

Eurocode 6: Design of masonry structures —

**Part 1-1: General rules for buildings —
Rules for reinforced and unreinforced
masonry —**

**(together with United Kingdom
National Application Document)**

ICS 91.080.30

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Committees responsible for this Draft for Development

The preparation of the National Application Document for use in the UK with ENV 1996-1-1:1995 was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/6, Use of masonry, upon which the following bodies were represented:

- Autoclaved Aerated Concrete Products Association
- Brick Development Association
- British Ceramic Research Ltd.
- British Precast Concrete Federation Ltd.
- Calcium Silicate Brick Association Limited
- Concrete Block Association
- National House-building Council

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National foreword

This publication comprises the English language version of ENV 1996-1-1:1995 *Eurocode 6: Design of masonry structures — Part 1-1: General rules and rules for buildings — Rules for reinforced and unreinforced masonry*, published by the European Committee for Standardization (CEN), plus the National Application Document (NAD) to be used with the ENV for the design of buildings to be constructed in the United Kingdom (UK).

ENV 1996-1-1:1995 results from a programme of work sponsored by the European Commission to make available a common set of rules for the design of building and civil engineering works.

An ENV is made available for provisional application during a period of trial use of 3 years, but does not have the status of a fully agreed European Standard (EN). At the end of the trial period the aim is to use the experience gained to modify the ENV so that it can be approved as an EN.

The values for certain parameters in the ENV Eurocodes may be set by CEN members so as to meet the requirements of national regulations. These parameters are designated by • (boxed values) in the ENV.

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

During the ENV period 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. The NAD takes precedence over corresponding provisions in the ENV.

The Building Regulations 1991, Approved Document A 1992 draws designers' attention to the potential use of ENV Eurocodes as an alternative approach to Building Regulation compliance. ENV 1996-1-1 has been thoroughly examined over a period of several years and is considered to offer such an alternative approach, when used in conjunction with this NAD.

Compliance with ENV 1996-1-1:1995 and this NAD does not of itself confer immunity from legal obligations.

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 to the question of whether the ENV can be converted to an EN.

Comments should be sent in writing to BSI, 389 Chiswick High Road, Chiswick, London W4 4AL, quoting the document reference, the relevant clause and, where possible, a proposed revision, within 2 years of the issue of this document.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to xxiv, the EN title page, pages 2 to 101 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 1996-1-1:1995**

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Introduction

This National Application Document (NAD) has been prepared by Subcommittee B/525/6. It has been developed from:

- a) a textual examination of ENV 1996-1-1;
- b) a parametric calibration against UK practice, supporting standards and test data;
- c) trial calculations.

It should be noted that this NAD, in common with ENV 1996-1-1 and supporting CEN standards, uses a comma where a decimal point would traditionally be used in the UK.

1 Scope

This NAD provides information required to enable ENV 1996-1-1:1995 (Eurocode 6-1-1) to be used for the design of buildings and civil engineering structures to be constructed in the UK.

2 References

2.1 Normative references

This National Application Document incorporates, by dated or undated reference, provisions from other publications. These references are made at the appropriate places in the text and the cited publications are listed on page xxiii. For dated references, only the edition cited applies; subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This National Application Document refers to other documents that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page xxiv, but reference should be made to the latest editions.

3 Partial safety factors, combination factors and other values

- a) The values for partial safety factors (γ) should be those given in Table 1 of this NAD;
- b) The values for combination factors (ψ) should be those given in Table 2 of this NAD;
- c) The values for other boxed values should be those given in Table 3 of this NAD.

Table 1 — Partial safety factors (γ factors)

Reference in ENV 1996-1-1	Definition	Symbol	Condition	Value boxed ENV 1996-1-1	UK
2.3.3.1	Partial factors for variable actions	γ_A	Accidental	1,0	1,0
		$\gamma_{F,inf}$	Favourable	0,0	0,0
		γ_Q	Unfavourable	1,5	1,5
		γ_Q	Reduced Favourable	0,0	0,0
		γ_Q	Reduced unfavourable	1,35	1,35
2.3.3.1	Partial factors for permanent actions	γ_{GA}	Accidental	1,0	1,0
		γ_G	Favourable	1,0	1,0
		γ_G	Unfavourable	1,35	1,35
		$\gamma_{G,inf}$	Favourable	0,9	0,9
		$\gamma_{G,sup}$	Unfavourable	1,1	1,1
		γ_p	Favourable	0,9	0,9
		γ_p	Unfavourable	1,2	1,2
	Accidental actions				
2.3.3.2 2)P	Verifying stability	γ_M	Category of execution		
			A	1,2	1,2
			B	1,5	1,5
			C	1,8	Not used
		γ_S	Steel	1,0	1,0
2.3.4 6)P	Serviceability limit state	γ_M	Except where stated	1,0	1,0
Table 2.3	Masonry: (see note) Category of manufacturing control:	γ_M	Category of execution		
	I		A	1,7	2,0
			B	2,2	2,5
			C	2,7	Not used
	II	γ_M	A	2,0	2,3
			B	2,5	2,8
			C	3,0	Not used
	Anchorage and tensile and compressive resistance of wall tiles and straps	γ_M	Category of execution		
			A	2,5	2,5
			B	2,5	2,5
			C	2,5	Not used
	Anchorage bond	γ_M	A	1,7	1,5
			B	2,2	2,0
			C	—	Not used
	Steel (referred to as γ_S)	γ_M	A	1,15	1,15
			B	1,15	1,15
			C	—	Not used
NOTE The value of γ_M for concrete infill should be taken as that appropriate to the category of manufacturing control of the masonry units in the location of the masonry units where the infill is being used.					

Table 2 — Combination factors (ψ factors)

Variable action	Building type	ψ_0	ψ_1	ψ_2
Imposed floor loads	Dwellings	0,5	0,4	0,2
	Other occupancy classes ^a	0,7	0,6	0,3
	Parking	0,7	0,7	0,6
Imposed roof loads	All occupancy classes ^a	0,7	0,2	0,0
Wind loads	All occupancy classes ^a	0,7	0,2	0,0

^a As listed and defined in Table 1 of BS 6399-1:1984.

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition	Value boxed ENV 1996-1-1	UK
	Masonry units		
3.1.1 3)	Category 1 classification — probability of failing to reach the specified compressive strength	$\leq 5 \%$	$\leq 2.5 \%$
	Shear strength of masonry		
Table 3.5	Initial shear strength, f_{vko} (N/mm²)		
	Masonry unit	Mortar	
	Group 1 clay units	M10 to M20	0,3
		M2,5 to M9	0,2
		M1 to M2	0,1
	Group 1 units, other than clay and natural stone	M10 to M20	0,2
		M2,5 to M9	0,15
		M1 to M2	0,1
	Group 1 natural stone units	M2,5 to M9	0,15
		M1 to M2	0,1
	Group 2a clay units	M10 to M20	0,3
		M2,5 to M9	0,2
		M1 to M2	0,1
	Group 2a and group 2b units other than clay and group 2b clay units	M10 to M20	0,2
		M2,5 to M9	0,15
		M1 to M2	0,1
	Group 3 clay units	M10 to M20	0,3
		M2,5 to M9	0,2
		M1 to M2	0,1

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition		Value boxed ENV 1996-1-1	UK
Table 3.5	Limiting shear strength, f_{vk} (N/mm²)			
	Masonry unit	Mortar		
	Group 1 clay units	M10 to M20	1,7	1,7
		M2,5 to M9	1,5	1,5
		M1 to M2	1,2	1,2
	Group 1 units, other than clay and natural stone	M10 to M20	1,7	1,7
		M2,5 to M9	1,5	1,5
		M1 to M2	0,1	0,1
	Group 1 natural stone units	M2,5 to M9	1,0	1,0
		M1 to M2	1,0	1,0
	Group 2a clay units ^a	M10 to M20	1,4	1,4
		M2,5 to M9	1,2	1,2
		M1 to M2	1,0	1,0
	Group 2a and group 2b units other than clay and group 2b clay units ^a	M10 to M20	1,4	1,4
		M2,5 to M9	1,2	1,2
		M1 to M2	1,0	1,0
	Anchorage bond strength of reinforcement in concrete infill, confined within masonry units			
Table 3.6	Characteristic anchorage bond strength, f_{bok}			
	For plain carbon steel bars	Strength class of concrete		
		C12/15	1,3	Not used
		C16/20	1,5	Not used
		C20/25	1,6	1,6
		C25/30, or stronger	1,8	1,6
	For high-bond carbon steel and stainless steel bars	C12/15	2,4	Not used
		C16/20	3,0	Not used
		C20/25	3,4	3,4
		C25/30, or stronger	4,1	3,4
	^a For the two cases of “group 2a clay units” and “group 2a and group 2b units other than clay and group 2b clay units”, the shear strength can also be calculated without using these boxed values.			

