BS 5268-6.1:
1996
Incorporating Amendments Nos. 1 and 2

Structural use of timber —

Part 6: Code of practice for timber frame walls —

Section 6.1 Dwellings not exceeding seven storeys

British Standards

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/525, Building and Civil Engineering Structures, to Subcommittee B/525/5, Structural use of timber, upon which the following bodies were represented:

British Woodworking Federation

Department of the Environment (Building Research Establishment)

Department of the Environment (Property and Buildings Directorate)

Health and Safety Executive

Institution of Civil Engineers

Institution of Structural Engineers

National House-Building Council

Timber Research and Development Association

Timber Trade Association

Co-opted members

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9256	June 1996	Indicated by a sideline in the margin
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Contents

Foreword

This Section of BS 5268 has been prepared by Subcommittee B/525/5.

The start and finish of text introduced or altered by Amendment No. 1 is indicated in the text by tags A2⟩ ⟨A2.

BS 5268 consists of the following other Parts:

— *Part 2: Code of practice for permissible stress design, materials and workmanship;*

— *Part 3: Code of practice for trussed rafter roofs;*

— *Part 4: Fire resistance of timber structures;*

— *Section 4.1: Recommendations for calculating fire resistance of timber members;*

— *Section 4.2: Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions;*

— *Part 5: Code of practice for the preservative treatment of structural timber;*

— *Part 7: Recommendations for the calculation basis for span tables.*

This Section of BS 5268 was first published in 1988 and revised in 1996 to cover buildings of up to four storeys. Since then it has been used extensively by an increasing number of designers, including those new to timber frame.

However, since 1996, designers have gained increasing experience with this form of construction and in the light of further research (notably the TF2000 project at BRE Cardington) this edition of BS 5268-6.1, has extended the scope to cover dwellings up to seven storeys high. The opportunity has also been taken to further clarify certain parts of the text and to refer to new, appropriate European Standards. Guidance has also been included to facilitate the design of movement joints.

This British Standard relates to dwellings up to seven storeys high and covers only the structural design of timber frame walls, although some of the information may also be relevant to other similar forms of construction.

Whilst this Section of BS 5268 covers the structural design of timber frame walls, the following constructional features may significantly affect the basis of the design, and they are drawn to the attention of the designer:

a) weathering;

b) condensation control;

c) thermal insulation;

d) fire resistance;

e) sound insulation;

f) durability;

g) movement joint design.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 34, 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.

Section 1. General

1.1 Scope

This Section of BS 5268 gives recommendations for the design, testing, fabrication and erection of timber frame walls for dwellings not exceeding [A2) seven (A2] storeys and consisting of timber frame walls, with studs not exceeding 610 mm centre to centre and one or both faces of the studs being partly or wholly connected to sheathing, lining, gusset plates or other forms of bracing. Although the information on racking resistance given in this Section of BS 5268 is restricted to wall panels no greater in height than 2.7 m, it is not intended that it should be so restrictive where wall panels are not subject to racking forces or where racking resistance can be justified by other means. All structural materials are assumed to be subject only to service classes 1 and 2 as defined in BS 5268-2.

The design information contained in this Section of BS 5268 may also be relevant to other types of building where the storey heights, proportions and configuration are similar to those covered by this Section of BS 5268.

1.2 References

1.2.1 Normative references

This British Standard incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 33. Subsequent amendments to, or revisions of, any of these publications apply to this British Standard only when incorporated in it by updating or revision.

1.2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 34, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this Section of BS 5268 the definitions given in BS 6100 and the symbols given in BS 5268-2 apply together with the following.

1.3.1
cripple stud
vertical member in a framed partition or wall that supports a lintel

1.3.2
racking resistance
ability of a partition or wall panel to resist horizontal wind forces in the plane of the panel

1.3.3
spandrel panel
wall panel for a gable

1.3.4
stud
vertical member in a framed partition or wall

1.3.5
timber frame wall
wall constructed of timber framing members, bracing and/or wall sheathing

1.3.6
wall lining
manufactured sheet or board used to line a wall or partition

1.3.7
wall panel
component that forms part of a timber frame wall

1.3.8
wall sheathing
manufactured sheet or board used as a bracing

Section 2. Materials

2.1 General

The materials used should conform to the appropriate British Standards.

Reference should be made to BS 5268-5 for information on wood preservation.

All sheathing and lining materials should be adequately thick and robust to avoid damage during manufacture, transport and erection.

2.2 Species of timber

[A2⟩ *Note deleted* ⟨A2]

All structural timber should be stress graded in accordance with BS 5268-2.

2.3 Sheathing materials

2.3.1 Plywood

The species and grades of plywood for sheathing should be one of those described in BS 5268-2.

2.3.2 Fibre building boards

Fibre building boards for use as structural sheathing should be one of the following types:

[A2⟩ a) type HB.HLA2 tempered hardboard conforming to BS EN 622-2:1997;

b) type MBH.HLS1 or MBH.HLS2 medium board conforming to BS EN 622-3:2004;

c) impregnated softboard type SB.HLS conforming to BS EN 622-4:1997.

2.3.3 Particleboard

Particleboard sheathing should be type P5 conforming to BS EN 312-5:1997 or type P7 conforming to BS EN 312-7:1997.

2.3.4 Oriented strand board

Oriented strand board for sheathing should be type OSB/3 or OSB/4 conforming to BS EN 300:2006

2.3.5 Cement bonded particleboard

Cement bonded particleboard should be type OPC bonded conforming to BS EN 634-2:1997

2.3.6 Other sheathings

Designers should assure themselves of the suitability and durability of any sheathing material with a view to its intended end use.

Other sheet materials may be used provided that they are either covered by a British or European Standard of manufacture, including reference to their suitability as a sheathing material, or have been proven for use as a sheathing by an independent testing authority. ⟨A2]

2.4 Gypsum plasterboard

Where gypsum plasterboard is assumed to make a structural contribution in the design of a timber frame wall, the plasterboard should be manufactured in accordance with [A2⟩ BS EN 520 ⟨A2].

2.5 Adhesives

Adhesives used in the construction of timber frame wall panels should be of a type [A2⟩ , durability ⟨A2] and quality suitable for the conditions of use.

NOTE Further advice on suitable adhesives and the quality of workmanship is given in BS 5268-2 and BS 6446.

2.6 Fasteners

All structural fasteners within the scope of this Section of BS 5268 should be corrosion resistant and should be checked for compatibility with any [A2] *Text deleted* [/A2] treatments used and any other metal work with which they are in contact.

[A2] Fasteners used in the construction of panels and for fixing sheathing should be manufactured from mild steel, suitably protected against corrosion, or stainless steel, and be of round head or "D" head configuration and a size specified by the timber frame wall designer. [/A2]

2.7 Masonry

Where masonry cladding is assumed to have a shielding effect on the timber frame or to contribute to the racking resistance of a timber frame wall it should be designed in accordance with BS 5628-1, BS 5628-2 [A2] , BS 5628-3 [/A2] and should be at least 100 mm thick and have a minimum mass of 75 kg/m^2 of surface.

Section 3. Loading

3.1 General

Timber frame walls should be designed to carry the appropriate dead, imposed and wind loads given in BS 6399-1, BS 6399-2 and BS 6399-3 and to transfer such loads to the foundation without undue distortion and movement.

[A2⟩ Timber framed buildings should be designed to be robust. When timber framed buildings of certain classes are specifically required to be additionally designed to resist disproportionate collapse this should be carried out in accordance with the provisions in BS 5268-2. ⟨A2]

3.2 Wind loading

3.2.1 Distribution of wind load

Wind acting on a building induces external and internal pressures on the roof and walls, as described in BS 6399-2. Both horizontal and vertical loads thus developed should be considered in the design of timber frame walls.

[A2⟩ Where the building consists of a number of independent structural units the wind transfer between units, for example by party wall straps or similar devices, should be proven. ⟨A2]

NOTE The wind load is resisted primarily by transfer directly to the ground at the base of the wall and by the racking resistance of timber frame supporting walls, the load having been transferred via the floor and ceiling diaphragms. Other unquantifiable factors assisting in the resistance to wind loads are taken into account in the interaction factor given in **4.9.5**.

3.2.2 Wind loading on masonry clad timber frame walls

[A2⟩ Where timber frame walls are clad by masonry walls and the following specifications are complied with, the external wind loading transferred to the timber structure should be determined in accordance with **3.2.3**.

a) The masonry walls should be constructed of:

1) clay masonry units conforming to BS EN 771-1;

2) calcium silicate masonry units conforming to BS EN 771-2;

3) aggregate concrete masonry units conforming to BS EN 771-3;

4) autoclaved aerated concrete masonry units conforming to BS EN 771-4;

5) manufactured stone masonry units conforming to BS EN 771-5;

6) natural stone masonry units conforming to BS EN 771-6;

7) bricks of special shapes and sizes conforming to BS 4729.

b) The mortar should conform to the requirements of BS 5628-3 and be at least strength class M4 to BS EN 998-2, or of designation iii) to BS 5628. Alternatively, a 1:1:5 to 6 CEM1: lime: sand mortar batched by volume or weight of dry materials may be used [site batched designation iii)].

