



Timber structures

Part 3: Design criteria for timber-framed residential buildings



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 - Engineers Australia
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Australian Standard[®]

Timber structures

Part 3: Design criteria for timber-framed residential buildings

Originated as AS 1684.1—1999.
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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee TM-010, Timber Structures and Framing, to supersede AS 1684.1—1999, *Residential timber-framed construction, Part 1: Design criteria*.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to provide users with the design criteria considered suitable for the design of conventional timber-framed residential buildings, subject to the requirements and limitations described in the Scope. Design criteria for the most commonly used timber members are provided.

This revision continues to recognize the ongoing development of timber framing systems and the need to cater for a widening variety of materials and design conditions. Significant changes include—

- (a) closer alignment with the relevant requirements of AS 1720.1;
- (b) adoption of the nomenclature and relevant requirements of the AS/NZS 1170 series of loading standards and, in particular, the recently revised edition of AS 4055;
- (c) de-linking of this Standard from the timber member span tables components of AS 1684.2, AS 1684.3 and AS 1684.4;
- (d) inclusion of design criteria for additional members—wind beams;
- (e) limitation to Class 1 and 10 buildings as defined by the National Construction Code—Building Code of Australia;
- (f) adjustment of the structural models used for joist and bearer design;
- (g) removal of alternative characteristic beam shear strengths for F-grades; and
- (h) correcting errors and addressing anomalies and inconsistencies.

Mandatory statements in notes and footnotes to tables are deemed to be requirements of this Standard.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

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STANDARDS AUSTRALIA

Australian Standard
Timber structures**Part 3: Design criteria for timber-framed residential buildings**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE AND APPLICATION**1.1.1 Scope**

This Standard sets out the design methods, assumptions and other criteria, including uplift forces and racking pressures, suitable for the design of timber-framed buildings constructed within the limitations and parameters of, and using the building practice described in, AS 1684.2, AS 1684.3 and AS 1684.4.

The design criteria apply for the preparation of design data for conventional timber-framed construction where the loading and performance requirements correspond to those for Class 1 and Class 10 buildings as defined by the National Construction Code—Building Code of Australia.

1.1.2 Application

This Standard is to be read in conjunction with AS 1684.2, AS 1684.3 and AS 1684.4, the AS/NZS 1170 series, AS 4055 and AS 1720.1.

NOTE: While this Standard may be applied for Class 10 buildings less conservative levels of design may be permitted, for this Class, by building regulations and other Australian Standards.

The design criteria contained herein provide a basis for the design of timber members and timber-framed building systems and components, including the preparation of Span Tables and design data for structural wood products.

NOTE: The use of the design criteria contained in this Standard may provide evidence of satisfactory safety and serviceability performance.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1170	Structural design actions
1170.4	Part 4: Earthquake actions in Australia
1684	Residential timber-framed construction
1684.2	Part 2: Non-cyclonic areas
1684.3	Part 3: Cyclonic areas
1684.4	Part 4: Simplified—Non-cyclonic areas
1720	Timber structures
1720.1	Part 1: Design methods
4055	Wind loads for housing

AS/NZS

- 1170 Structural design actions
- 1170.1 Part 1: Permanent, imposed and the other actions
- 1170.2 Part 2: Wind actions
- 1170.3 Part 3: Snow and ice actions

CSIRO Low-rise domestic and similar framed structures

CSIRO BCE Report Notched composite beams, Dec. 97/169M, September 1997

1.3 OTHER METHODS

This Standard does not preclude the use of other methods of design, other assumptions or criteria for design or any other means of demonstrating satisfactory safety and serviceability performance in accordance with the requirements of the Building Code of Australia.

1.4 BASIS FOR DESIGN

1.4.1 General

The design criteria contained in this Standard are an interpretation of the AS/NZS 1170 series, AS 4055 and AS 1720.1. The criteria have been formulated for the preparation of generalized design data for residential buildings constructed using the conventional timber framing system described in AS 1684.2, AS 1684.3 and AS 1684.4. The design criteria are based upon the assumptions described in Clauses 1.4.2 to 1.4.11 below.

1.4.2 Geometric limitations

The following geometric limitations have been assumed:

- (a) The overall building width at any section, excluding eaves and lean-to verandahs but including verandahs under the main roof, does not exceed 16.0 m.
- (b) The roof pitch does not exceed 35°.
- (c) Roof shapes may be skillion or gable, hip or gable ended or any combination of these.
- (d) The number of trafficable floors supported by timber framing does not exceed two.
- (e) Wall height, measured from floor to ceiling, does not exceed 3.0 m.

NOTE: For further details refer to AS 1684.2, AS 1684.3 and AS 1684.4.

1.4.3 Design methods

1.4.3.1 General

The design methods used shall be based upon analytical and engineering principles and comply with the requirements of AS 1720.1.

1.4.3.2 Capacity factor

Values of capacity factor (ϕ) shall generally be determined based on Category 1 applications in accordance with AS 1720.1 Table 2.1. Area affected shall typically be computed as $\text{area} = \text{span} \times \text{load width} \times 2$ and where this value exceeds 25 m², as may be the case for a primary roof support member, the application shall be considered Category 2.

NOTE: Where a member supports a significant point load, such as for a lintel supporting a girder roof truss, special consideration may be required in determining area affected.

1.4.4 System-based assumptions

The design criteria include many system-based assumptions, which recognize the interactions between structural elements and other elements of the overall construction system. These assumptions are based upon the methods of assembly and materials given in AS 1684.2, AS 1684.3 and AS 1684.4.

NOTE: The use of materials (both structural and non-structural) or installation methods other than those given in AS 1684.2, AS 1684.3 and AS 1684.4, may invalidate the system-based assumptions contained in this Standard.

1.4.5 Durability

The structural design criteria have been developed on the assumption that materials used and their installation and maintenance ensure that components will fulfil their intended structural function for the intended life of the structure.

NOTE: In the selection of materials, specific consideration should be given to the risk of and resistance to biological attack and corrosion, long-term durability of adhesives and the long-term strength and rigidity of materials taking into account the short-term and long-term conditions of exposure.

1.4.6 Structural timber

The design criteria are provided primarily for, but are not limited to, design using the generic stress grades and sizes of scantling timber as specified in AS 1684.2, AS 1684.3 and AS 1684.4.

NOTE: For other materials, where the application and performance are claimed to be consistent with AS 1684.2, AS 1684.3 and AS 1684.4, the design procedures and assumptions may require modification in accordance with the requirements of AS 1720.1.

1.4.7 Design properties

The design properties given in AS 1720.1, for generic stress grades and strength groups, have been used as the basis for the development of the design criteria given in this Standard.

1.4.8 Bearing and crushing

A check of bearing strength is indicated, where considered necessary, in the member design Sections of this Standard. Care should be taken to ensure that relevant checks are performed where large concentrated loads may cause crushing of members, such as may occur under the ends of girder trusses, or at the supports for members supporting such high point loads.

1.4.9 Structural design actions

1.4.9.1 *Permanent (dead load)*

Permanent actions are based upon standardized allowances for the mass of roof, wall and floor constructions.

NOTES:

- 1 Where actions arise as a result of non-standardized imposed dead loads (including permanent proportion of live loads) which may include, but not be limited to, cupboards suspended from walls and or ceilings, roof mounted hot water systems, heavy stone bench tops, safes, tiled waterproof decking systems etc., then specific allowance in design is made for these actions.
- 2 Where mass or load allowances are different from those referred in this Standard are used, then such variation should be noted in any published data.

1.4.9.2 *Imposed (live load)*

Generally, the imposed actions used for design correspond to those given in AS/NZS 1170.1. The following departures and interpretations have been used:

- (a) The partial live load for the serviceability design of continuous span joists and bearers is taken as 0.75 kPa.

- (b) The permanent component of floor live load is taken as 0.5 kPa.
- (c) Balconies and decks 1 m or more above the ground, are designed for a 1.5 kPa floor live load for the serviceability limit state, as for balconies and decks less than 1 m above the ground.
- (d) For generic design, the concentrated load on primary ceiling support members, including ceiling joists, hanging beams and counter beams is taken as 1.4 kN regardless of cladding installation status and available headroom.

NOTES:

- 1 Live loads specific to construction, e.g. loads resulting from the use of fall protection devices or scaffolding attached to the structure, are not considered.
- 2 AS/NZS 1170.1 allows this load to be reduced to 0.9 kN for some defined design applications.

