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Characterization of Mechanical Properties on Tamarind Shell (TS) Powder and Wood Apple Shell (WAS) Powder Reinforced with Epoxy Resin and Hardener

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***Abstract* – In the present work, Variation of Tensile test, compression test, Bending test and Impact test of the Tamarind Shell (TS) and Wood Apple Shell (WAS) Particulate composites was studied. From experimental results, it is found that composites prepared with 25% of WAS and 5% TS powder reinforced epoxy composites exhibited better tensile, compression and flexural properties as compared to 0%+30%, 5%+25%, 10%+20% and 15%+15% combinations. For impact studies all samples have exhibited the same amount of energy absorbed for all combinations. This study reveals that, drop in the mechanical Properties for the 30% WAS + 0% TS composites and slight increment in the mechanical properties for increase in the TS percentage with the WAS.**

Keywords — Tamarind Shell Powder; Wood Apple Shell Powder; Hardener; Resin: Hardener; Impact Test.

I. INTRODUCTION

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical and mechanical properties.

The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate. Particulate composites have dimensions that are approximately equal in all directions. They may be spherical, platelets or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuous fiber composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement due to processing difficulties and brittleness.

The Continuous phase is the matrix, which is a polymer, metal or ceramic. Polymers have low strength and stiffness, metals have intermediate strength and stiffness but high ductility and ceramics have high strength and stiffness but are brittle. The matrix performs several critical functions, including maintaining the fibers in the proper orientation and spacing and protecting them from abrasion and the environment. In polymer and metal matrix composites that form a strong bond between the fiber and the matrix, the matrix transmits loads from the matrix to the fibers through shear loading at the interface.

II. MATERIALS AND METHODOLOGY

The flow chart shows the experimental work of the present work.

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A. Wood Apple Shell Powder

Figure.1. Wood Apple Shell Powder

The Wood apple shell was dried in outside and granulated into powder utilizing a pummeling machine; the powder was sieved as per BS 1377:1998 standard. The compound investigation of the wood apple shell was finished with Absorption Spectrometer (AAS) Peck in rudder 2006 model. The pelletized polyethylene waste was sundried and destroyed in a plastic smasher machine. The molecule size utilized was 280 µm.

B. Tamarind Shell Powder

Figure.2. Tamarind Shell Powder

Tamarind is one of the very developed trees in India. India is one of the most astounding cultivators of Tamarind on the planet. Tamarind comprises of 3 sections – tamarind organic product mash which is palatable, hard green natural product mash, and tamarind seed. Tamarind organic product test powder commonly known as Tamarind Shell Powder.

Table.1.Chemical composition of wood apple shell and tamarind seed particles.

Sample	WAS (%)	TS (%)
Cellulose	39.54	18.55
Hemi cellulose	26.06	47.6
Lignin	29.86	4.04
Ash	0.9	2.6

C. Matrix System

Figure.3. Epoxy Resin (L -12)

Epoxy L–12 is a fluid, unmodified epoxy sap of medium thickness which can be utilized with different hardeners for making glass fibre fortified composites.

Figure.4. Hardener (K -6)

Hardener K–6 is a low consistency room temperature restoring fluid hardener. It is normally utilized for hand layup applications. Being fairly responsive, it gives a short pot-life and fast fix at ordinary encompassing temperatures.

Table.2. Details of Constituent Properties as Supplied by Manufacturer

Constituent	Trade Name	Chemical Name	Epoxide Equivalent	Density
Resin	L-12	DGEBA	182 - 192	1.262
Hardener	K - 8	TETA		0.954

D. Size of particulate composites

A form of size 280 mm X 150 mm X 6mm was set up of hardened steel for getting ready Plate tests. Form comprises of a base plate, outline that could be destroyed to encourage simple evacuation of throwing after the restoring. Every one of the surfaces of the form was covered with wax. All the internal surfaces of shape, interacting with surfaces of composite to be cast are spread with uniform covering of wax so as to encourage the arrival of the cast piece.

