# British Standard

BRITISH STANDARD

BS 5268-7.4: 1989

# Structural use of timber —

## Part 7: Recommendations for the calculation basis for span tables —

## Section 7.4 Ceiling binders

UDC [624.011.1 + 674.038.5 + 691.1.11]:[692.54:691.5]:001.4

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Civil Engineering and Building Structures Standards Committee (CSB/-) to Technical Committee CSB/32 upon which the following bodies were represented:

British Woodworking Federation
Building Employers' Confederation
Chartered Institute of Building
Department of the Environment (Building Research Establishment, Princes Risborough Laboratory)
Department of the Environment for Northern Ireland
Department of the Environment (Housing and Construction Industries)
Department of the Environment (Property Services Agency)
Health and Safety Executive
Incorporated Association of Architects and Surveyors
Institute of Clerks of Works of Great Britain Inc.
Institute of Wood Science
Institution of Civil Engineers
Institution of Structural Engineers
International Truss Plate Association
National House-building Council
Royal Institute of British Architects
Royal Institution of Chartered Surveyors
Timber Research and Development Association
Timber Trade Federation
Coopted members

This British Standard, having been prepared under the direction of the Civil Engineering and Building Structures Standards Committee, was published under the authority of the Board of BSI and comes into effect on
30 June 1989



The following BSI references relate to the work on this standard:
Committee reference CSB/32
Draft for comment 85/14523 DC

**ISBN 0 580 16589 2**

**Amendments issued since publication**

| Amd. No. | Date of issue | Comments |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

# Contents

# Foreword

This Section of Part 7 of BS 5268 has been prepared under the direction of the Civil Engineering and Building Standards Committee.

The general principles for the design of structural timber components are given in BS 5268-2 and using these principles it is possible for span tables to be prepared for a wide range of components.

Experience has shown that different interpretations of these principles has led to inconsistencies in span tables prepared by different compilers. It is the purpose of BS 5268-7 to eliminate these differences by recommending the design equations and the loading to be used in the preparation of span tables. Part 7 is intended to ensure that different organizations produce span tables on a consistent basis in the future, and is not necessarily intended for use by designers for individual designs carried out in their day-to-day work, where simplified equations may produce adequate designs. This Section deals with ceiling binders. Other Sections of BS 5268-7, published or in preparation, are as follows.

— *Section 7.1: Domestic floor joists;*

— *Section 7.2: Joists for flat roofs;*

— *Section 7.3: Ceiling joists;*

— *Section 7.5: Rafters;*

— *Section 7.6: Purlins supporting rafters;*

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

BS 5268-2 gives grade stresses for very many combinations of species and grade and it is considered impractical to publish in a British Standard span tables for all possible combinations of species, grades and sizes. BS 5268-7 is therefore restricted to the basis of the calculations.

The solution of the design equations for many combinations of geometry and material is most conveniently undertaken by computer. A program written by the Timber Research and Development Association (TRADA) was used to prepare Appendix A and Appendix B. For users wishing to prepare their own span tables or computer programs Appendix A gives a sample calculation. Appendix B gives span tables for three typical combinations of species and grade. Although the presentation of span tables is not covered in BS 5268-7, it is recommended that tables for predetermined ceiling binder centres and loading follow this format.

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 and ii, pages 1 to 14, an inside back cover and a back cover.

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

## 1 Scope

This section of BS 5268 recommends a calculation basis for the permissible clear span of ceiling binders used in traditional pitched roof construction, i.e. not including trussed rafter roofs. The method of calculation is for single span ceiling binders formed from solid timber and supported at each end by external or internal walls. The roof space is assumed to be accessible, thus both uniform loads and a single concentrated load are considered. A typical example of roof construction is given in Figure 1.

This Section of BS 5268 is applicable to the species and grades of timber given in BS 5268-2.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

## 2 Definitions

For the purposes of this Section of BS 5268, the definitions given in BS 6100-4.1 to BS 6100-4.4, BS 6100-2.1 and BS 5268-2 apply, together with the following.

**2.1**
**grade stress**

stress that can safely be permanently sustained by material of a specific section size and of a particular strength class or species and grade

**2.2**
**load-sharing system**

assembly of pieces or members that are constrained to act together to support a common load

**2.3**
**permissible stress**

stress that can safely be sustained by a structural material under a particular condition

NOTE For the purposes of this Section of BS 5268 it is the product of the grade stress and the appropriate modification factors for section size, service and loading.

**2.4**
**strength class**

classification of timber based on particular values of grade stress

**2.5**
**bearing length**

length at each end of the binder in contact with the support

**2.6**
**notional bearing length**

bearing length required for the calculation of permissible clear spans

**2.7**
**effective span**

span from centre-to-centre of the minimum bearing lengths at each end

**2.8**
**permissible effective span**

lowest value of effective span found from the calculations for bending strength, shear strength and deflection

**2.9**
**permissible clear span**

permissible unsupported span of a binder, measured between the faces of the supports at its two ends