1.4.9.3 Wind

Wind actions for member design are derived from AS 4055 using wind classifications N1 to N4 and C1 to C3 and associated design wind pressures as specified in Appendix A. Pressure coefficients are determined from AS 4055 unless noted otherwise in the member design information. It is assumed that all of the cladding elements including windows, doors and garage doors are capable of resisting the design winds and comply with the relevant Australian standards. Wind actions for tie-down design are determined from AS 4055 and AS/NZS 1170.2.

1.4.9.4 Snow

Snow actions, determined in accordance with AS/NZS 1170.3, up to 0.2 kPa have been considered and determined as not critical. For this reason, snow actions are not included in the action combinations given for member design in this Standard.

1.4.9.5 Earthquake

AS 1170.4—2007 introduces a performance parameter K_pZ which is calculated using return period factor determined from the annual probability of exceedance and the hazard factor for the site. Domestic structures designed and detailed for lateral wind forces in conjunction with AS 1684 or AS 1720.1 with a $K_pZ \leq 0.11$ do not require specific earthquake design. For this reason, earthquake actions are not included in the action combinations given for member design or considered necessary for the calculation of racking loads to be resisted by bracing.

1.4.9.6 Combinations of actions

Combinations of actions included for the determination of the strength limit states and the serviceability limit states for each member are those considered appropriate in accordance with AS/NZS 1170.1.

1.4.10 Strength limit states

For each member, all strength limit states have been considered; however, only those strength limit states deemed as potentially critical are included in the design criteria and are required to be assessed for the purposes of this Standard.

NOTE: For non-generic timber-based products, design may require consideration of strength limit states other than those included in this Standard.

1.4.11 Serviceability limit states

The serviceability limit states used for the design have been determined on the basis of experience with the known serviceability performance of individual member types in typical applications. Serviceability limits used are intended to provide satisfactory rigidity for average situations.

NOTES:

- 1 For installations where greater than usual rigidity may be required it is anticipated that larger sizes and or materials with higher or more uniform modulus of elasticity should be used (see AS 1720.1), e.g. granite kitchen benchtops, large ceramic floor tiles, island benches.
- 2 Consider the relative deformation of joists parallel and close to relatively rigid walls (either above or below the floor). Resultant localized differential deflection can cause cracking of rigid surface finishes and can cause high/narrow furniture to lean noticeably.
- 3 The serviceability limit states given are for individual elements. Where one element is supported by another, the cumulative deflection of the system of elements should be considered to prevent cracking of linings, cladding or glazing and to prevent result in load transfer to joinery items and consequent damage.
- 4 The limits on deflection used as part of the definition of the serviceability limit states are limits intended for comparison with calculated deflections only. Actual or measured deflections may differ from calculated deflections due to any or all of the following factors:
 - (a) Differences between actual loads and design loads used for serviceability calculations.
 - (b) Differences between the actual modulus of elasticity of components and the average value used for design.
 - (c) Differences between the structural behaviour of the system and the structural models used for design.

1.5 DEFINITIONS

For the purpose of this Standard, the following definitions apply.

1.5.1 Balcony

An external trafficable floor area of a house.

1.5.2 Birdsmouth

A triangular notch cut into the underside of a sloping beam (e.g. rafter) to permit seating on the supporting member.

1.5.3 Bracing

An assembly intended to resist racking forces including diagonal members, shear panels, diaphragms, cantilevered columns or portal (rigid) frames.

1.5.4 Cladding

Material used for the external surface of walls or roofs.

1.5.5 Deck

An external attached or detached trafficable floor area.

1.5.6 Flooring or decking

Boards or sheets overlying floor joists intended to support floor loads. Flooring is usually tongue and groove jointed along the edges whereas decking comprises individual non-connected boards.

1.5.7 Generic stress grades

Stress grades for which properties are included in AS 1720.1.

1.5.8 Lining

The materials used for the internal faces of walls or ceilings.

1.5.9 Loadbearing walls

Walls required to support vertical loads from roofs and/or floors.

NOTE: This definition differs from that given in the Building Code of Australia.

1.5.10 Nogging

A horizontal member, fitted between studs in a wall frame, which restrains the studs against buckling in the plane of the wall. Noggings may also be used for attachment of cladding or lining or as part of a bracing system.

1.5.11 Non-loadbearing walls

Partition walls not supporting roofs or floors. Non-loadbearing walls may support ceilings and may incorporate posts for the support of roof or floor loads.

NOTE: This definition differs from that given in the Building Code of Australia.

1.5.12 Sheet roofing

Includes sheet metal tile panels and other metal deck roofing of mass up to 10 kg/m².

1.5.13 Span

1.5.13.1 *Effective span*

The effective span of flexural members shall be taken as the distance between the centres of areas of bearing or of connections.

For members that extend over bearings longer than is necessary, it is appropriate to measure the span as the distance between centres of imaginary bearings which are chosen in such a way that their lengths are adequate to comply with the requirements of AS 1720.1.

1.5.13.2 *Single span*

The span of a member supported at or near both ends with no immediate supports. This includes the case where members are partially cut through over intermediate supports to remove spring.

1.5.13.3 *Continuous span*

Members supported at or near both ends and at one or more intermediate points such that no span is greater than twice another.

NOTE: Truss spans have traditionally been measured from outside to outside of pitching plates.

1.5.14 Standard roof truss

An engineered, triangulated framework installed at similar centres to rafters and designed to transfer roof and ceiling loads, usually, to external walls.

1.5.15 Tie-down

The connections or fixings designed to resist uplift forces due to wind.

1.5.16 Tiled roofing

Includes slate, terracotta and concrete tiles of mass up to 60 kg/m².

1.5.17 Wall/brick tie

A bracket connecting brick cladding to a timber wall frame.

1.6 NOTATION

Generally, the notation used in AS 1720.1, AS 1684 series, AS 4055 and the AS/NZS 1170 series is used also in this Standard. Notation specific to each clause is defined in that clause. Some general notation symbols used in this Standard are as follows:

b	=	breadth of member
CLW	=	ceiling load width
d	=	depth of member
FLW	=	floor load width
K_c	=	pressure combination factor (see Section 6)
L	=	general symbol used for span
L_o	=	horizontal span for rafter overhang
P	=	general symbol for concentrated load
RLW	=	roof load width
S	=	general symbol used for spacing
w	=	general symbol for distributed load

SECTION 2 DESIGN OF ROOF MEMBERS

2.1 ROOF BATTENS

2.1.1 Description

A roof batten is a rectangular section used on its flat to provide direct support for sheet or tile roofing. Spans for roof battens are limited to 1200 mm. For tile roofs a standard spacing of 330 mm is considered whereas for sheet roofs, spacings up to 1200 mm are included.

Battens are assumed to span continuously over rafters (or trusses) for at least two spans (see Figure 2.1.1).

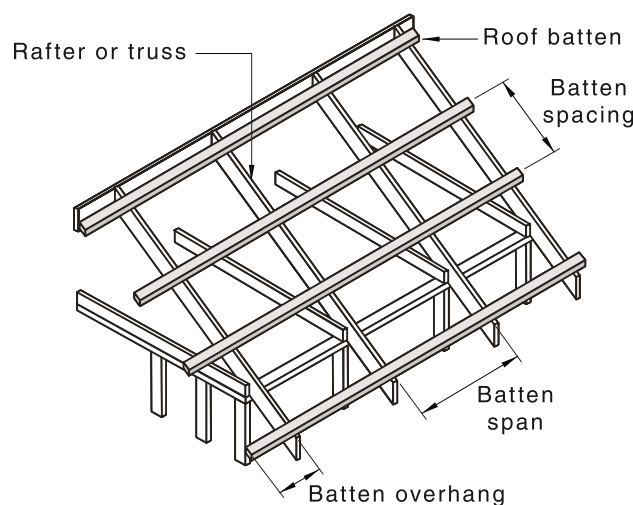


FIGURE 2.1.1 ROOF BATTENS

2.1.2 Design for safety

2.1.2.1 General consideration

Design for safety requires consideration of the strength limit states for bending about the minor axis only and shear.

NOTE: Battens are assumed prevented from bending in the plane of the roof by the attached cladding.

2.1.2.2 Design actions

The actions used for the determination of the design action effects shall be as follows:

- (a) *Permanent* Permanent actions, G , corresponding to the typical roof constructions, are determined from Table 2.1.2.2(A).

