SLOVENSKI STANDARD

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Preskusne metode za ugotavljanje prispevka k požarni odpornosti konstrukcijskih elementov - 3. del: Zaščita betonskih elementov

Test methods for determining the contribution to the fire resistance of structural members - Part 3: applied protection to concrete members

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 3: Brandschutzmaßnahmen für Betonbauteile

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 3: Protection appliquée aux éléments en béton

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13.220.50	Požarna odpornost gradbenih materialov in elementov	Fire-resistance of building materials and elements
91.080.40	Betonske konstrukcije	Concrete structures

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EUROPEAN STANDARD

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English Version

Test methods for determining the contribution to the fire resistance of structural members - Part 3: Applied protection to concrete members

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 3: Protection appliquée aux éléments en béton

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This European Standard was approved by CEN on 8 November 2014.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 13381-3:2015) has been prepared by Technical Committee CEN/TC 127 “Fire safety in buildings”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by October 2015 and conflicting national standards shall be withdrawn at the latest by October 2015.

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

This document supersedes ENV 13381-3:2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of 89/106/EEC.

The dimension tolerances regarding the manufacturing of the specimen indicated in the ENV 13381-3:2002 led to tensile stress values of 290 +/- 30 N/mm² in the reinforcement bars depending on the type of structural member. In order to harmonize the mechanical constraint applied on the structural member, the bending moment has been modified to produce the same tensile stress on reinforcement bars equal to 300 N/mm². This value is corresponding to 60 % of the grade of the steel to be used. Due to this approach, the result of tests carried out according to ENV 13381-3:2002 can be taken into account for assessment according to the present document.

In comparison with ENV 13381-3:2002, the following significant changes have been made:

— the bending moment has been modified to be adapted to the thickness of the slab;

— the location of thermocouple used within beams for the calculation of equivalent thickness of concrete is now at 25 mm away from the beam bottom corner instead of 55 mm;

— the graphs to be used for the determination of equivalent concrete thickness for slabs has been improved and extended and is directly available in the standard.

This European Standard is one of a series of standards for evaluating the contribution to the fire resistance of structural members by applied fire protection materials. The other parts of this standard are:

— *Part 1: Horizontal protective membranes*

— *Part 2: Vertical protective membranes*

— *Part 4: Applied protection to steel members*

— *Part 5: Applied protection to concrete/profiled sheet steel composite members*

— *Part 6: Applied protection to concrete filled hollow steel columns*

— *Part 7: Applied protection to timber members*

— *Part 8: Applied reactive protection to steel members*

Annexes A, B and C are normative.

Caution: The attention of all persons concerned with managing and carrying out this fire resistance test is drawn to the fact that fire testing can be hazardous and that there is a possibility that toxic and/or harmful smoke and gases can be evolved during the test. Mechanical and operational hazards can also arise during the construction of test elements or structures, their testing and the disposal of test residues.

An assessment of all potential hazards and risks to health should be made and safety precautions should be identified and provided. Written safety instructions should be issued. Appropriate training should be given to relevant personnel. Laboratory personnel should ensure that they follow written safety instructions at all times.

The specific health and safety instructions contained within this standard should be followed.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies a test method for determining the contribution of fire protection systems to the fire resistance of structural concrete members, for instance slabs, floors, roofs and walls and which can include integral beams and columns. The concrete can be lightweight, normal weight or heavyweight concrete and of all strength classes (e.g. 20/25 to 50/60 for normal strength concrete and for high strength concrete 55/67 to 90/105). The member is to contain steel reinforcing bars.

The test method is applicable to all fire protection materials used for the protection of concrete members and includes sprayed materials, reactive coatings, cladding protection systems and multi-layer or composite fire protection materials, with or without a gap between the fire protection material and the concrete member

This European Standard specifies the tests which are to be carried out to determine the ability of the fire protection material to remain coherent and fixed to the concrete and to provide data on the temperature distribution throughout the protected concrete member, when exposed to the standard temperature time curve.

In special circumstances, where specified in national building regulations, there can be a need to subject the protection material to a smouldering curve. The test for this and the special circumstances for its use are detailed in Annex A.

The fire test methodology makes provision for the collection and presentation of data which can be used as direct input to the calculation of fire resistance of concrete members in accordance with the procedures given in EN 1992-1-2.

This European Standard also contains the assessment which prescribes how the analysis of the test data is to be made and gives guidance to the procedures by which interpolation is to be undertaken.

