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Fabrication and Mechanical Properties Evaluation of CNT Reinforced Hybrid Composite (Hemp)

Piyush Kanoujia, Kapil Kumar Bhatti, Nitesh Kumar
Department of Mechanical Engineering, SET, Sharda University, Greater Noida, India.
Corresponding author: nitesh.kumar4@sharda.ac.in

Abstract.
In this papera hybrid multi-scale epoxy composite reinforced with conventional carbon fibre (CF) fabrics surface-attached with hemp fibre carbon nanofiber mats is described in this paper, along with its fabrication and mechanical properties. The composite is reinforced with carbon fibre and hemp, two sheets were fabricated, one with CNT and one without CNT and is prepared using vacuum bagging method. Several tests such as tensile test, bending test were performed and results were calculated. The bending and tensile analysis of multi-wall carbon nanotubes (MWCNT) reinforced sheet core sandwich composite plate of HEMP and Glass fiber has been performed based on the higher-order shear deformation theory using finite element formulations. The parametric study on the static behavior of honeycomb sandwich composite plates hybrid with MWCNT with the influence of the weight percentage of CNTs for core material and upper and bottom skins with various boundary conditions, different ply configuration was performed

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I. Introduction

Composite-based materials can be made using a wide range of manufacturing techniques. This experiment shows how the composite material responds to a wide range of environmental conditions and loading conditions. Create new composite materials that can be used in a variety of applications is the project's goal. We're looking for innovation in this area so that new composite materials can be created.There are numerous industrial applications for composite materials, and they have been used in a variety of ways. Composites compensations and manufacturing processes that completely rummage-sale these materials must be investigated immediately.

Sandwich composite is extensively preferable in most structural parts. Composite structures are in Aerospace, automotive, marine, railcar, and Windmill industries due to their excellent stiffness and strength at the deficient weight. Various studies have on the bending analysis problem of the laminated sandwich composite plate for the analysis of the composite plate

A competitive advantage is the wide range of possessions standards that composites can achieve, as well as the ability to adapt the assets. Composite materials have much higher strength-to-weight and modulus-to-weight ratios than typical production and constructible materials.

When compared to a standard material construction, it can reduce the structure's weight by 20 to 30 percent in terms of its topographies. In terms of weight loss, it can be interpreted as a savings if the recital has sufficient energy

High creep resistance and good absorption properties are just two of the desirable active properties of composites that have recently been developed. Composite materials can be used to replace worn-out metallic frames because of their higher fatigue presentation.

It is possible to shape, size, and densify composite materials in virtually any way, making it easier to build complex systems with fewer components.

II. Properties of Multi-Wall Carbon Nanotubes (MWCNT)

The availability of high-quality products has increased as major manufacturers have increased production and lowered prices.There are a wide variety of structural and electrical components that use these materials, such as disc brake rotors and pistons, extruded angles and channels, and even golf clubs. Machinery like bicycles and golf clubs also rely on them.

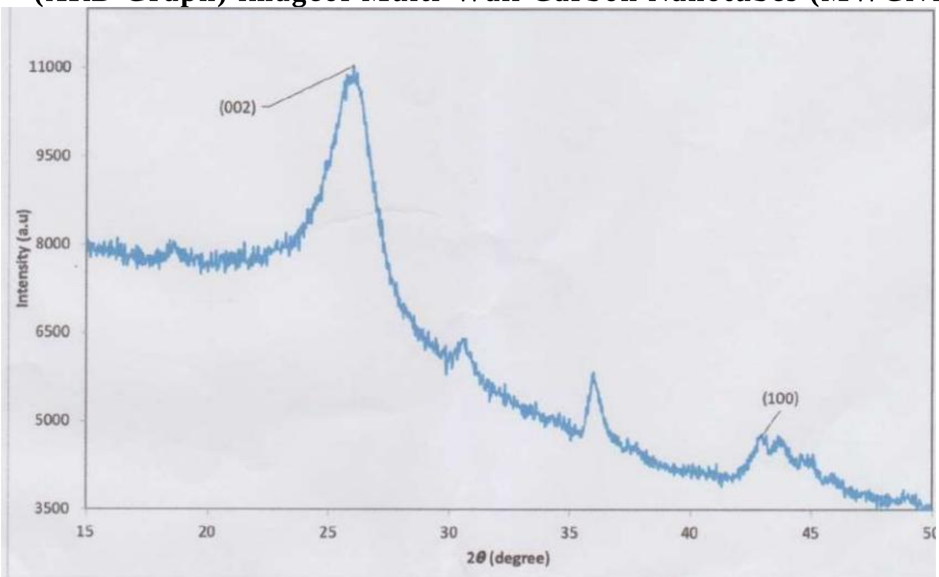
In terms of heat conductivity, they outperform diamond; in terms of thickness relative to length, they have an aspect ratio exceeding 1000.

Nearing the theoretical maximum of the tip's surface area (the smaller the tip-surface area, the more concentrated the electric field, and the greater the field enhancement factor).

CNT	DESCRIPTION
Purity	**99%**
Outer diameter	**10-30 NM**
Inner diameter	**5-10 NM**
Length	**≥ 10 μM**
Surface area	**110-350 m^2/g**
CNT content	**95-99 %**
Bulk density	**0.04 g/cm^2**
Chemical formula	**C**
Physical form	**FLUFFY, POWDER**
Odour	**ODOURLESS**
Colour	**BLACK**

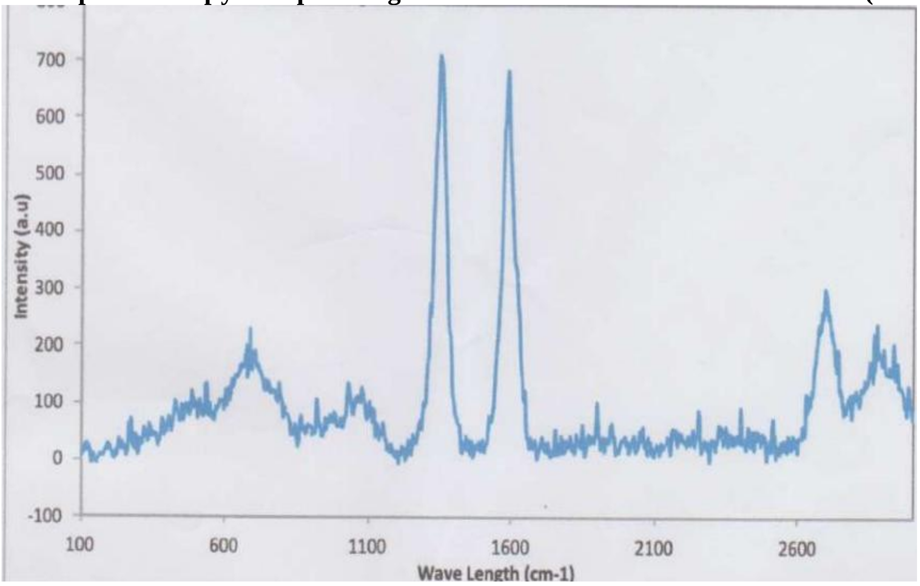
TABLE 1. Properties of Multi-Wall CNT

III. (XRD Graph) imageof Multi-Wall Carbon Nanotubes (MWCNT)



Techniques for studying materials' molecular structure can be found through the use of XRD, which is short for X-ray diffraction (XRD).
In general, it is non-destructive and works best with crystalline materials.
There is a more formal name for this method, which is called powder diffraction

