SLOVENSKI STANDARD
SIST ENV 13381-5:2003

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Preskusne metode za ugotavljanje prispevka k poġarni odpornosti konstrukcijskih elementov - 5. del: Zaġļ ita kompozitnih elementov iz betona in jeklene profilirane ploļ evine

Test methods for determining the contribution to the fire resistance of structural members - Part 5: Applied protection to concrete/profiled sheet steel composite members

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 5: Brandschutzmaßnahmen für profilierte Stahlblech/Beton Verbundkonstruktionen

Méthodes d'essai pour déterminer la contribution a la résistance au feu des éléments de construction - Partie 5: Protection appliquée aux dalles mixtes béton/tôle d'acier profilée

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English version

Test methods for determining the contribution to the fire resistance of structural members - Part 5: Applied protection to concrete/profiled sheet steel composite 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 13381-5:2002 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 the 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 3: Applied protection to concrete members.

Part 4: Applied protection to steel members.

Part 6: Applied protection to concrete filled hollow steel composite columns.

Part 7: Applied protection to timber members.

Annexes A and B are normative.

Caution

The attention of all persons concerned with managing and carrying out this fire resistance test, is drawn to 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 European Prestandard specifies a test method for determining the contribution of fire protection systems to the fire resistance of structural concrete/profiled sheet steel composite members or slabs. The concrete can be lightweight, normal-weight or heavy-weight concrete and of strength classes 20/25 (LC/C/HC) to 50/60 (LC/C/HC).

The method is applicable to all fire protection systems used for the protection of such structural composite members or slabs and includes sprayed fire protection, coatings, cladding protection systems and multi-layer or composite fire protection materials.

The test method and its assessment procedure are designed to permit direct application of the results to cover a range of thicknesses of the applied fire protection material.

The test method is only applicable to fire protection systems which are fixed directly to the underside of the concrete/steel composite member or slab. Fire protection systems where the fire protection material is not attached directly to the composite member, leading to a continuous cavity between the concrete/steel composite member and the fire protection system of size greater than 5 mm is the subject of ENV 13381-1.

This European Prestandard contains the fire test which specifies the tests which shall be carried out to determine the ability of the fire protection system to remain coherent and fixed to the composite member and to provide data on the temperatures of the steel sheet, throughout the depth of the concrete (for extended application purposes) and the unexposed surface of the concrete, when exposed to the standard temperature/time curve according to the procedures defined herein.

In special circumstances, where specified in national building regulations, there can be a need to subject reactive 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/steel composite members in accordance with the procedures given in ENV 1994-1-2.

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 steel/concrete composite structures, steel types and thicknesses, concrete 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.

EN 206-1 Concrete - Part 1: Specification, performance, production and conformity.

ENV 10080	Steel for the reinforcement of concrete - Weldable ribbed reinforcing steel B 500 - Technical delivery conditions for bars, coils and welded fabric.
EN 10147	Continuously hot-dip zinc coated structural steels strip and sheet - Technical delivery conditions.
ENV 1992-1-1	Eurocode 2: Design of concrete structures Part 1-1: General rules and rules for buildings.
ENV 1994-1-1:1992	Eurocode 4: Design of composite steel and concrete structures Part 1-1: General rules and rules for buildings.
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, together with the following, apply.

3.1.1
concrete/steel composite member or slab (generally referred to as slab)
element of building construction which is loadbearing and is fabricated from a profiled steel sheet lower surface, defined according to EN 10147, and a concrete upper layer, defined according to EN 206-1. It may contain steel reinforcing bars

3.1.2
fire protection material
any material or combination of materials applied to the surface of a concrete/steel composite slab for the purpose of increasing its fire resistance

3.1.3
passive fire protection materials
materials which do not change their physical form on heating, providing 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 provides 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 structural concrete/steel composite slab

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

3.1.7
test specimen
concrete/steel composite test slab plus the fire protection system under test

3.1.8
fire protection thickness
thickness of a single layer fire protection system or 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, and furnace and test specimen surface temperatures, such that its ability to provide fire protection is not significantly impaired

