DAYANANDA SAGAR COLLEGE OF ENGINEERING

Shavige Malleshwara Hills, Kumaraswamy Layout, Bangalore-560078
(An Autonomous Institute affiliated to VTU, Approved by AICTE &ISO 9001: 2008 Certified)
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Department of Mechanical Engineering

Batch Number 33

Project Work Synopsis Presentation-2024

Title: Investigation of mechanical behavior of natural fibers-based hybrid adhesive bonded composite joints

Guide Name	**Dr. NITISH KUMAR**			
Designation	**Assistant Professor**			
Student Name	**MD KAMRAN SHAIKH**	**SRIKANTH**	**SUMEET G HONGEKAR**	**YOGESH S CHAVAN**
USN	**1DS22ME429**	**1DS22ME458**	**1DS22ME460**	**1DS22ME470**

Contents

Abstract

The increasing focus on sustainable materials has led to the exploration of natural fibers as alternatives to synthetic fibers in composite structures. This study investigates the mechanical behavior of hybrid adhesive bonded composite joints made from banana and pineapple fibers. These natural fibers were selected due to their high availability, biodegradability, and favorable mechanical properties.

The composite joints were fabricated by reinforcing a polymer matrix with a combination of banana and pineapple fibers, followed by bonding the composites using a structural adhesive. The mechanical performance of the joints was evaluated through tensile, shear, and peel tests, which are critical for understanding the strength and reliability of bonded composite joints.

Results revealed that the hybrid composite joints exhibit notable tensile and shear strength, with performance comparable to, and in some cases exceeding, that of joints made from synthetic fiber composites. The combination of banana and pineapple fibers resulted in a synergistic effect, enhancing the mechanical properties of the bonded joints. Additionally, the study analyzed the influence of fiber orientation, adhesive type, and joint configuration on the overall performance

Introduction

When investigating the mechanical behavior of banana and pineapple-based natural fiber composites, it’s important to begin by understanding the motivation behind using these materials. The introduction should cover the significance of natural fibers in the context of composite materials, highlighting their benefits, potential applications, and the reasons for choosing banana and pineapple fibers specifically

In recent years, there has been a growing interest in the development and application of natural fiber-reinforced composites, driven by the increasing demand for sustainable and environmentally friendly materials. Natural fibers such as those derived from plants have emerged as promising alternatives to synthetic fibers due to their biodegradability, low cost, renewability, and satisfactory mechanical properties. Among various natural fibers, banana and pineapple fibers have gained attention for their potential in composite material development.

The combination of banana and pineapple fibers in composite materials presents an opportunity to leverage the complementary properties of these fibers. The integration of these natural fibers into polymer matrices has the potential to produce composite materials with enhanced mechanical performance, suitable for applications in various industries, including automotive, construction, and packaging.

Introduction

Banana fibres are obtained from the pseudo-stem of banana plants (Musa species). These fibers are known for their good mechanical properties, including high tensile strength and flexibility, which make them suitable for reinforcement in composite materials. Additionally, banana fibers are abundantly available in regions where bananas are cultivated, providing an economical and sustainable source of raw material.

Pineapple fibers, on the other hand, are extracted from the leaves of pineapple plants (Ananas comosus). Pineapple leaves, which are often considered agricultural waste, contain fibers with excellent mechanical properties, including high specific strength and stiffness. The utilization of pineapple leaf fibers not only provides value addition to agricultural by-products but also contributes to waste reduction.

Literature Review

1.Natural Fibre Composites and Their Mechanical Properties

Natural fibers such as banana and pineapple have been extensively studied for their potential as reinforcement materials in composite structures. These fibers are characterized by their high specific strength, low density, biodegradability, and availability in regions where these crops are grown. Previous research has demonstrated that both banana and pineapple fibers can significantly improve the mechanical properties of polymer composites, including tensile strength, flexural strength, and impact resistance.

For example, research by Kalyani et al. (2013) on banana fiber composites highlighted the fiber's ability to enhance tensile and flexural properties when appropriately treated and oriented within the matrix. Similarly, studies on pineapple leaf fiber (PALF) composites by Mukhopadhyay and Fangueiro (2009) have shown that PALF-reinforced composites exhibit excellent mechanical performance due to the high cellulose content and crystalline structure of the fibers.

2. Hybrid Composites and the Role of Fiber Hybridization

Hybrid composites, which combine two or more types of fibers within a single matrix, have been the subject of numerous studies due to their potential to offer improved properties by leveraging the strengths of different fibers. The hybridization of banana and pineapple fibers, in particular, has been explored to enhance the mechanical properties of composite materials. This hybridization often leads to a synergistic effect, where the combined properties of the two fibers exceed those of individual fiber composites.

Researchers such as Rajesh et al. (2016) have investigated the mechanical behavior of hybrid composites made from banana and pineapple fibers. Their findings suggest that the combination of these fibers can lead to an optimal balance between strength and toughness, making the hybrid composites suitable for structural applications. The fiber-matrix interface and the distribution of fibers within the matrix play critical roles in determining the overall performance of these composites.

