Analysis of Mechanical Properties Sandwich Composite Honeycomb-Unidirectional with Matrix Vinyl Ester using VARI Method

Muhammad Farhan Ramadhan[2], Nurul Lailatul Muzayadah[1, a)], Afid Nugroho[1], Awang Rahmadi[1], Kukuh Indra Jaya[1], and Rian Suari Aritonang[1]

[1]Aeronautics Technology Center, National Institute of Aeronautics and Space (LAPAN), Bogor, Indonesia
[2]Universitas Dirgantara Marsekal Suryadarma. Jakarta, Indonesia

[a)] Corresponding email: nurul.lailatul@lapan.go.id

Abstract. The Composite are material consists of two or more materials which combine macroscopically, for now the strength of the material, it must be test with various method which is represented by the specimen. On this paper will research about material sandwich Composite with flexural three-point bending and flatwise compressive test method. In manufactured generally Composite using vary method. Usually manufacturing uses hand lay-up, vacuum bagging, VARI method and other. In this research author will be use VARI method, the reason is VARI method has a low-cost process and more efficient. In this experiment was carried out on sandwich Composite using carbon fiber unidirectional 0^0 , with aramid honeycomb core. Specimen and testing will be follow ASTM C365 standard which is flatwise testing standard, for specimen with lycal resin the results average is 56089.6 N Maximum load, 26.68 MPa Compressive of strength, 5.04 moduli of elasticity 5.04 MPa, while for specimen with Vinyl Ester resin the results average is 56089.6 MPa Maximum load, 26.68 MPa Compressive of the core strength, 5.04 MPa moduli of elasticity and Flexural three-point banding will be follow ASTM C393 standard which is Flexural testing standard. The Results of the specimen using Vinyl Ester resin is 1029.14 N maximum load, 13.78 MPa Facing stress, 861.94 moduli of elasticity.

INTRODUCTION

Construction of sandwich Composite generally consist form thin face sheet (skin) and separated by light core. Usually face sheet used for to withstand bending loads, and core for shear/Compressive loads. On core section frequently used material is balsa, foam, and honeycomb, each other have advantages and disadvantages.

Advantages of Carbon UD material is lightweight, more controlled/precise construction, and produce high ultimate strength, disadvantages of Carbon UD is not suitable for parts which is need high strength anisotropic (strength in all directions). Honeycomb core has several advantages, the material is light and low density but produces a good stiffness value, the disadvantage of honeycomb core is the frequent entry of fluid into the cell core which affects the value of material properties[1]. Core using honeycomb significantly reduces the weight of the Composite material itself compared to foam and balsa wood[2], besides honeycomb using organic materials produces other advantages, namely greater flexibility and low electrical conductivity, on the other hand, honeycomb has disadvantages for use. As a Composite sandwich core, this deficiency becomes a general challenge when making a Composite sandwich using honeycomb, which is the entry of resin into the cell core during the vacuuming process.

In general, to avoid the resin entering the cell core, researchers use many methods such as prepreg and hand lay-up, prepreg is an advanced manufacturing technique, in making this Composite it uses heat, heat is obtained with autoclave tools, the disadvantage of this method is high cost. so, it is less economical[3], then hand lay-up is a lamination process in which the fibers and resin have not been fused, and this process is done by laminating a mixture of resin and hardener on the fiber using a brush or roller, where the flatness of the resin is very dependent on how to laminate

The 8th International Seminar on Aerospace Science and Technology – ISAST 2020
AIP Conf. Proc. 2366, 040004-1–040004-12; https://doi.org/10.1063/5.0062092
Published by AIP Publishing. 978-0-7354-4123-1/$30.00

the resin to the fiber. Based on Cavatorta's research, this wet lay-up process is good if you use a unidirectional (one-way) fiber system[4], the hand lay-up process has a lower production cost (low-cost production). However, the resulting Composite material really depends on the expertise of a laminator in laminating the resin on the fiber so that the mechanical properties produced by the hand lay-up process tend to have a lower average value[5].

In previous research, as stated by S. Eksi, UD carbon has a low-density value but a high compression strength value of 1.31 g/cm^3 and 118 MPa coMPared to other reinforcement such as Woven Glass, woven aramid, woven carbon and Glass UD[6], and from other studies using honeycomb cores and Carbon UD to perform flexural and flatwise Compressive tests.

In this study we focused on using carbon fiber and honeycomb core aramid materials using the vacuum assisted resin infused method, the reason using the vacuum assisted resin infusion (VARI) method is because it has several advantages. Vacuum infusion shows the better mechanical properties because in the process it gets a compression force that can keep the time of resin spreading to cures completely. In addition, the process is also carried out in vacuum conditions so that the gases inside the mold have been removed. Indirectly, the atmospheric pressure will reduce the voids or space inside the sample. Minimized the voids or space inside the sample can improve the mechanical properties[7]. This is proven by K. Abdurrahman[8], in his research he stated that in his experiment composite shows that vacuum infusion is the most effective manufacturing process[8].

