International journal of science, engineering, and information technology
Volume 09, Issue 02, July 2025
Journal homepage: https://journal.trunojoyo.ac.id/ijseit

The Effect of Mesh Variations Coconut Fiber on Tensile Tests Using Polyester Resin Matrix

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A B S T R A C T

A nation's transport system is one of the many aspects that affect its economic growth. One mode of transportation that is frequently used by society at large is the train. With advancement. Because technology is developing so quickly, humans are needed to carry out new inventions. More contemporary, the innovation being created frequently is the application of composite materials made of raw natural fibres. One of the uses of coconut fiber is as a composite material used as a coating for the train carbody. This study will test composite materials on coconut fiber using a polyester resin matrix with a random fiber arrangement using the hand lay-up method and mesh variations of coconut fiber 50, 100, 150, and 200 at volume fraction 40%. In the tensile, the mesh variation had the highest tensile strength in 100 mesh variatons, with results 28.52 N/mm^2.

Keywords: Coconut Fiber, Hand Lay-up, Mesh, Polyester, Tensile Test

Article History
Received 12 November 24 Received in revised form 10 December 24 Accepted 10 Januari 2025

1. Introduction

Transportation is the one of major factors affected to country economic growth. The development of economic mega-urban in 2045 pushed government to realize multi transportation mode that connected in among region. The better transportation facilitated citizen to move in one region to others easily. The movement of people related with each other exchanged oney so the even distribution reached. High speed train development research already conducted by Japan, China, France, Italia, Maroko, South Korea, UEA. The faster train to transport made time efficiency of travelling.

It is undeniable that natural fiber is one of the basic materials as a constituent of natural fiber-based composites that have many advantages for various applications, especially non-structural materials in automotive components, residential, railways and the aerospace industry. (Dosoputranto dkk., 2021) Natural fibers also offer significant cost advantages and benefits associated with the processing in extraction and preparation as compared to synthetic fibers such as glass, nylon, carbon, etc. However, mechanical properties of natural fiber composites are much lower than those of synthetic fiber composites. (Jayabal dkk., 2011) The use of natural fibers can reduce vehicle weight by up to 40%, making it more fuel efficient.(Zulkifli dkk., 2018)

Natural fibers offer economical and environmental advantages over traditional inorganic reinforcements and fillers. As a result of these advantages, natural fiber reinforced thermoplastic composite are gaining popularity in automotive components. They are used as a replacement for glass fiber in automotive components. They are used as trim parts in dashboards, door panels, parcel shelves, seat cushions, and backrest and cabin linings. (Kumar & Kumar, 2012) On the other hand, the study of fatigue behaviour of natural fibers composites has received little attention from the scientific community. Recently, however the natural fibers reinforced composites have attracted substantial attention as a potential structural material for low cost applications. (Mulinari dkk., 2011)

Coconut fiber was used as reinforcement in the study, as it is non-toxic, inexpensive, has high lignin content, low density, easily availability, and less tool wear. Several studies have shown that fiber weight fraction has a significant effect on the mechanical properties of composites such as strength, stiffness and toughness. (Kumar dkk., t.t.) When compared to synthetic fibres and manmade fibres natural fibres become best alternative and it is cheaper and more economic and environmental friendly composite material.

Coconut fiber was known as one of main fifteen plant and animal fibers in the world. This fiber has a high concentration of lignin among vegetable fibers, up to nearly 50%, which makes it stronger. Coconut fiber is extracted from the tissues surrounding the envelope of the coconut palm, which is grown on 10 million ha of land throughout the tropics. Results from several studies confirm that coconut fiber is not very strong and stiff. However, its high strain-to-failure value can improve the toughness of composites when used as composite reinforcement. In the future, more research and investigations are needed to show that coconut fiber is a possible reinforcement in the construction field.(Bui dkk., 2020)

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E-ISSN 2548-4214

Composite materials are a combination of two or more different materials into a microscopic unit form, which is made of various combinations of properties or combinations of fibers and matrix (Nurhidayat & Irnawan, 2022). The train industry, one of which is INKA, still uses a type of polyester matrix and glass fiber (fiberglass) as raw materials that function as reinforcing fibers for composite materials. The replacement of the type of matrix as a composite material can later become a material that has a stronger strength than the type of matrix used by the INKA industry at this time.(Fathimahhayati, 2019)