Literature Review

3. Adhesive Bonding in Natural Fiber Composites

Adhesive bonding is a crucial aspect of composite joint formation, especially in hybrid composites where the bonding between different fibers and the matrix significantly impacts mechanical performance. The choice of adhesive and the surface treatment of fibers are key factors that influence the bond strength and durability of the composite joints.

Several studies have focused on the effectiveness of different adhesives, such as epoxy, polyurethane, and phenolic resins, in bonding natural fiber composites. Epoxy-based adhesives are commonly used due to their high bond strength and compatibility with a variety of fibers. For instance, Gowda et al. (2018) examined the adhesive bonding of banana and pineapple fiber-reinforced epoxy composites and found that surface treatments such as alkali treatment improved the adhesive bond strength and mechanical properties of the joints.

4. **Mechanical Behavior of Hybrid Adhesive Bonded Composite Joints**

The mechanical behavior of adhesive bonded composite joints made from banana and pineapple fibers has been studied with a focus on parameters such as tensile strength, shear strength, and fatigue resistance. The effectiveness of these composite joints in load-bearing applications depends on the quality of the adhesive bond and the distribution of stresses at the fiber-matrix interface.

Studies by Madhukiran et al. (2017) have shown that hybrid adhesive bonded joints exhibit improved mechanical properties compared to single fiber composite joints. The combination of banana and pineapple fibers within the composite enhances the load distribution and resistance to crack propagation under mechanical stress.

Objectives of the Project:

1. To fabricate the natural fiber Composite Based ASTM standards.
2. Develop hybrid composite joints using a combination of banana and pineapple fibers with suitable adhesive bonding techniques.
3. The main goal is to understand how these composite joints behave under various mechanical stresses, such as tension and bending.
4. To predict the strength of various bonded joints with experimental results.

Methods/Methodology

Selection Of Fiber(Banana and pineapple)

⬇

Specimen Preparation(Sizing and Cutting)

⬇

Fabrication Methods(Hand Lay-Up method)

⬇

Curing

⬇

Post-Processing(Trimming and Finishing)

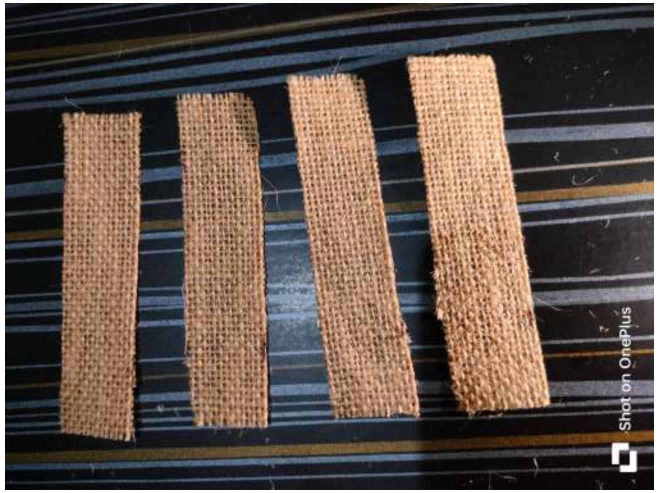
⬇

Testing and Characterization

Selection Of Fiber

Fibers	Cellulose (wt%)	Density (g/cm3)	Moisture Content (wt %)	Microfibrillar angle (degrees)	Young's Modulus (GPa)	Tensile strength (MPa)	Elongation at break (%)
Abaca	55–62	1.5	14	–	10–12	400	3–10
Coir	31–42	1.1	10	30–40	4–6	106–175	17–47
Cotton	84–91	1.5–1.6	8	–	6–12	290–800	7–8
Banana	17	1.3	7	10	7–20	54–754	10.35
Ramie	67–75	1.5	8	–	61–127	400–900	1–4
Sisal	64–70	1.45	10	10–22	9–15	568–640	3–7
Jute	60–70	1.3	11	–	12–25	393–770	7–9
Pineapple Leaf	20–80	1.44	12	8–14	34–82	413–1627	0.8–1
Hemp	67	1.48	10	–	60–70	690	1.6