IV. Raman Spectroscopy Graph imageof Multi-Wall Carbon Nanotubes (MWCNT)



Raman Spectroscopy is a non-destructive chemical analysis technique that provides detailed information about the chemical structure.
A Raman spectrum features a number of peaks, showing the intensity and wavelength position of the Raman scattered light.
Each peak corresponds to a specific molecular bond vibration, including individual bonds such as C-C, C=C, N-O, C-H, etc.

V. Glass Fibre

As an industrial material, glass is a non-metallic fibre. As far back as 1713, people have been spinning glass yarns to create textiles. It was at the 1893 Chicago World's Columbian Exposition that Georgia Cavan wore a dress made of spun glass fibres held together with silk threads.
However, the fabric was too stiff to drape to make it wearable. Glass fibres are made primarily from silica, which can be found in a variety of forms, including sand, limestone, stone ash, and borax.

VI. Properties of Hardener HY917

HARDENER	DESCRIPTION
Name	Hardener HY 917
Boiling point	195 ℃
Chemical description	Acid Anhydrides
Fabric composition	Fibers from stems of the *Cannabis*sativa plan
Moisture-wicking abilities	High
Decomposition	≥ 200 ℃
Density	Specific gravity=1.20
Sample description	Liquid epoxy hardener
Solution date	Ph=3

VII. Sample Preparation

To proceed in the process of fabricating we cut the sample before the fabrication.

6.1 Cutting of sheets

Cutting HEMP fibre 30x30 cm

Figure AHEMP Cut 30x30 cm

6.2 Cutting of Glass fiber 30x30 cm

Figure B. Glass fiber cut 30x30 cm

6.3 Weight of HEMP Sheet

Figure C. HEMP fiber weight 124 gm (approx.)

6.3. Weight of Glass Fiber Sheet

Figure D. Glass fiber weight 70 gm (approx.)

VIII. Procedure of Fabrication

The thickness is built up by manually laying out fiber-reinforced material and applying resin to a mould. Using hand or roller pressure, you can remove any air that may have been trapped.

Hand layup is a labour-intensive, low-volume method best suited for large items like boat hulls. Using a variety of techniques, fibres are positioned manually in the open mould and resin is applied. Curing resins that can be used at room temperature are very common. Different moulding techniques can be employed depending on the final product's design. It is important to consider the matrix and reinforcement materials, as well as the amount of product that will be made. Automated equipment can often be justified by large quantities.

Vacuum bag moulding, pressure bag moulding, autoclave moulding, and resin transfer moulding are a few of the production methods available to designers and manufacturers (RTM).
Reinforcements pre-impregnated with resin are a common manufacturing method. Prepreg is a term for these kinds of reinforcements. Prepreg is typically kept at a lower temperature because it is activated by heat during the composite moulding process.

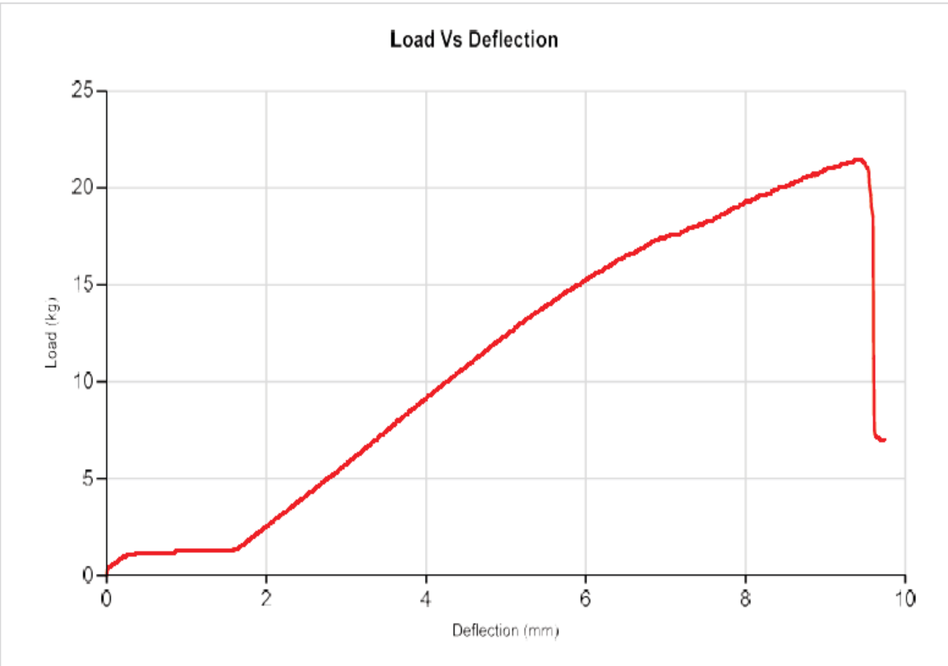
Instantly and permanently, the colour of a prepreg laminating press changes colour when it is pressed against the rollers or plates. It facilitates the following outcomes:

- Properly align rollers to ensure uniform resin application and fabric wet-out
- Detect and correct prepreg uniformity issues to reduce off-spec fiber content
- Prevent defects such as resin content inconsistency in the resin metering stage

