MAGRYN

STRUCTURAL CALCULATIONS

for

ALUMINIUM BATTENS AND FIXINGS

for

KNOTWOOD PTY LTD

Project No. 16391
November 2016

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CALCULATION SHEET

PROJECT Battens & Fixings
Knotwood

DATE Nov 2016 SHEET NO 1
IN NA JOB NO 16391

Wind Speed Determination

to AS/NZS 1170.2 - 2011 :

$V_{sit,\beta} = V_R M_d (M_{z,cat} M_s M_t)$

$p = (0.5 \rho_{air})[V_{des,\theta}]^2 C_{fig} C_{dyn}$

$C_{fig} = C_{p,n} K_p$ OR $C_{fig} = K_{ar} K_i C_d$

Building importance 2 $\rightarrow V_{500}$

$V_R = 45$ m/s (Region A)

57 m/s (Region B)

$66 \times F_C = 66 \times 1.05 = 69.3$ m/s (Region C)

$M_d = 1.0$ (any direction)

Terrain category 2

$M_{z,cat} = 1.08$ (height ≤ 20 m)

$M_s = 1.0$

$M_t = 1.0$

$\rho_{air} = 1.2$ kg/m³

$C_{dyn} = 1.0$

$C_{p,n} = 1.61$ $(\theta = 0°)$
1.61 $(\theta = 45°)$
± 1.2 $(\theta = 90°)$
] with $b/c \leq 5$

$K_p = 1 - (1 - \delta)^2$

$= 1.0$

$K_{ar} = 1.0$

$k_i = 1.0$

$C_d = 1.70$ (Ellipse)

1.20 (Square with round corners)

2.20 (Square, sharp-edged)

2.78 (Rectangular prism) – for $d/b = 0.50$

→ C_{fig} (critical) $= K_{ar}\, k_i\, C_d$

$= 1.0 \times 1.0 \times 2.78 = 2.78$

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Region A

$V_{sit,\beta} = 45 \times 1.0 \times (1.08 \times 1.0 \times 1.0)$

$= 48.6$ m/s

$C_{fig} = 2.78$

$p = (0.5 \times 1.2) \times (48.6)^2 \times (2.78) \times 1.0$

$= \underline{\underline{3.94 \text{ kPa}}}$

Region B

$V_{sit,\beta} = 57 \times 1.0 \times (1.08 \times 1.0 \times 1.0)$

$= 61.6$ m/s

$C_{fig} = 2.78$

$p = (0.5 \times 1.2) \times (61.6)^2 \times (2.78) \times 1.0$

$= \underline{\underline{6.33 \text{ kPa}}}$

Region C

$V_{sit,\beta} = 69.3 \times 1.0 \times (1.08 \times 1.0 \times 1.0)$

$= 74.8$ m/s

$C_{fig} = 2.78$

$p = (0.5 \times 1.2) \times (74.8)^2 \times (2.78) \times 1.0$

$= \underline{\underline{9.33 \text{ kPa}}}$

Aluminium :

Components :
- Starter Bracket
- Battens (50 mm, 100 mm, 150 mm, 200 mm)
- Batten Joiner
- Batten 45° Joiner
- Elliptical Cap (150 mm, 200 mm)

Alloy & Temper 6063 - T6 (AS/NZS 1664.1)

Mechanical Properties :	Capacity Factors :
F_{tu} = 207 MPa	ϕ_y = 0.95
F_{ty} = 172 MPa	ϕ_b = 0.85
F_{cy} = 172 MPa	ϕ_c = 0.85
F_{su} = 131 MPa	ϕ_u = 0.85
F_{sy} = 96 MPa	ϕ_{cp} = 0.80
F_{bu} = 434 MPa	ϕ_v = 0.80
F_{by} = 276 MPa	ϕ_{vp} = 0.90
E = 70 000 MPa	ϕ_w = 0.90

