DRAFT FOR DEVELOPMENT

DD ENV
1996-2:2001

Eurocode 6: Design of masonry structures —

Part 2: Design, selection of materials and execution of masonry

(together with United Kingdom National Application Document)

ICS 91.010.30; 91.080. 30

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/525/6, Use of masonry, upon which the following bodies were represented:

Association of Consulting Engineers

Autoclaved Aerated Concrete Products Association

Brick Development Association

British Ceramic Research Ltd.

British Masonry Society

British Precast Concrete Federation Ltd.

Construction Federation

Concrete Block Association

Department of the Environment, Transport and the Regions — represented by the Building Research Establishment

Department of the Environment, Transport and the Regions — Construction Research Directorate

Institution of Civil Engineers

Institution of Structural Engineers

National House Building Council

Royal Institute of British Architects

This Draft for Development, having been prepared under the direction of the Building and Civil Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Committee and comes into effect on 15 September 2001

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Contents

National foreword

This Draft for Development was prepared by Subcommittee B/525/6 and is the English language version of ENV 1996-2:1998, *Eurocode 6: Design of masonry structures — Part 2: Design, selection of materials and execution of masonry*, 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 for the design of masonry structures to be constructed in the UK.

ENV 1996-2:1998 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.

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

An ENV is made available for provisional application during a trial period of use of three years, 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 □(boxed values) in the ENV.

During the ENV period of validity, reference should be made to the supporting documents listed in the NAD. The purpose of the NAD is to provide essential information, particularly in relation to safety, to enable the ENV to be used for masonry structures constructed in the UK and the NAD takes precedence over corresponding provisions in the ENV.

Approved Document A to The Building Regulations 1991 [1], draws designers' attention to the potential use of ENV Eurocodes as an alternative approach to Building Regulation compliance. ENV 1996-2 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 1996-2:1998 and this NAD does not in 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, British Standards House, 389 Chiswick High Road, London W4 4AL, quoting the document reference, the relevant clause and, where possible, a proposed revision.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to xii, the ENV title page, pages 2 to 54, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

National Application Document

for use in the UK with ENV 1996-2:1998

Contents of National Application Document

Introduction

This National Application Document (NAD) was prepared by Subcommittee B/525/6, Use of masonry. It has been developed from a textual examination of ENV 1996-2:1998.

It should be noted that this NAD, in common with ENV 1996-2 and supporting European Standards, uses a comma (,) where a decimal point (.) would be traditionally used in the UK.

1 Scope

This NAD provides information to enable ENV 1996-2:1998 to be used for the design of buildings and civil engineering works to be constructed in the UK.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this NAD. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 3921:1985, *Specification for clay bricks*.

BS 4551-2, *Methods of testing mortars, screeds and plasters — Part 2: Chemical analysis and aggregate grading*.

BS 5628-1:1992, *Code of practice for use of masonry — Part 1: Structural use of unreinforced masonry*.

BS 5628-2:2000, *Code of practice for use of masonry — Part 2: Structural use of reinforced and prestressed masonry*.

BS 5628-3:2001, *Code of practice for use of masonry — Part 3: Materials and components, design and workmanship*.

BS 6477, *Specification for water repellents for masonry surfaces.*

BS 8104:1992, *Code of practice for assessing exposure of walls to wind-driven rain*.

DD ENV 1996-1-1:1996, *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).*

3 Boxed values for parameters used in ENV 1996-2:1998

Where either designated or undesignated boxed values are cited in the text or in equations they should be as given in Table 1 of this NAD.

Table 1 — Boxed values in ENV 1996-2:1998

Location in ENV 1996-2:1998	Description of parameter	Boxed value in ENV 1996-2:1998	UK value
2.2.5 (2)	Distance of the drip line of copings and sills from the face of the masonry	40 mm	40 mm
2.3.8.2.2 (1) Table 2.2	Maximum recommended horizontal spacing of vertical movement joints in external unreinforced, non-loadbearing walls built using:		
	— clay masonry;	12 m	15 m
	— calcium silicate masonry;	8 m	9 m
	— aggregate concrete masonry;	6 m	9 m
	— autoclaved aerated concrete masonry;	6 m	6 m
	— natural stone masonry	12 m	20 m
2.3.8.2.2 (1)	Maximum distance of the first joint from a restrained end of a wall	0,5 times value given in Table 2.2	0,5 times value given in Table 2.2
2.4.2.3 (3)	Minimum air cavity width in a cavity wall	50 mm	50 mm
2.4.2.6 (1)	Minimum cavity width in a cavity wall with full fill insulation	80 mm	50 mm
2.4.2.6 (2)	Maximum recess depth of joints in fully filled insulated cavity walls	5 mm	5 mm
2.4.2.6 (3)	Minimum air cavity width in a cavity wall with partial fill insulation	50 mm	50 mm
3.6.1 (2)	Maximum overhang of the first course of masonry over the edge of a floor or foundation slab.	15 mm	15 mm
3.6.3 (1) Table 3.1	Maximum permissible deviations for masonry elements:		
	— verticality:		
	— in one storey;	±20 mm	±20 mm
	— in total building height;	±50 mm	±50 mm
	— vertical alignment;	±20 mm	±20 mm
	— straightness:		
	— in any 1 m;	±5 mm	±5 mm
	— in any 10 m;	±20 mm	±20 mm
	— thickness:		
	— of wall leaf (the greater of);	±5 mm or ±5 %	±5 mm or ±5 %
	— overall cavity wall	±10 mm	±10 mm
3.7.3 (6)	Maximum spacing of weepholes (open perpend joints)	1,5 m	1 m
3.7.4.2 (1)	Depth of raking for pointed mortar joints	10 mm to 15 mm	10 mm to 25 mm
3.7.4.3 (1)	Maximum depth of recess for joints in walls less than 200 mm thick	5 mm	5 mm[a]
3.7.4.3 (2)	Maximum depth of recess for joints in walls made with perforated units: (fraction of shell thickness)	$\frac{1}{3}$	$\frac{1}{3}$
3.7.5 (3)	Minimum overlap of sealed joints in damp proof courses and membranes	150 mm	100 mm
3.7.6.1 (2)	Maximum horizontal spacing of wall ties	900 mm	900 mm
	Maximum vertical spacing of wall ties	600 mm	450 mm
	Maximum vertical spacing of shear ties	600 mm	450 mm
3.7.6.2 (2)	Maximum horizontal spacing of shear ties	900 mm	450 mm

[a] In the UK the limit applies to all wall thicknesses

4 Reference codes: Actions codes

To assess exposure of walls to wind driven rain, BS 8104:1992 should be followed.

5 Reference documents and standards

5.1 Reference documents

Where reference is made in ENV 1996-2 and in this NAD to national regulations, such references refer to Building and Buildings [1] in England and Wales, to Building and Buildings [2] in Scotland and to Building Regulations [3] in Northern Ireland.

5.2 Reference standards

The supporting standards to be used, including materials specifications and standards for construction should be those given in Table 4 of the NAD to ENV 1996-1-1:1995 or those referred to in clause **2** of the NAD to ENV 1996-1-1:1995.

6 Additional recommendations

6.1 General

In all cases, if no reference is given to the NAD to ENV 1996-1-1 and no alternative specification or guidance is given then the relevant clause in ENV 1996-2 should be followed to be in accordance with British building regulations.

6.2 Section 2: Design considerations

a) *Subclause 2.1.2*

Table 2 of this NAD gives guidance on the equivalence between present UK exposure categories and the system in ENV 1996-2:1998. Where an exposure class is specified in accordance with ENV 1996-2:1998, **2.1.2** the designer should look up the equivalent category in Table 2 of this NAD and should then select materials in accordance with BS 5628-2:2000, clause **6** and BS 5628-3:2001, **5.6.6, 5.6.7** and **5.7.**

NOTE 1 This is a very complex area since the provisions have to deal with two main situations:

a) masonry itself with its surfaces exposed to various climatic conditions; and

b) metal reinforcement and connecting components buried within masonry with its surfaces exposed to various climatic conditions.

NOTE 2 Most masonry materials are porous and can be affected by water, acidified water, soluble salts, freezing of absorbed water, mechanical attrition by water, air and solid matter carried in water and air. Processes can occur both at the surface and within the pore structure.

NOTE 3 Metals are not porous so are unaffected by frost or salt crystallisation processes but are susceptible to surface corrosion in the presence of water and oxygen.

NOTE 4 ENV 1996-2 designates five main exposure classes with the two most common classes divided into two subclasses in an informative annex. These classes are used as the basis of a performance specification system for materials. BS 5628 contains specific recommendations regarding masonry units, mortars and ancillary components but gives similar general guidance to ENV 1996-2 for using reinforcing steel.

b) *Subclause 2.2.2.1, item (1)*

Pending the implementation of EN 771, Table 2 of this NAD should be used do determine the equivalent exposure class.

c) *Subclause 2.2.2.2, item (1)*

Pending the implementation of EN 771, Table 2 of this NAD should be used for the selection of masonry units with respect to freeze–thaw resistance.

d) *Subclause 2.2.2.3, item (1)*

Pending the implementation of EN 771, Table 2 of this NAD should be used for the selection of masonry units with respect to sulfate resistance.

Table 2 — Equivalence between micro conditions of exposure (classes) as described in Table A.1 of ENV 1996-2 and exposure categories in BS 5628-2:2000, 10.1 and BS 5628-3:2001, 5.6 and Table 13

ENV 1996-2	Micro condition of masonry	Examples of masonry in this condition	BS 5628-2:2000	BS 5628-3:2001
MX1	**In a dry environment**			
		Interior of buildings for normal habitation and for offices, including the inner leaf of external cavity walls not likely to become damp. Rendered masonry in exterior walls, not exposed to moderate or severe driving rain, and isolated from damp in adjacent masonry or materials.	E1	D,E
MX2	**Exposed to moisture or wetting**			
MX2.1	Exposed to moisture but not exposed to freeze–thaw cycling or external sources of significant levels of sulfates or aggressive chemicals	Internal masonry exposed to high levels of water vapour, such as in a laundry. Masonry exterior walls sheltered by overhanging eaves or coping, not exposed to severe driving rain or frost. Masonry below frost zone in well drained non-aggressive soil.	E1	A1, C1, D, E, F1, G, H1, H3, J1, K1, L1, L2 and L3
MX2.2	Exposed to severe wetting but not exposed to freeze–thaw cycling or external sources of significant levels of sulfates or aggressive chemicals	Masonry not exposed to frost or aggressive chemicals, located: in exterior walls with cappings or flush eaves; in parapets; in freestanding walls; in the ground; under water.	E2	A2, L1, L2 and L3
MX3	**Exposed to wetting plus freeze–thaw cycling**			
MX3.1	Exposed to moisture and freeze–thaw cycling but not exposed to external sources of significant levels of sulfates or aggressive chemicals.	Masonry as class MX2. 1 exposed to freeze–thaw cycling.	E3	A1, C1 D, F1, G, H1, H3, J1, K1, L1, L2 and L3
MX3.2	Exposed to severe wetting and freeze–thaw cycling but not exposed to external sources of significant levels of sulfates or aggressive chemicals.	Masonry as class MX2.2 exposed to freeze–thaw cycling.	E3	A3, B2, C2, F2, H2, I, J2 and K2
MX4	**Exposed to saturated salt air or sea water**			
		Masonry in a coastal area	E4	None, seek specialist advice.
MX5	**In an aggressive chemical environment**			
		Masonry in contact with natural soils or filled ground or groundwater, where moisture and sulfates are present. Masonry in contact with highly acidic soils, contaminated ground or groundwater. Masonry near industrial areas where aggressive chemicals are airborne.	E4	None, seek specialist advice.
NOTE In deciding the exposure of masonry the effect of applied finishes and protective claddings should be taken into account.				

e) *Subclause 2.2.2.4, item (1)*

Pending the implementation of EN 771, Table 2 of this NAD should be used for the selection of clay units in accordance with BS 3921 with respect to active soluble salts content.

f) *Subclause 2.2.2.5, item (1)*

Pending the implementation of EN 771, Table 2 of this NAD should be used in the selection of materials with respect to resistance to chloride attack.

g) *Subclause 2.2.3.1, items (1), (2), (4) and (5)*

Pending the implementation of EN 998-2, Table 2 of this NAD should be used in the selection of general purpose mortar. There are no specific recommendations on thin layer or light weight mortars in BS 5628 thus selection should be on the basis of an equivalent performance to general purpose mortars with respect to structural properties and durability.

NOTE Materials meeting suitable certification such as a European Technical Approval or a National Technical Approval [1] may be deemed to exhibit equivalent performance to general purpose mortars with respect to structural properties and durability.

h) *Subclause 2.2.3.1, items (3) and (5)*

Pending the implementation of EN 206, Table 2 of this NAD (and BS 5628-2:2000, clause **6**) should be used for concrete infills.

i) *Subclause 2.2.3.1, item (6)*

Pending the implementation of EN 771, where adhesion between masonry units and mortar is a particular design requirement, BS 5628-1:1992, clause **24** should be used.

