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**Fiber-reinforced plastic
composites—Determination of
compressive properties in the
in-plane direction**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Plastics Industry Federation (JPIF)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS K 7018:1999**), which has been technically revised, and **JIS K 7076:1991**, which has been withdrawn.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, published patent application or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, published patent application or utility model rights.

NOTE Based on Article 9 of the Supplementary Provisions to the Unfair Competition Prevention Act etc., any submission of proposal, or employment of procedures such as deliberation by the Japanese Industrial Standards Committee under the previous Industrial Standardization Act shall be deemed to have been conducted pursuant to the provision of Article 12, paragraph (1) of the revised Industrial Standardization Act.

Fiber-reinforced plastic composites— Determination of compressive properties in the in-plane direction

Introduction

This Japanese Industrial Standard was established in 1999 based on **ISO/DIS 14126:1995** which was published based on several related **ASTMs** and **ISO 8515**, while also incorporating **JIS K 7056:1995**. This revised edition has been prepared based on **ISO 14126:1999** with some modifications of the technical contents. This revision is intended to incorporate **JIS K 7076:1991** (Testing methods for compressive properties of carbon fiber-reinforced plastics) as well as to add a new test method (Method 4).

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JG.

1 Scope

1.1 This Standard specifies four methods for determining compressive properties, in directions parallel to the plane of lamination, of fibre-reinforced plastic composites.

1.2 The compressive properties are of interest for specifications and quality-control purposes.

1.3 Four testing methods and seven types of specimen are described as follows.

See Table 1 for combination of test method, loading method, compression fixture and specimen shape, and the procedure for fitting the specimen to the compression fixture.

a) **Test methods** The following four methods are described:

- **Method 1:** provides shear loading of the specimen (gauge length unsupported).
- **Method 2:** provides mixed loading of shear loading and end loading of the specimen (gauge length unsupported).
- **Method 3:** provides end loading of the specimen with the buckling prevention fixture attached to the parallel-sided portion of the specimen and uses $\neq$ shaped test fixture.

NOTE For tabbed specimens that are end-loaded, some load is transferred into the specimen gauge length by shear through the tabs.

- **Method 4:** provides end loading of the specimen with the cylindrical support end fixture (gauge length unsupported).

b) **Specimen shapes** The following seven types of specimen are described:

- **Type A specimen:** rectangular cross-section, fixed thickness, end-tabbed, three sizes available (A1, A2, A3).

- **Type B specimen:** rectangular cross-section, range of thickness, untabbed or end-tabbed, three sizes available (B1, B2, B3).
- **Type C specimen:** dumbbell-shaped with a parallel-sided portion, untabbed.

Table 1 Combination of test method, loading method, compression fixture and specimen shape

Test method		Loading method (schematic diagram)	Compression fixture	Specimen shape	Procedure for fitting the specimen to the compression fixture
Method 1	a	Shear loading (see Figure 2)	Figure B.1	A1	—
	b		Figure B.2	B1, B2	
	c		Figures JA.1 and JA.2	A3	Annex JD
Method 2		Mixed loading (see Figure 3)	Figure C.1	—	—
Method 3	a	≠ shaped support end loading (see Figure 4)	Figure C.2	—	
	b		Figure JB.1	C	—
	c		Figure JB.2	A2	Annex JE
Method 4		Cylindrical support end loading (see Figure 5)	Figures JC.1 to JC.7	B1, B3	Annex JF

—: Not applicable.

NOTE 1 Method 1a above is equal to Method 2 in **JIS K 7018:1999**, and Method 1 in **ISO 14126:1999** [Method A (Celanese) in **ASTM D3410/D3410M:1995**].

NOTE 2 Method 1b above is equal to Method 2 in **JIS K 7018:1999**, and Method 1 in **ISO 14126:1999** [Method B (IITRI) in **ASTM D3410/D3410M:1995**].

NOTE 3 Method 1c above is equal to Method B described in **JIS K 7076:1991**.

NOTE 4 Method 2 above is equal to Method 3 in **JIS K 7018:1999**, and Method 2 in **ISO 14126:1999** (Method B in **ISO 8515:1991**). **ISO 14126:1999** does not have specimen size requirement, while **ISO 8515:1991** specifies specimen size of 120 mm × 10 mm × $t/3$ mm to $t/10$ mm (tab length 50 mm).

