

Code of practice for

Use of masonry —

**Part 3: Materials and components,
design and workmanship —**

(formerly CP 121-1)

UDC 624.012:693.1/3

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Civil Engineering and Building Structures Standards Committee (CSB/-) to Technical Committee CSB/33, upon which the following bodies were represented:

- Association of Consulting Engineers
- Autoclaved Aerated Concrete Products Association
- Brick Development Association
- British Ceramic Research Association
- British Precast Concrete Federation Ltd.
- Building Employers Confederation
- Calcium Silicate Brick Association Limited
- Cement and Concrete Association
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Housing and Construction Industries)
- Department of the Environment (Property Services Agency)
- District Surveyors Association
- Greater London Council
- Incorporated Association of Architects and Surveyors
- Institution of Civil Engineers
- Institution of Structural Engineers

The following bodies were also represented in the drafting of the standard, through sub-committees and panels:

- Aggregate Concrete Block Association
- Association of British Roofing Felt Manufacturers
- Association of Teachers in Technical Institutions
- Eurisol (UK) Association of Manufacturers of Mineral Fibre Insulation
- Fire Offices Committee
- Institute of Clerks of Works of Great Britain Inc.
- National Cavity Insulation Association
- National Federation of Clay Industries Ltd.
- Refractories Association of Great Britain
- Royal Institute of British Architects
- Royal Institution of Chartered Surveyors
- Coopted members

This British Standard, having been prepared under the direction of the Civil Engineering and Building Structures Standards Committee, was published under the authority of the Board of BSI and comes into effect on 29 March 1985

© BSI 11-1999

The following BSI references relate to the work on this standard:
Committee reference CSB/33
Draft for comment 77/11249 DC

ISBN 0 580 14368 6

Amendments issued since publication

Amd. No.	Date of issue	Comments
4974	November 1985	Indicated by a sideline in the margin

Contents

	Page
Committees responsible	Inside front cover
Foreword	iii
Section 1. General	
1 Scope	1
2 Definitions	1
3 Related British Standards	3
4 Alternative materials, components and methods of design and construction	3
Section 2. Materials and components	
5 Masonry units	4
6 Materials for mortar	4
7 Wall ties	4
8 Anchorages, dowels and fixings	4
9 Reinforcement	6
10 Damp-proof courses	6
11 Sealants	6
12 Airbricks, gratings and flues	6
13 Sills	6
14 Lintels	7
15 Copings	7
16 Flashings and weatherings	8
Section 3. Design	
17 General	9
18 Design for stability	10
19 Structural detailing for stability	19
20 Movement in masonry	31
21 Exclusion of moisture	36
22 Durability	56
23 Selection of mortars	67
24 Fire resistance	68
25 Thermal properties	73
26 Sound absorption and noise reduction	73
27 Masonry bonds and other constructional details	74
Section 4. Workmanship	
28 Setting out	83
29 Scaffolding	83
30 Storage on site	83
31 Batching, mixing and use of mortars	84
32 Laying of masonry units	86
33 Constructional details	90
34 Provision of services, including fixings and chases	91
35 Protection against damage during construction	91
36 Supervision	92
Appendix A Determination of movement in masonry	93
Appendix B Masonry bonds and joint finishes	98
Index	102
Figure 1 — Wind zones	12
Figure 2 — Walls with edge restraint	14

	Page
Figure 3 — Fixed support conditions in solid walls	15
Figure 4 — Fixed support conditions in cavity walls	16
Figure 5 — Fixed and simple supports	17
Figure 6 — Limiting dimensions of internal walls for stability	18
Figure 7 — Typical ways of connecting floors and roofs	20
Figure 8 — Typical anchorages, dowels and fixings	26
Figure 9 — Typical chimney details	29
Figure 10 — Movement joints	35
Figure 11 — Overlap between exposure categories	38
Figure 12 — Damp-proof systems	47
Figure 13 — Matching facing masonry	77
Figure 14 — Brick arches	81
Figure 15 — Sizes of corbels	82
Figure 16 — Factors affecting movement	96
Figure 17 — Brick masonry bonds	99
Figure 18 — Block masonry bonds	100
Figure 19 — Joint finishes	101
Table 1 — Anchorages, dowels and fixings	5
Table 2 — Sills	6
Table 3 — Lintels	7
Table 4 — Copings	7
Table 5 — Flashings and weatherings	8
Table 6 — Selection of materials for masonry	10
Table 7 — Height to thickness ratio for freestanding single-leaf walls without piers	11
Table 8 — Maximum permitted areas of certain walls	13
Table 9 — Wall ties	28
Table 10 — Classification of exposure to local wind-driven rain	37
Table 11 — Assessment of resistance to rain penetration	39
Table 12 — Physical properties and performance of materials for d.p.cs	42
Table 13 — Durability of masonry in finished construction	59
Table 14 — Protection of metal components (other than wall ties) built into masonry	66
Table 15 — Mortar mixes	67
Table 16 — Notional fire resistance of walls	69
Table 17 — Ready-mixed lime : sand mixes for specified cement : lime : sand mortars	85
Table 18 — Bulk density, water demand and yield of wet mortars	86
Table 19 — Linear thermal movement of masonry units and mortar	94
Table 20 — Moisture movement of concrete and calcium silicate masonry units	95
Table 21 — Shrinkage of mortars due to change in moisture content	95
Publications referred to	Inside back cover

Foreword

This Part of BS 5628, prepared under the direction of the Civil Engineering and Building Structures Standards Committee, is a new code of practice for the design and construction of brick and block masonry. It supersedes CP 121-1:1973, which is therefore withdrawn.

The recommendations of this code are based on experience of single-leaf and unfilled cavity walls. Filling the complete cavity of a wall with thermal insulation will increase the risk of rain penetration through the wall. (See BRE Digest 236 “Cavity Insulation” 1980¹⁾.)

Accordingly, a number of recommendations have been made for design detailing and workmanship to minimize this effect of cavity insulation on the performance of the wall.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 108, an inside back cover and a back cover.

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

¹⁾ Available from the Building Research Station, Garston, Watford, Herts WD25 9AR.

Section 1. General

1 Scope

This Part of BS 5628 gives general recommendations for the design and construction of brick and block masonry, including materials and components, the main aspects of design, other than structural, which is covered by BS 5628-1 and BS 5628-2, and workmanship.

This code does not cover natural stone masonry. Reference should be made to BS 5390.

NOTE The publications referred to in this standard are listed on page 107.

2 Definitions

For the purposes of this standard the definitions given in BS 6100-5 or in the British Standard for the given material or component apply together with the following.

2.1

bat

portion of a brick either specially manufactured or cut on site

2.2

capping

unit or assemblage placed at the head of a wall that does *not* shed rainwater from the top of the wall clear of all exposed surfaces of the walling beneath

NOTE Examples of cappings are brick-on-edge and other cappings that may be flush or overhanging but that do *not* incorporate a throating or other device designed to shed rainwater clear of the walling beneath.

2.3

cavity tray

component provided to divert water that has entered a cavity to the outside of the building

2.4

closer

portion of a masonry unit used to maintain masonry bond, either specially manufactured or cut [see Figure 17(a)]

2.5

coping

unit or assemblage placed at the head of a wall and designed to shed rainwater from the top of the wall clear of all exposed faces of the walling it is intended to protect

NOTE Examples of copings are copings complying with BS 5642-2, some types of continuous sheet metal or extruded plastic copings and built up details, such as tile creasing.

2.6

course

layer of masonry that includes a layer of mortar as well as a layer of units

2.7

datum

defined level to which other levels may be related

2.8

efflorescence

salts on the surface of the wall left by evaporation (see clause 22)

2.9

fair faced

work built with particular care, both to line and with even joints, where the finished work is to be visible

2.10

frog

purpose-made indentation in either or both of the bed faces of a brick

2.11

indenting

recesses formed in masonry to receive future work

2.12

jamb

part of a wall at the side of an opening

2.13

jointing

finishing of a mortar joint as the work proceeds (see B.3)

2.14

lime bloom

particular kind of efflorescence (see 2.8)

2.15

masonry

assemblage of units jointed with mortar

2.16

masonry bond

disposition of units in masonry (for examples, see B.1 and B.2)

2.17

masonry unit

brick or block

2.18

panel

area of masonry with defined boundaries, that may contain openings

2.19

pier

member that forms an integral part of a wall, in the form of thickened sections placed at intervals along the wall

2.20**pointing**

filling and finishing of raked-out joints

2.21**quoin**

external corner

2.22**string course**

distinctive course in a wall, usually horizontal, and projecting

2.23**toothing**

masonry units left projecting to bond with future work

2.24 Types of joint**2.24.1****bed joint**

mortar layer upon which masonry units are set

2.24.2**collar joint**

continuous vertical joint parallel to the face of the wall

2.24.3**cross joint**

joint, other than a bed joint, at right angles to the face of a wall

2.24.4**movement joint (control joint)**

joint designed to permit relative movement of sections of a structure built in masonry to occur without impairing the functional integrity of the structure (see Figure 10)

2.24.5**perpend joint**

vertical cross joint

2.25**shell bedding**

bedding consisting of two separate strips of mortar covering the outer and inner face shells of the blocks in both horizontal and vertical joints, neither strip being more than 50 mm wide

2.26 Types of masonry unit**2.26.1****fixing unit**

masonry unit made to facilitate the driving of nails and screws and to achieve good holding

2.26.2**header**

masonry unit laid on its bed face with its longer face perpendicular to the face of the wall [see Figure 17(a)]

2.26.3**pistol brick**

brick, purpose made or sawn from whole brick on site to form an accurate sized rebated shape to fit over and face the nibs [see Figure 13(b)]

2.26.4**slip**

masonry unit, either specially manufactured or cut, of the same height and length as a header (see 2.26.2) or stretcher (see 2.26.8), and usually with a thickness of between 20 mm and 50 mm

2.26.5**snap header**

half unit with its end showing as a header (see 2.26.2) on the face of the wall

2.26.6**special unit**

masonry unit whose shape is other than a rectangular prism

2.26.7**squint**

special brick used at an oblique quoin

2.26.8**stretcher**

masonry unit laid on its bed with its longer face parallel to the face of the wall [see Figure 17(a)]

2.27 Types of support**2.27.1****fixed support**

support to the edge of a wall that restrains the wall against lateral movement and also substantially against rotation [see Figure 5(a)]

2.27.2**simple support**

support to the edge of a wall that may permit rotation but restrains the wall against lateral movement [see Figure 5(b)]

2.28 Types of wall**2.28.1****single-leaf wall**

wall of masonry units laid to overlap in one or more directions and set solidly in mortar

2.28.2**cavity wall**

two parallel single-leaf walls, usually at least 50 mm apart and effectively tied together with wall ties

2.28.3**double-leaf (collar-jointed) wall**

two parallel single-leaf walls, with a space between not exceeding 25 mm, filled solidly with mortar and so tied together as to result in common action under load

2.28.4**freestanding wall**

wall without top or side support that depends for stability on its mass and/or base fixity

2.28.5**grouted cavity wall**

two parallel single-leaf walls, spaced at least 50 mm apart, effectively tied together with wall ties and with the intervening cavity filled with fine aggregate concrete (grout) that may be reinforced so as to result in common action under load

2.28.6**sleeper wall**

wall, usually honeycombed, built to support a suspended ground floor

2.28.7**veneered wall**

wall having a facing that is attached to the backing, but not so bonded as to result in common action under load

2.29**weathering**

cover applied to a structure, or the geometrical form of a part of a structure, enabling rain-water to be shed

3 Related British Standards

This code gives general guidance applicable to all brick and block masonry. In certain cases its recommendations may need to be supplemented by reference to other British Standards, including the following.

