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Fibre-reinforced composites — Measurement of interfacial shear strength by means of a micromechanical single-fibre pull-out test

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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.

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 documents 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*.

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Introduction

Fibre-reinforced composites have become an indispensable part of modern high-tech applications due to the excellent tensile properties of the reinforcement fibres incorporated in the composite. This requires that the loads in a composite need to be distributed evenly to all fibres by means of a matrix. Therefore, a high interfacial shear strength is required for a good load transfer. Hence, the interfacial shear strength is one of the key parameters in composite technology.

To characterize the interfacial shear strength, composites with unidirectional aligned fibres are manufactured. A tensile test is then performed perpendicular to the fibre orientation (transverse tensile test), or a short beam shear strength test (as defined for instance in ISO 14130 or ASTM D2344) is performed to measure the apparent interlaminary shear strength (ILSS).

However, the maximum stress found in such macromechanical tests does not only depend on the fibre-matrix adhesion strength, it is also governed by the following additional factors: the fibre content, orientation, length, diameter and fibre distribution homogeneity, the pore void of the test specimens, and the mechanical properties of the fibre and the matrix. To achieve repeatable results for the fibre-matrix adhesion strength through macromechanical tests, it is necessary to keep a rigid control of the manufacturing process of the specimen, making the overall testing procedure laborious and difficult to compare across laboratories.

Micromechanical testing techniques have several advantages over the macromechanical methods. By involving only single fibres in the test, most dependencies on the manufacturing process of the test specimen listed above are avoided. Whereas macroscopic methods can only determine the apparent interfacial shear strength, the single-fibre pull-out test as a micromechanical test method also can determine the local interfacial shear strength, the interfacial frictional stress, and the critical interfacial energy release rate. Here, the local interfacial shear strength is essential for composites applications with cyclic load, since it characterizes to which stress a composite can be loaded before the interface between fibre and matrix is damaged. The critical interfacial energy release rate and the interfacial frictional stress have a strong impact on the energy absorption of composites, which is important in crash situations as for example in mobility applications.

This document describes stringent methods for specimen preparation, conditioning, and pull-out testing. Practical trials have shown that following these procedures leads to minimum variability in the test results.

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Fibre-reinforced composites — Measurement of interfacial shear strength by means of a micromechanical single-fibre pull-out test

1 Scope

This document specifies a test method for determining the interfacial shear strength between a single fibre and a matrix by means of a pull-out test. The method can be used to measure the critical energy release rate.

The method is applicable to reinforcement fibres, such as carbon fibres, glass fibres, basalt fibres and similar stiff reinforcement fibres and to thermoset, thermoplastic and fine-grained concrete matrices. It can be used for polymeric reinforcement fibres and for other inorganic matrices.

It is not applicable to:

a) elastomeric fibres and elastomeric matrices such as rubber;

b) matrices which cure or melt at temperatures above 400 °C;

c) matrices that show a strong tendency to bubble formation or expansion during the sample-preparation process;

d) foams.

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 1973, *Textile fibres — Determination of linear density — Gravimetric method and vibroscope method*

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

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

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
constant-rate-of-extension testing machine
CRE testing machine
tensile testing machine provided with one specimen holder, which is stationary, and one clamp, which moves with a constant speed throughout the test, the entire testing system being virtually free from deflection

[SOURCE: ISO 5079:2020, 3.10, modified — “clamp” was replaced with “specimen holder“.]

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