DRAFT FOR DEVELOPMENT

DD ENV 1992-1-6:1996

Eurocode 2: Design of concrete structures —

Part 1.6 General rules — Plain concrete structures —

(together with United Kingdom National Application Document)

ICS 91.040.91.080.40

Committees responsible for this Draft for Development

The preparation of this Draft for Development was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/2, Structural use of concrete, upon which the following bodies were represented:

Association of Consulting Engineers
British Cement Association
British Precast Concrete Federation Ltd.
Department of the Environment (Property and Buildings Directorate)
Department of Transport (Highways Agency)
Federation of Civil Engineering Contractors
Institution of Civil Engineers
Institution of Structural Engineers
Steel Reinforcement Commission

This Draft for Development, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 August 1996

The following BSI references relate to the work on this Draft for Development:
Committee reference B/525/2

ISBN 0 580 25823 8

Amendments issued since publication

Amd. No.	Date	Comments

Contents

National foreword

This Draft for Development was prepared by Subcommittee B/525/2 and is the English language version of ENV 1992-1-6:1994 *Eurocode 2: Design of concrete structures — Part 1.6: General rules — Plain concrete structures*, as published by the European Committee for Standardization (CEN). This Draft for Development also includes the United Kingdom (UK) National Application Document (NAD) to be used with the ENV in the design of buildings to be constructed in the UK.

ENV 1992-1-6 results from a programme of work sponsored by the European Commission to make available a common set of rules for the structural and geotechnical design of building and civil engineering works.

This publication is not to be regarded as a British Standard.

An ENV is made available for provisional application, but does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard. The publication of this ENV and its National Application Document should be considered to supersede any reference to a British Standard in previous DD ENV Eurocodes concerning the subject covered by these documents.

The values for certain parameters in the ENV Eurocodes may be set by individual CEN Members so as to meet the requirements of national regulations. These parameters are designated by |_| in the ENV.

During the ENV period of validity, reference should be made to the supporting documents listed in the National Application Document (NAD).

The purpose of the NAD is to provide essential information, particularly in relation to safety, to enable the ENV to be used for buildings constructed in the UK and the NAD takes precedence over corresponding provisions in the ENV.

The Building Regulations 1991, Approved Document A 1992, draws attention to the potential use of ENV Eurocodes as an alternative approach to Building Regulation compliance. ENV 1992-1-6 is considered to offer such an alternative approach, when used in conjunction with its NAD.

Users of this document are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted to an EN.

Comments should be sent in writing to the Secretary of B/525/2, BSI, 389 Chiswick High Road, London, W4 4AL, quoting the document reference, the relevant clause and, where possible, a proposed revision, by 31 October 1996.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, the ENV title page, pages 2 to 15 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

National Application Document for use in the UK with ENV 1992-1-6:1994

Contents of National Application Document

Introduction

This National Application Document (NAD) has been prepared by Subcommittee B/525/2. It has been developed from the following.

a) A textual examination of ENV 1992-1-6.

b) A parametric calibration against BS 8110, supporting standards and test data.

c) Trial calculations.

1 Scope

This NAD provides information to enable ENV 1992-1-6 (hereafter referred to as EC2-1.6) to be used for the design of buildings to be constructed in the UK. It will be assumed that it will be used in conjunction with DD ENV 1992-1-1, the NAD of which refers to BSI publications for values of actions.

2 Partial factors, combination factors and other values

a) The values for combination coefficients (ψ) should be those given in Table 1 of the NAD for EC2-1.1.

b) The values for partial factors for normal temperature design should be those given in EC2-1.1 except where modified by the NAD for that code.

c) Other values should be those given in EC2-1.1, except where modified by the NAD for that code, and EC2-1.6 except for those given in Table 1 of this NAD.

3 Reference standards

Supporting standards including materials specifications and standards for construction are listed in Table 2 of this NAD.