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition		Value boxed ENV 1996-1-1	UK
	Anchorage bond strength of reinforcement in mortar or concrete not confined within masonry units			
Table 3.7	Characteristic anchorage bond strength, f_{bok}			
	For plain carbon steel	Strength class of concrete		
		C12/15	0,7	Not used
		C16/20	1,2	Not used
		C20/25	1,4	1,4
		C25/30, or stronger	1,5	1,4
		Strength class of mortar		
		M5 to M9	0,7	0,7
		M10 to M14	1,2	1,2
	For high-bond carbon steel and stainless steel bars	M15 to M19	1,4	Not used
		M20	1,5	Not used
		Strength class of concrete		
		C12/15	1,0	Not used
		C16/20	1,5	Not used
		C20/25	2,0	2,0
		C25/30, or stronger	2,5	2,0
		Strength class of mortar		
		M5 to M9	1,0	1,0
		M10 to M14	1,5	1,5
		M15 to M19	2,0	Not used
		M20	2,5	Not used
	Mechanical properties of unreinforced masonry			
	Compression			
3.6.2.2 1)	K values of walls made using general purpose mortar			
	<i>Without longitudinal joints</i>			
	Group 1 masonry units:			
	Clay units		0,60	0,70
	Lightweight aggregate concrete, AAC		0,60	0,70
	Dense aggregate concrete, concrete brick, calcium silicate		0,60	0,70
	Group 2a masonry units, apart from dense aggregate concrete units		0,55	0,55
	Dense aggregate concrete units		0,55	0,55
	Group 2b masonry units, apart from dense aggregate concrete units		0,50	0,50
	Dense aggregate concrete units		0,50	0,50

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition	Value boxed ENV 1996-1-1	UK
	<i>With longitudinal joints</i>		
	Group 1 masonry units	0,50	0,50
	Group 2a masonry units	0,45	0,45
	Group 2b masonry units	0,40	0,40
	Group 3 masonry units	0,40	0,40
3.6.2.3 2)	K values of walls made using thin layer mortar		
	Group 1 masonry units	0,70	0,70
	Group 2a masonry units	0,60	0,60
	Group 2b masonry units	0,50	0,50
3.6.2.4 1)	K values of walls made using lightweight mortar		
	Of density 600 kg/m ³ to 1 500 kg/m ³ , with lightweight aggregate blocks and AAC units	0,80	0,80
	Of density 700 kg/m ³ to 1 500 kg/m ³ , with clay units, calcium silicate units and dense aggregate units	0,70	0,70
	Of density 600 kg/m ³ to 700 kg/m ³ , with clay units, calcium silicate units and dense aggregate units	0,55	0,55
3.6.2.6 1)	K values of walls made using shell bedded unreinforced masonry		
	When $b/t \leq 0,5$	0,60	0,60
	When $b/t \leq 0,8$	0,30	0,30
	Shear		
3.6.3 3)	Factor use to calculate masonry shear strength, will all joints considered filled	0,065	0,065
3.6.3 4)	Factor used to calculate masonry shear strength, with perpend joints unfilled	0,045	0,045
3.6.3 5)	Factor used to calculate masonry shear strength of shell bedded masonry	0,025	0,025
	Modulus of elasticity		
3.8.2 2)	Factor used to calculate short term secant modulus under service conditions	1 000	1 000

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition		Value boxed ENV 1996-1-1	UK
Table 3.8	Deformation properties of unreinforced masonry			
	Final creep coefficient			
		Type of masonry unit		
	Design values:	Clay	1,0	1,5
		Calcium silicate	1,5	1,5
		Dense aggregate concrete and manufactured stone	1,5	1,5
		Lightweight aggregate concrete	2,0	1,5
		Autoclaved aerated concrete	1,5	1,5
		Natural stone	0	1,5
	Final moisture expansion or shrinkage			
		Calcium silicate	−0,2	−0,2
		Dense aggregate concrete and manufactured stone	−0,2	−0,2
			−0,4	
		Lightweight aggregate concrete	0,2	−0,4
		Autoclaved aerated concrete	+0,1	−0,2
		Natural stone		+0,1
	Coefficient of thermal expansion			
	Type of masonry unit			
Design values:	Clay	6	6	
	Calcium silicate	9	10	
	Dense aggregate concrete and manufactured stone	10	10	
	Lightweight aggregate concrete	10	10	
	Autoclaved aerated concrete	8	10	
	Natural stone	7	10	
	Stiffened walls			
4.4.4.2 2)	Minimum thickness of a stiffening wall	85 mm	85 mm	
	Walls restrained by:			
4.4.4.3 2) i)	Concrete floors or roofs	0,75	0,75	

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition	Value boxed ENV 1996-1-1	UK
4.4.4.3 2) ii)	Timber floors or roofs For timber floor, minimum bearing thickness	1,00 85 mm	1,00 85 mm
	Walls		
4.4.6 1)P	Maximum slenderness	27	27
4.4.7.2 2)	Accidental eccentricity factor (for all categories of execution)	450	450
5.1.3 1)	Minimum thickness of loadbearing walls Minimum thickness of veneer walls	100 mm 70 mm	75 mm 70 mm
	Vertically loaded members		
4.7.1.4 2)	Maximum slenderness ratio	27	27
	Reinforced masonry deep beams		
4.7.3.1 2)	The value of the constants to be used to calculate z, the lever arm, in deep reinforced beams: Either or,	$l_{ef} \times 0,7$ $h \times 0,4$ $l_{ef} \times 0,2$	0,7 0,4 0,2
Table 5.2	Minimum concrete cover^a		
	Reinforcement		
	Minimum area of reinforcement used:		
5.2.3 2)	To enhance strength	0,10 %	0,10 %
5.2.3 3)	To enhance resistance to lateral loads To control cracking	0,03 % 0,03 %	0,03 % 0,01 %
5.2.3 4)	In reinforced grouted cavity masonry	0,05 %	0,05 %
5.2.6 1)	Minimum area of shear reinforcement	0,01 %	0,01 %
	Confined masonry		
5.2.9 2)	Minimum size of opening requiring reinforced members Maximum spacing between reinforced members	1,5 m ² 4 m	
5.2.9 3)	Confining members Minimum cross-sectional area Minimum dimension Minimum area of reinforcement larger of either	0,02 m ² 100 mm t multiplied by 0,02 or 200 mm ²	(see note)
5.2.9 5)	Minimum bar diameter with group 1, 2a and 2b units Minimum bar spacing with group 1, 2a and 2b units	6 mm 600 mm	
5.4.2.2 2)	Cavity walls Minimum number of wall ties/m ²	2	2,5
5.4.2.3 2)	Double-leaf walls Minimum number of wall ties/m ²	2	2,5
NOTE The use of confined masonry is not applicable to the UK.			
^a See 6.5 c) of this NAD.			

Table 3 — Boxed values (other than γ and ψ values)

Reference in ENV 1996-1-1	Definition		Value boxed ENV 1996-1-1	UK
	Permissible deviation in masonry			
6.8 2)	Verticality:	Height of storey	20 mm	20 mm
	Lower of:	Height of building:	50 mm	50 mm
	Vertical alignment: Maximum	Per metre	20 mm	20 mm
	Straightness: or, maximum	Per metre	5 mm	5 mm
		Per 10 m	20 mm	20 mm

4 Loading codes

The loading codes to be used are:

BS 648, *Schedule of weights of building materials*.

BS 6399, *Design loading for buildings*.

BS 6399-1, *Code of practice for dead and imposed loads*.

BS 6399-2, *Code of practice for wind loads*.

BS 6399-3, *Code of practice for imposed roof loads*.

CP 3, *Code of basic data for the design of buildings*.

CP 3: Chapter V, *Loading*.

CP 3: Chapter V-2, *Wind loads*.

When using these documents with ENV 1996-1-1 the following modifications should be noted.

- Loads from separate sources acting on a member or a component should be considered as separate actions;
- The design loading on a particular member or component may include the relevant load combination factors described in 2.3.2.2 and 2.3.4 of ENV 1996-1-1:1995. Alternatively for the ultimate limit state the simplification of design load given in 2.3.3.1 3) of ENV 1996-1-1 may be used;
- The imposed floor loads of a building should be treated as one variable action to which the reduction factors given in BS 6399-1:1984 are applicable;
- Snow drifts arising from local drifting should be treated as an accidental loading condition with the local drift being the accidental action A_d , in equation (2.18) of ENV 1996-1-1:1995.

