Modelling, Analysis and Mechanical Properties of C.F with S.T. Fiber Reinforced Polymer Hybrid Composites

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Abstract

Natural fibre composites have piqued the interest of researchers because to its improved properties, affordability, and simplicity of supply. One such plant-based leaf fibre that hasn't been thoroughly investigated by the research communityis Sansevieria trifasciata fibre. This fiber's cellulose content is over 80%, suggesting that it might be a viable substitute for synthetic fibre due to its potential to improve tensile strength and other qualities. This work's primary goal is to use matrix composites and the Sansevieria Trifasciata fibre as possible reinforcement. Because it is inexpensive and simple to utilize, unsaturated resin is employed as a matrix. The composite slabs are made by the compression moulding process. Under room curing temperature, composites with varying fibre lengths and fibre loadings (0% to 20% wt.) are made, and their mechanical properties are examined. Up to a certain weight percentage, the impact, flexural, and tensile strength of a matrix are improved by adding Sansevieria Trifasciata fibre as reinforcement; after that, the strength significantly declines with additional fibre addition. First, the impact of weight percentage and fibre length on the mechanical characteristics of composites madeby compression moulding at room temperature is presented.

The mechanisms for surface degradation, such as fibre pulling and separation, under tensile pressures of 15% STF and 20% STF. Because sansevieria trifasciata wets short fibre composites, the polymer resin is weak. The treated fibre’s wax, lignin, and amorphous hemicelluloses content keeps the fibre from getting moist with the matrix. The fibres are forced out of the die by an applied tensile load. The fibres are pulled out of the matrix, creating the cavities. Less than 20 percent of STF fibres have faults and have more fibre ends when the percentage of fibers rises from 15 to 20 percent. Thus, 20% STF fibers are observed to have the greatest fibre recovery. The tensile strength decreases as the proportion of fibers rises to 20% because more fibre extraction takes place, leading to a comparatively larger cavity size and fibre tangling. It is assumed that the crucial proportion of fibers is 30% based on the tensile behaviour of the compounds.

This article analyzes the mechanical properties of hybrid plastic composites made of carbon fibre (CF) and Sansevieria trifasciata fibre (STF) through tensile testing, impact testing, and flexural testing. In addition to the five different STF fibre percentages (0, 5, 10, 15, and 20), percentages of carbon fibre (50, 45, 40, 35, and 30) were also used in the creation of the hybrid composite laminates. In reality, the production process was completed using a manual layup technique. The mechanical properties of sansevieria trifasciata fibre-reinforced composites are the subject of further investigation. The compression moulding process is used to create these composites. The optimal fibre length is 60 mm, and the ideal fibre weight percentage is 50% Epoxy + 30% CF + 20% STF% wt. The curing temperatures for these composites vary, ranging from 30 ^{0}C to 150 ^{0}C. The results are given, and Ansys was used to analyse the mechanical properties.

Keywords: carbon fiber, snake plant, sansevieria trifasciatafibre

1. INTRODUCTION

This chapter goes into great length regarding the many types of composite materials, with a focus on polymer matrix composites. Sansevieria trifasciata, the snake plant, is well recognized for its capacity to both create and absorb vast volumes of oxygen and carbon dioxide. It can often be accessed in remote locations.

The cross-sectional location of carbon fiber, which is between 5 and 10 micrometers, may offer better adaptability. Carbon fiber and graphite are blended together.

Research on composites consisting only of sansevieria trifasciata fiber and hybrid composites comprising both sansevieria trifasciata and carbon fiber are carried out using thermal gradient analysis [1]. Composites using carbon fiber (CF) [2] composed of hybrid polymers.

The extensive usage of artificial fibers in automobiles and aerospace, such as carbon and ST [3] fiber, ensures their excellent overall functionality. This article discusses the mechanical properties of hybrid carbon fiber (CF) plastic composites made of Sansevieria trifasciata (STF) fibers, as well as the results of the tensile, impact, flexural tests. Flexural and tensile tests were used to ascertain the composite sample's mechanical characteristics [5]. It isforced to ask for circumstances that, in actuality, depend on oil. Depleting petroleum reserves, volatile crude oil prices, disposal concerns, and synthetic toxins have all raised questions about potential solutions (Koronis et al., 2011). In the case of randomly oriented composites, natural fibers with optimal fiber percentage and weight fractions [6, 7 and 8]. In fact, applications involving heatsurfaces use carbon fiber [9]. Fibres 2 are used in conjunction with kenaf, flax, hemp, and ramie to produce fiber. Composites [10] are in high demand for architectural needs.

Together with two different materials, such as Sansevieria trifasciata, carbon fiber, and matrix, complex components [12] are made. In reality, compound [13] goods weigh substantially less. Laminated flooring with different percentage structures and directions is made of compositematerials.

The carbon fibers have a cross- sectional location of 5–10 microns and are more flexible. Graphite and carbon fiber are mixedtogether. In fact, thermal surface applications use carbon fibers [14].

Carbon fibres as well as Sansevieria Trifasciata fibres reinforced with proven plastic 4 compounds to drive mechanical buildings such as tensile, impact, flexural strength and improve protection against high temperature damage [15] Composites have improved commercial properties and construction techniques such as traction, impact, stiffness and flexural characteristics as a result of the hybridization of artificial and natural yarns. The transverse location of carbon fibres is actually 5 to 10 microns.

Figure 1.1: Sansevieria Trifasciata plant (snake plant)

Figure 1.2: Sansevieria Trifasciata fibre

It is well known that carbon fiber has greater strength, more thermic conductivity, and greater durability. Carbon fiber is a material that is long and thin, usually consisting of carbon fiber atoms in longitudinal dimensions of 0.0002-0.0004 in and 0.005-0.010 mm in diameter. carbon fibers that are typically 1 to 5 μmin size. Carbon fiber fibers with sizes between 6 and 10 μm are usedas an enhancing product in polyester and epoxy materials to create high-tightness compositesbecause they have high flexible moduli and strengths. Actually, carbon fibers are a long, thin substance made up of carbon fiber atoms that have longitudinal diameters of 0.005-0.010 mm and 0.0002-0.0004 mm. The support could be manufactured using materials such carbon fiber, glass, boron, and aramid. [2]

Figure 1.3: Carbon fibre mat

Figure 1.4: Epoxy and Hardener

Composites consist of two or more components, one of which is a filler or reinforcement consisting of long, tension fibers or even a particle product, and the other of which is a binder, source, or resin that holds the filler in place. [16] Synthetic and natural fibers are the two types of fibers that are genuinely used as encouragement. [17] According to some descriptions, carbon fiber contains at least 90% carbon that is obtained through the carefully regulated pyrolysis of perfect fibers.

Higher elastic moduli and durability are possessed by carbon fiber fibers with diameters in therange of 6–10. These fibers are utilized as an enhancer in epoxy and rayon materials to create composites with increased stiffness. Young's modulus is 125–181 Gpa, and the carbon fiber exhibits excellent heat resistance, chemical resistance, compressive strength, hardness, and tensile durability (4127 J/m^3). [18]

[19] Because oil serves as the primary raw material for the production of carbon fiber and other man-made fibers, the high overall efficiency of these materials.

❖ APPLICATIONS AND ADVANTAGES OF HYBRID COMPOUNDS S.T& C.F.

when plants are grown inside, with a maximum temperature of 65 to 80 °F.For the source, plant nutrients that include N-P-K (nitrogen-phosphorus-potassium in the blood) are fed to the plants in a 7:4:10 ratio in the spring. The Snake plant is one of 15 types of plants that can absorb pollutants from the air, according to a NASA clean air research.

MATERIALS AND METHODS

A component made of carbon fiber (CF) from Go, Chennai's eco-friendly products. The carbon fiber specification includes directions for 90 ^{0} C as well as HS 12K on a 0^0 C trajectory. ASTM D 1777 specifies a density of 0.45 mm for carbon fiber, while ASTM D 3776 specifies a distance of 1005 mm. The ASTM D 3801 value for carbon fiber is 419 g/mm^2, and the thread size is 7µ. In actuality, carbon fiber has an adhesion advantage of 3450 MPa. In reality, the carbon-fibre-reinforced polymer is a lightweight, extremely durable plastic that is reinforced with carbon fibers.

Epoxy products and hardeners are LY 556, HY951. The transverse composite laminates actually had 8 levels. A hybrid composite with randomly oriented carbon fibres as well as fibres of sansevieria trifasciata within the plastic matrix has been prepared.

Carbon fibre (CF) purchased from Go Chennai Green Products. The crossover complex test method involves 8 layers along with epoxy and hardener. The dimensions of the samples are 63X12X3. In the impact test, the sample size was actually 63.5 X12.7 X3. In the tensile test, the sample sizes are 165X13X3.The Sansevieria Trifasciata, which is now being reviewed here, is made of carbon fiber. Hindupur, Anantapuramu District (A.P.), India is the source of S T. In actuality, the S.T. fiber comes from S.T. Cut leaves spend approximately a month breaking down in water that has been agitated.

