www.ijecs.in
International Journal Of Engineering And Computer Science
Volume 10 Issue 4 April 2021, Page No. 25316-25320
ISSN: 2319-7242 DOI: 10.18535/ijecs/v10i4.4575

Experimental Investigation on Vibration Responses of Fiberglass Reinforced Plastic

Nanang Endriatno

Mechanical Engineering, Halu Oleo University-Indonesia

Abstract: The purpose of this study is to analyze the vibration displacement on fiberglass reinforced plastic beams with variations in the number of fibers in the resin matrix. Composite beams were made with fiberglass and polyester resin matrix with a number of fiberglass: 0, 24, and 48. Composite beams were manufactured by hand lay-up method with the unidirectional fiber orientation. The composite beams used have the dimension of length: 500 mm, height: 20 mm, and width: 20 mm. During the experimental test, the beam was vibrated using an exciter motor which was placed at the end of the cantilever support and then with using a vibration meter, the vibration displacement data (mm) was measured by placing the vibration transducer at positions: 50 mm, 250 mm, and 450 mm from cantilever support. During the vibration test, the vibration displacement data on the vibration meter screen were recorded using a camera recorder and the data were taken 6 times at each of the measurement points. The experimental results show that the value of vibration displacement (mm) decreases when the fiberglass was added to the composite beam, or in other words, the addition of fiberglass provided an increase in the ability of the beam to withstand vibrations. The maximum vibration displacement value on composites with 0 fiberglass: 0.641 mm, then the vibration displacement decreased in composites with 24 fiberglass: 0.506 mm and the lowest displacement value for the composites with 48 fiberglass: 0.395 mm. Whereas for 3 measurement points at positions 50 mm, 250 mm, and 450 mm along the beam for three kinds of composites, the maximum value of vibration displacement value was obtained at the end of beam composites or at 450 mm from cantilever support: 0.735 mm on composite beam with 0 fiberglass and minimum at position 50 mm near the cantilever support with the value of vibration displacement: 0.323 mm on composite beam with 48 fiberglass.

Keywords: vibration, composite, fiberglass, displacement

1. Introduction

Technological advances have driven an increase in demand for composite materials, the aircraft, automotive, sports, oil, and gas industries have used composites to build their infrastructure. The application above, the composite structure promises special advantages, such as strength, lightweight, and corrosion resistance. One of the advantages of composite materials is the ability to accept loads in certain directions, which means that the material is only strong and stiff in certain directions and weak in unwanted directions. This ability is clearly lacking in isotropic materials which have the same strength and stiffness in all directions [1].

In determining the mechanical properties of the composite structure, there are several factors that influence, including the orientation of the fibers in the composite material as reinforcement and the fiber volume fraction or the number of fibers used. The placement of the fiber with a certain direction angle in the composite matrix can function that the stress that occurs can be distributed evenly on the fiber parts so that it can provide good stiffness [2]

The use of composites in transportation or industrial equipment causes this material to experience a lot of vibrations. The amount of vibration response received by a material is determined by the property of the dynamic system which is influenced by its mass and stiffness distribution [3].

One type of composite used is a fiberglass reinforced plastic composite. Fiberglass reinforced plastic composite (FRP) is a non-metallic material that is a combination of fiberglass and thermosetting plastic. Fiberglass material is flexible strands and lightweight. In general, FRP is used as a composite material for pipes, valves, pumps, tanks, and others [4].

Several studies have examined vibration levels to detect damage to a system or engine component [5], [6], [7]. Other studies have examined the characteristics of composite materials where the structure of the material and the volume fraction of the material affect its mechanical properties [8], [9].

Meanwhile, research on cantilever beams has been investigated including the analysis of the effect of composite structures on fiber-reinforced cantilever beams on vibration characteristics [10], [11].

Several studies have analyzed the vibration characteristics of a machine or material structure to measure the level of vibration. where it was found that the material and structure affect the elastic modulus of the material. The elastic modulus and stiffness of the material will affect the vibration characteristics. Composite is a material whose elastic modulus can be adjusted, the use of fibers such as fiberglass can increase the elastic modulus. fiberglass composites are widely used in transportation so that this material often experiences vibrations. Large vibrations in transportation or other structures will certainly affect the material lifetime limit and the user comfort level. Although composite materials have several advantages for design and construction compared to other materials, a number of problems have not been resolved and have not been adequately resolved, especially in the manufacturing industry. Mainly about the ability to withstand loads due to the influence of the vibration load. Therefore, research on the vibration characteristics of a structure is needed, because many vibrations occur in the structure or machine. The structure of a material determines the stiffness of a material and determines its vibration characteristics. So the study of the structure of the material to its vibration response is very important. This study is focused on knowing the vibration response due to variations in the composite structure. This study aims to determine the vibration displacement responses due to vibrations on composite cantilever beams with variations in the amount of fiberglass in the resin matrix.