MATERIAL

The face sheet uses unidirectional carbon, the core uses HRH10/OX-4.8-48, Aramid Honeycomb core, and uses Vinyl Ester resin + Promoter (Cobalt) 1.7% + catalyst to bond the carbon fiber. The core properties can be seen in Table 1.

Vinyl Ester Panel Composite data:

- UD Carbon Fiber (4 sheets) = 85.45 gr , Vinyl Ester Resin = 699.39 gr
- Catalyst = 12.107 gr, Promotor (Kobalt) = 0.7122 gr
- Core = 72.82 gr (240x240x25 mm)
- After manufacturing process, the total resin is 59.22 %, Carbon Fiber 21.8 %, and Core 18.97%

TABLE 1. Core Properties

Property	**HRH10/OX-4.8-48**
Bare Compression , MPa	2.21
Stabilized Compression, MPa	2.41
L Shear, MPa	0.79
L Moduli, MPa	21
W Shear, MPa	0.93
W Moduli, MPa	41

EXPERIMENTAL & MANUFACTURE

The procedure used in this study can be seen on the flow chart.

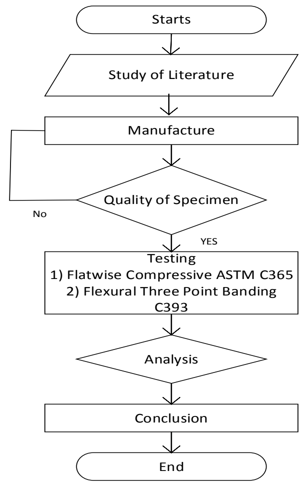


FIGURE 1. Flowchart Procedure Sandwich Composite Process

In this study, Composites were made using four layers of carbon fiber unidirectional (unidirectional) 0^0 which has a mass per unit area of 300 g/m^2, a density of 1.42 g/cm^3. The Composite panel manufacturing process can be seen in Fig. 1. Unlike the manual hand layup, in the vacuum infusion process all the fiber plies are stacked first. On top of the fiber layer, it is covered with peel plies which has been smeared with release agent then placed on top of the flow mesh as a resin flow medium then covered with a bagging film. The VARI process schematic can be seen in Fig. 2.

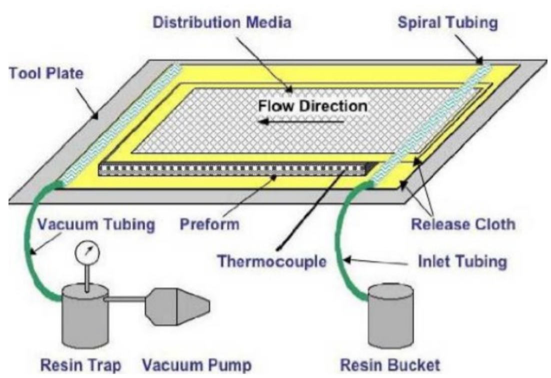


FIGURE 2. Vacuum assisted resin infusion Schematic (VARI)[15]

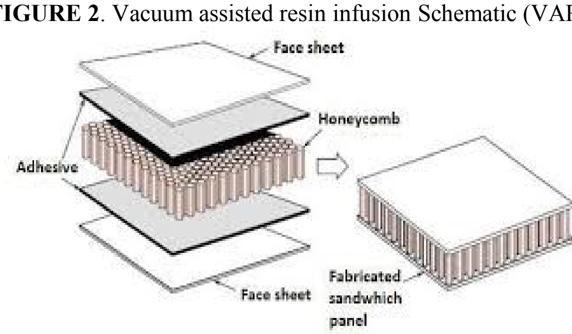


FIGURE 3. Sandwich Composite Structure[16]

After the components have been installed properly, the vacuuming process can be done. The vacuum panel can be done first with a pressure of 100 kPa to remove the air in the panel space for 15-20 minutes and make sure there are no leaks in the bagging film. Prepare Vinyl Ester resin to be put into the vacuum chamber. To tie the face sheet / carbon fiber through a tube with a length of 90 cm with a diameter of 1 cm, after the entire layer is exposed to the resin, let the resin sit for 1 day under vacuum pressure with a pressure of 100 kPa. The sandwich composite structure panel schematic can be seen in Fig. 3.

