Draft standard

Cross Laminated Timber Design Methods - D02

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FWPA Standard D02

Cross Laminated Timber Design Methods

First Edition

Public Comment Draft August 2026

Foreword

The Standard has been taken through a formal public review process under the guidance of the FWPA Cross Laminated Timber Design Methods Standards Writing Committee. This FWPA Standard was issued for comment on the ?, for a period of X weeks, approved on behalf of FWPA by the Standards Writing Committee (SWC) on ? 2026 and published on insert 2026.

FWPA wishes to acknowledge the participation of expert individuals who contributed to the development of the Standard through their representation on the Committee and through the public comment period.

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FWPA Standards are living documents that reflect progress in science, technology, systems, and regulations. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued.

Standards may also be withdrawn. It is important that readers assure themselves they are using the current Standard, which should include any since the Standard was published.

Detailed information about FWPA Standards, drafts, amendments and new projects can be found by visiting www.fwpa.com.au.

FWPA welcomes suggestions for improvements and encourages readers to notify us immediately of any apparent inaccuracies or ambiguities.

Amendment Schedule

Edition	Date	Description

Preface

The objective of this Standard is to provide comprehensive solutions for the structural design of elements constructed from Cross Laminated Timber (CLT), subject to the requirements and limitations described in the Scope.

This Standard has been developed by Forest & Wood Products Australia (FWPA) to provide design methods for structural Cross Laminated Timber (CLT) elements. The Standard has undergone independent technical review and is intended to facilitate the future incorporation of CLT design provisions into AS 1720.1.

It is anticipated that the design methods contained herein will form the basis of a future AS 1720.1 section covering CLT design. Following such incorporation, references to AS 1720.1 within this Standard may be removed.

CLT panels are made of orthogonally laminated timber boards, denominated lamellas, that may be edge-glued or non-edge-glued. CLT Panels are structural building components for floors, roofs, stairs, soffits, balconies, internal and external walls.

In respect of the application of this Standard, NOTES to the text contain general information and guidance. They are not an integral part of the Standard.

The terms ‘normative’ and ‘informative’ are used in this Standard to define the application of the standard. A ‘Normative’ Appendix is an integral part of this Standard, whereas an ‘Informative’ Appendix is only for information and guidance.

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Section 1 Scope and General

1.1 Scope

This FWPA Standard D02 Cross Laminated Design Methods 2026 (referred to hereafter as "Standard") sets out limit state structural design methods of Cross Laminated Timber elements, which are based on the principles of structural mechanics, international standards and drawing on best practices.

1.2 Application

This Standard shall be used for the design and appraisal of structural elements composed of Cross Laminated Timber (CLT) and shall be used in conjunction with the AS/NZS 1170 series.

This Standard supplements the requirements of AS 1720.1 for the design of CLT elements. AS 1720.1 is an integral part of, and shall be used in conjunction with, this Standard except where otherwise specified.

This standard does not apply to the use of CLT panels as the external finished surface of facades or roofs, or in areas where high levels of moisture exposure are anticipated without the ability for adequate drying.

1.3 Limitations

This Standard is limited to the design of structural elements. Matters relating to durability, robustness and connections are addressed only insofar as they affect element design. The design of connections and overall building systems is not included.

1.4 Normative documents

The normative documents referenced in this Standard are listed in Appendix A.

NOTE Documents referenced for information purposes are listed in the bibliography.

1.5 Definitions

For the purposes of this Standard, the definitions in AS 1720.1 apply. These definitions, not currently listed in AS 1720.1, also apply.

1.5.1 Adhesive: Bonding agent used to join lamellas within or between layers to achieve the structural integrity of the cross-laminated timber panel.

1.5.2 Cross Laminated Timber (CLT): An engineered timber product consisting of layers of timber boards (lamellas) arranged orthogonally and bonded together to form solid panels.

1.5.3 Lamella: An individual timber board forming a layer within a cross-laminated timber panel.

1.5.4 Rolling shear: Shear deformation occurring in the plane of a lamella, perpendicular to the grain direction, is typically associated with cross layers in cross-laminated timber.

1.5.5 Shear modulus: A material property representing the ratio of shear stress to shear strain, used to characterise stiffness in shear.

1.6 Manufacturing Requirements

Cross Laminated Timber (CLT) shall be certified to be manufactured in accordance with ISO 16696-1.

1.7 Notations

Except where specifically defined in a particular Clause, the quantity symbols and factors shall be as listed in Appendix B.

1.8 Units

Unless otherwise stated, the units of measurement used in this Standard shall be in accordance with the International System of Units (SI).

Note that in general, newtons (N), millimetres (mm) and megapascals (MPa) are appropriate units to be used.

1.9 Materials

Where manufacturer published properties are used in lieu of properties determined in accordance with this Standard, those properties shall be substantiated by either:

(a) a current product certification issued by a body accredited under ISO/IEC 17065 against a recognised product standard, or

(b) a current European Technical Assessment (ETA) issued by a Technical Assessment Body under the EU Construction Products Regulation, based on the relevant European Assessment Document (EAD).

Section 2 Design

2.1 General

2.1.1 Application

This Section sets out the design principles and methods for cross-laminated timber (CLT) elements in non-fire load design scenarios.

For the purposes of this Standard, the major axis of a CLT panel is parallel to the outer lamellas, and the minor axis is perpendicular to the outer lamellas.

Structural properties shall be determined for the relevant axis direction, with regard to the panel configuration, support conditions, and load effects.

Where panel properties are determined for the minor axis, outer lamellas oriented perpendicular to the span direction shall be ignored.

2.1.2 Loads

CLT structures and structural elements shall be designed to resist the design action effects produced by:

(a) The combination of actions for the strength, stability and serviceability limit states as specified in AS/NZS 1170 series; or

(b) Such other design actions deemed to be acceptable for the limit state as appropriate to the intended end-use service conditions or accidental actions of a structure or its structural elements.

2.1.3 Robustness

CLT structures shall be designed to be sufficiently robust in accidental situations to ensure that the loss of individual members or components does not cause the disproportionate collapse of the entire structure or large parts of it. The design for any potential damage due to (but not limited to) explosions, impact or the consequences of human error, should not be disproportionate to the original cause. Due consideration shall be given to the brittle nature of CLT material and the significance of its connections to the overall structural performance and collapse mechanisms.

NOTE 1 Design actions shall be determined with due consideration of the behaviour of timber buildings, including creep, shrinkage, connection stiffness, shortening effects and robustness design cases.

NOTE 2 Appendix D4 provides guidance for robustness design.

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2.2 Design properties

2.2.1 Design values for strength and stiffness

The net geometrical sectional properties normal to the plane of CLT (i.e. the net areas (A_{net}), the net section modulus (Z_{net}) and the net second moment of area (I_{net})) to determine design capacities in accordance with AS 1720.1 Clause 2.1.2 shall be determined in accordance with Clause 2.2.1.1 unless alternative values are provided by the manufacturer, in accordance with Clause 1.9.

The effective geometrical sectional properties normal to the plane of CLT (i.e. the effective second moment of area (I_{ef})) to determine member deformations are to be determined in accordance with Clause 2.2.1.2 unless alternative values are provided by the manufacturer, in accordance with Clause 1.9.

Section properties in the plane of CLT shall be determined in accordance with Clause 2.2.1.3 unless alternative values are provided by the manufacturer, in accordance with Clause 1.9.

2.2.1.1 Sectional properties for strength normal to the plane of CLT

Definitions for use in the calculation of section properties are as follows:

(a) The thickness of the individual layers (t_i) of the CLT assembly shall be taken as the actual lamella thickness.

(b) The overall thickness of the panel (d) is the summation of the actual individual lamella thickness as defined in item (a)

(c) The neutral axis and static heights are defined as:

a_i = distance of the centroid of the i-th lamella measured from the bottom face of the CLT panel (in mm)

$\bar{y}_i$ = distance between the centroid of the i-th lamella and the neutral axis (in mm)

= $a_i - y_c$

y_c = neutral axis location of the CLT section from the bottom face of the CLT panel

= $\frac{\sum E_i\, t_i\, b\, a_i}{\sum E_i\, t_i\, b}$

E_R = reference modulus of elasticity for cross sections with lamellas of different material properties, taken as the modulus of the outermost lamella parallel to the panel span (in MPa)

E_i = modulus of elasticity of lamellas in the i-th layer (in MPa)

$E_i = E_0$ for lamellas parallel to the span direction, refer to Clause 2.2.1.4.

$E_i = E_{90}$ for lamellas perpendicular to the span direction

b = panel width, typically taken as 1000 mm

n = number of individual lamellas in the CLT assembly

t_i = the thickness of the individual layers Net second moment of area (I_{net}) (in mm^4)

$$I_{net} = \sum_{i=1}^{n} \frac{E_i b}{E_R} \left(\frac{t_i^3}{12} + t_i\, \bar{y}_i^2\right) \qquad 2.2.1.1\ (1)$$

(d) Net section modulus (Z_{net}) (in mm^3)

$$Z_{net} = \frac{I_{net}}{y_c} \qquad 2.2.1.1\ (2)$$

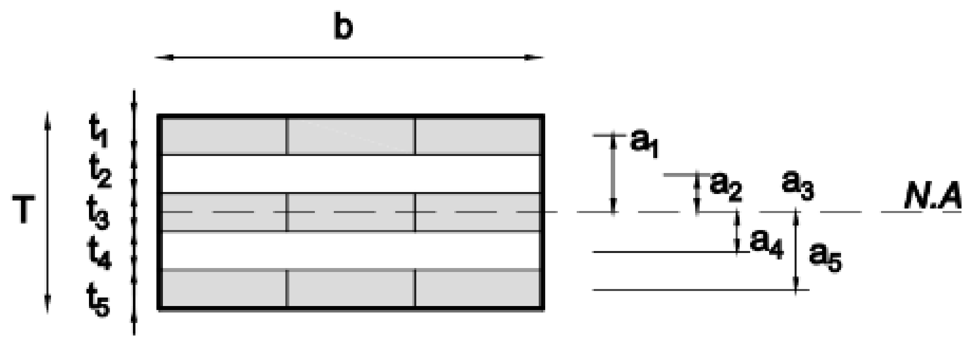


Figure 1 – Generic CLT panel cross-section with symmetric lamella layout

NOTE This method should only be applied for symmetrical sections; refer to the Gamma method in Appendix C2 for asymmetrical sections, including design for fire.

(e) The static moment of area (Q_{net}) (in mm^3) of the CLT section can be determined as follows:

$$Q_{net} = \sum_{i=1}^{m} \frac{E_i}{E_R} b t_i a_i \qquad 2.2.1.1\ (3)$$

Where

m = index of the critical lamella closest to the portion of the centre of gravity as seen from the top edge of the cross-section.

2.2.1.2 Sectional properties for stiffness normal to the plane of CLT

For serviceability limit state checks, the shear flexibility of the transverse lamellas shall be taken into consideration. For this purpose, the effective second moment of area (I_{eff}) shall be determined in accordance with the procedures in Appendix C1, unless alternative values are provided in accordance with Clause 1.9.

2.2.1.3 Sectional properties in the plane of CLT

The calculation of the net second moment of area and the net section modulus accounts for lamellas parallel to the longitudinal axis of the CLT element. The contribution of perpendicular lamellas shall be ignored. Definitions as per Clause 2.2.1 apply.

(a) Net second moment of area ($I_{net,in}$) (in mm^4)

$$I_{net,in} = \sum_{i=1}^{n} \frac{E_i}{E_R} \frac{t_i\, d^3}{12} \qquad 2.2.1.3\ (1)$$

Where

n = number of layers of lamellas parallel to the span direction of the CLT element

d = member depth (in mm)

t_i = thickness of the lamellas parallel to the span (in mm)

(b) Net section modulus ($Z_{net,in}$) in mm^3

$$Z_{net,in} = \frac{I_{net,in}}{y_c} \qquad 2.2.1.3\ (2)$$

2.2.1.4 Material design properties

Material properties shall be taken as the properties of the individual lamellas provided in Clause 2.3 when determining sectional properties and strength in accordance with Clauses 2.5 and 2.6, unless alternative values are provided by the manufacturer in accordance with Clause 1.9.

