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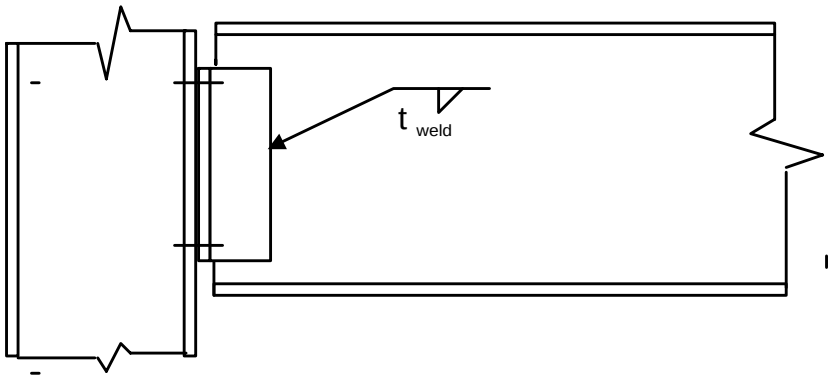
SIMPLE BEAM TO COLUMN CONNECTION

CONNECTION TYPE:BEAM TO COLUMN/CLIP ANGLE/BOLTED AT COLUMN

CONNECTION TYPE :BC-5/20/734 + AXIAL=50 kN



Description:

2 clip angles welded to flange of beam
2 clip angles bolted to flange or web of column

FOR DIMENSIONS AND CAPACITY SEE THE LAST PAGE

INPUT DATA

COLUMN: $Fyg := 300 \cdot MPa$ $Fug := 450 \cdot MPa$

BEAM :

$Fyb := 300 \cdot MPa$

$Fub := 450 \cdot MPa$

$db := 460 \cdot mm$ $Bb := 191 \cdot mm$ $tfb := 16 \cdot mm$ $twb := 9.9 \cdot mm$

CLIP ANGLE :

$LEG := 100 \cdot mm$ $ta := 12 \cdot mm$ $Fya := 235 \cdot MPa$ $Fua := 375 \cdot MPa$

Clip Angle Length : $l := 400 \cdot mm$

Clip Angle Weld to Beam: $t_{weld} := 10 \cdot mm$

BOLT : ASTM A325 Class B Surface

$N := 5$ **number of rows of bolts**

$d := 20 \cdot mm$ $Fubolt := 830 \cdot MPa$

$Vs := 0.53 \cdot 0.50 \cdot 0.89 \cdot \pi \cdot \frac{d^2}{4} \cdot Fubolt$ $Tr := 0.75 \cdot 0.67 \cdot \pi \cdot \frac{d^2}{4} \cdot Fubolt$

$Vs = 61.5\,kN$ $Tr = 131\,kN$

PITCH $p := 80 \cdot mm$ **EDGE DISTANCE** $e := 40 \cdot mm$ **GAGE** $G := 120 \cdot mm$

TOS to 1st bolt $dp := 100 \cdot mm$

AXIAL LOAD: $P_f := 50 \cdot kN$

WELD : $Xu := 480 \cdot MPa$

RESISTANCE FACTORS : $\phi := 0.9$ $\phi w := 0.67$

REFERENCES: 1) CAN/CSA-S16.1-94 LIMIT STATES DESIGN OF STEEL STRUCTURES
2) AMERICAN INSTITUTE OF STEEL CONSTRUCTION:MANUAL OF STEEL CONSTRUCTION/VOLUME II/CONNECTIONS

1.0 CALCULATION OF SHEAR CAPACITY OF BOLTS

1.1 CHECK BOLT SHEAR CAPACITY FOR SERVICE LOAD

$Vbolt := 2 \cdot N \cdot Vs$ $Vbolt = 614.98\,kN$

2.0 CHECK WEB SHEAR CAPACITY

2.1 WEB SHEAR CHECK

$h := db$

$Vrs := \phi \cdot 0.5 \cdot twb \cdot h \cdot Fub$ $Vrs = 922.2\,kN$

2.2 WEB BLOCK SHEAR CHECK

$twb = 9.9\,mm$

$$Vbs := \phi \cdot \left[0.5 \cdot l + \frac{0.85 \cdot (LEG - 10 \cdot mm)}{2} \right] \cdot twb \cdot Fub$$

$Vbs = 955.3\,kN$

3.0 CHECK CLIP ANGLE CAPACITY

3.1 SHEAR CHECK OF CLIP ANGLE

$Ln := l - N \cdot (d + 4 \cdot mm)$ $Ln = 280\,mm$

$Vr := (0.5 \cdot \phi \cdot Ln \cdot ta \cdot Fua) \cdot 2$ $Vr = 1134\,kN$

3.2 BOLT CAPACITY BY BEARING

$Br1 := 0.67 \cdot ta \cdot e \cdot Fua$ $Br2 := 3 \cdot 0.67 \cdot ta \cdot d \cdot Fua$