The test conditions in laboratory conditions are in a temperature of 23 ℃ and Humidity 47.2% RH, for Flexural Test testing based on ASTM[17] C393 is carried out for 9-13 minutes with a speed rate of 2 mm / min, using Vinyl Ester resin with a size of 150x25x25 mm, while for the Compressive Test testing based on ASTM[18] C365, carried out for 3-5 minutes with a speed of 2 mm / min, using lycal and Vinyl Ester resin with a size of 75x75x25 mm.

Testing Method

Flexural Strength

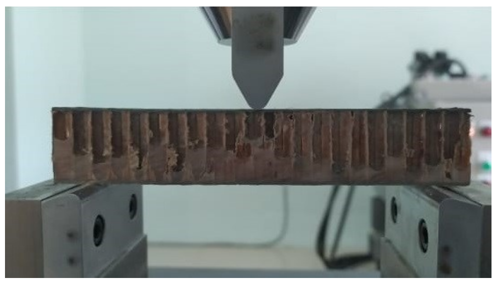


FIGURE 4. Flexural Three-point Bending Test

Based on ASTM[17] C393, the test specimen shall be rectangular in cross section. This process can be seen in Fig. 4. The depth of the specimen shall be equal to the thickness of the sandwich construction, and the width shall be not less than twice the total thickness, not less than three times the dimension of a core cell, nor greater than one half the span length. The specimen length shall be equal to the span length plus 50 mm or plus one half the sandwich thickness whichever is the greater**.**

- Thickness Core = 20 mm
- Thickness of face sheet = 1mm x 4 (plies) = 4 mm
- Total Thickness = 24 mm

So, in this experimental specimen will be used 25 mm for width of specimen, and 150 mm for length of specimen.

Flatwise Compressive Strength

FIGURE 5. Flatwise Compressive Test

TABLE 2. Maximum Facing Area

Minimum cell size (mm)	Maximum cell size (mm)	Maximum Cross-sectional Area (mm^2)
0	3	625
3	6	2500
6	9	5625

Based on ASTM[18] C365, for core which is used honeycomb core, the test specimen shall be rectangular and the required facing area of the specimen is dependent upon the cell size, to ensure a minimum number of cells are tested. This process can be seen in Fig. 5. Maximum facing areas are recommended in Tab. 2 above.

As depend by size of maximum and minimum cell core, minimum of cell core is 4 mm, maximum of cell core is 7 mm. Based on the Table specimen will use maximum cross section area is 5625 mm^2, thus length or width will be square-root of max cross-section, i.e., 75 mm.

Theoretical Analysis

Mechanical Properties calculation

Flexural Strength, single point load in Fig. 6. belows

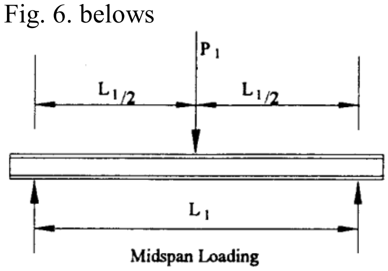


FIGURE 6. Single-Point Load[17]

Core Shear Stress (Single-Point Midspan Load)—Calculate the core shear stress as follows:

$$\tau = \frac{P}{(d+c)b} \tag{1}$$

where:

τ = core shear stress, MPa (psi); P = load, N (lb); d = sandwich thickness, mm (in.); c = core thickness, mm (in.); and b = sandwich width, mm (in.).

Obtain the ultimate shear strength using Eq. (1) where P equals the maximum load; the shear yield strength where P equals the yield load for core materials that yield more than 2 % strain using the 2 % offset method for the yield strength.

Facing Bending Stress (Midspan Load)—Calculate the facing bending stress as follows:

$$\sigma = \frac{PL}{2t(d+c)b} \tag{2}$$

where:

σ = facing bending stress, MPa (psi); t = facing thickness, mm (in.); and L = span length, mm (in.).

Sandwich Beam Deflection (Midspan Load)—Calculate the midspan deflection as follows:

$$\Delta = \frac{PL^3}{48D} + \frac{PL}{4U}\text{, total bending shear} \tag{3}$$

where:

D = total beam midspan deflection, mm (in.); G = core shear moduli, MPa (psi); E = facing moduli, MPa (psi); and D = panel bending stiffness, N-mm^2 (lb-$in.^2$).

$$D = \frac{E(d^3 - c^3)b}{12}\text{, same facings} \tag{4}$$

$$D = \frac{E_1\, t_1 E_2\, t_2 (d+c)^2 b}{4(E_1\, t_1 + E_2\, t_2)}$$, different facings (5)

$$U = \frac{G(d+c)^2 b}{4c}$$, U = panel shear rigidity, N (lb) (6)