Volume = Length x Breadth x Height
Volume = 280 x 150 x 6
Volume = 252000 mm^2
= 252 cm^3

Specifications

Density of the epoxy = 1.26 g/ cm^3
Density of the Tamarind shell powder = 0.51 g/ cm^3
Density of the Wood apple shell powder = 1.068 g/cm^3

Calculations of Volume to Mass

Mass of Epoxy = Density x Volume
= 1.26 x 252
= 317.52 grams
Mass of Tamarind shell = Density x Volume
= 0.51 x 252
= 128.52 grams
Mass of Wood apple shell = Density x Volume
= 1.068 x 252
= 269.13 grams

Calculations of Mass for percentage.

Mass calculation for plate A

Mass of Epoxy = Percentage x mass of Epoxy
= (70/100) x 317.52
= 222.26 grams
Mass of Tamarind shell = Percentage x mass of T S

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= (15/100) x 128.52
= 19.28 grams
Mass of Wood apple shell = Percentage x mass WAS
= (15/100) x 269.13
= 40.36 grams

Mass calculation for plate B

Mass of Epoxy = Percentage x mass of Epoxy
= (70/100) x 317.52
= 222.26 grams
Mass of Tamarind shell = Percentage x mass of TS
= (10/100) x 128.52
= 12.85 grams
Mass of Wood apple shell = Percentage x mass of WAS
= (20/100) x 269.13
= 53.83 grams

Mass calculation for plate C

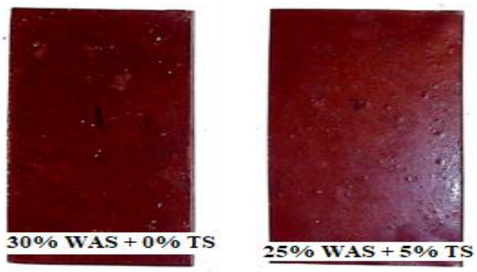
Mass of Epoxy = Percentage x mass of Epoxy
= (70/100) x 317.52
= 222.26 grams
Mass of Tamarind shell = Percentage x mass of TS
= (5/100) x 128.52
= 6.426 grams
Mass of Wood apple shell = Percentage x mass of WAS
= (25/100) x 269.13
= 67.28 grams

Mass calculation for plate D

Mass of Epoxy = Percentage x mass of Epoxy
= (70/100) x 317.52
= 222.26 grams
Mass of Tamarind shell = Percentage x mass of TS
= (0/100) x 128.52
= 0 grams
Mass of Wood apple shell = Percentage x mass of WAS
= (30/100) x 269.13
= 80.73 grams

E. Sample Preparation

Four totally different compositions (30%+0%, 25%+5%, 20%+10%, 15%+15%) of WAS+TS powder dispersed in epoxy glue to prepare composites by using hand lay-up technique. For this purpose metal mold of 280x150x6 mm cube is employed. Waxed Mylar sheet is used to cover the mold for good surface finish and easy withdrawal of prepared specimen. First off the Wood apple shell and Tamarind shell was washed with the distilled water to get rid of the surface impurities.



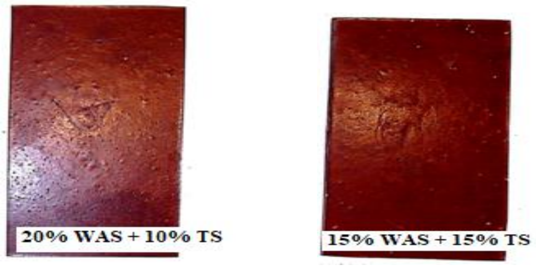


Figure.5. Sample Preparations

Table.3. Sample Coding

Sl. No.	Sample Code	Combinations of fiber powders	
		WAS	TS
1.	30% WAS + 0% TS	30%	0%
2.	25% WAS + 5% TS	25%	5%
3.	20% WAS + 10% TS	20%	10%
4.	15% WAS + 15% TS	15%	15%

The composite plates of various composites were cut according to ASTM standards for different tests.

