

English Version

Precast concrete products - Classification of glassfibre reinforced concrete performance

Produits préfabriqués en béton - Classification des performances des composites ciment-verre

Betonfertigteile - Klassifizierung der Leistungseigenschaften von Glasfaserbeton

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European foreword

This document (EN 15191:2024) has been prepared by Technical Committee CEN/TC 229 “Precast Concrete Products”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2025, and conflicting national standards shall be withdrawn at the latest by June 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 15191:2009.

EN 15191:2024 includes the following significant technical changes with respect to EN 15191:2009:

- a) typical composition and performance moved to an informative annex;
- b) introduction of a criterion on the ratio between the bending stress at limit of proportionality and the bending stress at modulus of rupture;
- c) update and simplification of the table of characteristic values for the classification of GRC;
- d) modification of the provisions related to the application specific parameters, with the introduction of default values.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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1 Scope

This document deals with the classification of glassfibre reinforced concrete. This classification conforms to the needs of the design process of glassfibre reinforced concrete components. This document applies only if EN 1169 is followed.

This document does not deal with design methods.

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.

EN 1170, *Precast concrete products — Test methods for glassfibre reinforced concrete*

EN 14649:2005, *Precast concrete products — Test method for strength retention of glass fibres in cement and concrete*

EN 15422, *Precast concrete products - Specification of glassfibres for reinforcement of mortars and concretes*

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 Terms and definitions

3.1.1

additive

product that may be added to the matrix composition to improve some properties

Note 1 to entry: It can be reactive (e.g. silica fumes) or inert, mineral or organic (e.g. polymer dispersions).

Note 2 to entry: inorganic additives are called additions in EN 206:2013.

3.1.2

admixture

constituent added during the mixing process in small quantities related to the mass of cement to modify the properties of fresh or hardened concrete

[SOURCE: EN 206:2013]

3.1.3

strand

glassfibre reinforcement element formed by binding together individual filaments of a nominal diameter between 10 µm to 30 µm

3.1.4

glassfibre reinforced concrete

GRC

composite material consisting of a matrix of hydraulic binder reinforced with glassfibres usually randomly distributed throughout the matrix, these materials being compatible

3.1.5

matrix

part of GRC which does not contain AR glassfibres, normally composed of sand, cement, water and additives and admixtures when used

3.1.6

process with oriented fibres

process whereby chopped strands or roving of glassfibre are placed in the matrix in a defined direction

3.1.7

SIC test

test method for strength retention of glassfibres in cement and concrete

3.1.8

characteristic value

value of a property corresponding to a given fractile above which the population of all possible measurements of that property are expected to lie

3.1.9

acceptance test

test carried out on a predetermined regular basis to confirm that batches of product conform to specification

3.1.10

initial type testing

complete set of tests or other procedures described in the technical specification, to determine the performance of samples of products representative of the product type for the characteristics

3.1.11

cement

hydraulic binder

finely ground inorganic material which, when mixed with water, forms a paste that sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water

[SOURCE: EN 206:2013, modified with the addition of the term hydraulic binder as synonym]

3.1.12

sand

granular mineral material of low granular class suitable for use in concrete

Note 1 to entry: Sands can be natural or artificial.

3.2 Symbols and abbreviated terms

AR alkali resistant

GRC	glassfibre reinforced concrete
LOP	limit of proportionality
MOR	modulus of rupture
SIC	strand in cement
$L_{\sigma\text{MOR}}$	application factor of resistance related to the control performance (28-day-value)
ϵ_{LOP}	strain at limit of proportionality
ϵ_{MOR}	strain at failure
σ_{LOP}	stress at limit of proportionality, in megapascals
σ_{MOR}	stress at failure, in megapascals

4 Properties of glassfibre reinforced concrete

4.1 Characteristics of composite material

Glassfibre reinforced concrete is a composite material for which the glassfibre has the function of a reinforcement for the cementitious matrix.

The properties of the composite material as manufactured depend on:

- a) the properties of the matrix as base;
- b) the properties, geometry, quantity and orientation of the glassfibre as reinforcement;
- c) the bond between matrix and glassfibre;
- d) the manufacturing processes;
- e) the conditions and the treatments during production (curing).

The mechanical properties of GRC depend on the mix design and shall be consistent with the product requirements.