5 Reference standards

The supporting standards to be used, including materials specifications and standards for construction, are listed in Table 4.

Table 4 — References in ENV 1996-1-1 to other publications

Reference in ENV 1996-1-1	Document referred to	Document title or subject area	Status	UK document
2.2.2.2 1)P	ENV 1991	Basis of design and actions on structures	In preparation	BS 648, BS 6399 and CP 3
2.2.3.2 3)P	EN 846-5 EN 846-6 EN 1052-1 EN 1052-2 EN 1052-3 EN 1052-4	Wall ties: tested in couplets Wall ties: tested at one end Masonry: compressive strength Masonry: flexure Masonry: shear Masonry: dpc	In preparation In preparation In preparation In preparation In preparation In preparation	DD 140-1 DD 140-1 BS 5268-1:1992 BS 5268-1:1992 — DD 86-1
3.1.1 1)P	EN 771-1 EN 771-2 EN 771-3 EN 771-4 EN 771-5 EN 771-6	Clay units Calcium silicate units Aggregate concrete units (dense and lightweight aggregate) AAC units Manufactured stone units Natural stone units	In preparation In preparation In preparation In preparation In preparation In preparation	BS 3921 BS 187 BS 6073 BS 6073 BS 6073, BS 1217 and BS 6457 —
3.1.1 3)P	EN 772-1	Compressive tests on units	In preparation	BS 187, BS 3921 and BS 6073
3.1.2.2 1)P	ENV 1996-2	Design and selection of materials and workmanship in masonry	In preparation	BS 5628-3:1986
3.2.1 1)P	EN 998-2	Masonry: mortar	In preparation	BS 4721 and BS 4551
3.2.2.1 1)P	EN 1015-11	Masonry: compressive strength	In preparation	BS 4551
3.3.1 P)	EN 206	Concrete. Performance, production placing and compliance criteria	In preparation	BS 5328 DD ENV 206:1992

Table 4 — References in ENV 1996-1-1 to other publications

Reference in ENV 1996-1-1	Document referred to	Document title or subject area	Status	UK document
3.4.1 1)P	EN 10080 EN 10088	Reinforcing steel Stainless steel	In preparation Published	BS 4449 and BS 4482 BS 6744
3.4.1 2)P	EN 845-3	Bed joint reinforcement	In preparation	—
3.4.3 3)	—	Requirement for galvanizing reinforcing carbon steel	In preparation	— (BS 729)
3.5.1 1)P	EN 10138	Prestress steel	In preparation	BS 5896 and BS 4486
3.6.3 2)	—	Requirements for testing shear strength of unreinforced masonry	—	—
3.7.2 3)	EN 846-2	Anchorage bond strength of reinforcement	In preparation	—
3.9.2 3)	EN 845-1	Wall ties, straps, hangers, brackets and support angles	In preparation	BS 1243, DD 140-2:1987 and BS 6178
3.9.4 1)P	EN 845-2	Prefabricated lintels	In preparation	BS 5977
3.9.5 1)P	ENV 1992-1-1	Anchorage, couplers, ducts and sheaths used in prestressing	Published	BS 4447
Table 5.1	EN 998-1	Rendering mortar	In preparation	BS 5262
5.4.2.2 7)	ENV 1998	Designing for seismic loading	—	—
5.9 1)P	ENV 1998-1-3	Designing for seismic loading	Published	—
5.10 P)	ENV 1996-1-2	Structural fire design of masonry	Published	BS 5628-3:1985

6 Additional recommendations

6.1 Guidance on ENV 1996-1-1 clauses

When designing to ENV 1996-1-1, clauses 6.2 to 6.7 of this NAD should be followed. Clauses referred to in this NAD are from ENV 1996-1-1:1995, unless reference is specifically made to another standard.

6.2 Chapter 2. Basis of design

a) Clause 2.1 2)P and 2.1 3)

The design requirements for providing structural integrity by limiting the effects of accidental damage are given in section 5 of Approved Document A 1992 of the Building Regulations 1991.

6.3 Chapter 3. Material properties

a) Clause 3.1.2.1 2)

The compressive strengths of units produced following the BS methods should be multiplied by 1,2 to convert them from wet tested values into equivalent air dry values for use with ENV 1996-1-1.

b) Clause 3.1.2.1 4)

In the absence of EN 772-1, the values of the normalized compressive strengths for units laid flat can be obtained by multiplying the normalized compressive strength of the unit by 0,8.

c) Clause 3.2.1 1)P

The materials to be used in the production of mortar should conform to the following standards:

- the cement types used should be Portland cement — Class 42.5 conforming to BS 12; sulfate resisting Portland cement — Class 42.5 conforming to BS 4027; Portland blastfurnace cement conforming to BS 146; or masonry cement, Class 12.5 (including air-entraining agent) conforming to BS 5224;
- the lime to be used should conform to BS 890;
- the sand used should conform to BS 1200;
- any plasticizer used should conform to BS 4887.

Table 5 — Strength classes to be ascribed to mortar designations to be used in ENV 1996-1-1

Mortar Designation	(i)	(ii)	(iii)	(iv)
Cement: lime: sand	1 : 0 to $\frac{1}{4}$: 3	1 : $\frac{1}{2}$: 4 to 4 $\frac{1}{2}$	1 : 1 : (5 to 6)	1 : 2 : (8 to 9)
Masonry cement: sand	—	1 : 2 $\frac{1}{2}$ to 3 $\frac{1}{2}$	1 : (4 to 5)	1 : (5 $\frac{1}{2}$ to 6 $\frac{1}{2}$)
Cement: sand with plasticizer	—	1 : 3 to 4	1 : (5 to 6)	1 : (7 to 8)
Strength Class	M12	M6	M4	M2

d) Clause 3.2.2

A list of strength classes to be ascribed to mortar designations is given in Table 5 of this NAD.

e) Clause 3.2.2 1)P

Prior to the publication of ENV 1996-2, the selection of mortar on the basis of durability should be based on clauses 22 and 23 of BS 5628-3:1985.

f) Clause 3.3.1 1)P

Concrete conforming to BS 5328-1 and BS 5328-2 may also be used.

The cement types used in concrete for infill should be Portland cement — Class 42.5 conforming to BS 12; Portland cement — Class 52.5 conforming to BS 12; sulfate resisting Portland cement — Class 42.5 conforming to BS 4027 or Portland blastfurnace cement conforming to BS 146. Masonry cement and high alumina cement should not be used.

Concrete used for infill should be normal weight concrete comprising natural aggregates as defined in ENV 206 or alternatively as defined in BS 5328.

Admixtures used in infill should be in accordance with clause 2.11 of BS 5628-2:1995.

g) Clause 3.3.2 4)P

It should be noted that the principle here also requires the concrete infill to have sufficient workability to ensure that it can be fully compacted after placing in voids. In practice, as far as UK unplasticized mixes are concerned, this will normally mean using a slump class S2, S3 or S4, as appropriate, in accordance with ENV 206 or slumps in the range of 75 mm to 175 mm, as appropriate, in accordance with BS 5328-2:1991.

h) Clause 3.3.3

For UK applications the concrete specification will often be for a C20/25 mix or stronger for durability reasons.

i) Clause 3.4.1 3)

High ductility bars should be used when bending dimensions to BS 4466 are specified (see clause 6.2.4 3)P).

j) Clause 3.4.2 1)P

As EN 10080 is not yet available, the characteristic strength of reinforcing steel should be obtained from Table 4 and clause 2.3.1, both of BS 5628-2:1995.

k) Clause 3.4.3 2)

The following grades of austenitic stainless steels meet the requirements of this clause:

- type 304S31 or type 316S33 conforming to BS 6744;
- type 304S15, type 304S31 or type 316S33 excluding free machining specifications conforming to BS 970-1.

l) Clause 3.4.3 3)

Carbon steel, which is galvanized, should be in accordance with BS 729.

m) Clause 3.5.1 2)P

As ENV 10138 is not yet available, prestressing steel should conform to the requirements of the current British Standards, given in clause 2.3.2 of BS 5628-2:1995.

n) *Clause 3.6.4 2)*

In the absence of any test data obtained by following EN 1052-2, values for the characteristic flexural strength of unreinforced masonry should be taken from Table 3 of BS 5628-1:1992. The values of f_{xk1} refer to the case where the plane of failure is parallel to the bed joints, and f_{xk2} refer to the case where the plane of failure is perpendicular to the bed joints. The mortar designations used in this table are the same as those specified in clause 3.2.2.