Table 1 — Values to be used in referenced clauses instead of boxed values

Reference in EC2-1.6	Definition	UK values
5.4.7.1 (101)	Minimum thickness of plain in-situ walls (depth, h_w)	150 mm not 120 mm
5.4.10 (101)	Ratio of depth to projection of strip footing	1.5 not 2

Table 2 — Reference in EC2-1.6 to other codes and standards

Reference in EC2-1.6	Document referred to	Document title or subject area	Status	UK document
Various	ENV 1992-1-1	*Design of concrete structures — General rules and rules for buildings*	Published 1991	DD ENV 1992-1-1:1992
1.1.2 P(101)	ENV 206	*Concrete — Performance, production, placing and compliance criteria*	Published 1990	DD ENV 206:1992
1.1.2 P(107) P(110)	ENV 1992-1-4	*Members made with lightweight aggregate concrete*	Published 1994	DD ENV 1992-1-4:1996
1.1.2 P(107) P(110)	ENV 1992-1-3	*Precast concrete elements and structures*	Published 1994	DD ENV 1992-1-3:1996

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EUROPEAN PRESTANDARD
PRÉNORME EUROPÉENNE
EUROPÄISCHE VORNORM

ENV 1992-1-6

October 1994

ICS 91.040.00; 91.080.40

Descriptors: Buildings, concrete structure, computation, building codes, rules of calculation

English version

Eurocode 2: Design of concrete structures — Part 1-6: General rules — Plain concrete structures

Eurocode 2: Calcul des structures en béton — Partie 1-6: Règles générales — Structures en béton non armé

Eurocode 2: Plannung von Stahlbeton- und Spannbetontragwerken — Teil 1-6: Allgemeine Regeln — Tragwerke aus unbewehrtem Beton

This European Prestandard (ENV) was approved by CEN on 1993-06-25 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. ENV 1992-1-6:1994 E

Foreword

Objectives of the Eurocodes

(1) The "Structural Eurocodes" comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.

(2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship needed to comply with the assumptions of the design rules.

(3) Until the necessary set of harmonized technical specifications for products and for the methods of testing their performance are available, some of the Structural Eurocodes cover some of these aspects in informative Annexes.

Background of the Eurocode programme

(4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various Member States and would ultimately replace them. These technical rules became known as the "Structural Eurocodes".

(5) In 1990, after consulting their respective Member States, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.

(6) CEN Technical Committee CEN/TC250 is responsible for all Structural Eurocodes

Eurocode programme

(7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991, Eurocode 1: Basis of design and actions on structures.

EN 1992, Eurocode 2: Design of concrete structures.

EN 1993, Eurocode 3: Design of steel structures.

EN 1994, Eurocode 4: Design of composite steel and concrete structures.

EN 1995, Eurocode 5: Design of timber structures.

EN 1996, Eurocode 6: Design of masonry structures.

EN 1997, Eurocode 7: Geotechnical design.

EN 1998, Eurocode 8: Design provisions for earthquake resistance of structures.

EN 1999, Eurocode 9: Design of aluminium alloy structures.

(8) Separate sub-committees have been formed by CEN/TC250 for the various Eurocodes listed above.

(9) This Part 1-6 of Eurocode 2 is being published as a European Prestandard (ENV) with an initial life of three years.

(10) This Prestandard is intended for experimental application and for the submission of comments.

(11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.

(12) Meanwhile feedback and comments on this Prestandard should be sent to the Secretariat of CEN/TC250/SC2 at the following address:

Deutsches Institut für Normung e.V. (DIN)

Burggrafenstrasse 6

D — 10787 Berlin

phone: (+ 49) 30 – 26 01 – 25 01

fax: (+ 49) 30 – 26 01 – 12 31

or to your national standards organization.

National Application Documents (NAD'S)

(13) In view of the responsibilities of authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by [ ] ("boxed values"). The authorities in each member country are expected to assign definitive values to these safety elements.

(14) Some of the supporting European or International Standards may not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving definitive values for safety elements, referencing compatible supporting standards and providing national guidance on the application of this Prestandard, will be issued by each member country or its Standards Organization.

