British Standard

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Structural use of timber —

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

Section 7.2 Joists for flat roofs

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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

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Contents

Foreword

This Section of Part 7 of BS 5268 has been prepared under the direction of the Civil Engineering and Building Structures 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. Section 7.2 deals with joists for flat roofs. Other sections of BS 5268-7 published or in preparation are as follows.

— *Section 7.1: Domestic floor joists;*

— *Section 7.3: Ceiling joists;*

— *Section 7.4: Ceiling binders;*

— *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 flat roof joist 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 for joists for flat roofs and roofs with a slope of up to 10° The recommendations apply to joists at a maximum spacing of 610 mm centre-to-centre, this being the maximum spacing for which the "load-sharing" assumption may be adopted as described in BS 5268-2. The method of calculation makes no allowance for any contribution of the roof decking to the load resistance of the joists although it is assumed that the decking should be capable of providing lateral load distribution. It does not cover the design of joists taking account of a structural contribution by sheet material supporting the roofing where such action can be provided by adequate design of its attachments as in a stressed skin panel roof.

The uniform and concentrated loads recommended in BS 6399-1 and BS 6399-3 are considered.

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 6100-4.2 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 joist 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 joist, 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

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 joist
E	Modulus of elasticity
F	Total load per metre length
F_d	Dead load per square metre applied by mass of ceiling and roofing materials (excluding joist self weight)
F_j	Self weight of joist per metre length
F_p	Point load
G	Shear modulus
h	Depth of joist

l	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 joists, centre-to-centre
w	Deflection
Z	Section modulus
ρ	Density
σ	Stress
τ	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**

tra or ⊥	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.

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 apply to systems of at least four roof joists, at a maximum spacing of 610 mm centre-to-centre, and having roofing adequate to provide lateral load distribution. Because load sharing takes place the load sharing modification factor K_8 and the mean modulus of elasticity should be used.

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

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

4.3 Loading

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

a) *Imposed load*[1)]

1) with access: 1.5 kN/m^2 uniformly distributed, or a concentrated load of 1.8 kN, whichever governs the design;

2) without access: 0.75 kN/m^2 uniformly distributed, or a concentrated load of 0.9 kN, whichever governs the design.

The concentrated load, 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 medium term load for both roofs with access and those without access. 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 and roofing materials, insulation, etc. Weights of materials are given in BS 648.

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

4.4 Design loads

For roofs with or without access three loading conditions should be considered.

a) A uniform imposed load condition, the loading consisting of uniformly distributed imposed load, dead load and member self weight. This loading should be considered as medium term.

[1)] The numerical values are examples of imposed loads, including snow load, specified in BS 6399-1. For other snow loads reference should be made to BS 6399-3.

b) A point imposed load condition, the loading consisting of a point imposed load plus uniformly distributed dead load and member self weight. This loading should be considered as short term.

c) A long term load condition, the loading consisting of uniformly distributed dead load and member self weight with no imposed load. This loading should be considered as long term.

With access

For the uniform imposed load condition F (in kN/m) is given by the equation

$$F = (1.5 + F_d)\left(\frac{s}{1000}\right) + F_j \quad (1)$$

For the point imposed load condition

$F_p = 1.8$ kN

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

$$F_d\left(\frac{s}{1000}\right) + F_j \quad (2)$$

For the long term load condition, i.e. dead load and self weight alone, F (in kN/m) is given by the equation

$$F = F_d\left(\frac{s}{1000}\right) + F_j \quad (3)$$

Without access

For the uniform imposed load condition F (in kN/m) is given by the equation

$$F = (0.75 + F_d)\left(\frac{s}{1000}\right) + F_j \quad (4)$$

For the point imposed load condition

$F_p = 0.9$ kN

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

$$F_d\left(\frac{s}{1000}\right) + F_j \quad (5)$$

For the long term load condition, i.e. dead load and self weight alone, F (in kN/m) is given by the equation

$$F = F_d\left(\frac{s}{1000}\right) + F_j \quad (6)$$

In equations (1) to (6)

s is the joist spacing (in mm);

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

F_j is the self weight of joist (in kN/m).

