SLOVENSKI STANDARD
SIST ENV 1992-1-2:2004

01-september-2004

Eurocode 2: Projektiranje betonskih konstrukcij - 1-2. del: Projektiranje požarnovarnih konstrukcij

Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design

Eurocode 2: Planung von Stahlbeton- und Spannbetontragwerken - Teil 1-2: Allgemeine Regeln - Tragwerksbemessung für den Brandfall

Eurocode 2: Calcul des structures en béton - Partie 1-2: Règles générales - Calcul du comportement au feu

Ta slovenski standard je istoveten z: **ENV 1992-1-2:1995**

ICS:

13.220.50	Požarna odpornost gradbenih materialov in elementov	Fire-resistance of building materials and elements
91.010.30	Tehniļ ni vidiki	Technical aspects
91.080.40	Betonske konstrukcije	Concrete structures

SIST ENV 1992-1-2:2004 **en**

EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ENV 1992-1-2

November 1995

ICS 91.040.00; 91.080.40

Descriptors: buildings, concrete structures, design, computation, fire resistance

English version

Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design

Eurocode 2: Calcul des structures en béton - Partie 1-2: Règles générales - Calcul du comportement au feu

Eurocode 2: Planung von Stahlbeton- und Spannbetontragwerken - Teil 1-2: Allgemeine Regeln - Tragwerksbemessung für den Brandfall

This European Prestandard (ENV) was approved by CEN on 1994-01-14 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 an European Standard (EN).

CEN members are required to announce the existance 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.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart,36 B-1050 Brussels

Contents

Foreword

Objectives of the Eurocodes

(1) The "Structural Eurocodes" comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.

(2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship needed to comply with the assumptions of the design rules.

(3) Until the necessary set of harmonized technical specifications for products and for the methods of testing their performance are available, some of the Structural Eurocodes cover some of these aspects in informative Annexes.

Background of the Eurocode program

(4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various Member States and would ultimately replace them. These technical rules became known as the "Structural Eurocodes".

(5) In 1990, after consulting their respective Member States, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.

(6) CEN Technical Committee CEN/TC250 is responsible for all Structural Eurocodes.

Eurocode program

(7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991	Eurocode 1	Basis of design and actions on structures
EN 1992	Eurocode 2	Design of concrete structures
EN 1993	Eurocode 3	Design of steel structures
EN 1994	Eurocode 4	Design of composite steel and concrete structures
EN 1995	Eurocode 5	Design of timber structures
EN 1996	Eurocode 6	Design of masonry structures
EN 1997	Eurocode 7	Geotechnical design
EN 1998	Eurocode 8	Design provisions for earthquake resistance of structures
EN 1999	Eurocode 9	Design of aluminium alloy structures

(8) Separate subcommittees have been formed by CEN/TC250 for the various Eurocodes listed above.

(9) This Part 1-2 of Eurocode 2 is being published as a European Prestandard (ENV) with an initial life of three years.

(10) This Prestandard is intended for experimental application and for the submission of comments.

(11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.

(12) Meanwhile feedback and comments on this Prestandard should be sent to the Secretariat of CEN/TC250/SC2 at the following address:

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or to your national standards organisation

National Application Documents (NAD'S)

(13) In view of the responsibilities of authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by |_| ("boxed values"). The authorities in each member country are expected to assign definitive values to these safety elements.

(14) Some of the supporting European or International standards may not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving definitive values for safety elements, referencing compatible supporting standards and providing national guidance on the application of this Prestandard, will be issued by each member country or its Standards Organisation.

(15) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this prestandard

(16) The scope of Eurocode 2 is defined in 1.1.1 of ENV 1992-1-1 and the scope of this Part of Eurocode 2 is defined in 1.1. Additional Parts of Eurocode 2 which are planned are indicated in 1.1.3 of ENV 1992-1-1; these will cover additional technologies or applications, and will complement and supplement this Part.

(17) In using this Prestandard in practice, particular regard should be paid to the underlying assumptions and conditions given in 1.3 of ENV 1992-1-1.

(18) The provisions of this Prestandard are based substantially on recent CEB and FIP documents.

(19) This Part 1-2 of Eurocode 2 complements ENV 1992-1-1 for the particular aspects of structural fire design of concrete structures. The provisions in this Part 1-2 have to be considered additionally to those in other Parts of ENV 1992.