Fiber Preparation



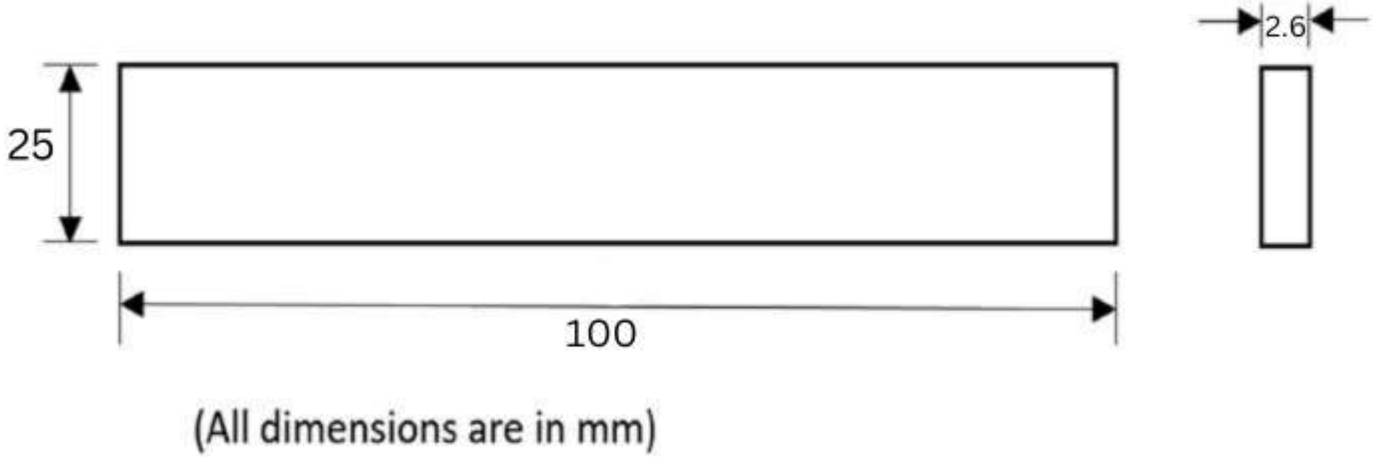
Fiber Preparation

Specimen Preparation

Specimen Preparation

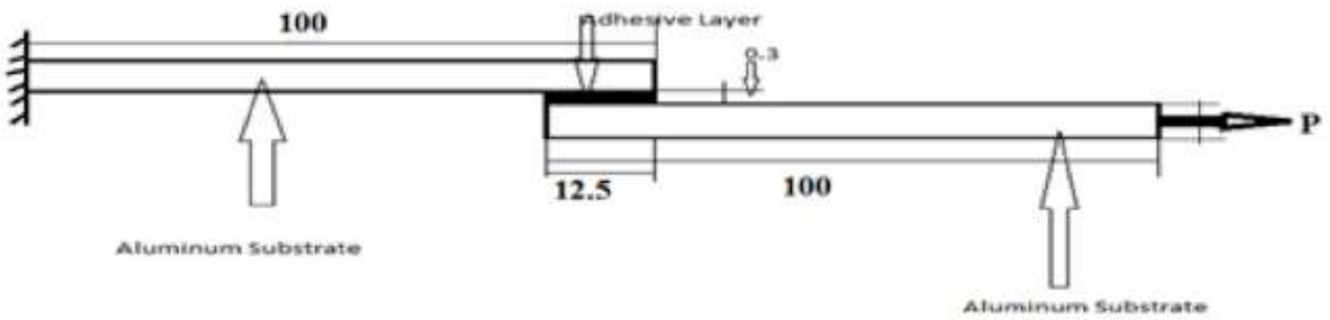
- Fiber Preparation and Resin Application:-
  - Fibers were cut to size and coated with epoxy.
- Layering and Compaction:-
  - Each layer was rolled to bond and remove air bubbles.
- Curing:-
  - The composite was set aside to harden into a solid structure

Curing, Trimming And Finishing

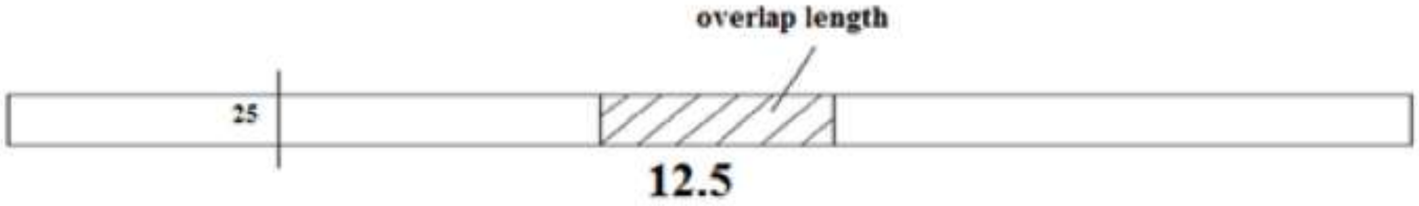


1. Curing- The composite was cured for 1 day to harden and bond the layers.
2. Trimming- Excess material was trimmed to achieve the final shape.
3. Finishing- The surface was smoothed for a polished appearance.
4. Inspection- A final check ensured quality and defect-free results.

