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STUDY THE EFFECT OF EXTERNAL CRACK ON THE MECHANICAL PROPERTIES OF COMPOSITE MATERIALS

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ABSTRACT

Increasing the strength of the matrix material rather than increasing stiffness is frequently the primary objective when designing composite materials. This is typically the case when the matrix is made of brittle, low-strength material. the resilience of this matrix substance Usually, it is determined by the initial flaws in the raw material. Depending on the microstructure of the composite material, these flaws or fissures may be large or minor. The orientations of the foil fibers, which can be customized to improve the performance of the laminate, have a significant impact on the properties of fiber reinforced polymer (FRP) laminates.

This study's goal is to look at how matrix cracking affects the mechanical characteristics of FRP chips. The presence and absence of exterior cracks are examined in unidirectional glass fiber reinforced polymer strips. Samples were manually cast using plastic molds constructed in accordance with ASTM standards. It were able to comprehend the impact of external cracking on composite materials through the mechanical tests that were conducted since it causes the material to weaken. Consequently, it is seen as a location where tensions are concentrated.

KEYWORDS: Composite materials; Crack; Fracture mechanics; Polymer; Mechanical properties

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1. INTRODUCTION

As strong and lightweight building materials for high-performance constructions, composites have a lot of potential. When compared to metals, one of these materials' main advantages is the fundamental manner that heterogeneity resists crack extension. The fibers in a fiber/matrix composite system tend to make cracks occur at closer intervals and postpone the development of a big crack. Despite extensive testing of composite materials, little progress has been achieved in the comprehension of and creation of a predictive method for composite failure. Mechanical flaws of any size can have a noticeable impact on the composite material's strength. Without realistic rules to regulate the manufacturing quality of composite systems, it would be impossible to design predictive procedures for composite failure. A topic of study called fracture mechanics focuses on the failure of materials brought on by the initiation and propagation of cracks. Whether the same assumption may be used to explain failure of the fiber/matrix composite system depends on how the specimen size is scaled in proportion to fiber spacing and the size of the critical crack or damage zone leading to catastrophic fracture. Instead of addressing the pervasive problem of composite failure, the focus of this volume is on composite systems with crack-like faults and their interactions with the stress intensity factor parameters that are so frequently used in the linear theory of fracture mechanics. The basic stress and/or displacement solutions are proposed as the basis for developing prediction algorithms for a range of composite systems (Sih and Chen, 1981).

The use of fiber reinforced plastics is widespread, with applications in the construction, automotive, aerospace, and other sectors. Laminates are susceptible to numerous damage types, including transverse cracking, delamination, fiber fracture, longitudinal splitting, and others. The local stress redistribution and the laminate's actual stiffness can both be significantly impacted by the developed fissures. Studies on modeling stiffness loss due to matrix deterioration, notably for cross-ply laminates, have increased significantly in recent decades. Following that, he determined stiffness reduction and stresses for cross-ply laminates using the theory of minimal complementary energy (Ogihara and Vinogradov, 2018).

2. METHODOLOGY

2.1. Materials

The polymeric substance used in this study is transparent epoxy type (Ren floor HT 2000), One plate of short fiber E glass (E6-CR) for reinforcement. Table 1 shows the sample name and the corresponding symbol within this study.

Table 1. Sample name and the corresponding symbol within this study.

No.	Sample Name	Symbol
Impact & Hardness samples		
1	Pure epoxy	1H
2	Epoxy + 1 Fiber Glass	2H
3	Epoxy + 1 Fiber Glass+ external crack	3H
Tensile samples		
4	Pure epoxy	1T
5	Epoxy + 1 Fiber Glass	2T
6	Epoxy + 1 Fiber Glass+ external crack	3T

2.2. The method of work

Using a mechanical mixer, epoxy resin (ren floor HT2000) and hardener (HT2000) are combined in a weight-to-volume ratio of 2:1 for 10 minutes (Ayatollahi et al., 2012). The epoxy beaker and hardener are initially placed inside a saucepan with hot water and a glass beaker. The mixture was mixed mechanically using the mechanical mixer (MODEL NO. HE-133). Put the mixture in the mold, then add Unidirectional fiberglass.

Next a crack has been made which is a surface crack with dimensions (10 mm * 1 mm * 1 mm) for tensile, impact and hardness samples, Fig. 1. The external crack is made 36 hours after pouring the sample, where the dimensions are plotted on the samples, and then an iron blade has been used to remove the part that was planned.