In the absence of manufacturer-provided values, the following values may be used in design:

(a) The elastic modulus perpendicular to grain (E_{90}) may be approximated using $E_0/30$, where E_0 is the elastic modulus parallel to grain of the layer under consideration.

(b) The modulus of rolling shear, G_r can be approximated as G/10, where G is the modulus of rigidity.

2.2.3 Tolerance of CLT

Designers should consider dimensional tolerances, such as out-of-width, out-of-length, and flatness of panels, in accordance with ISO 16696-1 or as provided by the manufacturer in structural design calculations.

2.3 Modification factors

2.3.1 General

Modification factors for strength and stiffness shall be taken from the relevant clauses in AS 1720.1 Section 2.

2.3.2 Capacity factor

The capacity factor (ϕ) to be used in the computation of the design capacities for CLT structural elements shall be taken as 0.85.

2.3.3 Duration of load

The modification factors for the duration of load on strength (k1) and on stiffness (j2 and j3), as given in AS 1720.1 Clause 2.4.1, shall be applied.

2.3.4 Moisture condition

CLT shall not be used in conditions subject to an average moisture content for a 12-month period that will exceed 20%.

Where any CLT is likely to be temporarily exposed to water or to damp conditions, the CLT shall be bonded with Type 1 adhesive specified in accordance with ISO 16696-1.

NOTE 1 The above requirement excludes the use of CLT in exterior conditions.

NOTE 2 Designers must consider potential distortion due to moisture content-induced dimensional change and take into account manufacturers' recommendations and tested data

2.3.5 Temperature

The provisions of AS 1720.1 Clause 2.4.3 for seasoned timber/dry shall apply to structural CLT in a similar manner.

2.3.6 Modification factor for strength sharing

The strength sharing factor k_9 for CLT panels is to be taken as:

$$k_9 \quad = g_{31} \leq 1.2 \qquad 2.3.6\ (1)$$

where g_{31} is as per AS 1720.1 Clause 2.4.5.3, and the number of members in the combined parallel system is the number of lamellas resisting the imposed load action effect. Refer to Figure 2 and Figure 3 for possible cases.

The strength sharing factor k_9 shall be taken as 1 for the verification of shear (longitudinal and rolling shear), compression perpendicular to the grain or for bending in the plane of the CLT panel.

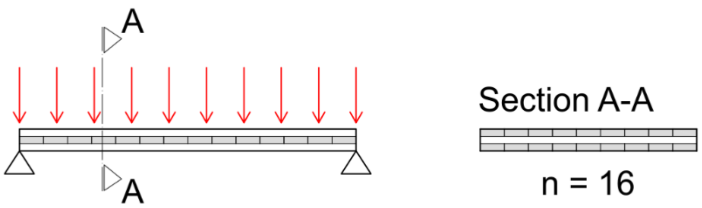


Figure 2 – Examples of the number of lamellas resisting the imposed effect for loading normal to the plane of the CLT panel

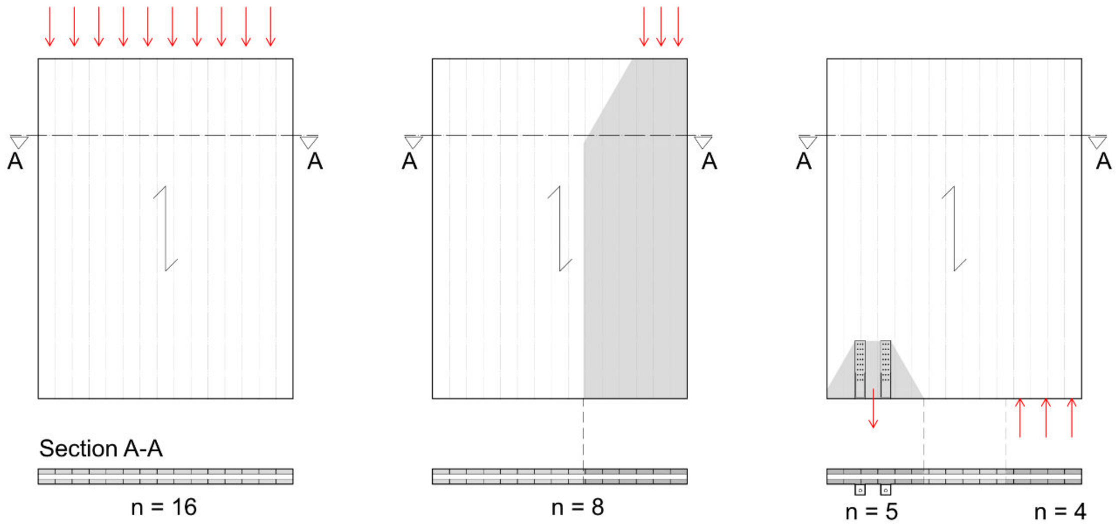


Figure 3 – Examples of the number of lamellas resisting the imposed action effect for loading in the plane of the CLT panel

NOTE 1 If an in-plane axial force in tension or compression is resisted by several layers of lamellas (i.e., not equally applied to the full cross section), then the rolling shear strength distributing the load between the layers of lamellas needs to be verified. The effect of bending actions resulting from load eccentricity also needs to be verified.

NOTE 2 For loading normal to the plane, the number of members is to be taken as the number of lamellas in a single outer layer only.

2.4 Design for serviceability

2.4.1 Deflections

Deflections shall be determined using the stiffness properties specified in this Standard and shall account for the effects of material properties, panel configuration and load duration.

For deflection normal to the plane of the CLT panel, the cross-sectional stiffness shall be based on the effective stiffness, EI_{eff}, or apparent stiffness, EI_{app}, as appropriate, determined in accordance with Appendix C. Deflection calculations shall take account of shear deformation in transverse layers and the material properties of individual lamellas.

For deflection in the plane of the CLT panel, stiffness shall be based on the net second moment of area determined in accordance with Clause 2.2.1.3, considering only lamellas oriented parallel to the span direction.

In multi-storey construction, elastic axial shortening of CLT walls and through-thickness deformation of CLT floor panels resulting from compression perpendicular to the grain shall be taken into account.

The duration of load factor, j_2, given in AS 1720.1 Table 2.4, shall be used when calculating deflections.

NOTE Guidance on suitable deflection limits is provided in AS 1720.1 Appendix B, Table B1.

2.4.2 Floor Vibration

Where occupant comfort due to human-induced vibration is required to be assessed, the vibration-controlled span limit, *L*, shall be determined using Equation 2.4.2 (1).

$$L \leq 0.11 \frac{\left(\frac{EI_{eff}}{10^6}\right)^{0.29}}{m^{0.12}} \qquad 2.4.2\ (1)$$

Where

L	=	vibration-controlled span limit (in m) taken as the clear span measured from face to face between the two end supports
m	=	linear mass of bare CLT only for a 1m wide panel (in kg/m)
EI_{eff}	=	effective bending stiffness in the major strength direction for a 1-m wide panel (in N-mm^2).

Where the shear analogy method is used, EI_{app} shall be used in place of EI_{eff}.

Where the superimposed dead load exceeds twice the self-weight of the CLT panel, the vibration-controlled span determined from Equation 2.4.2 (1) may be increased by 10%, provided that:

(a) the resulting span does not exceed 8 m; and

(b) the floor assembly does not incorporate a concrete topping.

For multi-span floor systems, each span shall not exceed the vibration-controlled span limit determined from Equation 2.4.2 (1).

NOTE 1 Occupant comfort is subjective and may be influenced by factors not explicitly considered by Equation 2.4.2(1), including vibration frequency, acceleration, velocity, amplitude and damping characteristics.

NOTE 2 Equation 2.4.2 (1) is based on empirical observations of bare CLT floor systems. The effects of toppings, floor finishes and other non-structural elements on mass, stiffness and damping are not considered.

NOTE 3 Equation 2.4.2 (1) may not be applicable to:

(a) floors requiring enhanced vibration performance, such as those supporting sensitive equipment or premium occupancy requirements;

(b) non-rectilinear floor geometries;

(c) floors supported by flexible structural elements, such as beams;

(d) vibration sources other than normal walking activities, including rhythmic activities, machinery or vehicular traffic;

(e) floors incorporating toppings or other elements that significantly affect mass, stiffness or damping; or

(f) floors incorporating stiffening elements, such as partition walls.

NOTE 4 More detailed vibration assessment methods are available in the revised EN 1995-1-1:2025, SCI P354 and WoodSolutions Technical Design Guide 49.

NOTE 5 For detailed vibration assessments, a critical damping ratio of 0.02 may be assumed unless a higher value is justified by analysis or testing.

2.4.3 Shear deformation in the plane of the CLT panel

The effective shear modulus ($G_{CLT,in}$) in the plane of the CLT panel can be determined as

$$G_{CLT,in} = \frac{G_{mean}}{1 + 2\left(\frac{t_{max}}{b_{l,mean}}\right)^{1.2}} \qquad 2.4.3\ (1)$$

Where

G_{mean} = shear stiffness of lamellas, use a weighted average for lamellas of different grade

t_{max} = maximum lamella thickness of CLT member

$b_{l,mean}$ = mean lamella width (in the absence of any information on the lamella width, use a width of 80 mm)

The shear stiffness of a CLT panel in-plane per unit length can be calculated as

$$G_{CLT,in} \,.\, b_{in} \qquad 2.4.3\ (2)$$

Where

b_{in}= overall breadth of the CLT member in the plane of loading (in mm)

2.4.4 Joint stiffness

Appropriate estimates of joint stiffness shall be included in the global structural analysis of a CLT structure for the calculation of:

(a) Overall deflections; and

(b) Design actions on CLT elements and joints

Joint stiffness estimates shall account for joint slip and load-deflection characteristics of the joint using the following references as appropriate:

AS 1720.1 Appendix C3 for joints containing nails, wood screws and bolts.

Values of properties for full-thread and partial-thread engineered wood screws or proprietary connectors incorporating mechanical fasteners, supported by an ETA, equivalent independent technical assessment, or documented test data, may be used in design, provided that they meet the requirements of Clause 1.9.

NOTE Joint stiffness behaviour is complex, and estimates using simplified models may vary significantly from reality. Sensitivity studies in structural analyses shall be undertaken to assess the impact of variation in joint stiffness, particularly in the analysis of lateral load resisting structures and floor diaphragms.

2.5 Loading Normal to the Plane of the CLT PANEL

2.5.1 General

The design capacity and deflection for a CLT panel when subject to loading normal to the plane of the panel (i.e. out-of-plane actions) shall satisfy the requirements of Clauses 2.5.1, 2.5.2, 2.5.3 & 2.5.4. Design checks shall be carried out in the major and minor panel directions for all appropriate service conditions to ensure the structure will perform in a manner appropriate for its intended function and purpose.

Loading is to be predominantly uniformly distributed. Where significant point loads are present, the structural analysis of the panel shall consider an appropriate effective width to determine section capacities by accounting for the orthogonal properties of the panel.

Structural analysis and design checks shall assess the effect of joint stiffness, notches, rebates, openings, and penetrations.