Design Model of Lap Joint



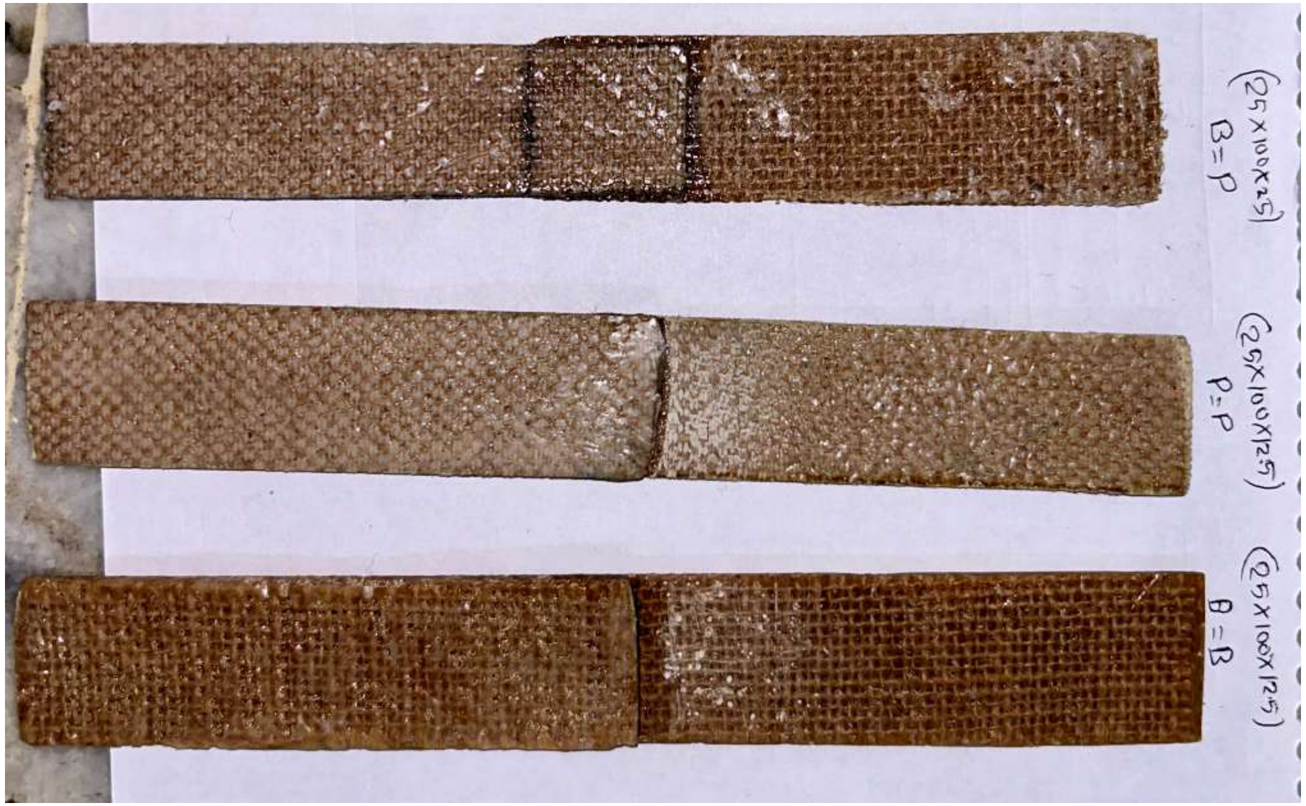
(a) Design model of lap joint



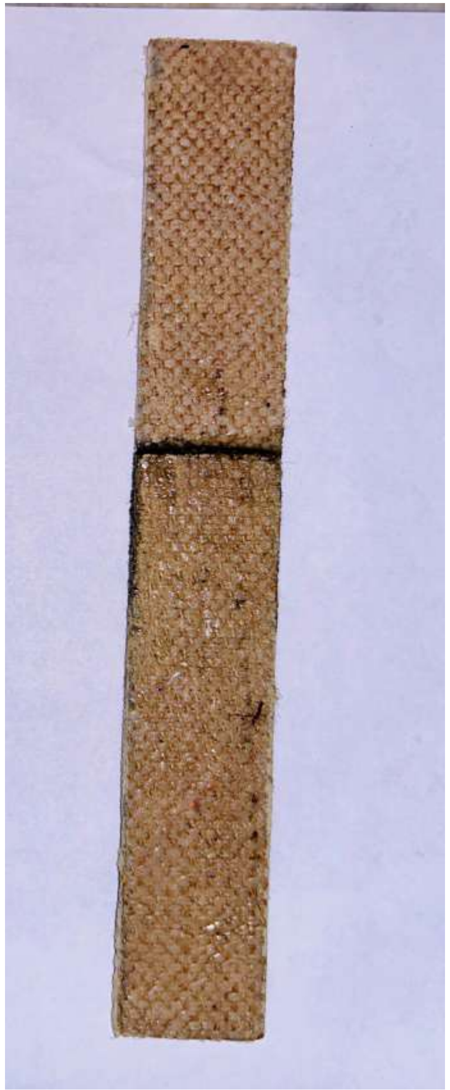
(b) Top view of lap joint

Prepared Specimen According to Design

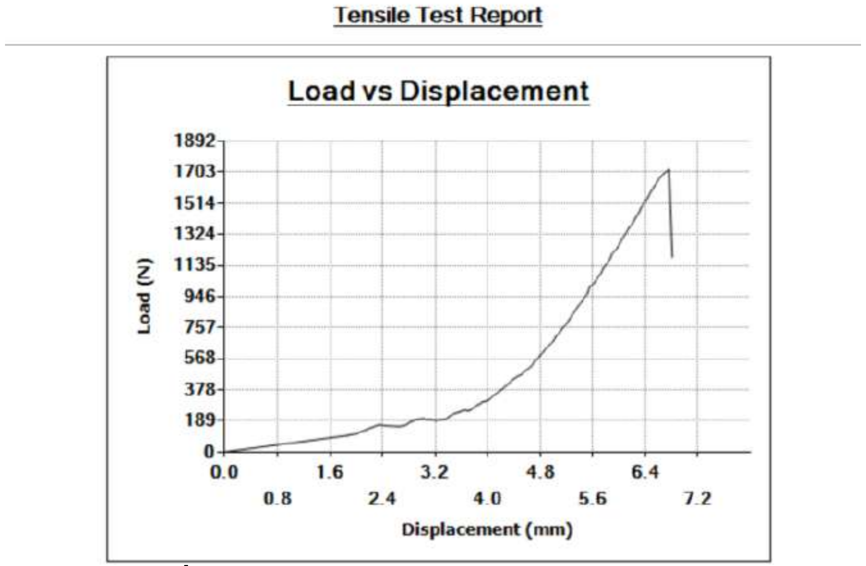
- ➢ As per the design and Dimensions, we prepared the Specimen.
- ➢ We designed the Specimen By considering ASTM Standards.
- ➢ We prepared two Diff Material (Banana And Pineapple) with diff Dimensions.
- ➢ We also Prepared Specimen With Diff pair of Combination.



