AGX™-V Autograph™

Application News

Evaluation of Temperature Dependent In-Plane Compressive Properties of Carbon Fiber Reinforced Plastic

T. Murakami, T. Yamamoto*
* Testing and Analysis Division, Shimadzu Techno-Research, Inc.

User Benefits

- ◆ Provides a simple method for evaluating the compression properties of composite materials.
- ◆ Enables measurement based on ASTM D3410.

■ Introduction

Carbon fiber reinforced plastic (CFRP) has high specific strength and stiffness in comparison with conventional materials and has attracted considerable interest for weight reduction of transportation equipment, but it is difficult to design products by CAE analysis due to the anisotropy and complex structure of CFRP. To overcome this problem and improve design accuracy, an accurate understanding of various mechanical properties such as compressive properties is necessary.

This article introduces an example in which the in-plane compressive property of a thermosetting type CFRP was evaluated based on ASTM D3410 (common name: IITRI method) using a Shimadzu Autograph AGX-V precision universal testing machine (Fig. 1).

■ Test Method

The IITRI method is a representative compression test method for CFRP provided in ASTM D3410 and in JIS K 7018 as method 1b (Fig. 2). It was developed in the 1980s by the Illinois Institute of Technology Research Institute (US) and is now widely used in various industrial fields.(1) As distinctive features, a compressive load can be applied to the test specimen evaluation area with shear force by clamping the two ends of the test specimen with inverted wedge grips, and the method can be applied to comparatively large test specimens. Fig. 3 shows the geometry of the test specimen used in the test introduced here. ASTM D3410 provides a type of test specimen with attached tabs to reduce the influence of the grips and a type without the attached tabs. With both types, strain gauges are installed on the front and back sides of the test specimen evaluation area, and the strain gauge output is used to evaluate the sample properties and judge whether buckling occurs or not.

In this test, the elastic modulus and compressive strength of a quasi-isotropic laminate of a thermosetting CFRP were evaluated at -30 ˚C, room temperature, and 100 ˚C. Table 1 shows an example of the test equipment configuration and test conditions.

Fig. 1 Autograph™AGX™-V Precision Universal Testing Machine

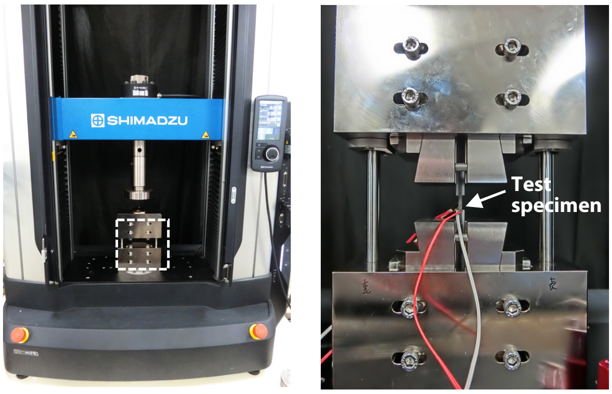

Fig. 2 Views of IITRI Compression Test

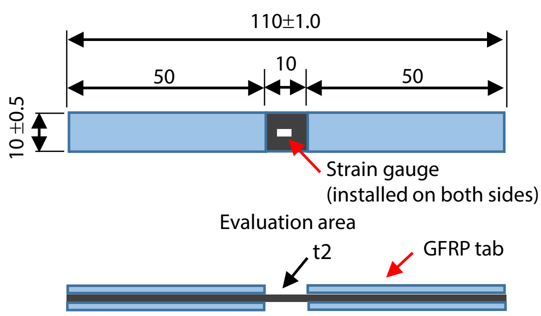

Fig. 3 Geometry of Test Specimen

Table 1 Measurement Samples

Instrument	: Autograph AGX-50kNV precision universal testing machine
Test jigs	: Compression test jig for composite materials (ASTM D3410) (special shape) Fixed type pressure plate and direct push rod (special shape)
Thermostatic chamber	: TCR-1W temperature controlled refrigerator thermostatic chamber
Test temperatures	: -30 ˚C, room temperature (R.T.), 100 ˚C
Test speed	: 1.5 mm/min
Test software	: TRAPEZIUM™X-V
Test specimen	: T700 (Toray Industries, Inc.) quasi-isotropic laminate $[-45/90/0/+45]_{1s}$ *1
Strain measurement	: KFG1-120-D16-11L1M2S strain gauge (Kyowa Electronic Instruments Co., Ltd.)
Dynamic strain amplifier	: DPM952A (Kyowa Electronic Instruments Co., Ltd.)

*1 The CFRP laminate used in this experiment was prepared by stacking prepregs with fibers oriented in one direction. The expression $[45/0/-45/90]_{1s}$ in Table 1 indicates that a total of 8 prepreg layers are stacked with fiber orientations -45, 90, 0 and +45 as one stacking sequence.

■ Compressive Properties of Thermosetting CFRP

Fig. 4 shows the relationship of stress and strain obtained from the strain gauges installed on the front and back sides of the test specimen in the test at room temperature. The red and blue line show the values measured by the strain gauges on the front side and back side, respectively. There is little divergence between the output values of these two strain gauges from the start of loading until fracture. Fig. 5 shows the condition after the test. It can be understood that a satisfactory compression test was possible, as the test specimen has fractured in the evaluation area, and there was also little divergence of the front and back gauge outputs in the stress-strain curves.