Composite material properties depend on the elemental properties, geometry, and distribution of its constituents. One of the parameters is the volume fraction (weight) reinforcement or fiber volume ratio. The reinforcement distribution determines homogeneity or uniformity of the material.(Wijaya & Hidayat, 2022) Polyester resin is widely used because of its good electrical and mechanical properties as well as its low price. The use of Polyester includes in the automotive industry for body panels, home equipment, electronic devices, etc. (Bifel dkk., 2015) NaOH or alkali immersion treatment affects the surface topography of the fiber, which becomes rough and increases mechanical interlocking in natural fiber composites and polyethylene matrix.(Hastuti dkk., 2021)

2. Literature Review

Research by Eddi Dosoputranto, et al. (2021) which can be seen based on the results obtained from tensile testing machine data, the tensile strength and strain increase with increasing fiber and stick volume fractions up to a volume fraction of 50%, while at a volume fraction of 60% the tensile strength and strain decrease.

Research by Sri Hastuti, et al. (2021) using the method of research method for making fiber-reinforced composites from coconut fiber was carried out with 15% NaOH treatment for 5 hours and fiber volume fractions of 10%, 15%, and 20%. This shows that increasing the fiber volume fraction with 15% NaOH immersion will increase the mechanical properties of the composite bending and impact. NaOH immersion has an effect on the absorption capacity of coconut fiber on the Unsaturated Polyester matrix which can increase the adhesion between the fiber reinforcement and the matrix, thereby increasing the mechanical properties of the composite bending and impact.

3. Research Method

Related Work

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Fiber

The fiber in the composite material acts as the main part that holds the load, so the strength of the composite material depends on the strength of the forming fiber. The smaller the material (fiber diameter close to crystal size), the stronger the material, due to the lack of defects in the material. Alkalization of fibers is a method of immersing fibers into an alkaline base. The alkalization process removes fiber constituent components that are less effective in determining interfacial strength, namely hemicellulose, lignin or pectin. With the reduction of hemicellulose, lignin or pectin, the wetability of the fiber by the matrix will be improved, so that the strength will increase. In addition, the reduction of hemicellulose, lignin or pectin, will increase the surface roughness resulting in better mechanical interlocking.(Zulkifli dkk., 2018)

In this research, the fibers used were coconut fibers that were dried in the sun, then soaked in an alkalization process with NAOH 15% for 2 hours. Furthermore, the fibers were dried using an oven with a temperature of 60 degrees for 1 hour. When it is dry, the fiber is cut and mashed into powder and filtered using a mesh sieve.

Figure 1. Coconut Fiber

Matrix

Polyester is a thermoset resin that is liquid with a relatively low viscosity. With the addition of a catalyst, polyester hardens at room temperature. Polyester resin contains a lot of styrene monomer so the thermal deformation temperature is lower than that of other thermoset resins and the long-term heat resistance is approximately 110 - 140°C. The cold resistance of this resin is relatively good. During alkali treatment of natural fibers, some of the constituent elements of the fiber can be dissolved in the alkaline solution.

Lignin and hemicellulose as well as other substances such as wax, ash, and other impurities can be removed due to the alkali treatment of natural fibers. Lignin and hemicellulose as well as other substances such as wax, ash, and other impurities can be removed due to alkali treatment of the fiber.(Bifel dkk., 2015)

Tensile Test

Tensile testing is a type of testing destructive testing. This test is to determine the elastic modulus elastic modulus, tensile strength, tensile stress, and transition stress of a material. transition of amaterial. Tensile testing in this research uses the ASTM D638 standard.

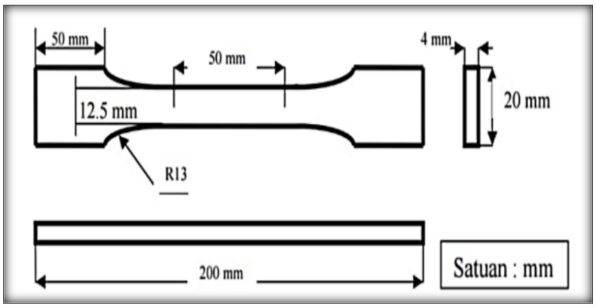

Figure 2. ASTM D638 standard

4. Result and Discussions

The tensile test results at 40% volume fractions coconut fiber composite material with polyester resin and 50, 100, 150 and 200 mesh variations show the best value taken with the tensile strength test in the graph below.

