TABLE 5.3

ASSEMBLY FACTORS g_{19} FOR BEARING AND SHEAR NORMAL TO THE FACE OF THE PLYWOOD PANEL AND IN FLATWISE BENDING

Property	Direction of face plies	Assembly factor g_{19}
Bending strength	perpendicular to span	
	—3 ply	1.2
	—5 ply or more	1.0
	parallel to span	1.0
Shear strength	any orientation	0.4
Bearing strength	any orientation	1.0
Bending deflection	parallel or perpendicular to span	1.0
Shear deformation	parallel or perpendicular to span	1.0

5.4.3 Shear strength (interlamina shear)

The design capacity of plywood in beam shear (ϕV_p), for strength limit state, shall satisfy—

$$(\phi V_p) \geq V_p^* \quad \ldots 5(3)$$

where

$$(\phi V_p) = \phi\, k_1\, k_{19}\, g_{19} \left[f_s'\, A_s\right] \quad \ldots 5(4)$$

and

V_p^* = design action effect for shear normal to the face of the plywood panel as shown in Figure 5.1

ϕ = capacity factor (see Clause 2.3)

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

k_{19} = modification factor for moisture condition (see Table 5.2(A))

g_{19} = modification factor for plywood assembly (see Table 5.3)

f_s' = characteristic strength in panel shear (in-plane)

A1, A2

A_s = $\frac{2}{3}(bt)$ (see Figure 5.1), for shear in bending;

or

A_s = full shear area, for local (punching) shear

where

b = breadth of plywood

t = full thickness of plywood

NOTE: The values of f_s' for plywood assigned an F-grade classification are given in Table 5.1.

5.4.4 Bearing strength

The design capacity of plywood in bearing (ϕN_p), for strength limit state, shall satisfy—

$$(\phi N_p) \geq N_p^* \quad \ldots 5(5)$$

where

$$(\phi N_p) = \phi\, k_1\, k_7\, k_{19}\, g_{19} \left[f_p'\, A_p\right] \quad \ldots 5(6)$$

and

N_p^* = design action effect for bearing normal to the face of the plywood panel as shown in Figure 5.1

ϕ = capacity factor (see Clause 2.3)

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

k_7 = modification factor for length of bearing (see Table 2.10)

k_{19} = modification factor for moisture condition (see Table 5.2(A))

g_{19} = modification factor for plywood assembly (see Table 5.3)

f'_p = characteristic strength in compression normal to the plane of the panel

A_p = bearing area under the design loads.

NOTE: The values of f'_p for plywood assigned an F-grade classification are given in Table 5.1.

5.4.5 Deflection in bending

In calculating deflection, the cross-section stiffness shall be based on the second moment of area (I) determined in accordance with AS/NZS 2269 (see Appendix J), the characteristic modulus of elasticity values given in Table 5.1, the moisture content stiffness factor j_6 given in Table 5.2(B) and the assembly factor g_{19} given in Table 5.3. The duration of load factor j_2 given in Table 2.8 shall be used in computing deflections.

5.5 LOADING IN THE PLANE OF THE PLYWOOD PANEL

5.5.1 General

The design capacity and deformation for a plywood panel when subject to design loads that act in the plane of the plywood, as shown in Figure 5.2, shall satisfy the requirements of Clauses 5.5.2 to 5.5.8.

