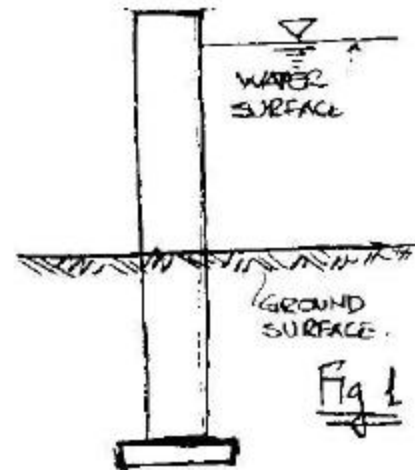


MID TERM EXAMINATION

Open book and notes.
Exam's time = 55 minutes

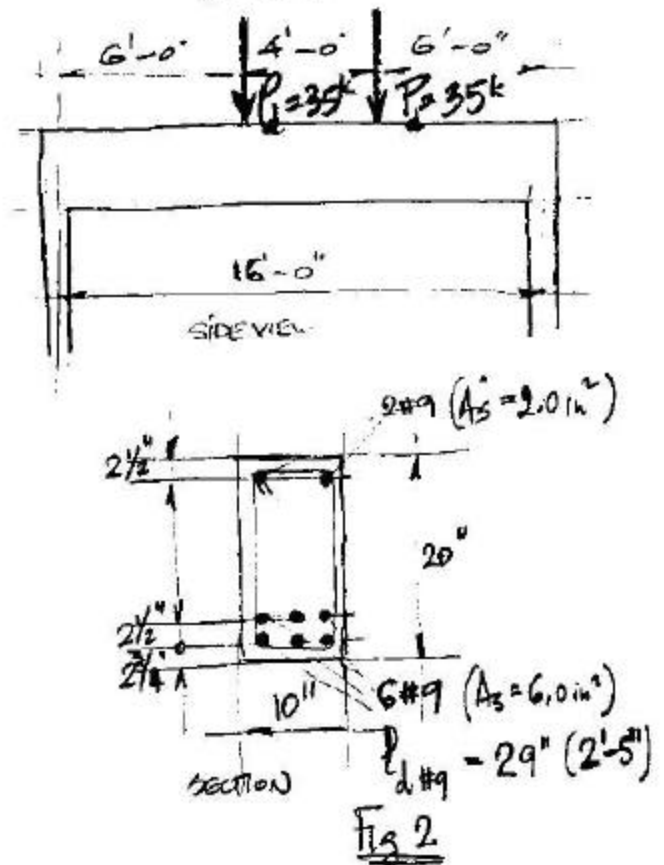
PROBLEM 1 (40 pts)

- (1) Which side of the retaining wall (shown in the figure) should be reinforced? Show reinforcement arrangement including transversal, (if required, explain why it is needed, in one sentence only). (20 pts)
- (2) How would you arrange a "ribbed" wall in this case to be most efficient. (Show vertical and horizontal cross-section and mark side of water). (20 pts)



PROBLEM 2 (70 pts)

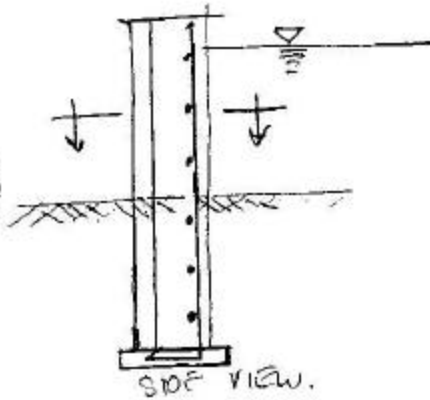
- (1) Determine the capacity diagram for the beam 10" x 20" shown in the figure. The beam is made of concrete $f'_c = 3000$ psi and reinforced by steel $f_y = 40000$ psi. Show the diagram in a scaled sketch. (25 pts)
- (2) Determine the required moment diagram^[1] including the "expanded diagram" for reinforcement cover. Show the diagram in the sketch made for (1). (10 pts)
- (3) Determine capacity of section with only 3 #9 bars at bottom of section. (15 pts)
 (Instead of 6 #9 in two layers).
- (4) Determine the length of the 3 #9 bars (upper layer) if you have to interrupt them in order to match optimally the diagram. Show modified capacity diagram. (20 pts)



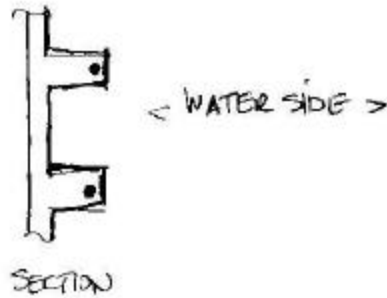
[1] Note: $M_{max} = P \cdot a$

Problem #1

(1) a Reinforcement shown in the tension side. Transverse reinforcement ($A_{s,trans} = 0.018 bd$) required for shrinkage crack control.