(15) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this Prestandard

(16) The scope of Eurocode 2 is defined in **1.1.1** of ENV 1992-1-1 and the scope of this Part of Eurocode 2 is defined in **1.1.2**. Additional Parts of Eurocode 2 which are planned are indicated in **1.1.3** of ENV 1992-1-1; these will cover additional technologies or applications, and will complement and supplement this Part.

(17) In using this Prestandard in practice, particular regard should be paid to the underlying assumptions and conditions given in **1.3** of ENV 1992-1-1.

(18) The seven chapters of this Prestandard are complemented by four Appendices which have the same normative status as the chapters to which they relate. These Appendices have been introduced by moving some of the more detailed Principles/Application Rules, which are needed in particular cases, out of the main part of the text to aid its clarity.

(19) As indicated in paragraph (14) of this Foreword, reference should be made to National Application Documents which will give details of compatible supporting standards to be used. For this Part of Eurocode 2, particular attention is drawn to the approved Prestandard ENV 206 (Concrete — performance, production, placing and compliance criteria), and the durability requirements given in **4.1** of this Prestandard.

(20) The provisions of this Prestandard are based substantially on the 1978 edition of the CEB Model Code and other more recent CEB and FIP documents.

(21) In developing this Prestandard, background documents have been prepared, which give commentaries on and justifications for some of the provisions in this Prestandard.

For ENV 1992-1-6, the following additional sub-clauses apply:

(22) This Part 1-6 of Eurocode 2 complements ENV 1992-1-1 for the particular aspects of plain concrete structures.

(23) The framework and structure of this Part 1-6 correspond to ENV 1992-1-1. However, Part 1-6 contains Principles and Application Rules which are specific to structures made with plain concrete.

(24) Where a particular sub-clause of ENV 1992-1-1 is not mentioned in this ENV 1992-1-6, that sub-clause of ENV 1992-1-1 applies as far as deemed appropriate in each case.

Some Principles and Application Rules of ENV 1992-1-1 are modified or replaced in this Part, in which case they are superseded.

Where a Principle or Application Rule in ENV 1992-1-1 is modified or replaced, the new number is identified by the addition of 100 to the original number. Where a new Principle or Application Rule is added, it is identified by a number which follows the last number of ENV 1992-1-1 with 100 added to it.

A subject not covered by ENV 1992-1-1 is introduced in this Part by a new sub-clause. The sub-clause number for this follows the most appropriate clause number in ENV 1992-1-1.

(25) The numbering of equations, figures, footnotes and tables in this Part follow the same principles as the clause numbering in (24) above.

Contents

1 Introduction

This clause of ENV 1992-1-1 is applicable except as follows:

1.1 Scope

1.1.2 Scope of part 1-6 of Eurocode 2

Replacement of Principle P(1) by:

P(101) Part 1-6 of ENV 1992 provides supplementary rules to the general rules given in ENV 1992-1-1 for the design of components in building and civil engineering works in plain concrete made with normal weight aggregate as defined in ENV 206 (see **1.1.3** of Part 1-1 for supplementary parts covering additional methods of construction, materials, and type of structure).

Addition after Principle P(5):

(106) This Part 1-6 applies to members, for which the effects of dynamic actions may be neglected. Such members may include:

— plain concrete members mainly subjected to compression other than that due to prestressing, e.g. walls, columns, arches, and tunnels;

— plain concrete strip and pad footings for foundations;

— plain concrete retaining walls.

P(107) This Part 1-6 may also be used for members made with lightweight aggregate concrete with closed structure according to ENV 1992-1-4 and for precast concrete elements and structures covered by ENV 1992-1-3. However, in these cases the design rules may be modified accordingly.

P(108) This Part 1-6 does not preclude the provision of steel reinforcement needed to satisfy serviceability and/or durability requirements, nor reinforcement in certain parts of the members. This reinforcement may be taken into account for local ultimate limit state verifications as well as for checks in the serviceability limit states.

(109) Examples of such reinforcement is the joint reinforcement in the top of a wall to avoid splitting and the joint reinforcement for columns into a footing.

P(110) For plain precast concrete it is, in addition, necessary to comply with ENV 1992-1-3. For lightweight aggregate concrete with closed structure see ENV 1992-1-4.