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

$$F_j = 9.80665 \times 10^{-9} \times \rho bh \quad (7)$$

where

ρ is the timber density (in kg/m^3);

b is the joist breadth (in mm);

h is the joist depth (in mm).

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

$$F = \frac{1000 \times 2F_p}{L} + F_d\left(\frac{s}{1000}\right) + F_j \quad (8)$$

In shear strength calculations

$$F = \frac{1000 \times 2F_p}{L} + F_d\left(\frac{s}{1000}\right) + F_j \quad (9)$$

In deflection calculations:

For bending deflection

$$F = \frac{1000 \times 1.6F_p}{L} + F_d\left(\frac{s}{1000}\right) + F_j \quad (10)$$

For shear deflection

$$F = \frac{1000 \times 2F_p}{L} + F_d\left(\frac{s}{1000}\right) + F_j \quad (11)$$

In equations (8) to (11)

F_p = 1.8 kN with access or 0.9 kN without access;

L is the span (in mm).

5 Permissible spans

5.1 General

The permissible effective span of a timber joist 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/mm²) is given by the equation

$$\sigma_{m,adm} = \sigma_{m,g} K_3 K_7 K_8 \qquad (12)$$

where

- $\sigma_{m,g}$ is the grade bending stress (in N/mm²) (see BS 5268-2);
- K_3 is the load duration modification factor, 1.0 for long term, 1.25 for medium term or 1.5 for short term (see Table 17 of BS 5268-2:1988);
- K_7 is the section depth modification factor (see **14.6** of BS 5268-2:1988);
- K_8 is the load sharing modification factor 1.1 [see clause **13** item a) of BS 5268-2:1988].

Expanding the equation

$$\sigma_{m,adm} = \frac{M}{Z} \qquad (13)$$

leads to the following equations.

With access

Uniform imposed load condition

$$\sigma_{m,g} \times 1.25 \times K_7 \times 1.1 = \left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (14)$$

Point imposed load condition

$$\sigma_{m,g} \times 1.5 \times K_7 \times 1.1 = \left\{\frac{3600}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (15)$$

Long term load condition, i.e. dead load and self weight alone

$$\sigma_{m,g} \times 1.0 \times K_7 \times 1.1 = \left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (16)$$

Without access

Uniform imposed load condition

$$\sigma_{m,g} \times 1.25 \times K_7 \times 1.1 = \left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (17)$$

Point imposed load condition

$$\sigma_{m,g} \times 1.5 \times K_7 \times 1.1 = \left\{\frac{1800}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (18)$$

Long term load condition, i.e. dead load and self weight alone

$$\sigma_{m,g} \times 1.0 \times K_7 \times 1.1 = \left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L^2}{8}\,\frac{6}{bh^2} \qquad (19)$$

NOTE These equations lead to the following polynomials in L.

With access

Uniform imposed load condition

$$\frac{3}{4bh^2}\left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L^2 - \sigma_{m,g} \times 1.25 \times K_7 \times 1.1 = 0 \qquad (20)$$

Point imposed load condition

$$\frac{3}{4bh^2}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L^2 + \frac{2700}{bh^2}L - \sigma_{m,g} \times 1.5 \times K_7 \times 1.1 = 0 \qquad (21)$$

Long term load condition, i.e. dead load and self weight alone

$$\frac{3}{4bh^2}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L^2 - \sigma_{m,g} \times 1.0 \times K_7 \times 1.1 = 0 \qquad (22)$$

Without access

Uniform imposed load condition

$$\frac{3}{4bh^2}\left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L^2 - \sigma_{m,g} \times 1.25 \times K_7 \times 1.1 = 0 \qquad (23)$$

Point imposed load condition

$$\frac{3}{4bh^2}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L^2 + \frac{1350}{bh^2}L - \sigma_{m,g} \times 1.5 \times K_7 \times 1.1 = 0 \qquad (24)$$

Long term load condition, i.e. dead load and self weight alone

$$\frac{3}{4bh^2}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L^2 - \sigma_{m,g} \times 1.0 \times K_7 \times 1.1 = 0 \qquad (25)$$

5.3 Limitation of shear stress

From BS 5268-2, the permissible shear stress τ_{adm} (in N/mm²) is given by the equation

$$\tau_{adm} = \tau_g K_3 K_8 \qquad (26)$$

where

- τ_g is the grade shear stress (in N/mm²) (see BS 5268-2);
- K_3 is the load duration modification factor, 1.0 for long term, 1.25 for medium term or 1.5 for short term (see Table 17 of BS 5268-2:1988);
- K_8 is the load sharing modification factor, 1.1 [see clause **13** item a) of BS 5268-2:1988].