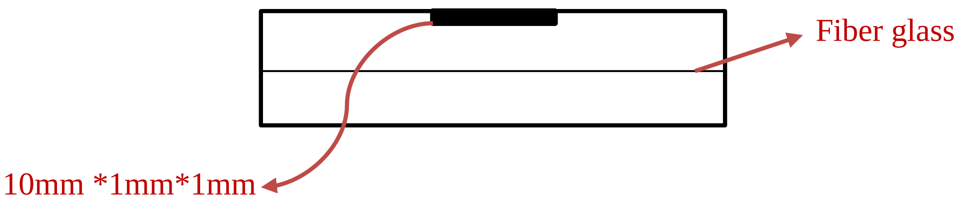

Fig. 1. external crack in composite materials.

The molds were manufactured from plastic using CNC machines and according to ASTM specifications, Fig. 2.

(a) (b)

Fig. 2. a) Tensile Specimens According to ASTM (D638-14), thickness (5mm) (ASTM D638, 2006)

b) Impact and hardness specimens mold according to ASTM (D256-04), thickness (5mm).

2.3. Mechanical Tests

2.3.1. Tensile Strength Test

It is crucial that the material be able to sustain tensile loads that are applied at both ends of the specimens (Alavudeen et al., 2015). The test was conducted at the College of Engineering, University of Babylon, using Time group INC's universal electronic testing machine (WDW-5E, 0536), which has a maximum capacity of 5 kN. The manufacturer has approved the device's specifications. According to ASTM, three samples were evaluated for each combination at a transverse velocity of 5 mm/min (638-14) during the test, which was carried out at room temperature (ASTM D638, 2006). The average value was then calculated (Kiran et al., 2018). The gadget is displayed in Fig. 3. While, Fig. 4 shows the samples before and after the tensile test.

Fig. 3. Tensile testing device.

Fig. 4. Tensile samples before and after the test.

2.3.2. Impact Test

This test was created to determine whether a material or application would hold up to sudden force (Mallakpour and Behranvand, 2016); it was conducted using a machine (Digital IZOD and Charpy Impact testing machine) affiliated with Chinese company Laryee Technology Co., Ltd. in the college of engineering at Al-Qadisiyah University. Five samples were tested using the standard impact specimen ASTM (D256-04) during the impact test, which was carried out at room temperature as depicted in Fig. 5, and an average was calculated for each composite (Kiran et al., 2018). By electronically entering information into the device that displays the sample's dimensions using the Charpy method and the value of the pendulum moment (15), which is equivalent to 8.0385 Nm, the test was carried out on the sample. Fig. 6 Shows samples before and after the Impact test.

Fig. 5. Impact test device.

Fig. 6. Impact samples before and after the test.

2.3.3. Hardness Test

After five distinct portions of each sample were evaluated in line with (ASTM D-2240, 2010), the hardness value that was read by this instrument was averaged. The term "Hardness" describes the value of materials that deform when focused force is applied to their surface (Naito et al., 2018). The test was conducted using a digital shore D hardness tester type SD- J in the College of Engineering at Al-Qadisiyah University, Fig. 7.

Fig. 7. Shore D Hardness testing device.

3. RESULTS AND DISCUSSION

The mechanical properties of the composite material are of great importance in its field of use, as the values of these properties are high and acceptable in order to perform its work efficiently. And through these tests that were carried out on samples consisting of epoxy (Ren floor HT 2000) and one panel of short glass fibers E (E6-CR), and in both cases of the presence and absence of external cracks, the obtained results are shown in the graphs that represent the values of tensile strength and impact strength and hardness.

After completing the tensile test, the results obtained as shown in Fig. 8 and Table 2.