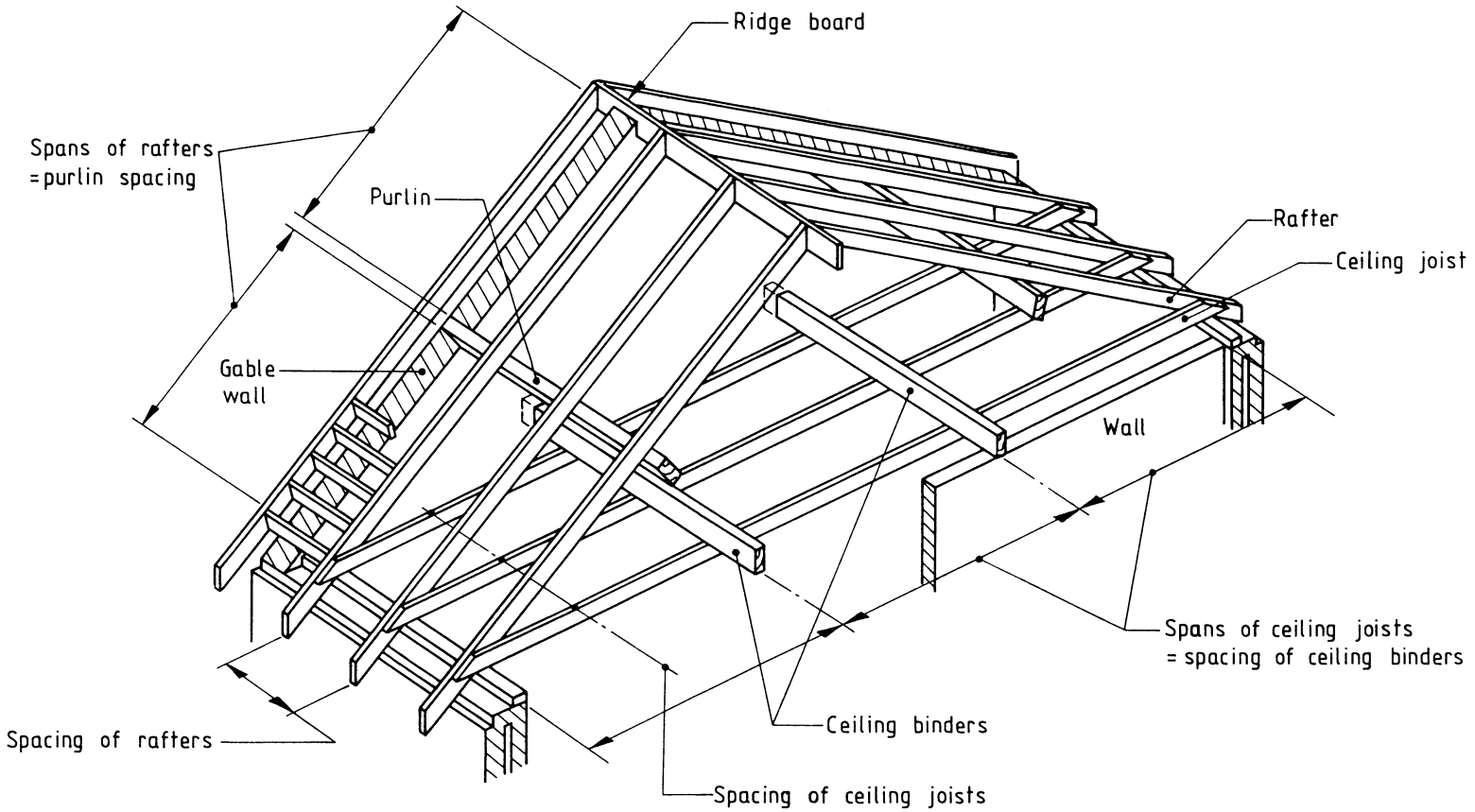
NOTE Permissible clear span is equal to permissible effective span less the notional bearing length.

**2.10**
**point load**

concentrated load referred to in BS 6399-1, that is regarded as acting at a point for calculation purposes

**2.11**
**ceiling binder**

member that gives intermediate support to ceiling joists




NOTE Span of purlins and ceiling binders is not shown. Bracing is not shown.

**Figure 1 — Roof construction**

## 3 Symbols

For the purposes of this Section of BS 5268, the following symbols apply.

NOTE The symbols used are in accordance with ISO 3898, published by the International Organization for Standardization, supplemented by the recommendations of CIB-W18-1 "*Symbols for use in structural timber design*" published by the International Council for Building Research Studies and Documentation, which takes particular account of timber properties.

The symbols used are:

| | |
|---|---|
| $a$ | Distance (notional bearing length) |
| $b$ | Breadth of binder |
| $b_s$ | Breadth of supported members (ceiling joists) |
| $E$ | Modulus of elasticity |
| $F$ | Total load per metre length |
| $F_d$ | Dead load per square metre applied by mass of ceiling materials, insulation etc. (excluding ceiling joist and binder self weights) |
| $F_j$ | Self weight of binder per metre length |
| $F_s$ | Weight of supported members (ceiling joists) per metre length |
| $F_p$ | Point load |
| $G$ | Shear modulus |
| $h$ | Depth of binder |
| $h_s$ | Depth of supported members (ceiling joists) |
| $I$ | Second moment of area |
| $K$ | Modification factor (always with a subscript) |
| $L$ | Effective span |
| $L_{adm}$ | Permissible effective span |
| $L_{cl}$ | Permissible clear span |
| $M$ | Bending moment |
| $s$ | Spacing of binders, centre-to-centre |
| $s_s$ | Spacing of supported members (ceiling joists), centre-to-centre |
| $w$ | Deflection |
| $Z$ | Section modulus |
| $\rho$ | Density |
| $\rho_s$ | Density of supported members (ceiling joists) |
| $\sigma$ | Stress |
| $\tau$ | Shear stress |

The following subscripts are used:

a) **Type of force, stress etc.**

| | |
|---|---|
| c | Compression |
| m | Bending |

b) **Significance**

| | |
|---|---|
| adm | Permissible |
| cl | Clear |
| g | Grade |
| max | Maximum |

c) **Geometry**

| | |
|---|---|
| par or \|\| | Parallel (to the grain) |
| tra or $\perp$ | Perpendicular (to the grain) |

It is recommended that where more than one subscript is used, the categories should be separated by commas.

Subscripts may be omitted when the context in which the symbols are used is unambiguous except in the case of modification factor $K$.

## 4 Design considerations

### 4.1 General

The design calculations recommended by this Section of BS 5268 are based on engineers' bending theory and are consistent with the recommendations of BS 5268-2. The design method ensures that the permissible bending and shear stresses, as given in BS 5268-2, are not exceeded and that the deflection due to bending and shear does not exceed the recommended limit of 0.003 times the span (see **14.7** of BS 5268-2:1988).

NOTE A sample calculation is given in Appendix A and Table 1 to Table 3 in Appendix B contain specimen span tables.