Coefficients :

k_t = 1.0

k_c = 1.12

k_1 = 0.50, k_2 = 2.04 } flat plates in bending

k_1 = 0.35, k_2 = 2.27 } flat plates in compression

Shear at 'Clip-in' connections : (Clause 3.4.24)

$$B_s = F_{sy}\left[1 + \frac{(F_{sy})^{1/3}}{17.7}\right] = 96 \times \left(1 + \frac{(96)^{1/3}}{17.7}\right) = 121 \text{ MPa}$$

$$D_s = \frac{B_s}{10}\left(\frac{B_s}{E}\right)^{1/2} = \frac{121}{10} \times \left(\frac{121}{70000}\right)^{1/2} = 0.50 \text{ MPa}$$

$$C_s = 0.41 \frac{B_s}{D_s} = 0.41 \times \frac{121}{0.50} = 99.2$$

$$S_1 = \frac{B_s - \phi_y F_{sy} / \phi_{vp}}{1.25\ D_s} = \frac{121 - 0.95 \times 96 / 0.90}{1.25 \times 0.50} = 31.5$$

$h/t < S_1$:

$$\phi F_L = \phi_y F_{sy}$$

$$= 0.95 \times 96 = 91.2 \text{ MPa}$$

$$\Rightarrow \phi V = \phi F_L A$$

Bending in 'Plate Components' : (Clause 3.4.14)

$$B_{br} = 1.3 F_{cy}\left[1 - \frac{(F_{cy})^{1/3}}{13.3}\right] = 1.3 \times 172 \times \left(1 + \frac{(172)^{1/3}}{13.3}\right) = 317 \text{ MPa}$$

$$D_{br} = \frac{B_{br}}{20}\left(\frac{6 B_{br}}{E}\right)^{1/2} = \frac{317}{20} \times \left(\frac{6 \times 317}{70000}\right)^{1/2} = 2.61 \text{ MPa}$$

$$C_{br} = \frac{2\ B_{br}}{3\ D_{br}} = \frac{2 \times 317}{3 \times 2.61} = 81.0$$

$$S_1 = \frac{B_{br} - 1.3 \frac{\phi_y F_{cy}}{\phi_b}}{2.3\ D_{br}} = \frac{317 - 1.3 \times \frac{0.95 \times 172}{0.85}}{2.3 \times 2.61} = 11.2$$

$\frac{d}{t}\sqrt{\frac{L_b}{d}} < S_1$:

$$\phi F_L = 1.30\ \phi_y F_{cy}$$

$$= 1.30 \times 0.95 \times 172 = 212 \text{ MPa}$$

$$\Rightarrow \phi M = \phi F_L Z$$

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Compression in 'Plate Components' : (Clause 3.4.9.2)

$$B_p = F_{cy}\left[1 + \frac{(F_{cy})^{1/3}}{21.7}\right] = 172 \times \left(1 + \frac{(172)^{1/3}}{21.7}\right) = 216 \text{ MPa}$$

$$D_p = \frac{B_p}{10}\left(\frac{B_p}{E}\right)^{1/2} = \frac{216}{10} \times \left(\frac{216}{70000}\right)^{1/2} = 1.20 \text{ MPa}$$

$$C_p = 0.41\,\frac{B_p}{D_p} = 0.41 \times \frac{216}{1.20} = 73.8$$

$$S_1 = \frac{B_p - \frac{\phi_y F_{cy}}{\phi_c k_c}}{5.1\, D_p} = \frac{216 - \frac{0.95 \times 172}{0.85 \times 1.12}}{5.1 \times 1.20} = 7.25$$

$b/t < S_1$:

$$\phi F_L = \phi_y F_{cy} / k_c$$

$$= 0.95 \times 172 / 1.12 = 146 \text{ MPa}$$

$$S_2 = \frac{C_p}{5.1} = \frac{73.8}{5.1} = 14.5$$

$S_1 < b/t < S_2$:

$$\phi F_L = \phi\left(B_p - 5.1\, D_p\, \frac{b}{t}\right)$$

$b/t > S_2$:

$$\phi F_L = \frac{\phi_c \pi^2 E}{(5.1\, b/t)^2}$$

$$\Longrightarrow \phi N = \phi F_L A$$

Battens – 200 mm wide :

width = 200 mm max. (design with 250 mm) ← to allow for 45° Joiner

weight = 0.924 + 1.502 + 3.752 = 6.178 kg/m

DL : 1.35 × weight

1.35 × 6.178 = 0.083 kN/m

WL : 1.0 × p × width

1.0 × 3.94 × 0.250 = 0.985 kN/m (Region A)

1.0 × 6.33 × 0.250 = 1.583 kN/m (Region B)

1.0 × 9.33 × 0.250 = 2.333 kN/m (Region C)

Moment at Wall Face :

$M^* = WL \times 0.250/2$

Shear at 'Clip-in' connection :

