British Standard

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BRITISH STANDARD

BS 5268-6.1:1996

Incorporating Amendment No. 1

Structural use of timber —

Part 6: Code of practice for timber frame walls —

Section 6.1 Dwellings not exceeding four storeys

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

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 March 1996

The following BSI references relate to the work on this standard:
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Amendments issued since publication

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Contents

Foreword

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

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. Since then it has been used extensively by an increasing number of designers, including those new to timber frame. Bearing in mind that the 1988 version was innovative in its approach to design and testing for racking resistance, it has been well received with very few demands for change or revision.

However, since 1988, designers have gained increasing experience with this form of construction and in the use of this British Standard. In this edition of BS 5268-6.1, this confidence is reflected in an extension of the scope to cover dwellings up to four storeys high. The opportunity has also been taken to further clarify certain parts of the text and to refer to new, appropriate European Standards. In particular, EN 594, which covers testing for racking resistance, forms, the basis for section **5** (load testing) of this British Standard.

This British Standard relates to dwellings up to four storeys high, although some of the information may also be relevant to other similar forms of construction. However, it is expected that design information for buildings other than dwellings will be incorporated in a new Section **6.2** to BS 5268.

In this Section of BS 5268, the information relating to the contribution of plasterboard to racking and the influence of masonry cladding is much simplified and known to be conservatively based. However, experience suggests that the respective contributions are adequate for most cases and ensure safe designs.

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) weathering;

b) condensation control;

c) thermal insulation;

d) fire resistance;

e) sound insulation;

f) durability.

At the time of publishing this Section of this British Standard, it is known that the references to British Standards will be subject to amendment when European Standards, presently in preparation, are published. This Section of BS 5268 will be considered for further revision when the contents of relevant European Standards are known.

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

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 22, 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 four 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 22. 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 22, 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

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

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:

a) impregnated softboard type SBS conforming to BS 1142;

b) type HME/HMN medium board conforming to BS 1142;

c) type THE tempered hardboard conforming to BS 1142.

2.3.3 Wood chipboard

Wood chipboard sheathing should be type C3M, C4M or C5 conforming to BS 5669-2.

2.3.4 Oriented strand board

Oriented strand board for sheathing should be type F2 conforming to BS 5669-3.

2.3.5 Cement bonded particleboard

Cement bonded particleboard should be type T2 conforming to BS 5669-4.

2.3.6 Other sheathings

NOTE 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.

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

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 BS 1230-1.

2.5 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.

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 preservative, treatments used and any other metal work with which they are in contact.

Nails used in the construction of panels and for fixing sheathing should be manufactured from mild steel or stainless steel, and be of round head or “D” head configuration and a size specified by the timber frame wall designer.

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 and BS 5628-3 or BS 5390 for stone masonry 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.

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.

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

Where timber frame walls are clad by masonry walls and the following items are met, 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 bricks conforming to BS 3921;

2) concrete bricks conforming to BS 6073-1;

3) calcium silicate bricks conforming to BS 187;

4) clay and calcium silicate modular bricks conforming to BS 6649;

5) concrete blocks conforming to BS 6073-1;

6) reconstructed stone conforming to BS 6457;

7) stone masonry conforming to BS 5390;

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

b) The mortar should conform to the relevant Part of BS 5628 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.

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.

3.2.3 Wind load transferred to timber frame wall

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).

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.

Table 1 — Modification factor K_{100}

Number of storeys	Percentage of loaded wall occupied by openings[a]	K_{100}		
		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 or with buttresses or returns less than 550 mm, wall length no greater than 4.5 m[c]**	**For masonry walls without buttresses or returns or with buttresses or returns of less than 550 mm[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
		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 no greater than 4.5 m[c]**	**For masonry walls without buttresses or returns or with buttresses or returns of less than 950 mm[d]**
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 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.

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.

[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_{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 EN 594.

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

4.2 Permissible stresses

The grade stresses for timber, plywood, tempered hardboard and wood chipboard 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 the dry exposure condition[1)].

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.

4.4 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.

Shear resisting connections should be provided to resist sliding.

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

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.

[1)] Will correspond to service class 2 in future revisions of BS 5268-2.

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.