### 4.2 Qualifying assumptions

The calculations given in this Section of BS 5268 are for single-span binders providing intermediate support for ceiling joists. The ceiling joists may be continuous or composed of shorter lengths joined at the binder. Since continuous joists load the binder more severely, this is the case considered in this Section.

The uniformly distributed dead and imposed loads are as given in BS 6399-1 for ceiling joists. Ceilings with access are assumed. The 0.9 kN concentrated load is applied only once to the binder and not simultaneously in any other position. The designs produced by this specification do not allow for water tank loads.

The binders are treated as solid timber members acting alone, with no provision for load sharing. In accordance with **14.7** of BS 5268-2:1988, the minimum value of modulus of elasticity is used in the calculations.

Lateral support should be provided in accordance with **14.8** of BS 5268-2:1988.

The bearing length required at each end of the binder, calculated in accordance with **5.5**, may not be sufficient for practical construction purposes.

### 4.3 Loading

The design calculations provide for binder loads which consist of the following.

a) *Imposed load.* 0.25 kN/m$^2$ uniformly distributed on the ceiling and transmitted by ceiling joists to the binder, together with a concentrated load on the binder of 0.9 kN which in accordance with BS 6399-1 is taken as a point load for calculation purposes.

The point load is assumed to act in the position which produces maximum stress or deflection.

The imposed distributed load should be considered as a long term load. The imposed point load should be considered as a short term load, as given in Table 8 of BS 5268-3:1985.

b) *Dead load.* Dead load per square metre $F_d$ (in kN/m$^2$) to provide for the mass of ceiling materials, insulation etc., transmitted by ceiling joists to the binder. Weights of materials are given in BS 648.

c) *Weight of ceiling joists.* Weight per metre length of ceiling joist $F_s$ (in kN/m) to provide for the mass of the ceiling joists supported by the binder. The timber densities (in kg/m$^3$) given in Tables 9 and 92 of BS 5268-2:1988 should be used.

d) *Self weight.* Self weight per metre length $F_j$ (in kN/m) to provide for the mass of the binder. The timber densities (in kg/m$^3$) given in Tables 9 and 92 of BS 5268-2:1988 should be used.

### 4.4 Design loads

Two loading conditions should be considered:

a) A point and uniform imposed load condition, the loading consisting of uniformly distributed imposed and dead loads, point load on the binder, weight of ceiling joists and binder self weight. This loading should be considered as short term.

b) A uniform imposed load condition, the loading consisting of uniformly distributed imposed and dead loads, weight of ceiling joists and binder self weight. This loading should be considered as long term.

In both cases the loading (in N) transmitted by a single ceiling joist to the binder is given by the expression

$$1.25s \left\{ (0.25 + F_d) \left( \frac{s_s}{1000} \right) + F_s \right\} \quad (1)$$

where

the factor 1.25 is to account for the reaction at the centre of a continuous two-span ceiling joist;

$s$ is the binder spacing (in mm);

$s_s$ is the ceiling joist spacing (in mm);

$F_d$ is the dead load (in kN/m$^2$);

$F_s$ is the weight of ceiling joists (in kN/m).

This load is applied on a length $s_s$ of the binder, and treating it as uniformly distributed, the uniform load (in N/mm or kN/m) applied along the binder is given by the expression

$$1.25 \frac{s}{s_s} \left\{ (0.25 + F_d) \left( \frac{s_s}{1000} \right) + F_s \right\} \quad (2)$$

The binder loading conditions will therefore be:

point and uniform imposed load condition

$F_p = 0.9$ kN

acting together with uniform imposed and dead loads and self weight (in kN/m)

$$1.25 \frac{s}{s_s} \left\{ (0.25 + F_d) \left( \frac{s_s}{1000} \right) + F_s \right\} + F_j \quad (3)$$

Uniform imposed load condition $F$ (in kN/m) is given by the equation

$$F = 1.25 \frac{s}{s_s} \left\{ (0.25 + F_d) \left( \frac{s_s}{1000} \right) + F_s \right\} + F_j \quad (4)$$

where $F_j$ is the self weight of binder (in kN/m).

The value of $F_j$ (in kN/m) may be found from the equation

$$F_j = 9.80665 \times 10^{-9} \rho b h \quad (5)$$

where

$\rho$ is the timber density (in kg/m$^3$);

$b$ is the binder breadth (in mm);

$h$ is the binder depth (in mm).

The value of $F_s$ (in kN/m) may be found from the equation

$$F_s = 9.80665 \times 10^{-9}\, \rho_s\, b_s\, h_s \qquad (6)$$

where

$\rho_s$ is the timber density for ceiling joists (in kg/m$^3$);

$b_s$ is the breadth of ceiling joists (in mm);

$h_s$ is the depth of ceiling joists (in mm).

NOTE Since the loading of a binder is a function of the spacing and weight of the ceiling joists it supports, these variables should occur in rigorous design solutions. Provision has been made in the design equations of this Section for such solutions but the calculation of binder spans for Appendix B has been based on 50 mm × 150 mm ceiling joists at 450 mm spacing having the same density as the binder. The assumption of a uniformly distributed load becomes too inaccurate if less than three ceiling joists are supported on the binder span. For this reason spans below 1 600 mm have been omitted from the specimen tables.

For the calculation of spans under loading incorporating a point load, the combined effect of uniform and point loads may be obtained using the equivalent uniformly distributed load $F$. $F$ (in kN/m) is given by the following equations.

In bending strength calculations

$$F = \frac{1000 \times 2F_p}{L} + \\ + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j \qquad (7)$$

In shear strength calculations

$$F = \frac{1000 \times 2F_p}{L} + \\ + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j \qquad (8)$$

In deflection calculations:

For bending deflection

$$F = \frac{1000 \times 1.6F_p}{L} + \\ + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j \qquad (9)$$

For shear deflection

$$F = \frac{1000 \times 2F_p}{L} + \\ + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j \qquad (10)$$

In equations (7) to (10)

$F_p = 0.9$ kN;

$L$ is the span (in mm).

# 5 Permissible spans

## 5.1 General

The permissible effective span of a timber binder subjected to the applied loads given in **4.3** should be the shortest effective span resulting from calculations for bending strength, shear strength and deflection, as given in **5.2**, **5.3** and **5.4**.

