SLOVENSKI STANDARD
SIST ENV 1994-1-2:2004

01-september-2004

Eurocode 4: Projektiranje sovprežnih konstrukcij iz jekla in betona – 1-2. del: Splošna pravila – Projektiranje požarnovarnih konstrukcij

Eurocode 4: Design of composite steel and concrete structures - Part 1-2: General rules - Structural fire design

Eurocode 4 - Bemessung und Konstruktion von Verbundtragwerken aus Stahl und Beton - Teil 1-2: Allgemeine Regeln - Tragwerksbemessung für den Brandfall

Eurocode 4 - Calcul des structures mixtes acier-béton - Partie 1-2: Regles générales - Calcul du comportement au feu

Ta slovenski standard je istoveten z: **ENV 1994-1-2:1994**

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
91.080.99	Druge konstrukcije	Other structures

SIST ENV 1994-1-2:2004 **en**

EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ENV 1994-1-2

October 1994

ICS 13.220.50; 91.080.10; 91.080.40

Descriptors: buildings, steel construction, concrete structures, design, safety requirements, accident prevention, fire protection, fire resistance, mechanical properties, thermodynamic properties, computation, mechanical strength

English version

Eurocode 4 - Design of composite steel and concrete structures - Part 1-2: General rules - Structural fire design

Eurocode 4 - Calcul des structures mixtes acier-beton - Partie 1-2: Règles générales - Calcul du comportement au feu

Eurocode 4 - Bemessung und Konstruktion von Verbundtragwerken aus Stahl und Beton - Teil 1-2: Allgemeine Regeln - Tragwerksbemessung für den Brandfall

This European Prestandard (ENV) was approved by CEN on 1993-11-23 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

General

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 Programme

(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 Programme

(7) Work is in hand on the following Structural Eurocodes, each generally consisting od 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 sub-committees have been formed by CEN/TC250 for the various Eurocodes listed above.

(9) This Part 1.2 of Eurocode 4 is being published as an European Prestandard (ENV) with an initial life of three years, from the date on the version is made available by CEN CS to Members of CEN.

(10) This Prestandard is intended for experimental practical 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 action.

(12) Meanwhile feedback and comments on this Prestandard should be sent to the Secretariat of sub-committee CEN/TC 250/SC 4 at the following address:

NSAI
Glasnevin, Dublin 9
IRELAND

or to your national standards organization.

National Application Documents (NAD's)

(13) In view of the responsibilities of authorities in member countries for the 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 therfore 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 Organization.

(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

Safety requirements

(16) The scope of Eurocode 4 is defined in ENV 1994-1-1, section 1.1.1 and 1.1.2, and the scope of this Part 1.2 of Eurocode 4 is defined in section 1.1. Additional parts of Eurocode 4 which are planned are indicated in ENV 1994-1-1, section 1.1.3.

(17) The general objectives of fire protection are to limit risks with respect to the individual and society, neighbouring property, and where required, directly exposed property, in the case of fire.

(18) Construction Products Directive 89/106/EEC gives the following essential requirement for the limitation of fire risks:
"The construction works must be designed and build in such a way, that in the event of an outbreak of fire

- the load bearing resistance of the construction can be assumed for a specified period of time
- the generation and spread of fire and smoke within the works are limited
- the spread of fire to neighbouring construction works is limited
- the occupants can leave the works or can be rescued by other means
- the safety of rescue teams is taken into consideration".

(19) According to the Interpretative Document "Safety in Case of Fire" the essential requirement may be observed by following various fire safety strategies, including passive and active fire protection measures.

(20) The Structural Eurocodes deal with specific aspects of passive fire protection in terms of designing structures and parts thereof for adequate load bearing resistance and for limiting fire spread as relevant.

(21) 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.

(22) This Part 1.2, together with ENV 1991-2-2, Actions on structures exposed to fire, gives the supplements to ENV 1994-1-1, which are necessary so that structures designed according to this set of Structural Eurocodes may also comply with structural fire resistance requirements.

(23) Supplementary requirements concerning, for example
- the possible installation and maintenance of sprinkler systems
- conditions on occupancy of building or fire compartment
- the use of approved insulation and coating materials, including their maintenance

are not given in this document, because they are subject to specification by the competent authority.