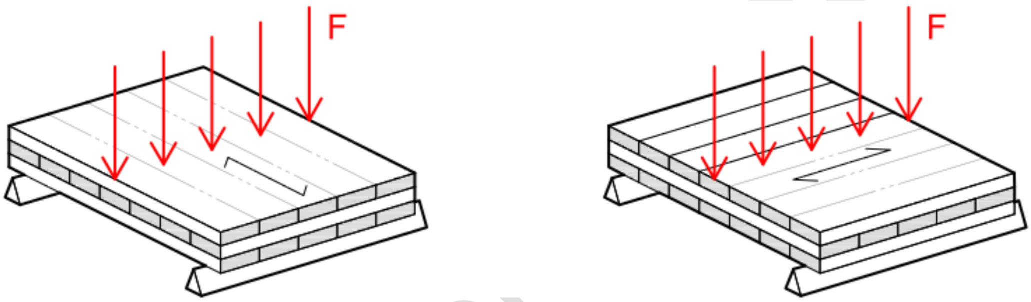


Figure 4 – Loading normal to the plane of CLT

2.5.2 Bending strength

The design capacity of CLT panels in bending ($M_{d,p}$) for the strength limit state shall satisfy the following:

$$M_{d,p} \geq M_p^* \qquad 2.5.2\ (1)$$

Where

$$M_{d,p} = \phi k_1 k_4 k_6 k_9 f_b' Z_{net} \qquad 2.5.2\ (2)$$

and

M_p^* = design action effect for flatwise bending (in kNm)

$M_{d,p}$ = design capacity of CLT in bending (in kNm)

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)

k_9 = modification factor for strength sharing (see AS 1720.1 Clause 2.4.5.3)

f_b' = characteristic value in bending for the section size (in MPa)

Z_{net} = net section modulus about the axis of bending (in mm^3) (Clause 2.2.1.1)

2.5.3 Shear strength

The design capacity of CLT in shear ($V_{d,p}$) for the strength limit state shall satisfy the following:

$$V_{d,p} \geq V_p^* \qquad 2.5.3\ (1)$$

Where

$V_{d,p}$ is the lesser of —

$$V_{d,r} = \frac{\phi k_1 k_4 k_6 f'_{s,r} I_{net} b}{Q_{net}} \qquad 2.5.3\ (2)$$

$$V_{d,l} = \frac{\phi k_1 k_4 k_6 f'_s\, I_{net} b}{Q_{net}} \qquad 2.5.3\ (3)$$

With

V_p^* = the design action effect in shear (in kN)

$V_{d,r}$ = design capacity of CLT in rolling shear (in kN)

$V_{d,l}$ = design capacity of CLT in longitudinal shear (in kN)

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)

f'_s = characteristic longitudinal shear stress value (in MPa)

$f'_{s,r}$ = characteristic rolling shear stress value (in MPa)

b = width of the panel (in mm), generally taken as 1000 mm

I_{net} = net second moment of area (in mm^4) (Clause 2.2.1.1)

Q_{Net} = static moment of area (in mm^3) (Clause 2.2.1.1)

NOTE Notched CLT panels loaded normal to their plane have an inherent weakness due to the stress concentration at the notch and the lower rolling shear resistance. Refer to the NZ Wood Guideline Chapter 12.6 Reinforcement of timber members for more guidance.

2.6 Loading in the Plane of the CLT PANEL

2.6.1 General

The design capacity and deformation for a CLT panel when subject to design loads that act in the plane of the CLT, as shown in Figure 5, shall satisfy the requirements of Clauses 2.6.2, 2.6.3, 2.6.4, 2.6.5 & 2.6.6. This section applies to elements with a minimum depth of 300 mm in the plane of loading. Structural analysis and design checks shall assess the effect of joint stiffness, notches, rebates, openings, and penetrations.

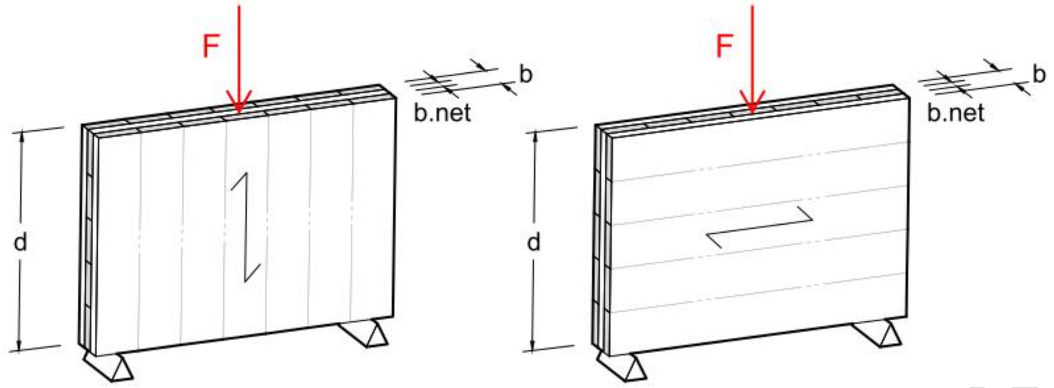


Figure 5 – Loading in the plane of CLT

d = depth in loaded direction of the CLT member in the plane of loading (in mm)

b = overall breadth of the CLT member in the plane of loading (in mm)

b_{net} = effective breadth of the CLT member in the plane of loading calculated as the sum of lamella thickness of the longitudinal lamellas (in mm)

2.6.2 Bending strength

The design capacity of CLT in bending ($M_{d,i}$) for the strength limit state shall satisfy the following:

$$M_{d,i} \geq M_i^* \qquad 2.6.2\ (1)$$

Where

$$M_{d,i} = \phi\, k_1\, k_4\, k_6\, k_9\, k_{12}\, f'_b\, Z_{net,i} \qquad 2.6.2\ (2)$$

and

M_i^* = design action effect for bending in the plane of CLT (in kNm)

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for temperature (see AS 1720.1 Clause 2.4.3)

k_9 = modification factor for strength sharing (see Clause 2.3.6)

k_{12} = Stability factor for bending in the plane of CLT (see Clause 2.6.2.2)

$Z_{net,i}$ = net section modulus for bending in the plane of CLT (see Clause 2.2.1.3)

f'_b = characteristic bending strength of longitudinal lamellas (in MPa)

NOTE 1 If lamellas of different properties are used this shall be taken into account.

NOTE 2 For elements with d > 450 mm, characteristic tension strength shall be used in place of characteristic bending strength.

2.6.2.1 Slenderness coefficient for lateral buckling

The slenderness coefficient shall be calculated in accordance with AS 1720.1 Clause 3.2.3. The following parameters for CLT loading in the plane of the panel shall be adopted in this calculation.

(a) d shall be taken as d_{in}

(b) b shall be taken as $b_{in,net}$

2.6.2.2 Stability factor for elements bending in the plane of CLT

The stability factor k_{12} for elements in bending shall be calculated in accordance with AS 1720.1 Clause 3.2.4.

Material constant (ρ_b) shall be in determined from AS 1720.1 Appendix E2 (Table E1) with ratio r = 0.25.

2.6.3 Shear strength

The design capacity of CLT in shear ($V_{d,i}$) for strength limit state, shall satisfy the following:

$$V_{d,i} \geq V_i^* \qquad 2.6.3\ (3)$$

Where

$V_{d,i}$ is the lesser of-

$$V_{d,i} = \phi\, k_1\, k_4\, k_6\, f'_{s,g}\, A_s \qquad 2.6.3\ (4)$$

$$V_{d,i} = \phi\, k_1\, k_4\, k_6\, f'_{s,n}\, A_{net,i} \qquad 2.6.3\ (5)$$

$$V_{d,i} = \phi\, k_1\, k_4\, k_6 \frac{2}{3}\left(\frac{b_{l,min}}{t_{max}}\right) f'_{s,tor}\, A_{net,i} \qquad 2.6.3\ (6)$$

and

V_i* = design action effect for shear in the plane of CLT panel (in kN)

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for temperature (see AS 1720.1 Clause 2.4.3)

$f'_{s.g}$ = characteristic CLT gross shear strength taken as the lamella characteristic shear strength parallel to grain (f'_s) or as provided by the manufacturer in accordance with Clause 1.9 (in MPa)

$f'_{s.n}$ = characteristic CLT net shear strength taken as 5.5 MPa or as provided by manufacturer in accordance with Clause 1.9 (in MPa)

$f'_{s.tor}$ = characteristic CLT torsional shear strength taken as 2.5 MPa or as provided by manufacturer in accordance with Clause 1.9 (in MPa)

$b_{l,min}$ = minimum lamella width in CLT panel. Shall be taken as 80 mm or as provided by the manufacturer (in mm)

t_{max} = maximum lamella thickness in CLT panel (in mm)

A_s = gross shear plane area (in mm^2) = $\frac{2}{3}.d.b$

$A_{net,i}$ = net shear plane area (in mm^2) = $\min\begin{cases}A_{net,i,0}\\A_{net,i,90}\end{cases}$

$A_{net,i,0}$ = net area in the longitudinal CLT direction (in mm^2)

$A_{net,I,90}$ = net area in the transverse CLT direction (in mm^2)

d = depth in the loaded direction of the CLT member in the plane of loading (in mm)

b = overall breadth of the CLT member in the plane of loading (in mm)

The provisions of this clause apply to CLT panels used as racking or shear walls (refer to Clause 2.6.7) as well as CLT panels used in diaphragms.

NOTE 1 The capacity-reducing effect of notches and penetrations in CLT shall be accounted for.

NOTE 2 In calculating the design action effect in shear, it is acceptable to disregard the design actions located within a distance of 1.5 x d from the inside face of the support. This does not apply for notched members.

2.6.5 Compression strength

The design capacity of CLT in compression ($N_{d,c}$) for the strength limit state shall satisfy the following:

$$N_{d,c} \geq N_c^* \qquad 2.6.5\ (1)$$

Where

$$N_{d,c} = \phi\, k_1.k_4.k_6.k_9.k_{12}.f_c'\, A_{net,c} \qquad 2.6.5\ (2)$$

and

N_c^* = design action effect in compression (in kN)

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)

k_9 = modification factor for strength sharing (see Clause 2.3.6)

k_{12} = modification factor for stability (see AS 1720.1 Clause 3.3)

$A_{net,c}$ = net cross-sectional area subjected to compression (in mm^2) = b_{net} d

b_{net} = net panel width (in mm), defined as the sum of lamella thicknesses parallel to the loading direction

d = depth of the member or effective depth of the member as per Section 2.6.5.1 subjected to the design action effect in compression (in mm)

f_c' = characteristic value in compression parallel to the grain (in MPa)

For members d ≤ 600mm, the characteristic values of compression strength shall be multiplied by a reduction factor of 0.7.

The compressive strength of CLT should be taken as zero if d ≤ 1.5b.

NOTE 1 Members with shallow depths d might buckle in the in-plane direction. AS 1720.1 Section 3.3 with in-plane net section properties shall be used to check capacity.

NOTE 2 The effect from concentrated loads shall be superimposed with that from uniformly distributed loads over the same CLT panel.

2.6.5.1 Effective breadth

The effective breadth (b_{eff}) of CLT panels subjected to direct compression (refer to Figure 6) from loads applied to the panel edge or compression forces from overturning (refer to Clause 2.6.7) can consider the dispersion of loads.

The effective compression breadth can be estimated with a load dispersion angle (α) of 30° from the vertical over the first quarter of the panel height (H_w), as shown in Figure 6. A more detailed method can be found in Appendix D1.

The proximity of any load introduction at panel ends, panel joints, openings or any horizontal or vertical joints shall also be taken into account.