The permissible clear span should be calculated as the permissible effective span less the notional bearing length calculated in accordance with **5.5**.

## 5.2 Limitation of bending stress

From BS 5268-2 the permissible bending stress $\sigma_{m,adm}$ (in N/mm$^2$) is given by the equation

$$\sigma_{m,adm} = \sigma_{m,\,g}\, K_3\, K_7 \qquad (11)$$

where

$\sigma_{m,\,g}$ is the grade bending stress (in N/mm$^2$) (see BS 5268-2);

$K_3$ is the load duration modification factor, 1.0 for long term or 1.5 for short term (see Table 17 of BS 5268-2:1988);

NOTE There is no medium term load case.

$K_7$ is the section depth modification factor (see **14.6** of BS 5268-2:1988).

Expanding the equation

$$\sigma_{m,\,adm} = \frac{M}{Z} \qquad (12)$$

leads to the following equations.

Point and uniform imposed load condition

$$\sigma_{m,g} \times 1.5 \times K_7 \\ = \left[\frac{1800}{L} + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + \right. \\ \left. + F_j\right]\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (13)$$

Uniform imposed load condition

$$\sigma_{m,g} \times 1.0 \times K_7 \\ = \left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + \right. \\ \left. + F_j\right]\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (14)$$

NOTE These equations lead to the following polynomials in $L$.

Point and uniform imposed load condition

$$\frac{3}{4bh^2}\left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j\right]L^2 + \\ + \frac{1350}{bh^2}\,L - \sigma_{m,g} \times 1.5 \times K_7 = 0 \qquad (15)$$

Uniform imposed load condition

$$\frac{3}{4bh^2}\left[1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+F_j\right]L^2 - \\ -\sigma_{m,g}\times 1.0\times K_7 = 0 \qquad (16)$$

### 5.3 Limitation of shear stress

From BS 5268-2 the permissible shear stress $\tau_{adm}$ (in N/mm$^2$) is given by the equation

$$\tau_{adm} = \tau_g K_3 \qquad (17)$$

where

$\tau_g$ is the grade shear stress (in N/mm$^2$) (see BS 5268-2);

$K_3$ is the load duration modification factor, 1.0 for long term or 1.5 for short term (see Table 17 of BS 5268-2:1988).

NOTE There is no medium term load case.

Expanding the equation

$$\tau_{adm} = \frac{3}{2}\,\frac{FL}{2bh} \qquad (18)$$

leads to the following equations.

Point and uniform imposed load condition

$$\tau_g\times 1.5 = \frac{3}{2}\left[\frac{1800}{L}+1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+F_j\right]\frac{L}{2bh} \qquad (19)$$

Uniform imposed load condition

$$\tau_g\times 1.0 = \frac{3}{2}\left[1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+F_j\right]\frac{L}{2bh} \qquad (20)$$

NOTE These equations lead to the following polynomials in $L$.

Point and uniform imposed load condition

$$\frac{3}{4bh}\left[1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+F_j\right]L + \\ +\frac{1350}{bh}-\tau_g\times 1.5 = 0 \qquad (21)$$

Uniform imposed load condition

$$\frac{3}{4bh}\left[1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+F_j\right]L - \\ -\tau_g\times 1.0 = 0 \qquad (22)$$

### 5.4 Limitation of deflection

From **14.7** of BS 5268-2:1988 the recommended deflection limitation $W_{max}$ (in mm) for general application is given by the equation

$$W_{max} = 0.003\,L \qquad (23)$$

The design equation limiting deflection[1] is:

Point and uniform imposed load condition

$$w_{max} = \frac{5}{384}\,\frac{FL^4}{EI}+\frac{3}{20}\,\frac{FL^2}{Gbh}+\frac{1}{48}\,\frac{F_pL^3}{EI}+ \\ +\frac{3}{10}\,\frac{F_pL}{Gbh} \qquad (24)$$

where

$E$ is the minimum modulus of elasticity.

Taking $G$ as $\frac{E}{16}$ (see clause **11** of BS 5268-2:1988):

Point and uniform imposed load condition

$$w_{max} = \frac{5}{384}\,\frac{FL^4}{EI}+\frac{12}{5}\,\frac{FL^2}{Ebh}+\frac{1}{48}\,\frac{F_pL^3}{EI}+ \\ +\frac{24}{5}\,\frac{F_pL}{Ebh} \qquad (25)$$

or, inserting the expressions for equivalent uniformly distributed load,

$$w_{max} = \left[\frac{1000\times 1.6F_p}{L}+ \right. \\ \left. +1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+ \right. \\ \left. +F_j\right]\frac{5}{384}\,\frac{L^4}{EI}+\left[\frac{1000\times 2F_p}{L}+ \right. \\ \left. +1.25\,\frac{s}{s_s}\left\{(0.25+F_d)\left(\frac{s_s}{1000}\right)+F_s\right\}+F_j\right]\times \\ \times\,\frac{12}{5}\,\frac{L^2}{Ebh} \qquad (26)$$

where $F_p = 0.9$ kN.

With a deflection limitation of 0.003 $L$:

[1] In addition to the deflection due to bending the shear deflection may be significant and has been taken into account.

point and uniform imposed load condition

$$0.003L = \left[\frac{1440}{L} + \right.$$
$$\left. + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j\right] \times$$
$$\times \frac{5}{384}\,\frac{L^4}{E}\,\frac{12}{bh^3} + \left[\frac{1800}{L} + \right.$$
$$\left. + 1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j\right] \times$$
$$\times \frac{12}{5}\,\frac{L^2}{Ebh} \qquad (27)$$

NOTE This equation leads to the following polynomial in $L$.

Point and uniform imposed load condition

$$\frac{5}{32Ebh^3}\left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + F_s\right\} + F_j\right]L^3 +$$
$$+ \frac{225}{Ebh^3}L^2 + \frac{12}{5Ebh}\left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + \right.\right.$$
$$\left.\left. + F_s\right\} + F_j\right]L + \frac{4320}{Ebh} - 0.003 = 0 \qquad (28)$$

### 5.5 Permissible clear spans

The calculation of clear spans requires the deduction of a notional bearing length from an effective span.