Mechanical Vibration

Repetitive movement of structures or systems about position an equilibrium usually referenced vibrations. Because these vibrations cannot be measured by sight and touch, measurements are made using a measuring instrument. One way to measure mechanical vibrations into electronic signals is to use a vibration meter. The equipment can be used to measure the level of vibration at various frequencies (Hz) and can be expressed in terms of displacement (mm), velocity (m/s), and acceleration (m/s^2). A system that vibrates in one cycle in a period (T) around the equilibrium point will experience displacement. The largest displacement is called the amplitude (A) which is determined by the mass distribution (m) and the stiffness (k) [3]. In figure 1, it can be seen a mass hanging on a spring, if the spring is pulled down, the mass will periodically move around the equilibrium point for a certain time.

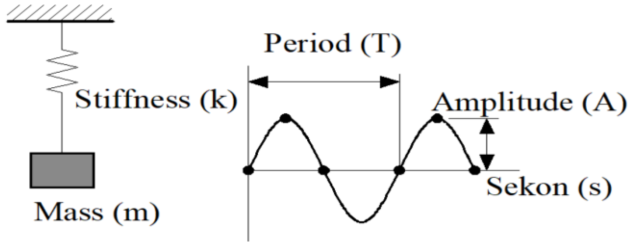


Figure 1: Spring mass system

Composites

In general, a composite material is defined as a macroscopic mixture of fibers and a matrix. Fiber functions to strengthen the matrix because generally, the fiber is much stronger than the matrix. The matrix functions to protect the fibers from environmental effects and damage due to impact. Composite material is a combination of two or more materials. Volume fraction rules can be constructed to calculate certain properties of composites if the geometric distribution can be determined. To be effective, the reinforcing material must have a modulus of elasticity greater than the modulus of elasticity of the matrix. The surface between the reinforcement and the matrix transmits shear loads so that there must be a mechanical bond between them. In order to fulfill good strength, a composite with a very high elastic modulus fiber that is easy to form is required for its intended use as a machine or construction component. The properties of the composite material were studied from the analysis based on the mechanical properties of their respective constituents. Because it is known the mixed rule to calculate the tensile stress strength and the elastic modulus of composites. For composites with continuous fibers, where the layered fiber arrangement and loading is in the direction of the fiber (iso strain condition), the greater the elastic modulus of the reinforcement is given, the elastic modulus of the composite will increase. The addition of reinforcing fibers to a certain volume will increase the elastic modulus of the composites [2].

One type of composite that is widely used in transportation or industrial equipment is Fiberglass-reinforced plastics (FRP). In FRP composites, fiberglass is available in various types, such as unidirectional fabric, bi-directional fabrics, mats, yarn, etc. FRP is widely used because it has high mechanical strength but is still light [4].

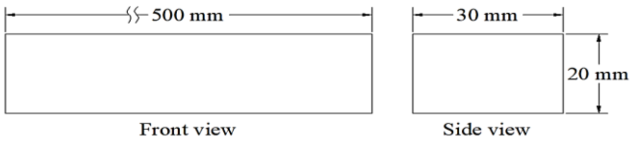
2. Research Methodology

This research was conducted at the Design and Construction Laboratory of the Halu Oleo University for vibration testing and the Materials Laboratory of the Halu Oleo University, Kendari City, South East of Sulawesi, Indonesia for the manufacture of composite materials. The main equipment used in this study consists of a vibration meter (Type KW0600332 Vibration Tester), an exciter, and cantilever support. While the materials used are composite beams made of Unsaturated Polyester Resin (Yukalac 157 BQTN-

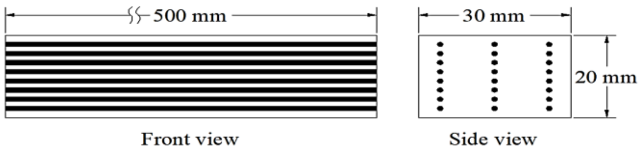
EX), hardener (Mepoxe), and fiberglass (unidirectional, Type E-glass).