6.4 Chapter 4. Design of masonrya) *Clause 4.1.1 4)*

For guidance on the application of this clause, reference should be made to clause 2.5.1.3 of ENV 1992-1-1:1992, the Eurocode for the design of concrete structures.

b) *Clause 4.1.2*

The design requirements for providing structural integrity by limiting the effects of accidental damage are given in section 5 of Approved Document A 1992 of the Building Regulations 1991.

c) *Clause 4.4.5*

The effective thickness of walls stiffened by piers should be taken from Figure 3 and Table 5, both of BS 5628-1:1992.

d) *Clause 4.5.3 7)*

The value of f_{vko} should be taken from clause 3.6.3. The characteristic vertical shear strength of bonded masonry should be taken from clause 25 of BS 5628-1:1992.

e) *Clause 4.6.2.2 2)*

The values of the bending moment coefficient should be taken from Table 9 of BS 5628-1:1992.

f) *Clause 4.6.2.4 2)*

In the absence of test results obtained in accordance with EN 846-5 or EN 846-6, guidance on the performance of wall ties can be obtained from DD 140-1:1986 or taken from clauses 29.1 and 36.2 of BS 5628-1:1992. In the case of clause 36.2, the reference to γ_m values should be ignored.

Guidance on the interpretation of test results and on the performance of wall ties should be taken from DD 140-1:1986.

g) *Table 4.1*

For the case of a cantilevered wall having a reinforcement ratio of greater than 0,005, the deflection should be checked by calculation.

h) *Clause 4.7.1.6*

Where reinforced masonry members are subjected to a combination of vertical loading and bending, such that the design axial force exceeds $0.1f_k A_m$, the provisions of clause 4.3 of BS 5628-2:1995 may be followed using the partial safety factors, material characteristic strengths, effective height, effective thickness and slenderness given in the relevant clauses of ENV 1996-1-1.

The design of walls incorporating bed joint reinforcement to enhance lateral load resistance may follow the guidance in annex A of BS 5628-2:1995 with the following exceptions:

- i) mortars should conform to clause 3.2.2.1 of ENV 1996-1-1;
- ii) the characteristic compressive strength of masonry f_k to be used in bending should be taken from clause 3.6.2 of ENV 1996-1-1 for the appropriate direction of loading;
- iii) the partial safety factor for actions should be taken from clause 2.3.3 of ENV 1996-1-1:1995;
- iv) the partial safety factor for the compressive strength of masonry should be taken from clause 2.3.3.2 of ENV 1996-1-1:1995 for the appropriate categories of execution and manufacturing control of the masonry units.

The anchorage length for reinforcement should be determined in accordance with clauses 5.2.5 and 3.7.2 of ENV 1996-1-1:1995.

The minimum area of reinforcement used should be in accordance with clause 5.2.3 2) of ENV 1996-1-1:1995.

Using Method 1, **A.3** or Method 2, **A.4** of BS 5628-2:1995, the verification of the reinforced section in bending should be in accordance with **4.7.1.6** and annex F of ENV 1996-1-1. The lateral load resistance of the unreinforced wall should be determined in accordance with clauses **4.6.2.1** and **4.6.2.2** of ENV 1996-1-1:1995.

Using Method 3, **A.5** of BS 5628-2:1995, the moment of resistance about the wall horizontal axis should be determined in accordance with clauses **4.6.2.1** and **4.6.2.2** of ENV 1996-1-1:1995. The design moment of resistance about the vertical axis should be determined in accordance with clause **4.7.1.6** and annex F of ENV 1996-1-1:1995. The lateral load resistance of the unreinforced wall should be determined in accordance with **4.6.2.1** and **4.6.2.2** of ENV 1996-1-1:1995.

Using Method 4, **A.6** of BS 5628-2:1995, the failure strength of the wall, excluding reinforcement, should be determined in accordance with clauses **4.6.2.1** and **4.6.2.2** of ENV 1996-1-1:1995 taking the value of γ_m as 1,0. The partial safety factor for masonry, γ_m , for the serviceability limit state to be used in the calculation of wall service strength should be taken as 1,5.

Where wall ties are required to transmit forces between the leaves of cavity walls where either one or both leaves include bed joint reinforcement for lateral load enhancement, wall tie design should be in accordance with clause **4.6.2.4** of ENV 1996-1-1:1995.

i) *Clause 4.7.2.1*

Where shear forces act in the plane of a wall, ie racking shear, the principles of **4.7.2** apply.

In the verification of walls containing no shear reinforcement using equation 4.42, b and d should be replaced by L and t, the length and thickness of the wall.

j) *Clause 4.7.2.2 1)*

For the case where bars are embedded in bedjoints, vertical joints and other sections where the reinforcement is wholly surrounded by mortar of strength class M5 or greater, f_{vk} may be taken as 0.35 N/mm^2 .

For cases where the main longitudinal steel reinforcement is placed within pockets, cores, or cavities filled with concrete infill, the value of f_{vk} used in equation 4.42 should be modified as follows:

$$f_{vk} = 0,35 + 17,5\rho$$

where $\rho = A_s/bd$, provided that f_{vk} is not taken to be greater than 0.7 N/mm^2 .

k) *Clause 4.7.2.2 2)*

The characteristic shear strength enhancement given in equation 4.4.3 is applicable to simply supported beam or cantilever reinforced sections in which the main longitudinal steel reinforcement is placed in bed or vertical joints and other sections where the reinforcement is wholly surrounded with mortar of strength class M5 or greater.

For simply supported reinforced beams or cantilever retaining walls in which the main longitudinal steel reinforcement is placed in pockets, cores or cavities filled with concrete infill and where the ratio of the shear span to the effective depth, d, is 6 or less, f_{vk} may be increased by a factor of (2,5 to 0,25 (shear span/d)), where the shear span is the ratio of the maximum design bending moment to the maximum design shear force, and provided that f_{vk} is not taken to be greater than 1.75 N/mm^2 .

l) *Figure 4.12*

It should be verified that the effective depth d can be contained within the clear height of the wall h less the distance from the underside of the deep beam to the centre of the reinforcement.

m) *Clause 4.7.3.2 5)*

Guidance is given in clause **5.2.3 3)**.

n) *Clause 4.7.3.2 6)*

Reference should be made here to clause **5.2.5**, rather than **5.2.6**.

o) *Clause 4.7.4.3*

Additional guidance on the limitation of cracking is given in clause **4.3.5** of BS 5628-2:1995.

p) *Clause 4.8.1*

The design guidance given in section 5 of BS 5628-2:1995 will satisfy these general requirements.

q) *Clause 4.8.2.2 2)P*

The tensile stresses in the masonry should be limited to zero. The initial prestressing force should be limited to 70 % of the characteristic breaking load of the tendon.

More detailed guidance on the limiting levels of compressive stress in the masonry is given in clause 5.3.2 of BS 5628-2:1995.

r) *Clause 4.8.3.2 2)P*

Stresses in unbonded tendons in post-tensioned members should be limited to 70 % of their characteristic strength.

The stress/strain curve to be used for the determination of the stresses in bonded tendons, whether initially tensioned or untensioned, should be taken from either Figure 5 of BS 5628-2:1995 or Figure 4.6 of ENV 1992-1-1:1991. The actual values of the modulus of elasticity for prestressing steels should be confirmed from manufacturers' certificates.

s) *Clause 4.8.3.2 3)P*

Guidance on the design of members subjected to loading in the plane of the member is given in clause 5.2.1 of BS 5628-2:1995.

t) *Clause 4.8.3.2 5)P*

Guidance on the design of members subjected to shear is given in clause 5.2.3 of BS 5628-2:1995.

u) *Clause 4.8.4.2 2)*

Further guidance on the design of anchorages is given in clause 5.5 of BS 5628-2:1995.

v) *Clauses 4.8.4.3 2) and 4.8.4.3 3)*

These factors affecting the prestress losses should be evaluated in accordance with the guidance given in clauses 5.4.2 and 5.4.3 of BS 5628-2:1995, with the exceptions that:

- i) the short term masonry elastic modulus, E , should be determined in accordance with clauses 3.8.2 1)P and 3.8.2 2)P;
- ii) the short term concrete elastic modulus, E_{cm} , should be determined in accordance with clause 3.1.2.5.2 of ENV 1992-1-1:1991;
- iii) the short term prestressing steel elastic modulus, E_s , should be determined in accordance with clause 3.4.1.7 of BS 5628-2:1995 or clause 3.3.4.4 of ENV 1992-1-1:1991. The actual value of the modulus of elasticity should be confirmed from manufacturers' certificates;
- iv) moisture, thermal and creep movement of masonry should be evaluated in accordance with clause 3.8.4.

