APPLICABILITY OF COMPRESSION BENDING TEST TO MEASURE COMPRESSIVE FAILURE STRAIN

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1 Introduction

Carbon fiber reinforced plastics (CFRPs) are widely used because of their high strength- and modulus-to-density ratios. However, the CFRPs have, at the same time, several shortcomings such as low interlaminar shearing strength and relatively low compressive strength. Thus it becomes necessary to measure precisely the compressive strength as well as compressive failure strain. Although some standards such as JIS[1] prescribes the compression test method, it is not necessarily appropriate to get reliable compressive strength and failure strain.

In the past, one of the authors proposed a so-called compression bending test method to evaluate the bending strength of high performance CFRPs[2,3]. This method can be applied to measure the compressive failure strain[4,5].

The subject of the present paper is to demonstrate the applicability of the compression bending test to evaluate the compressive properties of CFRPs with several kinds of stacking sequences. Conventional compression tests[1] were also conducted as a reference.

2 Principle and Test Methods

2.1 Principle of Compression Bending

Because the principle of compression bending was reported elsewhere, for example in Ref.[3], only a brief idea is shown here.

Figure 1 shows the schematic view of the half length of the compression bending which is based on the Euler buckling. The bending moment at the midspan A is

$$M_A = P\delta_A \quad (1)$$

where P is the applied load and δ_A is the midspan deflection.

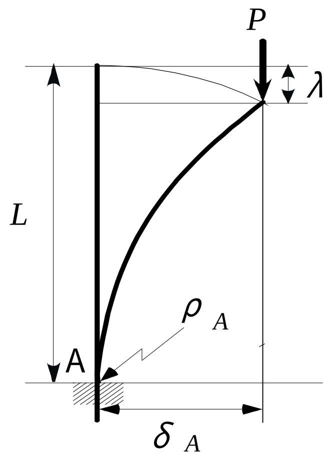

Fig.1. Schematic view of compression bending

Knowing the bending moment, we can calculate the bending stress and hence, the bending strength. The bending modulus can also be calculated if we know the radius of curvature at point A, ρ_A. We have also derived that the midspan deflection, δ_A, and the radius of curvature, ρ_A, are functions of the crosshead movement, λ, which shows that if we measure only the applied load and the amount of crosshead movement during the compression bending test, we can derive necessary mechanical properties such as bending strength and modulus. This is the essence of the compression bending.

Although the compressive strength cannot be measured by the above method, we can measure the skin strain at failure. If a unidirectional ply is stacked on the skin, the compressive failure strain of the unidirectional composite can be measured. The present paper is based on this idea.

2.2 Specimens and Test Methods

Several kinds of laminated plates, shown in Table 1, were fabricated using Toray T700S/Epoxy prepregs by hot press method with picture frame.

Table.1 Stacking sequence of each laminated plates

Specimen	Stacking sequence	Specimen	Stacking sequence
TA1	$[0]_8$	TA2	$[0]_{16}$
TB1	$[(0)_2/(90)_2]_s$	TB2	$[(0)_4/(90)_4]_s$
TC1	$[(0)_2/\pm 45]_s$	TC2	$[(0)_4/(\pm 45)_2]_s$

The thickness of 8-ply panes was about 1mm and that of 16-ply laminates was 2mm. From these plates, test specimens were cut out. The specimen size for the compression bending is 120mm in length and 10mm in width and that for the compression test is 110mm length and 6mm width.

The compression bending test was conducted using a pair of simplified grips[3]. At the center of the specimen, strain gages were glued on both surfaces and the midspan deflection was measured with a displacement transducer.

The compression test was carried out in accordance with the B-method of JIS K 7076. The gage length was 8mm and strain gages were used to measure the failure strain.

3 Results and Discussion

Figure 2 demonstrates applied load, midspan deflection in terms of δ / L, strains on both surfaces (ε_c and ε_t) vs. crosshead movement (λ / L) during the compression bending process in the case of Type TB2. The applied load increased until buckling and it decreased gradually. The strains of both surfaces decreased first with almost the same amount and after buckling, they separated toward tension and compression. These results are all reasonable and the strain at the point F is the compressive failure strain on the surface, 0-degree fiber orientation. All specimen failed from the compressive surface.

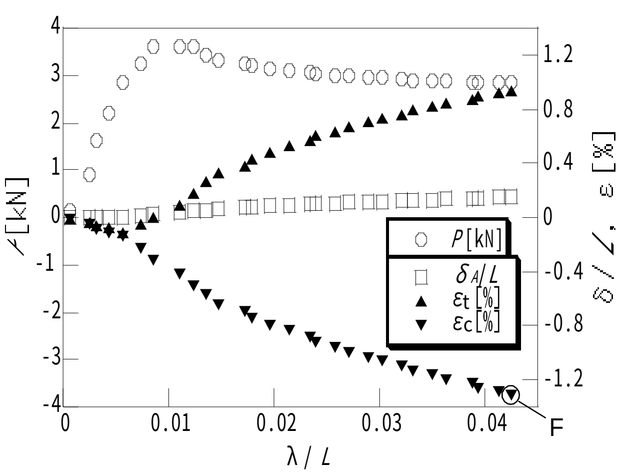

Fig.2. Example of test results (TB2)

Figure 3 summarizes the failure strains of total 6 types of specimens where the circles are failure strains measured by the compression test and the triangles are those by means of the compression bending test. The failure strains obtained by the compression bending test were always larger than the conventional compression test. At present, there still remains fairly large discrepancy between the two. One reason might be our inferior skill for the compression test. More reliable data reduction is left for future work.

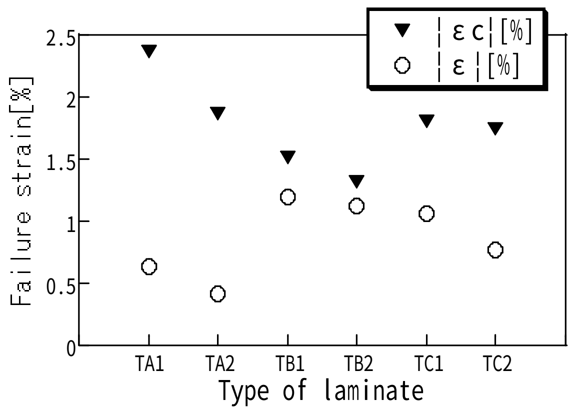

Fig.3. Failure strain of each laminate

References

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