1.4 Definitions

1.4.2 Special terms used in part 1-6 of Eurocode 2

Replacement of Principles P(1) and P(2) by:

P(101) Plain concrete member: Structural concrete member having no reinforcement (plain concrete) or less reinforcement than the minimum amounts defined in section **5.4** “Structural Members” of ENV 1992-1-1.

1.7 Special symbols used in this part 1-6 of Eurocode 2

1.7.2 Latin upper case letters

Addition:

$A_{c, eff}$ Effective cross section [**4.3.1.2**(107)]

I_y, I_z Second moment of cross-sectional area related to the y- and z-axis respectively

N_{Rd} Resisting design axial compression force

1.7.3 Latin lower case letters

Addition:

a	Projection of a pad footing from the columns face
e_a	Additional eccentricity covering the effects of geometrical imperfections
e_0	First order eccentricity
e_y, e_z	Components of an eccentricity e in direction of the y- and z-axis respectively
e_{tot}	Total eccentricity
f_{ctd}	Design value of the tensile strength of concrete
h_F	Depth of a pad footing
h_w	Overall depth of a wall
i	Radius of gyration
l_h	Clear horizontal length of a wall between vertical restraints (Figure 4.135)
l_{ht}	Horizontal length of a transverse wall stabilizing the wall under consideration
l_w	Clear height of a wall (Figure 4.135)
l_0	Effective length of a compression member

1.7.4 Greek symbols

Addition:

α	Reduction coefficient to allow for the effect of long term loading on the concrete compression strength
β	Effective height coefficient: $\beta = l_0/l_w$
γ_n	Additional partial safety factor for concrete
λ	Slenderness ratio: $\lambda = l_0/i$
σ_{cm}	Average concrete compressive stress
σ_{ct}	Concrete tensile stress
σ_{gd}	Design value of the ground pressure
σ_{Sd}	Design value of the applied normal stress
τ_{Sd}	Design value of the applied shear stress

2 Basis of design

This clause of ENV 1992-1-1 is applicable except as follows:

2.3 Design requirement

2.3.3 Partial safety factors for ultimate limit states

2.3.3.2 *Partial Safety Factors for Materials*

Addition after Application Rule (6):

P(107) Due to the less ductile properties of plain concrete, the partial safety factor for concrete in compression and tension shall be multiplied with a coefficient γ_n.

(108) It is recommended to multiply the partial safety factors γ_c for concrete given in Table 2.3 in ENV 1992-1-1 by γ_n = |1.2| in compression and γ_n = |1.2| in tension, that is

for fundamental combinations: γ_c = |1.80| in compression and
γ_c = |1.80| in tension,

for accidental design situations (except earthquakes): γ_c = |1.56| in compression and
γ_c = |1.56| in tension.

2.5 Analysis

2.5.3 Calculation methods

2.5.3.2 ***Types of Structural Analysis***

2.5.3.2.2 *Ultimate Limit States*

Replacement of clause **2.5.3.2.2** in ENV 1992-1-1 by:

P(101) Since plain concrete members have limited deformability, linear analysis with redistribution or a plastic approach to analysis, e.g. methods without an explicit check of the deformation capacity, shall not be used unless their application can be justified.

(102) Structural analysis may be based on the non-linear or the linear elastic theory. In the case of a non-linear analysis (e.g. fracture mechanics) a check of the deformation capacity should be performed.

3 Material properties

This clause of ENV 1992-1-1 applies as far it is deemed appropriate in each case.

4 Section and member design

This clause of ENV 1992-1-1 is applicable except as follows:

4.2 Design data

4.2.1 Concrete

4.2.1.1 ***General***

Addition after Application Rule (6):

P(107) For the calculation of the design resistance of plain concrete members, the strength and deformation properties as for reinforced concrete shall be used.

(108) When tensile stresses are considered in concrete (see **4.3.2.1**), the stress-strain diagram in section **4.2.1.3.3** of ENV 1992-1-1 can be extended in tension up to the design strength

$$f_{ctd} = f_{ctk,\ 0.05}/\gamma_c \qquad (4.184)$$

(109) Fracture mechanic methods may be used provided it can be shown that they lead to the required level of safety.