Flexural Stiffness and Core Shear Moduli—If deflections of the same sandwich are determined under central load, P on span L1 and also under total load P applied at quarter-span L2, the flexural stiffness D and core shear moduli G may be determined from simultaneous solution of the deflection equations as follows:

$$D = \frac{P_1\, L_1{}^3 [1-(\,11 L_2{}^2/8 L_1{}^2)]}{48\Delta_1\, [1-\left(\frac{2P_1\, L_1\, \Delta_2}{P_2\, L_2\, \Delta_1}\right)]} \qquad (7)$$

$$G = \frac{P_1\;\, L_1\, c[\,8 L_1{}^2/11 L_2{}^2 - 1]}{\Delta_1\, b(d+c)^2 [\left(\frac{16 P_1\, L_1{}^3 \Delta_2}{11 P_2\, L_2{}^3 \Delta_1}\right) - 1]} \qquad (8)$$

Flatwise Compressive Strength

Ultimate Strength—Calculate the ultimate flatwise compressive strength using Eq. (1) and report the results to three significant figures.

$$F_z^{fcu} = \frac{P_{max}}{A} \qquad (9)$$

where:

F_z^{fcu}= ultimate flatwise compressive strength, MPa [psi], Pmax = ultimate force prior to failure, N [lbf], and A = cross-sectional area, mm^2[in.^{2}].

2 % Deflection Stress—If 2 % deflection is achieved prior to stopping the test, calculate the flatwise compressive stress at 2 % deflection using Eq. (2) and report the results to three significant figures.

$$\sigma_z^{fc0.02} = \frac{P_{0.02}}{A} \qquad (10)$$

where:

$\sigma_z^{fc0.02}$= ultimate flatwise compressive strength, MPa [psi], $P_{0.02}$ = applied force corresponding to $\delta_{0.02}$, N [lbf], $\delta_{0.02}$ = recorded deflection value such thatd/tis closest to 0.02, and t = measured thickness of core specimen prior to loading, mm [in.]

Compressive Moduli—Calculate the flatwise com-pressive chord moduli using Eq. (3) and report the results to three significant figures. The deflection values selected are intended to represent the lower half of the core's stress-strain curve. For core materials which fall bellow δ/t = 0.006, a deflection range of 25 to 50 % of ultimate is recommended. However, for some other materials, another range may be more appropriate. Other definitions of chord moduli may be evaluated and reported at the user's discretion. If such data are generated and reported, report also the definitions used, the deflection range used, and the results to three significant figures.

$$E_z^{fc} = ((P_{0.003} - P_{0.001}.).t/(\delta_{0.003} - \delta_{0.001}).A)) \qquad (11)$$

where:

E_z^{fc}= core flatwise compressive chord moduli, MPa [psi], $P_{0.003}$ = applied force corresponding to $\delta_{0.003}$, N [lbf], $P_{0.001}$ = applied force corresponding to $\delta_{0.001}$, N [lbf], $\delta_{0.003}$= recorded deflection value such that δ/t is closest to 0.003, and $\delta_{0.001}$= recorded deflection value such that δ/t is closest to 0.001.

DISCUSSION

Flexural Test Result

The three-point appeal Flexural testing is carried out based on C393. In previous study by Zongwen Li and Jianxun Ma[13], result for flexural shear stress[13] is 1,2 MPa. This test aims to obtain the maximum stress value and core moduli of the composite sandwich material using Vinyl Ester resin. The test results of displacement on the specimens are as follows in Fig. 7.

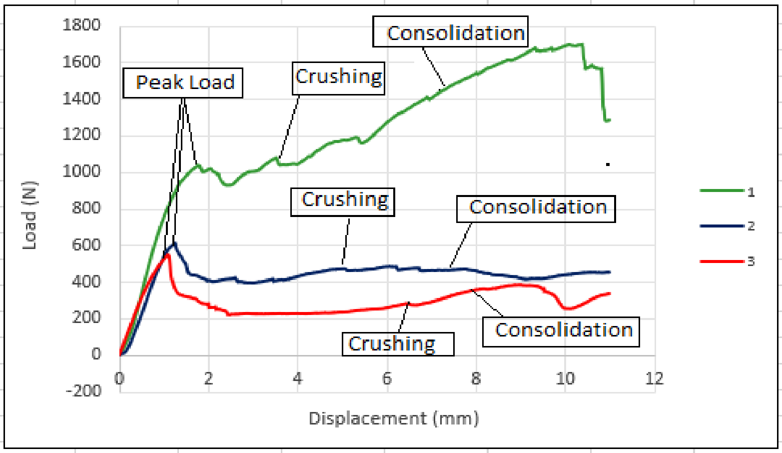


FIGURE 7. Displacement Vinyl Ester-Sandwich Composite Structure Flexural Test Results

The naming of the graph follows previous research, where the Load-displacement graph has the same trend[14], the first highest peak is peak load, then core crushing and consolidation. In Tab. 3 has shown mechanical properties Vinyl Ester-Sandwich composite structure flexural test results on load, stress and elongation moduli. The specimens before test can be seen in Fig. 10.