From the above material then with the hand lay-up method a glass fiber reinforced composite beam was made with different amounts of fiberglass: 0, 24, and 48 in the composite. Procedure for making specimens:

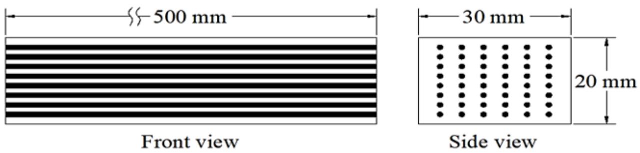
1. Composite materials such as fiberglass, epoxy resin, hardener were prepared.
2. Fiberglass was arranged in a unidirectional direction as shown in Figure 2 using the hand lay-up method
3. Composite mold was prepared according to specimen size
4. Resin, hardener, and fiberglass were mixed in the container
5. The fiberglass composites were dried, the test specimens as shown in figure 3.



(a)



(b)



(c)

Figure 2: Details of composites beam

(a) Schematic view of beam with pure resin matrix
(b) Schematic view of beam with 24 fiberglass in composites
(c) Schematic view of beam with 48 fiberglass in composites

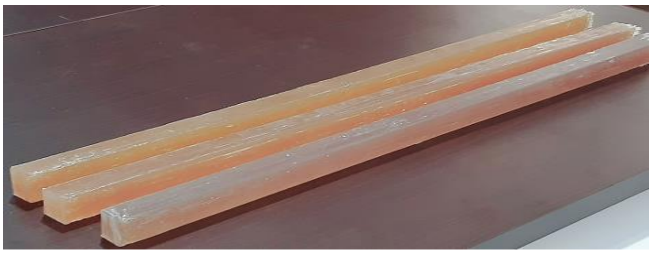


Figure 3: Test specimens of fiberglass reinforced plastic

The vibration testing installation on the composite beam is shown in Figure 4. The vibration testing procedure is:

1. A composite beam placed on cantilever support.
2. The transducer (vibration sensor) was placed in one of the positions: 50 mm, 250 mm, and 450 mm.
3. The exciter motor was installed in a position at the end of cantilever support.
4. The vibration meter, exciter motor, and camera recorder were turned on. The exciter rotates at a low frequency to avoid damage to the material, and the beam vibrated in elastic deformation
5. Vibration displacement data were recorded from the vibration sensor using a video camera.
6. Steps 1-5 were repeated for the other composite beams

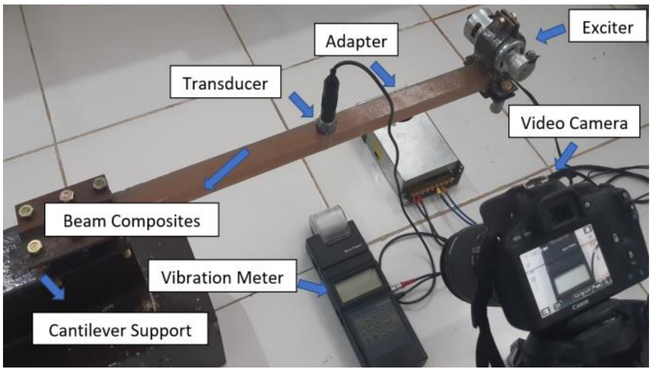


Figure 4: Vibration displacement measurement system

The experimental results of the vibration displacement test on composite beams can be seen in Tables 1, 2, and 3. The displacement measurement data for each beam were taken 6 times at each transducer position at: 50 mm, 250 mm, and 450 mm from the cantilever support.

Table 1: Summary of vibration test of composites beam with 0 amount of fiberglass

Data (Pure Resin)	*Displacement (mm)*		
	50 mm	*250 mm*	*450 mm*
1	0.541	0.650	0.730
2	0.530	0.652	0.738
3	0.530	0.657	0.740
4	0.548	0.651	0.741
5	0.521	0.652	0.731
6	0.548	0.650	0.730
Average (mm)	0.536	0.652	0.735
Average (mm)	0.641		

Table 2: Summary of vibration test of composites beam with 24 amount of fiberglass

Data (24 Fiberglass)	Displacement (mm)		
	50 mm	250 mm	450 mm
1	0.441	0.508	0.575
2	0.440	0.506	0.570
3	0.440	0.501	0.571
4	0.442	0.500	0.572
5	0.443	0.501	0.577
6	0.440	0.505	0.570
Average (mm)	0.441	0.504	0.573
Average (mm)	0.506		

Table 3: Summary of vibration test of composites beam with 48 amount of fiberglass

Data (48 Fiberglass)	Displacement (mm)		
	50 mm	250 mm	450 mm
1	0.321	0.391	0.470
2	0.319	0.390	0.475
3	0.322	0.400	0.479
4	0.330	0.390	0.470
5	0.323	0.381	0.471
6	0.320	0.390	0.470
Average (mm)	0.323	0.390	0.473
Average (mm)	0.395		

3. Results and Discussion

Figure 5 is generated from the average displacement values in tables 1, 2, and 3. This value is obtained from the results of vibration testing on composite beams at various variations in a number of fibers.