A1

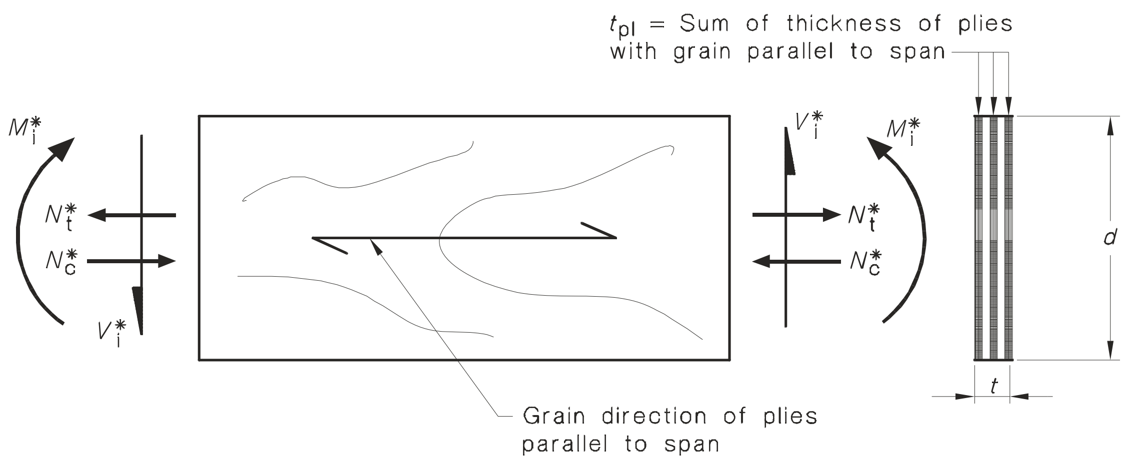

FIGURE 5.2 NOTATION FOR SHEAR, COMPRESSION AND TENSION ACTING IN THE PLANE OF A PLYWOOD PANEL AND FOR EDGEWISE BENDING

5.5.2 Bending strength

The design capacity of plywood in bending, for strength limit state, shall satisfy—

$$(\phi M_i) \geq M_i^* \quad \ldots 5(7)$$

where

A1 $$(\phi M_{\mathrm{i}}) = \phi\, k_1\, k_{12}\, k_{19}\, g_{19} \left[f'_{\mathrm{b}}\, Z_{\mathrm{i}}\right] \quad \ldots 5(8)$$

and

M_{i}^* = design action effect for edgewise bending of the plywood panel as shown in Figure 5.2

ϕ = capacity factor (see Clause 2.3)

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

k_{12} = modification factor for stability (see Appendix J)

k_{19} = modification factor for moisture condition (see Table 5.2(A))

g_{19} = modification factor for plywood assembly (see Table 5.4)

A1 f'_{b} = characteristic strength in bending

Z_{i} = section modulus of plywood

$$= \frac{t_{\mathrm{pl}}\, d^2}{6}$$

where

t_{pl} = the sum of thicknesses of veneers having their grain parallel to the span (see Figure 5.2)

d = overall depth

A2 NOTE: The values of f'_{b} for plywood assigned an F-grade classification are given in Table 5.1.

TABLE 5.4

ASSEMBLY FACTORS g_{19} FOR LOADING IN THE PLANE OF THE SHEET OF PLYWOOD (EDGEWISE BENDING)

Property	Direction of grain of plies with respect to stress direction or span	Portion of cross-section considered (effective cross-section area)	Assembly factor g_{19}
Compression and bending strength	parallel or perpendicular	parallel plies only	1.0
	±45°	full cross-section	0.34
Tension strength	parallel or perpendicular	parallel plies only	1.0
	±45°	full cross-section	0.17
Shear strength	parallel or perpendicular	full cross-section	1.0
	±45°	full cross-section	1.5
Shear deformation	parallel or perpendicular	full cross-section	1.0
Bending deflection	parallel or perpendicular	parallel plies only	1.0
Deformation in compression or tension	parallel or perpendicular	parallel plies only	1.0
	±45°	full cross-section	0.17

5.5.3 Shear strength

The design capacity of plywood in shear, for strength limit state, shall satisfy—

$$(\phi V_{\mathrm{i}}) \geq V_{\mathrm{i}}^* \quad \ldots 5(9)$$

where

$$(\phi V_{\mathrm{i}}) = \phi\, k_1\, k_{12}\, k_{19}\, g_{19} \left[f'_{\mathrm{s}}\, A_{\mathrm{s}}\right] \quad \ldots 5(10)$$

and

V_{i}^* = design action effect for shear in the plane of the plywood panel as shown in Figure 5.2

