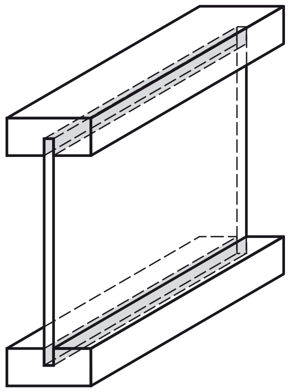

FIGURE 5.4 BEAMS WITH WEBS PARTIALLY EMBEDDED INTO FLANGES

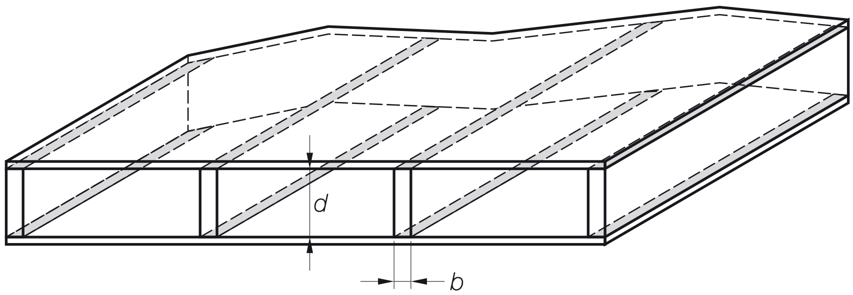

FIGURE 5.5 STRESSED SKIN PANELS

TABLE 5.5

ASSEMBLY FACTOR g_{19} FOR GLUED INTERFACES

Type of construction	Position of shear	Stress direction with respect to grain direction in face plies	Assembly factor: Area to be considered	Assembly factor: Modification factor (g_{19})
Box beam and I-beams with plywood webs	Full depth web-shear between web and flanges (see Figure 5.3)	Parallel or perpendicular	Full area of contact between plywood and flange	0.2 × characteristic value
		±45° (see Table 5.4)	Full area of contact between plywood and flange	0.2 × characteristic value
	Webs partially embedded in flanges—shear between web and flanges (see Figure 5.4)	Parallel or perpendicular	Full area of contact between plywood and flange	0.4 × characteristic value
Stressed skin panels	Shear between plywood and framing members (see Figure 5.5). End nogging shall be used where the depth of framing members exceeds twice their breadth	Parallel or perpendicular	Full area of contact between plywood and members	0.4 × characteristic value in shear for interior framing members
				0.2 × characteristic value in shear strength for edge framing members
		±45° (see Table 5.4)	Full area of contact between plywood and framing member	0.4 × characteristic value in shear for interior framing members
				0.2 × characteristic value in shear for edge framing members

SECTION 6 ROUND TIMBERS

6.1 GENERAL

Whether naturally round timbers are used as simple structural members (that is, as poles or piles or as elements of a composite structure) the design procedures shall be in accordance with the procedure given in Section 3, subject to the provisions of Clauses 6.2, 6.3, 6.4 and 6.5.

6.2 CHARACTERISTIC VALUES FOR STRUCTURAL DESIGN

The characteristic values for structural design for untrimmed logs, poles or piles which conform in quality to the grade requirements specified in AS 3818.3 or AS 3818.11, as appropriate, are determined by the species. Species strength groups are listed for common species in Tables H2.3 and H2.4, Appendix H; these strength groups are used to determine the applicable F-grade in accordance with Table 6.1. For round timbers, the unseasoned condition shall be assumed. Design properties are taken as for F-graded timber in accordance with Appendix H.

Alternatively, characteristic values can be determined by testing and evaluation in accordance with the AS/NZS 4063 series.

TABLE 6.1

ROUND TIMBERS GRADED TO AS 3818.3 or AS 3818.11— RELATIONSHIP BETWEEN STRENGTH GROUPS AND F-GRADES

Strength group	Stress grade
S1	F34
S2	F27
S3	F22
S4	F17
S5	F14
S6	F11
S7	F8

NOTE: The equivalence expressed is based on the assumption that all poles or logs are cut from mature trees. Factors for immaturity are given in Clause 6.4.1.

