

# Mechanical characterization and finite element analysis of composite material

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**ABSTRACT** : Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. Composites are made up of individual materials referred to as constituent materials. The composite material is prepared from the glass fibre and the unsaturated polymer resin also known as the general purpose resin. Then the filler material teak wood powder is used to increase the strength of the glass fibre composite. The preparation of composite is being made by hand layup technique. The prepared composite is being cut to the required dimensions as per ASTM standards. Then tensile strength and impact strength of the prepared composite is carried out. Then the modeling of the specimens carried out Fusion 360<sup>o</sup> software and the tensile, impact analysis is carried out using ANSYS 15 software. The experimental results and analysis results are compared and checked the percentage of error.

## 1. INTRODUCTION

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter or less expensive when compared to traditional materials. Composite materials are generally used for buildings, bridges and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite and cultured marble sinks and counter tops. The most advanced examples perform routinely on spacecraft and aircraft in demanding environments. Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart the special mechanical and physical properties to enhance the

matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination. Engineered composite materials must be formed to shape. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mould cavity or onto the mould surface. The matrix material experiences a melding event, after which the part shape is essentially set. Depending upon the nature of the matrix material, this melding event can occur in various ways such as chemical polymerization or solidification from the melted state. The principal factors impacting the methodology are the natures of the chosen matrix and reinforcement materials. Another important factor is the gross quantity of material to be produced.

## 2. METHODOLOGY

The General purpose resin (5522 polylyte epoxy) act as the matrix for the composites to bind the composite material together and transfer the component forces that may act on the part of the fibres in the composite material. Fibres offer vivid range of properties due to their unique constituents and manufacturing process and some of the key points to be looked after while selecting fibre quality, fibre volume fraction, orientation, fibre type, length of fibre. Glass fibre is a material consisting of numerous extremely fine fibres of glass. Here in this project E- type glass fibre, filler material as teak wood powder.

**Table-1:** Properties of epoxy resin

Density	2.64g/cm <sup>3</sup>
Young's modulus	1.41Gpa
Melting temperature	100degree-200degree
S.G of the epoxy	5522
Low viscosity	-
Low volatility during cure	-

**Table-2:** Properties of E-glass fibre

Density	2500-2590 kg/m <sup>3</sup>
Longitudinal thermal Expansion	5.04-5.4 * 10 <sup>-6</sup> /°C
Tensile modulus	72.345 GPa
Tensile strength	3.45 GPa
Elongation	4.4%
Poisons ratio	0.22
Thermal conductivity	1.05 W/m/°C

**Table-3:** Properties of teak wood

Specific gravity	0.55-0.66
Modulus of rupture	97.1 MPa
Elastic modulus 1	12.28 GPa
Crushing strength	54.8 MPa

**2.1 Specimen preparation:**

Composite specimens are prepared by using hand lay-up method. . In our experiment general purpose resin is used as a matrix material and two types of reinforcement such as glass fibre and teak wood powder are used.

Three types of specimen composites are prepared with two different types of reinforcement and base material as resin which composite consisting of different weight percentage of glass fibre and prepared different combination of slabs /work pieces as follows

1. Combination of 60% glass fibre and 40% resin.
2. Combination of 70% glass fibre and 30% resin.
3. Combination of 80% glass fibre and 20% resin.
4. Combination of 60% glass fibre, 40% resin and filler material as teak wood powder



**Fig-1:** Prepared tensile test specimen with 70% glass fibre and 30% resin



**Fig-2 :** Prepared tensile test specimen with 60% glass fibre and 40% resin



**Fig-3:** Prepared tensile test specimen with 80% glass fibre and 20% resin



Fig-4: Prepared impact test specimen of glass fiber



Fig-5 : Prepared impact test specimen of glass fiber

30%R				
80%GF+ 20%R	100.23	116.43	91.74	102.8
60%G+ 40%R+ TWP	105.64	142.26	118.4	122.1

**3.2 ANSYS result of the pure glass fibre composite tensile test.**

Tensile test results are obtained by the ANSYS using the following data.

Tensile strength obtained from the analyses 121.57 N/mm<sup>2</sup>.