NOTE Depending upon exposure situations higher strength class (or designation) mortars may be appropriate. BS 5628-3 provides guidance on mortar selection and use.

c) Masonry claddings should be connected to the timber frame with wall ties or wall tie systems that have sufficient strength and stiffness to transfer wind loads to the timber frame wall.

Wall ties and wall tie systems should conform to BS EN 845-1. Wall tie user classes and their load capacity definition are given in Annex B.

d) Wall tie design should take into consideration all the anticipated differential vertical movement across the cavity as defined in **4.13**. ⟨A2]

3.2.3 Wind load transferred to timber frame wall

[A2⟩ **3.2.3.1** ***Timber frame walls not exceeding four storeys*** ⟨A2]

The wind load used in calculating the racking load and overturning and sliding forces to be resisted by the timber frame walls should be derived by multiplying the external wind load on the masonry cladding by the modification factor K_{100} appropriate to the number of storeys being considered (see Table 1).

A2 For buildings not exceeding three storeys, the K_{100} values in the third and fourth columns of Table 1 should only be used if the masonry wall has buttresses or returns not less than 550 mm. For four storey buildings, the K_{100} values in the third and fourth columns of Table 1 should only be used if the masonry wall has buttresses or returns not be less than 950 mm. A2

In calculating the racking load and overturning and sliding forces, it should be assumed that the modified wind load acts uniformly over the entire area of the shielded timber frame wall. A2 The modification factor K_{100} should not be applied to the design of individual elements, for example, studs. A2

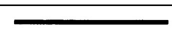
A2 **3.2.3.2** ***Timber frame walls exceeding four storeys***

The wind load used in calculating the racking load and overturning and sliding forces to be resisted by the timber frame walls should be derived by multiplying the external wind load on the masonry cladding by the following K_{100} modification factors:

— For all storeys above the fourth storey, a K_{100} value of 1.00 should be used.

— For the lower four storeys, the K_{100} value should be determined from Table 1 with the percentage of loaded wall occupied by openings being calculated using the lower four storeys only. The K_{100} values in the third and fourth columns of Table 1 should only be used if the masonry wall has buttresses or returns not less than 1 200 mm. A2

Table 1 — Modification factor K_{100}

Number of storeys	Percentage of loaded wall occupied by openings[a]	K_{100}		
				
		A2⟩ **For masonry walls with buttresses or returns as defined in 3.2.3.1 and 3.2.3.2 and not greater than 9 m centre to centre**[b] ⟨A2	A2⟩ **For masonry walls with buttresses or returns as defined in 3.2.3.1 and 3.2.3.2 at one end only and wall length not greater than 4.5 m**[c] ⟨A2	**For masonry walls without buttresses or returns**[d]
1 and 2	0	0.45	0.60	0.75
	10	0.50	0.64	0.78
	20	0.56	0.68	0.80
	30	0.61	0.72	0.83
	40	0.66	0.76	0.85
	50	0.71	0.80	0.88
	60	0.77	0.84	0.90
	70	0.82	0.88	0.93
	>70	1.00	1.00	1.00
3	0	0.50	0.68	0.85
	10	0.55	0.71	0.87
	20	0.60	0.74	0.88
	30	0.65	0.78	0.90
	40	0.70	0.81	0.92
	50	0.75	0.84	0.93
	60	0.80	0.87	0.94
	70	0.85	0.91	0.96
	>70	1.00	1.00	1.00
		A2⟩ *Text deleted* ⟨A2		
4	0	0.60	0.74	0.88
	10	0.64	0.77	0.89
	20	0.69	0.80	0.91
	30	0.73	0.83	0.93
	40	0.77	0.86	0.95
	50	0.81	0.89	0.96
	60	0.86	0.92	0.98
	70	0.90	0.95	1.00
	>70	1.00	1.00	1.00

NOTE 1 Values for intermediate percentages of wall occupied by openings may be obtained by linear interpolation.

NOTE 2 A2⟩ For buildings of four or less storeys, the K_{100} factors and support conditions (where relevant) should be selected on the basis of the maximum height of the wall under consideration and be applied to the whole wall. For buildings of more than four storeys refer to the provisions of **3.2.3.2**. ⟨A2

NOTE 3 For walls longer than 9 m, the values of K_{100} given in column 3 may be used provided additional buttresses or returns are added to the masonry wall at a maximum centre to centre spacing of 9 m.

A2⟩ NOTE 4 For spandrel panels a value for K_{100} of 1.0 should be applied. ⟨A2

[a] A2⟩ In calculating the percentage of wall occupied by openings for buildings of four or less storeys, the height of the wall should be taken as the height to the eaves. In calculating the percentage of wall occupied by openings for buildings of more than four storeys, the height of the wall should be taken as the height to the top of the fourth storey. ⟨A2

[b] Values of K_{100} to be used where a masonry wall is supported at both ends by adequate masonry buttresses or returns.

[c] Values of K_{100} to be used where a wall, which otherwise has adequate buttresses or returns, incorporates a vertical movement joint (i.e. the wall has the required buttress or return at one end, but is not adequately supported at the other).

[d] Values of K_{100} to be used where a wall has no masonry returns or buttresses or has inadequate supports at its ends.

Section 4. Design of timber frame walls

4.1 Assessment of structural adequacy

The structural design of a timber frame wall should be carried out by any one or combinations of the following methods:

a) design using the laws of structural mechanics (using data obtained from BS 5268-2);

b) design in accordance with the method described in this section;

c) load testing of full-size wall units in accordance with [A2] BS [/A2] EN 594.

NOTE Attention is drawn to the importance of checking the overall stability of the building.

4.2 Permisible stresses

The grade stresses for timber, plywood [A2] and other wood-based boards [/A2] should be those given in BS 5268-2 modified for duration of loading, load sharing, depth and width factors, and slenderness ratio as appropriate.

A timber frame external wall should be designed using stresses for [A2] service class 2 as described in BS 5268-2 [/A2].

4.3 Composite action with other materials

Where a timber frame wall is designed to act compositely with other materials such as cladding, sheathing or lining, the appropriate composite action should be established by test or by calculation or, in the case of racking resistance, based on information given in Table 2.

NOTE Where composite action is not assumed but the other materials are partly self-supporting and are capable of carrying a share of the horizontal wind loading, the timber frame wall can be designed to carry a corresponding reduced horizontal wind loading.

[A2] 4.4 Stability

4.4.1 General

The designer should ensure overall building stability by checking that it has adequate racking, overturning and sliding resistance to lateral loads.

These checks should be made at critical levels for the completed building and for the various construction stages, when subjected to dead load, zero imposed load, and both horizontal and vertical components of the wind load.

Stability is generally obtained from racking walls, set in two orthogonal directions. Unless demonstrated otherwise, walls with significant openings, for example doors, should be considered as separate discrete walls. The racking resistance of each wall should be calculated in accordance with **4.7** for each direction.

4.4.2 Overturning

4.4.2.1 *General*

Subject to the limitations in **4.5**, it may be assumed that floor diaphragms are capable of distributing the wind load to each racking wall in proportion to its racking resistance. Due account should be taken of any significant eccentricity between the centroids of the wind load and the aggregated wall racking resistance.

The stability of each racking wall should be checked at the base as follows:

a) The overturning moment is the product of the apportioned wind load and the vertical distance between its centroid and the wall base.

b) The overturning resistance of a wall is the product of the dead load (reduced by any vertical component of the wind load) and the horizontal distance between its centroid and the leeward corner.

Additional dead load from return walls, where present, can be utilized but should be limited to an outstand distance equal to the panel height or the distance to a door or window opening, whichever is the lesser (small openings as defined in **4.9.4** may be ignored). The connection between the return wall and the racking wall should be designed to transfer the shear loads based on the resultant applied design forces. Tension fixings may also be used to mobilize dead load from the underlying construction and their capacity added to the dead load as a contribution to the overturning resistance.

[A2] *Footnote deleted* [/A2]

c) The factor of safety of a racking wall against overturning is defined as the overturning resistance divided by the overturning moment. For each racking wall, under its apportioned wind load, the factor of safety should be ≥ 1.2.

The factor of safety of the total racking wall resistance, under the total wind load, should be ≥ 1.4.

4.4.2.2 *Overturning for dwellings of three or less storeys*

For dwellings of three or less storeys, and with a maximum height to width ratio of 2:1, the overturning resistance of the building may be determined as the product of its total dead load (reduced by any vertical component of the wind load) and the horizontal distance between the load centroid and the leeward edge. The factor of safety, as defined in **4.4.2.1**c), should be ≥ 1.4.

4.4.3 Sliding

The designer should ensure that there is a factor of safety of 1.4 against sliding at the top and bottom of each racking wall, and at sole plate level. Friction, under dead load only, may be used in conjunction with metal fasteners when calculating the resistance to sliding. The coefficient of friction between timbers in contact or on the underside of the soleplate may, in the absence of other information, be taken as 0.3. A2

4.5 Horizontal diaphragms

The design method for timber frame walls given in this British Standard assumes that, for the range of dwellings covered, the normal construction of floors and roofs provides adequate diaphragm action, provided that, in the case of intermediate floors, a floor deck or sub-deck is fixed directly to the top faces of the joists, or the floor is braced by some other means. In the case of pitched roofs it is assumed that the plasterboard ceiling under the roof, together with the roof bracing recommended in BS 5268-3 is sufficient to transfer applied wind forces to the resisting walls.