Design procedures

(24) A full analytical procedure for structural fire design would take into account the **behaviour of the structural system at elevated temperatures, the potential heat exposure** and the beneficial effects of **active fire protection** systems, together with the uncertainties associated with these three features and the importance of the structure (consequences of failure).

(25) At the present time it is possible to undertake a procedure for determining adequate performance which incorporates some, if not all, of these parameters and to demonstrate that the structure, or its components, will give adequate performance in a real building fire. However the principal current procedure in European countries is one based on results from standard fire resistance tests. The grading system in regulations, which call for specific periods of fire resistance, takes into account (though not explicitely), the features and uncertainties described above.

(26) Due to the limitations of the test method, further tests or analyses may be used. Nevertheless, the results of standard fire tests form the bulk of input for calculation models for structural fire design. This prestandard therefore deals in the main with the design for the standard fire resistance.

(27) Application of this Part 1.2 of Eurocode 4 with the thermal actions given in ENV 1991-2-2, is illustrated in table 0.1. For design according to this part, ENV 1991-2-2 is required for the determination of temperature fields in structural elements, or when using advanced calculation models for the analysis of the structural response.

Table 0.1: Design procedures

Thermal actions given in ENV 1991-2-2	according to national specifications:		design by tabular data given in ENV 1994-1-2	design by calculation models given in ENV 1994-1-2
standard temperature-time curve	FOR VERIFYING	standard fire resistance requirements	as relevant 1) or from fire resistance tests	as relevant 1)
other nominal temperature-time curves	FOR VERIFYING	other nominal fire resistance requirements	not applicable	by advanced calculation models
standard temperature-time curve	FOR VERIFYING	fire resistance - for equivalent time of fire exposure	not applicable	by advanced calculation models
parametric fire exposure	FOR VERIFYING	fire resistance - for specified period of time or - for entire fire duration	not applicable	by advanced calculation models
1) depending on the assessment methods included in this document				

Design aids

(28) Where simple calculation models are not available, the Eurocode fire parts give design solutions in terms of tabular data (based on tests or advanced calculation models), which may be used within the specified limits of validity.

(29) It is expected, that design aids based on the calculation models given in ENV 1994-1-2, will be prepared by interested external organizations.

1 General

1.1 Scope

(1)P This Part 1.2 of Eurocode 4 deals with the design of composite steel and concrete structures for the accidental situation of fire exposure and shall be used in conjunction with ENV 1994-1-1 and ENV 1991-2-2. This Part 1.2 only identifies differences from, or supplements to, normal temperature design.

(2)P This document deals only with passive methods of fire protection. Active methods are not covered.

(3)P This Part 1.2 applies to structures which for reasons of general fire safety, are required to fulfil certain functions in exposure to fire, in terms of

- avoiding premature collapse of the structure (load bearing function)
- limiting fire spread (flames, hot gases, excessive heat) beyond designated areas (separating function).

(4)P This Part 1.2 gives principles (i)P and application rules (j) (see section 1.2 in ENV 1994-1-1), for designing structures for specified requirements in respect to the aforementioned functions and levels of performance.

(5) In this document, columns subjected to fire conditions are assumed to be equally heated all around their cross-section, whereas beams supporting a floor are supposed to be heated only from the three lower sides.

(6) For beams connected to slabs with profiled steel sheets a three side fire exposure may be assumed, when at least 90 % of the upper side of the steel profile is directly covered by the steel sheet.

(7)P This document only applies to structures or parts of structures, which are within the scope of ENV 1994-1-1 and are designed accordingly.

(8) The commonly used composite cross-section types, partially developed in view of fire resistance requirements are described in figures 1.1 to 1.8.

(9)P For all composite cross-sections longitudinal shear connection between steel and concrete shall be assured according to the principles of ENV 1994-1-1.

(10) Typical examples of concrete slabs with profiled steel sheets with or without reinforcing bars are given in figure 1.1.