The calculation of the notional bearing length to be deducted from the permissible effective span to produce the clear span is made after finding $L_{adm}$, the smallest of the effective spans for a given cross section, as limited by:

a) bending stress under point and uniform imposed load;

b) bending stress under uniform imposed load;

c) shear stress under point and uniform imposed load;

d) shear stress under uniform imposed load;

e) deflection under point and uniform imposed load.

From BS 5268-2 the permissible compression perpendicular to the grain stress $\sigma_{c,\perp,adm}$ (in N/mm$^2$) is given by the equation

$$\sigma_{c,\perp,adm} = \sigma_{c,\perp,g}\,K_3 \qquad (29)$$

where

$\sigma_{c,\perp,g}$ is the grade compression perpendicular to the grain stress (in N/mm$^2$) (see BS 5268-2)[a];

$K_3$ is the load duration modification factor, 1.0 for long term or 1.5 for short term (see Table 17 of BS 5268-2:1988).

[a] BS 5268-2 provides two values for the grade compression perpendicular to the grain stress. When the specification specifically prohibits wane at bearing areas, the higher value may be used, otherwise the lower value applies. (See footnotes to Tables 9, 10, 11, 12 and 13 of BS 5268-2:1988.) The span table should indicate whether wane is permitted.

NOTE There is no medium term load case.

The notional bearing length $a$ (in mm) required at each end should be found from the equation

$$\sigma_{c,\perp,adm}\,ba = \text{support reaction} \qquad (30)$$

where $b$ is the breadth of the binder (in mm).

Inserting appropriate expressions for the support reaction, equation (30) gives:

Point and uniform imposed load condition with bending stress or deflection governing

$$\sigma_{c,\perp,g} \times 1.5ba$$
$$= 450 + \left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + \right.\right.$$
$$\left.\left. + F_s\right\} + F_j\right]\frac{L_{adm}}{2} \qquad (31)$$

Point and uniform imposed load with shear stress governing

$$\sigma_{c,\perp,g} \times 1.5ba$$
$$= 900 + \left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + \right.\right.$$
$$\left.\left. + F_s\right\} + F_j\right]\frac{L_{adm}}{2} \qquad (32)$$

Uniform imposed load condition

$$\sigma_{c,\perp,g} \times 1.0ba$$
$$= \left[1.25\,\frac{s}{s_s}\left\{(0.25 + F_d)\left(\frac{s_s}{1000}\right) + \right.\right.$$
$$\left.\left. + F_s\right\} + F_j\right]\frac{L_{adm}}{2} \qquad (33)$$

In equations (31) to (33)

$a$ is the notional bearing length (in mm);

$b$ is the breadth of the binder (in mm);

$L_{adm}$ is the permissible effective span (in mm).

The equation corresponding to the loading condition governing the permissible effective span should be solved for $a$, and half the value of $a$ should be deducted from each end of the span (total deduction $a$, see Figure 2) to give the permissible clear span. $L_{cl}$ (in mm) is given by the equation

$$L_{cl} = L_{adm} - a \quad (34)$$

## 6 Bearing length

Although correct for the calculation of clear span the procedure given in **5.5** for the calculation of notional bearing length may not ensure that the permissible compression perpendicular to the grain stress is not exceeded for all loading cases.

The design of some members may be governed by a loading case which does not represent the greatest total load of all loading cases. For example the governing design case may include a concentrated load, but another less critical loading case may consist of a greater total load uniformly distributed along the span.

## 7 Information to be given in span tables

There are many possible formats for span tables. A typical format suitable for ceiling binders at predetermined centres and for quoted loading is given in Appendix B.

This Section of BS 5268 does not recommend formats for different components but whatever format is used the following information should be given in the heading or in the main body or in the footnotes of the span tables, or in an introduction to the tables:

a) the loading;

b) details of the arrangement of the members;

c) the member sizes and their maximum permissible deviations and/or the standards that define these quantities;

d) the species, stress grade or strength class and/or the standards that define these properties;

e) a statement specifying any requirements additional to those given in the stress grading rules, e.g. whether wane is prohibited at bearings;

f) a statement that the spans have been calculated in accordance with the recommendations of BS 5268-2 and BS 5268-7.4.

g) a statement specifying any structural requirements that may be necessary to comply with the qualifying assumptions made in **4.2**, e.g. lateral support requirements, accommodation of lateral thrust at supports;

h) the permissible clear spans.

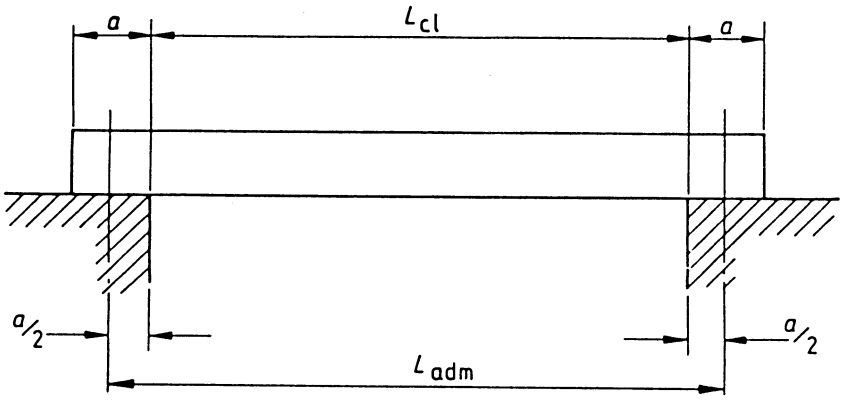



**Figure 2 — Bearing length, permissible effective and permissible clear span**

## Appendix A Sample calculations for a ceiling binder

The object is to find the permissible clear span, given the following data as applicable to a particular design case.