Due account should be taken of the eccentricity of the loading in relation to the wall panels providing resistance.

4.6 Design of wall studs

4.6.1 General

Wall studs should be designed as compression members, subject where appropriate, to bending in a direction perpendicular to the plane of the wall, in accordance with BS 5268-2.

4.6.2 Lateral restraint

Lateral restraint in the plane of the wall should be provided by noggings, sheathing or plasterboard lining.

In calculating the slenderness ratio of studs sheathed with any of the board materials described in Table 2 and fixed to the studs as recommended in Table 2, the effective length should be assumed to be 0.85 times the actual length when considering buckling out of the plane of the wall. Solid rectangular studs in timber frame walls covered on one or both sides with any of the board materials described in Table 2 and fixed as recommended in Table 2, should be assumed to be fully restrained laterally in the plane of the wall.

4.6.3 Interaction with sheathing

Where advantage is taken of the interaction between the studs and sheathing in resisting compression and bending or in reducing deflection, account should be taken of the relative stiffnesses of the materials acting compositely and of the slip under load of mechanical fastenings.

4.6.4 Eccentricity of load

Allowance should be made for eccentricity of load.

Loads transmitted from trusses, joists, lintels, beams or attached claddings bearing on the timber frame wall should be applied at the centroid of the bearing area.

Bending moments due to eccentric loads applied at the top of a timber frame wall should be taken as zero at the base of the wall.

Where studs are continuous through more than one storey, bending moments applied at an intermediate floor should be divided between the upper and lower storeys in proportion to their stiffnesses.

NOTE For studs of constant cross section throughout their height, the bending moment may be divided equally between upper and lower storeys provided the ratio of storey heights does not exceed 1.5.

A2⟩

Table 2 — Basic racking resistances for a range of materials and combinations of materials

Primary board material	Fixing	Racking resistance kN/m	Additional contribution of secondary board on timber frame wall kN/m			
			Category 1 material	Category 2 material	Category 3 material	Category 4 material
Category 1 materials: — 9.5 mm plywood; — 9.0 mm medium board; — 12.0 mm particleboard (type P5 or P7); — 6.0 mm tempered hardboard; — 9.0 mm OSB (type OSB/3 or OSB/4)	3.00 mm diameter wire nails at least 50 mm long, maximum spacing 150 mm on perimeter, 300 mm internal	1.68	0.84	0.28	0.18	0.12
Category 2 materials: — 12.5 mm bitumen impregnated insulation board	3.00 mm diameter wire nails at least 50 mm long, maximum spacing 75 mm on perimeter, 150 mm internal	0.90	N/A	0.45	0.30	0.20
Category 3 materials: — separating wall of minimum 30 mm plasterboard (in two or more layers) (see also Note 4 and Note 9)	Each layer should be individually fixed with plasterboard screws of 3.5 mm shank diameter at 300 mm spacing. The screws for each layer should penetrate at least 25 mm into stud.	0.60	N/A	N/A	0	0
Category 4 materials: — 12.5 mm plasterboard (see also Note 9)	Plasterboard screws, at least 38 mm long, of 3.5 mm shank diameter at 300 mm spacing	0.40	N/A	N/A	N/A	0.20

NOTE 1 Timber members in wall panels should be not less than 38 mm × 72 mm rectangular section with linings fixed to the narrower face, with ends cut square and assembled in accordance with the relevant clauses of section 6.

NOTE 2 Timber members of rectangular section less than 38 mm × 72 mm, but not less than 38 mm × 63 mm, should be taken into account for internal walls (excluding separating walls), but in such cases all values for basic racking resistance given in this table should be reduced by 15%.

NOTE 3 Studs should be spaced at centres not exceeding 610 mm.

NOTE 4 Board edges should be backed by, and nailed to timber framing at all edges except in the case of the underlayers in separating wall construction where it is normal to fix boards horizontally, in which case the intermediate horizontal joint may be unsupported. It should be noted that for separating walls where, for acoustic or other reasons, the plasterboard lining does not extend to the bottom rail, the basic racking resistances of Table 2 do not apply.

NOTE 5 Studs should be of species and stress grade satisfying strength class C16 or better (as defined in BS 5268-2).

NOTE 6 The additional contribution from a secondary layer of category 1, 2, 3 or 4 materials should only be included once in the determination of basic racking resistance, no matter how many additional layers may be fixed to the wall panel.

NOTE 7 The values given in Table 2 together with the modification factors in **4.8** and **4.9** assume that the wall under consideration is adequately fixed to ensure resistance to sliding and overturning.

NOTE 8 Where a secondary board is fixed on the same side of a wall as the primary sheathing then the fastener lengths given in the table should be increased to take account of the additional thickness.

NOTE 9 For both category 3 and 4 board materials, if the fixing specification for each plasterboard layer is changed to 2.65 mm diameter plasterboard nails at 150 mm spacing, then their basic racking resistances, both as a primary board or as a secondary board, may be increased by 50%.

⟨A2

4.6.5 Lateral deflection

Where it is necessary to consider deflection of wall studs out of the plane of the wall, this should be calculated in accordance with [A2] the procedures in [/A2] BS 5268-2.

[A2] In calculating wall stud deflection, under the action of wind loads, the assumptions made in respect of end fixity and effective length, as implied in **4.6.2**, should be taken into account. Wall studs should have board materials, complying with the requirements of Table 2, fixed to both stud faces.

For the purposes of this calculation, vertical load should be ignored and no composite action between wall studs and board materials should be taken into account.

Where the wall stud length does not exceed 3.0 m the calculated deflection of wall studs under wind loads should not exceed 0.0045 of the effective stud length.

NOTE Where wall studs have actual lengths exceeding 3.0 m consideration should be given to alternative limiting stud deflections from the above criteria. [/A2]

4.6.6 Cripple studs

NOTE Lintels or beams in the plane of the wall may be supported by cripple studs adjacent and connected to an ordinary stud.

Cripple studs supporting lintels or beams should be considered to act compositely with the adjacent ordinary stud provided they are adequately connected together throughout their height.

4.6.7 End bearing

Where studs bear on to horizontal timber members or horizontal timber members bear on to studs the permissible compression perpendicular to grain stress should be checked.

NOTE See BS 5268-2 for permissible compression perpendicular to grain stress where wane is excluded at the junction of studs and timber member [A2] *Text deleted* [/A2].

4.6.8 Spandrel panels

Spandrel panels are part of the external timber frame wall and should be designed to resist any vertical or horizontal loads.

4.6.9 Fixing of sheathing or lining

Where sheathing [A2] is [/A2] nailed to studs, the nails should be positioned so that the distance between the nail and the edge of the board or the face of the stud is not less than 7mm. Nails should be spaced at centres not greater than 300 mm or less than 50 mm. [A2] *Text deleted* [/A2]

[A2] 4.6.10 Fixing of plasterboard lining

Where plasterboard linings contribute to racking resistance, nails or screws should be no closer to the bound (or formed) edges of the board than 10 mm and no closer to the ends of the board than 13 mm. Nails should be spaced at centres not greater than 150 mm and screws should be spaced at centres not greater than 300 mm. [/A2]

4.7 Racking resistance

4.7.1 Racking resistance of wall panels

Resistance to horizontal wind forces (racking resistance) should be provided by stiffening elements in the plane of the wall. These should consist of timber frames that are sheathed with board materials or diagonally braced or constructed with moment connections.

The racking strength and stiffness of timber frame wall panels should be determined by one of the methods described in **4.7.2**.

4.7.2 Methods of determining racking resistance of walls

The racking resistance of walls constructed from a number of braced or sheathed wall panels should be derived using one of the following methods.

a) *Assessment method* (see **4.8**). The basic racking resistances given in Table 2 should be modified by application of material modification factors (see **4.8**) and wall modification factors (see **4.9**), as appropriate. The racking resistance of a wall should be calculated from the formula:

$$R_b \times L \times K_m \times K_w$$

where

R_b is the basic racking resistance (in kN/m) (see Table 2);

L is the wall length (in m);

K_m are the material modification factors K_{101}, K_{102} and K_{103};

K_w are the wall modification factors K_{104}, K_{105}, K_{106}, K_{107} and K_{108}.

b) *Load testing* (see **5.9.5**). Square panels (2.4 m × 2.4 m) should be tested in accordance with [A2] BS [/A2] EN 594 and the results interpreted in accordance with section **5** of this British Standard to find the basic test racking resistance of a particular combination of materials and construction. In all respects the panel should be representative of the construction to be used in the design.

The basic test racking resistance values derived from load testing should be substituted for the values given in Table 2 and modified by the wall modification factors described in **4.9**.

As load testing refers to a specific combination of materials and their fixings, the material modification factors given in **4.8** (i.e. K_{101}, K_{102} and K_{103}) should not be applied to basic test racking resistance. The racking resistance of a wall should be calculated from the formula:

$R_b \times L \times K_w$

where

R_b is the basic test racking resistance (in kN/m) (as derived from load testing);

L is the wall length (in m);

K_w are the wall modification factors K_{104}, K_{105}, K_{106}, K_{107} and K_{108}.