TABLE 3. Mechanical Properties Vinyl Ester-Sandwich Composite Structure Flexural Test Results

Test Specimen No	Max Point Load (N)	Min Point Stress (MPa)	E. Moduli (MPa)
1	1695.2	21.818	675.08
2	813.25	8.2	595.44
3	26.87	578.99	11.283
Avg	1029.14	13.78	861.94
St. Deviation	834.6211	325.6858	362.4473

After knowing the value of facing stress and core shear moduli, the Composite sandwich has experienced the first test failure which can be identified by the form of test failure based on ASTM C393 in the Fig. 8 below. The test failure is divided into 3 types of characters, namely the type of failure that occurred, the failure area and the location where the failure occurred. Failure model three-point bending can be seen in Tab. 4, and the specimens after test with failure model can be seen in Fig. 9.

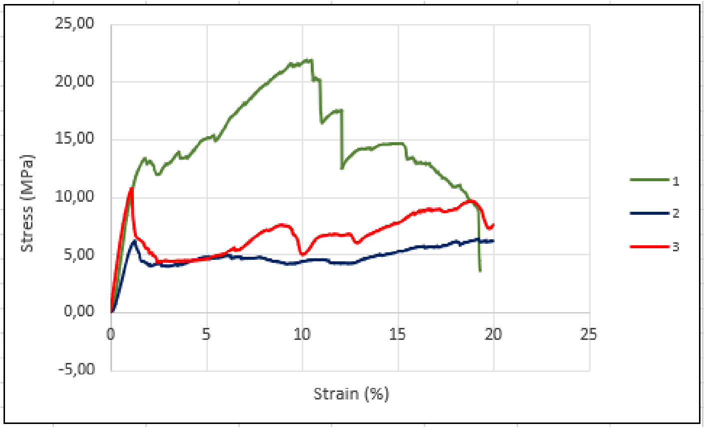
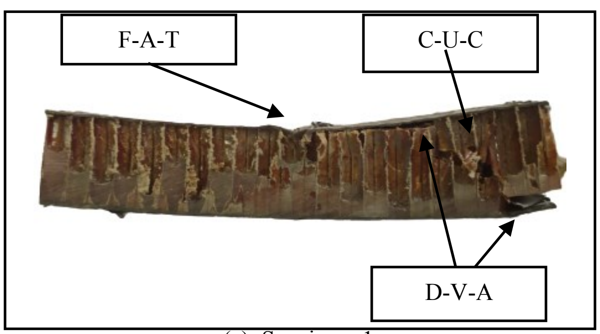


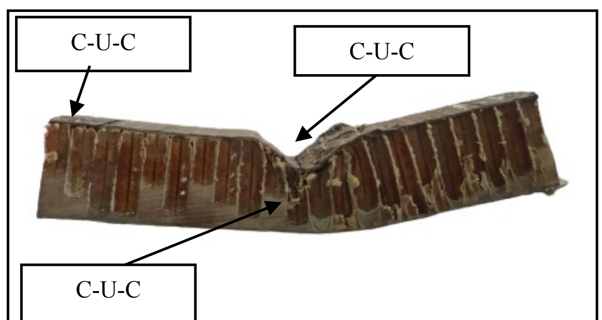
FIGURE 8. Stress and Strain Vinyl Ester-Sandwich Composite Structure Flexural Test Results

TABLE 4. Failure Model Three-point Bending

First Character		Second Character		Third Character	
Failure Type	**Code**	**Failure Area**	**Code**	**Failure Location**	**Code**
Core crushing	C	At load bar	A	Core	C
Skin to core delimination	D	Gage	G	Core-facing bond	A
Facing Failure	F	Multiple area	M	Bottom facing	B
Multi-mode	M (x,y,z)	Outside	O	Top facing	T
Transverse Shear	S	Various	V	Both facing	F
Explosive	X	Unknown	U	Various	V
Other	O			Unknown	U



(a). Specimen 1.



(b). Specimen 2.

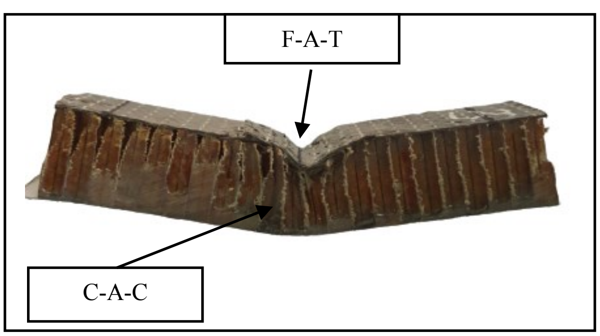


FIGURE 9. Failure Model All Specimen Three-point Bending Vinyl Ester-Sandwich Composite Structure

Failure area occurs in an area where the load on the test specimen and for the face / skin has a crack or crack in the same area in the upper skin. While the lower skin did not fail. This shows that the load that is given will first hit the upper skin which is then passed on to the core which acts to withstand the load. Because the nature of the core is weaker than the skin, the first failure occurs in the core. The load that continues to press the upper skin to the core causes the lower skin to experience a pull and tends to change from its initial shape.