NOTE Such performance characteristics may be checked in the laboratory, if necessary, by use of the wallette method given in BS 5628-1:1992, **A.3** or for site tests using the method given in BRE Digest 360 [4].

j) *Subclause 2.2.4.1, item (1)*

Pending the implementation of EN 845-1 for wall ties, straps, brackets and joist hangers; EN 845-2 for lintels and EN 845-3 for bed joint reinforcement, products conforming to the British Standards listed in Table 4 of the NAD to ENV 1996-1-1 give equivalent performance and should be used.

k) *Subclause 2.2.4.1, item (2)*

The appropriate materials and protection systems in relation to exposure classes defined in ENV 1996-2 that should be used are given in Table 2 of this NAD.

l) *Subclause 2.2.4.2*

Materials and protection systems for cavity wall ties should be chosen in accordance with BS 5628-3:2001, **5.3.5** on the basis that walls in low-rise buildings on sheltered sites are exposed at level MX2, walls in low-rise buildings on exposed sites and all walls of buildings exceeding three stories are exposed at level MX3, and that unlined chimneys are exposed at level MX5.

m) *Subclause 2.2.4.3*

The materials and protection systems for tension straps, joist hangers and brackets should be chosen in accordance with BS 5628-3:2001, Table 2 on the basis that internal walls and the inner leaves of cavity walls are exposed at level MX1 and the outer leaves of cavity walls and externally exposed solid walls are exposed at level MX3.

n) *Subclause 2.2.4.4*

The materials and protection systems for lintels should be chosen in accordance with BS 5628-3:2001, Table 2 for all exposure conditions.

o) *Subclause 2.2.4.5*

The materials and protection systems for reinforcement for structural use should be chosen from BS 5628-2:2000, Table 4 for the appropriate exposure condition chosen from Table 2 of this NAD.

The materials and protection systems for bed joint reinforcement for non-structural use should be chosen from BS 5628-3:2001, Table 2 on the basis that internal walls and the inner leaves of cavity walls are exposed at level MX1 and the outer leaves of cavity walls and externally exposed solid walls are exposed at level MX3.

p) *Subclause 2.3.1.1*

Only the normal category and the special category mentioned in BS 5628-1:1992, **27.2.2** should be used. These two categories are equivalent, to categories A and B in ENV 1996-2:1998, respectively. Category C should not be used in the UK.

q) *Subclause 2.3.3, item (3)*

Pending the implementation of EN 1052-2, EN 1052-5 (flexure) and EN 1052-3 (shear), equivalent test methods are listed in Table 4 of the NAD to ENV 1996-1-1.

r) *Subclause 2.3.7.2, item (2)*

In the absence of test data, the values for the coefficient of thermal expansion and other movement characteristics of unreinforced masonry should be taken from Table 3 of the NAD to ENV 1996-1-1.

s) *Subclause 2.3.8.3*

Sealants for incorporation within masonry should conform to the recommendations given in BS 5628-3:2001, **4.8**. The installation for movement joints should be in accordance with BS 5628-3:2001, **5.4.4**.

t) *Subclause 2.3.12*

Water repellent agents for use with masonry should conform to BS 6477.

u) *Subclause 2.4.2.2*

The design of fair faced single leaf walls to resist wind driven rain should be in accordance with BS 5628-3:2001, **5.5.4.2.3** and appropriate columns of Table 12 of BS 5628-3:2001.

v) *Subclause 2.4.2.3*

The design of cavity walls to resist wind driven rain should be in accordance with BS 5628-3:2001, **5.5.4.2.4** and should take into account of BS 5628-3:2001, **5.5.2.4.5** to **5.5.2.4.10**. Design details for suitable damp-proof courses, cavity trays and water barriers of various types are given in BS 5628-3:2001, **5.5.5**.

w) *Subclause 2.4.2.4*

Design details for suitable damp-proof courses, cavity trays and water barriers of various types suitable for veneer walls are given in BS 5628-3:2001, **5.5.5**.

x) *Subclause 2.4.2.6*

The design of insulated cavity walls should be in accordance with BS 5628-3:2001, **5.5.4.2.7** and should take into account BS 5628-3:2001, **5.5.2.4.5** to **5.5.2.4.10**.

NOTE Design details for suitable damp-proof courses, cavity trays and water barriers of various types are given in BS 5628-3:2001, **4.7**.

y) *Subclause 2.4.3*

Pending the implementation of EN 13914-1, the design of rendered single leaf walls should be in accordance with BS 5628-3:2001, **5.5.4.2.3** and BS 5628-3:2001, Table 12. Ventilated cladding systems, e.g. tile hanging, should be designed in accordance with manufacturers specifications.

6.3 Section 3 Execution

a) *Subclause 3.2*

The category of execution should be one of two categories which are listed in Table 1 of the NAD to ENV 1996-1-1.

b) *Subclause 3.4.3.2*

When sampled and tested in accordance with BS 4551-2, the chloride content of site made mortars and concrete infill should not exceed the level set out in of BS 5628-2:2000, Table 2.

c) *Subclause 3.4.3.3, item (1)*

Pending the implementation of EN 1015-11, when the strength of mortar and concrete infill need to be monitored, they should be tested in accordance with BS 4551-2.

d) *Subclause 3.7.5, item (2)*

The recommendation to not pierce the damp course in respect of vertical reinforcement in Quetta, grouted cavity and pocket-type walls should be ignored.

e) *Subclause 3.7.7*

When incorporating reinforcement and pre-stressing materials, **6.5**f) of the NAD to ENV 1996-1-1 should be used.

f) *Subclause 3.7.10*

When incorporating thermal insulation materials follow appropriate British Standard as listed in Table 4 of the NAD to ENV 1996-1-1:1995.

Bibliography

Standards publications and standards to be published

EN 206, *Concrete*.

EN 771, *Specification for masonry units*.

EN 845-1, *Specification for ancillary components for masonry — Part 1: Ties, tension straps, hangers and brackets*.

EN 845-2, *Specification for ancillary components for masonry —- Part 2: Lintels*.

EN 845-3, *Specification for ancillary components for masonry — Part 3: Bed joint reinforcement of steel meshwork*.

EN 998-2, *Specification for mortar for masonry — Part 2: Masonry mortar*.

EN 1015-11, *Methods of test for mortar for masonry — Part 11: Determination of flexural and compressive strength of hardened mortar*.

EN 1052-2, *Methods of test for masonry — Part 2: Determination of flexural strength*.

EN 1052-3, *Methods of test for masonry — Part 3: Determination of initial shear strength*.

EN 1052-5, *Methods of test for masonry — Part 5: Determination of bond strength*.

EN 13914-1, *The design, preparation and application of external rendering and internal plastering — Part 1: External rendering*.

Other documents

[1] GREAT BRITAIN. The Building Regulations 1991. London, The Stationery Office.

[2] GREAT BRITAIN. The Building Standards (Scotland) Regulations 1990. London: The Stationery Office.

[3] GREAT BRITAIN. The Building Regulations (Northern Ireland) 1990. London: The Stationery Office.

[4] BRE. Testing bond strength of masonry. Digest 360. 1991. Watford: BRE and CRC.

EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ENV 1996-2

November 1998

ICS 91.010.30; 91.080.30

Descriptors: buildings, construction, masonry work, computation, materials, choice, implementation

English version

Eurocode 6: Design of masonry structures - Part 2: Design, selection of materials and execution of masonry

Eurocode 6: Calcul des ouvrages en maçonnerie - Partie 2: Calcul, choix des matériaux et mise en oeuvre des maçonneries

Eurocode 6: Bemessung und Konstruktion von Mauerwerksbauten - Teil 2: Plannung, Auswahl der Baustoffe und Ausführung von Mauerwerk

This European Prestandard (ENV) was approved by CEN on 27 February 1998 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.

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, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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

CONTENTS

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 is 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 2 of Eurocode 6 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 - NABau, Burggrafenstrasse 6, Postfach 1107
D107732 - BERLIN 30, Germany.

or to your national standards organization.

National Application Documents (NADs)

(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 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 might 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 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 6 is defined in ENV 1996-1-1, and this includes information on the other Parts of Eurocode 6 and the further Parts which are planned.

(17) The scope of this Part of Eurocode 6 is defined in its clause 1.1.

(18) This Part 2 of Eurocode 6 replaces all of Section 6 of ENV 1996-1-1. Section 6 will eventually be omitted from ENV 1996-1-1.

1 GENERAL

1.1 Scope

(1)P The scope of Eurocode 6 for Masonry Structures as given in **1.1.1** of ENV 1996-1-1 applies also to this Part 2.

(2)P This Part 2 provides the necessary Principles and Application Rules for masonry to be designed and constructed satisfactorily in order to comply with the design assumptions of the other Parts of Eurocode 6. Except for the items as given in **1.1(3)P**, it deals with ordinary aspects of masonry design and construction including:

- the selection of materials;
- methods of combining masonry materials and of incorporating other materials required to give functional performance;
- factors affecting the performance and durability of masonry;
- resistance of buildings to moisture penetration;
- storage, preparation and use of materials on site;
- the erection of walls and the connection of walls to walls and to other elements of structure;
- protective procedures during construction.

(3)P This Part 2 does not cover the following items:

- those aspects of masonry covered in other Parts of Eurocode 6;
- applied wall finishes;
- safety aspects of how masonry is erected;
- the environmental effects of masonry buildings, civil engineering works and structures on their surroundings.

1.2 Distinction between Principles and Application Rules

(l)P Depending on the character of the individual paragraphs, a distinction is made in this Part between principles and application rules.

(2)P The principles comprise:

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

(3) The Principles are identified by the letter P following the paragraph number.

(4)P The application rules are generally recognised rules that follow the principles and satisfy their requirements. Alternative rules different from the application rules given in this Part may be used

provided that it is shown that the alternative rule accords with the relevant principles and has at least the same reliability.

(5) In this Part application rules are identified by a number in brackets, as in this paragraph.

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 only for the purposes for which it was designed.

(2)P Design shall be in accordance with Section 2 and shall take into account Section 3. Execution shall be in accordance with the design and Section 3. The design Principles are valid only when the Principles for execution and workmanship given in Section 3 are complied with.

(3)P Numerical values identified by [ ] are given as indications. Other values may be specified by Member States.

1.4 Normative references

(1) This European Prestandard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 771 (all Parts)	Specification for masonry units
EN 998-2	Specification for mortar for masonry - Masonry mortar
EN 845 (all Parts)	Specification for ancillary components for masonry
EN 1015-17	Methods of test for masonry mortar - Determination of water-soluble chloride content of fresh mortars
EN 1052 (all Parts)	Methods of test for masonry
ENV 206	Concrete - Performance, production, placing and compliance criteria
ENV1996-1-1	Eurocode 6: Design of masonry structures - Part 1: General rules for buildings - Rules for reinforced and unreinforced masonry
ISO 1000	The use of SI units
ISO 8930	Terminology

1.5 Definitions

1.5.1 Terms common to all Eurocodes

(1)P Unless otherwise stated in the following, the terminology used in International Standard ISO 8930 and the terminology common for all Eurocodes shall apply to ENV 1996-2 (see 1.4.1 of ENV 1996-1-1).

1.5.2 Special terms used in ENV 1996-1-1

(1)P Unless otherwise stated in the following, the special terminology used in ENV 1996-1-1 shall apply to Part 2.

1.5.3 Special terms used in ENV 1996-2

1.5.3.1 Terms relating to communication of design

(1)P **design specification**: Documents describing the designer's requirements for the construction, including drawings, schedules, references to parts of other documents and written instructions.

(2)P **manufacturer:** Maker of products or agent of the maker.

1.5.3.2 Terms relating to climatic factors and exposure conditions

(1)P **macro conditions** Climatic factors dependent on the general climate of the region in which a structure is built, modified by the effects of local topography and/or other aspects of the site.

(2)P **micro conditions** Localised climatic and environmental factors dependent on the position of a masonry element within the overall structure and taking into account the effect of protection, or lack of protection, by constructional details or finishes.

1.5.3.3 Terms relating to masonry units

(1)P **accessory masonry unit**: A masonry unit which is shaped to provide a particular function, e.g. to complete the geometry of the masonry

1.5.3.4 Terms relating to mortars

(1)P Unless otherwise stated in this Part 2, the terminology used in EN 998-2 shall apply for mortars and their constituent materials.

1.5.3.5 Other terms

(1)P **applied wall finish:** A covering of material continuously bonded to the surface of the masonry.

(2)P **cavity width:** The distance perpendicular to the plane of the wall between the cavity faces of the masonry leaves of a cavity wall or that between the cavity face of a veneer wall and the masonry backing structure.

(3)P **cladding:** A covering of material(s) fastened or anchored in front of the masonry and not continuously bonded to it.

1.6 S.I. units

(1)P S.I. units in accordance with ISO 1000 shall be used.

1.7 Symbols

(1)P Symbols in accordance with ENV1996-1-1 shall be used.

2 DESIGN CONSIDERATIONS

2.1 Factors affecting the durability of masonry

2.1.1 General

(1)P Masonry shall be designed to have adequate performance for its intended use.

2.1.2 Micro conditions of exposure

(1)P The micro conditions to which the masonry is expected to be exposed shall be taken into account in the design.

(2)P When deciding the micro conditions of exposure of the masonry, the effect of applied finishes and protective claddings shall be taken into account

(3) Micro conditions of exposure of completed masonry should be categorised into classes:

MX1 - In a dry environment;
MX2 - Exposed to moisture or wetting;
MX3 - Exposed to wetting plus freeze/thaw cycling;
MX4 - Exposed to saturated salt air or seawater;
MX5 - In an aggressive chemical environment.

NOTE : When necessary, more closely defined conditions within these classes may be specified using the sub-classes in **Annex A** (e.g. MX2.1 or MX2.2).

(4) To produce masonry that meets specified performance criteria and withstands the environmental conditions to which it is exposed, the determination of the exposure class should take into account:

- climatic factors;
- severity of exposure to wetting;
- exposure to freeze/thaw cycling;
- presence of chemical materials that may lead to damaging reactions.

