ANNEX 15

NATIONAL ANNEX

TO STANDARD

SFS-EN 1994-1-2 EUROCODE 4: DESIGN OF COMPOSITE STEEL AND CONCRETE STRUCTURES

Part 1-2: General rules. Structural fire design

Preface

This National Annex is used together with Standard SFS-EN 1994-1-2.

This National Annex sets out:

a) National parameters for the paragraphs of Standard SFS-EN 1994-1-2 where national selection is permitted.

National selection is permitted in the following paragraphs of Standard SFS-EN 1994-1-2:

- 1.1(16)
- 2.1.3(2)
- 2.3(1)P
- 2.3(2)P
- 2.4.2(3)
- 3.3.2(9)
- 4.1(1)P
- 4.3.5.1(10)

b) Guidance on the use of the Informative Annexes A, B, C, D, E, F and G and also on replacing the Informative Annex H.

1.1 Scope

1.1(16)

When designing in accordance with Standard SFS-EN 1994-1-2, the highest strength class of concrete is C50/60.

2.1.3 Parametric fire exposure

2.1.3(2)

No values are given for the average temperature rise $\Delta\theta_1$ and for the maximum temperature rise $\Delta\theta_2$ during the cooling phase of fire.

Explanation:

The requirement for separating function EI is only based on a standard fire and on temperature limits set by it.

The fire safety requirement is also deemed to be satisfied if the building is designed and executed based on design fire scenarios which cover the situations likely to occur in the said building. Satisfaction of the requirement is attested case-by case taking into account the properties and use of the building (The National Building Code of Finland E1:1.3.2).

2.3 Design values of material properties

2.3(1)P

The values of partial safety factors for mechanical properties of steel and concrete are $\gamma_{M,fi,a} = 1.0$; $\gamma_{M,fi,s} = 1.0$; $\gamma_{M,fi,c} = 1.0$; $\gamma_{M,fi,v} = 1.0$.

2.3(2)P

The values of partial safety factors for thermal properties of steel and concrete in the equations (2.2a) and (2.2b) are $\gamma_{M,fi} = 1.0$.

2.4.2 Member analysis

2.4.2(3)

Note 1: Partial safety factors of loads in accordance with the National Annex to Standard SFS-EN 1990 are used in Finland. An equivalent, conforming to Fig. 2.1 in Standard SFS-EN 1994-1-2, is set out in the following Fig. 2.1(FI) where the reduction factor η_{fi} has been calculated as a function of the load ratio $Q_{k,1}/G_k$ using the values in the Finnish National Annex to Standard SFS-EN 1990.

Note 2: As a simplification, the recommended value $\eta_{fi} = 0.65$ is used excluding load class E (storage and industrial premises) in accordance with Standard SFS-EN 1991-1-1 where the value $\eta_{fi} = 0.7$ is used.

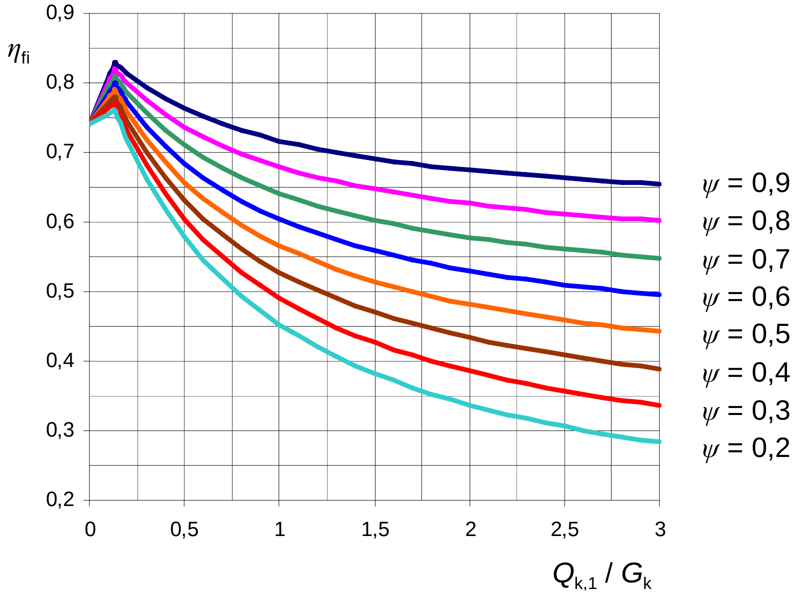

Fig. 2.1(FI) Variation of the reduction factor η_{fi} as a function of the load ratio $Q_{k,1}/G_k$ when partial safety factors in accordance with the National Annex to Standard SFS-EN 1990 are used.

3.3.2 Normal weight concrete

3.3.2(9)

An upper limit value in accordance with expression (3.6a) in Standard SFS-EN 1994-1-2 is used for the thermal conductivity λ_c of normal weight concrete.

4.1 Introduction

4.1(1)P

Advanced calculation methods may be used in Finland. Their validity is verified in accordance with paragraph 4.4.4.

