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Application News

High-Speed Impact Testing Machine HITS™-TX
Hyper Vision™ HPV™-X2 High-Speed Video Camera

Test Speed Dependence Evaluation of Shear Strength of Adhesive and Fracture Observation

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User Benefits

- Test speed dependence evaluation of the mechanical properties of adhesives and fracture observation are possible.
- High-speed tensile tests at up to 20 m/s can be conducted by HITS-TX.
- High-speed video camera HPV-X2 enables high-speed imaging of up to 10 Mfps/sec.

■ Introduction

Adhesives are used for joining and fixing various components, as well as improving the watertightness and airtightness properties of joints in applications such as piping. Especially in the automotive field, adhesives are lighter compared with welding and bolting, and additionally, using the appropriate adhesive can also reduce the vibration and noise of components. Therefore, replacement with adhesives is being put into practical use to improve fuel efficiency. In the transportation field, including automobiles, it is considered important to evaluate the impact properties and the test speed dependence of the mechanical properties, as components may be subjected to impact loads.

This paper presents a study evaluating the test speed dependence of shear strength for four types of adhesives commonly used in automotive applications, tested using high-speed impact testing machine HITS-TX. Additionally, by using the high-speed video camera HPV-X2, the progression of cracks during shear fracture could be observed.

■ Specimen Information

Adhesive samples consisting of four types, ThreeBond (TB) 1160, TB2237J, TB2049/2149, and TB3953, were used to bond stainless steel plates together. The dimensions are as shown in Fig. 1. Stainless steel plates of 40×11 mm were bonded together with a bond area of 11×11 mm. In addition, 11×16 mm stainless steel plates were bonded at both ends of the specimen as spacers. The above specimen information is detailed in Table 1. The curing conditions for each adhesive are also as shown in Table 2.

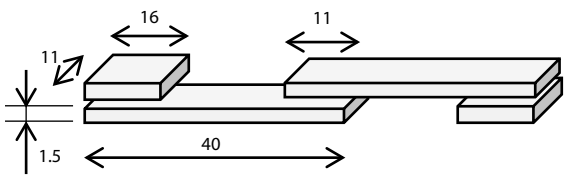

Fig. 1 Specimen Shape

Table 1 Specimen Information

Adhesive Type	:	(1) TB1160 (2) TB2237J (3) TB2049/2149 (4) TB3953
Dimension	:	W11 × t3 × L69 mm Only TB1160 has a clearance of 1 mm, resulting in a thickness of 4 mm.
Bond Area	:	11 × 11 mm

Table 2 Curing Condition

TB 1160	: (23 °C, 50 %RH) × 168 h
TB 2237J	: 120 °C × 60 min
TB 2049/2149	: 25 °C × 24 h
TB 3953	: (23 °C, 50 %RH) × 7 days

■ Measurement System

A high-speed impact testing machine HITS-TX (Fig. 2) was used for evaluating test speed dependence, and a high-speed video camera HPV-X2 (Fig. 3) was used for high-speed imaging. The configuration of the testing equipment used in this article is shown in Table 3. Additionally, a view of the test is shown in Fig. 4.

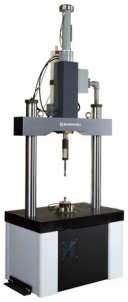

Fig. 2 High-Speed Impact Testing Machines HITS™-TX

Fig. 3 Hyper Vision™ HPV™-X2 High-Speed Video Camera

Table 3 Testing Equipment

High-Speed Impact Testing Machine	:	HITS-TX
Load Cell	:	10 kN
Jig	:	Grip for flat plate samples
Displacement Measuring Device	:	Chuck displacement gauge
High-Speed Video Camera	:	HPV-X2
Light	:	Stroboscope
Lens	:	Macro lens

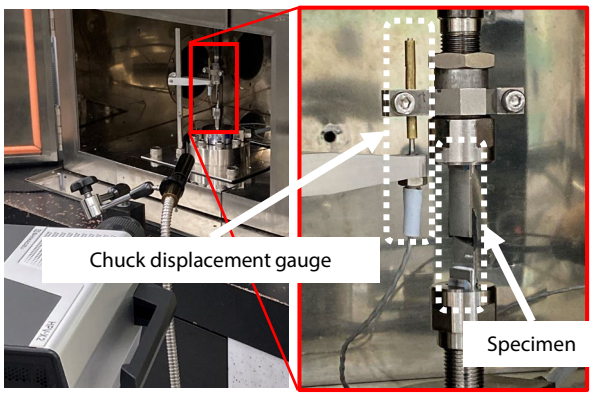

Fig. 4 View of the Test

■ Test Conditions and Test Results

The test conditions are shown in Table 4. The tests were conducted at three speed conditions of 0.0002, 0.02, and 2 m/s to evaluate test speed dependence. Fracture observation of the shear test was also conducted using the HPV-X2 in the TB2049/2149 test at 2 m/s.

