6.5.1.3 *Compression strength*
The compression strength of plywood loaded in the plane of the sheet shall satisfy

$$N_c^* \leq \phi N_{nc} \quad \text{(Eq. 6.13)}$$

where

ϕN_{nc}	=	design compressive strength
ϕ	=	strength reduction factor
N_c^*	=	design axial compressive load
N_{nc}	=	nominal compressive strength

The nominal compressive strength for plywood loaded in the plane of the sheet shall be taken as

$$N_{nc} = k_1 k_8 k_{14} k_{15} f_{pc} t_e d \quad \text{(Eq. 6.14)}$$

where

k_1, k_{14}, k_{15}	=	modification factors given in section 2 or 6.3
k_8	=	stability factor given in 6.6.4
f_{pc}	=	characteristic compression stress given in table 6.1
t_e	=	effective panel thickness
	=	thickness of plies parallel to direction of stress
d	=	depth of panel

6.5.1.4 *Panel shear*
The shear strength of plywood loaded in the plane of the sheet shall satisfy

$$V_p^* \leq \phi V_{ni} \quad \text{(Eq. 6.15)}$$

where

ϕV_{ni}	=	design panel shear strength
ϕ	=	strength reduction factor
V_p^*	=	design panel shear force
V_{ni}	=	nominal panel shear strength

The nominal panel shear strength for plywood loaded in the plane of the sheet shall be taken as

$$V_{ni} = \frac{2}{3} k_1 k_8 k_{14} k_{15} k_{18} f_{ps} t d \quad \text{(Eq. 6.16)}$$

where

k_1 to k_{18}	=	modification factors given in section 2 or 6.3
k_8	=	stability factor given in 6.6.4, but used with the alternative method in 6.3.8
f_{ps}	=	characteristic shear stress given in table 6.1
t	=	total panel thickness
d	=	depth of panel

6.5.2 *Combined stresses*

6.5.2.1
Combined compression, bending and shear shall satisfy:

$$\left(\frac{N_c^*}{\phi N_{nc}}\right)+\left(\frac{M_i^*}{\phi M_{ni}}\right)^2+\left(\frac{V_i^*}{\phi V_{ni}}\right)\leq 1.0 \qquad \text{(Eq. 6.17)}$$

6.5.2.2
Combined tension, bending and shear shall satisfy:

$$\left(\frac{N_t^*}{\phi N_{nt}}\right)+\left(\frac{M_i^*}{\phi M_{ni}}\right)+\left(\frac{V_i^*}{\phi V_{ni}}\right)\leq 1.0 \qquad \text{(Eq. 6.18)}$$

6.5.3 *Deflection*
Deflections shall be calculated from standard bending and shear formulae using:

$$EI=\frac{k_{14}k_{16}}{k_2}E\frac{t_e d^3}{12} \qquad \text{(Eq. 6.19)}$$

$$GA=\frac{k_{14}k_{16}}{k_2}Gtd \qquad \text{(Eq. 6.20)}$$

where

EI	=	effective bending stiffness
GA	=	effective shear stiffness
k_2, k_{14}, k_{16}	=	modification factors given in section 2 or 6.3
E	=	short term modulus of elasticity from table 6.1
G	=	short term modulus of rigidity from table 6.1
t	=	total panel thickness
t_e	=	effective panel thickness
d	=	depth of panel

6.6 Plywood components

6.6.1 *General*
The design of specific items such as box beams, stressed skin panels etc. shall incorporate the material resistances from the clauses above for plywood, relevant provisions in this clause pertaining to jointing and design details, and material resistances for the other materials used in the construction.

6.6.2 *Component design*

6.6.2.1
The resistances and stiffnesses of each component shall be calculated allowing for the different properties of the materials (e.g. plywood and timber), using section properties transformed according to their elastic moduli as outlined below, or using a similar approach. Critical sections in some components are illustrated in figure 6.2.

C6.6.2.1
Design methods are outlined in literature available from a number of manufacturers, associations and in the Timber Use Manual.