$V^* = M^* / 0.0436$

Pull-out at Single Fixing (central) :

$N^* = M^* / 0.025$

Pull-out at Double Fixing (@ 25 mm cts) :

$N^* = M^* / 0.0375$

Moment in Wall Bracket Plate :

$M_{pl}^* = V^* \times 0.0218$

Components - Regions A, B, C :

$M^* = 2.333 \times 0.250 / 2 = 0.292$ kNm/m

$V^* = 0.292 / 0.0436 = 6.689$ kN/m

$M^*_{pl} = 6.689 \times 0.0218 = 0.146$ kNm/m

Shear in 'Clip-in' connection :

h/t (max.) $= 3.31 / 1000 = 0.00331$

h/t (min.) $= 1.20 / 1000 = 0.0012$

$\Rightarrow h/t \ll S_1$

(2 No. clips)

A (critical) $= 2\,ht = 2 \times 1.20 \times 1000 = 2400$ mm²

$\Rightarrow \phi V = 91.2 \times 2400 = 219$ kN/m $> V^*$ OK!

Compression in 'Plate Component' :

b/t (max.) $= 44.60 / 1.50 = 29.7$

b/t (min.) $= 44.80 / 1.80 = 24.9$

$\Rightarrow b/t > S_2$

$$\phi F_L = \frac{0.85 \times \pi^2 \times 70000}{(5.1 \times 29.7)^2} = 25.6 \text{ MPa}$$

A (critical) $= dt = 1000 \times 1.50 = 1500$ mm²

$\Rightarrow \phi N = 25.6 \times 1500 = 38.4$ kN/m $> V^*$ OK!

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<u>Bending in Starter Bracket :</u>

$$\frac{d}{t}\sqrt{\frac{L_b}{d}} = \frac{3.0}{1000} \times \sqrt{\frac{25.0}{3.0}} = 0.009$$

$$\Rightarrow \frac{d}{t}\sqrt{\frac{L_b}{d}} \ll S_1$$

$$Z = t d^2/6 = 1000 \times 3.0^2/6 = 1500 \text{ mm}^3$$

$$\Rightarrow \phi M = 212 \times 1500 = 0.318 \text{ kNm/m} \quad > M^*_{pl} \quad \text{OK!}$$

Fixings - Region A :

Single Fixing :

Shear = $\sqrt{0.083^2 + 0.985^2}$ = 0.99 kN/m

Pull-out = (0.985 × 0.250/2)/0.025 = 4.93 kN/m

Double Fixing :

Shear = 0.99 / 2 = 0.49 kN/m

Pull-out = (0.985 × 0.250/2)/0.0375 = 3.28 kN/m

Fixings - Region B :

Single Fixing :

Shear = $\sqrt{0.083^2 + 1.583^2}$ = 1.59 kN/m

Pull-out = (1.583 × 0.250/2)/0.025 = 7.92 kN/m

Double Fixing :

Shear = 1.59 / 2 = 0.79 kN/m

Pull-out = (1.583 × 0.250/2)/0.0375 = 5.28 kN/m

Fixings - Region C :

Single Fixing :

Shear = $\sqrt{0.083^2 + 2.333^2}$ = 2.33 kN/m

Pull-out = (2.333 × 0.250/2)/0.025 = 11.7 kN/m

Double Fixing :

Shear = 2.33 / 2 = 1.17 kN/m

Pull-out = (2.333 × 0.250/2)/0.0375 = 7.78 kN/m

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Battens - 350 mm wide :

width = 350 mm max. (installed at 90° only)

weight = 0.924 + 3.297 + 3.752 = 7.973 kg/m

DL : 1.35 × weight

1.35 × 7.973 = 0.108 kN/m

WL : 1.0 × p × width

1.0 × 3.94 × 0.350 = 1.379 kN/m (Region A)

1.0 × 6.33 × 0.350 = 2.216 kN/m (Region B)

1.0 × 9.33 × 0.350 = 3.266 kN/m (Region C)

Moment at Wall Face :

$M^* = WL \times 0.350 / 2$

Shear at 'Clip-in' connection :

$V^* = M^* / 0.0436$

Pull-out at Single Fixing (central) :

$N^* = M^* / 0.025$

Pull-out at Double Fixing (@25 mm cts) :

$N^* = M^* / 0.0375$

Moment in Wall Bracket Plate :

$M^*_{pl} = V^* \times 0.025$

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Components - Regions A, B, C :

$M^* = 3.266 \times 0.350 / 2 = 0.572$ kNm/m

$V^* = 0.572 / 0.0436 = 13.11$ kN/m

$M^*_{pl} = 13.11 \times 0.0218 = 0.286$ kNm/m

Shear in 'Clip-in' connection :

$\Rightarrow \phi V = 219$ kN/m $> V^*$ OK!

