NATIONAL ANNEX

TO

CYS EN 1992-1-1:2004

Eurocode 2: Design of concrete structures

Part1.1: General rules and rules for buildings

Public Enquiry Draft

Period of Public Enquiry

Prepared by: CYS/TC18 EUROCODES COMMITTEE

Cyprus Organisation of Standardisation

INTRODUCTION

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

# SCOPE

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

1. 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)

1. Decisions on the use of the Informative Annexes A, B, D, E, F, G, H , I and J (see Section NA 3)
2. 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

# NATIONALLY DETERMINED PARAMETERS

## Clause 2.3.3(3) Deformations of concrete

The value of djoint 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.

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

The value of partial factor *γ*SH is specified as 1,0.

## Clause 2.4.2.2: Partial factors for prestress

(1) The value of *γ*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 *γ*P,unfav in the stability limit state for global analysis is specified as 1,3.

(3) The value of *γ*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.

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

The value of *γ*F,fat is specified as 1,0.

## 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 *γ*C,fat and *γ*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.

## Clause 2.4.2.5(2): Partial factors for materials for foundations

The value of *k*f is specified as 1,1.

## 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.

## 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.

## Clause 3.2.2(3)P: Properties

The upper limit of *f*yk is specified as 600 MPa.

## Clause 3.2.7(2): Design assumptions

The value of *ε*ud is specified as 0,9*ε*uk.

## Clause 3.3.4(5): Ductility characteristics

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

## Clause 3.3.6(7): Design assumptions

The value of *ε*ud is specified as 0,90*ε*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.

## 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:

1,5 x diameter of strand or plain wire

2,5 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 Δ*c*dur,*γ* is specified as 0 mm.

(7) The value of Δ*c*dur,st , without further specification, is specified as 0 mm.

(8) The value of Δcdur,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.

## Clause 4.4.1.3: Allowance in design for deviation

(1)P The value of Δ*c*dev is specified as 10 mm.

(3) The reductions in Δ*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 Δcdev may be reduced: 10 mm ≥ Δ*c*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 Δcdev may be reduced: 10 mm ≥ Δcdev ≥ 0 mm

(4) The values of *k*1 and *k*2 are specified as 40mm and 75mm respectively.

## 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 (*γ*Q*Q*k + *γ*G*G*k + *P*m), other spans carrying only the design permanent load, *γ*G*G*k + *P*m and

(b) any two adjacent spans carrying the design variable and permanent loads (*γ*Q*Q*k + *γ*G*G*k + *P*m). All other spans carrying only the design permanent load, *γ*G*G*k + *P*m.

## Clause 5.2(5): Geometric Imperfections

The value of *θ*0 is specified as 1/200.

## 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/*ε*cu2)

*k*3 = 0,54

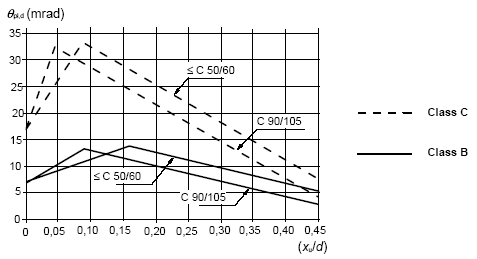
*k*4=1,25(0,6+0,0014/*ε*cu2)

*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.

## Section 5.6.3(4): Rotation capacity

The values of *θ*pl,dfor 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, *θ*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, *θ*pl,d should be multiplied by *k*λ:

 (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:

λ = *M*Sd / (*V*Sd*d*) (5.12CYS)

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

The value of *λ*lim follows from:

*λ*lim = 20.*A.B.C*/ (5.13CYS)

where:

*A* = 1 / (1+0,2*ϕ*ef) (if *ϕ*ef is not known, *A*=0,7 may be used)

*B* =  (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⏐ ≥ ⏐ *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* ≤ 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.

## 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.

## 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.

## Section 5.8.6(3): General method

The value of *γ*CE is specified as 1,2.

## Section 5.10.1(6): General

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

## 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.

## 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.

## 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.

## Section 5.10.8: Effects of prestressing at ultimate limit state

(2) The value of Δ*σ*p,ULS is specified as 100 MPa.

(3) The values of *γ*ΔP,sup and *γ*ΔP,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 *γ*ΔP,sup and *γ*ΔP,inf are specified as 1,0.

## 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.

## Clause 6.2.2: Members not requiring design shear reinforcement

(1) The value of *C*Rd,c is specified as 0,18/*γ*c, the value of *v*min is given by Expression (6.3CYS) and the value of kI is specified as 0,15.