Fig. 5 shows the shear stress-displacement (chuck displacement) curves for TB1160 and TB3953 at each speed condition as an example of the test results. From these results, it can be seen that the shear strength increases as the test speed increases. Additionally, TB1160, which is made of modified silicone has higher elongation compared with TB3953, which has characteristics of both modified silicone and epoxy resin, and it showed a tendency for increased displacement at maximum stress with increasing speed.

Table 4 Test Condition

Test Speed	:	0.0002 m/s, 0.02 m/s, 2 m/s
Recording Speed	:	500 kfps
Recording Capacity	:	128 images

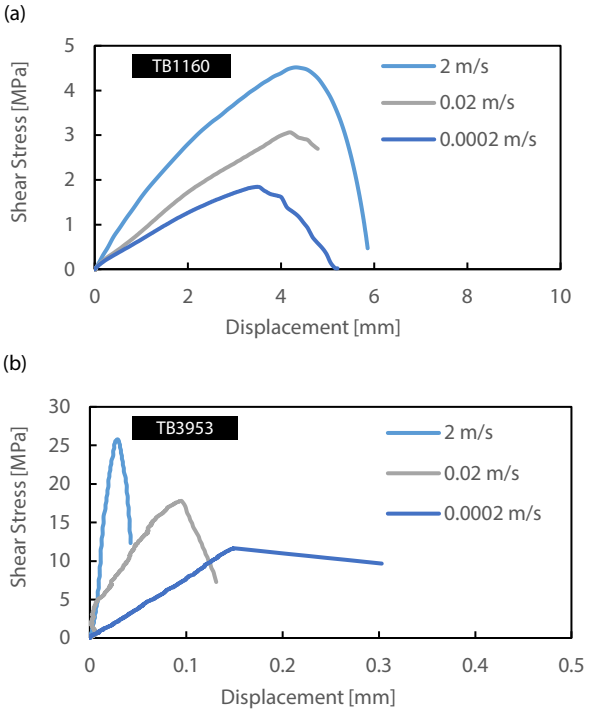

Fig. 5 Stress-Displacement Curves (a) TB1160 (b) TB3953

Fig. 6 shows the relationship between the shear strength and test speed. It is confirmed that the higher the test speed, the higher the shear strength for all specimens. In particular, the strength of the three types TB1160, TB2049/2149, and TB3953 was approximately two times higher at 2 m/s than at 0.0002 m/s, indicating stronger test speed dependence compared with TB2237J.