Analysis of structures

Unreinforced masonry	BS 5628-1
----------------------	-----------

Reinforced and prestressed

masonry	BS 5628-2
---------	-----------

Accuracy in building

BS 5606

Access for the disabled to buildings

BS 5810

Basic data for design of buildings

BS 6399, CP 3

Cleaning and surface repair of masonry

BS 6270-1

Foundations

CP 101, CP 2004

Manholes

BS 8301, CP 2005

4 Alternative materials, components and methods of design and construction

Where materials, components and methods of design and construction are not covered by this code or by any other British Standard, this is not to be regarded as discouraging their use. The designer should satisfy himself by reference to appropriate manufacturers' literature and test certificates issued by competent, independent authorities that the materials and methods to be employed are such as to ensure a level of performance at least equal to that recommended in this standard.

Section 2. Materials and components

5 Masonry units

5.1 Fired-clay masonry units

Fired-clay masonry units should comply with BS 3921 or BS 6649.

5.2 Calcium silicate masonry units

Calcium silicate masonry units should comply with BS 187 or BS 6649.

5.3 Concrete masonry units

Concrete masonry units should comply with the relevant British Standard.

Concrete flue blocks	BS 1289
Precast concrete masonry units	BS 6073-1
Reconstructed stone masonry units	BS 6457

6 Materials for mortar

6.1 Cement

Cement should comply with the relevant British Standard.

Portland cement (ordinary and rapid hardening)	BS 12
Portland blastfurnace cement	BS 146-2
Sulphate-resisting Portland cement	BS 4027
Masonry cement	BS 5224

6.2 Lime

Limes should comply with BS 890.

6.3 Aggregate

6.3.1 Natural aggregates. When specifying aggregates from natural sources designers should refer to BS 882 or BS 1200. For guidance, see clause 23.

6.3.2 Lightweight aggregates. Lightweight aggregates should comply with BS 877-2 or BS 3797-2.

6.4 Admixtures

6.4.1 General. Admixtures may affect the strength and adhesion of mortars and care should be exercised in their use. For guidance, see clause 23.

6.4.2 Calcium chloride. Calcium chloride and admixtures containing calcium chloride should never be added to mortars (see 23.3).

6.4.3 Plasticizers. Mortar plasticizers should comply with BS 4887. For guidance on use, see 23.2.5 and 31.3.

6.4.4 Colouring agents. Colouring agents (pigments) should comply with BS 1014. For guidance on use, see 31.3.

6.5 Water

Water should be mains water or other potable supply. If mains water is not available, the water should be clean and should not contain any material, either in solution or in suspension, in quantity sufficient to have a harmful effect on the mortar or on metals or to impair the durability of the construction.

In cases where water supplies may be of doubtful quality, the methods of sampling and testing the water should be as described in BS 3148.

6.6 Ready-to-use mortars and ready-mixed lime : sand

Ready-mixed lime : sand for mortar and ready-to-use retarded cement : lime : sand and retarded cement : sand mortars, which are all delivered wet to the site, should comply with BS 4721.

Dry-packaged cementitious mixes should comply with BS 5838-2.

NOTE 1 The term sand is used here to include all permitted aggregates.

NOTE 2 Ready-mixed lime : sand for mortar is produced by adding damp sand to lime in the form of lime putty or dry hydrated lime. This process is normally undertaken in a factory away from the building site.

NOTE 3 Ready-to-use building mortars are factory made mortars (cement : lime : sand and cement : sand) which contain a cement-set retarding admixture and require no further treatment before use. The cement is normally ordinary Portland cement but may be sulphate-resisting Portland cement or Portland-blastfurnace cement or, for non-lime mortars, masonry cement.

7 Wall ties

Wall ties should comply with BS 1243. For guidance on selection and use of wall ties, see 19.5.

8 Anchorages, dowels and fixings

Materials for anchorages, dowels and fixings, including bonding ties, joist hangers and lateral restraint straps, are given in Table 1.

For guidance on selection of materials for anchorages, dowels and fixings, see 22.7.1.

Typical fixings are illustrated in Figure 8.

Joist hangers required only for vertical support should comply with BS 6178-1. Joist hangers required both for vertical support and lateral support, as shown in Appendix C of BS 5628-1:1978, should be purpose made.

Table 1 — Anchorages, dowels and fixings

Category	Base material	Form	Grade and standard to be complied with	Protective measures to be carried out after fabrication
A	Hot-dip galvanized low carbon steel	Sheet	BS 2989, Z1 or Z2, coating type G 600. Minimum mass of coating 600 g/m ² including both sides	All external cut edges to be protected using a one-pack chemical-resistant paint complying with HF1A to HF2F in part 4 of Table 4H of BS 5493:1977 and modified to give adequate adhesion to the fixing
			BS 2989, Z1 or Z2, coating type G 275. Minimum mass of coating 275 g/m ² including both sides	Coating to be applied after fabrication to the external surfaces and consisting of either: a) bituminous solution complying with types 1 or 2 of BS 3416 and of minimum thickness 25 µm; <i>or</i> b) a one-pack chemical-resistant paint complying with HF1A to HF2F in part 4 of Table 4H of BS 5493:1977 and modified to give adequate adhesion to the fixing. Where the zinc is removed on internal surfaces during fabrication, e.g. by welding, further protection should be applied to these areas
B	Low carbon steel	Strip	BS 1449-1:1983 (mechanical requirements in Table 11 only)	Post-galvanizing complying with BS 729.
			BS 4360 grade 43A	Minimum mass of coating 460 g/m ² including both sides
C	Low carbon steel	Strip	BS 1449-1:1983 (mechanical requirements in Table 11 only)	Post-galvanizing complying with BS 729.
			BS 4360 grade 43A	Minimum mass of coating 940 g/m ² including both sides
D	Copper		BS 6017	
	Copper alloys		BS 2870:1980, grades listed in Tables 8 and 12	Material other than phosphor bronze to be formed either: a) by bending at dull red heat and allowing to cool in still air; <i>or</i> b) by cold forming and subsequently stress relief annealing at 250 °C to 300 °C for 30 min to 1 h Effectiveness of stress relieving of cold formed components to be tested by the supplier using the mercurous nitrate test described in clause 11 of BS 2875:1969
			BS 2873:1969, grades listed in Tables 4 and 6	
			BS 2874:1968, grades listed in Tables 6, 8 and 9 <i>except</i> CA 106	
	Austenitic stainless steel, minimum 18/8 composition and excluding free machining specifications	Strip	BS 1449-2	
		Bar	BS 970-1	
		Rod	BS 6323-8	
		Tube	BS 1554	
		Wire	BS 3111-2	

9 Reinforcement

Reinforcement for structural use should follow the recommendations of BS 5628-2. Reinforcement for non-structural use, e.g. crack control (see **20.5**), should be of a type approved by the designer.

Stainless steel reinforcement should be fabricated from austenitic stainless steel complying with grades 3042S15, 316S31 or 316S33 of BS 970-1. Other types of steel reinforcement should be protected against corrosion (see **22.7**).

10 Damp-proof courses

Materials for damp-proof courses (d.p.cs) should comply with the relevant British Standard.

Bitumen	BS 6398
Brick	BS 3921
Polyethylene	BS 6515
All others	BS 743

The criteria for suitability of materials for d.p.cs are set out in **21.4** and Table 12.

11 Sealants

Sealants should comply with the relevant British Standard.

One-part polysulphide sealants	BS 5215
Two-part polysulphide sealants	BS 4254
Silicone-based building sealants	BS 5889

For guidance on choice and application of sealants and back up materials, see **20.4**.

12 Airbricks, gratings and flues

Airbricks and gratings should comply with BS 493. Flues should follow the recommendations of BS 5440-1 or BS 6461, as appropriate.

13 Sills

Sills should comply with the relevant British Standard given in Table 2. For guidance on d.p.cs below sills, see **21.5.3**.

Table 2 — Sills

Material	Standard to be complied with	Other recommendations
Brick and block	BS 187, BS 3921 or BS 6073-1	Sills formed from bricks or blocks should be in accordance with Table 13 (I)
Cast stone	BS 5642-1	
Clay tile	BS 402	
Clayware	BS 5642-1	
Concrete	BS 5642-1	
Natural stone	BS 5642-1	
Slate	BS 5642-1	
Steel	BS 6510	
Timber	BS 1186-1 and BS 1186-2 and BS 5642-1	Timber sills should comply with the requirements for coordinating dimensions and performance given in BS 5642-1 and the requirements for quality given in BS 1186-1 and BS 1186-2

14 Lintels

Lintels should comply with the relevant British Standard given in Table 3. For guidance on use, see 19.3 and on workmanship, see 33.4.

15 Copings

Copings should comply with the relevant British Standard given in Table 4. For guidance on use, see 21.6.

Copper copings may cause staining of external walls. To avoid electrolytic action between metallic copings and metal roofing where dissimilar metals are to be used, consideration should be given to the use of non-metallic copings.

Table 3 — Lintels

Material	Standard to be complied with	Other recommendations
Autoclaved aerated concrete Cast concrete Reinforced concrete	BS 5977-2	
Pressed steel Rolled low carbon steel	BS 5977-2	
Prestressed concrete plank	BS 5977-2	
Reinforced masonry	BS 5628-2	Bricks and blocks used for lintels should be of the appropriate quality recommended in Table 13.
Timber	BS 5977-2	

Table 4 — Copings

Material	Standard to be complied with	Recommended thickness	Other recommendations
Aluminium	BS 1470	mm 0.9 min.	Commercial or super purity quality aluminium should be used. Copings should preferably be preformed
Brick and block	BS 187, BS 3921 or BS 6073-1		Copings formed from bricks or blocks should be of the appropriate quality recommended in Table 13 (I)
Cast stone	BS 5642-2		
Clay tile	BS 402 or BS 1286		
Concrete (cast)	BS 5642-2		
Concrete tile	BS 473 & BS 550 or BS 1197		
Copper	BS 2870, grades C 104 or C 106 in the O condition		
Lead	BS 1178	1.8 min. (code no. 4)	
Natural stone	BS 5642-2		
Zinc	BS 849	0.8 min.	Copings should preferably be preformed. In heavily polluted atmospheres, it is advisable to use a heavier sheet, e.g. 1.0 mm thick or use another material

16 Flashings and weatherings

Flashings and weatherings should comply with the relevant British Standard given in Table 5. For guidance on use, see 21.6.