Compression in 'Plate Component' :

$\Rightarrow \phi N = 38.4$ kN/m $> V^*$ OK!

Bending in Starter Bracket :

$\Rightarrow \phi M = 0.318$ kNm/m $> M^*_{pl}$ OK!

Fixings – Region A:

Single Fixing:

Shear = $\sqrt{0.108^2 + 1.379^2}$ = 1.38 kN/m

Pull-out = (1.379 × 0.350/2)/0.025 = 9.65 kN/m

Double Fixing:

Shear = 1.38 / 2 = 0.69 kN/m

Pull-out = (1.379 × 0.350/2)/0.0375 = 6.44 kN/m

Fixings – Region B:

Single Fixing:

Shear = $\sqrt{0.108^2 + 2.216^2}$ = 2.22 kN/m

Pull-out = (2.216 × 0.350/2)/0.025 = 15.5 kN/m

Double Fixing:

Shear = 2.22 / 2 = 1.11 kN/m

Pull-out = (2.216 × 0.350/2)/0.0375 = 10.3 kN/m

Fixings – Region C:

Single Fixing:

Shear = $\sqrt{0.108^2 + 3.266^2}$ = 3.27 kN/m

Pull-out = (3.266 × 0.350/2)/0.025 = 22.9 kN/m

Double Fixing:

Shear = 3.27 / 2 = 1.64 kN/m

Pull-out = (3.266 × 0.350/2)/0.0375 = 15.2 kN/m

Battens - 350 mm wide at 45°:

width = 350 mm max. (design with 400 mm) ← to allow for 45° Joiner

weight = 0.924 + 1.502 + 3.297 + 3.752 = 9.475 kg/m

DL : 1.35 × weight

1.35 × 9.475 = 0.128 kN/m

WL : 1.0 × p × width

1.0 × 3.94 × 0.400 = 1.576 kN/m (Region A)

1.0 × 6.33 × 0.400 = 2.532 kN/m (Region B)

1.0 × 9.33 × 0.400 = 3.732 kN/m (Region C)

Moment at Wall Face :

$M^* = WL \times 0.400/2$

Shear at 'Clip-in' connection :

$V^* = M^*/0.0436$

Pull-out at Single Fixing (central) :

$N^* = M^*/0.025$

Pull-out at Double Fixing (@ 25 mm cts) :

$N^* = M^*/0.0375$

Moment in Wall Bracket Plate :

$M^*_{pl} = V^* \times 0.025$

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Components – Regions A,B :

$M^* = 2.532 \times 0.400 / 2 = 0.506$ kNm/m

$V^* = 0.506 / 0.0436 = 11.61$ kN/m

$M^*_{pl} = 11.61 \times 0.0218 = 0.253$ kNm/m

Shear in 'Clip-in' connection :

⟹ $\phi V = 219$ kN/m $> V^*$ OK!

Compression in 'Plate Component' :

⟹ $\phi N = 38.4$ kN/m $> V^*$ OK!

Bending in Starter Bracket :

⟹ $\phi M = 0.318$ kNm/m $> M^*_{pl}$ OK!

Fixings - Region A:

Single Fixing:

Shear = $\sqrt{0.128^2 + 1.576^2}$ = 1.58 kN/m

Pull-out = (1.576 × 0.400/2)/0.025 = 12.6 kN/m

Double Fixing:

Shear = 1.58/2 = 0.79 kN/m

Pull-out = (1.576 × 0.400/2)/0.0375 = 8.42 kN/m

Fixings - Region B:

Single Fixing:

Shear = $\sqrt{0.128^2 + 2.532^2}$ = 2.54 kN/m

Pull-out = (2.532 × 0.400/2)/0.025 = 20.3 kN/m

Double Fixing:

Shear = 2.54/2 = 1.27 kN/m

Pull-out = (2.532 × 0.400/2)/0.0375 = 13.5 kN/m

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Battens – 500 mm wide :

width = 500 mm max. (design with 550 mm) ← to allow for 45° joiner

weight = 0.924 + 1.502 + 2 × 3.297 + 3.752 = 12.772 kg/m

DL : 1.35 × weight

1.35 × 12.772 = 0.172 kN/m

WL : 1.0 × p × width

1.0 × 3.94 × 0.550 = 2.167 kN/m (Region A)

1.0 × 6.33 × 0.550 = 3.482 kN/m (Region B)

1.0 × 9.33 × 0.550 = 5.132 kN/m (Region C)

Moment at Wall Face :

$M^* = WL \times 0.550/2$

Shear at 'Clip-in' connection :

$V^* = M^*/0.0436$

Pull-out at Single Fixing (central) :

$N^* = M^*/0.025$

Pull-out at Double Fixing (@25 mm cts) :

$N^* = M^*/0.0375$

Moment in Wall Bracket Plate :

$M^*_{pl} = V^* \times 0.025$

Components - Region A:

$M^* = 2.167 \times 0.550 / 2 = 0.596$ kNm/m

$V^* = 0.596 / 0.0436 = 13.67$ kN/m

$M^*_{pl} = 13.67 \times 0.0218 = 0.298$ kNm/m

Shear in 'Clip-in' connection:

$\Longrightarrow \phi V = 219$ kN/m $> V^*$ OK!

Compression in 'Plate Component':

$\Longrightarrow \phi N = 38.4$ kN/m $> V^*$ OK!

Bending in Starter Bracket:

$\Longrightarrow \phi M = 0.318$ kNm/m $> M^*_{pl}$ OK!

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Fixings - Region A:

Single Fixing:

Shear $= \sqrt{0.172^2 + 2.167^2} = 2.17$ kN/m

Pull-out $= (2.167 \times 0.550/2)/0.025 = 23.8$ kN/m

Double Fixing:

Shear $= 2.17/2 = 1.09$ kN/m

Pull-out $= (2.167 \times 0.550/2)/0.0375 = 15.9$ kN/m

Fixings to Aluminium Starter Bracket :

Shear : (Clause 5.3.2)

Tear - Out :

$\phi P_{as} = \phi_{sc} P_{us}$ $\phi_{sc} = 0.50$

$P_{us} = \frac{\phi_y}{\phi_{sc}} D F_{by} t$

$P_{us} = \frac{\phi_u}{1.2 \phi_{sc}} D F_{bu} t$

$P_{us} = 4.2 (t^3 D)^{1/2} F_{tu}$

Tension : (Clause 5.3.3)

Pull - Out :

not applicable

Pull - Over :

$\phi P_{at} = \phi_{sc} P_{ut}$ $\phi_{sc} = 0.50$

$P_{ut} = C t F_{tu} (D_{ws} - D_h)$

$C = 1.0$

t = member thickness

D = nominal fixing diameter

D_{ws} = nominal washer / head diameter (≤ 13 mm)

D_h = nominal hole diameter

Aluminium 6063 - T6 :

$F_{by} = 276$ MPa $\phi_y = 0.95$

$F_{bu} = 434$ MPa $\phi_u = 0.85$

$F_{tu} = 207$ MPa

#10 Screws :

Shear :

$$P_{us} = \frac{0.95}{0.50} \times 4.7 \times 276 \times 3.0 = 7.39 \text{ kN}$$

$$= \frac{0.85}{1.2 \times 0.50} \times 4.7 \times 434 \times 3.0 = 8.67 \text{ kN}$$

$$= 4.2 \times (3.0^3 \times 4.7)^{1/2} \times 207 = 9.79 \text{ kN}$$

$$\Rightarrow \phi P_{as} = 0.50 \times 7.39 = \underline{\underline{3.70 \text{ kN}}} \text{ per screw}$$

Pull-Over :

$$P_{ut} = 1.0 \times 3.0 \times 207 \times (9.4 - 5.7) = 2.30 \text{ kN}$$

$$\Rightarrow \phi P_{at} = 0.50 \times 2.30 = \underline{\underline{1.15 \text{ kN}}} \text{ per screw}$$

#12 Screws :

Shear :

$$P_{us} = \frac{0.95}{0.50} \times 5.5 \times 276 \times 3.0 = 8.65 \text{ kN}$$

$$= \frac{0.85}{1.2 \times 0.50} \times 5.5 \times 434 \times 3.0 = 10.1 \text{ kN}$$

$$= 4.2 \times (3.0^3 \times 5.5)^{1/2} \times 207 = 10.6 \text{ kN}$$

$$\Rightarrow \phi P_{as} = 0.50 \times 8.65 = \underline{\underline{4.33 \text{ kN}}} \text{ per screw}$$