6.5 Chapter 5. Structural detailing

a) *Clause 5.2.2.2 1)*

Masonry exposed to de-icing salts should be placed in class 4, unless it would otherwise be in class 5.

b) *Table 5.1*

For the UK, the references to unprotected carbon steel located in mortar under exposure classes 2 and 3 should be ignored.

In addition, in the UK note 1 applies to walls whether or not they are "likely to become damp".

Where carbon steel is galvanized as the method of providing primary durability protection it should be galvanized following the procedure in BS 729.

c) *Table 5.2*

This table should be replaced in its entirety by Table 14 of BS 5628-2:1995. Exposure classes 1, 2 and 3 should be considered equivalent to exposure situations E1, E2 and E3 respectively as given in clause 6.1.2.2 of BS 5628-2:1995. Exposure classes 4 and 5 should be considered equivalent to exposure situation E4 as given in clause 6.1.2.2 of BS 5628-2:1995.

d) *Clause 5.2.4 1)P*

As EN 845-3 is not yet available, the minimum size of the longitudinal wires for prefabricated bed joint reinforcement to be used in design applications is 3 mm.

e) *Clause 5.2.5.1 8)*

EN 846-2 is not yet available. It is advisable in all cases to consult the manufacturer of the bed joint reinforcement, especially where some form of coating against corrosion has been specified for use on the steel.

f) *Clause 5.2.5.2 3)*

The guidance given in this clause should not be used. Instead, the lap length provided between two reinforcing bars should not be less than l_b the anchorage length required to develop full bond in the smaller of the two bars lapped. The lap length should also not be less than 25 bars diameters plus 150 mm for tension reinforcement and not less than 20 bar diameters plus 150 mm for compression reinforcement.

g) *Clause 5.2.5.2 5)*

EN 846-2 is not yet available. It is advisable in all cases to consult the manufacturer of the bedjoint reinforcement, especially where some form of coating against corrosion has been specified for use on the steel.

h) *Clause 5.2.6 1)*

The effective width may be taken as the width of the section at the level of the tensile reinforcement. For UK applications, 0,1 % can be applied, but only to beams. Rules detailed in 5.2.6 2) and 3) are of general application.

i) *Clause 5.2.9*

Whilst ENV 1996-1-1 and the National Application Document are not intended to be restrictive or to limit innovation, confined masonry is not a traditional form of construction in the UK and its use is not applicable to the UK.

j) *Clause 5.4.1*

The requirements of this clause will be deemed to be met if the detailed guidance given in appendix C of BS 5628-1:1992 is followed.

k) *Clause 5.4.2.2*

When cavity walls are to be filled with concrete, for example in reinforced concrete filled cavity walls, then guidance on wall ties and their spacing can be found in clause 6.4 and annex B, both of BS 5628-2:1995.

l) *Clause 5.4.2.2 2)*

Where the minimum boxed value for the spacing of wall ties is used, the ties should conform to BS 1243 or DD 140-2:1987.

m) *Clause 5.5.2 1)*

A chase within 5° of vertical can be assumed to be vertical.

n) *Table 5.3*

Where note 5 applies to walls exceeding 2,0 m in length, the cumulative width limit should be applied to any 2,0 m length of wall.

In walls less than 175 mm thick, local widening of chases to a maximum of 150 mm wide by 100 mm high is permitted so long as the length of the wall is at least 900 mm and not more than one such widening is made in any 900 mm length of wall.

o) *Table 5.4*

Where the length of the chase is less than, or equal to, 1250 mm, the limiting length should be taken as either the length of the chase, or half the length of the wall, whichever is smaller.

p) *Clause 5.7 3)*

Pending publication of ENV 1996-2, this clause will be satisfied by following the recommendations given in BS 5628-3:1985 clause 20.3.

q) *Clause 5.7 4)*

Pending publication of ENV 1996-2, this clause will be satisfied by following the recommendations given in BS 5628-3:1985 clause 20.3.

6.6 Chapter 6. Execution

a) *Clause 6.2.4 3)*

The appropriate national standard is BS 4466.

b) *Clause 6.3.2 5)*

Concrete infill shall also have sufficient workability to ensure that it can be fully compacted after placing in voids.

c) *Clause 6.3.3 4)*

Concrete infill shall also have sufficient workability to ensure that it can be fully compacted after placing in voids.

d) *Clause 6.9 5)*

Categories “A” and “B” execution control are defined as follows; category “C” execution control is not used in this NAD.

Category “A” execution control

Category “A” execution control may be assumed when both of the following conditions are satisfied:

- regular inspection of the work is made by appropriately qualified persons independent of the constructor’s site staff to verify that the work is being executed in accordance with the drawings and specification;

NOTE In the case of Design-and-Build contracts, the Designer may be considered as a person independent of the site organization for the purposes of inspection of the work.

- preliminary compressive strength tests carried out on the mortar to be used indicate conformity to the strength requirements given in Table 5 of this NAD and regular testing of the mortar used on site shows that conformity to the strength requirements given in Table 5 is being maintained.

Category “B” execution control

Category “B” execution control should be assumed when either or both of the conditions for category “A” are not satisfied.

Category B level of execution should not be used for reinforced or prestressed masonry, except in the following instances:

- deep beam, composite lintel construction and walls incorporating bed joint reinforcement to enhance lateral load resistance;
- masonry containing prefabricated bed joint reinforcement used solely to control cracking.

e) *Clause 6.9 6)*

This clause should be ignored, as category “C” execution control is not used in this NAD.

6.7 Annex C

a) *Clause C.1 1)*

When using the simplified frame diagram in Figure C.1, one analysis is required to determine the moment at the top of a wall panel and a second separate analysis is required to find the moment at the bottom of the wall panel, as is shown in Figure 1 of this NAD.

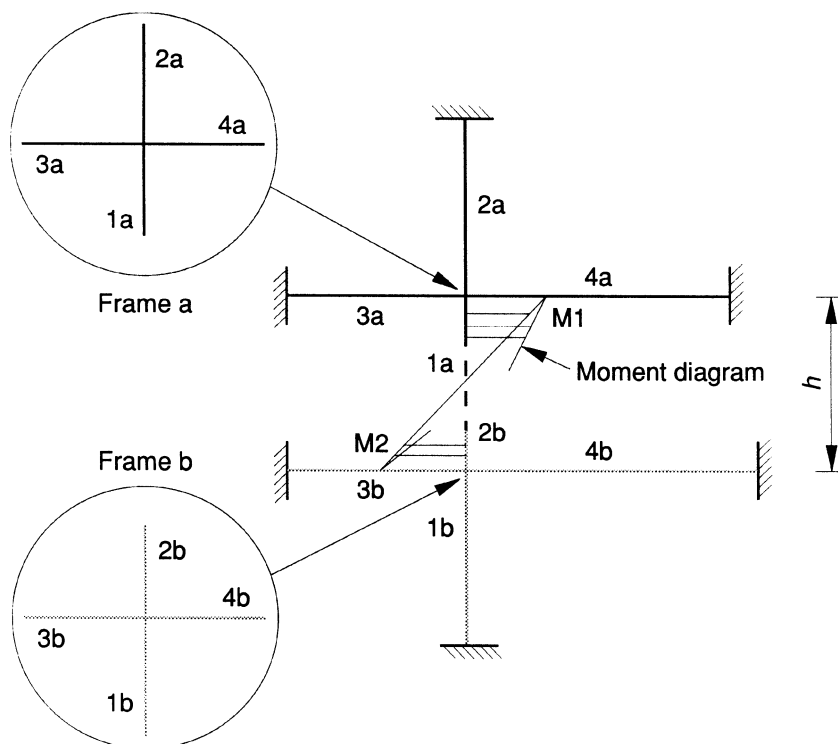
b) *Equation (C.1)*

In equation (C.1) the short term modulus of elasticity should be used for floor members to correspond with the use of short term values as recommended for the masonry.

When calculating the second moment of area for use in equation (C.1) wall openings may be ignored, but circumstances which reduce the second moment of area of the floors should not be ignored.

Where equation (C.1) is applied to cavity walls, only leaves supporting floor or roof members should be taken into account. Where both leaves in a storey support floor or roof members, the wall stiffness should be taken as the sum of the stiffnesses for each leaf.

NOTE The moments calculated from equation (C.1) are independent of the axial vertical load in the wall above the joint. Consequently, the moments may be the same from one level to another of a repetitive multi-storey building, but the eccentricities will diminish as the design vertical load increases.



