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Tensile and Flexural Properties of Cat-Tail Fiber Reinforced Unsaturated Polyester Composite

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Abstract— **Composite material is a combination of two or more materials/fibers prepared to improve the desired mechanical and chemical properties. Composite materials are widely used in many light weight and high strength application because of their excellent directional oriented properties. Economy and heavy strength of these composites make them to be used in many applications.**

Conventional fiber reinforcement has high strength and durability, which are not eco-friendly and biodegradable. Natural fiber have high strength, eco-friendly, biodegradable and recyclable. So, natural fibers have more advantage over conventional fiber in this regard.

In this project an attempt has been made to fabricate a natural composite with unsaturated polyester resin. The reinforcement consists of cat-tail fiber;

Tensile and flexural properties are evaluated as per ASTM standards of D 5083-02 and 790-03. The samples were prepared with various fiber volumes. It was found that the tensile strength improved by increasing the fiber volume content.

Tensile strength was upto 109.83 Mpa. Flexural strength was maximum with fiber volume ratio of the order 9820.8 Mpa.

Index Terms— **composite structure, cat-tail, polyester resin (Ecmalon 4413) mixed with a cobalt accelerator and catalyst (MEKP, methyl ether ketone peroxide, Hand lay-up process, mechanical properties.**

I. INTRODUCTION

Md. Mominul Haque have studied palm fiber reinforced polymer composites. They have tested for tensile, flexural, impact and hardness properties with and without benzene diazonium salt treatment. The treated composites improved the mechanical properties than untreated composites.[1]

The coir and abaca fiber reinforced polypropylene composites were tested for mechanical properties by Rezaur Rahman . Have studied coir and abaca fiber-reinforced polypropylene composites. They have tested for tensile, Young's modulus and flexural properties with and without benzene diazonium salt treatment. The treated composites improved the mechanical properties than untreated composites. [2]

Maries Idicula have studied banana and sisal hybrid fiber reinforced polyester composites. They have tested for tensile, flexural and impact properties. The author said that the mechanical properties improved for increase in banana fiber volume. They have also said that banana and sisal fiber ratio of 3:1 gave the higher tensile strength values.[3]

Hybrid palm ash-silica-natural rubber composites were studied by H. Ismail . ash-silica-natural rubber composites. They have tested for tensile strength, tensile modulus and fatigue life of composites. The author said that incorporation of palm ash shortened the curing time of hybrid palm ash-silica-natural rubber composites.[4]

The effect of acrylonitrile treatment of bamboo mats on bamboo-reinforced epoxy and polyester resin composites was investigated by Pradeep K. Kushwaha They have tested for tensile strength and tensile modulus. The author has said that treated composites improved the mechanical properties. They have also said that water absorbent capacity decreased in treated fibers. [5]

Sanjay K. Nayak and have studied the hybrid composites of polypropylene (PP) reinforced with short sisal and glass fibers. They have tested for tensile, flexural and impact properties with and without Maleic anhydride grafted PP. The author said that treated composites improved the mechanical properties. They have also said that water absorbing capacity decreased in the treated composites. [6]

A study was done studied the bamboo-glass fiber-reinforced epoxy hybrid composites by H. Raghavendra Rao have. They have tested for flexural and compressive properties with and without alkali treatment. The alkali treated composites improved the mechanical properties. [7]

K. Raghu . have studied the silk-sisal unsaturated polyester-based hybrid composites. They have tested for different alkalis, acids and solvents. The author said that the weight gain is observed in all the chemical reagents except carbon tetrachloride. They have also said that the composite is resistant to water. [8]

A study had been done on stem kenaf fiber and Ecoflex by Nor Azowa Ibrahim. They have tested for tensile and flexural properties with and without alkaline treatment. The author said that the treated composites of 40% fibre loading gave the higher value of mechanical properties.

The reinforced composite of short sun hemp, sisal and banana fiber was studied by C.udaya kiran [9] they have studied They have tested for tensile properties with respect to fiber weight ratio and fiber lengths. The sisal fiber reinforced composites showed low tensile strength than others. [10]

Flax fiber-reinforced polypropylene composites had been studied by T. czigany The composites tested for loading and fracture toughness by acoustics emission method. The damage zone was smaller than glass and carbon fiber reinforced composites. [11]

Reinforced natural fiber and woven sisal fiber hybrid composites had been studied by Maya Jacob. They have tested hybrid composites for chemical, alkali and heat treatments. The mechanical properties had improved for heat treated fabrics. [12]

Cat-tail

Fig 1.1 Cattail plant

Common Cattails are a familiar sight along the shore of any marsh, pond, lake, or river. They can even be found in ditches. Cattails are tall, stiff plants, growing almost ten feet tall. The leaves look like giant blades of grass, about one inch wide. The flower has two parts; a brown cylinder (the female part), and a yellow spike (the male part). Inflorescence: female flower spike (seed head) is tightly packed and in the shape of a cigar; seed head can be green, tan or brown depending on maturity; male flower spike is separated from the female spike by 1/2 to 5 inches of naked stem. Growing along margins and may grow out to 2 feet of water. Plant lays dormant in winter, turning brown and can completely ring the shoreline of a pond in a few years if not controlled.