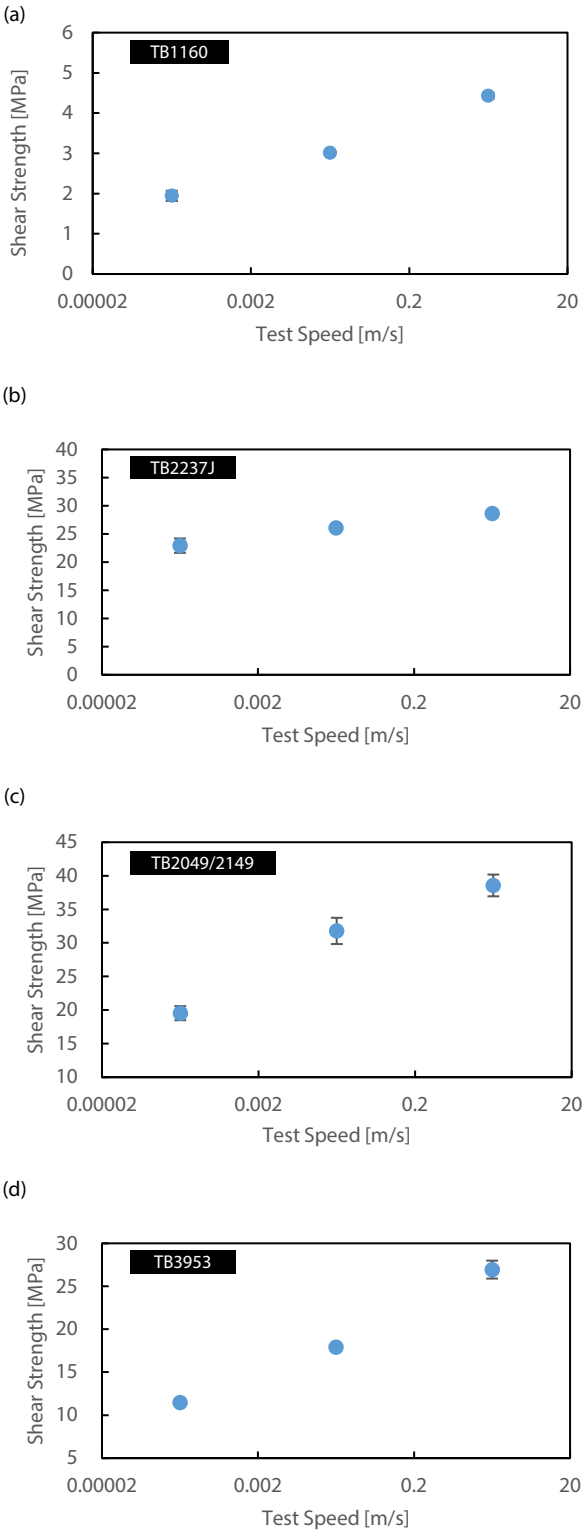

Fig. 6 The Relationship between Shear Strength and Test Speed
(a) TB1160 (b) TB2237J (c) TB2049/2149 (d) TB3953

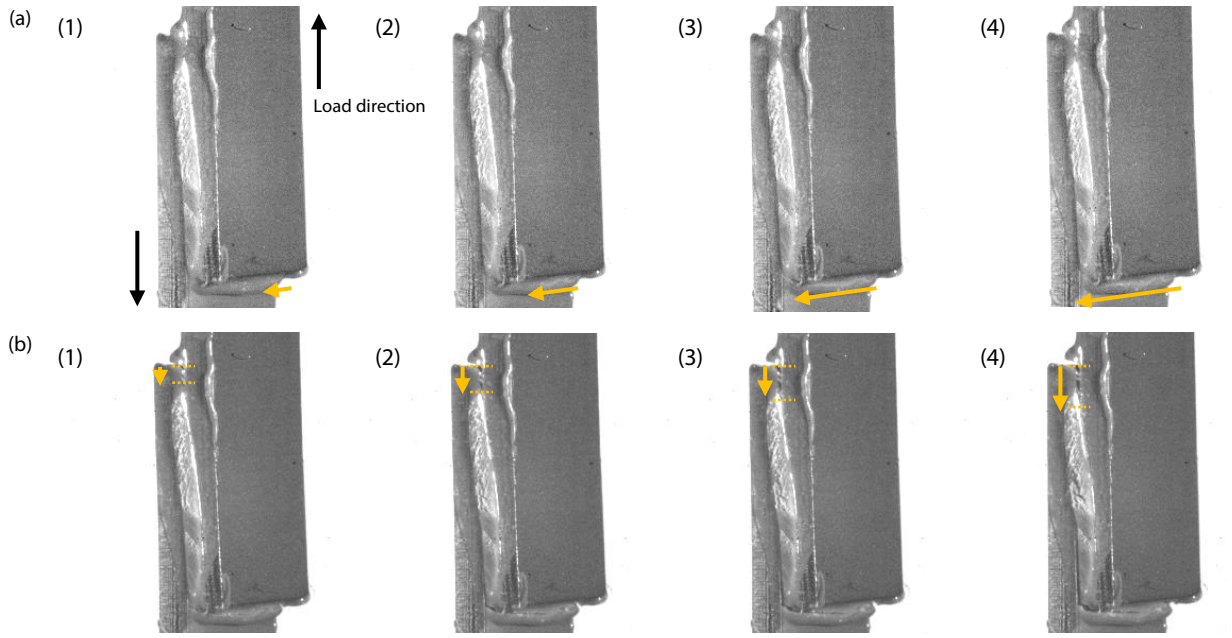

Fig. 7 Shear Fracture of TB2049 at 2 m/s
The time interval between images is (a) 6 µs (b) 10 µs.

Fig. 7 shows the shear fracture recording by the HPV-X2. First, in Fig. 7(a) (1) to (4), a crack progressed horizontally from the back right corner of the specimen's bonding part. On the other hand, in Fig. 7(b) (1) to (4), it was observed that the crack progressed vertically from the upper left of the specimen bonding part.

■ Conclusion

In this article, the test speed dependence of shear strength for four types of adhesives was evaluated using the high-speed impact testing machine HITS-TX. High-speed recording of shear fracture was also conducted using the high-speed video camera HPV-X2.

The results from the high-speed shear tests revealed that the shear strength has test speed dependence, particularly for the three types TB1160, TB2049/2149, and TB3953, which have strong test speed dependence. In addition, detailed observation of crack progression during shear fracture was possible from the images recorded by the HPV-X2.

Acknowledgements

We would like to express our heartfelt gratitude to ThreeBond Co., Ltd., and ThreeBond Arvel Keiji Co., Ltd. for their significant support, including the provision of specimens, in the creation of this application.

<Related Applications>

1. Shear Fatigue Test of Adhesives,
   Application News No. 01-00790-EN
2. Temperature Dependence Evaluation of Tensile Shear Strength of Adhesive,
   Application News No. 01-00799-EN

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