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Tensile Test of Chicken Feather Fiber Composite Material and Application

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Abstract*. The purpose of this study is to perform the tensile tests on chicken feather fiber composites to evaluate their potential in practical engineering applications. The study employed the experimental method as a laboratory activity, in which chicken feathers fibers were fused with epoxy resin at different ratios of 5%, 10%, 12% and 14% to form composite specimens. In order to find the ultimate tensile strength, yield strength and the modulus of elasticity of the composites, tensile testing of the composites was done according to the the American Society of Testing and Materials (ASTM) D3039 standard test method. Results showed that in as low as 5% reinforcement of chicken feathers, the mechanical properties of the resin were greatly improved, with the ultimate tensile strength reaching 48.672 N/mm² and the yield strength being 39.168 N/mm². This shows the promise of using chicken feather fiber composites as strong and light materials that are also eco-friendly for various uses. The discussion topics mentioned the behavior of stress-strain transition from elastic to plastic region on increasing the load, which showed the strength and flexibility of the composites are in essence, the opposite of each other. This study advances the view that there is more development to be done on chicken feather fiber composites to enable them satisfy the standards of various sectors thereby offering an environmentally friendly method in cutting waste and reducing the burden of the environment from synthetic materials.*

Keywords *Chicken feathers, fiber, composite, resin, tensile strength*

1. INTRODUCTION

Chicken feather fibre composite material is a relatively new and innovative material that has gained attention for its potential applications in various industries. The unique properties of chicken feathers, such as their high tensile strength and light weight, make them a promising alternative to traditional synthetic fibers. In recent years, researchers have been exploring different methods to extract and process chicken feathers to create a durable and sustainable composite material. This material has the potential to revolutionize the way we think about waste management and resource utilization in the future. Furthermore, the production of chicken feather composite materials could also help reduce the environmental impact of traditional materials like plastic and fiberglass. By repurposing a waste product that would otherwise be disposed of, we can create a more sustainable and eco-friendly option for various industries. As technology continues to advance, we may see more innovative uses for chicken feather composite materials that could benefit both the economy and the environment. Overall, the future looks bright for this unique and versatile material.

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2. LITERATURE REVIEW

Tensile testing is a crucial component of material analysis, providing valuable data on the strength and durability of a material under tension. By subjecting a sample to controlled stress, we can determine its ultimate tensile strength, yield strength, and elongation at break. This information is essential for engineers and researchers looking to design and develop new materials for a wide range of applications. Tensile testing can also help identify any potential weaknesses or defects in a material, allowing for improvements to be made before it is put into use. In addition, the data obtained from tensile testing can be used to compare the performance of different materials and determine which is best suited for a particular application. Overall, tensile testing plays a vital role in ensuring the quality and reliability of materials used in various industries. Furthermore, tensile testing can also provide valuable insights into the behavior of materials under different conditions, such as temperature and pressure. This allows for a more thorough understanding of how a material will perform in real-world applications, helping to prevent failures and accidents. By conducting tensile testing, engineers can make informed decisions about the materials they use, ultimately leading to safer and more efficient products. In conclusion, the importance of tensile testing cannot be overstated in the field of materials science and engineering.

Previous studies on chicken feather fiber composites have shown promising results in terms of durability and impact resistance. Traditional polycarbonate visors and motorcycle visors made of composites of chicken feather fibers had comparable impact resistance. Demonstrated that chicken feather fiber composites have the potential to be more lightweight and flexible, making them more comfortable for riders to wear for extended periods of time. Overall, the literature suggests that the use of chicken feather fibre in motorcycle visors has the potential to revolutionize the industry and provide numerous benefits for both riders and the environment. By utilizing a renewable and sustainable material like chicken feathers, manufacturers can reduce their carbon footprint and contribute to an eco-friendlier manufacturing process. This innovative approach could also lead to cost savings in production, as chicken feathers are a byproduct of the poultry industry and are readily available. With further research and development, chicken feather fiber composites may become the material of choice for motorcycle visors in the future, offering a combination of durability, comfort, and environmental benefits unlike any other material currently on the market.