2.1.3 Climatic factors (macro conditions of exposure)

(1) The effect of the macro conditions on the micro conditions should be taken into account when determining the relative wetness of masonry and its exposure to freeze/thaw cycling.

(2) Concerning the macro conditions the following should be taken into account:

- rain and snow;
- the combination of wind and rain;
- temperature variation;
- relative humidity variation.

2.1.4 Exposure to wetness

(1) The exposure to wetness should be taken into account in determining the micro conditions of exposure of the masonry. The effect of any applied finishes, cladding, weathered overhanging sills, copings, string courses, drainage or other features intended to throw water clear of the masonry should be taken into account.

NOTE : It is acknowledged that climates (macro conditions) vary considerably throughout Europe and that certain aspects of climate can influence the risk of exposure of masonry to wetting and/or freeze/thaw cycling. However, it is the classification of the micro conditions that is relevant for determining the durability of masonry rather than the ranking of the macro conditions. Examples of relative exposure to wetness of masonry elements in a typical building are shown in **figures 2.1 and 2.2.**

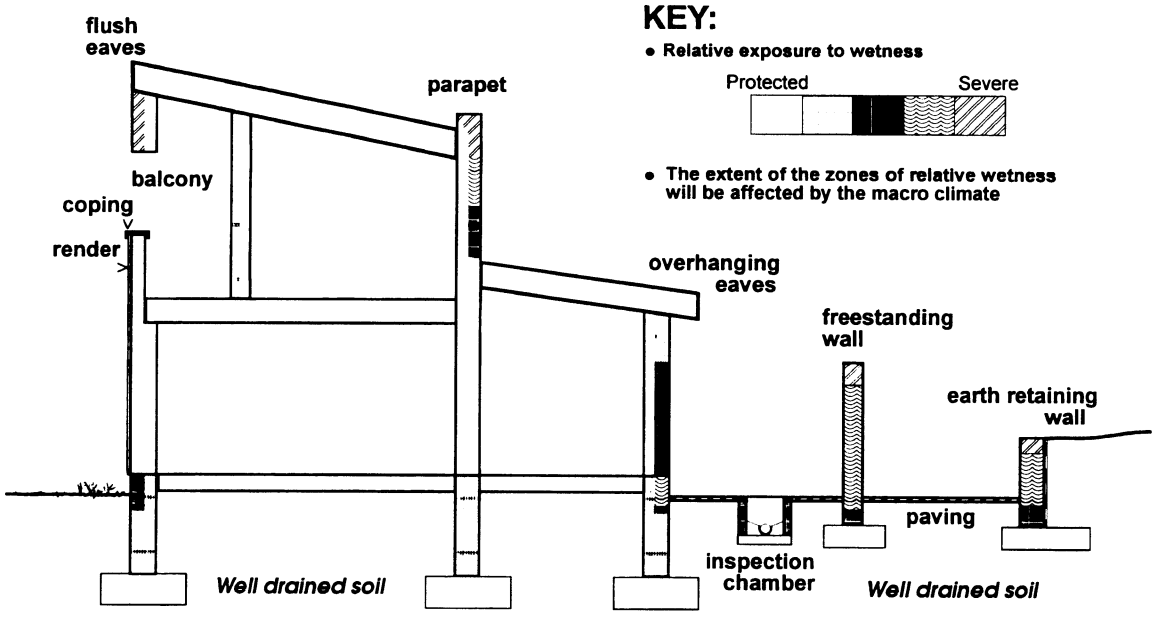

Figure 2.1 (Part of NOTE to **2.1.4(1)**): **Examples of relative exposure to wetness of masonry (not protected by applied finishes or cladding except where indicated)**

2.1.5 Exposure to freeze/thaw cycling

(1) The range and nature of temperature variations should be taken into account in determining the classification of micro conditions of exposure of the masonry.

2.1.6 Aggressive chemical environments

2.1.6.1 General

(1) The presence of sulfates, chlorides and other aggressive chemicals in the environment should be taken into account in determining the classification of micro conditions of exposure of the masonry.

(2) In coastal areas the exposure of masonry to saturated salt air or seawater should be taken into account.

(3) Where the presence of aggressive chemicals in the environment, other than salt air or seawater, can affect masonry, class MX5 should be assumed. The concentrations, quantities available and rates of reaction of these chemicals should be assessed, as necessary, to enable the selection of masonry materials that are durable in the conditions. Where salts can be transported by water moving through the masonry, the potential for increased concentrations and quantities of available chemicals should be taken into account.

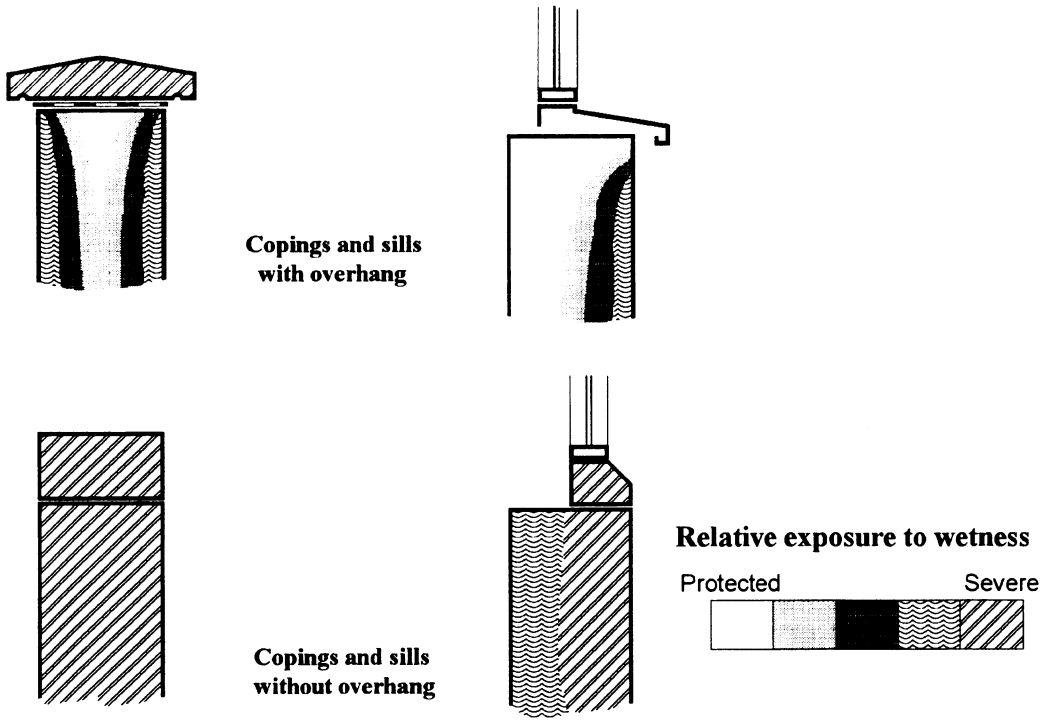

Figure 2.2 (Part of NOTE to **2.1.4(1)**): **Examples of the effect of building detail on relative exposure to wetness of masonry**

2.1.6.2 Sulfate attack

(1) Where the occurrence of sulfates in the environment can affect masonry, the sources of sulfates should be assessed to determine the selection of materials and the need for any additional protection. Possible sources of sulfates that should be taken into account include the following:

- natural soils;
- groundwater;
- waste deposits and filled ground;
- construction materials;
- airborne pollutants.

2.2 Selection of materials

2.2.1 General

(1)P Materials, where incorporated in the works, shall be adequate to resist the actions to which they are exposed including environmental actions.

(2)P Only materials, products, and proprietary systems with established suitability shall be used.

NOTE : Established suitability may result from conformity to a European standard, that is either referred to by this prestandard or that specifically refers to uses within the scope of this prestandard. Alternatively, where either there is no appropriate European standard, or the material or product deviates from the requirements of an appropriate European Standard, established suitability may result from conformity to either:

- a Technical Approval, or

- a national standard, or

- other provisions,

any of which refer specifically to uses within the scope of this prestandard and are accepted in the place of use of the material or product.

(3)P The design specification shall state the characteristics of the materials that are required as a result of the design and the means of their verification.

(4) The selection of materials should take account of the micro conditions of exposure and, where resistance to moisture penetration through walls is a requirement, it should take into account the recommendations in clause 2.4.

2.2.2 Masonry units

2.2.2.1 General

(1) For masonry units the characteristics required should be specified in accordance with the appropriate Part of EN 771 for the type of material:

- EN 771-1 for clay masonry units;
- EN 771-2 for calcium silicate masonry units;
- EN 771-3 for aggregate concrete masonry units;
- EN 771-4 for autoclaved aerated concrete masonry units;
- EN 771-5 for manufactured stone masonry units;
- EN 771-6 for natural stone masonry units.

NOTE : Masonry unit specifications may be selected from **table B.1** in relation to durability.

(2) For products not in accordance with EN 771 (e.g. reclaimed products) the design specification should state the required product performance characteristics and the means of their verification including the requirements for sampling and frequency of testing.

2.2.2.2 Selection of masonry units for freeze/thaw resistance

(1) Where there is a risk of masonry freezing and thawing while in a wet condition, masonry units should be selected to be freeze/thaw resistant in accordance with the relevant Parts of EN 771.

2.2.2.3 Selection of masonry units for exposure to sulfates

(1) Where masonry is likely to remain wet for long periods, (e.g. in freestanding walls, retaining walls, parapet walls, masonry below or near ground level, and elevations exposed to severe wind-driven rain) the masonry units should be selected to resist attack from any sulfates present in the construction and/or in the environment.

2.2.2.4 Selection of sulfate bearing clay masonry units

(1) When selecting clay masonry units to suit the micro conditions of exposure of the masonry, the category of active soluble salt content in the units should be appropriate for the exposure conditions.

NOTE : For clay masonry units, EN 771-1 provides for the categorisation of active soluble sulfate content, as given in **table B.1**. Other masonry units do not normally contain significant amounts of soluble sulfates and there is no similar categorisation in the other Parts of EN 771.

2.2.2.5 Chloride attack

(1) Where masonry is exposed to saline conditions the selection of masonry units should take this into account.

2.2.2.6 Natural stone masonry exposed to crystallising salts

(l) Where natural stone masonry is exposed to sources of crystallising salts including rising damp, sea spray or atmospheric pollution, the use of limestone should be avoided, unless the detailing and materials are selected to provide adequate resistance to the effects of salt crystallisation within the pores of the stone.

2.2.3 Masonry mortar and concrete infill

2.2.3.1 Selection of factory made masonry mortar and concrete infill

(1) For factory made masonry mortar, the type and characteristics required should be specified in accordance with EN 998-2. The type should be one of the following:

- general purpose mortar;
- thin layer mortar;
- light weight mortar.

(2) Masonry mortar should be selected according to the exposure condition of the masonry and the specification of the masonry units.

NOTE : Until a European Standard method of test for durability is available, the suitability of masonry mortars conforming to EN 998-2 is based on the manufacturer's experience appropriate to the intended use.

(3) Concrete for infilling should be selected in accordance with ENV 206 taking into account the exposure condition of the masonry.

(4) In exposure classes MX1, MX2 or MX3, masonry mortar should be specified for durability using the terms defined in EN 998-2:

- masonry subjected to passive exposure;

- masonry subjected to moderate exposure;

- masonry subjected to severe exposure.

NOTE : For general applications mortar durability designations may be selected from table B.1.

(5) When factory made masonry mortar or concrete infill is considered for use in exposure classes MX4 or MX5 the manufacturer's advice should be sought as to its suitability.

(6) Where adhesion between masonry units and mortar (bond strength) is a particular design requirement, the required value should be specified for factory made and pre-batched mortars, or alternatively, the shear strength values given in ENV 1996-1-1, table 3.5 may be specified for general purpose mortars that do not contain additions or admixtures.

(7) Where there is a high soluble sulfate content in the masonry, the application of rendering, adhesive fixed tile cladding, or a surface coating such as a masonry paint should be avoided in conditions where any moisture can penetrate to the masonry backing through imperfections developing in the finish or by any other route. Alternatively, the mortar for masonry jointing and the first coat of any rendering, adhesive or coating should be sulfate resisting.

2.2.3.2 Selection of site-made masonry mortar and concrete infill

(1) For site-made masonry mortar and concrete infill the design specification should state the required product performance characteristics and the means of their verification including the requirements for sampling and frequency of testing. In addition, where the designer is satisfied that a prescriptive specification will provide the required performance, a detailed specification of the constituent materials, their proportions and the method of mixing may be given either on the basis of tests carried out on trial mixes and/or on the basis of authoritative publicly available references acceptable in the place of use.

(2) Masonry mortar should be selected according to the exposure condition of the masonry and the specification of the masonry units. Until a European Standard method of test for durability is available, the suitability of site-made masonry mortars should be determined on the basis of established local experience of the performance of the particular materials and mix proportions.

(3) The guidance in 3.4.3 should be taken into account particularly where admixtures, additions and pigments are to be used.

(4) In exposure classes MX1, MX2 or MX3, the masonry mortar should be specified for durability using the terms defined in EN 998-2:

- masonry subjected to passive exposure;

- masonry subjected to moderate exposure;

- masonry subjected to severe exposure.

NOTE : **2.2.3.2(1)** requires performance characteristics to be specified in all cases. For durability, **2.2.3.2(4)** requires it to be done by reference to the stated terminology. It is then an option for the designer to give, and accept responsibility for, a prescriptive specification that will fulfil the performance requirements, or alternatively, it can be done as an execution task in accordance with **3.4.3.1(2)**. For general applications mortar durability designations may be selected from **table B.1**.

