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Fibre-reinforced plastic composites — Determination of the in-plane shear modulus by the plate twist method

Composites plastiques renforcés de fibres — Détermination du module de cisaillement dans le plan par la méthode de torsion de plaque

Reference number
ISO 15310:1999(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15310 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

Annex A of this International Standard is for information only.

Fibre-reinforced plastic composites — Determination of the in-plane shear modulus by the plate twist method

1 Scope

1.1 This International Standard specifies a method for determining the in-plane shear modulus (G_{12}) of fibre-reinforced plastic composites using a standard plate specimen. When applied to isotropic materials, the shear modulus measured is independent of direction.

1.2 The method is used to determine the shear modulus of the test specimens but not to determine the shear strength. It applies to a plate supported on two points on one diagonal and loaded on the other diagonal by the simultaneous movement of two loading points attached to a cross-beam.

1.3 The method is suitable for use with fibre-reinforced plastic composites with both thermoset and thermoplastic matrices.

Due to the shear deformation being applied under flexural conditions, for laminated materials with different fibre formats and/or different orientations, the layers of material must be well distributed across the section so that it is approximately "homogeneous" in the through-thickness direction.

The principal material axes, if present, must be orientated normal to the plate edges (see 3.8).

NOTE This method can be applied to unreinforced polymers and other materials (e.g. metals, ceramics and metal- or ceramic-matrix composites).

For material fabricated using unidirectional plies, the shear modulus obtained using a multidirectional specimen (i.e. 0°/90°/± 45°) is not the same as that obtained for unidirectional or cross-ply (0°/90°) material.

1.4 The method is performed using specimens which may be moulded to the chosen dimensions, machined from test plates or machined from flat areas of products.

1.5 The method specifies preferred 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 and the conditioning of the specimens, can influence the results. Consequently, when comparative data are required, these factors must be carefully controlled and recorded.

NOTE The stress-strain response in shear is very non-linear at higher strain levels. This test method determines the modulus within a low strain region and is not applicable to higher strains.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 1268:1974[1)], *Plastics — Preparation of glass fibre reinforced, resin bonded, low-pressure laminated plates or panels for test purposes.*

ISO 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 2818:1994, *Plastics — Preparation of test specimens by machining.*

ISO 5893:1993, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Description.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
plate deflection
w
the distance over which the loading points move relative to the support points (see Figure 2), expressed in mm

NOTE The plate deflection is normally taken from the movement of the rigid cross-beam carrying the two loading points.

3.2
modulus of elasticity in shear
in-plane shear modulus
G_{12}
<isotropic materials> the shear modulus, expressed in GPa, in a direction other than that of the reinforcement, measured between plate deflections of 0,1h and 0,3h, where h is the plate thickness (see 3.7)

3.3
speed of testing
the rate of movement of the loading points relative to the support points, expressed in mm/min

3.4
span
S
the mean of the distance S_1 between the two support points and the distance S_2 between the two loading points (see Figure 3), expressed in mm

3.5
diagonal length
D
the distance between diametrically opposite corners of the plate, expressed in mm

It is calculated as follows:

$$D = \left(a'^2 + a''^2\right)^{\frac{1}{2}}$$

1) ISO 1268:1974 is under revision in nine parts covering a wide range of composite materials and fabrication processes (e.g. RTM, SMC, filament winding).

3.6
specimen widths
a', *a*''
the mean widths of the specimen in each direction (see Figure 2), expressed in mm

3.7
specimen thickness
h
the mean thickness of the specimen, expressed in mm

3.8
specimen coordinate axes
the coordinate axes for the material under test, as defined in Figure 1

The direction parallel to the principal fibre axis is defined as the "1"-direction, and the direction perpendicular to this axis, and in the plane of the fibres, as the "2"-direction. The "1"-direction is also referred to as the 0-degree (0°) or longitudinal direction, and the "2"-direction as the 90-degree (90°) or transverse direction. A similar definition can be used for material with a preferred lay-up of fibres and for cases where a direction (e.g. length) can be related to the production process.

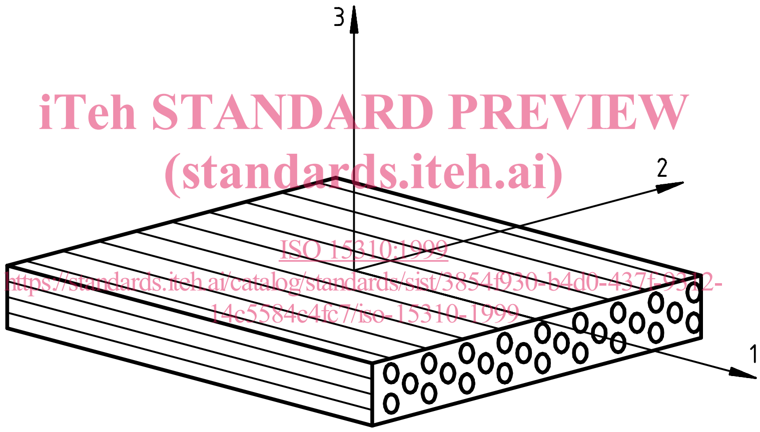


Figure 1 — Symmetry axes for a fibre-reinforced material

4 Principle

The test specimen is supported on two support points positioned near opposite corners on one diagonal of the plate. The plate is deflected at constant rate by two loading points on the opposite diagonal (see Figure 2) until the deformation of the specimen reaches a pre-determined value. During this procedure, the total force on the loading points is measured as a function of the deflection of the loading points.