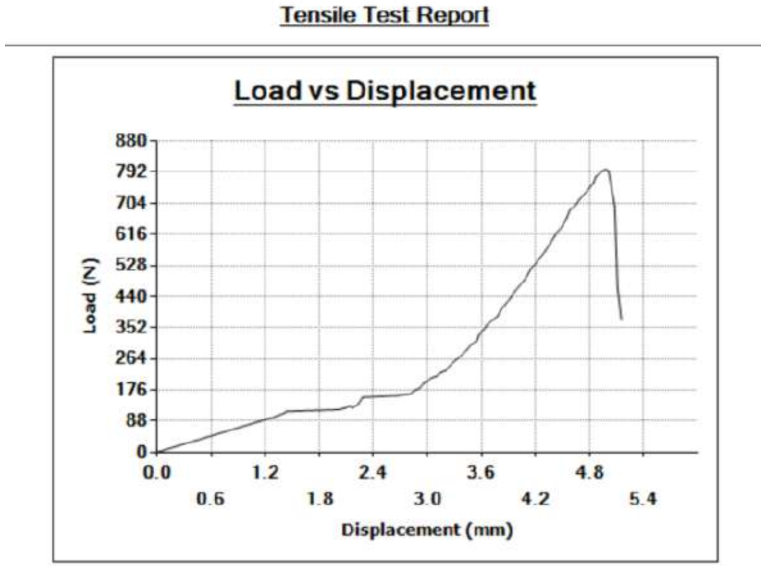
Specimen Preparation & Testing



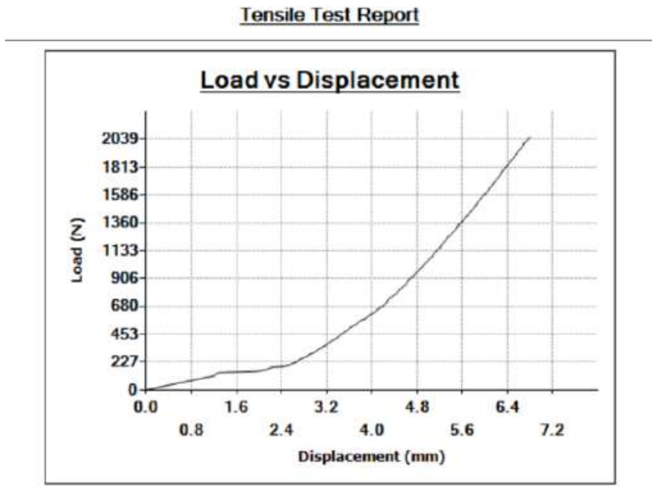
Specimen Preparation(25*100*12.5)