Tensile testing methods used in similar materials have shown promising results in terms of strength and flexibility, making chicken feather fiber composites a viable option for various applications beyond motorcycle visors. By understanding the mechanical properties of these composites, manufacturers can further optimize their production processes to ensure consistent quality and performance. Additionally, ongoing research and collaboration with industry partners will be crucial in exploring the full potential of this sustainable material and driving its widespread adoption in the manufacturing sector. With continued advancements in technology and materials science, there is potential for chicken feather fiber composites to revolutionize the way we approach manufacturing in various industries. By harnessing the unique properties of this natural material, we can create products that are not only durable and lightweight but also environmentally friendly. As more research is conducted and partnerships are formed, the possibilities for utilizing chicken feather fiber composites in new and innovative ways are endless.

One of the industries that could greatly benefit from the use of chicken feather fiber composites is the automotive industry. With the push for more sustainable and eco-friendly vehicles, manufacturers are constantly looking for new materials that can help reduce the overall carbon footprint of their products. By incorporating chicken feather fiber composites into the design and production of cars, we can create vehicles that are not only lighter and more fuel-efficient, but also have a lower impact on the environment. This innovative approach to manufacturing could potentially revolutionize the way cars are made, leading to a more sustainable future for the automotive industry. In addition to being eco-friendly, chicken feather fiber composites are also strong and durable, making them an ideal material for use in vehicle manufacturing. By utilizing this innovative material, car manufacturers can potentially reduce their reliance on traditional materials that are harmful to the environment. Overall, incorporating chicken feather fiber composites into the automotive industry could pave the way for a greener and more sustainable future for transportation.

3. METHODS

The research method applied is a laboratory experiment. The sample was made by mixing chicken feathers and epoxy resin as an adhesive, then poured into a standard ASTM D3039 mold with random fibers and allowed to dry. Rectangular composite specimens were made with several variations in composition. The aim was to analyze the comparison of tensile test capabilities in various variations. The composition of the resin and chicken feather mixture was (100%: 5%), (100%: 10%), (100%: 12%), (100%: 14%), and pure resin (100%).

Materials and Equipment:

a. Chicken feathers
b. Epoxy resin
c. Hardener (catalyst)
d. Two sheets of glass measuring 20 cm x 30 cm and 5 mm thick
e. Double foam tape green foam
f. Digital scales, used to weigh chicken feathers and resin
g. Blender to smooth chicken feathers
h. Vernier callipers to measure composite specimens
i. Cutter, used to cut composite edges
j. small spoon is used to stir and smooth the composite mixture in the mould
k. Ruler, to measure the mould to be made
l. Gloves,
m. Plastic cup as a container for mixing resin and fibre
n. Sandpaper, used to smooth composite specimens
o. Scissors
p. Tensile testing machine (universal testing machine) model: GT-A-0.3C

Sample preparation

a. Composite making: prepare chicken feathers that have been ground using a blender; mix chicken feather fibers with epoxy resin and stir until evenly distributed. Ensure even fiber distribution and drying process for 24 hours.

Figure 1. Documentation

b. Specimen dimensions: make a mould using green double foam tape and stick it on a 20 cm x 30 cm glass sheet with standard ASTM D3039 random fibre size; typical dimensions are a rectangle with a length of 250 mm, a thickness of 2.5 mm, and a width of 25 mm. The composite is poured into the mould, put the second glass on top and pressed using a bucket of water.

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Figure 2. Documentation

c. Conditioning: the material will harden at room temperature for 2 days and is removed from the mold, so that the composite material is completely dry.

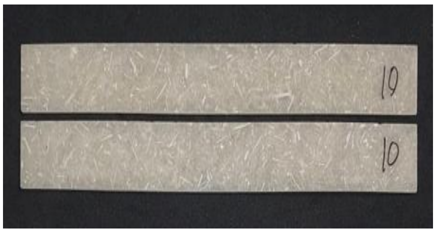

Figure 3. Documentation

Test setup

a. Sample installation: fix the specimen in the vise of the tensile testing machine. The accuracy of installing the specimen must be straight and accurate to ensure that the tensile load is evenly distributed along the axis of the specimen.