The additional contribution values of a secondary layer of category 1, 2 [A2] , 3 or 4 [/A2] material (see Table 2) should only be used where the basic test racking resistance of the primary board material does not exceed 2.1 kN/m. In all other cases the additional contribution should be quantified by load testing the primary board material with and without the secondary board material.

c) *Load testing of full-sized walls* (see **5.10**). The walls should be tested in the form in which they are to be used, the permissible racking resistance for the wall derived in accordance with [A2] BS [/A2] EN 594 and the results interpreted in accordance with section **5** of this British Standard. Material and wall modification factors (K_{101} to K_{108}) should not be applied to wall racking test data derived in this manner.

d) *Detailed analytical methods outside the scope of this British Standard*. The material modification factors given in **4.8** and wall modification factors given in **4.9** should not be applied to designs carried out independently of this British Standard.

4.7.3 Racking deflection

The permissible racking deflection should be within limits appropriate to the type of construction, having particular regard to the possibility of damage to surface materials, ceilings, partitions, doors, windows and finishings.

The basic racking resistances given in Table 2 may be reduced proportionally in respect of a lower deflection limit, but they should not be increased.

NOTE The basic racking resistances given in Table 2 are based upon a maximum deflection of 0.003 × panel height.

4.7.4 The contribution of plasterboard to racking resistance

4.7.4.1 *General*

With the specific exception of separating walls comprising two or more built-up layers of plasterboard (see **4.7.5**), plasterboard alone should not be relied upon to provide the racking resistance of a dwelling.

Plasterboard should however be assumed to make a contribution to racking resistance if the principal resistance is provided by a category 1 or 2 material (see Table 2). When considering the walls providing resistance to wind forces in any one direction, the plasterboard linings described in **4.7.4.2** and **4.7.4.3** should be taken into account if their total contribution does not exceed 50% of the resistance provided by category 1 or 2 materials as defined in Table 2.

For plasterboard to contribute to the racking resistance:

a) the plasterboard should be fixed in accordance with Table 2;

b) the walls should be fully supported throughout their length and connected to supports in such a way as to ensure the transfer of applied shear forces.

4.7.4.2 ***Plasterboard linings to external sheathed walls***

The contribution of plasterboard to external sheathed walls should be calculated by using the additional lining contribution values given in Table 2 modified as appropriate by modification factors K_{103} to K_{108}. [A2) The plasterboard should be fixed on either the opposite face to or the same face as the sheathing, providing that it is independently fixed. Where the sheathing and plasterboard are fixed to the same side the length of fixings for the outermost lining should be increased nailed and the sheathing nails are extended in length to take to account of for the increased thickness of the wall innermost lining. (A2]

4.7.4.3 ***Internal walls***

Where internal walls, lined each side with plasterboard, are required to make a contribution to the racking resistance of the dwelling, the basic racking resistance should be taken from Table 2 using the basic racking resistance for a plasterboard lined wall plus the contribution of the second layer. The value thus obtained should be modified by modification factors K_{103} to K_{108} as appropriate.

Plasterboard lined internal walls are subject to the overall recommendations for plasterboard contribution given in **4.7.4.1**.

Door openings in internal walls should be regarded as structural discontinuities and the racking resistances should be derived from the sum of the racking resistances of the plain panels on either side of the openings.

In calculating the racking resistance of internal walls, the length should be taken as the length of each plain section of wall under consideration.

4.7.5 Plasterboard lined separating walls

The restrictions on the contribution of plasterboard given in **4.7.4.1** should not be applied to separating wall panels constructed from two or more layers of plasterboard and nailed in accordance with Table 2.

When sole reliance is placed upon plasterboard at the separating wall, care should be taken to ensure that additional bracing is provided in one of the following ways.

a) Full panel height diagonal bracing should be fixed to each separating wall panel such that there are no less than two braces on any separating wall leaf. The diagonal braces should be of 100 mm × 25 mm timber and nailed to each stud with at least three steel nails of 3.25 mm diameter with a pointside penetration of at least 35 mm.

b) A panel height sheathing of category 1 material (see Table 2) totalling at least 1200 mm in width, with no individual sheet less than 600 mm wide, should be placed on each separating wall leaf. [A2) The material should be fixed in accordance with the requirements of Table 2. (A2]

c) One of the layers of gypsum plasterboard fixed to each leaf of the timber frame separating wall should be of a moisture-resisting grade.

4.8 Assessment method for determining the basic racking resistance of certain material combinations

4.8.1 General

Where the assessment method, as described in **4.7.2**a, is to be used to determine the racking resistance of a timber frame wall, the values given in Table 2 should be used for the relevant combination of sheathing and lining materials.

NOTE 1 The values given in Table 2 are basic racking resistances based upon test evidence of fully sheathed panel walls, 2.4 m square, and for the generic materials described in section 2. Specific test results derived from tests in accordance with section 5 can be substituted for the values given in the table subject to the conditions given in 4.7.2b).

NOTE 2 The values given in Table 2 take account of the appropriate load duration factors given in BS 5268-2 for loads of short and very short term, and are based upon zero vertical load.

The use of Table 2 materials or test evidence of basic racking resistance should not be taken to imply that a particular material is fit for the purpose for which it is intended. Designers should assure themselves of the required durability for the intended use of materials.

4.8.2 Modification factors for variation in fixing and thickness of the materials described in Table 2

4.8.2.1 *Variation in nail diameter*

For [A2] sheathings other than plasterboard, with [/A2] variations in nail diameter between 2.25 mm and 3.75 mm the values for basic racking resistance given in Table 2 should be multiplied by K_{101}:

$$K_{101} = \frac{D_n}{3}$$

where

D_n is the proposed nail diameter (in mm).

[A2] *Note deleted* [/A2]

4.8.2.2 *Variation in nail spacing*

For sheathings other than plasterboard the values for basic racking resistance given in Table 2 should be multiplied by K_{102} to take account of variations in nail spacing:

$$K_{102} = \frac{1}{0.6A + 0.4}$$

$$A = \frac{S_p}{s_p}$$

where

S_p is the proposed perimeter spacing (in mm);

s_p is the perimeter spacing of nails as given in Table 2 (in mm).

K_{102} should not be used to modify the basic racking resistance given in Table 2 for plasterboard. Plasterboard nailed [A2] or screwed [/A2] at centres greater than prescribed in Table 2 should not be considered to contribute to racking resistance.

Where plasterboard is combined with other sheathing on the same wall, the combined basic racking resistance value as given in Table 2 should not be increased by increasing the nail density.

NOTE The sheathing acting alone may provide a greater basic racking resistance under these circumstances and may be substituted for the combined value.

4.8.2.3 *Variation in board thickness*

The values for basic racking resistance given in Table 2 may be modified by K_{103} to account for variations in thickness of sheathings or linings:

$$K_{103} = (2.8B - B^2 - 0.8)$$

$$B = \frac{T_b}{t_b}$$

where

T_b is the proposed board thickness (in mm);

t_b is the board thickness as given in Table 2 (in mm).

In no case should B be less than 0.75 or greater than 1.25.

[A2] NOTE K_{103} is not applicable to plasterboard thickness on separating walls. [/A2]

4.9 Modification factors for wall height, length, openings, vertical load and interaction

4.9.1 Height of wall panels

For wall panels of height between 2.1 m and 2.7 m, the height effect factor K_{104} should be calculated as follows:

$$K_{104} = \frac{2.4}{H_{wp}}$$

where

H_{wp} is the wall panel height (in m).

For wall panels exceeding 2.4 m in height and where an intermediate horizontal joint in the sheathing or lining is required, such joints should be framed and nailed in accordance with the relevant clauses of section **6**. The formula for K_{104} should not be used to extrapolate values for wall panels of heights less than 2.1 m or greater than 2.7 m.

4.9.2 Length of walls

The basic racking resistance should be modified to take account of the length of a timber frame wall. The length effect factor K_{105} should be taken from Table 3 or calculated as follows:

a) for wall lengths, L, from 0 m to 2.4 m

$$K_{105} = \frac{L}{2.4}$$

b) for wall lengths, L, from 2.4 m to 4.8 m

$$K_{105} = \left(\frac{L}{2.4}\right)^{0.4}$$

c) for wall lengths, L, in excess of 4.8m

$K_{105} = 1.32$

Table 3 — Some values of modification factor K_{105}

Length of wall m	K_{105}
0.6	0.25
1.2	0.50
1.8	0.75
2.4	1.00
3.0	1.09
4.2	1.25
$\geq$ 4.8	1.32

Where wall panels are combined to form the lengths of wall given in this clause it is essential that the following conditions are met.

1) Tops of individual wall panels should be linked by a member or construction that is continuous across panel joints.

2) The faces of end studs of contiguous panels should be fixed such that any vertical shear is transferred. In the absence of more specific information, end studs should be fixed with the equivalent of 3.35 mm nails of length 75 mm at 300 mm centres.

3) The coupled panels should be able to resist overturning forces.

4.9.3 Window, door and other fully framed openings in walls

For a wall with framed openings, the permissible racking resistance should be reduced to take account of the effect of framed openings. The opening effect factor K_{106} should be taken from Table 4 or calculated as follows:

$$K_{106} = (1 - 1.3p)^2$$

$$p = \frac{A_a}{A_t}$$

where

A_a is the aggregate area of opening in the wall;

A_t is the total area of wall including openings.

Where $p > 0.75$, $K_{106} = 0$.