In actuality, the default quantity of LY-556, HY-951 tampers with the 10:1 ratio. In reality,all intricate structures are created by laminating wood forms. The product is first cured for 24 hours at room temperature before being exposed to an 8-hour curing period at 600 °C. There are eight fully blended layers of epoxy and hardener that makeup the complicated laminates Carbon Fiber and Sansevieria Trifasciata. In actuality, the laminates' total typical fullness measured 3 mm. In actuality, hybrid composites with an area weight of 380g/m2 have been created, beginning with the STRP structure and altering the carbon fiber layer.

❖ MATERIALS USED

The different types of materials used to treat all the compounds under investigation are presented below:

❖ MATRIX MATERIAL

The unsaturated isophthalic polymer (USP) resin used in this study has a density of 1.2 g/cc and a viscosity of 12,000 MPa. It is sourced from Green Products, Chennai, India. Dibasic organic acids and polyhydric alcohols react to generate chemically double bonds, which are commonly seenin unsaturated polymer resin.

❖ FIBRE MATERIAL

In the present work, Sansevieria trifasciata (ST) fibre has been used as the reinforcing material in all the composites. Carbon fibre (CF) is used for studying the effect of hybridization along with sansevieria trifasciata fibre. The chemical properties of ST and CF used in this investigation are shown in Table 2.1.Table 2.1 Chemical properties of fibre as referred and also procured. (80, 93)

Properties / **Fibre**	**Cellulose content (Wt. %)**	**Lignin content (Wt. %)**	**Wax content (Wt. %)**	**Moisture content (Wt. %)**	**TOTAL**
STF	79.7	3.8	0.09	3.08	86.67

❖ FABRICATION OF COMPOSITES

The curing reaction is started by using the unsaturated polymer epoxy resin grade LY556 and hardener HY951 as a matrix (10 ml of hardener was taken for every 100 g of epoxy resin). Figure 3.1 displays the equipment used in compression moulding). The mould is squeezed by supplying a curing pressure of 1000 kg onceit is placed in the machine.

Figure 2.1 Laminate preparations with Compression moulding equipment

2.1 MECHANICAL TESTING

The mechanical testing is carried out to understand the mechanical performance such as Flexural, tensile and impact of the composites by using Universal Testing Machine (UTM) [137] and impact tester. It will be explained in detail in this section.

2.1.1 TENSILE TEST

A material's tensile strength indicates how well it can tolerate tearing. A Universal Testing Machine (UTM) with a -3T capacity typically conducts the tensile test; one such UTM is depicted in Figure 2.2. The tests are carried out in compliance with ASTM D 638. The tensile test specimen is displayed in Figure 2.3. A 3 mm thickness is kept constant.

Table 2.2 Mechanical properties for sample 40%-10% composition for Tensile test

Sr. No.	Results	Value	Units
1	Area	69.9612	mm²
2	Yield Force	8634.22	N
3	Yield Elongation	7.69	mm
4	Break Force	9436.0	N
5	Break Elongation	8.25	mm
6	Tensile Strength at Yield	123.41	N/mm²
7	Tensile Strength at Break	134.87	N/mm²
8	Tensile Strength at Max	134.87	N/mm²
9	% Elongation	18.33	%
10	Max Force	9435.96	N
11	Max Elongation	8.25	mm
11	Modulus of Elasticity	712.23	N

Table 2.3 Mechanical properties for sample 30%-20% composition for Tensile test

Specimen code	SAMPLE-30%-2		
Ref. Standard	ASTM D638		
Grip Length	37	Guage Length	37
Sample Width	13.64	Sample Thickness	4.51
Speed of testing (mm/min)	5		

Specimen code	Sample 40%		
Ref. Standard	ASTM D638		
Grip Length	45	Guage Length	45
Sample Width	13.48	Sample Thickness	5.19
Speed of testing (mm/min)	5		

Sr. No.	Results	Value	
1	Area	61.5164	mm²
2	Yield Force	7562.61	N
3	Yield Elongation	9.05	mm
4	Break Force	8505.7	N
5	Break Elongation	9.80	mm
6	Tensile Strength at Yield	122.94	N/mm²
7	Tensile Strength at Break	138.27	N/mm²
8	Tensile Strength at Max	137.65	N/mm²
9	% Elongation	26.48	%
10	Max Force	8468.01	N
11	Max Elongation	9.80	mm
11	Modulus of Elasticity	520.48	N

Figure 2.2 Universal testing machine

Figure 2.3 Typical tensile test Hybrid composite specimens

2.1.2 FLEXURAL TEST

The force needed to bend a beam under three-point load conditions is measured by the flexural test. To ascertain the sample's flexural strength, a three-point flexural test is conducted. The transverse head was stretched 63 mm while keeping its speed constant at 5 mm/min. Figure 2.4 depicts the 3-point flexural fixation. The samples for the flexural tests are displayed in Figure. 2.5 and are carried out in accordance with ASTM D7 9003. Only the sample's center shouldcome into contact with the sample's point of application when it is put on the holder. The sample's breaking point is reached when a specific load is applied to it. The reading is now interpreted as the sample's load and deviation. For every test, five samples are collected, and the average of the data is used. The mechanical properties found from the flexural test was shown in following table.

Obtained Results			
Sr. No.	Results	Value	Unit
1	Area	37.5768	**mm²**
2	YIELD Force	564.9212269	**N**
3	YIELD Deflection	2.38	**mm**
4	Max Force	685.0	**N**
5	Max Deflection	4.6	**mm**
6	FLEXURAL STRENGTH @ YIELD	88.43	**N/mm²**
7	FLEXURAL STRENGTH @ Max	427.5296077	**Mpa**
8	Flexural Strain	0.037118661	
9	Flexural Modulus at 1% Strain	53476.02	**Mpa**
10	FLEXURAL MODULUS OF ELASTICITY	3439.993947	**N/mm²**

Table 2.4 Mechanical properties for sample 40%-10% composition for flexural test

Sample Details			
Specimen code	**SAMPLE-40%-4**	Ref. Standard	**ASTM D790**
Span Length	**48**	Test Speed (mm/min)	**5**
Sample Width	**12.24**	Sample Thickness	**3.07**

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Table 2.5 Mechanical properties for sample 30%-20% composition for Flexural Test

Sample Details			
Specimen code	**SAMPLE-30%-2**	Ref. Standard	**ASTM D790**
Span Length	**48**	Test Speed (mm/min)	**5**
Sample Width	**12.34**	Sample Thickness	**3.06**

Obtained Results

Sr. No.	Results	Value	Unit
1	Area	37.7604	**mm²**
2	YIELD Force	408.6135808	**N**
3	YIELD Deflection	1.43	**mm**
4	Max Force	446.1	**N**
5	Max Deflection	1.6	**mm**
6	FLEXURAL STRENGTH @ YIELD	63.14	**N/mm²**
7	FLEXURAL STRENGTH @ Max	277.9529878	**Mpa**
8	Flexural Strain	0.01275337	
9	Flexural Modulus at 1% Strain	34880.37	**Mpa**
10	FLEXURAL MODULUS OF ELASTICITY	3554.22649	**N/mm²**

Figure 2.4 UTM with 3-point flexural attachment

Figure 2.5 Typical flexural test Hybrid Composite specimens

2.1.3 IMPACT TEST

Impact tests are intended to gauge a material's resistance to fracture under unexpected impact.Impact testers are used to conduct the testing in compliance with ASTM D 256. The most popular methods for determining impact toughness or relative toughness are the Charpy test. Figure 2.6 depicts the impact test apparatus, whereas Figure 2.7 shows the test parts. The machine's installed electronic screen is used to calculate the impact energy [139] (J). For every test, five samples were obtained, and the outcomes were averaged.

Figure 2.6 Impact testing machine **Figure 2.7 Fractured impact test Hybrid Composite specimens**

2.2 SUMMARY

This chapter presents:

- The materials used for the experiments are discussed.
- Details of the production and characterization [145] of composites.
- Description of the different test procedures.
- The next chapter discusses the effect of fibre percentage and weight on the mechanical properties and Analysis of Mechanical Properties using Ansys Work Bench Tool of fibre- reinforced sansevieria trifasciata polymer composites.

3. RESULTS & DISCUSSION

This chapter discusses the mechanical properties of fibre-reinforced sansevieria trifasciata polymer composites. The interpretation of the results and the comparison between the different composite samples are also presented.

Table 3.1. Details of mechanical properties of ST/PE composites with varying wt. percentageof fibre content at optimum fibre percentage.

