

Faculty of Engineering
CIVE 3205: Steel I
Mid-Term Examination 1 A, February 5, 2015

Name (Last, First): SOLUTION

Student No.: _____

Notes:

- 1) Time limit: **1 hr 30 minutes**
- 2) This examination paper has 10 pages, including this title page.
- 3) Answer all questions. There is no choice.
- 4) Answer all questions in the space provided **on this examination paper**. You may use the reverse side of these pages for rough work.
- 5) Write your name and student number on the top of **each page**. We will not discuss grading later if that has not been done.
- 6) Do not separate the pages.
- 7) Show **all** necessary steps to support your answers.
- 8) If you feel that any information is incorrect or incomplete, make a reasonable assumption, state it clearly, and proceed. **DO NOT ASK QUESTIONS: 2 marks will be deducted for each question answered.**
- 9) Authorized memoranda: calculator (without document-storage capability), one letter-size page, steel handbook.
- 10) Do not write below.

Question	1	2	3	4	5	6	Total
Mark							
Max	15	15	10	15	20	20	95

Revisions:

- Feb 9, 2015: revised marking scheme Q3, Q4.
corrected Agv, Tr for Q4.

9:16 - 9:28 = 8m.

Name: _____

Student No.: _____

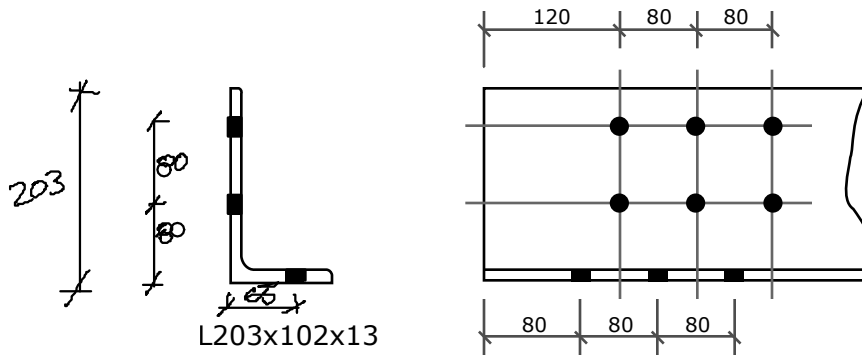
CIVE 3205 Steel I

Mid-Term Examination 1 A, February 5, 2015

2

Question 1 (15 marks)

Calculate, A_{ne} – the Effective Net Area for Shear Lag – for the following angle tension member. It is connected with 9 M16 bolts in drilled holes. Assume usual gauges.

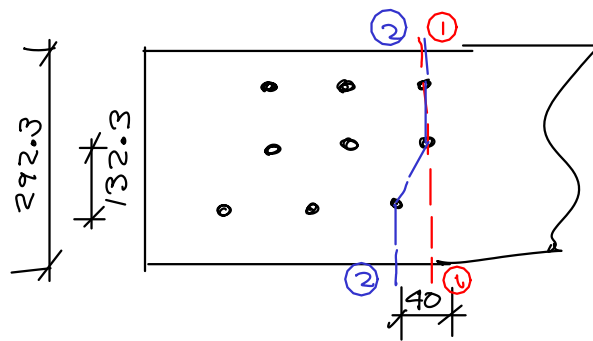


L203x102x13

[4 marks]

$$\begin{array}{r} 203 \\ + 102 \\ - 12.7 \\ \hline 292.3 \end{array}$$

$$\begin{array}{r} 80 \\ + 65 \\ - 12.7 \\ \hline 132.3 \end{array}$$



[3 marks]

Path ①-①

$$w_n = 292.3 - 2 \times (16 + 2) = 256.3$$

Path ②-②

$$w_n = 292.3 - 3 \times (16 + 2) + \frac{40^2}{4 \times 132.3} = 241.3 \leftarrow \text{gov}$$