The limits of applicability of the results of the assessment arising from the fire test are defined together with permitted direct application of the results to different concrete structures, densities, strengths, thicknesses and production techniques over the range of thicknesses of the applied fire protection system tested.

The test method, the test results and the assessment method are not applicable to structural hollow concrete members.

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.

EN 206, *Concrete - Specification, performance, production and conformity*

EN 823, *Thermal insulating products for building applications - Determination of thickness*

EN 1363-1, *Fire resistance tests - Part 1: General Requirements*

EN 1363-2, *Fire resistance tests - Part 2: Alternative and additional procedures*

EN 1992-1-1, *Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings*

EN 1992-1-2, *Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design*

EN 10080, *Steel for the reinforcement of concrete - Weldable reinforcing steel - General*

EN 12467, *Fibre-cement flat sheets - Product specification and test methods*

EN ISO 13943, *Fire safety - Vocabulary (ISO 13943)*

ISO 8421-2, *Fire protection - Vocabulary - Part 2: Structural fire protection*

3 Terms and definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1363-1, EN ISO 13943, ISO 8421-2 and EN 206 and the following apply.

3.1.1
concrete member
element of building construction which is loadbearing and is fabricated from concrete, defined according to EN 206 and shall contain steel reinforcing bars

3.1.2
fire protection material
material or combination of materials applied to the surface of a concrete member for the purpose of increasing its fire resistance

3.1.3
passive fire protection materials
materials which do not change their physical form upon heating and which provide fire protection by virtue of their physical or thermal properties and may include materials containing water which, on heating, evaporates to produce cooling effects

3.1.4
reactive fire protection materials
materials which are specifically formulated to provide a chemical reaction upon heating such that their physical form changes and in so doing provide fire protection by thermal insulation and cooling effects

3.1.5
fire protection system
fire protection material together with a prescribed method of attachment to the concrete member

3.1.6
fire protection
protection afforded to the concrete member by the fire protection system such that the temperature throughout the depth of the structural member and upon any steel reinforcing bars within it is limited throughout the period of exposure to fire

3.1.7
test specimen
concrete slab or beam test member plus the fire protection system under test

3.1.8
fire protection thickness
thickness of a single layer fire protection system or the combined thickness of all layers of a multilayer fire protection system, excluding the width or height of supporting profiles, clips and other fixings

3.1.9
stickability
ability of a fire protection material to remain sufficiently coherent and in position for a well defined range of deformations, furnace and test specimen surface temperatures, such that its ability to provide fire protection is not significantly impaired

3.1.10
critical temperature
temperature at which failure is expected to occur in steel reinforcement within the concrete at a given load level

3.1.11
lathing
mechanical fixing aids comprising non-combustible wires or similar constructions fixed to the concrete before sprayed fire protection material is applied

3.1.12
adhesive bond promoter
material applied to the surface of the concrete, prior to application of the fire protection material, for promotion of increased bonding

3.1.13
equivalent thickness of concrete
theoretical thickness of concrete which provides the same thermal insulation for a given period of test as does the given thickness of the applied fire protection system

Note 1 to entry: Care shall be taken to ensure when using "equivalent thickness" that in the practical situation the concrete thickness will not be reduced by spalling, etc.

3.1.14
characteristic temperature

average of the mean temperature and the maximum individual temperature [(mean + maximum)/2] for each thermocouple group at equivalent location defined in 9.3.4

3.2 Symbols and units

Symbol	Unit	Designation
L_{exp}	mm	Length of the test specimen exposed to the furnace
L_{sup}	mm	Centre to centre distance between the test specimen supports
L_{spec}	mm	Total length of the test specimen
W_{exp}	mm	Width of the test specimen exposed to the furnace
h	mm	Thickness of concrete slab or height of concrete beam specimen
l_{sup}	mm	Distance of loading points from the specimen support points
P	kN	Loading applied to the slab or beam test specimen
θ	°C	Characteristic temperature
θ_{crit}	°C	Critical temperature as specified in EN 1992-1-2
d	mm	Depth in concrete
d_{θ}	mm	Depth in concrete at which chosen θ_{crit} is noted
d_p	mm	Thickness of fire protection material: $d_{p(min)}$ is minimum thickness and $d_{p(max)}$ is maximum applied thickness of fire protection material
$\Delta\theta_{CL}$	°C	Temperature rise, as a function of time

d_{cc}	mm	Depth in unprotected concrete slab at which $\Delta\theta_{CL}$ is noted [used in Annex C]
d_{cp}	mm	Depth in protected concrete at which temperature rise $\Delta\theta(d_{cp},t)$ is measured at time t
$\Delta\theta(d_{cp,}t)$	°C	Temperature rise measured in protected concrete at measured depth d_{cp}
f_y	N/mm^2	Yield strength of steel as defined in EN 10080
ε	mm	Equivalent concrete thickness