| | | | |
|---|---|---|---|
| **Timber** | Strength class SC3 | | (see Tables 3 to 6 of BS 5268-2:1988) |
| **Dimensions** | Binder breadth, $b$ | = 63 mm | |
| | Binder depth, $h$ | = 170 mm | |
| | Binder spacing, $s$ | = 2 100 mm | |
| **Loading** | Dead load, $F_d$ | = 0.25 kN/m$^2$ | [see **4.3** b)] |
| | Imposed load | = 0.25 kN/m$^2$ | [see **4.3** a)] |
| | together with 0.9 kN point load | | |
| | Weight of ceiling joists, $F_s$ | = 50 × 150 × 540 × 9.80665/10$^9$ = 0.03972 kN/m, joists at 450 mm spacing | (see **4.4**) |

The following data are given in BS 5268-2

| **Grade stresses and density** | | **BS 5268-2:1988 reference** |
|---|---|---|
| Grade bending stress, $\sigma_{m,g}$ | = 5.3 N/mm$^2$ | Table 9 |
| Grade shear stress, $\tau_g$ | = 0.67 N/mm$^2$ | Table 9 |
| Grade minimum modulus of elasticity, $E$ | = 5 800 N/mm$^2$ | Table 9 |
| Grade compression perpendicular to the grain stress (with wane permitted) $\sigma_{c,\perp,g}$ | = 1.7 N/mm$^2$ | Table 9 |
| Density, $\rho$ | = 540 kg/m$^3$ | Table 9 |
| **Modification factor** | | |
| Uniform load, load duration, $K_3$ | = 1.0 long term | Table 17 |
| Point and uniform load, load duration, $K_3$ | = 1.5 short term | Table 17 |
| Depth, $K_7$ | = $(300/h)^{0.11}$ | **14.6** |

| **Permissible stresses and recommended deflection limitation** | | **BS 5268-7.4 reference** |
|---|---|---|
| Permissible bending stress, $\sigma_{m,adm}$ (in N/mm$^2$) | = $\sigma_{m,g}\, K_3 K_7$ | **5.2** |
| | = 8.463 N/mm$^2$ for point and uniform load | |
| | or = 5.642 N/mm$^2$ for uniform load (long term) | |
| Permissible shear stress, $\tau_{adm}$ (in N/mm$^2$) | = $\tau_g\, K_3$ | **5.3** |
| | = 1.005 N/mm$^2$ for point and uniform load | |
| | or = 0.670 N/mm$^2$ for uniform load (long term) | |
| Recommended deflection limitation, $W_{max}$ (in mm) | = 0.003 $L$ | **5.4** |
| Permissible compression perpendicular to the grain stress, $\sigma_{c,\perp,adm}$ (in N/mm$^2$) | = $\sigma_{c,\perp,g}\, K_3$ | **5.5** |
| | = 2.55 N/mm$^2$ for point and uniform load | |
| | or = 1.7 N/mm$^2$ for uniform load (long term) | |

Application of the design equations from **5.2** to **5.4** leads to the following solutions for effective span $L$:

a) limitation of bending stress, point and uniform imposed load — $L$ = 3 064 mm [equation (15)];

b) limitation of bending stress, uniform imposed load — $L$ = 2 925 mm [equation (16)];

c) limitation of shear stress, point and uniform imposed load — $L$ = 7 840 mm [equation (21)];

d) limitation of shear stress, uniform imposed load — $L$ = 5 976 mm [equation (22)];

e) limitation of deflection, point and uniform imposed load — $L$ = 2 443 = [equation (28)].

The permissible effective span $L_{adm}$ is therefore

$L_{adm}$ = 2 443 mm

The appropriate equation is selected from **5.5** to calculate the notional bearing length, $a$, as 15 mm.

The permissible clear span $L_{cl}$ for the binder is then

$L_{cl} = L_{adm} - a$

$L_{cl}$ = 2 428 mm

## Appendix B Specimen span tables for ceiling binders

There are many possible formats for span tables and Table 1, Table 2 and Table 3 are typical examples. Whatever format is used, the information listed in clause **7** should be given.