[3 marks]

$$A_n = 241.3 \times 12.7 = 3065 \text{ mm}^2$$

[3 marks]

$$A_{ne} = A_n \text{ (by } \S 12.3.3.1)$$

[2 marks]

$$\underline{\underline{A_{ne} = 3065 \text{ mm}^2}}$$

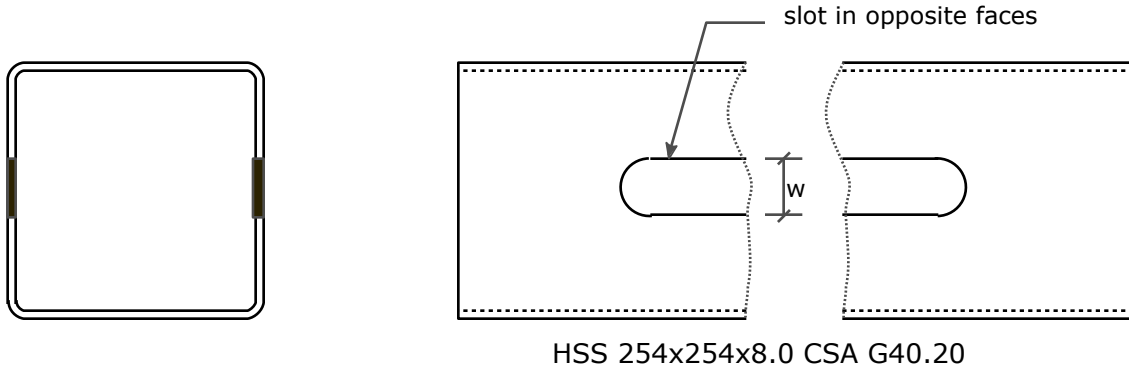
← Ans.

Question 2 (15 marks)

An HSS254x254x8.0 (CSA G0.20) is used as a cross-brace in a building to resist earthquake forces by acting in tension. In order to ensure proper ductility during an earthquake, a slot is cut in two opposite faces of the HSS; proper design of this slot will ensure that the member yields over the gross cross-section before any other failure occurs. Calculate the width, W, of slot required, to ensure that $T_r = 2110\text{kN}$ with respect to yielding of the gross cross section.

For the purpose of this question, you may use the reduced cross-sectional area at the slot as the gross cross-sectional area.

Assume CSA G40.21 350W steel.



$$T_r = \phi A_g F_y$$

[4 marks]

$$2110 \text{ kN} = 0.9 A_g \times 35 \frac{\text{kN}}{\text{mm}^2}$$

$$A_g = 6698 \text{ mm}^2$$

$$\text{HSS, } A = 7660 \text{ mm}^2$$

$$\begin{array}{r} \text{slots remove} \quad 7660 \\ - 6698 \\ \hline 962 \text{ mm}^2 \end{array}$$

[6 marks]

$$\text{or } \frac{962}{2} = 481 \text{ mm}^2 / \text{slot}$$

$$t = 7.95 \text{ mm}$$

$$Wt = 481$$

$$W = \frac{481}{7.95}$$

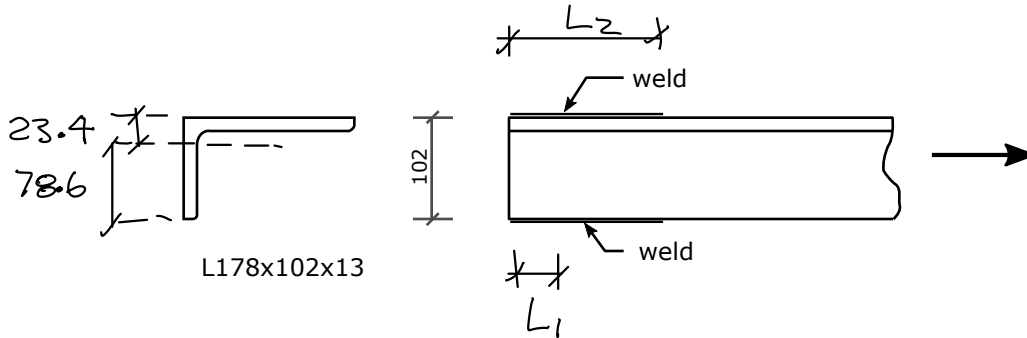
[5 marks]

$$W = 60.5 \text{ mm}$$

← Ans.

Question 3 (10 marks)

Two sides of the short leg of an L178x102x13 angle tension member are welded to a gusset plate (not shown). A total of 800mm of weld is necessary to provide the required tension resistance. Calculate the length of weld required on each side of the leg to maintain a "balanced" weld.