ϕ = capacity factor of plywood (see Clause 2.3)

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

k_{12} = modification factor for stability (see Appendix J)

k_{19} = modification factor for moisture condition (see Table 5.2(A))

g_{19} = modification factor for plywood assembly (see Table 5.4)

f'_s = characteristic strength in panel shear

A1 A2 A_s = $\frac{2}{3}(dt)$ (see Figure 5.2), for shear in bending;

or

A_s = (dt) for localized shear

where

d = overall depth of plywood

t = full thickness of plywood.

NOTE: The values of f'_s for plywood assigned an F-grade classification are given in Table 5.1.

5.5.4 Tension strength

The design capacity of plywood in tension for strength limit state, shall satisfy—

$$(\phi N_t) \geq N_t^* \qquad \text{. . . 5(11)}$$

where

$$(\phi N_t) = \phi\, k_1\, k_{19}\, g_{19} \left[f'_t\, A_t\right] \qquad \text{. . . 5(12)}$$

and

N_t^* = design action effect for tension in the plane of the plywood as shown in Figure 5.2

ϕ = capacity factor of plywood (see Clause 2.3)

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

k_{19} = modification factor for moisture condition (see Table 5.2(A))

g_{19} = modification factor for plywood assembly (see Table 5.4)

f'_t = characteristic strength in tension

A_t = effective cross-sectional area defined in Table 5.4 which for parallel plies only is d times the sum of thicknesses of veneers having their grain parallel to the direction of load.

NOTE: The values of f'_t for plywood assigned an F-grade classification are given in Table 5.1.

5.5.5 Compression strength

The design capacity of plywood in compression (ϕN_c), for strength limit state shall satisfy—

$$(\phi N_c) \geq N_c^* \qquad \text{. . . 5(13)}$$

where

$$(\phi N_c) = \phi\, k_1\, k_{12}\, k_{19}\, g_{19} \left[f'_c\, A_c\right] \qquad \text{. . . 5(14)}$$

and

N_c^* = design action effect for compression in the plane of the plywood panel as shown in Figure 5.2

ϕ = capacity factor of plywood (see Clause 2.3)

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

k_{12} = modification factor for stability (see Appendix J)

k_{19} = modification factor for moisture condition (see Table 5.2(A))

g_{19} = modification factor for plywood assembly (see Table 5.4)

f'_c = characteristic strength in compression

A_c = effective cross-sectional area as defined in Table 5.4 which for parallel plies only is d times the sum of thicknesses of veneers having their grain parallel to direction of load.

NOTE: The values of f'_c for plywood assigned an F-grade classification are given in Table 5.1.

5.5.6 Combined loads

For the case of combined loads, the following interaction criteria shall be satisfied:

(a) For combined compression, bending and shear—

$$\left(\frac{N_c^*}{\phi N_c}\right)+\left(\frac{M_i^*}{\phi M_i}\right)+\left(\frac{V_i^*}{\phi V_i}\right)\leq 1.0 \qquad \text{. . . 5(15)}$$

(b) For combined tension, bending and shear—

$$\left(\frac{N_t^*}{\phi N_t}\right)+\left(\frac{M_i^*}{\phi M_i}\right)+\left(\frac{V_i^*}{\phi V_i}\right)\leq 1.0 \qquad \text{. . . 5(16)}$$

5.5.7 Deflection in bending

In calculating deflection, the cross-section stiffness shall be based on the second moment of area (I) of the plies parallel to the direction of span, the characteristic modulus of elasticity values given in Table 5.1, the moisture content stiffness factor j_6 given in Table 5.2(B) and the assembly factor g_{19} given in Table 5.4. The duration of load factor j_2 given in Table 2.7 shall be used in calculating deflections.

