Design of power window panel components using bamboo composite material

**Erastus Natanael**1*, Agustinus Purna Irawan1, Sofyan D.1, Linda Lin Chin Lin2
1Faculty of Engineering, Universitas Tarumanagara, Indonesia
2Kun Shan University, Taiwan

*erastus.515150010@stu.untar.ac.id

**Abstract.** Bamboo fiber has the potential to be developed as a natural composite material. This study aims to develop power window panel products on cars using bamboo fiber composite materials. The method used in this design is a simulation method using software to design a power window panel and to simulate the strength due to the load received. The strength of the bamboo fiber composite material used was obtained from secondary reference studies from journals. The results of the design and simulation of the strength of the power window panel show that the bamboo fiber composite material has good strength to be developed as a power window panel material. These results will be a reference in further development. Keywords: design, bamboo composite material, power window panel.

1. Introduction
At the end of this decade, one of the fastest growing materials in the field is composite. Composite materials are the first choice in product development because they have several advantages over conventional metal materials [1-2]. Composite is a material that is formed from a combination of two or more forming materials through mixing that is not homogeneous. Composite has better mechanical properties than metals, type rigidity (modulus Young / density) and higher specific strength than metals [3-5]. Indonesia has abundant natural resources and has a very large number of examples, namely bamboo. Bamboo is widely used in building construction as an alternative to wood and metal because of its high flexibility and strength. This research is expected to increase the use value of bamboo, so that bamboo can be used by large industries. In this study, there are 2 ways, namely by critical analysis of bamboo composites using the latest journals that received 2 tests, namely tensile test and bending test. And testing is simulated in Fusion 360 software.

2. Method
This methodology is carried out in several stages starting from the critical analysis of bamboo composites using the latest journals. After that, the measurement of the power window panel, making 3D images and simulations that have been done on Autodesk fusion 360 software with 4 variations of force are 250 N, 500 N, 750 N and 1000 N get several results, namely Von Mises, 1st Principal, 3rd Principal, Displacement, analysis of test results [6-9]

3. Result and Discussion
This test cannot be carried out in a laboratory but is carried out by critical analysis of bamboo composites and a simulation due to The following test data are test results obtained from the Autodesk Fusion 360 software with 4 load variations, namely 250 N, 500 N, 750 N and 1000 N, which have several results, namely Von Mises, 1st Principal, 3rd Principal, Displacement [10].
3.1 Tensile test composite bamboo
Tensile test is a measurement of a material to determine the mechanical properties including stress, strain, ductility, and toughness to a certain stress and increase in length experienced by the material until it breaks. The following tensile test results obtained in journal studies [11-15].

| Volume Fraction (%) | NaOH Treatment (%) | Tensile Strength (MPa) | Modulus of Elasticity (GPa) | Strain (%) |
|---------------------|--------------------|------------------------|-----------------------------|------------|
| 20                  | 4                  | 19.50                  | 4.88                        | 0.40       |
|                     | 6                  | 21.00                  | 3.81                        | 0.55       |
|                     | 8                  | 16.10                  | 2.92                        | 0.55       |

3.2 Bending test composite bamboo
After bending test with ASTM D 790-03 standard and volume fraction of 95%, 90%, 85%, and 80%, the test data can be collected as follows:

| Resin (%) | Fiber (%) | Yield Strength (MPa) | Modulus of Elasticity (GPa) |
|-----------|-----------|----------------------|----------------------------|
| 95        | 5         | 54.11                | 2.80                       |
| 90        | 10        | 68.79                | 3.26                       |
| 85        | 12        | 79.68                | 3.25                       |
| 80        | 20        | 97.71                | 4.38                       |

3.3 Design of power window panel
The power window panel used in this study belongs to a Fortuner’s car purchased from the Jakarta area. Power window panels are manually measured using calipers, with widths: 75 mm, length: 340 mm, and thickness: 12 mm

3.4 Von Mises test result
The Von Mises test aims to predict the height of the material's yield strength to the loading conditions. Based on simulation testing, the results of Von Mises are as follows Table 3.

From the simulation table data that the value of bamboo von Mises which has the highest number is 19.77 MPa, with a force of 1000 N, and the lowest value of bamboo von Mises is 6.24 MPa, with a force of 250 N. From the results of Von Mises simulation get the safety factor as follows Table 4.
Table 3. The results of Von Mises test

| Force | Result | Force | Result |
|-------|--------|-------|--------|
| 250N  |        | 750 N |        |
|       |        |       |        |
|       | [MPa] 6.245 |       | [MPa] 14.83 |
|       | 500N   | 1000N |        |
|       | [MPa] 9.886 |       | [MPa] 19.77 |

Table 4. Safety factor of power window panel

| Force (N) | Von Mises (MPa) | Safety Factor |
|-----------|-----------------|---------------|
| 250       | 6.24            | 5.1           |
| 500       | 9.88            | 3.2           |
| 750       | 14.83           | 2.2           |
| 1000      | 19.77           | 1.8           |

From the safety factor table data which has the highest number is 5.1, with a Von Mises value of 6.2 MPa, and the lowest safety factor value is 1.8, with a Von Mises value of 19.77 MPa.