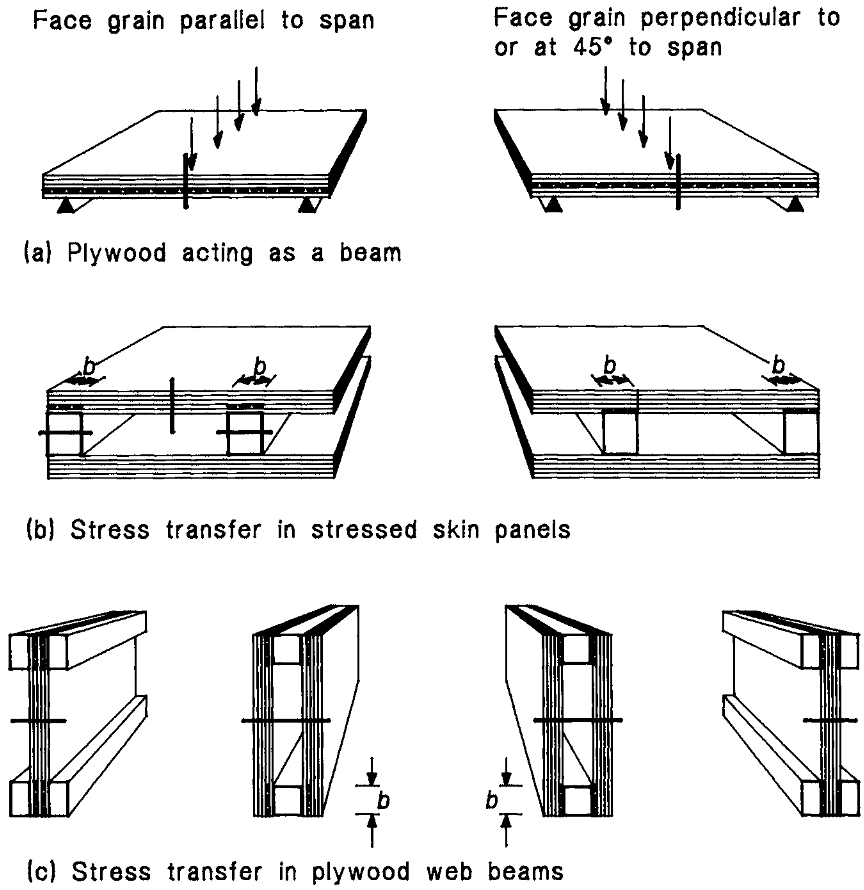

Figure 6.2 – Critical sections in some plywood components

6.6.2.2 *Bending*
Design bending strength at a section in a flexural component shall satisfy

$$M^* \le \phi M_n \quad \text{.......(Eq. 6.21)}$$

where

M^* = design bending moment
ϕM_n = design bending strength
ϕ = strength reduction factor
M_n = nominal bending strength

The nominal bending strength M_n is the minimum bending strength determined when each part of the section is checked with an equation of the form

$$M_n = kfZ_{eff} \quad \text{.......(Eq. 6.22)}$$

where

k = relevant modification factors
f = characteristic bending stress of part being considered
Z_{eff} = effective transformed section modulus = $\Sigma EI/(E_i y_i)$
ΣEI = total sum of EI of the individual parts of the component
E_i = elastic modulus of the part being considered
y_i = distance from the neutral axis to the point farthest from the neutral axis in the part being considered.

6.6.2.3 *Axial load*

The design axial strength at a section in a component shall satisfy

$$N^* \leq \phi N_n \qquad \text{(Eq. 6.23)}$$

where

N^* = design axial load
ϕN_n = design axial strength
ϕ = strength reduction factor
N_n = nominal axial strength

The nominal axial strength N_n is the minimum axial strength determined when each part of the section is checked with an equation of the form

$$N_n = kfA_{eff} \qquad \text{(Eq. 6.24)}$$

where

k = relevant modification factors
f = characteristic axial stress of part being considered
A_{eff} = effective area = $\Sigma EA/E_i$
ΣEA = total sum of EA of the individual parts of the component
E_i = elastic modulus of the part being considered where the strength is being determined.

6.6.2.4 *Shear*
The design shear strength at a section in a flexural component shall satisfy

$$V_p^* \leq \phi V_n \qquad \text{(Eq. 6.25)}$$

where

V_p^* = design shear force
ϕV_n = design shear strength
ϕ = strength reduction factor
V_n = nominal shear strength

The nominal shear strength V_n is the minimum shear strength determined when each part of the section is checked with an equation of the form

$$V_n = kfw\, I/Q \qquad \text{(Eq. 6.26)}$$

where

k = relevant modification factors
f = characteristic rolling or panel shear stress of part being considered
Q = area outside the section multiplied by its lever arm about the neutral axis
w = width of the shear surface
I/Q = $\Sigma EI/\Sigma EQ$ where ΣEQ is the sum of the EQ of only the required first moments of area of the parts outside the section being considered and ΣEI is the total sum of EI of the individual parts of the component.

