BRITISH STANDARD

BS 5268-6.2:2001
Incorporating
Corrigendum No. 1

Structural use of timber —

Part 6: Code of practice for timber frame walls —

Section 6.2: Buildings other than dwellings not exceeding four storeys

ICS 91.060.10; 91.080.20

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

Construction User Group

Department of the Environment, Transport and the Regions

Health and Safety Executive

Institution of Civil Engineers

Institution of Structural Engineers

National House-Building Council

Trussed Rafter Association

Timber Research and Development Association

Timber Trade Federation

United Kingdom Forestry Products Association

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Contents

Foreword

This section of BS 5268 has been prepared by Subcommittee B/525/5, Structural use of timber.

BS 5268 is published in the following parts and sections:

— *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 6: Code of practice for timber frame walls;*

— *Section 6.1: Dwellings not exceeding four storeys;*

— *Section 6.2: Buildings other than dwellings not exceeding four storeys;*

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

— *Section 7.1: Domestic floor joists;*

— *Section 7.2: Joists for flat roofs;*

— *Section 7.3: Ceiling joists;*

— *Section 7.4: Ceiling binders;*

— *Section 7.5: Domestic rafters;*

— *Section 7.6: Purlins supporting rafters;*

— *Section 7.7: Purlins supporting sheeting or decking.*

BS 5268-6.1 was first published in 1988 (with subsequent revisions) and covers the design of timber frame walls in dwellings up to four storeys in height.

In recent years the demand for timber frame structures for building other than dwellings has developed rapidly and it has been estimated that around 50 % of the output of the timber frame manufacturing industry is produced for non-domestic buildings.

This section of BS 5268 follows a similar methodology to BS 5268-6.1, but because of the demand for greater storey heights in non-domestic buildings, it is based upon an extensive range of tall wall panel racking tests carried out on wall panels up to 4.8 m in height. It is essentially written for buildings other than dwellings, but some of the information in respect of the performance of wall panels over 2.7 m in height may also be appropriate for use in the design of tall wall panels in dwellings.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

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1 Scope

This section of BS 5268 gives recommendations for the design, testing, fabrication and erection of timber frame walls for buildings other than dwellings not exceeding four storeys in height and where the following conditions apply.

a) The maximum overall height of any building is 15 m.

b) The maximum panel height in a single storey building is 6.2 m.

c) The maximum panel height in buildings of more than one storey is 4.8 m.

This section of BS 5268-6 gives recommendations for timber frame walls, with studs continuous in length throughout the panel height, not exceeding 610 mm centre to centre and one or both faces of the studs being partly or wholly connected to sheathing or lining. The design information contained in this section of BS 5268 is principally intended to cover storey height panel construction. Much of the information is also relevant to other forms of panel construction, for example, where studs are continuous through two or more storeys.

All structural materials are assumed to be subject only to service classes 1 and 2, as defined in BS 5268-2:1996.

The design information on the racking performance of tall wall panels (over 2.7 m in height), contained in this section of BS 5268-6, may also be relevant to the design of tall wall panels in dwellings. The design method described in this section of BS 5268-6 may be used in validating the racking performance of wall panels over 2.7 m in height for use in dwellings in combination with designs in accordance with the recommendations of BS 5268-6.1.

This section of BS 5268 covers only 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) susceptibility to weathering;

b) condensation control;

c) thermal insulation;

d) fire resistance;

e) sound insulation;

f) durability.

2 Normative references

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

BS 187, *Specification for calcium silicate (sandlime and flintstone) bricks.*

BS 1230-1, *Gypsum plasterboard — Part 1: Specification for plasterboard excluding materials submitted to secondary operations.*

BS 3921, *Specification for clay bricks.*

BS 4551:1980, *Methods of testing mortars, screeds and plasters.*

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

BS 5268-2:1996, *Structural use of timber — Part 2: Code of practice for permissible stress design, materials and workmanship.*

BS 5268-3:1998, *Structural use of timber — Part 3: Code of practice for trussed rafter roofs.*

BS 5268-5:1989, *Structural use of timber — Part 5: Code of practice for the preservative treatment of structural timber.*

