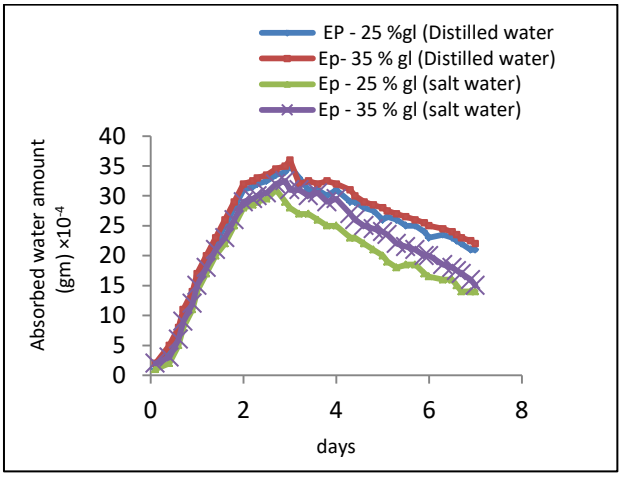

Figure 2. Relation between each type of solution and the percentage of reinforced material

3.2. Hardness test

Durometer Hardness instrument type (Shore D) was used to execute the hardness test. Pointed dibbing tool was used in this equipment. Hardness test was given excellent information about durability and coherence. Figure 3 illustrates the relation between the hardness values against time. It can be seen that the hardness values was decreased with increasing time. The decreasing was attributed to expansion of the epoxy resin. On the other hand, the percentage of glass fiber was affected on the value of hardness, therefore when the percentage was increased, the harness value increased.

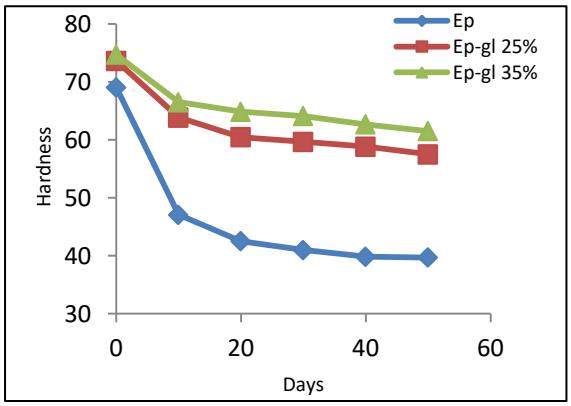

Fig.3. Relation between the hardness values against time

3.3. Fatigue test

Alternating bending fatigue machine was performed. Fluctuating bending to a cantilevered strip was used. Sinusoidal varying stress was imposed. Millions of cycles were achieved with some of hours. Figure 4 shows S-N curve of epoxy and the effect of the solutions.

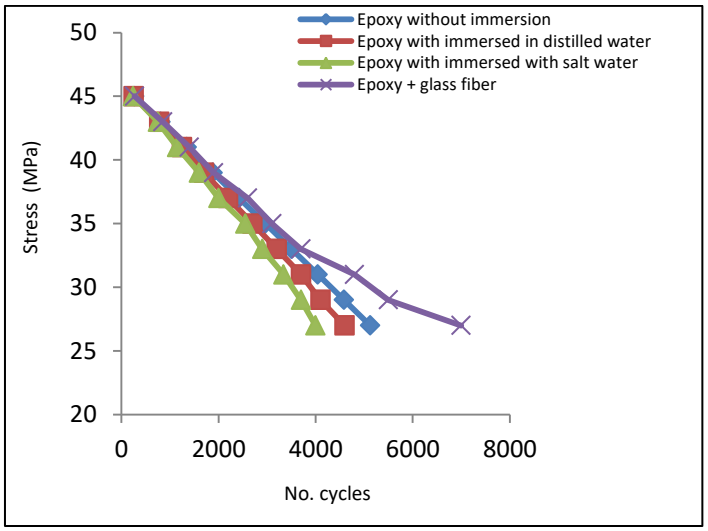

Figure 4. S-N curve of epoxy and the effect of the solutions

It can be seen, when the stress decreased, the no. cycles increased for all the specimens. The relation between the stress and no. cycles was reverse. On the other hand, the immersing by distilled water and salt water was decreased fatigue life. The decreasing was attributed to the decreasing of the value of hardness. Figure 5 and figure 6. illustrate fatigue regimes of the above specimens