(5) When site made masonry mortar or concrete infill is to be specified for use in exposure classes MX4 or MX5, the mix proportions to provide adequate durability for the particular conditions should be selected on the basis of authoritative publicly available references acceptable in the place of use.

(6) Where adhesion between masonry units and mortar (bond strength) is a particular design requirement, evidence should be provided that the required strength can be obtained.

NOTE : The manufacturer of masonry units may give advice on the type of masonry mortar to be used or tests may be carried out in accordance with relevant Parts of EN 1052.

(7) Where there is a high soluble sulfate content in the masonry, the application of rendering, adhesive fixed tile cladding, or a surface coating such as a masonry paint should be avoided in conditions where any moisture can penetrate to the masonry backing through imperfections developing in the finish or by any other route. Alternatively, the mortar for masonry jointing and the first coat of any rendering, adhesive or coating should be sulfate resisting.

2.2.4 Ancillary components and reinforcement

2.2.4.1 General

(1) For ancillary components the type and characteristics required should be specified in accordance with the appropriate Part of EN 845:

- EN 845-1 for ties, tension straps, hangers and brackets;
- EN 845-2 for lintels;
- EN 845-3 for bed joint reinforcement.

(2) Environmental conditions for use in selecting ancillary components and reinforcement should be classified as exposure class MX1, MX2, MX3, MX4 or MX5.

NOTE : Annex C gives guidance on materials and corrosion protection systems for ancillary components in relation to exposure classes.

2.2.4.2 Wall ties

(1) The materials for wall ties and appropriate protective coating systems should be selected to give adequate resistance to corrosion for the appropriate Exposure Class.

2.2.4.3 Tension straps, joist hangers and brackets

(1) The materials and appropriate protective coating systems for tension straps, joist hangers and brackets should be selected to give adequate resistance to corrosion for the appropriate Exposure Class.

2.2.4.4 Lintels

(1) The materials for lintels and appropriate protective coating systems should be selected to give adequate resistance to corrosion for the appropriate Exposure Class.

2.2.4.5 Reinforcement, including bed joint reinforcement

(1) The materials for reinforcement, including bed joint reinforcement, should be selected to give adequate resistance to corrosion for the appropriate Exposure Class. Reinforcing steel should be selected following the recommendations given in 5.2.2.3 of ENV 1996-1-1.

(2) Where carbon steel requires coating to provide adequate durability (e.g. bed joint reinforcement in exposure classes other than MX1), it should either be galvanized such that the thickness of zinc coating is not less than that required to provide the necessary durability, or be given equivalent protection.

2.2.5 Copings, cappings and sills

(1) When selecting materials for copings, cappings and sills, the following factors should be taken into account:

- adhesion to units and mortar;
- the necessity to provide a damp proof course (e.g. under jointed units);
- differential movement between the leaves of a cavity wall;
- differential movement between copings, cappings, sills and adjacent masonry;
- resistance to accidental displacement;
- exposure conditions.

NOTE : Masonry materials adequate for wall construction may not be durable as copings, cappings or sills.

(2) Coping units and sills should have a sloping top surface to guide water away and a drip line being not less than [40 mm] from the face of the masonry.

2.2.6 Damp proof course materials and damp proof membranes

(1) Damp proof courses and damp proof membranes should be capable of resisting the passage of water.

(2) Sheet materials specified for forming damp proof courses and damp proof membranes should be materials that are able to resist the design stresses without exuding, puncturing or shearing.

2.2.7 Insulation materials

(1) Where insulation materials are specified for incorporation into masonry, they should be of a type suitable for inclusion.

2.3 Masonry

2.3.1 General

2.3.1.1 Execution categories

(1)P The category required to be used shall be stated in the design specification.

NOTE : An example of the relevant conditions to be considered for Categories of execution A, B and C is given in informative **Annex D**.

(2) Category of execution C should not be used for reinforced or prestressed masonry, with the following exceptions:

- composite lintel construction, where the performance of the details of the construction have been proved by experience or testing and the mortar is mechanically mixed;

- masonry containing prefabricated bed joint reinforcement used solely to control cracking;

- deep masonry beams with a clear span not greater than 2.5 m and containing bed joint reinforcement prefabricated in accordance with EN 845-3.

2.3.1.2 Detailing

(1) Where the detailing of masonry is not otherwise covered in Part 2, it should be done in accordance with local practice and experience.

2.3.2 Masonry bonds

2.3.2.1 General

(1)P Masonry units in a wall shall be bonded together with mortar so that the wall acts as a single structural element.

2.3.2.2 Masonry bonds for regular shaped units of uniform size

(1) To ensure adequate bonding, units should be overlapped on alternate courses by a length equal to at least 0,4 times the height of the unit or 40 mm, whichever is the greater. At corners or junctions the overlap of the units should not be less than the width of the units or 0,4 times the height of the units, whichever is the lesser. Accessory masonry units should be used to achieve the specified overlap in the remainder of the wall.

(2) Where it is necessary to deviate from **2.3.2.2(1)**, measures should be taken to achieve the required wall strength.

NOTE : Measures might include the addition of reinforcement or verification of the design by testing in accordance with the relevant Parts of EN 1052.

2.3.2.3 Special considerations for bonds for dimensioned natural stone masonry units.

2.3.2.3.1 Orientation of bedding planes

(1) Sedimentary, and metamorphosed sedimentary, natural stone should normally be specified to be laid with its bedding planes horizontal or near horizontal.

2.3.2.3.2 Masonry bonds for regular shaped units of mixed sizes

(1) Adjacent natural stone masonry facing units should overlap by a distance equal to at least 0.25 times the dimension of the smaller unit, with a minimum of 40 mm, unless other measures are taken to ensure adequate strength.

2.3.2.3.3 Solid walls

(1) In walls where the masonry units do not extend through the thickness of the wall, bonding units with a length equal to between 0.6 and 0.7 times the thickness of the wall, should be built in at spacing not exceeding l m both vertically and horizontally. Such masonry units generally should have a height not less than 0.3 times their length. Through units are not recommended due to the risk of water penetration along the unbroken mortar joints

2.3.3 Adhesion

(1)P The adhesion between the mortar and the masonry units shall be adequate for the correct functioning of the masonry.

(2) If the design relies on shear strength or flexural strength, guidance on the characteristics of particular masonry and appropriate wetting procedures should be included in the design specification.

NOTE : Such guidance may be obtained from the manufacturer of the masonry units and where appropriate from the manufacturer of factory made mortar.

(3) If the shear strength or flexural strength of the masonry is to be derived from tests in accordance with the relevant parts of EN1052, the materials, bonding pattern, and curing should be specified to be the same as in the tests.

2.3.4 Joint finishes

(1)P Joint finishes shall be suitable to achieve the required performance and appearance of the wall.

(2) When specifying joint finishes the following factors should be taken into account:

- the base required for applied finishes;
- the shape of the joint finish;
- any special requirements for compressing the joint by tooling;
- pointing to achieve a particular effect or colour;
- the effect of recessed joints and string courses.

(3) Where surface treatments such as high build paint or thin render are to be used, joint finishes should be in accordance with the surface treatment manufacturer's instructions and the requirements of the relevant European Standard or Technical Approval.

(4) Pointing mortar should have deformation characteristics that are compatible with the deformation characteristics of the jointing mortar.

2.3.5 Reinforced walls

(1) In reinforced walls, reinforcing bars or bed joint reinforcement should be embedded in mortar or concrete in such a way that the materials act together.

2.3.6 Connection of walls to walls and to other elements

(1) If vertical or lateral actions are required to be transferred between intersecting walls the joint at the intersection of the walls should be in accordance with 5.4 of ENV 1996-1-1.

2.3.7 Masonry movement

2.3.7.1 General

(1)P Masonry movement shall be taken into account in the design so as to reduce the development of excessive stresses within the masonry.

(2) Movement joints or reinforcement should be used in order to minimise cracking, bowing or distortion caused by expansion, shrinkage or differential movements.

(3) Combinations of the various movements that can occur together and the temperature and moisture conditions of the masonry materials at the time of construction should be taken into account to predict the worst likely expansion and contraction.

(4) Where two or more types of masonry unit are used in the same wall construction, allowance should be made for any differences in their performance. Movement due to differences in materials within the same leaf should be taken into account.

(5) Where intersecting walls have different deformation behaviour, the connection should be able to accommodate the differential movement.

(6) Where connecting internal single-leaf walls to cavity walls just the inner leaf of the cavity wall should be connected to the single-leaf wall.

2.3.7.2 Thermal and moisture movement

(1)P Allowance shall be made for dimensional variations caused by moisture changes, temperature changes and temperature gradients within the masonry.

(2) In the absence of test data, the values for the coefficient of thermal expansion and shrinkage of unreinforced masonry should be in accordance with 3.8.4 of ENV 1996-1-1.

2.3.7.3 External effects

(1) Masonry movement due to the effects of actions, restraints and support conditions including foundation conditions should be taken into account.

2.3.8 Movement joints

2.3.8.1 General

(1) Movement joints should be designed and positioned having regard to:

- the type of masonry unit material;
- the geometry of the structure taking into account openings and the proportions of panels;
- degree of restraint;
- the response of the masonry to long and short term loading and thermal and climatic conditions;
- fire resistance, and sound and thermal insulation requirements;
- the presence or not of reinforcement.

(2) The width of a movement joint should be sufficient to accommodate the movements, both reversible and irreversible, without damage to the masonry.

(3) All movement joints should pass through the full thickness of the leaf and through any finishes that are insufficiently flexible to be able to accommodate the movement.

(4) Slip planes should be designed to allow parts of the construction to slide, one in relation to the other, to reduce tensile and shear stresses in the adjacent elements.

(5) In external walls, movement joints and slip planes should be designed to prevent water penetration into the building.

(6) Joints should be specified to be built in as work proceeds.

2.3.8.2 Spacing of movement joints

2.3.8.2.1 General

(1) The spacing of movement joints should take into account the items mentioned in **2.3.8.1**.

2.3.8.2.2 External non-loadbearing walls

(1) The horizontal spacing of vertical movement joints in external unreinforced masonry walls or leaves should be not more than the values given in **table 2.2**, and the distance of the first joint from a restrained end of a wall should not exceed [0,5] the values given in **table 2.2**.

(2) The maximum horizontal spacing of vertical movement joints given in **table 2.2** may be increased for walls with reinforcement in the bed joints. Guidance may be obtained from the manufacturers of bed joint reinforcement.

(3) Where horizontal joints are required to accommodate vertical movement in an unreinforced veneer wall or in an unreinforced non-loadbearing outer leaf of a cavity wall, the spacing of horizontal movement joints should take into account the positioning of the support system.

Table 2.2 Maximum recommended horizontal spacing of vertical movement joints in external unreinforced non-loadbearing walls

Type of masonry	Spacing
Clay masonry	[12 m]
Calcium silicate masonry	[8 m]
Aggregate concrete masonry	[6 m]
Autoclaved aerated concrete masonry	[6 m]
Natural stone masonry	[12 m]

2.3.8.2.3 Loadbearing walls and internal walls

(1) The spacing of movement joints should take into account the need to maintain structural integrity and the effects of openings, restraints and the expected variations in temperature and humidity.

2.3.8.3 Sealed movement joints

(1) Joint fillers and sealants should be specified taking into account the required performance of the wall, the masonry materials used and the expected range of movement.

NOTE : Joint fillers and sealants do need to be compressible.

(2) The distance of the joint filler from the joint face should allow the correct depth of sealant to be used, see **figure 2.3**. The depth of sealant should be specified in accordance with the manufacturer's recommendations.

NOTE : The ratio of the depth of sealant to the width varies from approximately ½ to 2 according to the type of sealant. Depths less than 10 mm are not normally recommended.

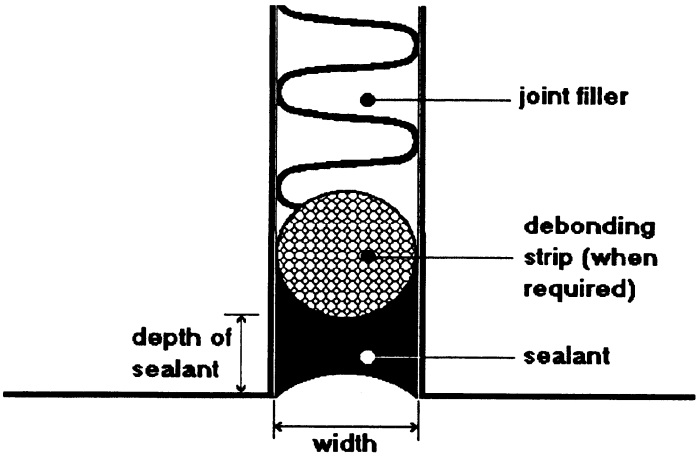

Figure 2.3 Sectional plan through filled and sealed movement joint identifying the terms used in 2.3.8.3

(3) Where necessary to avoid the sealant adhering to the joint filler or any problems of incompatibility between the joint filler and sealant, a debonding strip (e.g. closed cell foam polyethylene) or agent should be used.

2.3.9 Permissible deviations

(1) The permissible deviations for masonry elements given in **table 3.1** and those given in the relevant standards for materials, components, design and execution, should be taken into account in the design. If the design requires tighter tolerances, the permissible deviations should be stated in the design specification.