BS 5268-6, *Structural use of timber — Part 6: Code of practice for timber frame walls.*

BS 5268-6.1:1996, *Structural use of timber — Part 6: Code of practice for timber frame walls — Section 6.1: Dwellings not exceeding four storeys.*

BS 5390, *Code of practice for stone masonry.*

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

BS 5628-2:1985, *Code of practice for use of masonry — Part 2: Structural use of reinforced and prestressed masonry.*

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

BS 6073-1, *Precast concrete masonry units — Part 1: Specification for precast concrete masonry units.*

BS 6100 (all parts), *Glossary of building and civil engineering terms.*

BS 6399-1, *Loading for buildings — Part 1: Code of practice for dead and imposed loads.*

BS 6399-2, *Loading for buildings — Part 2: Code of practice for wind loads.*

BS 6399-3, *Loading for buildings — Part 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 6457, *Specification for reconstructed stone masonry units.*

BS 6649, *Specification for clay and calcium silicate modular bricks.*

BS EN 300:1997, *Oriented strand board (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 594:1996, *Timber structures — Test methods — Racking strength and stiffness of timber frame wall panels.*

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

BS EN 622-3:1997, *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 particleboards — Specifications — Part 2: Requirements for OPC bonded particle boards for use in dry, humid and exterior conditions.*

DD ENV 1995-1-1:1994, *Eurocode 5 — Design of timber structures — General rules and rules for buildings (together with United Kingdom National Application Document).*

3 Terms and definitions

For the purposes of this section of BS 5268 the following terms and definitions apply.

3.1

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

3.2

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

3.3

gable apex panel
wall panel forming the apex of a gable

3.4

stud
vertical member in a framed partition or wall

3.5

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

3.6

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

3.7

wall panel
component that forms part of a timber frame wall

3.8

wall sheathing
sheet or board used as a bracing

4 Materials

4.1 General

The materials used should conform to the appropriate British Standards.

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

All sheathing and lining materials should be of a thickness and robustness so that damage during manufacture, transport and erection is avoided.

4.2 Species of timber

All structural timber should be strength graded in accordance with the recommendations of BS 5268-2.

NOTE Any of the species of timber listed in BS 5268-2 may be used.

4.3 Sheathing materials

4.3.1 *Plywood*

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

4.3.2 *Fibre building boards*

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

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 622-3:1997;

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

4.3.3 *Wood chipboard*

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

4.3.4 *Oriented strand board*

Oriented strand board for sheathing should be type OSB/3 or OSB/4 conforming to BS EN 300:1997.

4.3.5 *Cement bonded particleboard*

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

4.3.6 *Other sheathings*

Where sheathings other than those described in **4.3.1**, **4.3.2**, **4.3.3**, **4.3.4** and **4.3.5** are to be used they should conform to the relevant British or European Standard.

The durability of any wall sheathing material with a view to its intended end use should be ensured.

4.4 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 BS 1230-1.

4.5 Adhesives

Adhesives used in the construction of timber frame wall panels should be of a type 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.

4.6 Fasteners

Structural fasteners should be corrosion resistant and should be compatible with any preservative treatments used and any other metalwork with which they are in contact.

In the construction of panels and for fixing sheathing mild steel or stainless steel nails should be used, of round head or D-head configuration, and the size to be used should be given in the design.

4.7 Masonry cladding

Where masonry cladding to be used for shielding the timber frame or to contribute to the racking resistance of a timber frame wall it should be designed in accordance with the appropriate part of BS 5628 or BS 5390 for stone masonry and should be at least 100 mm thick and have a minimum density of 750 kg/m^3.

5 Loading

5.1 General

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

5.2 Wind loading

5.2.1 *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.

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 non-specific factors assisting in the resistance to wind loads are taken into account in the interaction factor given in **5.2.3**.