TABLE 2.1.2.2(A)

PERMANENT ACTIONS FOR ROOF BATTENS

Roof type	Permanent action, (G) kN/m
Sheet roof	$0.1S + \text{self weight}$
Tile roof	$0.6S + \text{self weight}$

LEGEND:

S = spacing of roof battens, in metres
Self weight = roof batten self weight, in kN/m

- (b) *Imposed* The uniformly distributed imposed action, Q_1 (in kN/m), and concentrated imposed actions, Q_2 and Q_3 (both in kN), used for design are determined from—

$$(i) \quad Q_1 = 0.25S \quad \dots 2.1.2.2(1)$$

$$(ii) \quad Q_2 = g_{44} \times 1.1 \quad \dots 2.1.2.2(2)$$

$$(iii) \quad Q_3 = g_{45} \times 1.1 \quad \dots 2.1.2.2(3)$$

where

g_{44} = the lesser of $1.33S$ and 1.0

S = spacing of roof battens, in metres

and

g_{45} is calculated in accordance with Appendix B3, assuming a bargeboard of rigidity $E_f I_f = 18 \times 10^9 \text{ Nmm}^2$ is attached to the ends of the parallel overhanging battens, and $g_{47} = 1.0$ (i.e. no birdsmouth notch).

NOTE: The load distribution factor g_{44} is taken from CSIRO, *Low-rise domestic and similar framed structures* (see Clause 1.2). The use of this load distribution factor is based upon construction workers following the traditional practice of not treading at or near mid-span of closely spaced battens prior to the installation of roof claddings.

- (c) *Wind* The wind action, W_u (in kN/m), applicable for the strength limit state, is determined from—

$$W_u = q_u C_{pt} S \quad \dots 2.1.2.2(4)$$

where

q_u = free stream dynamic gust pressure, in kPa, for the ultimate limit state values of q_u are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.1.2.2(B)

S = spacing of roof battens, in metres

TABLE 2.1.2.2(B)
NET PRESSURE COEFFICIENTS FOR ROOF BATTENS

Wind classification	C_{pt}		
	General areas	Areas within 1.2 m of an edge	Areas within 1.2 m of an eaves corner
N1 to N4	+0.63, -1.0	-1.8	-2.61
C1 to C3	+0.95, -1.44	-2.25	-3.06

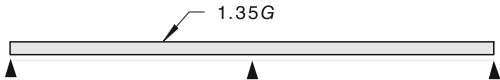
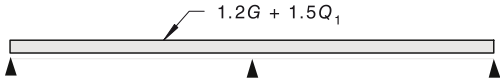
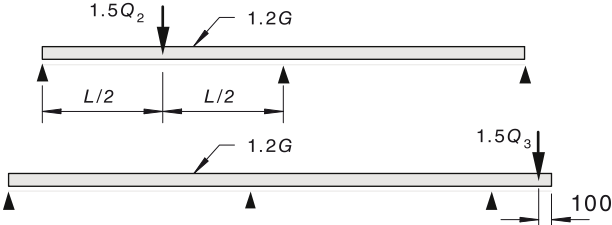
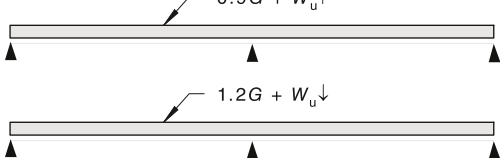
NOTES:

- 1 Local pressure effects may be catered for by specifying reductions in batten spacing near edges and eaves corners, as appropriate.
- 2 The value of C_{pt} for areas within 1.2 m of an eaves corner applies only to roof slopes less than 10° . Where there is no internal pressure, such as in open verandah or eave construction, this value of C_{pt} shall be increased to -2.7.
- 3 Values given in this Table are based on the assumption that a separate ceiling is provided with the maximum internal pressure coefficient (C_{pi}) for roof cavities in cyclonic regions considered as for non-cyclonic regions.

2.1.2.3 Structural models and action categories for strength design

The structural models used to calculate the member design action effects shall be as given in Table 2.1.2.3. Action combinations shown in Table 2.1.2.3 are divided into action categories that are used for the determination of member design capacity as specified in Clause 2.1.2.4.

TABLE 2.1.2.3
STRUCTURAL MODELS AND ACTION CATEGORIES—STRENGTH

Action category	Structural model
1	
2	
3	
4	

2.1.2.4 Member design capacity

The requirements of AS 1720.1 shall be applied to determine member design capacities in bending and shear. The following assumptions and modification factors shall be used:

- (a) *Load duration factor* The member design capacity includes the modification factor for load duration (k_1). Values of k_1 appropriate for each action category are given in Table 2.1.2.4.

TABLE 2.1.2.4
LOAD DURATION FACTORS FOR STRENGTH

Action category	Load duration factor (k_1)
1	0.57
2	0.94
3	0.97
4	1.00

- (b) *Moisture content of timber:*

- (i) *Unseasoned timber*—for Action category 4 given in Table 2.1.2.3, use values of k_4 appropriate for thickness as specified in AS 1720.1. For Action categories 1, 2 and 3, $k_4 = 1.0$.
- (ii) *Seasoned timber*— $k_4 = 1.0$ for all action categories.
- (c) *Member restraint* For battens, breadth is greater than or equal to depth and, hence, the lateral stability factor $k_{12} = 1.0$.

2.1.3 Design for serviceability

2.1.3.1 Design actions

The actions used for the serviceability limit states shall be as follows:

- (a) *Permanent* Permanent actions, G , corresponding to various typical roof constructions are determined from Table 2.1.2.2(A).
- (b) *Wind* The uniformly distributed wind action, W_s (in kN/m), applicable for the serviceability limit state is determined from—

$$W_s = q_s C_{pt} S \quad \dots 2.1.3.1$$

where

q_s = free stream dynamic gust pressure, in kPa, for the serviceability limit state; values of q_s are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.1.2.2(B)

S = spacing of roof battens, in metres

2.1.3.2 Structural models and action categories for serviceability design

The structural models for which deflections are calculated shall be as given in Table 2.1.3.2. Action cases included in Table 2.1.3.2 are divided into action categories for the purpose of allowing for the effect of duration of load on stiffness as specified in Clause 2.1.3.3.

TABLE 2.1.3.2
STRUCTURAL MODELS AND ACTION CATEGORIES—SERVICEABILITY

Action category	Structural model
1	
2	

2.1.3.3 Calculation of deflection

The requirements of AS 1720.1 for the calculation of deformation shall be applied using the duration of load factor for creep deformation as given in Table 2.1.3.3.

TABLE 2.1.3.3
LOAD DURATION FACTORS FOR DEFORMATION

Moisture content	Load duration factor (j_2)	
	Action category 1 (permanent loads)	Action category 2 (transient loads)
Seasoned	2.0	1.0
Unseasoned	3.0	1.0

2.1.3.4 Serviceability limits

The limits on deflection defining the serviceability limit state are given in Table 2.1.3.4.

TABLE 2.1.3.4
LIMITS ON DEFLECTION

Action category	Deflection limits	
	Mid-span	End of overhang
1	Span/300	Overhang/150 or 4 mm whichever is greater ^(see Note)
2	Span/150	No limitation

NOTE: Limit shall be ignored for upwards deflection.

2.2 RAFTERS

2.2.1 Description

Rafters are roof members that run parallel to the fall of the roof and support roof battens or purlins. They may also support ceilings, either directly or via ceiling battens or joists.

Rafters may be either single span or continuous span and may be cantilevered to form an eaves overhang either with or without a birdsmouth notch at the overhang support. Continuous span rafters are assumed not notched at intermediate supports.

For the determination of the maximum overhang the ends of rafters are assumed rigidly connected to a fascia that acts to share any concentrated loads to adjacent members [see Figure 2.2.1 and Clause 2.2.2.2(b)(iii)].

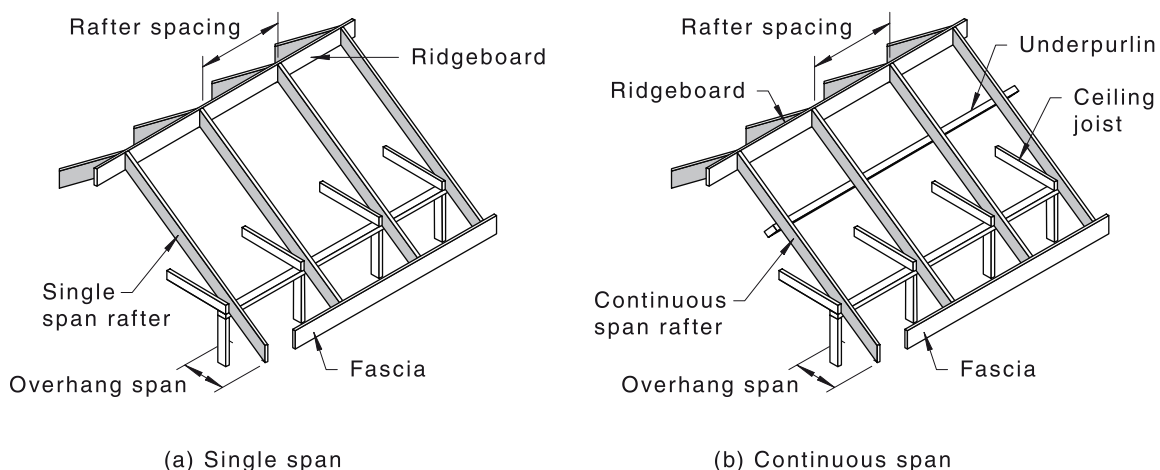


FIGURE 2.2.1 RAFTERS

2.2.2 Design for safety

2.2.2.1 General consideration

Design for safety requires consideration of the strength limit states for bending and shear. In addition, for birdsmouth notches associated with overhangs, the interaction of bending and shear shall also be considered.