Pull-Over :

$$P_{ut} = 1.0 \times 3.0 \times 207 \times (11.0 - 6.5) = 2.79 \text{ kN}$$

$$\Rightarrow \phi P_{at} = 0.50 \times 2.79 = \underline{\underline{1.40 \text{ kN}}} \text{ per screw}$$

#14 Screws :

Shear :

$P_{us} = \frac{0.95}{0.50} \times 6.3 \times 276 \times 3.0 = 9.91$ kN

$= \frac{0.85}{1.2 \times 0.50} \times 6.3 \times 434 \times 3.0 = 11.6$ kN

$= 4.2 \times (3.0^3 \times 6.3)^{1/2} \times 207 = 11.3$ kN

$\Rightarrow \phi P_{as} = 0.50 \times 9.91 = \underline{4.96 \text{ kN}}$ per screw

Pull-Over :

$P_{ut} = 1.0 \times 3.0 \times 207 \times (12.6 - 7.3) = 3.29$ kN

$\Rightarrow \phi P_{at} = 0.50 \times 3.29 = \underline{1.65 \text{ kN}}$ per screw

M8 Bolt :

Shear : (Pull-Over N/A)

$P_{us} = \frac{0.95}{0.50} \times 8.0 \times 276 \times 3.0 = 12.6$ kN

$= \frac{0.85}{1.2 \times 0.50} \times 8.0 \times 434 \times 3.0 = 14.8$ kN

$= 4.2 \times (3.0^3 \times 8.0)^{1/2} \times 207 = 12.8$ kN

$\Rightarrow \phi P_{as} = 0.50 \times 12.6 = \underline{6.30 \text{ kN}}$ per bolt

M10 Bolt :

Shear : (Pull-Over N/A)

$P_{us} = \frac{0.95}{0.50} \times 10.0 \times 276 \times 3.0 = 15.7$ kN

$= \frac{0.85}{1.2 \times 0.50} \times 10.0 \times 434 \times 3.0 = 18.4$ kN

$= 4.2 \times (3.0^3 \times 10.0)^{1/2} \times 207 = 14.3$ kN

$\Rightarrow \phi P_{as} = 0.50 \times 14.3 = \underline{7.15 \text{ kN}}$ per bolt

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Fixings to side of Aluminium Components :

→ only Shear for self-weight.

10 Screws :

$$P_{us} = \frac{0.95}{0.50} \times 4.7 \times 276 \times 1.5 = 3.70 \text{ kN}$$
$$= \frac{0.85}{1.2 \times 0.50} \times 4.7 \times 434 \times 1.5 = 4.33 \text{ kN}$$
$$= 4.2 \times (1.5^3 \times 4.7)^{1/2} \times 207 = 3.46 \text{ kN}$$
$$\Rightarrow \phi P_{as} = 0.50 \times 3.46 = \underline{\underline{1.73 \text{ kN}}} \quad \text{per screw}$$

30 Aluminium Rivets :

$$P_{us} = \frac{0.95}{0.50} \times 3.3 \times 276 \times 1.5 = 2.60 \text{ kN}$$
$$= \frac{0.85}{1.2 \times 0.50} \times 3.3 \times 434 \times 1.5 = 3.04 \text{ kN}$$
$$= 4.2 \times (1.5^3 \times 3.3)^{1/2} \times 207 = 2.90 \text{ kN}$$
$$\Rightarrow \phi P_{as} = 0.50 \times 2.60 = \underline{\underline{1.30 \text{ kN}}} \quad \text{per rivet}$$

20 Aluminium Rivets :

$$P_{us} = \frac{0.95}{0.50} \times 4.1 \times 276 \times 1.5 = 3.23 \text{ kN}$$
$$= \frac{0.85}{1.2 \times 0.50} \times 4.1 \times 434 \times 1.5 = 3.78 \text{ kN}$$
$$= 4.2 \times (1.5^3 \times 4.1)^{1/2} \times 207 = 3.23 \text{ kN}$$
$$\Rightarrow \phi P_{as} = 0.50 \times 3.23 = \underline{\underline{1.62 \text{ kN}}} \quad \text{per rivet}$$