6.3 DESIGN

6.3.1 Bending strength

The design capacity in bending of round timbers (M_d) for the strength limit state shall satisfy the following:

$$M_d \geq M^*$$ . . . 6(1)

where

$$M_d = \phi\, k_1\, k_4\, k_6\, k_9\, k_{12}\, k_{20}\, k_{21}\, k_{22}\, f'_b\, Z$$ . . . 6(2)

and

M^* = design action effect in bending produced by strength limit states design loads

ϕ = capacity factor (see Clause 2.3)

k_1 to k_9 = strength modification factors given in Section 2

k_{12}	=	stability factor
	=	1 for round timbers
k_{20}	=	immaturity factor as per Clause 6.4.1
k_{21}	=	shaving factor as per Clause 6.4.2
k_{22}	=	processing factor (0.85 if poles are steamed; otherwise 1.0)
f'_b	=	characteristic value in bending
Z	=	section modulus of a round timber
	=	$\frac{\pi d_p^3}{32}$, where d_p = pole diameter at the relevant section

NOTE: The characteristic value (f'_b) may be evaluated by in-grade testing.

6.3.2 Shear strength

The design capacity in shear of a round timber (V_d) shall satisfy the following:

$$V_d = V^* \qquad \text{. . . 6(3)}$$

where

$$V_d = \phi\, k_1\, k_4\, k_6\, k_{20}\, f'_s\, A_s \qquad \text{. . . 6(4)}$$

and

V^*	=	design action effect in shear
ϕ	=	capacity factor (see Clause 2.3)
k_1, k_4, k_6	=	modification factors given in Section 2
k_{20}	=	immaturity factor (Table 6.2)
f'_s	=	characteristic value in shear
A_s	=	shear plane area
	=	$\frac{3\pi d_p^2}{16}$, where d_p = smallest end pole diameter

6.3.3 Compressive strength

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

$$N_{d,c} \geq N^* \qquad \text{. . . 6(5)}$$

where

A1 $$N_{d,c} = \phi\, k_1\, k_4\, k_6\, k_{12}\, k_{20}\, k_{21}\, f'_c\, A_c \qquad \text{. . . 6(6)}$$

and

N^*	=	design action effect in compression
ϕ	=	capacity factor (see Clause 2.3)
A1 k_1, k_4 and k_6	=	modification factors given in Section 2
k_{12}	=	stability factor, determined in accordance with Clause 3.3.3, except that—

$$S = 1.15\ L/d_p$$

where

= slenderness coefficient

= distance between effective restraints in any plane and
d_p = nominal mid-length diameter between points of lateral restraint

k_{20} = immaturity factor as per Clause 6.4.1

k_{21} = shaving factor as per Clause 6.4.2

f'_c = characteristic value in compression parallel to the grain

A1 A_c = section area of a round timber column

$= \dfrac{\pi\, d_p^2}{4}$, where d_p is the nominal mid-length diameter

NOTE: The nominal mid-length diameter may be calculated from the small end diameter and the taper.

6.3.4 Deflections

Deflection calculations shall take into account the modification factors in Clause 2.4.1.2.

6.4 ADDITIONAL MODIFICATION FACTORS

6.4.1 Factor for immaturity

For poles having mid-length diameters less than 250 mm, due allowance shall be made for the properties of immature timber. For eucalypt and corymbia species and softwoods, the factors k_{20} and j_9 given in Tables 6.2(A) and 6.2(B) shall be used to determine capacity and rigidity, respectively.

NOTE: For hardwood species other than eucalypt and corymbia species, conservative assumptions with respect to k_{20}, j_9, and k_{21} should be used in design unless special investigations have been undertaken to derive accurate values.