Expanding the equation

$$\tau_{adm} = \frac{3}{2}\frac{FL}{2bh} \quad (27)$$

leads to the following equations.

With access

Uniform imposed load condition

$$\tau_g \times 1.25 \times 1.1 = \frac{3}{2}\left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}\frac{L}{2bh} \quad (28)$$

Point imposed load condition

$$\tau_g \times 1.5 \times 1.1 = \frac{3}{2}\left\{\frac{3600}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L}{2bh} \quad (29)$$

Long term load condition, i.e. dead load and self weight alone

$$\tau_g \times 1.0 \times 1.1 = \frac{3}{2}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L}{2bh} \quad (30)$$

Without access

Uniform imposed load condition

$$\tau_g \times 1.25 \times 1.1 = \frac{3}{2}\left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}\frac{L}{2bh} \quad (31)$$

Point imposed load condition

$$\tau_g \times 1.5 \times 1.1 = \frac{3}{2}\left\{\frac{1800}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L}{2bh} \quad (32)$$

Long term load condition, i.e. dead load and self weight alone

$$\tau_g \times 1.0 \times 1.1 = \frac{3}{2}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}\frac{L}{2bh} \quad (33)$$

NOTE These equations lead to the following polynomials in L.

With access

Uniform imposed load condition

$$\frac{3}{4bh}\left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L - \tau_g \times 1.25 \times 1.1 = 0 \quad (34)$$

Point imposed load condition

$$\frac{3}{4bh}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L + \frac{2700}{bh} - \tau_g \times 1.5 \times 1.1 = 0 \quad (35)$$

Long term load condition, i.e. dead load and self weight alone

$$\frac{3}{4bh}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L - \tau_g \times 1.0 \times 1.1 = 0 \quad (36)$$

Without access

Uniform imposed load condition

$$\frac{3}{4bh}\left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L - \tau_g \times 1.25 \times 1.1 = 0 \quad (37)$$

Point imposed load condition

$$\frac{3}{4bh}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L + \frac{1350}{bh} - \tau_g \times 1.5 \times 1.1 = 0 \quad (38)$$

Long term load condition, i.e. dead load and self weight alone

$$\frac{3}{4bh}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L - \tau_g \times 1.0 \times 1.1 = 0 \quad (39)$$

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

$$w_{max} = 0.003\,L \quad (40)$$

The design equation limiting deflection[2)] is:

Uniform imposed load condition

$$w_{max} = \frac{5}{384}\frac{FL^4}{EI} + \frac{3}{20}\frac{FL^2}{Gbh} \quad (41)$$

Point imposed load condition

$$w_{max} = \frac{5}{384}\frac{FL^4}{EI} + \frac{3}{20}\frac{FL^2}{Gbh} + \frac{1}{48}\frac{F_pL^3}{EI} + \frac{3}{10}\frac{F_pL}{Gbh} \quad (42)$$

where E is the mean modulus of elasticity.

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

Uniform imposed load condition

$$w_{max} = \frac{5}{384}\frac{FL^4}{EI} + \frac{12}{5}\frac{FL^2}{Ebh} \quad (43)$$

2) In addition to the deflection due to bending the shear deflection may be significant and has been taken into account.

