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In-plane Shear Properties of Glass Fiber Composite Laminates

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ABSTRACT:
glass fiber composite material Shear properties are of great important formentioning the elastic constants of such orthotropic material. There are numerous methods used to measure these important properties for example ±45 tensile in-plane shear test. Cross ply glass fiber composite laminates of [0/ 90]2s are contrived using hand-layup method. ±45 tensile in-plane shear specimen is cut and contrived from the produced [0/ 90]2s shield. The test is artless and newly pertinent. The main benefit of the test is its ease of manufacturing. The results give in-plane shear modulus for glass fiber composite shields in range of 30.32GPa, while the shear strength is about 27 MPa. Types of failure of the shear sample is similar to doge bone shape.

Keywords:

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I. INTRODUCTION

Composites structure material have a lot of use which make them common replacement for many monotonic material. The mechanical properties of such material mainly be governed by on stacking sequence and on the direction of load applied to fiber respect to principal material direction [1]. Failure in many composites material is due to shear stress.Thein-plane and interlaminar shear are two type shear performance. This fiber reinforced plastic composite (FRPC) structure have lesser modulus i.e shear in comparison to the longitudinal elastic modulus. Several tests are conducted to calculate modulus and in-plane shear strength, example of such test method are as follow; ±45 tension test, 10^o off-axis tensile test, Iosipescu sheartest, double notch for shear experiment, Torsion experiment.

In-plane shear test was conducted by **Khashaba** in which the shear properties were evaluated of GFRE i.e. Glass Fibre Reinforced Epoxy Composites (V-Notch). The results were deduced and compared with other experimental deductions i.e. the solid rod torsion test and thin walled tube torsion test, Flat section is used in the V- Notch shear test by which it is easier to fabricate during aperture attainment and uniform shear stress strain condition is generated over the test region. If we compare the value of young modulus calculated by two different methods i.e. stress strain diagram using strain gauge reading of tension test and testing equipment. It is found that former value is six order of magnitude greater than the later.

Mohamed et al [23]calculated in plane shear property if glass fiber compound laminates using ±45 of axis tension test, the results are acceptable for in-plane shear modulus whereas, miss estimated the shear strength.

This study is designed tomeasure in-plane shear modulus using simple test technique with great precision. Investigating the failure modes of such specimen under tension stress.

II. EXPERIMENTAL METHOD

Material and characterization

One type of GFRP composite laminate is obtained using normally hand layup method. The details of the basic materials of the composite laminate are illustrated in Table (1). The stackingmeasures of GFRP laminate is a $[0/90]_{2s}$ composite laminate. There are some mechanical and physical properties as shown in Table (2).

Table 1: Primary elements of composite laminates (CMB intl Company)

substance	**form**
Matrix	Kemapoxy Resin (150 RGL)
Reinforcement fiber	Alkalian E-Glass 2200gm/km

Table 2: Physical properties and mechanical properties of Fibre E-glass and Resin Epoxy is as follow

Property	**E glass**	**Kemapoxy (150 RGL)**
Density(kg/m2)	2541	1.06 ±0.01 kg/L
Tensile - strength (MPa)	1999	51-101
Tensile - modulus (GPa)	75	1.3-4.6
Ratio (Passion)	0.26	0.36
shear modulus (In plane)	30.9	1.25
Strain Failure		1.8

Inplane shear test method (±45 tensile)

In plane shear property are calculated using this method of shear test, laminate is subjected to the axial tension so that shear properties are calculated. It is easier to conduct as so specific test fittings are required, also samples can be retrieved, Sample is shown below. Also this method is termed as one of the easiest methods to calculate in – plane shear modulus with maximum accuracy. Laminate may not always be in a state of pure in plane shear stress. Therefore strain and stress considered values should be used with limitation. Several test standards are based on this method e.g. ASTM D3518. There are several advantages of of tensile sample stated below

1. Good reproductibility
2. Easy to aquire.
3. It is straight tensile test.
4. Cheaper products are required.
5. Simple data decline.
6. It is very easy for high and low temperature.

The cross– ply [0/ 90]2s laminate was divided at 45^{o} to gives the ±45 in-plane shear test i.e. tensile of piling order $[45/\text{-}45]_{2s}$

Quasi Static tensile test were also performed in which the displacement were controlled at the rate of 2mm/ min, as a result of the test performed following three parameters were obtained i.e.