NOTE 5 Method 3a above is equal to Method 3 in **JIS K 7018:1999**, and Method 2 in **ISO 14126:1999** [**ASTM D695** (modified) type from **prEN 2850:1997**]. **ISO 14126:1999** does not have specimen size requirement, while **prEN 2850:1997** specifies specimen size of 75 mm to 80 mm × 12.5 mm × $t/2$ mm (test length 5 mm for tabbed specimen, and the same planar dimension for untabbed specimen).

NOTE 6 Method 3b above is equal to both Method 1 in **JIS K 7018:1999** and the method described in **JIS K 7056:1995**.

NOTE 7 Method 3c above is equal to Method A described in **JIS K 7076:1991**.

1.4 The methods are suitable for fibre-reinforced thermoplastic and thermosetting plastic composites.

Unreinforced and particle-filled plastics, as well as those reinforced with short fibres (not more than 1 mm in length), are covered by **JIS K 7181**.

1.5 The methods are performed using specimens which may be machined according to **JIS K 7144** from a test panel made in accordance with **JIS K 7016-4** or equivalent methods.

1.6 The methods specify required dimensions for the specimen. Tests which are carried out on specimens of other dimensions, or on specimens which are prepared under different conditions, may produce results which are not comparable. Other factors, such as the speed of testing, the support fixture used and the condition of the specimens, can influence the results. Consequently, when comparative data are required, these factors must be carefully controlled and recorded.

1.7 Fiber-reinforced plastics are usually anisotropic. It is therefore often useful to cut test specimens in at least the two main directions of anisotropy, or in directions previously specified (for example a lengthwise direction associated with the production process).

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 14126:1999 *Fibre-reinforced plastic composites—Determination of compressive properties in the in-plane direction* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS K 6272 *Rubber—Tensile, flexural and compression test equipment (constant rate of traverse)—Specification*

NOTE Corresponding International Standard: ISO 5893 *Rubber and plastics test equipment—Tensile, flexural and compression types (constant rate of traverse)—Specification*

JIS K 6900 *Plastics—Vocabulary*

JIS K 7016-4 *Fibre-reinforced plastics—Methods of producing test plates—Part 4: Moulding of prepregs*

JIS K 7100 *Plastics—Standard atmospheres for conditioning and testing*

NOTE Corresponding International Standard: ISO 291 *Plastics—Standard atmospheres for conditioning and testing*

JIS K 7144 *Plastics—Preparation of test specimens by machining*

NOTE Corresponding International Standard: ISO 2818 *Plastics—Preparation of test specimens by machining*

JIS Z 9041-2 *Statistical interpretation of data Part 2: Techniques of estimation and test relating to means and variances*

NOTE Corresponding International Standard: ISO 2602 *Statistical interpretation of test results—Estimation of the mean—Confidence interval*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS K 6900**, and the following apply.

3.1

compressive stress, σ_c

compressive force experienced by the test specimen at any particular moment divided by the initial cross-sectional area of the parallel-sided portion of the specimen (MPa)

3.2

compressive strength, compressive failure stress, σ_{cM}

maximum compressive stress sustained by the specimen (MPa)

3.3

compressive strain, ϵ_{cl}

ratio of the decrease in the distance between the gauge marks on the parallel-sided portion of the test specimen (due to a compressive force) to the initial distance between the gauge marks

It is expressed as a dimensionless ratio or in percent.

3.4

compressive failure strain, ϵ_{clM}

longitudinal compressive strain at the compressive failure stress

It is expressed as a dimensionless ratio or in percent.

3.5

modulus of elasticity in compression, chord modulus, E_c

stress difference (σ_c'' minus σ_c') divided by the corresponding strain difference [ϵ_{cl}'' ($=0.002\ 5$) - ϵ_{cl}' ($=0.000\ 5$)] (see **10.2**) (MPa)

3.6

specimen coordinate axes

coordinate axes for the material with the fibres preferentially aligned in one direction (see Figure 1)

The direction parallel to the fiber axes is defined as the “1”-direction and the direction perpendicular to the fiber axes the “2”-direction. For other materials, the “1”-direction is normally defined in terms of a feature associated with the production process, such as the long direction for a continuous-sheet process. The “2”-direction is again perpendicular to the “1” direction.