TABLE 6.2(A)

IMMATURITY FACTORS—
IMMATURITY FACTOR k_{20} FOR DESIGN CAPACITY

Species	Factor k_{20} for capacities							
	Pole diameter at mid-length (d_p), mm							
	75	100	125	150	175	200	225	250
Eucalypt and corymbia	0.80	0.90	1.00	1.00	1.00	1.00	1.00	1.00
Softwoods	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00

TABLE 6.2(B)

IMMATURITY FACTORS—
IMMATURITY FACTOR (j_9) FOR STIFFNESS

Species	Factor j_9 for stiffness							
	Pole diameter at mid-length (d_p), mm							
	75	100	125	150	175	200	225	250
Eucalypt and corymbia	0.80	0.90	1.00	1.00	1.00	1.00	1.00	1.00
Softwoods	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00

6.4.2 Shaving factor

For timber members in natural pole form, the design capacity shall be reduced if the poles have been shaved. For poles that have been shaved to a smooth cylindrical form, the shaving factor k_{21} shall be taken as specified in Table 6.3. In addition, it shall be assumed that the effect of shaving will be to reduce the modulus of elasticity by 5% (see Note to Clause 6.4.1).

TABLE 6.3

SHAVING FACTOR (k_{21})

Stress	Factor k_{21}	
	Eucalypt and corymbia species	Softwoods
Bending	0.85	0.75
Compression parallel to grain	0.95	0.90
Compression perpendicular to grain and shear	1.00	1.00
Tension	0.85	0.75

6.5 DESIGN DETAILS

6.5.1 Effective cross-section of untreated timber

Unless subjected to adequate preservative treatment in accordance with an approved Standard, the sapwood of all timbers shall be disregarded in assessing the effective structural cross-section of poles at or above the ground-line where exposed to the weather or when used as piles above permanent water level.

6.5.2 Moisture content of timbers in ground contact

Poles embedded in the ground and up to 1 m above the ground shall be designed for the unseasoned condition.

6.5.3 Joints

Design of joints shall be in accordance with Section 4. The joint group shall be determined as for F-graded timber, in accordance with Appendix H.

SECTION 7 GLUED-LAMINATED TIMBER CONSTRUCTION

7.1 GENERAL

This Section shall be applied in conjunction with Sections 2 and 3. The provisions of this Section apply specifically to glued-laminated timber members manufactured in accordance with AS/NZS 1328.1.

Additional design methods, including methods for taper-cut and curved beams, are contained in Appendix E.

Where any glued-laminated timber is likely to be exposed to water or to damp conditions, the glued laminated timber shall be bonded with Type 1 adhesive specified in accordance with AS/NZS 1328.1.

7.2 STRUCTURAL DESIGN

The procedures given in Section 3 and Appendix E shall generally apply for design with glued-laminated timber except that values of properties and factors given in this Section shall apply.

Design of joints using glued-laminated timber shall be in accordance with the requirements of Section 4.

7.3 DESIGN PROPERTIES

7.3.1 Characteristic values for strength and stiffness properties

The characteristic values for strength properties and moduli of elasticity and rigidity for various GL-grade classifications of glued-laminated timber are given in Table 7.1.

Characteristic values related to the strength groups that apply to the computation of timber member design capacities in bearing (both perpendicular and parallel to the grain, in tension parallel to the grain, and in shear at joint details) shall be taken as for F-graded timber in Appendix H.

TABLE 7.1

CHARACTERISTIC VALUES FOR STRUCTURAL DESIGN—GL-GRADES

Stress grade	Characteristic values, MPa					
	Bending (f'_b)	Tension parallel to grain (f'_t)	Shear in beam (f'_s)	Compression parallel to grain (f'_c)	Short duration average modulus of elasticity parallel to the grain (E)	Short duration average modulus of rigidity for beams (G)
GL18	45	25	5.0	45	18500	1230
GL17	40	20	4.2	33	16700	1110
GL13	33	16	4.2	26	13300	900
GL12	25	11	4.2	22	11500	770
GL10	22	8	3.7	18	10000	670
GL8	19	6	3.7	14	8000	530

NOTE: The characteristic values for tension for GL grades apply for tension members with the larger cross-sectional dimension not greater than 150 mm. For tension members with a cross-sectional dimension greater than 150 mm, the characteristic values are determined by multiplying the value in the table by $(150/d)^{0.167}$, where d is the larger cross-sectional dimension of the section.

