

# **CYS National Annex to CYS EN 1992-1-1:2004**

## **Eurocode 2: Design of concrete structures**

### **Part 1-1:**

## **General rules and rules for buildings**

Prepared by

Eurocodes Committee, Scientific and Technical

Chamber of Cyprus under a Ministry of Interior's Programme



**NATIONAL ANNEX**

**TO**

**CYS EN 1992-1-1:2004 Eurocode 2: Design of concrete  
structures**

**Part1.1: General rules and rules for buildings**

**This National Annex has been approved by the Board of Governors of the Cyprus  
Organisation for Standardisation on 11/06/2010.**

## INTRODUCTION

This National Annex has been prepared by the Eurocodes Committee of the Technical Chamber of Cyprus which was commissioned by the Ministry of Interior of the Republic of Cyprus.

## NA 1 SCOPE

This National Annex is to be used together with CYS EN 1992-1-1:2004

This National Annex gives:

- (a) Nationally determined parameters for the following clauses of CYS EN 1992-1-1:2004 where National choice is allowed (see Section NA 2)
- 2.3.3 (3)
  - 2.4.2.1 (1)
  - 2.4.2.2 (1) & (2) & (3)
  - 2.4.2.3 (1)
  - 2.4.2.4 (1) & (2)
  - 2.4.2.5 (2)
  - 3.1.2 (2)P & (4)
  - 3.1.6 (1)P & (2)P
  - 3.2.2 (3)P
  - 3.2.7 (2)
  - 3.3.4 (5)
  - 3.3.6 (7)
  - 4.4.1.2 (3) & (5) & (6) & (7) & (8) & (13)
  - 4.4.1.3 (1)P & (3) & (4)
  - 5.1.3 (1)P
  - 5.2 (5)
  - 5.5 (4)
  - 5.6.3 (4)
  - 5.8.3.1 (1)
  - 5.8.3.3 (1) & (2)
  - 5.8.5 (1)
  - 5.8.6 (3)
  - 5.10.1 (6)
  - 5.10.2.1 (1)P & (2)
  - 5.10.2.2 (4) & (5)
  - 5.10.3 (2)
  - 5.10.8 (2) & (3)
  - 5.10.9 (1)P
  - 6.2.2 (1) & (6)
  - 6.2.3 (2) & (3)
  - 6.2.4 (4) & (6)
  - 6.4.3 (6)
  - 6.4.4 (1)
  - 6.4.5 (3) & (4)
  - 6.5.2 (2)

- 6.5.4 (4) & (6)
- 6.8.4 (1) & (5)
- 6.8.6 (1) & (2)
- 6.8.7 (1)
- 7.2 (2) & (3) & (5)
- 7.3.1 (5)
- 7.3.2 (4)
- 7.3.4 (3)
- 7.4.2 (2)
- 8.2 (2)
- 8.3 (2)
- 8.6 (2)
- 8.8 (1)
- 9.2.1.1 (1) & (3)
- 9.2.1.2 (1)
- 9.2.1.4 (1)
- 9.2.2 (4) & (5) & (6) & (7) & (8)
- 9.3.1.1 (3)
- 9.5.2 (1) & (2) & (3)
- 9.5.3 (3)
- 9.6.2 (1)
- 9.6.3 (1)
- 9.7 (1)
- 9.8.1 (3)
- 9.8.2.1 (1)
- 9.8.3 (1) & (2)
- 9.8.4 (1)
- 9.8.5 (3)
- 9.10.2.2 (2)
- 9.10.2.3 (3) & (4)
- 9.10.2.4 (2)
- 11.3.5 (1)P & (2)P
- 11.3.7 (1)
- 11.6.1 (1)
- 11.6.2 (1)
- 11.6.4.1 (1)
- 12.3.1 (1)
- 12.6.3 (2)
- A.2.1 (1) & (2)
- A.2.2 (1) & (2)
- A.2.3 (1)
- C.1 (1) & (3)
- E.1 (2)
- J.1 (3)
- J.2.2 (2)
- J.3 (2) & (3)

- (b) Decisions on the use of the Informative Annexes A, B, D, E, F, G, H, I and J (see Section NA 3)
- (c) References to non-contradictory complementary information to assist the user to apply CYS EN 1992-1-1:2004. In this National Annex such information is provided for the following clauses in CYS EN 1992-1-1:2004 (see Section NA 4)
  - None

## NA 2 NATIONALLY DETERMINED PARAMETERS

### NA 2.1 Clause 2.3.3(3) Deformations of concrete

The value of  $d_{\text{joint}}$  is specified as 30 m. For precast concrete structures the value may be larger than that for cast in-situ structures, since part of the creep and shrinkage takes place before erection.

### NA 2.2 Clause 2.4.2.1(1): Partial factor for shrinkage action

The value of partial factor  $\gamma_{\text{SH}}$  is specified as 1,0.

### NA 2.3 Clause 2.4.2.2: Partial factors for prestress

- (1) The value of  $\gamma_{\text{P,fav}}$  for persistent and transient design situations is specified as 1,0. This value may also be used for fatigue verification.
- (2) The value of  $\gamma_{\text{P,unfav}}$  in the stability limit state for global analysis is specified as 1,3.
- (3) The value of  $\gamma_{\text{P,unfav}}$  for local effects is specified as 1,2. The local effects of the anchorage of pre-tensioned tendons are considered in Clause 8.10.2 of EN 1992-1-1:2004.

### NA 2.4 Clause 2.4.2.3(1): Partial factor for fatigue loads

The value of  $\gamma_{\text{F,fat}}$  is specified as 1,0.

### NA 2.5 Clause 2.4.2.4: Partial factors for materials

- (1) The values of  $\gamma_{\text{C}}$  and  $\gamma_{\text{S}}$  for use for “persistent & transient” and “accidental” design situations are given in Table 2.1(CYS). These are not valid for fire design for which reference should be made to CYS EN 1992-1-2:2004.

For fatigue verification the partial factors for persistent design situations given in Table 2.1(CYS) are specified for the values of  $\gamma_{\text{C,fat}}$  and  $\gamma_{\text{S,fat}}$ .

**Table 2.1(CYS): Partial factors for materials for ultimate limit states**

Design situations	$\gamma_{\text{C}}$ for concrete	$\gamma_{\text{S}}$ for reinforcing steel	$\gamma_{\text{S}}$ for prestressing steel
Persistent & Transient	1,5	1,15	1,15
Accidental	1,2	1,0	1,0

- (2) The values of  $\gamma_C$  and  $\gamma_S$  in the serviceability limit state, for situations not covered by particular clauses of this Eurocode, are specified as 1,0.