4.3 Ultimate limit states

4.3.1 Ultimate limit states for bending and longitudinal force

4.3.1.2 ***Design Resistance to Bending and Longitudinal Force***

Addition to Principle P(1):

P(101) Principle P(1) of ENV 1992-1-1, paragraphs (i), (vii) and (viii) apply also for plain concrete. Paragraphs (ii), (v) and (vi) are not relevant for plain concrete. Paragraphs (iii) and (iv) are changed to:

(iii) The tensile strength of concrete is generally ignored.

(iv) The stresses in the concrete in compression are derived from the design stress-strain diagram in either Figure 4.2, 4.3 or 4.4 in ENV 1992-1-1 respectively.

Replacement of Application Rules (3) to (7) by:

P(103) It shall be demonstrated that equilibrium exists between the internal forces and moments and those due to external loads and/or imposed deformation. Possible uncertainties with regard to the position of the stress resultant shall be taken into account by appropriate measures.

(104) In the case of walls, subject to the provision of adequate construction details and proper curing, the imposed deformations due to temperature or shrinkage can be neglected.

(105) Rule (6) in **4.3.1.2** of ENV 1992-1-1 is not applicable for the design of plain concrete members.

P(106) The effects of significant openings, chases or recesses shall be taken into account in the design calculations.

(107) In a cross-section of a plain concrete member, subjected to the design longitudinal force N_{Sd} at a point G with the eccentricities e_y and e_z related to the centroid 0 of the uncracked cross-section A_c (Figure 4.134), a uniform stress distribution may be assumed in a part of that cross-section, denoted as the effective section $A_{c, eff}$. The remaining part of the cross-section may be considered inactive. The resulting eccentricity e of N_{Sd} should, where relevant, include second order effects and geometrical imperfections (see **4.3.5.3.6** below).

In general, $A_{c, eff}$ is limited by a straight secant and its centroid coincides with the point G. For simplification, $A_{c, eff}$ may be taken as rectangular with

$$A_{c, eff} = 2a_z * 2a_y \qquad (4.185)$$

where

$2a_z$, $2a_y$ denote the dimensions of the fictitious rectangle in the z- and y-axis respectively.

(108) If the effective cross-section is geometrically difficult to define, it may be substituted by any approximate effective section, included in the cross-section A_c whose centroid coincides with the point G, see Figure 4.134.

(109) The resisting design longitudinal compression force N_{Rd} is given by:

$$N_{Rd} = -\alpha * f_{cd} * A_{c, eff} \qquad (4.186)$$

where

α is a reduction factor taking account of long-term effects according to **4.2.1.3.3**, b), (11) of ENV 1992-1-1

$A_{c, eff}$ Area of effective cross-section.

(110) In the absence of a more rigorous calculation, the design resistance N_{Rd} of a rectangular cross-section with a uni-axial eccentricity e in the direction of h_w may be taken as

$$N_{Rd} = -\alpha * f_{cd} * b * h_w * (1-2e/h_w) \qquad (4.187)$$

where

b Overall width of the cross-section

h_w Overall depth of the cross-section

e Eccentricity of N_{Sd} in the direction h_w.