2.3.10 Use of thermal insulation

(1) Where thermal insulation is to be used in conjunction with masonry the following items should be taken into account in the design of the masonry:

- the position of the thermal insulation;
- the need for a vapour barrier;
- the fixing of the thermal insulation;
- the installation requirements of the insulation manufacturer and of the relevant standards;
- the effect of the insulation on the durability of the masonry;
- the effect of the insulation on the resistance of the wall to rain penetration or to moisture due to any condensation within the wall;
- detailing to minimise thermal bridges;
- the type and shape of insulation;
- whether insulation is to be incorporated at time of construction of the wall or subsequently;
- details at wall junctions, around openings and at junctions with other elements, especially with foam or loose materials that need to be contained on all sides.

2.3.11 Use of ancillary components

2.3.11.1 General

(1) Ancillary components and any fixings should be located so that deleterious chemical or electrochemical interaction between materials is avoided.

2.3.11.2 Wall ties

(1) Where wall ties are to be used, the following factors should be taken into account to ensure their suitability in the masonry:

- the required strength and stiffness;

- the type of tie needed to accommodate movement, as appropriate, between leaves, at junctions or at movement joints;

- the need for slope tolerant ties to accommodate differences in the level of joints in the leaves of a cavity wall;

- the need to resist the passage of water towards the interior;

- the need to restrain insulation, where appropriate.

NOTE : Ties may be separate components or may be connected together, as for example in prefabricated bed joint reinforcement.

(2) The required strength and spacing of ties should be determined taking into account their fixings and the particular application.

(3) The length of wall ties should be specified to ensure that at each end there is an adequate fixing or an embedment length not less than the manufacturer's declared value of design embedment length.

(4) Unless there is an alternative means of restraining the free edges of wall leaves at openings, additional ties should be provided to connect both leaves together.

(5) Where the extent of in-plane differential movements in a cavity wall or between a veneer wall and the structural frame requires it, movement-tolerant ties should be specified.

2.3.11.3 Tension straps

(1) Where tension straps are to be used, the following factors should be taken into account to ensure their suitability in the masonry:

- the number and location of the fixings at each end of the strap required to achieve the strength declared by the manufacturer;

- the number of tension straps required and their spacing, taking into account restrictions due to the location of openings;

- the required length and shape.

2.3.11.4 Lintels

(1) Where lintels are to be used, the following factors should be taken into account to ensure their suitability in the masonry:

- the required loadbearing capacity of the lintel taking into account flexure and shear;

- the stiffness of the lintel;

- the bearings;

- the cross-sectional shape, dimensions and position, including any features needed to control water movement, such as cavity trays, stop ends, and weepholes;

- the type of lintel and, in the case of composite or combined lintels, details of the complementary part of the lintel;

- thermal insulation and thermal bridges.

2.3.11.5 Joist hangers, brackets, and support angles

(1) Where joist hangers or brackets or support angles are to be used, the following factors should be taken into account to ensure their suitability in the masonry:

- the required load capacity;

- the design embedment length or fixing;

- the dimensions, to be declared by the manufacturer in accordance with EN 845-1, that affect the structural performance or positioning of the component;

- the required spacing.

2.3.12 Use of water repellent agents

(1) If water repellent agents are to be used, advice should be sought from both the manufacturer of the masonry units and the manufacturer of the water repellent agent on the suitability of the treatment.

NOTE : Treatments that decrease water vapour permeability can increase the risk of damage due to freeze/thaw cycling or salt crystallisation.

2.3.13 Constructional details to limit wetting

2.3.13.1 General

(1) Where the performance of the masonry and its constituent materials requires protection to limit exposure to wetting the construction should be designed accordingly.

2.3.13.2 Copings, cappings and sills

(1) Unless copings, cappings and sills in external walls are waterproof and have waterproof joints, a damp proof course should be placed in the mortar bed joint, immediately below such copings, cappings or sills. For sills the damp proof course should be turned up at the back and ends to form a tray.

(2) Detailing should allow for the movement of copings and cappings relative to the wall to allow for thermal and moisture effects.

2.3.13.3 Moisture from the ground

(1) At or near ground level a damp proof course in the masonry or other construction details should be provided so that water from the ground is prevented from rising to the superstructure and the interior of a building by capillary action.

(2) The surface of low permeability ground, or any paving, should be sloped to discharge water away from the base of the masonry.

2.3.13.4 Natural stone masonry

(1) Masonry should be detailed so that rain water run-off from limestone does not flow directly on to masonry units.

2.4 Resistance to moisture penetration through walls

2.4.1 General

(1)P Where there is a requirement to resist moisture penetration through walls, materials shall be specified and the masonry designed and detailed so that the relevant spaces and surfaces are kept dry.

(2) Where there is a need to resist rain penetration, the specification, design, and detailing of the total wall construction should be chosen to be appropriate for the anticipated exposure to wind driven rain.

(3) Where there is a need to prevent water coming through a masonry retaining wall, adequate drainage and a waterproof membrane should be provided.

2.4.2 Walls without applied finishes or cladding

2.4.2.1 Wind driven rain

(1) The following factors affecting the resistance to wind-driven rain should be taken into account in relation to other functions of the wall such as strength, durability, sound and thermal insulation:

- type of wall and its geometry including the thickness of the outer leaf;

- type of masonry units and mortar;

- water absorbed by the masonry;

- mortar joint, profile and finish;

- presence, type and thickness of any cavity insulation;

- constructional details and local practice;

- quality of workmanship (e.g. category of execution control).

NOTE : The physical characteristics of masonry units affect the amount of water absorbed by the masonry when exposed to wind driven rain, but penetration through the masonry is primarily via the brick/mortar interface at the joints. Resistance to rain penetration is not so dependent on the selection of materials as it is on the achievement of good mortar adhesion and solidly filled and effectively finished mortar joints, see 2.3.3 and 2.4.2.5

2.4.2.2 Single leaf walls

(1) Where resistance of the masonry to rain penetration is required, the thickness of a single leaf wall should be determined in accordance with local practice and experience.

2.4.2.3 Cavity walls

(1) Where resistance to rain penetration is required, the design and detailing of cavity walls should be done in such a way that no water passes from the external leaf to the internal leaf.

NOTE : In cavity walls, some water will penetrate the outer masonry leaf in prolonged periods of wind-driven rain. Proper design and positioning of damp-proof courses and trays, and of any insulation, is necessary to resist the passage of moisture from the outer to the inner leaf, especially at locations where the cavity is unavoidably bridged.

(2) Wall ties, damp proof courses and damp proof membranes should be specified and detailed to guide water outwards and to prevent water from being led from the outer to the inner leaf.

(3) The cavity width should be specified to be not less than [50] mm. In conditions of severe wetting, consideration should be given to the use of wider cavities.

2.4.2.4 Veneer walls

(1) The internal structure should be protected against moisture at all points where the veneer wall comes into contact with its backing wall or frame. Damp proof courses and damp proof membranes should be positioned to resist the passage of moisture from the outside. The recommendations for cavity walls, see **2.4.2.3**, should be taken into account in the design of veneer walls.

2.4.2.5 Mortar joint, profile and finish

(1) Except where shell bedding or strip bedding is intended, all perpend and bed joints should be specified as filled.

(2) The joint profile and finish should be specified.

NOTE : Tooled joints such as those with bucket handled and struck weathered profiles are beneficial in resisting rain penetration. The tooling action done at the correct time firms the mortar, reducing its permeability at the surface, and pushes it tight to the masonry units, thereby improving its adhesion to them and overcoming the intial shrinkage of the mortar.

2.4.2.6 Cavity insulation

(1) In a full-fill system, where the cavity space between the inner and outer masonry leaves is filled with insulation material either by building it in as construction proceeds or by injecting or blowing it into the cavity after the wall has been completed, the cavity width should be not less than [80] mm.

(2) Where the cavity width is equal to or less than 100 mm and fully filled with insulation, joints recessed by [5] mm or more should not be used.

(3) In a partial-fill system, where thermal insulation materials are built in so that a free air space is retained, the width perpendicular to the plane of the wall of the retained air space should be not less than [50] mm.

(4) All thermal insulation materials should be specified and installed in accordance with the manufacturer's instructions and the requirements of relevant European Standards or European Technical Approval.

2.4.3 Walls with applied external surface finishes or cladding

(1) Where there is a need for greater resistance to moisture penetration than can be provided by the masonry alone, the application of a suitable rendering, ventilated cladding or other suitable surface treatment should be used.

NOTE : Guidance on the use of external renderings is given in prEN CBQD-1, The design, preparation and application of external renderings. Where a total barrier to rain resistance is required, a ventilated waterproof cladding system may be applied to the masonry.

(2) Where cladding is used it should be detailed to shed water away from any masonry surfaces below.

3 EXECUTION

3.1 General

(1)P All materials used and all work constructed shall be in accordance with the design specification.

(2) All work should be executed by appropriately skilled and experienced personnel.

3.2 Category of execution

(1) The level of execution should be one of the three categories, Category A, Category B or Category C as required by the design specification.

NOTE : See Annex D for information on Categories of execution.

3.3 Acceptance, handling and storage of materials

3.3.1 General

(1)P The handling and storage of materials for use in masonry and masonry products shall be such that the materials are not damaged so as to become unsuitable for their purpose.

(2) Where required by the design specification, materials should be sampled and tested.

3.3.2 Masonry units

(1) Masonry units should be protected from damage during handling and storage, especially against weather (rain and freeze/thaw cycling) and splashing.

3.3.3 Factory made mortar

(1) The manufacturer's instructions for the storage and handling of factory made mortar should be obtained and followed. Where none are available the following recommendations should be followed:

- premixed lime:sand mortar should be handled and stored in such a way that it does not become contaminated;

- wet mortars should be stored in such a way that the moisture content is not seriously affected;

- in cold weather a protected environment should be provided for prepared lime:sand mortars and wet mortars to ensure that they do not freeze;

- dry and prebatched mortars should be stored dry;

- dry mortars delivered bagged should be stored in such a manner as to allow the bags to be used in rotation in order of delivery.

3.3.4 Materials for site-made mortars and concrete infill

(1) Binders should be protected against interaction with moisture and air during transport and storage. Different types of binders should be stored separately so that mixing cannot occur and bags should be used in rotation in order of delivery.

(2) Aggregates should be stored separately according to type and protected from contamination by harmful materials.

(3) Special aggregates should be stored separately away from all others. They should be obtained in sufficient quantity, at one time if possible, to enable material of the approved colour to be used for the whole of the work.

3.3.5 Ancillary components and products

(1) Components such as wall ties, tension straps, brackets and their fixings should be stored under cover and protected from soiling, distortion, cracking, damage to edges and trims, and damage to surfaces and coatings.

(2) Lintels and copings should be stacked the correct way up on an adequate number of level bearers clear of the ground, and stacks should be protected, if necessary, from staining and splashing, taking into account any particular requirements in the manufacturer's instructions.

(3) Different materials should be kept in separate stacks.

3.3.6 Reinforcement and prestressing materials

3.3.6.1 Reinforcement

(1) Damage or deformation of reinforcement should be avoided during storage and handling. Steel reinforcing bars and prefabricated bed joint reinforcement should be clearly identified, and stored off the ground, well away from mud, oil, grease, paint or welding operations.

3.3.6.2 Prestressing materials

(1) During storage and handling of the tendons, the following should be avoided:

- chemical, electro-chemical or biological attack liable to cause corrosion;
- damage to tendons;
- contamination liable to affect the durability or bond properties of the tendons;
- deformation of the tendons, not provided for in the design;
- any unprotected storage, exposure to rain or contact with the ground;
- welding in the vicinity of tendons without the provision of special protection (from splashes).

(2) For sheaths, the following should be taken into account:

- local damage and corrosion inside should be avoided;
- water-tightness should be ensured.

3.4 Preparation of materials

3.4.1 General

(1) Masonry products should be clean when used.

3.4.2. Cutting of masonry units

(1) Cutting should be done in accordance with the recommendations of the manufacturer of the masonry units.

(2) If accessory units are to be prepared by cutting, they should be cut in such a way that the dimensions necessary to give the required joint thickness are achieved.

3.4.3 Site-made mortars and concrete infill

3.4.3.1 General

(1)P The performance characteristics of mortar and concrete infill shall be as specified.

(2) Site-made mortars and concrete infill should be produced using a mix prescription that will result in the required performance characteristics. When the mix prescription is not given in the design specification, the detailed specification of constituents materials, their proportions and the method of mixing should be selected on the basis of tests carried out on trial mixes and/or on the basis of authoritative publicly available references acceptable in the place of use.

(3) Materials for mortar and concrete infill should be measured and mixed in such a way that the fresh mortar and concrete infill is correctly proportioned according to the mix prescription.

(4) When tests are required they should be carried out in accordance with the design specification. When test results indicate that the mix prescription is not giving the required performance characteristics, the mix prescription should be amended and if it is part of the design specification any amendments should be agreed with the designer.

3.4.3.2 Chloride content

(1) When sampled in accordance with Annex B of EN 998-2, and tested in accordance with EN 1015-17 or when using a calculation method based on measured chlorine ion content of the constituents of the mortar, the maximum value permitted in EN 998-2 should not be exceeded.

3.4.3.3 Strength of mortar and concrete infill

(1) When the properties of mortar or concrete infill need to be verified, the relevant test methods referenced in EN 998-2 or ENV 206 should be used, as appropriate.

3.4.3.4 Admixtures and additions

(1) Unless permitted by the design specification, admixtures, additions or pigments should not be used. Where the use of admixtures, additions or pigments is permitted they should be used in accordance with the manufacturer's instructions.

3.4.3.5 Gauging

(1) Mortar should be gauged by weight or volume in such a way that the specified mortar properties are consistently maintained.