**NA 2.6 Clause 2.4.2.5(2): Partial factors for materials for foundations**

The value of  $k_f$  is specified as 1,1.

**NA 2.7 Clause 3.1.2: Strength**

- (2)P The value of  $C_{max}$  is specified as C90/105.  
(4) The value of  $k_t$  is specified as 0,85.

**NA 2.8 Clause 3.1.6 Design compressive and tensile strengths**

- (1)P The value of  $\alpha_{cc}$  is specified as 1,0.  
(2)P The value of  $\alpha_{ct}$  is specified as 1,0.

**NA 2.9 Clause 3.2.2(3)P: Properties**

The upper limit of  $f_{yk}$  is specified as 600 MPa.

**NA 2.10 Clause 3.2.7(2): Design assumptions**

The value of  $\varepsilon_{ud}$  is specified as  $0,9\varepsilon_{uk}$ .

**NA 2.11 Clause 3.3.4(5): Ductility characteristics**

The value of  $k$  is specified as 1,1.

**NA 2.12 Clause 3.3.6(7): Design assumptions**

The value of  $\varepsilon_{ud}$  is specified as  $0,90\varepsilon_{uk}$ . If more accurate values are not known, the value of  $\varepsilon_{ud}$  is specified as 0,02 and the value of the ratio  $f_{p0,1k} / f_{pk}$  is specified as 0,90.

**NA 2.13 Clause 4.4.1.2: Minimum cover,  $c_{min}$**

- (3) The values of  $c_{min,b}$  for post-tensioned circular and rectangular ducts for bonded tendons, and pre-tensioned tendons are specified as follows:

circular ducts: diameter

rectangular ducts: greater of the smaller dimension or half the greater dimension.

There is no requirement for more than 80 mm for either circular or rectangular ducts.

The values for pre-tensioned tendons are specified as follows:

2,0 x diameter of strand or plain wire

3,0 x diameter of indented wire.

- (5) The Structural Class (design working life of 50 years) is S4 for the indicative concrete strengths given in Annex E of CYS EN 1992-1-1:2004 and the modifications to the structural class are given in Table 4.3(CYS). The minimum Structural Class is specified as S1.

The values of  $c_{min,dur}$  are given in Table 4.4(CYS) (reinforcing steel) and Table 4.5(CYS) (prestressing steel).

**Table 4.3(CYS): Recommended structural classification**

<b>Structural Class</b>							
<b>Criterion</b>	<b>Exposure Class according to Table 4.1 of CYS EN 1992-1-1:2004</b>						
	X0	XC1	XC2/XC3	XC4	XD1	XD2/XS1	XD3/XS2/XS3
Design Working Life of 100 years	increase class by 2	increase class by 2	increase class by 2	increase class by 2	increase class by 2	increase class by 2	increase class by 2
Strength Class <sup>1)2)</sup>	≥ C30/37 reduce class by 1	≥ C30/37 reduce class by 1	≥ C35/45 reduce class by 1	≥ C40/50 reduce class by 1	≥ C40/50 reduce class by 1	≥ C40/50 reduce class by 1	≥ C45/55 reduce class by 1
Member with slab geometry (position of reinforcement not affected by construction process)	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1
Special Quality Control of the concrete production ensured	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1

**Notes to Table 4.3(CYS):**

1. The strength class and w/c ratio are considered to be related values. Relationship can be established from specialist literature. A special composition (type of cement, w/c value, fine fillers) with the intent to produce low permeability may be considered.
2. The limit may be reduced by one strength class if air entrainment of more than 4% is applied.

**Table 4.4(CYS): Values of minimum cover,  $c_{min,dur}$ , requirements with regard to durability for reinforcement steel**

<b>Environmental Requirement for <math>c_{min,dur}</math> (mm)</b>							
<b>Structural Class</b>	<b>Exposure Class according to Table 4.1 of CYS EN 1992-1-1:2004</b>						
	X0	XC1	XC2/XC3	XC4	XD1/XS1	XD2/XS2	XD3/XS3
S1	10	10	10	15	20	25	30
S2	10	10	15	20	25	30	35
S3	10	10	20	25	30	35	40
S4	10	15	25	30	35	40	45
S5	15	20	30	35	40	45	50
S6	20	25	35	40	45	50	55

**Table 4.5(CYS): Values of minimum cover,  $c_{\min,dur}$ , requirements with regard to durability for prestressing steel**

Environmental Requirement for $c_{\min,dur}$ (mm)							
Structural Class	Exposure Class according to Table 4.1 of CYS EN 1992-1-1:2004						
	X0	XC1	XC2/XC3	XC4	XD1/XS1	XD2/XS2	XD3/XS3
S1	10	15	20	25	30	35	40
S2	10	15	25	30	35	40	45
S3	10	20	30	35	40	45	50
S4	10	25	35	40	45	50	55
S5	15	30	40	45	50	55	60
S6	20	35	45	50	55	60	65

- (6) The value of  $\Delta c_{dur,y}$  is specified as 0 mm.  
(7) The value of  $\Delta c_{dur,st}$  is specified as 0 mm.  
(8) The value of  $\Delta c_{dur,add}$  is specified as 0 mm.  
(13) The values of  $k_1$ ,  $k_2$  and  $k_3$  are specified as 5 mm, 10 mm and 15 mm respectively.

#### NA 2.14 Clause 4.4.1.3: Allowance in design for deviation

- (1)P The value of  $\Delta c_{dev}$  is specified as 10 mm.  
(3) The allowable reductions in  $\Delta c_{dev}$  are as follows:
- where fabrication is subjected to quality assurance system, in which the monitoring includes measurements of the concrete cover, the allowance in design for deviation  $\Delta c_{dev}$  may be reduced:  $10 \text{ mm} \geq \Delta c_{dev} \geq 5 \text{ mm}$
  - where it can be assured that a very accurate measurement device is used for monitoring and non conforming members are rejected (e.g. precast elements), the allowance in design for deviation  $\Delta c_{dev}$  may be reduced:  $10 \text{ mm} \geq \Delta c_{dev} \geq 0 \text{ mm}$
- (4) The values of  $k_1$  and  $k_2$  are specified as 40mm and 75mm respectively.