Wt. percentage of carbonfibre	**Tensile strength MPa**	**Flexural strength MPa**	**Impact strengthJ/cm^2**
50% Epoxy + 50% CF + 0% STF	344.6	564	59.52
50% Epoxy + 45% CF + 5% STF	230.35	505.28	28.60
50% Epoxy + 40% CF + 10% STF	157.61	443.33	31.95
50% Epoxy + 35% CF + 15% STF	150.01	295.66	38.91
50% Epoxy + 30% CF + 20% STF	144.83	447.66	39.67

3.1 EXPERIMENTAL RESULTS

3.1.1 EFFECT OF FIBRE PERCENTAGE ON TENSILE STRENGTH

Figure 4.1 illustrates how the percentage of fibers affects the tensile characteristics of hybrid compositions of sansevieria trifasciata and CF that are randomly oriented. The inter twining of the fibers is responsible for the decrease in tensile strength at higher percentages of ST fiber and lower percentages of carbon fiber. 10% STF & 40% CF fiber fraction yields a maximum tensile strength of 144.83 MPa. After reaching this level, the tensile strength decreases (10%STF & 40% CF). The tensile strength increases with the percentage of fibers. Figure 4.1 displays tensile specimens of short fiber composites made of sansevieria trifasciata. Table 3.2: Effect of fibre percentage on tensile strength

Wt. percentage of carbon fibre	Tensile strength MPa
50% Epoxy + 50% CF + 0% STF	344.6
50% Epoxy + 45% CF + 5% STF	230.35

50% Epoxy + 40% CF + 10% STF	157.61
50% Epoxy + 35% CF + 15% STF	150.01
50% Epoxy + 30% CF + 20% STF	144.83

Figure 3.1 STF –CF percentage on the tensile test specimen

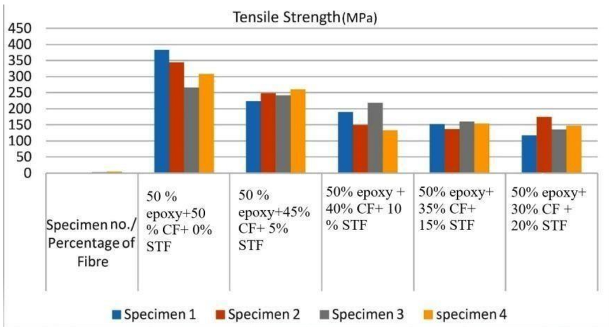

Figure 3.2 Effect of STF –CF percentage on the tensile strength of hybrid composites

3.1.2 EFFECT OF FIBRE WEIGHT PERCENTAGE ON TENSILESTRENGTH

The impact of thepercentage of fiber weight on the tensile characteristics of the sansevieria trifasciata short randomly oriented polymer compounds is depicted in Figure 4.3. When compared to pure polymer resin, it was discovered that a 20% increase in fiber weight could result in a tensile strength increase of up to 1.92. The ideal fiber weight percentage for this task is 20%.

Tensile samples of short fibrous polymer composites of sansevieria trifasciata are shown in Figure 3.3. The lower the percentage by weight of ST fibres increases (15% by weight), the smaller the number of fibres ends and defects. The extracted fibres are minimal. As the percentage by weight of the ST fibre increases from 15 to 20% by weight, the defects causedby the ends of the fibres are more. Thus, more fibre is extracted with a higher percentage of weight of STF. The tensile behaviour shows that the maximum tensile strength is 143.83 MPa and is obtained for optimum percentage of 20% STF by weight of the fibres in the composites.

Table 3.3. Details of fibre weight percentage on the tensile strength of sansevieria trifasciatafibre composites.

Fibre percentage	Specific weight	Tensile strength sp.1.	Tensile strength sp.2.	Tensile strength sp.3.	Tensile strength sp.4.
50% Epoxy+ 50% CF +0% STF	16.758	382.8	344.82	265.88	307.58
50% Epoxy+ 45% CF +5% STF	1.6758	223.73	248.31	241.68	259.62
50% Epoxy+ 40% CF +10% STF	3.3516	189.84	150.04	218.76	133.05
50% Epoxy+ 35% CF +15% STF	5.0274	152.73	137.05	159.38	153.66
50% Epoxy+ 30% CF +20% STF	6.07	117.02	174.11	134.87	147.05

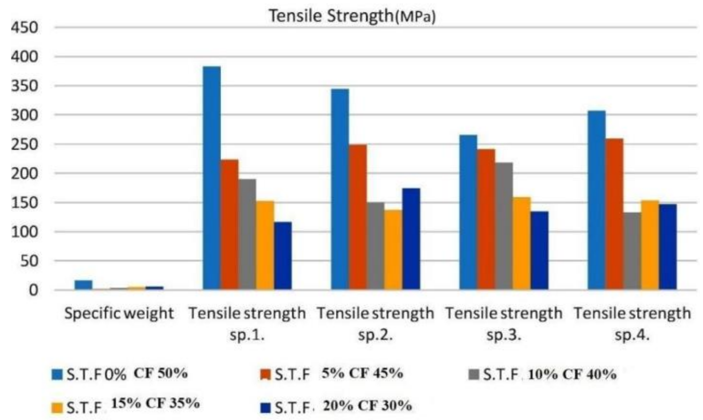

Figure 3.3 Effect of STF - CF weight percentage on the tensile strength of Hybrid composites

3.1.2 EFFECT OF FIBRE PERCENTAGE ON FLEXURAL STRENGTH

Figure 4.4 illustrates how the length of the fiber affects the flexural characteristics of composites made of short, randomly oriented sansevieria trifasciata fibers. The hybrid composites' 20% STF by weight flexural strength is 2.23 times greater than that of pure resin. A fiber content of 20% STF & CF yields a maximum flexural strength of 91.57 MPa. Flexural strength for all percentages by weight of fiber is drastically reduced for larger percentages of ST fibers than 20% STF, as opposed to 15% STF 35% of CF and 20% STF & 30% CF, respectively. As a result, higher percentages of ST fibers—more than 20%—can produce stronger resistance because improper load transfer is impeded by fiber winding and tangling (Fig. 3.4). Figure 4.4 displays the flexural fractography of short fibrous composites made of sansevieria trifasciata fiber. More harm caused by inadequate maintenance can be identified with the addition of the STF Percentage.

Figure 3.4 Specimens with fibre percentage on flexural strength

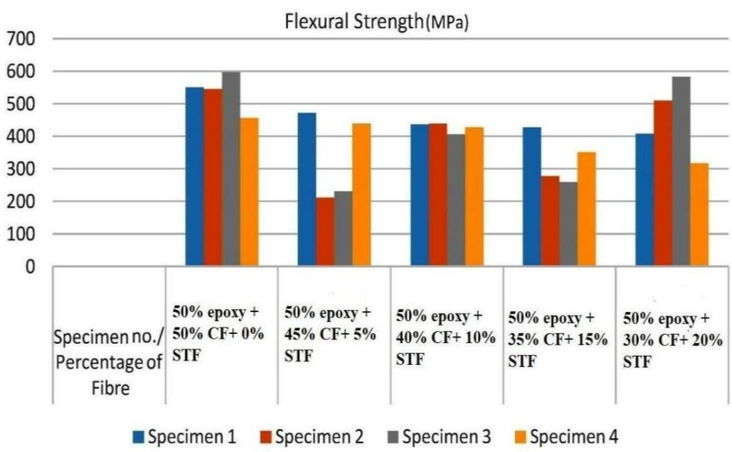

Figure 3.5 Effect of STF - CF % on the flexural strength of Hybrid composites

3.1.3 EFFECT OF FIBRE WEIGHT PERCENTAGE ON FLEXURALSTRENGTH

Figure 3.4 illustrates how the percentage of fiber weight affects the flexural strength of composites made of short, randomly oriented sansevieria trifasciata fiber. When compared to 10 and 15 percent fiber content in the composites, it is discovered that the flexural strength of 20 percent fiber weight increases by 37 and 9 percent, respectively. The flexural strength is found to decrease for 15 percentage wt. compared with 20 percentage wt. At lower weight percentage of fibre, there is a better stress transfer because of good compatibility of fibre with matrix.

Hence there is an increasing trend in flexural strengthfor increase in fibre weight percentage from 10 to 20 percentage. Figure 3.5 shows that there are more voids and fiber degradation at a 30% fiber weight percentage. However, fiber takes out results in a far smaller void, as seen for 20% of thefiber weight in Figure 3.5. Hence, at 20% fiber weight, more flexural strength is achieved.

Table 3.4. Details of fibre weight percentage on the flexural strength of sansevieria trifasciatafibre composites.

