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

Part 3: CFRP strips

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

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.

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

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

Part 3: CFRP strips

1 Scope

This document specifies test methods applicable to unidirectional carbon fibre-reinforced polymer (CFRP) strips as external-bonded reinforcements on the concrete substrate.

This document is applicable for the CFRP strips that:

— consist of carbon fibre and thermoset resin;

— are manufactured by pultrusion method;

— have a higher carbon fibre fraction such as over 60 %; and

— have a thickness within 3 mm.

Also, the test pieces for determining tensile properties are cut down from CFRP strips along the CFRP strips axis, and have bonded anchorage block at the both ends.

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 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 10406-2:2015, *Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 2: FRP sheets*

3 Terms and definitions

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

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

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

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

3.1
accelerated artificial exposure testing machine
machine that creates reproducible standard test conditions to accelerate weathering artificially

3.2
anchorage block
tab (3.6) corresponding to the test block to prevent bond failure of the CFRP strips

3.3
anchorage portion
end parts of a test piece fitted with anchoring devices to transmit loads from the testing machine to the test portion

3.4
Young's modulus
E_f
elastic modulus in the direction of the fibres

3.5
strip
flat board which has thin thickness compared to width, a flatness-formed rectangular section and stretches in the longitudinal direction

3.6
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

3.7
tensile capacity
F_u
maximum tensile load which the test piece bears during the tensile test

3.8
tensile strength retention rate
R_{ett}
ratio of the tensile strength after accelerated artificial exposure compared with tensile strength before accelerated artificial exposure

4 Symbols

For the purposes of this document, the symbols presented in Table 1 apply.

Table 1 — Symbols

Symbol	Unit	Description	Reference
A	mm^2	Cross-sectional area	5.4.3, 5.4.4
D_{tab}	°	Tab bevel angle	5.1.1
E_f	N/mm^2	Young's modulus	5.4.4
f_{fu}	N/mm^2	Tensile strength	5.4.3
f_{fu0}	N/mm^2	Average value for tensile strength before accelerated artificial exposure	6.4.3
f_{fu1}	N/mm^2	Average value for tensile strength after accelerated artificial exposure	6.4.3
F_u	N	Tensile capacity	5.4.3
L_{A1}	mm	Anchorage length	5.1.1
t_A	mm	Anchorage thickness	5.1.1
L_{A2}	mm	Anchorage portion length	5.1.1
b_{test}	mm	Width at the range of the test length	5.1.1
L_{test}	mm	Test length	5.1.1
t_{test}	mm	Thickness	5.1.1
L_{tot}	mm	Total length	5.1.1
R_{ett}	%	Tensile strength retention rate	6.4.3
ΔF	N	Difference between loads at 2 points at 20 % to 50 % tensile capacity	5.4.4

Table 1 *(continued)*

Symbol	Unit	Description	Reference
$\Delta\varepsilon$	—	Difference between strains at 2 points at 20 % and 50 % tensile capacity	5.4.4

5 Test method for determining tensile properties

5.1 Test pieces

5.1.1 Dimensions

The shape and dimensions of test pieces are given in Figure 1 and Table 2. Test pieces shall be prepared in accordance with the method described in 5.1.2. In case the width of the CFRP strips is 10 mm or less, the width of the test piece shall be equal to the width of the CFRP strips.

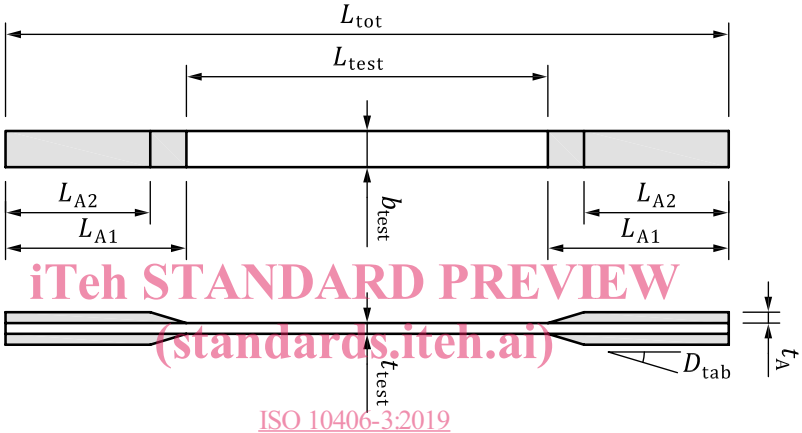


Figure 1 — Shape of the test piece

Table 2 — Dimensions of the test piece

Symbol		Dimensions of test piece mm
L_{tot}	Total length	≧200
b_{test}	Width at the range of the test length[1)]	10 to 15
t_{test}	Thickness	≦3
L_{test}	Test length	≧100
L_{A1}	Anchorage length	≧50
t_A	Anchorage thickness	0,5 to 2
L_{A2}	Anchorage portion length	≧50
D_{tab}	Tab bevel angle[2)]	5 to 90°

1) The width of the test piece can be selected to evaluate material characteristics stably and properly, using a test machine with a capacity of 100 kN or less.

2) Tab bevel angle is recommended to apply 90°.

