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# **Experimental Investigation of Mechanical Properties of Glass Fiber and Water Hyacinth Fiber Reinforced Polymer Composite**

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**ABSTRACT:** In this paper water hyacinth fiber as the major reinforcement and combination of glass fiber as an additional fiber to increase the mechanical properties with unsaturated polyester resin of composite which prepared by hand layup process according to ASTM standards. The result shows that high compatibility and improvement of mechanical properties of hybrid (glass/water hyacinth) fiber reinforced polyester composite and comparing the result with raw of water hyacinth fiber reinforced polyester composite with two different cutting size and hybrid of water hyacinth/banana fiber.

**KEYWORDS:** Glass fiber, Water hyacinth fiber, Polyester resin, Hand lay-up, Hybrid, Mechanical properties

## **I. INTRODUCTION**

Composite is the combination of two materials with altered in both chemical and physical properties at a distinct interface[1]. The vital reason for composite material selection is the versatility in their properties which are, a specific strength, high temperature resistance, high specific modulus, low thermal conductivity as compared to other traditional materials [2]. Nowadays, natural fiber reinforced polymer composites is exploding because of its many advantages. The water hyacinth (*Eichhorniacrassipes*) one of natural fiber that didn't used effectively as a source of reinforced and is a free-floating aquatic plant, native of the Amazon basin and belonging to Pontederiaceae family, with various growth habits under different environmental conditions [3]. Water hyacinth plant used in animal feed and animal production, organic fertilizer (green manure or compost) or mulching materials, for making paper, biogas production, phytoremediation and so on [4]. To apply the plant for different application area strength and integrity with a polymer and hybrid of glass fiber and banana fiber that subjected to mechanical testing such as tensile and compression tests should notorious, that is why this study needed to distinguish the mechanical properties of water hyacinth fiber reinforced polyester composite and hybrid of glass/water hyacinth fiber. The present study is taken up to understand the response of fiber reinforced plastic laminated and enhance the mechanical properties of the composite.

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## II. MATERIALS AND METHODOLOGY

### Materials

#### Matrix

Phthalic Anhydride based TOPAZ-1110 TP unsaturated polyester resin is used as matrix materials the property of this polyester resin is given in Table 1. And with Luperox® K10 catalyst which is purchased from World fiber glass and water proofing engineering plc. in Addis Ababa, Ethiopia.

Table 1. Property of Unsaturated polyester resin

| Property                             | Value |
|--------------------------------------|-------|
| Density, g/cm <sup>3</sup>           | 1.2   |
| Tensile strength, N/mm <sup>2</sup>  | 50    |
| Tensile modulus, N/mm <sup>2</sup>   | 3000  |
| Elongation, %                        | 2.5   |
| Flexural strength, N/mm <sup>2</sup> | 60    |
| Flexural modulus, N/mm <sup>2</sup>  | 3000  |
| Volume Shrinkage, %                  | 4     |

#### Water hyacinth fiber

Water hyacinth used as fiber that collected from Koka Lake in the Oromia region, Ethiopia. Figure 1. Shows that the mass dense covered by water hyacinth plant in Lake Koka.



Figure 1. Dense mat of water hyacinth plant in Lake Koka

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### Glass fiber

The glass fiber purchased from World fiber glass and water proofing engineering plc. Figure 2 display the glass fiber which is used for as reinforce in hybrid water hyacinth fiber reinforced polyester composite.



Figure 2. Glass fiber

### Methodology

#### Sample Preparation

Extract the water hyacinth and banana fiber manually and the fiber were cut into ~ 10.0 mm and 2.5mm for size 1 and size 2 respectively using a pair of scissors chopped water hyacinth fiber. Resin is act as a glue to hold the fiber together. In the present work polyester resin was selected with polyester and Luperox® K10 catalyst 10:1 ratio. Figure 3 shows that all the reinforced material fiber size 1 with 10mm cutting size and size 2 with 2.5mm cutting size also the glass fiber.