5.2.2 *Wind loading on masonry clad timber frame walls*

Where timber frame walls are clad by masonry and the following conditions are met, the external wind loading transferred to the timber structure should be determined in accordance with **5.2.3**.

a) The masonry walls should be constructed of:

— clay bricks conforming to BS 3921;

— concrete bricks conforming to BS 6073-1;

— calcium silicate bricks conforming to BS 187;

— clay and calcium silicate modular bricks conforming to BS 6649;

— concrete blocks conforming to BS 6073-1;

— reconstructed stone conforming to BS 6457;

— stone masonry conforming to BS 5390;

— bricks of special shapes and sizes conforming to BS 4729.

b) The mortar should conform to BS 5628-3 and be not lower than designation (iii) or conform to BS 5390 for stone masonry.

c) 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. The wall ties and tying pattern should also ensure adequate stability and robustness of the masonry cladding.

NOTE In the absence of other guidance on wall tie spacing, designers are directed to DD 140-2, which gives characteristic tensile and compressive forces for timber frame to masonry wall ties.

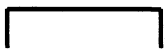
5.2.3 *Wind load transferred to timber frame wall*

In the case of buildings where storey heights do not exceed 3 m between floors or between floor and roof the wind load used in calculating the racking load, 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_{200}, appropriate to the height of building being considered (see Table 1).

For cases where storey heights exceed 3 m between floors or between floor and roof the modification factor, K_{200}, should be taken as 1.0.

NOTE In calculating the racking load, overturning and sliding forces, the wind load modification factor, K_{200}, where applicable, relates to the entire area of the shielded timber frame wall.

Table 1 — Modification factor, K_{200}

Height of building to eaves	Percentage of wall occupied by openings[a]	K_{200}		
				
		For masonry walls with buttresses or returns not less than 550 mm and not greater than 9 m centre to centre[b]	**For masonry walls with buttresses or returns at one end of wall not less than 550 mm, other end without buttresses or returns less than 550 mm, wall length not greater than 4.5 m[c]**	**For masonry walls without buttresses or returns or with buttresses or returns of less than 550 mm[d]**
<6 m	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
>6 m and <9 m	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
Height of building to eaves	**Percentage of wall occupied by openings[a]**	**For masonry walls with buttresses or returns not less than 950 mm and not greater than 9 m centre to centre[b]**	**For masonry walls with buttresses or returns at one end of wall not less than 950 mm, other end without buttresses or returns less than 950 mm, wall length not greater than 4.5 m[c]**	**For masonry walls without buttresses or returns or with buttresses or returns of less than 950 mm[d]**
>9 m and <12 m	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 The K_{200} 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.

NOTE 3 For walls longer than 9 m, the values of K_{200} 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.

[a] In calculating the percentage of wall occupied by openings, the height of the wall should be taken as the height to the eaves.
[b] Values of K_{200} to be used where a masonry wall is supported at both ends by adequate masonry buttresses or returns.
[c] Values of K_{200} 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_{200} to be used where a wall has no masonry returns or buttresses or has inadequate supports at its ends.

6 Design of timber frame walls

6.1 Structural design

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

a) using the laws of structural mechanics (using data given in BS 5268-2);

b) in accordance with the method described in this clause;

c) load testing of full-size wall units in accordance with BS EN 594 and the results interpreted in accordance with BS 5268-6.1, clause **5**.

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

6.2 Permissible stresses

The grade stresses for timber, plywood, tempered hardboard and wood chipboard used in the design should be as given in BS 5268-2:1996 or DD ENV 1995-1-1:1994, as appropriate.

A timber frame external wall should be designed using stresses for service class 2 as described in BS 5268-2:1996 or DD ENV 1995-1-1:1994, as appropriate.

6.3 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, on the basis of the 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 correspondingly reduced horizontal wind loading.

6.4 Overall stability

The factor of safety against overturning or sliding of a building with timber frame walls should be not less than 1.20 when subjected to dead loading, zero imposed loading and horizontal and vertical components of wind loading acting simultaneously.

Designers should assure themselves of the resistance of the structure to sliding under the action of horizontal wind forces. Where applicable, shear fixings and frictional resistance should be taken into account when considering the resistance to sliding.

NOTE Attention is drawn to the need to consider the stability of the building during construction.