Point imposed load condition

$$w_{max} = \frac{5}{384}\frac{FL^4}{EI} + \frac{12}{5}\frac{FL^2}{Ebh} + \frac{1}{48}\frac{F_pL^3}{EI} + \frac{24}{5}\frac{F_pL}{Ebh} \quad (44)$$

or, inserting the expressions for equivalent uniformly distributed load,

$$w_{max} = \left\{\frac{1000 \times 1.6F_p}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\} \times \frac{5}{384}\frac{L^4}{EI} + \left\{\frac{1000 \times 2F_p}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\} \times \frac{12}{5}\frac{L^2}{Ebh} \quad (45)$$

With a deflection limitation of 0.003 L

With access

Uniform imposed load condition

$$0.003L = \left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\} \times \left(\frac{5}{384}\frac{L^4}{E}\frac{12}{bh^3} + \frac{12}{5}\frac{L^2}{Ebh}\right) \quad (46)$$

Point imposed load condition

$$0.003L = \left\{\frac{2880}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\} \times \frac{5}{384}\frac{L^4}{E}\frac{12}{bh^3} + \left\{\frac{3600}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\} \times \frac{12}{5}\frac{L^2}{Ebh} \quad (47)$$

Without access

Uniform imposed load condition

$$0.003L = \left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\} \times \left(\frac{5}{384}\frac{L^4}{E}\frac{12}{bh^3} + \frac{12}{5}\frac{L^2}{Ebh}\right) \quad (48)$$

Point imposed load condition

$$0.003L = \left\{\frac{1440}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\} \times \frac{5}{384}\frac{L^4}{E}\frac{12}{bh^3} + \left\{\frac{1800}{L} + F_d\left(\frac{s}{1000}\right) + F_j\right\} \times \frac{12}{5}\frac{L^2}{Ebh} \quad (49)$$

NOTE These equations lead to the following polynomials in L.

With access

Uniform imposed load condition

$$\frac{5}{32Ebh^3}\left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L^3 + \frac{12}{5Ebh}\left\{(1.5 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L - 0.003 = 0 \quad (50)$$

Point imposed load condition

$$\frac{5}{32Ebh^3}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L^3 + \frac{450}{Ebh^3}L^2 + \frac{12}{5Ebh}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L + \frac{8640}{Ebh} - 0.003 = 0 \quad (51)$$

Without access

Uniform imposed load condition

$$\frac{5}{32Ebh^3}\left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L^3 + \frac{12}{5Ebh}\left\{(0.75 + F_d)\left(\frac{s}{1000}\right) + F_j\right\}L - 0.003 = 0 \quad (52)$$

Point imposed load condition

$$\frac{5}{32Ebh^3}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L^3 + \frac{225}{Ebh^3}L^2 + \frac{12}{5Ebh}\left\{F_d\left(\frac{s}{1000}\right) + F_j\right\}L + \frac{4320}{Ebh} - 0.003 = 0 \quad (53)$$

5.5 Permissible clear spans

The calculation of clear span 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 uniform imposed load;

b) bending stress under point imposed load;

c) bending stress under long term load alone;

d) shear stress under uniform imposed load;

e) shear stress under point imposed load;

f) shear stress under long term load alone;

g) deflection under uniform imposed load;

h) deflection under point 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

$$\sigma_{c,\perp,adm} = \sigma_{c,\perp,g} K_3 K_8 \tag{54}$$

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, 1.25 for medium term or 1.5 for short term (see Table 17 of BS 5268-2:1988);

K_8 is the load sharing modification factor, 1.1 [see clause **13** item a) 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 Table 9, Table 10, Table 11, Table 12 and Table 13 in BS 5268-2:1988). The span table should indicate whether wane is permitted.

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

$$\sigma_{c,\perp,adm}\, ba = \text{support reaction} \tag{55}$$

where b is the breadth of the joist (in mm).

Inserting appropriate expressions for the support reaction, equation (54) gives the following equations.

