Development of Minibus Interior Wall Panel Using Hybrid Sisal and False Banana Fiber Reinforced Epoxy Composite

Lemi Demissie[1], Araya Abera[2], Dr. Daniel Telahun[3]

[1]Departments of Mechanical and Industrial Engineering, Wollo University KIOT, Ethiopia.

[2,3]Departments of Mechanical and Industrial Engineering, Addis Ababa University AAiT, Ethiopia.

[*]Corresponding Authors:-lemidemissieboset@gmail.com

Abstract

In automobile sector due to the demanding need of rapid innovation and tough competition, the old products are reengineered by new product with composite materials. Replacement of old product by natural fiber composite is essential mainly due to their availability in large quantities, biodegradability, low cost, low density, renewability and ease of manufacturing. This paper study on application of hybrid Sisal and False Banana fiber for Minibus interior wall Panel, depending on experimental tests results of flexural strength, fracture toughness and water absorption test of new developed composite, from tests results 100% False Banana fiber composite has better than another species with flexural strength 70Mpa and flexural modulus 3.9 Gpa. 80% Sisal and 20% False Banana tested specimen has better stress intensity factor 2.9Mpa.m$^{1/2}$ and 100% Sisal fiber composite has minimum water absorption 2.8% after 24 hours than another fiber/fiber weight fraction composite and 50% Sisal and 50% False Banana fiber composite has better material properties than the other species and finally new Panel was fabricated from this fiber/fiber composite by using cold compression molding technique.

Key Words: Hybrid, Sisal, False Banana, Flexural strength, Fracture Toughness, Water Absorption

1. Introduction

1.1 Background

Natural fiber reinforced composites have a good potential as a substitute for wood-based material in many applications The development of environment-friendly green materials is because of natural fiber's biodegradability, light weight, low cost, high specific strength and renewing natural sources compared to glass and carbon composites. The wonder material with light-weight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, woods etc. The material scientists all over the world focused their attention on natural composites reinforced with jute, Sisal, Banana, coir, pineapple etc. primarily to cut down the cost of raw materials [1]. Fiber reinforced composite materials have been widely used in various transportation vehicle structures because of their high specific strength, modulus and high damping capability. If composite materials are applied to vehicles, it is expected that not only the weight of the vehicle is decreased but also that noise and vibration are reduced. In addition to that, composites have a very high resistance to fatigue and corrosion [13]. Composites are hybrid materials made of a polymer resin reinforced by fibers, combining the high mechanical and physical performance of the fibers and the appearance, bonding and physical properties of polymers. The mechanical properties of a natural-reinforced composite depend on many parameters, such as fiber strength, modulus, fiber length and orientation, in addition to the fiber-matrix interfacial bond strength. A strong fiber-matrix interface bond is critical for high mechanical properties of composites [12]. Banana fiber is a waste product of Banana cultivation and without any additional input cost, Banana fibers can be used for industrial and general purposes. Banana fiber is found to be a good reinforcement in polyester resin [11],[5]. The treated Sisal fiber/epoxy composite system has a high mechanical performance especially tensile strengths and modulus, besides its green nature. So this research muscularly gives confidence to utilize the advantages offered by renewable resources and its application in some aspects of industrial application such as automotive interior Panels as substitutes [12],[15]. The mechanical properties will be change with change in composition of fibers. On combination of Sisal and Banana where Banana is in excess amount than Sisal tensile strength value is high but bending values are low. Sisal fiber individually had the highest tensile strength but low bending and impact strength so it should be mix with Banana fiber to obtain the desired strength and mechanical properties [6]. Fracture toughness is defined as the amount of