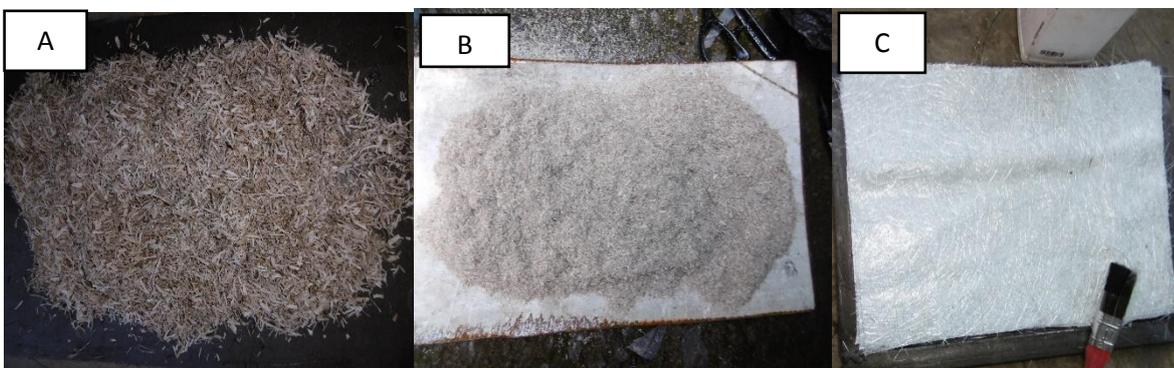


Figure 3. A. Water hyacinth fiber size 1 B. Water hyacinth fiber size 2 C. Glass fiber

Moulding preparation and Specimen preparation for hybrid glass/water hyacinth fiber: Two rectangular mild steel plate having dimensions of  $300 \times 200 \times 2.5 \text{ mm}^3$  and Volume of the die =  $150 \times 100 \times 5 \text{ mm}^3$  for tensile and compressive testing respectively as per ASTM. Chromium plated to give a smooth finished as well as to protect from rusting. The mould should be well cleaned and Release agent and the resin mixture were applied after those action First woven mat is laid

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into the moulded and apply the resin on mat by brush. Second mat is laid to first mat and Repeated the process up to 5 layers finally Mould is closed and moved to hydraulic pressing machine. Table 2 shows that the specimen name and designation for the sample specimen preparation.

Table 2. Specimen names

| Designation | Composition  |
|-------------|--|
| WHS1(T)     | Water hyacinth fiber (30wt%) and Polyester (70wt%) cutting size 1 for tensile                  |
| WHS2(T)     | Water hyacinth fiber (30wt%) and Polyester (70wt%) cutting size for tensile                    |
| WHGF(T)     | Hybrid of glass fiber and water hyacinth fiber reinforced polyester composite for tensile      |
| WHNF(T)     | Hybrid of false banana and water hyacinth fiber reinforced polyester composite for tensile     |
| WHR30wt%(C) | Water hyacinth fiber reinforced polyester composite 30/70 fiber/matrix ratio for compression   |
| WHGF(C)     | Hybrid of glass fiber and water hyacinth fiber reinforced polyester composite for compression  |
| WHNF(C)     | Hybrid of false banana and water hyacinth fiber reinforced polyester composite for compression |

### Test Apparatus

#### Universal Testing Machine (UTM)

Universal Testing Machine is a testing system that is highly integrated testing packages. Figure 4-6 displays that the universal testing machine and both tensile and compression test machine in the universal testing machine. The UTM model: WP310 (GuntHumburg). Hydraulic Universal Material Tester of 50 KN capacity at cross head speed of 5 mm/min, at Defense Engineering College. Operating area, WxH: 300x925mm.