4.3.5.1 Structural behaviour

4.3.5.1(10)

The values *0.5* and *0.7* times the system length *L* are used for the buckling lengths L_{ei} and L_{et} .

Annexes A, B, C, D, E, F, G and I

Informative Annexes A, B, C, D, E, F, G and I may be used.

Annex H
Simple calculation model for concrete filled hollow sections exposed to fire all around the column according to the standard temperature-time curve

Informative Annex H is not used in Finland.

Simple design methods may be used for fire design of concrete filled hollow sections, the principles of which are set out in paragraph 4.3.5.1 of Standard SFS-EN 1994-1-2. These methods concern columns exposed to standard fire exposure on each side in the same way.

(1) The simple methods described are only used when designing columns in braced frames. The model should include data on the temperatures θ_i, on which the calculations of the compressive resistance of the cross-section and effective flexural stiffness of the column are based.

(2) With simple methods, the design value for compression resistance of an axially loaded column is calculated as a buckling load from the expression:

$$N_{fi,Rd} = \chi(\bar{\lambda}_\theta) N_{fi,pl,Rd} \tag{4.12}$$

where

$\chi(\bar{\lambda}_\theta)$ is a reduction factor conforming to the buckling curve c set out in paragraph 6.3.1 of Standard SFS-EN 1993-1-1 corresponding to the relative slenderness $\bar{\lambda}_\theta$, unless demonstrated reliably that some other buckling curve is more correct,

$N_{fi,pl,Rd}$ is the fire design value for cross-sectional compression resistance.

(3) Cross-section is divided into parts according to the materials where “a” is used for steel profile, “s” for reinforcement and “c” for concrete.

(4) Fire design value for cross-sectional compression resistance is:

$$N_{fi,pl,Rd} = \sum_j \left(A_{a,\theta} f_{ay,\theta}\right) / \gamma_{M,fi,a} + \sum_k \left(A_{s,\theta} f_{sy,\theta}\right) / \gamma_{M,fi,s} + \sum_m \left(A_{c,\theta} f_{c,\theta}\right) / \gamma_{M,fi,c} \tag{4.13}$$

where

$A_{i,\theta}$ is the area of each part of cross-section at the temperature θ.

(5) Effective flexural stiffness is calculated from:

$$(EI)_{fi,eff} = \sum(\varphi_{a,\theta} E_{a,\theta} I_{a,\theta}) + \sum(\varphi_{s,\theta} E_{s,\theta} I_{s,\theta}) + \sum(\varphi_{c,\theta} E_{c,sec,\theta} I_{c,\theta}) \tag{4.14}$$

where

$I_{i,\theta}$ is the second moment of area of material part *i* related to the considered axis,

$\varphi_{i,\theta}$ is the reduction factor which is calibrated to match the compression resistances achieved in loaded fire tests so that the result is on the safe side.

$E_{c,sec,\theta}$ is the characteristic value of secant modulus of concrete during fire which is calculated by dividing $f_{c,\theta}$ by compression $\varepsilon_{cu,\theta}$.

(6) Critical buckling load during fire in accordance with the elasticity theory is

$$N_{fi,cr} = \pi^2 (EI)_{fi,eff} / \ell_\theta^2$$

where

ℓ_θ is the buckling length during fire calculated in accordance with paragraph 4.3.5.1(10).

(7) Relative slenderness during fire is: $\bar{\lambda}_\theta = \sqrt{\dfrac{N_{fi,pl,R}}{N_{fi,cr}}}$

where

$N_{fi,pl,R}$ is the value of cross-sectional resistance $N_{fi,pl,Rd}$ in accordance with paragraph (4) when the partial safety factors $\gamma_{M,fi,a}$, $\gamma_{M,fi,s}$ and $\gamma_{M,fi,c}$ are = 1,0.

(8) The design value $N_{fi,Rd,\delta}$ of compression resistance in an eccentrically loaded column is

$$N_{fi,Rd,\delta} = N_{fi,Rd}\left(1 - \left(1 - \frac{f_{cd}A_c}{N_{pl,Rd}}\right)\frac{M_{Ed,1}}{M_{pl,Rd}}\right)$$

where $f_{cd} = f_{ck}/\gamma_c$ is the design strength of concrete at normal temperature and $M_{Ed,1}$ = the maximum first order design moment due to design load at normal temperature. $N_{pl,Rd}$ and $M_{pl,Rd}$ are the design resistances of the column cross-section in accordance with Standard SFS-EN 1994-1-1.

NOTE 1:

The values of reduction factors $\varphi_{i,\theta}$ are characteristic to each method and depend on the temperatures θ of steel section, reinforcement and concrete used in the method and also on the curve included in the buckling analysis.

NOTE 2:

Reduction factors used in the method may be calibrated on the basis of compression resistances achieved in fire tests of loaded columns so that, when calculating the values $N_{fi,pl,R}$ and $(EI)_{fi,eff}$, the temperatures included in the design model and the material characteristics corresponding to these set out in paragraphs 3.2.1, 3.2.2 and 3.2.3 in Standard SFS-EN 1994-1-2, are used.