Moment M_1 is found from frame 'a' and moment M_2 from frame 'b'

Figure 1 — Moment at top and bottom of wall panel from two simplified frames

c) C.1 2) and 3)

The limit on average design vertical stress levels may be disregarded in circumstances where the slight joint rotation leading to slight cracking at the joint can be accepted. The reduced moments calculated from equations (C.1) and (C.2) may then be used to assess the eccentricity in the wall at average design vertical stress levels less than $0,25 \text{ N/mm}^2$.

Where the calculated resultant eccentricity due to loads exceeds 0.4 at the top or the bottom of a laterally restrained wall panel the design may be in accordance with C.1 4) whereby the maximum value of Φ_1 becomes 0.2.

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

- BS 12:1991, *Specification for Portland cement.*
- BS 146:1991, *Specification for Portland blastfurnace cement.*
- BS 187:1978, *Specification for calcium silicate (sandlime and flintlime) bricks.*
- BS 648:1964, *Schedule of weights of building materials.*
- BS 729:1971, *Specification for hot dip galvanized coatings on iron and steel articles.*
- BS 890:1995, *Specification for building limes.*
- BS 970, *Specification for wrought steels for mechanical and allied engineering purposes.*
- BS 970-1:1991, *General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels.*
- BS 1199 and BS 1200:1976, *Specifications for building sands from natural sources.*
- BS 1217:1986, *Specification for cast stone.*
- BS 1243:1978, *Specification for metal ties for cavity wall construction.*
- BS 3921:1985, *Specification for clay bricks.*
- BS 4027:1991, *Specification for sulfate-resisting Portland cement.*
- BS 4466:1989, *Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete.*
- BS 4447:1973, *Specification for the performance of prestressing anchorages for post-tensioned construction.*
- BS 4449:1988, *Specification for carbon steel bars for the reinforcement of concrete.*
- BS 4482:1985, *Specification for cold reduced steel wire for the reinforcement of concrete.*
- BS 4486:1980, *Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for prestressing of concrete.*
- BS 4551:1980, *Methods of testing mortars, screeds and plasters.*
- BS 4721:1981, *Specification for ready-mixed building mortars.*
- BS 4887, *Mortar admixtures.*
- BS 5224:1995, *Specification for masonry cement.*
- BS 5262:1991, *Code of practice for external renderings.*
- BS 5328, *Concrete.*
- BS 5328-1:1991, *Guide to specifying concrete.*
- BS 5328-2:1991, *Methods for specifying concrete mixes.*
- BS 5628, *Code of practice for use of masonry.*
- BS 5628-1:1992, *Structural use of unreinforced masonry.*
- BS 5628-2:1995, *Structural use of reinforced and prestressed masonry.*
- BS 5628-3:1985, *Materials and components, design and workmanship.*
- BS 5896:1980, *Specification for high tensile steel wire and strand for the prestressing of concrete.*
- BS 5977, *Lintels.*
- BS 6073, *Precast concrete masonry units.*
- BS 6178, *Joist hangers.*
- BS 6399, *Loading for buildings.*
- BS 6399-1:1984, *Code of practice for dead and imposed loads.*
- BS 6399-2:1995, *Code of practice for wind loads.*
- BS 6399-3:1988, *Code of practice for imposed roof loads.*
- BS 6457:1984, *Specification for reconstructed stone masonry units.*
- BS 6744:1986, *Specification for austenitic stainless steel bars for the reinforcement of concrete.*

CP 3, *Code of basic data for the design of buildings.*

CP 3: Chapter V, *Loading.*

CP 3: Chapter V-2:1972, *Wind loads.*

DD 86, *Damp-proof courses.*

DD 86-1:1993, *Methods of test for flexural bond strength and short-term shear strength.*

DD 140, *Wall ties.*

DD 140-1:1986, *Methods of test for mortar joint and timber frame connections.*

DD 140-2:1987, *Recommendations for design of wall ties.*

DD ENV 206:1992, *Concrete. Performance, production, placing and compliance criteria.*

CEN and CENELEC standards publications

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN) and EUROPEAN COMMITTEE FOR ELECTROTECHNICAL STANDARDIZATION (CENELEC), Brussels. (All publications are available from BSI Sales.)

ENV 206:1992, *Concrete Performance, placing, production and compliance criteria.*

ENV 1996, *Eurocode 6: Design of masonry structures.*

Other reference

Approved Document A, *Structure*, 1992 Edition. The Building Regulations 1991. Available from the Building Research Establishment, Watford, Herts, WD2 7RJ.

Informative references

CEN and CENELEC standards publications

EN 10088, *Stainless steels.*

ENV 1992, *Eurocode 2: Design of concrete structures.*

ENV 1992-1-1:1991, *General rules and rules for buildings.*

ENV 1996, *Eurocode 6: Design of masonry structures.*

ENV 1996-1-2:1995, *Structural fire design.*

ICS 91.080.30

Descriptors: Buildings, construction, masonry work, building codes, computation, generalities

English version

**Eurocode 6: Design of masonry structures —
Part 1-1: General rules for buildings —
Rules for reinforced and unreinforced masonry**

Eurocode 6: Calcul des ouvrages en
maçonnerie — Partie 1-1: Règles générales —
Règles pour la maçonnerie armée et non armée

Eurocode 6: Bemessung und Konstruktion von
Mauerwerksbauten — Teil 1-1: Allgemeine
Regeln — Regeln für bewertes und nicht
bewertes Mauerwerk

This European Prestandard (ENV) was approved by CEN on 1994-06-10 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 an 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.

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CEN

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

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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 it is necessary to indicate the quality of the construction products, and the standard of workmanship needed on and off site to comply with the assumptions of the design rules.
- 3) Until the necessary set of harmonized technical specifications for products and for the methods for 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/TC 250 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 of structures for earthquake resistance.

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 ENV 1996-1-1 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/TC 250/SC6 at the following address:—

DIN
Burggrafenstrasse 6
10772 Berlin
Germany

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 1996-1-1 have been assigned indicative values which are identified by □ ("boxed values"). The authorities in each member country are expected to review the "boxed values" and may substitute alternative definitive values for these safety elements for use in national application.
- 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 any substitute definitive values for safety elements, referencing compatible supporting standards and providing guidance on the national application of this prestandard, will be issued by each member country or its Standards Organisation.
- 15) It is intended that this prestandard is used in conjunction with the NAD valid in the country where the building and civil engineering work is located.

Matters specific to this prestandard

16) The general scope of Eurocode 6 is defined in clause 1.1.1 of this ENV 1996-1-1 and the scope of this part of Eurocode 6 is defined in clause 1.1.2. Additional parts of Eurocode 6 which are planned are indicated in clause 1.1.3 of this ENV 1996-1-1.

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1 General

1.1 Scope

1.1.1 Scope of Eurocode 6

- 1) P Eurocode 6 applies to the design of buildings and civil engineering works in unreinforced, reinforced, prestressed and confined masonry.
- 2) P Eurocode 6 is only concerned with the requirements for resistance, serviceability and durability of structures. Other requirements, for example, concerning thermal or sound insulation, are not considered.
- 3) P Execution¹⁾ is covered to the extent that is necessary to indicate the quality of the construction materials and products that should be used and the standard of workmanship on site needed to comply with the assumptions made in the design rules. Generally, the rules related to execution and workmanship should be considered as minimum requirements which may have to be further developed for particular types of buildings or civil engineering works¹⁾ and methods of construction¹⁾.
- 4) P Eurocode 6 does not cover the special requirements of seismic design. Provisions related to such requirements are given in Eurocode 8 “Design of structures in seismic regions”²⁾ which complements, and is consistent with, Eurocode 6.
- 5) P Numerical values of the actions on buildings and civil engineering works to be taken into account in the design are not given in Eurocode 6. They are provided in Eurocode 1 “Basis of design and actions on structures”³⁾.