3.5 1st Principal and 3rd Principal Test Results

1st principal test to predict shear stress height with maximum tensile stress. While testing the 3rd principal to predict the high shear stress with maximum stress. Based on a simulated test, the results of the 1st principal and 3rd principal are as follows.

Table 5. 1st Principal test results

| Force | 1st principal | Force | 3rd principal |
|-------|---------------|-------|---------------|
| 250N  | [MPa] -1.633, 2.674 | 750 N | [MPa] 5.37, 8.932 |
|       | [MPa] -1.633, 2.674 |       | [MPa] 5.37, 8.932 |
| 500N  | [MPa] -3.38, 5.055 | 1000 N| [MPa] 5.37, 8.932 |
Table 6. 3rd Principal test results

| Force | 1st Principal | 3rd Principal |
|-------|---------------|---------------|
| 250N  |               |               |
| 750N  |               |               |
| 500N  |               |               |
| 1000N |               |               |

From the simulation table 5 and 6 above, it can be concluded that the value of the 1st bamboo principal which has the highest number is 11.91 MPa, i.e. with a force of 1000 N, and the lowest value of the bamboo first principal is 2.67 MPa, i.e. with a 250 N force. While the value of the 3rd bamboo principal which has the highest number is 2.11 MPa, with a force of 1000N, and the lowest value of the bamboo 3rd principal is 0.461 MPa, with a force of 250 N.

3.6 Displacement test results
Displacement testing aims to find out about the shift with the dimensions that have been determined. Based on testing the Displacement results are as follows:

Table 7. Displacement test results

| Force | Result | Force | Result |
|-------|--------|-------|--------|
| 250N  |        | 750N  |        |
| 500N  |        | 1000N |        |

From the simulation Table 7 above, it can be concluded that the displacement value of bamboo which has the highest number is 0.169 MPa, with a force of 1000 N, and the lowest bamboo displacement value is 0.0446 MPa, with a force of 250 N.
4. Conclusion
Based on the results of research conducted, it can be concluded that: the tensile strength of polyester composites with bamboo reinforcement has the highest value of 21 MPa. The highest composite bending strength was obtained in composites with 80% resin volume fraction and 20% fiber that was 97.71 MPa, while the lowest bending strength values were obtained with 95% resin volume fraction and 5% fiber that was 54.11 MPa. The safety factor that has the highest number is 5.1, with a von Mises value of 6.24 MPa, and the lowest safety factor value is 1.8, with a Von Mises value of 19.77 MPa.

5. References
[1] Lukkasen D., Meidell A., 2007 Advanced Materials and Structures and Their Fabrication Process (Narvik University College, HIN).
[2] Verma, C.S., Chariar, V.M, 2012, Development of Layered Laminate Bamboo Composite and Their Mechanical Properties (New Delhi: AICTE Chanderlok Building, Janpath)
[3] Mazumdar, Sanjay K., 2002, Composites Manufacturing: Materials, Product, and Process Engineering (Florida: CRC Press LLC).
[4] Djamil Sofyan, 2018, Komposit Matriks Polimer (Jakarta: Universitas Tarumanagara).
[5] Irawan, A.P., Utama, D.W., E. Affandi, H. Suteja, 2019 IOP Conference Series: Materials Science and Engineering 508-012054
[6] H. Setyanto, R., 2012 Teknik Manufaktur Komposit Hijau dan Aplikasinya (Surakarta: Universitas Sebelas Maret)
[7] Irawan, A.P., Adianto, Sukania, I.W., 2018 IOP Conference Series: Materials Science and Engineering 420-1-012015
[8] Kosjoko, 2017 Prosiding SENSEI 2017 173
[9] Roby, Sofyan Djamil, Rosehan, 2019 Sifat Impak Dan Sifat Tekan Komposit Bambu Lamina Dengan Perlakuan Alkali Untuk Aplikasi Body Motor (Jakarta: Universitas Tarumanagara)
[10] A. C. Manalo, E. Wani, N. A. Zukarnain, W. Karunasena, K. T. Lau, 2015 Composite Part B Eng 80-73.
[11] A. Chandra, A. Asroni, 2017 Turbo 4-2-41
[12] Autodesk Support, 2017 Autodesk Knowledge Center
[13] Irawan, A.P., Sukania, I.W., Anggarina, P.T., Danendra, A.R., Baskara, G. D., 2020 IOP Conference Series: Materials Science and Engineering 852-1-012042
[14] Irawan, A.P., 2018 IOP Conference Series: Materials Science and Engineering 420-1-012060
[15] Marizar, E.S., Irawan, A.P., Beng, J.T. 2019 IOP Conference Series: Materials Science and Engineering 508-1-012104