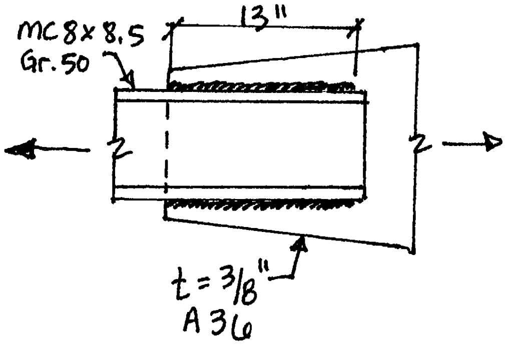
CE 470 SPRING 2009 HW 5 DUE 3/5/09

Segui Problems 7.11-1(a), 7.11-2(a), 7.11-4(a), 7.11-5(a).

Problem 7.11-1 (a)

Determine the maximum service load that can be applied if the live load-to-dead load ratio is 2.5. Investigate all limit states. The tension member is of A572 Gr. 50 steel and the gusset plate is A36. The weld is a 3/16-inch. fillet weld with E70 electrodes. Use LRFD.



MC 8×8.5, Gr. 50

$A = 2.50\ in^2$ $\quad d = 8.0\ in$

$\bar{x} = 0.428\ in$ $\quad t_w = 0.179\ in$

$t_f = 0.311\ in$

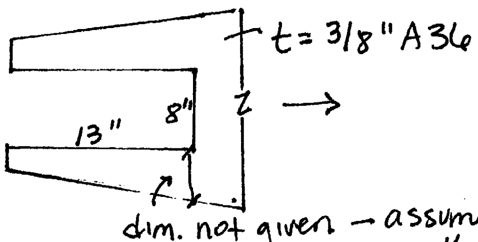
Yield of channel.

$\phi P_n = 0.9(50ksi)(2.50in^2) = \underline{113\ kips}$.

Net Area Fracture $\quad U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.428in}{13in} = 0.967$

$\phi P_n = 0.75(65ksi)(0.967)(2.50\ in^2) = \underline{118}\ kips$.

Block Shear (gusset)



$A_{gv} = A_{nv} = 2(13")(3/8") = 9.75in^2$

$A_{nt} = (8")(3/8") = 3.0\ in^2$

$\phi R_n = 0.75(0.6(58ksi)(9.75in^2) + 1.0(58ksi)(3.0in^2))$

$\leq 0.75(0.6(36ksi)(9.75in^2) + 1.0(58ksi)(3.0in^2))$

$\phi R_n = 385^k \leq \underline{288^k}$

Weld Shear: assume SMAW E70xx

$\phi R_n = 0.75(0.6)(70ksi)(2)(13")(\frac{\sqrt{2}}{2})(\frac{3}{16}") = \underline{108.6}\ kips$

→

Problem 7.11-1 (a), cont'd.

Base metal - check gusset plate

BM-SY $\phi R_n = (1.0)(0.6)(36\,ksi)(0.375") = 8.1$ kips/in

BM-SR $\phi R_n = (0.75)(0.6)(58\,ksi)(3/16") = 4.9$ kips/in

weld size "Purdue" method

Base metal - check tension member

BM-SY $\phi R_n = (1.0)(0.6)(50\,ksi)(0.179\,in) = 5.37$ kips/in

BM-SR $\phi R_n = (0.75)(0.6)(65\,ksi)(0.179\,in) = 5.24$ kips/in

$t_w <$ weld size so use 'typical' method. and t_w

of base metal checks, BM-SR of gusset plate controls.
$\rightarrow (4.9\,kips/in)(2)(13") = 127$ kips > 108.6 kips so weld shear controls

$\phi R_n = 108.6^k$ weld shear controls overall

$\phi R_n \geq P_u = 1.2D + 1.6L = 1.2(D) + 1.6(2.5D) = 5.2D$

$D \leq 20.9$ kips

$L = 52.3$ kips

service load

$P = D + L = 20.9 + 52.3 = \boxed{73.2\,kips}$

check
Block shear of Channel? (FYI only - not required for this problem)

$A_{gv} = A_{nv} = 2(13")(0.311\,in) = 8.1\,in^2$ (through flanges)

web $\rightarrow A_{nt} = (8")(0.179") = 1.43\,in^2$ A572 Gr. 50.