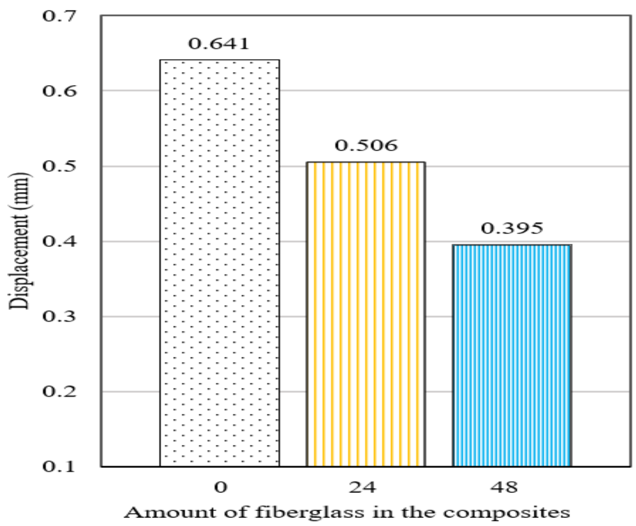


Figure 5: The average value of displacement with variations a number of fiberglass in the composite

The experimental results for vibration displacement are shown in tables 1, 2, and 3 and Figure 5. The average value of vibration displacement for each variation of the number of glass fibers for the 50 mm, 250 mm, and 450 mm positions, the minimum value received in a composite beam containing 48 fiberglass: 0.395 mm, then followed by a composite beam of 24 fiberglass: 0.506 mm and the maximum value of vibration displacement on the composite beam with 0 fiberglass: 0.641 mm. The increase in the volume of fiberglass or the number of fibers in the composite caused the displacement value to decreased, however, in beams without fiberglass (pure resin) the vibration displacement value increased. This shows that the addition of fibers in the composite makes the beam able to withstand displacement. Fiber serves to strengthen the matrix because the elastic modulus of fiberglass is higher than polyester resin. The addition of volume up to 48 fiberglass caused the stiffness of the composite to increase, according to the mixed rule, adding reinforcement (fibers) can increase the elastic modulus of the composite [12], [8]. The increase in elastic modulus has an impact on increasing the stiffness of the beam, resulting in a smaller displacement that occurs in the beam [10], [13].

Figure 6 shows the average displacement values at various distances from the cantilever support.

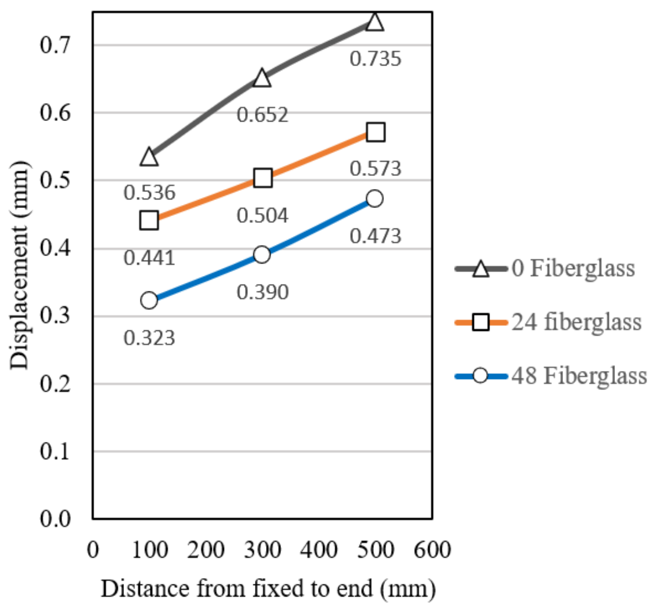


Figure 6: Average displacement at the different positions of transducer on the beams

In the vibration test, each beam was vibrated at a certain frequency then the vibration displacement was measured, then the displacement values at the 50 mm, 250 mm, and 450 mm points were compared. The difference in the measurement point from the support caused the displacement value to be different for each beam. When the beam was vibrated and the vibration displacement was measured at a point 450 mm from the cantilever support or the farthest measurement position, the value of the vibration displacement reached maximum value was compared to other points or at position 50 mm and 250 mm from the cantilever support. This was because at the measuring position of 450 mm and then the beam was vibrated under certain conditions, the beam tends to get a greater displacement than the measured position near the cantilever support [14], [15].