Table 4 — Some values of modification factor K_{106}

p	K_{106}
0	1.0
0.1	0.76
0.2	0.55
0.3	0.37
0.4	0.23
0.5	0.12
0.6	0.05
0.7	0.01
> 0.75	0

All edges other than the bases of door openings should be, supported by members having a thickness not less than the thickness of the studs.

A means should be provided of transferring horizontal forces in the plane of the panel above and below openings. Where no such provision is made, the wall lengths on either side of the opening should be designed as separate parts.

Where an opening is less than 300 mm from the corner of a building and the depth of opening is greater than half the panel height, then the length of that part of the wall, up to and including the opening, should be disregarded when determining the total length of wall (see **4.9.2**).

Where two framed openings are separated by less than 300 mm and the heights of both openings are greater than half the panel height, then the area of opening should be taken as that of the rectangle that encloses both openings.

NOTE This method of assessing the effect of wall openings takes account of the worst case of openings in a timber frame wall. Where higher values of racking resistance can be obtained by considering a wall as a number of shorter lengths then this approach is acceptable.

4.9.4 Small unframed openings

Recommendations for fully framed openings are given in **4.9.3**, but where small unframed openings occur, their size and position should be restricted as follows:

a) they should not exceed 250 mm in diameter or in length of side; and

b) the clear distance between openings should be not less than the greatest dimension of the openings; and

c) the clear distance between the edge of the sheathing and the edge of any opening should be not less than the greatest dimension of the opening; and

d) not more than one such opening should occur in any one 600 mm width of sheathing or lining.

Smaller unframed openings may occur to a greater extent, but their aggregate opening area should not exceed the total area of opening given in item a). The rules governing the position of openings given in items b), c) and d) should also apply.

4.9.5 Variation in vertical load on timber frame wall

Since the values of basic racking resistance given in Table 2 assume zero vertical load on the timber frame wall panels, the basic racking resistance should be multiplied by K_{107} to take account of the effect of other vertical load conditions.

The vertical load on the wall (F) used to calculate K_{107} should be calculated using only the dead or permanent loading and any net effects of wind. K_{107} should be calculated as follows:

$$K_{107} = 1 + \left[(0.09F - 0.0015F^2) \times \left(\frac{2.4}{L}\right)^{0.4}\right]$$

where

F is the uniformly distributed load (in kN/m) (limited to a maximum of 10.5 kN/m for the purpose of this calculation);

L is the length of wall (in m).

It is assumed that in applying K_{107} any uplift forces or overturning moments have been taken into account and any necessary holding down fixing designed, therefore the vertical load should not be considered to be less than zero. For the purposes of calculating K_{107} or using Table 5, concentrated vertical loads should be converted into an equivalent vertical uniformly distributed load by the equation:

$$F = \frac{2aF_p}{L^2}$$

where

F is the equivalent uniformly distributed load (in kN/m);

F_p is the concentrated load (in kN);

a is the distance from F_p to the leeward end of the wall panel under consideration (in m);

L is the length of wall under consideration (in m).

NOTE A concentrated load can also be assumed to be developed by connections directly between the wall panel studs and the substructure, or in the case of a corner or internal wall, the wall at right angles.

4.9.6 Interaction

In calculating the permissible racking resistance of walls, the basic racking resistance should be multiplied by the modification factor K_{108}, which has the value 1.1.

NOTE The basic racking resistance values given in Table 2 or as derived from test and modified as appropriate, by modification factors K_{101} to K_{107}, give reasonably true assessments of the racking resistance of plain walls when subjected to test racking loads. When walls form part of completed dwellings experience shows that the method of assessment underestimates the permissible racking resistance, since it does not take into account factors such as the stiffening effect of corners and the interaction of walls and floors through multiple fixings.

Table 5 — Some values of modification factor K_{107}

Length of wall m	K_{107} Vertical load F kN/m										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0.6	1.00	1.15	1.30	1.45	1.59	1.72	1.85	1.97	2.09	2.20	2.31
1.2	1.00	1.12	1.23	1.34	1.44	1.54	1.64	1.73	1.82	1.91	1.99
1.8	1.00	1.10	1.20	1.29	1.38	1.46	1.55	1.62	1.70	1.77	1.84
2.4	1.00	1.09	1.17	1.26	1.34	1.41	1.49	1.56	1.62	1.69	1.75
3.0	1.00	1.08	1.16	1.23	1.31	1.38	1.44	1.51	1.57	1.63	1.69
3.6	1.00	1.08	1.15	1.22	1.29	1.35	1.41	1.47	1.53	1.59	1.64
4.2	1.00	1.07	1.14	1.21	1.27	1.33	1.39	1.44	1.50	1.55	1.60
4.8	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.47	1.52	1.57
5.4	1.00	1.06	1.13	1.19	1.24	1.30	1.35	1.40	1.45	1.50	1.54
6.0	1.00	1.06	1.12	1.18	1.23	1.29	1.34	1.39	1.43	1.48	1.52
6.6	1.00	1.06	1.12	1.17	1.22	1.28	1.32	1.37	1.42	1.46	1.50
7.2	1.00	1.06	1.11	1.17	1.22	1.27	1.31	1.36	1.40	1.44	1.48
7.8	1.00	1.06	1.11	1.16	1.21	1.26	1.30	1.35	1.39	1.43	1.47
8.4	1.00	1.05	1.11	1.16	1.20	1.25	1.29	1.34	1.38	1.42	1.45
9.0	1.00	1.05	1.10	1.15	1.20	1.24	1.29	1.33	1.37	1.41	1.44
9.6	1.00	1.05	1.10	1.15	1.19	1.24	1.28	1.32	1.36	1.40	1.43
10.2	1.00	1.05	1.10	1.14	1.19	1.23	1.27	1.31	1.35	1.39	1.42

4.10 Contribution of masonry veneer to racking resistance

The permissible racking resistance for sheathed timber frame walls, for all combinations of sheathing, lining and vertical load conditions, should be increased to take account of the racking resistance of masonry cladding, provided that [A2⟩ adequate wall ties are provided at the required spacing ⟨A2].

The additional racking resistance for masonry cladding given in Table 6 should be applied only to those parts of the wall comprising a minimum of 2.4 m high masonry at least 600 mm wide backed by storey height timber frame. Masonry cladding should conform to **2.7**.

The contribution of the masonry to the permissible racking resistance of the timber frame wall should be determined by multiplying the relevant value in Table 6 by the total length of storey height masonry over 600 mm wide in the wall.

Under no circumstances should the contribution to permissible racking resistance provided only by the masonry cladding exceed 25 % of the permissible racking resistance provided by the timber frame wall to which it is fastened, when considering wind forces in any one direction.

NOTE Attention is drawn to **4.13.1**.

Under no circumstances should the modification factors given in **4.9** be applied to the values given in Table 6.

Table 6 — Contribution of masonry cladding

Minimum tie density	Racking resistance kN/m
4.4 ties/m^2, e.g. 600 mm horizontally, 380 mm vertically	0.5
3.7 ties/m^2, 600 mm horizontally, 450 mm vertically	0.4

4.11 Racking resistance for walls braced by other than sheet materials

Racking resistance for braced walls should be determined either by calculation or by load testing in accordance with section **5**.

Inclined bracing in the form of short pieces of blocking each fitted between adjacent studs should not be used unless they are [A2⟩ additionally ⟨A2] connected to lining, sheathing or gussets.

4.12 Joints

4.12.1 Mechanical joints

Except where justified by load testing or where permissible values are taken from this British Standard, joints should be designed in accordance with BS 5268-2.

4.12.2 Glued joints

Glued joints should be designed in accordance with BS 5268-2 and manufactured in accordance with BS 6446.

4.13 Other design considerations

4.13.1 Masonry cladding

Masonry cladding should be connected to the timber frame with wall ties that have sufficient strength and stiffness to transfer wind forces to the timber frame wall. Special care should be taken to ensure that adequate connections are provided for small free-standing piers of masonry.

[A2⟩ Masonry claddings move with time mainly due to variations in moisture equilibrium and temperature. Masonry movement characteristics may be assessed by a consideration of global movement effects. Nominal movement characteristics for masonry units may be obtained from the masonry unit manufacturer. ⟨A2]

[A2] Wall ties should have sufficient vertical flexibility to accommodate vertical downward movement of the timber frame in relation to the masonry cladding. In the absence of more detailed information, the masonry component of differential movement should be calculated in accordance with the guidance given in BS 5628.

4.13.2 Fixings and services

Timber frame buildings shorten in height through a combination of moisture content reduction, joint tightening, and elastic load effects. In the absence of more precise information, the following equation should be used to calculate the combined result utilizing the movement allowances given in Table 7.

Timber frame movement = Cross grain timber depth (mm) × Movement allowance (%)

Table 7 — Movement alowance for frame shortening

Frame material	Movement allowance
20% moisture content timber	2.8%
14% moisture content timber	1.2%
10% engineered wood products (e.g. laminated veneer lumber)	0.6%
NOTE 1 The depth of cross grain timber used in the above calculation should include all sole plates, rails, joists, and plates.	
NOTE 2 Moisture contents quoted in the table are average moisture contents taken at the time of erection.	
NOTE 3 The designer's attention is brought to the possible increased shortening caused by concentrated loads.	

4.13.3 ***Movement joint design***

Vertical movement joint (horizontal jointing) design should accommodate all cladding and frame movement components as described in **4.13.1** and **4.13.2** plus the minimum residual depth of any joint sealant.

