NATIONAL ANNEX TO CYS EN 1992 - 1 - 1:2004 (Including A1:2014 +AC:2010)

Eurocode 2: Design of concrete structures

Part 1.1: General rules and rules for buildings

CYPRUS ORGANISATION FOR STANDARDISATION

NATIONAL ANNEX

TO

CYS EN 1992-1-1:2004+A1:2014+AC:2010

Eurocode 2: Design of concrete structures Part 1.1: General rules and rules for buildings

This National Annex has been approved by the Board of Directors of the Cyprus Organisation for Standardisation (CYS) on 14.06.2019.

INTRODUCTION

This National Annex has been prepared by the CYS TC 18 National Standardisation Technical Committee of Cyprus Organisation for Standardisation. (CYS)

NA 1 SCOPE

This National Annex is to be used together with CYS EN 1992-1-1:2004+A1:2014+AC:2010.Any reference in the rest of this text to CYS EN 1992-1-1:2004 means the above document.

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 (1)
- 6.4.5 (3) & (4)
- 6.5.2 (2)
- 6.5.4 (4) & (6)
- 6.8.4 (1) & (5)
- 6.8.6 (1) & (3)
- 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)
- 11.6.4.2 (2)
- 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 (2)
- 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_{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 γ_{SH} is specified as 1,0.

NA 2.3 Clause 2.4.2.2: Partial factors for prestress

(1) The value of $\gamma_{P,fav}$ for persistent and transient design situations is specified as 1,0. This value may also be used for fatigue verification.

(2) The value of $\gamma_{P,unfav}$ in the stability limit state for global analysis is specified as 1,3.

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

NA 2.5 Clause 2.4.2.4: Partial factors for materials

(1) The values of γ_C and γ_S 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 $\gamma_{C,fat}$ and $\gamma_{S,fat}$.

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

Design situations	γ_C for concrete	γ_S for reinforcing steel	γ_S for prestressing steel
Persistent & Transient	1,5	1,15	1,15
Accidental	1,2	1,0	1,0

(2) The values of γ_C and γ_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 α_{cc} is specified as 1,0.

(2)P The value of α_{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 ε_{ud} is specified as 0,9ε_{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 ε_{ud} is specified as 0,90ε_{uk}. If more accurate values are not known, the value of ε_{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:

<u>1,5</u> x diameter of strand or plain wire

<u>2,5</u> 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

Structural Class							
Criterion	**Exposure Class according to Table 4.1 of CYS EN 1992-1-1:2004**						
	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 1) 2)	≥ 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. 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 in accordance with EN10080

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	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 $\Delta c_{dur,\gamma}$ is specified as 0 mm.

(7) The value of $\Delta c_{dur,st}$, without further specification, is specified as 0 mm.

(8) The value of $\Delta c_{dur,add}$, without further specification, 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 Δc_{dev} is specified as 10 mm.

(3) The reductions in Δc_{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 Δc_{dev} may be reduced: 10 mm ≥ Δc_{dev} ≥ 5 mm
- where it can be assured that a very accurate measurement device is used for monitoring an non conforming members are rejected (e.g. precast elements), the allowance in design for deviation Δc_{dev} may be reduced: 10 mm ≥ Δc_{dev} ≥ 0 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 θ_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:

$k_1 = 0,44$

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

$k_3 = 0,54$

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

$k_5 = 0,7$

$k_6 = 0,8$

ε_{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 values of $\theta_{pl,d}$ for steel Classes B and C (the use of Class A steel is not recommended for plastic analysis) and concrete strength classes less than or equal to C50/60 and C90/105 are given in Figure 5.6(CYS).

