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# Application News

No. i269

Precision Universal Testing Machine

# Axial Compression Test of Hat-Shaped Specimens

In the automotive industry, improvement of automobile fuel economy as a countermeasure for global warming has become a critical issue in recent years. Although various measures such as reducing the air resistance of the auto body and reducing the rolling resistance of the tires are conceivable, one of the most effective measures is reduction of auto body weight. Reducing the thickness of members can be considered as an approach for reducing auto body weight, but on the other hand, safety requirements must also be satisfied. High-strength materials are being developed from this viewpoint. As examples, CFRP (carbon fiber reinforced plastic) and high tensile strength steel may be mentioned.

CFRP is a resin material which is reinforced with carbon fiber, and has particularly high specific strength and specific rigidity, even among composite materials. CFRP in which thermosetting resin is used as the matrix resin is already used in racecars and luxury vehicles, and in recent years, CFRTP (carbon fiber reinforced thermoplastic composite) has also been developed by using a high formability thermoplastic resin as the matrix resin. On the other hand, high tensile strength steel is a class of materials with higher strength than general structural steel, and materials with strength of 1,000 MPa or more have also been developed.

In this research, hat-shaped specimens of CFRTP and high tensile strength steel were prepared as hollow frames, which are used in large numbers in automobile bodies, and were subjected to an axial compression test. In addition to measuring the compressive strength of the respective materials, video recording synchronized to the test results was also performed in order to identify the fracture point.

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## Measurement System

A Shimadzu AGX™-V Series precision universal testing machine was used in these tests. Because analog input equivalent to 20 channels is possible with the AGX-V Series, the hat-shaped specimens were divided into 10 sections in the height direction, a total of 20 strain gauges were attached to the front and back sides, and their signals were captured. Video recording was also performed using a USB camera, and the results were compared with the output from the strain gauges. Table 1 shows the specification of the test system used here. Fig. 1 shows the condition of the test, and Fig. 2 shows a test specimen after the strain gauges were attached.

**Table 1 Specification of Test System**

| | | |
|---|---|---|
| Instrument | : | AGX-300 kNV |
| Test jig | : | Fixed compression plate |
| Software | : | TRAPEZIUM X-V |
| USB camera | : | LifeCam Studio® |
| Dynamic strain gauge | : | DPM-952A |

## Measurement Results

The compression tests were conducted with the test speed set to 20 mm/min. Table 2 shows the test conditions. Fig. 3 shows the test force-displacement curves. The maximum test force of the hat-shaped specimens was 58.3 kN for the CFRTP and 132.6 kN for the high tensile strength steel. The earliest damage of the CFRTP occurred at approximately 50 kN, and after that point, the test force trended at around 40 kN in spite of increases and decreases. On the other hand, with the high tensile strength steel, the test force decreased greatly after achieving the maximum test force. However, as in the case of the CFRTP, the behavior of the test force after this point trended at around 40 kN with some variations.

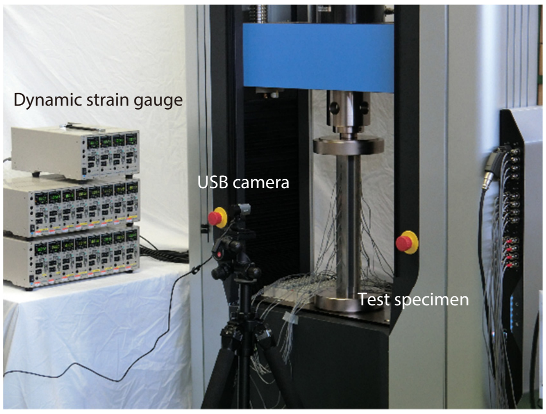


**Fig. 1 Condition of Test (High Tensile Strength Steel)**

**Fig. 2 Test Specimen after Attaching Strain Gauges (High Tensile Strength Steel)**

**Table 2 Test Conditions**

| | | |
|---|---|---|
| Test speed | : | 20 mm/min |
| Specimen height | : | 400 mm |
| Specimen materials | : | CFRTP, high tensile strength steel |
| Number of tests | : | n = 1 |