7.3.2 Capacity factor

The capacity factor (ϕ) to be used in the computation of the design capacities for glue-laminated timber structural elements shall be as given in Table 2.1.

7.3.3 Non-GL-grade properties

The use of other characteristic properties for glued-laminated timber is acceptable provided such characteristic properties are determined by testing and evaluation using procedures consistent with those given in the AS/NZS 4063 series.

7.4 MODIFICATION FACTORS

7.4.1 General

Modification factors for strength and stiffness, other than those specified in Clause 7.4, shall comply with Section 2.

7.4.2 Duration of load

The modification factors for duration of load (k_1) and for stiffness (j_2 and j_3) given in Clause 2.4.1 shall apply where appropriate.

NOTE: Long-term creep is dependent upon size, grade, environmental conditions and surface coatings.

7.4.3 Strength sharing between parallel members

The strength-sharing factor (k_9) for glued-laminated timber used in parallel systems shall be taken as unity (i.e., $k_9 = 1.0$).

7.4.4 Stability factor

The procedures given in Section 3 for calculation of the stability factor (k_{12}) shall generally apply for design with glued-laminated timber except that the material constant (ρ_b or ρ_c), for beams and columns shall be as given in Tables 7.2(A) and 7.2(B).

TABLE 7.2(A)

MATERIAL CONSTANT, ρ_b, FOR BEAMS

Stress grade	Ratio temporary design action effect/total design action effect (r)*				
	0	0.25	0.5	0.75	1.0
	Material constant (ρ) for beams†				
GL18	0.89	0.89	0.85	0.83	0.82
GL17	0.88	0.88	0.85	0.83	0.81
GL13	0.90	0.90	0.86	0.84	0.83
GL12	0.84	0.84	0.81	0.79	0.78
GL10	0.85	0.85	0.81	0.79	0.78
GL8	0.88	0.88	0.84	0.82	0.81

* See Paragraph E2.

† These values are derived from Equation E2(1), Appendix E using values of E and f'_b given in Table 7.1.

A1
A2

TABLE 7.2(B)

MATERIAL CONSTANT, ρ_c, FOR COLUMNS

Stress grade	Ratio temporary design action effect/total design action effect (r)*				
	0	0.25	0.5	0.75	1.0
	Material constant (ρ) for columns†				
GL18	1.08	1.08	1.03	1.00	0.98
GL17	0.99	0.99	0.95	0.92	0.90
GL13	0.99	0.99	0.94	0.91	0.89
GL12	0.98	0.98	0.93	0.91	0.89
GL10	0.96	0.96	0.91	0.88	0.86
GL8	0.95	0.95	0.90	0.87	0.85

* See Paragraph E2, Appendix E.

† These values are derived from Equation E2(3), Appendix E, using values of E and f'_c given in Table 7.1.

SECTION 8 STRUCTURAL LAMINATED VENEER LUMBER

8.1 GENERAL

The provisions of this Section are appropriate for use with structural laminated veneer lumber (LVL) manufactured and having structural properties determined in accordance with AS/NZS 4357.0.

Generally, structural design with LVL is similar to that given for sawn timber and hence this Section includes only those aspects of design that differ from those given for sawn timber elsewhere in this Standard.

Structural design of taper cut LVL shall be performed in accordance with Appendix E.

All structural LVL manufactured in accordance with AS/NZS 4357.0 is Type A bonded.

8.2 STRUCTURAL DESIGN

The procedures given in Section 3 and Appendix E shall generally apply for design with structural LVL, except that values of properties and factors given in this Section shall apply.