With access

Uniform imposed load condition

$$\sigma_{c,\perp,g} \times 1.25 \times 1.1 \times ba = \left\{ (1.5 + F_d) \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{56}$$

Point imposed load condition with bending stress or deflection governing

$$\sigma_{c,\perp,g} \times 1.5 \times 1.1 \times ba = \left\{ \frac{1800}{L_{adm}} + F_d \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{57}$$

Point imposed load condition with shear stress governing

$$\sigma_{c,\perp,g} \times 1.5 \times 1.1 \times ba = \left\{ \frac{3600}{L_{adm}} + F_d \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{58}$$

Long term load condition, i.e. dead load and self weight alone

$$\sigma_{c,\perp,g} \times 1.0 \times 1.1 \times ba = \left\{ F_d \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{59}$$

Without access

Uniform imposed load condition

$$\sigma_{c,\perp,g} \times 1.25 \times 1.1 \times ba = \left\{ (0.75 + F_d) \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{60}$$

Point imposed load condition with bending stress or deflection governing

$$\sigma_{c,\perp,g} \times 1.5 \times 1.1 \times ba = \left\{ \frac{900}{L_{adm}} + F_d \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{61}$$

Point imposed load condition with shear stress governing

$$\sigma_{c,\perp,g} \times 1.5 \times 1.1 \times ba = \left\{ \frac{1800}{L_{adm}} + F_d \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{62}$$

Long term load condition, i.e. dead load and self weight alone

$$\sigma_{c,\perp,g} \times 1.0 \times 1.1 \times ba = \left\{ F_d \left(\frac{s}{1000}\right) + F_j \right\} \frac{L_{adm}}{2} \tag{63}$$

In equations (56) to (63)

a is the notional bearing length (in mm);

b is the breadth of the joist (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 1) to give the permissible clear span. L_{cl} (in mm) is given by the equation

$$L_{cl} = L_{adm} - a \tag{64}$$

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 flat roof joists 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 5268-7.2;

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.

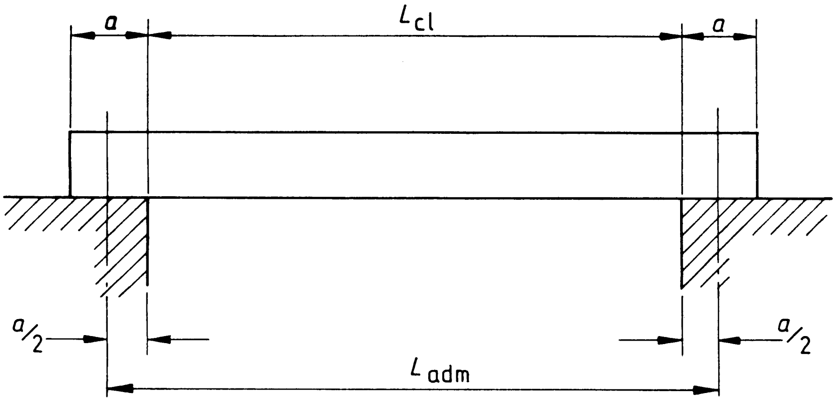

Figure 1 — Bearing length, permissible effective and permissible clear span

Appendix A Sample calculations for a flat roof joist

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 Table 3 to Table 6 of BS 5268-2:1988)
Dimensions	Joist breadth, b	= 50 mm	
	Joist depth, h	= 195 mm	
	Joist spacing, s	= 600 mm	
Loading (without access)	Dead load F_d	= 0.50 kN/m²	[see **4.3** b)]
	Imposed load	= 0.75 kN/m² or = 0.9 kN	[see **4.3** a)]

The following data are given in BS 5268-2:1988.

Grade stresses and density		**BS 5268-2:1988 reference**
Grade bending stress, $\sigma_{m,g}$	= 5.3 N/mm²	Table 9
Grade shear stress, τ_g	= 0.67 N/mm²	Table 9
Grade mean modulus of elasticity, E	= 8 800 N/mm²	Table 9
Grade compression perpendicular to the grain stress (with wane permitted), $\sigma_{c,\perp,g}$	= 1.7 N/mm²	Table 9
Density, ρ	= 540 kg/m³	Table 9

Modification factors		
Uniform load, load duration, K_3	= 1.00 long term	Table 17
Uniform load, load duration, K_3	= 1.25 medium term	Table 17
Point load, load duration, K_3	= 1.5 short term	Table 17
Depth, K_7	$= (300/h)^{0.11}$	**14.6**
Load sharing, K_8	= 1.1	**13**