4.2 GRC with oriented fibres

Processes using oriented fibres may result in mechanical properties that differ from the above. The achievable properties depend on the following factors:

- a) geometry of the product;
- b) direction of the oriented fibres;
- c) position and cross section of the oriented fibres in the product.

In case of oriented fibres, the position of the test pieces in the test according to EN 1170 is defined by the orientation of the fibres. In this case the classification of GRC is related to the direction of the fibre in the test.

5 Classification of GRC

5.1 Classification according to mechanical properties

Glassfibre reinforced concrete shall be classified in accordance with this document on the basis of its material specific properties σ_{LOP} and σ_{MOR} . The values of σ_{LOP} and σ_{MOR} shall be determined in accordance with EN 1170. See Figure 1.

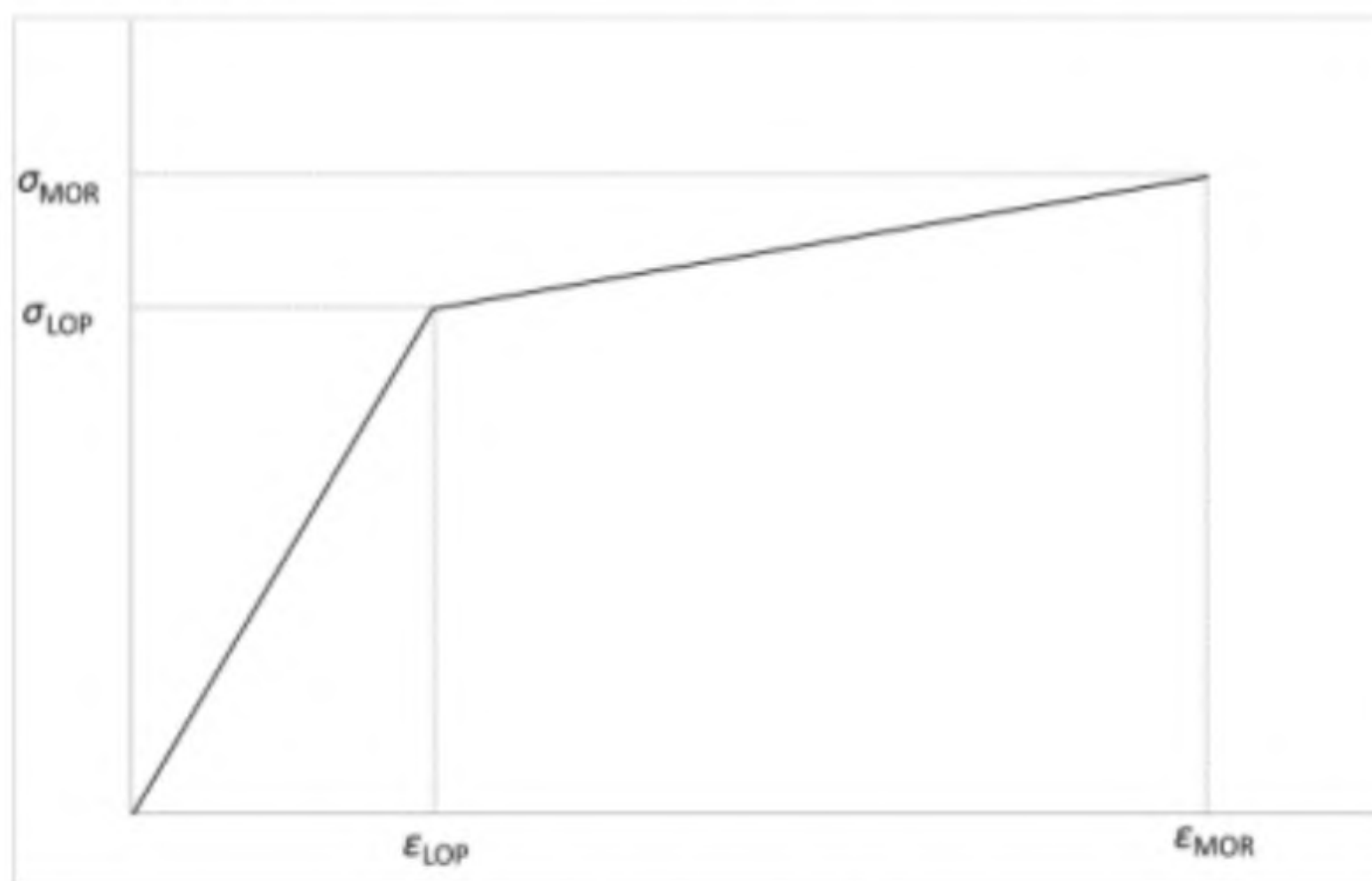


Figure 1 — Stress - strain diagram

5.2 Material classes

5.2.1 Classification parameters

The material class of GRC is defined on the basis of the following characteristic values:

- Bending stress at limit of proportionality (σ_{LOP});
- Bending stress at modulus of rupture (σ_{MOR}).