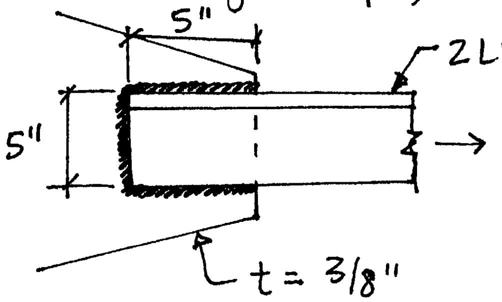
upper limit on ϕR_n will control

$\phi R_n = 0.75\,(0.6(50\,ksi)(1.43\,in^2) + (1.0)(65\,ksi)(8.1\,in^2))$

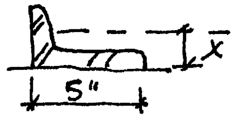
$= 427^k$ - does not control. ∴ block shear of gusset would happen first, and weld shear controls overall

Problem 7.11-2(a)

Determine the maximum service load that can be applied if the live load-to-dead load ratio is 3.0. Investigate all limit states. All structural steel is A36 and the weld is a 1/4-inch fillet weld with E70 electrodes. The tension member is a double angle shape, and both of the angles are welded. Use LRFD.



2L5x3½x5/16 LLBB.
$A = 5.12\ in^2$ (2 angles)
$\bar{x} = 0.829\ in$



Yield of angles.

$\phi P_n = 0.9(36ksi)(5.12\ in^2) = \underline{166}$ kips

Fracture of angles $\quad U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.829\ in}{5\ in} = 0.834.$

$\phi P_n = 0.75(58ksi)(0.834)(5.12\ in^2) = \underline{186}$ kips

Block shear of gusset $\quad A_{gv} = A_{nv} = 2(5'')(3/8'') = 3.75\ in^2$

would control over angles? $\quad A_{nt} = (5'')(3/8'') = 1.875\ in^2$

$\phi R_n = 0.75\,(0.6(58ksi)(3.75in^2) + (1.0)(58ksi)(1.875\ in^2))$

$\leq 0.75\,(0.6(36ksi)(3.75in^2) + (1.0)(58ksi)(1.875\ in^2))$

$\phi R_n = 179.4^k \leq \underline{\underline{142.3}}^k$

Weld Shear: Assume SMAW., E70xx. $a = 1/4''$

$\phi R_n = 0.75(0.6)(70ksi)(\frac{\sqrt{2}}{2})(1/4'')(15'') = 83.5$ kips.

or. $R_n = 0.85R_{wl} + 1.5R_{wt}$ (AISC J2.4) larger permitted

$\phi R_n = 0.75\,(0.6)(70ksi)(\frac{\sqrt{2}}{2})(1/4'')(\,2(5'')(0.85) + 1.5(5'')) = \underline{\underline{89.1}}^k$

$\times$ 2 angles $= \underline{\underline{178}}$ kips

BM-SY $\quad 2 \times \frac{5}{16}'' = 5/8'' > 3/8''$ gusset plate controls over angles

$\phi R_n = (1.0)(0.6)(36ksi)(3/8'')(15'') = \underline{\underline{121.5}}^k.$

(conservatively assume BM-SY applicable along transverse weld)

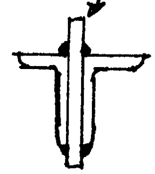
→

Problem 7.11-2(a), cont'd.

BM-SR. $2 \times \frac{1}{4}$" (weld size) = 1/2" > t = 3/8" gusset

∴ typical method used

$\phi R_n = 0.75\,(0.6)(58\text{ ksi})(3/8")(15") = \underline{147}^k$



Overall, BM-SY of gusset controls $\phi R_n = 121.5^k$

$\phi R_n \geq P_u$.