Fibre percentage	Specific weight	Flexural strength sp.1.	Flexural strength sp.2.	Flexural strength sp.3.	Flexural strength sp.4.
50% Epoxy + 50% CF +0%STF	16.758	550.68	545.34	597.18	455.92
50% Epoxy + 45% CF +5% STF	1.6758	472.84	212.47	232.31	438.26
50% Epoxy + 40% CF +10%STF	3.3516	437.12	438.21	405.91	427.53
50% Epoxy + 35% CF +15% STF	5.0274	427.97	277.95	259.82	351.52
50% Epoxy + 30% CF +20% STF	6.07	407.77	509.35	582.65	317.59

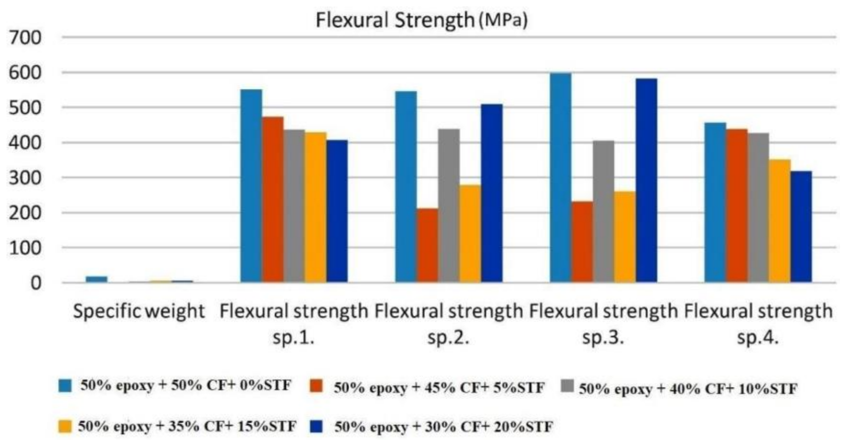

Figure 3.6 Effect of STF-CF weight percentage on the flexural strength of hybridcomposites

3.1.5 EFFECT OF FIBRE PERCENTAGE ON IMPACT STRENGTH

Figure 3.7 illustrates how the percentage of fiber affects the impact characteristics of randomly oriented short composites made of sansevieria trifasciata fibers. For 20 ST fibers at 30% CF, the highest impact resistance is 11.123 J / cm^2. Because longer fiberscan swiftly transfer impact energy between them, they are more resistant to impacts. When compared to pure hardened resin, the impact resistance of 20% ST fiber and 30%CF composites is increased 22 times.

Figure 3.7 STF-CF % on the impact strength specimens.

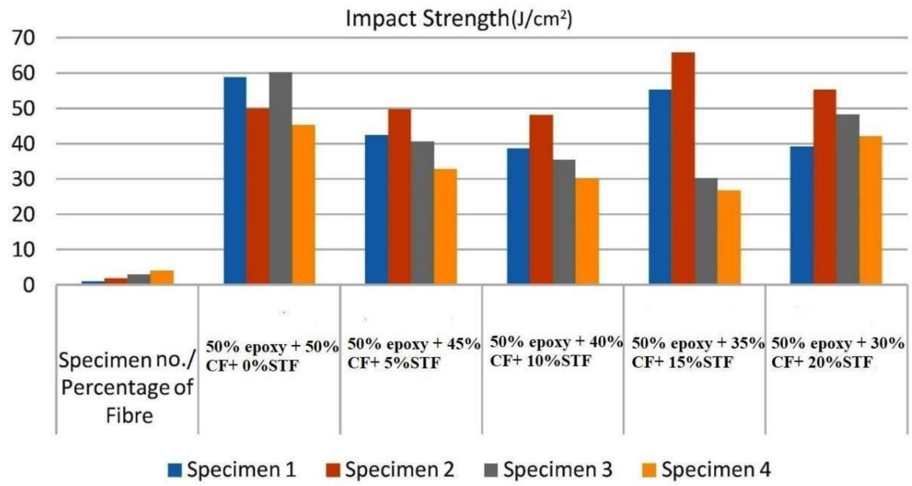

Figure 3.8 Effect of STF-CF % on the impact strength of hybrid composites.

3.1.6 EFFECT OF FIBRE WEIGHT PERCENTAGE ON IMPACTSTRENGTH

The highest impact strength is achieved at 20% STF and 30% CF by weight. Gradually increase the impact resistance gradually increases for all percentages of fibre weight from a minimum of 4.43 J / cm2 for 20 percent STF & 30% CF of the weight ofthe fibres to a maximum of 11.123 J / cm^2 for 30% STF & 20% CF of the weight of the fibres, resulting in a total 15% increase in impact strength of composites. Therefore, greater impact resistance is obtained at a fibre content of 30% STF & 20 CF%.

Table 3.5.

Fibre percentage	**Specific weight**	**Impact strengthsp.1.**	**Impact strengthsp.2.**	**Impact strengthsp.3.**	**Impact strengthsp.4.**
50% Epoxy +50% CF + 0% STF	16.758	58.9	50.02	60.2	45.29
50% Epoxy +45% CF + 5% STF	1.6758	42.36	49.68	40.6	32.84
50% Epoxy +40% CF +10% STF	3.3516	38.68	48.2	35.5	30.2
50% Epoxy +35%CF+15% STF	5.0274	55.25	65.9	30.23	26.8
50% Epoxy +30%CF+20%STF	6.07	39.23	55.23	48.26	42.11

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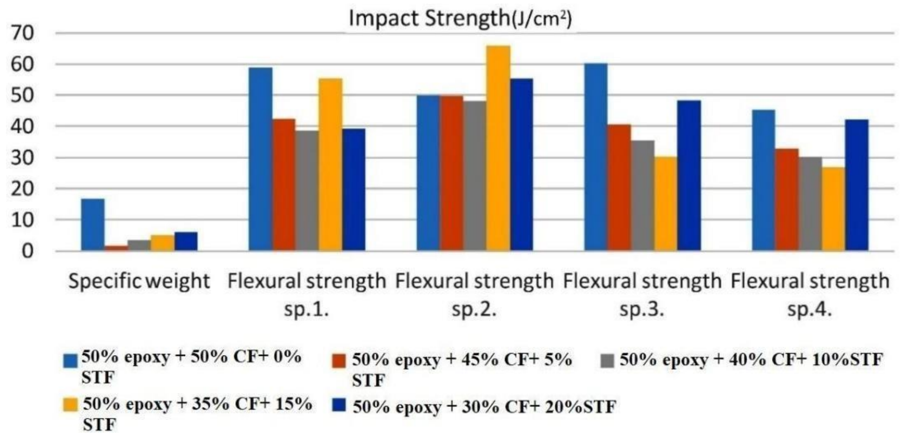


Figure 3.9 Effect of ST fibre CF weight percentages on the impact strength of Hybridcomposites.

3.2 ANALYSIS RESULTS

3.2.1 STRUCTURAL ANALYSIS FOR TENSILE STRENGTH

3.2.1.1 MODELLING OF TEST SPECIMEN

The tensile test specimen is modelled by using Siemens NX Tool, Siemens NX is sometimescalled just NX or even Unigraphics. It's a really cool, high-end tool that helps with CAD (which stands for Computer-Aided), CAM (Computer-Aided Manufacturing), & CA (Computer-Aided Engineering). Made by Siemens Digital Industries Software.

This software is super powerful It helps through the whole process of making a product— starting from the first idea all the way to when it's finally made. With its fancy features in CAD, CAM, and CAE, Siemens NX is like a best friend for engineers & manufacturers. They use itto create great products that are both high-quality and innovative—quickly too!

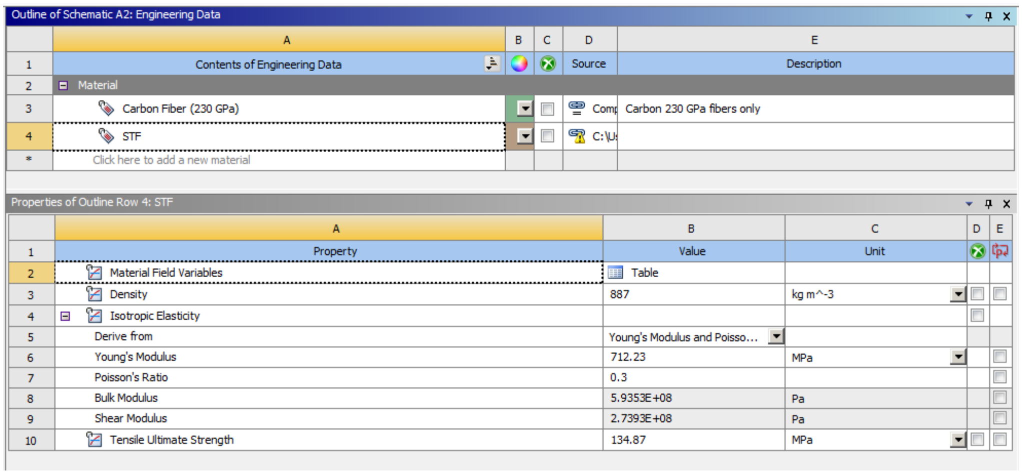
3.2.1.2 ANSYS WORKBENCH

In Ansys workbench the static structural analysis module is used. The engineering material which is used for specimen preparation is added to the material library of engineering data.