#### NA 2.15 Clause 5.1.3(1)P: Load cases and combinations

The following simplified load arrangements are allowed for buildings:

- (a) alternate spans carrying the design variable and permanent loads ( $\gamma_Q Q_k + \gamma_G G_k + P_m$ ), other spans carrying only the design permanent load,  $\gamma_G G_k + P_m$  and  
(b) any two adjacent spans carrying the design variable and permanent loads ( $\gamma_Q Q_k + \gamma_G G_k + P_m$ ). All other spans carrying only the design permanent load,  $\gamma_G G_k + P_m$ .

#### NA 2.16 Clause 5.2(5): Geometric Imperfections

The value of  $\theta_0$  is specified as 1/200.

#### NA 2.17 Clause 5.5(4): Linear elastic analysis with limited redistribution

The values of  $k_1$ ,  $k_2$ ,  $k_3$ ,  $k_4$ ,  $k_5$  and  $k_6$  are specified as follows:

$$k_1 = 0,44$$

$$k_2 = 1,25(0,6+0,0014/\varepsilon_{cu2})$$

$$k_3 = 0,54$$

$$k_4 = 1,25(0,6+0,0014/\varepsilon_{cu2})$$

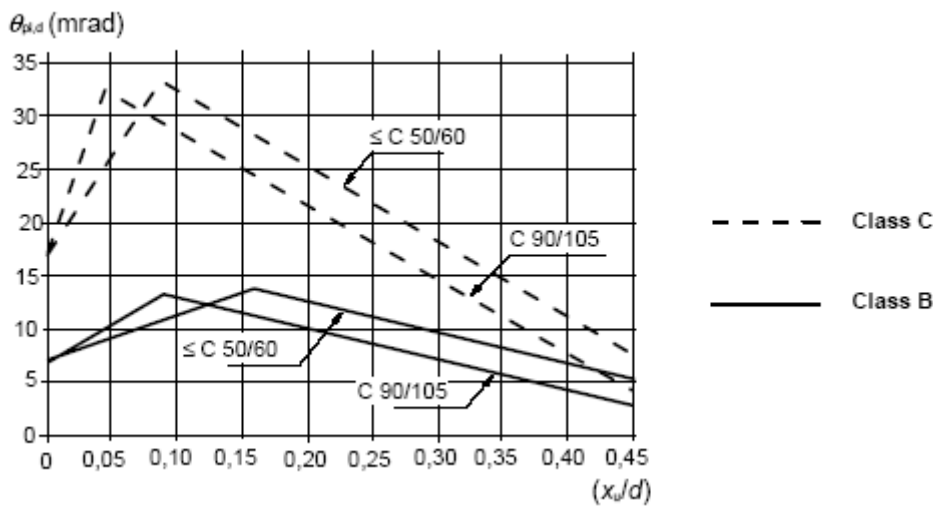
$$k_5 = 0,7$$

$$k_6 = 0,8$$

$\varepsilon_{cu2}$  is the ultimate strain according to Table 3.1 of CYS EN 1992-1-1:2004.

### NA 2.18 Section 5.6.3(4): Rotation capacity

The value of  $\theta_{pl,d}$  for steel Classes B and C (the use of Class A steel is not recommended for plastic analysis) and concrete classes less than or equal to C50/60 and C90/105 are given in Figure 5.6(CYS), which corresponds to Figure 5.6N of CYS EN 1992-1-1:2004.



**Figure 5.6(CYS): Allowable plastic rotation,  $\theta_{pl,d}$ , of reinforced concrete sections for Class B and C reinforcement. The values apply for a shear slenderness  $\lambda = 3,0$**

The values for concrete strength classes C55/67 to C90/105 may be interpolated accordingly. The values apply for a shear slenderness  $\lambda = 3,0$ . For different values of shear slenderness,  $\theta_{pl,d}$  should be multiplied by  $k_\lambda$ :

$$k_\lambda = \sqrt{(\lambda/3)} \quad (5.11CYS)$$

Where  $\lambda$  is the ratio of the distance between point of zero and maximum moment after redistribution and effective depth,  $d$ .

As a simplification  $\lambda$  may be calculated for the concordant design values of the bending moment and shear:

$$\lambda = M_{Sd} / (V_{Sd} \cdot d) \quad (5.12CYS)$$

### NA 2.19 Section 5.8.3.1(1): Slenderness criterion for isolated members

The limiting slenderness value  $\lambda_{lim}$  is given by:

$$\lambda_{lim} = 20.A.B.C / \sqrt{n} \quad (5.13CYS)$$

where:

$\lambda$  is the slenderness ratio as defined in 5.8.3.2 of CYS EN 1992-1-1:2004

$A = 1 / (1 + 0,2\varphi_{ef})$  (if  $\varphi_{ef}$  is not known,  $A=0,7$  may be used)

$B = \sqrt{1 + 2\omega}$  (if  $\omega$  is not known,  $B=1,1$  may be used)

$C = 1,7 - r_m$  (if  $r_m$  is not known,  $C=0,7$  may be used)

$\varphi_{ef}$  effective creep ratio; see 5.8.4 of CYS EN 1992-1-1:2004

$\omega = A_s f_{yd} / (A_c f_{cd})$ ; mechanical reinforcement ratio;

$A_s$  is the total area of longitudinal reinforcement

$n = N_{Ed} / (A_c f_{cd})$ ; relative normal force

$r_m = M_{01} / M_{02}$ ; moment ratio

$M_{01}, M_{02}$  are the first order end moments,  $|M_{02}| \geq |M_{01}|$

If the end moments  $M_{01}$  and  $M_{02}$  give tension on the same side,  $r_m$  should be taken positive (i.e.  $C \leq 1,7$ ), otherwise negative (i.e.  $C > 1,7$ ).

In the following cases,  $r_m$  should be taken as 1,0 (i.e.  $C = 0,7$ ):

- for braced members with first order moments only or predominantly due to imperfections or transverse loading
- for unbraced members in general.

### NA 2.20 Section 5.8.3.3 Global second order effects in buildings

(1) The value of  $k_1$  is specified as 0,31.

(2) The value of  $k_2$  is specified as 0,62.

### NA 2.21 Section 5.8.5(1): Methods of analysis

Both Simplified Methods (a) and (b) are allowed, subject to the limitations given in 5.8.5 (3) and 5.8.5 (4).

### NA 2.22 Section 5.8.6(3): General method

The value of  $\gamma_{cE}$  is specified as 1,2.