4. Conclusion

In this study, the vibration displacement values were analyzed on the variation in the amount of fiberglass in the composite. Based on the results of the experiment and analysis, it can be concluded as follows:

1. The difference in the amount of fiberglass in each composite beam caused the vibration displacement value in the beam tended to change. When the amount of fiberglass in the composite increased the value of the vibration displacement response was getting smaller, this indicates an increase in the ability of the beam to withstand the vibrations received.

2. The difference in the distance of the measuring point at a certain distance from the support caused the vibration displacement value on each composite beam to change. The maximum vibration displacement value occurred at the cantilever end, and the minimum was at the position near the cantilever support.

References

[1] Smallman, R. E., Bishop, R. J. (1999). Modern physical metallurgy. Boston: Elsevier Science.

[2] Van Vlack, L. H. (1985). Elements of Materials Science and Engineering. Britania Raya: Addison-Wesley Publishing Company.

[3] Taylor, J. I. (2003). The Vibration Analysis Handbook: A Practical Guide for Solving Rotating Machinery Problems. Amerika Serikat: VCI.

[4] Cheremisinoff, N. P., Cheremisinoff, P.N. (1978). Fiberglass reinforced plastics deskbook. Ann Arbor : Ann Arbor Science Publisher

[5] N. Eddy, Andriyansa, A. Halim, and R. W. Purbaya, "Analisis Getaran pada Bantalan Luncur yang Diakibatkan oleh Pengaruh Kekentalan Pelumasan," *Pros. Semin. Nas. Apl. Sains Teknol.*, no. November, pp. 111–116, 2014.

[6] J. T. Mesin, P. Manufaktur, and N. Bangka, "Manutech : Jurnal Teknologi Manufaktur Pengukuran Getaran Untuk Menentukan Tingkat Getaran Pada Sistem Transmisi Variable Speed Mesin Milling Dengan Menggunakan Getaran Overall," vol. 11, no. 02, 2019.

[7] S. Aritonang, P. H. Wulanuari, and U. Pertahanan, "Analisis kerusakan yang disebabkan oleh vibrasi pada sistem suspensi kendaraan roda empat damage analysis cau [1]sed by vibration at suspension system of four wheels vehicle," *J. Teknoogi Daya Gerak*, 2018.

[8] Endriatno, N., KAWAI, K., SUEHIRO, T., KITAYAMA, S., SAKAMOTO, J., & KINARI, T. (2019). Experimental Study on Hoop Stress Affecting Braided Carbon Fiber Reinforced Plastics Subjected to Internal Pressure. *Journal of Textile Engineering*, *65*(1), 11-17.

[9] Setiawan, A. T., Salimin, S., & Endriatno, N. Analisa Sifat Mekanik Komposit Serat Gelas Pada Lapisan Yang Berbeda. *ENTHALPY*, *4*(2).

[10] Endriatno, N., & Gunawan, Y. Kaji Eksperimental Getaran Balok Komposit Epoksi Yang Diperkuat Serat Ijuk. *Dinamika: Jurnal Ilmiah Teknik Mesin*, *4*(1).

[11] N. Endriatno, "Penentuan Frekuensi Pribadi Balok Kantilever Pada Dimensi Yang Berbeda," *Din. J. Ilm. Tek. Mesin*, 2020, doi: 10.33772/djitm.v11i2.11689.

[12] Potluri, P., Manan, A., Francke, M., & Day, R. J. (2006). Flexural and torsional behaviour of biaxial and triaxial braided composite structures. *Composite Structures*, *75*(1-4), 377-386.

[13] Whitney, S. (1999). Vibrations of cantilever beams: Deflection, frequency, and research uses. *Website: Apr*, *23*(10).

[14] Esen, I. (2011). Dynamic response of a beam due to an accelerating moving mass using moving finite element approximation. *Mathematical and Computational Applications*, *16*(1), 171-182.

[15] Endriatno, N. ., Sudia, B. ., Rinova Sisworo, R. ., & Faisal, M. . (2020). Dynamic Response at Various Points of Aluminum Cantilever Beam. *International Journal of Engineering and Computer Science*, *9*(12), 25260–25264. https://doi.org/10.18535/ijecs/v9i12.4546