$\phi R_n \geq P_u = 1.2D + 1.6L$

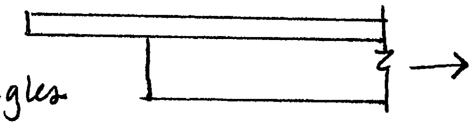
$= 1.2(D) + 1.6(3D) = 6D$

$D \leq 20.25$

$L = 60.75$

service load, $P = D + L = \boxed{81 \text{ kips}}$

Double-
Check block shear of angles.



$A_{gv} = A_{nv} = 2(5")(\frac{5}{16}")$ 2 angles

$= 3.125 \text{ in}^2$

$A_{nt} = 2(5")(5/16") = 3.125 \text{ in}^2$ ← > A_{nt} for gusset

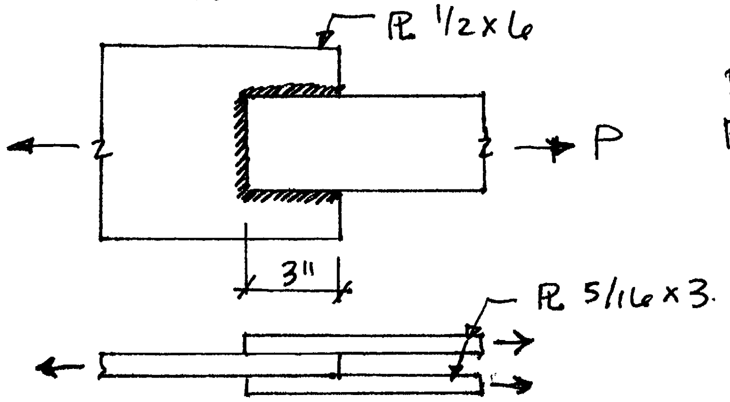
upper limit on ϕR_n will control ∴ will not control?

$\phi R_n = 0.75\,(0.6(36\text{ ksi})(3.125\text{ in}^2) + (1.0)(58\text{ ksi})(3.125\text{ in}^2))$

$= \underline{187 \text{ kips}}$ does not control.

Problem 7.11-4(a)

A tension member splice is made with 1/4" E70 fillet welds as shown. Each side is welded as shown. The inner member is a PL 1/2 × 6 and each outer member is a PL 5/16 × 3. All steel is A36. Determine the maximum service load, P, that can be applied if the load is equal parts dead and live load. Use LRFD.



Yield.

PL 1/2 × 6 $\quad A = (\frac{1}{2}")(6") = 3\ in^2$

PL 5/16 × 3 $\quad A = (\frac{5}{16}")(3") = 0.9375\ in^2$

× 2 plates

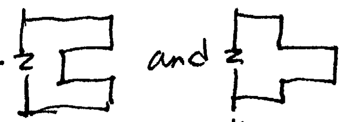
controls → $1.875\ in^2$

$$\phi P_n = 0.9(36\,ksi)(1.875\,in^2) = \underline{60.8\ kips}$$

Fracture $\quad U = 1.0$ since longitudinal + transverse welds

$$\phi P_n = 0.75(58\,ksi)(1.0)(1.875\,in^2) = \underline{81.6}\ kips$$

Block shear center plate $\quad A_{gv} = A_{nv} = 2(3")(1/2") = 3\ in^2$ ← and



$A_{nt} = (3")(1/2") = 1.5\ in^2$

$$\phi R_n = 0.75\left(0.6(58\,ksi)(3\,in^2) + (1.0)(58\,ksi)(1.5\,in^2)\right) = 143.6^k$$

$$\leq 0.75\left(0.6(36\,ksi)(3\,in^2) + (1.0)(58\,ksi)(1.5\,in^2)\right) = \underline{113.9}^k$$

(see next page for mode 3)

Weld Shear $\quad$ Assume SMAW.

