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

Méthode 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
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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

This European Prestandard (ENV) was approved by CEN on 1 March 2002 as a prospective standard for provisional application.

The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard.

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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Foreword

This document ENV 13381-3:2002 has been prepared by Technical Committee CEN/TC127 "Fire safety in buildings", the secretariat of which is held by BSI.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

As there was little experience in carrying out these tests in Europe CEN/TC127 agreed that more experience should be built up during a prestandardization period before agreeing text as European Standards. Consequently all parts are being prepared as European Prestandards.

This European Prestandard is one of a series of standards for evaluating the contribution to the fire resistance of structural members by applied fire protection materials. Other parts of this ENV 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.

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 prestandard should be followed.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This part of this European Prestandard 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, normalweight or heavyweight concrete and of strength classes 20/25 (LC/C/HC) to 50/60 (LC/C/HC). The member can 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, coatings, cladding protection systems and multi-layer or composite fire protection materials, when the gap between the fire protection material and the concrete member is less than 5 mm. Otherwise the test methods in prENV 13381-1 or ENV 13381-2, as appropriate, apply.

This European Prestandard contains the fire test which specifies the tests which should 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 ENV 1992-1-2.

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

2 Normative references

This European Prestandard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1363-1	Fire resistance tests - Part 1: General requirements.
EN 1363-2	Fire resistance tests - Part 2: Alternative and additional procedures.
ENV 10080	Steel for the reinforcement of concrete - Weldable ribbed reinforcing steel B 500 - Technical delivery conditions for bars, coils and welded fabric.
EN 206-1	Concrete - Part 1: Specification, performance, production and conformity.
ENV 1992-1-1	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings.
ENV 1992-1-2	Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design.

ISO 8421-2 Fire protection - Vocabulary - Part 2: Structural fire protection.

EN ISO 13943 Fire safety - Vocabulary (ISO 13943:1999).

3 Terms and definitions, symbols and units

3.1 Terms and definitions

For the purposes of this European Prestandard, the terms and definitions given in EN 1363-1, EN ISO 13943, ISO 8421-2 and EN 206-1, 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 206-1. It may 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. They 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 insulative 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

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 Care should be taken to ensure when using "equivalent thickness" that in the practical situation the concrete thickness will not be reduced by spalling etc.

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_{crit}	°C	Critical temperature as specified in ENV 1992-1-2
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 $dp_{(max)}$ 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
$\Delta\theta_{(dcp,t)}$	°C	Temperature rise measured in protected concrete at measured depth d_{cp}
f_y	N/mm^2	Yield strength of steel as defined in ENV 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.

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

The load (P) applied to the test specimen shall be calculated, taking account of 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, such that the following bending moments are produced and that the same stresses exist within the steel reinforcement:

small slabs	5 kN.m/m width
large slabs	14 kN.m/m width
beams	25 kN.m

For concrete slab test specimens the 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.

For concrete beam test specimens the 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.

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 small concrete test slabs to provide additional test results for the fire protection system when:

- it is to be applied to a concrete member of concrete thickness less than that specified in this test method;
- it is to be applied at intermediate fire protection thickness between maximum and minimum thickness;
- the test is carried out to the smouldering curve (annex A).

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 6.1.1a) and 6.1.1b) shall be tested.

To one the minimum thickness of the fire protection system shall be applied and to the other 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, and the applicability of the result restricted.

In addition to the mandatory full size tests, small size tests may be carried out to obtain further data, as defined in 6.1.1d). One such test shall be carried out for each and every variable of concrete thickness or intermediate fire protection thickness to be considered. 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 exemplified 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 mm minimum
Span (mm) L_{sup}	≥ 1 500 and < 2 700 $(L_{exp}+200) > L_{sup} < (L_{exp}+400)$ [note]	4 200 minimum $(L_{exp}+200) > L_{sup} < (L_{exp}+400)$ [note]
Specimen length (mm) L_{spec}	≥ 1 700 and < 3 000 $(L_{exp}+400) > L_{spec} < (L_{exp}+700)$	4 400 mm minimum $(L_{exp}+400) > L_{spec} < (L_{exp}+700)$
Exposed width (mm) W_{exp}	≥ 1 000 and < 2 000	≥ 3 000
Thickness (mm) h	(90 ± 10)	(120 ± 10)
Position of loading points from support points (mm)	(600 ± 10)	(1000 ± 10)

NOTE 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 200 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 200 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.

The position of the loading points from the support points ($l$sup) shall be (1 000 ± 10) mm.

The beam construction is shown in Figure 3.

6.3 Construction of concrete test specimens

6.3.1 Concrete slab test members

Concrete slab test members shall contain a reinforcing mesh, which may comprise single reinforcement bars tied together with lashing wire or a prefabricated "welded fabric" mesh.

The mesh (placed towards the exposed surface and protected by the fire protection material) shall comprise 10,0 mm diameter ribbed bars for the large slab and 8,0 mm diameter ribbed bars for the small slab. The permitted tolerances on dimensions of reinforcing bars are given in ENV 10080.

For the large slab test member, only an upper mesh, at the unexposed surface, shall be used. It shall comprise 6,0 mm diameter ribbed bars.

Reinforcing bars shall be centred (150 ± 10) mm apart in both directions. The position of the main reinforcing bars with respect to the exposed and unexposed concrete surfaces shall be ensured by the use of spacers, either plastic or concrete, such that the concrete cover obtained is (20,0 ± 0,5) mm.

The actual position of the main reinforcing bars at the exposed and unexposed surfaces shall be accurately measured and recorded after the test at the positions of the thermocouples specified in 9.3. This shall be achieved by cutting the concrete slab into at least two pieces through or close to the required positions.

6.3.2 Concrete beam test members

Each concrete beam test member shall contain four ribbed reinforcing bars of 12 mm diameter, fixed with 8,0 mm diameter stirrups at (200 ± 10) mm centres. The permitted tolerances on dimensions of reinforcing bars are given in ENV 10080.

The position of the 12 mm reinforcing bars with respect to the concrete surface shall be ensured by the use of spacers, either plastic or concrete, such that the concrete cover obtained is (25,0 ± 0,5) mm.

The actual position of the reinforcing bars at the concrete surface shall be accurately measured and recorded after the test at the positions of the thermocouples specified in 9.3. This shall be achieved by cutting the concrete beam into at least two pieces through or close to the required positions.

6.3.3 Fabrication of concrete test members

Slab and beam concrete test members shall be prepared in a smooth surfaced framework made from steel or timber. To facilitate release of the slab or beam from the framework, soluble oils or emulsions shall be used. The actual material used for this purpose shall be detailed in the test report.

Waxes, insoluble oils or other release agents may be used within this test method but they shall be subject to restricted application (see 15.10) and each release agent intended to be used shall be separately assessed.

6.3.4 Application of fire protection material to concrete test member

The fire protection material shall be uniformly applied to the concrete, as in practice, including any required fixing aids, e.g. lathes, meshes and wires or adhesive bond promoters, and in the same manner for both maximum and minimum fire protection thickness.

The fire protection material shall extend over the full exposed surface(s) of beams and slabs, and be applied prior to the application of the test load.

Where a fire protection system creates a small cavity between the concrete and the fire protection material, the ends shall be sealed with fire resistant material to prevent any flow of hot gases out of the cavities.

Fixing profiles for board type fire protection systems can be orientated in both longitudinal and transverse directions of the test specimen. Fixing profiles orientated in the longitudinal direction, for each line of fixing profiles, shall include a joint at mid span.