Fig. 4 shows the measurement results of the strain gauges attached to the front side of the CFRTP hat-shaped specimen. In the figure, the symbols in the legend indicate the strain gauge attachment positions. The strain gauges were attached at equal intervals from the top of the hat-shaped specimen, in order from the smallest number. Because the CFRTP used in this test is a material in which tape materials are arranged randomly, local variations in the measurement results were considered possible. However, it can be understood that strain was concentrated in the upper side, for example, at Front 1 (Strain) and Front 3 (Strain) in Fig. 4. Fig. 5 shows the image capture points in the test force-displacement diagram of the CFRTP hat-shaped specimen, and Fig. 6 shows the test images corresponding to Fig. 5. From images (1) to (3) in Fig. 6, damage was not particularly evident in the images, but there were also strain concentrations in the upper side, and in image (4), damage can be observed directly under the upper compression plate. After that point, destruction proceeded in the form of spreading under pressure from the part in contact with the compression plate, but buckling did not occur.

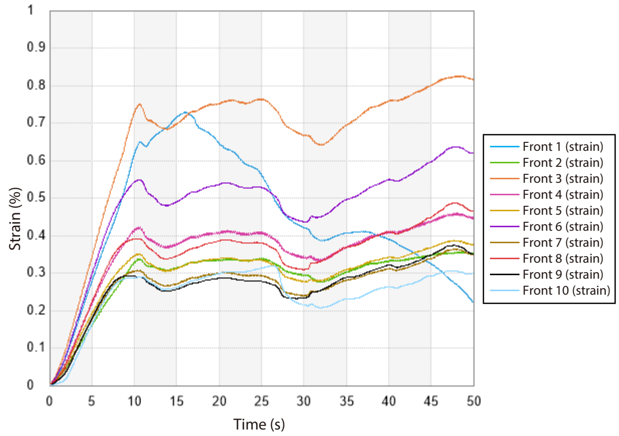


**Fig. 4 Measurement Results of Strain Gauges on Front Side of CFRTP Hat-Shaped Specimen**

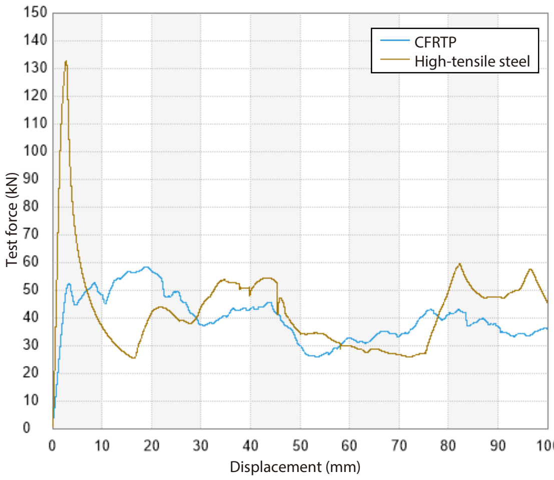


**Fig. 3 Test Force-Displacement Curves**

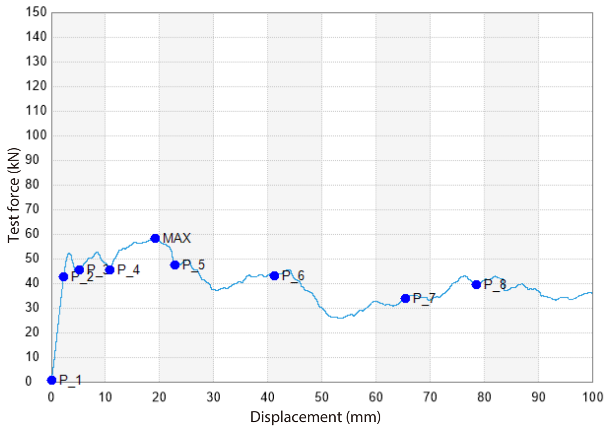


**Fig. 5 Image Capture Points on Test Force-Displacement Curve of CFRTP Hat-Shaped Specimen**

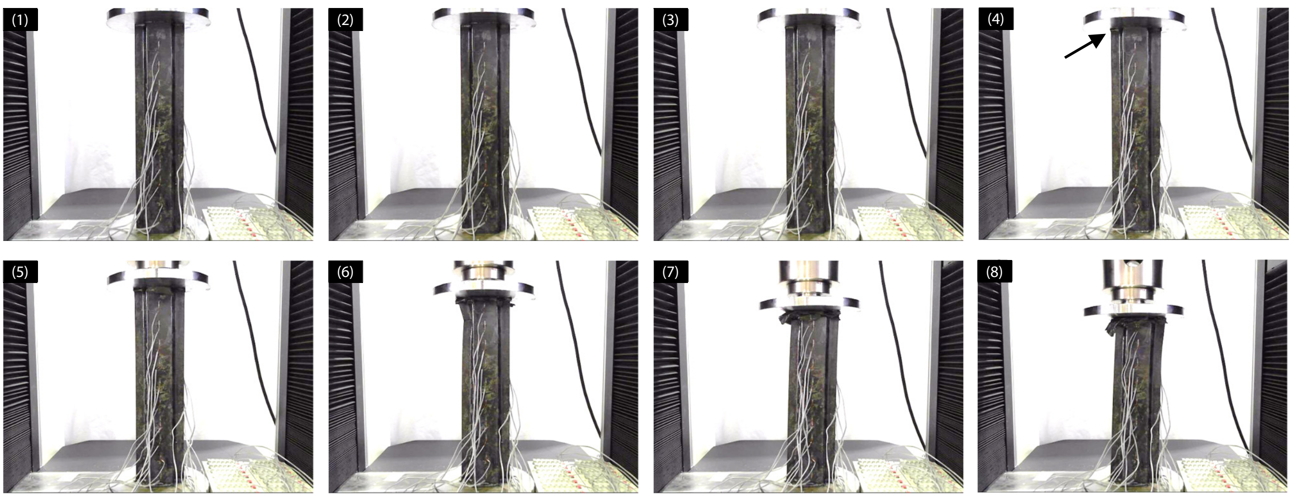