6.5 Horizontal diaphragms

When lateral loading acts on vertically spanning stud walls, horizontal diaphragms are essential to transfer such loads to other walls capable of providing racking resistance. A check that adequate diaphragm action is provided should be carried out.

Some horizontal diaphragms have sufficient strength and stiffness to transmit lateral forces to supporting walls without the need for further design consideration or calculations, provided that, in the case of intermediate floors or flat roofs, a wood-based deck, sub-deck or lining is fixed directly to the upper or lower faces of the joists, and in the case of pitched roofs, a plasterboard ceiling is combined with roof bracing as recommended in BS 5268-3.

Such diaphragms should have no horizontal dimension exceeding 12 m between supporting walls and a length to width ratio, l/w, not greater than 2, where l is the greatest horizontal dimension of the diaphragm and w is the smallest horizontal dimension.

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

Primary board material	Fixing	Racking resistance	Additional contribution of secondary board on timber frame wall	
			Category 2 or 3 materials	Category 1 material
		kN/m	kN/m	kN/m
Category 1 materials: — 9.5 mm plywood; — 9.0 mm medium board; — 12.0 mm chipboard (type P5 or P7); — 6.0 mm tempered hardboard[a]; — 9.0 mm OSB (type OSB/3).	3.00 mm diameter wire nails at least 50 mm long, maximum spacing 150 mm on perimeter, 300 mm internal	1.68	0.28	0.84
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	0.45	1.06
Category 3 materials: — 12.5 mm plasterboard.	2.65 mm diameter plasterboard nails at least 40 mm long, maximum spacing 150 mm	0.90	0.45	1.06

NOTE 1 Timber members in external and internal wall panels should be not less than 38 mm thick with a minimum width of 72 mm or 0.026 times the panel height in millimetres (mm), whichever is the greater. All members to be rectangular section with linings fixed to the narrower face, with ends cut square and assembled in accordance with the relevant recommendations of clause **7**.

NOTE 2 In the specific case of internal wall panels, smaller timber members may be used but in this case should be not less than 38 mm thick with a minimum width of 63 mm or 0.023 times the panel height in millimetres (mm) whichever is the greater, and 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.

NOTE 5 Studs should be of species and stress grade satisfying strength class C16 or better (as defined in BS 5268-2:1996).

NOTE 6 The additional contribution from a secondary layer of category 1, 2 or 3 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 **6.8** and **6.9** 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 nail lengths given in the table should be increased to take account of the additional thickness.

[a] For wall panels in excess of 2.7 m in height the thickness of tempered hardboard should be increased to 9 mm.

6.6 Design of wall studs

6.6.1 *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.

6.6.2 *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.

6.6.3 *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 stiffness of the materials acting compositely and of the slip under load of mechanical fastenings.

6.6.4 *Eccentricity of load*

Consideration should be given to eccentricity of load.

Loads transmitted from trusses, joists, lintels, beams or attached claddings bearing on the timber frame wall should be considered to act 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 the stiffness of the studs.

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.

6.6.5 *Lateral deflection*

Designers should assure themselves about the serviceability of external walls subject to horizontal wind forces.

The calculation of the out of plane lateral deflection of studs in wall panels of composite walls is complex and outside the scope of this standard. However, calculation of the out of plane deflection of wall studs alone, ignoring the contribution of cladding materials, gives an indication of the robustness of the wall panel and its likely performance within a composite wall, even though this will give a conservative estimate of the actual deflection of the wall construction. Such calculations should be carried out in accordance with BS 5268-2.

In calculating deflection, under the action of wind loads, the assumptions made in respect of end fixity, as implied in **6.6.2**, should be taken into account. For the purpose of this calculation, vertical load should be ignored.

6.6.6 *Cripple studs*

Cripple studs supporting lintels or beams should be considered to act compositely with the adjacent ordinary stud provided that they are connected together throughout their height with mechanical fastenings designed specifically for this purpose.

6.6.7 *End bearing*

Where studs bear onto 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, and in respect of length and position of bearing.

6.6.8 *Gable apex panels*

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

6.6.9 *Fixing of sheathing or lining*

Where sheathing or linings are 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 7 mm. Nails should be spaced at centres not greater than 300 mm or less than 50 mm. Where plasterboard linings contribute to racking resistance, nails 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, and should be spaced at centres not exceeding 150 mm.