5.5.8 Shear deformation

In calculating shear deformations, the cross-section stiffness shall be based on the gross cross-section, using the characteristic moduli values given in Table 5.1, the moisture factor j_6 given in Table 5.2(B) and the assembly factor g_{19} given in Table 5.4. The duration of load factor j_2 given in Table 2.6 shall be applied.

5.6 JOINTS IN COMPOSITE PLYWOOD TO TIMBER CONSTRUCTION

5.6.1 Nailed and screwed joints

Recommendations for the design strength and stiffness of nailed and screwed joints between plywood and solid timber are given in Appendix C.

5.6.2 Shear strength at glued interfaces

The design capacity of a glued interface in shear between a plywood section and timber section (ϕV_{sj}), for strength limit state shall satisfy—

$$(\phi V_{sj}) \geq V_{sj}^* \qquad \text{. . . 5(17)}$$

where

$$(\phi V_{sj}) = \phi\, k_1\, k_{19}\, g_{19} \left\lfloor f'_s A_{sj} \right\rfloor \qquad \text{. . . 5(18)}$$

and

V_{sj}^* = design action effect for shear at the glued interface of the plywood and timber sections

ϕ = capacity factor of plywood (see Clause 2.3)

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

k_{19} = modification factor for moisture condition (see Table 5.2(A))

A1 g_{19} = modification factor for assembly appropriate to the type of construction (see Table 5.5)

f'_s = characteristic strength in shear

A_{sj} = area at glued interface as shown in Figures 5.3, 5.4 and 5.5 and defined in Table 5.5.

NOTE: The values of f'_s for plywood assigned an F-grade classification are given in Table 5.1.