Table 5 — Flashings and weatherings

Material	Standard to be complied with	Recommended thickness	Other recommendations
Aluminium Aluminium alloy	BS 1470	mm 0.6 to 0.9 (sheet or strip)	Flashings and weatherings should be protected from contact with mortar by a coating of bituminous paint
Asbestos bitumen sheet (semi-rigid)			See CP 143-16
Bituminous felt	BS 747		For guidance on installation, see CP 144
Copper	BS 2870 grades C 104 and C 106 in the O condition	0.4 to 0.7	
Lead	BS 1178	1.8 min. (code no. 4)	
Zinc	BS 849		

Section 3. Design

17 General

17.1 Factors to be considered

The designer should consider the following factors when designing masonry:

- a) stability (see clauses 18 and 19);
- b) accommodation for movement (see clause 20);
- c) adhesion (see 17.5);
- d) resistance to rain penetration (see clause 21);
- e) durability (see clause 22);
- f) fire, thermal and acoustic performance (see clauses 24, 25 and 26);
- g) masonry bonds, provision of services and other constructional details (see clause 27).

Other factors, not dealt with in detail in this code, may also need to be considered:

- 1) whether there is an applied facing or finish to provide characteristics not inherent in the basic construction, and the compatibility of this facing or finish with the masonry;
- 2) the effect of the weight of the wall, including finishes, on the strength of the supporting structure;
- 3) the effect of the thickness of the wall, including finishes, on the useable floor area;
- 4) speed of construction;
- 5) accuracy of construction.

17.2 Loading

The loading requirements for masonry and the lateral wind pressures that should be allowed for in design are given in BS 6399-1 and CP 3:Chapter V-2. Masonry should also be designed to withstand any additional loads which may arise, e.g. if materials are to be stacked or heaped against walls.

17.3 Impact resistance

Impact damage may be caused to walls in various ways. Where there is an applied finish, resistance to light impacts is largely a matter of the resistance of this finish. Where the wall is likely to be subject to heavier impact loads, either the structure of the wall and the applied finish should be sufficiently strong and stable to withstand the impact without undue damage, or the wall should be protected, e.g. by positioning of bollards where there is danger of damage from motor vehicles.

17.4 Foundations

Masonry walls should be built on adequate foundations. For guidance, see CP 101 and CP 2004.

17.5 Adhesion

It is essential to ensure that in any masonry construction adequate adhesion exists between the masonry units and the mortar. Where the design relies on flexural strength and there is insufficient experience or information on the adhesion characteristics of particular masonry units and mortar designations, preliminary tests as described in A.3 of BS 5628-1:1978 should be carried out to establish whether adequate adhesion can be achieved.

Depending on their characteristics, masonry units may be highly porous and, particularly in warm weather, rapidly absorb the moisture from the mortar when laid. In such cases the mortar becomes harsh and insufficiently plastic to allow repositioning of the unit during laying and levelling and it is possible that no adhesion between the unit and the mortar will be obtained.

Experience has shown that adhesion will be adversely affected when masonry is allowed to dry out rapidly in warm, dry conditions. Laying mortar beds in shorter lengths, thus limiting water loss from the mortar before the next course is laid, is advantageous in such conditions.

Wetting may assist in removing dust from bricks and thus further improve adhesion. However, the bricks should not be over wetted, as this may lead to "floating" on the mortar bed and also to excessive efflorescence and staining of the brick face.

In fired-clay brickwork, optimum adhesion is likely to be achieved when the suction rate of the bricks at the time of laying is not greater than 1.5 kg/(m².min). A suitable test for suction rate of fired-clay bricks is given in Appendix H of BS 3921:1985. Where the achievement of maximum flexural strength is critical, e.g. in infill panels, and bricks of higher suction rate are used, the consistency of the mortar should be adjusted or the bricks should be wetted (docked) just before use.

In very dry conditions, easier laying and better adhesion of calcium silicate bricks may be achieved by adjusting the consistency of the mortar or dipping the bricks briefly in water just before use. The bricks should not be soaked in water.

Concrete masonry units should not be wetted. Instead, the consistency of the mortar should be adjusted to suit the suction, if necessary using water-retaining admixtures.

For guidance on the characteristics of particular masonry units and appropriate wetting procedures, the manufacturer should be consulted.

17.6 Selection of masonry units and materials

The selection of masonry units and associated materials should be made bearing in mind the criteria listed in Table 6.

Table 6 — Selection of materials for masonry

Criterion	Clause reference
Durability	22
Strength	18, 23
Adhesion	17.5
Fire resistance	24
Thermal and acoustic properties	25, 26
Handling, including weight of blocks	35
Appearance	—

18 Design for stability

18.1 Masonry in general

All masonry should be designed to have adequate strength, stiffness and stability. The designer should consider the interaction of the whole structure, of which the masonry forms part, to ensure that connections of other elements with walls are sufficient to transmit all vertical and lateral loads safely to the foundations. Temporary support for masonry during construction may need to be considered, e.g. where composite action is required.

Recommendations for the structural design of masonry are given in BS 5628-1 and BS 5628-2.

Depending on the type of masonry, the necessary stiffness and stability are derived from one or more of the following.

- a) Thickness in relation to height and length.

NOTE The useful thickness will be reduced by using recessed joints.

- b) Self weight.
- c) Presence of piers.
- d) Interaction with other walls, columns, floors, roofs or structural elements.

Careful consideration should be given to the effect of introducing movement joints or slip planes.

The designer should always bear in mind the need for robust construction, including the effect of accidental loading.

18.2 Walls and columns subjected to imposed vertical and lateral loads

Walls and columns subjected to imposed vertical and lateral loads should be designed following the recommendations of BS 5628-1 or BS 5628-2.

18.3 Walls subjected to concentrated loads

Where a concentrated load occurs in a wall, e.g. at a lintel or beam bearing, due regard should be given to the local bearing stress (see clause 34 of BS 5628-1:1978) and, where necessary, suitable bearing plates, spreader beams, padstones, piers or columns should be provided.

Lintels or beams should not bear on a short length of cut block. Where possible, the masonry should be set out to provide a full block under a bearing.

Certain types of cellular, frogged or hollow unit which are normally suitable for the construction of the wall may not provide sufficient bearing strength at points of concentrated load and may need to be filled.

18.4 Walls subjected to imposed lateral load only

18.4.1 Freestanding walls. The recommendations in this subclause apply to freestanding single-leaf walls without piers that are subjected only to wind loads. Other types of freestanding wall should be designed following the recommendations of BS 5628-1 or BS 5628-2. For guidance on loading and minimum heights for parapets and balustrades, see BS 6180.

Freestanding single-leaf walls without piers that are subjected only to wind loads may be designed with a height to thickness ratio as given in Table 7, subject to the following conditions.

- a) The height should be taken to be the overall height of the wall above the level of lateral restraint.
- b) The walls should be constructed of masonry units having a compressive strength not less than 3.5 N/mm^2 and a density not less than 1400 kg/m^3 , subject to the recommendations for durability given in clause 22.
- c) The walls should be located in an area with many windbreaks, such as a town, city or well wooded area, i.e. in protection category 3 described in DD 93.

If the wall is located in open farmland, on the top of an escarpment or cliff, or in any other exposed area, the wall should be designed following the recommendations of BS 5628-1 or BS 5628-2.

- d) The walls should either not contain a horizontal d.p.c. or have a d.p.c. which is capable of developing the same flexural resistance as the remainder of the wall, e.g. engineering bricks.

Table 7 — Height to thickness ratio for freestanding single-leaf walls without piers

Wind zone (see Figure 1)	Maximum permitted height to thickness ratio, R
1	8.5
2	7.5
3	6.5
4	6.0

A horizontal d.p.c. which cannot resist flexure will reduce the stability of the wall. If such a d.p.c. is used, the wall thickness should be taken to be the greater of:

$$1.33h_d/R,$$

or

$$h_l/R,$$

where

h_d is the height of the wall above the d.p.c.;

R is the ratio obtained from Table 7 for the appropriate wind zone;

h_l is the height of the wall above the lowest level of lateral restraint below the d.p.c.; lateral restraint to the base of walls may be assumed where there is a continuous support, e.g. a concrete slab.

18.4.2 Walls with edge restraint

18.4.2.1 Maximum areas of walls. Walls with edge restraint which are subjected to wind loads may be designed following the recommendations of BS 5628-1. However, certain rectangular walls and gables in buildings up to and including four storeys high may be proportioned as given in Table 8, subject to the following conditions.

a) The walls should be in buildings up to and including four storeys high situated in the wind zones shown in Figure 1.

b) The building of which the wall forms part should be situated in an area with many windbreaks, such as a town, city or well wooded area, i.e. in protection category 3 described in DD 93.

If the building is located in open farmland, on the top of an escarpment or cliff, or in any other exposed area, the wind pressure should be obtained from CP 3:Ch V-2 and the wall designed following the recommendations of BS 5628-1 or BS 5628-2.

c) The walls should be free from any doors, windows or other openings, unless either:

1) intermediate supports are provided, such as those shown in Figure 2(a);

or

2) the total area of such openings is not greater than 10 % of the appropriate maximum area given in Table 8 or 25 % of the actual area of the wall, whichever is the less, and no opening is less than half its maximum dimension from the edge of the wall, other than its base, or from any other opening [see Figure 2(b)].

d) In a single-leaf, double-leaf or grouted-cavity wall, the distance between supports should not exceed 40 times the total thickness of the wall.

e) In a cavity wall:

1) the distance between supports should not exceed 30 times the total thickness of the masonry in the wall;

2) the thickness of each leaf should be not less than 100 mm *excluding* plaster or render;

3) the cavity width should not exceed 100 mm;

4) wall ties should be spaced in accordance with 19.5.

f) Pitched gable ends which have support at the top (see 19.2) should be regarded as being equivalent to a rectangular area whose height is measured to half way up the triangular portion [see Figure 2(c)]. Three- or four-sided support should be assumed as appropriate.

g) Mortar should not be weaker than designation iii) (see Table 15).

