Assignment #3

Design the typical floor composite beam & girder using the same loads as in Assignment #1

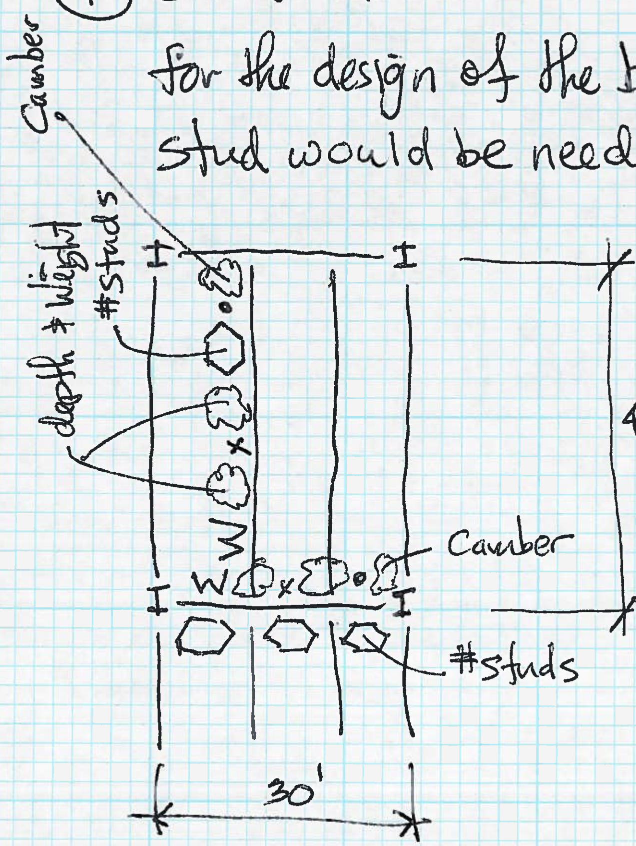
Choose W sections based on the following requirements:

Beams Unshored construction
Camber $\leq 1\frac{1}{2}''$

Girders Unshored construction
Camber $\leq \frac{3}{4}''$

Find the following for both Beams & Girders:

1. $\phi M_n > M_u$
2. Number of studs for partial composite
3. Check $\Delta_L < L/360$
4. Can the live load be increased to 100 psf for the design of the beam? How many stud would be needed?



Assignment #3

Typical Beam

Loads from Assignment #1 $w_D = 860$ #/' $w_L = 400$ #/'

Const DL = 56 psf LL = 20 psf.

$w_u = 1.2(.056 \times 10') + 1.6(0.020 \times 10') = 0.992^{k/'}$

$M_u = 0.992 \times 40^2/8 = 198'^k$

$$\text{Req'd } Z = \frac{M_u}{\phi F_y} = \frac{198 \times 12}{0.9 \times 50} = \underline{53 \text{ in}^3}$$

Camber $\leq 1\frac{1}{2}$" $\Delta_{DL} \leq 1.50/0.8 = 1.875$"

$$\text{Req'd } I = \frac{5(0.056 \times 10)40^4 \times 12^3}{384 \times 29000 \times 1.875"} = \underline{593 \text{ in}^4}$$

<u>Try W18x40</u> $Z = 78.4 \text{ in}^3$ $I = 612 \text{ in}^4$ $A = 11.8 \text{ in}^2$ $d = 17.9$"

$$\left.\begin{array}{l} b = 10' \times 12 = 120" \\ b = 40 \times 12/4 = 120" \end{array}\right\} b = 120"$$

$A_s F_y = 11.8 \times 50 = 590^k$

$a = 590/(0.85 \times 120 \times 3\text{ksi}) = 1.93" < 2\frac{1}{2}"$ <u>OK</u>

$$M_n = 590\left(\frac{17.90}{2} + 5.5" - \frac{1.93}{2}\right)/12 = 590(13.49")/12$$
$$= 663'^k$$

$\phi M_n = 0.9 \times 663 = 597'^k \gg M_u = 408'^k$

<u>Partial Composite</u>

$$V = \frac{(408/0.9) \times 12}{13.49"} = 403.4^k$$

No. studs $= 403.4/17.2 = 23 > 20$ or 1 per flute

Try 5 flutes w/ 2 studs + 15 flutes w/ 1 stud

$\Sigma Q_n = 5 \times 2 \times 14.6^k + 15 \times 17.2 = 404 > V$

<u>25</u> stud per 1/2 beam

$$\%\text{ Partial Composite} = \frac{404}{590} \times 100 = 68\%$$

Deflection Calculations $(n = 8)$

$$\bar{y} = \frac{(120''/8)(2.5'')2.5/2 + (5.5'' + 17.90/2)11.8}{11.8 + (120/8)2.5} = 4.41''$$

$$I_{tr} = \frac{(120/8)2.5^3}{12} + 612 + (4.41 - 2.5/2)^2\left(\frac{120}{8} \times 2.5\right) + \left(\frac{17.9}{2} + 5.5 - 4.41\right)^2 11.8$$

$$= 19.5 + 612 + 374.5 + 1189.5 = 2196 \text{ in}^4$$

$$I_{eff} = 0.75\, I_{tr} = 1647 \text{ in}^4$$

$$I_{eff} = I_s + \sqrt{\frac{\Sigma Q_n}{C_f}}\,(I_{tr} - I_s) = 612 + \sqrt{\frac{403.4}{590}}\,(2196 - 612)$$

$$= 1922 \text{ in}^4$$

<u>Use</u> $I_{eff} = 1647 \text{ in}^4$

$$\Delta_{LL} = \frac{5(0.40)40^4 \times 12^3}{384 \times 29000 \times 1647} = 0.48'' < L/360 = \frac{40 \times 12}{360} = 1.33''$$