2.2.2.2 Design actions

The actions used for the determination of the design action effects shall be as follows:

- (a) *Permanent* Permanent actions, G , corresponding to various typical roof constructions, are determined from Table 2.2.2.2(A).

TABLE 2.2.2.2(A)
PERMANENT ACTION

Roof type	Permanent action, (G) kN/m
Sheet roof only	$0.1S + \text{self weight}$
	$0.2S + \text{self weight}$
Sheet roof and ceiling	$0.4S + \text{self weight}$
Tile roof only	$0.6S + \text{self weight}$
Tile roof and ceiling	$0.9S + \text{self weight}$

LEGEND:

S = spacing of rafters, in metres

Self weight = rafter self weight, in kN/m

- (b) *Imposed* The distributed imposed action, Q_1 (in kN/m), and concentrated imposed actions Q_2 and Q_3 (in kN), are determined from—

$$(i) \quad Q_1 = 0.25S \quad \dots 2.2.2.2(1)$$

$$(ii) \quad Q_2 = g_{42} \times 1.1 \quad \dots 2.2.2.2(2)$$

$$(iii) \quad Q_3 = g_{45} \times 1.1 \quad \dots 2.2.2.2(3)$$

where

S = spacing of rafters, in metres

g_{42} = load distribution factor for concentrated load, applied to a grid system, calculated in accordance with AS 1720.1, assuming the crossing members are battens with rigidity and spacing as follows:

(1) *Sheet roofs:* $E_c I_c = 2.3 \times 10^9 \text{ Nmm}^2$, and spacing = 1200 mm.

(2) *Tile roofs:* $E_c I_c = 380 \times 10^6 \text{ Nmm}^2$, and spacing = 330 mm.

g_{45} = load distribution factor for parallel rafter overhangs, calculated as detailed in Appendix B for the case where the depth of the birdsmouth notch is no greater than one third of the rafter depth and a structural fascia of minimum rigidity $86 \times 10^9 \text{ Nmm}^2$ is attached to the end of each rafter. Where these conditions are not met, $g_{45} = 1$

- (c) *Wind* The wind action, W_u (in kN/m), applicable for the strength limit state is determined from—

$$W_u = q_u C_{pt} S \quad \dots 2.2.2.2(4)$$

where

q_u = free stream dynamic gust pressure, in kPa, for the ultimate limit state; values of q_u are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.2.2.2(B)

S = spacing of rafters, in metres

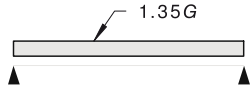
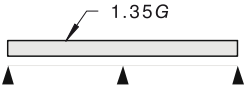
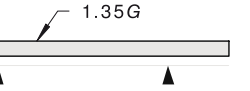
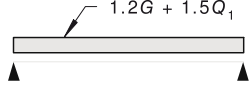
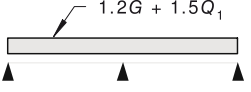
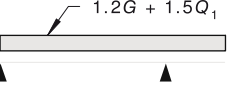
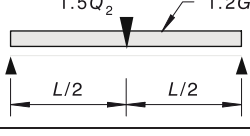
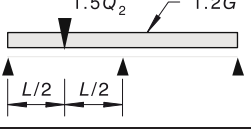
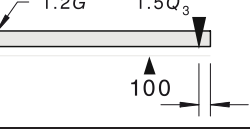
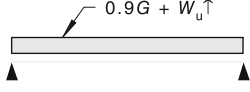
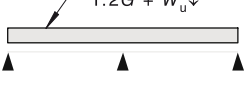
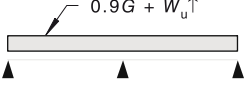
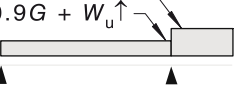
TABLE 2.2.2.2(B)
NET PRESSURE COEFFICIENTS
FOR RAFTERS—STRENGTH

Wind classification	C_{pt}	
	Main spans	Overhang
N1 to N4	+0.63 or -0.99	+0.95 or -1.44
C1 to C3	+0.95 or -1.44	+0.95 or -1.44

2.2.2.3 Structural models and action categories for strength design

The structural models used to calculate the member design action effects shall be as given in Table 2.2.2.3. Action combinations shown in Table 2.2.2.3 are divided into action categories that are used for the determination of member design capacity as specified in Clause 2.2.2.4.

TABLE 2.2.2.3
STRUCTURAL MODELS AND ACTION CATEGORIES—STRENGTH

Action category	Structural model		
	Single span	Continuous span	Overhang
1			
2			
3			
4	 	 	 

2.2.2.4 Member design capacity

The requirements of AS 1720.1 shall be applied to determine member design capacities in bending and shear. In addition, for birdsmouth notches associated with rafter overhangs, the procedures given in Appendix B shall be applied, assuming the notch depth is one third of the rafter depth. The following assumptions and modification factors shall be used:

- (a) *Load duration factor* The member design capacity includes the modification factor for load duration (k_1). Values of k_1 appropriate for each action category, as defined in Table 2.2.2.3, are given in Table 2.2.2.4.

TABLE 2.2.2.4
LOAD DURATION FACTORS FOR STRENGTH

Action category	Load duration factor (k_1)
1	0.57
2	0.94
3	0.97
4	1.00

- (b) *Moisture content of timber:*
- (i) *Unseasoned timber*—for Action category 4 given in Table 2.2.2.3, use values of k_4 appropriate for thickness as specified in AS 1720.1. For action categories 1, 2 and 3, $k_4 = 1.0$.
 - (ii) *Seasoned timber*— $k_4 = 1.0$ for all action categories.
- (c) *Strength sharing* For scantling timber, the strength sharing factor (k_9) is applied as follows:
- (i) For calculating maximum main spans, k_9 is determined in accordance with AS 1720.1, assuming $n_{\text{mem}} = 5$ and $n_{\text{com}} = 1$ (for single members).
 - (ii) For calculating maximum overhangs and for negative moment only (see Appendix B)—
- $$k_9 = 1.24 - 0.24 (S/L_o), \text{ but not less than } 1.0 \quad \dots 2.2.2.4$$
- where
- S = spacing of rafters
- L_o = horizontal span of the overhang
- (d) *Member restraint* For the determination of bending capacity the following assumptions related to lateral restraint are used:
- (i) *At supports*—rafters are assumed torsionally restrained at their supports.
 - (ii) *Between supports*—
 - (A) the top edges of rafters are assumed laterally restrained by battens, or purlins, at 330 mm centres for tile roofs and 1200 mm centres for sheet roofs; and
 - (B) *in addition*, continuous span rafters are assumed restrained against torsional buckling at the points of contraflexure taken as one quarter of the span from the intermediate support.

2.2.3 Design for serviceability

2.2.3.1 Design actions

The actions used for the purpose of assessing the serviceability limit states shall be as follows:

- (a) *Permanent and imposed* Permanent actions and imposed actions are determined as described in Clause 2.2.2.2.
- (b) *Wind* The uniformly distributed wind action, W_s (in kN/m), applicable for the serviceability limit state is determined from—

$$W_s = q_s C_{pt} S \quad \dots 2.2.3.1$$

where

q_s = free stream dynamic gust pressure, in kPa, for the serviceability limit state; values of q_s are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.2.3.1

S = spacing of rafters, in metres

TABLE 2.2.3.1
NET PRESSURE COEFFICIENTS FOR RAFTERS—
SERVICEABILITY

Wind classification	C_{pt}	
	Main spans	Overhang
N1 to N4 and C1 to C3	+0.63 or -0.99	+0.95 or -1.44

2.2.3.2 Structural models and action categories for serviceability design

The structural models for which deflections are calculated shall be as given in Table 2.2.3.2.

Action cases included in Table 2.2.3.2 are divided into action categories for the purpose of allowing for the effect of duration of load on stiffness, as specified in Clause 2.2.3.3.

