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Fabrication and Testing of Leaf Spring (Bamboo)

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ABSTRACT

The present project focuses on the fabrication and testing of a leaf spring, a critical component in vehicle suspension systems. Leaf springs are widely used in automobiles to support loads, absorb shocks, and ensure ride comfort. The main objectives of project is to fabricate a leaf spring, using suitable materials, and evaluate its mechanical performance under different loading conditions. The fabrication process involves selecting appropriate raw materials, shaping the spring, and assembling it according to design specifications. Subsequently, the leaf spring is subjected load testing and deflection analysis to determine its strength, stiffness and durability. The experimental results are compared with theoretical calculations. This study provides valuable insights into material behavior, structural performance, contributing to safer and more efficient suspension systems.

Keywords: Leaf Spring, Fabrication, Load testing, Mechanical Properties.

1. INTRODUCTION

Leaf springs are vital components in vehicle suspension system, primarily used to absorb shocks and vibrations from uneven road surfaces, ensuring passenger comfort and vehicle stability and load-bearing capacity. However, steel leaf springs are heavy and may not be environmentally sustainable. In recent years, there has been growing interest in using composite materials for automotive components to reduce weight, improve fuel efficiency, and promote sustainability. Bamboo, a natural composite material, has emerged as a promising alternative due to its high strength to weight ratio, flexibility, and eco-friendly characteristics. Bamboo exhibits excellent mechanical properties, making it suitable for applications where both strength and flexibility are required. The aim of this project is to fabricate a leaf spring using composite bamboo material and test its mechanical performance. This study demonstrates the feasibility of using sustainable materials.

2. LITERATURE REVIEW

Previous studies have explored the use of composite materials such as glass fiber reinforced polymer (GFRP) and carbon fiber reinforced polymer (CFRP) for leaf springs. These materials significantly reduce weight while maintaining strength. Research on natural fibers such as jute, flax, and bamboo indicates that they offer moderate strength with environmental benefits. However, variability in natural fibers and bonding issues remain key challenges. Bamboo, in particular, has shown promising tensile strength but requires proper treatment and processing.

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Objective

The main objective of this project is to reduce vehicle weight by using bamboo as a lightweight spring material, To study the deflection and stress behavior of bamboo under different loads, To enhance the sustainability of automotive components using natural materials, To enhance the sustainability of automotive components using natural materials.

Materials Used

The materials used in this project include:

1. Bamboo strips: Selected for their high tensile strength and flexibility.
2. Plywood: Used as a base and used to give support to make a leaf spring.
3. Laminate Sheet: Used as a smooth surface layer and mold curving to ensure proper finishing.
4. Epoxy resin: Used as a binding material for composite Formation.
5. Hardener: Mixed with epoxy to initiate curing.

The combination of bamboo and epoxy forms a composite material with improved stiffness and load-bearing capacity.

3. METHODOLOGY

The fabrication and testing of the bamboo composite leaf spring were carried out in several systematic stages. Initially, bamboo was selected as the primary material due to its excellent strength-to-weight ratio, natural composite structure, and environmental sustainability. The bamboo strips were cut according to the required dimensions of the leaf spring (900 mm length, 50 mm width, and 14 mm thickness), cleaned, sanded, and treated with an anti-fungal solution to enhance durability. After drying, the strips were prepared for lamination using epoxy resin as the binding agent. A wooden mold was prepared with a curved profile matching the desired leaf spring shape, having an approximate curvature angle of 30°.

The mold surface was coated with a release agent to prevent the composite from sticking. Bamboo strips were then placed layer by layer in the mold with a uniform coating of resin between each layer, ensuring proper alignment of fibers along the length of the spring for maximum load-bearing capacity. The layers were tightly clamped and allowed to cure under room temperature conditions for about 24–48 hours. Once cured, the composite leaf spring was removed from the mold, trimmed, and finished by sanding and applying a protective resin coating to prevent moisture absorption. For testing, the fabricated bamboo composite leaf spring was mounted on a testing rig, and loads were applied gradually at the center. The corresponding deflections were measured to determine the stiffness and load-bearing capacity of the spring. The results were then compared with those of conventional steel leaf springs to evaluate performance improvements in terms of weight reduction, flexibility, and strength. Throughout the process, safety precautions such as wearing gloves, masks, and ensuring proper ventilation during resin application were strictly followed to maintain a safe working environment.

Fabrication Process

Bamboo Selection: Mature and defect-free bamboo was selected to ensure good strength and durability. Proper selection is important to avoid cracks and weak fibers in the final composite.