The criteria of the following formulae shall be satisfied:

$$\sigma_{\text{MOR}} \geq 1,2 \times \sigma_{\text{LOP}} \quad (1)$$

$$\varepsilon_{\text{MOR}} \geq 1,2 \times \varepsilon_{\text{LOP}} \quad (2)$$

The general ranges of these characteristic values are given in Table 1:

Table 1 — Range of characteristic values for the classification of GRC

class	6/8	7/10	7/12	7/14	7/16	7/18
σ_{LOP}	6	7	7	7	7	7
σ_{MOR}	8	10	12	14	16	18

Other classes may be agreed provided they are based on the same criteria for characteristic values.

5.2.2 Specification of the parameters

The characteristic values correspond to the 5 % fractile values (probability of 95 % to be above the corresponding value) with a confidence level of 75 %. The values are related to test performed on specimens at the age of 28 days.

The characteristic values (f_c) defined by the producer refer to his production control system. The values are obtained by statistical analysis of the test results in accordance with the equation $f_c = f - k \cdot s$ (see Formulae (3) and (4)).

with

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2}, \text{ standard deviation;} \quad (3)$$

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i, \text{ arithmetic mean value.} \quad (4)$$

The values of k for the fractile 5 % and for a confidence level of 75 %, when the population standard deviation s is known, for n individual results, are given in Table 2.

Table 2 — Coefficients k for estimation of the fractile when the standard deviation s is known

n	3	4	5	6	10	20	40	100
k	2,03	1,99	1,95	1,92	1,86	1,79	1,75	1,71

[SOURCE: ISO 12491:1997]

Examples of GRC denomination:

- GRC 7/18 corresponding to $\sigma_{\text{LOP}} = 7 \text{ MPa}$ and $\sigma_{\text{MOR}} = 18 \text{ MPa}$,
- GRC 7/10 corresponding to $\sigma_{\text{LOP}} = 7 \text{ MPa}$ and $\sigma_{\text{MOR}} = 10 \text{ MPa}$.

5.3 Application specific parameter

5.3.1 General

Application specific parameters depend on the conditions to which the GRC components will be exposed.

With the application specific parameter $L_{\sigma\text{MOR}}$ the long-term exposure to natural weathering is considered.

5.3.2 Test methods

In case no long-term data are available, the long-term exposure to natural weathering can be considered in accordance with EN 1170:2024, Annex C: Cyclic ageing type test.

5.3.3 Application specific value in case of exposure to natural weathering

In case no data according 5.3.1 is available, the minimum value of $L_{\sigma\text{MOR}}$ is specified in Table 3.

Table 3— Minimum value of $L_{\sigma\text{MOR}}$

class	6/8	7/10	7/12	7/14	7/16	7/18
σ_{LOP} (MPa)	6	7	7	7	7	7
σ_{MOR} (MPa)	8	10	12	14	16	18
$L_{\sigma\text{MOR}}$	0,75	0,7	0,7	0,6	0,6	0,6

6 Special properties

When further requirements in addition to the materials and application specific requirements of this document, are made on GRC or a component made thereof, e.g.:

- a) resistance to fire;
- b) resistance to frost;
- c) impermeability to water.

An appropriate proof shall be made, as well as in case of other special requirements.

7 Requirements of glassfibre

The glassfibre properties shall be assessed in accordance with EN 15422.

The test method for strength retention of glassfibre in cement and concrete (SIC test) is defined in EN 14649.

The strength retention by strand (SIC) of the glassfibre shall be Category B as defined in EN 14649:2005.

Bibliography

- [1] EN 206:2013, *Concrete — Specification, performance, production and conformity*
- [2] ISO 12491:1997, *Statistical methods for quality control of building materials and components*
- [3] EN 1169, *Precast concrete products - General rules for factory production control of glass-fibre reinforced cement*