FIGURE 10. Specimen Three-point Bending Vinyl Ester-Sandwich Composite Structure before Test

Flatwise Compressive Test Result

In previous studies that used the same fiber and core material but had differences in the binding resin, the results were as follows, research by Zongwen Li and Jianxun Ma[13] on flatwise compressive strength = 44. 675 MPa, elasticity moduli[13] = 1.475 MPa, while the results by K Chandrashekhara[14] on flatwise compressive strength = 50.04 MPa, moduli of elasticity[14] = 1.103 MPa.

Testing of flatwise Compressive Sandwich Composites was carried out with the aim of knowing the strength of the Composite specimen sandwich pressed with a certain load to determine the core Compressive strength (σ) and core Compressive moduli (G) according to ASTM C 365 using lycal and Vinyl Ester resins. The test results on the specimens of load-displacement are shown in Fig. 11. Mechanical properties flatwise compressive test Vinyl Ester-Sandwich composite structure are shown in Tab. 5.

Flatwise Compressive Resin Vinyl Ester

TABLE 5. Mechanical Properties Flatwise Compressive Test Vinyl Ester-Sandwich Composite Structure

Test Specimen No	Max Point Load (N)	Min Point Stress (MPa)	E. Moduli (MPa)
1	30645	14.358	0.9551
2	12249	5.8715	0.7443
3	12873	6.231	1.0429
4	19143	8.8512	2.2442
avg	18727.5	8.82	1.246625
St. Deviation	8533.182	3.91862	0.676

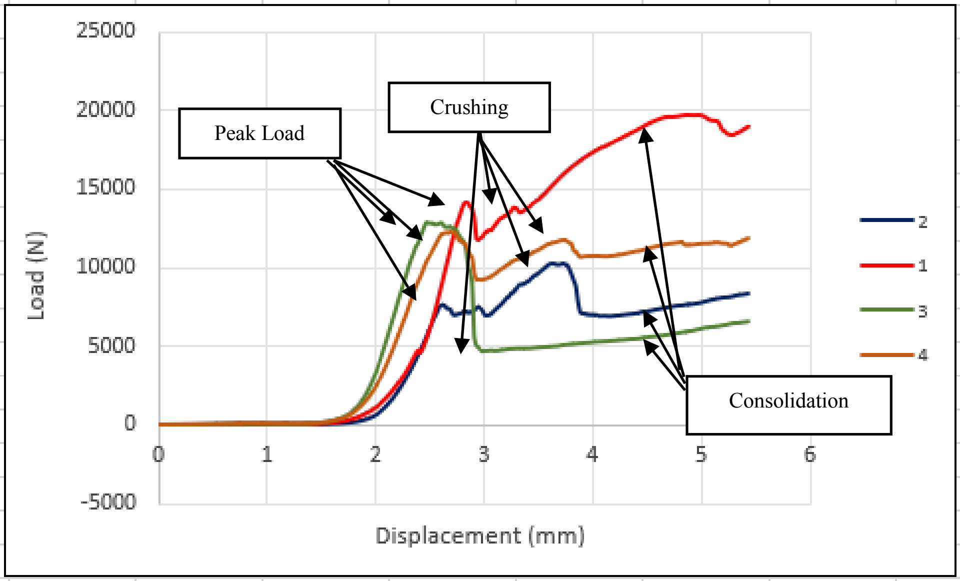


FIGURE 11. Displacement Properties Flatwise Compressive Test Vinyl Ester-Sandwich Composite Structure

The naming of the graph follows previous research, where the Load-displacement graph for flatwise compressive test has the same trend[14], the first highest peak is peak load, then core crushing and consolidation. Fig. 12 shown stress-strain chart result of flatwise compressive test vinyl ester-sandwich composite structure.