**Table 1 — Permissible clear spans for ceiling binders: SC3[a], regularized sizes[b]**

| Size of binder | Dead load (in kN/m$^2$) supported by ceiling, excluding the self weight of the ceiling joists and binder[c] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Not more than 0.25 (25.5 kg/m$^2$) | | | | | More than 0.25 but not more than 0.50 (51 kg/m$^2$) | | | | |
| | Centre-to-centre spacing of binders (in m) | | | | | | | | | |
| | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 |
| | Permissible clear span | | | | | | | | | |
| mm | m | m | m | m | m | m | m | m | m | m |
| 38 × 147 | 1.937 | 1.837 | 1.755 | 1.685 | 1.624 | 1.778 | 1.677 | | | |
| 170 | 2.298 | 2.174 | 2.073 | 1.987 | 1.913 | 2.101 | 1.977 | 1.877 | 1.792 | 1.720 |
| 195 | 2.691 | 2.541 | 2.419 | 2.316 | 2.228 | 2.453 | 2.304 | 2.184 | 2.084 | 1.999 |
| 220 | 3.084 | 2.908 | 2.765 | 2.645 | 2.542 | 2.805 | 2.631 | 2.492 | 2.376 | 2.247 |
| 44 × 122 | 1.650 | | | | | | | | | |
| 147 | 2.060 | 1.953 | 1.865 | 1.791 | 1.726 | 1.890 | 1.782 | 1.694 | 1.621 | |
| 170 | 2.439 | 2.307 | 2.200 | 2.109 | 2.031 | 2.230 | 2.098 | 1.992 | 1.903 | 1.827 |
| 195 | 2.852 | 2.693 | 2.564 | 2.455 | 2.362 | 2.600 | 2.443 | 2.316 | 2.211 | 2.121 |
| 220 | 3.265 | 3.079 | 2.928 | 2.801 | 2.693 | 2.970 | 2.787 | 2.640 | 2.518 | 2.414 |
| 47 × 122 | 1.697 | 1.614 | | | | | | | | |
| 147 | 2.116 | 2.006 | 1.916 | 1.839 | 1.773 | 1.941 | 1.831 | 1.741 | 1.665 | 1.600 |
| 170 | 2.504 | 2.369 | 2.258 | 2.165 | 2.085 | 2.289 | 2.155 | 2.045 | 1.954 | 1.877 |
| 195 | 2.926 | 2.763 | 2.631 | 2.519 | 2.424 | 2.668 | 2.507 | 2.377 | 2.269 | 2.177 |
| 220 | 3.349 | 3.158 | 3.003 | 2.874 | 2.763 | 3.046 | 2.859 | 2.708 | 2.584 | 2.477 |
| 50 × 122 | 1.742 | 1.656 | 1.586 | 1.525 | | 1.606 | | | | |
| 147 | 2.170 | 2.057 | 1.965 | 1.886 | 1.818 | 1.991 | 1.877 | 1.785 | 1.707 | 1.641 |
| 170 | 2.566 | 2.428 | 2.314 | 2.219 | 2.137 | 2.346 | 2.208 | 2.096 | 2.003 | 1.924 |
| 195 | 2.998 | 2.831 | 2.695 | 2.581 | 2.483 | 2.733 | 2.568 | 2.435 | 2.325 | 2.231 |
| 220 | 3.429 | 3.233 | 3.075 | 2.943 | 2.830 | 3.119 | 2.928 | 2.774 | 2.646 | 2.538 |
| 63 × 147 | 2.381 | 2.256 | 2.154 | 2.068 | 1.993 | 2.183 | 2.058 | 1.957 | 1.872 | 1.800 |
| 170 | 2.808 | 2.656 | 2.532 | 2.428 | 2.339 | 2.567 | 2.416 | 2.294 | 2.193 | 2.107 |
| 195 | 3.273 | 3.091 | 2.943 | 2.819 | 2.713 | 2.985 | 2.805 | 2.661 | 2.542 | 2.440 |
| 220 | 3.737 | 3.525 | 3.353 | 3.210 | 3.088 | 3.401 | 3.194 | 3.028 | 2.890 | 2.773 |
| 75 × 195 | 3.492 | 3.298 | 3.140 | 3.009 | 2.896 | 3.184 | 2.994 | 2.841 | 2.714 | 2.606 |
| 220 | 3.981 | 3.756 | 3.574 | 3.422 | 3.293 | 3.625 | 3.405 | 3.229 | 3.083 | 2.960 |

NOTE 1 The tables are computed on the basis that the specification does not exclude wane at bearings.
NOTE 2 The spans have been calculated in accordance with the recommendations of BS 5268-2 and BS 5268-7.4. Lateral support should be provided in accordance with **14.8** of BS 5268-2:1988.
NOTE 3 The material should be stress graded in accordance with BS 4978.
NOTE 4 The sizes and their maximum permissible deviations should be in accordance with BS 4471.
[a] For species/grade combinations in this strength class see Tables 3 to 8 of BS 5268-2:1988.
[b] Regularized sizes are given in BS 4471.
[c] For the calculation of this table it was assumed that the binders carried 50 mm × 150 mm ceiling joists of the same density as the binder, at 450 mm spacing.

**Table 2 — Permissible clear spans for ceiling binders: redwood/whitewood, SS grade, basic sizes**[a]

| Size of binder | Dead load (in kN/m$^2$) supported by joist, excluding the self weight of the ceiling joists and binder[b] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Not more than 0.25 (25.5 kg/m$^2$) | | | | | More than 0.25 but not more than 0.50 (51 kg/m$^2$) | | | | |
| | Centre-to-centre spacing of binders (in m) | | | | | | | | | |
| | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 |
| | Permissible clear span | | | | | | | | | |
| mm | m | m | m | m | m | m | m | m | m | m |
| 38 × 125 | 1.731 | 1.646 | | | | | | | | |
| 150 | 2.149 | 2.036 | 1.944 | 1.866 | 1.798 | 1.970 | 1.857 | 1.765 | 1.688 | 1.622 |
| 175 | 2.569 | 2.429 | 2.314 | 2.218 | 2.135 | 2.346 | 2.207 | 2.094 | 2.000 | 1.920 |
| 200 | 2.990 | 2.821 | 2.685 | 2.570 | 2.472 | 2.723 | 2.557 | 2.424 | 2.313 | 2.219 |
| 225 | 3.411 | 3.214 | 3.055 | 2.923 | 2.809 | 3.100 | 2.907 | 2.753 | 2.626 | 2.517 |
| 44 × 125 | 1.842 | 1.750 | 1.674 | 1.610 | | 1.696 | 1.602 | | | |
| 150 | 2.281 | 2.161 | 2.063 | 1.979 | 1.908 | 2.090 | 1.970 | 1.872 | 1.791 | 1.721 |
| 175 | 2.723 | 2.574 | 2.452 | 2.350 | 2.263 | 2.486 | 2.338 | 2.219 | 2.120 | 2.036 |
| 200 | 3.165 | 2.986 | 2.842 | 2.721 | 2.617 | 2.882 | 2.707 | 2.566 | 2.450 | 2.350 |
| 225 | 3.607 | 3.399 | 3.231 | 3.091 | 2.972 | 3.278 | 3.075 | 2.913 | 2.779 | 2.665 |
| 47 × 125 | 1.893 | 1.798 | 1.720 | 1.654 | | 1.742 | 1.646 | | | |
| 150 | 2.342 | 2.219 | 2.118 | 2.032 | 1.959 | 2.146 | 2.022 | 1.922 | 1.839 | 1.767 |
| 175 | 2.794 | 2.641 | 2.516 | 2.411 | 2.322 | 2.551 | 2.399 | 2.277 | 2.176 | 2.089 |
| 200 | 3.246 | 3.063 | 2.914 | 2.791 | 2.685 | 2.956 | 2.776 | 2.632 | 2.513 | 2.411 |
| 225 | 3.697 | 3.484 | 3.313 | 3.169 | 3.047 | 3.361 | 3.153 | 2.987 | 2.850 | 2.733 |
| 50 × 125 | 1.942 | 1.844 | 1.764 | 1.696 | 1.637 | 1.787 | 1.688 | 1.608 | | |
| 150 | 2.401 | 2.274 | 2.170 | 2.083 | 2.007 | 2.199 | 2.073 | 1.970 | 1.884 | 1.811 |
| 175 | 2.862 | 2.705 | 2.577 | 2.470 | 2.378 | 2.613 | 2.458 | 2.333 | 2.229 | 2.140 |
| 200 | 3.323 | 3.136 | 2.984 | 2.857 | 2.749 | 3.026 | 2.843 | 2.695 | 2.573 | 2.470 |
| 225 | 3.784 | 3.566 | 3.390 | 3.244 | 3.119 | 3.439 | 3.227 | 3.058 | 2.917 | 2.798 |
| 63 × 150 | 2.628 | 2.488 | 2.374 | 2.278 | 2.196 | 2.406 | 2.267 | 2.155 | 2.062 | 1.982 |
| 175 | 3.125 | 2.954 | 2.814 | 2.697 | 2.597 | 2.853 | 2.684 | 2.548 | 2.435 | 2.339 |
| 200 | 3.622 | 3.418 | 3.253 | 3.116 | 2.998 | 3.299 | 3.100 | 2.940 | 2.808 | 2.696 |
| 225 | 4.117 | 3.881 | 3.691 | 3.533 | 3.398 | 3.745 | 3.515 | 3.332 | 3.180 | 3.052 |
| 75 × 200 | 3.859 | 3.642 | 3.467 | 3.321 | 3.196 | 3.516 | 3.304 | 3.135 | 2.995 | 2.876 |
| 225 | 4.381 | 4.132 | 3.930 | 3.763 | 3.620 | 3.987 | 3.744 | 3.550 | 3.389 | 3.254 |