### NA 2.23 Section 5.10.1(6): General

Methods *A*, *B* and *E* for avoiding brittle failure are allowed.

### NA 2.24 Section 5.10.2.1(1)P: Maximum stressing force

(1)P The values of  $k_1$  and  $k_2$  are specified as 0,8 and 0,9 respectively.

(2) The value of  $k_3$  is specified as 0,95.

**NA 2.25 Section 5.10.2.2: Limitation of concrete stress**

(4) The value of  $k_4$  is specified as 50 and the value of  $k_5$  is specified as 30.

(5) The value of  $k_6$  is specified as 0,7.

**NA 2.26 Section 5.10.3(2): Prestress force**

The value of  $k_7$  is specified as 0,75 and the value of  $k_8$  is specified as 0,85.

**NA 2.27 Section 5.10.8: Effects of prestressing at ultimate limit state**

(2) The value of  $\Delta\sigma_{p,ULS}$  is specified as 100 MPa.

(3) The values of  $\gamma_{\Delta P,sup}$  and  $\gamma_{\Delta P,inf}$  are specified as 1,2 and 0,8 respectively. If linear analysis with uncracked sections is applied, then the values of both  $\gamma_{\Delta P,sup}$  and  $\gamma_{\Delta P,inf}$  are specified as 1,0.

**NA 2.28 Section 5.10.9(1)P: Effects of prestressing at serviceability limit state and limit state of fatigue**

The values of  $r_{sup}$  and  $r_{inf}$  are specified as follows:

- for pre-tensioned or unbonded tendons:  $r_{sup} = 1,05$  and  $r_{inf} = 0,95$
- for post-tensioning with bonded tendons:  $r_{sup} = 1,10$  and  $r_{inf} = 0,90$
- when appropriate measures (e.g. direct measurements of pretensioning) are taken:  $r_{sup} = r_{inf} = 1,0$ .

**NA 2.29 Clause 6.2.2: Members not requiring design shear reinforcement**

(1) The value of  $C_{Rd,c}$  is specified as  $0,18/\gamma_c$ , the value of  $v_{min}$  is given by expression (6.3CYS) and the value of  $k_1$  is specified as 0,15.

$$v_{min} = 0,035k^{3/2} \cdot f_{ck}^{1/2} \quad (6.3CYS)$$

(6) The value of the strength reduction factor for concrete cracked in shear,  $v$ , is given by:

$$v = 0,6[1 - f_{ck}/250] \quad (f_{ck} \text{ in MPa}) \quad (6.6CYS)$$

**NA 2.30 Clause 6.2.3 Members requiring design shear reinforcement**

(2) The limiting values of  $\cot\theta$  are given in Expression (6.7NCYS):

$$1 \leq \cot\theta \leq 2,5 \quad (6.7CYS)$$

(3) The value of the strength reduction factor for concrete cracked in shear,  $v_1$ , is specified as  $v$ .

For reinforced and prestressed members, if the design stress of the shear reinforcement is below 80 % of the characteristic yield stress  $f_{yk}$ ,  $v_1$  may be taken as:

$$v_1 = 0,6 \quad \text{for } f_{ck} \leq 60\text{Mpa} \quad (6.10.aCYS)$$

$$v_1 = 0,9 - f_{ck}/200 > 0,5 \quad \text{for } f_{ck} \geq 60\text{Mpa} \quad (6.10.bCYS)$$

The value of  $\alpha_{cw}$  is specified as follows:

$$\alpha_{cw} = 1 \quad \text{for non-prestressed structures}$$

$$\alpha_{cw} = (1 + \sigma_{cp}/f_{cd}) \quad \text{for } 0 < \sigma_{cp} \leq 0,25 f_{cd} \quad (6.11.aCYS)$$

$$\alpha_{cw} = 1,25 \quad \text{for } 0,25 f_{cd} < \sigma_{cp} \leq 0,5 f_{cd} \quad (6.11.bCYS)$$

$$\alpha_{cw} = 2,5 (1 - \sigma_{cp}/f_{cd}) \quad \text{for } 0,5 f_{cd} < \sigma_{cp} < 1,0 f_{cd} \quad (6.11.cCYS)$$

$\sigma_{cp}$  is the mean compressive stress, measured positive, in the concrete due to the design axial force. This should be obtained by averaging it over the concrete section taking account of the reinforcement. The value of  $\sigma_{cp}$  need not be calculated at a distance less than  $0,5d \cot\theta$  from the edge of the support.

### NA 2.31 Clause 6.2.4(6): Shear between web and flanges of T- sections

(4) The permitted range of the values for  $\cot \theta_f$ , in the absence of more rigorous calculation, are:

$$1,0 \leq \cot \theta_f \leq 2,0 \quad \text{for compression flanges } (45^\circ \geq \theta_f \geq 26,5^\circ)$$

$$1,0 \leq \cot \theta_f \leq 1,25 \quad \text{for tension flanges } (45^\circ \geq \theta_f \geq 38,6^\circ)$$

(6) The value of  $k$  is specified as 0,4.

### NA 2.32 Clause 6.4.3(6): Punching shear calculation

The values of  $\beta$  are specified in Figure 6.21(CYS).

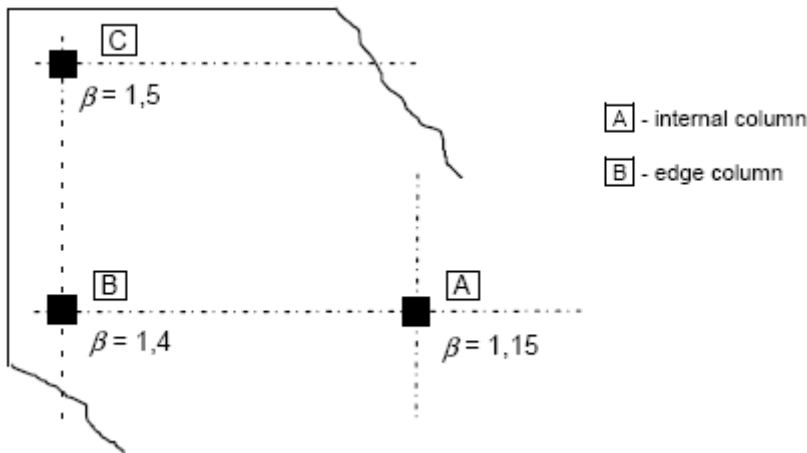


Figure 6.21(CYS): Specified values for  $\beta$

### NA 2.33 Clause 6.4.4(1): Punching shear resistance of slabs and column bases without shear reinforcement

The value for  $C_{Rd,c}$  is specified as  $0,18/\gamma_c$ , the value of  $v_{min}$  is given by Expression (6.3CYS) and the value of  $k_1$  is specified as 0,1.