Figure E. Fabricated Sheet and Stir Machine

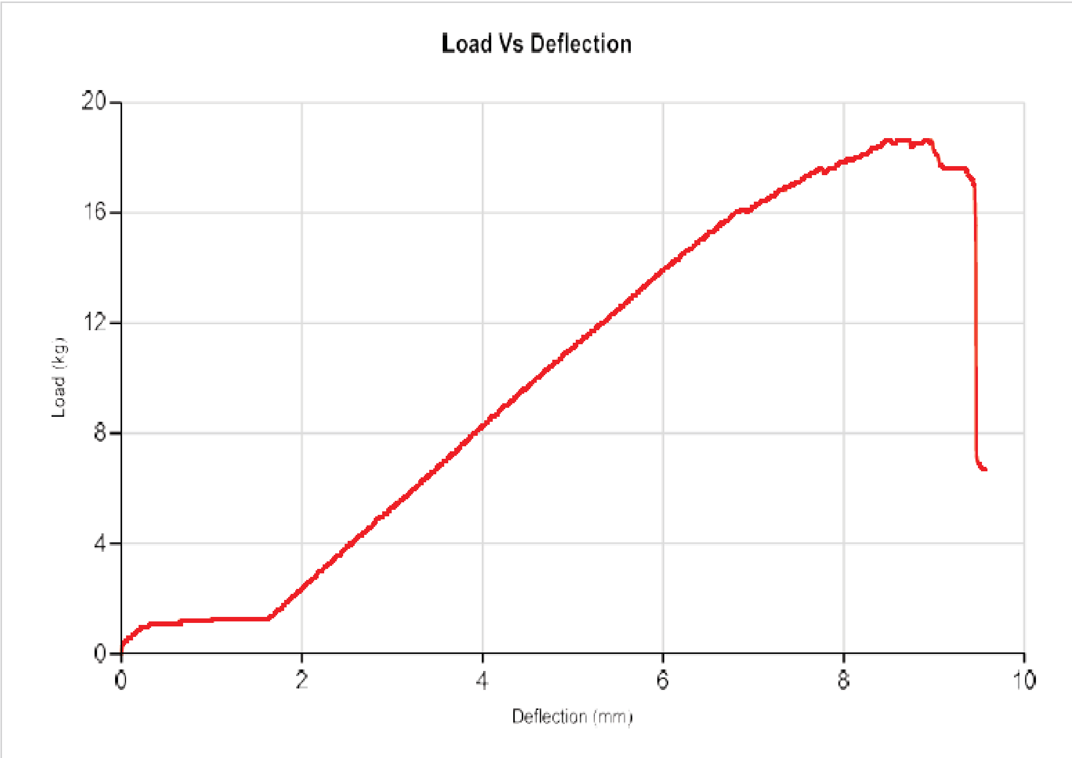
IX. Results and discussions

Sample 1.1. of Bending Test performed on UTM machine consisting CNT



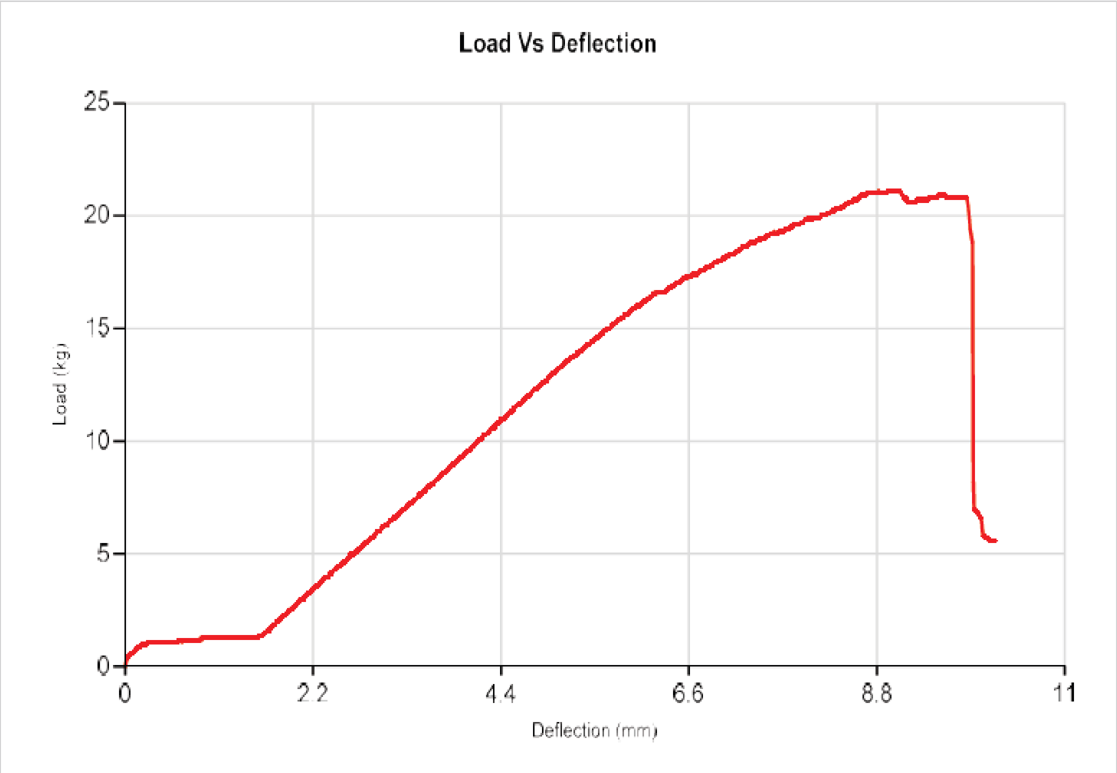
Test Date	5/7/2022 1:23:24 PM	Peak Force	21.4 kg
Test No	20	Force at Break	7 kg
Specimen	composite Bending	Defl. at Peak	9.36 mm
Shape	Rectangle	Defl. at Break	9.738 mm
Reference No.	ABC	Test Time	194.2 sec
Party Name.	BSS	Test Speed	3 mm/min
Model No.	GH	Flexural Strength	15.047 kg/mm²
Nature of Test	Bending	Flexural Strain	0
Width	20 mm	MOR	15.047 kg/mm²
Thickness	4 mm	MOE	1579.116 kg/mm²
Span	150 mm	Prop. Load	19.5 kg
Area	80 mm²	Prop. Defl	8.14 mm
Test Speed	3 mm/min	Bending Elastic Slope	