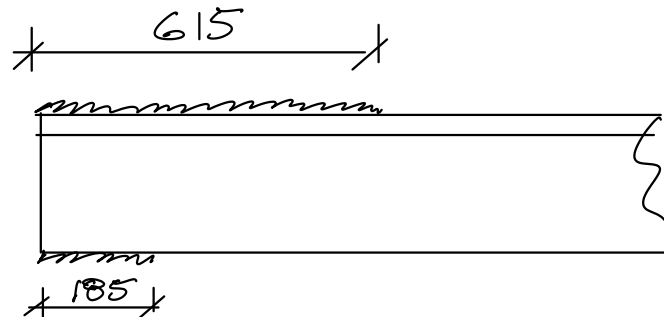


[4 marks] $78.6 L_1 = 23.4 L_2$
 $L_2 = 3.359 L_1$

$L_2 + L_1 = 800$
 $3.359 L_1 + L_1 = 800$

[4 marks] $L_1 = 183.5$ say 185
 $L_2 = 800 - 185 = 615$

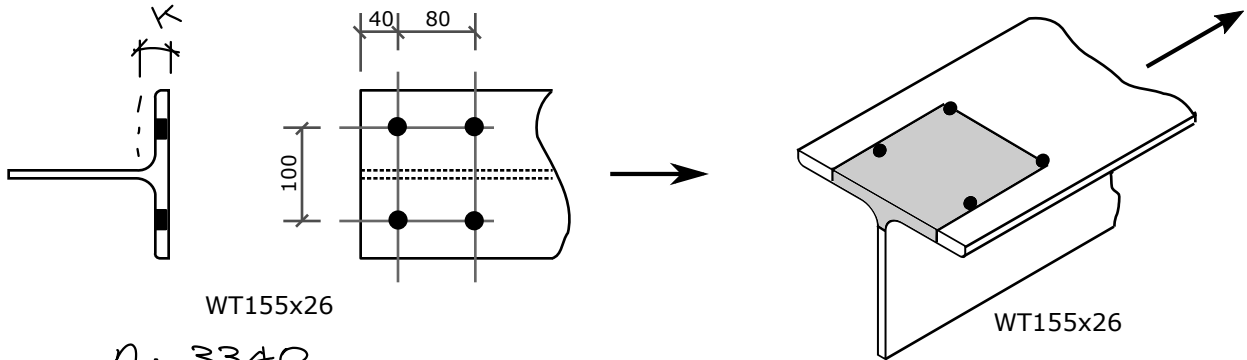
[2 marks]



Question 4 (15 marks)

A WT155x26 tension member is connected via M20 bolts in punched holes, through the flange only. One of the failure modes that must be checked is block shear. Calculate the factored tension resistance, T_r , with respect to the block shear failure pattern shown as the shaded area on the oblique view. Compute only that value - do not consider other failure modes.

Use CSA G40.21 350W steel.



$A = 3340$

$b = 167$

$d = 159$

$t = 13.2$

$w = 7.6$

$k = 30.0$

[5 marks]

$$A_n = 3340 - 7.6(159 - 30) - \left(\frac{167 - 100}{2} + \frac{20 + 20}{2} \right) \times 2 \times 13.2 = 1158 \text{ mm}^2$$

[5 marks]

$$A_{gv} = 2 \times 120 \times 13.2 + 120 \times 7.6 = 4080 \text{ mm}^2$$

$U_t = 1.0$

See note below

[4 marks]