**NA 2.34 Clause 6.4.5: Punching shear resistance of slabs and column bases with shear reinforcement**

- (3) The value of  $v_{Rd,max}$  is specified as  $0,5v_f c_{cd}$ .  
(4) The value of  $k$  is specified as 1,5.

**NA 2.35 Clause 6.5.2(2): Struts**

The value of  $v$  is given by Expression (6.57CYS):

$$v = 1 - f_{ck} / 250 \quad (6.57CYS)$$

**NA 2.36 Clause 6.5.4: Nodes**

- (4) The value of  $k_1$  is specified as 1,0, the value of  $k_2$  is specified as 0,85 and the value of  $k_3$  is specified as 0,75.  
(6) The value of  $k_4$  is specified as 3,0.

**NA 2.37 Clause 6.8.4: Verification procedure for reinforcing and prestressing steel**

- (1) The value of  $\gamma_{F,fat}$  is specified as 1,0.

The values of parameters for reinforcing steels and prestressing steels S-N curves are given in Tables 6.3(CYS) and 6.4(CYS) for reinforcing and prestressing steel respectively.

**Table 6.3(CYS): Parameters for S-N curves for reinforcing steel**

Type of reinforcement	N*	stress exponent		$\Delta\sigma_{Rsk}$ (MPa) at N* cycles
		$k_1$	$k_2$	
<b>Straight and bent bars<sup>1</sup></b>	$10^6$	5	9	162,5
<b>Welded bars and wire fabrics</b>	$10^7$	3	5	58,5
<b>Splicing devices</b>	$10^7$	3	5	35

**Note 1:** Values for  $\Delta\sigma_{Rsk}$  are those for straight bars. Values for bent bars should be obtained using a reduction factor  $\zeta = 0,35 + 0,026 D / \varphi$   
where:  
 $D$  diameter of the mandrel  
 $\varphi$  bar diameter

**Table 6.4(CYS): Parameters for S-N curves of prestressing steel**

S-N curve of prestressing steel used for	N*	stress exponent		$\Delta\sigma_{Rsk}$ (MPa) at N* cycles
		$k_1$	$k_2$	
<b>pre-tensioning</b>	$10^6$	5	9	185
<b>post-tensioning</b>				
- single strands in plastic ducts	$10^6$	5	9	185
- straight tendons or curved tendons in plastic ducts	$10^6$	5	10	150
- curved tendons in steel ducts	$10^6$	5	7	120
- splicing devices	$10^6$	5	5	80

- (5) The value of stress exponent  $k_2$  is specified as 5.

**NA 2.38 Clause 6.8.6: Other verifications**

- (1) The value of  $k_1$  is specified as 70 and the value of  $k_2$  is specified as 35.  
(2) The value of  $k_3$  is specified as 0,9.

**NA 2.39 Clause 6.8.7(1): Verification of concrete under compression using damage equivalent stress range**

The value of  $N$ , number of cycles, is specified as  $10^6$ .

The value of  $k_f$  is specified as 0,85.

**NA 2.40 Clause 7.2: Stress limitation**

- (2) The value of  $k_1$  is specified as 0,6.  
(3) The value of  $k_2$  is specified as 0,45.  
(5) The values of  $k_3$ ,  $k_4$  and  $k_5$  are specified as 0,8, 1 and 0,75 respectively.

**NA 2.41 Clause 7.3.1(5): General considerations**

The value of the limiting calculated crack width,  $w_{max}$ , is given in Table 7.1 (CYS).

**Table 7.1 (CYS): Values of  $w_{\max}$  (mm)**

Exposure Class	Reinforced members and prestressed members with unbonded tendons	Prestressed members with bonded tendons
	Quasi-permanent load combination	Frequent load combination
X0, XC1	0,4 <sup>1</sup>	0,2
XC2, XC3, XC4	0,3	0,2 <sup>2</sup>
XD1, XD2, XS1, XS2, XS3		Decompression
<p><b>Note 1:</b> For X0, XC1 exposure classes, crack width has no influence on durability and this limit is set to guarantee acceptable appearance. In the absence of appearance conditions this limit may be relaxed</p> <p><b>Note 2:</b> For these exposure classes, in addition, decompression should be checked under the quasi-permanent combination of loads.</p>		

In the absence of specific requirements (e.g. water-tightness), it may be assumed that limiting the calculated crack widths to the values of  $w_{\max}$  given in Table 7.1(CYS), under the quasi-permanent combination of loads, will generally be satisfactory for reinforced concrete members in buildings with respect to appearance and durability.

The durability of prestressed members may be more critically affected by cracking. In the absence of more detailed requirements, it may be assumed that limiting the calculated crack widths to the values of  $w_{\max}$  given in Table 7.1(CYS), under the frequent combination of loads, will generally be satisfactory for prestressed concrete members. The decompression limit requires that all parts of the tendons or duct lie at least 25mm within concrete in compression.

**NA 2.42 Clause 7.3.2(4): Minimum reinforcement areas**

The value of  $\sigma_{ct,p}$  is specified as equal to the value of  $f_{ct,eff}$  in accordance with 7.3.2(2) of EN 1992-1-1:2004.

**NA 2.43 Clause 7.3.4(3): Calculation of crack widths**

The values of  $k_3$  and  $k_4$  are specified as 3,4 and 0,425 respectively.

**NA 2.44 Clause 7.4.2(2): Cases where calculations may be omitted**

Values of K are given in Table 7.4(CYS). Values obtained using Expression (7.16) of EN 1992-1-1:2004 for common cases (C30,  $\sigma_s = 310$  Mpa, different structural systems and reinforcement ratios  $\rho = 0,5$  % and  $\rho = 1,5$  %) are also given.