Sample 1.2. of Bending Test performed on UTM machineconsisting CNT



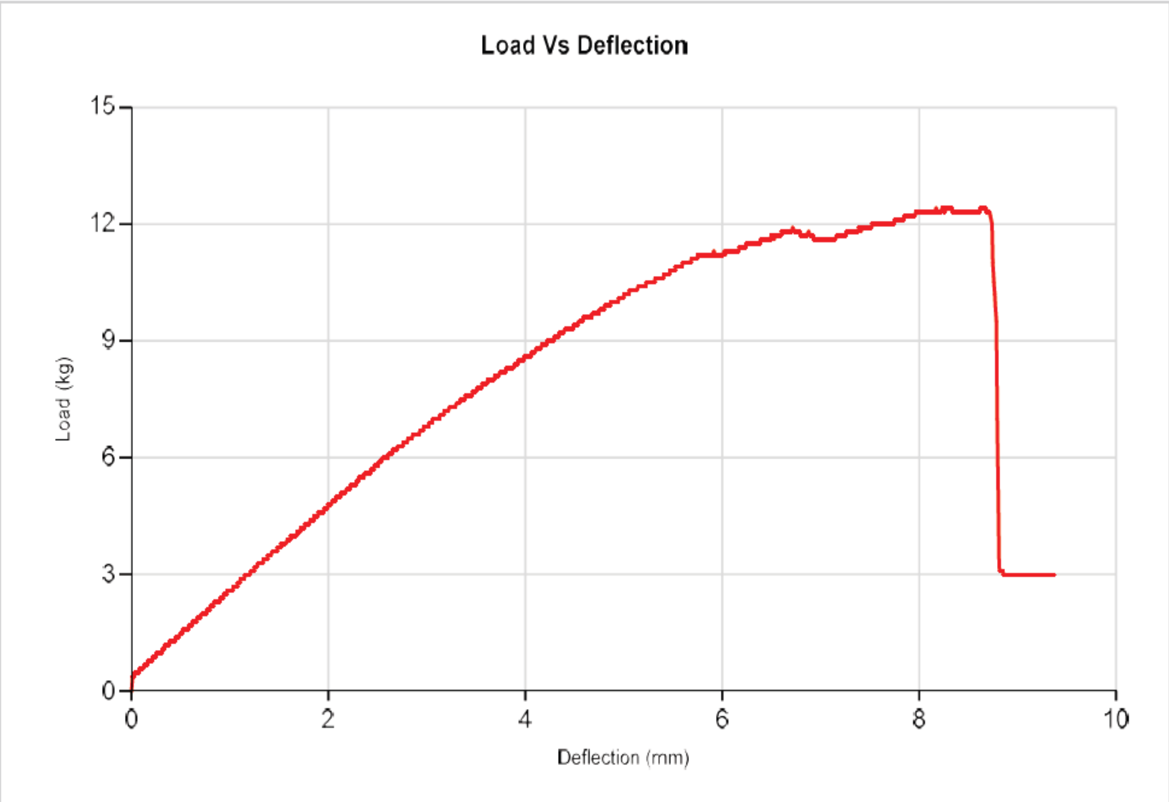
Test Date	5/7/2022 1:30:01 PM	Peak Force	18.6 kg
Test No	21	Force at Break	6.7 kg
Specimen	composite Bending	Defl. at Peak	8.46 mm
Shape	Rectangle	Defl. at Break	9.567 mm
Reference No.	ABC	Test Time	190.8 sec
Party Name.	BSS	Test Speed	3 mm/min
Model No.	GH	Flexural Strength	13.078 kg/mm²
Nature of Test	Bending	Flexural Strain	0
Width	20 mm	MOR	13.078 kg/mm²
Thickness	4 mm	MOE	1498.136 kg/mm²
Span	150 mm	Prop. Load	17.5 kg
Area	80 mm²	Prop. Defl	7.7 mm
Test Speed	3 mm/min	Bending Elastic Slope	

Sample 1.3. of Bending Test performed on UTM machineconsisting CNT



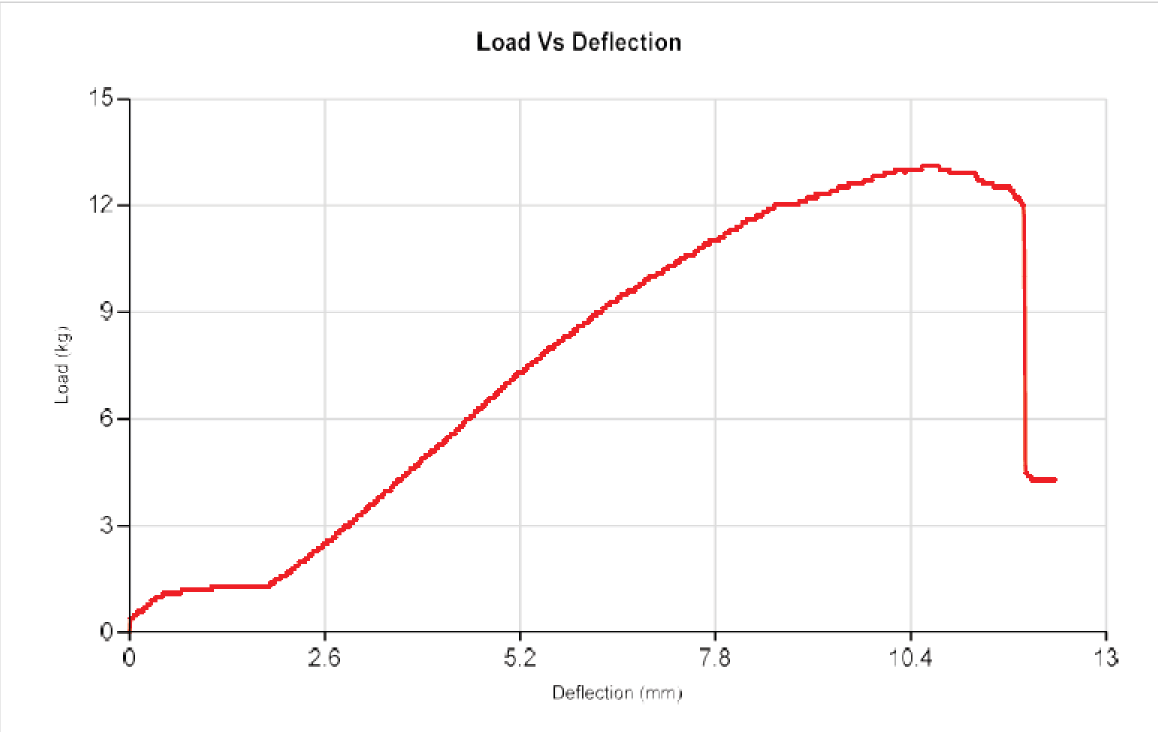
Test Date	5/7/2022 1:34:51 PM	Peak Force	21.1 kg
Test No	22	Force at Break	5.6 kg
Specimen	composite Bending	Defl. at Peak	8.82 mm
Shape	Rectangle	Defl. at Break	10.179 mm
Reference No.	ABC	Test Time	203.1 sec
Party Name.	BSS	Test Speed	3 mm/min
Model No.	GH	Flexural Strength	14.836 kg/mm²
Nature of Test	Bending	Flexural Strain	0
Width	20 mm	MOR	14.836 kg/mm²
Thickness	4 mm	MOE	1731.429 kg/mm²
Span	150 mm	Prop. Load	14 kg
Area	80 mm²	Prop. Defl	5.33 mm
Test Speed	3 mm/min	Bending Elastic Slope	