1.1.2 Scope of Part 1-1 of Eurocode 6

- 1) P Part 1-1 of Eurocode 6 gives a general basis for the design of buildings and civil engineering works in unreinforced, reinforced, prestressed and confined masonry made with the following masonry units laid in mortar made with natural sand, or crushed sand, or lightweight aggregate:
 - fired clay units, including lightweight clay units;
 - calcium silicate units;
 - concrete units, made with dense or lightweight aggregates;
 - autoclaved aerated concrete units;
 - manufactured stone units;
 - dimensioned natural stone units.
- 2) P Part 1-1 deals with reinforced masonry where the reinforcement is added to provide ductility, strength or serviceability. The principles of the design of prestressed masonry and confined masonry are given, but application rules are not provided.
- 3) In so far as Part 1-1 gives the basis for the design of reinforced and prestressed masonry, the designer should consider the extent of any concrete infill and the contribution of the masonry to the load resistance and, where the concrete infill makes a much greater contribution to the load resistance than the masonry, Eurocode 2 should be used and the strength of the masonry should be ignored.
- 4) For those types of structures not covered entirely, new structural uses for established materials, new materials, or where actions and other influences outside normal experience have to be resisted, the same principles and application rules may be applicable, but may need to be supplemented.
- 5) In addition, Part 1-1 gives detailed rules which are mainly applicable to ordinary buildings. The applicability of these rules may be limited, for practical reasons or due to simplifications; their use and any limits of applicability are explained in the text where necessary.
- 6) P The following subjects are dealt with in Part 1-1:
 - Section 1: General.
 - Section 2: Basis of design.
 - Section 3: Materials.

¹⁾ For the meaning of these terms, see 1.4.1

²⁾ At present at the draft stage

³⁾ At present at the draft stage.

- Section 4: Design of masonry.
- Section 5: Structural detailing.
- Section 6: Construction.

7) P Sections 1 and 2 are common to all Eurocodes, with the exception of some additional clauses which are required for masonry.

NOTE The material independent clauses in Section 2 will be replaced by references to ENV 1991-1, when it is published.

8) P Part 1-1 does not cover:

- resistance to fire (which is dealt with in ENV 1996-1-2);
- particular aspects of special types of building (for example, dynamic effects on tall buildings);
- particular aspects of special types of civil engineering works (such as masonry bridges, dams, chimneys or liquid-retaining structures);
- particular aspects of special types of structures (such as arches or domes).

1.1.3 Further parts of Eurocode 6

1) P Part 1-1 of Eurocode 6 will be supplemented by further parts which will complement or adapt it for particular aspects of special types of building or civil engineering works, special methods of construction and certain other aspects of design which are of general practical importance.

2) P Further parts of Eurocode 6 which, at present, are being prepared or are planned, include the following:

- Part 1-2: Structural fire design;
- Part 1-3: Detailed rules on lateral loading;
- Part 1-X: Complex shape sections in masonry structures;
- Part 2: Design, selection of materials and execution of masonry;
- Part 3: Simplified and simple rules for masonry structures;
- Part 4: Constructions with lesser requirements for reliability and durability;

1.2 Distinction between principles and application rules

1) P Depending on the character of the individual clauses, distinction is made in this Part 1-1 of ENV 1996 between principles and application rules.

2) P The principles comprise:

- general statements and definitions for which there is no alternative;
- requirements and analytical models for which no alternative is permitted unless specifically stated.

3) P The principles are defined by the letter P, following the paragraph number, for example, 1)P.

4) P The application rules are generally recognised rules which follow the principles and satisfy their requirements.

5) P It is permissible to use alternative design rules differing from the application rules given in this Eurocode, provided that it is shown that the alternative rules accord with the relevant principles and have not less than the same reliability.

6) P The application rules are all clauses not indicated as being principles.

1.3 Assumptions

1) P The following assumptions apply:

- Structures are designed by appropriately qualified and experienced personnel.
- Adequate supervision and quality control is provided in factories, in plants, and on site.
- Construction is carried out by personnel having the appropriate skill and experience.
- The construction materials and products are used as specified in this Eurocode or in the relevant material or product specifications.
- The structure will be adequately maintained.
- The structure will be used in accordance with the design brief.

2) P The design procedures are valid only when the requirements for execution and workmanship given in Section 6 of this ENV 1996-1-1 are also complied with.

3) P Numerical values identified by $\square$ are given as indications. Other values may be specified by Member States.

1.4 Definitions

1.4.1 Terms common to all Eurocodes

1) P Unless otherwise stated in the following, the terminology used in International Standard ISO 8930 applies.

2) P The following terms are used in common for all Eurocodes with the following meanings:

— **Construction works:** Everything that is constructed or results from construction operations.⁴⁾ This term covers both building and civil engineering works. It refers to the complete construction comprising both structural and non-structural elements.

— **Execution:** The activity of creating a building or civil engineering works. The term covers work on site; it may also signify the fabrication of components off site and their subsequent erection on site.

NOTE In English, “construction” may be used in certain combinations of words, when there is no ambiguity (for example, “during construction”).

— **Structure:** Organised combination of connected parts designed to provide some measure of rigidity.⁵⁾ This term refers to load carrying parts.

— **Type of building or civil engineering works:** Type of “construction works” designating its intended purpose, for example, dwelling house, industrial building, road bridge.

NOTE “Type of construction works” is not used in English.

— **Form of structure:** Structural type designating the arrangement of structural elements, for example, beam, triangulated structure, arch, suspension bridge.

— **Construction material:** A material used in construction work, for example, concrete, steel, timber, masonry.

— **Type of construction:** Indication of principal structural material, for example, reinforced concrete construction, steel construction, timber construction, masonry construction.

— **Method of construction:** Manner in which the construction will be carried out, for example, cast in place, prefabricated, cantilevered.

— **Structural system:** The loadbearing elements of a building or civil engineering works and the way in which these elements are assumed to function, for the purpose of modelling.

NOTE The equivalent terms in six languages are given in Table 1-1.

1.4.2 Special terms used in this ENV 1996-1-1

1.4.2.1 Masonry

1) **P Masonry:** An assemblage of masonry units laid in a specified pattern and joined together with mortar.

2) **P Reinforced masonry:** Masonry in which bars or mesh, usually of steel, are embedded in mortar or concrete so that all the materials act together in resisting forces.

3) **P Prestressed masonry:** Masonry in which internal compressive stresses have been intentionally induced by tensioned reinforcement.

4) **P Confined masonry:** Masonry built rigidly between reinforced concrete or reinforced masonry structural columns and beams on all four sides (not designed to perform as a moment resistant frame).

5) **P Masonry bond:** Disposition of units in masonry in a regular pattern to achieve common action

⁴⁾ This definition accords with the International Standard ISO 6707-1.

⁵⁾ The International Standard ISO 6707-1 gives the same definition, however, adds “or a construction works having such an arrangement”. For Eurocodes this addition is not used, in order to avoid ambiguous translations.

Table 1-1 — List of equivalent terms in Community languages (to be completed for other Community languages)

ENGLISH	FRANCAIS	DEUTSCH	ITALIANO
Construction works	Construction	Bauwerk	Costruzione
Execution	Exécution	(Bau-) Ausführung	Esecuzione
Structure	Structure	Tragwerk	Struttura
Type of building or civil engineering works	Nature de construction	Art des Bauwerks	Tipo di costruzione
Form of structure	Type de structure	Art des Tragwerks	Tipo di struttura
Construction material	Matériau de construction	Baustoff; Werkstoff (Stahlbau)	Materiale da costruzione
Type of construction	Mode de construction	Bauart	Sistema costruttivo
Method of construction	Procédé d'exécution	Bauverfahren	Procedimento esecutivo
Structural system	Système structural	Tragsystem	Sistema strutturale

Table 1-1— List of equivalent terms in Community languages (to be completed for other Community languages)

ENGLISH	NEDERLANDS	ESPAÑOL	PORTUGUES
Construction works	Bouwwerk	Construcción	Obras de construção
Execution	Uitvoering	Ejecucion	Execução
Structure	Draag-constructie	Estructura	Estrutura
Type of building or civil engineering works	Type bouwwerk	Naturaleza de la construcción	Tipos de obras de construção
Form of structure	Type draag-constructie	Tipo de estructura	Tipo de estrutura
Construction material	Constructie materiaal	Material de construcción	Material de construção
Type of construction	Bouwwijze	Modo de construcción	Tipo de construção
Method of construction	Bouwmethode	Procedimiento de ejecucion	Processo de construção
Structural system	Constructief systeem	Sistema estructural	Sistema estrutural

1.4.2.2 Strength of masonry

1) **P Characteristic strength of masonry:** The value of strength corresponding to a 5 % fractile of all strength measurements of the masonry.

NOTE the value may be taken from the results of specific tests or from an evaluation of test data or other specified values.

2) **P Compressive strength of masonry:** The strength of masonry in compression without the effects of platten restraint, slenderness or eccentricity of loading.

3) **P Shear strength of masonry:** The strength of masonry subjected to shear forces.

4) **P Flexural strength of masonry:** The strength of masonry in pure bending.