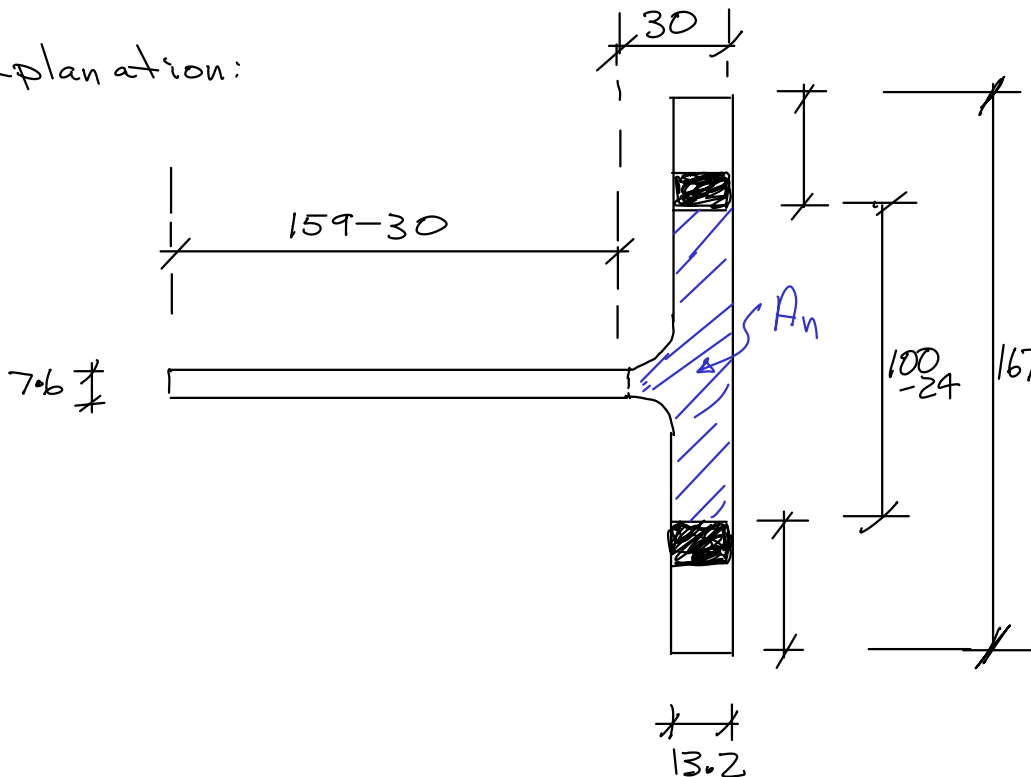
$$T_r = 0.75 \left[1.0 \times 1158 \times 0.45 + 0.6 \times 4080 \frac{0.35 + 0.45}{2} \right]$$

[1 marks]

$T_r = 1125 \text{ kN}$

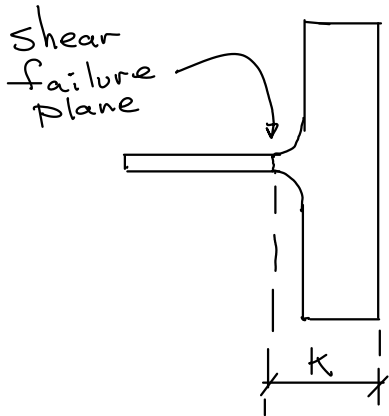
← Ans.

Explanation:



Determine A_n by subtracting $(159 - 30) \times 7.6$ and $(167 - (100 - 24)) \times 13.2$ from tabulated A

(Workspace for Question 4)

Note

1. 'k' is distance to toe of fillet.
2. 'y' tabulated on p. 6-90 for WT155x26 is not the same.
3. Must find 'k' for W310x52 on page 6-53.
4. Because of errors on posted handouts, I will accept use of 'y' dimension instead of 'k' for this time only.

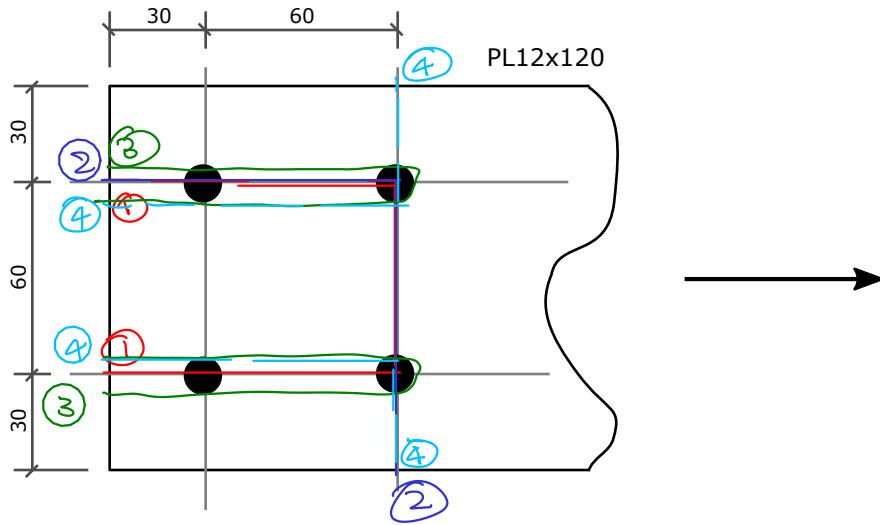
Using $k = 33.1$ (an error)

$$A_n = 1182 \text{ mm}^2$$

$$T_r = 1133 \text{ kN}$$

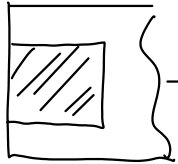
Question 5 (20 marks)