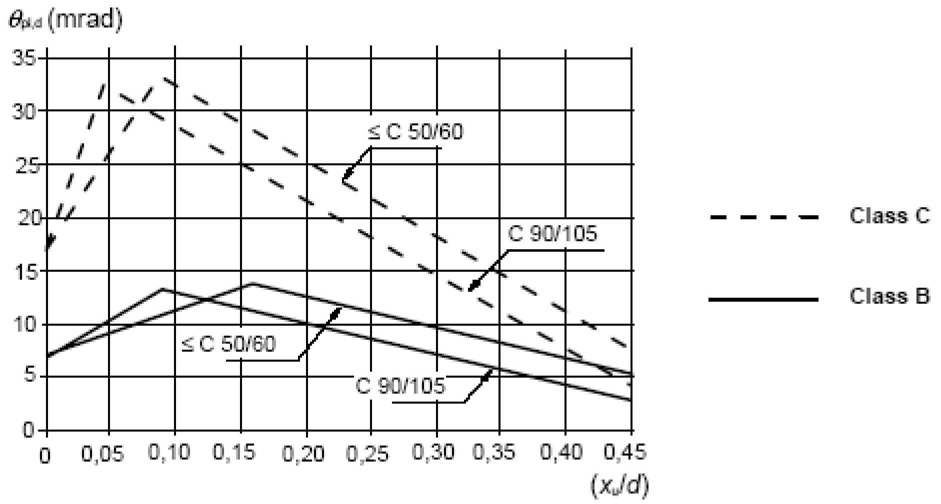


Figure 5.6(CYS): Basic value of allowable plastic rotation, $\theta_{pl,d}$, of reinforced concrete sections for Class B and C reinforcement. The values apply for a shear slenderness λ = 3,0

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

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

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

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

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

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

The value of λ_{lim} follows from:

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

where:

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

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

ω $= A_s f_{yd} / (A_c f_{cd})$; 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 in which the first order moments arise only from 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 (2) and 5.8.5 (3) of CYS EN 1992-1-1:2004.

NA 2.22 Section 5.8.6(3): General method

The value of γ_{CE} is specified as 1,2.

NA 2.23 Section 5.10.1(6): General

Brittle failure should be avoided by following one or more of Methods *A*, *B*, C, D and*E*.

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, a lower limit of deformations may be assumed and 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-tensioning 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_l is specified as 0,15.

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

(6) The value of v is given by:

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

NA 2.30 Clause 6.2.3 Members requiring design shear reinforcement

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

$$1 \leq \cot\vartheta \leq 2{,}5 \qquad (6.7CYS)$$

(3) The value of the strength reduction factor for concrete cracked in shear, v_1, is specified as v (see Expression (6.6CYS)).

If the design stress of the shear reinforcement is below 80 % of the characteristic yield stress f_{yk}, v_1 is taken as:

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

$\nu_1 = 0{,}9 - f_{ck}/200 > 0{,}5$ for $f_{ck} \geq 60$MPa (6.10.bCYS)

The value of α_{cw} is specified as follows:

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

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

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

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

where:

σ_{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 σ_{cp} need not be calculated at a distance less than 0,5d cotϑ from the edge of the support.

NA 2.31 Clause 6.2.4(6): Shear between web and flanges

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

$1{,}0 \leq \cot \vartheta_f \leq 2{,}0$ for compression flanges ($45^o \geq \vartheta_f \geq 26{,}5^o$)

$1{,}0 \leq \cot \vartheta_f \leq 1{,}25$ for tension flanges ($45^o \geq \vartheta_f \geq 38{,}6^o$)

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

NA 2.32 Clause 6.4.3(6): Punching shear calculation

The values of β are specified in Figure 6.21(CYS).

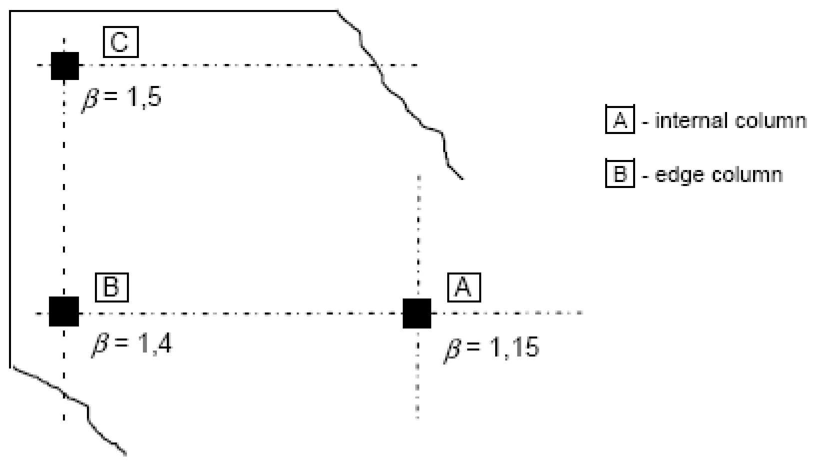


Figure 6.21(CYS): Specified values for β

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

(1) The value of k_{max} is specified as 1,5.