Table.4. ASTM Standard Chart

Property Studies	ASTM Standard Number
Tensile Test	D 3039-T6
Compressive Test	D 3410
Bending Test	D 2344-84
Impact Test	A 6110

III. RESULTS AND DISCUSSIONS

A. Tensile Test

The tensile tests were conducted with respect to ASTM D3039-76 standards in a Universal Testing Machine.

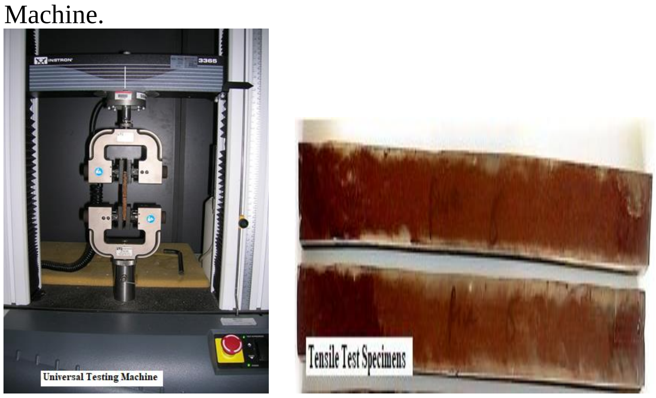


Figure.6. Universal Testing Machine and Tensile Test Specimens

The tensile test results were tabulated in table.5 and it shows the results of tensile strength and yield stress for the

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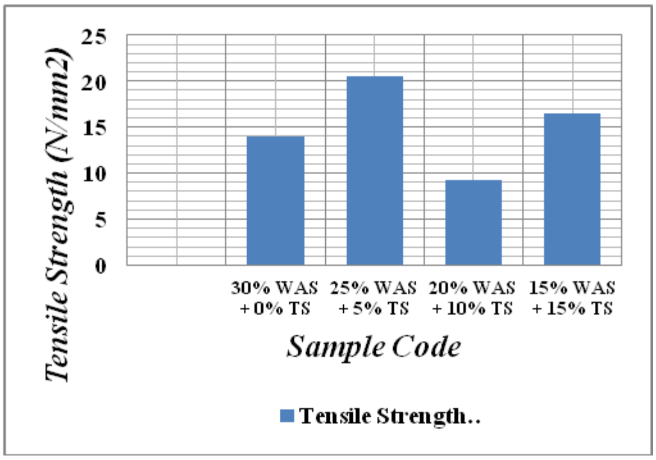
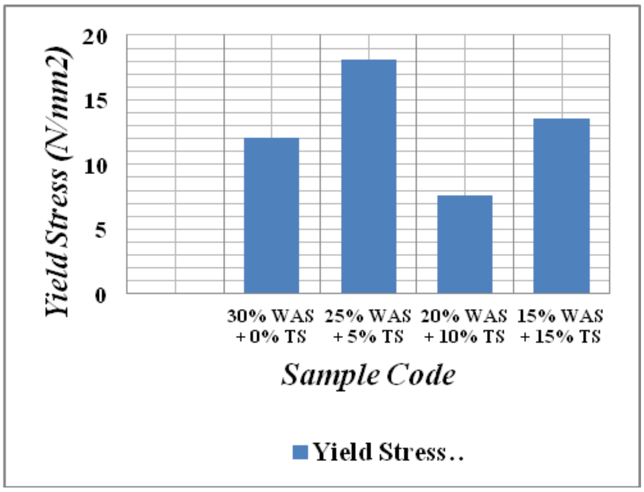
WAS and TS powder composites with different combinations.