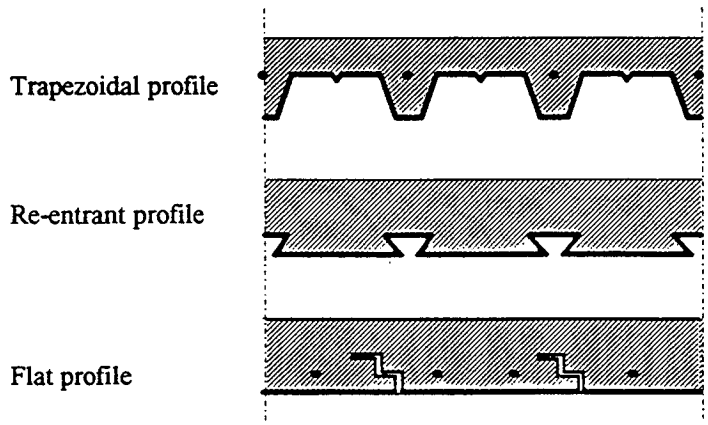

Fig. 1.1

(11) Typical examples of composite beams are given in figures 1.2 to 1.5.

Note: No rules are given in ENV 1994-1-1 for the normal temperature design of a steel beam partially encased in a slab, as given in figure 1.4.

Note: Constructional detailing of steel beams with partial concrete encasement as given in figures 1.3 and 1.5, is covered in section 5.

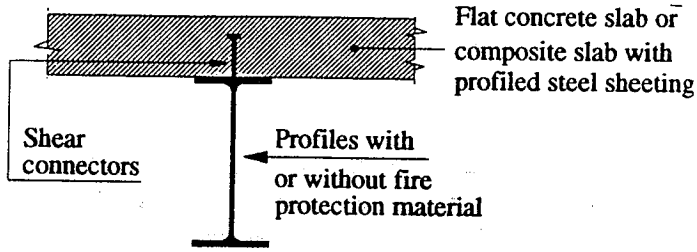

Fig. 1.2: Composite beam comprising steel beam with no concrete encasement

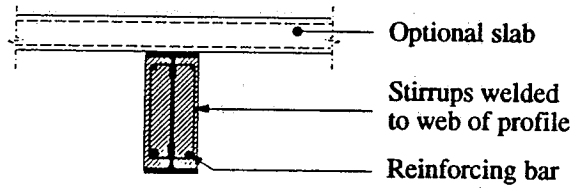

Fig. 1.3: Steel beam with partial concrete encasement

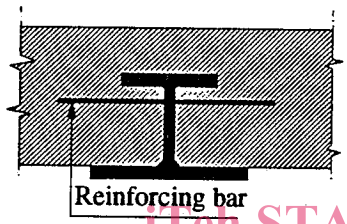

Fig. 1.4: Steel beam partially encased in slab

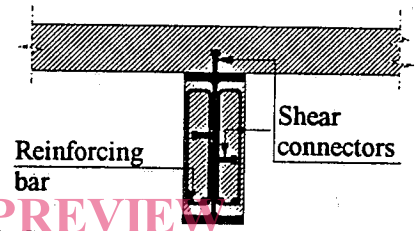

Fig. 1.5: Composite beam comprising steel beam with partial concrete encasement

(12) Typical examples of composite columns are given in figures 1.6 to 1.8.

Note: Constructional detailing of composite columns is covered in section 5.

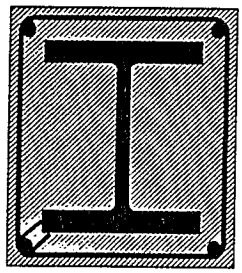

Fig. 1.6: Concrete encased profiles

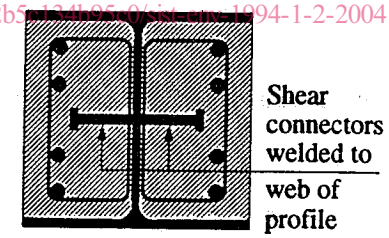

Fig 1.7: Partially encased profiles

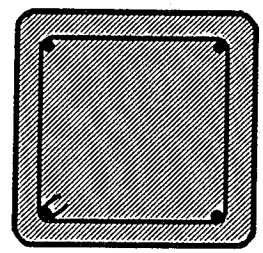

Fig. 1.8: Concrete filled profiles

(13) Different shapes, like circular or octagonal cross-sections may also be used for columns. Where appropriate, reinforcing bars may be replaced by other steel sections like half sections, core sections etc.