$$\phi R_n = 0.75(0.6)(70\,ksi)(\tfrac{\sqrt{2}}{2})(\tfrac{1}{4}")(3"+3"+3") = 50.1\ kips.$$

OR. $\quad$ use larger.

$$\phi R_n = 0.75(0.6)(70\,ksi)(\tfrac{\sqrt{2}}{2})(\tfrac{1}{4}")(2(3")(0.85) + 1.5(3")) = \underline{53.4}\ kips$$

× 2 plates (welds)

→ $\underline{106.8}$ kips

BM-SY. $\quad 2 \times \frac{5}{16}" = \frac{5}{8}" > 1/2"$

center plate controls

$$\phi R_n = (1.0)(0.6)(36\,ksi)(1/2")(3"+3"+3") = \underline{97.2\ kips}$$

→

Problem 7.11-4(a), cont'd.

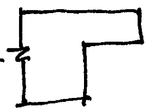
BM-SR. $2 \times 1/4" = 1/2"$ ← weld size — same as t of PL
so either 'Typical' method or 'Purdue' method OK

$\phi R_n = (0.75)(0.6)(58\text{ ksi})(1/2")(9") = \underline{117.5\text{ kips}}$.

→ Overall, yield of 2 PL 5/16 × 3 controls, $\phi P_n = 60.8$ kips

$\phi P_n \geq P_u = 1.2D + 1.6L = 2.8D$ (D=L)
$D = 21.7$ kips
$L = 21.7$ kips

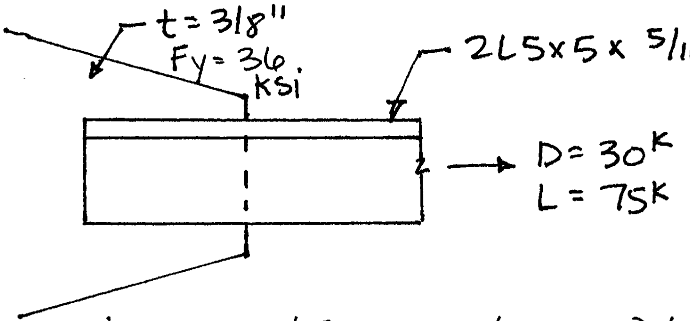
Service Load, $P = (21.7\text{ kips})(2) = \boxed{43.4\text{ kips.}}$

Check  block shear mode?

$A_{gv} = (3")(\tfrac{1}{2}") = 1.5\text{ in}^2$
$A_{nt} = (4.5")(\tfrac{1}{2}") = 2.25\text{ in}^2$
upper limit controls → ϕR_n
$\phi R_n = 0.75\,(0.6\,(36\text{ksi})(1.5\text{ in}^2) + (1.0)(58\text{ksi})(2.25\text{ in}^2))$
$= 122^{k}$
∴ this mode does not control block shear capacity or overall capacity

Problem 7.11-5(a)

Design a welded connection. The given loads are service loads. Use $F_y = 50$ ksi for the double angle tension member and $F_y = 36$ ksi for the gusset plate. Show your results on a sketch, complete with dimensions. Use LRFD



$P_u = 1.2D + 1.6L$
$= 1.2(30^K) + 1.6(75^K)$
$= \underline{156^K}$

Yield $\quad \phi T_n = 0.9(50\text{ksi})(2)(3.03\text{in}^2) = 273^K > 156^K$ ✓ OK.