Cutting: The bamboo was cut into required lengths as per the leaf spring dimensions. This step ensures uniformity and ease in further processing.

Soaking: Bamboo strips were soaked in water to improve flexibility and reduce brittleness. This helps in easy shaping and prevents cracking during processing.

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Peeling: The bamboo was peeled into thin strips to form reinforcement layers. Thin strips ensure better resin penetration and improved bonding.
Length: 0.2 to 0.7mm
Drying: The strips were dried to remove moisture content before resin application. Proper drying is essential to avoid weak bonding and material failure.
Epoxy Resin Application: Epoxy resin was applied using a brush to coat each bamboo strip uniformly. This ensures proper adhesion between layers and improves strength. 2kg epoxy resin is applied.
Layer Stacking: The coated strips were arranged in layers in a specific orientation. Proper stacking enhances load distribution and structural performance.
Molding: The layered structure was placed in a mold to achieve the desired leaf spring shape. Molding ensures correct curvature and dimensional accuracy.
Curing: The composite was left to cure at room temperature for a 72 hours Curing hardens the resin and forms a bonded structure.
Finishing: After curing, the leaf spring was trimmed and surface-finished. This improves appearance and removes excess material for proper fitting.

Fig.1 Mold & Leaf Spring (Front View)

Fig.2 Mold & Leaf Spring (Top View)

Expriemental Setup

The experimental evaluation of the fabricated bamboo composite leaf spring was conducted using a Universal Testing Machine (UTM) under static loading conditions to determine its load-carrying capacity and deflection behavior.
The leaf spring had dimensions of 900 mm length, 50 mm width, and 14 mm thickness, consisting of four layers of bamboo strips bonded using epoxy resin. The fabricated leaf spring was mounted on the UTM in a simply supported configuration, with supports provided at both ends to simulate actual working conditions in automotive suspension systems.

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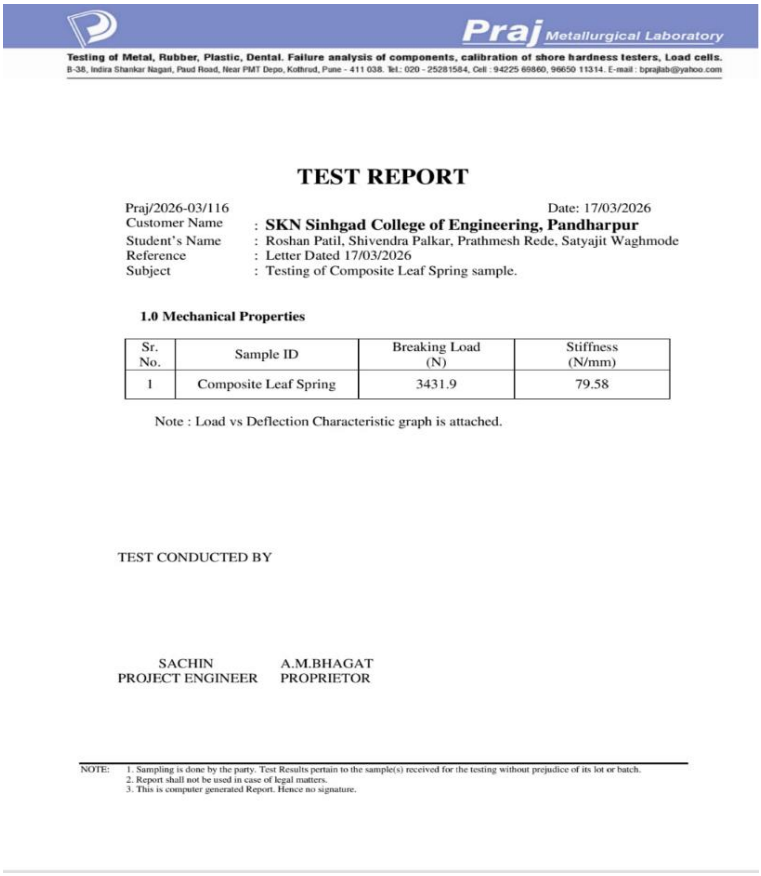
A hydraulic-type UTM with a capacity of 100 KN was used for testing. Load was applied gradually at the midpoint of the specimen to induce bending stress, closely replicating real-life loading conditions. The loading was increased incrementally, and the corresponding deflection values were recorded at each stage.