6.6.2.5 *Deflections*
Deflection calculations for plywood components shall make due allowance for bending and shear deformation, joint slip and creep. Bending stiffness EI and shear stiffness GA shall be

determined from the sum of the *EI*'s and *GA*'s of the individual parts of the component. Deflections may be calculated using standard engineering formulae.

6.6.3 *Plate action*
If plywood bending perpendicular to the face grain is supported on four edges, Appendix G may be used to allow for plate action.

6.6.4 *Stability*

6.6.4.1 *General*
Design of plywood components shall make allowance for the stability of the whole and each part of the component using the stability factor k_8.

6.6.4.2 *Plywood*
Factor k_8 shall be determined from 6.3.8. For stressed skin panels loaded directly on the compression skin, stability need not be assessed if deflections of the skin are less than span/180, assuming simple support conditions in simple beam theory.

6.6.4.3 *Other parts*
The stability of each part of a component shall be determined from appropriate material standards. In web beams and diaphragms, the stability of the flange timber under load reversal and compression buckling should be calculated in accordance with 2.10.

C6.6.4
A method for calculating stability factors for webbed beams is given in Chapter B10 of the Timber Use Manual.

6.6.4.4 *Stiffeners in web beams*
The recommended distance between vertical stiffeners, L'_s in flexural components is given by figure 6.3, for locations where the applied shear is equal to the design shear strength. Where the applied shear is less, the spacing, L_s may be increased to:

$$L_s = L'_s \left(1 + \frac{(100 - p_s)}{25}\right) \qquad \text{(Eq. 6.27)}$$

where p is the applied shear (V_p^*) as a percentage of the design shear (V_n), provided that p_s shall not be taken as less than 50 %. The maximum value of L_s shall be $3L'_s$ or $3h_w$.