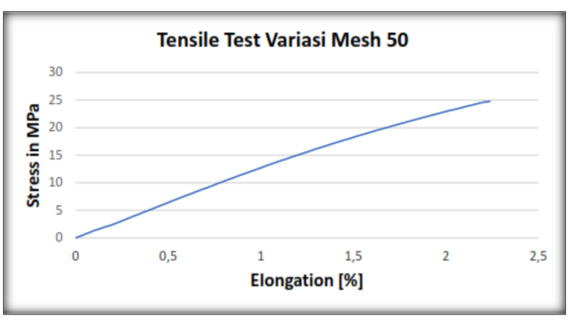

Figure 3. Tensile Test Volume in 50 Mesh Variatons

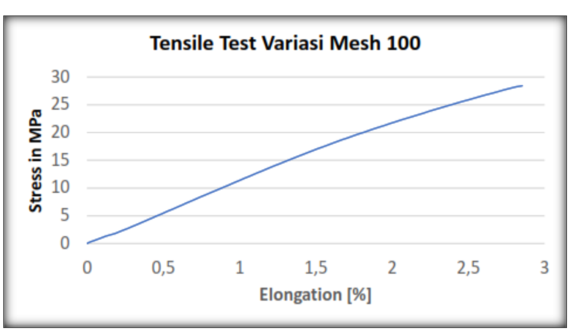

Figure 4. Tensile Test Volume in 100 Mesh Variatons

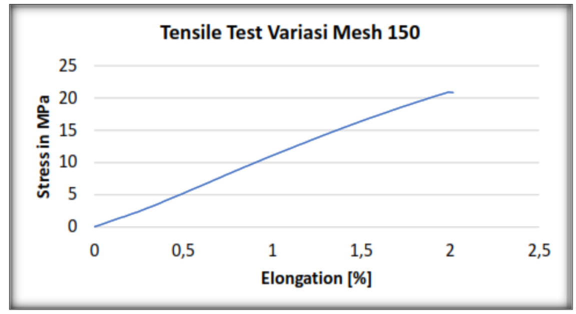

Figure 5. Tensile Test Volume in 150 Mesh Variatons

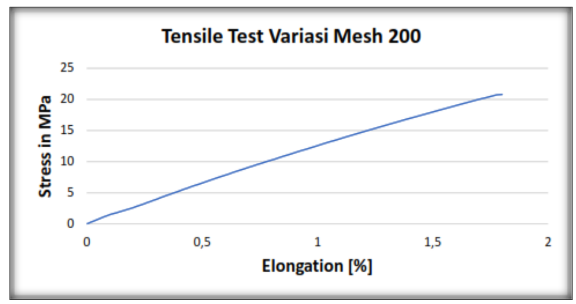

Figure 6. Tensile Test Volume in 200 Mesh Variatons

Table 1. Tensile Test result Value of Coconut Fiber Variations Mesh

No	Mesh Variations	Force (P)	Tensile Stress (σ)	Strain (ε)	Elastic Modulus (E)	A_0
		N	MPa	%	MPa	mm^2
1	50	1074.61	24.89	2.23	11.1614	43.14
2	100	1283.11	28.52	2.85	13.0228	44.99
3	150	1096.38	21.10	2.19	8.3399	43.40
4	200	833.89	20.94	1.79	11.6983	39.93

Based on Figure 3 -6, the tensile test results of mesh variations 50, 100, 150 and 200 show two parameters, namely stress and strain. In Figure 3 with mesh 50, the stress graph results slowly increase from 0 until it reaches a maximum value of 24.89 N/mm^2 and the specimen stretches slowly following the load and tensile strength, so it stretches up to 2.23%. In Figure 4 with mesh 100, the maximum stress is 28.52 N/mm^2 and stretches up to 2.85%. Specimens of the 100 mesh variation have increased compared to mesh 50.

In Figure 5 with mesh 150, it shows the maximum stress, namely 21.10 N/mm^2 and stretches slowly following the load and tensile strength, so that the specimen stretches up to 2.19%. In Figure 6 with mesh 200, the maximum stress is 20.94 N/mm^2 and stretches up to 1.79%. The strain value on mesh 200 has the lowest value compared to other mesh variations. Figure 3-6 explains that the particle sizes in various meshes have varying results with each strength value, this proves that different articles influence the strength value of the specimen.