Table.5. Results of Tensile Test

Sample Code	No. of Readings	Tensile Strength (N/mm^2)	Yield Stress (N/mm^2)
30% WAS + 0% TS	1	7.6	6.9
	2	20.5	17.2
25% WAS + 5% TS	1	22.7	20
	2	18.5	16.3
20% WAS + 10% TS	1	13.3	10.9
	2	5.2	4.3
15% WAS + 15% TS	1	14.8	12.1
	2	18.1	15



Graph.1. Comparison of tensile strength for different combinations



Graph.2. Comparison of Yield Stress for different combinations

Graph.1 and 2 depicts the comparison of tensile strength and yield stress values among different combinations considered in this work. Out of four categories, second type of combination i.e. composites comprised with 25% WAS +5% TS had shown good results for both tensile (20.6 N/mm^2) and yield stress (18.15 N/mm^2).

B. Compression Test

Compression test was conducted for the above said specimen categories as per the ASTM standard D3410 in a Compression Testing Machine.

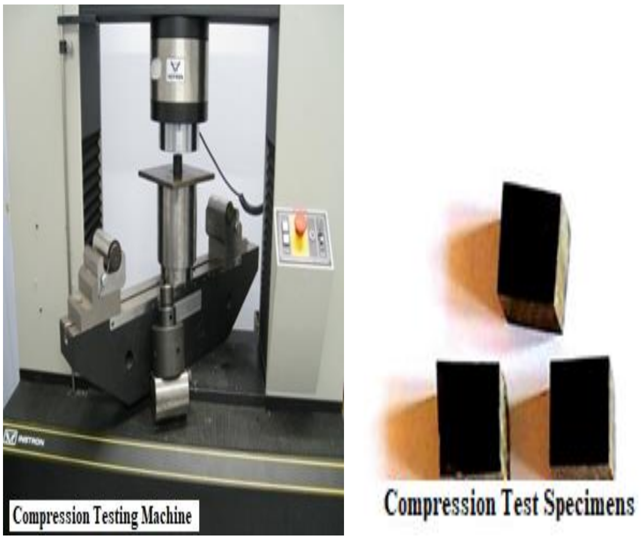


Figure.6. Compression Testing Machine and Compression Test Specimens

The Compression test results were tabulated in table.6 and it shows the results of compression strength and Ultimate Load for the WAS and TS powder composites with different combinations.

Table.6. Results of Compression Test

Sample Code	No. of Readings	Compression Strength (N/mm^2)	Ultimate Load (kN)
30% WAS + 0% TS	1	93.8	7.81
	2	90.1	7.61
25% WAS + 5% TS	1	91.5	7.12
	2	95.5	7.16
20% WAS + 10% TS	1	80.6	7.27
	2	81.4	7.56
15% WAS + 15% TS	1	74.6	4.61
	2	66.2	3.56

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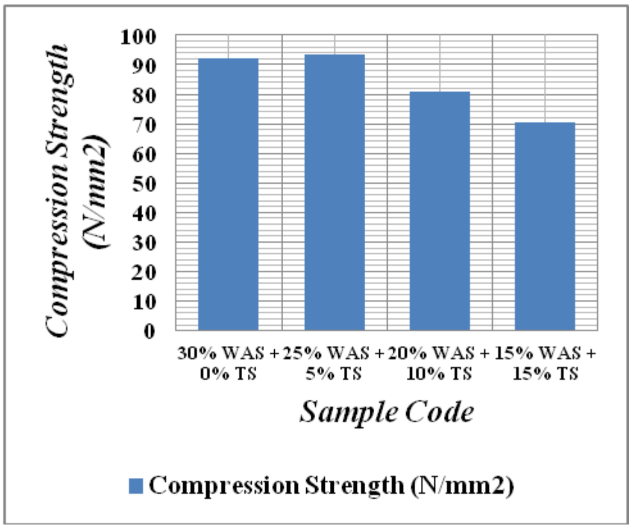
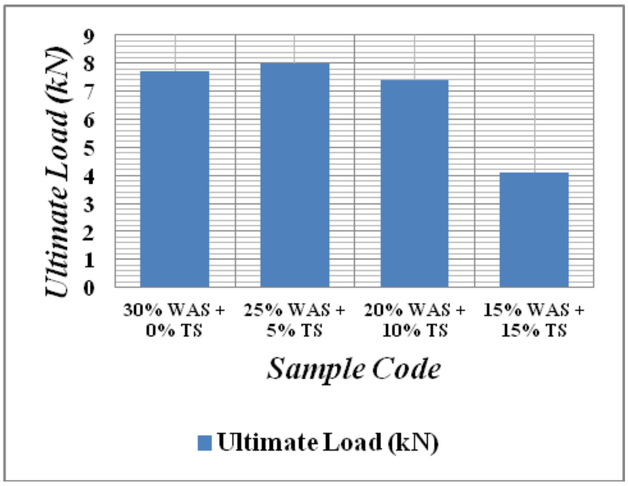