Results for specimens cut parallel to the “1”-direction are identified by the subscript “11” (e.g. E_{c11}). Similarly, results for specimens cut parallel to the “2”-direction are identified by the subscript “22” (e.g. E_{c22}).

NOTE The “1”-direction is also referred to as the 0° or longitudinal direction, and the “2”-direction as the 90° or transverse direction. More generally, the X, Y and Z (through-thickness) coordinate system for any material can be equated to the “1”-, “2”- and “3”-directions.

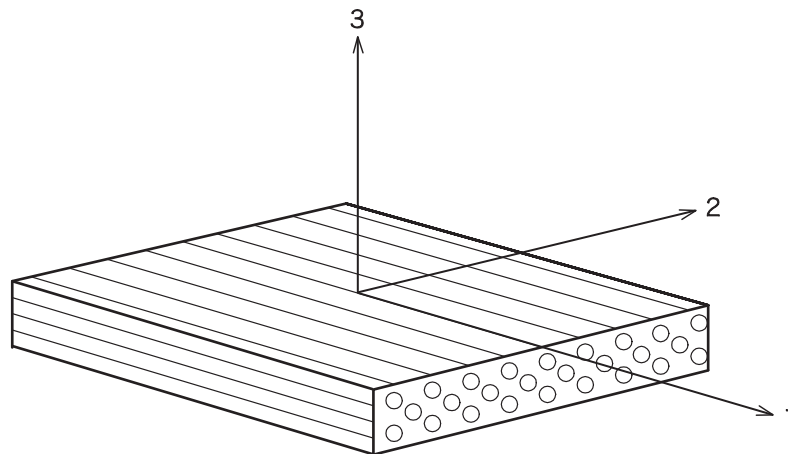


Figure 1 Unidirectionally reinforced composite plate element showing symmetry axes

3.7

Poisson's ratio, μ_{cb}

absolute value of the ratio between strain ε_{ct} in the transverse direction of the specimen perpendicular to the compressive stress direction and strain ε_{cl} in the longitudinal direction of the specimen parallel to the compressive stress direction, within elastic limit

4 Principle

An axial force is applied to the unsupported length (in the through-thickness direction) of a rectangular or dumbbell-shaped specimen held in a loading fixture, while the applied load and strain in this area are monitored. This test method concentrates on the quality of the axial deformation experienced by the specimen. For some methods and specimens, an assessment using Poisson's ratio is also specified. However, the measured Poisson's ratio may not be comparable with respect to the specimen size. Any testing method can be used, provided specimen failure occurs below a 10 % bending strain in the specimen (see **9.8**).

The compressive load is applied to the material

- by shear through end tabs (Method 1);
- by mixed loading of end loading and shear loading through fixture (Method 2);
- or by direct end loading of the specimen (Methods 3 and 4).

Methods 2, 3a, 3c, and 4 using a tabbed specimen results in load introduction into the test area by a combination of direct compression and shear through the tabs.

NOTE It is important to realize that the test results obtained by these four methods are not necessarily comparable.

5 Apparatus

5.1 Test machine

5.1.1 General

The machine shall conform to **JIS K 6272** as appropriate to the requirements given in **5.1.2** and **5.1.3**.

5.1.2 Speed of testing

The test machine shall be capable of maintaining the required speed of testing (see **9.5**).

5.1.3 Indication of load

The error for the indicated load shall not exceed $\pm 1\%$.

5.2 Strain measurement

Strain shall be determined by means of either strain gauges or suitable extensometers. Strain gauge elements shall be not more than 3 mm in length or shall be as agreed between the interested parties, and the deviation from the indicated strain shall not exceed $\pm 1\%$. The gauges, the surface preparation and the bonding agents used shall be chosen to give adequate performance with the materials being tested, and suitable strain-recording equipment shall be employed to conduct measurement at both faces of the specimen.

5.3 Micrometer

A micrometer, or equivalent, reading to less than or equal to 0.01 mm shall be used to determine the thickness h and width b of the test specimen. The micrometer shall have faces appropriate to the surface being measured (i.e. flat faces for flat, polished surfaces and round faces for other cases).