Combination Pineapple & Pineapple Fibre



Combination Bananna & Bananna Fibre



Combination Pineapple & Bananna Fibre

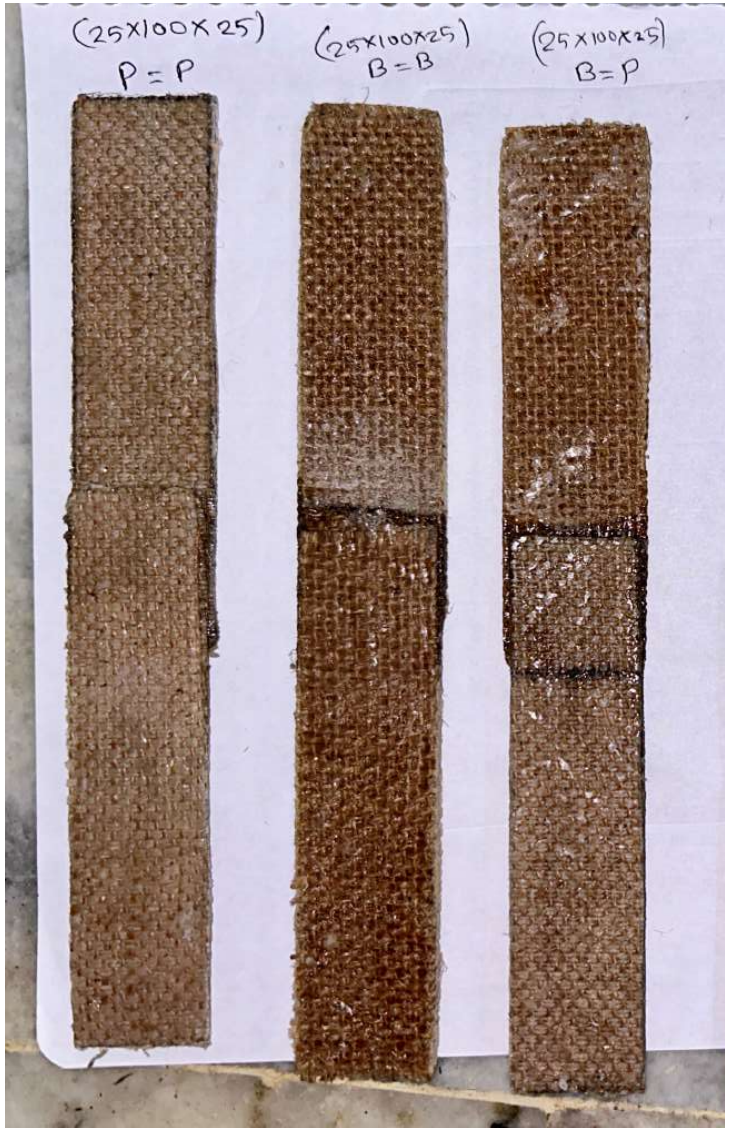
Specimen Failure After Testing

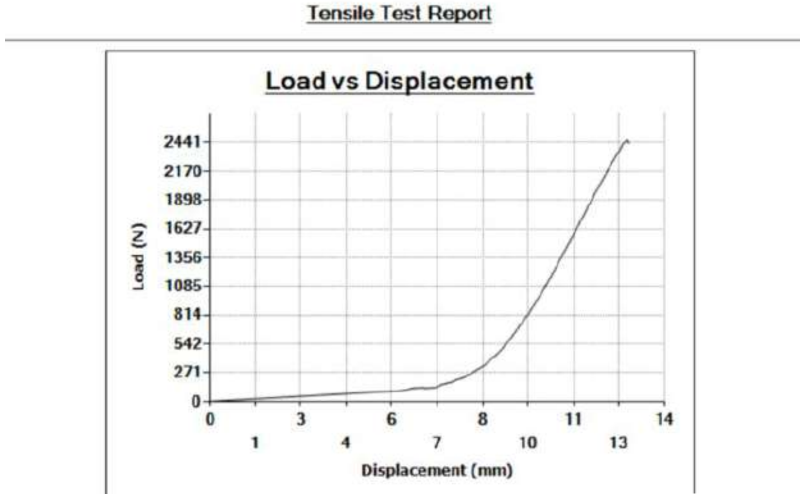
Banana & Banana Fibre

Pineapple & Pineapple Fibre

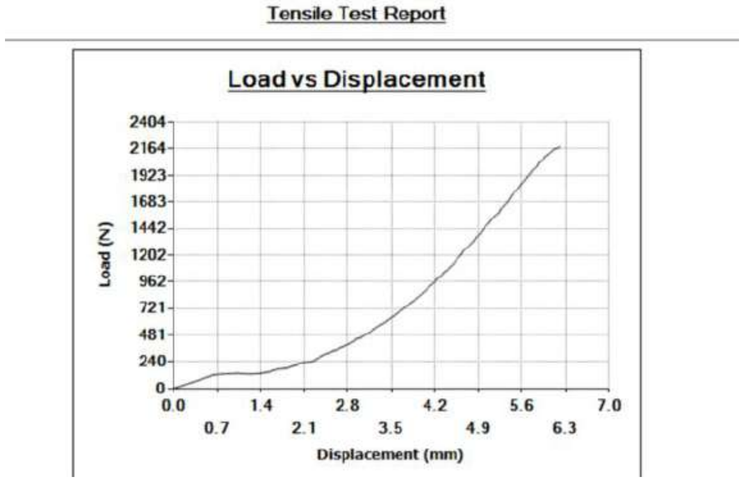
Banana & Pineapple Fibre

Specimen Results(25*100*25)

