



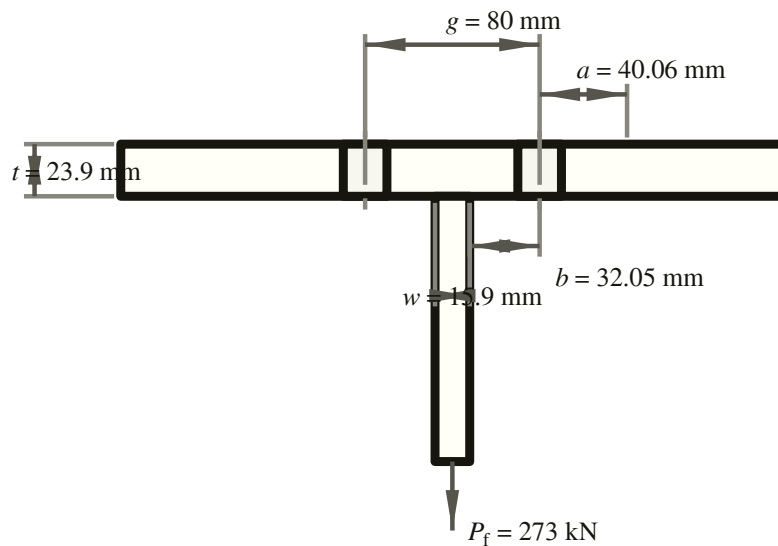
Bolt prying action

Prying action on a bolted tee or angle flange: flange, connection, bolt and web checks.

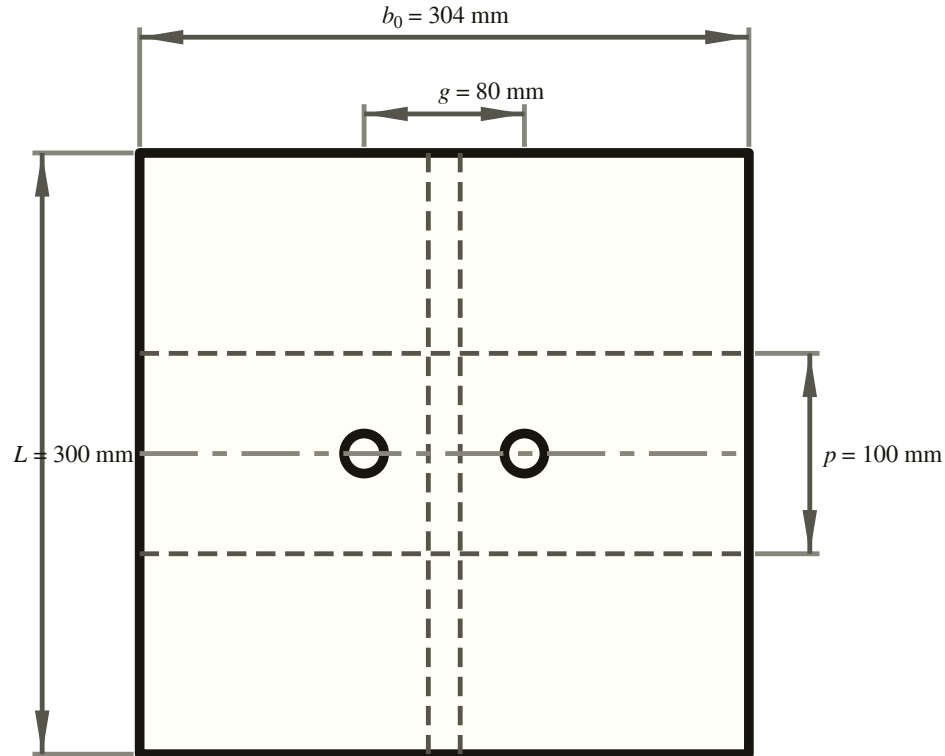
Inputs

Symbol	Value	Unit	Description
F_{ub}	830	MPa	Tensile strength of bolt
d	20	mm	Diameter of bolt
n	4		Number of bolts
g	80	mm	Gauge of bolts
p	100	mm	Pitch of bolts
L	300	mm	Length of the member
f_y	300	MPa	Yield strength of member
P_f	273	kN	Factored axial load
ϕ	0.9		Resistance factor, member
ϕ_b	0.8		Resistance factor, bolts
section	W920x223		Tee or W section

Figures



Section through the tee, with the two prying lever arms as the calc computes them.