5) **P Anchorage bond strength:** The bond strength, per unit surface area, between reinforcement and concrete or mortar when the reinforcement is subjected to tensile or compressive forces.

1.4.2.3 Masonry units

1) **P Masonry unit:** A preformed component, intended for use in masonry construction.

2) **P Groups 1, 2a, 2b and 3 masonry units:** Group designations for masonry units, according to the percentage size and orientation of holes in the units when laid.

3) **P Bed face:** The top or bottom surface of a masonry unit when laid as intended.

4) **P Frog:** A depression, formed during manufacture, in one or both bed faces of a masonry unit.

5) **P Hole:** A formed void which may or may not pass completely through a masonry unit.

6) **P Griphole:** A formed void in a masonry unit to enable it to be more readily grasped and lifted with one or both hands or by machine.

7) **P Web:** The solid material between the holes in a masonry unit.

8) **P Shell:** The peripheral material between a hole and the face of a masonry unit.

9) **P Gross area:** The area of a cross-section through the unit without reduction for the area of holes, voids and re-entrants.

10) **P Compressive strength of masonry units:** The mean compressive strength of a specified number of masonry units.

NOTE For the purposes of this Eurocode, reference is made to EN 772-1, "Methods of test for masonry units. Part 1: Determination of compressive strength".

11) **P Normalized compressive strength of masonry units:** The compressive strength of masonry units converted to the air dried compressive strength of an equivalent 100 mm wide × 100 mm high masonry unit.

12) **P Characteristic compressive strength of masonry units:** The compressive strength corresponding to a 5 % fractile of the compressive strength of a specified number of masonry units.

NOTE For the purposes of this Eurocode, reference is made to EN 772-1, "Methods of test for masonry units. Part 1: Determination of compressive strength".

1.4.2.4 Mortar

1) **P Mortar:** A mixture of inorganic binders, aggregates and water, together with additions and admixtures if required.

NOTE For the purposes of this Eurocode, reference is made to EN 998-2, "Specification for mortar for masonry. Part 2: Masonry mortar".

2) **P General purpose mortar:** A mortar for use in joints with a thickness greater than 3 mm and in which only dense aggregates are used.

3) **P Thin layer mortar:** A designed mortar for use in joints between 1 mm and 3 mm in thickness.

4) **P Lightweight mortar:** A designed mortar with a dry hardened density lower than 1 500 kg/m³.

5) **P Designed mortar:** A mortar designed and manufactured to fulfil stated properties and subjected to test requirements.

6) **P Prescribed mortar:** A mortar made in predetermined proportions, the properties of which are assumed from the stated proportion of the constituents.

7) **P Factory made mortar:** A mortar batched and mixed in a factory and supplied to the building site.

8) **P Pre-batched mortar:** A material consisting of constituents batched in a plant, supplied to the building site and mixed there under factory specified proportions and conditions.

9) **P Site-made mortar:** A mortar composed of primary constituents batched and mixed on the building site.

10) **P Compressive strength of mortar:** The mean compressive strength of a specified number of mortar specimens after curing for 28 days.

NOTE For the purposes of this Eurocode, reference is made to EN 1015-11, "Methods of test for mortar for masonry. Part 11: Determination of flexural and compressive strength of hardened mortar".

1.4.2.5 Concrete infill

1) **P Concrete infill:** A concrete mix of suitable consistency and aggregate size to fill cavities or voids in masonry.

1.4.2.6 Reinforcement

1) **P Reinforcing steel:** Steel reinforcement for use in masonry.

2) **P Bed joint reinforcement:** Steel reinforcement that is prefabricated for building into a bed joint.

NOTE For the purposes of this Eurocode, reference is made to EN 845-3, "Specification for ancillary components for masonry. Part 3: Bed joint reinforcement".

3) **P Prestressing steel:** Steel wires, bars or strands for use in masonry.

1.4.2.7 Ancillary components

1) **P Damp proof course:** A layer of sheeting, masonry units or other material used in masonry to resist the passage of water.

- 2) **P Wall tie:** A device for connecting one leaf of a cavity wall across a cavity to another leaf or to a framed structure or backing wall.
- 3) **P Strap:** A device for connecting masonry members to other adjacent components, such as floors and roofs.

1.4.2.8 Mortar joints

- 1) **P Bed joint:** A mortar layer between the bed faces of masonry units.
- 2) **P Perpend joint:** A mortar joint perpendicular to the bed joint and to the face of wall.
- 3) **P Longitudinal joint:** A vertical mortar joint within the thickness of a wall, parallel to the face of the wall.
- 4) **P Thin layer joint:** A joint made with thin layer mortar having a maximum thickness of 3 mm.
- 5) **P Movement joint:** A joint permitting, free movement in the plane of the wall.
- 6) **P Jointing:** The process of finishing a mortar joint as the works proceeds.
- 7) **P Pointing:** The process of filling and finishing raked out mortar joints.

1.4.2.9 Wall types

- 1) **P Load-bearing wall:** A wall of plan area greater than $0,04\text{m}^2$, or one whole unit if Group 2a, Group 2b or Group 3 units of plan area greater than $0,04\text{m}^2$ are used, primarily designed to carry an imposed load in addition to its own weight.
- 2) **P single-leaf wall:** A wall without a cavity or continuous vertical joint in its plane.
- 3) **P Cavity wall:** A wall consisting of two parallel single-leaf walls, effectively tied together with wall ties or bed joint reinforcement, with either or both leaves supporting vertical loads. The space between the leaves is left as a continuous cavity or filled or partially filled with non-loadbearing thermal insulating material.
- 4) **P Double-leaf wall:** A wall consisting of two parallel leaves with the longitudinal joint between (not exceeding 25 mm) filled solidly with mortar and securely tied together with wall ties so as to result in common action under load.
- 5) **P Grouted cavity wall:** A wall consisting of two parallel leaves, spaced at least 50 mm apart, with the intervening cavity filled with concrete and securely tied together with wall ties or bed joint reinforcement so as to result in common action under load.
- 6) **P Faced Wall:** A wall with facing units bonded to backing, units so as to result in common action under load.
- 7) **P Shell bedded wall:** A wall in which the masonry units are bedded on two general purpose mortar strips at the outside edges of the bed face of the units.
- 8) **P Veneer wall:** A wall used as a facing but not bonded or contributing to the strength of the backing wall or framed structure.
- 9) **P Shear wall:** A wall to resist lateral forces in its plane.
- 10) **P Stiffening wall:** A wall set perpendicular to another wall to give it support against lateral forces or to resist buckling and so to provide stability to the building.
- 11) **P Non-loadbearing wall:** A wall not considered to resist forces such that it can be removed without prejudicing the remaining integrity of the structure.

1.4.2.10 Miscellaneous

- 1) **P Chase:** Channel formed in masonry.
- 2) **P Recess:** Indentation formed in the face of a wall.
- 3) **P Grout:** A pourable mixture of cement, sand and water for filling small voids or spaces.

1.5 S.I. units

- 1) P S.I. Units shall be used in accordance with ISO 1 000.
- 2) For calculations, the following units are recommended:
 - forces and loads : kN, kN/m, kN/m^2 ;

- unit mass : kg/m^3 ;
- unit weight : kN/m^3 ;
- stresses and strengths : N/mm^2 (= MN/m^2 or MPa);
- moments (bending, etc): kNm .

1.6 Symbols used in this ENV 1996-1-1

1) P Particular material-independent symbols used are as follows:

A	accidental action;
A_d	design value of an accidental action;
A_k	characteristic value of an accidental action;
C_d	nominal value, or function, of certain design properties of materials;
E	action effect;
E_d	design value of an action effect;
$E_{d,dst}$	design value of a destabilizing action effect;
$E_{d,stb}$	design value of a stabilizing action effect;
F	action;
F_d	design value of an action;
F_k	characteristic value of an action;
G	permanent action;
G_d	design value of a permanent action;
$G_{d,inf}$	lower design value of a permanent action;
$G_{d,sup}$	upper design value of a permanent action;
G_k	characteristic value of a permanent action;
$G_{k,inf}$	lower characteristic value of a permanent action;
$G_{k,sup}$	upper characteristic value of a permanent action;
P	prestressing action;
Q	variable action;
Q_d	design value of a variable action;
Q_k	characteristic value of a variable action;
R	resistance capacity;
R_d	design value of resistance capacity;
S_d	design value of an internal action effect;
W_k	characteristic value of wind action;
X_d	design value of a material property;
X_k	characteristic value of a material property;
a_d	design value of geometrical data;
a_{nom}	nominal value of geometrical data;
Δ_a	additive (or reducing) safety element for geometrical data;