5.1.2 Preparation

Test pieces shall be prepared using the following method.

a) Prepare plate cut to a predetermined length from the CFRP strips for tensile test.

b) Grind the substrate of anchorage portions of CFRP strips and anchorage block by sandpaper, sand blaster or equivalent.

c) Paste adhesive on the substrate of anchorage portions of CFRP strips and anchorage block. Also, adhesive shall have sufficient tensile shear bonding strength to keep tensile load during tensile test.

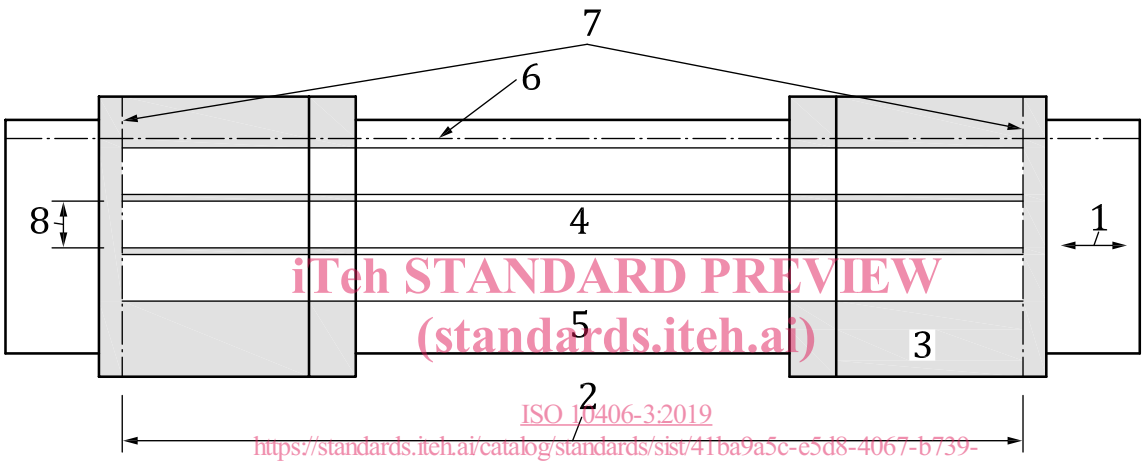
d) Bond and set up the anchorage to the anchorage portions to form the test pieces, and cure until adhesive hardens.

e) Draw a marking line along the CFRP strips axis at the position which is approximately 5 mm from edge of CFRP strips and marking lines on both ends of test pieces as shown in Figure 2.

f) Cut off along the markings.

g) Cut out test pieces in accordance with cutting accuracy described in 5.1.4.

h) Also, in case of using aluminium tab, tab shall be bonded after cutting out test pieces.



Key

1 direction of fibre axis
2 section used to prepare test piece: ≧200 mm
3 tab
4 test piece portion
5 CFRP strip
6 marking line along to CFRP strips axis
7 marking lines of both ends of test pieces
8 width of test piece

Figure 2 — Dimensions of plate used to prepare test pieces

5.1.3 Cutting equipment

Diamond blades or other equipment blades shall be used for cutting the test pieces.

5.1.4 Cutting accuracy for width of test piece

The cutting accuracy of the width of test pieces shall be within ±1 mm per 100 mm in axial direction.

5.1.5 Number of test pieces

Determine the number of test pieces suitable for the objective of the test. It shall be no fewer than five.

5.2 Testing machine and measuring devices

5.2.1 Testing machine

The testing machine shall conform to ISO 7500-1. The testing machine shall have a loading capacity in excess of the tensile capacity of the test piece and shall be capable of applying loading at the required loading rate.

5.2.2 Strain gauges/extensometers

a) Strain gauges/extensometers used to measure the elongation of the test piece under loading should be capable of recording all variations in the test length or elongation during testing with a strain measurement accuracy of at least 10×10^{-6}.

b) When sanding is used to mount strain gauges on the surface of the test pieces, it shall be ensured that this does not damage the test pieces.

5.3 Test method

5.3.1 Dimensions of test pieces

Measure the width and thickness of the test portion of the test pieces. The width and thickness of the test piece shall be determined as the minimum value of at least three readings taking from different locations at the range of the test length on the test piece. Measurements shall be taken to an accuracy of 0,01 mm.

5.3.2 Mounting of strain gauges/extensometers

Mount the strain gauges/extensometers at the centre of the test portion of the test piece to determine the Young's modulus.

5.3.3 Mounting of test piece

Mount the test piece in such a way that the long axis of the test piece coincides with the centreline between the two chucks.

5.3.4 Loading rate

The standard loading rate shall be a constant strain rate equivalent to 1 %/min to 3 %/min strain with reference to the test length.

5.3.5 Test temperature

In principle, conduct the test in the same atmosphere used for conditioning the test piece, unless otherwise agreed by the interested parties (e.g. for testing at elevated or low temperature).

5.3.6 Range of test

Perform the loading test until tensile failure and record the measurement of loads and strain continuously or at regular intervals at least up to two third of tensile capacity.

5.4 Calculation and expression of test results

5.4.1 General

Results obtained from the test pieces fractured by explosive failure or splitting failure (see Table 3) can be used. The test results from test pieces that show tensile failure or slippage at the anchorage portion