Sample 1.4.of Bending Test performed on UTM machine without CNT



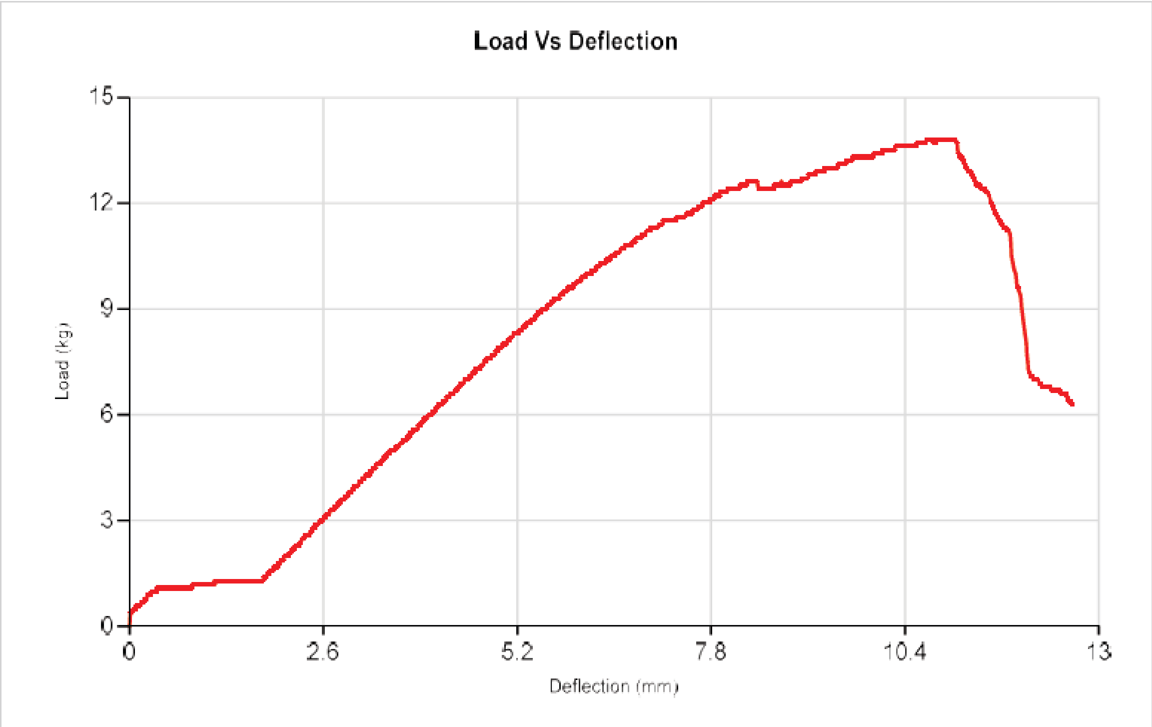
Test Date	5/7/2022 1:03:11 PM	Peak Force	12.4 kg
Test No	17	Force at Break	3 kg
Specimen	composite Bending	Defl. at Peak	8.172 mm
Shape	Rectangle	Defl. at Break	9.369 mm
Reference No.	ABC	Test Time	187.1 sec
Party Name.	BSS	Test Speed	3 mm/min
Model No.	GH	Flexural Strength	8.719 kg/mm²
Nature of Test	Bending	Flexural Strain	0
Width	20 mm	MOR	8.719 kg/mm²
Thickness	4 mm	MOE	1424.79 kg/mm²
Span	150 mm	Prop. Load	8.3 kg
Area	80 mm²	Prop. Defl	3.84 mm
Test Speed	3 mm/min	Bending Elastic Slope	

Sample 1.5. of Bending Test performed on UTM machine without CNT



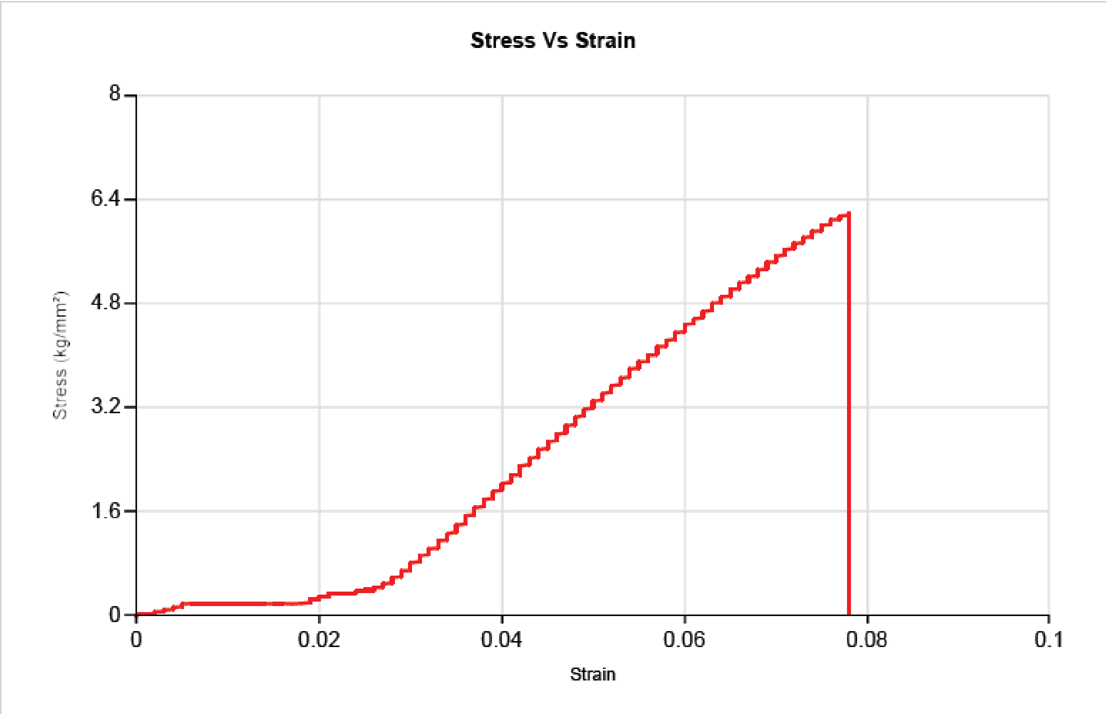
Test Date	5/7/2022 1:10:04 PM	Peak Force	13.1 kg
Test No	18	Force at Break	4.3 kg
Specimen	composite Bending	Defl. at Peak	10.548 mm
Shape	Rectangle	Defl. at Break	12.321 mm
Reference No.	ABC	Test Time	245.8 sec
Party Name.	BSS	Test Speed	3 mm/min
Model No.	GH	Flexural Strength	9.211 kg/mm²
Nature of Test	Bending	Flexural Strain	0
Width	20 mm	MOR	9.211 kg/mm²
Thickness	4 mm	MOE	939.985 kg/mm²
Span	150 mm	Prop. Load	7.9 kg
Area	80 mm²	Prop. Defl	5.54 mm
Test Speed	3 mm/min	Bending Elastic Slope	