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 C3M, C4M or C5); — 6.0 mm tempered hardboard; — 9.0 mm 0SB (type F2)	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
— separating wall of minimum 30 mm plasterboard (in two or more layers)	Each layer should be individually fixed with 2.65 mm diameter plasterboard nails at 150 mm spacing, nails for the outmost layer should be at least 60 mm long	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 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.

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 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 **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 nail lengths given in the table should be increased to take account of the additional thickness.

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 BS 5268-2.

In calculating deflection, under the action of wind loads, the assumptions made in respect of end fixity, as implied in **4.6.2**, should be taken into account. For the purpose of this calculation, vertical load should be ignored.

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, and in respect of length and position of bearing.

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 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.

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 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 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 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 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}. The plasterboard should be fixed on either the opposite face to or the same face as the sheathing, providing that it is independently nailed and the sheathing nails are extended in length to take account of the increased thickness of the wall lining.

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 1 200 mm in width, with no individual sheet less than 600 mm wide, should be placed on each separating wall leaf.

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 **4.7.2** 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.

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 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).

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.

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 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.

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 4.8 m

$K_{105} = 1.32$

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
≥ 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 the wall ties and their fasteners have a minimum design horizontal shear strength of at least 150 N at deformations of 5 mm or more and a 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 annex A.

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 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.

Wall ties 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.

4.13.2 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.

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 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 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 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 under the assumed maximum vertical load and the other under minimum vertical load. In addition, at least two stiffness tests should be carried out, one under the maximum vertical load and another under the minimum vertical load. 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 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 EN 594:1995, 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 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 7) to take account of the number of similar panels tested.

NOTE 1.25 converts the load prediction for a deflection of $0.002 \times H_{wp}$ to an estimate of acceptable performance at $0.003 \times H_{wp}$.

Table 7 — 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 7.

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 8).

Table 8 — 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

[a] 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 8.

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 EN 594:1995) 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 9).

Table 9 — 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 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 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 $^{0}_{-3}$ 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 (normative) Method for determining design horizontal shear strength and stiffness of wall ties

NOTE This annex describes a method for determining the design horizontal shear strength and stiffness of wall ties intended for connecting one leaf of masonry to a timber frame.

A.1 General recommendations for test equipment

A.1.1 All testing devices or universal test machines should be fitted with a rigid connection between the clamping plate used to apply load to the specimen and the machine cross head or loading device, i.e any pivot ball joint or universal joint connection to the load cells should be locked.

A.1.2 Unless otherwise stated, the long axis of the tie bodies should always coincide with the principal axis of the test machine.

A.1.3 Deformation should be recorded using at least two symmetrically placed dial gauges or electrical linear displacement transducers measuring the shear displacement of the timber frame and masonry components. These should be capable of reading to the nearest 0.01 mm.

Deformation should not be measured by recording the cross-head travel of the test machine as this can result in exaggerated readings for the stiffer types of tie.

A.1.4 The load should be measured using a load cell device having an electrical or visual read-out system with a minimum resolution of 2 % of full scale reading. The system should be chosen to ensure that the maximum load reading occurs at about 25 % of full-scale reading.

A.1.5 Load should be applied to the specimen so that the rate of loading and the increments between successive load increases should be as follows.

Rate of load increase = 100 N/min

Load increments = 20 N

A.1.6 For plastics ties the tests should be carried out at 30 °C $^{+5}_{0}$ °C.

A controlled temperature room or a controlled temperature chamber that fits on the test machine should be used.

A.2 Preparation of test specimen

A.2.1 Cut two pieces of sheathing material not less than 300 mm × 200 mm with the 200 mm dimensions in the vertical direction of the sheet of sheathing as used in the timber panel. Cut two pieces of timber studding not less than 200 mm in length from a softwood species in accordance with strength class C14 or strength class C16 as described in BS 5268-2, 38 mm to 42 mm wide and 65 mm to 90 mm deep. Drill one piece of studding with holes suitable for bolting the specimen to the loading plate of the testing machine or provide other appropriate means of clamping the specimen to the testing machine.

A.2.2 Nail the sheathing materials to each narrow side of the studding as shown in Figure A.1 using two sheathing nails at 150 mm ± 10 mm centres at each connection, equidistant from the ends of the studding.