18.4.2.2 Support conditions. A fixed support may be assumed in a single-leaf, double-leaf or grouted-cavity wall in the cases shown in Figure 3 or where the wall abuts, and is adequately tied to, a column capable of resisting without excessive deflection horizontal forces applied to it.

A fixed support may be assumed in a cavity wall in the cases shown in Figure 4.

A simple support may be assumed where the wall is permitted to rotate but is restrained against lateral movement.

In all cases, the wall should be adequately connected to its support and all supports should be sufficiently strong and rigid to carry the transmitted loads. For guidance, see Figure 5.

Any chases cut in the wall should be taken account of (see 19.6).

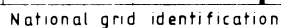
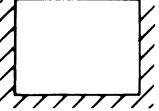
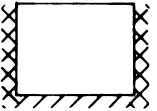
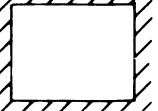


Figure 1 — Wind zones (for use with 18.4)

Table 8 — Maximum permitted areas of certain walls

Wind zone	Height																		
		A		B		C		D		E		F		G		H		I	
		Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall	Cavity wall	190 mm solid wall
1	m	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²	m ²
	5.4	11.0	13.5	17.5	19.0	26.5	28.5	20.5	29.0	32.0	41.0	32.0	41.0	8.5	10.0	14.0	19.0	19.5	30.5
2	10.8	9.0	11.5	13.0	15.5	17.5	21.5	15.5	23.5	24.0	32.5	32.0	41.0	7.0	8.0	10.0	14.5	15.5	21.5
	5.4	9.5	12.0	14.0	17.0	21.0	24.0	17.5	25.5	27.0	35.5	32.0	41.0	7.5	8.5	10.5	16.5	17.0	24.5
3	10.8	8.0	9.5	11.5	14.0	13.5	17.5	13.0	20.5	19.0	28.5	28.0	36.5	6.0	7.0	9.0	11.0	13.0	17.5
	5.4	8.5	10.5	12.5	15.0	15.5	20.0	14.5	22.5	22.0	31.0	30.5	40.5	6.5	7.5	9.5	13.5	14.5	20.0
4	10.8	7.0	8.5	10.0	12.0	11.5	15.5	11.0	17.5	14.5	24.5	24.5	31.5	5.0	6.0	7.5	9.0	11.5	15.0
	5.4	8.0	9.5	11.0	13.5	13.0	17.0	12.5	19.5	18.0	27.5	27.0	35.0	6.0	6.5	8.5	10.5	12.5	17.0
	10.8	6.5	7.5	9.0	11.0	10.5	13.5	9.5	14.5	12.5	21.0	21.5	27.5	4.0	5.5	6.5	7.5	10.0	12.5

NOTE 1 Key to support conditions. Types of support are described in 18.4.2.2.

Free edge shown thus 

Simple support shown thus 

Fixed support shown thus 

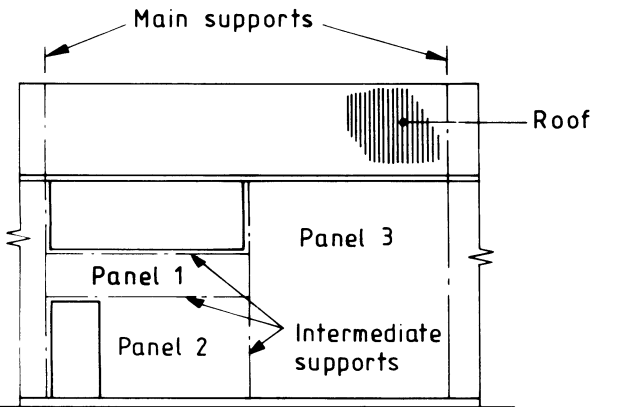
NOTE 2 The term solid is used in this table to denote single-leaf walls, collar-jointed walls (see 2.28.3) or grouted-cavity walls (see 2.28.5). The 190 mm solid walls are of any brick, or blocks of compressive strength not less than 3.5 N/mm².

NOTE 3 Cavity walls consist of the following:

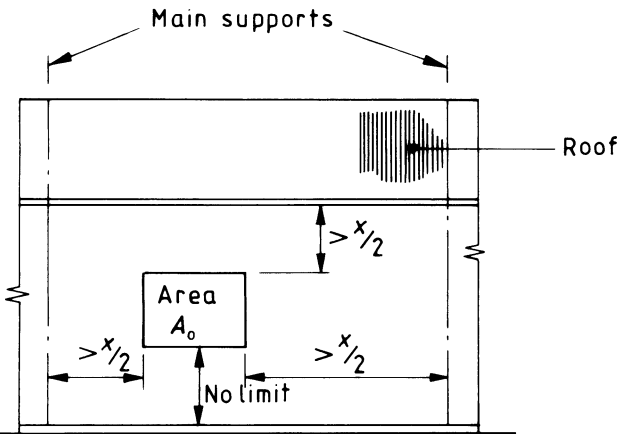
a) an outer leaf, 100 mm minimum thickness, of any brick or blocks of compressive strength not less than 14.0 N/mm².

b) an inner, leaf, 100 mm minimum thickness, of any brick, or blocks of compressive strength not less than 3.5 N/mm².

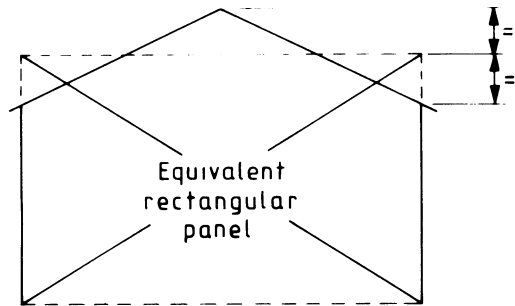
If either leaf of a cavity wall is increased to 140 mm using blocks of the respective strength, the areas given in the table may be increased by 20 %.



(a) Example of division of a wall into panels with intermediate supports



x is the maximum dimension of opening (height or length)
 A_o is the permitted area of opening [see 18.4.2.1 c)].
(b) Effect of opening in a wall



(c) Gable walls [see 18.4.2.1 f)].