Sample 1.6.of Bending Test performed on UTM machine without CNT



Test Date	5/7/2022 1:18:09 PM	Peak Force	13.8 kg
Test No	19	Force at Break	6.3 kg
Specimen	composite Bending	Defl. at Peak	10.683 mm
Shape	Rectangle	Defl. at Break	12.645 mm
Reference No.	ABC	Test Time	252.4 sec
Party Name.	BSS	Test Speed	3 mm/min
Model No.	GH	Flexural Strength	9.703 kg/mm²
Nature of Test	Bending	Flexural Strain	0
Width	20 mm	MOR	9.703 kg/mm²
Thickness	4 mm	MOE	1059.173 kg/mm²
Span	150 mm	Prop. Load	8.5 kg
Area	80 mm²	Prop. Defl	5.29 mm
Test Speed	3 mm/min	Bending Elastic Slope	

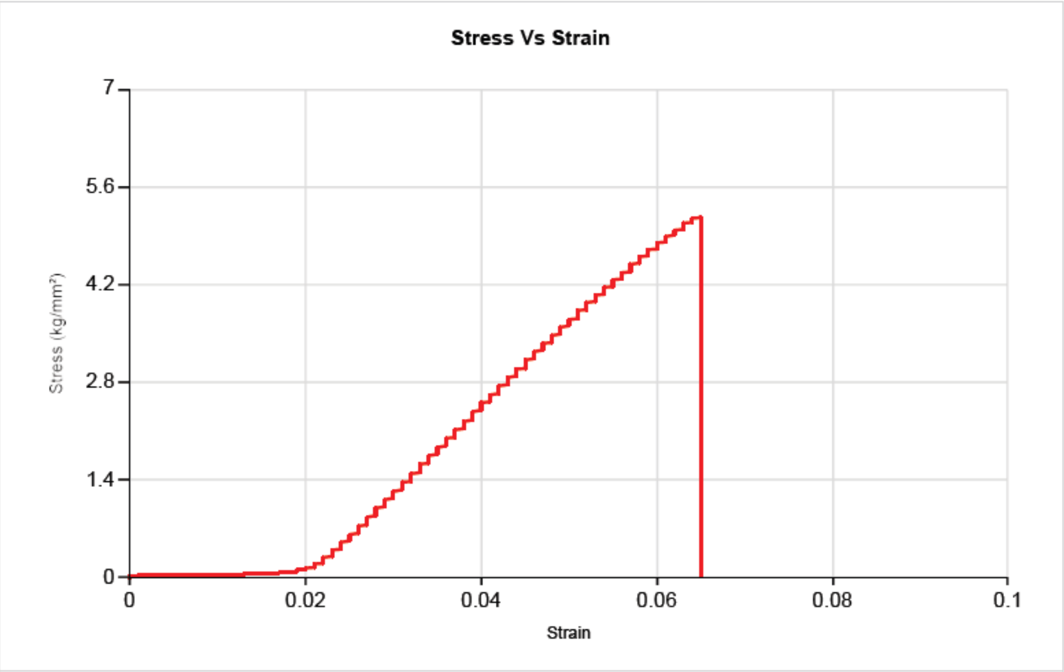
Sample 2.1of Tensile Test performed on UTM machineconsisting CNT



Test Date	5/7/2022 12:42:57 PM
Test No	14
Specimen	composite Tensile
Shape	Rectangle
Reference No.	ABC
Party Name.	BSS
Model No.	GH
Nature of Test	TENSILE
Width	25 mm
Thickness	4 mm
G.Length	75 mm
Area	100 mm²
Test Speed	3 mm/min

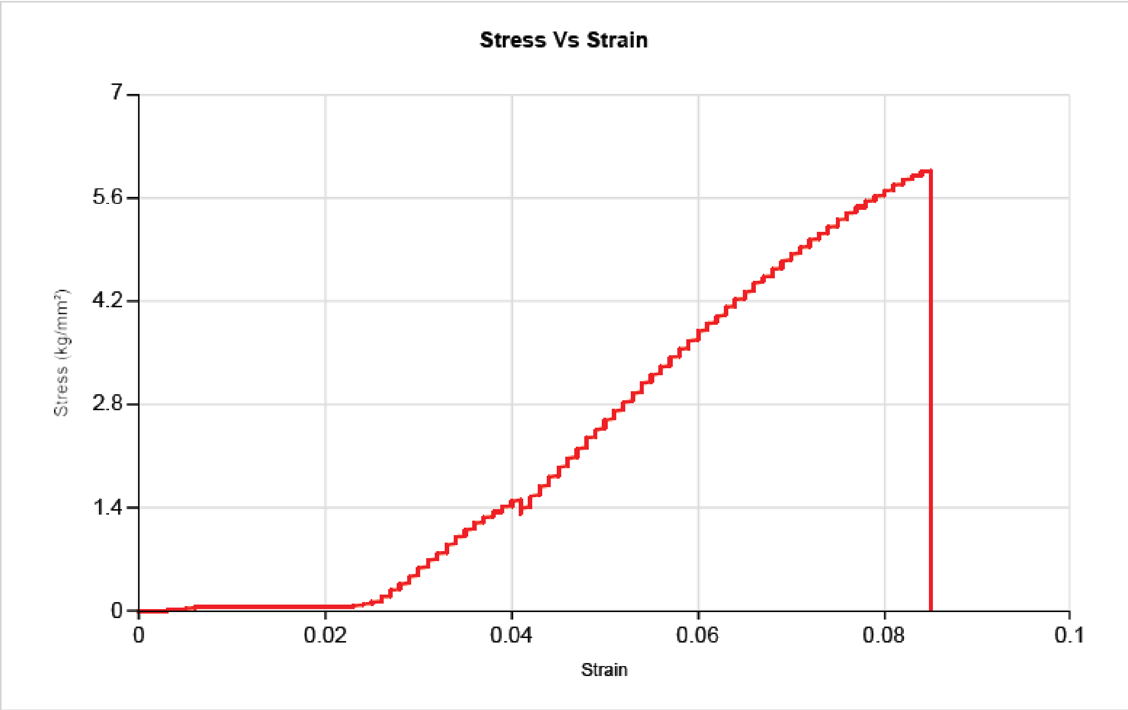
Peak Force	618.4 kg
Force at Break	367.8 kg
Elong. at Peak	5.841 mm
Elong. at Break	5.85 mm
Test Time	119.7 sec
Proof Load	0 kg
Peak Stress	6.18 kg/mm²
Peak Strain	0.078
Strength	6.184 kg/mm²
% Elongation	150.67
Avg Peak Force	NaN kg
Adhessive Strength	NaN kg/mm
Tear Strength	154.6 kg/mm²
Peel Strength	
Yield Load	611.4 kg
Yield Stress	6.114 kg/mm²
Elong. at Yield	5.77 mm