3.4.3.6 Mixing method and mixing time

(1) The mixing method and the time of mixing should ensure consistent production of the correct mix proportions. The mortar should be mixed effectively so that a uniform distribution and proper activation of all the mortar materials is ensured.

(2) The mixing time should be counted from the time when all constituent materials have been added.

> NOTE : In general, a machine mixing time of 3 minutes to 5 minutes after all the constituents have been added is suitable. Wide variation in the mixing time of different batches should be avoided. Prolonged mixing where air-entraining agents are used can lead to excessive air entrainment and thus to a reduction in adhesion and durability. Except in the case of retarded mortars the mixing time should not exceed 15 minutes.

(3) The mortar or concrete infill should be mixed to have sufficient workability for it to fill the spaces, into which it is placed and appropriately compacted.

3.4.3.7 Workable life of mortars and concrete infill containing cement

(1) Mortars and concrete infill containing cement should be ready for use when they are discharged from the mixer, and no subsequent additions of binders, aggregates, admixtures, or water should be made.

(2) Mortar and concrete infill should be used before its workable life has expired. Any mortar or concrete infill left after the initial set has commenced should be discarded and should not be reconstituted.

3.4.3.8 Mixing in cold weather

(1) Water, sand or premixed lime:sand mortars containing ice particles should not be used.

3.4.4 Factory made mortar and concrete infill and semi-finished factory made mortar.

(1)P Factory made mortars and pre-batched mortars shall be used in accordance with the manufacturer's instructions, including mixing time and type of mixer.

(2) Mortar should be mixed effectively so that a uniform distribution of the constituents is ensured.

(3) The site mixing equipment, procedures, including mixing in cold weather and care of mixing plant and mixing time specified by the manufacturer, should be used.

(4) Pre-mixed lime:sand mortars should be mixed with the binder according to **3.4.3**.

(5) Ready-to-use factory made mortars should be used before the expiry of the workable life stated by the manufacturer.

3.4.5 Ancillary components and products

(1)P Products shall be examined to ensure that they conform to the required specification and that they are clean and not damaged or missing any parts.

(2) Where necessary, ancillary products should be assembled in accordance with the manufacturer's instructions.

3.4.6 Reinforcement and prestressing materials

3.4.6.1 Reinforcement

(1)P The surface condition of reinforcement shall be examined prior to use and it shall be free from deleterious substances that may affect the steel, concrete or mortar or the bond between them.

(2) Reinforcement should be cut and bent in accordance with the relevant specifications to the shape required by the design specification.

(3) Prefabricated bed joint reinforcement should be cut and bent in accordance with the manufacturer's instructions, so as to avoid the following:

- mechanical damage and distortion;
- rupture of welds in prefabricated bed joint reinforcement;
- surface deposits damaging to bond properties;
- lack of identification.

3.4.6.2 Prestressing materials

(1)P The tendons and the devices used in anchoring and coupling tendons shall be in accordance with a European standard or a European Technical Approval. Sheaths shall be as specified in the design specification.

(2) Particular attention should be given to:

- maintaining identification marks on all materials;
- appropriate methods of cutting;
- straight entry into anchorages and couplers;
- when lifting by crane, avoiding any local crushing or bending of the tendons.

(3) Prestressing bars should be straight.

3.5 The appearance of facing masonry

(1) Where an assessment of the appearance of facing masonry is required, a suitable procedure should be agreed between the relevant parties prior to the commencement of the work affected.

NOTE : One such suitable procedure is given in **Annex E.**

3.6 Setting out and levelling

3.6.1 Setting out

(1) Setting out and levelling should be in accordance with the design specification.

(2) Unless otherwise specified, the first course of masonry should not overhang the edge of a floor or foundation by more than [15] mm.

(3) Dimensions and planeness should be checked as the work proceeds.

3.6.2 Levelling

(1)P Unless required otherwise by the design specification, masonry shall be built plumb and level with bed joints horizontal, within the relevant permissible deviations.

(2) Where the masonry is to be built with thin layer mortar and the floor or the foundation is too rough or not horizontal enough to permit the use of thin layer mortar, the first course of masonry units may be placed in a general purpose mortar of adequate strength.

3.6.3 Permissible deviations

(1) Where permissible deviations are not given in the design specification, the values in **table 3.1** should be used in order to satisfy the assumptions of the structural design. Permissible deviations for other purposes should be in accordance with European and International standards but, where the deviations exceed the values in **table 3.1**, such deviations should be specially taken into account in the design. Maximum values of verticality and vertical alignment should not normally exceed those shown in **figure 3.1**.

NOTE : The deviations in **table 3.1** are taken into account in the ENV 1996-1-1 design formulae. Smaller or larger deviations may need to be specified for other reasons. An European standard for such deviations is not yet available.

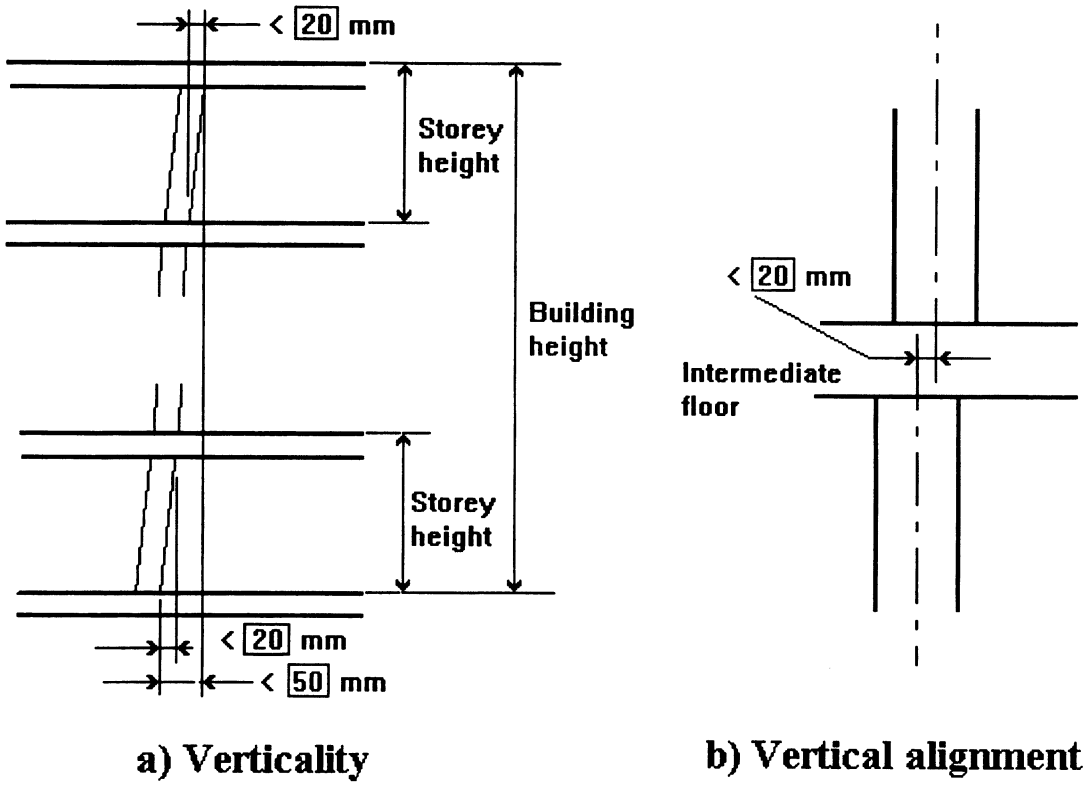

Figure 3.1 Maximum vertical deviations

Table 3.1: Permissible deviations for masonry elements

Position	Maximum deviation, mm
Verticality:	
In one storey	[± 20 mm]
In total building height	[± 50 mm]
Vertical alignment	[± 20 mm]
Straightness: (1)	
In any one metre	[± 5 mm]
In 10 metres	[± 20 mm]
Thickness:	
Of wall leaf (2)	[± 5 mm] or [± 5%] of the leaf thickness whichever is the greater
Overall cavity wall	[± 10 mm]

Note 1. Straightness is measured as the maximum deviation from a straight line between any two points.

Note 2. Excluding leaves of single masonry unit width or length, where the dimensional tolerances of the masonry units govern the leaf thickness.

3.7 Erection of walls to meet requirements

3.7.1 Laying masonry units

(1)P Masonry units shall either be laid in the bond arrangements given in the design specification or, where not given in the design specification, the bonding of masonry units shall be in accordance with **2.3.2.2**.

(2) Where required by the design specification, mortar joints should be executed to fill cells and recesses in the masonry units. Unless otherwise stated in the design specification, masonry units with frogs should be laid in the orientation indicated by the manufacturer and the frogs should be fully filled with mortar.

(3) Cavities should be prevented from being bridged by mortar droppings.

3.7.2 Achievement of satisfactory adhesion

(1) Satisfactory adhesion should be achieved by proper preparation of the masonry units and mortar. The necessity for wetting masonry units before use should be obtained from the design specification. Where there are no requirements in the design specification, the recommendations from the manufacturer of the units and, where appropriate, from the manufacturer of factory made mortar should be followed.

3.7.3 Bedding and toothing

(1)P The bedding of masonry units in mortar shall be as specified by the designer.

(2) Mortar joints should be of uniform thickness. Unless otherwise specified the thickness of bed and perpend joints made with general purpose mortar and lightweight mortar should be between 8 mm and 15 mm, and the thickness of bed and perpend joints made with thin layer mortar should be between 1 mm and 3 mm.

(3) After placing units on a bed of general purpose mortar, they should not be disturbed. Units that have been moved or shifted for any reason or by accident after their initial placement should be laid again in fresh mortar.

(4) Joints should be filled with mortar unless otherwise permitted by the design specification.

(5) Unless otherwise permitted by the design specification, the width of perpend joints that are not to be filled with mortar should not be more than 5 mm.

NOTE : Some types of masonry units have interlocking features and do not require the perpend joints to be filled with mortar.

(6) Where required for the purpose of ventilation and drainage of cavities, perpend joints at not more than [1,5 m] spacing should be left open at the top and bottom of the wall and also above openings in the wall.

(7) Collar joints should be filled with mortar course by course, but may be grouted where specified so by the designer.

(8) Where shell bedding or strip bedding is used, the recommendations, if any, of the masonry unit manufacturer should be followed.

NOTE : Some masonry units are intended to be laid on two strips of mortar at the edge of the unit (shell bedding) or on three or more strips (strip bedding).

3.7.4 Pointing and jointing

3.7.4.1 General

(1)P Joints shall be executed so as to ensure their resistance against the actions to which they will be exposed.

(2) Regardless of the method used, the construction should be adjusted to take account of the then current weather conditions and the properties of the masonry materials, inclusive of any changes arising during construction. The actual suction of the units and the actual properties of the mortar, such as its consistency and water retentivity, should be taken into account.

3.7.4.2 Pointing

(1) Where joints are to be pointed, the joints should be raked out to a depth of between [10 mm and 15 mm] measured from the finished surface of the joint. Before pointing, the whole area should be cleaned and wetted to give the best practicable adhesion for the subsequent pointing. Mortar should be compacted during pointing to ensure good durability.

3.7.4.3 Jointing

(1) Joints should not be recessed to a depth more than [5] mm in walls of thickness [200] mm or less without the consent of the designer.

(2) When using perforated masonry units, the mortar joints should not be recessed more than [1/3] of the shell thickness unless otherwise specified.

(3) Where masonry is finished by jointing during construction, the appropriate tools should be used and the mortar should be compacted before it has lost its plasticity.

3.7.5 Incorporation of damp proof courses

(1)P Damp proof courses including damp proof membranes shall be installed in accordance with the design specification so as to inhibit the passage of moisture.

(2) Damp proof course sheet materials should extend the full thickness of the wall and preferably project beyond the external face. They should not be pierced by services, reinforcement, fixings and the like nor bridged by pointing or applied surface finishes.

(3) Unless otherwise specified by the designer, overlapping joints in damp proof course and damp proof membrane sheet materials should have a lap of not less than [150 mm] and should be sealed in accordance with the recommendations of the manufacturer.

3.7.6 Incorporation of ancillary components

3.7.6.1 Wall ties

(1)P Wall ties shall be positioned at the required spacing and installed carefully with an actual embedment length or fixing at each end to give the required performance based on the manufacturer's specification in accordance with EN 845-1.

(2) Where the spacing of wall ties is not given in the design specification, the maximum horizontal distance between two successive ties, placed in the same course, should not exceed [900] mm and the maximum height difference between courses in which ties are placed should not exceed [600] mm. Wall ties should normally be staggered in alternate courses.

(3) Unless otherwise recommended by the manufacturer of the wall ties, they should be placed in bed joints and built in as the work proceeds. They should not be placed in perpend joints or pushed into bed joints after the units above have been laid. Wall ties should not be bent out of their intended position during the construction process.

(4) For other ties including those fixed directly to the masonry units the instructions of the manufacturer of the wall ties should be carefully followed.

(5) In cavity walls and veneer walls, ties should be installed so that water is prevented from passing to the inner leaf. Wall ties with insulation material retaining clips should be installed carefully according to the instructions of the manufacturer so as to prevent water from being diverted to the inner leaf.

3.7.6.2 Shear ties

(1)P Shear ties shall be positioned at the required spacing and installed carefully with an actual embedment length or fixing at each end to give the required performance based on the manufacturer's specification in accordance with EN 845-1.

(2) Where the spacing of shear ties is not given in the design specification, the maximum horizontal distance between two successive ties, placed in the same course, should not exceed [900] mm and the maximum height difference between courses in which ties are placed should not exceed [600] mm. Shear ties should normally be staggered in alternate courses.