3.1.10
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

3.1.11
limiting exposure time
time at which the adherence of a fire protection system to the concrete/steel composite test slab can be no longer considered acceptable, as indicated by a defined, significant increase in maximum recorded temperature at any point on the steel surface

3.1.12
limiting temperature
maximum value of temperature reached on the lower surface of the ribs of the profiled steel sheet when the limiting exposure time is reached

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 supports of the test specimen.
L_{spec}	mm	Total length of the test specimen.
W_{exp}	mm	Width of test specimen exposed to the furnace.
h	mm	Thickness of concrete in concrete/steel composite test specimen. (h_1 = depth of concrete above the steel ribs and h_2 = depth of concrete within the steel profile. Thickness $h = h_1 + h_2$
l_p	mm	Length of the components of the trapezoidal or re-entrant profile of the steel sheet (l_{p1}, l_{p2} and l_{p3})
P	kN	Loading applied to concrete/steel composite test specimen.
$\theta_{m,l}$ ($\theta_{m,u}$)	°C	Limiting temperature.
h_{eff}	mm	the effective thickness of the concrete/steel composite test slab.
h_e	mm	the equivalent effective thickness of the concrete/steel composite test slab.
h_{eq}	mm	the equivalent thickness of concrete corresponding to the particular thickness of the fire protection system tested.

t_r	min	The time at which an increase of the characteristic temperature of all thermocouples on the unexposed concrete surface of 140 °C (or a maximum of 180 °C from a single thermocouple) is recorded.
f_y	N/mm²	Yield strength of steel.
d_p	mm	Thickness of fire protection material.

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 equipment shall conform to that specified in 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 under specified temperature/time conditions, in horizontal orientation, with fire exposure applied from below.

Tests are carried out on a loaded large size test slab and an unloaded small size test slab to provide information on:

- the temperature of the profiled steel sheet behind the fire protection system;
- the behaviour of the fire protection system and its stickability;
- the temperature of the unexposed side of the test specimen;
- the temperature throughout the concrete (optional for extended application purposes).

It is recommended that the test be continued until the temperature of the exposed profiled steel surface reaches a mean value of at least 400 °C, (or any single maximum value of 500 °C is recorded), to give the necessary information on the stickability of the fire protection system. 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 EN 1363-2 (if relevant) shall be followed in the performance of this test method unless specific contrary instruction is given.

5.2 Support and restraint conditions

5.2.1 Standard conditions

The concrete/steel composite slab test specimens shall be tested as a simply supported one way structure with two free edges and an exposed surface and span as specified in 6.3.

The concrete/steel composite slab test specimens shall be installed onto the furnace to allow freedom for longitudinal movement and deflection 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 will be restricted to those tested.

5.3 Loading conditions

Loading shall be applied to the full size test specimens.

The magnitude and distribution of the load shall be such that the moment caused by the applied load (P) taking account of the dead weight of the specimen (measured or derived from samples of the components, see 6.5.1) and the weight of load distribution plates or beams represents 60 % of the design moment resistance according to equation 7.5 (b) of ENV 1994-1-1:1992.

The design moment resistance shall be calculated from the nominal material properties of the particular profiled steel sheet and the actual properties of the concrete used.

If the calculated load, when first applied, causes a deformation, at normal temperature, exceeding $L_{sup}/250$ then it shall be reduced until this criterion is met.

The load shall be symmetrically applied to the test specimen along two transverse loading lines, each one at a distance ($L_{sup}/4$) from each of the supports. The proportion of the total load applied at each loading position shall be $P/2$, as specified in Figure 1. 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 (see Figure 1a)).

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 concrete surface of the 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 Figure 1a).

6 Test specimens

6.1 Number of test specimens

At least one loaded full size concrete/steel composite test slab with the maximum thickness of applied fire protection system and one unloaded small size concrete/steel composite test slab with the minimum thickness of applied fire protection system shall be tested. If the fire protection system is only available in one thickness, the full size loaded test only shall be carried out, at that thickness and the applicability of the result restricted.

Additional small scale tests (one test per variable) may be carried out to provide further test data for the fire protection system when:

- it is to be applied to a concrete/steel composite member of composite thickness less than that specified in this test method;

- it is to be applied at intermediate fire protection thicknesses between maximum and minimum thickness;

- the test is carried out to the smouldering curve, in which case a small size test slab with both maximum and minimum thickness of applied fire protection material shall be tested, according to annex A.

