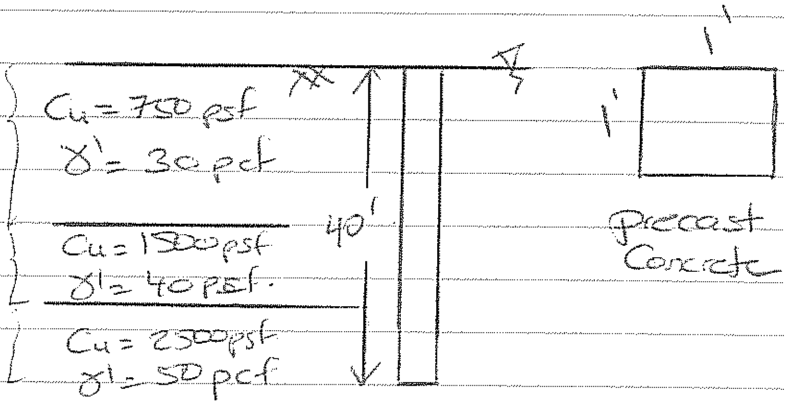
577

$\frac{1\phi 9}{1200}$ $\frac{115}{200}$

Solution for HW3

Problem 1: $f'_c = 5000$ psi
α-method = ?
β-method = ?
$f_u \le 0.33 f'_c$



*** Alpha Method:**

layer 1: $\sigma'_{v,1} = \gamma'\left(\frac{20}{2}\right) = 30\times10 = 300$ psf, $c_u = 750$ psf $\Rightarrow \frac{C_u}{\sigma'_v} = \frac{750}{300} = 2.5 \Rightarrow \alpha_1 = 0$

layer 2: $\sigma'_{v,2} = (30)(20) + (40)(5) = 800$ psf, $C_u = 1500$ psf $\Rightarrow \frac{C_u}{\sigma'_v} = \frac{1500}{800} = 1.87 \Rightarrow \alpha_2 = 0.$

Layer 3: $\sigma'_{v,3} = 30\times20 + (40)(10) + (50)(5) = 1250$ psf, $C_u = 2500 \Rightarrow \frac{C_u}{\sigma'_v} = \frac{2500}{1250} = 2.0 \Rightarrow \alpha_3 = 0$

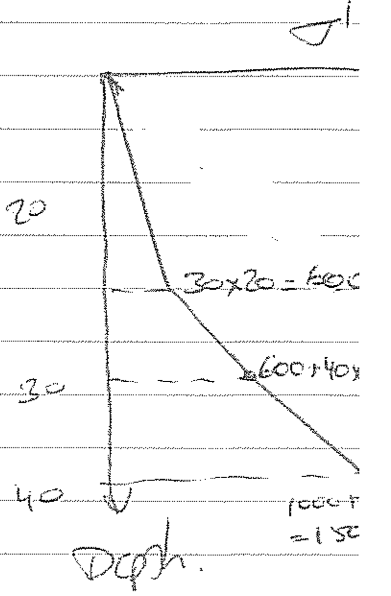
$Q_{ult} = Q_{side} + Q_{tip}$
$Q_{tip} = 9 C_u A_{tip} = 9\times2500\times1'\times1' = 22{,}500$ lb
$Q_{side} = \sum \alpha C_u A_{side} = (0.4\times750\times20 + 0.43\times1500\times10 + 0.42 \ldots) \times (1'+1'+1'+1')$
$= 91{,}800$ lb

$\Rightarrow Q_{ult} = 91{,}800 + 22{,}500$
$\Rightarrow Q_{ult} = 114{,}300$ lb $= 114.3$ kips
$\Rightarrow Q_{all} = \frac{114{,}300}{3.0} = 38.1$ kips $\le 0.33 f'_c \times A \le 237.6$ kips

$\Rightarrow Q_{all} \le 0.33 f'_c A$
and $Q_{ult} = 114.3$ kips is also less than $0.33 f'_c A$ (237.6 kips)

* **β method:** $Q_{side} = p \cdot L \cdot f_{av}$

$f_{av} = \lambda(\bar{\sigma}'_o + 2\bar{C}_u)$



$\bar{C}_u = (C_{u_1}L_1 + C_{u_2}L_2 + C_{u_3}L_3)/L$

$= [(750)(20) + (1800)(10) + (2500)(10)]/40$

$= 1375$ psf

$\bar{\sigma}'_o = (A_1 + A_2 + A_3)/L$

$= \left[\frac{(600)(20)}{2} + \left(\frac{600+1000}{2}\right)(10) + \left(\frac{1500+1000}{2}\right)(10)\right]/40$

$= 662$ psf.