Figure 2 — Walls with edge restraint

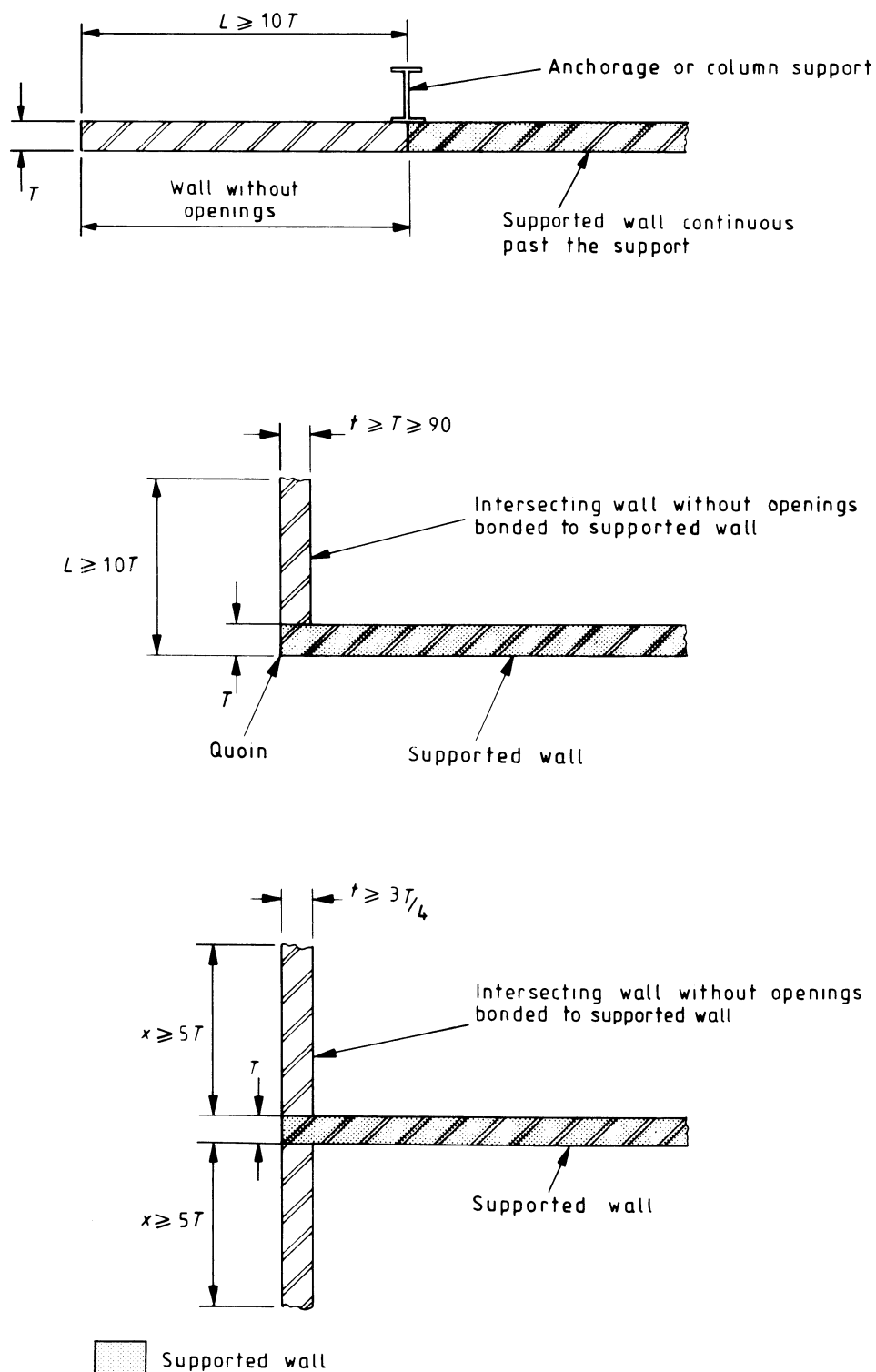


Figure 3 — Fixed support conditions in solid walls

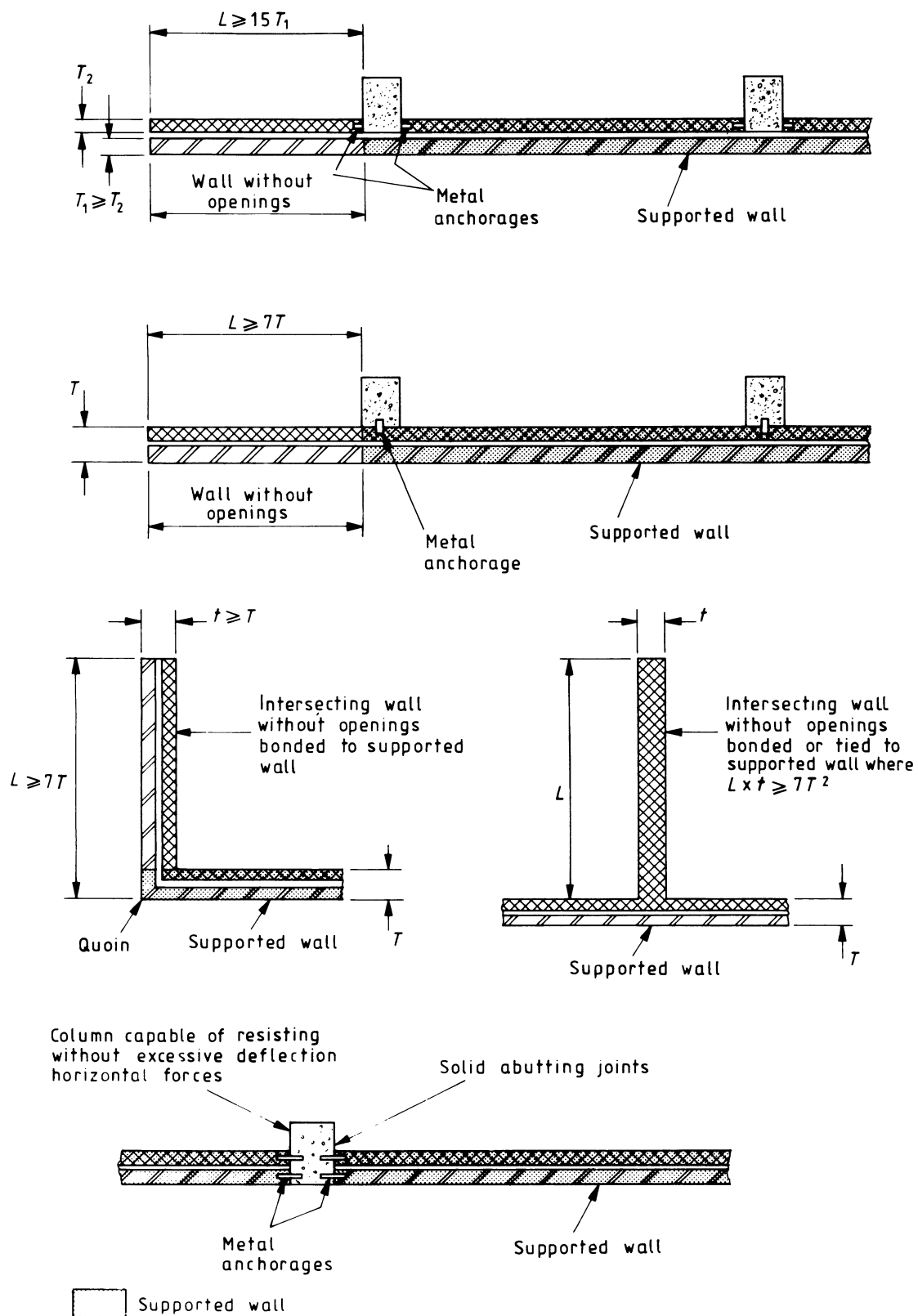
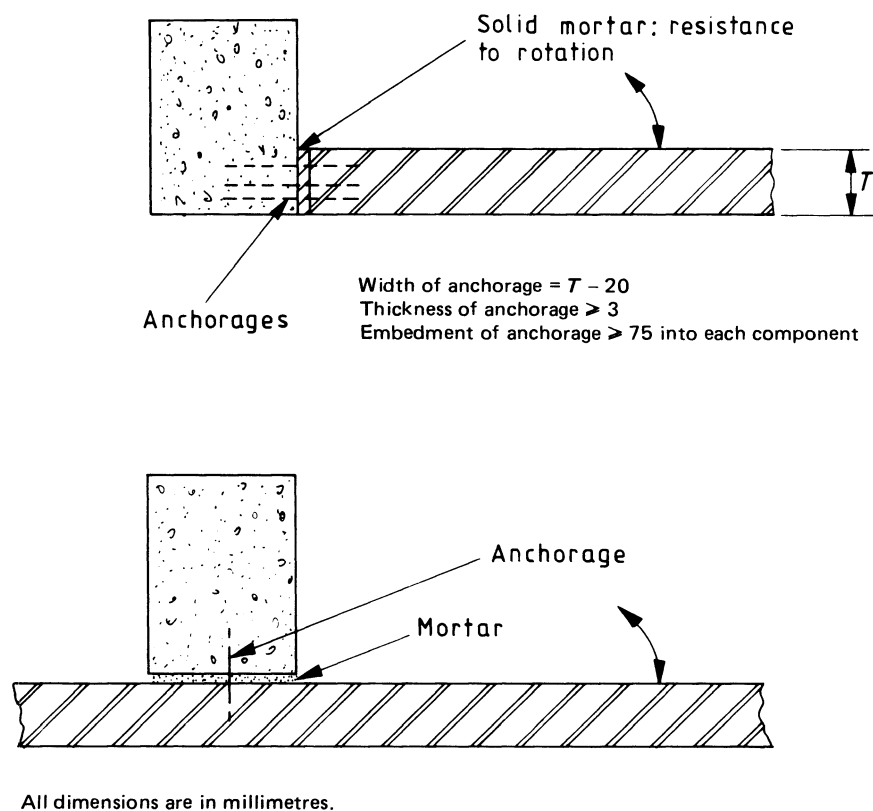
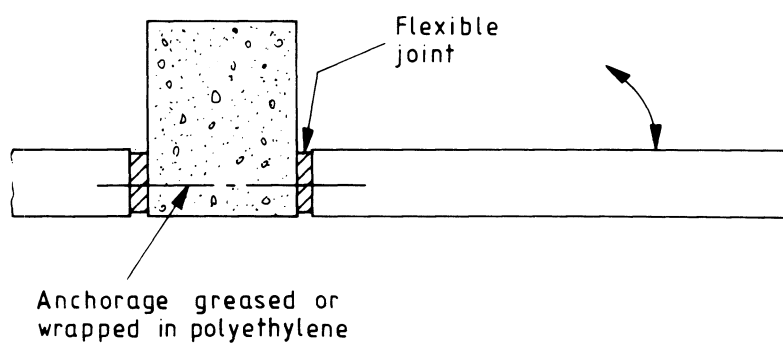


Figure 4 — Fixed support conditions in cavity walls



All dimensions are in millimetres.

(a) Fixed supports



(b) Simple support

Figure 5 — Fixed and simple supports

18.5 Internal walls or partitions not designed for imposed loading

Unless it is designed as a freestanding wall (see 18.4.1), an internal wall or partition should be laterally restrained by horizontal or vertical continuous or intermittent supports, similar to those given in Table 8. The length or height of the wall in relation to its thickness should be within the limits given in Figure 6.

Consideration should also be given to the following factors which may affect stability:

- a) accommodation for movement (see clause 20);
- b) openings;
- c) chasing (see 19.6);
- d) the likelihood of exceptional lateral loading, arising from the nature of use of the building;
- e) wind load (see CP 3:Ch V-2).

Where it is known that an internal wall or partition is to be plastered, a maximum thickness of 13 mm of plaster to one side or both sides of the partition may be included when determining the thickness of the wall for design in accordance with Figure 6. In such a case, the wall may require temporary bracing prior to plastering.

NOTE The graphs in Figure 6 are derived from the following empirical formulae:

- i) wall restrained at both ends but not at the top
 $t \geq L/40$ and $t \geq H/90$ or $t \geq H/15$ with no restriction on the value of L or $t < L/40$ and $t > L/59$ and $t \geq H + 2 L/133$;
- ii) wall restrained at both ends and at the top
 $t \geq L/50$ and $t \geq H/90$ or $t \geq H/30$ with no restriction on the value of L or $t < L/40$ and $t \geq L/110$ and $t \geq (3H + L)/200$;
- iii) wall restrained at the top but not at the ends
 $t \geq H/30$;

where
 t is the thickness (in mm);
 H is the height (in mm);
 L is the length (in mm).

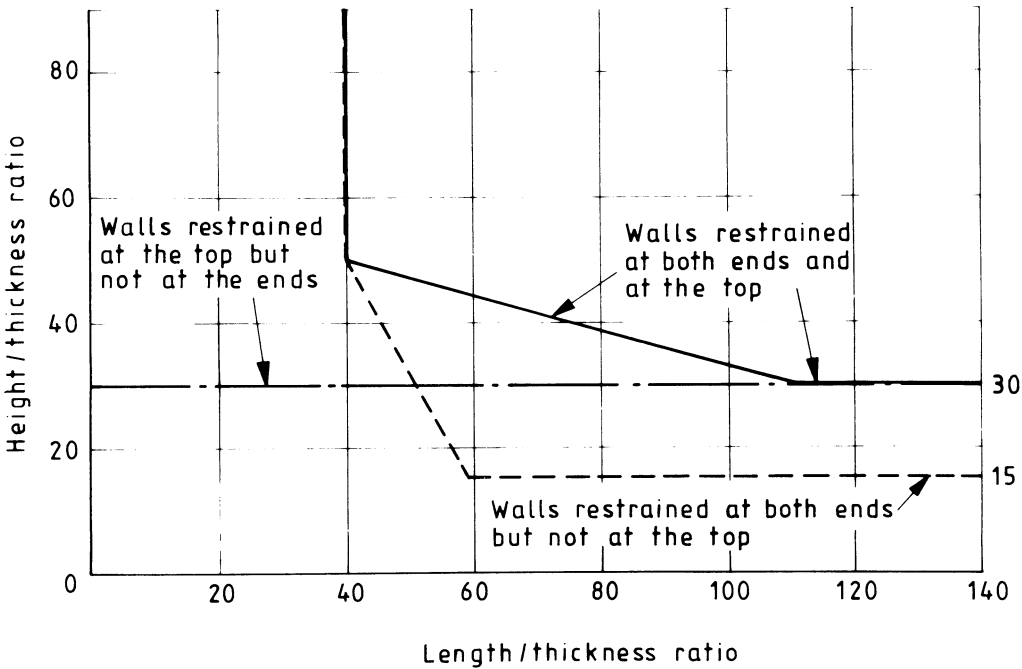


Figure 6 — Limiting dimensions of internal walls for stability

19 Structural detailing for stability

19.1 Floors

Typical ways of connecting floors with walls are shown in Figure 7(a) to Figure 7(c). Where floors are required to provide lateral restraint, reference should be made to Appendix C of BS 5628-1:1978.

Suspended timber floors near to the ground should preferably be supported independently by sleeper walls. Where this is not practicable, offsets or corbels from external walls may be used. Suspended timber floors elsewhere may be built into the walls or supported by offsets, corbels or joist hangers.