6.2 Size of test specimens

The size of the test specimens shall be as specified in Table 1 and exemplified in Figure 1.

6.3 Construction of test specimens

6.3.1 Construction of concrete/steel composite test slabs

The concrete/steel composite test slabs shall comprise a trapezoidal or re-entrant steel profile plus concrete of thickness h_1, given in Table 1, over the upper ribs of the profiled steel sheet. The concrete shall contain prefabricated welded steel mesh, and may also include additional reinforcing bars.

The welded steel mesh, placed towards the unexposed surface in both small and large test slabs shall comprise 4,0 mm diameter ribbed bars such that the area of reinforcing steel bars is (70 to 100) mm^2 per metre of width of the concrete/steel composite test element.

The position of the welded steel mesh with respect to the exposed steel 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 ± 2,0) mm.

For large test slabs, only, a second welded steel mesh, laid on the surface of the upper ribs of the profiled steel sheet shall be used. It shall comprise 6,0 mm diameter ribbed bars such that the area of reinforcing steel bars is (70 to 100) mm^2 per meter of width of the concrete/steel composite test element.

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 under 9.3. This shall be achieved by cutting the composite slab into at least two pieces through or close to the required positions.

Lifting hooks may be incorporated into the composite slab. These should be of sufficient number and location to avoid longitudinal and transverse moments. Alternatively, the composite slabs should be supported on steel beams for lifting purposes.

Fixtures to which hangers may be attached may be provided on the unexposed side in order to avoid the collapse of the test specimen during the test, especially where the test is continued beyond the recommended termination

temperature of 400 °C.

Table 1 - Sizes of test specimens

	small test specimen	large test specimen
Exposed length (mm) L_{exp}	≥ 1 300	≥ 3 000[1)]
Span (mm) L_{sup}	≥ 1 500 $[(L_{exp} + 200) > L_{sup} < (L_{exp} + 400)]$[2)]	≥ 3 200[1)] $[(L_{exp} + 200) > L_{sup} < (L_{exp} + 400)]$[2)]
Length (mm) L_{spec}	≥ 1 700 $[(L_{exp} + 400) > L_{sup} < (L_{exp} + 700)^{3)}]$	≥ 3 400 $[(L_{exp} + 400) > L_{sup} < (L_{exp} + 700)]$[3)]
Exposed width (mm) W_{exp}	≥ 1 000	≥ 2 000
Thickness $h = [h_1 + h2]$ (mm)	$[(50 \pm 5)$ + height of ribs $(h_2)]$	$[(60 \pm 5)$ + height of ribs $(h_2)]$
Position of loading points from support points	none	$L_{sup}/4$ (symmetrically distributed)

1) a span of 3 000 mm is mainly valid for trapezoidal decking with height of ribs of 50/60 mm and steel thickness of 1 mm.

2) 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 min) a distance of 100 mm at either end is recommended. For tests of longer duration, this can be increased to 200 mm at either end, to protect the test equipment from heat damage.

3) the additional length beyond the supports, required for installation purposes, shall be kept as small as it is practically possible.

6.3.2 Fabrication of concrete/steel composite slab test members

Composite slab test members shall be prepared in a smooth surfaced framework made from steel or timber. To facilitate release of the edges of the slab from the framework, soluble oils or emulsions shall preferably be used, although wax, non-soluble oil or non-soluble emulsions may be used. The actual material used for this purpose shall be detailed in the test report.

6.3.3 Application of the fire protection system to the composite test slab

The steel surface of the composite test element shall be prepared as in practice. The surface of the steel face of the concrete/steel composite test slab shall normally be dried prior to the application of the fire protection system.

The fire protection system shall be uniformly applied to the test specimen, as in practice, including any required fixing aids and in the same manner for both maximum and minimum thickness.

The fire protection material shall extend over the full exposed surface of the concrete/steel composite test slab and be applied prior to the application of the test load (if any).

Where a fire protection system creates small cavities between the concrete/steel composite test element 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.