Figure 4. Documentation

b. Calibration and zeroing: Calibrate the tensile testing machine according to the manufacturer's instructions. Zero the force and displacement readings before starting the test.

c. Test parameters: change the unit on the machine by (N) at the standard speed of the tensile testing machine (Good Tech model GT-A-0.3C)

Figure 5. Documentation

Tensile testing is a mechanical stress-strain test that aims to determine the stress, strain, and modulus of elasticity of a material by pulling the specimen until it breaks.
The following formula determines the relationship between stress and strain under tensile load:

$$\sigma = \frac{F}{A} \tag{1}$$

Where:

F = Load (N); A = Cross-sectional area (mm^2); σ = Stress (N/mm^2)

The magnitude of the strain is the amount of increase in length due to loading compared to the measuring area (gauge length), which can be calculated using the equation:

$$\varepsilon = \frac{\Delta l}{l_\circ}$$

(2)

Where:

ε = Strain (mm/mm); Δl = Length increase (mm); $l_\circ$ = Length of measuring area (mm)

The value of the composite elastic modulus is the ratio between stress and strain in the proportional area and can be calculated using the equation:

$$E = \frac{\sigma}{\varepsilon}$$

(3)

Where:

E = Modulus of elasticity (N/mm^2

Data collection:

The tensile test result data was obtained from the tests that had been carried out. The data collected included the maximum tensile load value and the change in length. For the tensile test, the specimen size followed the ASTM D3039 standard with dimensions 250 mm x 25 mm x 2.5 mm.

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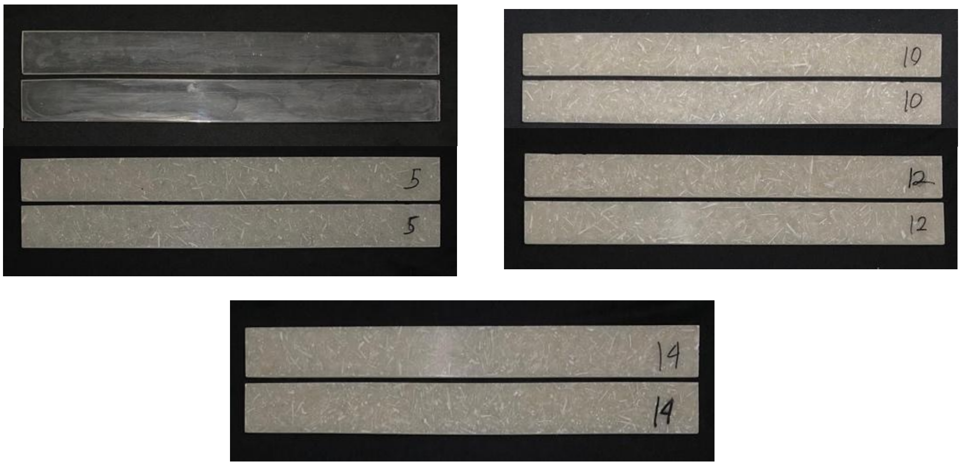
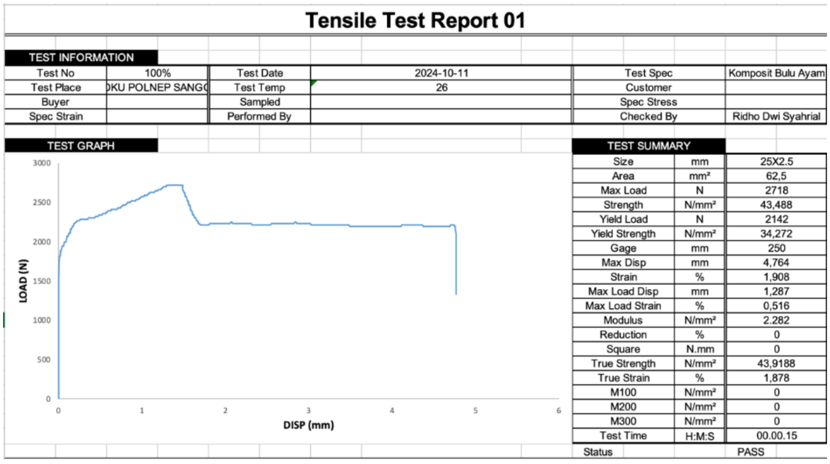


Figure 6. Documentation

Above are the ASTM D3039 tensile test specimen images of random fibre variants (100% resin), (100%: 5%), (100%: 10%), (100%: 12%), (100%: 14%).

