International Standard

ISO 10406-2

Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods —

Part 2: FRP sheets

Polymère renforcé par des fibres (PRF) pour l'armature du béton — Méthodes d'essai —

Partie 2: Feuilles en PRF

Third edition
2025-11

Reference number
ISO 10406-2:2025(en)

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Published in Switzerland

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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 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 6, *Non-traditional reinforcing materials for concrete structures.*

This third edition cancels and replaces the second edition (ISO 10406-2:2015), which has been technically revised.

The main changes are as follows:

— “Terms and definitions" has been revised to appropriately reflect the content of the main text.

— Figure 3 has been revised to appropriately reflect the content of the main text.

— “Test report” has been revised.

A list of all parts in the ISO 10406 series can be found on the ISO website.

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Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods —

Part 2: FRP sheets

1 Scope

This document specifies test methods applicable to fibre-reinforced polymer (FRP) sheets for the upgrading of concrete members.

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 31-0:1992, *Quantities and units — Part 0: General principles*

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

ISO 4892 (all parts), *Plastics — Methods of exposure to laboratory light sources*

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

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*

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 Definitions

3.1.1
accelerated artificial exposure testing machine
machine that creates reproducible standard test conditions to accelerate weathering artificially

3.1.2
ambient temperature
environmental conditions corresponding to the usual atmospheric conditions in laboratories with uncontrolled temperature and humidity

Note 1 to entry: In hot and humid areas, temperature and humidity have no effect on the experimental results.

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3.1.3
anchorage block
block corresponding to the test block to prevent bond failure of the FRP sheet

Note 1 to entry: Additional FRP sheet circumferentially jackets the block with sheets being tested to provide higher bond strength (in this block).

3.1.4
anchoring portion
end parts of a test piece fitted with anchoring devices to transmit loads from the testing machine to the test portion

3.1.5
bond strength
strength calculated by dividing the maximum load by the effective bond area

3.1.6
concrete block
rectangular block of concrete used to study the bond properties of FRP sheets to concrete

Note 1 to entry: Steel reinforcement or steel bars are embedded in the axial direction at the centre of the cross-sectional area of the concrete block to transmit tensile strength. Concrete blocks are made up of a test block and an anchorage block.

3.1.7
conditioning
storage of test pieces at a prescribed temperature and humidity to keep them under identical conditions before testing

3.1.8
effective bond length
length of the portion in which the bond stress between the FRP sheet and the concrete acts effectively at maximum load before the FRP sheet comes loose from the concrete

3.1.9
fibre bundle
several fibre filaments bound together to form a bundle

3.1.10
fibre mass per unit area
mass of fibre in the direction of reinforcement in dry sheet (fibre sheets before impregnation with resin)

Note 1 to entry: Expressed as mass per square metres.

3.1.11
interfacial fracture energy
amount of energy per unit bond area necessary to produce interfacial fracture

3.1.12
plate
FRP sheet impregnated with resin from which the test pieces are cut

3.1.13
steel device
mechanism made of steel connected to a loading machine to apply tensile force

Note 1 to entry: Adhesive is used to mount the device to the FRP sheet attached to the concrete surface. The shape of the bond surface is either square or circular.

3.1.14
tab
plate made of fibre-reinforced polymer, aluminium, or any other suitable material bonded to the test piece to transmit loads from the testing machine to the test portion

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3.1.15
tensile capacity
maximum tensile load which the test piece bears during the tensile test

3.1.16
test block
block used to study the bond properties of FRP sheets

3.1.17
test portion
part of a test piece that is in between the anchoring portions and is subjected to testing

3.1.18
ultimate strain
strain corresponding to the tensile capacity

3.2 Symbols

For symbols used in this document, see Table 1.

