CIVE 3205 January 2012

Example T-5:

Compute the factored tension capacity, T_r, of a tension member similar to that used extensively in the new construction at the corner of Bank St. & Sunnyside Ave, Ottawa, Fall 2010. In that construction, these tension members are bracing to resist lateral loads due to wind and earthquake.

The tension members are square HSS with plates welded to the ends for the connections.

See the photos on the next 2 pages.

The problem starts on page 4, where the particulars are given:

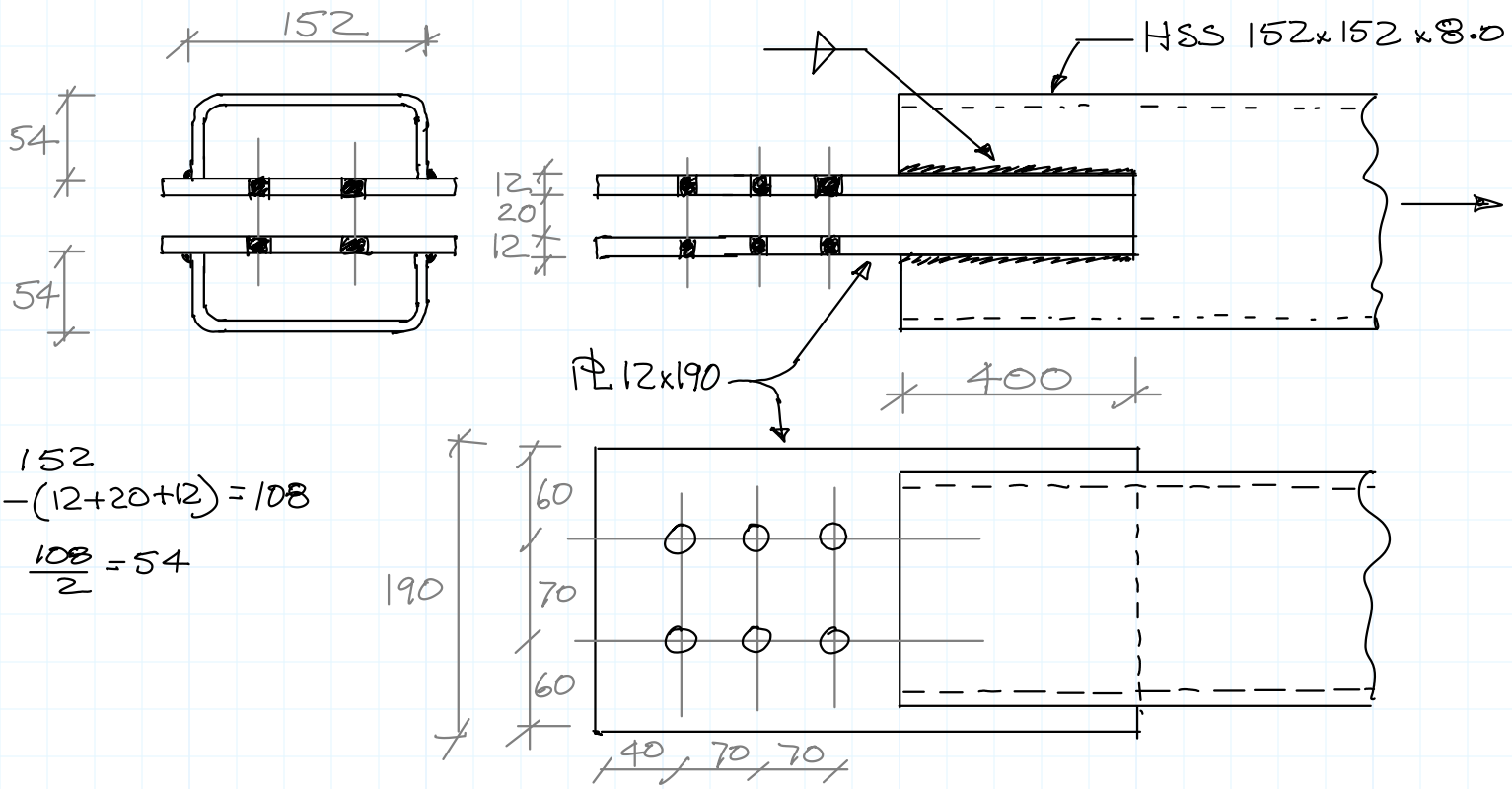
Assume: G40.21 350 W Steel
M20 bolts
punched holes

Do not calculate the strength of the fasteners (the bolts and welds).