Timber wall plates should not be built into any wall.

Unreinforced concrete floors laid on the ground or on fill should not bear on walls, as this may give rise to cracking due to differential movement.

The design should ensure that the bearing of all types of floor is not less than 75 mm, taking normal tolerances into account. Concrete floors should normally have a bearing of not less than 90 mm; however, this bearing may be reduced at the discretion of the designer, taking into account relevant factors such as loading, span, tolerances, height of support and the provision of continuity reinforcement.

19.2 Roofs

The design should ensure that the roof structure provides adequate lateral restraint for the wall. Typical ways of connecting roofs with walls are shown in Figure 7(d) to Figure 7(h). Reference should also be made to Appendix C of BS 5628-1:1978.

Particular care should be taken when detailing the bearings of flat roofs upon walls, to reduce the danger of displacement of the top courses of masonry as a result of thermal movements in the roof and deflection of the structure. Temperature variations may be reduced by providing external insulation or reflective coatings.

Timber joists and joist hangers should have a minimum bearing of 75 mm on walls. The frogs of bricks should be filled to provide an even bearing. It may be desirable to provide a wall plate in certain cases.

Concrete roofs should normally have a bearing of not less than 90 mm. However, this bearing may be reduced at the discretion of the designer, taking into account relevant factors such as loading, span, tolerances, height of support and the provision of continuity reinforcement.

Binders or other beams giving rise to concentrated loads on the wall may need to be provided with a padstone or spreader beam (see 18.3).

19.3 Support over openings

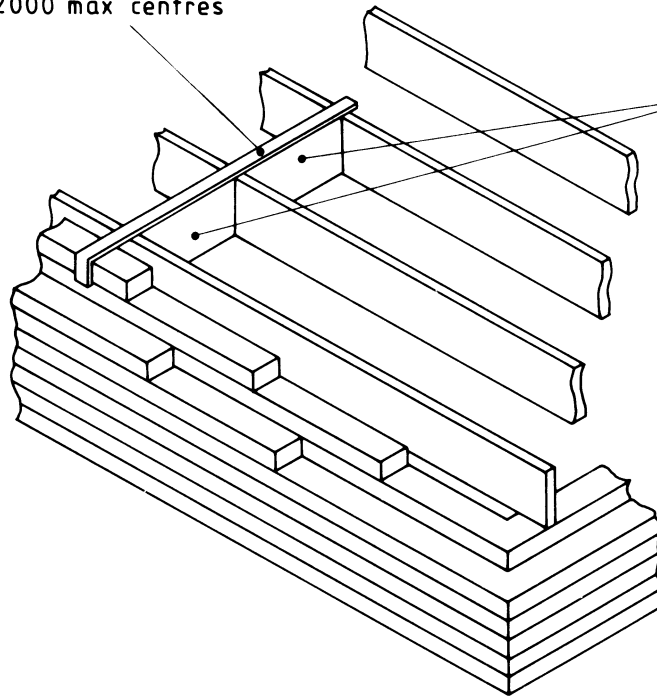
Masonry should not be supported on window or door frames which are not designed for the purpose. Where lintels are used, these should have adequate bearings, commensurate with the solidity of the support (see 18.3) and the load for which they are designed and in any case not less than 100 mm in length. Lintels should not bear on a short length of cut block. Where possible, the masonry should be set out to provide a full block under a bearing.

Pressed steel lintels should have a bearing of not less than 150 mm in length and may need stiffening over the bearing length to resist the total load. Protective measures for steel lintels, including provision of d.p.cs where appropriate, should comply with BS 5977-2.

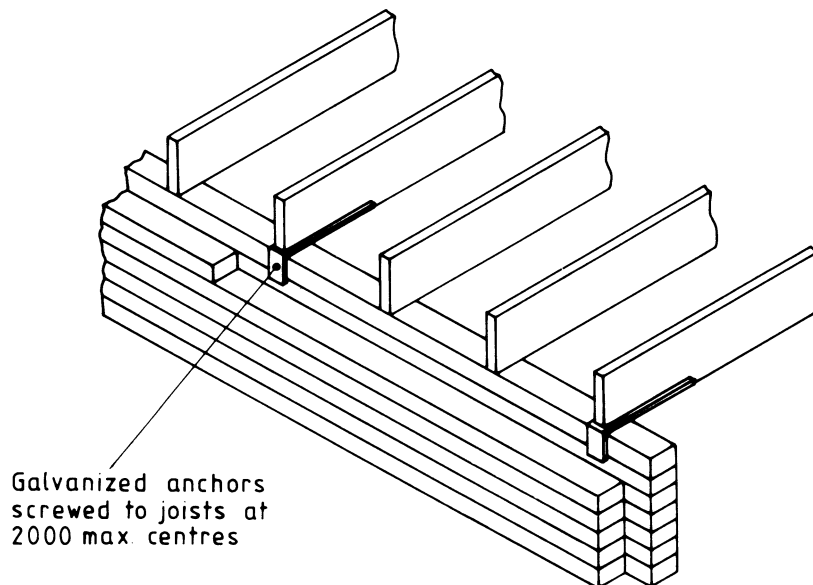
Where composite lintels, e.g. prestressed concrete plank lintels, are used, no chase or hole should be formed in the area comprising the composite section nor should any inclusion, such as joists, be built into this section, with the exception of d.p.c. materials which intrude not more than one-quarter of the width of the bed joint or 30 mm, whichever is the lesser. Installation should follow the recommendations of the manufacturers.

Galvanised anchors
at 2000 max centres

Noggins



(a) Two or three storey house or flats: joists parallel to wall



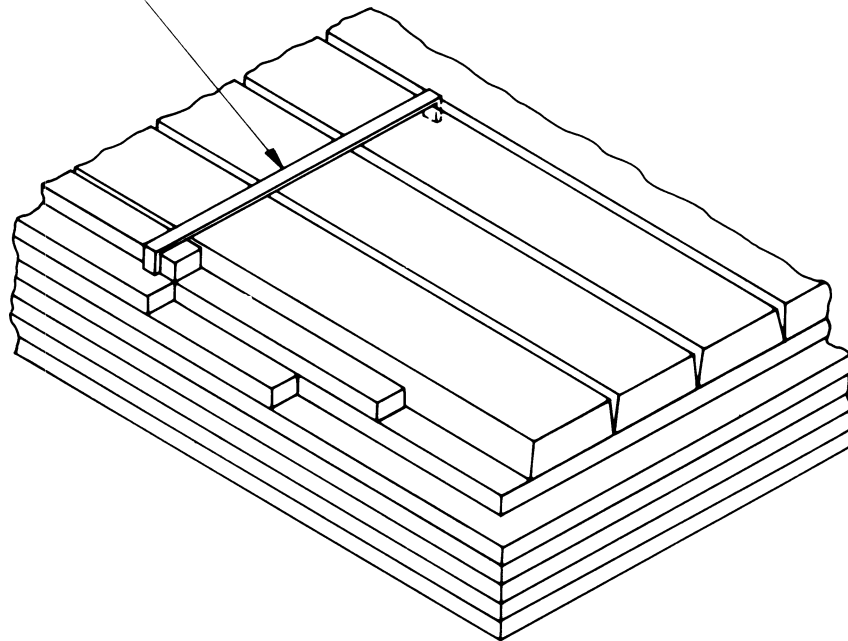
Galvanized anchors
screwed to joists at
2000 max centres

(b) Three storey flats: joists at right angles to wall

All dimensions are in millimetres.

Figure 7 — Typical ways of connecting floors and roofs

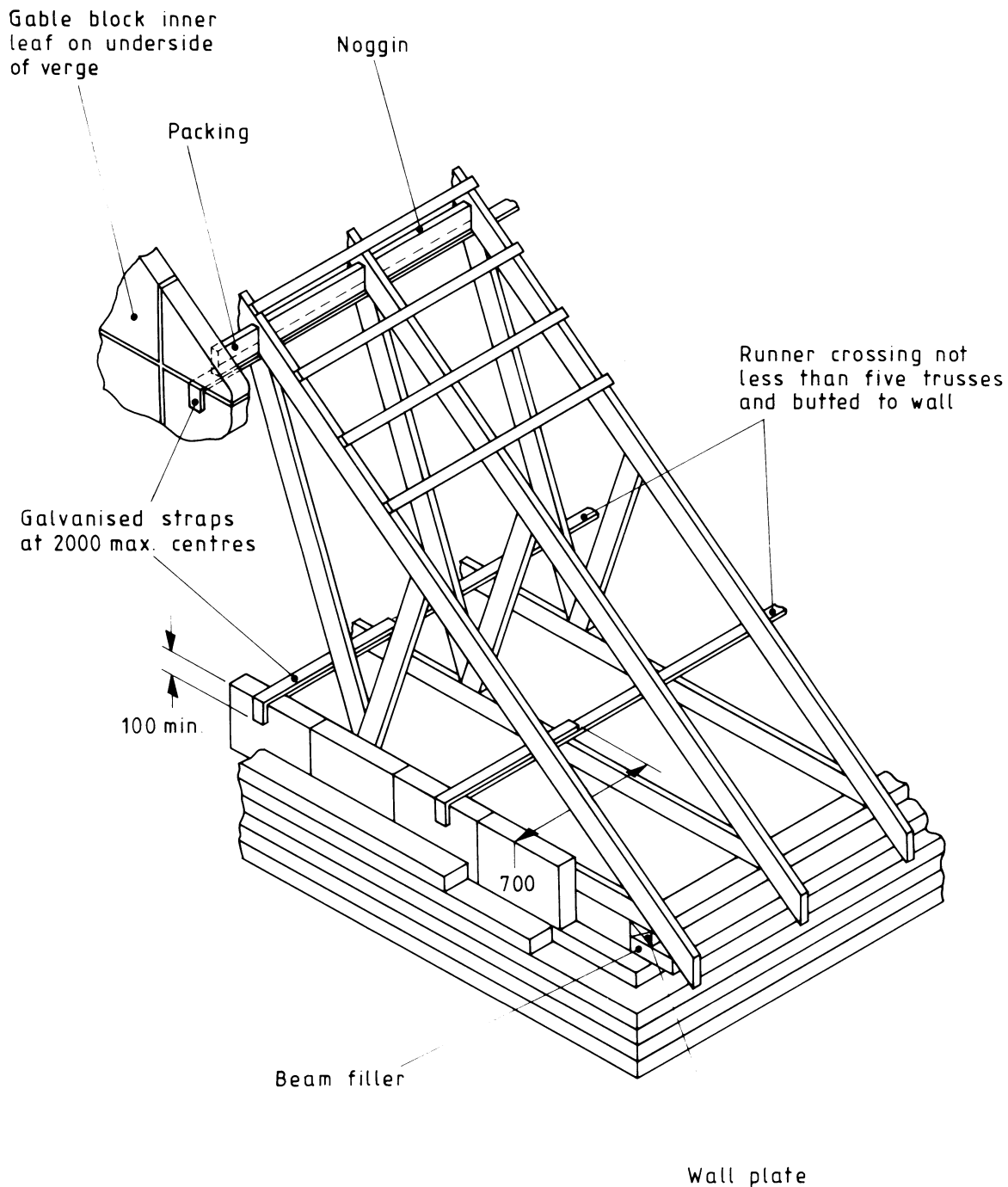
Galvanised anchors
at 2000 max. centres



Dimension is in millimetres.

