
**Fibre-reinforced polymer (FRP)
reinforcement for concrete
structures — Specifications of FRP
sheets**

*Polymère renforcé par des fibres (PRF) pour l'armature du béton —
Spécifications des feuilles en PRF*

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#).

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 6, *Non-traditional reinforcing materials for concrete structures*.

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Fibre-reinforced polymer (FRP) reinforcement for concrete structures — Specifications of FRP sheets

1 Scope

This International Standard specifies requirements for fibre-reinforced polymer (FRP) sheets for upgrading of concrete members. The methodologies to express the mechanical properties as characteristic values, appearance and dimensions, and sampling test are specified in this International Standard. The properties for design are calculated from the characteristic values, as prescribed in an appropriate design code which is in accordance with ISO 14484. The fibre orientation of the FRP sheets covered by this International Standard is unidirectional.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 10406-2, *Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 2: FRP sheets*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10406-2 and the following apply.

3.1

dry sheet

fibres in sheet form including sizing agent and weft, before application of the saturating resin matrix

3.2

sizing agent

any material applied to fibres to facilitate the handling and use of the fibres

Note 1 to entry: 'Sizing agent' is synonymous with 'size' which is described in ISO 10548.

3.3

weft

thread to shape bundles in sheet form

4 Symbols

See [Table 1](#).

Table 1 — Symbols

Symbol	Unit	Description	Reference
t	mm	nominal thickness	6.2.2
ρ_s	g/m ²	fibre mass per unit area	6.2.2
ρ_{sh}	g/cm ³	density	6.2.2

5 Mechanical properties

5.1 General

The mechanical properties of FRP sheet shall be expressed by the characteristic values of tensile strength, Young's modulus, and ultimate strain. The tests shall be conducted in accordance with [Clause 6](#).

5.2 Characteristic value of tensile strength

Characteristic value of tensile strength shall be determined by subtracting three times the standard deviation from the mean strength. The definitions of the standard deviation and mean strength are provided in ISO 10406-2.

5.3 Characteristic value of Young's modulus

Characteristic value of Young's modulus shall be the mean value, the definition of which is provided in ISO 10406-2.

5.4 Characteristic value of ultimate strain

Characteristic value of ultimate strain shall be determined by the characteristic value of tensile strength divided by the characteristic value of Young's modulus.

6 Appearance and dimensions

6.1 Appearance

The dry sheet shall have a smooth surface without folds and/or remarkable waves by visual inspection. There shall be no remarkable breakage of fibres through whole bundles.

6.2 Dimensions

6.2.1 Length and width

The length and width of the dry sheet shall be agreed upon between interested parties.

6.2.2 Nominal thickness

The nominal thickness, t , of the dry sheet shall be calculated using Formula (1).

$$t = \frac{\rho_s}{\rho_{sh}} \times 10^{-3} \quad (1)$$

where

ρ_s is the fibre mass per unit area of dry sheet, determined by [Annex A](#), expressed in grams per square metres;

NOTE The nominal fibre mass per unit area provided by the material manufacturer can be used.

ρ_{sh} is the density of dry sheet, expressed in grams per cubic centimetres.

NOTE The nominal density provided by the material manufacturer can be used.

7 Sampling test

7.1 Sampling

The number of test pieces for initial testing shall be no fewer than 20. The number of test pieces for periodic inspection shall be no fewer than five.

7.2 Appearance

Defects and their distribution shall be evaluated by inspecting the dry sheet illuminated by daylight or by a daylight-type fluorescent lamp with a colour temperature of $6\,500\text{ K} \pm 650\text{ K}$ and a power rating of not less than 40 W.

7.3 Dimensions

7.3.1 Conditions of measurement

Measurements of dimensions shall be made at room temperature, except that, in cases of dispute, measurements shall be made under standard conditions, as specified in ISO 291. The temperature of $27\text{ °C} \pm 2\text{ °C}$ and the humidity of $65\% \pm 5\%$ is also applicable for warm countries. For measurements made in ambient conditions, due allowance shall be made to dimensional changes with consideration of the differences in temperature and relative humidity at different test locations.

7.3.2 Width

The width shall be measured with a precision of 1 mm.

7.4 Tensile test

The tensile test shall be conducted in accordance with ISO 10406-2.

Annex A (normative)

Determination of fibre mass per unit area of dry sheet

A.1 Apparatus

- a) **Metal rule**, which has a minimum graduation of 1 mm or less.
- b) **Die**, which can cut off a square specimen of 100 mm ± 0,5 mm in one side length from the dry sheet shall be used, unless a specimen with an equivalent area is available.
- c) **Balance**, with a precision of 0,001 g or above.

A.2 Procedure

- a) Square specimens of 100 mm ± 0,5 mm shall be cut off from the dry sheet. The edge parts of the sheet (30 mm from the edges) shall not be used since they might contain ears. The number of specimens shall be determined according to the objectives of the test, but at least three specimens are required.
- b) The mass of each specimen shall be measured with a precision of 0,001 g.
- c) Fibre mass of the dry sheet shall be determined with sizing agent and weft removed. If the content of the sizing agent is less than 0,5 % in mass fraction, its mass can be ignored. Also, if the content of the weft is less than 0,5 % in mass fraction, its mass can be ignored.

A.3 Calculation

The fibre mass per unit area of the dry sheet shall be calculated using Formula (A.1).

$$\rho_s = \frac{m - m_w}{A} \cdot \left(1 - \frac{S_C}{100}\right) \times 10^6 \quad (\text{A.1})$$

where

ρ_s is the fibre mass per unit area of dry sheet, expressed in grams per square metres;

m is the mass of the specimen, expressed in grams;

m_w is the mass of the weft of the specimen, expressed in grams;

A is the area of the specimen, expressed in square millimetres;

S_C is the content of sizing agent, mass of the sizing agent expressed as a percentage of the sized fibre yarn.

The results shall be rounded off with a precision of three significant digits in accordance with ISO 5725. When the moisture absorption of the fibre is a concern, fibre mass shall be corrected by measuring the moisture absorption of the fibre. The content of sizing agent should be determined in accordance with ISO 10548.

A.4 Test report

The test report shall include the following:

- a) the results of the individual determinations (as indicated in [A.3](#)) and their mean value;
- b) any other changes in appearance of the specimens.

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