4. RESULTS

Tensile Strength Graph Analysis (100% resin)



Tensile Test Report 01

TEST INFORMATION

Test No	100%	Test Date	2024-10-11	Test Spec	Komposit Bulu Ayam
Test Place	)KU POLNEP SANG(	Test Temp	26	Customer	
Buyer		Sampled		Spec Stress	
Spec Strain		Performed By		Checked By	Ridho Dwi Syahrial

TEST GRAPH

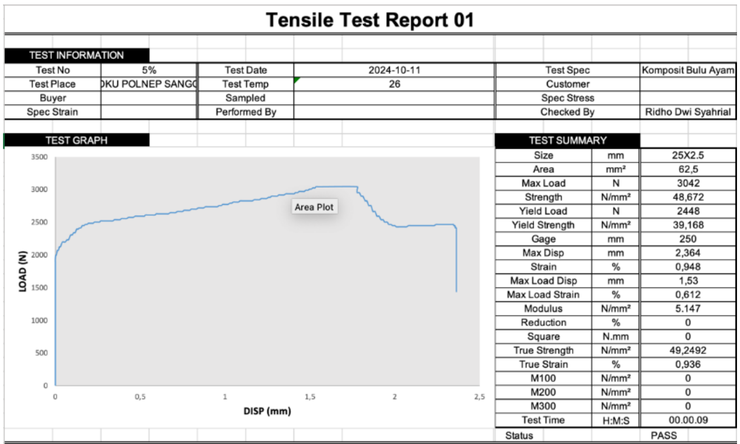
TEST SUMMARY

Size	mm	25X2.5
Area	mm²	62,5
Max Load	N	2718
Strength	N/mm²	43,488
Yield Load	N	2142
Yield Strength	N/mm²	34,272
Gage	mm	250
Max Disp	mm	4,764
Strain	%	1,908
Max Load Disp	mm	1,287
Max Load Strain	%	0,516
Modulus	N/mm²	2.282
Reduction	%	0
Square	N.mm	0
True Strength	N/mm²	43,9188
True Strain	%	1,878
M100	N/mm²	0
M200	N/mm²	0
M300	N/mm²	0
Test Time	H:M:S	00.00.15
Status		PASS

Figure 7. Tensile Strength 100% resin

This tensile test graph provides a detailed picture of the mechanical properties of a 100% resin epoxy material. The initial linear region of the graph represents elastic deformation, where the material stretches proportionally to the applied load and returns to its original shape upon unloading. The slope of this linear region corresponds to the Young's modulus, a measure of the material's stiffness, which is 2.282 N/mm² according to the report. As the load increases, the graph curves, indicating the onset of plastic deformation, where the material undergoes permanent deformation. The maximum point on the graph corresponds to the ultimate tensile strength, 43.488 N/mm², the maximum stress the material can withstand before failure. Beyond this point, the material exhibits necking, a localized reduction in cross-sectional area, which leads to a decrease in load-carrying capacity and eventual fracture. The yield strength, 34.272 N/mm², signifies the stress at which the material transitions from elastic to plastic deformation. The graph also reveals that the material has a moderate level of ductility, as evidenced by the extent of plastic deformation before failure. This analysis suggests that the 100% resin epoxy material possesses a good balance of stiffness, strength, and ductility, making it suitable for applications that require these mechanical properties.