(c) Concrete floor with beams parallel to wall

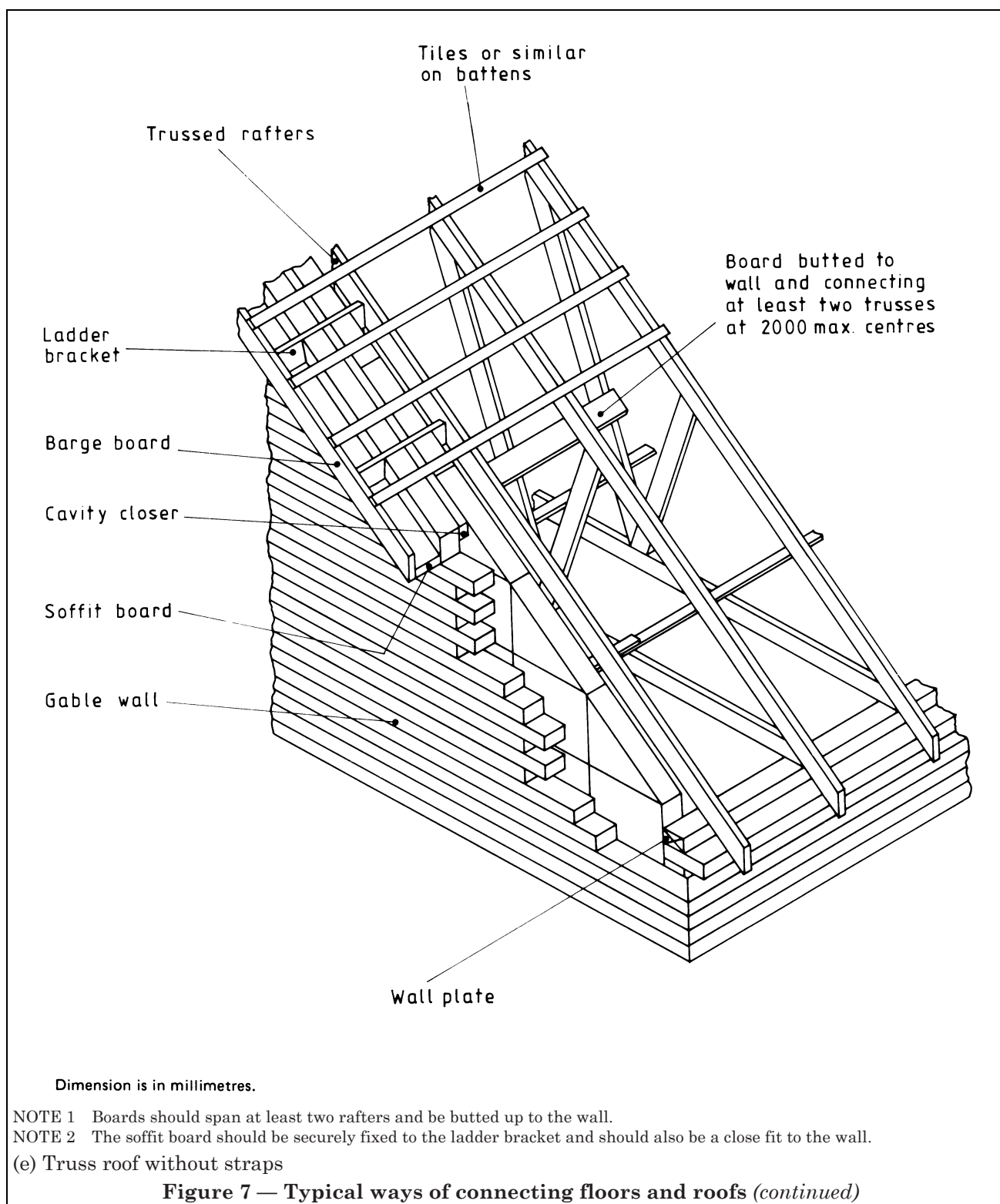
Figure 7 — Typical ways of connecting floors and roofs *(continued)*

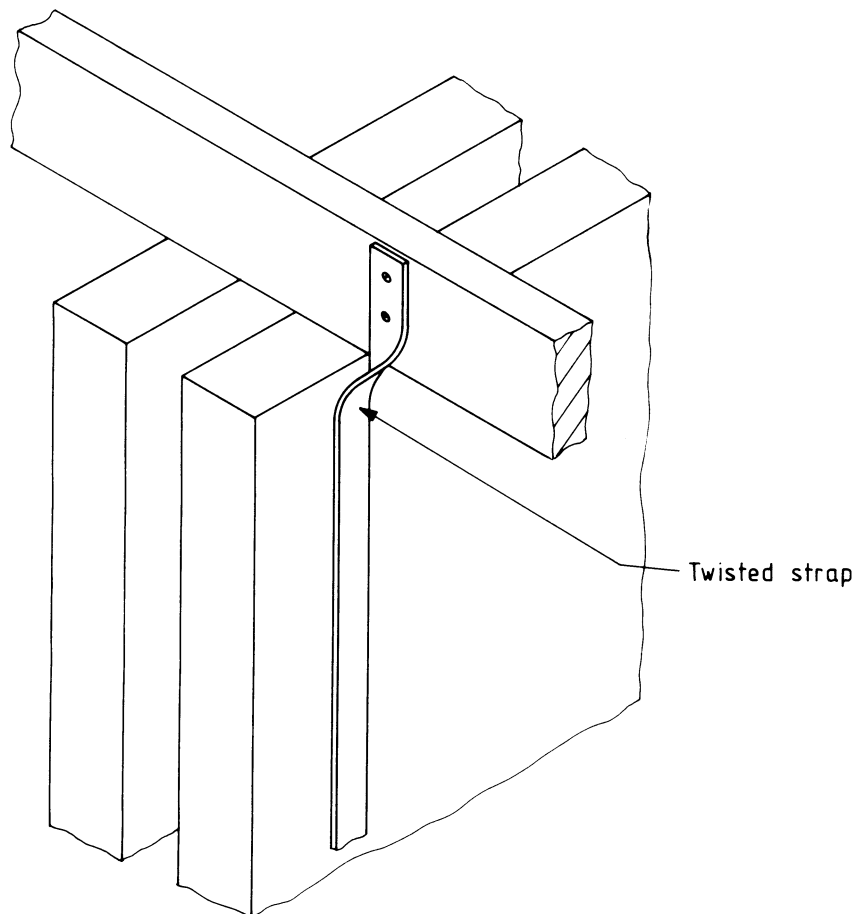


All dimensions are in millimetres.

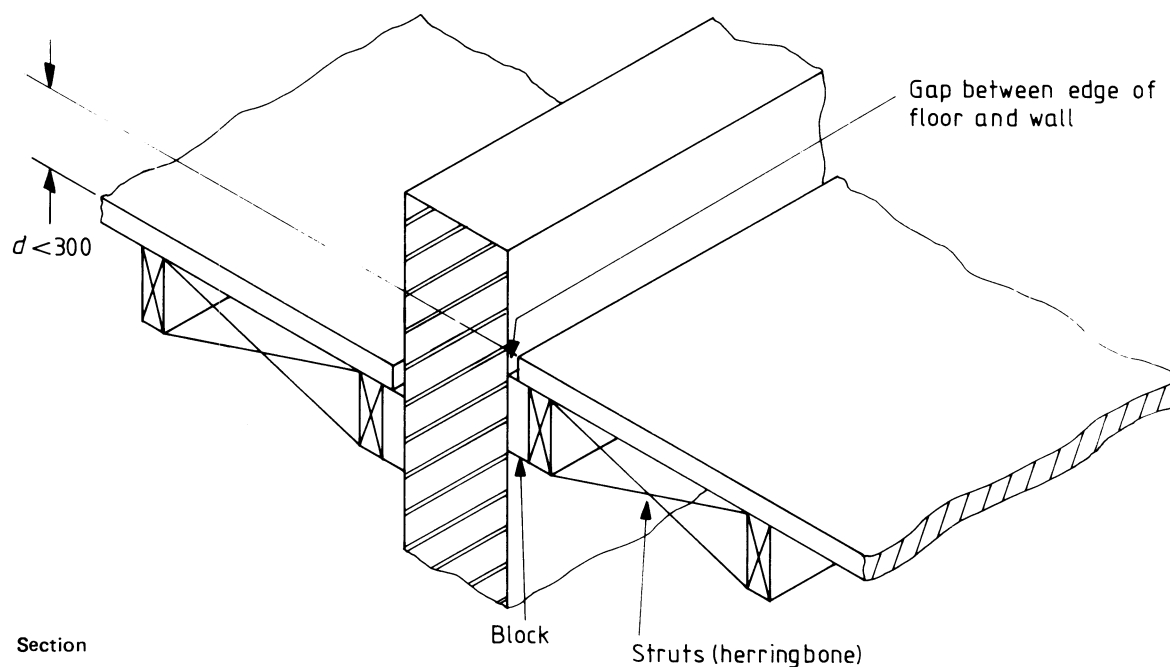
(d) Truss roof with straps

Figure 7 — Typical ways of connecting floors and roofs (continued)