Sample 2.2of Tensile Test performed on UTM machineconsisting CNT



Test Date	5/7/2022 12:48:04 PM	Peak Force	516.6 kg
Test No	15	Force at Break	295.2 kg
Specimen	composite Tensile	Elong. at Peak	4.86 mm
Shape	Rectangle	Elong. at Break	4.887 mm
Reference No.	ABC	Test Time	100.5 sec
Party Name.	BSS	Proof Load	0 kg
Model No.	GH	Peak Stress	5.17 kg/mm²
Nature of Test	TENSILE	Peak Strain	0.065
Width	25 mm	Strength	5.166 kg/mm²
Thickness	4 mm	% Elongation	152
G.Length	75 mm	Avg Peak Force	NaN kg
Area	100 mm²	Adhessive Strength	NaN kg/mm
Test Speed	3 mm/min	Tear Strength	129.15 kg/mm²
		Peel Strength	
		Yield Load	295.2 kg
		Yield Stress	2.952 kg/mm²
		Elong. at Yield	4.89 mm

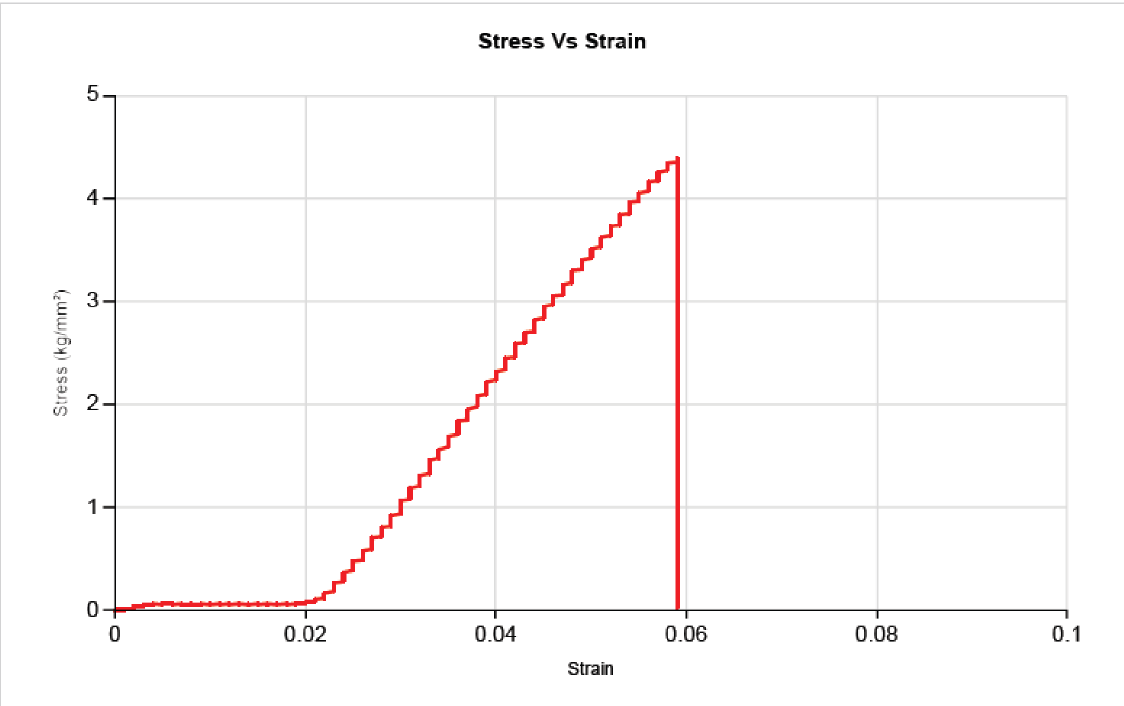
Sample 2.3of Tensile Test performed on UTM machineconsisting CNT



Test Date	5/7/2022 12:53:12 PM
Test No	16
Specimen	composite Tensile
Shape	Rectangle
Reference No.	ABC
Party Name.	BSS
Model No.	GH
Nature of Test	TENSILE
Width	25 mm
Thickness	4 mm
G.Length	75 mm
Area	100 mm²
Test Speed	3 mm/min

Peak Force	597 kg
Force at Break	452.9 kg
Elong. at Peak	6.372 mm
Elong. at Break	6.39 mm
Test Time	130.2 sec
Proof Load	0 kg
Peak Stress	5.97 kg/mm²
Peak Strain	0.085
Strength	5.97 kg/mm²
% Elongation	153.33
Avg Peak Force	NaN kg
Adhesive Strength	NaN kg/mm
Tear Strength	149.25 kg/mm²
Peel Strength	
Yield Load	482 kg
Yield Stress	4.82 kg/mm²
Elong. at Yield	5.27 mm

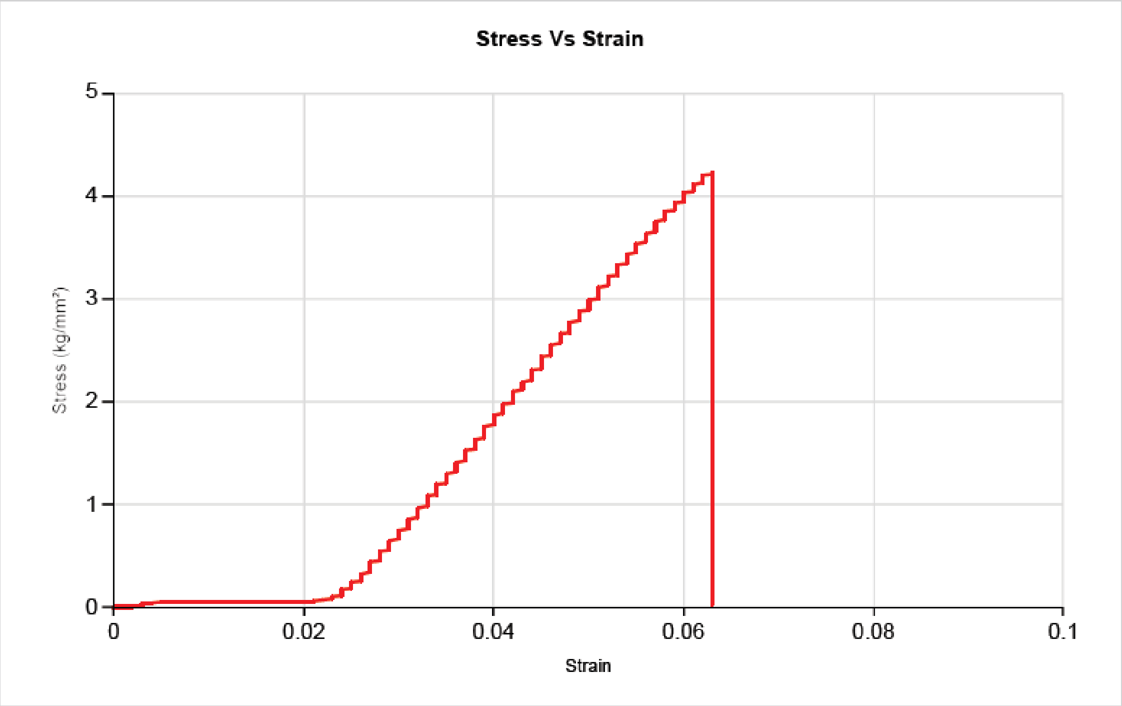
Sample 2.4of Tensile Test performed on UTM machinewithout CNT