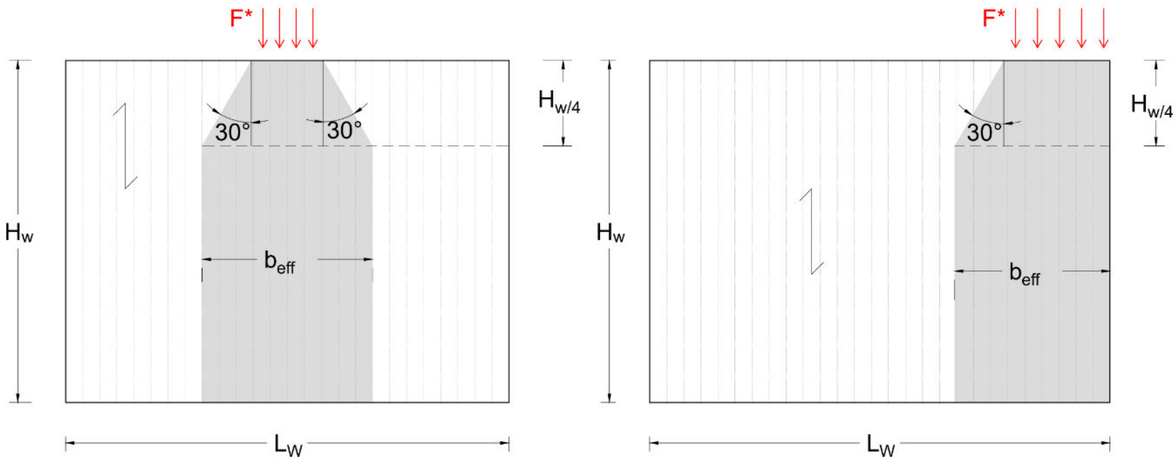


Figure 6 – Effective breadth from concentrated compression loads

2.6.5.2 Stability factor for elements in compression

The stability factor k_{12} for elements in compression shall be calculated using AS 1720.1 Clause 3.3.3.

Material constant (ρ_c) shall be determined from AS 1720.1 Appendix E2 (Table E3) with ratio r = 0.25.

2.6.5.3 Eccentricity of Vertical Load

For consideration of combined axial and compression actions, the design eccentricity of a vertical load applied to the top of a wall shall be determined as follows:

(a) for platform construction, with a discontinuous floor, one third of the length of the bearing area measured from the span face of the wall.

(b) for platform construction with a continuous floor, the eccentricity may be taken as zero.

(c) for loads applied to the face of the wall (e.g., corbels, face fixed beams), an eccentricity of at least equal to half the wall thickness, plus any additional eccentricity from eccentric support conditions or applied load position shall be considered.

(d) the aggregated load from all floors above the floor at the top of the wall being designed may be taken to be zero.

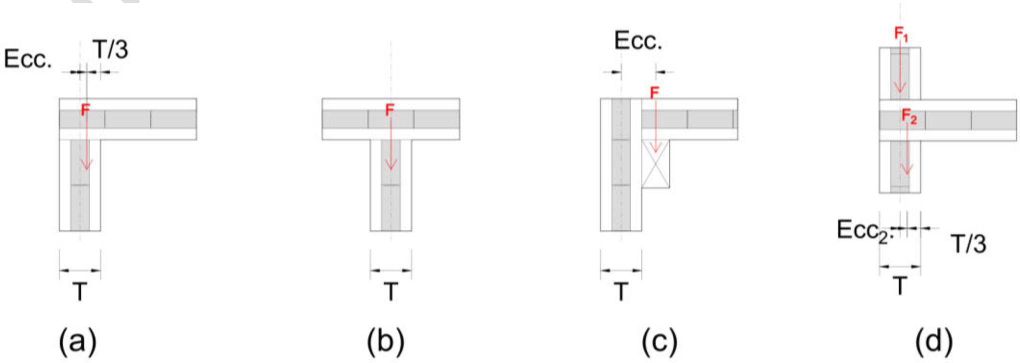


Figure 7 − Eccentricity of Vertical Load

The resultant eccentricity of the total load from (a) and (b) and (c) and (d) shall be calculated but taken as not less than 0.05T, where T is the total thickness of the supporting CLT member.

2.6.6 Tensile strength

The design capacity of cross-laminated timber in tension ($N_{d,t}$) for the strength limit state shall satisfy the following:

$$N_{d,t} \geq N_t^* \qquad 2.6.6\ (7)$$

Where

$$N_{d,t} = \phi k_1 k_4 k_6 k_9 f_t' A_{net} \qquad 2.6.6\ (2)$$

and

N_t^* = design action effect in tension parallel to grain (in kN)

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)

k_9 = modification factor for strength sharing (see Clause 2.3.6)

A_{net} = net cross-sectional area subjected to tension (in mm^2) = b_{net} d

b_{net} = net panel width, defined as the sum of lamella thicknesses parallel to the loading direction (in mm)

d = depth of the member or effective depth of the member subjected to the design action effect in tension (in mm)

f_t' = characteristic value in tension parallel to the grain (in MPa)

The effective depth in tension can be calculated similarly as for the compression case as per Clause 2.6.5.1.

Refer to Appendix D3 for more information.

2.6.7 Racking strength

CLT wall panels resisting racking or overturning actions from wind, seismic or other lateral loads shall be designed by:

(a) verifying the in-plane bending strength in accordance with Clause 2.6.2 for wall aspect ratios $H_b/Lw \geq 4$ (slender wall): or

(b) verifying the in-plane lateral resistance using Appendix D2 or an analysis method appropriate for wall aspect ratios $H_b/Lw < 4$ (squat walls).

Where H_b is the wall height unrestrained in the out-of-plane direction, and L_w is the length of a single wall panel, as shown in Figure 8 or the combined length of coupled adjacent parallel walls.

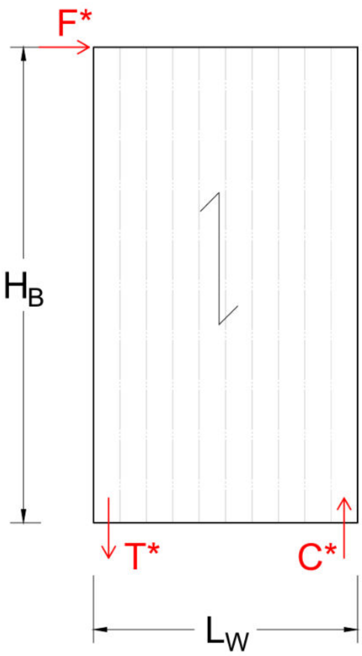


Figure 8 – Definition for cantilevered (shear) CLT walls

The in-plane shear capacity of the wall shall be verified in either case in accordance with Clause 2.6.3.

Potential brittle failure modes at hold-down locations where tension forces (T*) are resisted shall be verified in accordance with Clause 2.6.8.

NOTE 1 Classical bending theory is not applicable to squat walls, where stress distributions are no longer valid.

NOTE 2 The influence of axial compression loads in slender walls with aspect ratios $H_b/L_w \geq 4$ may be accounted for by superimposing the action effects in accordance with Clause 2.7.

NOTE 3 Connections between adjacent panels (segmented shear walls) or connections of the shear wall into the foundations or the wall below (hold down and shear) are to be specifically designed.

NOTE 4 For seismic applications, refer to AS 1170.4 for Australia and NZS 1170.5 and NZS AS 1720.1.

2.6.8 Brittle failures in tension

Brittle failure modes due to the introduction of concentrated tension loads (i.e. from diaphragm straps or from hold-down connections in racking walls as per Clause 2.6.7) shall be verified for the tension capacity as per Clause 2.6.6, taking the lamellas parallel to the design action effect into account. For loads applied to lamellas perpendicular to the design action effect, rolling shear also needs to be verified.

NOTE 1 Appendix C provides a simplified method for the verification brittle failure modes.

NOTE 2 Brittle failure mode predictions for splitting, row shear, block shear, plug shear and net tensile failure as per EN 1995-1-1:2025 or CSA O86:24 can be used, but their applicability to CLT is to be assessed on a case by case basis, due to the presence of transverse layers and additional weakness due to rolling shear.

2.7 Bearing Strength

2.7.1 Bearing strength perpendicular to the grain

The design capacity of CLT in bearing perpendicular to the grain ($N_{d,p}$) of a structural element for the strength limit state, shall satisfy the following:

$$N_{d,p} \geq N_p^* \qquad 2.7.1\ (1)$$

Where

$$N_{d,p} = \phi k_1 k_4 k_6 k_7 f_p' A_p \qquad 2.7.1\ (2)$$

and

N_p^* = design action effect (in kN) for bearing normal to the face of the CLT panel

φ = capacity factor of CLT (see Clause 2.3.2)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)

k_7 = modification factor for length of bearing (see AS 1720.1 Table 2.6)

f_p' = characteristic value (in MPa) for bearing perpendicular to grain. A value of 3 MPa should be used for Radiata pine to limit deformation.

A_p = bearing area for loading perpendicular to grain (in mm^2)

NOTE Larger values of f'_p can be assumed in design, as long as the deformation perpendicular to grain is taken into account. The value should not exceed the characteristic value for bearing perpendicular to grain of the lamella at the contact area, which is typically determined at 2mm deflection.

2.7.2 Panel edge bearing

The design capacity of CLT in bearing at supports when subject to design loads that act in the plane of the CLT element shall be calculated in accordance with Clause 2.7.1, where A_p is taken as the full contact area of the support. The characteristic bearing strength $f'_{p,i}$ shall be taken as 5 MPa or as provided by the manufacturer in accordance with Clause 1.9.

The value of $f'_{p,i}$ is based on the bearing load being parallel to the grain of the transverse lamella and ignoring perpendicular grain resistance of the longitudinal lamella.

A more detailed analysis to determine the bearing strength can be carried out, where the compression parallel to the grain strength can be used only for lamellas parallel to the load introduction.

For bearing of CLT member onto another timber member perpendicular to grain (i.e. a CLT column onto a CLT floor panel), the bearing strength of the supporting member might be governing.

2.8 Combined Actions

Notwithstanding the requirements of AS 1720.1, for the case of combined loads, the following interaction criteria shall be satisfied:

a) For combined compression and bending in the plane of the CLT panel:

$$\frac{M_i^*}{M_{d,i}} + \frac{N_c^*}{N_{d,c}} \leq 1 \qquad 2.8\ (1)$$

b) For combined tension and bending in the plane of the CLT panel:

$$\frac{M_i^*}{M_{d,i}} + \frac{N_t^*}{N_{d,t}} \leq 1 \qquad 2.8\ (2)$$

The equations above also apply for the case of combined loads with bending due to normal loading to the plane of the CLT panel, where values of M_i^* and $M_{d,i}$ are to be replaced with M_p^* and $M_{d,p}$, respectively.

2.9 Joints in CLT

2.9.1 General

This section applies to joints in CLT elements using mechanical fasteners.

The design of mechanical fasteners shall be carried out using one of the following approaches:

(a) Nails, common (gauge) screws, bolts, or coach screws designed in accordance with AS 1720.1 Section 4; or

(b) Where test data determined in accordance with this Standard is unavailable for full-thread or partial-thread engineered wood screws, design properties may be determined from manufacturer-published values supported by a current European Technical Assessment (ETA), or equivalent independent technical assessment that meets the requirements of Clause 1.9.

The designer shall verify that the published values are applicable to the intended design conditions, including timber product type, density, moisture content, fastener arrangement, load orientation and duration of load assumptions.

NOTE 1: European Technical Assessments (ETAs) commonly derive characteristic fastener properties using test and evaluation procedures referenced in EN 1995-1-1 and associated European assessment documents.

NOTE 2: In addition to CLT and fasteners, joints may also include other custom or proprietary metal hardware, e.g. brackets and plates. These other hardware elements shall be designed according to their respective material standards and/or ETAs.

2.9.2 Durability of fasteners

The material selection and/or protective coating of the selected fasteners and connectors shall be appropriate for the short and long-term exposure conditions.

2.9.3 Joint group

For joints designed in accordance with AS 1720.1 Section 4, the appropriate joint group shall be provided by the CLT manufacturer in accordance with Clause 1.9.

NOTE: Due to the orthogonal orientation of the lamellas, the joint group of CLT is not to be taken as the joint group of the individual lamellas.

2.9.4 Characteristic density, withdrawal parameter and head pull through parameter

2.9.4.1 Characteristic density

For type 1 joints with laterally loaded fasteners, the characteristic density for the fastener calculation shall be taken as

$$\rho' = 1.1 \min\left(\rho'_{lamination,i}\right) \qquad 2.9.4\ (1)$$

Where

$\rho'_{lamination,i}$ = the characteristic density of any of the lamellas of the CLT layup

Alternatively, the characteristic density may be taken from manufacturer-published values for the specific CLT layup, which meets the requirements of Clause 1.9.