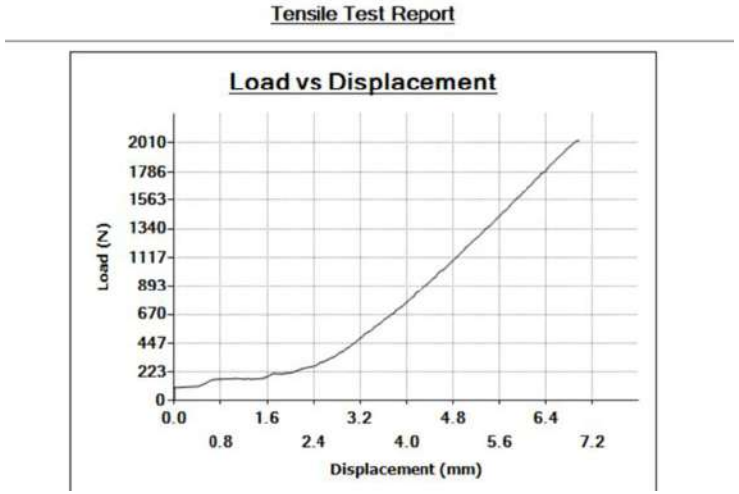




Combination Pineapple & Pineapple Fibre



Combination Bananna & Bananna Fibre



Combination Pineapple & Bananna Fibre

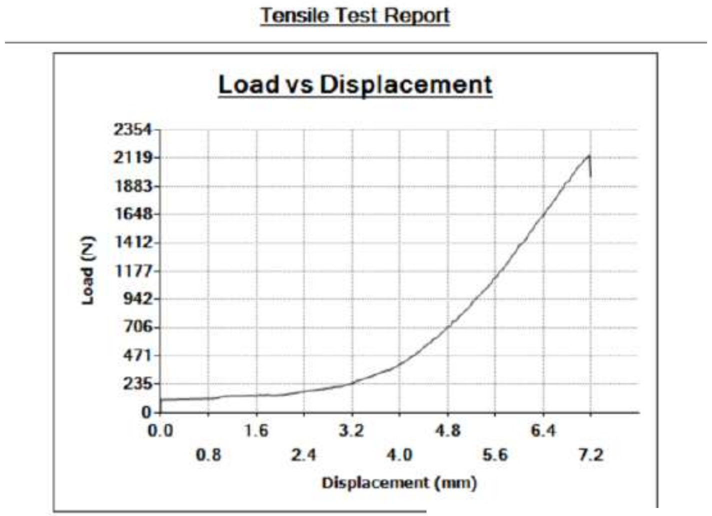
Specimen Failure After Testing

Banana & Banana Fibre

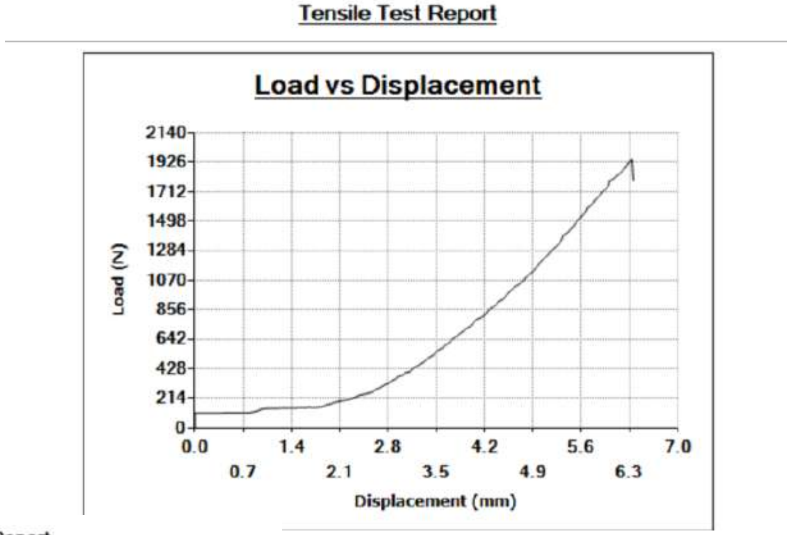
Pineapple & Pineapple Fibre

Banana & Pineapple Fibre

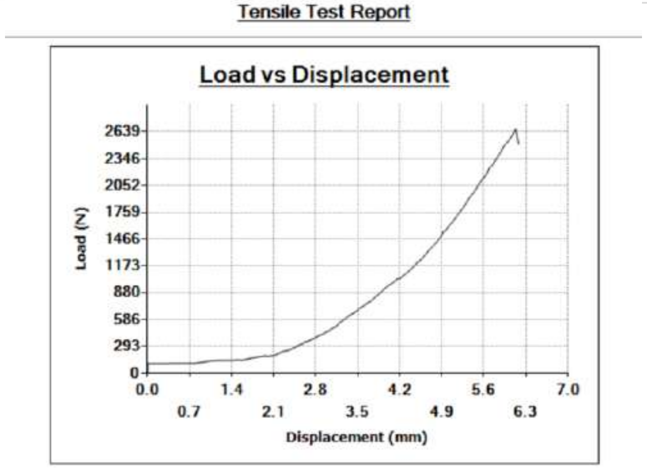
Specimen Results(25*100*37.5)



Combination Pineapple & Pineapple Fibre



Combination Banana & Banana Fibre



Combination Pineapple & Banana Fibre

Specimen Failure After Testing

Banana & Banana Fibre

Pineapple & Pineapple Fibre

Banana & Pineapple Fibre

Comparing Peak Load

Specimens and Load	12.5 mm	25 mm	37.5 mm
Banana & Pineapple	792 N	2164 N	1926 N
Pineapple & Pineapple	1703 N	2441 N	2119 N
Banana & Banana	2093 N	2010 N	2639 N

Conclusion on Lap Joint Strength for Different Material Combinations:

1. Effect of Lap Joint Size:* Increasing the lap joint size (from 12.5 mm to 37.5 mm) generally results in higher load-bearing capacity for all material combinations. Larger lap joints provide more bonding area, thus enhancing joint strength.*
2. Impact of Material Combinations:* Banana & Pineapple has the lowest load capacity across all lap sizes, suggesting weaker compatibility.* Pineapple & Pineapple shows good strength at smaller lap joints, outperforming Banana &Pineapple.* Banana & Banana achieves the highest strength at the largest lap joint size (37.5 mm), indicating that matching materials perform best, especially with larger joints.
3. Recommendations:* For maximum strength, use Banana & Banana with a larger lap joint (37,5 mm).* For smaller joints, Pineapple & Pineapple is a better choice than mixed materials.

