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Composites and reinforcement fibres — Carbon fibre reinforced plastics (CFRPs) and metal assemblies — Combined stress test

Composites et fibres de renfort — Assemblages de plastiques renforcés de fibres de carbone (CFRP) et de métal — Essais sous contraintes combinées

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document provides a test method for producing a well-controlled combined stress state in plane-stress conditions. This methodology can provide an accurate means for evaluating the strength of bonded metal-composite assemblies that depends only on the interaction between dissimilar adherend, the adhesive, and the interfaces subjected to various combined loadings. The results can be used to create the failure envelope for metal-composite assemblies for use in the design optimization of metal-composite assemblies. The original fixture was designed to study the shear properties of polymers[1] and later modified to perform combined load tests for various materials, including bonded assemblies of dissimilar materials.[2],[3]

This document is intended to provide experimental apparatus, test procedures, and manipulation of the result for determining the strength of adhesive-bonded metal-CFRP-metal assemblies under combined loading conditions.

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Composites and reinforcement fibres — Carbon fibre reinforced plastics (CFRPs) and metal assemblies — Combined stress test

1 Scope

This document specifies the test method used to determine the strength of the adhesive-bonded carbon fibre reinforced plastics (CFRP) to metal assemblies under combined loading conditions. The loading fixture, a standard specimen, and procedure for combined shear and normal load tests under plane stress conditions are provided. The test method is also applicable to bonded joints between metals and other composite materials, including glass fibre-reinforced plastics.

This document does not cover specimen preparation of the adhesive joint.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 10365, *Adhesives — Designation of main failure patterns*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
applied load
F
force applied in the loading axis that causes simultaneous shear and normal stresses on the bonded area

Note 1 to entry: See Figure 1.

3.2
maximum applied load
F_{max}
highest value of force observed in the applied load-displacement curve

Note 1 to entry: See Figure 4.

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3.3
loading angle
α
angle between the loading axis and specimen axis

Note 1 to entry: See Figure 1.

3.4
normal load
F_t
force developed in the bonded area in the direction of the specimen axis

Note 1 to entry: See Figure 1.

Note 2 to entry: F_t is calculated using Formula (1).

3.5
maximum normal load
$F_{t,max}$
value of F_t determined at F_{max}

Note 1 to entry: $F_{t,max} = F_{max} \cos\alpha$

3.6
shear load
F_s
force developed in the bonded area in the direction perpendicular to the specimen axis

Note 1 to entry: See Figure 1.

Note 2 to entry: F_s is calculated using Formula (2).

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3.7
maximum shear load
$F_{s,max}$
value of F_s determined at F_{max}

Note 1 to entry: $F_{s,max} = F_{max} \sin\alpha$

3.8
normal stress
σ_t
force per unit area developed in the bonding area in the direction of the specimen axis during the combined load test

Note 1 to entry: σ_t is calculated using Formula (3).

3.9
maximum normal stress
$\sigma_{t,max}$
value of σ_t determined at F_{max}

Note 1 to entry: $\sigma_{t,max}$ is calculated using Formula (5).

3.10
shear stress
σ_s
force per unit area developed in the bonding area in the direction perpendicular to specimen axis during the combined load test

Note 1 to entry: σ_s is calculated using Formula (4).

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3.11
maximum shear stress
$\sigma_{s,\,max}$
value of σ_s determined at F_{max}

Note 1 to entry: $\sigma_{s,\,max}$ is calculated using Formula (6).

3.12
bonding area
A
area of the adhesive joint between metal and composite

Note 1 to entry: The direction of bonding area is parallel to the specimen axis (see Figure 1).

4 Principle

The shear stress and tensile stress are determined using a single fixture that allows combined loadings by rotating the specimen axis with respect to the loading axis. The loading axis is fixed, and the combined loading on the specimen is achieved by loading angles that parallel the specimen axis (see Figure 1). The maximum shear stress and maximum tensile stress combinations for particular loading angles are obtained from the maximum load determined from the monotonic tensile test on the loading axis.

5 Apparatus

5.1 Combined loading fixture

The combined loading fixture is illustrated in Figure 1. It shall consist of upper and lower parts for holding the test specimen. The direction of the loading axis shall be fixed, and loading angles are achieved through gripping holes made at angle increments. The specimen gripping shall be made in such a way that no movement, including slipping, occurs during the test. The fixture shall be made from a high-strength material not to create a compliance effect.

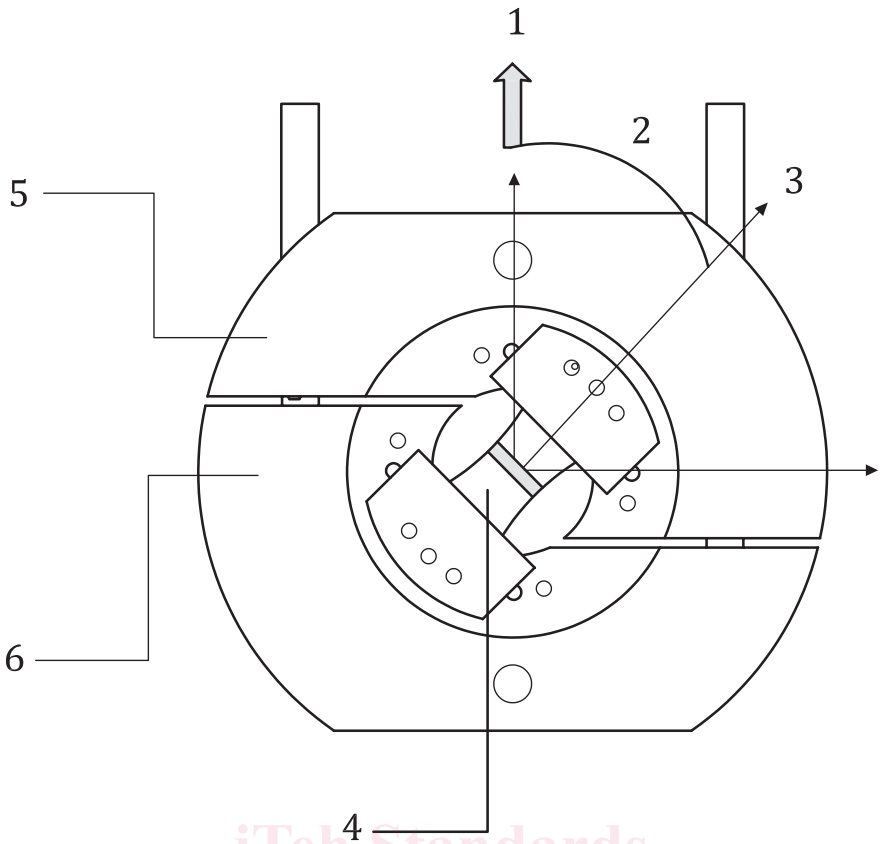
NOTE 1 It was found that using two load guiding bars in the combined loading fixture (Figure 1) can prevent possible bending introduced during the test. It also provides fixture rigidity and eliminates loading axis misalignment.

NOTE 2 A commercially available clearance-free guide unit with high-accuracy grade linear bearing has been used for low-friction slideways in guide bars.

NOTE 3 The dimensions and shape of the fixture used in the test are described in Annex A.

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Key

1 loading axis
2 loading angle (α)
3 specimen axis
4 specimen
5 upper part
6 lower part

Figure 1 — Typical combined load fixture

The following loading conditions shall be achieved for loading angles (α) shown in Figure 2.

α = 0° tensile loading

0 < α < 90° proportional tensile/shear loading

α = 90° shear loading

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