2.9.4.2 Characteristic withdrawal parameter

For Type 2 joints with axially loaded fasteners, the characteristic withdrawal parameter ($f_{ax,k}$) shall be determined with reference to the applicable ETA or equivalent technical assessment, which meets the requirements of Clause 1.9 and in proportion to the penetration length within each lamella and its corresponding characteristic density.

2.9.4.3 Characteristic head-pull through parameter

The characteristic head pull-through parameter, $f_{head,k}$, shall be obtained from a current European Technical Assessment (ETA), or equivalent technical assessment, for the relevant fastener that has met the requirements of Clause 1.9. The published value shall be applicable to the characteristic density of the timber member at the fastener head..

2.9.5 Design capacity of joints in CLT

2.9.5.1 General

The following clauses shall be taken into account when calculating design capacity of joints using either of the two joint design approaches outlined in Clause 2.9.1.

2.9.5.2 Angle to the grain

The angle to grain θ shall be taken as the angle between the load direction and the grain direction of the lamella closest to the load introduction.

NOTE: Examples of grain directions are:

(a) for externally mounted brackets, the angle to grain θ shall be relative to the outer lamellas;

(b) for slotted (internal) plates, the angle to grain θ shall be relative to the lamella closest to the plate.

2.9.5.3 Rope effect

The properties of the lamella at the fastener head should be considered if rope effect contribution is to be taken into account.

2.9.5.4 Design capacity of joints with engineered wood screws

The design capacity of Type 1 (laterally loaded) and Type 2 (axially loaded) screwed joints shall be determined using manufacturer-published properties supported by a current European Technical Assessment (ETA), an equivalent independent technical assessment, or documented test data for the specific fastener that meets the requirements of Clause 1.9.

The effective number of screws shall be determined in accordance with the design procedure associated with the published fastener.

For screws inserted in the edge of a panel, applicable modification factors shall be obtained from the fastener manufacturer's ETA, equivalent independent technical assessment, or documented test data that meets the requirements of Clause 1.9.

NOTE: The characteristic embedment strength may be referred to as the embedding strength in some sources.

2.9.5.5 Design capacity of joints with dowels

The design capacity of joints subject to Type 1 loading incorporating plain shank or self-drilling dowels shall be determined in accordance with the manufacturer-specific ETA, EN 1995-1-1:2025, an equivalent independent technical assessment, or documented test data for the specific fastener, provided such assessments or test data meet the requirements of Clause 1.9.

NOTE Dowels may be included as part of a proprietary connector system, and in this case design parameters should be included with the connector ETA.

2.9.6 Minimum thicknesses and fastener dimensions

2.9.6.1 Engineered wood screws

In all cases, the following limits shall apply:

(a) Minimum thickness of CLT: 10D (where D is screw diameter)

(b) Minimum lamella thickness: 3D

Table 1: Minimum substrate requirements for fasteners

Joint Type	Screw position in panel	Min. diameter of screw (D) (mm)	Min. no. of screws per joint	Min. effective length of screw (l_{ef})	Min no. of penetrated lamella
Type 1	Panel face	6	2	4D	1
	Panel edge	8	2	10D	-
Type 2	Panel face	8	3	12	3
	Panel edge	8	3	10D	-

NOTE 1 CLT may have gaps between boards, which are not required to be edge-glued, and can have localised defects. This can be ignored for the determination of edge distances and fastener spacings.

NOTE 2 For critical or highly loaded joints, and joints that rely on a limited number of fasteners, the designer should consider the board lay-up, board widths and potential local variations in the detailing of fasteners to provide redundancy.

NOTE 3 For Type 2 joint types, the minimum requirement for penetration of 3 lamellas is satisfied once the screw tip has reached 15 mm into the 3rd lamella.

2.9.7 Minimum spacings and distances

2.9.7.1 Nails and common (gauge) screws

Use the minimum distances as per AS 1720.1.

2.9.7.2 Engineered wood screws

Minimum spacings and distances for engineered wood screws in CLT shall be as per the values in Table 2 or Table 3, unless specified differently by the screw manufacturer, for the nominated CLT panel layup. Testing of mechanical fasteners is specified in AS 1649.

Table 2 Minimum spacing and edge distance for screws in the face of the panel

Denomination	Spacing
Spacing between fasteners parallel to the grain a_1	4D
Spacing between fasteners perpendicular to the grain a_2	2.5D
Distance from the loaded end $a_{3,t}$	6D
Distance from the unloaded end $a_{3,c}$	6D
Distance from the loaded edge $a_{4,t}$	6D
Distance from the unloaded edge $a_{4,c}$	2.5D

Table 3 Minimum Spacing and Edge Distance for screws in the edge of the panel

Denomination	Spacing
Spacing between fasteners parallel to the grain a_1	10D
Spacing between fasteners perpendicular to the grain a_2	4D
Distance from the loaded end $a_{3,t}$	12D
Distance from the unloaded end $a_{3,c}$	7D
Distance from the loaded edge $a_{4,t}$	6D
Distance from the unloaded edge $a_{4,c}$	3D

Where D is equal to the outer thread diameter of the screw. The distance to the end or the edge of the panel is dependent on the lamination closest to the force introduction.

NOTE Where test data to this standard is not available for full or partial thread engineered wood screws, the use of relevant manufacturer test data supported by a European Technical Assessment (ETA) may be considered by the designer and adopted as part of a Performance Solution (Aus) or Alternate Solution (NZ). Consideration shall be given to test conditions, material properties, and assumed partial load and material factors to ensure that the provided data is suitable for the chosen application.

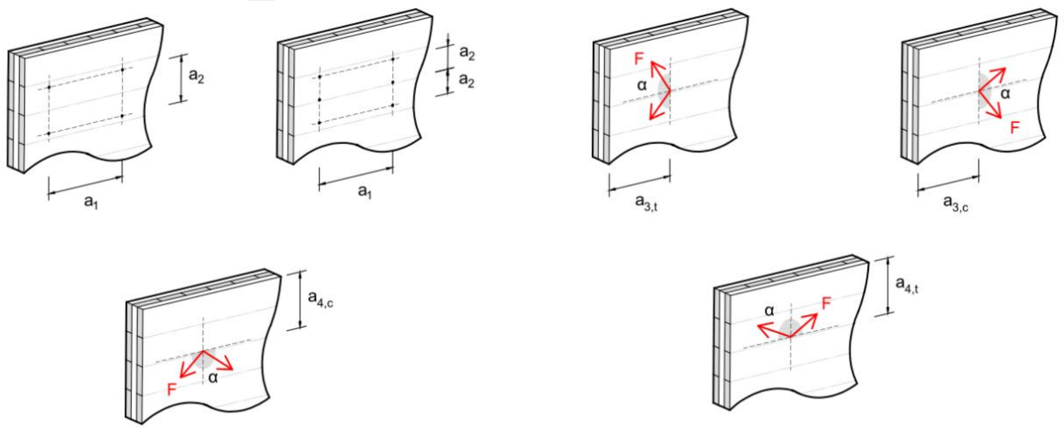


Figure 9 – Definition of spacing, end and edge distances in the plane surface

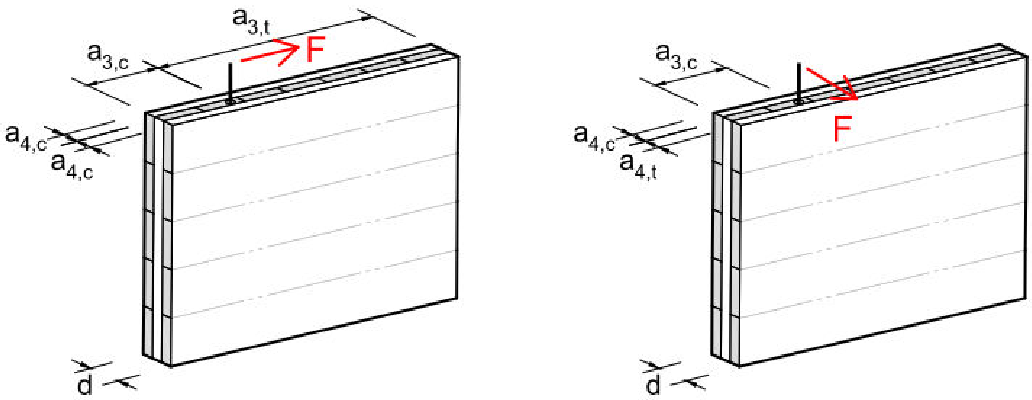


Figure 10 – Definition of spacing, end and edge distances in the edge surface

2.9.7.3 Bolts and dowels

Minimum spacings and distances for bolts or dowels in the wide face of the CLT panel shall be as per the values in Table 4.

Table 4 Minimum Spacing and Edge Distance for bolts and dowels in the face of the panel

Denomination	**Spacing**
Spacing between fasteners a_1 and a_2	5D
Distance from the loaded edge $a_{4,t}$	5D
Distance from the unloaded edge $a_{4,c}$	3D

Where D is equal to the shaft diameter.

NOTE: *Design actions perpendicular to the face of the panel should be assessed for the potential for panel splitting. Refer to Clause 2.6.8.*

SECTION 3 Design in fire load applications

3.1 General performance criteria

A member shall be designed to have a fire resistance period (FRP) for structural adequacy, integrity and insulation of not less than the required fire resistance level (FRL) as detailed by the project fire engineer. The designer shall verify that the application is within the limitations of the AS 1530.4 test data.

If applicable, the criteria for insulation shall be considered to be satisfied if the member meets the criteria for integrity and structural adequacy for that period.

3.2 Structural adequacy

The structural adequacy of the FRP for a member shall be established by either one of the following methods:

(a) Through test in accordance with AS 1530.4 for Australia and New Zealand or EN 1365 for New Zealand only; or;

(b) Predicted by methods of calculation using the residual section, taking into consideration the high temperature performance of the adhesive, calculated using char models as determined through testing to AS 1530.4. Checks shall be made for all relevant design actions based on test data from testing to AS 1530.4 or EN 1365 for New Zealand only, supplied by manufacturers, including loading limitations.

Methods of calculation for structural adequacy shall take into account:

- The presence of fire protective coverings;
- The number of faces exposed due to the element's position in the fire compartment;
- Second-order effects and eccentricity of elements resulting from the charred cross section.

NOTE Calculation methods can also be found in Eurocode (EN 1995-1-2), Canadian CLT Handbook and CSA-O86, and US IBC referenced design guides NDS and FDS.

3.3 Insulation and integrity

FRP for insulation and integrity shall be determined by testing in accordance with AS 1530.4 or EN 1365.

3.4 Joints & openings

Joints between members or between adjoining parts shall be constructed so that the FRL of the whole assembly is not less than that required for the member. Based on AS 1530.4 test data.

Need to consider loss of material from all partial or unprotected faces, including the inside opening, and the impact on structural adequacy, integrity and insulation.

3.5 Increasing FRPs by the addition of insulating materials

The FRP for insulation and structural adequacy of a CLT member may be increased by the addition to the surface of an insulating material supported by testing in accordance with AS 1530.4 or EN 1365 (NZ only).

3.6 Combustibility

Unprotected CLT is a material with combustibility as defined in AS 1530.1.

Appendix A References - Normative

The following are the normative documents referenced in this Standard.

AS 1170.4:2024, Structural design actions, Part 4: Earthquake actions in Australia.

AS 1530.1:2024, Methods for fire tests on building materials, components and structures, Part 1: Combustibility test for materials (ISO 1182:2020, NEQ).

AS 1530.4:2014, Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

AS 1649:2025, Timber - Methods of test for mechanical fasteners and connectors - Basic working loads and characteristic strengths.

