CivE 310 A5

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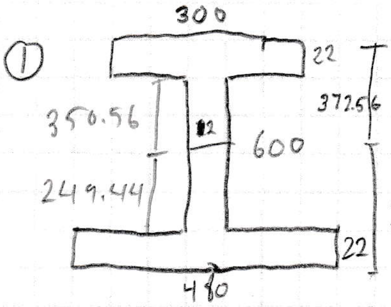
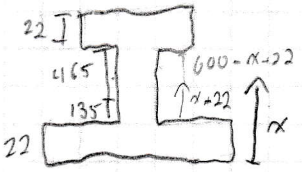


300W, $F_y = 300$ MPa, $F_u = 450$ MPa, $L < L_u$ assumed since laterally braced

a) E. NA $= \bar{y} = \dfrac{11(22\times480) + 322(12\times600) + 633(22\times300)}{(300+480)(22) + (600)(12)}$

$= 271.44$ mm

P. NA = Point of equal areas, assumed in flange

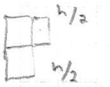


$480\times22 + (x-22)(12) = 300\times22 + (600+22-x)(12)$

$10296 + 12x = 14064 - 12x$

$24x = 3768$

$x = 157$ mm



$I_x = \iint y^2 dA = \sum \int b y^2 dy$

$= \frac{12}{3}(249.44)^3 + \frac{12}{3}(350.56)^3 + \frac{300}{3}(372.56^3 - 350.56^3) + \frac{480}{3}(271.44^3 - 249.44^3)$

$= 1814160932$ mm^4

$S_x = I/y$

$= \dfrac{1814160932}{372.56}$

$= 4869446.35$ mm^3

$Z_x = A_c y_c + A_T y_T$

$= 480\cdot22\cdot(135+11) + 135\cdot12\cdot67.5 + 465\times12\cdot232.5 + 300\cdot22\cdot476$

$= 6090060$ mm^3

Shape Factor $= \dfrac{M_p}{M_y} = \dfrac{Z}{S} = \dfrac{6090060}{4869446.35} = 1.25$

b) Section Classification

Flange

	Class 1	Class 2	Class 3
$\frac{b_{el}}{t} = \frac{480}{22.2} = 10.91 \leq$	$\frac{145}{\sqrt{300}} = 8.37$,	$\frac{170}{\sqrt{300}} = 9.81$,	$\frac{200}{\sqrt{300}} = 11.547$

∴ Flange class 3

Web

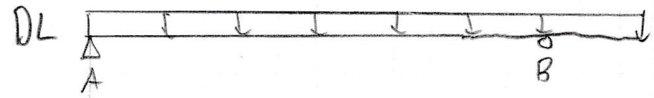
$\frac{h}{w} = \frac{600}{12} = 50$, $\frac{1100}{\sqrt{300}} = 63.5$ ∴ web class 1

∴ Section is class 3, fails at yield stress

$M_{max} = M_y = SF_y = 4869446.35 \cdot 300 \times 0.9^{phi} \times \left(\frac{1}{1000}\right)^2$

$= 1314.75$ kN.m

To find P_{max}, consider moment diagrams for DL and LL, respectively



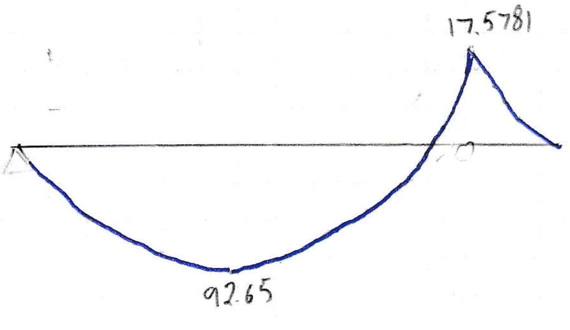
$M_B = 5.625(2.5)(1.25)$
$= 17.5781$ kN.m

Max moment between supports =

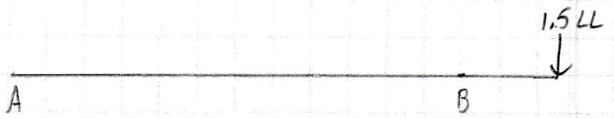
$\frac{w}{8l^2}(l+a)^2(l-a)^2 =$

$= \frac{5.625}{8 \cdot (12)^2}(12+2.5)^2(12-2.5)^2$

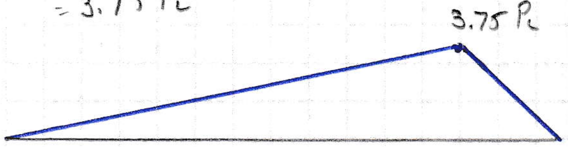
$= 92.65$ kN.m



LL



$M_B = 1.5 \cdot P_L \cdot 2.5$
$= 3.75 P_L$



From these two bending moment diagrams, it is clear that for large values of P_L, the maximum moment is found at reaction B. Since the maximum moment in the span is $92.65 \ll 1314.75$, failure can only happen at B. (assuming $M_{span} > M_B$)