1. Force (F)
2. Longitudinal and Traverse Strain (ε_{xx}) and (ε_{yy})

Using the above parameter values shear stress and strain (τ_{12} and γ_{12}) can be calculated as follow

$$\tau_{12} = F \ / \ 2wt \qquad (1)$$

$$\gamma_{12} = \varepsilon_{xx} - \varepsilon_{yy}$$

The sample has thickness ‘t’ and width ‘w’ , the strains which are longitudinal and traverse are calculated using two perperndicular elements gauges of strain. Digital strain meter is also shown in the figure below which is attached to the sample by the machine grippes.

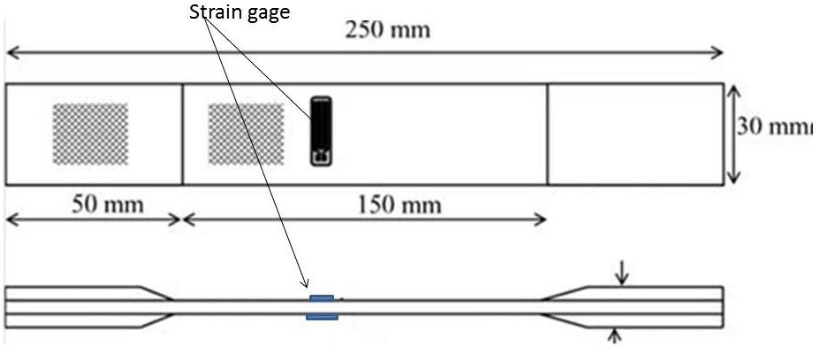

Fig. 1. ±45 Inplane shear test tensile standard specimen

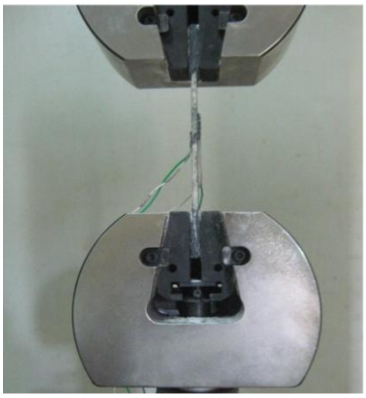

Fig. 2. Specimen of tension between the machine

III. RESULT AND DISCUSSION

Longitudinal stress-strain curve of $[45/-45]_{2s}$is shown in the fugure below of the test specimen. The purpose of the test is to obtain values for shear strength, material modulus under observation, Shear strength is arguable in relation to the load value which is used for it. The shear load which is responsible for the material failure is considered to be the first load drop. Most of the experimentalists define shear strength as the maximum value of the shear curve. Some of the experimentalists defines inplane shear strength as the maximum load values. This criteria is most suitable for the strength failure criteria. The relation between shear stress and strain in longitudinal and transverse direction is shown in the figure below , using this figure the shear stress and shear strain relations are built as shown in figure 5, Also their numeric values are calculated as follow:

$$\tau_{12} = \frac{F}{2wt}, \gamma_{12} = \varepsilon_{xx} - \varepsilon_{yy} \quad 2$$

Width of sample is represented by 'w' and thickness by 't', perpendicular-element strain gauge is used to calculated longitudinal and traverse strains. Also the slope of shear stress- strain diagram at 0.5 % is used to calculate the shear modulus as follow:

$$G_{12} = \frac{shear\ stress}{shear\ strian} = \frac{15.16}{0.5} \times 100 = 30320\ MPa = 30.32\ GPa \quad 3$$

