SHIMADZU
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Application Data Sheet

No. 30

Autograph Precision Universal Tester

Material Testing & Inspection

Evaluating the Strength of Carbon Fiber Reinforced Plastics (CFRP)

■Introduction

Various types of plastic materials have been developed that are light weight and also perform better than previous materials in terms of environmental resistance and in terms of strength. Consequently, there is a growing demand for such materials in aircraft, automotive, and many other fields.These plastic materials, such as carbon fiber reinforced plastic (CFRP), glass fiber reinforced plastic (GFRP), and aramid fiber reinforced plastic, are characterized by using fibers with advanced functionality (low weight, high strength, deformation resistance, corrosion resistance, and also heat resistance). Carbon fiber reinforced plastic (CFRP) is particularly representative of such materials and is increasingly used in sports equipment and other everyday products. Therefore, evaluating its strength, its fundamental feature, is very important.

This article presents results from testing carbon fiber reinforced plastic (CFRP) using a Shimadzu Autograph precision universal testing machine. (Test specimens and loading conditions conformed to JIS K7073-1988 Testing Method for Tensile Properties of Carbon Fiber Reinforced Plastics.)

■Measurement and Jigs

Specimens were Type-IV specified by JIS K7073-1988 (rectangular strips with no tabs). Tensile tests were conducted with an extensometer attached to measure longitudinal strain and a width sensor attached to measure lateral strain, as shown in Fig.1.

Fig. 1 Test Configuration

■Test Results

Test results indicate a tensile strength of 8.31×10^2 MPa, an elastic modulus of 5.76×10^5 MPa (determined from the slope between points at 100 MPa and 300 MPa), and a maximum tensile strain of 0.766 percent. Since these results were obtained using test specimens with fibers oriented perpendicular (lateral) to the direction of tensile load, the same test was performed with fibers oriented parallel (longitudinal) to the direction of tension. This resulted in an elastic modulus of about 13.00×10^5 MPa, which indicates a significant difference depending on the fiber orientation.

Fig.3 shows the relationship between stress and displacement in the direction perpendicular to tension, for the same test as before. A calculation of Poisson's ratio between 100 MPa and 300 MPa, as before, resulted in a value of 6.0×10^{-2}.

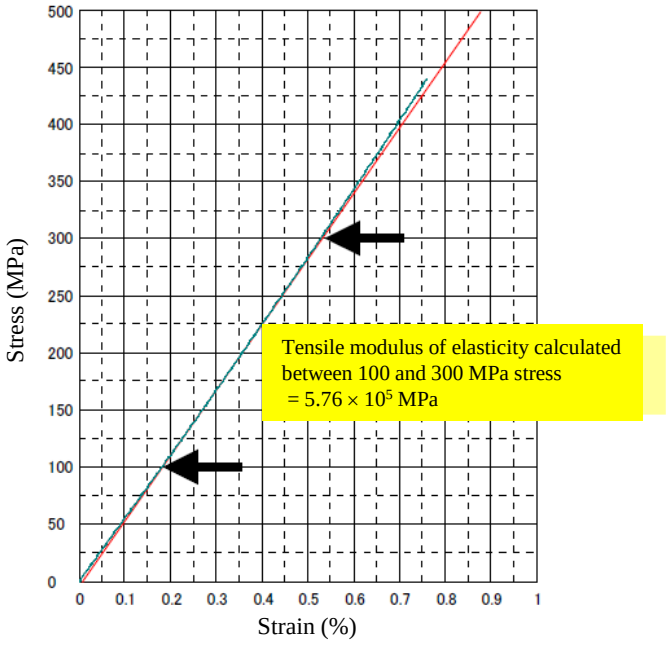

Fig.2 shows the results of testing to failure at a rate of 1 mm/min (stress vs. longitudinal strain curve).

Whereas the Poisson's ratio is about 0.3 for soft iron and about 0.46 to 0.49 for elastic rubber, the ratio for carbon fiber reinforced plastic (CFRP) is about one order of magnitude smaller, which means the deformation level of CFRP is extremely low.

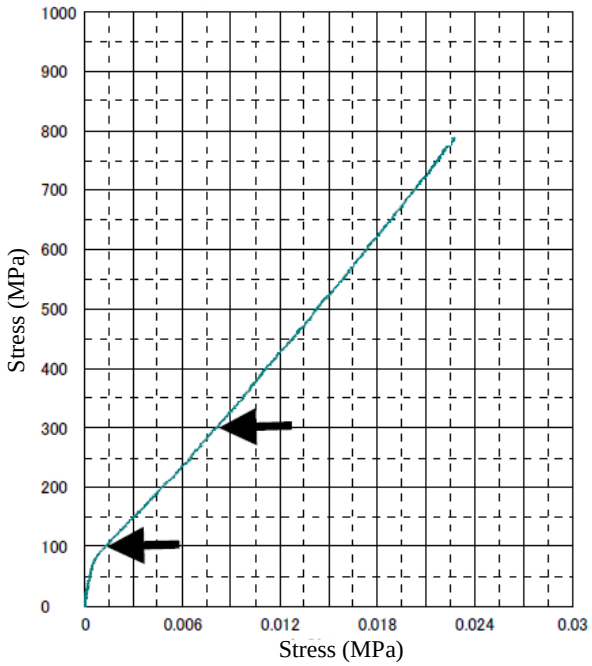

Fig. 3 Graph of Stress vs. Lateral Displacement

Poisson's ratio in left figure: 6.0×10^{-2}
(for range between 2 points, at 100 MPa and 300 MPa)

Method Used to Determine Poisson's Ratio
$\upsilon t = |\Delta\varepsilon 2/\Delta\varepsilon 1|$
υt: Poisson's ratio
$\Delta\varepsilon 1$: Strain increase in tensile direction
$\Delta\varepsilon 2$: Strain increase perpendicular to tension

■Test Conditions and Equipment Used

Tester:	AG-Xplus
Load Cell:	50 kN
Test Jig:	50 kN non-shift wedge type grips
Extensometer:	SG50-10 for measuring strain in tensile direction
	SGW-5 for measuring strain perpendicular to tensile direction
Software:	TRAPEZIUM X (Single)

AG-Xplus Floor-Type Precision Universal Tester

- A high-precision load cell is adopted. (The high-precision type is class 0.5; the standard-precision type is class 1.)
  Accuracy is guaranteed over a wide range, from 1/1000 to 1/1 of the load cell capacity. This supports highly reliable test evaluations.
- Crosshead speed range
  Tests can be performed over a wide range from 0.0005 mm/min to 1,000 mm/min.
- High-speed sampling
  Ultrafast sampling, as fast as 0.2 msec, allows assessment of sudden changes in test force, such as when brittle materials fracture.
- TRAPEZIUMX X operational software
  Designed for intuitive operation, it offers a variety of convenient and user-friendly features.
- Smart controller
  Real-time test force and position data are readily confirmed, and the manual dial enables fine adjustments to jig positioning.
- Optional Test Devices
  A variety of tests can be performed by switching between an abundance of jigs in the lineup.

First Edition: July 2015

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