3.2.1.3 MATERIAL ADDITION

The materials such carbon fibre and sansevieria trifasciata fiber material are added. Carbon fiber 230Gpa is directly added from the library of composite materials. Then, sansevieria trifasciata fiber (STF) is added to data source, the mechanical properties of STF are added from the table which are found through

experimental analysis as shown in figure 3.10



Outline of Schematic A2: Engineering Data

	A	B	C	D	E
1	Contents of Engineering Data			Source	Description
2	Material				
3	Carbon Fiber (230 GPa)			Comp	Carbon 230 GPa fibers only
4	STF			C:\U	
*	Click here to add a new material				

Properties of Outline Row 4: STF

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	887	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Young's Modulus and Poisso...			
6	Young's Modulus	712.23	MPa		
7	Poisson's Ratio	0.3			
8	Bulk Modulus	5.9353E+08	Pa		
9	Shear Modulus	2.7393E+08	Pa		
10	Tensile Ultimate Strength	134.87	MPa		

Figure 3.10 Material Properties for STF Fiber in Tensile test

3.2.1.4 GEOMETRY

The geometry which is modelled in NX is exported to IGES (Initial Graphics Exchange Specification) format. The IGES file is then imported to the geometry from the destination folder as shown in figure 3.11

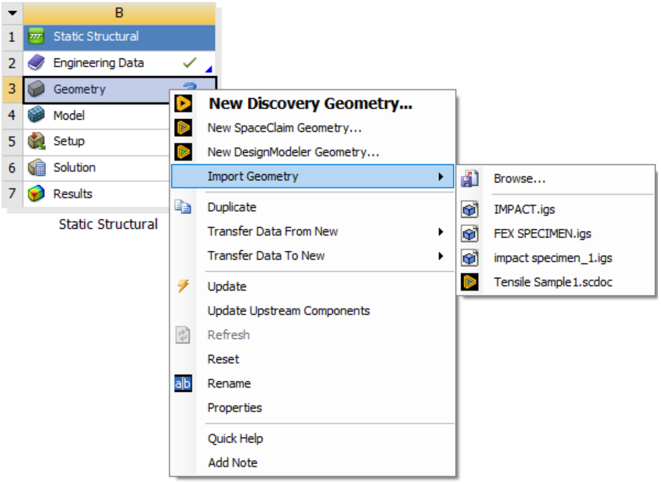


Figure 3.11 Importing Geometry in tensile test analysis

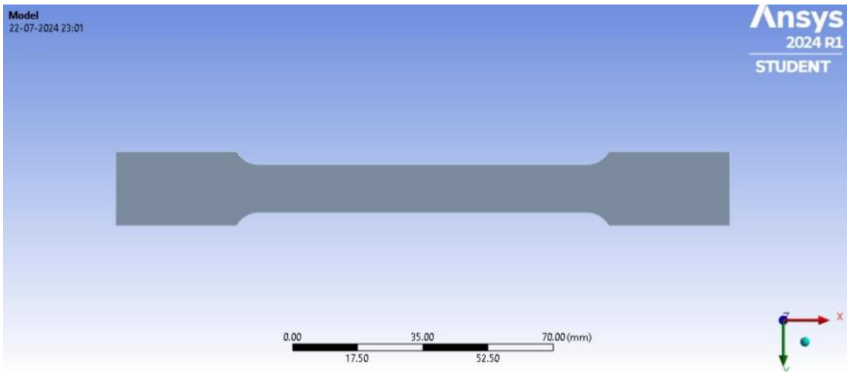
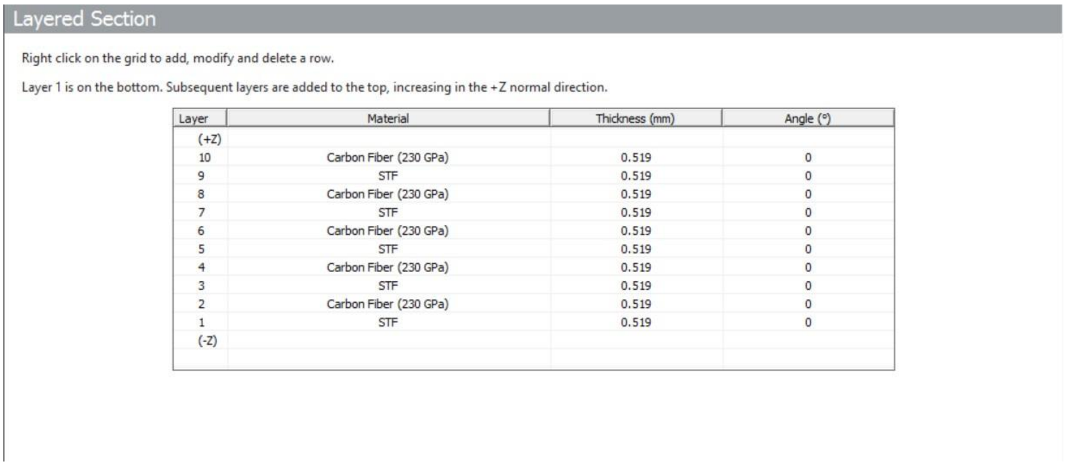


Figure 3.12 Tensile test specimen Model in Ansys Design Modular

3.2.1.5 MODEL SETUP

In this model module it can be observed that the preview of the imported IGES file. A new layered section is added to geometry to define the number of layers of composite material i.e., carbon fiber and sansevieria trifasciata fiber with layer thickness and orientation of the layer asshown in figure 3.13.


Layered Section

Right click on the grid to add, modify and delete a row.

Layer 1 is on the bottom. Subsequent layers are added to the top, increasing in the +Z normal direction.

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
10	Carbon Fiber (230 GPa)	0.519	0
9	STF	0.519	0
8	Carbon Fiber (230 GPa)	0.519	0
7	STF	0.519	0
6	Carbon Fiber (230 GPa)	0.519	0
5	STF	0.519	0
4	Carbon Fiber (230 GPa)	0.519	0
3	STF	0.519	0
2	Carbon Fiber (230 GPa)	0.519	0
1	STF	0.519	0
(-Z)			

Figure 3.13 Layered section for fiber composition in Tensile test

Mesh is the method used for meshing the test specimen by giving a element sizing of 2 mm. the specimen is eventually divided into 644 elements with 740 nodes. These elements and nodal points are completely program controlled according to the given input of element size. The meshed geometry is shown in Figure

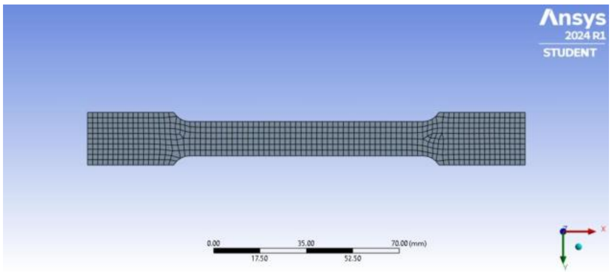


Figure 3.14 Meshed model of Specimen

3.2.1.6 LOAD AND BOUNDARY CONDITIONS

Structural loads and boundary conditions are applied as usual. Here we have two conditions.

3.2.1.6.1 Fixed support at one end of the specimen.

3.2.1.6.2 Force which is applied in another end negative X direction 8634 N.

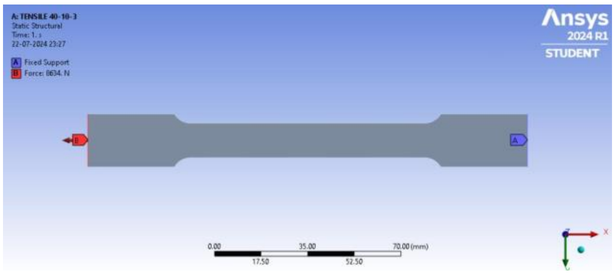


Figure 3.15 Boundary conditions for Sample

3.2.1.7 SOLUTION EXPLORER

In this module the type of solutions which are need to be evaluated are added to the explorer and then the solutions are evaluated for all the layers which are added in the layered section inthe geometry part as well as the stress is calculated for individual layer too. The test result is evaluated for the material composition of 50% Epoxy + 40% CF + 10% STF. The simulationresults are shown in figure 3.16.