II. HAND LAYUP PROCESS

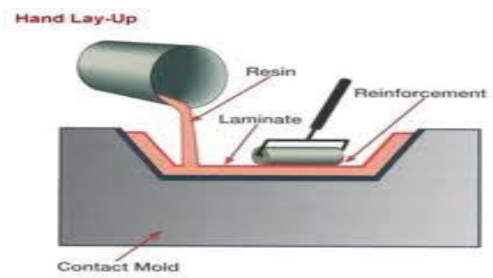

Fig 1.2 photograph of hand layup process

Hand layup process is simplest and oldest method used doe producing reinforced plastic laminates there is virtually no limit to the size of the part that can be made of hand layup process is illustrated in above figure.

Before starting the actual laminating process, the mold surface has to be cleaned and gel coat has to be applied. The catalyzed gel coat typically is applied after curing. Gel coat is tailored pigmented or non-pigmented resin that typically is applied as the first 400 to 700µm outer layer.

Cat-tail of required size is cut. Resin (LY556) is weighed of required weight and 5% hardener of (HY915) is mixed and then applied by pouring or brushing. Stirring is done properly. Then Cat-tail is placed on the mold and the mixture is added, it is seen that no air is trapped. Allowing mixture to flow in all the place of material, similarly the entire layer is placed and same procedure is followed. Curing time is typically a few hours at ambient temperature, after which application of resin and reinforcement can start.

III. SPECIMEN PREPARATION AND EXPERIMENTAL SETUP

In this project work experimental analysis was carried out to study the tensile & flexural behavior of cattail fiber reinforced polyester matrix composite were fabricated by varying the fiber volume fraction. Five composite of different fiber volume fraction were fabricated. The composite specimens were fabricated using naturally available cattail fiber. The specimens were fabricated hand lay-up technique. A commercially available unsaturated polyester resin (Ecmalon 4413) mixed with a cobalt accelerator and catalyst (MEKP, methyl ether ketone peroxide) is used in suitable proportions. The reinforced composites were prepared by varying cattail fiber weight. The curing time was around 6 to 8 hours at normal room temperature.

IV. SPECIMEN CONFIGURATION & TEST PROCEDURE FOR TENSILE STRENGTH

For testing of all the composites, ASTM-5083 standard was adopted. Figure 1 shows the specimen configuration.

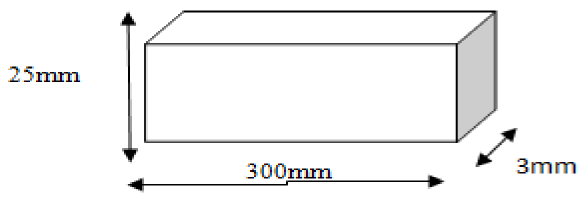

Fig.1.3: Tensile specimen

configuration

The specimens were tested without tabs in a standard UTM (universal testing machine). The cross head rate was 10mm/min. Load displacement curves were obtained for all the specimens. For each type of composites, five specimens were tested and their tensile property was evaluated.

Table 1.1: Tensile Test Specimen Specifications

Serial no	Cattail weight (grams)	Resin weight(grams)	Specimen weight (grams)	Number of specimen tested
1	2	250	248	5
2	4	250	250.2	5
3	6	250	266.6	5
4	8	250	307	5
5	10	250	330	5

Fig 1.4 :Tensile test specimen

V. SPECIMEN CONFIGURATION & TEST PROCEDURE FOR FLEXURAL STRENGTH

For testing of all the composites, ASTM-790 standard was adopted. Figure shows the specimen configuration.

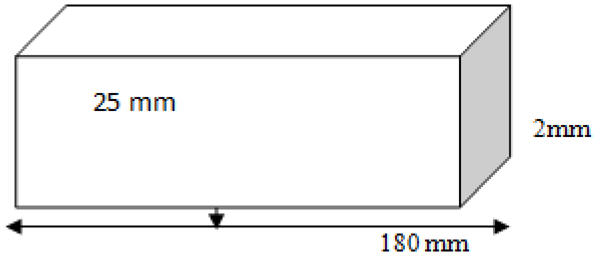

Fig 1.5: Flexural specimen configuration

The specimens were tested without tabs in a standard UTM (universal testing machine). The cross head rate was 10mm/min. Load displacement curves were obtained for all the specimens. For each type of composites, five specimens were tested and their flexural property was evaluated.