6.7 Racking resistance

6.7.1 *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 **6.7.2**.

6.7.2 *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 **6.8**)

The basic racking resistances given in Table 2 should be modified by application of material modification factors (see **6.8**) and wall modification factors (see **6.9**) as appropriate. The racking resistance of a wall should be calculated as:

$R_b L K_m K_w$

where

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

L is the wall length in metres (m);

K_m is the product of the material modification factors, $K_{201}K_{202}K_{203}$;

K_w is the product of the wall modification factors, $K_{204}K_{205}K_{206}K_{207}$.

b) *Load testing*

Square panels (2.4 m × 2.4 m) should be tested in accordance with BS EN 594 and the results interpreted in accordance with BS 5268-6.1:1996, clause **5** 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 **6.9**.

As load testing refers to a specific combination of materials and their fixings, the material modification factors given in **6.8** (i.e. K_{201}, K_{202} and K_{203}) should not be applied to basic test racking resistance. The racking resistance of a wall should be calculated as:

$R_b L K_w$

where

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

L is the wall length in metres (m);

K_w is the product of the wall modification factors, $K_{204}K_{205}K_{206}K_{207}$.

The additional contribution values of a secondary layer of category 1, 2 or 3 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.

c) *Load testing of full-sized walls*

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 BS EN 594 and the results interpreted in accordance with BS 5268-6.1:1996, clause **5**. Material and wall modification factors (K_{201} to K_{207}) 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.

6.7.3 *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 are based upon a maximum deflection limit of 0.003 times the panel height. Although it is acceptable to reduce the values given in Table 2 in respect of a smaller deflection limit, it is not acceptable to increase the values given in the table to take account of a higher limit.

6.7.4 *The contribution of plasterboard to racking resistance*

6.7.4.1 *General*

Where plasterboard is considered to make a contribution to racking resistance, its total contribution to external sheathed walls and internal walls should not exceed 50 % of that provided by category 1 or 2 materials (see Table 2) when considering the walls providing resistance to wind forces in any one direction.

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 at head and base in such a way as to ensure the transfer of applied shear forces.

6.7.4.2 *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 multiplied as appropriate by modification factors K_{203} to K_{207}. The plasterboard should be fixed on either the opposite face to the sheathing or on the same face as the sheathing, providing that it is independently nailed and the nails are extended in length to take account of the increased thickness of the wall lining.

6.7.4.3 *Internal walls*

Where internal walls, lined each side with plasterboard, are required to make a contribution to the racking resistance of the building, 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 multiplied by modification factors K_{203} to K_{207} as appropriate.

Plasterboard lined internal walls are subject to the overall recommendations for plasterboard contribution given in **6.7.4.1** and **6.7.4.4**.

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 the wall under consideration.

6.7.4.4 *Special internal walls*

The restriction on the contribution of plasterboard to racking resistance, as required in **6.7.4.1** should not apply in the case of internal walls only, lined each side with two or more layers of plasterboard where the lowermost layer on each side is of a moisture resisting grade of plasterboard. In this case the full contribution of plasterboard racking resistance given for a single layer of 12.5 mm plasterboard plus a secondary layer, as given in Table 2 (see **6.7.4.3**), may be taken for that wall without restriction. For multi-layer constructions the length of nails given in Table 2 should be increased accordingly.

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

6.8.1 *General*

Where the assessment method, as described in **6.7.2**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 wall panels and for the generic materials described in clause **4**. Specific test results derived from tests in accordance with BS EN 594 interpreted in accordance with BS 5268-6.1:1996, clause **5** can be substituted for the values given in the table subject to the conditions given in **6.7.2**b).

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.

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

6.8.2.1 *Variation in nail diameter*

For 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_{201}:

$$K_{201} = \frac{D_n}{3}$$

where

D_n is the proposed nail diameter in millimetres (mm).

NOTE The recommended size of nail for fixing plasterboard is 2.65 mm diameter. No enhancement of basic racking resistance is permitted for the use of any other size of nail.