*v*min = 0,035*k*3/2 . *f*ck1/2 (6.3CYS)

(6) The value of *ν* is given by:

*ν* = 0,6[1- *f*ck/250] (*f*ck in MPa) (6.6CYS)

## Clause 6.2.3 Members requiring design shear reinforcement

(2) The limiting values of cot*θ* are given in Expression (6.7CYS):

1 ≤ cot*θ* ≤ 2,5 (6.7CYS)

(3) The value of the strength reduction factor for concrete cracked in shear, *ν*1, is specified as *ν* (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:

*ν*1 = 0,6 for *f*ck ≤ 60MPa (6.10.aCYS)

*ν*1 = 0,9 - *f*ck/200 > 0,5 for *f*ck ≥ 60MPa (6.10.bCYS)

The value of *α*cwis specified as follows:

*α*cw = 1 for non-prestressed structures

*α*cw = (1 + *σ*cp/*f*cd) for 0 < *σ*cp ≤0,25 *f*cd (6.11.aCYS)

*α*cw = 1,25 for 0,25 *f*cd < *σ*cp ≤0,5 *f*cd (6.11.bCYS)

*α*cw = 2,5 (1 - *σ*cp/*f*cd) for 0,5 *f*cd < *σ*cp < 1,0 *f*cd (6.11.cCYS)

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 0,5*d* cot*θ* from the edge of the support.

## 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:

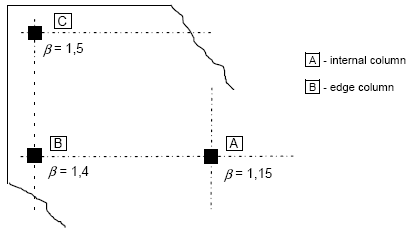
1,0 ≤ cot *θ*f ≤ 2,0 for compression flanges (45o ≥ *θ*f ≥ 26,5o)

1,0 ≤ cot *θ*f ≤ 1,25 for tension flanges (45o ≥ *θ*f ≥ 38,6o)

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

## Clause 6.4.3(6): Punching shear calculation

The values of *β* are specified in Figure 6.21(CYS). THE FIGURE NEEDS CORRECTION



**Figure 6.21(CYS): Specified values for *β***

## 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/*γ*c, the value of *v*min is given by Expression (6.3CYS) and the value of *k*1 is specified as 0,1.

## 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*vf*cd , where ν is given in Expression (6.6CYS).

(4) The value of *k* is specified as 1,5.

## Clause 6.5.2(2): Struts

The value of *ν* is given by Expression (6.57CYS):

*ν* = 1 - *f*ck / 250 (6.57CYS)

## Clause 6.5.4: Nodes

(4) The value of *k1* is specified as 1,0, the value of *k2* is specified as 0,85 and the value of *k3* is specified as 0,75.

(6) The value of *k4* is specified as 3,0.

## 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** |  | **stress exponent** | | **Δ*σ*Rsk (MPa) at N\* cycles** |
| **N\*** | ***k*1** | ***k*2** |
| **Straight and bent bars1** | 106 | 5 | 9 | 162,5 |
| **Welded bars and wire fabrics** | 107 | 3 | 5 | 58,5 |
| **Splicing devices** | 107 | 3 | 5 | 35 |
| **Note 1:** Values for Δ*σ*Rsk are those for straight bars. Values for bent bars should be obtained using a reduction factor ζ = 0,35 + 0,026 *D* / *φ*  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** |  | **stress exponent** | | **Δ*σ*Rsk (MPa) at N\* cycles** |
| **N\*** | ***k*1** | ***k*2** |
| **pre-tensioning** | 106 | 5 | 9 | 185 |
| **post-tensioning** |  |  |  |  |
| - single strands in plastic ducts | 106 | 5 | 9 | 185 |
| - straight tendons or curved tendons in plastic ducts | 106 | 5 | 10 | 150 |
| - curved tendons in steel ducts | 106 | 5 | 7 | 120 |
| - splicing devices | 106 | 5 | 5 | 80 |

(5) The value of *k*2 is specified as 5.

## 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.

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

The value of *N* is specified as 106 cycles.

The value of *k1* is specified as 0,85.

## 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.

## 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 | 0,41 | 0,2 |
| XC2, XC3, XC4 | 0,3 | 0,22 |
| 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.

## Clause 7.3.2(4): Minimum reinforcement areas

The value of *σ*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.

## 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.

## 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.

## Clause 8.2(2): Spacing of bars

The values of *k*1 and *k*2 are specified as 1 and 5 mm respectively.

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

The values of *φ*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) |
| *φ* ≤ 16 mm | 4*φ* |
| *φ* > 16 mm | 7*φ* |

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

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

## Clause 8.6(2): Anchorage by welded bars

The value of *F*btd is determined from Expression (8.8CYS) below:

*F*btd = *l*td *φ*t *σ*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 *φ*t (*f*yd / *σ*td)0,5 ≤ *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: *σ*td = (*f*ctd + *σ*cm)/*y* ≤ 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(-0,18*x*)

*x* is a function accounting for the geometry: *x* = 2 (*c*/*φ*t) + 1

*c* is the concrete cover perpendicular to both bars

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

The value of *φ*large is specified as 32 mm.