Graph.3. Comparison of Compression Strength for different combinations



Graph.4. Comparison of Ultimate Load for different combinations

Graph.3 and 4 depicts the compressive strength and ultimate load comparison for different samples. Through these graphs it was observed that, composite with 25% WAS + 5% TS powder exhibiting the highest compressive strength (93.3 N/mm^2), whereas composite with 30% WAS + 0% TS has got the better load bearing capacity (7.71 kN). Compressive strength for different specimens was found to be diminishing in nature as the TS powder percentage increases.

C. Bending Test

The Bending tests were conducted as per the ASTM D2344-84 using 3- point Bending Testing Machine with across head speed of 1 mm/min.

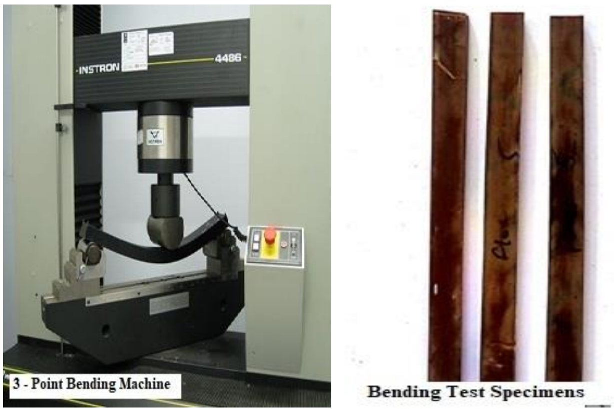
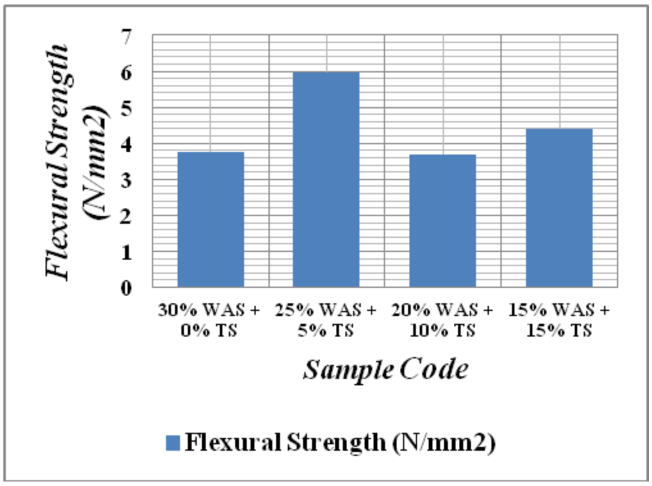


Figure.7. 3- Point Bending Testing Machine and Bending Test Specimens

The 3- point test results were tabulated in table.7 and it shows the results of Flexural strength and Ultimate Load for the WAS and TS powder composites with different combinations.