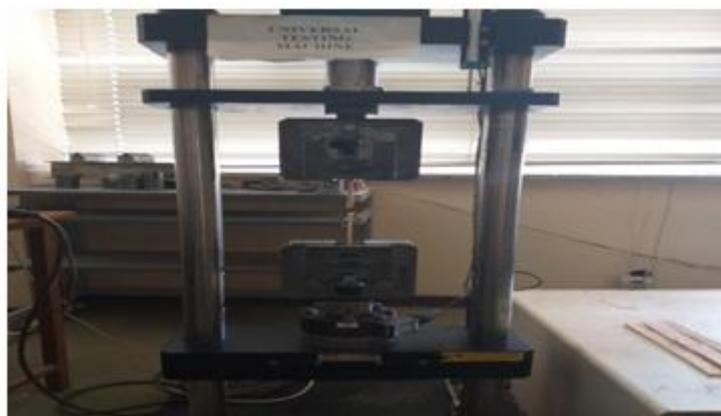


Figure 4. Universal testing machine

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**Tensile Strength Test:** The tensile test is used to evaluate the in-plane tensile properties of fiber composites. The test of the composite was carried out in universal tensile testing machine of. Tensile tests were conducted with ASTM D3039/D3039M [5].



Figure 5. Tensile testing machine

**Compression Strength Test:** The compression loading tests using the UTM. The compressive strength was performed using GUNTHAMBURG WP 310 Hydraulic Universal Material Tester of 50 kN capacity at cross head speed of 5 mm/min with ASTM D-695 M [6].

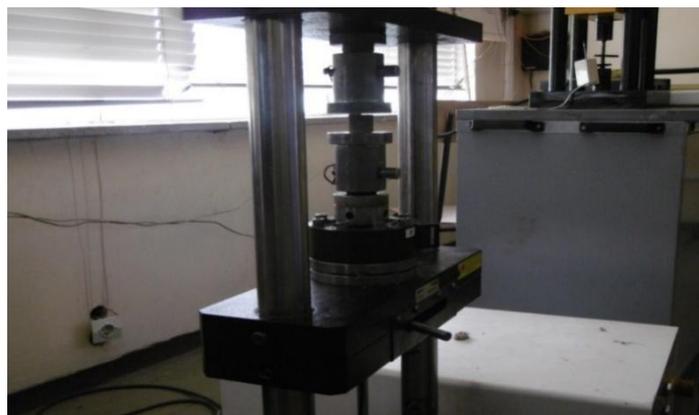


Figure 6. Compression test machine

### III. EXPERIMENTAL RESULTS

The experimental results were conducted by pure water hyacinth fiber in the two different cutting size of 10mm and 2.5mm for size 1 and size 2 respectively and combination of both glass and water hyacinth fiber composite materials and banana and water hyacinth fiber composite materials and to find the results on tensile strength and compressive strength at a constant fiber/matrix ratio. Finally the results are compared by two different fiber size ratio and with

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hybrid of water hyacinth fiber in the other hand comparing the hybrid of glass/water hyacinth fiber with hybrid of banana/water hyacinth fiber. The tensile strength result for water hyacinth fiber reinforced polyester composite size 1, water hyacinth fiber reinforced polyester composite size 2, hybrid of water hyacinth and glass fiber reinforced polyester composite, and hybrid of water hyacinth and banana fiber reinforced polyester composite were tabulated in table 3.

Table 3. Tensile strength result of four specimen groups

| Term    | Peak load<br>(KN) | Max. Displacement<br>(mm) | C/A<br>area<br>mm <sup>2</sup> | Maximum tensile<br>strength (MPa) |
|---------|-------------------|---------------------------|--------------------------------|-----------------------------------|
| WHS1(T) | 0.21              | 5.62                      | 125                            | 1.68                              |
| WHS2(T) | 1.41              | 6.40                      | 125                            | 11.28                             |
| WHNF(T) | 2.77              | 10.22                     | 125                            | 22.16                             |
| WHGF(T) | 7.04              | 15.02                     | 125                            | 56.32                             |

Figure 7. Illustrate that comparison of tensile strength result for water hyacinth fiber reinforced polyester composite size 1, water hyacinth fiber reinforced polyester composite size 2, hybrid of water hyacinth and glass fiber reinforced polyester composite, and hybrid of water hyacinth and banana fiber reinforced polyester composite both in graph and chart.