The test was continued until the specimen reached its failure point. Failure was observed in the form of crack initiation followed by delamination between bamboo layers, indicating interfacial bonding limitations. The maximum load sustained by the specimen was recorded as 350 kg, beyond which structural failure occurred.

The recorded load and deflection data were used to plot a load–deflection curve, which was further analyzed to evaluate the stiffness and mechanical performance of the bamboo composite leaf spring.

Testing Results



Praj Metallurgical Laboratory

Testing of Metal, Rubber, Plastic, Dental. Failure analysis of components, calibration of shore hardness testers, Load cells.

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TEST REPORT

Praj/2026-03/116 Date: 17/03/2026

Customer Name : **SKN Sinhgad College of Engineering, Pandharpur**

Student's Name : Roshan Patil, Shivendra Palkar, Prathmesh Rede, Satyajit Waghmode

Reference : Letter Dated 17/03/2026

Subject : Testing of Composite Leaf Spring sample.

1.0 Mechanical Properties

Sr. No.	Sample ID	Breaking Load (N)	Stiffness (N/mm)
1	Composite Leaf Spring	3431.9	79.58

Note : Load vs Deflection Characteristic graph is attached.

TEST CONDUCTED BY

SACHIN PROJECT ENGINEER

A.M.BHAGAT PROPRIETOR

NOTE: 1. Sampling is done by the party. Test Results pertain to the sample(s) received for the testing without prejudice of its lot or batch.
2. Report shall not be used in case of legal matters.
3. This is computer generated Report. Hence no signature.

Fig. 3 Test Report

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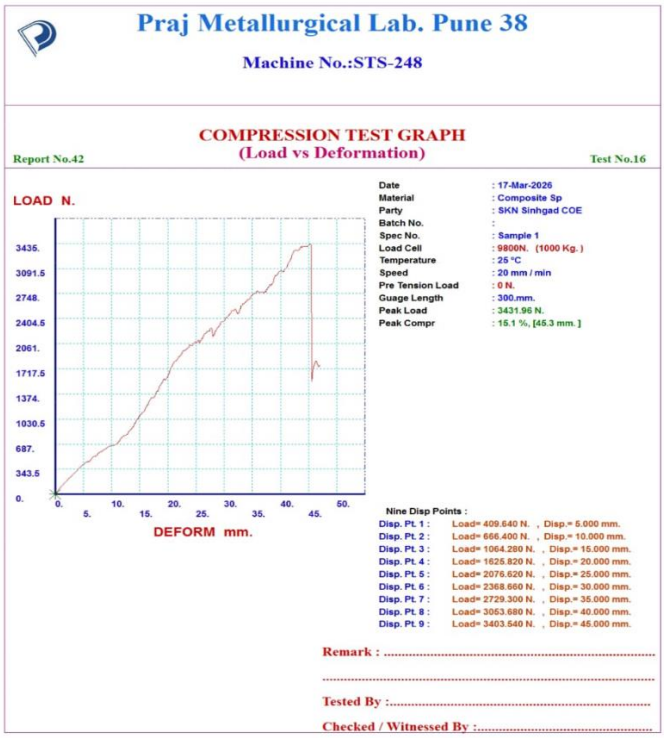

Fig. 4 Compression Test Graph

4. DICUSSION OF RESULT (TEST REPORT)

The compression test performed on the composite leaf spring demonstrates a progressive load-bearing behavior with increasing deformation. The load–deformation curve shows an initially linear region, indicating elastic deformation, followed by a nonlinear region as the material approaches failure. This behavior confirms that the composite material exhibits both elastic and plastic characteristics under compressive loading.

The maximum load sustained by the specimen was 3431.9 N, corresponding to a deformation of approximately 45 mm. Beyond this point, a sudden drop in load is observed in the graph, indicating failure or structural instability of the composite leaf spring. This drop suggests that the material does not fail gradually but undergoes a relatively abrupt loss of load-carrying capacity.

The calculated stiffness of the composite leaf spring is 79.58 N/mm, which reflects the material's resistance to deformation. The gradual increase in load with displacement indicates good energy absorption capability, making the composite suitable for applications requiring vibration damping and shock absorption, such as automotive suspension systems.

The deformation at peak load (~15.1%) indicates that the composite material has moderate ductility before failure. Compared to conventional steel leaf springs, composite materials generally offer advantages such as reduced weight and corrosion resistance, while maintaining adequate strength and stiffness.

Minor fluctuations in the load–deformation curve may be attributed to internal material heterogeneity, fiber-matrix interaction, or experimental factors such as alignment and gripping conditions during testing.