A.2.3 Attach one tie to each side of the timber specimen using the fastening provided with the ties. Drive the fastenings approximately perpendicular to the face of the timber; where the design precludes this, follow the manufacturer's instructions. Where a fastening misses the stud completely, or where it distorts before it is driven home, abandon the specimen. Position the fastenings such that the axes of the portion of the ties in the brickwork intersect the axis of the testing machine.

A.2.4 Lay the ties in the bed joint between two bricks as described in BS 5628-3, selecting a mortar designation to suit the intended end use. Check that the compressive strength of the mortar is within the appropriate range given in BS 5628-1, using three 100 mm mortar cubes for each batch in accordance with BS 4551. Do not use admixtures or additives in mortars for type tests, but these may be used where performance data are required for particular designs. Lay the ties in the bed joint in the configuration specified by the manufacturer, but with the cavity between the face of the timber and the face of the bricks 10 mm greater than the specified cavity to allow for variations in construction.

A.2.5 Construct the specimens inside a building and allow them to cure until the specified mortar strength is reached under the normal ambient temperature and humidity conditions.

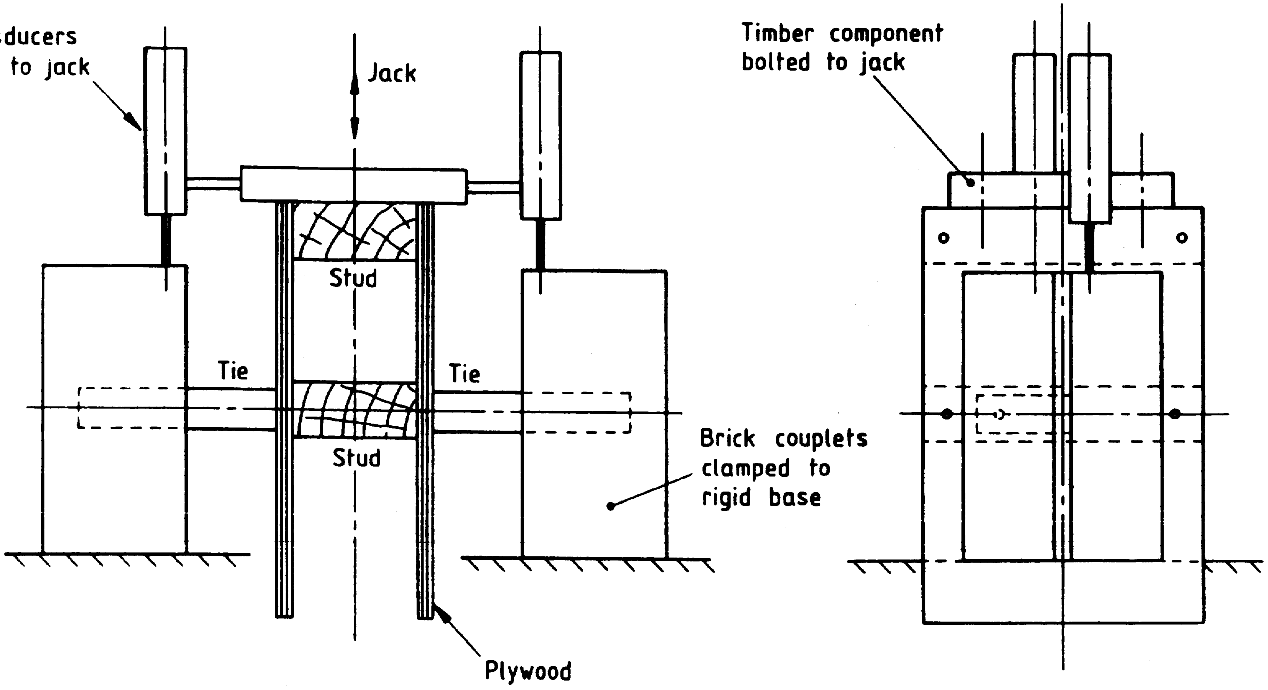


Figure A.1 — General arrangement of horizontal shear test

A.3 Test procedure

At the end of the curing period for the masonry, assemble the composite specimens as shown in Figure A.1 with any specified offset incorporated. Apply load smoothly to the timber component using the machine cross head or hydraulic drive, either continuously, or in increments, and record the load and/or displacement. Use the appropriate rate of load increase given in **A.1.5**.