Table 1 — Symbols

Symbol	Unit	Description	Reference
A	mm^2	Nominal cross-sectional area (general)	5.4
A_A	mm^2	Nominal cross-sectional area of type A test piece	5.4, 6.4
A_B	mm^2	Nominal cross-sectional area of type B test piece	5.4, 6.4
A_s	mm^2	Area of steel device	8.4
b_{av}	mm	Average width of FRP sheet	7.4
$b_{t,min}$	mm	Minimum width of test piece	5.4, 6.4
E_f	N/mm^2	Young's modulus	5.4, 7.4
f_{au}	N/mm^2	Bond strength	8.4
f_{fu}	N/mm^2	Tensile strength	5.4
$\overline{f}_{fu0}$	N/mm^2	Average value for tensile strength before treating, e.g. freezing and thawing or accelerated artificial exposure	9.4, 10.4
$\overline{f}_{fu1}$	N/mm^2	Average value for tensile strength after treating, e.g. freezing and thawing or accelerated artificial exposure	9.4, 10.4
f_{fus}	N/mm^2	Overlap splice strength	6.4
$\overline{f}_{fus0}$	N/mm^2	Average value for overlap splice strength before treating, e.g. freezing and thawing or accelerated artificial exposure	9.4, 10.4
$\overline{f}_{fus1}$	N/mm^2	Average value for overlap splice strength after treating, e.g. freezing and thawing or accelerated artificial exposure	9.4, 10.4
F_{au}	N	Maximum load	8.4
F_{last}	N	The load included in the last simultaneously recorded pair of values of the load and the strain when determining the ultimate strain	5.4.5
F_u	N	Tensile capacity	5.4, 6.4
G_f	N/mm	Interfacial fracture energy	7.4
L_{A1}	mm	Anchoring portion length	5.1.1
L_{A2}	mm	Anchorage thickness	5.1.1
L_{A3}	mm	Anchorage length	5.1.1
L_{end}	mm	Width at both ends	5.1.1
L_{ga}	mm	Gauge length	5.1.1
L_{th}	mm	Thickness	5.1.1
L_{tot}	mm	Total length	5.1.1

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Table 1 *(continued)*

Symbol	Unit	Description	Reference
l	mm	Effective bond length in test portion of FRP sheet	7.4
N_t	—	Number of fibre bundles in test piece	5.4
n	—	Number of plies of the sheet	7.4
n_u	strands/mm	Number of fibre bundles per unit area of the sheet	5.4
P_{max}	N	Maximum load	7.4
R_{ets}	%	Overlap splice strength retention	9.4
R_{ett}	%	Tensile strength retention	9.4
t	mm	Thickness of sheet, equal to $n \cdot \rho_S / \rho_{sh} \times 10^{-3}$	7.4
ΔF	N	Difference between loads at two points at 20 % and 50 % of tensile capacity	5.4
ρ_S	g/m^2	Fibre mass per unit area of dry sheet	5.4, 6.4, 7.4
ρ_{sh}	g/cm^3	Fiber density of dry sheet	5.4, 6.4, 7.4
ε_{last}	—	The strain included in the last simultaneously recorded pair of values of the load and the strain when determining the ultimate strain	5.4.5
ε_{fu}	—	Difference in strain between the two points used to calculate ΔF	5.4.5
$\Delta\varepsilon$	—	Ultimate strain	5.4
τ_u	N/mm^2	Bond strength	7.4

4 General provision concerning test pieces

Unless otherwise agreed upon, test pieces shall be taken from the sheet in the “as delivered” condition.

For the determination of the mechanical properties in the tensile, bond, and anchorage tests, the test piece may be artificially aged (after straightening, if applicable) depending on the performance requirements of the product.

When a test piece is “aged”, the conditions of the ageing treatment shall be stated in the test report.

5 Test method for determining tensile properties

5.1 Test pieces

5.1.1 Types and dimensions

Two types of test pieces may be used (see Figure 1 and Table 2):

a) Type A test pieces: Prepare type A test pieces in accordance with the method described in 6.1.2.1 and use them for the general tension test. The shape and the dimensions of type A test pieces are given in Figure 1 and Table 2, respectively.

b) Type B test pieces: Prepare type B test pieces in accordance with the method described in 6.1.2.2. These test pieces are suitable for FRP sheets in which the fibre bundles consist of a number of filaments that can be easily separated into individual bundles.

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