Screws in Breced Ecococon panel calculation

Wood type:	C24
Width of wooden element:	$t_1 := 45 \cdot mm$
Height of wooden element:	$t_2 := 95 \cdot mm$
Bracing angle:	$\alpha := 63.44 \cdot deg$
Screw length:	$l_s := 120 \cdot mm$
Screw diameter:	$d := 8 \cdot mm$
Threaded part of the screw 8,0x120:	$l_{g.1} := 80\ mm$
	$l_{ef.1} := l_{g.1} - d = 72\ mm$
Threaded part of the screw 8,0x100:	$l_{g.2} := 60\ mm$
	$l_{ef.2} := l_{g.2} - d = 52\ mm$
Threaded part of the screw 8,0x80:	$l_{g.3} := 50\ mm$
	$l_{ef.3} := l_{g.3} - d = 42\ mm$
Charac. density of the timber	$\varrho_k := 350 \cdot \frac{kg}{m^3}$
Partial factor for material properties:	$\gamma_M := 1.30$
Charac. tensile strength of each screw:	$f_{u.k} := 600 \cdot MPa$
Charac. load-carrying capacity of axially loaded screw:	$f_{c.90.k} := 5.1 \cdot MPa$
Material factor for connections:	$\gamma_{M.connection} := 1.3$
Factor for duration loading and service:	$k_{mod} := 0.6$

Axial design withdrawal capacity of the screw

$$f_{ax.k} := 3.6 \cdot 10^{-3} \cdot \left(q_k \cdot \frac{m^3}{kg} \right)^{1.5} \cdot N \cdot mm^{-2} = 23.572 \; MPa$$

$$f_{ax.\alpha.k} := \frac{f_{ax.k}}{(\sin(\alpha))^2 + 1.5 \cdot (\cos(\alpha))^2} = 21.43 \; MPa$$

For screw 8,0x120mm: $\beta := 1$

$$F_{ax.\alpha.Rk.1} := \left(\boldsymbol{\pi} \cdot d \cdot l_{ef.1} \cdot mm^{-2} \right)^{0.8} \cdot f_{ax.\alpha.k} \cdot mm^2 = 8.651 \; kN \qquad F_{ax.Rd.1} := \frac{F_{ax.\alpha.Rk.1} \cdot k_{mod}}{\gamma_{M.connection}} = 3.993 \; kN$$

For screw 8,0x100mm:

$$F_{ax.\alpha.Rk.2} := \left(\boldsymbol{\pi} \cdot d \cdot l_{ef.2} \cdot mm^{-2} \right)^{0.8} \cdot f_{ax.\alpha.k} \cdot mm^2 = 6.668 \; kN \qquad F_{ax.Rd.2} := \frac{F_{ax.\alpha.Rk.2} \cdot k_{mod}}{\gamma_{M.connection}} = 3.078 \; kN$$

Maximal axial tensional load in bracing:

$$F_{ax.Rd} := \left(F_{ax.Rd.1} + F_{ax.Rd.2} \right) = 7.071 \; kN$$

Embedment strength of timber

$$f_{h.k} := 0.082 \cdot \left(q_k \cdot \frac{m^3}{kg} \right) \cdot \left(d \cdot mm^{-1} \right)^{-0.3} \cdot N \cdot mm^{-2} = 15.38 \; MPa$$

Yield moment of a screw

$$M_{y.Rk} := 0.15 \cdot \left(f_{u.k} \cdot \frac{mm^2}{N} \right) \cdot \left(d \cdot mm^{-1} \right)^{2.6} \cdot N \cdot mm = \left(2.006 \cdot 10^4 \right) \; N \cdot mm$$

Shear strength for the screw 8,0x120

Failure mode (a): $F_{v.Rk.a} := f_{h.k} \cdot t_1 \cdot d = 5.537\ kN$

Failure mode (b): $F_{v.Rk.b} := f_{h.k} \cdot t_2 \cdot d = 11.689\ kN$

Failure mode (c):

$$F_{v.Rk.c} := \frac{f_{h.k} \cdot t_1 \cdot d}{1+\beta} \cdot \left(\sqrt{\beta + 2 \cdot \beta^2 \cdot \left(1 + \frac{t_2}{t_1} + \left(\frac{t_2}{t_1} \right)^2 \right) + \beta^3 \cdot \left(\frac{t_2}{t_1} \right)^2} - \beta \cdot \left(1 + \left(\frac{t_2}{t_1} \right) \right) \right) + \frac{F_{ax.\alpha.Rk.1}}{4} = 6.113\ kN$$

$$F_{v.Rk.d} := 1.05 \cdot \frac{f_{h.k} \cdot t_1 \cdot d}{2+\beta} \cdot \left(\sqrt{2 \cdot \beta \cdot (1+\beta) + \frac{4 \cdot \beta \cdot (2+\beta) \cdot M_{y.Rk}}{f_{h.k} \cdot t_1^{\ 2} \cdot d}} - \beta \right) + \frac{F_{ax.\alpha.Rk.1}}{4} = 4.543\ kN$$