4 Test equipment

4.1 General

The furnace and test equipment shall be as specified in EN 1363-1.

4.2 Furnace

The furnace shall be designed to permit the dimensions of the test specimen to be exposed to heating to be as specified in 6.2 and its installation to be as specified in Clause 7.

4.3 Loading equipment

Loading shall be applied according to EN 1363-1. The loading system shall permit loading, of the magnitude defined in 5.3, to be applied along the length and width of the test specimen.

The loading equipment shall not inhibit the free movement of air above the test specimen and no part of the loading equipment, other than at the loading points, shall be closer than 60 mm to the unexposed surface of the test specimen.

5 Test conditions

5.1 General

Test specimens, subjected to predefined loading, are heated upon a furnace in horizontal orientation to provide information on each of the following:

— the temperature distribution within the concrete test member;

— the behaviour of the fire protection system and its stickability;

— the behaviour of the test specimen with respect to specified performance criteria.

It is recommended that the test be continued until the mean temperature upon the main reinforcing bars within the concrete reaches 700 °C, or any single maximum value of 750 °C is recorded, to give the necessary information on the stickability of the fire protection system. However, these temperatures may be modified if requested by the sponsor, with possible consequences on the application field.

If the recommended termination temperatures are not reached after 6 hours test duration, the test shall normally be terminated.

The procedures given in EN 1363-1 and, if applicable, EN 1363-2, shall be followed in the performance of this test method unless specific contrary instruction is given herein.

5.2 Support and restraint conditions

5.2.1 Standard support and restraint conditions

Concrete slab test specimens shall be tested as a simply supported one way structure with two free edges and an exposed surface and span as defined in 6.2.

Concrete beam test specimens shall be tested simply supported. The test arrangement shall provide lateral stability.

The concrete slab or beam test member shall be installed onto the furnace to allow freedom for longitudinal movement and deformation using at one side rolling support(s) and at the other hinge support(s).

The surface of the bearings shall be smooth concrete or steel plates. The width of the bearings shall be the minimum representative of practice.

5.2.2 Other support and restraint conditions

If the support and restraint conditions differ from the standard conditions specified in 5.2.1, these conditions shall be described in the test report and the validity of the test results shall be restricted to those tested.

5.3 Loading conditions

Loading shall be applied to all test specimens.

The magnitude and distribution of the load (P) applied to the specimen shall be calculated taking into account the dead-weight of the specimen (measured or derived by calculation from samples of the components, see 6.5.1) and the weight of load distribution beams or plates, as follows.

The bending moments produced at mid-span of the specimens shall be calculated according to the formula in Annex D, in order to produce a tensile stress in the lower reinforcement bars of the standard concrete test structures equal to 300 MPa.

For concrete slab test specimens the line load shall be symmetrically applied to the test specimen along two transverse loading lines, each one at a distance (l_{sup}) from each of the supports. The proportion of the total load applied at each loading position shall be as specified in Figure 1 (small slab test specimen) and Figure 2 (large slab test specimen). The load shall produce stresses approximating to a uniformly distributed load on the transverse loading lines.

For concrete beam test specimens the line load shall be symmetrically applied to the test specimen by a two point loading system, each one at a distance (l_{sup}) from each of the supports. The proportion of the total load applied at each loading position shall be as specified in Figure 3. The load shall produce stresses approximating to a uniformly distributed load on the transverse loading line.

Point loads shall be transferred to the test specimen through load distribution beams or plates (Figures 1, 2 and 3).

The total contact area between these and the concrete surface of the test specimen shall be as specified in EN 1363-1, provided that the load distribution beam or plate chosen has a flexural rigidity large enough to give the required distribution of the load.

Load distribution beams, for safety reasons, shall have a height to width ratio of < 1.