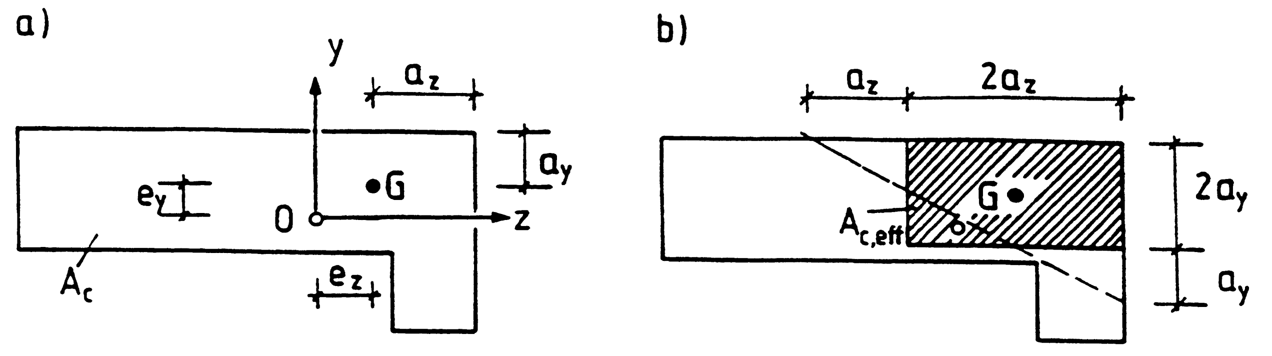


Figure 4.134 — Effective cross-section $A_{c, eff}$ in the case of bi-axial eccentricities; a longitudinal force N_{Sd} acts in point G, the centroid of the uncracked section is located in point O
a) Geometry and notations for the uncracked section
b) Effective cross-section $A_{c, eff}$

4.3.1.3 ***Local Failure***

Replacement of clause **4.3.1.3** in ENV 1992-1-1 by:

P(101) Unless measures to avoid local tensile failure of the cross-section have been taken, the maximum eccentricity of the longitudinal force N_{Sd} in a cross-section shall be limited to appropriate values.

4.3.2 Shear

4.3.2.1 ***General***

Replacement of clause **4.3.2.1** in ENV 1992-1-1 by:

P(101) In plain concrete members account may be taken of the concrete tensile strength in the ultimate limit state for shear, provided that either by calculations or by experience brittle failure can be excluded and adequate resistance can be ensured.

(102) For plain concrete members subjected to a combination of shear, bending and longitudinal force it should be verified that

$$\tau_{Sd} \leq \sqrt{f^2_{ctd} + \eta * \sigma_{cm} * f_{ctd}} \qquad (4.188)$$

where

τ_{Sd} Design value of the applied shear stress

σ_{cm} Average concrete compressive stress

$f_{ctd} = f_{ctk0.05}/\gamma_c$, with γ_c according to **2.3.3.2** above.

η Reduction coefficient. Generally, η may be taken as η = | 1.0 |.

According to the actual state of stress, τ_{Sd} should be calculated for the uncracked, or in the case of cracks, for the effective section $A_{c,\,eff}$, see **4.3.1.2** above.

(103) A concrete member may be considered to be uncracked in the ultimate limit state if either it remains completely under compression or if the principal concrete tensile stress σ_{ct1} does not exceed $f_{ctd} = f_{ctk0.05}/\gamma_c$ with $f_{ctk0.05}$ according to Table 3.1 of ENV 1992-1-1 and γ_c according to **2.3.3.2** above.

4.3.3 Torsion

4.3.3.1 ***Pure Torsion***

Replacement of Application Rules (2) and (3), Principle P(4) and Application Rules (5) to (9) in ENV 1992-1-1 by:

P(102) Clause **4.3.2.1** of this ENV 1992-1-6 above applies for torsion analogously.

P(103) Cracked members shall not be considered to resist torsional moments unless adequate resistance to torsion can be justified.

4.3.3.2 ***Combined effects of actions***

4.3.3.2.1 *General procedure*

Addition after Application Rule (4):

P(105) Clause **4.3.2.1** in this ENV 1992-1-6 applies for torsion combined with shear analogously.

4.3.5 Ultimate limit states induced by structural deformation (buckling)

4.3.5.3 *Classification of Structures and Structural Members*

4.3.5.3.5 *Slenderness of Isolated Columns and Walls*

Addition to Application Rules (1) and (2) in ENV 1992-1-1:

(103) The slenderness of an isolated column or wall is given by

$$\lambda = l_0/i \quad (4.189)$$

where

i Minimum radius of gyration

l_0 Effective length of the member which can be assumed to be:

$$l_0 = \beta * l_w \quad (4.190)$$

where

l_w Clear height of the member

β Coefficient which depends on the support conditions. For columns β = 1 should in general be assumed, for cantilever columns or walls β = 2. For other walls β-values are given in Figure 4.135 below.