energy required to form new surfaces. Prasad et al. studied that fracture mechanics is divided into two theories which are Linear Elastic Fracture Mechanics for brittle material and Elastic Plastic Fracture Mechanics for ductile material [14]. Moisture absorption in unidirectional composite specimens was also studied numerically in this work using finite element techniques. In particular, the effects of specimen geometry the edge effect and specimen orthotropic on moisture absorption by the composites were evaluated. Significant differences in the moisture absorption properties of the composites were found indicating that the effect of moisture on the mechanical and electrical properties of the insulators will depend on the type of composite used [2]. Natural fiber reinforced composites have a good potential as a substitute for wood-based material in many applications like automobile, electronics, structural and etc materials. Wood-based Panels are one kind of hydrophilic material, they are easily to absorb or release moisture when ambient temperature and relative humidity fluctuated, consequently mechanical properties were weaken or enhance especially internal bond and modulus of elasticity, does not have good screw holding capacity and not take nails very well [10]. The Minibus interior wall Panel is made from wood based fiber board MDF. It is failed or fully broken during over loaded the vehicle and absorb moisture. Failed interior wall Panel of Addis Ababa city Minibus tax is shown in figure below.

Figure 1.1 Addis Ababa city Minibus tax interior wall Panel

This research is answer the question what are applications of natural fiber composite in Automobile body by using hybrid Sisal and False Banana fiber reinforced epoxy resin hybrid composite for Minibus interior wall Panel which is developed from fiber/fiber weight fraction composite which has better in flexural strength, fracture toughness and moisture absorption test results.

2. Material and Method

2.1 Materials

A. Natural Fibers (Sisal, False Banana)
B. Epoxy resin (GP)
C. Hardener(HY-951)
D. NaoH (PALLETS 93% CH880)
E. Water (H_2O)

2.2 False Banana fiber extraction

Mature False Banana pseudo-stem was obtained from farm and was cut into length of 500 mm The stems from False Banana plants were selected from an 11-month-old plantation. The plantation is located 1,050 meters above sea level and the stem of False Banana is cut and extracted by hand by using wood lumber and another sharp wood after extracted the fiber dry in the sun. False Banana fiber is extracted from southwestern of Ethiopia.

Figure 2.1 False Banana fibers

2.3 Sisal fiber extraction

Ethiopian Sisal leave is 500mm long and it is vary in its length depend on is age and is location Sisal leaves were extracted by blunt knives, after the fiber is extracted it is dry in the sun. Sisal fiber extracted from Ethiopia around Adama town.

Figure 2.2 Sisal fiber

2.4 Preparation of epoxy resin (GP)

Epoxy resin density of 1.15-1.20g/cm³, mixed with hardener density of 0.97-0.99g/cm³, is used to prepare composite material is purchased from local market.

2.5 Pattern

The pattern is designed by as per ASTM standard. The pattern is made up of mild steel. The pattern Size is (229 x 229 x 25) in mm. The pattern consists of three parts.

Figure 2.3 Mould Pattern

2.6 weight and volume fraction calculation

Calculated weight and volume fraction from (70/30) % of epoxy/fiber ratio is shown in table 2.1 below, 70/30% epoxy/fiber matrix composite have better tensile and flexural strength rather than other epoxy/fiber ratio [3],[14],[15].

Designation	Composition		Volume (cm^3)			Weight (g)		
	Sisal	False Banana	Epoxy	Sisal	False Banana	Epoxy	Sisal	False Banana
100S	100%	-	193.4	68.5	-	232	99.5	-
100B	-	100%	193.4	-	72.28	232	-	96
20S80B	20%	80%	193.4	12.8	55.75	232	18.6	75.26
50S50B	50%	50%	193.4	35.5	33	232	44.6	51.4
80S20B	80%	20%	193.4	54	14.5	232	78.5	19.6

Table 2.1 calculated weight and volume fraction for each matrix that used to prepare sample specimen

2. 7 Fabrication of new Panel

By using predefined (70/30) % epoxy/fiber weight ratio therefore the new developed Panel made up of 50S50B fiber/fiber hybrid composite by cold compression molding technique is shown in figure below.

Figure 2.4 Developed Panel

3. Tests, Results& Discussions

The formation of reinforced (70/30) % epoxy/fiber of hybrid Sisal and False Banana fiber epoxy composite and different combinations of Sisal, False Banana composites were obtained through cold compression mold technique. Three tests experiments are done such as flexural strength, fracture toughness and water absorption properties of the material. All tests are done by standard test specimen ASTM standard. Test specimen, testing machine and testing equipment used to test is shown in figure below.

