53:139 Foundation Engineering

Homework #7 Solutions

Spring Semester 2009

8.1 Refer to the diagram.

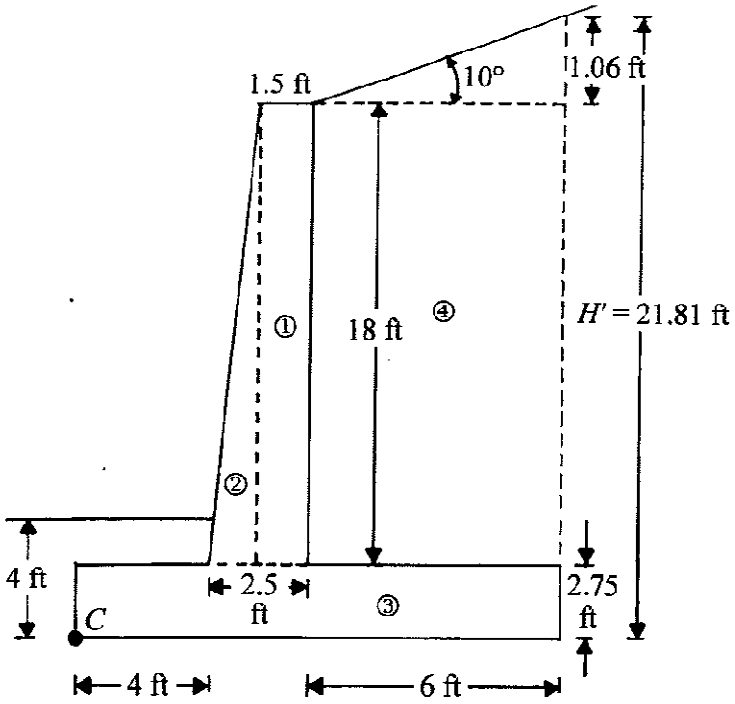


Table 7.1. $\phi'_1 = 34°$; $\alpha = 10°$; $K_a = 0.294$

$$P_a = \frac{1}{2}(H')^2 \gamma_1 K_a = \frac{1}{2}\left(\frac{(21.81)^2(117)(0.294)}{1000}\right) = 8.18 \text{ kip / ft}$$

$P_v = P_a \sin 10° = 1.42$ kip / ft

$P_h = P_a \cos 10° = 8.06$ kip / ft

Section	Weight (kip / ft)	Moment arm from C (ft)	Moment about C (kip-ft / ft)
1	$(1.5)(18)(\gamma_c) = 4.05$	5.75	23.29
2	$\frac{1}{2}(1.0)(18)(\gamma_c) = 1.35$	$4 + \frac{2}{3}(1) = 4.67$	6.3
3	$(12.5)(2.75)(\gamma_c) = 5.156$	6.25	32.23
4	$\frac{(18+19.06)}{2}(6)(0.117) = 13.01$	$4 + 2.5 + \frac{6}{2} = 9.5$	123.6
	$P_v = 1.42$	12.5	17.75
	Σ 24.986		Σ203.17

$$M_o = P_h \frac{H'}{3} = (8.06)\left(\frac{21.81}{3}\right) = 58.6 \text{ kip - ft / ft}$$

$$\text{FS}_{\text{overturning}} = \frac{203.17}{58.6} = \mathbf{3.47}$$

$$\text{FS}_{\text{sliding}} = \frac{\Sigma V \tan\left[\left(\frac{2}{3}\right)\phi_2'\right] + B\left(\frac{2}{3}\right)c_2'}{P_a \cos\alpha} = \frac{(24.986)\tan\left(\frac{2}{3}\times 18\right) + (12.5)\left(\frac{2}{3}\right)(0.8)}{8.06}$$

$$= \mathbf{1.49}$$

$$e = \frac{B}{2} - \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} = 6.25 - \frac{203.17 - 58.6}{24.986} = 0.464 \text{ ft}$$

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right) = \frac{24.986}{12.5}\left[1 + \frac{(6)(0.464)}{12.5}\right] = 2.44 \text{ kip / ft}$$

$B' = 12.5 - (2)(0.464) = 11.572$ ft

$$q_u = c'_2 N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \frac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