Horizontal movement joints (vertical jointing) in masonry should be designed in accordance with the guidance given in BS 5628.

Where other claddings are used consideration should be given to the cladding movement and jointing characteristics.

4.13.4 ***Fixings and services***

Consideration should be given at the design stage to provisions for fixing and jointing linings and claddings, internal fittings (e.g. cupboards and wash basins) and the accommodation of services within timber frame walls.

Allowance should be made in the design for any notching or drilling that is necessitated by the installation of services. In the absence of more specific design information the recommendations of BS 5268-2 should be adopted.

4.13.5 ***Value of γ_{global} for use with wall tie design***

The global safety factor, γ_{global}, to be applied to the declared strength of wall ties conforming to BS EN 845-1 should be 4.2 (see also Table B.3). This global safety factor comprises material strength and load effect partial safety factors for direct use in this part of this permissible stress code of practice.

Reference should also be made to BS 5628-1. [A2]

Section 5. Load testing

5.1 General

For timber frame walls loaded by a combination of vertical loads and combined with racking forces the test procedure should be conducted in accordance with A2 BS A2 EN 594.

Wherever possible more than one panel should be tested to allow assessment of any possible variability.

NOTE 1 General load testing of timber structures is dealt with in BS 5268-2.

NOTE 2 The A2 BS A2 EN 594 test method can be used to determine any of the following.

a) The racking resistance of a given configuration of framework, sheathing, lining, fixings etc. The basic test racking resistances for that configuration can then be derived and substituted for the values of basic racking resistance given in Table 2 subject to the limitations given in **4.7.2**b).The tests are carried out on 2.4 m square panels representative of the typical structure but excluding features such as openings, and cover a range of vertical load conditions.

b) The racking resistance of a full-scale wall for designs outside the scope of **4.8**.

c) The racking performance of panels where a quality control check is required as part of the manufacturing process.

5.2 Testing authority

Tests on timber frame wall panels should be designed, supervised and certified by a competent authority to ensure that the tests are in accordance with A2 BS A2 EN 594.

5.3 Information required

The following information should be provided:

a) a copy of the detailed drawings and specifications for the panel and fixings;

b) details of design loads (both racking and vertical) when known;

c) either:

1) conditions of exposure, humidity and temperature in which the panel is to be used; or

2) moisture content of the timber and sheet materials used for design purposes.

Any other data or information required for the purposes of the test should be deposited with the testing authority before the tests are commenced.

5.4 Materials

The materials used in the test panel should be of the minimum basic sizes allowed by the specification. The quality should be, as far as practicable, the minimum quality, and in no case better than the average quality allowed by the specification.

Where testing is being carried out in order to derive basic test racking resistance for use in place of the values given in Table 2, the wall panel should be constructed from timber no better than strength class C16 as defined in BS 5268-2 and be of average density for the species.

5.5 Manufacture

Where a prototype or production timber frame wall is to be tested, the manufacture and assembly of the wall should conform to the design specification, and the methods of test used should simulate as closely as possible those which would normally be used in production or site assembly.

Where a timber frame test panel is used to determine the basic test racking resistance of a combination of materials, a 2.4 m square panel should be assembled simulating as closely as possible the typical panel construction with regard to:

a) size, spacing and specification of studs and horizontal members;

b) type, thickness, size and orientation of sheathing and/or lining;

c) size and spacing of mechanical fasteners;

d) method of assembly.

5.6 Test conditions

The test panels should be installed in the test rig and fixed to the base by methods that simulate as closely as possible the fixings to be used in service. Where the method of holding down the panel is not known at the time of test, the fixings to the base should be such that uplift or horizontal movement of the bottom plate of the panel is minimal during the test. Particular attention should be given to the positioning of panels on the base and the location of bearers at loading points, to ensure that no loads are applied directly to the sheathing or plasterboard lining except through the fixings between the timber frame and the sheathing or plasterboard lining.

Lateral restraint at right angles to the plane of the test panel should be provided equivalent to that likely to be attained in service. Care should be taken to ensure that these restraints do not inadvertently resist movements in the plane of the panel.

Where it is clear that there is unavoidable and significant divergence from service conditions either in load application or restraint, it is essential that this is noted and taken into account when analysing the test results.

5.7 Criteria for selection of test loads

NOTE 1 With regard to structural performance, the serviceability of panels subject to racking loads may be limited by either stiffness or strength, both of which are dependent on the applied vertical load.

Where vertical loads likely to occur in service are known they should be used to establish the suitability of the panel for use under the specified load combination.

Where a panel is intended for use under a range of vertical loads, a minimum of two similar panels should be tested. One panel should be tested for strength [A2⟩ and stiffness ⟨A2] under the assumed maximum vertical load and the other under minimum vertical load. [A2⟩ *Text deleted* ⟨A2] In the absence of any specified alternative, the minimum vertical load should be taken as zero.

NOTE 2 Further tests at intermediate vertical loads are helpful in the interpolation and derivation of the permissible design racking loads over the range of vertical loads considered.

When testing a panel to derive basic test racking resistance (see item a) of note **2** to **5.1**), the vertical load should be applied as equal point loads over the stud positions at approximately 600 mm centres.

NOTE 3 When applied as equal point loads over the stud positions at approximately 600 mm centres, the load intensity is described as the point load in kilonewtons per stud.

The equivalent uniformly distributed load F (in kN/m) should be calculated from the equation:

$$F = \frac{F_v \times 5}{2.4}$$

where

F_v is the vertical stud load (in kN).

In the particular case where the basic test racking resistance (see item a) of note 2 to **5.1**) of the combination of materials is being assessed, the vertical loads should range between 0 kN and 5 kN per stud or equivalent.

NOTE 4 The load test described in this section is not intended for assessing the racking resistance of panels subject to a net vertical uplift. Where it can be shown that uplift forces are effectively transmitted through the structure independent of the sheathing or bracing, the permissible racking load for this condition is based on racking tests with zero vertical load.

5.8 Test method

The basic test racking resistance (see item a) of note 2 to **5.1**) should be determined in accordance with the test procedure given in [A2⟩ BS ⟨A2] EN 594 and this section of this British Standard.

For items b) and c) of note 2 to **5.1**, the test procedure and annex A of [A2⟩ BS EN 594:1996 ⟨A2], should be referred to.

The maximum racking loads (F_{max}) and racking stiffnesses (R) used to derive design values for each panel tested should be related to the type of test panel (including its base fixing) and the vertical load condition.

5.9 Determination of basic test racking resistance values

5.9.1 General

Only tests performed on the standard test panel and in accordance with the test procedure given in A2 BS A2 EN 594 should be used to determine the basic test racking resistance of a combination of materials. In the calculation of basic test racking resistance at least three replicates for each of the maximum and minimum vertical load conditions should be tested.

5.9.2 Test racking stiffness load

NOTE The test racking stiffness load is the load predicted to produce a racking deflection of 0.003 × panel height.

The test racking stiffness load should be calculated by averaging the racking stiffness loads for similar panel tests. The racking stiffness load R_1 (in kN) for each new panel should be calculated from the equation:

$$R_1 = R \times 0.002 \times H_{wp} \times 1.25 \times K_{109}$$

where

R is the racking stiffness of the panel (expressed in kN/mm as a load per unit deflection);

H_{wp} is the panel height (in mm);

K_{109} is a modification factor (see Table A2 8 A2) to take account of the number of similar panels tested.

NOTE 1.25 converts the load prediction for a deflection of 0.002 × Hwp to an estimate of acceptable performance at 0.003 × Hwp.

Table 8 — Modification factor K_{109} for test racking stiffness load and test racking strength load

No. of similar panels tested under the same conditions	K_{109}
1	0.80
2	0.87
3	0.93
4	0.97
5	1.00

5.9.3 Test racking strength load

The test racking strength load should be determined from similar panels tested under the same vertical load conditions using the minimum value of racking load (F_{max}) obtained from the series of tests, multiplied by the appropriate modification factor K_{109} from Table A2 8 A2.

5.9.4 Test racking design load

The test racking design load for the particular vertical load under which a panel was tested should be taken as the lesser of:

a) the test racking stiffness load, determined in accordance with **5.9.2**;

b) the test racking strength load, determined in accordance with **5.9.3**, divided by the appropriate factor of safety (see Table A2 9 A2).

Table 9 — Factors of safety for test racking strength load

Sheathing, lining or combination	Factor of safety
a) Any sheet material other than the plasterboard described in section **2**	1.6
b) Plasterboard or any other sheet material not covered by a)	2.4
c) Combination of two materials as described in a)	1.6
d) Combination of two materials where either one or both are as described in b)	2.4
[A2) NOTE (A2] When the combination is of one material as described in a) and one as described in b), the factor of safety of 2.4 need only be applied to the additional racking strength load obtained using the material as described in b).	

When a particular panel type has been tested under more than one vertical load, the test racking stiffness loads and the test racking strength loads should be linearly interpolated for intermediate vertical loads. For any particular vertical load, the test racking design load should be taken as the smaller of the interpolated test racking stiffness or the interpolated test racking strength values, divided by the appropriate factor of safety given in Table [A2) 9 (A2].

Test results and test racking design loads should not be extrapolated outside the range of vertical loads applied during the test.