NOTE 1 The tables are computed on the basis that the specification does not exclude wane at bearings.
NOTE 2 The spans have been calculated in accordance with the recommendations of BS 5268-2 and BS 5268-7.4. Lateral support should be provided in accordance with **14.8** of BS 5268-2:1988.
NOTE 3 The material should be stress graded in accordance with BS 4978.
NOTE 4 The sizes and their maximum permissible deviations should be in accordance with BS 4471.

[a] Basic sizes are given in BS 4471.
[b] For the calculation of this table it was assumed that the binders carried 50 mm × 150 mm ceiling joists of the same density as the binder, at 450 mm spacing.

**Table 3 — Permissible clear spans for ceiling binders: spruce-pine-fir, joist and plank no. 2 grade, CLS sizes**[a]

| Size of binder | Dead load (in kN/m$^2$) supported by ceiling, excluding the self weight of the ceiling joists and binder[b] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Not more than 0.25 (25.5 kg/m$^2$) | | | | | More than 0.25 but not more than 0.50 (51 kg/m$^2$) | | | | |
| | Centre-to-centre spacing of binders (in m) | | | | | | | | | |
| | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 |
| | Permissible clear span | | | | | | | | | |
| mm | m | m | m | m | m | m | m | m | m | m |
| 38 × 140 | 1.866 | 1.772 | 1.694 | 1.627 | | 1.712 | 1.616 | | | |
| 184 | 2.572 | 2.431 | 2.315 | 2.218 | 2.134 | 2.343 | 2.202 | 2.088 | 1.993 | 1.912 |
| 235 | 3.394 | 3.197 | 3.038 | 2.905 | 2.791 | 3.076 | 2.883 | 2.728 | 2.600 | 2.491 |
| 285 | 4.201 | 3.949 | 3.746 | 3.578 | 3.434 | 3.795 | 3.550 | 3.355 | 3.194 | 2.971 |

NOTE 1 The tables are computed on the basis that the specification will not exclude wane at bearings.
NOTE 2 The spans have been calculated in accordance with the recommendations of BS 5268-2 and BS 5268-7.4. Lateral support should be provided in accordance with **14.8** of BS 5268-2:1988.
NOTE 3 The material should be stress graded in accordance with NLGA rules.
NOTE 4 The sizes and their maximum permissible deviations should be in accordance with Appendix A, BS 4471:1987.
[a] CLS sizes are given in Appendix A of BS 4471:1987.
[b] For the calculation of this span table it was assumed that the binders carried 50 mm × 150 mm ceiling joists of the same density as the binder, at 450 mm spacing.

*blank*

# Publications referred to

BS 648, *Schedule of weights of building materials.*

BS 4471, *Specification for sizes of sawn and processed softwood.*

BS 4978, *Specification for timber grades for structural use.*

BS 5268, *Structural use of timber.*

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

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

BS 5268-7.1, *Domestic floor joists*[2)].

BS 5268-7.2, *Joists for flat roofs*[2)].

BS 5268-7.3, *Ceiling joists*[2)].

BS 5268-7.5, *Rafters*[2)].

BS 5268-7.6, *Purlins supporting rafters*[2)].

BS 5268-7.7, *Purlins supporting sheeting or decking*[2)].

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

BS 6100-2.1, *Structural design and elements.*

BS 6100-4.1, *Characteristics and properties of timber and wood based panel products.*

BS 6100-4.2, *Sizes and quantities of solid timber.*

BS 6100-4.3, *Wood based panel products.*

BS 6100-4.4, *Carpentry and joinery.*

BS 6399, *Loading for buildings.*

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

ISO 3898, *Bases for design of structures — Notations — General symbols.*

CIB-W18-1, Symbols for use in structural timber design. International Council for Building Research Studies and Documentation, Post Box 20704, 3001 JA Rotterdam, The Netherlands.

NLGA 1979, The national grading rules for dimension lumber. National Lumber Grades Authority, 1460-1055 West Hastings Street, Vancouver, British Columbia, Canada V6E 2G8.

[2)] Referred to in the foreword only.

# BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

**Revisions**

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

**Buying standards**

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

**Information on standards**

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

**Copyright**



BSI
389 Chiswick High Road
London
W4 4AL