Permissible stresses and recommended deflection limitation		**BS 5628-7.2 reference**
Permissible bending stress, $\sigma_{m,adm}$ (in N/mm²)	$\sigma_{m,g} K_3 K_7 K_8$ = 7.641 N/mm² for uniform load (medium term) or = 9.175 N/mm² for point load or = 6.113 N/mm² for uniform load (long term)	**5.2**
Permissible shear stress, τ_{adm} (in N/mm²)	$= \tau_g K_3 K_8$ = 0.921 N/mm² for uniform load (medium term) or = 1.1055 N/mm² for point load or = 0.737 N/mm² for uniform load (long term)	**5.3**
Recommended deflection limitation, w_{max} (in mm)	$= 0.003\ L$	**5.4**

BS 5268-7.2 reference

Permissible compression perpendicular to the grain stress, $\sigma_{c,\perp,adm}$ (in N/mm²) $= \sigma_{c,\perp g} K_3 K_8$ **5.5**

$= 2.3375$ N/mm² for uniform load (medium term)

or $= 2.805$ N/mm² for point load

or $= 1.87$ N/mm² 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, uniform imposed load $L = 4\ 916$ mm [equation (20) or (23)];

b) limitation of bending stress, point imposed load $L = 5\ 964$ mm [equation (21) or (24)];

c) limitation of bending stress, long term load alone $L = 6\ 638$ mm [equation (22) or (25)];

d) limitation of shear stress, uniform imposed load $L = 1\ 4940$ mm [equation (34) or (37)];

e) limitation of shear stress, point imposed load $L = 35\ 752$ mm [equation (35) or (38)];

f) limitation of shear stress, long term load alone $L = 47\ 517$ mm [equation (36) or (39)];

g) limitation of deflection, uniform imposed load $L = 4\ 230$ mm [equation (50) or (52)];

h) limitation of deflection, point imposed load $L = 4\ 484$ mm [equation (51) or (53)];

The permissible effective span L_{adm} is therefore

$L_{adm} = 4\ 230$ 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 joists is then

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

$L_{cl} = 4\ 215$ mm

Appendix B Specimen span tables for flat roof joists

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, Table 2 and Table 3 apply only to flat roofs where no access is provided to the roof (other than that necessary for cleaning and repair). The tables should not be used for the design of flat roofs with permanent access. Load span tables covering both types of loadings and covering a wider range of timber sizes are available from a number of trade organizations.

Table 1 — Permissible clear spans for roof joists without access, imposed load 0.75 kN/m²: SC3[a], regularised sizes[b]