6.8.2.2 *Variation in nail spacing*

For sheathings other than plasterboard the values for basic racking resistance given in Table 2 should be multiplied by K_{202} to take account of variations in nail spacing:

$$K_{202} = \frac{1}{(0.6A + 0.4)}$$

where

A is given by S_p/s_p;

S_p is the proposed perimeter spacing in millimetres (mm);

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

K_{202} should not be used to modify the basic racking resistance given in Table 2 for plasterboard. Plasterboard nailed 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.

6.8.2.3 *Variation in board thickness*

The values for basic racking resistance given in Table 2 may be modified by K_{203} to account for variations in thickness of sheathings or linings:

$$K_{203} = \left(2.8B - B^2 - 0.8\right)$$

where

B is given by T_b/t_b;

T_b is the proposed board thickness in millimetres (mm);

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

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

6.9 Modification factors for wall shape, openings, vertical load and interaction

6.9.1 *Shape factor for wall panels*

The basic racking resistance should be modified to take account of the length and height of a timber frame wall. The shape factor should be calculated as follows, where L is the length of wall in metres (m) and h is the height of the wall panel in metres (m) under consideration:

a) for L/h of 1 or less:

$K_{204} = L/h$

b) for L/h greater than 1 and L not greater than 4.8 m:

$K_{204} = (L/h)^{0.4}$

c) for L/h greater than 1 and L greater than 4.8 m:

$K_{204} = (4.8/h)^{0.4}$

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 recommendations of clause **7**.

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

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

b) 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 with a pointside penetration of at least 38 mm and at 300 mm distance centre to centre.

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

6.9.2 *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_{205} should be calculated as:

$$K_{205} = (1 - 1.3p)^2$$

Or, in the specific case where openings are no closer to panel edges than 1 200 mm as:

$$K_{205} = (1 - p)^2$$

In either case, when p > 0.75:

$$K_{205} = 0$$

where:

p is given by A_a/A_t;

A_a is the aggregate area of opening in the wall;

A_t is the total area of wall including openings.

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 **6.9.1**).

When K_{205} is taken as $(1 - 1.3p)^2$ and 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.

When K_{205} is taken as $(1 - p)^2$ and two framed openings are separated by less than 600 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.

6.9.3 *Small unframed openings*

Recommendations for fully framed openings are given in **6.9.3**, 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.

b) The clear distance between openings should be not less than the greatest dimension of the openings.

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.

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 a).

The rules governing the position of openings given in b), c) and d) should also apply.

6.9.4 *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_{206} to take account of the effect of other vertical load conditions.

The vertical load on the wall, F, used to calculate K_{206} should be calculated using only the dead or permanent loading and any net effects of wind. K_{206} should be calculated as:

$$K_{206} = \left\{ 1 + \left(0.09F - 0.0015F^2 \right) \left(\frac{2.4}{L} \right)^{0.4} \right\}$$

where

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

L is the length of wall in metres (m).

It is assumed that in applying K_{206} 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_{206} concentrated vertical loads should be converted into an equivalent vertical uniformly distributed load:

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

where

F is the equivalent uniformly distributed vertical load in kilonewtons per metre (kN/m);

F_p is the concentrated load in kilonewtons (kN);

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

L is the length of wall under consideration in metres (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.

6.9.5 *Interaction*

In calculating the permissible racking resistance of walls, the basic racking resistance should be multiplied by the modification factor K_{207}, 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_{201} to K_{206}, give reasonably true assessments of the racking resistance of plain walls when subjected to test racking loads. When walls form part of completed buildings, 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.

6.10 Contribution of masonry veneer to racking resistance

Where masonry veneer is considered to make a contribution to the permissible racking resistance for sheathed timber frame walls comprising a combination of sheathing, lining and varying vertical load conditions, the permissible racking resistance for the wall should be taken from the values given in Table 3. This is provided that the wall ties and their fasteners have a minimum design horizontal shear strength of 150 N at deformations of 5 mm or more and characteristic horizontal shear stiffness of not less than 30 N/mm over the deformation range 0 mm to 5 mm when tested in accordance with the recommendations of BS 5268-6.1:1996, Annex A.