Fig 1.6: Flexural testing of composite test specimen

Table1.2: Flexural Test Specimen Specifications

Serial no	Cattail fiber weight (g)	Resin weight (g)	Specimen weight (g)	Number of specimen tested
1	2	150	105	5
2	4	150	147	5
3	6	150	179.6	5
4	8	150	181.4	5
5	10	150	213.2	5

NOMENCLATURE

ρ_c= total mass/total volume

V_f= $(\rho_C-\rho_R)/(\rho_{Co}-\rho_R)$

Vf= $(\rho_C-\rho_R)/(\rho_S-\rho_R)$

σ_t= load/cross sectional area in Mpa

σ_f= $3PL/2bd^2$

where, ρ_c = Density of the composite, g/mm^3

Vf= Fiber volume fraction,

ρ_R = Density of Resin, g/mm^3

ρ_S=Density of Sisal fiber, g/mm^3

ρ_{Co}= Density of coconut particulate, g/mm^3

σ_t= Tensile strength, Mpa

σ_f= Flexural strength, Mpa

P= Maximum load, N

L= Span Length, mm

b= width of the specimen, mm

d= depth of the specimen, mm

VI. RESULTS AND DISCUSSIONS

This chapter gives the outcome of the experiments performed for the evaluation of respective tests.

Variation of Tensile Strength with Fiber Volume for cattail fiber Reinforced Unsaturated Polyester Composite

Table 2.1: Tensile strength, Strain, Young's modulus & Fiber volume fraction for 2 grams specimen

Specimen no	Max deflection	Max load(KN)	Tensile strength(MPa)	Strain	Young's modulus(MPa)	Fibre volume fraction(%)
1	2.4	6.12	81.6	0.016	5100	2.77
2	4.5	8.5	113.22	0.03	3777.67	2.77
3	3.4	7.6	101.13	0.023	4461.62	2.77
4	5.1	7.84	104.45	0.034	3072.05	2.77
5	2	6.20	82.66	0.0133	6199.5	2.77
Avg	3	7.25	81.74	0.02326	4522.16	2.77

The table gives values for deflection, strain, young's modulus for fiber volume fraction of 2.77 %. The values of max deflection & max load were obtained by testing each specimen in UTM for tensile test. A total of 5 specimens were tested and their average is taken.

Table 2.2: Tensile strength, Strain, Young's modulus & Fiber volume fraction for 10 grams specimen

Specimen no	Max deflection	Max load(KN)	Tensile strength(MPa)	Strain	Young's modulus(MPa)	Fibre volume fraction(%)
1	27	7.32	97.6	0.018	5422.22	6.012
2	3.5	8.62	114.93	0.0230	4996.9565	6.012
3	3.9	8.8	117.3	0.026	4511.53	6.012
4	3.1	7.6	101.3	0.0206	4901.61	6.012
5	2.9	8.8	118	0.018	6210.52	6.012
Avg	3.02	7.968	109.83	0.02240	5208.566	6.012

The above table gives values for deflection, strain, young's modulus for fiber volume fraction of 6.012 %. The values of max deflection & max load were obtained by testing each specimen in UTM for tensile test. A total of 5 specimens were tested and their average is taken.

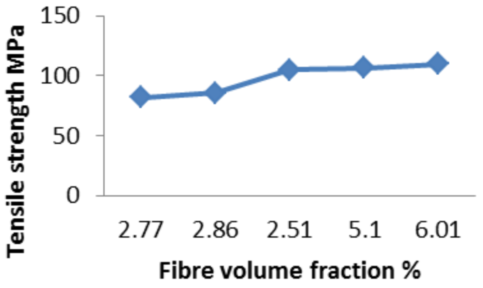

Fig 2.1: Tensile strength Vs Fiber volume for cattail reinforced polyester composite

Figure shows the variation of tensile strength with fiber volume for cattail reinforced polyester composite. It can be seen from the graph that as the fibre volume fraction increases, the bending strength also increases. At 6.01% of fiber volume fraction, the tensile strength is maximum whose value is 109.83MPa and at 2.77% of fiber volume fraction, the tensile strength is minimum whose value is 81.75MPa.