5.9.5 Basic test racking resistance

The basic test racking resistance for a combination of materials should be derived by testing a wall panel (see Figure 1 of [A2) BS EN 594:1996 (A2]) over a range of vertical loads that include 0 kN and 5 kN or equivalent.

The basic test racking resistance R_b (in kN/m) should be taken as the lowest value obtained as follows:

$$R_b = \frac{R_d}{2.4 \times K_{111}}$$

where

R_d is the test racking design load (see **5.9.4**) for each vertical load condition (in kN);

K_{111} is the vertical load modification factor(see Table [A2) 10 (A2]).

Table 10 — Vertical load modification factor K_{111} for point loads at nominal 600 mm centres on a test panel used for determining values of basic test racking resistance

Vertical load per stud kN	K_{111}
0	1.00
1	1.18
2	1.35
2.5	1.43
3	1.50
4	1.65
5	1.77

5.10 Determination of design values

NOTE 1 The test results for any panel tested in accordance with [A2⟩ BS ⟨A2] EN 594 can be used to determine design values using the procedures given in **5.9.2**, **5.9.3** and **5.9.4**. Design values are only appropriate to panels identical to those tested, to similar base fixing methods and to the range of vertical loads covered by the tests.

Where it is clear that there is unavoidable and significant divergence from service conditions either in load application or method of restraint, the differences should be clearly noted.

Only design values from standard test panels (see Figure 1 of [A2⟩ BS ⟨A2] EN 594:1995) should be used with the design method given in section **4** of this British Standard.

NOTE 2 A panel is deemed suitable for sustaining a specified design racking load if the test racking design load determined in accordance with **5.9.4** is equal to or greater than the specified design racking load.

5.11 Use of test panels

Panels that have been subjected to strength tests should not be used for structural purposes.

Section 6. Workmanship

6.1 Fabrication

6.1.1 General

Drawings should be available showing the sizes of the wall panels and openings, and details of the framing, sheathing, connections, cutting and notching, and specifications of all relevant materials.

Fabrication should be in accordance with the specifications and drawings.

A system of identification of pre-fabricated timber frame wall panels should be agreed between the purchaser and the supplier and such identification should be clearly marked to ensure correct positioning on site in accordance with the detailed drawings.

6.1.2 Inspection

Fabricators of timber frame wall panels should provide purchasers and their authorized representatives with the necessary facilities for inspection during fabrication and by arrangement should permit access at all reasonable times to all places where relevant work is being carried out.

6.1.3 Moisture content

The moisture content of wall panels at the time of fabrication should be in accordance with the relevant clauses of BS 5268-2.

6.1.4 Timber tolerances

Timber used in the fabrication of wall panels should be within the tolerances for sawing and machining specified in BS EN 336.

6.1.5 Assembly

Pre-fabricated timber frame wall panels should be assembled so as to ensure dimensional accuracy and flatness.

All members should be accurately cut to ensure firm contact along the abutting faces, and should be accurately cut to length to within a tolerance of ± 1 mm. No gaps over 2 mm between abutting faces of timber should be permitted unless allowed for in the design.

Timber frame wall panels should be fabricated so that horizontal and vertical dimensions are within mm of the size specified by the designer.

All mechanical fasteners should be of the type and sizes specified and should be located so that the specified spacing, end and edge distances are maintained. Nails or screws should be fully driven home without undue damage to the surface of the materials being joined.

Glued assemblies should conform to BS 6446.

6.1.6 Finger jointing

Glued finger joints in structural softwood should conform to BS EN 385.

6.2 Handling and erection

6.2.1 Storage

Timber frame wall panels should at all times be stored on raised bearers to avoid contact with the ground and vegetation and should be supported so as to prevent distortion. They should preferably be stored vertically, but when stored horizontally, the sheathing should be uppermost to prevent any risk of water collecting and supported to avoid warping. Reasonable precautions should be taken to avoid any damage to materials as a result of exposure to rain.

6.2.2 Handling and transport

Care should be taken in handling to avoid damage to sheathing and local overstressing during lifting.

The general recommendations given in **6.2.1** for on-site storage should also be followed for storage during transport.

6.2.3 Erection

Modifications to timber frame wall panels, repairs to damaged panels or measures adopted to remedy defects discovered after erection of a wall panel should be in accordance with this British Standard.

Panels should not be notched, cut or drilled unless expressly provided for in the design, or unless carried out in accordance with BS 5268-2.

Panels should be erected accurately, aligned and positioned, and fastened to adjacent wall panels, floor and roof in accordance with the detailed drawings.

Care should be taken to ensure that adequate bearing is provided for the timber frame wall by the supporting structure.

It is essential that nailing specifications for the on-site nailing of sheathings and linings where such materials are contributing to the structural performance of the walls are adhered to.

6.2.4 Temporary bracing

Such temporary bracing or fixing as is required to ensure stability of wall panels, floor and roof during the construction period should be provided and maintained for as long as is necessary.

Annex A *deleted*

Annex B (normative) User categories for the selection and application of timber framed wall ties

B.1 General

Wall ties are grouped into user categories for convenience of selection and application. Such grouping enables ties, meeting a combination of performance criteria, to be referenced more easily in design guidance, design specifications and execution instructions. The type references and qualifying criteria for the user grouping of timber framed wall ties are given in Table B.1, Table B.2 and Table B.3.

B.2 Classification

Timber framed wall ties are classified according to their end use as shown in Table B.1.

Table B.1 — Classification of timber framed wall ties by end use

Classification	Field of use		
	Type of structure	Tie density	Geographical location
Type 5 (Timber frame)	Suitable for tying masonry outer cladding on to softwood structural framework of residential and industrial/commercial buildings up to three storeys and not greater than 15 m total height. Not suitable for attaching masonry to other materials nor for use in multi-storey structures of more than three storeys.	4.4 ties/m^2 in main areas; or alternatively 7 ties/m^2 (see Geographical location). 3–4 ties/m run at unbonded edges.	Suitable at a tie density of 4.4 ties/m^2 for buildings on flat sites within towns and cities anywhere in the UK, except the north western fringes of Scotland and Ireland (where the basic wind speed exceeds 25 m/sec) and any areas where the site is at an altitude of 150 m or more above sea level. In more severe situations the tie density should be increased to 7 ties/m^2.
Type 6 (Timber frame: high movement e.g. 18 mm)	As for Type 5, but suitable for four storey buildings, being designed to accommodate the potential increased vertical differential movement likely to be encountered in the fourth storey of a building not greater than 15 m in total height.	As Type 5	As Type 5
Type 7 (Timber frame: higher movement e.g. greater than 18 mm)	As for type 5, but suitable for five to seven storey buildings, being designed to accommodate the potential increased vertical differential movement likely to be encountered in a greater than 4-storey building, but with the building not being greater than 18 m total height.	Calculated for actual performance required for each site location.	Calculated for actual performance required for each site location.
NOTE There are no limits on the length of ties or technically, on the width of the cavity over which they are designed to function, but the cavity width range for which each product is designed is declared by the manufacturer and the performance data measured for the worst case (usually the widest cavity). See Table B.3			

B.3 Functional sections

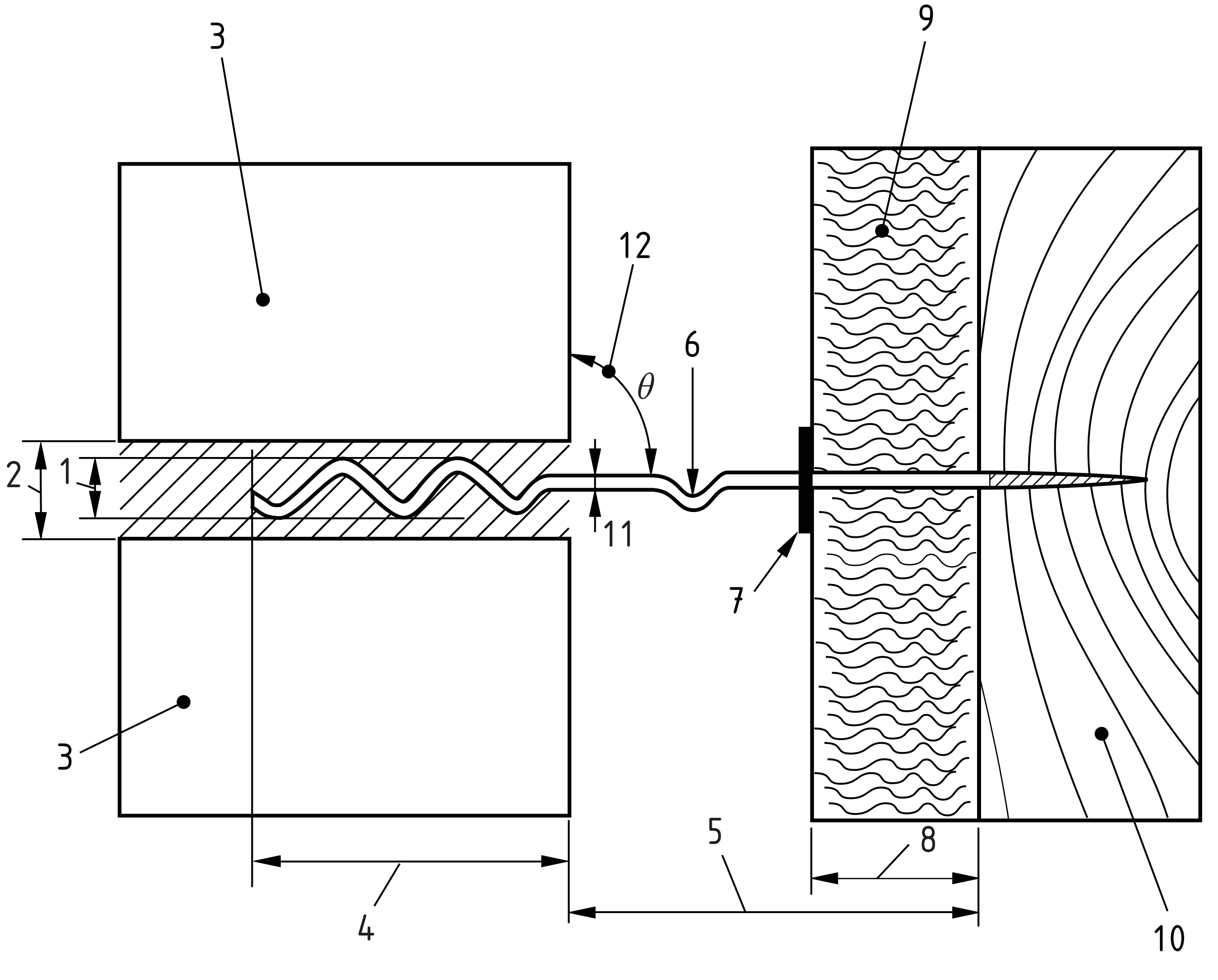
The tie should consist of three functional sections, namely:

a) an timber frame connection,

b) cavity spanning section,

c) an outer leaf masonry cladding connection.

The classification of ties by end use is given in Table B.2 and Figure B.1 for the appropriate type of tie; the angle, θ, should be limited to between 65° and 90°, and drips should be approximately in the centre of the cavity air space, subject to the restrictions noted in the key to Figure B.1.



Key

1 Profile height
2 Mortar joint thickness
3 Masonry units forming outer leaf
4 Design embedment length
5 Cavity width
6 Drip
7 Insulation retaining clip
8 Insulation width
9 Insulation
10 Inner leaf material, e.g. timber
11 Diameter of wire or thickness of plate
12 Angle between the tie and the masonry veneer

Figure B.1 — Functional sections of timber frame-masonry wall ties in an external wall construction

Table B.2 — Functional sections (see Figure B.1)

Type (see Table B.1)	Timber frame connection	Cavity spanning section	Outer leaf masonry cladding connection
Type 5 (Timber frame)	Should be arranged to permit each tie to be attached to timber-frame elements using a single suitable fixing[a], driven through a preformed hole in the tie, through any breather membrane and sheathing and into the vertical timber stud. Should be designed to provide sufficient access clearance for access of fixing tools. Alternative fixings to the timber frame, which can be integral to the tie itself, may be used if they provide an equivalent structural performance.	Should transmit the forces (tensile and compressive) arising from service loads on the masonry, while permitting the following movements: (a) a net downward vertical movement of the inner (timber frame) connection in relation to the outer (masonry leaf) connection of up to 12 mm without failure; NOTE This requirement is to allow for possible vertical differential movements between the masonry outer leaf cladding and the timber frame during drying-out of the building, (b) reversible differential movements in the vertical direction between the two leaves during the full service life of the wall of up to 10 mm resulting from thermal and moisture effects but subject to an aggregate maximum vertical differential movement [(a) + (b)] of 12 mm; (c) differential movements in the horizontal direction during service life of the walling of up to 6 mm (in the plane of the wall). Should be designed such that either there is a slope of 10° or more down from the timber frame to the masonry cladding outer leaf even after the 12 mm given in (a), or such that water will drip off before reaching the timber frame.	Should consist of a rod, wire, bar or plate formed in such a way as to be able to bond to mortar. Should have a thickness of material not exceeding half the design joint thickness and an overall depth across the vertical profile not exceeding 80% of the design joint thickness in order that the tie may be accommodated within the mortar joint.
Type 6 (Timber frame)	As for Type 5, but should permit the tie to be attached to the timber frame using not more than two suitable fixings driven through preformed holes in the tie and by way of any breather membrane or sheathing materials into the vertical timber stud. Alternative fixings to the timber frame, which can be integral to the tie itself, may be used if they provide an equivalent structural performance.	As for Type 5, but allowing a net vertical downward movement of up to 18 mm.	As Type 5
Type 7 (Timber frame)	A performance fixing to the timber frame, which may not be integral to the tie itself (e.g., supporting channel) providing adequate structural performance.	As for Type 5, but allowing a net vertical downward movement defined by the tying device performance criteria, but usually greater than 18 mm.	As Type 5

[a] In UK practice the minimum performance requirement for a single suitable fixing has been based upon the shear and pull-out performance provided by a 3.35 mm minimum diameter ring shank nail of 50 mm minimum length embedded in C16 timber.

B.4 Dimensions and tolerances of ties

The design of the tie should be such as to meet the requirements of this British Standard, whilst allowing for the tolerances normal in buildings, such as the width of the cavity varying from the stated design cavity width.

The masonry cladding outer leaf minimum embedment length for the wall tie should be 50 mm or the wall tying device manufacturer's declared embedment length, whichever is the greater embedment. Masonry should be built in accordance with BS 5628-3.

The design of the tie should be such as to accommodate both increases and decreases in length of one or more of the functional sections, within the range likely within normal workmanship and still meet the recommendations of this British Standard. (Under site conditions the width of the cavity in building may vary from the stated design cavity width).

B.5 Performance of wall ties

The tensile and compressive load capacities of tie types should be equal to, or greater than, the specified load capacities for a specified embedment length, but should not be less than the values given in Table B.3, when the tie minimum embedment length into the masonry cladding outer leaf is taken to be 50 mm or the wall tying device manufacturer's declared embedment length if greater.

Table B.3 — Minimum declared tensile load capacity and compression load capacity for timber frame tie type

Tie type	Minimum mortar class and designation	Tensile load capacity N	Compressive load capacity N
5[a]	M4 (iii)	600	425
6[b]	M4 (iii)	630	440
7[c]	M4 (iii)	Declared by tying device manufacturer	Declared by tying device manufacturer

[a] In UK practice the tensile and compressive load capacities have also been valid for a timber frame simulated movement of 12 mm.

[b] In UK practice the tensile and compressive load capacities have also been valid for a timber frame simulated movement of 18 mm.

[c] The tensile and compressive load capacities will need to be valid for a timber frame simulated movement as declared by the wall tying device manufacturer.

List of references

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

[A2] BS 4729, *Specification for dimensions of bricks of special shapes and sizes.*

BS 5268, *Structural use of timber.*

BS 5268-2, *Code of practice for permissible stress design, materials and workmanship.*

BS 5268-3, *Code of practice for trussed rafter roofs.*

BS 5268-5, *Code of practice for the preservative treatment of structural timber.*

BS 5628, *Code of practice for use of masonry.*

BS 5628-1, *Structural use of unreinforced masonry.*

BS 5628-2, *Structural use of reinforced and prestressed masonry.*

BS 5628-3, *Materials and components, design and workmanship.*

BS 6100, *Glossary of building and civil engineering terms.*

BS 6399, *Loading for buildings.*

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

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

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

BS 6446, *Specification for manufacture of glued structural components of timber and wood based panel products.*

BS EN 300:2006, *Oriented strand boards (OSB) — Definitions, classification and specifications.*

BS EN 312-5:1997, *Particleboards — Specifications — Part 5: Requirements for load-bearing boards for use in humid conditions.*

BS EN 312-7:1997, *Particleboards — Specifications — Part 7: Requirements for heavy-duty load-bearing boards for use in humid conditions.*

BS EN 336, *Structural timber — Coniferous and poplar — Sizes — Permissible deviations.*

BS EN 385, *Finger jointed structural timber — Performance requirements and minimum production requirements.*

BS EN 520, *Gypsum plasterboards — Definitions, requirements and test methods.*

BS EN 622-2:1997, *Fibreboards — Specifications — Part 2: Requirements for hardboards.*

BS EN 622-3:2004, *Fibreboards — Specifications — Part 3: Requirements for medium boards.*

BS EN 622-4:1997, *Fibreboards — Specifications — Part 4: Requirements for softboards.*

BS EN 634-2:1997, *Cement-bonded particle boards — Specification — Part 2: Requirements for OPC bonded particleboards for use in dry, humid and exterior conditions.* [A2]

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 5268, *Structural use of timber*.

BS 5268-4, *Fire resistance of timber structures*[1].

A2 BS 5268-4.1 A2, *Recommendations for calculating fire resistance of timber members*.

A2 BS 5268-4.2 A2, *Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions*.

BS 5268-7, *Recommendations for the calculation basis for span tables*[1].

DD 140, *Wall ties*.

A2 DD 140-2 A2, *Recommendations for design of wall ties*.

CEN publications

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN), Brussels. (All publications are available from Customer Services, BSI.)

A2 BS EN 594:19965 A2, *Timber structures — Test methods — Racking strength and stiffness of timber frame wall panels*.

1)

[1] Referred to in the foreword only.

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