Size of joist	Dead load per square metre (in kN/m²) supported by joist, excluding the self weight of the joist								
	Not more than 0.50 (51 kg/m²)			More than 0.50 but not more than 0.75 (76.5 kg/m²)			More than 0.75 but not more than 1.00 (102 kg/m²)		
	Centre-to-centre spacing of joists (in mm)								
	400	450	600	400	450	600	400	450	600
	Permissible clear span								
mm	m	m	m	m	m	m	m	m	m
38 × 72	1.145	1.136	1.109	1.109	1.096	1.063	1.077	1.063	1.024
97	1.738	1.719	1.666	1.666	1.642	1.578	1.605	1.578	1.507
122	2.368	2.336	2.250	2.250	2.212	2.113	2.155	2.113	2.005
147	3.020	2.974	2.851	2.851	2.797	2.659	2.717	2.659	2.511
170	3.631	3.571	3.368	3.412	3.342	3.166	3.239	3.166	2.980
195	4.303	4.226	3.855	4.025	3.939	3.629	3.810	3.719	3.446
220	4.943	4.762	4.340	4.641	4.491	4.087	4.383	4.274	3.881
44 × 72	1.231	1.221	1.191	1.191	1.177	1.139	1.155	1.139	1.096
97	1.861	1.840	1.781	1.781	1.755	1.685	1.714	1.685	1.607
122	2.527	2.492	2.399	2.399	2.357	2.249	2.295	2.249	2.133
147	3.214	3.164	3.031	3.031	2.973	2.824	2.886	2.824	2.665
170	3.856	3.791	3.535	3.620	3.545	3.329	3.435	3.356	3.157
195	4.559	4.436	4.044	4.262	4.170	3.810	4.033	3.936	3.620
220	5.175	4.988	4.551	4.888	4.708	4.289	4.632	4.480	4.076
47 × 72	1.272	1.260	1.229	1.229	1.214	1.175	1.192	1.175	1.130
97	1.919	1.896	1.835	1.835	1.808	1.735	1.765	1.735	1.654
122	2.602	2.565	2.468	2.468	2.425	2.313	2.360	2.313	2.192
147	3.304	3.252	3.115	3.115	3.055	2.900	2.964	2.900	2.736
170	3.960	3.892	3.612	3.716	3.639	3.402	3.525	3.444	3.232
195	4.677	4.530	4.132	4.372	4.277	3.893	4.136	4.037	3.700
220	5.282	5.093	4.649	4.991	4.808	4.383	4.747	4.577	4.166
50 × 72	1.310	1.299	1.266	1.266	1.250	1.209	1.227	1.209	1.162
97	1.974	1.950	1.887	1.887	1.858	1.782	1.814	1.782	1.699
122	2.672	2.635	2.534	2.534	2.489	2.373	2.422	2.373	2.249
147	3.390	3.336	3.194	3.194	3.132	2.973	3.039	2.973	2.804
170	4.059	3.989	3.685	3.807	3.729	3.472	3.611	3.528	3.300
195	4.789	4.618	4.215	4.476	4.360	3.973	4.234	4.132	3.777
220	5.383	5.192	4.742	5.088	4.904	4.472	4.847	4.669	4.252
63 × 147	3.722	3.662	3.444	3.503	3.434	3.246	3.330	3.256	3.069
170	4.439	4.345	3.969	4.161	4.074	3.744	3.945	3.853	3.561
195	5.141	4.961	4.537	4.864	4.689	4.282	4.612	4.468	4.074
220	5.771	5.572	5.101	5.464	5.270	4.816	5.212	5.024	4.585
75 × 195	5.415	5.229	4.791	5.129	4.949	4.526	4.894	4.719	4.310
220	6.074	5.869	5.383	5.758	5.558	5.088	5.497	5.303	4.847

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 5268-7.2. 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 Table 3 to Table 7 of BS 5268-2:1988.

[b] Regularized sizes are given in BS 4471.

Table 2 — Permissible clear spans for roof joists without access, imposed load 0.75 kN/m²: redwood/whitewood, SS grade, basic sizes[a]