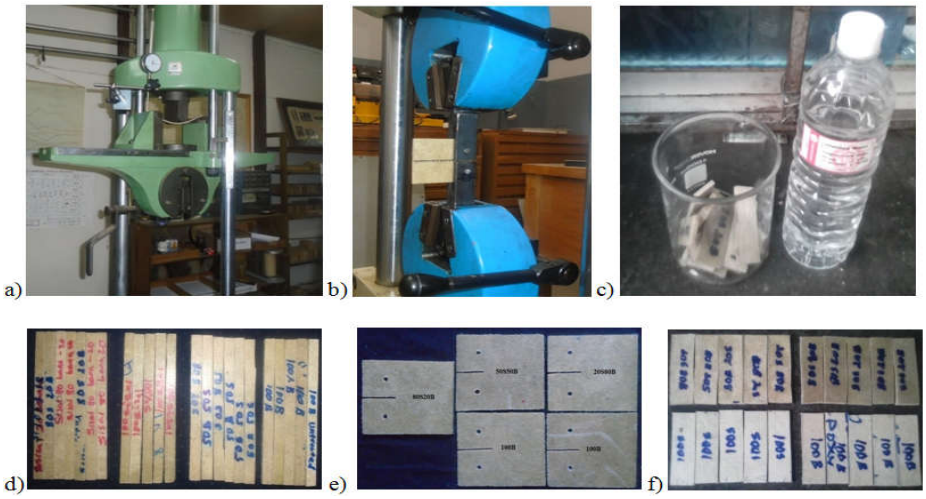

Figure 3.1

a) UTM of Ethiopia wood technology and research center in mechanical testing laboratory
b) Fracture toughness test done by UTM machine in AAIT mechanical department laboratory
c) Water Absorption equipment
d) Flexural test specimen
e) Fracture toughness test specimen after test is done
f) Water absorption test specimen

3.1 Flexural test [8]

ASTM-D7264:- Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials. The flexural test specimens are prepared as per the ASTM D7264 standards. The five test specimens of each made up of Sisal/False Banana fiber reinforced epoxy composites are prepared and tested by applying three point flexural loading is done with the help of UTM. The testing process involves placing the test specimen in the UTM and applying force to it until its fractures and breaks.

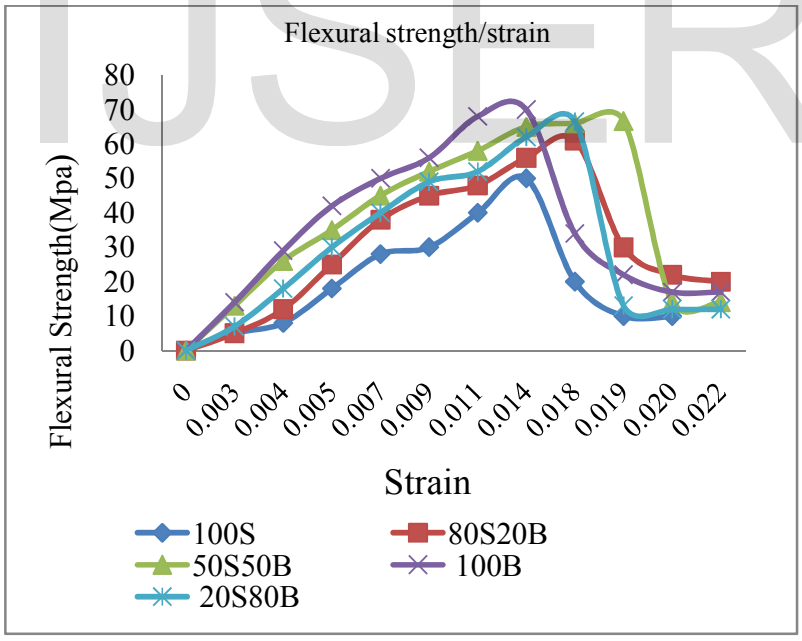

Figure 3.2. Flexural Test result for different mass composition, flexural strength Vs Strain

☞ Sisal/ False Banana weight ratio did affect the flexural strength of the Sisal and False Banana fiber reinforced epoxy composite. False Banana fiber is individual better in flexural strength and Sisal fiber epoxy composite has less flexural strength from the all

fiber/matrix ratio. 100% False Banana fiber reinforced epoxy composite has greater flexural strength and flexural modulus.