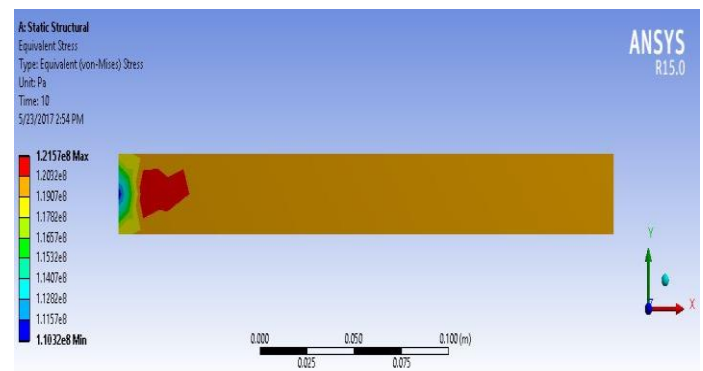


Fig-6: ANSYS result of tensile strength for pure glass fibre

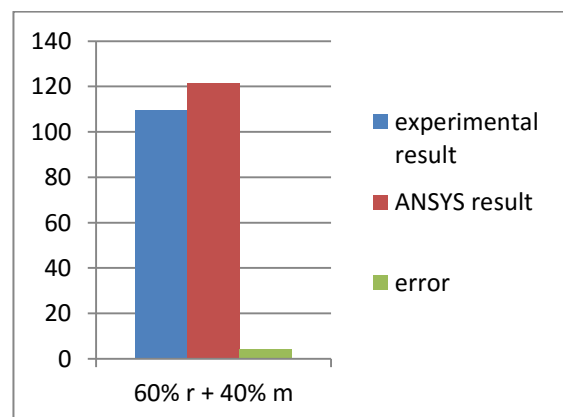
**3. RESULT AND DISCUSSION**

**3.1 Tensile strength:**

This test was according in accordance to ASTM D3039 method using a minimum of three specimens (250mm\*15mm\*4mm) for each composite. A Fine Spavy Associates and Engineers PVT. LTD., Miraj testing machine with software connected to a computer was used for the test. The maximum load carrying capacity of the machine is 40 tons. Tensile strength and young's modulus are found out using the following formula  $\rho = F/A$ ,  $E = \rho L/\delta$ .

Table -4 : Tensile strength results

Material	Tensile strength (MPA)	Tensile strength (MPA)	Tensile strength (MPA)	Average Tensile strength (MPA)
60%GF+ 40% R	126.68	97.08	104.51	109.42
70%GF+	61.07	74.67	54.00	63.25



Graph -1: Tensile strength results comparison

**3.3 Impact strength:**

Impact test results are summarized in the following table. The addition of the reinforcement into the epoxy increases the impact strength. SL-1 pendulum impact tester machine is used to carry out the impact test. The amount of energy dissipated during the time of

failure is noted. As the material gets harder with increased density its impact strength decreases. Specimen was prepared according to ASTM D256 type with an angle of 45° and 2.5mm. A specimen size of 60mm\*25mm\*5mm was used.

**Table-5:** Impact strength results

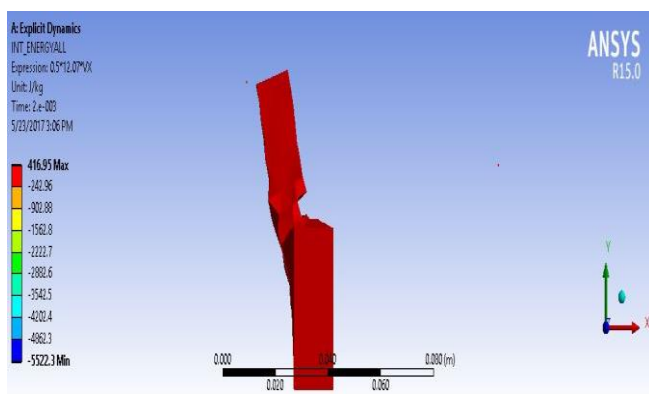
Materials	Energy absorbed (J)	Impact strength (J/m)	Impact strength (J/m)	Impact strength (J/m)	Average impact strength (J/m)
60% GF + 40% R	3.25	403.8	576.9	624.9	535.2
60% GF+ 40%R+ TWP	4.05	778.8	731.4	750.6	753.6

**3.4 ANSYS result of the pure glass fibre composite impact test.**

Impact test results are obtained by the

ANSYS using the following data.

Impact strength obtained from the analyses 416.95.



**Fig-7:** ANSYS result of pure glass fibre impact test

**3.5 Hardness:**

The hardness of the given specimens were tested using barcoal hardness tester according to the

ASTM D2240.the depth of the penetration of the incident is used to characterize the hardness of the indentation in comparison to the penetration of an indenter. The values were taken at five different points and mean values are noted.

**Table-6:** Hardness readings

Specimen	Barcoal hardness number
Pure glass fibre	35
Glass fibre with filler material	50.33

**3.6 Comparision between experimental and ANSYS results**

Sl no	Composite	Experimental result	ANSYS results	Error %
1	GF (tensile)	109.42 N/mm <sup>2</sup>	121.57 N/mm <sup>2</sup>	4.03
2	Glass fibre (impact)	403.8 J/m	416.95 J/m	3.15

**4. CONCLUSION**

An experiment was conducted on universal testing machine and SL-1 pendulum impact tester machine for the prepared glass fibre composite and the glass fibre composite with filler material as teak wood powder, the experiment resulted in

1. It can be accomplished from experiment and analysis in ANSYS 15 that the glass fiber composite with filler material as teak wood powder is having the more tensile and impact strength than the pure glass fibre composite.
2. Thus instead of using glass fibre we can replace them with glass fibre composite with filler material of teak wood powder as it is having good mechanical properties.
3. The amount of energy absorbed during the impact testing is more in the composite having the filler material.

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