$\therefore\ 5.625(2.5)(2.5/2) + 3.75 P_L = 1314.75$

$P_L = 345.913$ kN at failure

c) $E = 2E5\ N/mm^2$, $w = 4.5\ kN/m = 4.5\ N/mm$

$$\Delta_{overhang} = \frac{wa}{24EI}(4a^2 l - l^3 + 3a^3) + \frac{Pa^2}{3EI}(l + a)$$

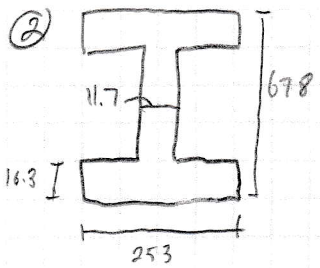
$$= \frac{4.5(2500)}{24 \cdot 2E5 \cdot 1814160932}(4 \cdot 2500^2 \cdot 12000 - 12000^3 + 3 \cdot 2500^3) + \frac{345913 \cdot 2500^2}{3 \cdot 2E5 \cdot 1814160932}(14500)$$

$= -1.71 + 28.80$

$= 27.09$ mm $\downarrow$

$\frac{L}{360} = \frac{2500}{360} = 6.94$ mm $\downarrow$

$\therefore$ Excessive deflection

② 

125 kg/m'
$S_x = 3500 \times 10^3 \ mm^3$
$Z_x = 4010 \times 10^3 \ mm^3$, Joists @ 2500 mm o/c

Factored load = 1.25 (15) + 1.5 (38)
= 75.75

a) Unbraced length = 2500 mm do to joist spacing
From beam table, $L_u = 3190$.
Since 2500 < L_u, lateral-torsional buckling will not control

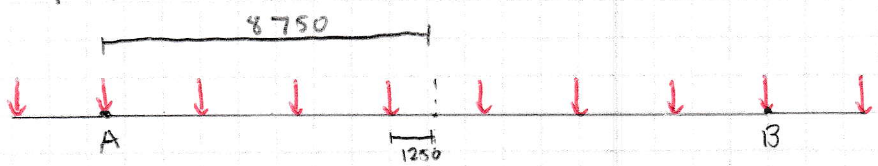
b) Section classification

Flange $\frac{b_{el}}{t} = \frac{253/2}{16.3} = 7.76 \le \frac{145}{\sqrt{345}} = 7.8$, ∴ Class 1

Web $\frac{h}{w} = \frac{678 - 16.3(2)}{11.7} = 55.16 \le \frac{1100}{\sqrt{345}} = 59.22$, ∴ Class 1

∴ Can reach plastic moment
$M_p = \phi Z_x F_y = 0.9 \cdot 4010E3 \times 345 \times (1/1000)^2$
$= 1245.105$ kN·m

$P = 1.25(15) + 1.5(38) = 75.75$ kN



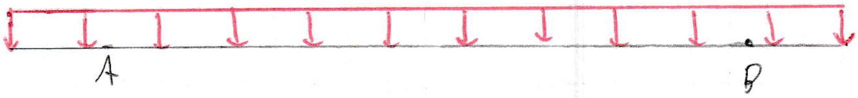
$M_A = M_B = 75.75 \cdot 2.5 = 189.375$ kNm

$A_y = B_y = \frac{75.75 \times 10}{2} = 378.75$ kN

Max moment in mid span, ∴ $M = 75.75 [1.25 + (1.25 + 2.5) + (1.25 + 2 \times 2.5) + (1.25 + 3 \times 2.5) + (1.25 + 4 \times 2.5)]$
$- 378.75 (8.75)$
$= 2367.19 - 3314.0626$
$= 946.875$ kN·m

946.875 < 1245.105, ok

c)



$w_D = \frac{15 \cdot 1.25 \times 10}{22.5} = 25/_3$ kN/m

$w_L = \frac{1.5 \cdot 38 \cdot 10}{22.5} = \frac{76}{3}$ kN/m

$\therefore w_T = \frac{101}{3}$ kN/m

$M_A = M_B = \frac{101}{3} \cdot 2.5 \times 1.25$

$= 105.208$ kN·m

$A_y = B_y = \frac{\frac{101}{3} \times 22.5}{2} = 378.75$ kN

$M_{midspan} = \frac{101}{3} \times \frac{(8.75+2.5)^2}{2} - 378.75 \cdot 8.75$

$= 2130.4688 - 3314.0625$

$M_{midspan} = 1183.59$ kNm

This method is very conservative, yielding a moment 236.72 kNm greater than reality. However, the moment calculated is below the plastic moment, and therefore it passes.

Thus, both methods demonstrate that the beam passes, but the latter is less accurate.