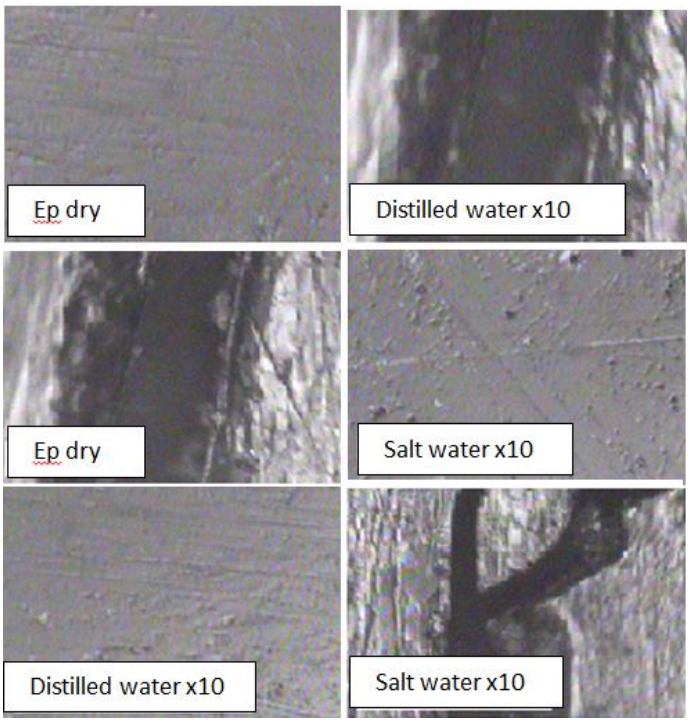

Figure 5. Fatigue regimes of Epoxy specimens

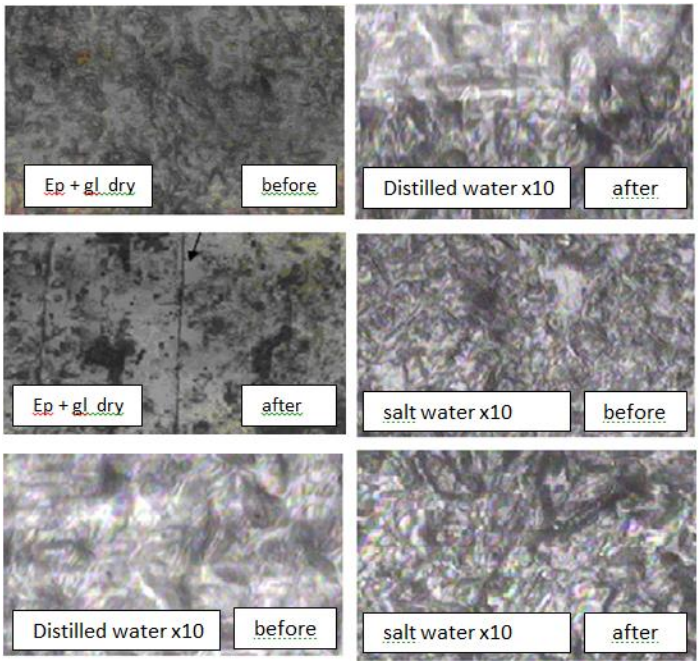

Figure 6. Fatigue regimes of Ep + glass specimens

4. Conclusions

Based on results, it can be revealed that the increasing of glass fiber reinforced material was led to increasing of hardness value. Thereby, when the hardness value increased, the fatigue life increased. On the other hand, when the immersing solution was used, the hardness value was decreased, and then the fatigue life was decreased. Although the high percentage of glass fiber was absorbed higher amount of water than the lower, the fatigue life was the best

Acknowledgments
The author would like to recognize Southern technical university to provide the suitable laboratories to complete the current project.

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