(14) The fire resistance of these forms of constructions may be increased by applying fire protection materials.

Note: The design principles and rules given in sections 4.2, 4.3 and 5 refer to steel surfaces directly exposed to the fire, which are free of any fire protection material, unless explicitly specified otherwise.

(15)P The steel properties for structural steel given in this document correspond to the steel grades Fe 360, Fe 430 and Fe 510 as specified in EN 10025 (March 1990) and to the steel grade S275, S355, S420 and S460 as specified in EN 10113 (March 1993).

Note: At present the use of steel grades S 420 and S 460 is not covered by ENV 1994-1-1.

(16)P For profiled steel sheeting, reference shall be made to section 3.4 of ENV 1994-1-1.

(17)P Reinforcing bars shall be in accordance with EN 10080.

(18)P Normal weight concrete, as defined in ENV 1994-1-1, is applicable to the fire design of composite structures. The use of light weight concrete is permitted for composite slabs which may be connected or not to the steel beam below.

(19)P The following concrete grades are applicable in case of fire design of composite structures:

Concrete grades	20/25	25/30	30/37	35/45	40/50	45/55	50/60
f_{ck} (N/mm^2)	20	25	30	35	40	45	50

Note: Grades lower than those given here, like C12/15 and C16/20 according to section 3.1.2.4, of ENV 1992-1-1, are not allowed.

Note: f_{ck} means the characteristic compressive cylinder strength of concrete at 28 days (identical to $f_{c,20°C}$ of section 3.2.2.).

1.2 Normative references

(1) This European Prestandard incorporates provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed below. For undated references the latest edition of the publication referred to applies.

(2) Normative reference is made to the following CEN standards:

* EN 10025 "Hot rolled products of non-alloy structural steels: Technical delivery conditions"

* EN 10113 "Hot rolled products in weldable fine grain structural steels"
- Part 1 "General delivery conditions"
- Part 2 "Delivery conditions for normalized rolled steels"
- Part 3 "Delivery conditions for thermomechanically rolled steels"

* EN 10210 "Hot finished steel hollow sections"
- Part 1 "Technical delivery conditions"

* EN 10219 "Cold formed structural steel hollow sections"
- Part 1 "Non-alloy and fine grain steels"

* EN yyy1 "Fire tests for building materials"
- Part 1 "Fire resistance, general requirements"
- Part 2 "Fire resistance, additional requirements"

* EN yyy3 "Test methods for fire resistance of loadbearing elements"
- Part 1 "Fire resistance of internal walls"
- Part 2 "Fire resistance of external walls"
- Part 3 "Fire resistance of floors"
- Part 4 "Fire resistance of roofs"
- Part 5 "Fire resistance of beams"
- Part 6 "Fire resistance of columns"

* EN yyy5 "Method of test for the determination of the contribution to fire resistance of structural members"
- Part 1A "Horizontal protective membranes"
- Part 1B "Vertical protective membranes"
- Part 3 "Applied protection to steel elements"
- Part 4A "Applied protection to profiled steel sheets of composite slabs"
- Part 4B "Applied protection to concrete filled hollow steel columns"

* ENV 1991 "Eurocode 1. Basis of design and actions on structures"
- Part 1 "Basis of design"
- Part 2.1 "Densities, Self-Weight, Imposed Loads, Snow Loads"
- Part 2.2 "Actions on structures exposed to fire"
- Part 2.3 "Wind actions"

* ENV 1992 "Eurocode 2. Design of concrete structures"
Part 1.1 "General rules and rules for buildings"
Part 1.2 "Structural fire design"
* ENV 1993 "Eurocode 3. Design of steel structures"
Part 1.1 "General rules and rules for buildings"
Part 1.2 "Structural fire design"
Part 1.3 "Cold formed thin gauge members and sheeting"
* ENV 1994 "Eurocode 4. Design of composite steel and concrete structures"
Part 1.1 "General rules and rules for buildings"

(3) Normative reference is made to the following ISO standard
* ISO 1000 "SI units"

1.3 Definitions

(1)P For the purpose of this Part 1.2 of Eurocode 4, the following definitions apply:

Configuration factor: Solid angle within which the radiating environment can be seen from a particular point on the member surface, divided by 2π.