Based on the results in table 1 of tensile tests on mesh variations of 50, 100, 150, and 200 using coconut fiber with polyester resin. The highest tensile strength value was obtained for the 100 mesh variation, namely with value tension 28.52 N/mm^2, while the lowest tensile strength value is the variation mesh 200, namely with a stress value of 20.94 N/mm^2.

5. Conclusion

Based on the tensile test results on mesh variations of 50, 100, 150, and 200 with the same treatment, namely the 40/60 fraction, the highest mesh 100 value can be obtained because the fibers in the mesh variations have more bonds between the fiber and resin. Variations in mesh with less than superior value can be caused by several factors that can influence the strength of the specimen, such as: Small fiber lengths cannot bond between other fibers, fibers are less evenly distributed in the mold, and resin settles, making the fibers and matrix less binding.

Acknowledgements

We would like to thank the Politeknik Negeri Madiun providing the opportunity for the entire research team to carry out this research.

REFERENCES

[1] Bifel, R. D. N., Maliwemu, E. U. K., Adoe, D. G. H., Adisucipto, J., & Ntt, P.-K. (2015). Pengaruh Perlakuan Alkali Serat Sabut Kelapa terhadap Kekuatan Tarik Komposit Polyester. 02(01).

[2] Bui, H., Sebaibi, N., Boutouil, M., & Levacher, D. (2020). Determination and Review of Physical and Mechanical Properties of Raw and Treated Coconut Fibers for Their Recycling in Construction Materials. Fibers, 8(6), 37. https://doi.org/10.3390/fib8060037

[3] Dosoputranto, E., Musanif, I., Bawano, F., & Sumolang, E. (2021). KARAKTERISTIK KEKUATAN TARIK DAN BENDING KOMPOSIT HYBRID SERAT DAN LIDI KELAPA. SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin, 15(2), 136. https://doi.org/10.24853/sintek.15.2.136-142

[4] Fathimahhayati, L. Di. (2019). Prosiding Seminar Nasional Teknologi.

[5] Hastuti, S., Budiono, H. S., Ivadiyanto, D. I., & Nahar, M. N. (2021). Peningkatan Sifat Mekanik Komposit Serat Alam Limbah Sabut Kelapa (Cocofiber) yang Biodegradable. Reka Buana : Jurnal Ilmiah Teknik Sipil dan Teknik Kimia, 6(1), 30–37. https://doi.org/10.33366/rekabuana.v6i1.2257

[6] Jayabal, S., Natarajan, U., & Murugan, M. (2011). Mechanical property evaluation of woven coir and woven coir–glass fiber-reinforced polyester composites. Journal of Composite Materials, 45(22), 2279–2285. https://doi.org/10.1177/0021998311401080

[7] Kumar, S., Deka, K., & Suresh, P. (t.t.). Mechanical Properties of Coconut Fiber Reinforced Epoxy Polymer Composites. 03(07).

[8] Kumar, S., & Kumar, D. B. (2012). STUDY OF MECHANICAL PROPERTIES OF COCONUT SHELL PARTICLE AND COIR FIBRE REINFORCED EPOXY COMPOSITE. Vol. No., 4.

[9] Mulinari, D. R., Baptista, C. A. R. P., Souza, J. V. C., & Voorwald, H. J. C. (2011). Mechanical Properties of Coconut Fibers Reinforced Polyester Composites. Procedia Engineering, 10, 2074–2079. https://doi.org/10.1016/j.proeng.2011.04.343

[10] Nurhidayat, A., & Irnawan, D. (2022). KAJIAN VARIASI SEBUK KELAPA KOMPOSIT TEMPURUNG KELAPA TERHADAP SIFAT MEKANIK. 03(01).

[11] Wijaya, D., & Hidayat, S. (2022). Pengaruh Fraksi Volume Serat pada Komposit Hibrid Serat Tebu dan Serat Sabut Kelapa terhadap Kekuatan Tarik.

[12] Zulkifli, Z., Hermansyah, H., & Mulyanto, S. (2018). Analisa Kekuatan Tarik dan Bentuk Patahan Komposit Serat Sabuk Kelapa Bermatriks Epoxyterhadap Variasi Fraksi Volume Serat. JTT (Jurnal Teknologi Terpadu), 6(2), 90. https://doi.org/10.32487/jtt.v6i2.459