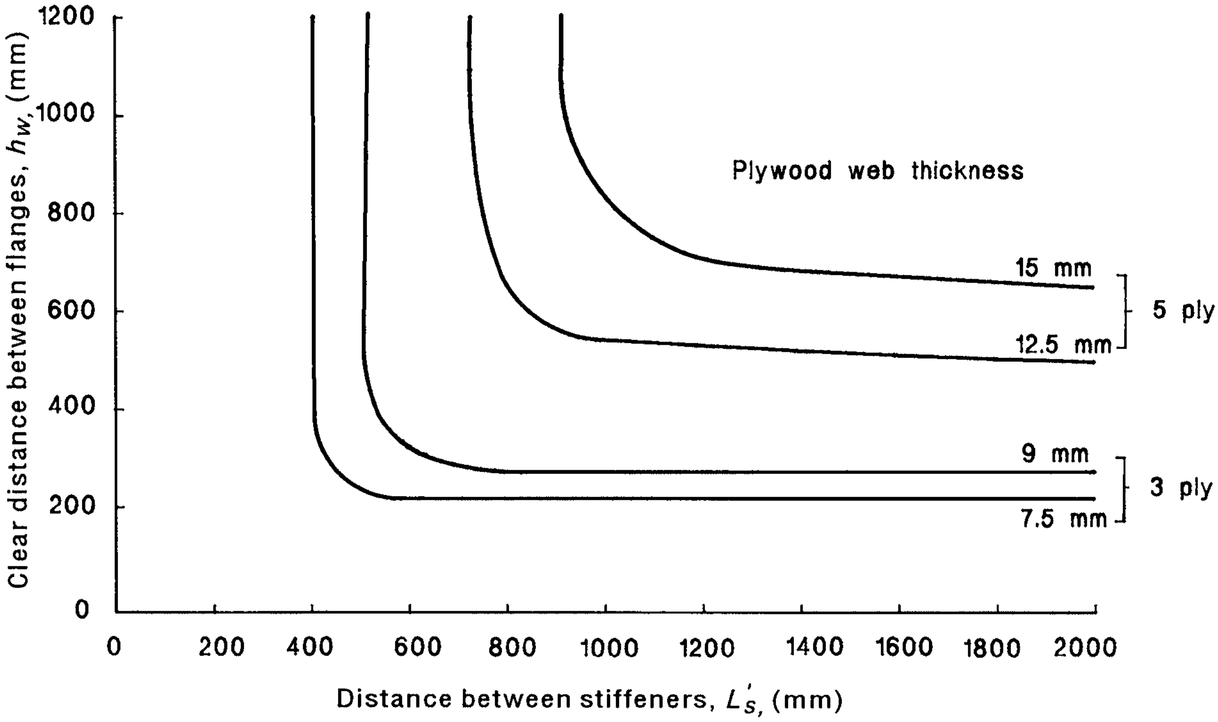

Figure 6.3 – Stiffener spacing for plywood webs in flexural components

6.6.5 *Nailed and screwed joints in plywood*

6.6.5.1 *General*
Refer to 4.2.2.2, 5.2.3 and 5.2.4. Provisions for nails can be applied also to screws of the same shank diameter.

6.6.5.2 *Spacing of nails in plywood*
Spacing of nails and screws in plywood is normally controlled by the limits on spacings in framing timbers. Nails shall not be closer than 3 nail diameters to the edge of the sheet.

6.6.5.3 *Nails in withdrawal*
Permanent axial loading of nails is not recommended. Withdrawal loads for nails and screws shall be as for solid timber of the same species.

6.6.6 *Other mechanical fasteners*
Other fasteners may be used with plywood (bolts, staples etc) provided suitable test data and design procedures are applied.

6.6.7 *Glued interfaces*

6.6.7.1 *General*
Structural glued joints between plywood and timber framing shall comply with 4.7.

C6.6.7.1 Nail gluing

For nail gluing of plywood to framing timber, nails should be spaced at not more than 75 mm with panels less than 10 mm thick and no more than 100 mm for other panels. There should be a row of nails for each 50 mm nominal width of framing timber. Nails should have a large head and should be at least three times the plywood thickness in length.

6.6.7.2 *Load capacity of a jointed interface*

The strength of a jointed interface shall satisfy

$$V^*_p \leq \phi Q_{nsi} \qquad \text{(Eq. 6.28)}$$

where

V^*_p	=	design shear force
ϕQ_{nsi}	=	design strength of the joint
ϕ	=	strength reduction factor
Q_{nsi}	=	nominal strength of the joint

For a glued joint the nominal strength of the joint can be taken as the lesser of

$$Q_{nsi} = k_1 k_{14} k_{15} k_{17} f_{sh} w \, I/Q \qquad \text{(Eq. 6.29)}$$

or

$$Q_{nsi} = k_1 k_{14} f_s w \, I/Q \qquad \text{(Eq. 6.30)}$$

and for a nailed joint the nominal strength of the joint can be taken as

$$Q_{nsi} = \frac{kQ_k w I/Q}{s} \qquad \text{(Eq. 6.31)}$$

where

k_1	=	load duration factor
f_{sh}	=	characteristic rolling shear stress f_{sr} or panel shear stress f_{ps} for plywood from table 6.1 as applicable
f_s	=	characteristic shear stress for timber from table 2
kQ_k	=	nominal strength of a nail from 4.2.2
I/Q	=	effective shear area, calculated as in 6.6.2.4 or
	=	$2/3bd$ for a rectangular section of uniform E glued at neutral axis
s	=	nail spacing for a single row of nails
k_{14}, k_{15}, k_{17}	=	modification factors given in 6.3

7 ROUND TIMBERS

7.1 General

7.1.1

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 procedure shall be similar to that given in section 3, Design of structural members, subject to the provisions of 7.2 and 7.3.

7.1.2

Naturally round timber shall be assumed to be in the green or dry condition according to its moisture content at the time of fabrication or installation and in service as shown in table 2.1 except that timbers in ground contact shall in all cases be assumed for design purposes to be in the green condition at the ground line.

7.2 Characteristic stresses and elastic moduli

The characteristic stresses and elastic moduli for logs, poles, or piles conforming in quality to the requirements of NZS 3605 shall be as given by table 7.1. For Australian timbers the values given by the limit states version of AS 1720 shall be used. The supplier of poles in the high density category shall either:

(a) Provide evidence that the poles have an outer density exceeding the minimum value specified, or

(b) Subject the poles to the proof testing requirements of NZS 3605.