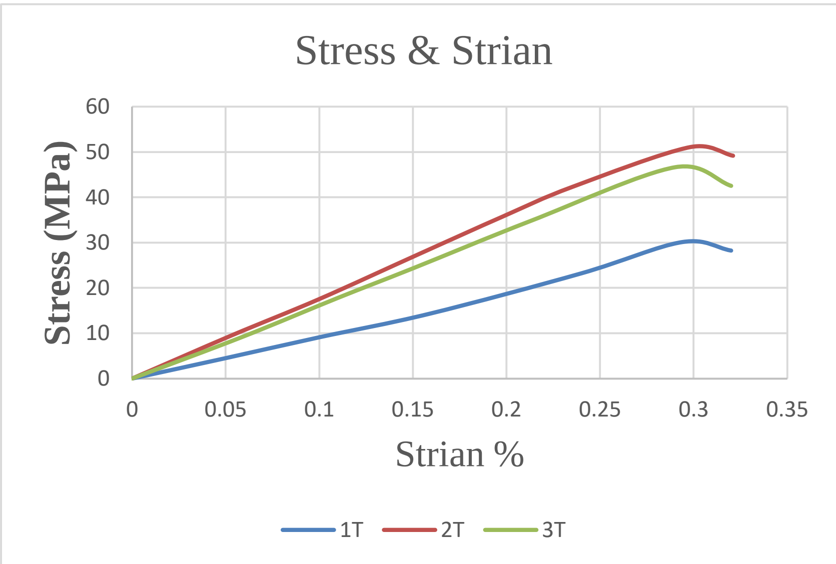

Fig. 8. Tensile strength of the composite materials used.

Table 2. Ultimate Tensile Stress (MPa)

Samples	T1	T2	T3
Ultimate Tensile Stress (Mpa)	30.1	51.1	46.6

Tensile strength: -The pure composite materials are brittle materials, where the highest stress value was 30.1 MPa, but when adding fiberglass fibers, the tensile strength increased, and the highest stress was 51.1MPa, as the fibers work to bear the largest part of the applied load. In the case of the presence of external cracks, it reduces the tensile strength in relation to for composite materials where the external cracks are areas of stress concentration, where the tensile strength value was 46.6, which is less than the case of the absence of external cracks.

Upon completion of the impact test, the obtained results are shown in Fig. 9 and Table 3.

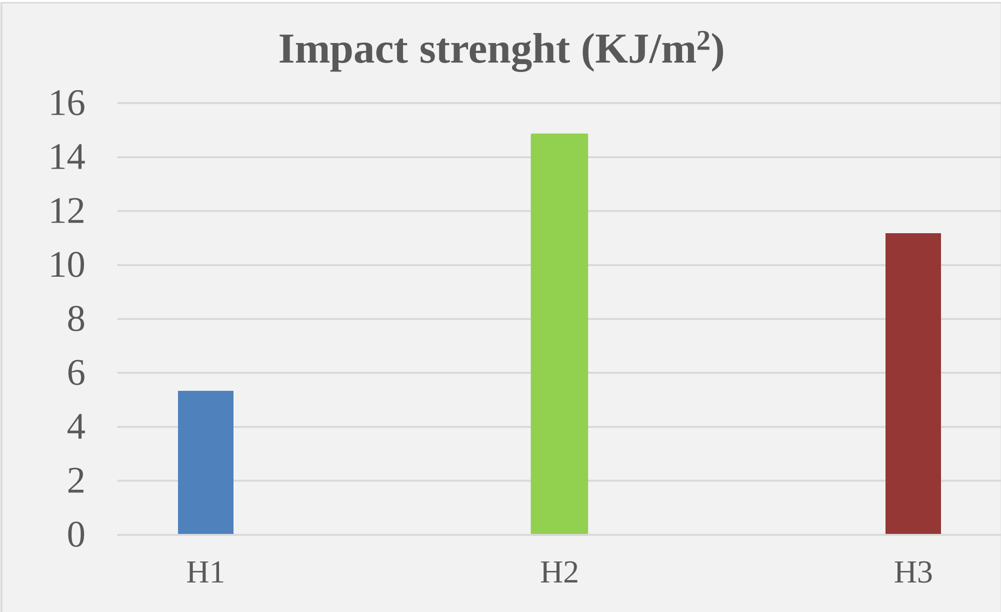

Fig. 9. Impact strength (KJ/m^2).

Table 3. Impact strength (KJ/m^2).

Samples	H1	H2	H3
Impact strength (KJ/m^2)	5.33	14.84	11.17

Impact resistance: - As fragile materials, pure composite materials have impact resistance that is only 5.33 KJ/m^2 at its highest value. However, when fiberglass fibers were added, the impact resistance increased to 14.84 KJ/m^2 as the fibers helped to carry the majority of the applied load. The presence of external cracks reduces the impact resistance for composite materials, where the external cracks are areas of concentration of stresses, and they reduce the bonding strength between the layers, where the impact strength value was 11.17 KJ /m^2, which is less than the case of the absence of external cracks.

