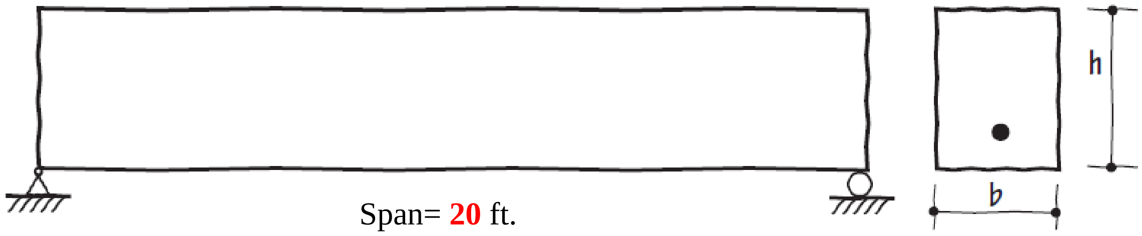
Assignment 2

1. Design a rectangular beam for flexural of **20** ft length which is required to carry dead load of 2 k/ft and live load of 4 k/ft. Given that, f_c'= 4 ksi and f_y = 60 ksi. Assume, b=12 inch.



Span= **20** ft.

Solution:

$$\rho_{min} = \frac{3\sqrt{f_c'}}{f_y}$$

$$= \frac{3 \times \sqrt{4000}}{60000}$$

$$= 0.00316$$

$$\rho_{max} = 0.85\beta_1 f_c'/f_y \times \frac{\varepsilon_u}{\varepsilon_u + 0.005}$$

$$= 0.85 \times 0.85 \times \frac{4}{60} \times \frac{0.003}{0.003 + 0.005}$$

$$\simeq 0.01806$$

For our design,

$$\rho_{min} \leq \rho_{design} \leq \rho_{max}$$

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For design;

$$\rho_{min} \leq \rho_d \leq \rho_{max}$$

Choose, $\rho_d = 0.75 \times \rho_{max} = 0.01377$

In general, self weight of beam can be 10 to 15% of dead load.

Assuming, 12.5% of Dead load,

$$\text{Self wt.} = 2 \times \frac{12.5}{100} = 0.25 \text{ k/ft}$$

$$W_u = 1.2 \times DL + 1.6 \times LL$$
$$= 1.2 \times (2 + 0.25) + 1.6 \times 4$$
$$= 9.1 \text{ k/ft}$$

$$M_u = \frac{W_u L^2}{8} = \frac{9.1 \times 20^2}{8} = 455 \text{ k-ft}.$$

$$M_u = \phi M_n = 0.9 \rho b d^2 f_y' \left(1 - \frac{\rho f_y}{1.7 f_c'}\right)$$

$$\Rightarrow 455 \times 12 = 0.9 \times 0.01377 \times 12 \times d^2 \times 60 \times \left(1 - \frac{0.01377 \times 60}{1.7 \times 4}\right)$$

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$\Rightarrow \quad d = 26.39 \approx 26.5''$

Now, Area of steel, $A_s = \rho bd = 0.01377 \times 12 \times 26.5$
$= 4.38 \text{ in}^2$

4.38 in^2 can be provided in number of ways.

Like, $4\#10$ bar $\Rightarrow 4 \times 1.27 = 5.08 \text{ in}^2$

$6\#8$ bar $\Rightarrow 6 \times 0.79 = 4.74 \text{ in}^2$ (✓)

$8\#7$ bar $\Rightarrow 8 \times 0.60 = 4.80 \text{ in}^2$

Select, $6\#8$ as most economical,

Revised, $\rho = \dfrac{4.74}{12 \times 26.5} = 0.0149 < \rho_{max}$

So, $\varepsilon_t \geq 0.005$

or, $a = \dfrac{4.74 \times 60}{0.85 \times 4 \times 12} = 6.971 \Rightarrow c = \dfrac{6.971}{0.85} = 8.20$

$\varepsilon_t = \dfrac{\cancel{26.5}\ d-c}{c} \times 0.003 = \dfrac{26.5 - 8.2}{8.2} \times 0.003$

$= 0.00669 > 0.005$

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Revised capacity,

$$\phi M_n = \phi A_s f_y (d - a/2)$$

$$= 0.9 \times 4.74 \times 60 \times \left(26.5 - \frac{6.971}{2}\right)$$

$$= 5890.80 \text{ k-in}$$

$$= 490.899 \text{ k-ft}$$

$$\simeq 490.90 \text{ k-ft}$$

Or,

$$\phi M_n = \phi \rho b d^2 f_y \left(1 - \frac{\rho f_y}{1.7 \times f'_c}\right)$$

$$= 0.9 \times 0.0149 \times 12 \times 26.5 \times 60 \times \left(1 - \frac{0.0149 \times 60}{1.7 \times 4}\right)$$

$$= 5888.9 \text{ k-in}$$

$$= 490.8 \text{ k-ft}$$

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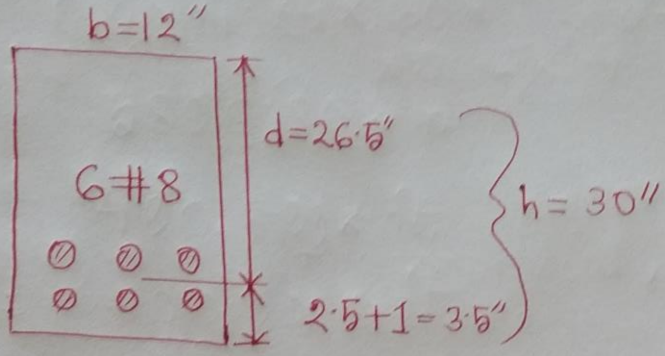
Detailing:

6#8 bar should be provided in two layer.



Self wt. Check:

$$150\times\frac{12\times30}{144} = 375\ lb/ft = 0.375\ k/ft$$

$$W_u = 1.2\times(2+0.375)+1.6\times4$$
$$= 9.25\ k/ft.$$

$$M_{max} = \frac{W_u L^2}{8}$$
$$= \frac{9.25\times20^2}{8}$$
$$= 462.5\ k/ft < \phi M_n\ (okay)$$