**Fig. 6 Condition of Test of CFRTP Hat-Shaped Specimen**

Fig. 7 shows the measurement result of the strain gauges attached to the front side of the high tensile strength steel hat-shaped specimen. The numbering of the strain gauges is the same as that of the CFRTP hat-shaped specimen. Fig. 8 shows the image capture points on the test force-displacement curve of the high tensile strength steel hat-shaped specimen, and Fig. 9 shows the test images corresponding to Fig. 8. From Fig. 7, compressive strain could be measured by any of the strain gauges until 5 s, but after 5 s, tensile strain occurred at half of the strain gauges. As can be understood from image (2) of Fig. 9 and others, this behavior is thought to have occurred because periodic wrinkles formed in the specimen, and as a result, tensile strain was generated at the locations where the strain gauges were attached. Furthermore, although the output from strain gauge Front 9 decreased greatly in Fig. 7, from Front 9 in image (3) of Fig. 9, this is considered to be due to large deformation at the position of the strain gauge. After image (3) of Fig. 9, a condition in which destruction proceeded as though the hat-shaped specimen was being folded from the bottom side was observed.

## Conclusion

Here, axial compression tests of hat-shaped specimens prepared using CFRTP and high tensile strength steel were carried out as tests of actual structures. The AGX-V Series enables 14 more channels of analog input than conventional type testing machines, and thus makes it possible to perform strain measurements at a larger number of points in actual-structure tests. Furthermore, an evaluation comparing the test results and test images was also possible by using a USB camera to record video synchronized with the test results.

The AGX-V Series is expected to be a useful tool for tests of actual structures.