After completing the hardness test, the obtained results are shown in Fig. 10 and Table 4;

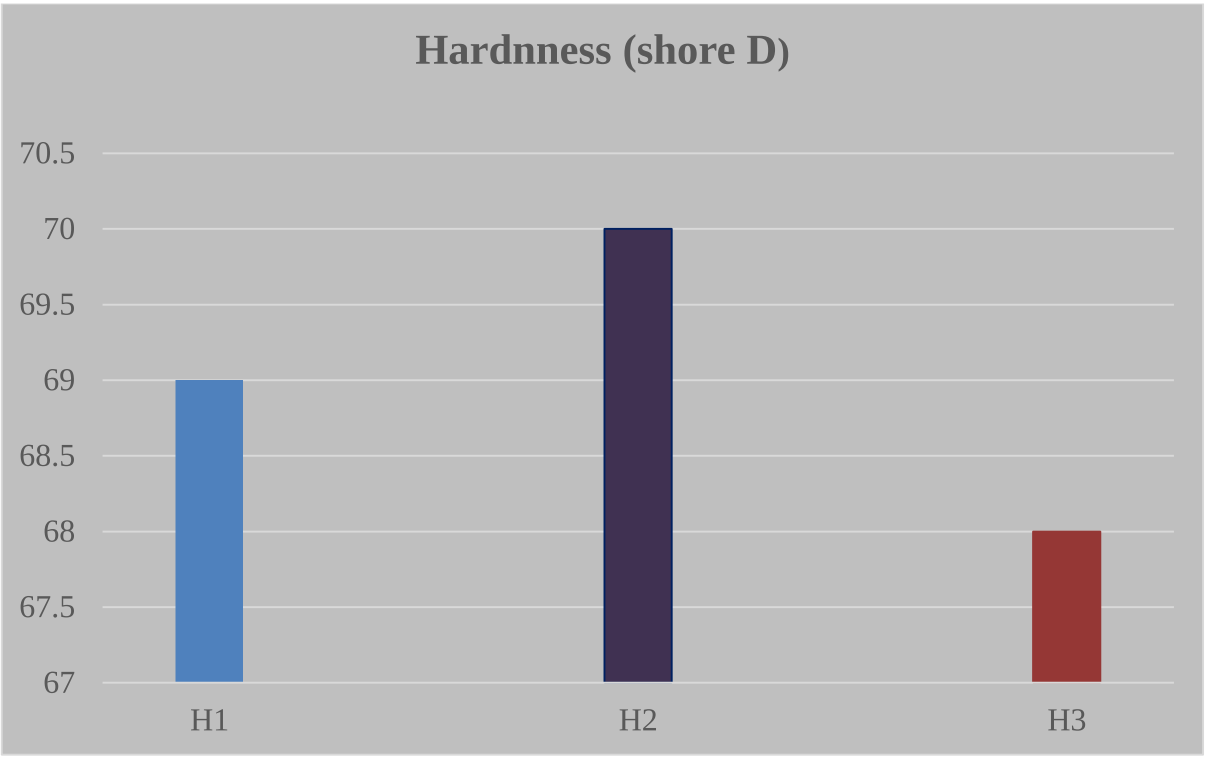

Fig. 10. Hardness (shore D).

Table 4. Hardness (shore D).

Samples	H1	H2	H3
Hardness (shore D)	69	70	68

Hardness: - When fiberglass fibers are added to composite materials, their hardness rises to its highest value of 70. This is because the fibers help to carry the majority of the applied load as well as provide a hard surface by increasing the cohesion bonding forces at the surface. Pure composite materials are brittle because of the amount of connections they have, which is 69. In the case of the presence of external cracks, it reduces the surface hardness for composite materials, where the external cracks are areas of stress concentration, and they reduce the bonding strength between the layers, as the value of the surface hardness was 68, which is less than the case of the absence of external cracks.

4. CONCLOSION

The presence of external cracks or manufacturing defects in the composite materials reduces their mechanical properties, and this is what has been obtained through the results. Where the external crack works to reduce the tensile and shock resistance and the surface hardness of the polymer reinforced with glass fibers, as they are stress concentration areas.

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