TABLE 2.2.3.2
STRUCTURAL MODELS AND ACTION CATEGORIES—SERVICEABILITY

Action category	Structural model		
	Single span	Continuous span	Overhang (cantilevered)
1			
2			
3			

2.2.3.3 Calculation of deflection

The requirements of AS 1720.1 for the calculation of deflection shall be applied using the duration of load factor for creep deformation as given in Table 2.2.3.4(A). In addition, the deflection at the ends of overhangs for birdsmouth-notched rafters shall be determined using the modified rafter rigidity given in Appendix B.

2.2.3.4 Serviceability limits

The limits on deflection, defining the serviceability limit state, are given in Table 2.2.3.4(B).

TABLE 2.2.3.4(A)
LOAD DURATION FACTORS FOR DEFORMATION

Moisture content	Load duration factor (j_2)	
	Action category 1	Action category 2 or 3
Seasoned	2.0	1.0
Unseasoned	3.0	1.0

TABLE 2.2.3.4(B)
LIMITS ON DEFLECTION

Action category	Deflection limits	
	Mid-span	End of overhang
1	Span/300 or 20 mm max.	10 mm
2	Span/250	10 mm
3	Span/150	20 mm

2.3 ROOF BEAMS—RIDGE OR INTERMEDIATE BEAMS

2.3.1 Description

Ridge or intermediate beams are roof beams that support rafters, which in turn support roof or roof and ceiling loads. Roof beams run perpendicular to the slope of the roof, are either single or continuous span and may cantilever to support a verge overhang. Overhang spans are determined assuming roof beams are not notched at the overhang support.

For the purpose of determining lateral stability, roof beams are assumed to be laterally restrained by rafters fixed to their top edge (see Figure 2.3.1).

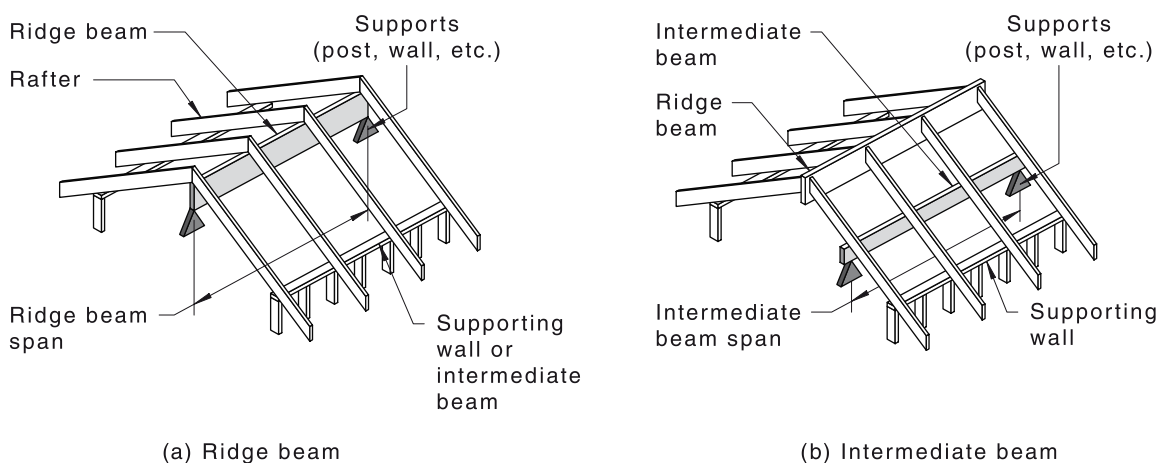


FIGURE 2.3.1 ROOF BEAMS—RIDGE OR INTERMEDIATE BEAM

2.3.2 Design for safety

2.3.2.1 General consideration

Roof beam design for safety requires consideration of the strength limit state for bending, shear and bearing.

2.3.2.2 Design actions

The actions used for the determination of the design action effects shall be as follows:

- (a) *Permanent* The uniformly distributed permanent action, G (in kN/m), corresponding to various typical roof constructions with additional allowance for the weight of the rafters, is determined from—

$$G = 0.01(RM)(RLW) + 0.02(RLW)^2 + \text{self weight} \quad \dots 2.3.2.2(1)$$

where

RM = standardized roof mass, i.e. 10, 20, 40, 60 or 90 kg/m²

RLW = roof load width for the roof beam, in metres

self weight = roof beam self weight, in kN/m

- (b) *Imposed* The distributed imposed action, Q_1 (in kN/m), and concentrated imposed action, Q_2 (in kN), are determined from—

(i) $Q_1 = 0.25(RLW)$... 2.3.2.2(2)

(ii) $Q_2 = 1.1$... 2.3.2.2(3)

where

RLW = roof load width for the roof beam, in metres

- (c) *Wind* The uniformly distributed wind action, W_u (in kN/m), applicable for the strength limit state is determined from—

$$W_u = q_u C_{pt}(RLW) \quad \dots 2.3.2.2(4)$$

where

q_u = free stream dynamic gust pressure, in kPa, for the ultimate limit state values of q_u are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.3.2.2

RLW = roof load width for roof beam, in metres

TABLE 2.3.2.2
NET PRESSURE COEFFICIENTS FOR ROOF BEAMS—
STRENGTH

Wind classification	C_{pt}	
	Main spans	Overhang
N1 to N4	+0.63 or -0.99	+0.95 or -1.44
C1 to C3	+0.95 or -1.44	+0.95 or -1.44
N1 to N4 and C1 to C3 for alfresco and carports	+0.95 or -1.44	+0.95 or -1.44

2.3.2.3 Structural models and action categories for strength design

The structural models used to calculate the member design action effects shall be as given in Table 2.3.2.4(A). Action combinations shown in Table 2.3.2.4(A) are divided into action categories that are used for the determination of member design capacity as specified in Clause 2.3.2.4.

2.3.2.4 Member design capacity

The requirements of AS 1720.1 shall be applied to determine member design capacities in bending, shear and bearing. The following assumptions and modification factors shall be used:

- (a) *Load duration factor* The member design capacity includes the modification factor for load duration (k_1). Values of k_1 appropriate for each action category, as defined in Table 2.3.2.4(A), are given in Table 2.3.2.4(B).
- (b) *Moisture content of timber*:
 - (i) *Unseasoned timber*—for action categories 3 and 4 given in Table 2.3.2.4(A), use values of k_4 appropriate for thickness as given in AS 1720.1. For action categories 1 and 2, $k_4 = 1.0$.
 - (ii) *Seasoned timber*— $k_4 = 1.0$ for all action categories.

TABLE 2.3.2.4(A)
STRUCTURAL MODELS AND ACTION CATEGORIES—STRENGTH

Action category	Structural model		
	Single span	Continuous span	Overhang
1			
2			
3			
4			

TABLE 2.3.2.4(B)
LOAD DURATION FACTORS FOR STRENGTH

Action category	Load duration factor (k_1)
1	0.57
2	0.94
3	0.97
4	1.00

- (c) *Strength sharing* Where multiple sections of scantling timber are nail-laminated, the strength sharing factor (k_9) is applied for the combined member, assuming $n_{mem} = 1$ and n_{com} = number of combined sections.

- (d) *Member restraint* For the determination of bending capacity, the following assumptions relating to lateral restraint are used:
- (i) *At supports*—roof beams are assumed torsionally restrained at their supports.
 - (ii) *Between supports*:
 - (A) The top edges of roof beams are assumed restrained at 1200 mm centres.
 - (B) Continuous span roof beams are assumed restrained against buckling at the points of contraflexure.

NOTE: Where nail-laminated members are used, the breadth of member used to derive the slenderness coefficient (S_1) is taken as the breadth of an individual lamination.