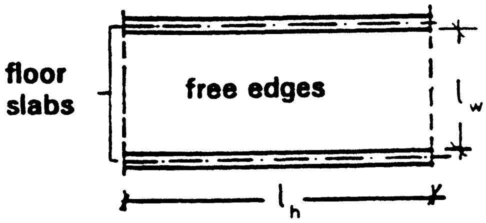
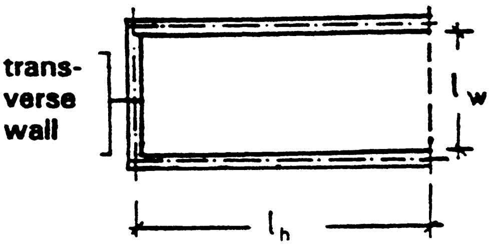
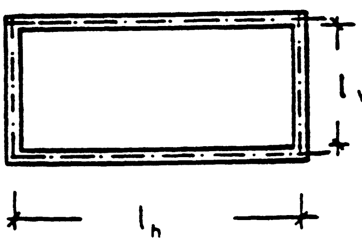
Type of restraint	Factor β
Wall held along 2 sides 	$\beta = 1.0$ for any ratio l_w/l_h
Wall held along 3 sides 	$\beta = \dfrac{1}{1 + \left(\dfrac{l_w}{3l_h}\right)^2}$
Wall held along 4 sides 	$l_w \leq l_h$: $\beta = \dfrac{1}{1 + \left(\dfrac{l_w}{l_h}\right)^2}$ if $l_w > l_h$: $\beta = \dfrac{1}{2 * (l_w/l_h)}$

Figure 4.135 — Factor B for the determination of the effective height l_0 of walls

Figure 4.135 assumes that the wall has no openings with a height exceeding |1/3| of the wall height l_w or with an area exceeding |1/10| of the wall area. In walls held along 3 or 4 sides with openings exceeding these limits, the parts between the openings should be considered as held along two sides only and be designed accordingly.

(104) The β-values should be increased appropriately if the transverse bearing capacity is affected by chases or recesses.

(105) Transverse walls may be considered as bracing walls if

— their total depth is not less than |0.5| h_w, where h_w is the overall depth of the braced wall;

— they have the same height l_w as the braced wall under consideration;

— their length l_{ht} is at least equal to l_w/|5|, where l_w denotes the clear height of the braced wall;

— within the length l_{ht} the transverse wall has no openings.

(106) In the case of walls held along two sides which are connected at the top and bottom in flexurally rigid manner by in-situ concrete and reinforcement so that the edge moments can be fully resisted, it may be assumed that

$$\beta = 0.85 \text{ if } l_w < l_h \qquad (4.191)$$

(107) The slenderness of isolated columns or walls in plain concrete cast in-situ should generally not exceed λ = |86| (e.g. l_w/h_w = 25). Independently from the actual λ-value, columns are considered to be slender. However, for compression members with l_w/h_w < 2.5, second order analysis is not necessary.

4.3.5.6 *Simplified Design Method for Walls and Isolated Columns*

Replacement of clause **4.3.5.6.3** by:

(101) In absence of a more rigorous approach, the longitudinal force which can be resisted by a slender column or slender wall in plain concrete may approximately be calculated from:

$$N_{Rd} = -\, b * h_w * \alpha * f_{cd} * \Phi \qquad (4.192)$$

where

N_{Rd} Resisting design compression force of the cross-section

b Overall width of the cross-section

h_w Overall depth of the cross-section

α Reduction factor taking account of longterm effects according to **4.2.1.3.3**, b), (11) of ENV 1992-1-1

The function Φ which allows for the second order effects on the load bearing capacity of compression members in non-sway buildings is given by:

$$\Phi = 1.14 * (1-2e_{tot}/h_w) - |\underline{0.020}| \cdot l_0/h_w \qquad (4.193)$$

where:

$$\Phi \le 1-2e_{tot}/h_w$$
$$\ge 0$$

$$e_{tot} = e_0 + e_a + e\varphi \qquad (4.194)$$

e_0 First order eccentricity including, where relevant, the effects of floors (e.g. possible clamping moments transmitted to the wall from a slab) and horizontal actions;

e_a Additional eccentricity covering the effects of geometrical imperfections. In absence of more accurate information, e_a may be taken as $e_a = 0.5 * l_0$/|200|.

eφ Eccentricity due to creep. As a rule, eφ may be neglected because it is already included in equ. (4.193).

