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Application News

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Material Testing System

Open-Hole Compression Test of Composite Material

Introduction

Carbon fiber reinforced plastic (CFRP) has gained attention due to their strength and low weight, and have quickly been adopted for use in aeronautics and astronautics. CFRP has excellent strength characteristics in terms of specific strength and high rigidity, but lose much of their strength when a cutout is made. Consequently, composite materials used in aeroplanes must be evaluated by tests that use specimens with a hole cut out of their center. We performed open-hole compression testing of a CFRP according to ASTM D6484.

Measurement System

The CFRP specimen used was T800S/3900. As shown in Fig. 1, a hole was created in the middle of the specimen. ASTM D6484 describes test methods in both SI and Imperial units, where the dimensions of the jigs and specimens differ in each. We performed testing with Imperial units. Specimen information is shown in Table 1.
ASTM D6484 includes two loading methods, which are described as Method A and Method B. In Method A, the specimen and test fixture are clamped in a gripping device, and the specimen is compressed by shear force applied by the fixture and gripping device. In Method B, compression plate is present at the ends of the specimen and fixture, and are used to compress the specimen. Method B was used, as shown in Fig. 2. Table 2 shows a list of the equipment used and Table 3 shows the test conditions used.

Table 1 Specimen Information

Length	: 305 mm
Width	: 38.1 mm
Thickness	: 3.1 mm
Lamination Method	: $[45/0/-45/92]_{2S}$

Fig. 1 Specimen

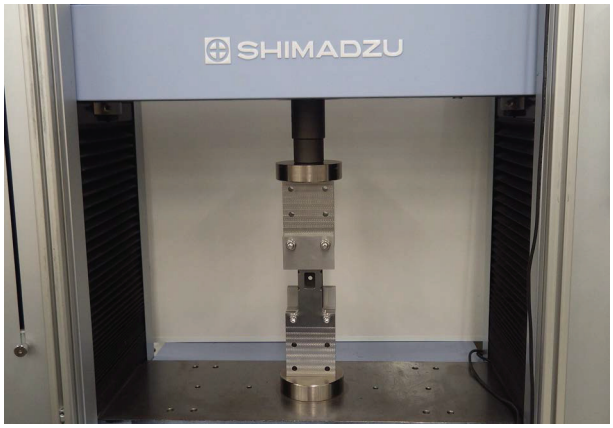

Fig. 2 Test Setup

Table 2 Experimental Equipment

Testing Machine	: AG-Xplus
Load Cell	: 50 kN
Test Fixture	: Open-Hole Compression Test Fixture

Table 3 Test Conditions

Test Speed : 2 mm/min

Results

Measurements were performed twice. Test results are shown in Table 4 and stress-displacement curves are shown in Fig. 3. As shown in Table 4, the mean open-hole compressive strength was 275.6 MPa.

Table 4 Test Results

Specimen Name	Open-Hole Compressive Strength
1st	278.2 MPa
2nd	273.0 MPa
Mean	275.6 MPa

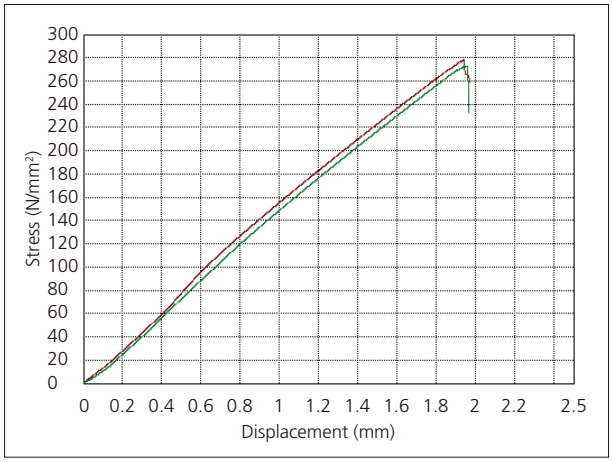

Fig. 3 Stress-Displacement Curves

Results (DIC Analysis)

Using the TRViewX non-contact extensometer allows for images and video of the specimen to be collected synchronized with test result collection. Also, applying a random pattern of paint to the observed specimen surface allows the images or video to be used to determine the strain distribution on the observed specimen surface during the test by DIC analysis[1]. Open-hole compression testing and DIC analysis were performed using the specimen described in Table 5. Fig. 4 shows a photograph of the open-hole compression test system with a non-contact extensometer. Fig. 5 shows strain distributions around the open hole in the specimen that were obtained by DIC analysis. Fig. 5 shows that strain accumulates at the vertical sides of the open hole (regions (1) and (3)), strain appears along the axis of compression from those points, and the final break occurs at the vertical sides of the hole. Meanwhile, almost no strain appears in the central part of the hole (region (2)) throughout the test. This strain distribution probably occurred due to a 0° fiber orientation on the surface of the specimen.

Table 5 Specimen Information (DIC)

Length	: 305 mm
Width	: 38 mm
Thickness	: 1.6 mm
Lamination Method	: $[0/90]_{2S}$

1) DIC analysis is an analysis method that measures strain and shows the strain distribution in a specimen based on movement of a random pattern of paint applied to the observed specimen surface before and during testing.

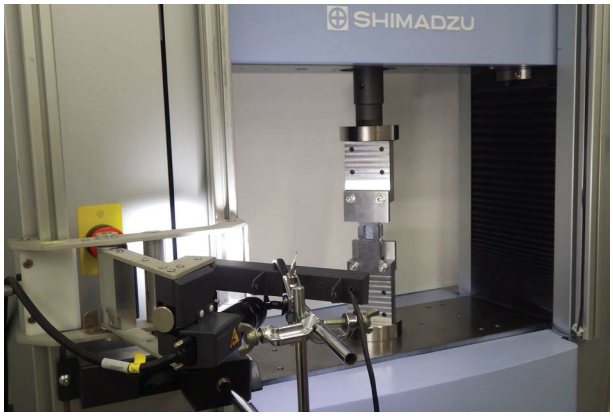

Fig. 4 Experimental Setup (DIC)

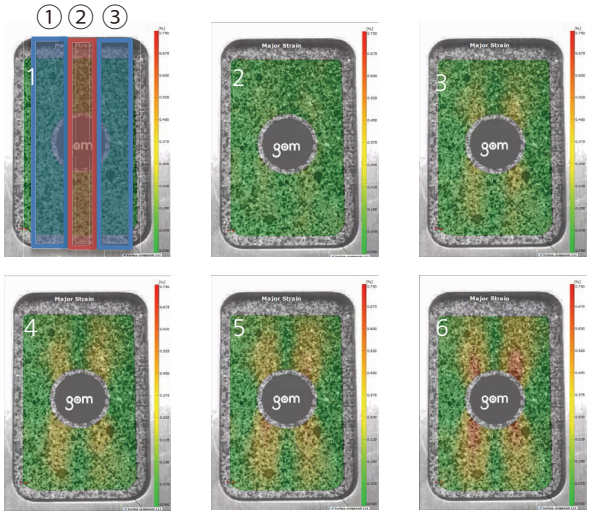

Fig. 5 DIC Analysis Results

Conclusion

Using this test system, open-hole compression testing of a CFRP was successfully performed according to ASTM D6484. Using a non-contact extensometer, we were also able to capture video (images) synchronized with the test force and crosshead displacement data obtained from the testing machine. Performing DIC analysis based on this video allowed an evaluation of the strain distribution on the observed specimen surface. This testing system will be extremely useful for the development of CFRPs and products that use CFRPs.

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