5.4 Loading fixtures

5.4.1 General

Fixtures appropriate to the loading method chosen shall be used. The compression fixture shall load the specimen so that the requirement on allowable specimen bending given in **9.8** is met. The fixture used shall be identified in the test report.

5.4.2 Shear loading (Method 1)

The load is applied to the specimen by shear through the faces of the end tabs. It is permissible to use different types of grip and sleeve (trapezoidal, for example). Aligned hydraulic grips in aligned test machines are also acceptable. A schematic diagram of a compression fixture for shear loading is given in Figure 2.

The compression fixture for Method 1c (see Table 1) is specified in Annex JA.

NOTE Some Method 1a and Method 1b (see Table 1) fixtures in common use are shown in Annex B.

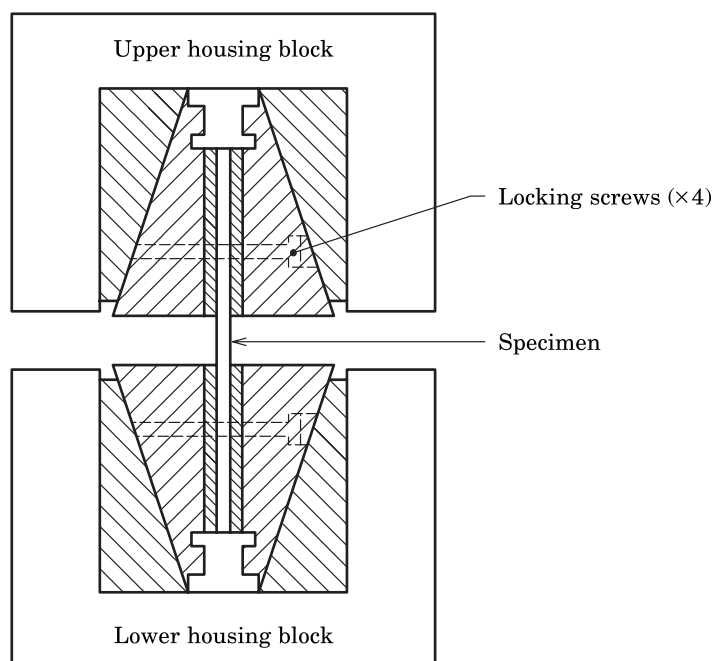


Figure 2 Schematic diagram of compression specimen and test fixture for Method 1

5.4.3 Mixed loading (Method 2)

The load is applied directly to the end of the specimen. For a tabbed specimen, the loading is by a combination of end loading and shear loading through the tab. A schematic diagram of a compression fixture for mixed loading is given in Figure 3.

5.4.4 ≠ shaped support end loading (Method 3)

The load is applied to the end while preventing buckling through serration on the ≠ shaped support part. For Method 3b, Type C specimen, and for Method 3c, Type A2 specimen is used. For a tabbed specimen, the loading is by a combination of direct end loading and shear loading through the tab. A schematic diagram of a compression fixture for ≠ shaped support end loading is given in Figure 4.

NOTE Normally, the ≠ shaped loading fixture with an L-shaped base as shown in Figure C.2 is used.

5.4.5 Cylindrical support end loading (Method 4)

The load is applied directly to the end of the specimen. A schematic diagram of a compression fixture for cylindrical support end loading is given in Figure 5, and its shape and dimensions, in Annex JC. Type B1 or B3 specimen, untabbed, is used.

NOTE 1 Some Method 2 and Method 3a fixtures in common use are shown in Annex C, e.g. the fixture specified in **ISO 8515:1991** (Figure C.1) and that in **ASTM D695** or in **ASTM D695** modified version in **prEN 2850** (Figure C.2). The **ASTM D695** fixture gives a lower degree of support to the end of the specimen than the fixture of **ISO 8515**.

NOTE 2 The main aspect of the fixture design for both loading methods is the alignment (initial and throughout the test), and for Method B (Method 1b)

of **ASTM D3410/D3410M** a further important aspect is prevention of failure at the end of the specimen.