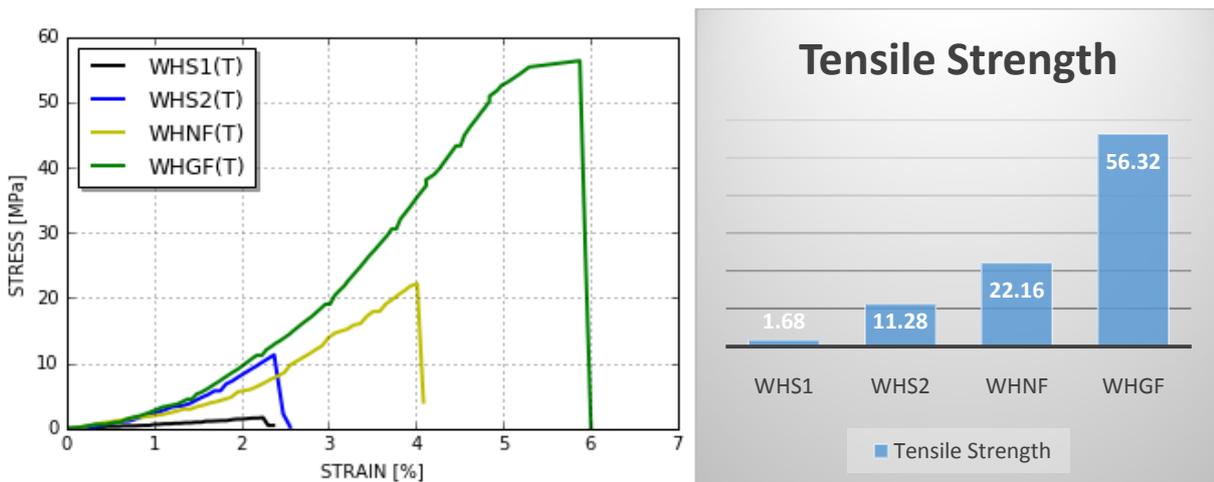


Figure 7. Comparing the tensile result of WHS1 (T), WHS2 (T), WHNF (T) and WHGF (T)

Figure 7. Shows the four specimen cases are water hyacinth fiber reinforced polyester composite size 1, water hyacinth fiber reinforced polyester composite size 2, hybrid of water hyacinth fiber with banana fiber and the hybrid of water hyacinth fiber with glass fiber. Hybrid composite which is the mixing of glass fiber and water hyacinth fiber takes high tensile strength than the water hyacinth fiber reinforced polyester composite both from size 1 and size 2 result value. As

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expected glass fiber polyester composite exhibited superior strength properties than untreated and 10% and 20% treated. This is due to the intrinsic property of glass fiber.

A.Arbeliz et al. [7] reported that 30wt% of glass fiber and flax fiber bundle are high tensile strength and flexural strength than glass fiber.

According to [8] with three preparation plan test 1 only glass reinforcement, test 2 with the arrangement of 2 glass fiber, 1 jute fiber and 2 glass layer and the last test is glass, jute, glass, jute, glass layer arrangement and the outcome of tensile strength is 335.09N/mm<sup>2</sup>, 122.07N/mm<sup>2</sup> and 62.76N/mm<sup>2</sup> for test 1, test 2 and test 3 result respectively. This implies pure glass fiber has high tensile strength than the rest one and when the jute fiber layer raises the tensile strength reduces. Hybrid composite which is mixing of false banana fiber and water hyacinth fiber take high tensile strength than water hyacinth fiber reinforced polymer composite both from size 1 and size 2.

N. venkateshwaran et al. [9] reported that hybrid composite of banana/sisal fiber has better tensile strength. Properties of banana are 63% cellulose, 19% hemicellulose, 5% lignin, 1350kg/m<sup>3</sup> density, and 54Mpa tensile strength. They observed that the tensile strength increased about 54% along the longitudinal direction and 66% along the transverse direction.

According to [10] they testified mechanical properties of hybrid composite banana and pineapple and reported that after the hybrid test 20/20% weight fraction tensile strength become 42Mpa this behavior correlated to hybridization effect as both fibers contributed to higher strength of composite this conclusion came up since each fiber tensile strength is 55.3Mpa and 60Mpa for banana fiber and sisal fiber respectively. The Compression strength result for water hyacinth fiber reinforced polyester composite, hybrid of water hyacinth and glass fiber reinforced polyester composite, and hybrid of water hyacinth and banana fiber reinforced polyester composite were tabulated in table 4.