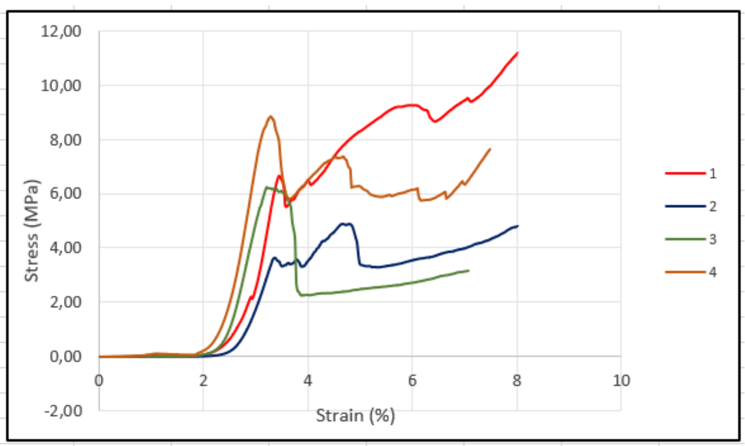
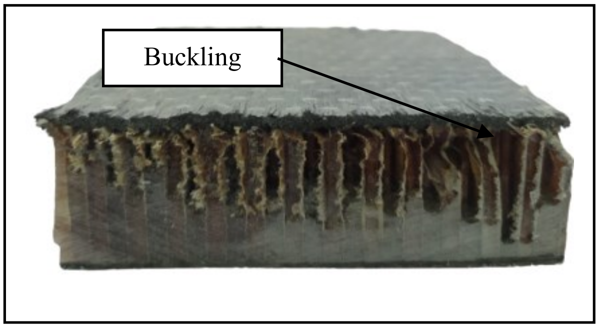


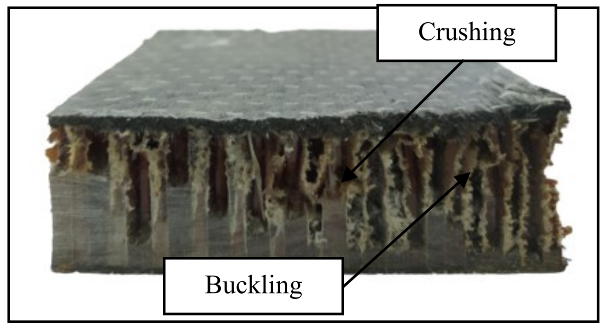
FIGURE 12. Stress-Strain Properties Flatwise Compressive Test Vinyl Ester-Sandwich Composite Structure

After knowing the value of the core strength value and core moduli, the Composite sandwich has experienced the first test failure which can be identified macroscopically in the Fig.13 (a)-(d). The form of test failure based on ASTM C365 can be categorized in Tab. 6.

TABLE 6. Failure Mode Flatwise Compressive Test Vinyl Ester-Sandwich Composite Structure

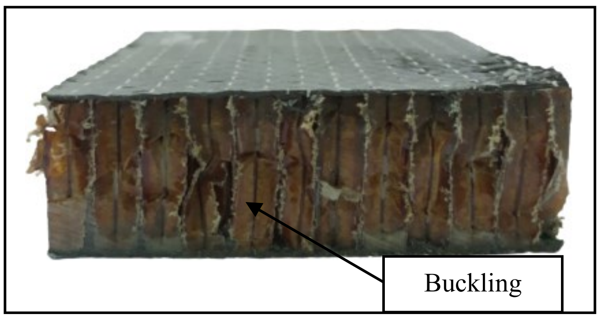
Vinyl Ester	
Spesimen	**Failure Core**
1	Buckling
2	Buckling, Crushing
3	Buckling
4	Crushing

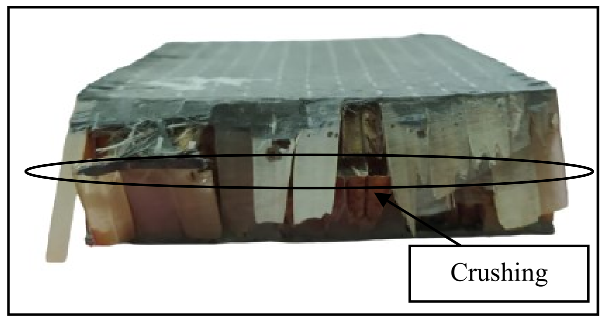




(a). Specimen 1

(b). Specimen 2





(c). Specimen 3

(d). Specimen 4

FIGURE 13. Failure Model All Specimen Flatwise Compressive Test Vinyl Ester-Sandwich Composite Structure

In lycal resin specimens 4 and 5 experienced crush cores in several parts, making the thickness change from the initial specimens, whereas in vinyl crush core resins found in specimens 2 and 4, almost all specimens using vinyl and lycal experienced buckling in the cores but there was no delimitation between cores and skins.