Plan on the flange: the bolt pair and the tributary length the calc divides by.

Checks

Name	Check	Result
Geometry valid	$g \leq b_0 \Rightarrow 80 \text{ mm} \leq 304 \text{ mm}$	PASS
Flange adequate	$t_{p,\min} \leq t \Rightarrow 11.19 \text{ mm} \leq 23.9 \text{ mm}$	PASS
Connection adequate	$P_f \leq F_r \Rightarrow 273 \text{ kN} \leq 699.4 \text{ kN}$	PASS
Bolt adequate	$T_{fb} \leq T_{rb} \Rightarrow 68.25 \text{ kN} \leq 156.5 \text{ kN}$	PASS
Web adequate	$P_f \leq P_r \Rightarrow 273 \text{ kN} \leq 1.288 \text{ MN}$	PASS

Results

Quantity	Description	Value	Unit
$t_{p,\min}$	Minimum flange thickness, with prying fully developed	11.19	mm
$t_{p,\max}$	Flange thickness at which prying can be disregarded	14.93	mm
F_r	Factored connection capacity	699.4	kN
T_{rb}	Factored bolt tensile resistance	156.5	kN
P_r	Factored web tensile resistance	1.288	MN

Derivation

$$b_0 = 304 \text{ mm}$$

Width of flange or horizontal leg

$$t = 23.9 \text{ mm}$$

Thickness of flange

$$w = 15.9 \text{ mm}$$

Thickness of web

$$\begin{aligned} b &= \frac{g - w}{2} \\ &= \frac{80 \text{ mm} - 15.9 \text{ mm}}{2} \\ &= 32.05 \text{ mm} \end{aligned}$$

$$\begin{aligned} b' &= b - \frac{d}{2} \\ &= 32.05 \text{ mm} - \frac{20 \text{ mm}}{2} \\ &= 22.05 \text{ mm} \end{aligned}$$

$$\begin{aligned} a &= \min \left(\frac{b_0 - g}{2}, 1.25 \cdot b \right) \\ &= \min \left(\frac{304 \text{ mm} - 80 \text{ mm}}{2}, 1.25 \cdot 32.05 \text{ mm} \right) \\ &= 40.06 \text{ mm} \end{aligned}$$

$$\begin{aligned} a' &= a + \frac{d}{2} \\ &= 40.06 \text{ mm} + \frac{20 \text{ mm}}{2} \\ &= 50.06 \text{ mm} \end{aligned}$$

$$\begin{aligned} d' &= d + 2 \text{ mm} \\ &= 20 \text{ mm} + 2 \text{ mm} \\ &= 22 \text{ mm} \end{aligned}$$

$$\begin{aligned} P_{fb} &= \frac{P_f}{n} \\ &= \frac{273 \text{ kN}}{4} \\ &= 68.25 \text{ kN} \end{aligned}$$

CISC HSB Cl. 6.3

$$\begin{aligned}
 \delta &= 1 - \frac{d'}{p} && \text{CISC HSB Cl. 6.3 (net over gross section)} \\
 &= 1 - \frac{22 \text{ mm}}{100 \text{ mm}} \\
 &= 0.78
 \end{aligned}$$

$$\begin{aligned}
 T_{rb} &= \frac{0.75 \cdot \phi_b \cdot F_{ub} \cdot \pi \cdot d^2}{4} && \text{Cl. 13.12.1.3} \\
 &= \frac{0.75 \cdot 0.8 \cdot 830 \text{ MPa} \cdot \pi \cdot (20 \text{ mm})^2}{4} \\
 &= 156.5 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 K &= \frac{4 \cdot b' \cdot 1 \text{ GPa}}{\phi \cdot p \cdot f_y} && \text{CISC HSB Eq. 6.13} \\
 &= \frac{4 \cdot 22.05 \text{ mm} \cdot 1 \text{ GPa}}{0.9 \cdot 100 \text{ mm} \cdot 300 \text{ MPa}} \\
 &= 3.267
 \end{aligned}$$