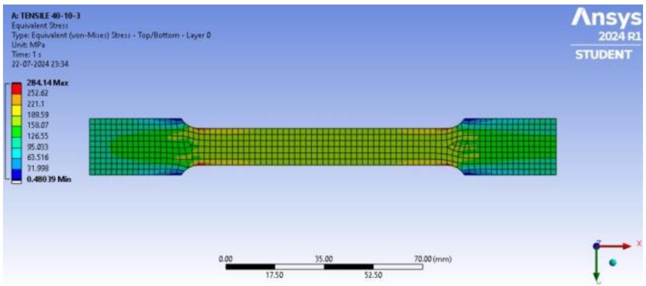


Figure 3.16 Tensile test result for fiber composition 50% Epoxy + 40% CF + 10% STF

Similarly, one more analysis is done for the material composition 50% Epoxy + 30% CF + 20% STF which is the maximum fibre condition by changing the mechanical properties ofsansevieria trifasciata fiber and by changing the load value of 5120 N with same fixed supportat the end. The Equivalent stress is found out from the results as shown in figure 3.17.

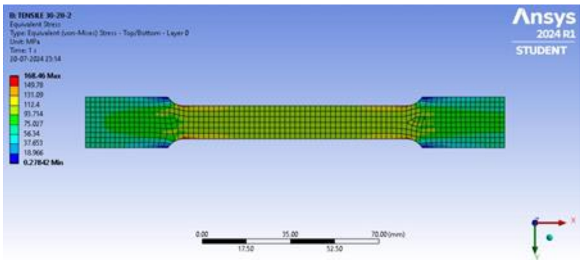


Figure 3.17 Tensile test result for fiber composition 50% Epoxy + 30% CF + 20% STF

The Experimental and Analysis results from Ansys for the material compositions are comparedeach other and shown in table 3.6.

Table 3.6 Experimental and Analysis results comparison for tensile strength

RESULT TYPE		FIBER COMPOSITION	
		50% Epoxy + 40% CF +10% STF	50% Epoxy + 30% CF +20% STF
Tensile Strength	Experimental value	241.68	174.11
	Analytical value	284.14	168.46

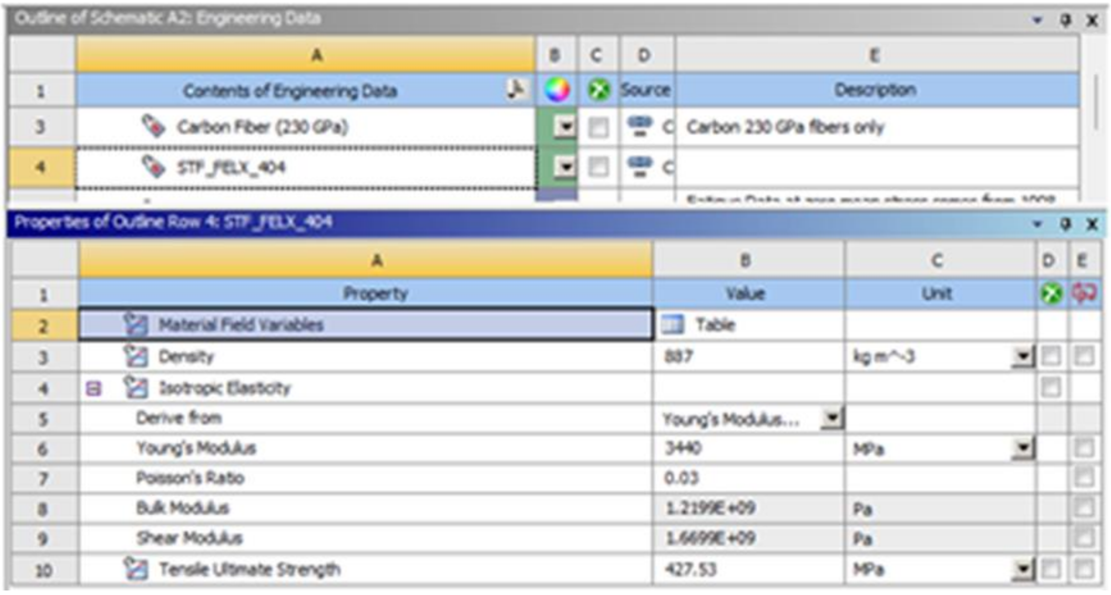


Figure 3.18 Experimental and Analysis results comparison for tensile strength

3.2.2 STRUCTURAL ANALYSIS FOR FLEXURAL STRENGTH

It has been discovered that the flexural strength of composites made of sansevieria trifasciata fibers increases up to a 20 percent fiber weight percentage before decreasing at higher fiber weight percentages. In order to undertake structural analysis, the test specimen is modelled as a rectangular slab and exported into the IGES format. In Ansys workbench static structural analysis module is used to find the flexural strength on the specimen. The procedure of performing the analysis is similar to the Tensile strength.

The parameters such as Mechanical properties, model, Layer stacking and boundary conditions are changed.The mechanical properties are added in the Engineering Data source as shown in figure 3.19

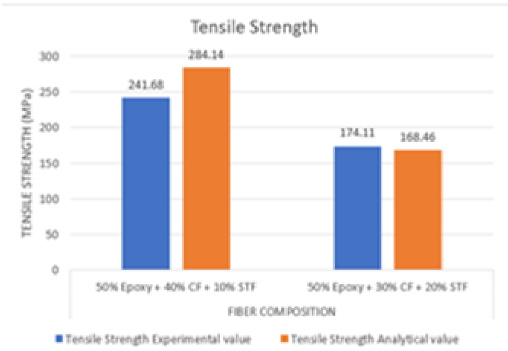


Figure 3.19 Material properties for fiber composition 50% Epoxy + 40% CF + 10% STF

Outline of Schematic B2: Engineering Data

	A	B	C	D	E
1	Contents of Engineering Data			Source	Description
3	Carbon Fiber (230 GPa)			C	Carbon 230 GPa fibers only
4	STF_FELX_404			C	

Properties of Outline Row 4: STF_FELX_404

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	887	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Young's Modulus...			
6	Young's Modulus	3554.3	MPa		
7	Poisson's Ratio	0.03			
8	Bulk Modulus	1.2604E+09	Pa		
9	Shear Modulus	1.7254E+09	Pa		
10	Tensile Ultimate Strength	278	MPa		

Figure 3.20 Material properties for fiber composition 50% Epoxy + 30% CF + 20% STF

- The IGES model is imported to the geometry section in the module as shown in the figure 3.21.

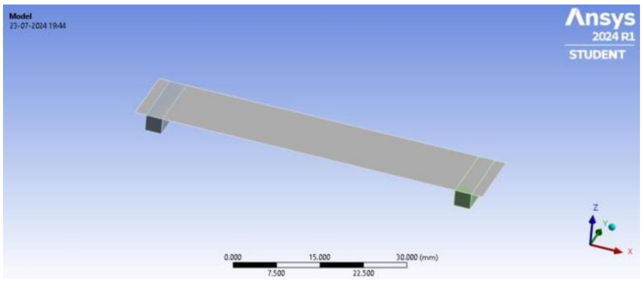


Figure 3.21 Flexural test specimen Model in Ansys Design Modular

In this model module it can be observed that the preview of the imported IGES file. A new layered section is added to geometry to define the number of layers of composite material i.e., carbon fiber and sansevieria trifasciata fiber with layer thickness and orientation of the layer as shown in figure 3.22.

Layered Section

Right click on the grid to add, modify and delete a row.

Layer 1 is on the bottom. Subsequent layers are added to the top, increasing in the +Z normal direction.

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
10	Carbon Fiber (230 GPa)	0.31	0
9	STF_FELX_404	0.31	0
8	Carbon Fiber (230 GPa)	0.31	0
7	STF_FELX_404	0.31	0
6	Carbon Fiber (230 GPa)	0.31	0
5	STF_FELX_404	0.31	0
4	Carbon Fiber (230 GPa)	0.31	0
3	STF_FELX_404	0.31	0
2	Carbon Fiber (230 GPa)	0.31	0
1	STF_FELX_404	0.31	0
(-Z)			

Figure 3.22 Layered section for fiber composition in Flexural test

Mesh is the method used for meshing the test specimen by giving a element sizing of 2mm. the specimen is eventually divided into 792 elements with 1972 nodes. These elements and nodal points are completely program controlled according to the given input of element size. The meshed geometry is shown in Figure

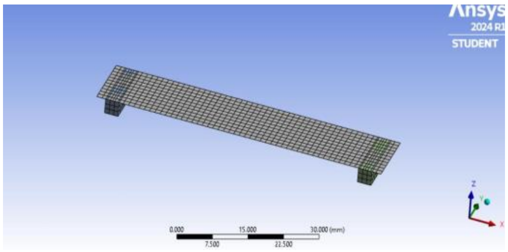


Figure 3.23 Meshed model of Specimen for flexural test

Structural loads and boundary conditions are applied as usual. Here we have two conditions.

Fixed support: the two rectangular blocks which are shown in figure are set tobe fixed supports.

A force of 685 N is applied on the center of the slab along the Z direction for the specimen composition 50% Epoxy + 40% CF + 10% STF as shown infigure.4.24. A force of 1280 N is applied on the center along the Z direction of the slab forthe specimen composition 50% Epoxy + 30% CF + 20% STF as shown in

Figure 3.25.