Tensile Strength Graph Analysis (5% Chicken Feather)



Tensile Test Report 01

TEST INFORMATION

Test No	5%	Test Date	2024-10-11	Test Spec	Komposit Bulu Ayam
Test Place	OKU POLNEP SANGG	Test Temp	26	Customer	
Buyer		Sampled		Spec Stress	
Spec Strain		Performed By		Checked By	Ridho Dwi Syahrial

TEST GRAPH

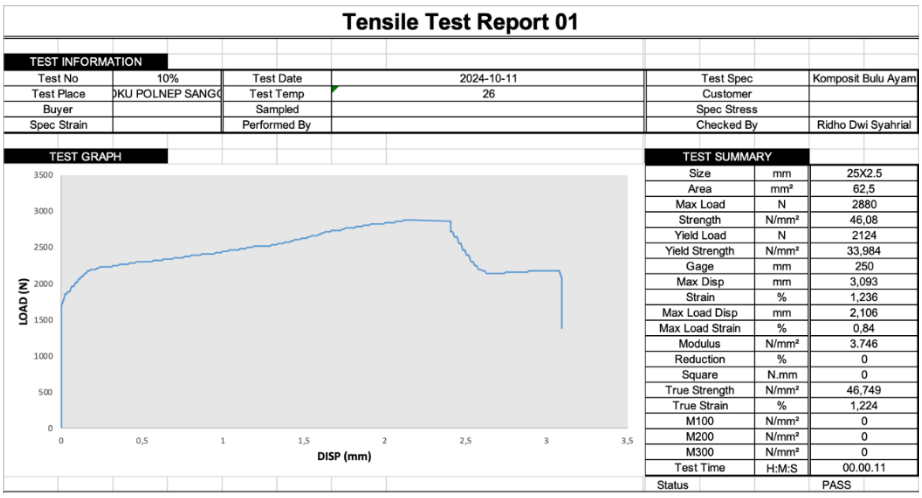
TEST SUMMARY

Size	mm	25X2.5
Area	mm²	62,5
Max Load	N	3042
Strength	N/mm²	48,672
Yield Load	N	2448
Yield Strength	N/mm²	39,168
Gage	mm	250
Max Disp	mm	2,364
Strain	%	0,948
Max Load Disp	mm	1,53
Max Load Strain	%	0,612
Modulus	N/mm²	5.147
Reduction	%	0
Square	N.mm	0
True Strength	N/mm²	49,2492
True Strain	%	0,936
M100	N/mm²	0
M200	N/mm²	0
M300	N/mm²	0
Test Time	H:M:S	00.00.09
Status		PASS

Figure 8. Tensile Strength 5% Chicken Feather

This tensile test graph illustrates the mechanical behavior of a resin material reinforced with 5% chicken feathers. The initial linear portion of the graph represents the elastic region, where the material deforms reversibly under stress. The slope of this region corresponds to the Young's modulus, which is 5.147 N/mm², indicating the material's stiffness. As the applied load increases, the graph transitions into a non-linear region, signifying the onset of plastic deformation, where the material undergoes permanent changes in shape. The peak of the curve corresponds to the ultimate tensile strength, 48.672 N/mm², representing the maximum stress the material can withstand before failure. After this point, the material experiences necking, a localized reduction in cross-sectional area, leading to a decrease in load-bearing capacity and eventual fracture. The yield strength, 39.168 N/mm², marks the stress at which the material begins to deform plastically. The inclusion of 5% chicken feathers seems to have a positive impact on the material's strength, as evidenced by the relatively high ultimate tensile strength. However, a comprehensive analysis would require comparing these results with the properties of the neat resin to isolate the specific contribution of the chicken feathers.