Compute the factored tension resistance, T_r of the 12x120 plate tension member, with respect to block shear only. Make sure to check all possible block shear failure patterns. Assume M20 bolts in punched holes and CSA G40.21 350W steel.



Pattern ①-①

$$A_n = (60 - (20 + 2 + 2)) \times 12 = 432 \text{ mm}^2$$



$$A_{gv} = (30 + 60) \times 12 = 1080 \text{ mm}^2$$

$$T_r = 0.75 \left[1.0 \times 432 \times 0.45 + 0.6 \times 1080 \times \frac{0.35 + 0.45}{2} \right]$$

$$= 535 \text{ kN}$$

[4 marks]

Pattern ②-②

$$A_n = (90 - 1.5(20 + 2 + 2)) \times 12 = 648 \text{ mm}^2$$



$$A_{gv} = 90 \times 12 = 1080 \text{ mm}^2$$

$$U_t = 0.6$$

$$T_r = 0.75 \left[0.6 \times 648 \times 0.45 + 0.6 \times 1080 \times 0.4 \right]$$

$$= 326 \text{ kN} \quad \leftarrow \text{goy}$$

[4 marks]

③-③ (tearout)

$$A_n = 0$$

$$A_{gv} = 4 \times 90 \times 12 = 4320 \text{ mm}^2$$



$$T_r = 0.75 \times 0.6 \times 4320 \times 0.4$$

$$= 777 \text{ kN}$$

[4 marks]

(Workspace for Question 5)

④-④

$$A_n = \left(30 + 30 - 2 \times \left(\frac{20 + 2 + 2}{2} \right) \right) \times 12$$

$$= 432 \text{ mm}^2$$

$$A_{gv} = 2 \times (30 + 60) \times 12$$

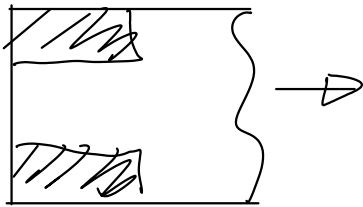
$$= 2160 \text{ mm}^2$$

$$U_t = 0.9$$

$$T_r = 0.75 (0.9 \times 432 \times 0.45 + 0.6 \times 2160 \times 0.4)$$

$$= 520 \text{ kN}$$

[4 marks]



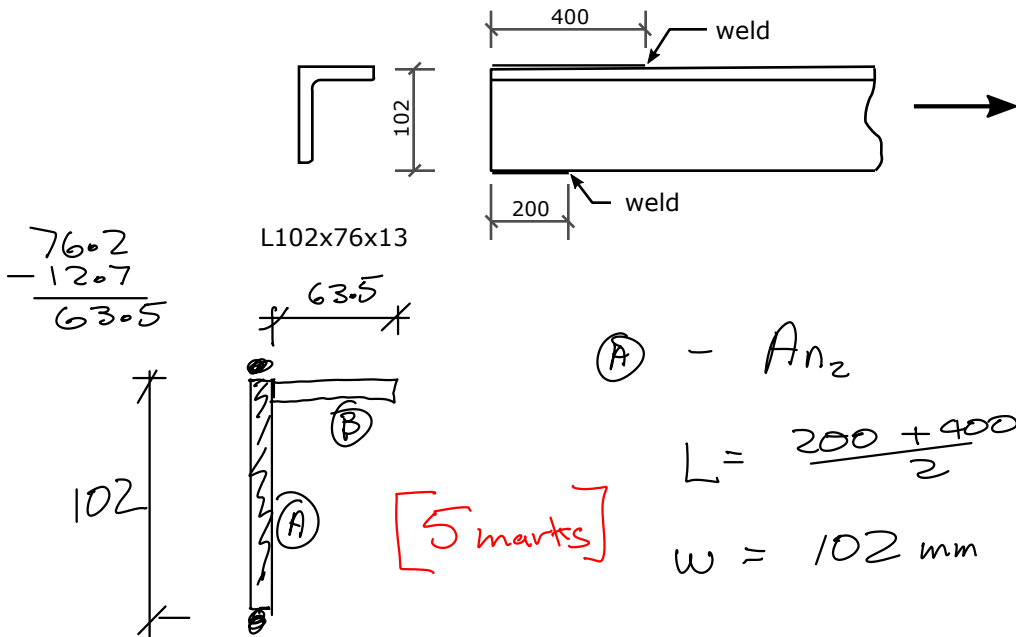
[4 marks]