Table 7.1 – Characteristic stresses (MPa) and modulus of elasticity (GPa) for naturally round softwood timber in green condition

Outer zone density, kg/m^3		Property					
Category	Minimum	f_b	f_t	f_c	f_s	f_p	E
High	450	52	31	25	3.5	7.7	12.1
Normal	350	38	23	16	3.1	6.4	8.7

7.3 Design

7.3.1

Round timber members shall be designed using the procedures outlined in section 3 subject to the additional requirements of 7.3 to 7.6 and changes to the appropriate section properties.

C7.3.1
The effect of 7.3.1 is that design strengths for naturally round timbers are obtained by modifying the characteristic stresses of table 7.1 in the same way as for sawn timbers but with three additional modification factors where applicable.

7.3.2

The slenderness coefficient, S for the calculation of stability factor, k_8 as used in 3.3.2 for round members in axial compression is defined as:

$$S = L / d_p$$

where

L = length between points of lateral restraint
d_p = mean of diameters at points of lateral restraint.

7.4 Modification factor, k_{20} for trimming or shaving

The characteristic stress and the modulus of elasticity shall be multiplied by the appropriate value of k_{20} as given by table 7.2 according to the method used to remove the bark. Where a naturally round timber is shaved to a smooth cylindrical or tapering form, as permitted by NZS 3605, or where a slab is removed to provide a flat bearing surface, it shall be considered to be machine shaved. Where the machine used to remove bark follows the pole contours it shall be considered to be machined peeled.

Table 7.2 – Peeling or shaving factor, k_{20}

Applied to	Machine peeling	Machine shaving
f_b or f_t	0.90	0.85
f_c, f_p or f_s	1.00	1.00
E	1.00	0.95

C7.4

The characteristic stresses and moduli of elasticity given in table 7.1 are applicable when the processes of branch trimming and bark removal cause no more damage, especially associated with knot whorls, than occurs in carefully prepared hand-peeled or hydraulically debarked poles.

7.5 Modification factor, k_{21} for preservative treatment involving steaming

For timber treated by the alternating pressure method or by the oscillating pressure method, the characteristic stress and the modulus of elasticity shall be multiplied by the appropriate value of k_{21} as given by table 7.3.

C7.5

These pressure treatments involve steaming of the timber. Details of the treatment are given in Timber Preservation Council specifications.

Table 7.3 – Steaming factor, k_{21}

Applied to	k_{21}
f_b or f_t	0.85
f_c, f_p or f_s	0.90
E	0.95

7.6 Modification factor, k_{22} for dry use conditions

For poles or parts of poles that are dry (see 7.1.2), the characteristic stress and the modulus of elasticity shall be multiplied by the appropriate value of k_{22} as given by table 7.4.

Table 7.4 – Dry use factor, k_{22}

Applied to	k_{22}
f_b, f_t, f_c or f_p	1.25
f_s	1.06
E	1.12

7.7 Effective sections

Section properties shall be calculated from the diameter at the critical section.

8 GLUED LAMINATED TIMBER

8.1 Scope
Section 8 covers the design of glued laminated timber members manufactured in accordance with NZS 3606.

8.2 Specification
The information supplied by the designer to the manufacturer of a glue laminated member shall include the following:

(a) Length, depth, width and shape of the member;

(b) Camber;

(c) Number, thickness, grade, species, and arrangement of laminations;

(d) Limitations on placement of butt joints (if used);

(e) Exposure category and service equilibrium moisture content;

(f) Preservative treatment (if any);

(g) Surface finish;

(h) Moisture content.

C8.2
Exposure categories and corresponding adhesives are specified in NZS 3606, section 5. Exposure categories defined therein are:

Category A (interior): In buildings provided with ventilation and with heat either whole or part-time and where the timber is permanently below 18 % moisture content, for example, houses and offices.

Category B (occasionally damp). In buildings with warm and damp conditions or very wide cyclical variations of temperature and humidity, such as laundries and dye works. Exposed to exterior atmosphere but sheltered from direct sun and rain, such as open sheds, porches and exposed beams under soffits.

Category C (fully exposed): Exposed directly to sun and rain, or in buildings with very high humidity such as wool scouring plants.

8.3 Standard sizes

8.3.1
Standard widths of horizontally laminated members (or depths of vertically laminated members) should be used.

C8.3.1
Standard widths are shown in table 8.1 when in the finished condition.

8.3.2
Standard thicknesses of laminations in straight members are:

(a) 45 mm if obtained from 50 mm call size laminations;

(b) 19 mm if obtained from 25 mm call size laminations.