(3) Shear ties should be fully embedded in the mortar and extend sufficiently into the masonry. Unless otherwise specified in the design specification, the extension on each side of the intersection should be in accordance with the recommendations of the manufacturer of the shear ties, for the actions and type of masonry units and mortar being used.

(4) Unless otherwise recommended by the manufacturer of the shear ties, they should be placed in bed joints and built in as the work proceeds. They should not be placed in perpend joints or pushed into bed joints after the units above have been laid.

(5) Crossing of shear ties in the same course should be avoided.

(6) By preference prefabricated shear ties designed for the relevant wall thickness should be used.

3.7.6.3 Lintels

(1) Installation of prefabricated lintels should follow the recommendations of the manufacturer.

(2) The end bearings of lintels should be on whole masonry units or padstones.

(3) Cast in-situ lintels of reinforced concrete or of reinforced masonry should be propped and allowed sufficient time to develop adequate strength before they carry loads.

3.7.6.4 Sills

(1)P Sills shall be laid in such a way that water penetration into the masonry is avoided.

(2) In general just the ends of one-piece sills should be bedded in mortar, and the remainder pointed afterwards.

(3) Tile sills in two courses should be bedded with staggered joints. All exposed joints should be filled with mortar, flush with the surface of the tiles.

3.7.6.5 Brackets and support angles

(1)P Brackets and support angles shall be installed with sufficient bearing or attachments to resist mechanical actions and in accordance with the design specification,

(2) No holes in brackets and support angles should be formed on site.

3.7.6.6 Joist hangers

(1) The back plate of a joist hanger should lie flat against the masonry support, any projecting material having first been removed.

(2) Any horizontal flange of a joist hanger should be built into the wall so that an adequate height of masonry exists above the flange, to provide resistance, in accordance with the manufacturer's declaration. Alternatively, the horizontal flange of the joist hanger should be mechanically fixed into the masonry beneath, to develop adequate resistance.

(3) Any packing used under the horizontal flange should have a compressive strength at least equal to that of the adjacent masonry

(4) No holes in a joist hanger should be formed on site.

3.7.6.7 Tension straps

(1)P Tension straps shall be carefully positioned and fixed at each end.

(2) No holes in tension straps should be formed on site.

3.7.7 Incorporation of reinforcement and prestressing materials

3.7.7.1 Incorporation of bar reinforcement

(1) Spacers and stirrups should be used where necessary to hold loose reinforcement in the required position to give the cover specified to the reinforcement.

(2) Where necessary, reinforcement should be tied together with wire to ensure that it does not move during mortar or concrete filling.

(3) The position of the reinforcement should be checked before infilling with mortar or concrete.

(4) For reinforced concrete filled cavity walls the cavity should be cleared of mortar droppings and debris before fixing the reinforcement sufficiently and filling commences. Filling should be carried out in layers ensuring that all voids are filled and the concrete does not segregate. The sequence of operations should be such that the masonry has adequate strength to resist the pressure of the fresh concrete.

(5) Where a wall uses an arrangement of units to provide pockets and is reinforced, the main reinforcement should be fixed sufficiently in advance of the masonry construction to allow it to proceed without hindrance. The cavities formed around the reinforcement, by the bonding pattern, should be filled with mortar or concrete as the works progresses.

(6) Where a wall uses perforated units with big perforations to provide pockets and is reinforced, the pockets should be cleared of mortar droppings and debris before filling commences. Filling should be carried out with mortar having a consistence enabling all voids to be filled.

3.7.7.2 Incorporation of bed joint reinforcement

3.7.7.2.1 General

(1)P Unless otherwise stated in the design specification, bed joint reinforcement shall be installed in accordance with the manufacturer's recommendations.

3.7.7.2.2 Bedding

(1)P Bed joint reinforcement shall be embedded within the mortar to achieve the cover required by the design specification.

(2) Where not given in the design specification, the cover for structural reinforced masonry should be in accordance with ENV 1996-1-1.

(3) For thin layer mortar the cover above and below the reinforcement should be maintained as large as practicable.

(4) Unless otherwise given in the design specification, the cover between reinforcing steel and wall faces should be maintained and be not less than 15 mm.

3.7.7.2.3 Anchorage and lapping

(1)P Bed joint reinforcement elements shall be adequately anchored or lapped to transmit the design forces in accordance with the design specification.

(2) Unless otherwise required by the design specification, each end of a bed joint reinforcement element should have an anchorage or overlap with the adjacent element, as appropriate, in accordance with the recommendations of the manufacturer of the bed joint reinforcement.

(3) Laps in reinforcement in successive courses should be staggered.

3.7.7.2.4 Wall to wall connections

(1) At corners and at changes in direction of walls, the reinforcement of both walls should be connected to each other, preferably by means of prefabricated corner and junction elements from the manufacturer of the bed joint reinforcement. Alternatively, continuity should be maintained by cutting and bending the bed joint reinforcement or by using L-shaped reinforcement or by a combination of both methods.

(2) Crossing of different reinforcement elements in the same course should be avoided. Where practicable, the reinforcement should be placed in successive courses of each wall.

3.7.7.3 Incorporation of prestressing steel and related components

3.7.7.3.1 Placing of the tendons

(1) Placing of tendons should be carried out having regard to:

- the concrete cover and the spacing of tendons;
- the specified tolerances in respect of the position of the tendons, anchorages and couplers;
- the ease with which the surrounding concrete can be cast.

(2)P The tolerances required for the placing of the tendons shall be as stated in the design specification.

(3) Where sheaths are used, they should be fixed carefully according to the designer's specification of dimensions, spacers and supports. After placing sheaths in position, vents should be provided at both ends and at their high points, as well as at all points where air or water may accumulate. Such sheaths should be protected from penetration of extraneous materials until the completion of grouting.

(4) Tendons should have a straight entry into all anchorages and couplers.

3.7.7.3.2 Tensioning of the tendons

(1)P Prestressing shall be carried out by appropriately qualified operatives in accordance with the tensioning sequence given in the design specification.

(2) The jacking force and the corresponding tendon elongation should be recorded.

3.7.8 Movement joints

3.7.8.1 Forming movement joints

(1) The width, as constructed, of a movement joint should not be less than that specified .

(2) Unless otherwise stated in the design specification, the deviations from the specified width should be maintained within 0 mm to +2 mm.

(3) Except for slip ties, components including copings and cappings should not bridge movement joints.

3.7.8.2 Filling and sealing movement joints

(1)P Only the joint fillers and sealants specified shall be used.

(2) Back-up material and, where required, a debonding strip should be placed within the joint in such a way that the distance of its face from the joint face will allow the correct depth of sealant to be used, see figure **2.3**. Unless otherwise required by the design specification, the depth of sealant should be in accordance with the manufacturer's recommendations.

(3) The faces of the joint to which sealant is to be applied should be clean and free from loose material. They should also be dry unless otherwise specified.

(4) Application of primer and sealant should be in accordance with the manufacturer's instructions.

(5) The sealant should be applied to the full specified depth, avoiding bubbles.

(6) The sealant should adhere to each side of the joint.

3.7.9 Chasing

(1) When instructions about forming chases are not given in the design specification the recommendations of 5.5 of ENV1996-1-1 should be followed.

(2) Where forming chases care should be taken to avoid damaging anchors and reinforcement.

(3) When chasing is carried out on newly erected masonry, particular care should be taken with non structural walls to avoid the applied force from the chasing equipment disturbing the wall. Where there is such a risk, the wall should be supported.

3.7.10 Incorporation of thermal insulation materials

(1)P Unless otherwise stated in the design specification, thermal insulation materials shall be installed in accordance with the manufacturer's instructions.

> NOTE : The quality of workmanship actually achieved both when constructing masonry and when installing any insulation material is a very important factor affecting resistance to rain penetration.

3.7.11 Cleaning facing masonry

(1) Masonry should be kept clean throughout the construction process. Splashes of mortar, grout or other stains should be avoided. Any that do occur should be cleaned off as soon as practicable after they occur and preferably by brushing before cementitious based materials have hardened.

(2) Masonry should be cleaned and stains removed in such a way that the masonry is not damaged. The cleaning method should be one recommended by the manufacturer of the masonry units taking into account the kind of staining or efflorescence.

3.7.12 Water repellent agents

(1) A water repellent agent should not be applied without taking into account guidance from the manufacturer of the masonry units and the manufacturer of the mortar.

(2) The method of application of the water repellent should be in accordance with the manufacturer's recommendations, which should include guidance on:

- suitable application techniques and number of coats;

- the minimum application temperature to achieve proper penetration.

3.8 Curing and protective procedures during construction

3.8.1 General

(1)P Suitable precautions shall be taken to avoid damage to newly constructed masonry.

(2) During mortar hydration, newly constructed work should be suitably protected against excessive moisture loss or uptake.

3.8.2 Protection against rain

(1) Completed masonry should be protected from rain falling directly on the construction until the mortar has matured. It should be protected from mortar being washed out of the joints and from cycles of wetting and drying.

(2) In order to protect the completed masonry, sills, thresholds, gutters and provisional rain water downpipes should be installed as soon as practicable after finishing the bricklaying and pointing.

(3) Bricklaying and pointing should be stopped during periods of heavy rain and the masonry units, mortar and the fresh pointing should be protected.

(4) Freshly pointed masonry should be protected from spells of heavy rain.

3.8.3 Protection against freeze/thaw cycling

(1) Precautions should be taken to avoid damage to freshly completed masonry and pointing from freezing and thawing.

(2) Damaged masonry that cannot reach its full strength and durability should be removed and replaced with new masonry.

3.8.4 Protection against effects of heat

(1) Newly constructed masonry should be protected from high temperatures. Where necessary, it should be covered with a vapour resistant material, such as polyethylene, to prevent excessive evaporation of moisture. The protective measures should be continued until the cement in the mortar has hydrated.

3.8.5 Protection against effects of low humidity

(1) Newly constructed masonry should be protected from low humidity conditions including the drying effects of wind. It should be kept moist until the cement in the mortar has hydrated.

3.8.6 Protection against mechanical damage

(1) Masonry surfaces, vulnerable arrises at corners and openings, plinths and other projecting features should be protected as appropriate from damage and disturbance taking into account:

- other works in progress and subsequent construction operations;
- activities of construction traffic;
- concrete being poured above;
- use of scaffoldings and the construction processes carried out from them.

(2) Completed masonry should be protected from construction operations that would stain fair-faced masonry or affect bonding with future work such as rendering.

3.8.7 Construction height and loading of masonry

(1)P Masonry shall not be subjected to actions until it has achieved adequate strength to resist such actions without damage.

(2) The height of the masonry to be built in one day should be limited so as to avoid instability and overstressing of the fresh mortar. The wall thickness, the type of mortar, the shape and density of the units and the degree of exposure to the wind should be taken into account in determining an appropriate limit.

(3) Backfilling against retaining walls should not be carried out until the wall is capable of resisting actions from the backfilling.

(4) Attention should be paid to walls that are temporarily unrestrained during construction and may be subjected to wind actions or construction actions. Temporary shoring should be provided, where necessary, to maintain stability.

Annex A (informative) Classification of micro conditions of exposure of completed masonry

Table A.1 Classification of micro conditions of exposure of completed masonry

Class	Micro condition of the masonry	Examples of masonry in this condition
MX1	**In a dry environment**	Interior of buildings for normal habitation and for offices, including the inner leaf of external cavity walls not likely to become damp. Rendered masonry in exterior walls, not exposed to moderate or severe driving rain, and isolated from damp in adjacent masonry or materials.
MX2	**Exposed to moisture or wetting**	
MX2.1	Exposed to moisture but not exposed to freeze/thaw cycling or external sources of significant levels of sulfates or aggressive chemicals	Internal masonry exposed to high levels of water vapour, such as in a laundry. Masonry exterior walls sheltered by overhanging eaves or coping, not exposed to severe driving rain or frost. Masonry below frost zone in well drained non-aggressive soil.
MX2.2	Exposed to severe wetting but not exposed to freeze/thaw cycling or external sources of significant levels of sulfates or aggressive chemicals	Masonry not exposed to frost or aggressive chemicals, located: in exterior walls with capping or flush eaves; in parapets; in freestanding walls in the ground; under water.
MX3	**Exposed to wetting plus freeze/thaw cycling**	
MX3.1	Exposed to moisture and freeze/thaw cycling but not exposed to external sources of significant levels of sulfates or aggressive chemicals	Masonry as class MX2.1 exposed to freeze/thaw cycling.
MX3.2	Exposed to severe wetting and freeze/thaw cycling but not exposed to external sources of significant levels of sulfates or aggressive chemicals	Masonry as class MX2.2 exposed to freeze/thaw cycling.
MX4	**Exposed to saturated salt air or seawater**	Masonry in a coastal area
MX5	**In an aggressive chemical environment**	Masonry in contact with natural soils or filled ground or groundwater, where moisture and sulfates are present. Masonry in contact with highly acidic soils, contaminated ground or groundwater. Masonry near industrial areas where aggressive chemical are airborne.

NOTE 1 : In deciding the exposure of masonry the effect of applied finishes and protective claddings should be taken into account.

Annex B (informative) Acceptable specifications of masonry units and mortar for durable masonry in various exposure conditions

B.1 Selection of masonry units and mortar

(1) For normal uses, such as walls in habitable buildings, masonry units and mortar may be selected from **table B.1**, according to the exposure class of the masonry determined from **table A.1.**

(2) Masonry mortar is specified for durability using the terms defined in EN 998-2. For the purposes of **table B.1** they are abbreviated using the following symbols:

P - mortar for use in masonry subjected to passive exposure;
M - mortar for use in masonry subjected to moderate exposure;
S - mortar for use in masonry subjected to severe exposure.