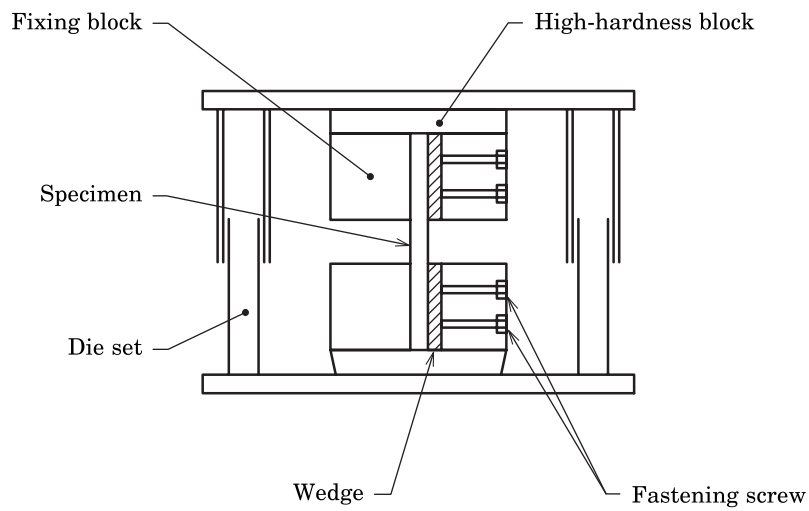


Figure 3 Schematic diagram of compression test fixture for Method 2

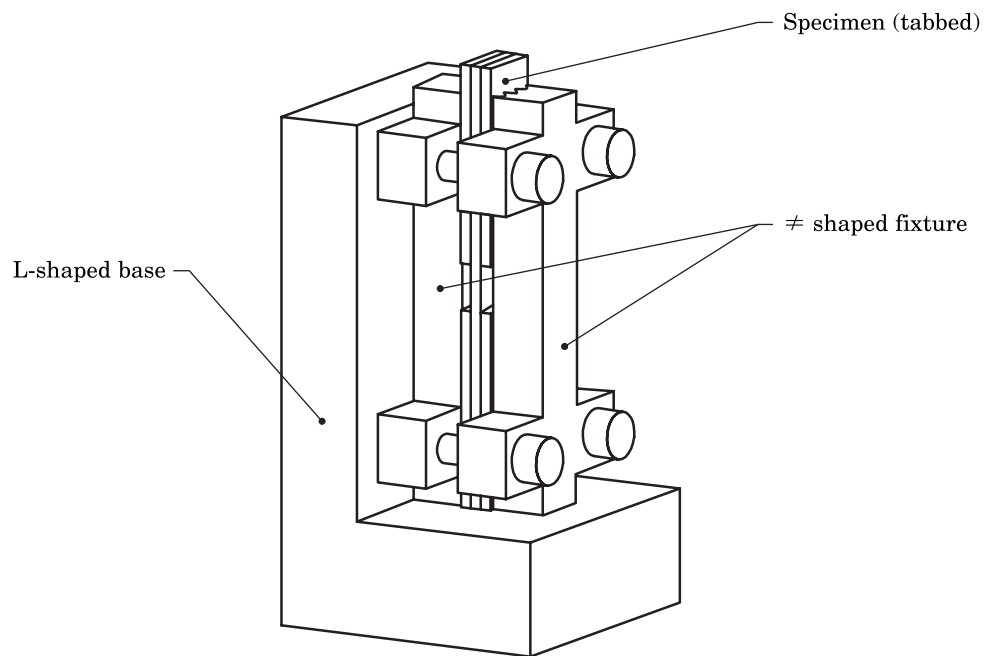


Figure 4 Schematic diagram of compression test fixture for Method 3

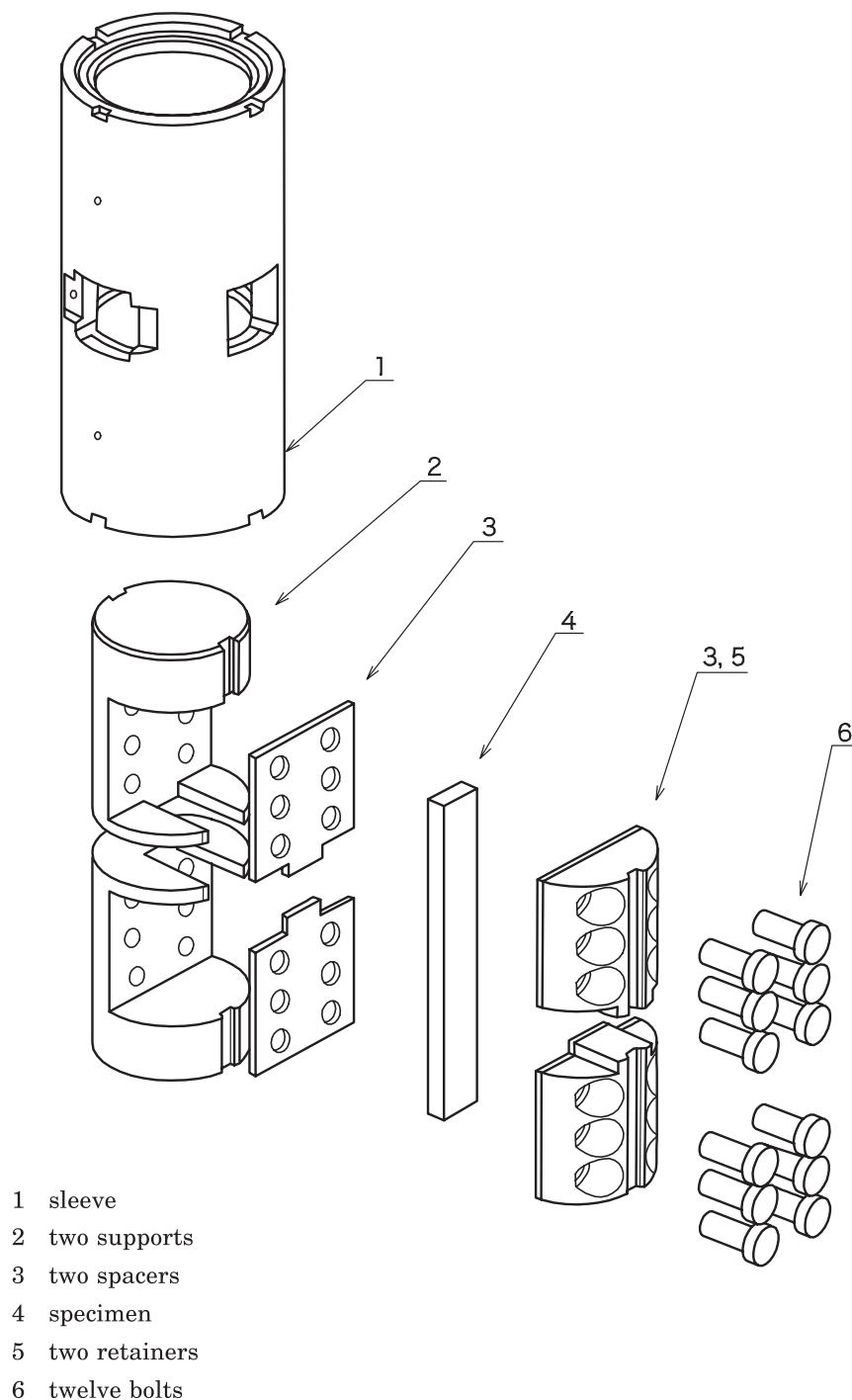


Figure 5 Schematic diagram of cylindrical support end fixture for Method 4

6 Test specimens

6.1 Shape and dimensions

6.1.1 Type A specimen

Type A1, A2, and A3 specimens shall be straight-sided and of rectangular cross-section, with the dimensions given in Table 2 (see also Figure 6).

6.1.2 Type B specimen

Type B1, B2, and B3 specimens shall be straight-sided and of rectangular cross-section, with the dimensions given in Table 3 (see also Figure 6). End tabs shall be used if necessary to avoid failure at the loaded ends of the specimen.

6.1.3 Type C specimen

Type C specimen shall be dumbbell shaped, with the dimensions given in Table 4.