4.4 Serviceability limit states

4.4.0 General

Replacement of clauses **4.4.0.1** and **4.4.0.2** in ENV 1992-1-1 by:

P(101) The serviceability of building components in plain concrete shall be ensured by means of suitable design checks and appropriate detailing.

P(102) Particular care is needed where stresses due to structural restraint are expected to occur.

(103) Appropriate measures to ensure adequate serviceability may include:

a) with regard to crack formation:
- — limitation of concrete tensile stresses to acceptable values;
- — provision of subsidiary structural reinforcement (surface reinforcement, tying system where necessary);
- — provision of joints;
- — methods of concrete technology (e.g. appropriate concrete composition, curing);
- — choice of appropriate method of construction.

b) with regard to limitation of deformations:
- — a minimum section size (see **5.4** below);
- — limitation of slenderness in the case of compression members.

P(104) Any reinforcement provided in plain concrete members, although not taken into account for load bearing purposes, shall comply with the durability requirements of section **4.1.3.3** "Concrete cover" of ENV 1992-1-1.

5 Detailing provisions

This clause of ENV 1992-1-1 is applicable except as follows:

5.4 Structural members

5.4.7 Plain concrete walls

5.4.7.1 *General*

Replacement of clause **5.4.7.1** in ENV 1992-1-1 by:

(101) The overall depth h_w of a wall should not be smaller than |120| mm for cast in-situ concrete walls.

(102) Chases and recesses are allowed only if it has been shown that adequate strength and stability can develop.

5.4.9 Construction joints

New clause:

(101) In construction joints where design concrete tensile stresses are likely to occur, an appropriately detailed reinforcement should be placed.

5.4.10 Strip and pad footings

New clause:

(101) In the absence of more detailed data, strip and pad footings approximately axially loaded may be designed and constructed as plain concrete if the ratio of the foundation depth h_F to the projection a from the column face is not less than (see Figure 5.121):

$$h_F/a \geq \sqrt{3\sigma_{gd}/f_{ctd}} \qquad (5.123)$$

where:

σ_{gd} is the design value of the ground pressure

f_{ctd} is the design value of the concrete tensile strength (in the same unit as σ_{gd})

As a simplification the relation $h_F/a \geq |\underline{2}|$ may be used.

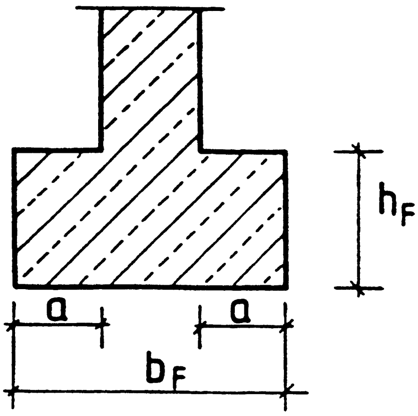


Figure 5.121 — Unreinforced pad footings; notations

6 Construction and workmanship

This clause of ENV 1992-1-1 is applicable as deemed appropriate in each case.

7 Quality control

This clause of ENV 1992-1-1 is applicable as deemed appropriate in each case.

Appendix 1 Additional provisions for the determination of the effects of time-dependent deformation of concrete

Appendix 1 of ENV 1992-1-1 applies for plain concrete structures.

Appendix 2 Non-linear analysis

Appendix 2 of ENV 1992-1-1 applies as deemed appropriate in each case.

Appendix 3 Supplementary information on the ultimate limit states induced by structural deformation

Appendix 3 in Part 1-1 of ENV 1992 applies as deemed appropriate in each case.

Appendix 4 Checking deflections by calculation

Appendix 4 in ENV 1992-1-1 applies as deemed appropriate in each case.

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