2.3.3 Design for serviceability

2.3.3.1 Design actions

The actions used for the serviceability limit state shall be as follows:

- (a) *Permanent and imposed* Permanent actions and imposed actions are determined as described in Clause 2.3.2.2.
- (b) *Wind* The uniformly distributed wind action, W_s (in kN/m), applicable for the serviceability limit state, is determined from—

$$W_s = q_s C_{pt}(RLW) \quad \dots 2.3.3.1$$

where

q_s = free stream dynamic gust pressure, in kPa, for the serviceability limit state; values of q_s are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.3.3.1

RLW = roof load width for roof beam, in metres

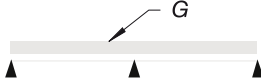
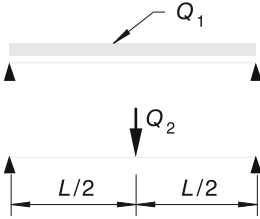
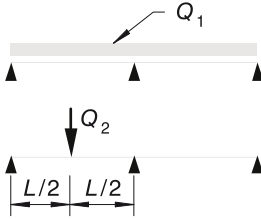
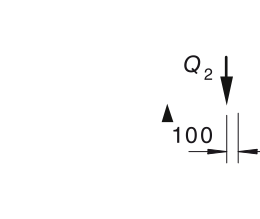
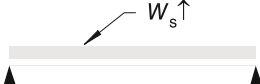
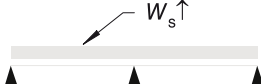
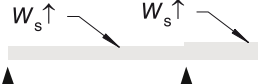
TABLE 2.3.3.1
NET PRESSURE COEFFICIENTS FOR ROOF BEAMS—
SERVICEABILITY

Wind classification	C_{pt}	
	Main spans	Overhangs
N1 to N4 and C1 to C3	+0.63 or -0.99	-0.9

2.3.3.2 Structural models and action categories for serviceability design

The structural models for which deflections are calculated shall be as given in Table 2.3.3.2. Action cases included in Table 2.3.3.2 are divided into action categories for the purpose of allowing for the effect of duration of load on stiffness, as specified in Clause 2.3.3.3.

TABLE 2.3.3.2
STRUCTURAL MODELS AND ACTION CATEGORIES—SERVICEABILITY

Action category	Structural model		
	Single span	Continuous span	Overhang (cantilevered)
1			
2			
3			

2.3.3.3 Calculation of deflection

The requirements of AS 1720.1 for the calculation of deflection shall be applied using the duration of load factor for creep deformation as given in Table 2.3.3.3.

TABLE 2.3.3.3
LOAD DURATION FACTORS FOR DEFORMATION

Moisture content	Load duration factor (j_2)	
	Action category 1	Action category 2 or 3
Seasoned	2.0	1.0
Unseasoned	3.0	1.0

2.3.3.4 Serviceability limits

The limits on deflection used to define the serviceability limit states are given in Table 2.3.3.4.

TABLE 2.3.3.4
LIMITS ON DEFLECTION

Action category	Deflection limits	
	Mid-span	End of overhang
1	Span/300 or 20 mm max.	10 mm
2	Span/250	10 mm
3	Span/150	30 mm

2.4 UNDERPURLINS

2.4.1 Description

Underpurlins provide intermediate support for rafters in coupled roof construction. They are orientated as shown in Figure 2.4.1 and primarily support roof loads normal to the plane of the roof over the middle part of the rafter length.

Sections with depth to overall breadth ratios greater than four are not considered for application as underpurlins. Further, where the depth to overall breadth ratio exceeds two, underpurlins are assumed torsionally braced at supports and fly-braced back to rafters at intervals not exceeding 1200 mm along their span. These requirements are intended to minimize weak axis sag that may reduce support to rafters and/or induce buckling, particularly for more steeply pitched roofs.

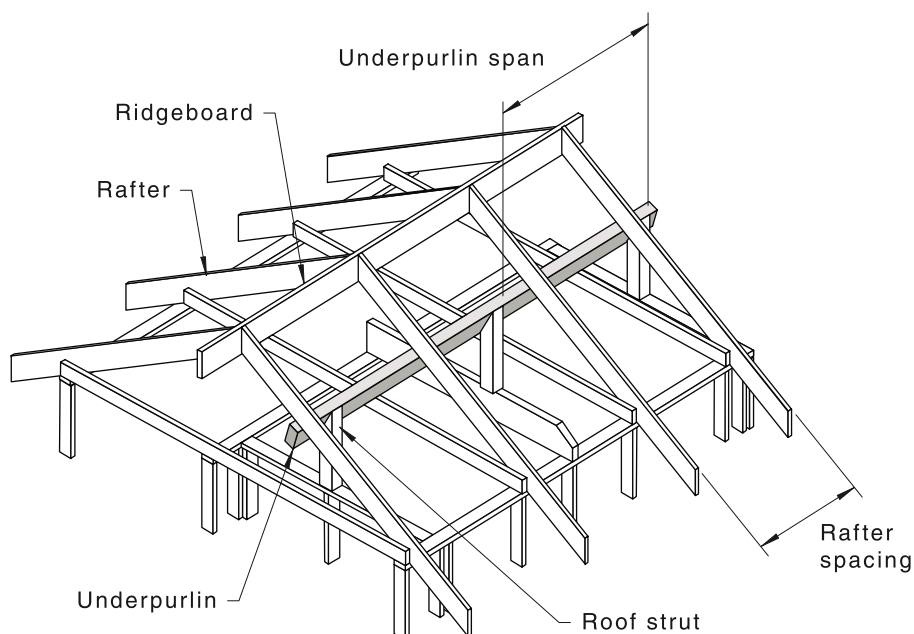


FIGURE 2.4.1 UNDERPURLINS

2.4.2 Design for safety

2.4.2.1 General consideration

Design for safety requires consideration of the strength limit states in bending and shear.

2.4.2.2 Design actions

The actions used for determination of the design actions effects shall be as follows:

- (a) *Permanent* Permanent actions include the self weight of the underpurlin, G_1 (in kN/m), and concentrated action, G_2 (in kN), imposed by the rafters. G_2 is determined from—

$$G_2 = 1.25(0.01RM)S_R(RLW) \quad \dots 2.4.2.2(1)$$

where

RM = standardized roof mass, i.e. 10, 20 or 60 kg/m²

S_R = spacing of rafters, i.e. 0.6 m or 1.2 m

RLW = roof load width for underpurlin, in metres

NOTE: The 1.25 factor in Equation 2.4.2.2(1) provides an allowance for the weight of supported rafters and the effect of their continuity.

- (b) *Imposed* Imposed actions applied via rafters are considered as concentrated actions, Q_1 (in kN), and are determined as follows:

$$Q_1 = 0.25S_R(RLW) \quad \dots 2.4.2.2(2)$$

where

S_R = spacing of rafters, i.e. 0.6 m or 1.2 m

RLW = roof load width for underpurlins, in metres

- (c) *Wind* Wind actions are considered as concentrated actions (W_u), imposed via the rafters. Concentrated actions, W_u (in kN), are determined as follows:

$$W_u = q_u C_{pt} S_R (RLW) \quad \dots 2.4.2.2(3)$$

where

q_u = free stream dynamic gust pressure, in kPa, for the ultimate limit state; values of q_u are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.4.2.2

S_R = spacing of rafters, i.e. 0.6 m or 1.2 m

RLW = roof load width for underpurlin, in metres

TABLE 2.4.2.2
NET PRESSURE COEFFICIENTS FOR UNDERPURLINS

Wind classification	C_{pt}
N1 to N4	+0.63 or -0.99
C1 to C3	+0.95 or -1.44

NOTE: Values given in this Table are based on the assumption that a separate ceiling is provided with the maximum internal pressure coefficient (C_{pi}) for roof cavities in cyclonic regions considered as for non-cyclonic regions.

2.4.2.3 Structural models and action categories used for strength design

The structural models used to determine the member design action effects shall be as given in Table 2.4.2.4(A). Action combinations shown in Table 2.4.2.4(A) are divided into action categories that are used for the determination of member design capacity as specified in Clause 2.4.2.4.

2.4.2.4 Member design capacity

The requirements of AS 1720.1 shall be applied to determine member design capacities in bending and shear. The following assumptions and modification factors shall be used:

- (a) *Load duration factor* The member design capacity includes the modification factor for load duration (k_1). Values of k_1 appropriate for each action category defined in Table 2.4.2.4(A) are given in Table 2.4.2.4(B).
- (b) *Moisture content of timber:*
- Unseasoned timber*—for action categories 2 and 3, use values of k_4 appropriate for member thickness as given in AS 1720.1. For Action category 1, $k_4 = 1.0$.
 - Seasoned timber*— $k_4 = 1.0$ for all action categories.
- (c) *Strength sharing* Where multiple sections of scantling timber are nail-laminated, the strength sharing factor (k_9) is applied for the combined member, assuming $n_{mem} = 1$ and n_{com} = number of combined sections.

(d) *Member restraint* For the determination of bending capacity, the following assumptions related to lateral restraint are used:

(i) *At supports*—underpurlins are considered torsionally restrained at their supports.

(ii) *Between supports*:

(A) The top edges of underpurlins are assumed restrained by rafters at 600 mm or 1200 mm centres, as appropriate.

(B) Underpurlins with a depth to overall breadth ratio greater than two are assumed torsionally restrained at 1200 mm centres.

(C) Continuous span underpurlins are assumed restrained against buckling at the points of contraflexure.