Tensile Strength Graph Analysis (10% Chicken Feather)



Tensile Test Report 01

TEST INFORMATION

Test No	10%	Test Date	2024-10-11	Test Spec	Komposit Bulu Ayam
Test Place	)KU POLNEP SANG(	Test Temp	26	Customer	
Buyer		Sampled		Spec Stress	
Spec Strain		Performed By		Checked By	Ridho Dwi Syahrial

TEST GRAPH

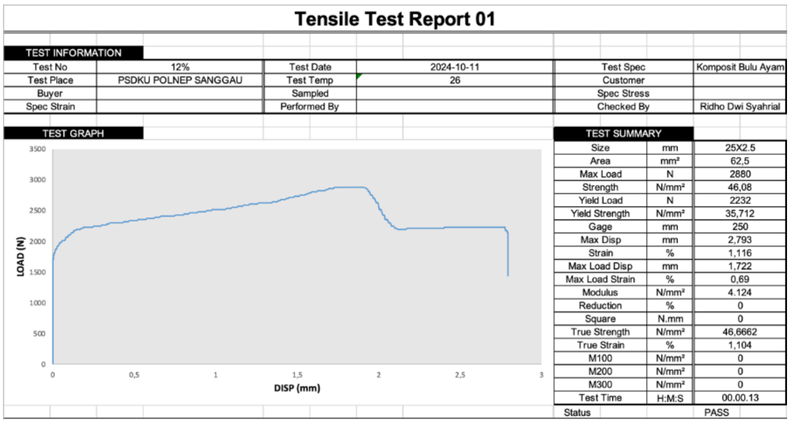
TEST SUMMARY

Size	mm	25X2.5
Area	mm²	62,5
Max Load	N	2880
Strength	N/mm²	46,08
Yield Load	N	2124
Yield Strength	N/mm²	33,984
Gage	mm	250
Max Disp	mm	3,093
Strain	%	1,236
Max Load Disp	mm	2,106
Max Load Strain	%	0,84
Modulus	N/mm²	3.746
Reduction	%	0
Square	N.mm	0
True Strength	N/mm²	46,749
True Strain	%	1,224
M100	N/mm²	0
M200	N/mm²	0
M300	N/mm²	0
Test Time	H:M:S	00.00.11
Status		PASS

Figure 9. Tensile Strength 10% Chicken Feather

The tensile test graph illustrates the mechanical behaviour of a resin material reinforced with 10% chicken feather under tension. Initially, the graph shows a steep linear region, indicating elastic deformation where the material stretches proportionally to the applied load. This region represents the material's stiffness, measured by the Young's modulus, which is 3.746 N/mm² according to the report. As the load increases, the graph curves, signifying the onset of plastic deformation. Here, the material undergoes permanent deformation, and the relationship between stress and strain is no longer linear. The maximum point on the graph corresponds to the ultimate tensile strength, 46.08 N/mm², the maximum stress the material can withstand before failure. After this point, the material exhibits necking, a localized reduction in cross-sectional area, leading to a decrease in load-carrying capacity and eventual fracture. The yield strength, 33.984 N/mm², indicates the stress at which the material starts to deform plastically. The presence of chicken feathers likely contributes to the material's overall strength and toughness, as evidenced by the relatively high tensile strength and the presence of plastic deformation. However, the exact influence of the chicken feathers on the material's properties would require further investigation and comparison with the properties of the neat resin.

Tensile Strength Graph Analysis (12% Chicken Feather)



Tensile Test Report 01

TEST INFORMATION

Test No	12%	Test Date	2024-10-11	Test Spec	Komposit Bulu Ayam
Test Place	PSDKU POLNEP SANGGAU	Test Temp	26	Customer	
Buyer		Sampled		Spec Stress	
Spec Strain		Performed By		Checked By	Ridho Dwi Syahrial