3.2 Fracture toughness test [9]

Testing Plane strain Fracture Toughness and Strain Energy Release Rate of Plastic Materials is done by test methods based on American Society of Testing Materials (ASTM) D 5045. Involve loading a notched specimen that has been pre cracked, under Compact Tension Test

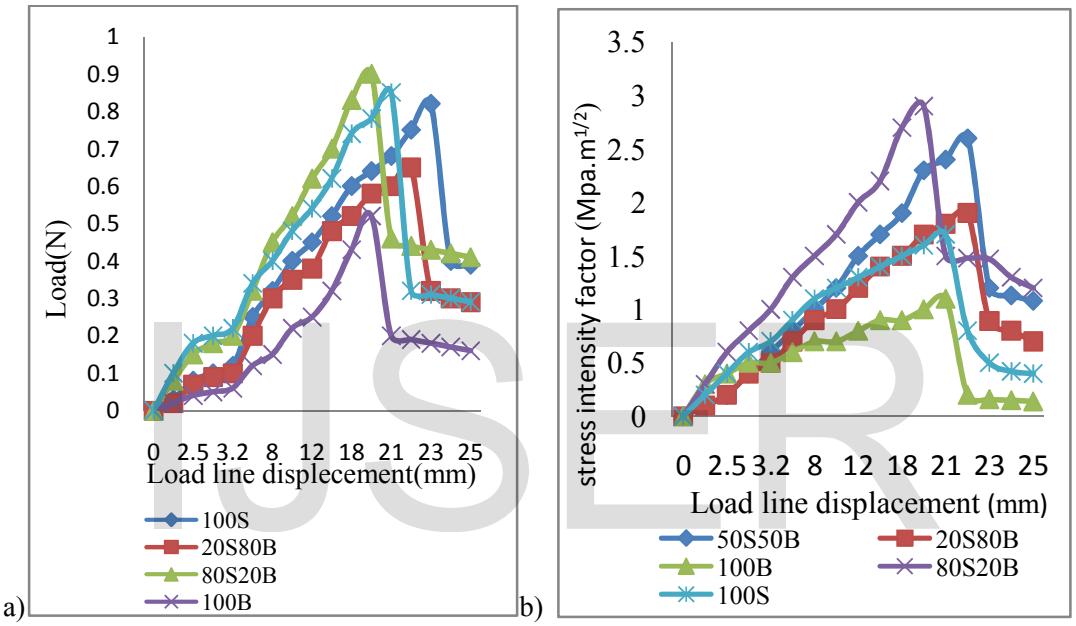

Figure 3.3. a) Load Vs Load line displacement b) stress intensity factor Vs Load line displacement