$$F_{v.Rk.e} := 1.05 \cdot \frac{f_{h.k} \cdot t_2 \cdot d}{1+2 \cdot \beta} \cdot \left(\sqrt{2 \cdot \beta^2 \cdot (1+\beta) + \frac{4 \cdot \beta \cdot (1+2 \cdot \beta) \cdot M_{y.Rk}}{f_{h.k} \cdot t_2^{\ 2} \cdot d}} - \beta \right) + \frac{F_{ax.\alpha.Rk.1}}{4} = 6.473\ kN$$

$$F_{v.Rk.f} := 1.15 \left(\sqrt{\frac{2 \cdot \beta}{1+\beta} \cdot (2 \cdot M_{y.Rk} \cdot f_{h.k} \cdot d)} \right) + \frac{F_{ax.\alpha.Rk.1}}{4} = 4.718\ kN$$

$$F_{v.Rk} := min\left(F_{v.Rk.a}, F_{v.Rk.b}, F_{v.Rk.c}, F_{v.Rk.d}, F_{v.Rk.e}, F_{v.Rk.f}\right) = 4.543\ kN \qquad F_{v.Rd.1} := \frac{F_{v.Rk} \cdot k_{mod}}{\gamma_{M.connection}} = 2.097\ kN$$

Shear strength for the screw 8,0x100

Failure mode (a): $F_{v.Rk.a} := f_{h.k} \cdot t_1 \cdot d = 5.537\ kN$

Failure mode (b): $F_{v.Rk.b} := f_{h.k} \cdot t_2 \cdot d = 11.689\ kN$

Failure mode (c):

$$F_{v.Rk.c} := \frac{f_{h.k} \cdot t_1 \cdot d}{1+\beta} \cdot \left(\sqrt{\beta + 2 \cdot \beta^2 \cdot \left(1 + \frac{t_2}{t_1} + \left(\frac{t_2}{t_1} \right)^2 \right) + \beta^3 \cdot \left(\frac{t_2}{t_1} \right)^2} - \beta \cdot \left(1 + \left(\frac{t_2}{t_1} \right) \right) \right) + \frac{F_{ax.\alpha.Rk.2}}{4} = 5.617\ kN$$

$$F_{v.Rk.d} := 1.05 \cdot \frac{f_{h.k} \cdot t_1 \cdot d}{2+\beta} \cdot \left(\sqrt{2 \cdot \beta \cdot (1+\beta) + \frac{4 \cdot \beta \cdot (2+\beta) \cdot M_{y.Rk}}{f_{h.k} \cdot t_1^{\ 2} \cdot d}} - \beta \right) + \frac{F_{ax.\alpha.Rk.2}}{4} = 4.048\ kN$$

$$F_{v.Rk.e} := 1.05 \cdot \frac{f_{h.k} \cdot t_2 \cdot d}{1+2 \cdot \beta} \cdot \left(\sqrt{2 \cdot \beta^2 \cdot (1+\beta) + \frac{4 \cdot \beta \cdot (1+2 \cdot \beta) \cdot M_{y.Rk}}{f_{h.k} \cdot t_2^{\ 2} \cdot d}} - \beta \right) + \frac{F_{ax.\alpha.Rk.2}}{4} = 5.977\ kN$$

$$F_{v.Rk.f} := 1.15 \left(\sqrt{\frac{2 \cdot \beta}{1+\beta} \cdot (2 \cdot M_{y.Rk} \cdot f_{h.k} \cdot d)} \right) + \frac{F_{ax.\alpha.Rk.2}}{4} = 4.222\ kN$$

$$F_{v.Rk} := min\left(F_{v.Rk.a}, F_{v.Rk.b}, F_{v.Rk.c}, F_{v.Rk.d}, F_{v.Rk.e}, F_{v.Rk.f}\right) = 4.048\ kN \qquad F_{v.Rd.2} := \frac{F_{v.Rk} \cdot k_{mod}}{\gamma_{M.connection}} = 1.868\ kN$$

Shear strength of the connection

$$F_{v.Rd} := F_{v.Rd.1} + F_{v.Rd.2} = 3.965\ kN$$

Axial strength and shear strength combined in connection

By taking as a foundation formula EC5 (8.28):

$$\left(\frac{F_{ax.Ed}}{F_{ax.Rd}}\right)^2+\left(\frac{F_{v.Ed}}{F_{v.Rd}}\right)^2$$

Maximal axial load in one bracing is being calculated:

$$N_{R.d}:=\sqrt{\frac{F_{ax.Rd}^{\ 2}\cdot F_{v.Rd}^{\ 2}}{F_{v.Rd}^{\ 2}\cdot \sin(\alpha)^2+F_{ax.Rd}^{\ 2}\cdot \cos(\alpha)^2}}=5.901\ kN$$