AS 1720.1-2010, Timber structures, Part 1: Design methods.

AS/NZS 1170.0:2002, Structural design actions, Part 0: General principles.

AS/NZS 1170.1:2002, Structural design actions, Part 1: Permanent, imposed and other actions.

AS/NZS 1170.2:2021, Structural design actions, Part 2: Wind actions.

AS/NZS 1170.3:2003, Structural design actions, Part 3: Snow and ice actions.

AS/NZS 4364:2010, Timber - Bond performance of structural adhesives.

EN 1365 series, Fire resistance tests for loadbearing elements.

EN 1995-1-1:2025, Eurocode 5 - Design of timber structures - Part 1-1: General rules and rules for buildings.

ISO 16696-1:2019, Timber structures - Cross laminated timber - Part 1: Component performance, production requirements and certification scheme.

ISO/IEC 17065:2012, Conformity assessment - Requirements for bodies certifying products, processes and services.

NZS 1170.5:2004, Structural design actions - Part 5: Earthquake actions - New Zealand.

NZS AS 1720.1:2022, Timber structures, Part 1: Design methods.

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

Appendix B Notations - Normative

Quantity symbols used in this Standard are listed below

A_i = cross-sectional area of the i-th longitudinal layer in mm^2

A_s = gross shear plane area (in mm^2) = $\frac{2}{3}.d.b$

$A_{net,l,0}$ = net area in the longitudinal CLT direction (in mm^2)

$A_{net,l,90}$ = net area in the transverse CLT direction (in mm^2)

$A_{\_net}$ = net cross-sectional area subjected to tension (in mm^2) = b_{net} d

$A_{\_(net,c)}$ = net cross-sectional area subjected to compression (in mm^2) = b_{net} d

A_p = bearing area for loading perpendicular to grain (in mm^2)

A_{rs} = rolling shear area under a 30° dispersion angle as per Figure 15 (in mm^2)

a_i = the distance from the centroid of the composite cross-section to the centroids of the i-th longitudinal layer (in mm)

B = width of the CLT panel (in mm)

$B_{l,min}$ = minimum lamella width in CLT panel. Shall be taken as 80mm or as provided by the manufacturer (in mm)

B_{net} = net panel width, defined as the sum of lamella thicknesses parallel to the loading direction (in mm)

B_A = beam A bending stiffness (in Nmm^2)

B_{Bbeam} = bending stiffness (in Nmm^2)

$b_{\_(in,net)}$ = effective breadth of the CLT member in the plane of loading calculated as the sum of lamella thickness of the longitudinal lamellas (in mm)

$b_{l,mean}$ = mean lamella width (in the absence of any information on the lamella width, use a width of 80 mm)

$b_{in=}$ = overall breadth of the CLT member in the plane of loading (in mm)

D = screw outer thread diameter (in mm)

d = member depth (in mm)

d_{in} = depth in loaded direction of the CLT member in the plane of loading (in mm)

E_R = reference modulus of elasticity for cross sections with lamellas of different material properties, take as the modulus of the outermost lamella parallel to the panel span (in MPa)

E_i = modulus of elasticity of lamellas in the i-th layer (in MPa).

E_i = E_0 for lamellas parallel to the span direction, refer to Clause 2.2.1.4.

E_i = E_{90} for lamellas perpendicular to the span direction

EI_{eff} = effective bending stiffness of the CLT section (in Nmm^2)

f'_t = characteristic value in tension parallel to the grain (in MPa)

f'_s = characteristic longitudinal shear stress value (in MPa)

$f'_{s,r}$ = characteristic rolling shear stress value (in MPa)

f'_p = characteristic value (in MPa) for bearing perpendicular to grain.

f'_b = characteristic value in bending for the section size (in MPa)

f'_b = characteristic bending strength of longitudinal lamellas (in MPa)

$f'_{s.g}$ = characteristic CLT gross shear strength taken as the lamella characteristic shear strength parallel to grain (f'_s) or as provided by the manufacturer in accordance with Clause 1.9 (in MPa)

$f'_{s.n}$ = characteristic CLT net shear strength taken as 5.5 MPa or as provided by the manufacturer in accordance with Clause 1.9 (in MPa)

$f'_{s.tor}$ = characteristic CLT torsional shear strength taken as 2.5 MPa or as provided by the manufacturer in accordance with Clause 1.9 (in MPa)

$f_{c^{\wedge\prime}}$ = characteristic value in compression parallel to the grain (in MPa)

G_{mean} = shear stiffness of lamellas, use a weighted average for lamellas of different grades

g_{50} = coefficient taking into account CLT panel layup

g_{51} = coefficient taking into account load application width

GA_{eff} = effective shear stiffness of the CLT section (in N)

G_i = shear modulus of the i-th layer (in MPa)

$G_{(R,12)}$ = shear modulus of the 1st transverse layer (in MPa)

$G_{(R,23)}$ = shear modulus of the 2nd transverse layer (in MPa)

I_{net} = net second moment of area (in mm4) (Clause 2.2.1.1)

k_1 = modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)

k_4 = modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)

k_6 = modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)

k_7 = modification factor for length of bearing (see AS 1720.1 Table 2.6)

k_9 = modification factor for strength sharing (see AS 1720.1 Clause 2.4.5.3)

k_{12} = Stability factor for bending in the plane of CLT (see Clause 2.6.2.2)

$K_{(s)}$ = shear deformation constants

l = span length (in mm)

L = length

l_{ef} = Effective length of threaded part of the screw, less the tip (in mm)

M_{i^*} = design action effect for bending in the plane of CLT (in kNm)

m = index of the critical lamella closest to the portion of the centre of gravity as seen from the top edge of the cross-section

m = linear mass of CLT for a 1m wide panel (in kg/m)

M_{p^*} = Design action effect for flatwise bending (in kNm)

$M_{d,p}$ = design capacity of CLT in bending (in kNm)

N_{p^*} = design action effect (in kN) for bearing normal to the face of the CLT panel

$N_{t,part^*}$ = part of the design action effect in tension parallel to grain (in kN) to be resisted by the tension lamellas not in direct contact with the connection. Calculated as the difference between the total design action effect and the tension capacity of the lamellas in direct contact with the connection.

Nc* = design action effect in compression (in kN)

n = number of individual lamellas in the CLT assembly

φ = capacity factor of CLT (see Clause 2.3.2)

ρ_c = material constant for seasoned timber columns (see AS 1720.1 Appendix E2)

N_{t^*} = design action effect in tension parallel to grain (in kN)

N_{ef} = n0.9

n = number of screws loaded axially in the same joint

ρ' = characteristic density as per Clause 2.8.4.1

θ = angle to the grain as per Clause (2.8.5.2.

Q_{Net} = static moment of area (in mm3) (Clause 2.2.1.1)

ρ_b = material constant for seasoned timber beams (see AS 1720.1 Appendix E2)

S_6 = slenderness coefficient for CLT panels

ti = thickness of the lamellas parallel to the span (in mm)

$Z_{net,i}$ = net section modulus for bending in the plane of CLT (see Clause 2.2.1.3)

V_{i^*} = design action effect for shear in the plane of CLT panel (in kN) as supplied by the manufacturer in accordance with Clause 1.9 (in MPa)

t_{max} = maximum lamella thickness in CLT panel (in mm)

t_l = lamination thickness (to which screw is driven into), in mm

t_i = thickness of the laminations in the i-th layer (in mm)

$\gamma_{(i)}$ = factor, which measures the connection efficiency of the cross layers,

$t_{1,2}$ = thickness of the 1st transverse layer (in mm) between 1st and 2nd longitudinal layers

$t_{2,3}$ = thickness of the 2nd transverse layer (in mm) between 2nd and 3rd longitudinal layers

$t_{net,0}$ = sum of lamella thicknesses parallel to the loading direction

$t_{net,90}$ = sum of lamella thicknesses perpendicular to the loading direction

V_{p^*} = the design action effect in shear (in kN)

$V_{d,r}$ = design capacity of CLT in rolling shear (in kN)

$V_{d,l}$ = design capacity of CLT in longitudinal shear (in kN)

$\bar{y}_i$ = distance between the centroid of the i-th lamella and the neutral axis (in mm) = $a_i - y_c$

y_c = neutral axis location of the CLT section from the bottom face of the CLT panel = $\frac{\sum E_i\, t_i\, b\, a_i}{\sum E_i\, t_i\, b}$

Z_{net} = net section modulus about the axis of bending (in mm^3) (Clause 2.2.1.1)

Appendix C: Miscellaneous CLT design methods Normative

Appendix C1 − Shear analogy method

The shear analogy method models the CLT panel as two imaginary beams, A and B.

- Beam A represents the flexural stiffness of the individual layers.
- Beam B accounts for the combined flexural and shear stiffness of all layers and connections.

In this method, the effective bending stiffness (*EI*EI_{eff}) is reduced to account for the shear deformation effects influenced by loading type, boundary conditions, span length and transverse layers effective shear stiffness (GA_{eff}). The resulting reduced effective stiffness is defined as apparent bending stiffness (EI_{app}) for use in serviceability design.

The shear analogy method is applicable to CLT panels with symmetric cross sections. It is not limited by the number of longitudinal layers in a panel.

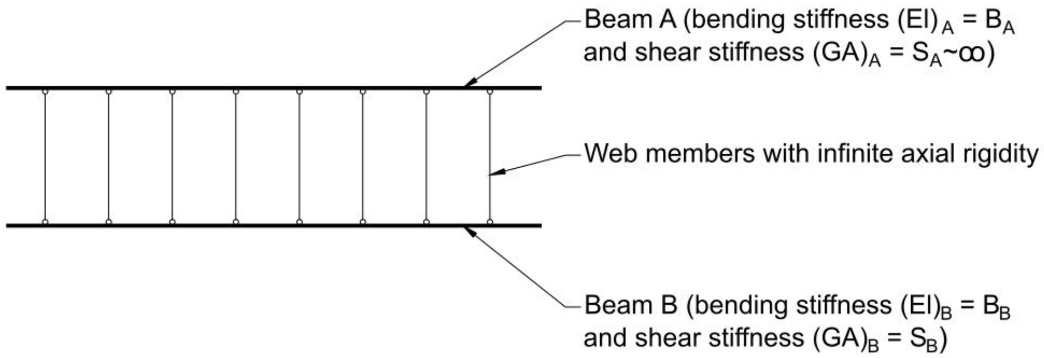


Figure C1A – Shear analogy method structural model

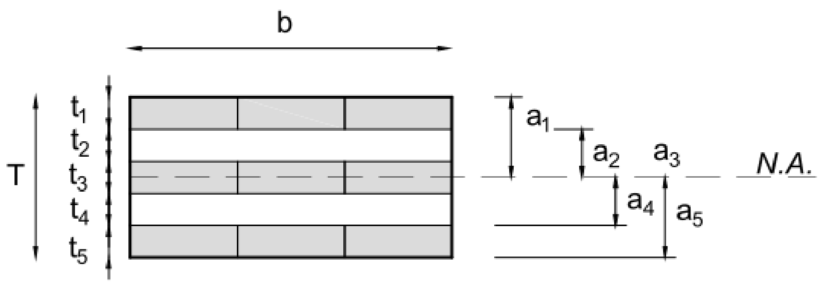


Figure C1B – Shear analogy method section parameters

$$EI_{eff} = B_A + B_B = \sum_{i=1}^{n} E_i . b . \frac{{t_i}^3}{12} + \sum_{i=1}^{n} E_i . A_i . a_i^2 \quad \text{C1 (1)}$$

$$GA_{eff} = \frac{\left(d - \frac{t_1}{2} - \frac{t_n}{2}\right)^2}{\left(\frac{t_1}{2.G_1.b}\right) + \left(\sum_{i=2}^{n-1} \frac{t_i}{G_i.b}\right) + \left(\frac{t_n}{2.G_n.b}\right)} \quad \text{C1 (2)}$$

$$EI_{app} = \frac{EI_{eff}}{1 + \frac{K_s EI_{eff}}{GA_{eff}.L^2}} \qquad \text{C1 (3)}$$

Where:

EI_{eff} = effective bending stiffness of the CLT section (in Nmm^2)

B_A =beam A bending stiffness (in Nmm^2)

B_B =beam B bending stiffness (in Nmm^2)

n = number of layers in the panel

E_i = modulus of elasticity of laminations in the ith layer (in MPa)

=E_0, for laminations in the longitudinal layers

=E_{90}, for laminations in the transversal layers

b = width of the CLT panel (in mm)

d = thickness of CLT panel (in mm)

t_i = thickness of the laminations in the i-th layer (in mm)

A_i = cross-sectional area of the i-th longitudinal layer (in mm^2)

a_i = the distance from the centroid of the composite cross-section to the centroids of the i-th longitudinal layer (in mm)

GA_{eff} = effective shear stiffness of the CLT section (in N)

G_i = shear modulus of the i-th layer (in MPa)

EI_{app} = apparent bending stiffness of the CLT section (in Nmm^2)

K_s = shear deformation constants (refer to C1 A below)

L = span of the CLT section (in mm)

Table C1 Shear deformation constants for various loading and boundary conditions

Loading	**End Fixity**	**K_s**
Uniformly distributed	Pinned	11.5
	Fixed	57.6
Point load at midspan	Pinned	14.4
	Fixed	57.6
Point load at quarter points	Pinned	10.5
Uniformly distributed	Cantilevered	4.8
Point load at free end	Cantilevered	3.6

Note: For structural configurations not covered by the above table, bending and shear deformation may be calculated separately using effective section properties calculated in C.1 (1) and C.1(2) above and added to give total deflection.