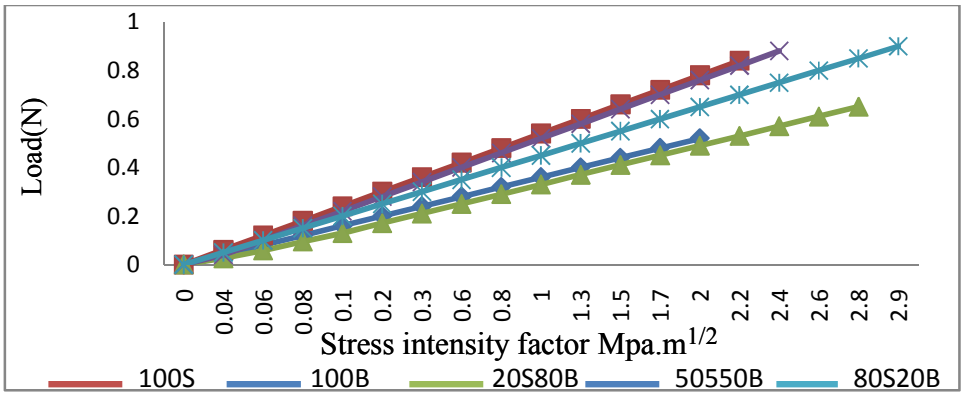

Figure 3.4 Fracture toughness test result (Load vs stress intensity)

- Fiber/matrix with high load have greater Stress Intensity factor and 80S20B have greater bending load resistivity and stress intensity factor. Combination of Sisal and False Banana fiber reinforced epoxy composite has better stress intensity factor than False Banana fiber reinforced epoxy composite.

3.3 Water absorption test [7]

Balance analytical capability of reading 0.0001. Uniform temperature at 23±1°C and 73.4±1.8°F**.** It must also immerse in two hours repeatedly immersion from 0hour to 24hours**.** Prepare three specimens for each Sisal/False Banana fiber epoxy composite and average result of water absorption of each specimen in repeatedly measuring by 2hours interval in 0, 2, 4, 6, 8, 10, 12 and 24hrs is calculated.

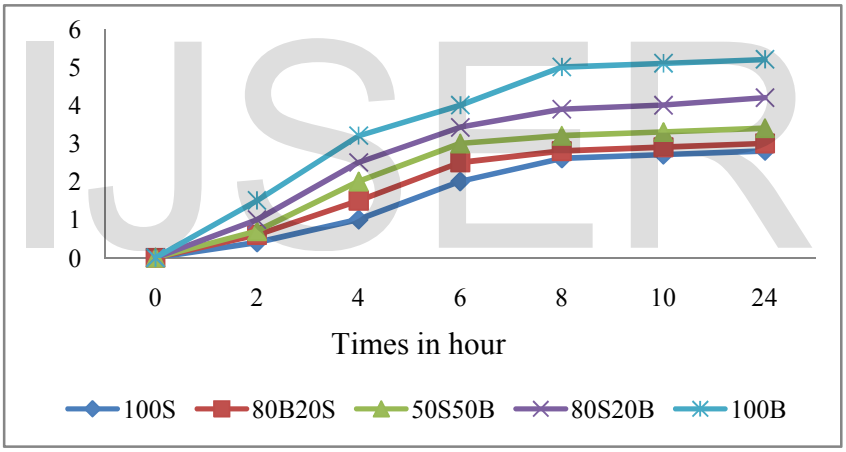

Figure 3.5 water absorption test specimen after soaking 24hours in water

- Sisal fiber reinforced epoxy composite is less water absorb than other species and the matrix has more Sisal fiber also better in water absorption properties. False Banana fiber reinforced epoxy composite is high water absorption than another species. Combination of Sisal and False Banana fiber composite is less water absorption property than False Banana fiber reinforced epoxy composite.

4. Conclusion

The panel is successfully fabricated from sisal and False Banana fiber reinforced epoxy composite by using simple cold compression molding technique. Using new composite panel is increase flexural strength by 42.8%, fracture toughness by 86% and water absorption properties

by 80% when I compared with wood based Panel. From all results and by comparisons with existing panel material I can conclude that the fabricated chopped sisal and False Banana fiber reinforced epoxy composite is better to use for Minibus interior wall Panel than wood based Panel.

Material Property	Hybrid Sisal and False Banana epoxy composite Panel	Wood based Panel [10]	Comparison of New Panel with existing Panel material by percentage
Flexural strength(Mpa)	61-70	18-42	42.8%
Fracture toughness(Mpa.m$^{1/2}$)	1.1-2.9	0.309-0.409	86%
Water absorption (%)	2.8-5.2	14-35	80%

Table 3.1 Comparison of developed Panel with existing Panel material

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