From Table 3.3, for $\phi'_2 = 18^\circ$, $N_c = 13.1$; $N_q = 5.26$; $N_\gamma = 4.07$

$$F_{cd} = 1 + 0.4\left(\frac{4}{11.572}\right) = 1.138$$

$$F_{qi} = F_{ci} = \left(1 - \frac{\psi}{90}\right)^2$$

$$\psi = \tan^{-1}\left(\frac{P_a \cos\alpha}{\Sigma V}\right) = \tan^{-1}\left(\frac{8.06}{24.986}\right) = 17.88^\circ$$

$$F_{qi} = F_{ci} = \left(1 - \frac{17.88}{90}\right)^2 = 0.642$$

$q = (4)(0.110) = 0.44$ kip / ft^2

$$F_{qd} = 1 + 0.31\left(\frac{4}{11.572}\right) = 1.107$$

$$F_{\gamma i} = \left(1 - \frac{17.88}{18}\right)^2 = 0$$

$q_u = (0.8)(13.1)(1.138)(0.642) + (0.44)(5.26)(1.107)(0.641) + 0 = 9.3$ kip / ft^2

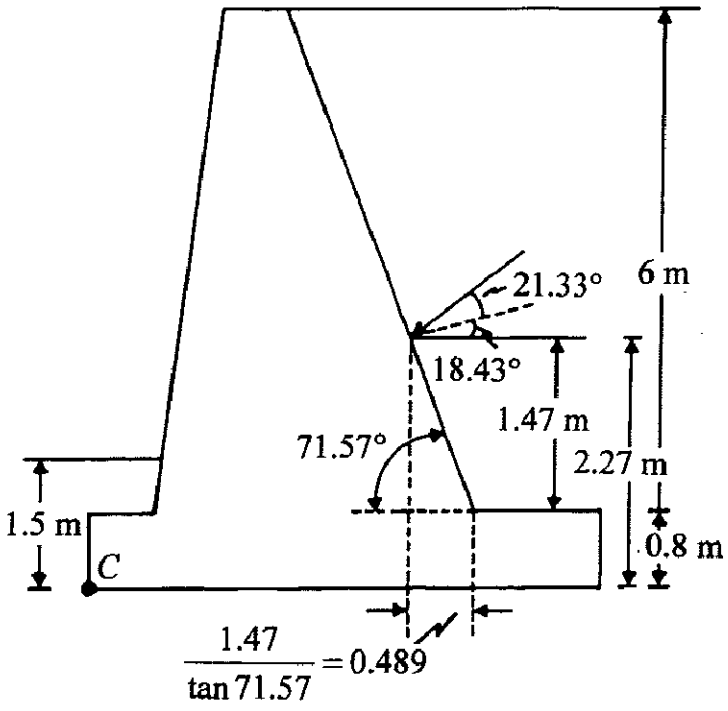
$$\text{FS}_{(\text{bearing})} = \frac{q_u}{q_{\text{toe}}} = \frac{9.3}{2.44} = \mathbf{3.81}$$

8.5 $\frac{\delta}{\phi_1'} = \frac{2}{3}$. From Table 7.4, for $\phi_1' = 32°$, $\alpha = 0$; $\beta = 71.57°$; $K_a = 0.45$; $\delta = 21.33°$

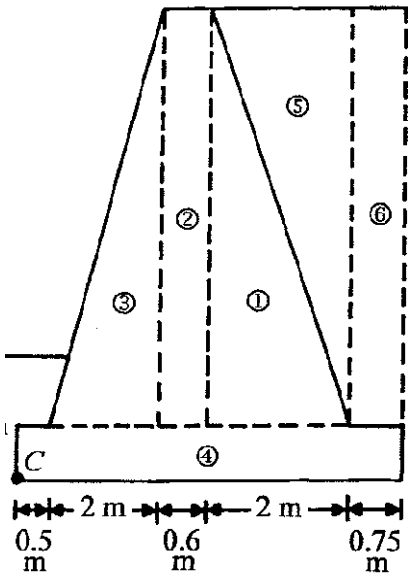
$$P_a = \frac{1}{2}(16.5)(6.8)^2(0.45) = 171.67 \text{ kN/m}$$

$$P_h = 171.67\cos(21.33 + 18.43) = 131.97 \text{ kN/m}$$

$$P_v = 171.67\sin(21.33 + 18.43) = 109.8 \text{ kN/m}$$



Refer to sections in the figure shown for Problem 8.4.