**Table 7.4(CYS): Basic ratios of span/effective depth for reinforced concrete members without axial compression**

Structural System	K	Concrete highly stressed $\rho = 1,5 \%$	Concrete lightly stressed $\rho = 0,5 \%$
Simply supported beam, one- or two-way spanning simply supported slab	1,0	14	20
End span of continuous beam or one-way continuous slab or two-way spanning slab continuous over one long side	1,3	18	26
Interior span of beam or one-way or two-way spanning slab	1,5	20	30
Slab supported on columns without beams (flat slab) (based on longer span)	1,2	17	24
Cantilever	0,4	6	8
<p><b>Note 1:</b> The values given have been chosen to be generally conservative and calculation may frequently show that thinner members are possible</p> <p><b>Note 2:</b> For 2-way spanning slabs, the check should be carried out on the basis of the shorter span. For flat slabs the longer span should be taken.</p> <p><b>Note 3:</b> The limits given for flat slabs correspond to a less severe limitation than a mid-span deflection of span/250 relative to the columns. Experience has shown this to be satisfactory.</p>			

The values given by Expression (7.16) of EN 1992-1-1:2004 and Table 7.4(CYS) have been derived from results of a parametric study made for a series of beams or slabs simply supported with rectangular cross section, using the general approach given in 7.4.3 of EN 1992-1-1:2004. Different values of concrete strength class and a 500 MPa characteristic yield strength were considered. For a given area of tension reinforcement the ultimate moment was calculated and the quasi-permanent load was assumed as 50% of the corresponding total design load. The span/depth limits obtained satisfy the limiting deflection given in 7.4.1(5) of EN 1992-1-1:2004.

#### **NA 2.45 Clause 8.2(2): Spacing of bars**

The values of  $k_1$  and  $k_2$  are specified as 1 and 5 mm respectively.

#### **NA 2.46 Clause 8.3(2): Permissible mandrel diameters for bent bars**

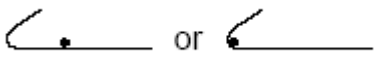
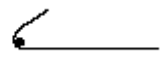
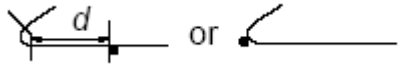
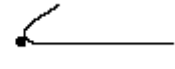
The values of  $\varphi_{m,min}$  are given in Table 8.1 (CYS)

**Table 8.1(CYS): Minimum mandrel diameter to avoid damage to reinforcement**

**a) for bars and wire**

Bar diameter	Minimum mandrel diameter for bends, hooks and loops (see Figure 8.1 of EN 1992-1-1:2004)
$\varphi \leq 16 \text{ mm}$	$4\varphi$
$\varphi > 16 \text{ mm}$	$7\varphi$

**b) for welded bent reinforcement and mesh bent after welding**

Minimum mandrel diameter	
 or 	 or 
$5\varphi$	$d \geq 3\varphi : 5\varphi$ $d < 3\varphi$ or welding within the curved zone: $20\varphi$
<b>Note:</b> The mandrel size for welding within the curved zone may be reduced to $5\varphi$ where the welding is carried out in accordance with prEN ISO 17660 Annex B	

**NA 2.47 Clause 8.6(2): Anchorage by welded bars**

The value of  $F_{\text{btd}}$  is determined from Expression (8.8CYS) below:

$$F_{\text{btd}} = l_{\text{td}} \varphi_t \sigma_{\text{td}} \text{ but not greater than } F_{\text{wd}} \quad (8.8\text{CYS})$$

where:

$F_{\text{wd}}$  is the design shear strength of weld (specified as a factor times  $A_s f_{\text{yd}}$ ; say  $0,5 A_s f_{\text{yd}}$  where  $A_s$  is the cross-section of the anchored bar and  $f_{\text{yd}}$  is its design yield strength)

$l_{\text{td}}$  is the design length of transverse bar:  $l_{\text{td}} = 1,16 \varphi_t (f_{\text{yd}} / \sigma_{\text{td}})^{0,5} \leq l_t$

$l_t$  is the length of the transverse bar, but not more than the spacing of bars to be anchored

$\varphi_t$  is the diameter of transverse bar

$\sigma_{\text{td}}$  is the concrete stress:  $\sigma_{\text{td}} = (f_{\text{ctd}} + \sigma_{\text{cm}}) / y \leq 3 f_{\text{cd}}$

$\sigma_{\text{cm}}$  is the compression in the concrete perpendicular to both bars (mean value, positive for compression)

$y$  is a function:  $y = 0,015 + 0,14 e^{(-0,18x)}$

$x$  is a function accounting for the geometry:  $x = 2 (c / \varphi_t) + 1$

$c$  is the concrete cover perpendicular to both bars

### NA 2.48 Clause 8.8(1): Additional rules for large diameter bars

The value of  $\varphi_{\text{large}}$  is specified as 32 mm.

### NA 2.49 Clause 9.2.1.1: Minimum and maximum reinforcement areas

(1) The value of  $A_{s,\text{min}}$  for beams is given in the following:

$$A_{s,\text{min}} = 0,26(f_{\text{ctm}}/f_{\text{yk}})b_t d \quad \text{but not less than } 0,0013b_t d \quad (9.1\text{CYS})$$

where:

$b_t$  denotes the mean width of the tension zone; for a T-beam with the flange in compression, only the width of the web is taken into account in calculating the value of  $b_t$ .

$f_{\text{ctm}}$  should be determined with respect to the relevant strength class according to Table 3.1.

Alternatively, for secondary elements, where some risk of brittle failure may be accepted,  $A_{s,\text{min}}$  may be taken as 1,2 times the area required in ULS verification.

(3) The value of  $A_{s,\text{max}}$  for beams is specified as  $0,04A_c$ .

### NA 2.50 Clause 9.2.1.2(1): Other detailing arrangements

The value of  $\beta_1$  for beams is specified as 0,15.

### NA 2.51 Clause 9.2.1.4(1): Anchorage of bottom reinforcement at an end support

The value of  $\beta_2$  for beams is specified as 0,25.

### NA 2.52 Clause 9.2.2: Shear reinforcement

(4) The value of  $\beta_3$  for beams is specified as 0,5.

(5) The value of  $\rho_{w,\text{min}}$  for beams is given in Expression (9.5CYS):

$$\rho_{w,\text{min}} = (0,08\sqrt{f_{\text{ck}}}) / f_{\text{yk}} \quad (9.5\text{CYS})$$

(6) The value of  $s_{l,\text{max}}$  is given in Expression (9.6CYS):

$$s_{l,\text{max}} = 0,75d (1 + \cot \alpha) \quad (9.6\text{CYS})$$

where  $\alpha$  is the inclination of the shear reinforcement to the longitudinal axis of the beam.