$$\underline{\underline{T_r = 326 \text{ kN}}}$$

← Ans.

Question 6 (20 marks)

An L102x76x13 tension member is welded along two sides of the long leg to a gusset plate (not shown). Compute the factored tension resistance, T_r , of the angle. Assume CSA G40.21 300W steel.



[5 marks]

(A) - A_{n2}

$$L = \frac{200 + 400}{2} = 300 \text{ mm}$$

$$w = 102 \text{ mm}$$

$$L > 2w$$

$$A_{n2} = wt = 102 \times 12.7 = 1295$$

(B) - A_{n3}

$$L = 400$$

$$w = 63.5$$

$$\bar{x} = 12.7 + \frac{63.5}{2} = 44.4$$

$$L > w$$

$$A_{n3} = \left(1 - \frac{44.4}{400}\right) 63.5 \times 12.7 = 717$$

$$A_{ne} = 2012 \text{ mm}^2$$

[4 marks] Net Fracture:

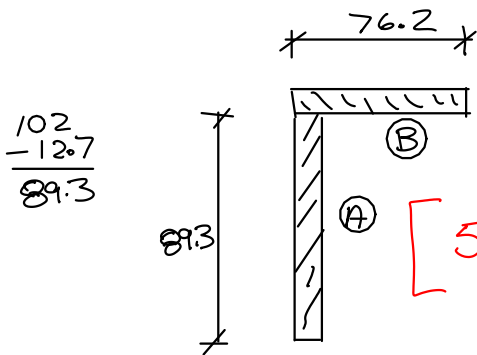
$$T_r = 0.75 \times 2012 \times 0.45 = 679 \text{ kN}$$

Gross Yield

[4 marks] $T_r = 0.9 \times 2100 \times 0.3 = 567 \text{ kN} \leftarrow \text{goy}$

[2 marks] $\underline{\underline{T_r = 567 \text{ kN}}} \leftarrow \text{Ans.}$

(Workspace for Question 6)

Alt. Solution

$$\begin{array}{r} 102 \\ -12.7 \\ \hline 89.3 \end{array}$$

$$\textcircled{A} - A_{n2}$$

$$L = \frac{200 + 400}{2} = 300$$

$$w = 89.3$$

$$L > 2w$$

$$A_{n2} = 89.3 \times 12.7 = 1134 \text{ mm}^2$$

$$\textcircled{B} A_{n3}$$

$$L = 400 \text{ mm}$$

$$w = 76.2 \text{ mm}$$

$$L > w$$

$$\textcircled{5 \text{ marks}} \quad \bar{x} = \frac{76.2}{2} = 38.1 \text{ mm}$$

$$A_{n3} = \left(1 - \frac{38.1}{400}\right) \times 76.2 \times 12.7$$

$$= 875.6 \text{ mm}^2$$

$$A_{ne} = 1134 + 875.6 \text{ mm}^2$$

$$= 2010 \text{ mm}^2$$

$\textcircled{4 \text{ marks}}$ Net Fracture:

$$T_r = 0.75 \times 2010 \times 0.45 = 678 \text{ kN}$$

$\textcircled{4 \text{ marks}}$ Gross Yield: $T_r = 0.9 \times 2100 \times 0.3 = 567 \text{ kN} \leftarrow \text{gov}$

$\textcircled{2 \text{ marks}}$

$$\underline{\underline{T_r = 567 \text{ kN}}}$$

$\leftarrow \text{Ans.}$