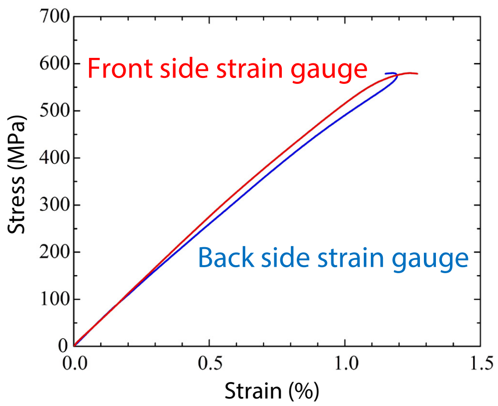

Fig. 4 Stress-Strain Curves Obtained in Room Temperature Test
(Comparison of Front and Back Strain Gauge Outputs)

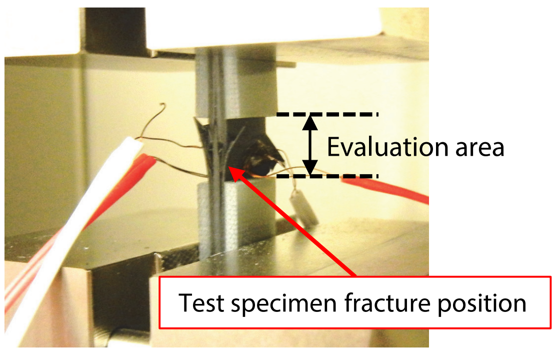

Fig. 5 Condition After Test

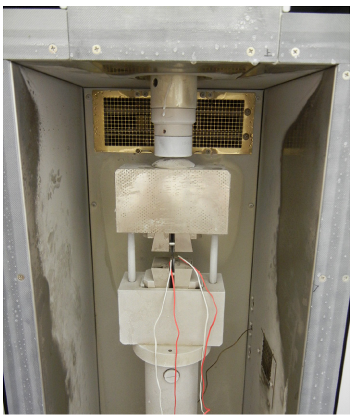

Fig. 6 View of Test (Using Thermostatic Chamber)

Fig. 6 shows a view of the test in the thermostatic chamber, and Fig. 7 shows the results of a comparison of the stress-strain curves obtained at -30 ˚C, 100 ˚C, and room temperature. Strain was calculated from the average value of the outputs of the strain gauges installed on the front and back sides of the test specimens. Table 2 shows the compressive strengths and compressive elastic moduli of the test specimens obtained at each test temperature. Although no clear differences can be seen in these property values in the stress-strain curves at -30 ˚C and room temperature, both the compressive elastic modulus and compressive strength decrease remarkably at 100 ˚C. As reference, Fig. 8 shows the condition of fracture in the evaluation area of the test specimens at each temperature.

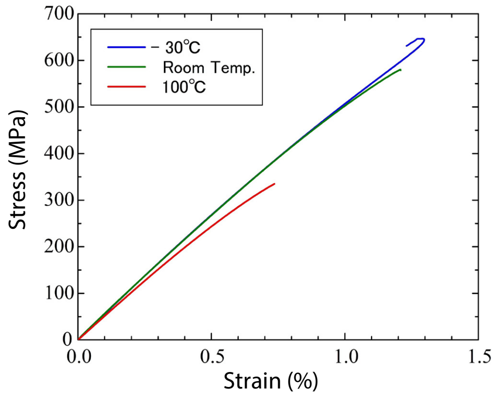

Fig. 7 Comparison of Stress-Strain Curves
(-30 ˚C, R.T., 100 ˚C)

Table 2 Compressive Property Values Obtained at Each Temperature

Compressive property	-30 ˚C	R.T	100 ˚C
Compressive strength (MPa)	646.5	580.1	279.8
Compressive elastic modulus (GPa) *2	54.4	53.6	47.3

*2 The compressive elastic modulus was calculated by the least squares method from the relationship of strain and stress when strain was 0.1 to 0.3 % calculated by the average value of the strain gauge outputs.

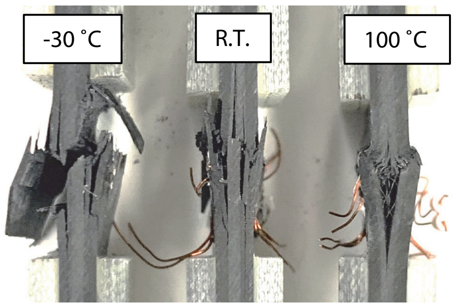

Fig. 8 Fracture Condition in Evaluation Area of Test Specimens
(-30 ˚C, R.T., 100 ˚C)

■ Conclusion

It is possible to evaluate the compressive properties of CFRP and their temperature dependence by using a Shimadzu Autograph AGX-V precision universal testing machine, compression test jig for composite materials, and optional parts.

<Reference>
(1) Toshio Ogasawara et al. JAXA Research and Development Memorandum, “Evaluation of standard compressive test methods for carbon fiber composites and proposal of a simple test method (NAL- II),” ISSN 1349-1121 JAXA-RM-08-010

SHIMADZU
Shimadzu Corporation
Analytical & Measuring Instruments Division
Global Application Development Center
www.shimadzu.com/an/

01-00108-EN First Edition: Jun. 2021

Related Products Some products may be updated to newer models.

AGX-V Series

AUTOGRAPH Precision Universal Tester

AGX-V2 Series

AUTOGRAPH Precision Universal Tester

Related Solutions

- Hydrocarbon Processing Industry (Petrochemical, Ch
- Automotive
- Clean Energy

- Price Inquiry
- Product Inquiry
- Technical Service / Support Inquiry
- Other Inquiry