(1) b See sketches side view and cross section



Problem #2

(a) Section is doubly reinforced. Assume $f_s = f_y$.

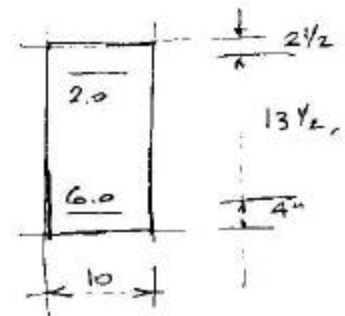
$$M_s = A_s \cdot f_y \cdot 13.5 = 2.0 \times 40 \times 13.5 = 1080 \text{ K-in}$$

$$A_s = 6.0 - 2.0 = 4.0 \text{ in}^2$$

$$k = \frac{4.0 \times 40}{10 \times 16 \times 0.85 \times 3} = 0.392$$

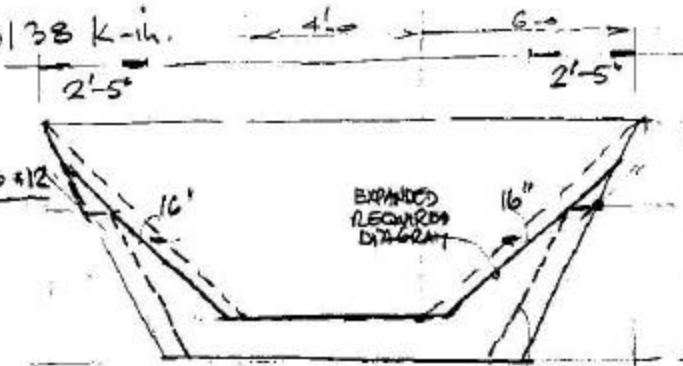
$$M_s^* = 4.0 \times 40 \times 16 \times \left(1 - \frac{0.392}{2}\right) = 2058 \text{ K-in}$$

$$M_{TOT} = 3138 \text{ K-in}$$



(b)

$$M_{cr} = \frac{35 \times 6.0 \times 12}{0.9} = 2800$$



A CAPACITY DIAGRAM.

3138 K-in.

modified capacity diagram for (d)

$$k_y = 0.85 \times \frac{2\frac{1}{2}}{17.25} \times \frac{0.003}{0.003 - \frac{40}{29000}} = 0.227 \quad (\text{No steel does not yield})$$

$$k = \sqrt{\left(\frac{\rho_s' E_{cu} E_s - \rho_s f_y}{1.7 \rho_s'} + \frac{\rho_s' E_{cu} E_s \beta_1 d'}{.85 f_c'} - \frac{f_c' E_{cu} E_s - \rho_s f_y}{1.7 f_c'} \right)}$$

$$= \sqrt{\left(\frac{(0.35 \cdot 87 - 0.0203 \times 40)}{1.7 \times 4} + \frac{0.0135 \times 87 \times .85 \times \frac{2.5}{17.25}}{.85 \cdot 4} - \frac{0.0135 \times 87 \times .85 \times \frac{2.5}{17.25}}{.85 \cdot 4} \right)}$$

$$= 0.0533 = 0.159$$

$$\rho_s' = E_s \cdot \epsilon_{cu} \cdot \frac{k - \beta_1 d'}{k}$$

$$= 87 \times \frac{0.159 - 0.85 \times 2.5 / 17.25}{0.159} = 19.59 \text{ k\%}$$

$$= 19.59 \text{ k\%}$$

$$M^i = 20 \times 19.59 \times 14.75 = 578$$

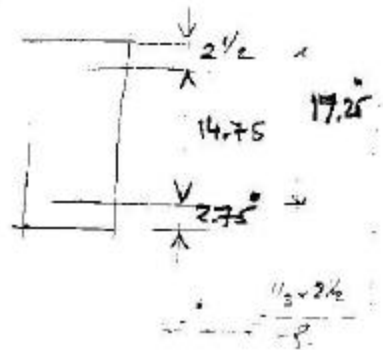
$$M^t = 10 \times 40 \times 17.25 \times (1 - 0.159/2) = 635$$

$$M_{tot} = 1213 \text{ K-in.}$$

$$(d) \quad a' = \frac{1213 + 0.9}{35} = 31.2''$$

$$l_0 = 16' - 0'' - 31.2'' \times 2 = 129.61$$

$$l_0 + 2d = 129.61 + 16 \times 2 = 161.6 \rightarrow 162 = 13' - 6''$$



$$\rho_s' = \frac{2.0}{10 \times 14.75} = 1.35\%$$

$$\rho_s = \frac{2.0}{10 \times 14.75} = 2.03\%$$

$$E_{cu} \cdot E_s = 87.$$

$$\frac{1.17 \times 0.812}{0.0533}$$