Test Date	5/7/2022 12:23:29 PM
Test No	11
Specimen	composite Tensile
Shape	Rectangle
Reference No.	ABC
Party Name.	BSS
Model No.	GH
Nature of Test	TENSILE
Width	25 mm
Thickness	4 mm
G.Length	75 mm
Area	100 mm²
Test Speed	3 mm/min

Peak Force	439.3 kg
Force at Break	436.6 kg
Elong. at Peak	4.428 mm
Elong. at Break	4.446 mm
Test Time	91.6 sec
Proof Load	0 kg
Peak Stress	4.39 kg/mm²
Peak Strain	0.059
Strength	4.393 kg/mm²
% Elongation	140
Avg Peak Force	NaN kg
Adhessive Strength	NaN kg/mm
Tear Strength	109.825 kg/mm²
Peel Strength	
Yield Load	343.8 kg
Yield Stress	3.438 kg/mm²
Elong. at Yield	3.73 mm

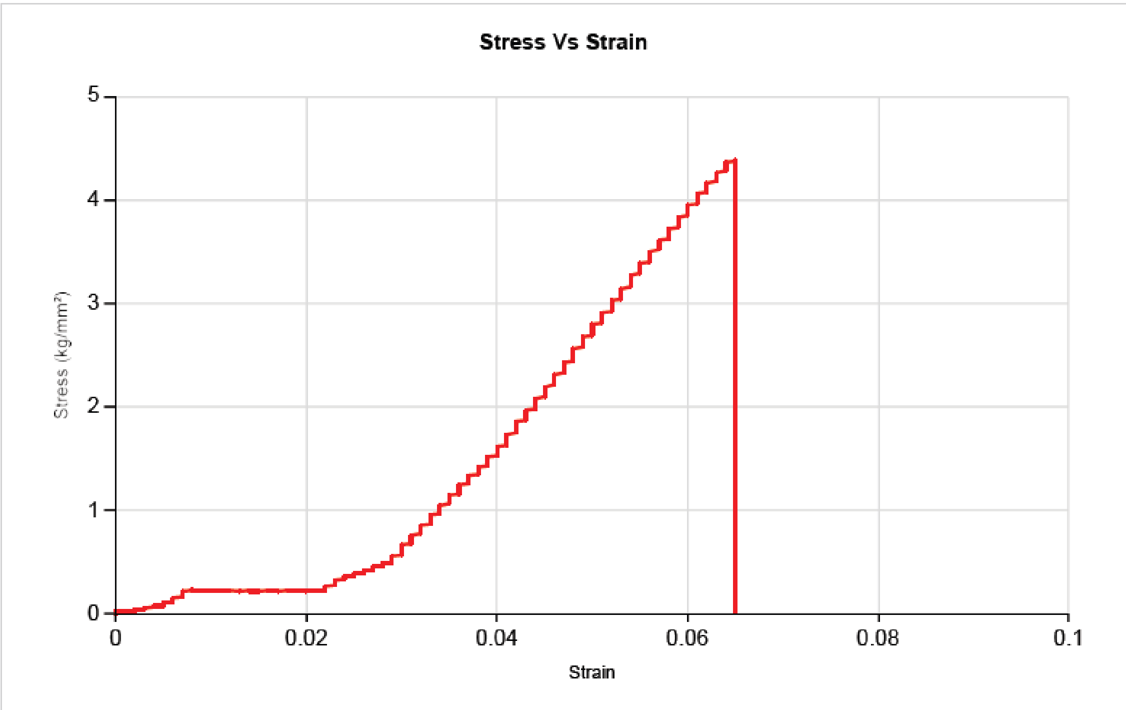
Sample 2.5of Tensile Test performed on UTM machinewithout CNT



Test Date	5/7/2022 12:30:47 PM
Test No	12
Specimen	composite Tensile
Shape	Rectangle
Reference No.	ABC
Party Name.	BSS
Model No.	GH
Nature of Test	TENSILE
Width	25 mm
Thickness	4 mm
G.Length	75 mm
Area	100 mm²
Test Speed	3 mm/min

Peak Force	423.1 kg
Force at Break	422.3 kg
Elong. at Peak	4.725 mm
Elong. at Break	4.734 mm
Test Time	97.4 sec
Proof Load	0 kg
Peak Stress	4.23 kg/mm²
Peak Strain	0.063
Strength	4.231 kg/mm²
% Elongation	141.33
Avg Peak Force	NaN kg
Adhessive Strength	NaN kg/mm
Tear Strength	105.775 kg/mm²
Peel Strength	
Yield Load	2.7 kg
Yield Stress	0.027 kg/mm²
Elong. at Yield	4.73 mm

Sample 2.6of Tensile Test performed on UTM machinewithout CNT



Test Date	5/7/2022 12:38:27 PM
Test No	13
Specimen	composite Tensile
Shape	Rectangle
Reference No.	ABC
Party Name.	BSS
Model No.	GH
Nature of Test	TENSILE
Width	25 mm
Thickness	4 mm
G.Length	75 mm
Area	100 mm²
Test Speed	3 mm/min

Peak Force	438.6 kg
Force at Break	406.2 kg
Elong. at Peak	4.851 mm
Elong. at Break	4.86 mm
Test Time	100 sec
Proof Load	0 kg
Peak Stress	4.39 kg/mm²
Peak Strain	0.065
Strength	4.386 kg/mm²
% Elongation	142.67
Avg Peak Force	NaN kg
Adhessive Strength	NaN kg/mm
Tear Strength	109.65 kg/mm²
Peel Strength	
Yield Load	406.2 kg
Yield Stress	4.062 kg/mm²
Elong. at Yield	4.86 mm

X. Conclusion

In composite tensile testing, We observed that the Test sample with CNT has 33.86% more tensile strength than the sample without CNT and the difference between the sample with CNT is 18.1337%, peak force varies in samples with CNT from 16.14% to 29.06%. And the peak force difference in samples without CNT is 0.616%. In composite bending testing we observed, Differences of 21.4 and 18.6 are 14% sample2 with CNT is a 13.084% decrease from sample one. And Difference between the sample with CNT and the sample without CNT is 53.25%. Hence the sample with CNT has more Tensile and Flexural strength as compared to the samples without CNT.

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