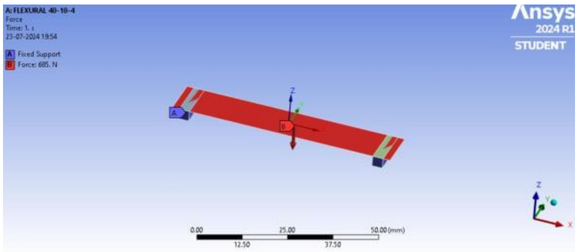


Figure 3.24 Boundary conditions for Sample with fiber composition 50% Epoxy +40% CF + 10% STF

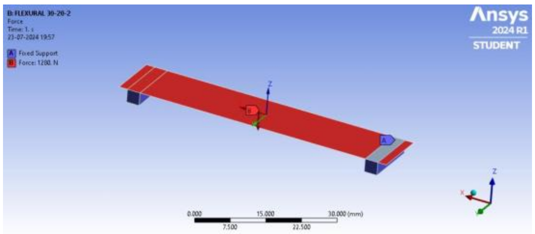


Figure3.25 Boundary conditions for Sample with fiber composition 50% Epoxy +30% CF + 20% STF

The solution Explorer such as Equivalent stress is added to find the maximum and minimum flexural strength for the individual specimens and the analysis images are shown in figure 3.26.

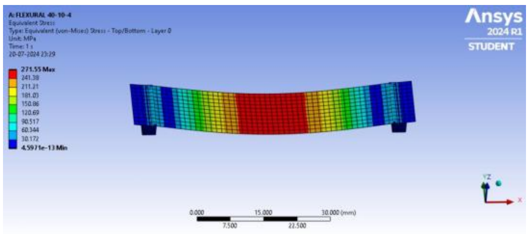


Figure 3.26 Flexural test result for fiber composition 50% Epoxy + 40% CF + 10% STF

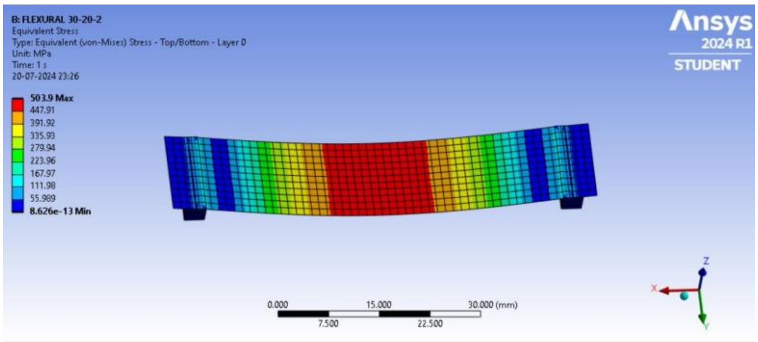


Figure 3.27 Flexural test result for fiber composition 50% Epoxy + 30% CF + 20% STF

It is observed that the maximum flexural strength of 271.55 MPa is reached in the sample with composition 50% Epoxy + 40% CF + 10% STF specimen.It is observed that the maximum flexural strength of 503.9 MPa is reached in the samplewith composition 50% Epoxy + 30% CF + 20% STF specimen. The Experimental and Analysis results from Ansys for the material compositions are compared each other and shown in table 3.7

Table 3.7 Experimental and Analysis results comparison for Flexural strength

RESULT TYPE		**FIBER COMPOSITION**	
		50% Epoxy + 40% CF+10% STF	**50% Epoxy + 30% CF+ 20% STF**
Flexural Strength	**Experimental value**	232.31	509.35
	Analytical value	271.55	503.9

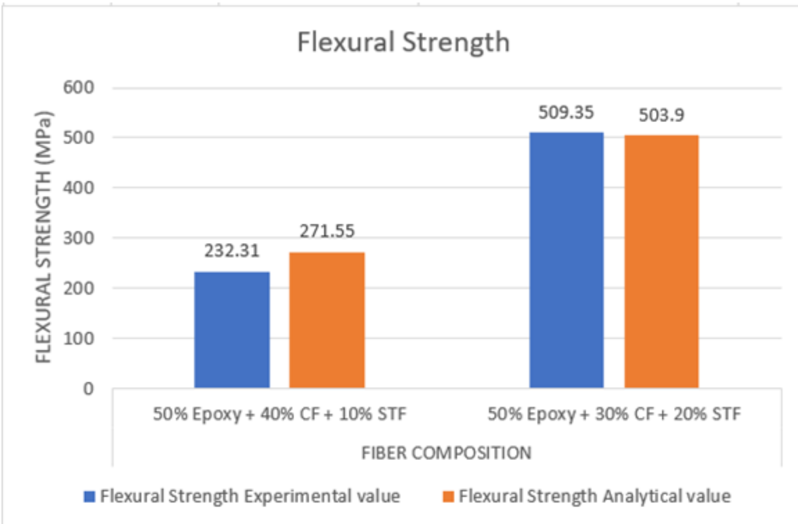


Figure 4.28 Experimental and Analysis results comparison for tensile strength

3.3 IMPACT ANALYSIS

The specimen for impact test analysis is modelled with the dimensions of 63.5 X12.7 X3 mmin rectangular slab. A ‘V’ Notch is grooved at centre for one side of the specimen. The modelis than exported to IGES format. Ansys Explicit Applied loads, high-speed impacts, and free falls are examples of discontinuous events or rapidly changing situations that are taken into account by explicit dynamics. The materials which are added in the engineering data source are same properties of the tensile test specimen Data for the two fiber compositions.

- The model IGES file is imported in the geometry from the local destination folder forthe analysis

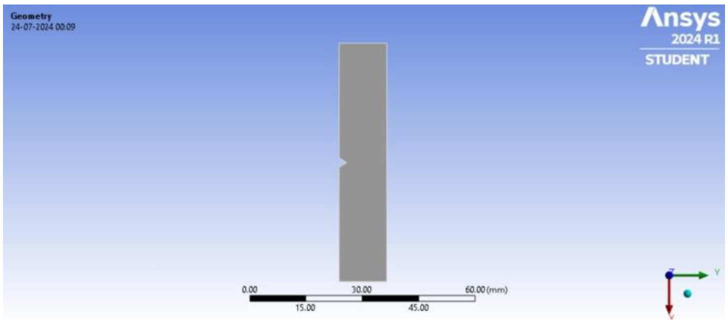


Figure 3.29 Test specimen for impact strength analysis

- Then the geometry is ready to move for the next step which is layer stacking or layeredsection where the fiber layers are added alternatively with certain thickness and at desired angle between the layers. The layered worksheet is shown in the figure. Thereis total 10 layers which are added as shown in figure 3.30

Layered Section

Right click on the grid to add, modify and delete a row.

Layer 1 is on the bottom. Subsequent layers are added to the top, increasing in the +Z normal direction.

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
10	Carbon Fiber (230 GPa)	0.31	0
9	STF_TENS_403	0.31	0
8	Carbon Fiber (230 GPa)	0.31	0
7	STF_TENS_403	0.31	0
6	Carbon Fiber (230 GPa)	0.31	0
5	STF_TENS_403	0.31	0
4	Carbon Fiber (230 GPa)	0.31	0
3	STF_TENS_403	0.31	0
2	Carbon Fiber (230 GPa)	0.31	0
1	STF_TENS_403	0.31	0
(-Z)			

Figure 3.30 Layered section for fiber composition in Impact test

- Now the model is ready to Mesh. Set the element size to 2mm and generate mesh, thegenerated mesh looks as shown in figure 3.31. the specimen is eventually divided into196 elements with 234 nodes. These elements and nodal points are completely program controlled according to the given input of element size.