Comparison and Conclusion

4. EFFECT OF OVERLAP AREA ON ADHESIVE-BONDED JOINT

In this section, we present the failure load of single-lap joint specimens with experimental investigation. In this regard, we have done the experiment by increasing the overlap

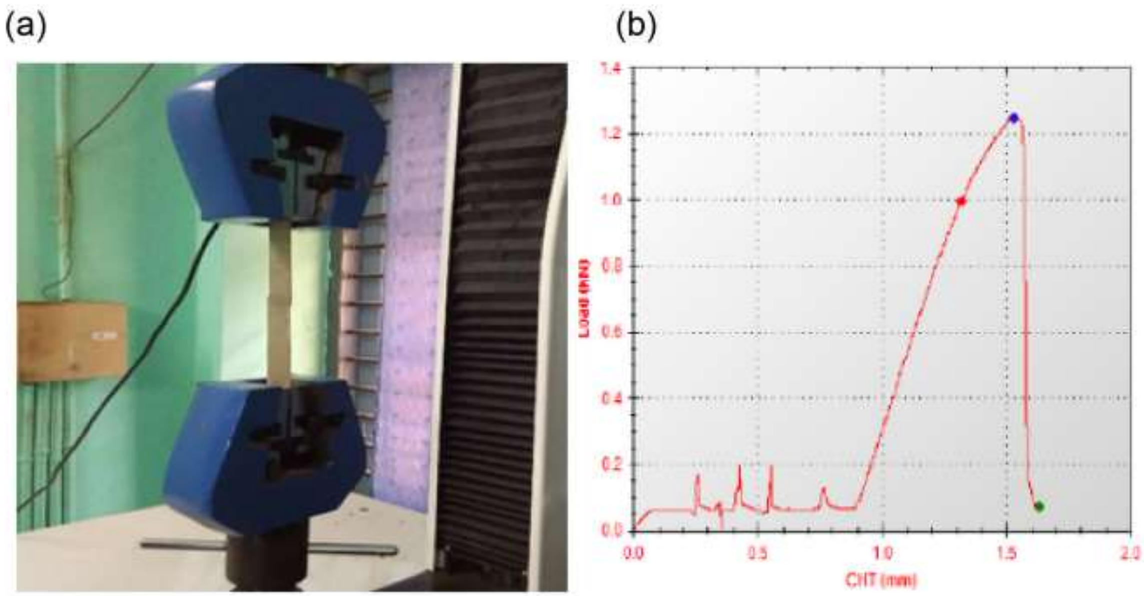
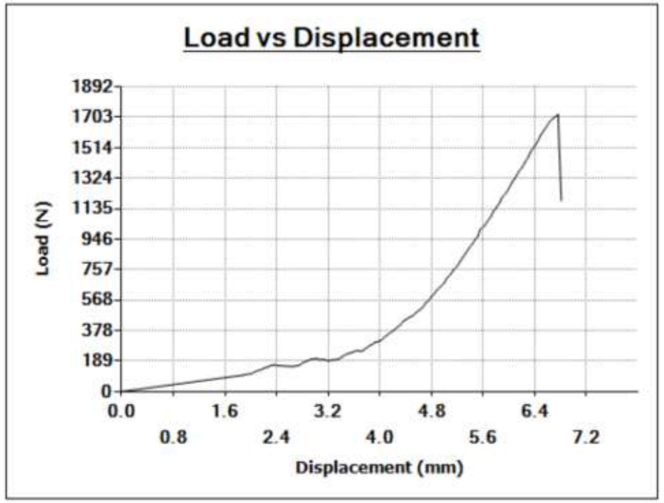


FIG. 6: (a) Lap-shear test of GFRP-GFRP bonded joint in UTM, and (b) load vs. deflection curve of GFRP-GFRP bonded joint (peak load 1.244 kN)

Tensile Test Report



Input Data

Batch Name		:	BATCH-33
Serial No		:	04
Specimen Type		:	Flat
Specimen Width	(mm)	:	25.00
Specimen Thickness	(mm)	:	2.50
C/S Area	(mm²)	:	61.86
Original Gaugelength	(mm)	:	160.00
Final Gaugelength	(mm)	:	162.00
Actual Test Speed	(mm/min)	:	10.0
Test Speed After Yield	(mm/min)	:	10.0
Test Time	(min)	:	0:00.31

Output Data

Ultimate Load	(N)	:	1720.000
Ult Tensile Strength	(N/mm²)	:	27.805
Disp at Ult Load	(mm)	:	6.760
Maximum Disp	(mm)	:	6.810
% Elongation	(%)	:	1.250
% Red in Area	(%)	:	-83.259
Breaking Load	(N)	:	1185.000
Breaking Stress	(N/mm²)	:	19156.160
Yield Load	(N)	:	1514.000
Yield Stress	(N/mm²)	:	24.475
Location of Failure		:	W.G.L

Tested approved by: : Dr Haseebuddin

Test date: : 12/11/2024

Material : PP(LAp-12.5)

Specimen: : 4