$< 1''$ AISC

Typical Girder

Loads from Assignment #1 $\quad w_D = 3560^{\#/\prime}$ $\quad w_L = 1120^{\#/\prime}$

$M_u = 682^{\prime k}$

Const DL $= 59^{\#/\square'}$ $\quad$ LL $= 20$

$$w_u = 1.2(59 \times 40) + 1.6(20 \times 40) = 4112^{\#/\prime}$$

$$M_u = 4.112 \times 30^2/8 = 462.6^{\prime k}$$

$$\text{Req'd } Z = \frac{462.6 \times 12}{0.9 \times 50} = \underline{123.4 \text{ in}^3}$$

Camber $\leq 3/4''$ $\quad \Delta_D = 0.75/0.8 = 0.94''$

$$\text{Req'd } I = \frac{5(0.059 \times 40)30^4 \times 12^3}{384 \times 29000 \times 0.94} = \underline{1578 \text{ in}^4}$$

Try W24x68 $\quad Z = 177 \text{ in}^3 \quad I = 1830 \text{ in}^4 \quad A = 20.1 \quad d = 23.73''$

$$\left.\begin{array}{l} b = 40' \times 12 = 480'' \\ b = 30' \times 12/4 = 90'' \end{array}\right\} b = 90''$$

$$A_s F_y = 20.1 \times 50 = 1005^k$$

$$a = 1005^k/(0.85 \times 90'' \times 3\text{ksi}) = 4.38'' > a_{max} = 3\tfrac{1}{2}'' + 2\tfrac{1}{2}'' = 4''$$

$\therefore$ Partial composite $T = C_{max}$

$$T = C_{max} = 0.85 \times 90'' \times 4'' \times 3ksi = 918^k$$

$$M_n = 918\left(\frac{23.73}{2} + 5.5'' - \frac{4''}{2}\right)/12 = 918(15.37'')/12 = 1174'^k$$

$$\phi M_n = 0.9 \times 1174 = 1057'^k \gg M_u = 682'^k$$

<u>Partial Composite</u>

$$V = \frac{(682/0.9) \times 12}{15.37''} = 592^k$$

$$\text{No. studs} = \frac{592^k}{21.5} = 27.5 \sim 28 \text{ studs over } 10'$$

2 rows @ $8\frac{1}{2}''$

$$\% \text{Composite} = \frac{28 \times 21.5}{1005} \times 100 = 60\%$$

Deflection Calculations ($n = 8$)

$$\bar{y} = \frac{(90/8)(4)(4/2) + (5.5 + 23.73/2)\,20.1}{20.1 + (90/8)(4'')} = 6.744''$$

$$I_{tr} = \frac{(90/8)\,4^3}{12} + 1830 + (6.744 - 4/2)\left(\frac{90}{8} \times 4\right) + \left(\frac{23.73}{2} + 5.5 - 6.744\right)^2 20.1$$

$$= 60 + 1830 + 1013 + 2267 = 5170 \text{ in}^4$$

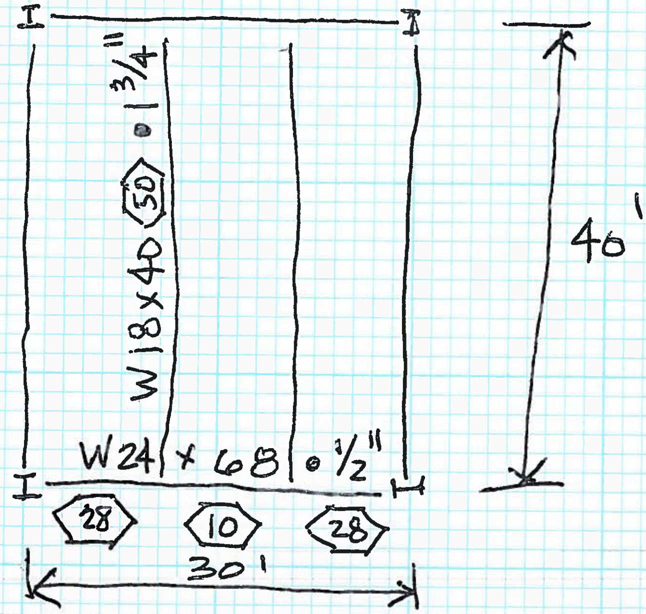
$$I_{eff} = 0.75 \times 5170 = 3878 \text{ in}^4$$

$$I_{eff} = I_s + \sqrt{\frac{\Sigma Q_n}{C_f}}\,(I_{tr} - I_s) = 1830 + \sqrt{\frac{28 \times 21.5}{918}}\,(5170 - 1830)$$

$$= 4535 \text{ in}^4 > \underline{3878 \text{ in}^4}$$

$$\Delta_{LL} = \frac{5(1.120)\,30^4 \times 12^3}{384 \times 29000 \times 3878} = 0.18'' < L/360 = \frac{30 \times 12}{360} = 1''$$

$< 1''$ AISC



100 psf LL on Beams

$$L = 100\left(0.25 + \frac{15}{\sqrt{2\times10\times40}}\right) = 78 \text{ psf}$$

$$w_u = 1.2(860) + 1.6(78\times10') = 2280^{\#/'}$$

$$M_u = 2.280\times40^2/8 = 456^{'k} < \phi M_n = 597^{'k} \quad \underline{\text{OK}}$$

$$V = \frac{(456/0.9)\times12}{13.49''} = 451^{k}$$

Try 9 flutes w/ 2 studs + 11 flutes w/ 1 stud

$$\Sigma Q_n = 9\times2\times14.6 + 11\times17.2 = 452^{k} > V$$

__29 studs__ per 1/2 beam