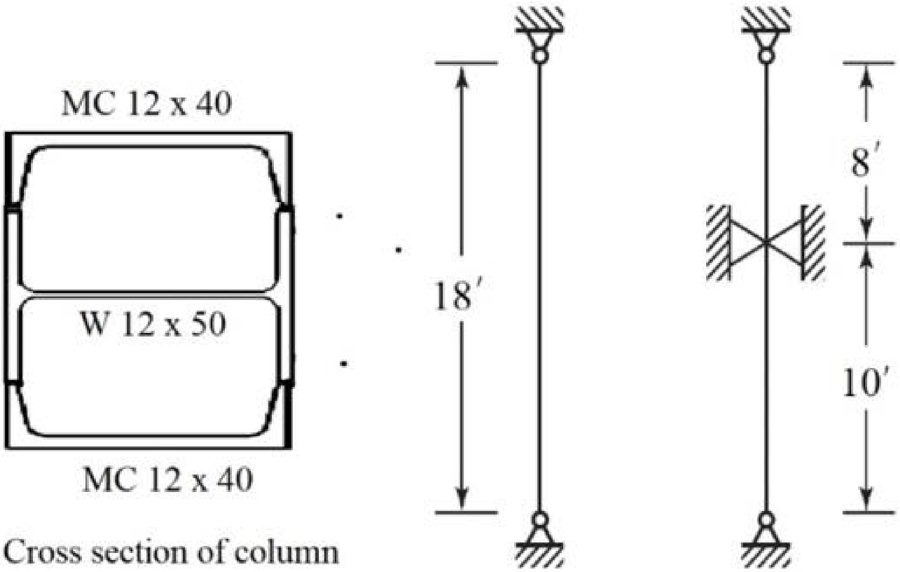
CE 437 – Quiz 2

Problem 1

Determine the maximum service load, which consists of 40% dead load and 60% live load, that the column shown below can carry.

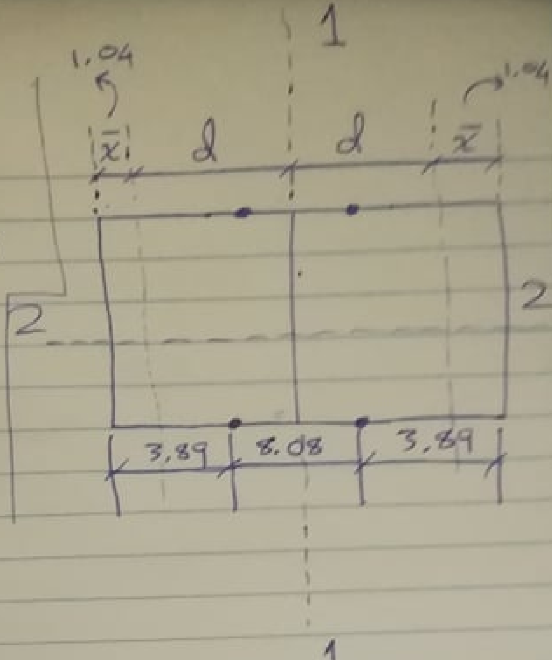
All steel has F_y 50 ksi and F_u 65.



Cross section of column

$$I_{2-2} = I_{x(w)} + 2I_{x(mc)}$$

$$= 391 + 2(273) = 937\ in^4$$



$$I_{1-1} = I_{x(w)} + 2[I_{y(mc)} + A_{(mc)} d^2]$$

$$d = \frac{1}{2} b_{f(w)} + b_{f(mc)} - \bar{x}_{mc}$$

$$= \frac{1}{2}(8.08) + 3.89 - 1.04$$

$$= 6.89\ in$$

$$I_{1-1} = 56.3 + 2[13.7 + (11.8)(6.89)^2] = 1204\ in^4$$

$$r_{2-2} = \sqrt{\frac{I_{2-2}}{A_{Tot}}} = \sqrt{\frac{937}{2(11.80) + 14.6}} = 4.95\ in$$

$$r_{1-1} = \sqrt{\frac{I_{1-1}}{A_{Tot}}} = \sqrt{\frac{1204}{2(11.80) + 14.6}} = 5.61\ in$$

~~$\left(\frac{kl}{r}\right) = (1)$~~ Mak the Column oriented such That The weaker direction is braced =

$$\left(\frac{kl}{r}\right)_{1-1} = \frac{(1)(18 \times 12)}{5.61} = 38.5, \quad \left(\frac{kl}{r}\right)_{2-2} = \frac{(1)(10 \times 12)}{4.95} = 24.24$$

Bucklig occurs about axis (1-1)

$$\left(\frac{kl}{r}\right)_{limit} = 4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000}{50}} = 113.43$$

$\left(\frac{kl}{r}\right)_{1-1} < \left(\frac{kl}{r}\right)_{limit} \Rightarrow$ Buckling is elastic

$\Rightarrow F_{cr} = \left(0.658^{F_y/F_e}\right) F_y$,

$F_e = \frac{\pi^2 E}{(kl/r)^2_{1-1}} = \frac{\pi^2 (29000)}{(38.5)^2} = 193.1$ ksi

$\Rightarrow F_{cr} = \left(0.658^{(50/193.1)}\right) 50 = 44.86$ ksi

$\Rightarrow \phi P_n = 0.9 (F_{cr})(A_{Tot}) = 0.9 (44.86)(2(11.80) + 14.6)$

$= 1542.3$ kips

$P_u = 1.2 (P_{D.L}) + 1.6 (P_{L.L})$

$P_u = 1.2 (0.40 P_s) + 1.6 (0.6 P_s) = 1.44 P_s$

$\phi P_n = 1.44 P_s \Rightarrow 1542.3 = 1.44 P_s \Rightarrow$ $P_s = 1071$ kips

Q(2):

$P_u = 1.2(130) + 1.6(260) = 572$ kips

The bracing is in the y-direction (weak axis):

Assume y-axis controls buckling:

$k_y \ell_y = (0.8)(10) = 8$ ft , where $k_y = 0.8$ as pinned-fixed condition, recomended

Entering Table 4-1 with $kL = 8$ ft

The lightest W10 is W10X49, $\phi_c P_n = 585$ kips

Checking x: $\frac{k_x \ell_x}{r_x/r_y} = \frac{(1)(18)}{1.71} = 10.53$ ft $> k_y \ell_y = 8$ ft

⇒ x axis controls:

Entering Table 4-1 with $kL = 10.53$ ft:

The lightest W10 is W10X54 with

interpolated strength $\phi_c P_n = \underline{595.87}$ kips $\simeq$ 596 kips

↓

or if I want to be conservative

use W10X54, A992 steel $\phi_c P_n = 595$ kips

[The Assumption I made in this problem & the previous one (bracing for y-axis) is a very logical assumption, since we depend on high I_x for the x-axis, & we strengthen y-axis by bracing.]