Convective heat transfer coefficient α_c [W/m^2K]**:** Convective heat flux to the member related to the difference between the bulk temperature of gas bordering the relevant surface of the member and the temperature of that surface.

Critical temperature of structural steel: For a given load level, the temperature at which failure is expected to occur in a structural steel element for a uniform temperature distribution.

Design fire: A specified fire development assumed for design purposes.

Design fire load density q_d [MJ/m^2]**:** The fire load density considered for determining thermal actions in fire design; the value of q_d makes allowance for uncertainties and safety requirements.

Effects of actions E: Moments, forces, deformations, displacements.

External member: Member located outside the building, which may be exposed to fire through openings in the building enclosure.

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.

Fire load density q [MJ/m^2]**:** The fire load per unit area related to the floor area q_f, or related to the surface area of the total enclosure, including openings, q_t.

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

Fire wall: A wall separating two spaces (generally two buildings) which is designed for fire resistance, including resistance to horizontal loading such that, in case of fire and failure of the structure on one side of the wall, fire spread beyond the wall is avoided.

Global structural analysis (for fire)**:** An 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.

Indirect fire actions: Thermal expansions and deformations or thermal gradients causing forces and moments.

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

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.

Load bearing function: The ability of a structure or member to sustain specified actions during the relevant fire, according to defined criteria.

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, except those resulting form thermal gradients.

Net heat flux $\dot{h}_{net}$ [W/m^2]**:** Energy per unit time and surface area absorbed by members.

Normal temperature design: Ultimate limit state design for ambient temperatures according to ENV 1994-1-1 for the fundamental combination of ENV 1991-1.

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

Resulting emissivity ε_{res} [-]**:** The ratio between the actual radiative heat flux to the member and the net heat flux that would occur if the member and its radiative environment were considered as black bodies.

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

Separating member: Structural or non-structural member (wall or floor) forming the enclosure of a fire compartment.

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 and for a stated period of time.

Standard temperature-time curve: The nominal temperature-time curve given in ENV 1991-2-2.

Structural members: The load-bearing members of a structure including bracings.

Subassembly 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 subassembly are considered, but no time-dependent interaction with other parts of the structure.
Where the effects of indirect fire actions within the subassembly are negligible, subassembly analysis is equivalent to member analysis. Where the effects of indirect fire actions between subassemblies are negligible, subassembly analysis is equivalent to global structural analysis.

Support and boundary conditions: Effects of actions and restraints at supports and boundaries when analysing the entire structure or only parts of the structure.

Temperature analysis: The procedure of determining the temperature development in members on the basis of the thermal actions (net heat flux), and the thermal material properties of the members and of protective surfaces, where relevant.

Temperature-time curves: Gas temperatures in the environment of member surfaces as a function of time. They may be

- **nominal**, in terms of conventional curves, adopted for classification or verification of fire resistance, e.g. the standard temperature-time curve,
- **parametric**, i.e. determined on the basis of fire models and the specific physical parameters describing the conditions in the fire compartment.

Thermal actions: Actions on the structure described by the net heat flux to the members.

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

1.4 Symbols

(1)P Supplementary to ENV 1994-1-1, the following units and symbols are used:

A	cross-sectional area
A_m	directly heated surface area of member per unit length
A_m/V	section factor of structural member
E 30	or E 60,... a member meeting the integrity criterion for 30, or 60... minutes in standard fire exposure
$E_{a,20°C}$; $E_{s,20°C}$	characteristic value for the modulus of elasticity of structural or reinforcing steel at 20°C
$\overline{E}_{a,\theta}$; $\overline{E}_{s,\theta}$	characteristic value for the slope of the linear elastic range of the stress-strain relationship of structural or reinforcing steel at elevated temperatures
$E_{c,sec,\theta}$	characteristic value for the secant modulus of concrete in the fire situation, given by $f_{c,\theta}$ divided by $\varepsilon_{cu,\theta}$
$E_{c0,\theta}$	characteristic value for the tangent modulus at the origin of the stress-strain relationship for concrete at elevated temperatures and for short term loading
E_d	design effect of actions for normal temperature design
$E_{fi,d}$	design effect of actions in the fire situation, supposed to be time independent
$E_{fi,d,t}$	design effect of actions, including indirect fire actions and loads, external forces and moments in the fire situation, at time t
I 30	or I 60,... a member meeting the thermal insulation criterion for 30, or 60... minutes in standard fire exposure
L	system length
$M_{fi,Rd}^+$; $M_{fi,Rd}^-$	design value of the sagging or hogging moment resistance in the fire situation
$N_{fi,cr}$	elastic critical load (≡ Euler buckling load) in the fire situation
$N_{fi,pl.Rd}$	design value of the plastic resistance to axial compression in the fire situation
$N_{fi,Rd}$	design value of the resistance of a member in axial compression (≡ design axial buckling load) and in the fire situation
$P_{fi,Rd}$	design shear resistance in the fire situation of a shear connector
R 30	or R 60,... a member meeting the load bearing criterion for 30, or 60... minutes in standard fire exposure
R_d	design load bearing resistance for normal temperature design
$R_{fi,d,t}$	design load bearing resistance in the fire situation, at time t
V	volume of the member per unit length
c	specific heat or buckling curve or concrete cover from edge of concrete to border of structural steel
e	thickness of profile or hollow section
$f_{amax,\theta}$; $f_{smax,\theta}$	characteristic value for the maximum stress level of the truncated stress-strain relationship of structural or reinforcing steel in the fire situation

$f_{ap,\theta}$; $f_{sp,\theta}$	characteristic value for the proportional limit of structural or reinforcing steel at elevated temperatures
$f_{au,\theta}$; $f_{vu,\theta}$	characteristic value for the tensile strength of structural steel or steel of stud connectors in the fire situation
$f_{ay,20°C}$; $f_{sy,20°C}$	characteristic value for the yield point of structural or reinforcing steel at 20°C
$f_{c,20°C}$; f_{ck}	characteristic value for the compressive cylinder strength of concrete at 28 days
$f_{c,\theta}$	characteristic value for the compressive cylinder strength of concrete in the fire situation
$f_{c,\theta,20°C}$	characteristic value for residual compressive cylinder strength of concrete, heated and cooled down to 20°C
$f_{fi,d}$	design strength property in the fire situation
k_θ	reduction factor for a strength or deformation property dependent on the material temperature
l	length or buckling length
t	duration of fire exposure
$t_{fi,d}$	design value of standard fire resistance of a member
$t_{fi,requ}$	required standard fire resistance
u_i or u_{si}	distance from border of concrete to centre of reinforcing bar
α_c	convective heat transfer coefficient
χ;φ;k	reduction or correction coefficients and factors
δ	eccentricity
Δt	time interval
ε	strain
$\varepsilon_{ce,\theta}$	the maximum concrete strain in the fire situation
$\varepsilon_{cu,\theta}$	the concrete strain corresponding to $f_{c,\theta}$
ε_m	emissivity coefficient related to the surface material of the member
ε_{res}	resultant emissivity
ϕ	diameter of a reinforcing bar
γ_G	partial safety factor for permanent action G_k
γ_{GA}	as γ_G but for accidental design situation
$\gamma_{M,fi}$	partial material safety factor in fire design
γ_Q	partial safety factor for variable action Q_k
η	load level referring to ENV 1994-1-1
η_{fi}	reduction factor applied to E_d in order to obtain $E_{fi,d}$
$\eta_{fi,t}$	load level for fire design
λ	thermal conductivity
$\bar{\lambda}$	non dimensional slenderness ratio
θ	temperature
θ_0	initial gas temperature
θ_a	temperature of structural steel
θ_{cr}	critical temperature of structural member
θ_s	temperature of reinforcing steel
θ_t	gas temperature at time t
ρ	unit mass