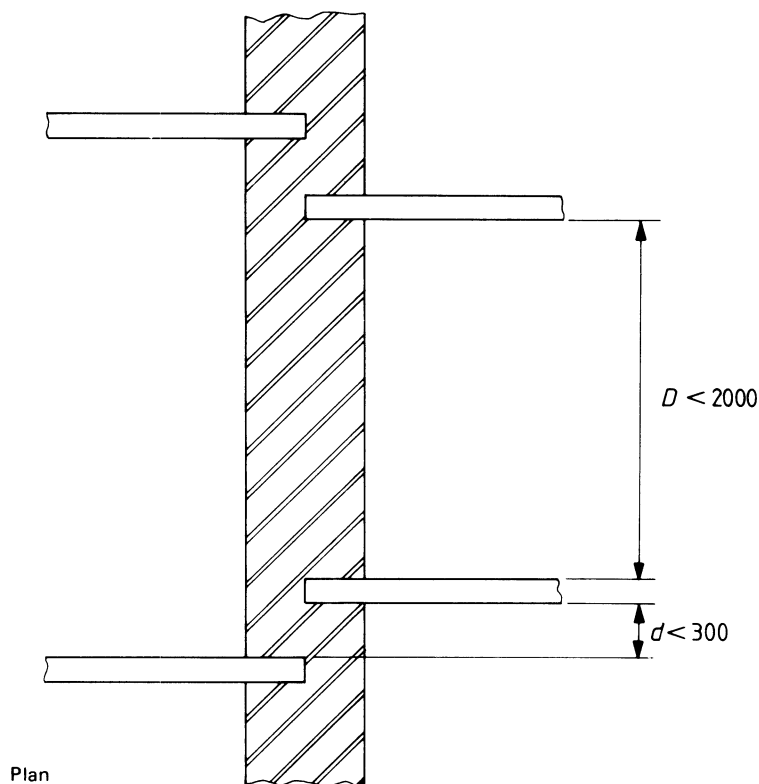




(f) Flat roofs and pitched roofs below 25°
Figure 7 — Typical ways of connecting floors and roofs (*continued*)



(g) Detail showing a floor or roof board in close proximity to wall or roof



(h) Detail showing position of timber purlin in roof where board or similar rigid decking material is not in close contact with wall

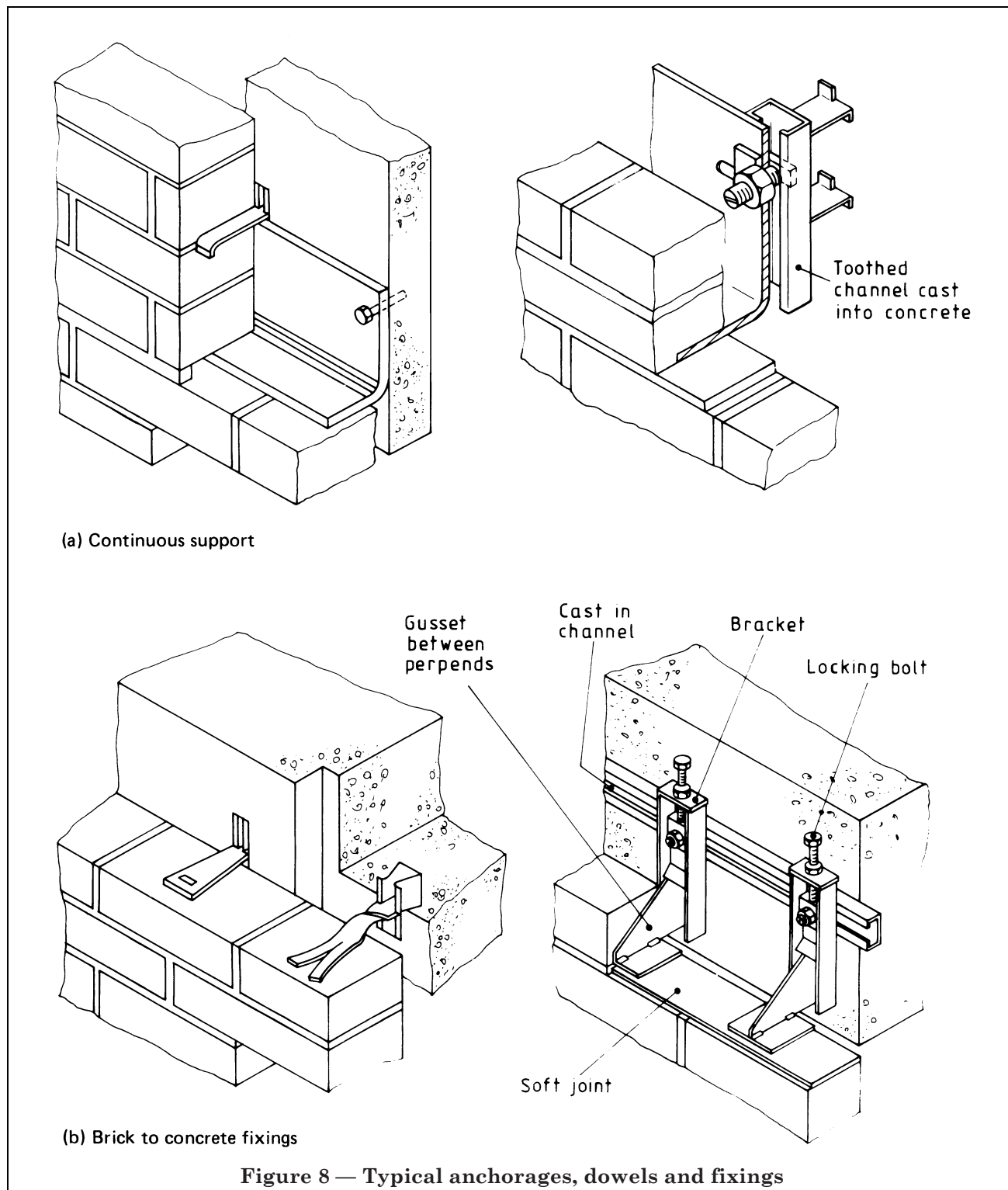
All dimensions are in millimetres.

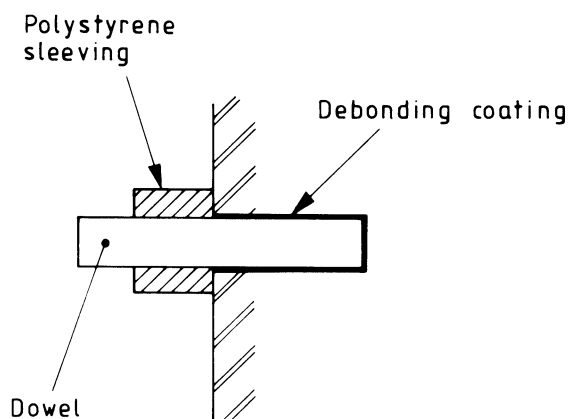
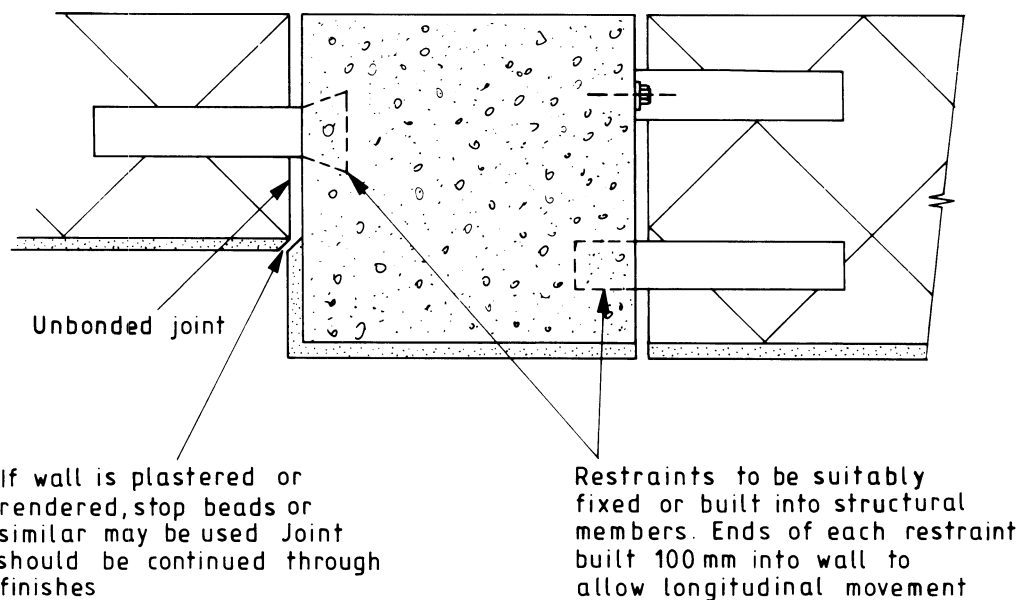
Figure 7 — Typical ways of connecting floors and roofs (concluded)

19.4 Anchorages, dowels and fixings

Typical anchorages, dowels and fixings are shown in Figure 8.

It is essential to select the correct materials for these components to ensure adequate resistance to corrosion (see clause 8).





(c) Dowels

Figure 8 — Typical anchorages, dowels and fixings (concluded)

19.5 Wall ties

The leaves of a cavity wall should be tied together by wall ties embedded in the horizontal mortar joints at the time the course is laid, to a minimum depth of 50 mm. The length of the wall tie should be chosen to suit the width between the two leaves. The ties should be placed at a frequency of not less than the values given in Table 9(A) and they should be staggered and evenly distributed. Additional ties should be provided within 225 mm of all openings so that there is one for each 300 mm of height of the opening. Consideration should be given to providing additional flexible ties across the cavity adjacent to movement joints.

The choice of the type of tie depends on the cavity width [see Table 9(B)]. In situations of Severe or Very Severe exposure as defined in 21.2, copper alloy or stainless steel ties should be used.

In chimneys where masonry bonding is not maintained (see Figure 9) stainless steel ties should be provided at intervals of three courses.

19.6 Provision for services and fittings

When making provision for services and fittings, designers should ensure that none of the functions of the wall are impaired by fixings, chases or holes.

The designer should consider the effects of chasing on stability, bearing in mind the recommendations of BS 5628-1, particularly where walls or leaves are constructed of hollow units. In walls or leaves constructed of solid units, the depth of horizontal chases should not normally exceed one-sixth of the thickness of the single leaf at any point, whilst the depth of vertical chases should not normally exceed one-third of the thickness of the single leaf at any point.

The cutting of holes up to approximately 300 mm square in the wall to accommodate items of equipment may be permitted.

Where heavy fittings are to be fixed to a wall, the effect on the stability of the masonry should be considered.

19.7 Chimneys

Where a chimney is not supported by adequate ties or otherwise made secure, its height, measured from the level of the highest point in line with the roof, gutter or other part of the building, and including any pot or flue terminal, should not be more than four and a half times its least width at that level.

Typical chimney details are shown in Figure 9 (see also 21.5.8).

Table 9 — Wall ties

(A) Spacing of ties					
Least leaf thickness (one or both)	Type of tie	Cavity width	Equivalent no. of ties per square metre	Spacing of ties	
				Horizontally	Vertically
mm		mm		mm	mm
65 to 90	All See Table 9(b)	50 to 75	4.9	450	450
90 or more		50 to 150	2.5	900	450
(B) Selection of ties					
			Type of tie in BS 1243	Cavity width	
↑ Increasing strength Increasing flexibility and sound insulation ↓				mm	
			Vertical twist	150 or less	
			Double triangle	75 or less	
			Butterfly	75 or less	