If the load distribution beams or plates are of steel or other high conductivity material, they shall be insulated from the surface of the concrete test specimen by a suitable thermal insulation material.

Unexposed surface thermocouples shall not be closer than 100 mm to any part of the load distribution system as shown in Figures 1, 2 and 3.

6 Test specimens

6.1 Type and number of test specimens

6.1.1 Type of test specimens

The type of concrete test member used is determined by the type and practical situation to which the fire protection system is to be used, i.e.:

a) fire protection systems to be used on flat, two dimensional concrete members only, such as slabs and walls, are evaluated by carrying out the test on large concrete slabs;

b) fire protection systems to be used on beams and columns only, and subject to three and four sided exposure, are evaluated by carrying out the test on concrete beams;

c) fire protection systems to be used on slabs, walls, beams and columns are evaluated by carrying out the test on both concrete slabs and beams according to a) and b) above;

d) tests may be carried out, in addition to the large scale tests, on loaded small concrete test slabs to provide additional test results for the fire protection system when:

1) it is to be applied to concrete of higher strength classes to evaluate the spalling behaviour;

2) the test is carried out to the smouldering curve (Annex A).

Test of intermediate thickness of protection system shall be performed on a loaded large specimen (beam and/or slab) to get representative behaviour of the protection product, especially regarding the stickability and influence of the deformation of the slab or beam on the thermal data.

6.1.2 Number of test specimens

Two full size loaded concrete members (either slabs or beams depending upon the end use as specified in 6.1.1 a) and 6.1.1 b) of the same concrete strength shall be tested.

To one member the minimum thickness of the fire protection system shall be applied and to the other member the maximum thickness. If the fire protection system is only available in a single thickness, then one test on one type of member only shall be carried out at that thickness.

In addition to the mandatory full size tests, following possibilities are available:

— An additional full size slab or beam may be tested with an intermediate thickness of the protection system;

NOTE Such additional test could extend the application field, for instance to get a better result than the direct interpolation method for equivalent concrete thickness, as given in Annex C.

To obtain further data, as defined in 6.1.1 d) loaded small size slab tests may be carried out:

— One such test shall be carried out with a specific thickness of the fire protection system requested by the sponsor to cover in the application field a higher concrete strength (see Clause 15);

— The use of the small slab in the smouldering fire is given in Annex A.

6.2 Size of test specimens

6.2.1 Concrete slabs

The concrete test slabs shall be of the sizes specified in Table 1 and an example is given in Figure 1 (small specimen) and Figure 2 (large specimen).

Table 1 — Sizes of concrete test slabs

	small specimen	large specimen
Exposed length (mm) L_{exp}	≥ 1 300 and ≤ 2 300	4 000 minimum
Span (mm) L_{sup}	≥ 1 500 and ≤ 2 700 $(L_{exp}+200) \leq L_{sup} \leq (L_{exp}+400)$ [note]	4 200 minimum $(L_{exp}+200) \leq L_{sup} \leq (L_{exp}+500)$ [note]
Specimen length (mm) L_{spec}	≥ 1 700 and ≤ 3 000 $(L_{exp}+400) \leq L_{spec} \leq (L_{exp}+700)$	4 400 minimum $(L_{exp}+400) \leq L_{spec} \leq (L_{exp}+700)$
Exposed width (mm) W_{exp}	≥1 000 and ≤2 000	≥ 3 000
Thickness (mm) h	(140 -20/+10) for higher strength class of concrete however the concrete thickness and the load shall be adjusted so that the tensile stress in the reinforcement bars is at least 300 N/mm² calculated in accordance with Annex D by updating parameter n to take into account the features of the high strength concrete.	(140 -20/+10)
Position of loading points from support points (mm)	(600 ± 10)	(1 000 ± 10)
The distance between the exposed part of the test specimen and the supports shall be kept as small as possible. For tests of short duration (less than 240 minutes), a distance of 100 mm at either end is recommended. For tests of longer duration, this could be increased to 250 mm at either end, to protect the test equipment from heat damage.		

6.2.2 Concrete beams

The concrete test beams shall be of a size such that an overall exposed length (L_{exp}) not less than 4 000 mm is obtained.

The span (L_{sup}) shall not be greater than the exposed length by more than 250 mm at each end.

The total specimen length (L_{spec}) shall be not greater than the exposed length by more than 350 mm at each end.

The beam shall be of height (450 ± 10) mm and width (150 ± 10) mm.