Appendix C2 − The gamma method

This method is suitable for CLT panels with two and three longitudinal layers. This method does not consider shear deformation in the longitudinal layers. The contribution of shear deformation in the longitudinal layers to the overall deformation tends to be more significant at shorter spans.

The Gamma method treats the longitudinal layers of a CLT panel as beams and the cross layers as continuously distributed connections. The method assumes that the load on the panel is carried only by the longitudinal layers. The cross layers' shear stiffness (or connection efficiency) is denoted by the γ_i factor. It is determined by the thickness of the cross layers and the material rolling shear modulus. This factor may vary from 0 to 1, indicating the degree of interaction, with 0 representing no connection between the longitudinal layers and 1 representing a rigid connection.

For CLT panels with more than 3 longitudinal layers, alternative methods that may be applied include the shear analogy method or the modified gamma method *(Reference may be made to Wallner-Novak, M., Pock, K., & Schickhofer, G. (2014). Cross-Laminated Timber Structural Design – Basic Design and Engineering Principles according to Eurocode. ProHolz Austria. for guidance on the modified gamma method)*

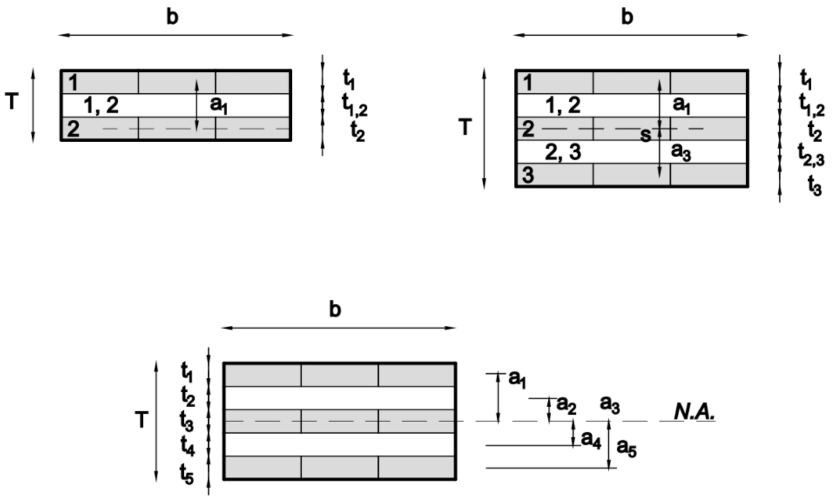


Figure 7A – Gamma method section parameters

For a unit width CLT panel, the effective panel stiffness (EI_{eff}) is calculated for n = 2 or n = 3, where there are two or three longitudinal layers, respectively:

$$EI_{eff} = \sum_{i=1}^{n} E_i . b . \frac{{t_i}^3}{12} + \sum_{i=1}^{n} \gamma_i . E_i . b . t_i . a_i^2 \qquad \text{C2 (1)}$$

$$\gamma_1 = \frac{1}{(1 + \frac{(\pi^2 . E_1 . A_1)}{l_{ref^2}} . \frac{t_{1,2}}{b . G_{R,12}})} \qquad \text{C2 (2)}$$

$$\gamma_2 = 1 \qquad \text{C2 (3)}$$

$$\gamma_3 = \frac{1}{(1 + \frac{(\pi^2 . E_3 . A_3)}{l_{ref^2}} . \frac{t_{2,3}}{b . G_{R,23}})} \qquad \text{C2 (4)}$$

$$a_2 = \frac{\gamma_1 . E_1 . b . t_1 . \left(\frac{t_1}{2} + t_{1,2} + \frac{t_2}{2}\right) - \gamma_3 . E_3 . b . t_3 . \left(\frac{t_2}{2} + t_{2,3} + \frac{t_3}{2}\right)}{\sum_{i=1}^{3} \gamma_1 . E_i . b . d_i} \qquad \text{C2 (5)}$$

$$a_1 = \left(\frac{t_1}{2} + t_{1,2} + \frac{t_2}{2}\right) - a_2 \qquad \text{C2 (6)}$$

$$a_3 = \left(\frac{t_2}{2} + t_{2,3} + \frac{t_3}{2}\right) + a_2 \qquad \text{C2 (7)}$$

Where:

γ_i = factor, which measures the connection efficiency of the cross layers,

E_i = modulus of elasticity of the i-th longitudinal layer in MPa

A_i = cross-sectional area of the i-th longitudinal layer in mm^2

t_i = thickness of the i-th longitudinal layer (in mm)

a_i = the distance from the centroid of the composite cross-section to the centroids of the i-th longitudinal layer (in mm).

b = width of the CLT panel (in mm)

$t_{1,2}$ = thickness of the 1st transverse layer (in mm) between 1st and 2nd longitudinal layers

$t_{2,3}$ = thickness of the 2nd transverse layer (in mm) between 2nd and 3rd longitudinal layers

$G_{R,12}$ = shear modulus of the 1st transverse layer (in MPa)

$G_{R,23}$ = shear modulus of the 2nd transverse layer (in MPa)

l = span length (in mm)

$l_{eff} = l$ for simply supported spans

$l_{eff} = 0.8 \times l$ for continuous spans (based on the shorter span length with unequal spans)

$l_{eff} = 2 \times l$ for cantilevers

Appendix D1: Miscellaneous CLT design methods Informative

Appendix D1 − Load Dispersion In CLT Wall Panels

The load dispersion in the plane of CLT panels is a function of the lamella thickness and orientation, the length of force application and the wall height.

For load applications away from wall edges, the dispersion angle (α) can be calculated as

$$\alpha = g_{50}\, g_{51} 30^\circ \qquad \text{D1 (1)}$$

and

$$g_{50} = 1.1 \left(\frac{t_{net,90}}{t_{net,0}}\right)^{0.25} \qquad \text{D1 (2)}$$

$$g_{51} = 1 - 1.5\frac{b}{L} \geq 0 \qquad \text{D1 (3)}$$

Where

- g_{50} = coefficient taking into account CLT panel layup
- g_{51} = coefficient taking into account load application width
- $t_{net,0}$ = sum of lamella thicknesses parallel to the loading direction
- $t_{net,90}$ = sum of lamella thicknesses perpendicular to the loading direction
- L = length of wall loaded in compression
- b = width of load application

The resulting effective depth (d_{eff}) of the compression column can be calculated as

$$d_{eff} = b + \frac{L}{2}\tan\alpha \qquad \text{D1 (4)}$$

For cases where the concentrated load is applied at CLT panel edge or joint, the effective depth can be calculated as follows

$$d_{eff} = 0.9\left(\frac{b}{L}\right)^{0.25} d \qquad \text{D1 (5)}$$

Appendix D2 − Simplified design method for squat racking walls

A simplified method using an equivalent moment couple, as illustrated in Figure D2A, may be developed using a neutral axis depth (x) determined from first principles based on the compression strength of laminations loaded parallel to the grain. The width of the resulting equivalent compression strut may be calculated in accordance with Clause 2.6.5.1 and verified in accordance with Clause 2.6.5.

The tensile capacity of the wall is deemed to be satisfied where verification against brittle failure is carried out in accordance with Clause 2.6.8.

Any axial loads applied to the wall shall be superimposed on the actions induced by overturning effects.

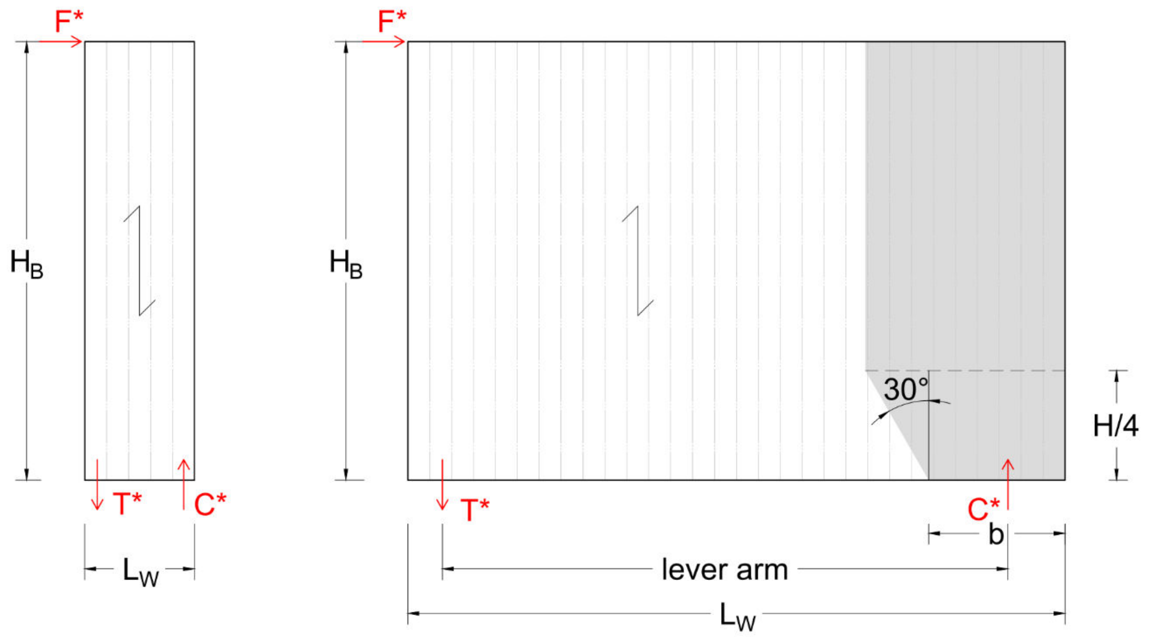


Figure 8A – Effective depth from racking or overturning loads

The presence of additional axial compression loads applied to the wall may be accounted for by considering the additional axial compression force into the determination of the neutral axis and into the verification of compression capacity.

NOTE 1 For possible analytical methods to determine the neutral axis depth in CLT racking walls, reference may be made to Lukacs et al. (2019), Strength and stiffness of cross laminated timber (CLT) shear walls: State of the art of analytical approaches, Engineering Structures, 178.

NOTE 2 The above simplified method ignores the stiffening effect from the remaining wall, as it only considers an equivalent free-standing column, providing a conservative design.