(7) The value of  $s_{b,\text{max}}$  is given in Expression (9.7CYS):

$$s_{b,\text{max}} = 0,6d (1 + \cot \alpha) \quad (9.7\text{CYS})$$

(8) The value of  $s_{t,\text{max}}$  is given in Expression (9.8CYS):

$$s_{t,\text{max}} = 0,75d \leq 600 \text{ mm} \quad (9.8\text{CYS})$$

### NA 2.53 Clause 9.3.1.1(3): General

The value of  $s_{\text{max,slabs}}$  is specified as follows:

- for the principal reinforcement,  $3h \leq 400$  mm, where  $h$  is the total depth of the slab;
- for the secondary reinforcement,  $3,5h \leq 450$  mm.

In areas with concentrated loads or areas of maximum moment those provisions become respectively:

- for the principal reinforcement,  $2h \leq 250$  mm,
- for the secondary reinforcement,  $3h \leq 400$  mm.

#### **NA 2.54 Clause 9.5.2: Longitudinal reinforcement**

(1) The value of  $\varphi_{\min}$  is specified as 8 mm.

(2) The value of  $A_{s,\min}$  is given by Expression (9.12CYS):

$$A_{s,\min} = 0,10 N_{Ed} / f_{yd} \text{ or } 0,002 A_c \text{ whichever is the greater}$$

where:

$f_{yd}$  is the design yield strength of the reinforcement

$N_{Ed}$  is the design axial compression force

(3) The value of  $A_{s,\max}$  is specified as  $0,04 A_c$  outside lap locations unless it can be shown that the integrity of concrete is not affected, and that the full strength is achieved at ULS. This limit should be increased to  $0,08 A_c$  at laps.

#### **NA 2.55 Clause 9.5.3(3): Transverse reinforcement**

The value of  $s_{cl,\max}$  is specified as the least of the following three distances:

- 20 times the minimum diameter of the longitudinal bars
- the lesser dimension of the column
- 400 mm

#### **NA 2.56 Clause 9.6.2(1): Vertical reinforcement**

The value of  $A_{s,v\min}$  is specified as  $0,002 A_c$ .

The value of  $A_{s,v\max}$  is specified as  $0,04 A_c$  outside lap locations unless it can be shown that the concrete integrity is not affected and that the full strength is achieved at ULS. This limit may be doubled at laps.

#### **NA 2.57 Clause 9.6.3(1): Horizontal reinforcement**

The value of  $A_{s,h\min}$  is specified as either 25 % of the vertical reinforcement or  $0,001 A_c$ , whichever is greater.

#### **NA 2.58 Clause 9.7(1): Deep beams**

The value of  $A_{s,db\min}$  is specified as 0,1 % but not less than  $150 \text{ mm}^2/\text{m}$  in each face and each direction.

#### **NA 2.59 Clause 9.8.1(3): Pile caps**

The value of  $\varphi_{\min}$  is specified as 8 mm.

#### **NA 2.60 Clause 9.8.2.1(1): General**

The value of  $\varphi_{\min}$  is specified as 8 mm.

#### **NA 2.61 Clause 9.8.3: Tie beams**

(1) The value of  $\varphi_{\min}$  is specified as 8 mm.

(2) The value of  $q_1$  is specified as 10 kN/m.

**NA 2.62 Clause 9.8.4(1): Column footing on rock**

The values of  $q_2$  and  $\varphi_{\min}$  are specified as 5 MPa and 8 mm respectively.

**NA 2.63 Clause 9.8.5(3): Bored piles**

The value of  $h_1$  is specified as 600 mm.

The value of  $A_{s,bpmin}$  is given in Table 9.6(CYS). This reinforcement should be distributed along the periphery of the section.

**Table 9.6(CYS): Recommended minimum longitudinal reinforcement area in cast-in-place bored piles**

<b>Pile cross section: <math>A_c</math></b>	<b>Minimum area of longitudinal reinforcement: <math>A_{s,bpmin}</math></b>
$A_c \leq 0,5 \text{ m}^2$	$A_s \geq 0,005 \cdot A_c$
$0,5 \text{ m}^2 < A_c \leq 1,0 \text{ m}^2$	$A_s \geq 25 \text{ cm}^2$
$A_c > 1,0 \text{ m}^2$	$A_s \geq 0,0025 \cdot A_c$

The minimum diameter for the longitudinal bars should not be less than 16 mm. Piles should have at least 6 longitudinal bars. The clear distance between bars should not exceed 200 mm measured along the periphery of the pile.

**NA 2.64 Clause 9.10.2.2(2): Peripheral ties**

The value of  $q_1$  is specified as 10 kN/m and the value of  $q_2$  is specified as 70 kN.

**NA 2.65 Clause 9.10.2.3: Internal ties**

(3) The value of  $F_{tie,int}$  is specified as 20 kN/m.

(4) The value of  $q_3$  is specified as 20 kN/m and the value of  $q_4$  is specified as 70 kN.

**NA 2.66 Clause 9.10.2.4(2): Horizontal ties to columns and/or walls**

The value of  $F_{tie,fac}$  is specified as 20 kN and the value of  $F_{tie,col}$  is specified as 150 kN.

**NA 2.67 Clause 11.3.5: Design compressive and tensile strengths**

(1)P The value of  $\alpha_{1cc}$  is specified as 0,85.

(2)P The value of  $\alpha_{1ct}$  is specified as 0,85.

**NA 2.68 Clause 11.3.7(1): Confined concrete**

The value of  $k$  is specified as:

1,1 for lightweight aggregate concrete with sand as the fine aggregate

1,0 for lightweight aggregate (both fine and coarse aggregate) concrete.

**NA 2.69 Clause 11.6.1(1): Members not requiring design shear reinforcement**

The value of  $C_{IRd,c}$  is specified as  $0,15/\gamma_c$ , the value of  $v_{1,min}$  is specified as  $0,30 k^{3/2} f_{ck}^{1/2}$  and the value of  $k_1$  is specified as 0,15.

**Table 11.6.1(CYS): Values of  $v_{1,min}$  for given values of  $d$  and  $f_{ck}$**

d (mm)	$v_{1,min}$ (MPa)						
	$f_{ck}$ (MPa)						
	20	30	40	50	60	70	80
200	0,36	0,44	0,50	0,56	0,61	0,65	0,70
400	0,29	0,35	0,39	0,44	0,48	0,52	0,55
600	0,25	0,31	0,35	0,39	0,42	0,46	0,49
800	0,40	0,28	0,32	0,36	0,39	0,42	0,45
$\geq 1000$	0,22	0,27	0,31	0,34	0,37	0,40	0,43

**NA 2.70 Clause 11.6.2(1): Members requiring design shear reinforcement**

The value of the reduction factor for the crushing resistance of the concrete struts,  $v_1$ , is given by the following Expression:

$$v_1 = 0,5\eta_1 (1 - f_{ick}/250)$$

(11.6.6CYN)

**NA 2.71 Clause 11.6.4.1: Punching shear resistance of slabs or column bases without shear reinforcement**

The value of  $k_2$  is specified as 0,08.