For on-flat bending and shear applications involving LVL containing cross bands, design shall be in accordance with the requirements for plywood in Section 5.

8.3 DESIGN PROPERTIES

8.3.1 Characteristic values for strength properties and elastic moduli

Characteristic values for structural LVL shall be obtained from the manufacturer. Characteristic values for LVL shall include consideration of the section sizes to which they are intended to apply.

Unless otherwise specified by the manufacturer, the characteristic values for LVL for bending and tension shall be modified as follows:

(a) For beam sections of depth 300 mm or less—no adjustment.

(b) For beams with depth exceeding 300 mm—multiply the published characteristic value for bending by $(300/d)^{0.167}$, where d is the depth of the beam.

(c) For tension members with width 150 mm or less—no adjustment.

(d) For tension members with the larger cross-sectional dimension exceeding 150 mm—multiply the published characteristic value for tension by $(150/d)^{0.167}$, where d is the larger cross-sectional dimension of the tension member.

Characteristic values for LVL shall not be assumed on the basis of the strength group of the species of manufacture.

8.3.2 Modulus of rigidity

The modulus of rigidity for LVL shall be taken as one-twentieth of the modulus of elasticity, except where otherwise determined by testing.

8.3.3 Section properties

Structural LVL is usually manufactured with the grain of all veneers orientated in the longitudinal direction; however, in some instances special constructions may incorporate cross-band veneers. For LVL not containing cross-band veneers, section properties shall be calculated using the actual cross-section dimensions.

For LVL containing cross-band veneers, the thickness of an individual ply shall be assumed to be in proportion to its nominal thickness, as the finished minimum LVL thickness is to the total of the nominal veneer thicknesses. Section properties for cross-banded LVL shall be determined as follows:

(a) Any veneers with nominal grain direction at right angles to the direction of stress shall be ignored for the calculation of area, first moment of area and second moment of area when assessing the edgewise bending, tension and compressive capacity and edgewise flexural rigidity.

(b) For on-flat bending and shear applications, section properties shall be determined in accordance with Paragraph I3 of Appendix I.

It is appropriate to assume the full sectional area is effective in resisting in-plane shear.

8.3.4 Capacity factors

The capacity factors to be used for the computation of design capacities for structural LVL elements shall be as given in Table 2.1.

8.4 MODIFICATION FACTORS

8.4.1 General

The modification factors for strength and stiffness given in Section 2 shall generally apply for design with LVL except for those factors specified in Clause 8.4.

8.4.2 Duration of load

The modification factors for duration of load for strength (k_1) and stiffness (j_2 and j_3) given in Clause 2.4.1 shall be used as appropriate.

8.4.3 Moisture condition

Where LVL is subjected to conditions, such that the average moisture content for a 12 month period will exceed 15%, the modification factors for strength (k_4) and for stiffness (j_6) given in Table 8.1 shall be used, except where different values have been determined by testing.

TABLE 8.1

MOISTURE CONTENT FACTORS FOR LVL

Property	Equilibrium moisture content (*EMC*)		
	≤15%	15% to 25%	≥25%
Bending and compression	$k_4 = 1.0$	$k_4 = 1.45 - 0.03\,EMC$	$k_4 = 0.7$
Tension and shear	$k_4 = 1.0$	$k_4 = 1.30 - 0.02\,EMC$	$k_4 = 0.8$
Modulus of elasticity	$j_6 = 1.0$	$j_6 = 1.30 - 0.02\,EMC$	$j_6 = 0.8$

8.4.4 Temperature

The provisions of Clause 2.4.3 for seasoned timber shall apply to structural LVL in a similar manner.

8.4.5 Length and position of bearing

Where rectangular bearing areas are located 75 mm or more from the end of a piece of LVL, it is permissible to increase the characteristic capacity in bearing perpendicular to the grain (refer to Clause 3.2.6) by the appropriate value of factor k_7 in Table 2.6. The length of bearing shall be measured parallel to the grain of the loaded member. For all other conditions, $k_7 = 1.0$.