$$\begin{aligned}
 t_{p,\min} &= \sqrt{\frac{K \cdot P_{fb}}{(1 + \delta \cdot 1) \cdot 1 \text{ GPa}}} && \text{CISC HSB Eq. 6.13} \\
 &= \sqrt{\frac{3.267 \cdot 68.25 \text{ kN}}{(1 + 0.78 \cdot 1) \cdot 1 \text{ GPa}}} \\
 &= 11.19 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 t_{p,\max} &= \sqrt{\frac{K \cdot P_{fb}}{(1 + \delta \cdot 0) \cdot 1 \text{ GPa}}} && \text{CISC HSB Eq. 6.13} \\
 &= \sqrt{\frac{3.267 \cdot 68.25 \text{ kN}}{(1 + 0.78 \cdot 0) \cdot 1 \text{ GPa}}} \\
 &= 14.93 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 t_{\text{utilization}} &= \frac{t_{p,\min}}{t} \\
 &= \frac{11.19 \text{ mm}}{23.9 \text{ mm}} \\
 &= 0.4683
 \end{aligned}$$

$$\begin{aligned}
 \alpha_{c0} &= \frac{\left(\frac{K \cdot T_{fb}}{t^2 \cdot 1 \text{ GPa}} - 1\right) \cdot a'}{\delta \cdot (a' + b')} && \text{CISC HSB Eq. 6.12, 6.13} \\
 &= \frac{\left(\frac{3.267 \cdot 156.5 \text{ kN}}{(23.9 \text{ mm})^2 \cdot 1 \text{ GPa}} - 1\right) \cdot 50.06 \text{ mm}}{0.78 \cdot (50.06 \text{ mm} + 22.05 \text{ mm})} \\
 &= -0.0937
 \end{aligned}$$

$$\begin{aligned}
 \alpha_c &= \min(1, \max(0, \alpha_{c0})) && \text{CISC HSB Cl. 6.3 (0} \leq \alpha \leq 1) \\
 &= \min(1, \max(0, -0.0937)) \\
 &= 0
 \end{aligned}$$

$$\begin{aligned}
 F_r &= \frac{t^2}{K} \cdot (1 + \delta \cdot \alpha_c) \cdot n \cdot 1 \text{ GPa} && \text{CISC HSB Eq. 6.13} \\
 &= \frac{(23.9 \text{ mm})^2}{3.267} \cdot (1 + 0.78 \cdot 0) \cdot 4 \cdot 1 \text{ GPa} \\
 &= 699.4 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 \text{connection}_{\text{utilization}} &= \frac{P_f}{F_r} \\
 &= \frac{273 \text{ kN}}{699.4 \text{ kN}} \\
 &= 0.3903
 \end{aligned}$$

$$\begin{aligned}
 \alpha_{b0} &= \frac{\frac{K \cdot P_{fb}}{t^2 \cdot 1 \text{ GPa}} - 1}{\delta} && \text{CISC HSB Eq. 6.13} \\
 &= \frac{\frac{3.267 \cdot 68.25 \text{ kN}}{(23.9 \text{ mm})^2 \cdot 1 \text{ GPa}} - 1}{0.78} \\
 &= -0.7817
 \end{aligned}$$

$$\begin{aligned}
 \alpha_b &= \min(1, \max(0, \alpha_{b0})) && \text{CISC HSB Cl. 6.3 (0} \leq \alpha \leq 1) \\
 &= \min(1, \max(0, -0.7817)) \\
 &= 0
 \end{aligned}$$

$$\begin{aligned}
 T_{fb} &= P_{fb} \cdot \left(1 + \frac{b' \cdot \delta \cdot \alpha_b}{a' \cdot (1 + \delta \cdot \alpha_b)}\right) && \text{CISC HSB Eq. 6.12} \\
 &= 68.25 \text{ kN} \cdot \left(1 + \frac{22.05 \text{ mm} \cdot 0.78 \cdot 0}{50.06 \text{ mm} \cdot (1 + 0.78 \cdot 0)}\right) \\
 &= 68.25 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}\text{BoltStr}_{\text{utilization}} &= \frac{T_{\text{fb}}}{T_{\text{rb}}} \\ &= \frac{68.25 \text{ kN}}{156.5 \text{ kN}} \\ &= 0.4362\end{aligned}$$

$$\begin{aligned}P_r &= \phi \cdot L \cdot w \cdot f_y && \text{Cl. 13.2 a) i)} \\ &= 0.9 \cdot 300 \text{ mm} \cdot 15.9 \text{ mm} \cdot 300 \text{ MPa} \\ &= 1.288 \text{ MN}\end{aligned}$$

$$\begin{aligned}\text{WebStr}_{\text{utilization}} &= \frac{P_f}{P_r} \\ &= \frac{273 \text{ kN}}{1.288 \text{ MN}} \\ &= 0.212\end{aligned}$$