(3) The value of $v_{Rd,max}$ is specified as $0{,}4 v f_{cd}$, where v is given in Expression (6.6CYS).

(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):

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

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 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	
Straight and bent bars[1]	10^6	5	9	162,5
Welded bars and wire fabrics	10^7	3	5	58,5
Splicing devices	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

φ 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	
pre-tensioning	10^6	5	9	185
post-tensioning				
- 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 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 MPa and the value of k_2 is specified as 35 MPa.

(3) The value of k_3 is specified as 0,9.

NA 2.39 Clause 6.8.7(1): Verification of concrete under compression or shear

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

The value of k_1 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 values of w_{max}, for relevant exposure classes are 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[1]	0,2
XC2, XC3, XC4	0,3	0,2[2]

XD1, XD2, XD3, XS1, XS2, XS3		Decompression
Note 1: For X0, XC1 exposure classes, crack width has no influence on durability and this limit is set to give generally acceptable appearance. In the absence of appearance conditions this limit may be relaxed **Note 2:** For these exposure classes, in addition, decompression should be checked under the quasi-permanent combination of loads.		

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 CYS 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 CYS EN 1992-1-1:2004 for common cases (C30/37, σ_s = 310 MPa, different structural systems and reinforcement ratios ρ = 0,5 % and ρ = 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 ρ = 1,5 %	Concrete lightly stressed ρ = 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
Note 1: The values given have been chosen to be generally conservative and calculation may frequently show that thinner members are possible **Note 2:** 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. **Note 3:** 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.			

The values given by Expression (7.16) of CYS 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 CYS 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 CYS 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

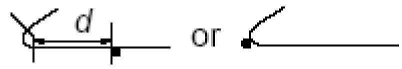
The values of $\varphi_{m,min}$ are given in Table 8.1(CYS)

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 CYS EN 1992-1-1:2004)
$\varphi \leq 16$ mm	4φ
$\varphi > 16$ mm	7φ

b) for welded bent reinforcement and mesh bent after welding

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

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

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

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

where:

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

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

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

φ_t is the diameter of transverse bar

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

σ_{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 φ_{large} is specified as 32 mm.

NA 2.49 Clause 9.2.1.1: Minimum and maximum reinforcement areas

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

$A_{s,min} = 0{,}26(f_{ctm}/f_{yk})b_t d$ but not less than $0{,}0013 b_t d$ (9.1CYS) 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_{ctm} should be determined with respect to the relevant strength class according to Table3.1 of CYS EN 1992-1-1:2004.

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

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

NA 2.50 Clause 9.2.1.2(1): Other detailing arrangements

The value of β_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 β_2 for beams is specified as 0,25.

NA 2.52 Clause 9.2.2: Shear reinforcement

(4) The value of β_3 for beams is specified as 0,5.

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

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

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

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

where α is the inclination of the shear reinforcement to the longitudinal axis of the beam.

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

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

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

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

NA 2.53 Clause 9.3.1.1(3): General

The value of $s_{max,slabs}$ 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 φ_{min} is specified as 8 mm.

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

$A_{s,min} = 0,10\ N_{Ed} / f_{yd}$ or $0,002\ A_c$ whichever is the greater (9.12CYS)

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 $s_{cl,tmax}$ 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 $A_{s,vmin}$ is specified as 0,002 A_c.

The value of $A_{s,vmax}$ 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 $A_{s,hmin}$ 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 $A_{s,dbmin}$ is specified as 0,001A_c but not less than 150 mm^2/m in each face and each direction.