NOTE: Where nail-laminated members are used, the breadth of member used to derive the slenderness coefficient (S_1) is taken as the breadth of an individual lamination and not the overall breadth.

TABLE 2.4.2.4(A)

STRUCTURAL MODELS AND ACTION CATEGORIES—STRENGTH

Design action effect	Structural models	
	Single span	Continuous span
In bending		
In shear		
Action category	Design actions	
1	$w = 1.35G_1$ and $P = 1.35G_2$	
2	$w = 1.2G_1$ and $P = (1.2G_2 + 1.5Q_1)$	
3	$w = 1.2G_1$ and $P = (1.2G_2 + W_u\downarrow)$ $w = 0.9G_1$ and $P = (0.9G_2 + W_u\uparrow)$	

NOTES:

1 S_R is rafter spacing, either 0.6 m or 1.2 m.

2 The number of concentrated actions considered will vary according to span, rafter spacing and locations of concentrated actions.

3 Actions within $1.5d$ of supports are ignored in the determination of the design action effect in shear.

TABLE 2.4.2.4(B)

LOAD DURATION FACTORS FOR STRENGTH

Action category	Load duration factor (k_1)
1	0.57
2	0.97
3	1.00

2.4.3 Design for serviceability

2.4.3.1 Design actions

The permanent actions and imposed actions used for the serviceability limit states shall be as described in Clause 2.4.2.2.

2.4.3.2 Structural models and action categories for serviceability design

The structural models for which deflections are calculated shall be as given in Table 2.4.3.2. Action cases given in Table 2.4.3.2 are divided into action categories for the purpose of allowing for duration of load on stiffness as specified in Clause 2.4.3.3.

TABLE 2.4.3.2
STRUCTURAL MODELS AND ACTION CATEGORIES—SERVICEABILITY

Action category	Structural models	
	Single span	Continuous span
1		
2		

LEGEND:

S_R = rafter spacing.

2.4.3.3 Calculation of deflection

The requirements of AS 1720.1 for the calculation of deflection shall be applied using the duration of load factor for creep deformation as given in Table 2.4.3.3.

TABLE 2.4.3.3
LOAD DURATION FACTORS FOR DEFORMATION

Moisture content	Load duration factor (j_2)	
	Action category 1	Action category 2
Seasoned	2.0	1.0
Unseasoned	3.0	1.0

2.4.3.4 Serviceability limits

The limits on deflection used to define the serviceability limit states are given in Table 2.4.3.4.

TABLE 2.4.3.4
LIMITS ON DEFLECTION

Action category	Deflection limits
1	Span/300
2	Span/250

2.5 STRUTTING BEAMS

2.5.1 Description

Strutting beams are horizontal or near horizontal single span beams, installed within the roof space clear of ceilings, which provide support to underpurlins via roof struts.

While strutting beams may be loaded by one or more struts located anywhere within the span, the design procedures given conservatively assume all roof load is applied via a single strut.

Strutting beams are assumed torsionally braced at supports and at midspan (see Figure 2.5.1).

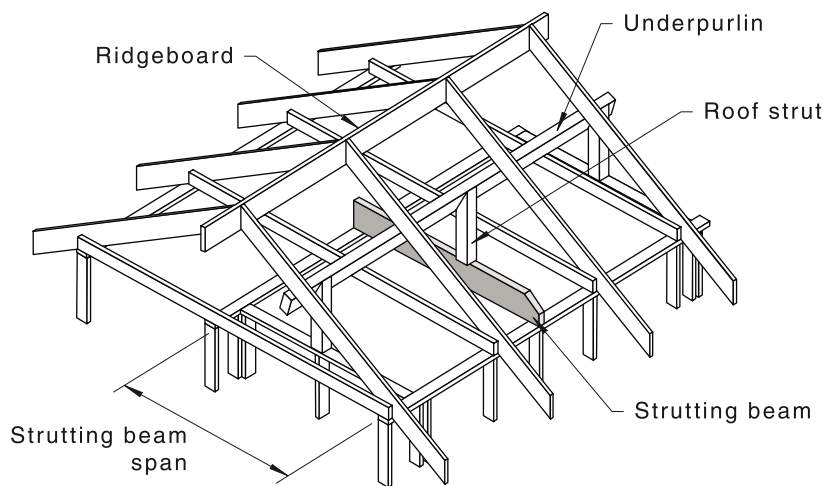


FIGURE 2.5.1 STRUTTING BEAMS

2.5.2 Design for safety

2.5.2.1 General consideration

Design for safety requires consideration of the strength limit states for bending and shear.

2.5.2.2 Design actions

Roof actions applied to strutting beams are calculated on the basis of roof area supported.

Design actions shall be as follows:

- (a) *Permanent* Permanent actions for strutting beams include the self weight of the strutting beam, G_1 (in kN/m), and the roof mass as a concentrated action, G_2 (in kN), determined as follows:

$$G_2 = 0.01(RM + 10)A \quad \dots 2.5.2.2(1)$$

where

RM = standardized roof mass allowance, i.e. 20 kg/m² for sheet roofs and 60 kg/m² for tile roofs

A = area of roof supported by the strutting beam, in square metres

- (b) *Imposed* Imposed roof action is considered applied as a concentrated action, Q_1 (in kN), determined as follows:

$$Q_1 = 0.25A \quad \dots 2.5.2.2(2)$$

where

A = area of roof supported by strutting beam, in square metres

- (c) *Wind* Wind action applicable for the strength limit state is considered applied as a concentrated action W_u (in kN), determined as follows:

$$W_u = q_u C_{pt} A \quad \dots 2.5.2.2(3)$$

where

q_u = free stream dynamic gust pressure, in kPa, for the ultimate limit state; values of q_u are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.5.2.2

A = area of roof supported by the strutting beam, in square metres

TABLE 2.5.2.2
NET PRESSURE COEFFICIENTS
FOR STRUTTING BEAMS

Wind classification	C_{pt}
N1 to N4	+0.63 or -1.0
C1 to C3	+0.95 or -1.44

NOTE: Values given in this Table are based on the assumption that a separate ceiling is provided with the maximum internal pressure coefficient (C_{pi}) for roof cavities in cyclonic regions considered as for non-cyclonic regions.

2.5.2.3 Structural models and action categories for strength design

The structural models used to calculate the member design action effect shall be as given in Table 2.5.2.4(A). Action combinations shown in Table 2.5.2.4(A) are divided into action categories that are used for the determination of member design capacity as specified in Clause 2.5.2.4.

2.5.2.4 Member design capacity

The requirements of AS 1720.1 shall be applied to determine member design capacities in bending and shear. The following assumptions and modification factors shall be used:

- (a) *Load duration factor* The member design capacity includes the modification factor for load duration (k_1). Values of k_1 appropriate for each action category, as defined in Table 2.5.2.4(A), are given in Table 2.5.2.4(B).
- (b) *Moisture content of timber:*
 - (i) *Unseasoned timber*—for action categories 2 and 3 given in Table 2.5.2.4(A), use values of k_4 appropriate for thickness as given in AS 1720.1. For Action category 1, $k_4 = 1.0$.
 - (ii) *Seasoned timber*— $k_4 = 1.0$ for all action categories.
- (c) *Strength sharing* Where multiple sections of scantling timber are nail-laminated, the strength sharing factor (k_9) is applied for the combined member, assuming $n_{mem} = 1.0$ and n_{com} = number of combined sections.
- (d) *Member restraint* For the determination of bending capacity the following assumptions relating to lateral restraint are used:
 - (i) *At supports*—strutting beams are assumed torsionally restrained at their supports.

- (ii) *Between supports*—strutting beams having a depth to breadth ratio greater than three are assumed torsionally restrained at midspan (the assumed load point).

NOTE: Where nail-laminated members are used, the breadth of member used to derive the slenderness coefficient (S_1) is taken as the breadth of an individual lamination.

TABLE 2.5.2.4(A)
STRUCTURAL MODELS AND ACTION CATEGORIES—
STRENGTH

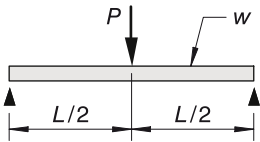
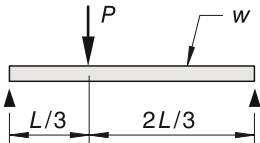
Design action effect	Structural models
In bending	
In shear	
Action category	Design actions
1	$w = 1.35G_1$ and $P = 1.35G_2$
2	$w = 1.2G_1$ and $P = (1.2G_2 + 1.5Q_1)$
3	$w = 1.2G_1$ and $P = (1.2G_2 + W_u \downarrow)$ $w = 0.9G_1$ and $P = (0.9G_2 + W_u \uparrow)$

TABLE 2.5.2.4(B)
LOAD DURATION FACTORS FOR STRENGTH

Action category	Load duration factor (k_1)
1	0.57
2	0.97
3	1.00

2.5.3 Design for serviceability

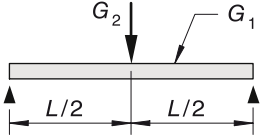
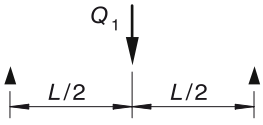
2.5.3.1 Design actions

The permanent actions and imposed actions used for the serviceability limit states shall be as described in Clause 2.5.2.2.