(20) The framework and structure of this Part 1-2 do not correspond to ENV 1992-1-1.

(21) This Part 1-2 contains five sections and four informative Annexes. These Annexes have been introduced by moving some of the more detailed Application Rules, which are needed in particular cases, out of the main part of the text to aid its clarity.

(22) Required functions and levels of performance are generally specified by the National Authorities - mostly in terms of standard fire resistance rating. Where fire safety engineering for assessing passive and active measures is accepted, requirements by authorities will be less prescriptive and may allow for alternative strategies.

1 General

1.1 Scope

(1)P ENV 1992-1-2 deals with the design of concrete structures for the accidental situation of fire exposure and shall be used in conjunction with ENV 1992-1-1 and ENV 1991-2-2. It provides additions to and identifies differences from the design of structures at normal temperatures.

(2)P Part 1-2 applies only to passive methods of fire protection. Active methods are not included.

(3)P Part 1-2 applies to structures which for reasons of general fire safety, are required to fulfil the following criteria when exposed to fire:

- avoid premature collapse of the structure (load-bearing function)
- limit fire spread (flames, hot gases, excessive heat) beyond designated areas (separation function)

(4)P Part 1-2 gives Principles and Application Rules (see 1.2 in ENV 1992-1-1) in respect to the design of structures to fulfil the criteria given in (3)P (e.g. in terms of required standard fire resistance).

(5)P Part 1-2 applies to those structures or parts of structures which are within the scope of Part 1-1, 1-3 to 1-6. However, it does not cover:

- structures with prestressing by external tendons
- shell structures.

(6) For structures using unbonded tendons reference should be made to 4.1(6) and 4.2.2(6).

1.2 Distinction between principles and application rules

(1) Depending on the character of the individual clauses, distinction is made in this Part between principles and application rules.

(2) The principles comprise:

- general statements and definitions for which there is no alternative, as well as
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The principles are identified by the letter P following the paragraph number.

(4) The application rules are generally recognized rules which follow the principles and satisfy their requirements.

(5) It is permissible to use alternative rules different from the application rules given in this Eurocode, provided it is shown that the alternative rules accord with the relevant principles and have at least the same reliability.

(6) In this Part the application rules are identified by a number in brackets eg. as this clause.

1.3 Normative references

(1) European standards for fire tests are under preparation. In National Application Documents reference may be made to national or international standards. For structural members ISO 834 is generally used.

1.4 Definitions

1.4.1 **critical temperature of reinforcement** : The temperature at which failure is expected to occur in reinforcement at a given load level.

1.4.2 **design fire** : A specified fire development assumed for design purposes.

1.4.3 **effects of actions E** (as described in ENV 1992-1-1, 2.2.2.5) : The effects of actions (E) are responses (for example internal forces and moments, stresses, strains) of the structure to the actions.

1.4.4 **fire compartment** : A space within a building extending over one or several floors which is enclosed by separating members such, that fire spread beyond the compartment is prevented during the relevant fire exposure.

1.4.5 **fire resistance** : The ability of a structure or part of it to fulfil its required functions (load-bearing and/or separating function) for a specified fire exposure, for a specified period of time.

1.4.6 **global structural analysis** (for fire) : The analysis of the entire structure, when either the entire structure or only parts of it are exposed to fire. Indirect fire actions are considered throughout the structure.

1.4.7 **indirect fire actions** : Thermal expansions or thermal deformations causing forces and moments.

1.4.8 **integrity criterion "E"** : A criterion by which the ability of a separating member to prevent passage of flames and hot gases is assessed.

1.4.9 **load-bearing criterion "R"** : A criterion by which the ability of a structure or a member to sustain specified actions during the relevant fire, is assessed.

1.4.10 **load-bearing function** : The ability of a structure or member to sustain specified actions during the relevant fire.

1.4.11 **member analysis** (for fire) : The thermal and mechanical analysis of a structural member exposed to fire in which the member is considered as isolated with appropriate support and boundary conditions. Indirect fire actions are not considered, apart from those resulting from thermal gradients.

1.4.12 **normal temperature design** : Ultimate limit state design for ambient temperatures according to ENV 1992-1-1 for the fundamental combination of actions (see ENV 1991-1).

1.4.13 **protected members** : Members for which measures are taken to reduce the temperature rise in the member due to fire.