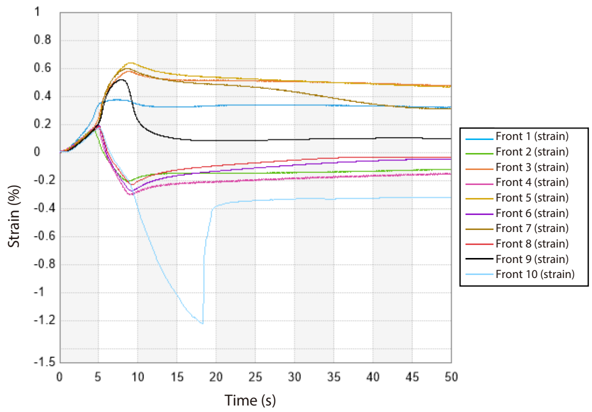


**Fig. 7 Strain-Time Curve**

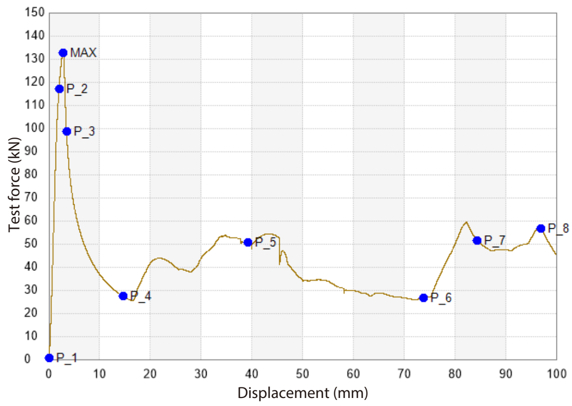


**Fig. 8 Image Capture Points in Test Force-Displacement Curve of High Tensile Strength Steel Hat-Shaped Specimen**

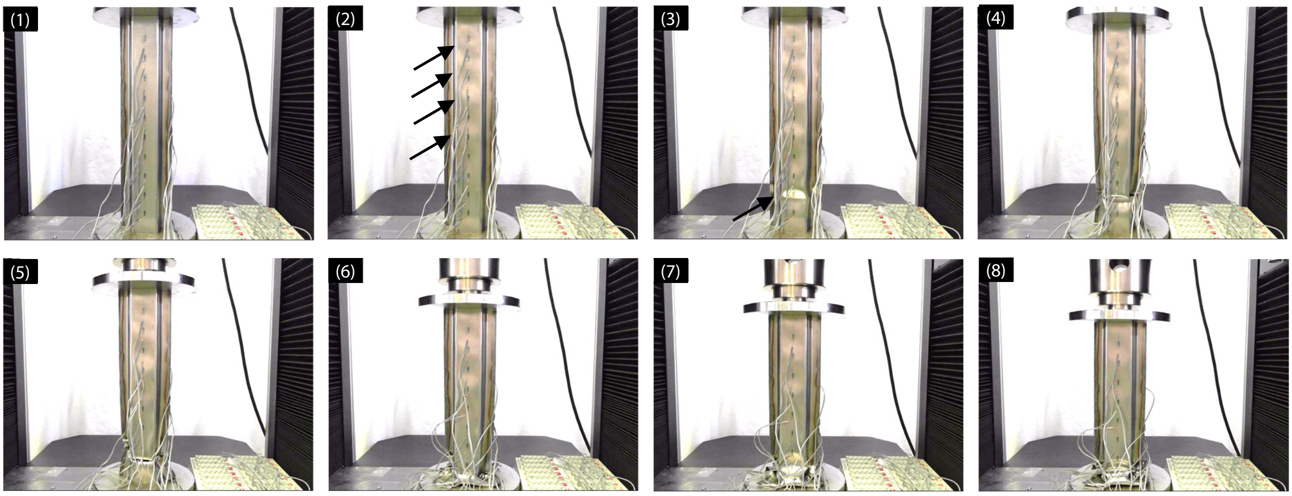


**Fig. 9 Condition of Test of High Tensile Strength Steel Hat-Shaped Specimen**

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