Overall, the results suggest that the composite leaf spring provides a good balance between strength, stiffness, and deformation capacity. However, the sudden failure behavior indicates the need for further optimization in material design or layering to improve toughness and prevent abrupt failure.

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5. CONCLUSION

The composite leaf spring made from bamboo material was sucessfully fabricated and tested using Universal Testing Machine. From the experimental results, it is observed that the leaf spring withstood a maximum load of 3431.96 N.

The load–deformation analysis showed an initial linear (elastic) behavior followed by non-linear deformation, indicating gradual material weakening before fracture. The stiffness of the composite leaf spring was found to be 79.58 N/mm, which reflects moderate resistance to deformation.

However, the specimen failed suddenly after reaching the peak load, indicating brittle behavior and limited load-carrying capacity compared to conventional steel leaf springs.

Despite lower strength, the bamboo composite leaf spring offers advantages such as lightweight, eco-friendliness, and low cost, making it suitable for low-load applications like bicycles, light electric vehicles (e-rickshaw with low capacity), and rural transport systems.

Thus, it can be concluded that bamboo composite material can be used as an alternative to conventional materials in light-duty applications, but further improvements in material composition and fabrication techniques are required for high - load applications.

REFERENCES

1. Godase, M. V., Mulani, A., Ghodak, M. R., Birajadar, M. G., Takale, M. S., & Kolte, M. A MapReduce and Kalman Filter based Secure IIoT Environment in Hadoop. Sanshodhak, Volume 19, June 2024.
2. Mulani, A. O., & Mane, P. B. (2017). Watermarking and cryptography based image authentication on reconfigurable platform. Bulletin of Electrical Engineering and Informatics, 6(2), 181-187.
3. Gadade, B., Mulani, A. O., & Harale, A. D. IoT Based Smart School Bus and Student Tracking System. Sanshodhak, Volume 19, June 2024.
4. Dhanawade, A., Mulani, A. O., & Pise, A. C. IOT based Smart farming using Agri BOT. Sanshodhak, Volume 20, June 2024.
5. Mulani, A., & Mane, P. B. (2016). DWT based robust invisible watermarking. Scholars' Press.
6. R. G. Ghodke, G. B. Birajdar, A.O. Mulani, G.N. Shinde, R.B. Pawar, Design and Development of an Efficient and Cost-Effective surveillance Quadcopter using Arduino, Sanshodhak, Volume 20, June 2024.
7. R. G. Ghodke, G. B. Birajdar, A.O. Mulani, G.N. Shinde, R.B. Pawar, Design and Development of Wireless Controlled ROBOT using Bluetooth Technology, Sanshodhak, Volume 20, June 2024.
8. Swami, S. S., & Mulani, A. O. (2017, August). An efficient FPGA implementation of discrete wavelet transform for image compression. In 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS) (pp. 3385-3389). IEEE.
9. Mane, P. B., & Mulani, A. O. (2018). High speed area efficient FPGA implementation of AES algorithm. International Journal of Reconfigurable and Embedded Systems, 7(3), 157-165.
10. Mulani, A. O., & Mane, P. B. (2016). Area efficient high speed FPGA based invisible watermarking for image authentication. Indian journal of Science and Technology, 9(39), 1-6.

ISSN: 2945-4565 VOL 05, ISSUE 02, 2026

11. Kashid, M. M., Karande, K. J., & Mulani, A. O. (2022, November). IoT-based environmental parameter monitoring using machine learning approach. In Proceedings of the International Conference on Cognitive and Intelligent Computing: ICCIC 2021, Volume 1 (pp. 43-51). Singapore: Springer Nature Singapore.
12. Nagane, U. P., & Mulani, A. O. (2021). Moving object detection and tracking using Matlab. Journal of Science and Technology, 6(1), 2456-5660.
13. Kulkarni, P. R., Mulani, A. O., & Mane, P. B. (2016). Robust invisible watermarking for image authentication. In Emerging Trends in Electrical, Communications and Information Technologies: Proceedings of ICECIT-2015 (pp. 193-200). Singapore: Springer Singapore.
14. Ghodake, M. R. G., & Mulani, M. A. (2016). Sensor based automatic drip irrigation system. Journal for Research, 2(02).
15. Mandwale, A. J., & Mulani, A. O. (2015, January). Different Approaches For Implementation of Viterbi decoder on reconfigurable platform. In 2015 International Conference on Pervasive Computing (ICPC) (pp. 1-4). IEEE.