Table.7. Results of 3- Point Bending Test

Sample Code	No. of Readings	Flexural Strength (N/mm^2)	Ultimate Load (kN)
30% WAS + 0% TS	1	4.1	0.31
	2	3.4	0.25
25% WAS + 5% TS	1	3.7	0.29
	2	4.5	0.37
20% WAS + 10% TS	1	3.7	0.27
	2	3.7	0.29
15% WAS + 15% TS	1	4.7	0.3
	2	4.1	0.24



Graph.5. Comparison of Flexural Strength for different combinations

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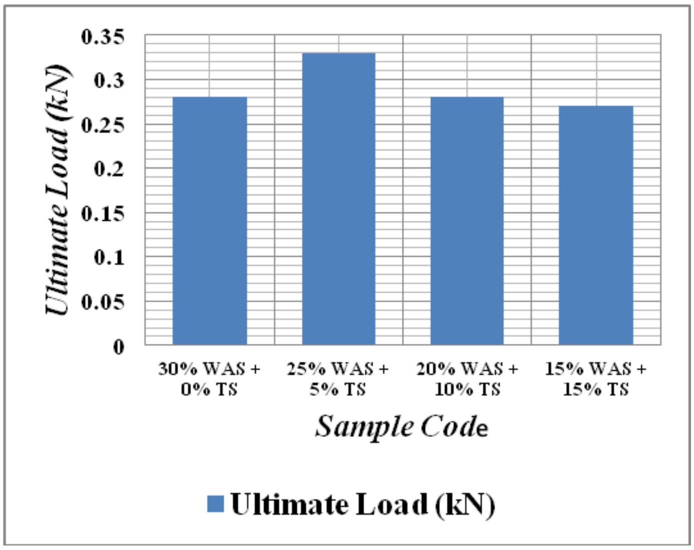

Graph.6. Comparison of Ultimate Load for different combinations

Graph.5 and 6 depicts the comparison of flexural strength and ultimate load for different samples tested. Among different categories, composites with 15% WAS + 15% TS powder composites have exhibited good flexural properties (4.4 N/mm2) and 25% WAS + 5% TS powder composites have shown good load bearing capacity (0.33 kN) for flexural loading condition as compared to other samples.

E. impact Test

An impact testing machine was used to do the impact test accompanying the specimen standards as per ASTM D 6110. The energy absorbed by the test samples from the results is divided by the area of cross-section of the specimen in order to estimate the values of the fracture occurred. Table.8 explains about the impact strength in terms of energy absorbed by the test samples.

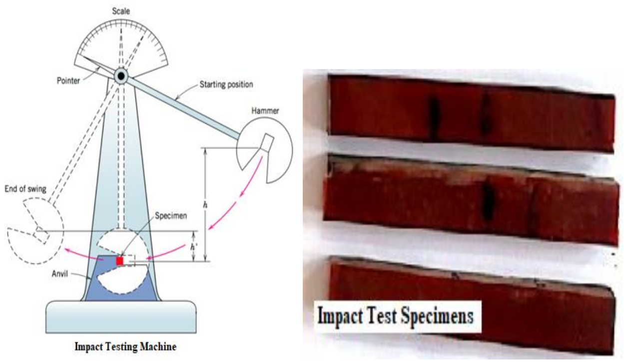

Figure.8. Impact Testing Machine and Impact Test Specimens

Table.8. Results of Impact Test

Sample Code	No. of Readings	Absorbed Energy (Joules)
30% WAS + 0% TS	1	2
	2	2
25% WAS + 5% TS	1	2
	2	2
20% WAS + 10% TS	1	2
	2	2
15% WAS + 15% TS	1	2
	2	2

Table.8 depicts the impact strength values of different combination composites, obtained results are identical for all the samples considered in this work. This indicates that, there was no effect of adding TS powder with WAS powder in composites for impact strength properties. For all the compositions, impact test results have indicated same results for all samples tested.

IV. CONCULSIONS

The variation of tensile, Compression, bending and impact properties of the tamarind shell and wood apple shell particulate composites was studied. From experimental results, it is found that, composites prepared with 25% of WAS and 5% TS powder reinforce epoxy composites exhibited better tensile, compression and flexural properties as compared to 30%WAS+0%TS, 20%WAS+10%TS and 15%WAS+15% TS combinations.

For impact studies all samples have exhibited the same amount of energy absorption (2 Joules) for all combinations. This study reveals that, drop in the mechanical properties for the 30% WAS + 0% TS composites and slight increment in the mechanical properties for increase in the TS percentage with the WAS.

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