Fig 2.2: Fractured specimen for tensile test

STRESS - STRAIN CURVES FOR TENSILE TEST SPECIMEN

Stress and Strain curve for specimen of fiber volume fraction of 2.77%

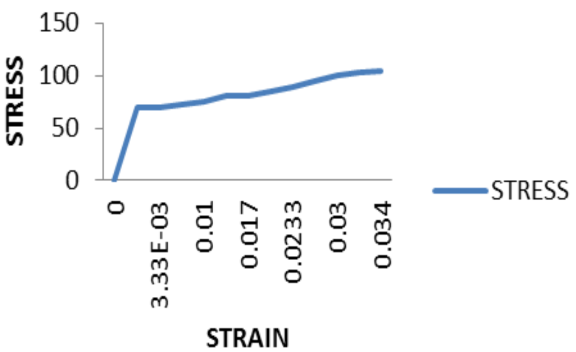

Fig 2.3 Stress and Strain curve for specimen of fiber volume fraction of 2.77%

The graph shows the stress v/s strain diagram for fiber volume fraction of 2.77%. The stress is taken on y axis in MPa and strain is taken on y axis. It is observed that from 0 to 74MPa the curve is linear, the proportional limit is up to 74MPa and thereafter curve is non - linear up to 104.53MPa.The max value of stress and strain are 104.53 and 0.034 respectively.

Stress and Strain curve for specimen of fiber volume fraction of 6.012%

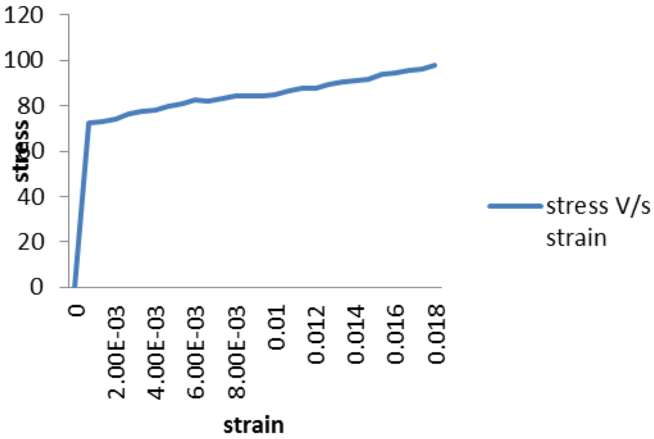

Fig 2.4: Stress and Strain curve for specimen of fiber volume fraction of 6.012%

The above graph shows the stress v/s strain diagram for fiber volume fraction of 6.012%. The stress is taken on y axis in MPa and strain is taken on y axis. It is observed that from 0 to 77.5MPa the curve is linear, the proportional limit is up to 77.5MPa and thereafter curve is non - linear up to97.6MPa.The max value of stress and strain are 97.6 and 0.018 respectively.

Table 2.3: Variation of flexural strength with fiber volume for cattail fiber reinforced polyester composite.

Serial no	Specimen weight (g)	Max deflection (mm)	Max load (KN)	Max flexural strength (Mpa)	Fiber volume fraction (%)
1	2	26	5.552	9028.28	1.6678
2	4	21.82	5.576	9252	2.33
3	6	16.54	5.208	9374.4	2.85
4	8	23.52	5.456	9712.8	2.98
5	10	14	5.392	9820.8	3.38

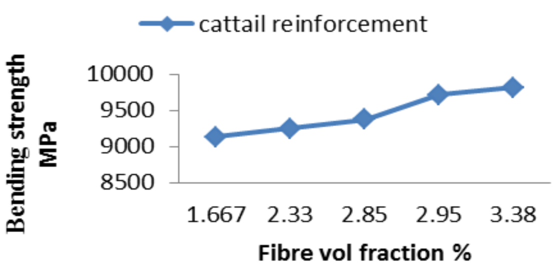

Fig 2.5: Flexural strength Vs fiber volume for cattail reinforced polyester composite

Figure 2.5 shows the variation of flexural strength with fiber volume for cattail reinforced polyester composite. It can be seen from the graph that as the fibre volume fraction increases, the bending strength also increases. At 3.38% of fiber volume fraction, the flexural strength is maximum whose value is 9820.8MPa and at 1.66% of fiber volume fraction, the flexural strength is minimum whose value is 9128.28MPa.

VII. CONCLUSION

In this project an attempt is made to determine the tensile and flexural properties of cat-tail fiber reinforced polyester composite. The experimental analysis of composites was carried out according to ASTM standards D5083 and D790-03. Tensile and flexural tests were conducted on five specimens of each type of composite & the average was considered for the value. The following observations were made:

- The strength of the composites increased as the fiber volume increased for all types of composite specimens irrespective of fiber and matrix materials.
- The tensile strength of composites increases as the fiber volume fraction increases.
- The flexural strength of composites increases as the fiber volume fraction increases.
- Maximum tensile strength is 109.83 MPa.
- Maximum flexural strength is 9820.8 MPa.

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