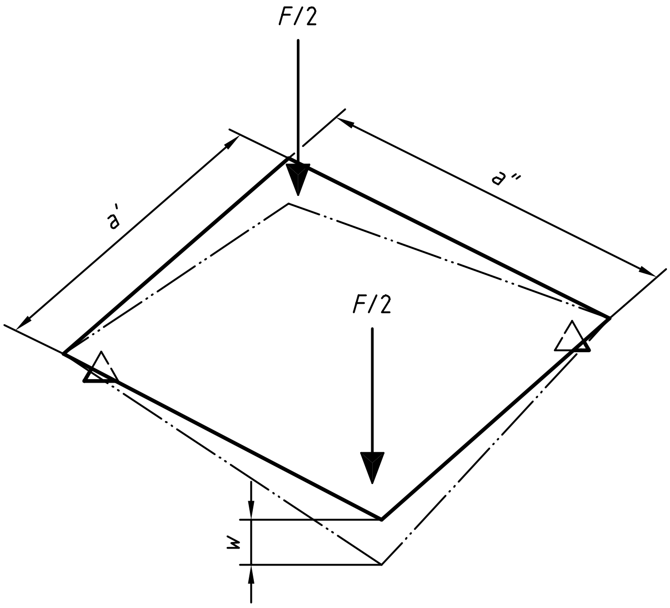
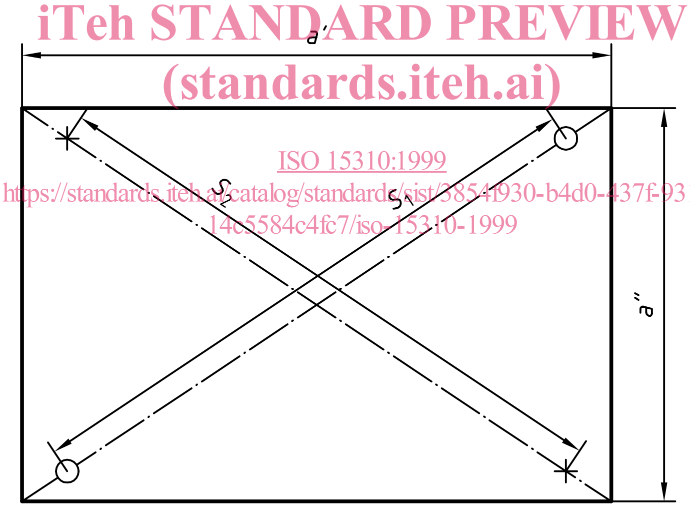


Figure 2 — Principle of test



+ Support point

O Loading point

Figure 3 — Positions of support and loading points

5 Apparatus

5.1 Test machine

5.1.1 General

The machine shall comply with ISO 5893 as appropriate to the requirements given in 5.1.2 to 5.1.4.

5.1.2 Speed of testing

The test machine shall be capable of maintaining a constant speed of 1 mm/min ± 20 %.

5.1.3 Support and loading points

Two support and two loading points are arranged as shown in Figure 3. The support and loading points shall be adjustable to within 0,5 mm of the required position.

The support and loading points are normally mounted on rigid cross-beams in the same manner as the support rollers in a flexure loading test, with the cross-beams set perpendicular to each other. As the test machine is operated, the loading points are moved, by virtue of their attachment to the rigid cross-beam, simultaneously and equally relative to the fixed support points.

NOTE A suitable design for the support and loading points is shown in Figure 4.

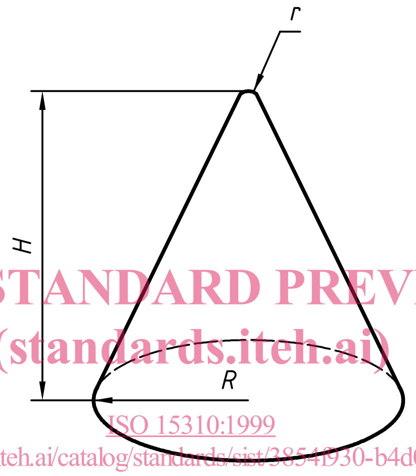


Figure 4 — Suggested support and loading point design

The radius r of the support and loading points shall be 2,0 mm ± 0,2 mm (see Figure 4). The recommended value for the cone height H is 20 mm and for the base radius R is 10 mm.

5.1.4 Indicators for load and deflection

The error in the indicated force and deflection shall not exceed ± 2 % of the full scale (see ISO 5893).

NOTE When crosshead movement is used to measure the plate deflection, a correction should preferably be made for the loading train deflection (i.e. errors due to all additional deflections, such as displacements in the test machine, flexure of the support beam, displacement in the load cell and local indentation).

5.2 Micrometers and gauges

5.2.1 Micrometer or equivalent, reading to less than or equal to 0,01 mm, for measuring the thickness h of the test specimen.

5.2.2 Vernier callipers or equivalent, accurate to within 0,1 mm, for determining the test spans and specimen widths.