NA 2.59 Clause 9.8.1(3): Pile caps

The value of φ_{min} is specified as 8 mm.

NA 2.60 Clause 9.8.2.1(1): General

The value of φ_{min} is specified as 8 mm.

NA 2.61 Clause 9.8.3: Tie beams

(1) The value of φ_{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

NA 2.63 The value of q_2 is specified as 5 MPa and the value of φ_{min} is specified as 8 mm. Clause 9.8.5(3): Bored piles

The values of $A_{s,bpmin}$ and the associated A_c are 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

Pile cross section: A_c	Minimum area of longitudinal reinforcement: $A_{s,bpmin}$
$A_c \leq 0,5$ m^2	$A_s \geq 0,005 \cdot A_c$
0,5 m^2 < $A_c \leq 1,0$ m^2	$A_s \geq 25$ cm^2
$A_c > 1,0$ 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 $\underline{Q}_2$ 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 $f_{tie,int}$ is specified as 20 kN/m 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 α_{lcc} is specified as 0,85.

(2)P The value of α_{lct} 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 $C_{lRd,c}$ is specified as $0,15/\gamma_C$, the value of $v_{l,min}$ is specified as

$0,028k^{3/2}f_{lck}^{1/2}$ and that for k_1 is specified as 0,15.

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

d (mm)	$v_{l,min}$ (MPa)						
	f_{lck} (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	0,23	0,28	0,32	0,36	0,39	0,42	0,45
≥ 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 v_1, is given by the following Expression:

$v_1 = 0,5\ (1 - f_{lck}/250)$ (11.6.6CYS)

For lightweight concrete v_1 should not be modified in accordance with Note 2 of 6.2.3(3) of CYS EN 1992-1-1:2004.

NA 2.71 Clause 11.6.4.1 (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 11.6.4.2(2): Punching shear resistance of slabs or column bases with shear reinforcement

The value of $v_{lRd,max}$ is specified as 0,4 $v\ f_{lcd}$, where v is taken equal to v_1 defined in expression (11.6.6CYS).

NA 2.73 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 2.74 Clause 12.6.3(2): Shear

The value of k is specified as 1,5.

NA 2.75 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 2.76 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 2.77 Clause A.2.3(1): Reduction based on assessment of concrete strength in finished structure

The value of η is specified as 0,85 and the value of $\gamma_{C,red4}$ is specified as 1,3.

NA 2.78 Clause C.1: General

(1) The values for the fatigue stress range with an upper limit of βf_{yk} and for the Minimum relative rib area are given in Table C.2(CYS). The value of β 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 ≥ 2 x 10^6 cycles) with an upper limit of βf_{yk}		≥150			≥100			10,0
Bond: Minimum relative rib area, $f_{R,min}$	Nominal bar size (mm)							
	5 – 6	0,035						
	6,5 to 12	0,040						5,0
	> 12	0,056						

Fatigue: 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 CYS 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 should satisfy the Expressions (C.1CYS) and (C.2CYS) when tested using the CEB/RILEM beam test:

$$\tau_m \geq 0{,}098\ (80 - 1{,}2\varphi) \qquad \text{(C.1 CYS)}$$

$$\tau_r \geq 0{,}098\ (130 - 1{,}9\varphi) \qquad \text{(C.2 CYS)}$$

where:

φ is the nominal bar size

τ_m is the mean value of bond stress (MPa) at 0,01, 0,1 and 1 mm slip

τ_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 ε_{uk} is specified as 0.

The minimum and maximum values of f_{yk}, k and ε_{uk} are given in Table C.3(CYS):

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
ε_{uk}	0,80 x minimum C_v	Not applicable

NA 2.79 Clause E.1(2): General

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

Table E.1(CYS): Indicative minimum 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 2.80 Clause J.1(2): 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 J.1 of CYS EN 1992-1-1:2004).

NA 2.81 Clause J.2.2(2): Frame corners with closing moments

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

NA 2.82 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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NA to CYS EN 1992-1-1:2004 (Including A1:2014 and AC:2010)

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