NOTE 3 The presence of perpendicular walls at the compression edge of the racking wall can be taken into consideration. Refer to AS 1720.1, Section E7 for more guidance on buckling restraints.

Appendix D3 − Simplified assessment of brittle failure modes in tension

This Appendix provides a simplified method for assessing localised brittle failure associated with the introduction of concentrated tensile forces into CLT panels. The method permits the effects of force dispersion and rolling shear transfer between laminations to be considered when determining the effective tension capacity of the panel.

To verify the localised brittle failure capacity of a direct load introduction into a CLT panel, a load dispersion of 30° over the joint and a resulting effective depth in tension as per Figure D3A may be taken into account. The tension capacity can then be verified as per Clause 2.6.6,

For load introduction into lamellas perpendicular to the load direction, and where the tension capacity of multiple laminations is relied upon to resist the applied design action, the rolling shear strength shall be verified as follows:

$$V_{d,r} \geq N^{*}_{t,part} \qquad \text{D3 (1)}$$

Where

$$V_{d,r} = \phi k_1 k_4 k_6 f'_{s,r} A_{rs} \qquad \text{D3 (2)}$$

and

$N_{t,part}^{*}$	= part of the design action effect in tension parallel to grain (in kN) to be resisted by the tension lamellas not in direct contact with the connection. Calculated as the difference between the total design action effect and the tension capacity of the lamellas in direct contact with the connection.
φ	= capacity factor of CLT (see Clause 2.3.2)
k_1	= modification factor for duration of load (see AS 1720.1 Clause 2.4.1.1)
k_4	= modification factor for moisture condition (see AS 1720.1 Clause 2.4.2.3)
k_6	= modification factor for the effect of temperature (see AS 1720.1 Clause 2.4.3)
$f'_{s,r}$	= characteristic rolling shear stress value (in MPa)
A_{rs}	= rolling shear area under a 30° dispersion angle as per Figure D3A (in mm^2)

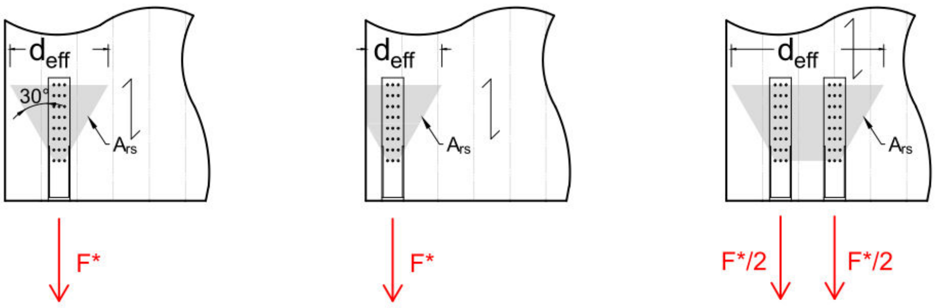


Figure D3A – Load dispersion at concentrated load introductions

NOTE: Equal distribution between force distribution hold-down brackets needs to be verified by designers.

Appendix D4 − Robustness

D4.1 Scope

This Appendix does not address whole-of-building robustness design, and reference should be made to available industry guidance, including the *ABCB Handbook: Structural Robustness*, and *WoodSolutions Technical Design Guide 39, Robustness in Structures*, to determine an appropriate approach to robustness design for the building.

NOTE Informative Annex A of BS EN 1995-1:2025 provide additional guidance for increasing the robustness of timber structures.

D4.2 General

Designing a robust structure requires a risk-based approach considering of the following:

(a) Building size, use, location and occupancy size/type

(b) Building movements of substructure and superstructure

(c) Material and connections behaviour under accidental conditions

(d) Construction methods and tolerances

(e) Provision of access for routine maintenance and inspection

In general, a robust structure may be demonstrated using one or a combination of the following approaches:

(a) ensuring that if any load-bearing or bracing element such as a column or defined length of wall is removed, disproportionate collapse will not occur (referred to as 'notional element removal')

(b) providing critical 'key' elements, which are designed to resist accidental loads appropriate to the determined risk for the building.

D4.3 Modification factors

Material and connection capacities shall be verified under accidental design actions. A load duration factor $k_1 = 1$ and φ = capacity factor of CLT shall apply.

D4.4 Accidental design cases

Where alternative load paths are relied upon, the relevant elements and connections that make up this load path shall be designed for the resulting actions and secondary effects.

Where catenary forces are relied upon, or large deformations are expected, the designer shall verify that joints and fasteners will have sufficient strength and ductility to resist tying actions and accommodate rotations.

Dynamic effects associated with sudden element removal should be considered.

Connection detailing shall minimise the likelihood of brittle failure modes under accidental design actions. Failure mechanisms should be governed by ductile failure of connections, rather than brittle failure of timber elements, where possible.

Appendix D5 − Punching Shear

D5.1 General

The following design guidance is based on research and applies only to panels with 5 or more layers. This method assumes that there is no moment transfer through the column. Perpendicular to the grain bearing shall be checked for the support area.

Design of panels with reinforcement for punching shear is outside of the scope of this section.

D 5.2 Punching shear central

The design capacity for unreinforced CLT panels, for the strength limit state, shall satisfy the following;

$$V_d \geq V*$$

Where;

$$V_d = \emptyset\, k1.k_4.k_6.f'_{v90}A_s$$

and;

$V*$ = Design action effect in shear on a face determined from the tributary area

$\emptyset$ = Capacity factor (see Clause 2.3.2)

$k_1, k_4, k_6,$ = Modification factors given in Section 2, AS 1720.1

f'_{v90} = Characteristic value of rolling shear strength for punching shear (MPa) taken as k_r x f_r, where k_r is the support condition modifier and f_r, is the characteristic value of rolling shear strength as supplied by the manufacturer in accordance with Clause 1.9.

Table D5.1 Punching Shear Values

Condition (refer Figure D5A)	k_r
Edge (a)	1.3
Centre (b)	1.3
Corner (c)	1.3
Perimeter (d)	1.0

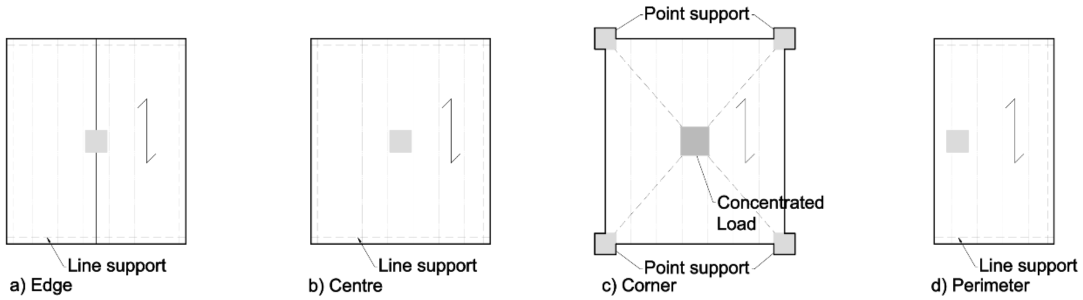


Figure D5A − Punching Shear Area

A_s = Shear plane area, determined for each face (mm^2)

Where

$d_s = \frac{E\,I_{eff}}{\sum E_i\,t_i\,\overline{y}_i}$ Effective shear depth, considering the panel lay-up

Where

EI_{eff} = Effective bending stiffness of the section, calculated using the Shear Analogy Method, refer Appendix C1

E_i = modulus of elasticity of the i-th longitudinal layer in MPa

t_i = thickness of the laminations in the i-th layer (in mm)

a_i = the distance from the centroid of the composite cross-section to the centroids of the i-th longitudinal layer (in mm)

NOTE Typically for a solid section, the shear area is taken as 2/3^{rds} of the depth, but this is not accurate for a composite section. This equation calculates the equivalent shear depth taking into account the different lay-ups of CLT panels.

D 5.3 Punching shear effective width and perimeter

The effective width, b_{eff}. of the shear face shall be taken as the width of the overlap with the support or concentrated load extended at an angle of 35 degrees off vertical.

Where panels have approximately equal spans on both sides of the support, with uniformly distributed loads, the effective perimeter, u, can be used instead of considering individual shear faces. The effective perimeter is defined by a line geometrically similar to the boundary of the effective area of a support or concentrated load and located at the surface of the CLT panel and taken at an angle of 35 degrees off vertical.

Where there are unequal spans or significant concentrated loads at the ends of the span, the localised stress on the appropriate face should be explicitly considered. The characteristic value for rolling shear for punching shear and the 35-degree angle can be assumed to apply in special studies of localised shear planes.

B_{Ax} = width of overlap with support or concentrated load

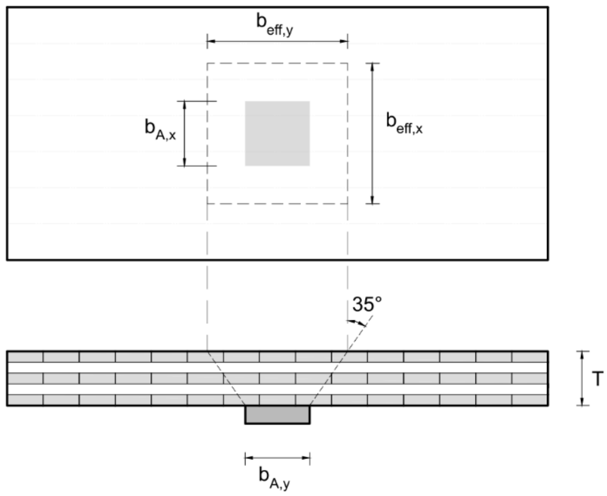
b_{Ay} = length of overlap with support or concentrated load

For central supports;

$u = 2b_{effx} + 2b_{effy}$

$b_{effx} = b_{Ax} + 0.7T$

$b_{effy} = b_{Ay} + 0.7T$

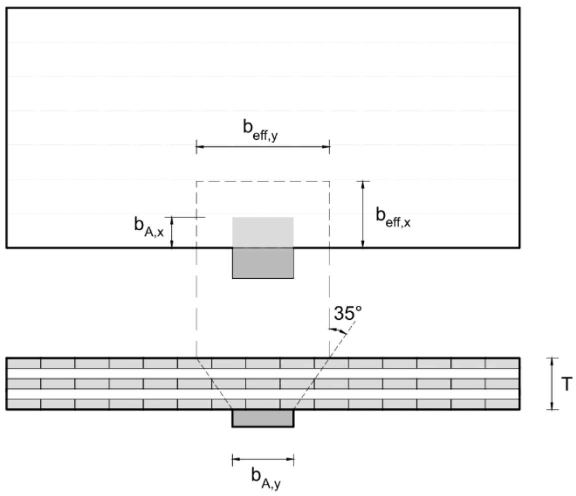


For edge supports;

$u = 2b_{effx} + b_{effy}$

$b_{effx} = b_{Ax} + 0.35T$

$b_{effy} = b_{Ay} + 0.7T$



For corner supports;

$u = b_{effx} + b_{effy}$

$b_{effx} = b_{Ax} + 0.35T$

$b_{effy} = b_{Ay} + 0.35T$

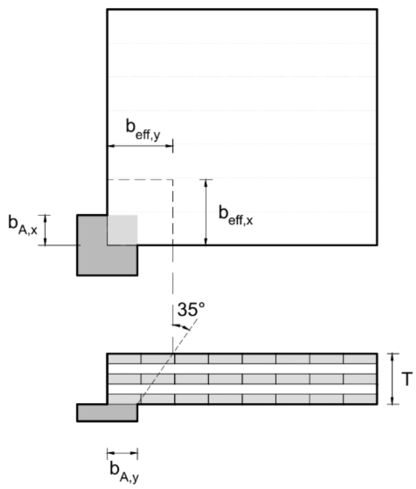


Figure D5B − Effective widths and perimeter for punching shear

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