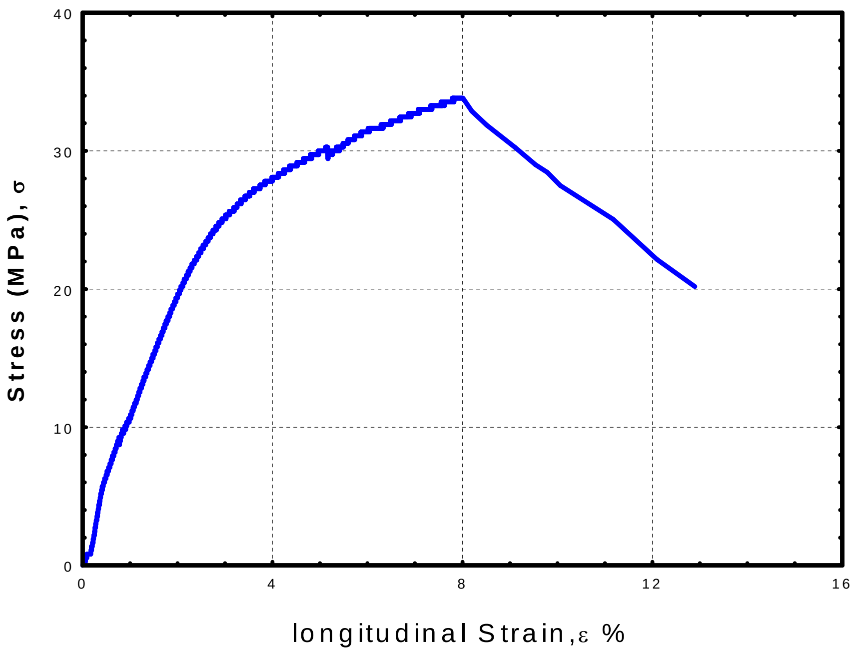

Fig. 3. Tensile stress longitudinal strain curve for [45/-45]2s specimen

At the start of the test shear strain drifts in a linear way in the beginning of the test. The dog bone like shape represent fracture mode of the sample, it is worth mentioning over here that this dog bone shape does not happen in even manner over the complete sample but it starts near one end of the sample and grows all along it.

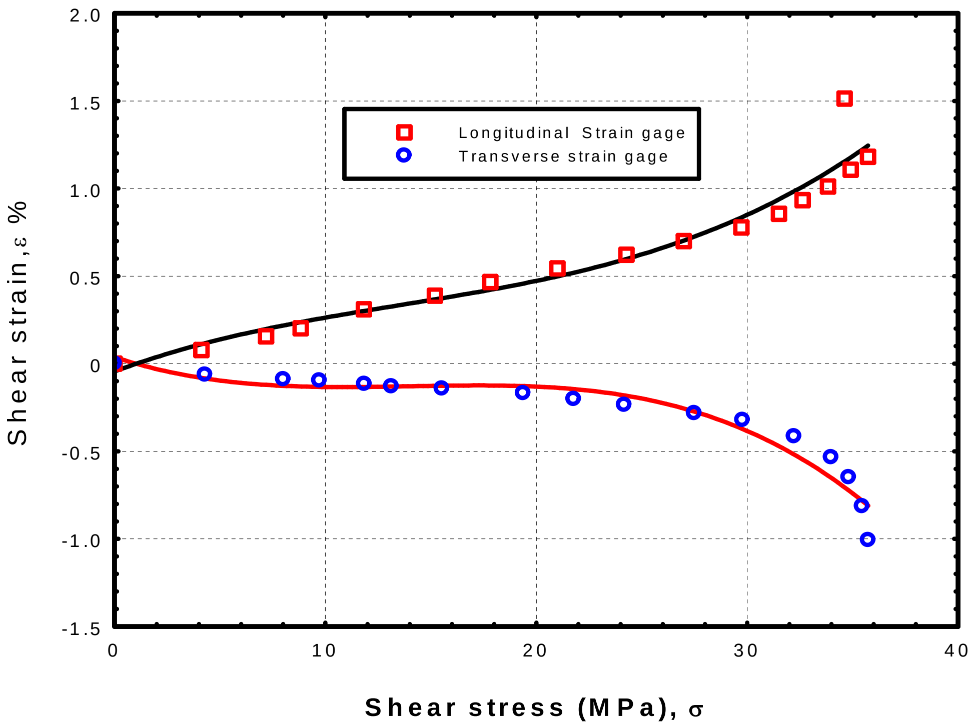

Fig. 4. Shear stress longitudinal and transvers strain curve for $[45/-45]_{2s}$ specimen