Table 2 Type A specimen dimensions

Unit: mm

Dimensions		Type A1 specimen	Type A2 specimen	Type A3 specimen
Overall length (minimum)	l_0	110 ± 1	78	134
Thickness	h	2 ± 0.2	2.0 ± 0.2	2.0 ± 0.2
Width	b	10 ± 0.5	12.5 ± 0.5	6.5 ± 0.2
Distance between end tabs/grips	L	10	8.0 ± 0.5	8.0 ± 0.5
Length of end tabs (minimum)	l_T	50	35.0 ± 0.5	63.0 ± 0.5
Thickness of end tabs	d_T	1	1	1

Table 3 Type B specimen dimensions

Unit: mm

Dimensions		Type B1 specimen	Type B2 specimen	Type B3 specimen
Overall length (minimum)	l_0	110 ± 1	125 ± 1	115 ± 1
Thickness	h	2 to 10 ± 0.2	> 4	2 to 10
Width	b	10 ± 0.5	25 ± 0.5	15 ± 0.5
Distance between end tabs/grips	L	10	25	$15^a)$
Length of end tabs (minimum)	l_T	50 (if required)	50 (if required)	$50^b)$
Thickness of end tabs	d_T	0.5 to 2 (if required)	0.5 to 2 (if required)	—

—: Not applicable.
Notes ^{a)} Test length.
^{b)} Length supported by jig.

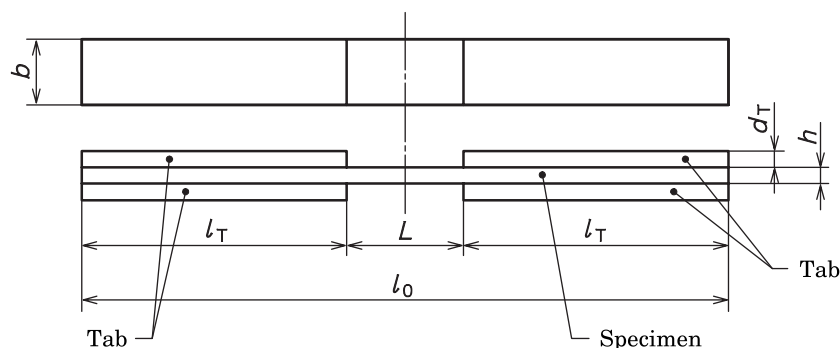


Figure 6 Type A and B tabbed-specimen designs

Table 4 Type C specimen design

		Unit: mm
Dimensions		Type C specimen
Overall length	l_0	77 ± 0.5
Length of parallel-sided portion	L	38 ± 0.5
Width at edge	b_0	19 ± 0.5
Width of parallel-sided portion	b	13 ± 0.5
Thickness	h	2 to 3
Transition radius	r	40

6.2 Preparation of specimens

6.2.1 General

A panel shall be prepared in accordance with **JIS K 7016-4** or another specified/agreed procedure. Specimens cut from finished parts (for example, for quality control during manufacture or on delivery) shall be taken from flat areas of uniform thickness.

6.2.2 End-tab material

The ends of the specimen shall be reinforced, if necessary, with end tabs made preferably from a 0°/90° cross-ply or fabric laminate made from glass-fiber/resin with the fiber axes in the fabric set at $\pm 45^\circ$ to the specimen axis. The tab thickness shall be between 0.5 mm and 2 mm in accordance with Tables 2 and 3, with a tab angle of 90° (i.e. not tapered). If tab failure occurs under high end loads, the fiber axes in the tab shall be set at 0°/90° to the specimen axis.

Alternatives of tabs, such as tabs made from the material under test, mechanically fastened tabs, unbonded tabs or friction materials (emery paper, grit paper or fine-finish grip faces), shall be shown, before use, to give at least equal strength values (see **JIS K 7161-1:2014, 10.5**) and smaller coefficient of variation (see **ISO 3534-1**) than the recommended tab material. When the test is carried out on untabbed specimens using Method 2, the “distance between tabs” shall be taken to be the distance between the tabs of a corresponding tabbed specimen (see **ISO 527-4:1997, Type 3 specimen**). Test according to Method 4 shall be carried out on untabbed specimens.

6.2.3 Application of end tabs

The end tabs shall be bonded to the specimen as shown in Annex A.

This procedure can be used for individual specimens or groups of specimens.

6.2.4 Machining the specimens

Specimens shall be machined in accordance with one of the following.

- a) **Method 1:** Machine the tab surfaces as necessary to ensure the tabs are symmetrical about the specimen thickness direction centreline and parallel to each other.