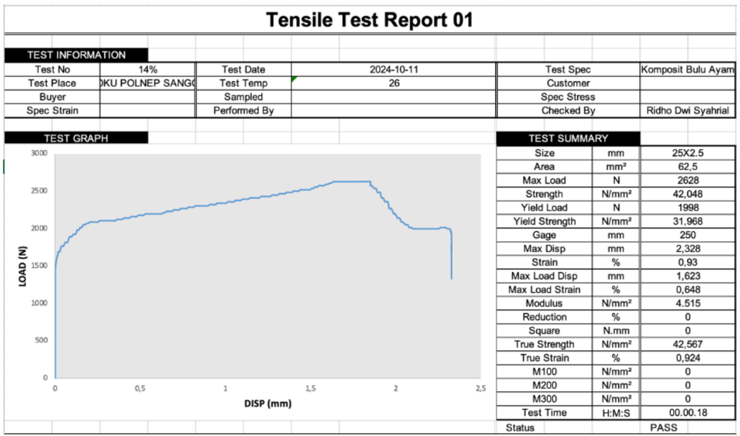
TEST SUMMARY

Size	mm	25X2.5
Area	mm²	62,5
Max Load	N	2880
Strength	N/mm²	46,08
Yield Load	N	2232
Yield Strength	N/mm²	35,712
Gage	mm	250
Max Disp	mm	2,793
Strain	%	1,116
Max Load Disp	mm	1,722
Max Load Strain	%	0,69
Modulus	N/mm²	4.124
Reduction	%	0
Square	N.mm	0
True Strength	N/mm²	46,6662
True Strain	%	1,104
M100	N/mm²	0
M200	N/mm²	0
M300	N/mm²	0
Test Time	H:M:S	00.00.13
Status		PASS

Figure 10. Tensile Strength 12% Chicken Feather

This tensile test graph reveals the mechanical properties of a resin material reinforced with 12% chicken feathers. The initial linear portion of the graph represents the elastic region where the material deforms reversibly, with a Young's modulus of 4.124 N/mm² indicating its stiffness. As the applied load increases, the graph transitions into a non-linear region, signifying plastic deformation, where the material undergoes permanent changes in shape. The peak of the curve corresponds to the ultimate tensile strength, 46.08 N/mm², the maximum stress the material can withstand before failure. Beyond this point, the material experiences necking, a localized reduction in cross-sectional area, leading to a decrease in load-bearing capacity and eventual fracture. The yield strength, 35.712 N/mm², marks the onset of plastic deformation. The inclusion of 12% chicken feathers appears to enhance the material's strength and ductility, as seen in the relatively high tensile strength and the extent of plastic deformation before failure. However, a direct comparison with the neat resin's properties would be necessary to definitively assess the contribution of the chicken feathers to the material's overall performance.

Tensile Strength Graph Analysis (14% Chicken Feather)



Tensile Test Report 01

TEST INFORMATION

Test No	14%	Test Date	2024-10-11	Test Spec	Komposit Bulu Ayam
Test Place	)KU POLNEP SANG(	Test Temp	26	Customer	
Buyer		Sampled		Spec Stress	
Spec Strain		Performed By		Checked By	Ridho Dwi Syahrial

TEST SUMMARY

Size	mm	25X2.5
Area	mm²	62,5
Max Load	N	2628
Strength	N/mm²	42,048
Yield Load	N	1998
Yield Strength	N/mm²	31,968
Gage	mm	250
Max Disp	mm	2,328
Strain	%	0,93
Max Load Disp	mm	1,623
Max Load Strain	%	0,648
Modulus	N/mm²	4.515
Reduction	%	0
Square	N.mm	0
True Strength	N/mm²	42,567
True Strain	%	0,924
M100	N/mm²	0
M200	N/mm²	0
M300	N/mm²	0
Test Time	H:M:S	00.00.18
Status		PASS

Figure 11. Tensile Strength 14% Chicken Feather

This tensile test graph provides insights into the mechanical behavior of a resin material reinforced with 14% chicken feathers under tensile loading. The initial linear portion of the graph represents the elastic region, where the material deforms reversibly and exhibits a Young's modulus of 4.515 N/mm², indicating its stiffness. As the applied tensile load increases, the graph transitions into a non-linear region, signifying the onset of plastic deformation, where the material **undergoes** permanent changes in shape. The peak of the curve corresponds to the ultimate tensile strength, 42.048 N/mm², representing the maximum stress the material can withstand before failure. Beyond this ultimate strength point, the material undergoes necking, a localized reduction in cross-sectional area, leading to a decrease in load-carrying capacity and eventual fracture. The yield strength, 31.968 N/mm², indicates the stress at which the material begins to deform plastically. The addition of 14% chicken feathers seems to influence the material's properties, but a definitive assessment of its contribution to strength and ductility would require a comparison with the tensile test results of the neat resin.