(3) Until a European test method is available, the designation of site-made mortar mix prescriptions, for which authoritative data are available, may be related to the P, M, or S designations in National Application Documents.

(4) In addition to selecting a mortar for durability, other performance characteristics such as compressive strength, bond strength, and water retentivity need to be taken into account so that the mortar is compatible with the selected masonry units and enables the masonry to satisfy all relevant design requirements.

In the present state of the art guidance on the suitability of mortars will generally need to be obtained from the manufacturers of factory made mortars or in the case of site made mortars from authoritative sources accepted in the place of use, see **2.2.3.2**.

Table B.1: Acceptable specifications of masonry units and mortars for durability (see NOTE 1)

Exposure class **(See table A.1)**	**Clay masonry units** conforming to EN771-1	**Calcium silicate masonry units** conforming to EN771-2	**Aggregate concrete masonry units** conforming to EN771-3 (Dense aggregate)	 (Lightweight agg.)	**Autoclaved aerated concrete masonry units** conforming to EN771-4	**Manufactured stone masonry units** conforming to EN771-5	**Natural stone masonry units** conforming to EN771-6
	Mortar *see B.1(2)*	***Mortar*** *see B.1(2)*	***Mortar*** *see B.1(2)*	***Mortar*** *see B.1(2)*	***Mortar*** *see B.1(2)*	***Mortar*** *see B.1(2)*	***Mortar*** *see B.1(2)*
MX1 *See NOTES 2 & 3*	Any *P,M,or S*	Any *P,M,or S*	Any *P,M,or S*	Any *P,M,or S*	Any strength/density *P,M,or S*	Any *P,M,or S*	Any *P,M,or S*
MX2.1	F0, F1 or F2 / S1 or S2 *M,or S*	Any *M or S*	Any *M or S*	Any *M or S*	Any strength/density *M or S*	Any *M or S*	Any *M or S*
MX2.2	F0, F1 or F2 / S1 or S2 *M or S (See NOTE 4)*	Any *M or S*	Any *M or S*	Any *M or S*	= or > 400 kg/m3 *M or S*	Any *M or S*	Any *M or S*
MX3.1	F1 or F2 / S1 or S2 *M or S*	Freeze/thaw resistant *M or S*	Freeze/thaw resistant *M or S*	Freeze/thaw resistant *M or S*	= or > 400 kg/m3 *M or S*	Any *M or S*	Consult manufacturer *M or S*
MX3.2	F2 / S1 or S2 *S (See NOTE 4)*	Freeze/thaw resistant *S*	Freeze/thaw resistant *S*	Freeze/thaw resistant *S*	= or > 400 kg/m3 *S*	Any *S*	Consult manufacturer *S*
MX4	In each case assess the degree of exposure to salts, wetting and freeze/thaw cycling and consult the manufacturers of the constituent materials.						
MX5	In each case a specific assessment should be made of the environment and the effect of the chemicals involved taking into accoupt concentrations, quantities available and rates of reaction and consult the manufacturers of the constituent materials.						

NOTES :

1) In each box of this table the upper line lists the masonry units and the lower line lists the mortars acceptable in masonry for each Exposure Class.

2) Class MX1 is valid only as long as the masonry, or any of its components, is not exposed during construction to more severe conditions over a prolonged period of time.

3) When designation P mortars are specified it is essential to ensure that masonry units, mortar and masonry under construction are fully protected from saturation and freezing.

4) When clay masonry units of Soluble Salts Content Category S1 is to be used in masonry where the Exposure Class is MX2.2, MX3.2, MX4 and MX5 the mortars should in addition be sulphate resisting

Annex C (informative) Selection of material and corrosion protection specifications for ancillary components according to exposure class

C.1 Exposure classes

(1) The range of environmental conditions encountered by ancillary components is classified into the five exposure classes MX1, MX2, MX3, MX4 and MX5 as given in **table A.1**.

(2) The choice of exposure class should take into account either the exposure of products during construction or in the finished work, whichever will be the more onerous.

C.2 Selection of materials

(1) The material and protective coating, if any, for ancillary components can be selected from the relevant Part of EN 845.

(2) Materials for the manufacture of ancillary components and their corrosion protection systems are specified in full in the relevant Part of EN 845 and each one is given a unique material/coating reference. This reference gives no indication of relative performance or quality.

(3) Materials for ties, tension straps, hangers and brackets, conforming to EN 845-1, can be selected using **table C.1**.

(4) Materials for lintels, conforming to EN 845-2, can be selected using **table C.2**.

(5) Materials for bed joint reinforcement, conforming to EN 845-3 can be selected using **table C.3**.

(6) **Tables C.1, C.2 and C.3** show the material/coating reference with a brief description of the materials and the exposure classes, in which the specification is suitable. This guidance is based on long term experience of the durability of such materials in a range of exposure conditions. Currently there is no accepted accelerated exposure test for measuring this parameter.

(7) Materials allocated to each exposure class will be expected to have an economically reasonable working life under the conditions described, subject to specialist advice being obtained in some cases, as indicated in the table. The choice will be dependent upon the particular application, its location and the intended working life.

(8) Where ancillary components need to be movement tolerant during installation or use, the ability of the materials and coatings to withstand the expected movement ought to be taken into account.

Table C.1 Corrosion protection systems for ties, tension straps, brackets and hangers in relation to exposure classes

Material (Note 1 and 2)	Ref. No.	Exposure class				
		MX1	MX2	MX3	MX4	MX5
Austenitic stainless steel (molybdenum chrome nickel alloys)	1	U	U	U	U	R
Plastic used for the body of ties	2	U	U	U	U	R
Austenitic stainless steel (chrome nickel alloys)	3	U	U	U	R	R
Ferritic stainless steel	4	U	X	X	X	X
Phosphor bronze	5	U	U	U	X	X
Aluminium bronze	6	U	U	U	X	X
Copper	7	U	U	U	X	X
Zinc coated (940 g/m²) steel wire	8	U	U	U	R	X
Zinc coated (940 g/m²) steel component	9	U	U	U	R	X
Zinc coated (710 g/m²) steel component	10	U	U	U	R	X
Zinc coated (460 g/m²) steel component	11	U	R	R	R	X
Zinc coated (300 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	12.1	U	U	U	R	X
Zinc coated (300 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	12.2	U	U	U	R	X
Zinc coated (265 g/m²) steel wire	13	U	R	R	X	X
Zinc coated (300 g/m²) steel strip or sheet with all cut edges organic coated	14	U	R	R	X	X
Zinc pre-coated (300 g/m²) steel strip or sheet	15	U	R	R	X	X
Zinc coated (137 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	16.1	U	U	U	R	X
Zinc coated (137 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	16.2	U	U	U	R	X
Zinc pre-coated (137 g/m²) steel strip with zinc coated edges	17	U	R	R	X	X
Zinc coated (60 g/m²) steel wire with organic coating over all surfaces of finished component	18	U	R	R	R	X
Zinc coated (105 g/m²) steel wire	19	U	R	R	X	X
Zinc coated (60 g/m²) steel wire	20	U	X	X	X	X
Zinc pre-coated (137 g/m²) steel sheet	21	U	X	X	X	X

KEY: U - unrestricted use of the material in listed class of exposure.
R - restricted use; consult the manufacturer or a specialist consultant for advice for the specific design conditions.
X - material not recommended for use in this exposure class.

Note 1. The full specification of the material and coating corresponding to the reference number is given in EN 845-1. The coating weights shown are approximate values for one surface.

Note 2. 95% zinc: 5% aluminium alloy coatings may be substituted for zinc coatings.

Table C.2 Corrosion protection systems for lintels in relation to exposure classes

Material (Note 1 and 2)	Ref. No.	Exposure class MX1	MX2	MX3	MX4	MX5
Austenitic stainless steel (chrome nickel alloys)	L3	U	U	U	R	R
Zinc coated (710 g/m²) steel component	L10	U	U	U	R	X
Zinc coated (460 g/m²) steel component	L11	U	D	D	R	X
Zinc coated (460 g/m²) steel component with organic coating on specified upper surfaces	L11.1	U	U	U	R	X
Zinc coated (460 g/m²) steel component with organic coating on specified upper surfaces	L11.2	U	U	U	R	X
Zinc coated (300 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	L12.1	U	U	U	R	X
Zinc coated (300 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	L12.2	U	U	U	R	X
Zinc coated (300 g/m²) steel strip or sheet with all cut edges organic coated	L14	U	D	D	R	X
Zinc coated (137 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	L16.1	U	D	D	R	X
Zinc coated (137 g/m²) steel strip or sheet with organic coating over all outer surfaces of finished component	L16.2	U	U	U	R	X
Concrete or concrete and masonry	A	U	U	R	R	R
Concrete or concrete and masonry	B	U	U	R	R	X
Concrete or concrete and masonry	C	U	U	R	X	X
Concrete or concrete and masonry	D	U	U	X	X	X
Concrete or concrete and masonry	E	U	X	X	X	X
Concrete or masonry with stainless steel reinforcement	F	U	U	R	R	R
Autoclaved aerated concrete with reinforcement protected by a coating system	G	U	R	R	R	R

KEY: U - unrestricted use of the material in listed class of exposure.
R - restricted use; consult the manufacturer or a specialist consultant for advice for the specific design conditions.
D - with a damp proof course on top of the lintel the use is unrestricted (U). Without a damp proof couse on top of the lintel the use is restricted (R).
X - material not recommended for use in this exposure class.

Note 1. The full specification of the material and coating or concrete cover corresponding to the reference number or letter is given in EN 845-2. The coating weights shown are approximate values for one surface.

Note 2. 95% zinc: 5% aluminium alloy coatings may be substituted for zinc coatings.

Table C.3 Corrosion protection systems for bed joint reinforcement in relation to exposure classes

Material (Note 1 and 2)	Ref. No.	Exposure class				
		MX1	MX2	MX3	MX4	MX5
Austenitic stainless steel (molybdenum chrome nickel alloys)	R1	U	U	U	U	R
Austenitic stainless steel (chrome nickel alloys)	R3	U	U	U	R	R
Zinc coated (265 g/m²) steel wire	R13	U	R	R	X	X
Zinc coated (60 g/m²) steel wire with organic coating over all surfaces of finished component	R18	U	U	U	R	X
Zinc coated (105 g/m²) steel wire	R19	U	R	R	X	X
Zinc coated (60 g/m²) steel wire	R20	U	X	X	X	X
Zinc pre-coated (137 g/m²) steel sheet	R21	U	X	X	X	X

KEY: U - unrestricted use of the material in listed class of exposure.
R - restricted use; consult the manufacturer or a specialist consultant for advice for the specific design conditions.
X - material not recommended for use in this exposure class.

Note 1. The full specification of the material and coating corresponding to the reference number is given in EN 845-3. The coating weights shown are approximate values for one surface.

Note 2. 95% zinc: 5% aluminium alloy coatings may be substituted for zinc coatings.

Annex D (informative) Categories of execution

D.1 General

(1) The relevant conditions to be used for the Categories of execution in table 2.3 of ENV 1996-1-1 are given in **D.2** to **D.4**.

D.2 Category A level of execution

(1) Supervision of the work is done by appropriately qualified and experienced personnel, from the construction organisation.

(2) Regular inspection by appropriately qualified and experienced personnel, familiar with the design and independent of the construction organisation, is made to verify that the work is being executed in accordance with the design specification.

NOTE : In the case of Design and Build Contracts, the Designer may be considered as a person independent of the construction organisation for the purposes of inspection of the work, provided that the Designer is an appropriately qualified person who reports to senior management independently of the construction team.

D.3 Category B level of execution

(1) Supervision of the work is done by appropriately qualified and experienced personnel, from the construction organisation.

D.4 Category C level of execution

(1) Category C may be assumed, when the rules for Category A or Category B are not met.

Annex E (informative) Reference panels

E.1 General

(1) Reference panels are one method for assessing the appearance of the finished masonry. Although the method cannot cover possible future visual defects such as lime blowing or the effects of freeze /thaw cycling, it may be used to assess consistency of the execution in respect of colour, texture and jointing.

E.2 Erection of reference panels

(1) Reference panels should be erected on a level firm foundation in a dry location, having good natural daylight.

(2) Reference panels should be sited so that they can be retained for further inspection and reference and should, therefore be protected from damage and the weather. Where necessary, provision should be made for ensuring lateral stability.

(3) Reference panels should be constructed to expose not less than 1 m^2 area of masonry facing or the faces of at least 100 masonry units, whichever is the lesser.

(4) The units should be selected as reasonably representative of the average quality of the whole consignment to be delivered.

(5) Reference panels should be built so that each one reasonably represents the finished work. In particular, masonry units should be laid in the bond selected for the finished work, using mortar of the same colour as for the finished work. Where colour and texture are to be included in the assessment, the joints should be tooled in the same manner as for the finished work.

E.3 Assessment of masonry

(1) Reference panels should be completed and accepted by all relevant parties prior to erection of the particular masonry to be assessed.

(2) The finished masonry should be viewed at the same distance as the corresponding reference panel.

(3) Agreement should be reached where, without close scrutiny of individual masonry units, the finished masonry and the reference panel do not differ significantly.

> NOTE : A viewing distance of 3 m is normally satisfactory for the purposes of this assessment. This distance may be varied by prior agreement between the parties. It should be noted that there may be differences in the incidence of minor visual defects, when compared with the reference panel, but the reference panel should be indicative of the average quality of the masonry.

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