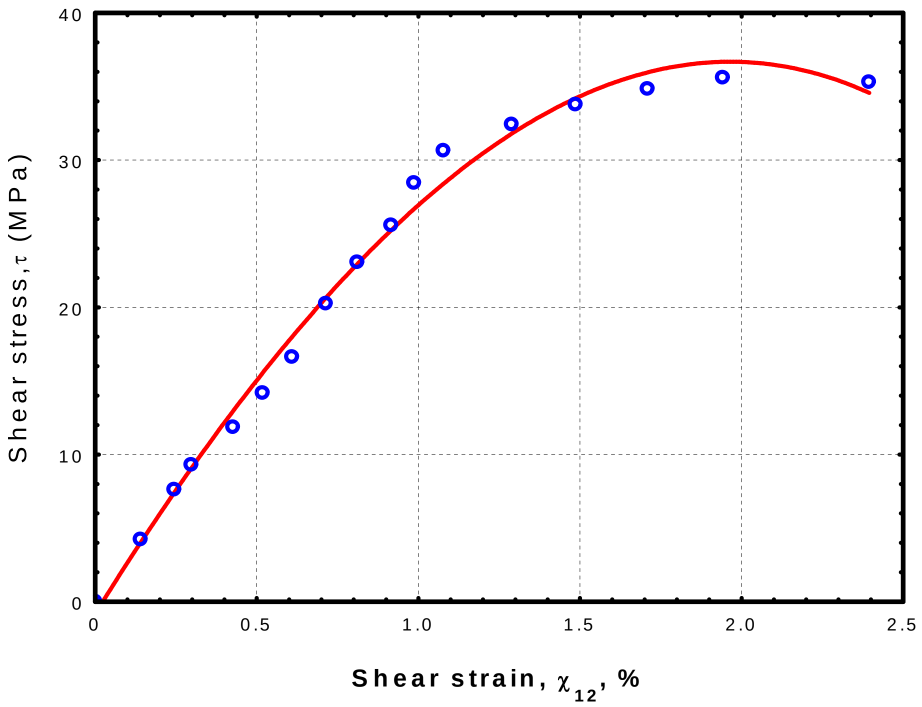

Fig. 5. Equivalent shear stress verses shear strain for $[45/-45]_{2s}$ specimen

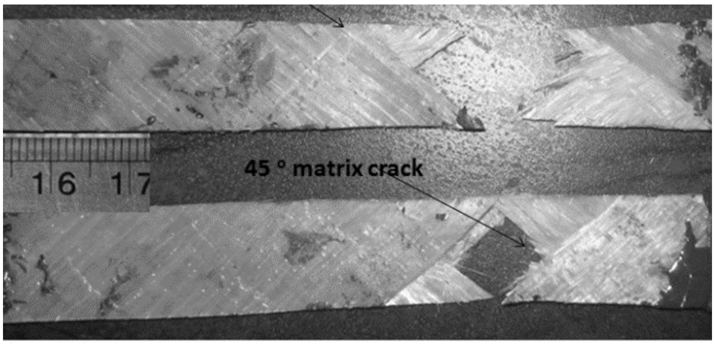

Fig. 6. Failure mode of $[45/-45]_{2s}$ Shear test

IV. CONCLUSION

It is verified that in-plane shear modulus can be calculated using simple tensile test sample. This practice is mainly based on the fiber direction in the composite laminates. A piling sequence of $[45/45]_{2s}$ can give a good results. While this test is lower estimated the shear strength. The simplicity and flexibility of the test make it acceptable for research proposed. But it is carefully acceptable in industry field as there is fault due to direction of fiber not effortlesslyachieved.