2.5.3.2 Structural models and action categories for serviceability design

The structural models for which deflections are calculated shall be as given in Table 2.5.3.2. Action cases given in Table 2.5.3.2 are divided into action categories for the purpose of allowing for duration of load on stiffness as specified in Clause 2.5.3.3.

TABLE 2.5.3.2
STRUCTURAL MODELS AND ACTION
CATEGORIES—SERVICEABILITY

Action category	Structural models
1	
2	

2.5.3.3 Calculation of deflection

The requirements of AS 1720.1 for the calculation of deflection shall be applied using the duration of load factor for creep deformation as given in Table 2.5.3.3.

TABLE 2.5.3.3
LOAD DURATION FACTORS FOR DEFORMATION

Moisture content	Load duration factor (j_2)	
	Action category 1	Action category 2
Seasoned	2.0	1.0
Unseasoned	3.0	1.0

2.5.3.4 Serviceability limits

The limits on deflection used to define the serviceability limit states are given in Table 2.5.3.4.

TABLE 2.5.3.4
LIMITS ON DEFLECTION

Action category	Deflection limits
1	Span/300 or 20 mm max.
2	Span/250 or 20 mm max.

2.6 COUNTER STRUTTING BEAMS

2.6.1 Description

Counter strutting beams support roof loads from roof struts and ceiling loads from hanging beams.

For design, loading from both roof and ceiling is considered concentrated at midspan.

Counter strutting beams are assumed torsionally braced at their supports and at midspan by the attachment of the hanging beams (see Figure 2.6.1).

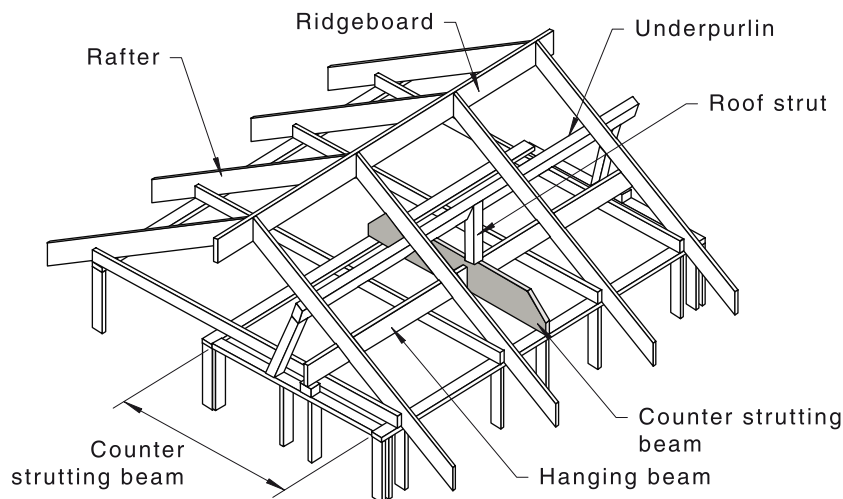


FIGURE 2.6.1 COUNTER STRUTTING BEAM

2.6.2 Design for safety

2.6.2.1 General consideration

Design for safety requires consideration of the strength limit states in bending and shear.

2.6.2.2 Design actions

The actions used for the determination of the design action effects shall be as follows:

- (a) *Permanent* Permanent actions include the self weight of the counter strutting beam G_1 (in kN/m) and the concentrated action due to the roof and ceiling mass, G_2 (in kN), determined from—

$$G_2 = 0.01(RM + 10)A + (0.06L + 0.005L^2)(CLW) \quad \dots 2.6.2.2(1)$$

where

RM = standardized roof mass allowance, i.e. 20 kg/m² for sheet roofs and 60 kg/m² for tile roofs

A = area of roof supported by the counter strutting beam, in square metres

L = span of the counter strutting beam, in metres

CLW = ceiling load width for the counter strutting beam, in metres

- (b) *Imposed* Imposed roof action is considered as a concentrated action, Q_1 (in kN), applied via a roof strut and determined from—

$$Q_1 = 0.25A \quad \dots 2.6.2.2(2)$$

where

A = roof area supported by the counter strutting beam, in square metres

- (c) *Wind* Wind action is considered applied as a concentrated action, W_u (in kN), applied via a single roof strut and determined from—

$$W_u = q_u C_{pt} A \quad \dots 2.6.2.2(3)$$

where

q_u = free stream dynamic gust pressure, in kPa, for the ultimate limit state; values of q_u are given in Appendix A, Table A2, for each wind classification

C_{pt} = net pressure coefficients given in Table 2.6.2.2

A = roof area supported by the counter strutting beam, in square metres

TABLE 2.6.2.2
NET PRESSURE COEFFICIENTS
FOR COUNTER STRUTTING BEAM

Wind classification	C_{pt}
N1 to N4	+0.63 or -1.0
C1 to C3	+0.95 or -1.44

2.6.2.3 Structural models and action categories for strength design

The structural models used to calculate the member design action effects shall be as given in Table 2.6.2.4(A). Action combinations shown in Table 2.6.2.4(A) are divided into action categories that are used for the determination of member design capacity as specified in Clause 2.6.2.4.

2.6.2.4 Member design capacity

The requirements of AS 1720.1 shall be applied to determine member design capacities in bending and shear. The following assumptions and modification factors shall be used:

- (a) *Load duration factor* The member design capacity includes the modification factor for load duration (k_1). Values of k_1 appropriate for each action category, as defined in Table 2.6.2.2, are given in Table 2.6.2.4(B).
- (b) *Moisture content of timber*:
 - (i) *Unseasoned timber*—for action categories 2 and 3 given in Table 2.6.2.4(A), use values of k_4 appropriate for thickness as specified in AS 1720.1. For Action category 1, $k_4 = 1.0$.
 - (ii) *Seasoned timber*— $k_4 = 1.0$ for all action categories.
- (c) *Strength sharing* Where multiple sections of scantling timber are nail-laminated, the strength sharing factor (k_9) is applied for the combined member, assuming $n_{mem} = 1.0$ and n_{com} = number of combined sections.
- (d) *Member restraint* For the determination of bending capacity the following assumptions relating to lateral restraint are used:
 - (i) *At supports*—counter strutting beams are assumed torsionally restrained at their supports.
 - (ii) *Between supports*—counter strutting beams are assumed torsionally restrained at midspan.

NOTE: Where nail-laminated members are used, the breadth of member used to derive the slenderness coefficient (S_1) is taken as the breadth of an individual lamination.

TABLE 2.6.2.4(A)
STRUCTURAL MODELS AND ACTION
CATEGORIES—STRENGTH

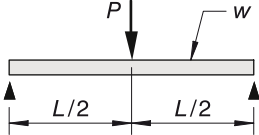
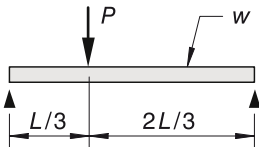
Design action effect	Structural models
In bending	
In shear	
Action category	Design actions
1	$w = 1.35G_1$ and $P = 1.35G_2$
2	$w = 1.2G_1$ and $P = (1.2G_2 + 1.5Q_1)$
3	$w = 1.2G_1$ and $P = (1.2G_2 + W_{u\downarrow})$ $w = 0.9G_1$ and $P = (0.9G_2 + W_{u\uparrow})$

TABLE 2.6.2.4(B)
LOAD DURATION FACTORS FOR STRENGTH

Action category	Load duration factor (k_1)
1	0.57
2	0.97
3	1.00

2.6.3 Design for serviceability

2.6.3.1 Design actions

The permanent actions and imposed actions used for the serviceability limit states shall be as described in Clause 2.6.2.2.

2.6.3.2 Structural models and action categories for serviceability design

The structural models for which deflections are calculated shall be as given in Table 2.6.3.2. Action cases given in Table 2.6.3.2 are divided into action categories for the purpose of allowing for duration of load on stiffness as specified in Clause 2.6.3.3.