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Fibre-reinforced plastic composites - Determination of interlaminar strength and modulus by double beam shear test

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Table of Contents

1 Scope

The document lays down the determination of the interlaminar shear strength and the interlaminar shear modulus of fibre-reinforced plastic composites by the double beam shear method, abbreviated DBS.

It applies to glass-fibre or carbon-fibre reinforced thermosetting plastic composites in which an acceptable interlaminar shear failure can occur.

It applies only to laminates with symmetric and balanced lay-ups, so that the test results are not affected by bending-twisting or bending-stretching coupling deformation, as noted in 6.2. It suits unidirectional laminates with the fibres arranged along the length, that is the axial direction, of the specimen particularly well.

For laminates with particular lay-ups, matrices and fibres, such as natural fibres, the delamination failure has to be assessed in order to decide whether the document is applicable.

2 Normative references

After the standard wording on dated and undated references, the clause cites ISO 291 on standard atmospheres for conditioning and testing of plastics, with a note that GB/T 2918-2018 is the corresponding Chinese document; ISO 472 on plastics vocabulary, with a note naming GB/T 2035-2008; ISO 1268, all parts, on methods of producing test plates for fibre-reinforced plastics, with a note naming GB/T 27797, all parts; ISO 2602 on the statistical interpretation of test results and the estimation of the mean and confidence interval; ISO 5893 on the specification for tensile, flexural and compression type rubber and plastics test equipment with a constant rate of traverse, with a note naming GB/T 17200-2008; and ISO 16012 on the determination of linear dimensions of test specimens for plastics.

3 Terms and definitions

The terms defined in ISO 472 and the following terms and definitions apply to the document. The addresses of the terminology databases maintained by ISO and IEC for standardization purposes are given as the ISO Online Browsing Platform and the IEC Electropedia.

3.1 critical load, denoted F with the subscript crit: the load at which delamination occurs under an acceptable failure mode, as described in 9.5. The note refers to failure modes 1 to 3.

3.2 interlaminar shear strength, denoted by the Greek letter tau with the subscript 13 max: the shear strength calculated from the critical load. The note refers to 10.1.

3.3 interlaminar shear modulus, denoted G with the subscript 13: the shear modulus calculated from the slope of the load-deflection curve. The note refers to 10.2.

3.4 span, denoted L: the distance between the outermost support points.

3.5 specimen coordinate axes: the first note defines the direction parallel to the longitudinal axis of the laminate as direction 1 and the direction perpendicular to the longitudinal axis of the laminate as direction 2, referring to ISO 1268-4, and the direction perpendicular to the laminate, that is along the thickness of the laminate, as direction 3. The second note refers to Figure 1.

3.5.1 longitudinal tensile modulus, denoted E with the subscripts 1 and 1: the tensile modulus in the longitudinal direction of the specimen, that is direction 1. The note gives the unit as GPa.

3.5.2 transverse tensile modulus, denoted E with the subscripts 2 and 2: the tensile modulus in the transverse direction of the specimen, that is direction 2. The note gives the unit as GPa.

3.5.3 in-plane shear modulus, denoted G with the subscripts 1 and 2: the shear modulus in the 1-2 plane. The note gives the unit as GPa.

3.5.4 in-plane Poisson ratio, denoted by the Greek letter nu with the subscripts 1 and 2: the Poisson ratio in the 1-2 plane. The first note states that the quantity is dimensionless. The second note states that the engineering elastic constants defined in 3.5.1 to 3.5.4 are supplied by the manufacturer or obtained by testing, and that they are used to calculate the interlaminar shear modulus, referring to 10.2. The term is printed on the page with a lower-case initial in Poisson.

Figure 1 shows the coordinate axes of a unidirectional fibre-reinforced plastic composite laminate, its key naming item 1 as the direction parallel to the longitudinal axis of the laminate, item 2 as the direction perpendicular to that axis and item 3 as the direction perpendicular to the laminate, that is along its thickness, to which all the laid-up plies are perpendicular.

4 Principle of the test

A beam specimen of rectangular cross-section is subjected to five-point bending loading; the applied load produces two pure shear sections between the two loading noses, as shown in Figure 2. When delamination failure occurs, the critical load borne by the specimen is used to determine the interlaminar shear strength, and the deflection produced in the specimen under the load is used to determine the interlaminar shear modulus. In order to calculate the interlaminar shear modulus, the following engineering elastic constants have to be obtained or tested: the longitudinal tensile modulus, the transverse tensile modulus, the in-plane shear modulus and the in-plane Poisson ratio.

Figure 2 shows the stress distribution in the DBS specimen. Its key names item 1 as the interlaminar shear stress and item 2 as the bending stress, and the lower-case letters a as the load, b as the pure shear section, c as the support force and d as the deflection measuring point; the horizontal extent of the shear stress plateau on each side is marked as three eighths of the span.

5 Apparatus

5.1.1 General: the testing machine shall comply with ISO 5893 and with 5.1.2 and 5.1.3.

5.1.2 Test speed: the test speed, denoted v, shall be capable of being held constant and shall comply with ISO 5893.

5.1.3 Load indicating device: the indication error of the load shall be less than +/-1 % of the load being measured, that is class 1 as defined in ISO 7500-1.

5.2 Dimension measuring instrument: an instrument with an accuracy of 0.01 mm or better is used to measure the thickness h and the width b of the specimen. The measuring instrument shall have a contact face suited to the surface of the specimen under test: a flat face for a flat and smooth surface, a hemispherical face for an irregular surface.

5.3 Loading device: a five-point bending fixture with an adjustable span, as shown in Figure 3. The loading noses and the supports are positioned evenly within the span, with a tolerance of +/-0.2 mm, as shown in Figure 4. The fillet diameter of the loading noses and the supports is 6 mm, with an upper deviation of 0 and a lower deviation of minus 0.1 mm. A typical loading device is shown in Figure 5.