Size of joist	Dead load per square metre (in kN/m²) supported by joist, excluding the self weight of the joist								
	Not more than 0.50 (51 kg/m²)			More than 0.50 but not more than 0.75 (76.5 kg/m²)			More than 0.75 but not more than 1.00 (102 kg/m²)		
	Centre-to-centre spacing of joists (in mm)								
	400	450	600	400	450	600	400	450	600
	Permissible clear span								
mm	m	m	m	m	m	m	m	m	m
38 × 75	1.325	1.313	1.279	1.279	1.264	1.221	1.239	1.221	1.173
100	1.971	1.947	1.883	1.883	1.854	1.778	1.810	1.778	1.694
125	2.651	2.613	2.512	2.512	2.468	2.352	2.401	2.352	2.228
150	3.352	3.298	3.157	3.157	3.095	2.936	3.002	2.936	2.768
175	4.065	3.994	3.684	3.808	3.728	3.468	3.609	3.524	3.294
200	4.783	4.611	4.201	4.463	4.348	3.957	4.218	4.115	3.758
225	5.368	5.172	4.716	5.067	4.880	4.443	4.823	4.642	4.222
44 × 75	1.422	1.409	1.371	1.371	1.354	1.307	1.327	1.307	1.254
100	2.107	2.081	2.010	2.010	1.979	1.895	1.930	1.895	1.804
125	2.826	2.784	2.674	2.674	2.626	2.500	2.553	2.500	2.366
150	3.563	3.505	3.322	3.352	3.285	3.114	3.185	3.114	2.934
175	4.310	4.234	3.865	4.035	3.949	3.641	3.822	3.731	3.460
200	5.012	4.831	4.406	4.720	4.558	4.152	4.460	4.337	3.947
225	5.618	5.417	4.945	5.308	5.114	4.662	5.055	4.868	4.432
47 × 75	1.468	1.453	1.414	1.414	1.396	1.347	1.368	1.347	1.292
100	2.170	2.143	2.069	2.069	2.036	1.950	1.986	1.950	1.855
125	2.907	2.864	2.750	2.750	2.699	2.569	2.624	2.569	2.431
150	3.661	3.601	3.394	3.442	3.373	3.197	3.270	3.197	3.011
175	4.424	4.330	3.949	4.140	4.051	3.721	3.920	3.827	3.536
200	5.116	4.932	4.501	4.833	4.656	4.243	4.571	4.431	4.034
225	5.734	5.529	5.050	5.419	5.222	4.763	5.162	4.972	4.529
50 × 75	1.511	1.496	1.455	1.455	1.436	1.385	1.407	1.385	1.328
100	2.231	2.203	2.126	2.126	2.092	2.002	2.040	2.002	1.904
125	2.984	2.940	2.821	2.821	2.769	2.635	2.691	2.635	2.492
150	3.754	3.692	3.463	3.528	3.457	3.263	3.351	3.276	3.085
175	4.531	4.416	4.029	4.240	4.149	3.797	4.014	3.919	3.610
200	5.215	5.028	4.591	4.928	4.748	4.329	4.677	4.520	4.117
225	5.843	5.636	5.151	5.525	5.325	4.859	5.264	5.071	4.622
63 × 150	4.114	4.044	3.731	3.862	3.783	3.518	3.665	3.581	3.346
175	4.919	4.745	4.338	4.624	4.484	4.093	4.377	4.272	3.894
200	5.594	5.399	4.940	5.293	5.105	4.663	5.047	4.865	4.439
225	6.262	6.046	5.538	5.930	5.721	5.231	5.658	5.455	4.981
75 × 200	5.890	5.689	5.215	5.580	5.385	4.928	5.326	5.137	4.694
225	6.588	6.367	5.843	6.247	6.032	5.525	5.966	5.757	5.264

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 5268-7.2. 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.

Table 3 — Permissible clear spans for roof joists without access, imposed load 0.75 kN/m²: spruce-pine-fir, joist and plank no. 2 grade, CLS sizes[a]

Size of joist	Dead load per square metre (in kN/m²) supported by joist, excluding the self weight of the joist								
	Not more than 0.50 (51 kg/m²)			More than 0.50 but not more than 0.75 (76.5 kg/m²)			More than 0.75 but not more than 1.00 (102 kg/m²)		
	Centre-to-centre spacing of joists (in mm)								
	400	450	600	400	450	600	400	450	600
	Permissible clear span								
mm	m	m	m	m	m	m	m	m	m
38 × 114	2.190	2.162	2.085	2.085	2.051	1.962	1.999	1.962	1.864
140	2.872	2.829	2.714	2.714	2.664	2.533	2.588	2.533	2.394
184	4.064	3.991	3.678	3.804	3.723	3.460	3.602	3.517	3.284
235	5.336	5.139	4.680	5.033	4.844	4.405	4.788	4.605	4.183
285	6.438	6.203	5.655	6.077	5.851	5.326	5.783	5.566	5.060

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 5268-7.2. 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 of BS 4471:1987.

[a] CLS sizes are given in Appendix A of BS 4471:1987.

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Publications referred to

BS 648, *Schedule of weights of building materials.*
BS 4471, *Specification for sizes of sawn and processed softwood.*
BS 4471-1, *Sizes of sawn and planed timber.*
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*[3].
BS 5268-7.3, *Ceiling joists*[3].
BS 5268-7.4, *Ceiling binders*[3].
BS 5268-7.5, *Rafters*[3].
BS 5268-7.6, *Purlins supporting rafters*[3].
BS 5268-7.7, *Purlins supporting sheeting or decking*[3].
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.*
BS 6399-3, *Code of practice for imposed roof 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, 1450-1055 West Hastings Street, Vancouver, British Columbia, Canada V6E 2G8.*

[3] Referred to in the foreword only.

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