5. DISCUSSION

In the case of data shown in the article, it can be stated that tensile properties of chicken feathers fiber composites can be further explored for a range of practical engineering solution considering its eco-friendliness. In terms of tensile strength, the analysis proved the theories whereby the **compounding** of chicken feathers fibers at different proportion with epoxy resin is able to influence the mechanical properties of composite like ultimate tensile strength, yield strength, and Modulus of elasticity. The composite bearing 5% of chicken feathers composite exhibited a higher value of tensile properties over the rest compositions with ultimate tensile strength of 48.672 N/mm² and yield strength of 39.168 N/mm². This implies that even as low as five percent of chicken feather reinforcement can improve resin strength characteristics. Furthermore, the elastic modulus values in other sections monitored how the tensile behaviour shifted from elasticity to plasticity with increase in load, giving an idea on the strength and flexibility compromise present in the material. The findings demonstrate the suitability of chicken feather fiber for production of composite materials which are light in weight and strong enough for varied industrial uses such as automotive and construction, and insulation properties with potential of industrial applications.

In addition, the results of the research draw attention to the importance of proper evaluation of the mechanical properties of chicken feather composites as compared to pure resin. The different stress-strain response phases observed – elastic deformation and plastic flow – reveal the function of fiber reinforcement in crack initiation and its effect on ductility. It can be seen that strain-to-fracture values indicate that fractures are generally ductile but the highest figure of 1.908 per cent gave composite, which depicts the point of difference between resin and fiber-reinforced samples in terms of de formation resistance. All this proves that use of agricultural waste products such as chicken composites help not only to cut down the use of unsustainable materials but also to finds new ways of using waste products in an eco-friendly manner. Further **studies** directed towards the improvement of fiber-resin ratios, compatibility as well as other applications could increase utility of chicken feather composites. Planning and development of the said strategy can play crucial role towards providing the much-needed eco-friendly materials for engineering requirements ensuring conservation of resources and minimizing waste from the poultry sector.

6. CONCLUSION

The results of the present study show that chicken feather fiber composites have encouraging tensile properties suggesting that such composites. Even a small percentage of chicken feather reinforcement (5%) can raise the tensile strength, yield strength,and elastic modulus of epoxy resin considerably. This means that the inclusion of chicken feather fibers into the structural **composite** material enhances the overall mechanical characteristics of the composite material, making it light weight and environment friendly solutions for automotive and construction industries. The versatility of the tensile structures that go from elastic when low load is applied to plastic under larger loads, is another area that this study aims to exploit to obtain materials with a favorable combination of strength and flexibility.

Moreover, it explains how the use of agricultural residues such as chicken feathers is beneficial for the environment as it not only minimizes wastes but assists in the creation of biodegradable products. The study underlines the need for advancement of fiber-resin ratios and further investigations on the fiber compatibility to improve the quality and the applications of the composite material. Future researches could widen the scope of the applications of chicken feathers **composites** and hence be more environmentally friendly in developing materials. This investigation lays a firm ground for the further study of chicken feathers fiber composites as replacement for synthetic materials as they are eco-friendly.

LIMITATION

The most important aspect of the study that can be criticized is the limited sample composition which combines only five ratios of chicken feather fiber and epoxy resin. Due to this scope, the entire range of possible mechanical properties which could be achieved using other fiber-resin ratios may not be presented. Further, the environmental aspects – temperature and humidity use, were also not included as variables which may affect the composite's tensile properties and thereby its applications in practice. One more limitation concerns the short-term, in this case, data on the aging of the composite material and durability of the material has not been collected, which is an important factor in determining if a material would stand practical applications over a period of time. The research was also conducted using a laboratory-based experiment and therefore the production method has not been shown to be applicable at the industrial scale. These limitations should be appropriately addressed in order to cover a wider range of fiber-resin ratios, environmental requirements, and the production method and its application at an industrial scale in order to improve the effectiveness of the chicken feather fiber composites.

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