1.4.14 **separating function** : The ability of a separating member to prevent fire spread by passage of flames or hot gases (integrity) or ignition beyond the exposed surface (thermal insulation) during the relevant fire.

1.4.15 **separating members** : Structural and non-structural members (walls or floors) forming the enclosure of a fire compartment.

1.4.16 **standard fire resistance** : The ability of a structure or part of it (usually only members) to fulfil required functions (load-bearing function and/or separating function) for exposure to heating according to the standard temperature-time curve, for a stated period of time.

1.4.17 **structural members** : The load-bearing members of a structure including bracings.

1.4.18 **sub-assembly analysis** (for fire) : The structural analysis of parts of the structure exposed to fire in which the respective part of the structure is considered as isolated with appropriate support and boundary conditions. Indirect fire actions within the sub-assembly are considered, but time-dependent interaction with other parts of the structure is not considered.

NOTE 1: Where the effects of indirect fire actions within the sub-assembly are negligible, sub-assembly analysis is equivalent to member analysis.

NOTE 2: Where the effects of indirect fire actions between sub-assemblies are negligible, sub-assembly analysis is equivalent to global structural analysis.

1.4.19 **support and boundary conditions** : Description of restraints at supports and boundaries for structural modelling.

1.4.20 **temperature analysis** : The procedure to determine the temperature development in members on the basis of thermal actions and the thermal material properties of the members and of the protective layers, where relevant.

1.4.21 **temperature-time curves** : Gas temperatures in the environment of member surfaces as a function of time. They may be either

- Nominal: Conventional curves, adopted for classification or verification of fire resistance, e.g. the standard temperature-time curve.

- Parametric: Determined on the basis of fire models and the specific physical parameters defining the conditions in the fire compartment.

1.4.22 **thermal actions** : Actions on the structure described by the net heat flux to the members.

1.4.23 **thermal insulation criterion "I"** : A criterion by which the ability of a separating member to prevent excessive transmission of heat is assessed.

1.5 Symbols

The following symbols supplement those given in ENV 1992-1-1:

$E_{d,fi}$ design effect of actions in the fire situation

E_d design effect of actions for normal temperature design

$R_{d,fi}$ design load bearing capacity (resistance) in the fire situation $R_{d,fi}(t)$ at a given time t.

R 30 or R 60,... a member meeting the load-bearing criterion for 30, or 60... minutes in standard fire exposure

E 30 or E 60,... a member meeting the integrity criterion for 30, or 60... minutes in standard fire exposure

I 30 or I 60,... a member meeting the thermal insulation criterion for 30, or 60... minutes in standard fire exposure

X_k characteristic value of a strength or deformation property for normal temperature design

$X_{d,fi}$ design strength or deformation property in the fire situation

a axis distance of the steel from the nearest exposed surface

c specific heat (characteristic value) [J/kgK]

$f_{ck}(\Theta)$ characteristic value of compressive strength of concrete at temperature Θ for a specified strain

$f_{pk}(\Theta)$ characteristic value of strength of prestressing steel at temperature Θ for a specified strain

$f_{sk}(\Theta)$ characteristic strength of reinforcing steel at temperature Θ for a specified strain

$k(\Theta) = X_k(\Theta)/X_k$ reduction factor to describe a strength or deformation property at temperature Θ

t time of fire exposure (min)

$\gamma_{M,fi}$ partial safety factor for a material in fire design

$\eta_{fi} = E_{d,fi}/E_d$ ratio of design effect of actions in the fire situation to that in normal design

$\epsilon_{s,fi}$ strain of the reinforcing or prestressing steel at temperature Θ.

λ thermal conductivity (characteristic value) [W/mK]

$\mu_{fi} = E_{d,fi}/R_{d,fi}(0)$ ratio of design effect of actions in the fire situation to the design resistance of the structural element at time $t = 0$

$\sigma_{c,fi}$ compressive stress of concrete in fire situation

$\sigma_{s,fi}$ steel stress in fire situation

Θ temperature [°C]

Θ_{cr} critical temperature [°C]

1.6 Units

(1) Temperature Θ in degrees Celsius (°C)

Temperature difference in kelvins (K)

Specific heat c in joule per kilogramme per kelvin (J/kgK)

Coefficient of thermal conductivity λ in watts per metre per kelvin (W/mK)

2 Basic principles

2.1 Performance requirements

(1)P Where structures are required to have mechanical resistance under fire conditions, they shall be designed and constructed in such a way that they maintain their load bearing function during the relevant fire exposure - Criterion "R".