REFERENCES

[1] Jones RM. Mechanics of composite materials. Taylor & Francis, Inc.; 1999.
[2] Jalali SJ, Taheri F. A new test method for measuring the longitudinal and shear moduli of fiber reinforced composites. J Compos Mater 1999;33(23):2135–60.
[3] Mujika F, Mondragon I, Berglund LA, Varna J. 45_ flexure testfor measurement of in-plane shear modulus. J Compos Mater2002;36(20):2313–37.
[4] Gentz M, Armentrout D, Rupnowski P, Kumosa L, Sutter JK,Kumosa M. Mechanical behavior of a woven graphite/PMR-15composite at room and elevated temperatures determined from the ±45_ tensile and Iosipescu shear tests. J Compos Technol Res 2003;25(1):22–34.
[5] Pierron F. Saint-Venant effects in the Iosipescu specimen. JCompos Mater 1999;33(22):2081–115.
[6] Bhatanagar N, Ramakrishnan N, Naik NK, Komanduri R. Onthe machining of fiber reinforced plastic (FRP) compositelaminates. J Mach Tools Manufact 1995;35(5):701–16.
[7] Morton J, Ho H, Tsai MY, Farley GL. An evaluation of theIosipescu specimen for composite materials shear property measurement.J Compos Mater 1992;26:708–50.
[8] He J, Chiang MYM, Hunston DL, Han CC. Application of the Vnotchshear test for unidirectional hybrid composites. J ComposMater 2002;36(23):2653–66.
[9] Searles K, Odegard G, Kumosa M. The effect of eccentric loadson the macroscopic strain and stress distributions in woven fabriccomposite Iosipescu specimens. J Compos Mater 2002;36(5):571–88.
[10] Nozawa T, Lara-Curzio E, Katoh Y, Snead LL, Kohyama A.Specimen size effect on the in-plane shear properties of siliconcarbide/silicon carbide composites. Japan Science and TechnologyCorporation, Fusion Materials, vol. 31, 2001. p. 35–9. Availablefrom: <http://www.ms.ornl.gov/programs/fusionmatls/pdf/dec2001/02.1%20-%2035-39%20NOZAWA.pdf>.
[11] Ali RH, Kilic H. Nonlinear behavior of pultruded FRP composites.J Compos: Part B 2002;33:173–91.
[12] Zhou G, Green ER, Morrison C. In-plane and interlaminar shearproperties of carbon/epoxy laminates. J Compos SciTechnol1995;55:187–93.
[13] Naik NK, Ganesh VK. Failure behavior of plain weave fabriclaminates under in-plane shear loading. J Compos Technol Res1994;16(1):3–20.
[14] Kumosa M, Odegard G, Armentrout D, Kumosa L, Searles K,Sutter JK. Comparison of the ±45 tensile and Iosipescu shear testsfor woven fabric composite. J Compos Technol Res 2002;24(1):3–15.
[15] Mujika F, Mondragon I, Berglund LA, Varna J. 45° flexure testfor measurement of in-plane shear modulus. J Compos Mater2002;36(20):2313–37.
[16] Unal O, Bansal NP. In-plane and interlaminar shear strength of aunidirectional Hi-nicalon fiber-reinforced celsian matrix composite.Ceram Int 2002;28:527–40.
[17] Gong XL, Gong XJ, Laksimi A, Benzeggagh ML. Application ofTsai–Wu criterion to notched and unnotched composite laminatesunder torque loading. J Compos Mater 2000;34(6):2081–115.
[18] Davalos JF, Qiao P, Wang J, Salim HA, Schlussel J. Shear moduliof structural composites from torsion tests. J Compos Mater2002;36(10):1151–73.Khashaba UA. Shear behavior of unidirectional GFRP composite.In: Proc of the Sixth IntConf on Prod Eng, Design andControl, vol. 1. Alexandria University, Egypt, 1997. p. 231–41.
[19] Khashaba UA, Ali-Eldin SS. Behavior of unidirectional GFR/epoxy composites under tension-torsion biaxial loading. In: Procof the Seventh IntConf on Prod Eng, Design and Control, vol. 3.Alexandria University, Egypt, 2001, p. 1977–93.
[20] Tarnopol's YM, Kincis T. Static test methods for composites.New York: Applied Science Publications; 1986.
[21] Ambur DR, Jaunky N, Hilburger MW. Progressive failure studies of stiffened panels subjected to shear loading. ICASE, NASA Langley Research Center, Hampton, Virginia, Report No. 2002-24, 2002. p. 1–21.
[22] Khashaba UA, In-plane shear properties of cross-ply composite laminates with different off-axis angles, Composite Structures 65 (2004) 167–177.
[23] Y. Mohammed, Mohamed K. Hassan, Abu El-Ainin H, , A. M. Hashem, Fracture Properties of Glass Fiber Composite Laminates and Size Effect, Sch. J. Eng. Tech., 2013; 1(1):13-26.
[24] Mallick, P.K, Fiber reinforced composites, Marcel Dekker Press, 2nd Edition, 1993.
[25] Gibson, Ronald F. Principles of composite material mechanics. CRC Press, 2011).

[26] Walrath, D. E., and D. F. Adams. "The losipescu shear test as applied to composite materials." Experimental Mechanics.1983; 23(1):105-110.
[27] Arcan, M., Z. Hashin, and A. Voloshin. "A method to produce uniform plane -stress states with applications to fiber-reinforced materials."Experimental mechanics, 1978; 18(4):141-146.
[28] ASTM D3518. "Standard Test Method for In- Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a±45°Laminate." W. Conshohocken, PA: Am. Soc.Test. Mater., 2001

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