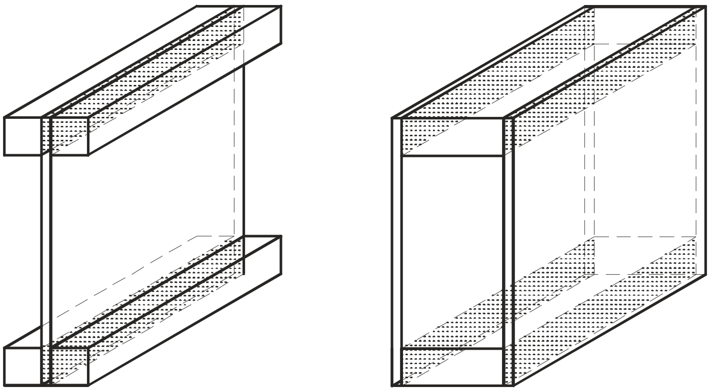

FIGURE 5.3 BEAMS WITH FULL DEPTH WEB

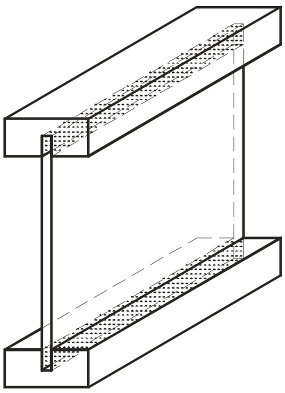

FIGURE 5.4 BEAMS WITH WEBS PARTIALLY EMBEDDED INTO FLANGES

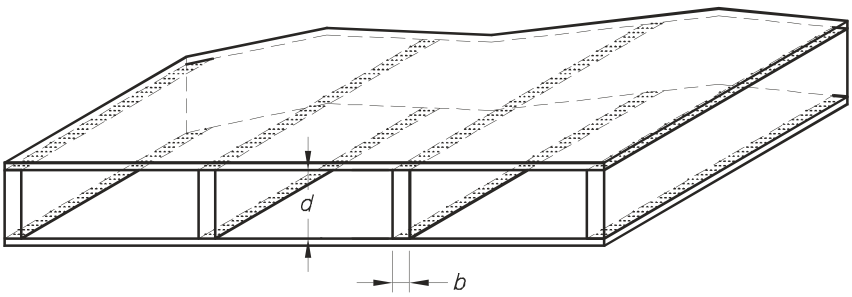

FIGURE 5.5 STRESSED SKIN PANELS

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	**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 H characteristic strength
		±45° (see Table 5.4)	Full area of contact between plywood and flange	0.2 H characteristic strength
	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 H characteristic strength
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 H characteristic shear strength for interior framing members
				0.2 H characteristic shear strength for edge framing members
		±45° (see Table 5.4)	Full area of contact between plywood and framing member	0.4 H characteristic shear strength for interior framing members
				0.2 H characteristic shear strength for edge framing members

SECTION 6 ROUND TIMBERS

6.1 GENERAL

Whether naturally round timbers are used as simple structural members, i.e. as poles or piles or as elements of a composite structure, the design procedures shall be similar to those given in Section 3, subject to the provisions of Clauses 6.2, 6.3, 6.4 and 6.5.

6.2 CHARACTERISTIC STRENGTHS AND ELASTIC MODULI

The characteristic strengths and elastic moduli for untrimmed logs, poles or piles which conform in quality to the grade requirements specified in AS 2209, shall, unless verified by in-grade testing, be those given in Tables 2.3 and 2.4. For any particular species, the appropriate stress grade is derived from its strength group as given in Table 6.1.

TABLE 6.1

ROUND TIMBERS GRADED TO AS 2209—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 (ϕM), for strength limit state, shall satisfy—

$$(\phi M) \geq M^{*} \qquad \ldots 6(1)$$

where

$$(\phi M) = \phi\, k_1\, k_4\, k_6\, k_9\, k_{12}\, k_{20}\, k_{21}\, k_{22} \left[f'_{\mathrm{b}}\, Z\right] \qquad \ldots 6(2)$$

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 strength in bending

Z = section modulus of a round timber

$= \dfrac{\pi d_p^3}{32}$, where d_p = pole diameter at the relevant section.

NOTE: The characteristic strength, f'_b, can be evaluated by in-grade testing.

6.3.2 Shear strength

The design capacity in shear of a round timber (ϕV) shall satisfy—

$$(\phi V) = V^* \qquad \ldots 6(3)$$

where

$$(\phi V) = \phi\, k_1\, k_4\, k_6\, k_{20}\, [f'_s\, A_s] \qquad \ldots 6(4)$$

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 strength in shear

A_s = shear plane area

$= \dfrac{3\pi d_p^2}{16}$, where d_p = smallest end pole diameter.

6.3.3 Compressive strength

The design capacity in compression of round timber columns (ϕN_c), for strength limit state, shall satisfy—

$$(\phi N_c) \geq N^* \qquad \ldots 6(5)$$

where

$$(\phi N_c) = \phi\, k_1\, k_4\, k_6\, k_9\, k_{12}\, k_{20}\, k_{21}\, [f'_c\, A_c] \qquad \ldots 6(6)$$

and

N^* = design action effect in compression

ϕ = capacity factor (see Clause 2.3)

k_1 to k_9 = product modification factors given in Section 2

k_{12} = stability factor, determined in accordance with Clause 3.3.3, except that the slenderness coefficient $S = 1.15\ L/d_p$ where L = 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 6.4.1

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

A_c = section area of a round timber columns

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

NOTES:

1 The characteristic strength, f'_c, can be evaluated by in-grade testing.

2 The nominal mid-length diameter may be calculated from the small end diameter and the taper as specified in AS 2209.

6.3.4 Deflections

Deflection calculations shall take into account the modification factors in Clause 2.5.1.2.

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, this may be done through multiplication of design strength and stiffness by the factors k_{20} and j_9 respectively given in Tables 6.2(A) and (B) (see Note).

NOTE: For hardwood species other than eucalypts and corymbias, 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, mm, (d_p)							
	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, mm, (d_p)							
	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 strength 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 stiffness by 5 percent (see Note to Clause 6.4.1).