AISC Table J2.4. $\quad t = 5/16"$ thinner part $\quad t > 1/4"$
$a_{min} = 3/16"$
$a_{max} = t - 1/16" = 5/16" - 1/16" = 1/4"$
TRY $w = 1/4"$

weld shear
assume SMAW
use E70xx

$\phi R_n = 0.75(0.6)(70\text{ksi})\left(\frac{\sqrt{2}}{2}\right)(1/4") = 5.57$ kips/in
$\times$ 2 weld groups
$\overline{\quad 11.1 \text{ kips/in}}$

BM-SY $\quad 2 \times 5/16" = 5/8"$ (50 ksi) $> 3/8"$ (36 ksi) $\therefore$ gusset plate controls
$\phi R_n = (1.0)(0.6)(36\text{ksi})(3/8") = 8.1$ kips/in

BM-SR $\quad 2 \times 1/4"$ (weld size) $= 1/2" > 3/8"$ gusset
use 'Typical' method
$\phi R_n = (0.75)(0.6)(58\text{ksi})(3/8") = 9.79$ kips/in

$\therefore$ BM-SY of gusset plate controls.
assume that BM-SY capacity same for transverse weld (if used)

total length required $= \dfrac{P_u}{\phi R_n/\text{in}} = \dfrac{156^k}{8.1 \text{ kips/in}} = 19.26$ in
say $19\frac{1}{2}$ in. →

Problem 7.11-5(a), cont'd.

Use longitudinal and transverse welds.

length of longitudinal welds $= \dfrac{19.5'' - 5''}{2} = 7.25''$

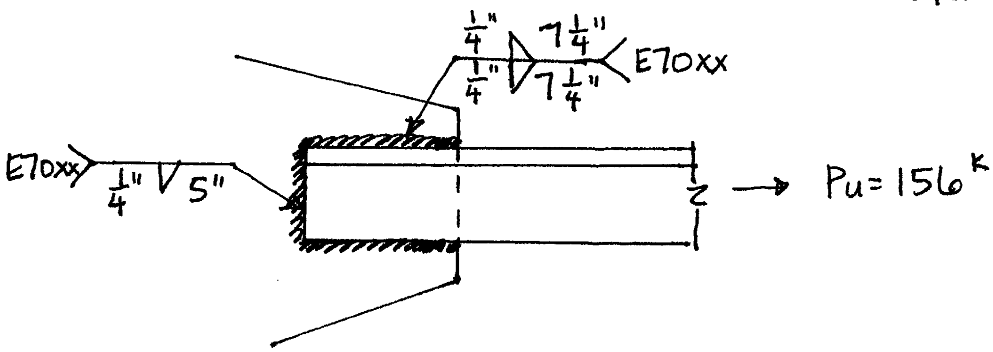
Check block shear of gusset plate

$A_{gv} = A_{nv} = (7.25'')(3/8'')(2)$
$= 5.44 \text{ in}^2$

$A_{nt} = (5'')(3/8'') = 1.875 \text{ in}^2$

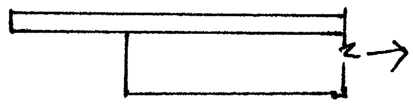
$\phi R_n = 0.75\,(0.6(58\text{ksi})(5.44\text{ in}^2) + (1.0)(58\text{ ksi})(1.875\text{ in}^2))$
$\leq 0.75\,(0.6(36\text{ksi})(5.44\text{ in}^2) + 1.0\,(58\text{ksi})(1.875\text{ in}^2))$

$\phi R_n = 223.5^k \leq \underline{\underline{169.7^k}} > P_u = 156^k$ ✓OK.



Double-check block shear of angles?

should not control, Gr. 50



$A_{gv} = A_{nv} = 2(7.25'')(5/16'')$
$= 4.53 \text{ in}^2$

$A_{nt} = 2(5'')(5/16'') = 3.125 \text{ in}^2$

upper limit controls for ϕR_n

$\phi R_n = 0.75\,(0.6(50\text{ksi})(4.53\text{ in}^2) + (1.0)(65\text{ksi})(3.125\text{in}^2))$
$= 254^k > P_u = 156^k$ ✓OK.

Net section fracture? $\quad U = 1 - \dfrac{\bar{X}}{L} = 1 - \dfrac{1.35''}{7.25''} = 0.81$

$\phi T_n = 0.75(65\text{ksi})(2)(0.81)(3.03\text{ in}^2) = 239^k$
$> P_u = 156^k$
✓OK