Table 4. Compression strength result for hybrid composite and water hyacinth fiber reinforced polyester composite

| Term        | Peak Load (KN) | Max. Displacement<br>(mm) | C/S<br>area<br>mm <sup>2</sup> | Maximum tensile<br>strength (MPa) |
|-------------|----------------|---------------------------|--------------------------------|-----------------------------------|
| WHR30wt%(C) | 2.10           | 0.67                      | 60                             | 35.00                             |
| WHGF(C)     | 13.43          | 2.61                      | 60                             | 223.83                            |
| WHNF(C)     | 10.20          | 1.78                      | 60                             | 170.00                            |

Figure 7. Appear that comparison of compression strength result of water hyacinth fiber reinforced polyester composite, hybrid of glass fiber and water hyacinth fiber reinforced polyester composite and hybrid of banana fiber and water hyacinth fiber reinforced polyester composite both in graph and chart.

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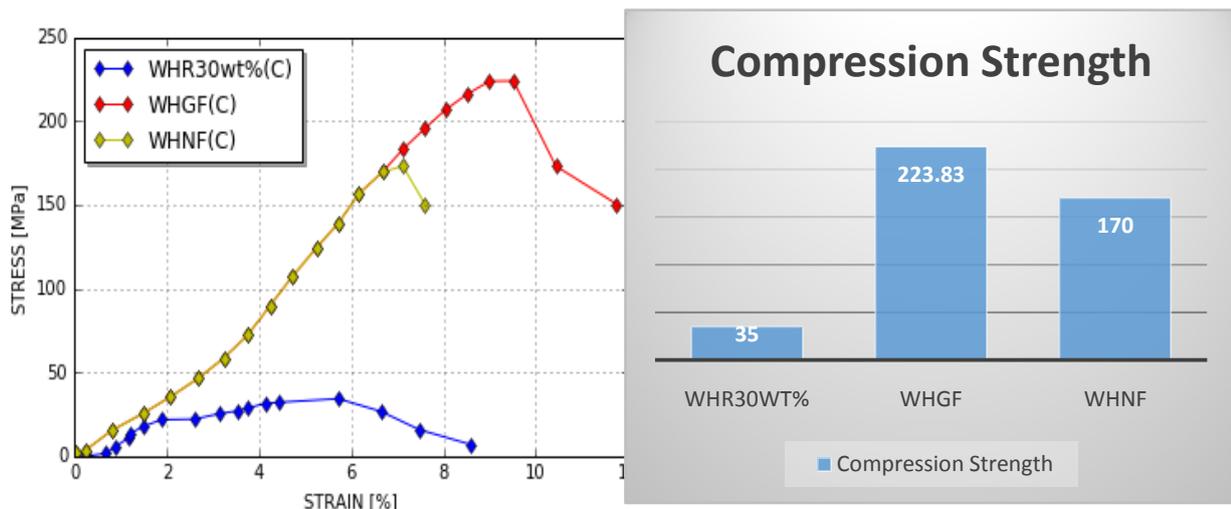


Figure 1 comparing the compression result for the WHR30wt%(C), WHGF(C) and WHNF(C)

Figure 8 shows the three specimen cases are water hyacinth fiber reinforced polyester composite, hybrid of water hyacinth fiber with banana fiber and hybrid of water hyacinth fiber with glass fiber. Hybrid composite which is the mixing of glass fiber and water hyacinth fiber takes high compressive strength than both the water hyacinth fiber reinforced polyester composite and the hybrid of water hyacinth fiber with banana fiber. Also hybrid of water hyacinth fiber with glass fiber gives a higher result comparing to the overall groups, as expected glass fiber polyester composite exhibited superior strength properties than untreated and 10% and 20% treated. This is due to the intrinsic property of glass fiber.

#### IV. CONCLUSION

In these experimental results by using data acquisition system it was found that when glass and water hyacinth fibers reinforced polyester composite gives higher tensile and compressive strength compared to normal water hyacinth fiber and hybrid of water hyacinth/banana fiber composite material.

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