CONCLUSION

In each test, there is an anomaly between the specimens, this is due to the entry of resin into the core, which affects the strength value of the specimen material. This can be seen in macroscopic resin which enters the core. In the flexural test, there were constraint in some parts of the face to core bond, and for the Compressive test there was no core to skin delimitation but there was core crushing in some specimens which made a thick change from the initial specimen. The specimen and testing process follow the ASTM C365 standard which is a flatwise test standard for specimens using lycal resin the average results show a maximum load of 56089.6 N, core strength 26.68 MPa, core compression moduli 5.04 MPa, while for specimens that are Using Vinyl Ester resin, the average results showed a maximum load of 56089.6 N, core strength of 26.68 MPa, core compression moduli of 5.04 MPa and ASTM C393 which is a three-point banding test. The test results showed the value of the specimen using Vinyl Ester resin with an average maximum load of 1029.14 N, facing stress 13.78 MPa, moduli of core shear 861.94 MPa. For the purposes of structural analysis, vibration and shear properties of the material are also needed, so in the future it is necessary to carry out the vibration test and shear test on the same material to get the properties.

REFERENCES

1. G. Kim and R. Sterkenburg, "Investigating the effects aviation fluids have on the flatwise compressive strength of Nomex® honeycomb core material," *J. Sandw. Struct. Mater.*, vol. 13, no. 7, pp. 332–338, 2019, doi: 10.1177/1099636219836645.
2. Z. Chen, N. Yan, S. Sam-Brew, G. Smith, and J. Deng, "Investigation of mechanical properties of sandwich panels made of paper honeycomb core and wood composite skins by experimental testing and finite element (FE) modelling methods," *Eur. J. Wood Wood Prod.*, vol. 72, no. 3, pp. 311–319, 2014, doi: 10.1007/s00107-014-0782-z.
3. Rahman Alfarisyi (2016), Analysis of Mechanical Properties and Strengths of S-Glass Fiber Composites, page 23
4. M.P. Cavatorta (2007), A comparative Study of The Fatigue and Post-Fatigue Behavior of Carbon-Glass/Epoxy Hybrid RTM And Hand Layup Composites Springer.
5. A. Jatmiko, S. Hadi, F. T. Elektro, and U. Telkom, "A Simple Controllable Wet Lay-up Instrument and the Analysis of Lay-up Process to the Mechanical Properties of Composite," vol. 4, no. 1, pp. 803–810, 2017.
6. S. Ekşi and K. Genel, "Comparison of mechanical properties of unidirectional and woven carbon, glass and aramid fiber reinforced epoxy composites," *Acta Phys. Pol. A*, vol. 132, no. 3, pp. 879–882, 2017, doi: 10.12693/APhysPolA.132.879.
7. Mohammed Farooq And Nemkumar Banthi 2018 An Innovative FRP Fibre For Concrete Reinforcement: Production of Fibre, Micromechanics, And Durability. Construction And Building Materials 172 406–421 7
8. K. Abdurohman, T. Satrio, N. L. Muzayadah, and Teten, "A comparison process between hand lay-up, vacuum infusion and vacuum bagging method toward e-glass EW 185/lycal composites," *J. Phys. Conf. Ser.*, vol. 1130, no. 1, 2018, doi: 10.1088/1742-6596/1130/1/012018.
9. D. S. Handbook, "Sandwich concept."
10. J. Dai, H. T. Hahn (2003), Flexural behavior of sandwich beams fabricated by vacuum-assisted resin transfer molding, Composite Structures 61, 247-253
11. H.G. A l l e n (1961)., Analysis and design of structural sandwich panels, Pergamon Press, London, U.K
12. J. Arbaoui, Y. Schmitt, J. L. Pierrot, and F. X. Royer, "Effect of core thickness and intermediate layers on mechanical properties of polypropylene honeycomb multi-layer sandwich structures," *Arch. Metall. Mater.*, vol. 59, no. 1, pp. 11–16, 2014, doi: 10.2478/amm-2014-0002.
13. Z. Li and J. Ma, "Experimental study on mechanical properties of the sandwich composite structure reinforced by basalt fiber and nomex honeycomb," *Materials (Basel).*, vol. 13, no. 8, 2020, doi: 10.3390/MA13081870.
14. V. G. K. Menta, R. R. Vuppalapati, K. Chandrashekhara, D. Pfitzinger, and N. Phan, "Manufacturing and mechanical performance evaluation of resin-infused honeycomb composites," *J. Reinf. Plast. Compos.*, vol. 31, no. 6, pp. 415–423, 2012, doi: 10.1177/0731684412439792.
15. Cano, R. J.; Loos, A. C.; Jensen, B. J.; etc. SAMPE Journal 2011, 47, 50–58.
16. G. Clarke, "Lt (N) Gregory C. Clarke, BSc," no. November, 2018.
17. ASTM C393, Standard Test Method for Flexural Properties of Sandwich Construction
18. ASTM C365, Standard Test Method for Flatwise Compressive Properties of Sandwich Cores