**NA 2.72 Clause 12.3.1(1): Concrete: additional design assumptions**

The value of both  $\alpha_{cc,pl}$  and  $\alpha_{ct,pl}$  is specified as 0,8.

**NA 2.73 Clause 12.6.3(2): Shear**

The value of  $k$  is specified as 1,5.

**NA 2.74 Clause A.2.1: Reduction based on quality control and reduced deviations**

- (1) The value of  $\gamma_{s,red1}$  is specified as 1,1.
- (2) The value of  $\gamma_{c,red1}$  is specified as 1,4.

**NA 2.75 Clause A.2.2: Reduction based on using reduced or measured geometrical data in design**

- (1) The value of  $\gamma_{s,red2}$  is specified as 1,05 and the value of  $\gamma_{c,red2}$  is specified as 1,45.
- (2) The value of  $\gamma_{c,red3}$  is specified as 1,35.

### NA 2.76 Clause A.2.3(1): Reduction based on assessment of concrete strength in finished structure

The value of the conversion factor  $\eta$  is specified as 0,85 and the value of  $\gamma_{c,red4}$  is specified as 1,3.

### NA 2.77 Clause C.1: General

(1) The values of the fatigue stress range with an upper limit of  $\beta f_{yk}$  and for the Minimum relative rib area are given in Table C.2(CYS). The value of  $\beta$  is specified as 0,6.

**Table C.2(CYS): Properties of reinforcement**

Product form		Bars and de-coiled rods			Wire Fabrics			Requirement or quantile value (%)
Class		A	B	C	A	B	C	-
Fatigue stress range (Mpa) (for $N \geq 2 \times 10^6$ cycles) with an upper limit of $\beta f_{yk}$		$\geq 150$			$\geq 100$			10,0
Bond: Minimum relative rib area, $f_{R,min}$	Nominal bar size (mm)							5,0
	5 – 6	0,035						
	6,5 – 12	0,040						
	> 12	0,056						

Exceptions to the fatigue rules may applied if the reinforcement is for predominantly static loading or if higher values of the fatigue stress range and/or the number of cycles are shown to apply by testing. In the latter case the values in Table 6.3 of EN 1992-1-1:2004 may be modified accordingly. Such testing should be in accordance with EN 10080.

Bond: where it can be shown that sufficient bond strength is achievable with  $f_R$  values less than specified above, the values may be relaxed. In order to ensure that sufficient bond strength is achieved, the bond stresses shall satisfy the Expressions (C.1(CYS)) and (C.2(CYS)) when tested using the CEB/RILEM beam test:

$$\tau_m \geq 0,098 (80 - 1,2\varphi) \quad (C.1(CYS))$$

$$\tau_r \geq 0,098 (130 - 1,9\varphi) \quad (C.2(CYS))$$

where:

$\varphi$  is the nominal bar size

$\tau_m$  is the mean value of bond stress (Mpa) at 0,01, 0,1 and 1 mm slip

$\tau_r$  is the bond stress at failure by slipping

(3) The value of  $a$  for  $f_{yk}$  is specified as 10 MPa and the value of  $a$  for both  $k$  and  $\varepsilon_{uk}$  is specified as 0.

The values of  $f_{yk}$ ,  $k$  and  $\varepsilon_{uk}$  are given in Table C.3(CYN):

**Table C.3(CYS): Absolute limits on test results**

Performance characteristic	Minimum value	Maximum value
Yield strength $f_{yk}$	0,97 x minimum $C_v$	1,03 x maximum $C_v$
$k$	0,98 x minimum $C_v$	1,02 x maximum $C_v$
$\varepsilon_{uk}$	0,80 x minimum $C_v$	Not applicable

**NA 2.78 Clause E.1(2): General**

Value of indicative strength classes are given in Table E.1(CYS):

**Table E.1(CYS): Indicative strength classes**

Exposure Classes according to Table 4.1 of EN 1992-1-1:2004										
Corrosion										
	Carbonation-induced corrosion				Chloride-induced corrosion			Chloride-induced corrosion from sea-water		
	XC1	XC2	XC3	XC4	XD1	XD2	XD3	XS1	XS2	XS3
Indicative Strength Class	C20/25	C25/30	C30/37		C30/37		C35/45	C30/37	C35/45	
Damage to Concrete										
	No risk	Freeze/Thaw Attack			Chemical Attack					
	X0	XF1	XF2	XF3	XA1	XA2		XA3		
Indicative Strength Class	C12/15	C30/37	C25/30	C30/37	C30/37			C35/45		

**NA 2.79 Clause J.1(3): Surface reinforcement**

The value of  $A_{s, surfmin}$  is defined as  $0,01 A_{ct,ext}$ , where  $A_{ct,ext}$  is the area of the tensile concrete external to the links (see Figure 9.7 of EN 1992-1-1:2004).

**NA 2.80 Clause J.2.2(2): Frame corners with closing moments**

The value of the lower limit of  $\tan \theta$  is specified as 0,4 and that of the upper limit is specified as 1.

**NA 2.81 Clause J.3: Corbels**

- (2) The value of  $k_1$  is specified as 0,25.
- (3) The value of  $k_2$  is specified as 0,5.

## **NA 3 DECISION ON USE OF THE INFORMATIVE ANNEXES A AND B**

### **NA 3.1 Annex A**

Annex A may be used

### **NA 3.2 Annex B**

Annex B may be used

### **NA 3.3 Annex D**

Annex D may be used

### **NA 3.4 Annex E**

Annex E may be used

### **NA 3.5 Annex F**

Annex F may be used

### **NA 3.6 Annex G**

Annex G may be used

### **NA 3.7 Annex H**

Annex H may be used

### **NA 3.8 Annex I**

Annex I may be used

### **NA 3.9 Annex J**

Annex J may be used

## **NA 4 REFERENCES TO NON-CONTRADICTORY COMPLEMENTARY INFORMATION**

None



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