## 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 0,04*A*c.

## Clause 9.2.1.2(1): Other detailing arrangements

The value of *β*1 for beams is specified as 0,15.

## 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.

## Clause 9.2.2: Shear reinforcement

(4) The value of *β*3 for beams is specified as 0,5.

(5) The value of *ρ*w,min for beams is given by Expression (9.5CYS):

 (9.5CYS)

(6) The value of *s*I,max is given by Expression (9.6CYS):

*s*I,max = 0,75*d* (1 + cot α ) (9.6CYS)

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

(7) The value of *sb*,max is given by Expression (9.7CYS):

*s*b,max = 0,6*d* (1 + cot α ) (9.7CYS)

(8) The value of *st*,max is given by Expression (9.8CYS):

*s*t,max = 0,75*d* ≤ 600 mm (9.8CYS)

## Clause 9.3.1.1(3): General

The value of *s*max,slabs is specified as follows:

- for the principal reinforcement, 3*h* ≤ 400 mm, where *h* is the total depth of the slab;

- for the secondary reinforcement, 3,5*h* ≤ 450 mm.

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

- for the principal reinforcement, 2*h* ≤ 250 mm

- for the secondary reinforcement, 3*h* ≤ 400 mm.

## 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.

## Clause 9.5.3(3): Transverse reinforcement

The value of *s*cI,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

## 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.

## 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.

## Clause 9.7(1): Deep beams

The value of *A*s,dbmin is specified as 0,001Ac but not less than 150 mm2/m in each face and each direction.

## Clause 9.8.1(3): Pile caps

The value of *φ*min is specified as 8 mm.

## Clause 9.8.2.1(1): General

The value of *φ*min is specified as 8 mm.

## 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.

## Clause 9.8.4(1): Column footing on rock

## 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 Ac 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 ≤ 0,5 m2 | *A*s ≥ 0,005 . *A*c |
| 0,5 m2 < *A*c ≤ 1,0 m2 | *A*s ≥ 25 cm2 |
| *A*c > 1,0 m2 | *A*s ≥ 0,0025 . *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.

## 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.

## 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.

## 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.

## Clause 11.3.5: Design compressive and tensile strengths

(1)P The value of *α*Icc is specified as 0,85.

(2)P The value of *α*Ict is specified as 0,85.

## 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.

## Clause 11.6.1(1): Members not requiring design shear reinforcement

The value of *C*IRd,c is specified as 0,15/*γ*C, the value of *v*I,min is specified as

0,028*k*3/2*f*lck1/2 and that for *k*1 is specified as 0,15.

**Table 11.6.1(CYS): Values of *v*I,min for given values of *d* and *f*Ick**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| d  (mm) | *v*I,min (MPa) | | | | | | |
| *f*Ick (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 |

## 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*Ick/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.

## 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.

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

The value of *v*IRd,max is specified as 0,4 *v* *f*Icd, where *v* is taken equal to *v*1 defined in expression (11.6.6CYS).

## Clause 12.3.1(1): Concrete: additional design assumptions

The value of both *α*cc,pl and *α*ct,pl is specified as 0,8.

## Clause 12.6.3(2): Shear

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

## Clause A.2.1: Reduction based on quality control and reduced deviations

(1) The value of *γ*S,red1 is specified as 1,1.

(2) The value of *γ*C,red1 is specified as 1,4.

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

(1) The value of *γ*S,red2 is specified as 1,05 and the value of *γ*C,red2 is specified as 1,45.

(2) The value of *γ*C,red3 is specified as 1,35.

## 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 *γ*C,red4 is specified as 1,3.

## Clause C.1: General

(1) The values for the fatigue stress range with an upper limit of *β f*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 106 cycles) with an upper limit of *β f*yk | | ≥150 | | | ≥100 | | | 10,0 |
| Bond:  Minimum relative rib area, *f*R,min | Nominal bar size (mm) |  | | | | | |  |
| 5 – 6  6,5 to 12  > 12 | 0,035  0,040  0,056 | | | | | | 5,0 |

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:

*τ*m ≥ 0,098 (80 – 1,2*φ*) (C.1CYS)

*τ*r ≥ 0,098 (130 – 1,9*φ*) (C.2CYS)

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 stess 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 |

## 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 | |

## 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).

## 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.

## 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.

# DECISION ON USE OF THE INFORMATIVE ANNEXES A AND B

## Annex A

Annex A may be used

## Annex B

Annex B may be used

## Annex D

Annex D may be used

## Annex E

Annex E may be used

## Annex F

Annex F may be used

## Annex G

Annex G may be used

## Annex H

Annex H may be used

## Annex I

Annex I may be used

## Annex J

Annex J may be used

# REFERENCES TO NON-CONTRADICTORY COMPLEMENTARY INFORMATION

None