$$Br3 := 0.67 \cdot 0.7 \cdot \pi \cdot \frac{d^2}{4} \cdot 0.6 \cdot Fubolt$$

$$Br := \min\begin{pmatrix} Br1 \\ Br2 \\ Br3 \end{pmatrix}$$ $Br = 73.4\,kN$

$Vbolt_{bear} := 2 \cdot N \cdot Br$ $Vbolt_{bear} = 733.76\,kN$

4.0 MAXIMUM CAPACITY OF CONNECTION

$V_{estim} := 750 \cdot kN$

To control weld size in Section 6.3, cope length and web thickness of supporting girder and axial force

$$V_{MAX} := \min\begin{pmatrix} Vrs \\ Vbs \\ Vr \\ Vbolt_{bear} \\ V_{estim} \end{pmatrix}$$ $V_{MAX} = 733.76\,kN$ $<$ $1.33 \cdot Vbolt = 817.93\,kN$

5.0 CHECK MINIMUM PLATE GIRDER THICKNESS(assuming one beam on each side)

$$twg := \frac{V_{MAX}}{3 \cdot 0.67 \cdot d \cdot Fug \cdot 2 \cdot N}$$ $twg = 4.06\,mm$

6.0 CHECK BEAM TO CLIP ANGLE WELD

6.1 WELD TREATED AS A LINE (INCLUDING EFFECT OF AXIAL FORCE)

$kl := LEG - 10 \cdot mm$ $xl := \frac{kl^2}{2 \cdot kl + l}$ $al := LEG - xl$

$$Ip := \frac{kl^3}{3} \cdot \frac{kl + 2 \cdot l}{l + 2 \cdot kl} + \frac{l^2}{12} \cdot (6 \cdot kl + l)$$

$$fh := \frac{0.5 \cdot V_{MAX} \cdot al \cdot l}{2 \cdot Ip} + \frac{0.5 \cdot P_f}{2 \cdot kl + l}$$

$$fv := \frac{0.5 \cdot V_{MAX}}{2 \cdot kl + l} + \frac{0.5 \cdot V_{MAX} \cdot al \cdot (kl - xl)}{Ip}$$

$$fr := \sqrt{fh^2 + fv^2} \qquad fr = 0.98 \frac{kN}{mm}$$

6.2 FACTORED FILLET WELD CAPACITY :

$Fy := if(Fya > Fyb, Fyb, Fya)$

$Vr1 := 0.67 \cdot \phi \cdot Fy$ $Vr2 := 0.67 \cdot \phi w \cdot 0.707 \cdot Xu$

$Vr := if(Vr1 > Vr2, Vr2, Vr1)$ $Vr = 0.14 \frac{kN}{mm^2}$

6.3 REQUIRED WELD SIZE :

$tw_{reqd} := \frac{fr}{Vr}$ $tw_{reqd} = 6.9\,mm$ < $t_{weld} = 10\,mm$

6.4 CHECK WEB STRESS IN BEAM WEB:

$twb = 9.9\,mm$

$Fr := 0.67 \cdot \phi \cdot Fyb \cdot twb$

$Fr = 1.79 \frac{kN}{mm}$ >= $fr = 0.98 \frac{kN}{mm}$

7.0 AXIAL LOAD CAPACITY

$P_f = 50\,kN$

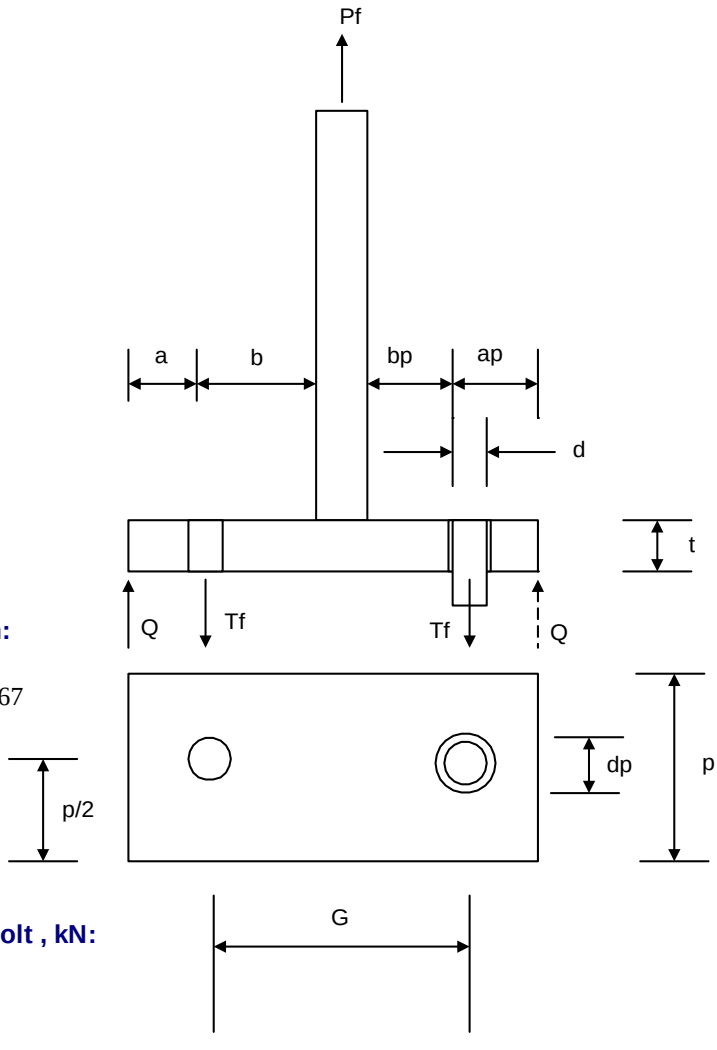
7.1 Prying Action

Total applied factored force:

$P_f = 50\,kN$

Number of flange bolts in tension:

$n := 2 \cdot N$ $n = 10$ $\phi b := 0.67$



Applied factored tensile load per bolt , kN:

$Pfb := \frac{P_f}{n}$ $Pfb = 5\,kN$

Factored tensile resistance of bolts, kN:

$T_r := \phi b \cdot 0.75 \cdot \pi \cdot \frac{d^2}{4} \cdot Fubolt$ $T_r = 131.03\,kN$

Yield strength of plate material: $Fya = 235\,MPa$

$a := e$ $a = 40\,mm$

$ap := a + \frac{d}{2}$ $ap = 50\,mm$ $d_p := d + 4 \cdot mm$ $d_p = 24\,mm$

$p = 80\,mm$ $ta = 12\,mm$ $\phi = 0.9$

$bp := LEG - ta - ap$ $bp = 38\,mm$

$\delta := \frac{[p - (d + 2 \cdot mm)] \cdot ta}{p \cdot ta}$ $\delta = 0.73$

$\alpha := \frac{1}{\delta} \cdot \left(\frac{4 \cdot Pfb \cdot bp}{\phi \cdot p \cdot ta^2 \cdot Fya} - 1 \right)$ $\alpha := if\left[\alpha > 1 , 1 , max\left(\begin{pmatrix} \alpha \\ 0 \end{pmatrix} \right) \right]$ $\alpha = 0$

Prying force: $Q := Pfb \cdot \frac{\alpha \cdot \delta}{1 + \alpha \cdot \delta} \cdot \frac{bp}{ap}$ $Q = 0\,kN$

Total force in bolts: $Tf := Pfb + Q$

$Tf = 5\,kN$ **<** $Tr = 131.03\,kN$

8.2 CHECK BOLTS IN COMBINED SHEAR AND TENSION

FOR BEARING:

$$\left(\frac{V_{MAX}}{Vbolt_{bear}} \right)^2 + \left(\frac{Pfb}{Tr} \right)^2 = 1$$ **<= 1.0**

FOR SLIP CRITICAL

$$\frac{\frac{V_{MAX}}{1.33}}{Vbolt} + \frac{1.9 \cdot \frac{Pfb}{1.33}}{n \cdot \pi \cdot \frac{d^2}{4} \cdot Fubolt} = 0.9$$ **< 1.0**

8.3 CHECK PLATE THICKNESS REQUIRED FOR BENDING DUE TO AXIAL FORCE

$M_{fa} := \frac{Pfb \cdot bp}{(1 + \alpha \cdot \delta)}$ $M_{fa} = 0.19\,kN \cdot m$

$t_{required} := \sqrt{\frac{4 \cdot M_{fa}}{\phi \cdot Fya \cdot p}}$

$t_{required} = 6.7\,mm$ **<=** $ta = 12\,mm$

$Mr := \phi \cdot p \cdot \frac{t_{required}^2}{4} \cdot Fya$ $Mr = 0.19\,kN \cdot m$

SUMMARY - CONNECTION TYPE PARAMETERS

Bolts

Minimum number of bolts rows	$N = 5$
Minimum number of bolts	$2 \cdot N = 10$
Minimum bolt diameter	$d = 20\,mm$
Maximum bolt pitch	$p = 80\,mm$
Bolt Gauge at girder	$G = 120\,mm$
Minimum edge distance	$e = 40\,mm$

Beam characteristics

Minimum steel yield strength	$Fyb = 300\,MPa$
Maximum beam depth	$db = 460\,mm$
Minimum flange width	$Bb = 191\,mm$
Minimum flange thickness	$tfb = 16\,mm$
Minimum web thickness	$twb = 9.9\,mm$
Minimum distance from Top of Steel (TOS) to first row of bolts	$dp = 100\,mm$

Column Characteristics

Minimum steel yield strength	$Fyg = 300\,MPa$
Minimum flange or web thickness	$twg = 4.06\,mm$

Clip Angle Characteristics

Minimum Length	$l = 400\,mm$
Minimum steel yield strength	$Fya = 235\,MPa$
Minimum leg dimension	$LEG = 100\,mm$
Minimum thickness	$ta = 12\,mm$

Weld Characteristics

Fillet weld size	$t_{weld} = 10\,mm$

Maximum Axial Force

$P_f = 50\,kN$

CAPACITY OF CONNECTION

$V_{MAX} = 733.76\,kN$