(2)P Where compartmentation is required, the members forming the compartment, including joints, shall be designed and constructed in such a way that they maintain their separating function during the relevant fire exposure, i.e.

- no integrity failure due to cracks, holes or other openings, which are large enough to cause fire penetration by hot gases or flame - Criterion "E"

- no insulation failure due to temperatures of the non-exposed surface exceeding ignition temperatures - Criterion "I".

(3) Criterion "I" may be assumed to be met where the average temperature rise over the whole of the non-exposed surface during the standard fire exposure does not exceed 140K and the maximum temperature rise of that surface does not exceed 180K.

(4)P Members shall comply with criteria R, E and I as follows:

separating only: E and I
loadbearing only: R
separating and loadbearing: R, E and I

(5) When using general calculation methods (see 4.4) the deformation criteria should be used where separating members or protective measures are affected by the deformation of the load bearing structure. Reference should be made to the relevant product specifications.

2.2 Actions

(1)P Thermal and mechanical actions shall be obtained from ENV 1991-2-2.

(2) Where rules given in this Part 1-2 are only valid for the standard fire exposure, this is identified in the relevant clauses.

2.3 Design values of material properties

(1)P Design values of thermal and mechanical properties ($X_{d,fi}$) are defined as follows:

- thermal properties for thermal analysis

if an increase of the property is favourable for safety

$$X_{d,fi} = X_k(\Theta)/\gamma_{M,fi} \quad (2.1)$$

if an increase of the property is unfavourable for safety

$$X_{d,fi} = X_k(\Theta)\ \gamma_{M,fi} \quad (2.2)$$

- strength and deformation properties for structural analysis

$$\underline{X}_{d,fi} = k(\Theta)\ X_k/\gamma_{M,fi} \quad (2.3)$$

where

$X_k(\Theta)$ is the characteristic value of a material property in fire design, generally dependent on the material temperature

X_k is the characteristic value of a strength or deformation property (e.g. f_{ck} and f_{yk}) for normal temperature design to ENV 1992-1-1

$k(\Theta) = X_k(\Theta)/X_k$ is the reduction factor for a strength or deformation property dependent on the material temperature - see 3.2 and 3.3

$\gamma_{M,fi}$ is the partial safety factor for material property in fire design

(2) For thermal and mechanical properties of concrete and steel reinforcement the partial safety factor for fire design should be taken as

$$\gamma_{M,fi} = |\underline{1,0}|$$

2.4 Verification methods

2.4.1 General

(1)P The fire resistance of a concrete structure may be determined by any of the methods given in 2.4.2 to 2.4.5.

(2) Tabulated data given in 4.2 are based on the standard temperature-time curve. The simplified and general calculation methods may also be used with parametrical temperature-time relationship, see ENV 1991-2-2.

2.4.2 Global structural analysis

(1)P For the global structural analysis, it shall be verified that

$$E_{d,fi}(t) \leq R_{d,fi}(t) \qquad (2.4)$$

where

$E_{d,fi}(t)$ is the design effect of actions in the fire situation, determined from the general rule given in ENV 1991-2-2, including indirect fire actions

$R_{d,fi}(t)$ is the corresponding design resistance at elevated temperatures

t is the relevant duration of fire exposure

(2)P The structural model adopted for design to this ENV 1992-1-2 shall reflect the expected performance of the structure in fire exposure.

(3) The global structural analysis should take into account the relevant failure mode in fire exposure, the temperature-dependent material properties including stiffness, and effects of thermal expansions and deformations (indirect fire actions).

(4) General calculation methods given in 4.4 are suitable for global structural analysis. They are based on models which determine the temperature development within the structure and the mechanical behaviour of the structure.

2.4.3 Analysis of parts of the structure

(1) As an alternative to the global structural analysis of the entire structure for various fire situations, a structural analysis of parts of the structure (sub-assemblies) may be performed, where the sub-assemblies are exposed to fire and analyzed in accordance with 2.4.2

(2) Sub-assemblies should be specified on the basis of the potential thermal expansions and deformations such, that their interaction with other parts of the structure can be approximated by time-independent support and boundary conditions during fire exposure.

(3) Effects of (permanent and variable) actions at supports and boundaries may be assumed to correspond to those in ENV 1992-1-1.