Record the maximum load and/or the load(s) at specified deformations. Where type tests are being carried out, plot a load deflection curve.

Test at least eight replicates.

A.4 Test reports

The test report should include the following information:

a) type of tie, including material and leading dimensions;

b) details of fastener for attaching tie to the timber component;

c) embedment length;

d) width of cavity in test specimen;

e) the type of masonry unit in the couplets;

f) the type of sheathing material and sheathing nails;

g) the tie offset;

h) compressive strength of masonry unit tested in accordance with the appropriate British Standard;

i) water absorption of fired-clay bricks tested in accordance with BS 3921;

j) compressive strength and age of the mortar cubes when tested in accordance with BS 4551;

k) for type tests, the load deformation curve for each specimen;

l) the value of F_{ult}, the ultimate load capacity or load at 20 mm deformation and f_{5-8}, the minimum load in the range of deformation from 5 mm to 8 mm for each specimen (see typical load deformation curves in Figure A.2);

m) mode of failure;

n) the characteristic ultimate load capacity of the ties F_k (in N) given by the equation:

$$F_K = 0.5\left[\bar{X} - \left(\frac{1.96S}{n^{0.5}}\right)\right]$$

where

$\bar{X}$ is the mean F_{ult} for sample;

S is the standard deviation of the sample;

n is the number of specimens.

NOTE The 0.5 allows for specimens containing two ties.

o) the characteristic strength of ties f_k (in N) given by the equation:

$$f_K = 0.5\left[\bar{x} - \left(\frac{1.96s}{n^{0.5}}\right)\right]$$

where

$\bar{x}$ is the mean f_{5-8} for the sample;

s is the standard deviation of the sample;

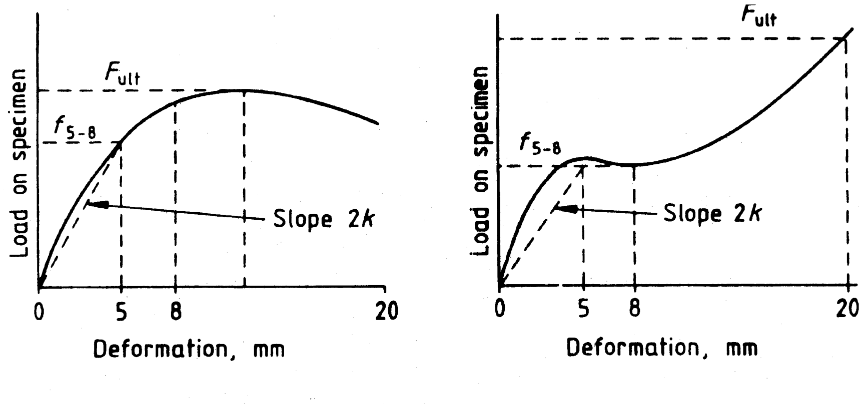
n is the number of specimens.

p) the design horizontal shear strength of the ties as the lesser of:

$$\frac{F_K}{1.6} \quad \text{or} \quad f_K$$

q) the characteristic horizontal shear stiffness K (in N/mm) of the ties given by the equation:

$$K = \frac{f_K}{5}$$



k is the linear stiffness at 5 mm.

Figure A.2 — Typical load deformation curves for ties

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Normative references

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BS 187:1978, *Specification for calcium silicate (sandlime and flintlime) bricks.*

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

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

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BS 5268, *Structural use of timber.*

BS 5268-2:1991, *Code of practice for permissible stress design, materials and workmanship.*

BS 5268-3:1985, *Code of practice for trussed rafter roofs.*

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BS 5390:1976, *Code of practice for stone masonry.*

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

BS 5628-1:1992, *Structural use of unreinforced masonry.*

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BS 5669-2:1989, *Specification for wood chipboard.*

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BS 5268, *Structural use of timber*.

BS 5268-4, *Fire resistance of timber structures*[2)].

BS 5268-4.1:1978, *Recommendations for calculating fire resistance of timber members*.

BS 5268-4.2:1989, *Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions*.

BS 5268-7, *Recommendations for the calculation basis for span tables*[2)].

DD 140, *Wall ties*.

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CEN publications

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

EN 594:1995, Timber structures — Test methods — Racking strength and stiffness of timber frame wall panels.

[2)] Referred to in the foreword only.

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