HSS Tension
Members


HSS
Tension Member

Compute T_r

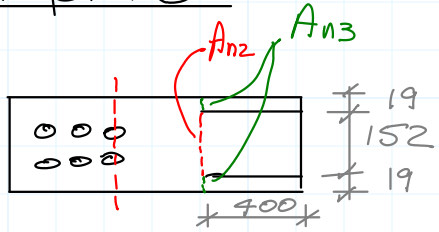


N.T.S. (Not to scale)

152
$-(12+20+12) = 108$

$\frac{108}{2} = 54$

12mm plates



$A_g = 12\text{mm} \times 190\text{mm} \times 2 = 4560\ \text{mm}^2$

holes: $A_n = 4560 - 2 \times 24 \times 12 \times 2 = 3408\ \text{mm}^2$

no reduction for shear lag

welds / shear lag

A_{n2}: $L = 400$ $w = 152$

$L > 2w$

$\therefore A_{n2} = 152 \times 12 \times 2 = 3648\ \text{mm}^2$

A_{n3}: $L = 400$ $w = 19$ $\bar{x} = 9.5$

$L > w$

$\therefore A_{n3} = \left(1 - \frac{9.5}{400}\right) \times 19 \times 12 \times 2 \times 2 = 890\ \text{mm}^2$

$A_{ne} = 3648 + 890 = 4538\ \text{mm}^2$

$\therefore A_n$ governs $A_n = 3408\ \text{mm}^2$

gross yield: $T_r = \phi A_g F_y$

$= 0.9 \times 4560\ mm^2 \times 350 \times 10^{-3}\ \frac{kN}{mm^2}$

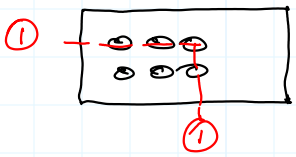
$= 1436\ kN$

net fracture: $T_r = \phi_u A_n F_u$

$= 0.75 \times 3408\ mm^2 \times 450 \times 10^{-3}\ kN/mm^2$

$= 1150\ kN$

Block tearout



Path 1-1

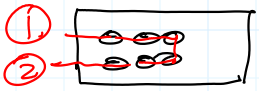
$A_n = (130 - 1.5 \times 24) \times 12 \times 2 = 2256\ mm^2$

$A_{gv} = (40 + 70 + 70) \times 12 \times 2 = 4320\ mm^2$

$T_r = \phi_u \left[U_t A_n F_u + 0.6 A_{gv} \frac{F_y + F_u}{2} \right]$ $\quad U_t = 0.9$

$= 0.75 \left[0.9 \times 2256 \times .450 + 0.6 \times 4320 \times \frac{.35 + .45}{2} \right]$

$= 1463\ kN$



Path 1-2

$A_n = (70 - 24) \times 12 \times 2 = 1104\ mm^2$

$A_{gv} = 4320 \times 2 = 8640\ mm^2$

$U_t = 1.0$

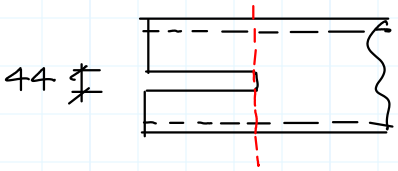
will not govern

$\therefore$ For plates, $T_r = 1150\ kN$

HSS 152 x 152 x 8.0

$A_g = 4430\ mm^2$

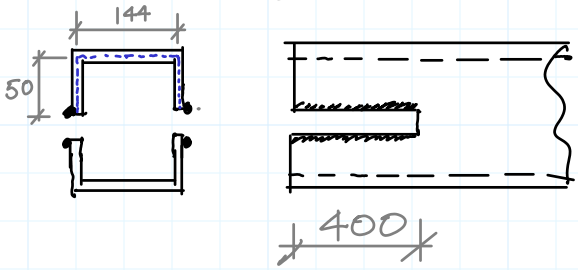
$t = 7.95\ mm$



Net area @ end of slot cut for plates -

$A_n = 4430 - 44 \times 7.95 \times 2 = 3730\ mm^2$

Shear lag - for load xfered by weld into the HSS



L - Length of weld

$L = 400\ mm$

w - width of plate

= circumferential dist. between welds

$w = 50 + 144 + 50 = 244\ mm.$

$2w > L > w$

$\therefore A_{n2} = (0.5 \times 244 \times 7.95 + 0.25 \times 400 \times 7.95) \times 2$

$= 3530\ mm^2$

$\therefore A_{ne} = 3530\ mm^2$

gross yield $T_r = \phi A_g F_y$

$= 0.9 \times 4430 \times .350$

$= 1395\ kN$

net fracture $T_r = \phi_u A_n F_u$

$= 0.75 \times 3530 \times 0.45$

$= 1190\ kN$

$\therefore$ Plates Govern

$T_r = 1150\ kN$ ⟵

this does <u>not</u> account for fastener (bolts, welds) strength.