The additional racking resistance for masonry cladding given in Table 3 should be applied only to those parts of the wall comprising a minimum of storey height masonry backed by storey height timber frame and L_m is not less than $h_m/4$, where L_m is the length of masonry wall being considered in metres (m) and h_m is the storey height of masonry cladding in metres (m).

Masonry cladding should conform to **4.7**.

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 3 by the total length of storey height masonry 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 **6.13.1**.

Under no circumstances should the modification factors given in **6.9** be applied to the values given in Table 3.

Table 3 gives ranges of wall tie density and the appropriate levels of racking resistance contribution that may be assumed. The use of Table 3 values in no way implies that the density of ties required for a racking resistance contribution is necessarily adequate to resist wind forces on the masonry wall. Designers should check the actual density of ties required based upon an assessment of the relevant wind loads, shielding factors etc.

Table 3 — Contribution of masonry cladding to racking resistance

Tie density ties/m^2	Racking resistance kN/m
>3.7 and <4.4[a]	0.4
≥ 4.4[b]	0.5

[a] 3.7 ties/m^2 is typified by ties spaced at 600 mm horizontally and 450 mm vertically.
[b] 4.4 ties/m^2 is typified by ties spaced at 600 mm horizontally and 375 mm vertically.

6.11 Racking resistance for walls braced by other than sheet materials

Racking resistance for walls braced by other means than with sheathing should be determined either by calculation or by load testing in accordance with BS EN 594 and the results interpreted in accordance with BS 5268-6.1:1996, clause **5**.

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

6.12 Joints

6.12.1 *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.

6.12.2 *Glued joints*

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

6.13 Other design considerations

6.13.1 *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. The wall ties and tying pattern should also ensure adequate stability and robustness of the masonry cladding. Special care should be taken to ensure that adequate connections are provided for small free-standing piers of masonry.

At vertical interruptions to masonry cladding, such as at windows and door reveals, movement joints and sloping verges to gable walls, additional wall ties should be provided to ensure stability of the masonry cladding.

6.13.2 *Connections to accommodate differential movement*

Wall ties between timber frame and masonry cladding should have sufficient vertical flexibility to permit vertical downward movement of the timber frame in relation to the masonry cladding. In the absence of more detailed information, the differential movement should be taken as 6 mm per storey height. Attention should also be given to the movement characteristics of masonry.

Similar provision should be made for connections to other parts of the building where differential movement may occur, such as connections between the timber frame and non-timber staircases, lift shafts or other structures.

6.13.3 *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.

7 Workmanship

7.1 Fabrication

7.1.1 *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.

7.1.2 *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.

7.1.3 *Moisture content*

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

7.1.4 *Timber tolerances*

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

7.1.5 *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 $^{0}_{-5}$ mm of the size specified by the designer and no diagonal should exceed the square root of the sum of the square of specified dimensions for opposite and adjacent edges of the panel.

All mechanical fasteners should be of the type and sizes specified and should be located so that the specified packing, 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.

7.1.6 *Finger jointing*

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

7.2 Handling and erection

7.2.1 *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.

7.2.2 *Handling and transport*

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

The general recommendations given in **7.2.1** for on-site storage should also be followed for storage during transportation.

7.2.3 *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. Deviations of panels from vertical should not exceed 6 mm over a height of 2.4 m, pro rata for other heights, subject to a maximum deviation of 12 mm.

Care should be taken to ensure that adequate bearing is provided for the timber frame walls 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.

7.2.4 *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.

Bibliography

Standards publications

BS 5268-4.1:1978, *Structural use of timber — Part 4: Fire resistance of timber structures — Section 4.1: Recommendations for calculating fire resistance of timber members.*

BS 5268-4.2:1990, *Structural use of timber — Part 4: Fire resistance of timber structures — Section 4.2: Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions.*

BS 5268-7, *Structural use of timber — Part 7: Recommendations for the calculation basis for span tables.*

DD 140-2, *Wall ties — Part 2: Recommendations for design of wall ties.*

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