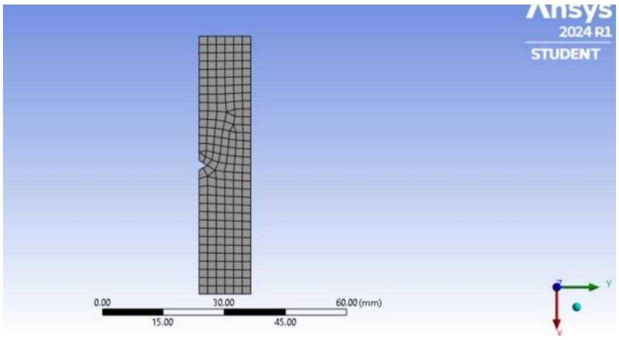


Figure 3.31 Meshed model of Specimen for Impact test

- The boundary conditions for the impact analysis are

Fixed support at the one end of specimen which is 12.7mm width side for the bothspecimens with different fiber compositions. Second Boundary condition is Velocity, which is applied along the Y Direction inthe Notch edges of the model as shown in figure 3.32 and V = 3000 mm/s

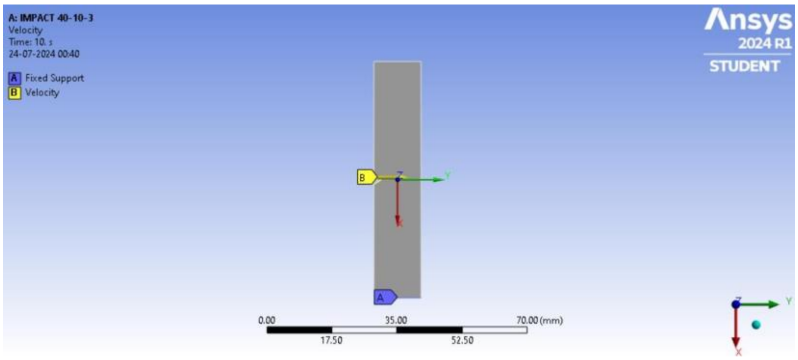


Figure 3.32 Boundary conditions for Impact Test

- The Boundary conditions for the specimens with different Fiber compositions are same except change in material properties.
- In solution Explorer the Equivalent stress is added to find the maximum and minimum strength for the given boundary conditions. The solution results for the two fiber composition specimens are shown in figure 3.33

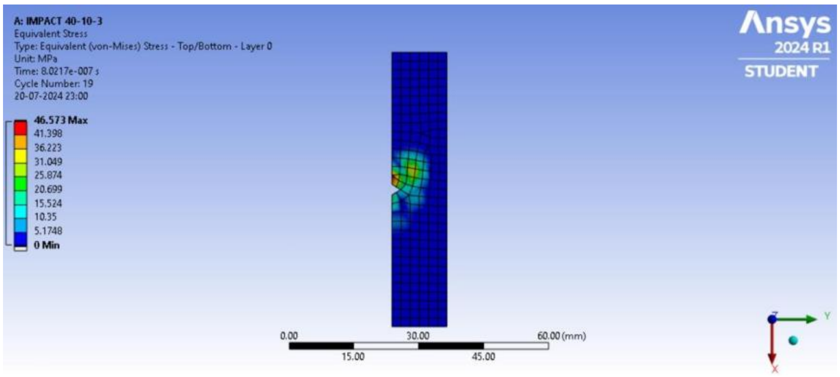


Figure 3.33 Impact test result for fiber composition 50% Epoxy + 40% CF + 10% STF

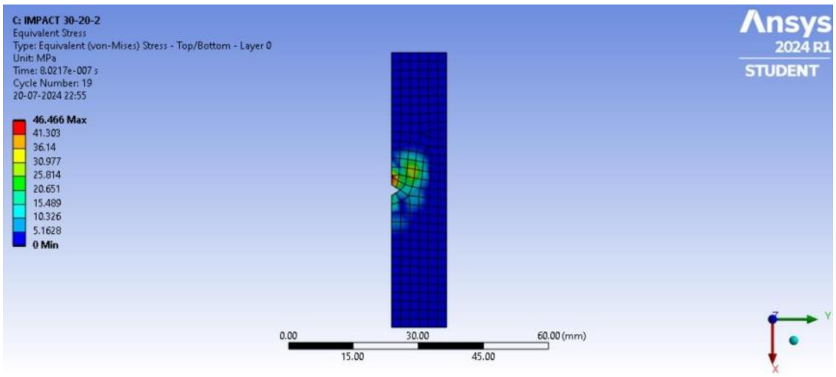


Figure 3.34 Impact test result for fiber composition 50% Epoxy + 30% CF + 20% STF

- It is observed from the results that the fiber composition with 50% Epoxy + 40% CF + 10% STF has reported 46.573 J/cm^2.
- It is observed from the results that the fiber composition with 50% Epoxy + 30% CF + 20% STF has reported 46.466 J/cm^2.
- The Experimental and Analysis results from Ansys for the material compositions are compared each other are shown in table 4.8

Table 3.8 Experimental and Analysis results comparison for Impact strength

RESULT TYPE		FIBER COMPOSITION	
		50% Epoxy + 40% CF + 10% STF	50% Epoxy + 30% CF + 20% STF
Impact Strength	Experimental value	40.6	55.23
	Analytical value	46.573	46.466

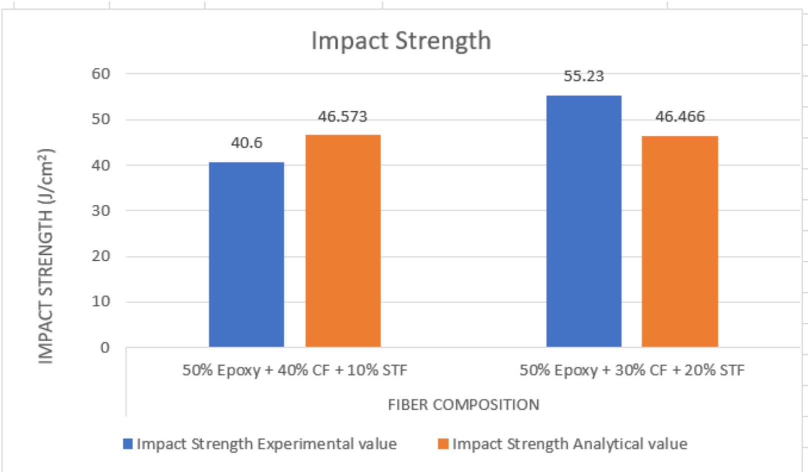


Figure 3.35 Experimental and Analysis results comparison for Impact strength

3.4 SUMMARY

The summary of this chapter is:

- The mechanical properties of the short randomly oriented fibrous polymer compositions sansevieria trifasciata vary with respect to their weight compositionand fibre length.
- Tensile and flexural strength of composites are found to progressively rise when the proportion of ST fibers increases from 10% STF to 15% STF, after which there is a decline in strength for the percentage of fibers from 20% STF. Similarly, tensile strength and flexural strength show an increasing with in the percentage of fibre weight from 10 percent to 15 percent STF and then a decrease in their strength by 20 percent STF by weight of fibre.
- In the case of impact resistance of composites, it gradually increases with increasing the percentage of fibres from 10% to 15% STF and then there is a decrease in its resistance to fibre f20% STF. Similarly, the impact resistance of the composite material increases with increasing fibre weight from 10% to 20% STF.
- For a 30% CF fiber percentage and 30% CF fiber weight, the maximum tensile strength and flexural strength are 63 MPa and 91 MPa, respectively. For 20% of the fibers and 20% of the fiber weight, a maximum value of 11 J / cm2 is obtained inthe case of impact resistance.
- The fibre percentage and fibre weight percentage are optimized as 15 percentageand20percentage.

4. CONCLUSIONS AND SCOPE OF FUTURE WORK

This chapter deals with the research findings of this present research work, limitation of the present research work and future scope.

4.1 CONCLUSIONS

- The critical fibre length, the optimum weight percentage and the optimum curing temperature are 40 mm, 20% and 60 ° C respectively.

- Excellent mechanical properties are obtained for composites produced at a curing temperature of 60 ° C for optimal fibre length and fibre content of 40 mm and20% by weight.
- Composites treated with KMnO4 show a higher modulus of tension, and compounds treated with Ca (OH) 2 show a higher modulus of bending.
- On the wear side, it is found that the variable load affects the specific wear rate in relation to the sliding distance. The change in the magnitude of the specific wear rate is observed in all chemical treatments that may occur due to the improvement of the adhesion and the change in the morphology of the fibre surface.
- The higher content of Sansevieria/ CF in hybrid composites gives greater strength to the composite structure. Among hybrid composites, the hybrid composite layer model retains the highest bending strength (hardened at 60° C). The general observation is that the inclusion of Sansevieria trifasciata fibre in the polymer matrix significantly reduces the strength of the composite and significantimprovements in mechanical, thermal and wear properties are observed at highercuring temperatures. Regardless of the fibre architecture, CF and STF reinforced composites show improved mechanical strength of pure polymer.
- It has been found that the sequence of the CF and STF layers affects both the tensile strength and the impact strength of hybrid composites at the same total weight content. In all cases, both alkaline and physiological treatment improve these properties.
- The maximum flexural strength is actually 582.68 N/mm^2 at maximum force 941.2N.
- The maximum tensile strength is actually 174.11 N / mm^2 at maximum force 1112.4N. Optimal impact resistance 55.23 KJ / mm^2.
- The mechanical properties of flexural strength are significantly reduced with addition of STF from 0 to 20% respectively.

4.2 SCOPE OF FUTURE WORK

- The experiment can be extended by adding other potential natural fibres, by changing fibre orientation and fibre content.
- Ansys Work Bench Tool can be used to model and analyze the experimental data for various compositions and properties, including wear testing, scanning electron microscope (SEM)analysis, differential thermo gravimetric analysis (DTG), and thermogravimetric analysis(T.G.A.).
- The tests can be expanded to include other machining operations like milling and drilling.

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