Section	Weight (kN / m)	Moment arm from C (m)	Moment about C (kN-m / m)
1	141.48	3.77	533.38
2	84.89	2.8	237.69
3	141.48	1.83	258.9
4	110.35	2.925	322.8
P_v	109.8	4.611	506.29
	Σ588		Σ1859.06

$$M_O = P_h \frac{H'}{3} = (131.97)\left(\frac{6.8}{3}\right) = 299.13 \text{ kN - m / m}$$

$$\text{FS}_{\text{(overturning)}} = \frac{1859.06}{299.13} = \mathbf{6.2}$$

$$\text{FS}_{\text{(sliding)}} = \frac{\Sigma V \tan\left(\frac{2}{3}\phi_2'\right) + \left(\frac{2}{3}\right)c_2' B}{P_h} = \frac{(588)\tan(14.66) + \left(\frac{2}{3}\right)(40)(5.85)}{131.97} = \mathbf{2.35}$$

8.9 a. $K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right) = \tan^2\left(45 - \frac{34}{2}\right) = 0.2827$

$$\text{Eq. (8.39): } t = \frac{(\gamma_1 H K_a S_V S_H)[\text{FS}_{(B)}]}{w f_y} = \frac{(119)(30)(0.2827)(3)(4)(3)}{(4.75)(38{,}000)} = \mathbf{0.201 \text{ in.}}$$

b. Eq. (8.38). At $z = 0$,

$$L = H\tan\left(45 - \frac{\phi_1'}{2}\right) + \frac{\text{FS}_{(P)} S_V S_H (K_a \gamma z)}{(2w\tan\phi_1')(\gamma z)}$$

$$= (30)\tan(45 - 17) + \frac{(3)(0.2827)(3)(4)}{(2)\left(\frac{4.75}{12}\right)(\tan 25)} = \mathbf{43.52 \text{ ft}}$$

8.10 a. Check for overturning: $P_a = \frac{1}{2}\gamma_1 H^2 K_a = \frac{1}{2}(119)(30^2)(0.2827) = 15{,}138.5$ lb / ft

$$M_o = P_a z' = (15{,}138.5)\left(\frac{30}{3}\right) = 151{,}385 \text{ lb - ft} \approx 151.4 \text{ kip - ft / ft;}$$

$L = 43.52$ ft

Eq. (8.41): $$M_r = (HL)(\gamma_1)\left(\frac{L}{2}\right) = H\gamma_1\left(\frac{L^2}{2}\right) = \frac{(30)(119)(43.52)^2}{2}$$

$$= 3{,}380{,}773 \text{ lb - ft} \approx 3381 \text{ kip - ft / ft}$$

$$\text{FS}_{\text{(overturning)}} = \frac{3381}{151.4} = \mathbf{22.33}$$

b. Check for sliding: Eq. (8.43):

$$\text{FS}_{\text{(sliding)}} = \frac{\gamma_1 HL \tan\left(\frac{2}{3}\phi_1'\right)}{P_a} = \frac{(119)(30)(43.52)\tan\left[\left(\frac{2}{3}\right)(34)\right]}{15{,}138.5} = \mathbf{4.29}$$

c. Check for bearing capacity: $\phi_2' = 25°$. From Table 3.3, $N_c = 20.72$; $N_\gamma = 10.88$

$$q_{ult} = c_2' N_c + \frac{1}{2}\gamma_2 L' N_\gamma$$

$$e = \frac{L}{2} - \frac{M_R - M_O}{\Sigma V} = \frac{43.52}{2} - \frac{3381 - 151.4}{(30)(43.52)(0.119)} = 0.97 \text{ ft}$$

$L' = 43.52 - (2 \times 0.97) = 41.58$ ft

$$q_u = (650)(20.72) + \frac{1}{2}(116)(41.58)(10.88) = 13{,}468 + 26{,}238.6 \approx 39{,}706.6 \text{ lb / ft}^2$$

$$\sigma'_{o(H)} = \gamma_1 H = (119)(30) = 3570 \text{ lb / ft}^2$$

$$\text{FS}_{\text{(bearing capacity)}} = \frac{39{,}706.6}{3570} = \mathbf{11.1}$$