$\Rightarrow \lambda_{L=12.2m} = 0.23$

$\Rightarrow Q_{side} = (0.23)(662 + 2 \times 1375)(40)(4)$

$\Rightarrow Q_{side} = 125,561$ lb $= 125.5$ kips.

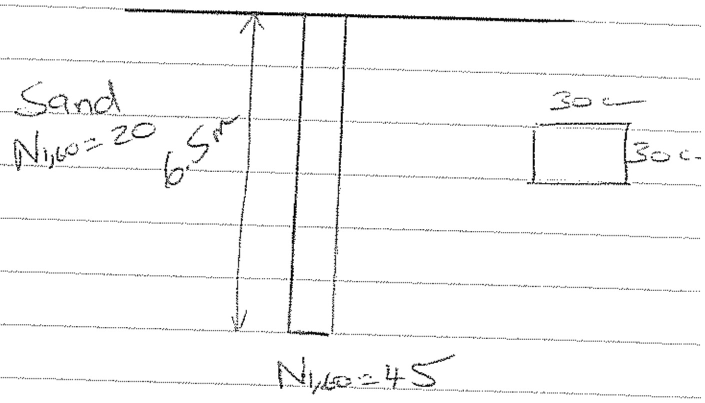
$\Rightarrow Q_{ult} = 125,561 + 22,500$

$\Rightarrow Q_{ult} = 148,061$ lb $= 148.1$ kips

$\Rightarrow Q_{all} = \frac{148.1}{3} =$ ~~49.38~~ 49.3 kips $\leq 0.33 f'_c \times A \leq 237.6$

and $Q_{ult} = 148.1$ kips $<< 237.6$ kips.

Problem 3:



$N_{1,60} = 20 \Rightarrow$ Medium Dense $\Rightarrow \gamma = 18\ kN/m^3$

$Q_{ult} = Q_{side} + Q_{tip}$

End Bearing:

$Q_{tip} = \sigma'_{v,tip} \cdot N_q^* \cdot A_{tip}$

$= (6.5)(18)(135)(0.3)(0.3)$

$= 1421\ kN$

Check $Q_{limit} = q_{limit} \times A_{tip} = (190\ ksf)(1ft \times 1ft) = 190\ kips = 862$

$\therefore Q_{tip} > Q_{limit} \Rightarrow \boxed{Q_{tip} = Q_{limit} = 862\ kN}$

Side Friction:

$f_s = K \sigma'_v \tan\delta$

$\sigma'_v = (18)(z) = 18z\ kN/m^2$

$K = 0.7 + 0.015 N_{1,60} = 0.7 + (0.015)(20) = 1.0$

$\delta = 32.5°$

$\cancel{\Rightarrow f_s = (1)(32.5)(}$

$\Rightarrow f_s = (1)(18z)(\tan 32.5) = 11.47z$

check f_s @ 6.5m $= 74.54\ kN/m^2$ to be less than $f_{s,limit} = 1.7\ ksf$
$= 83\ kN/m^2$

$\Rightarrow$ O.k.

$$\Rightarrow Q_s = \int_{z=0}^{6.5} (f_s \times p)\,dz$$

$$\Rightarrow Q_s = \int_{z=0}^{6.5} (11.47z)(4 \times 0.3).(dz)$$

$$\Rightarrow Q_s = \int_{z=0}^{6.5} 13.76\,z\,dz$$

$$\Rightarrow Q_s = \frac{13.76\,z^2}{2}\Bigg|_0^{6.5} = 290 \text{ kN}$$

$\Rightarrow$ Pile Capacity $Q_u = 290 + 862 = 1152$ kN

$$\Rightarrow Q_{all} = \frac{Q_u}{FS} = \frac{1152}{3} = 384 \text{ kN}$$

Check structural Capacity:

$$\phi\, Q_{structural} = 0.33 f'_c \times A = (0.33)(5000 \text{ psi})\left(\frac{30}{2.54} \times \frac{30}{2.54}\right)$$

$\Rightarrow Q_{structural} = \cancel{3104}$ kN

1069

$\Rightarrow Q_{all} = 384$ kN is less than $Q_{structural}$

But $Q_{ult} = 1152$ kN is slightly greater than $Q_{structural}$

MEMORANDUM

To: Prof. Robert B. Gilbert

From: Bob Gilbert

Date: November 10, 2004

Subject: Axial Capacity of Deep Foundations

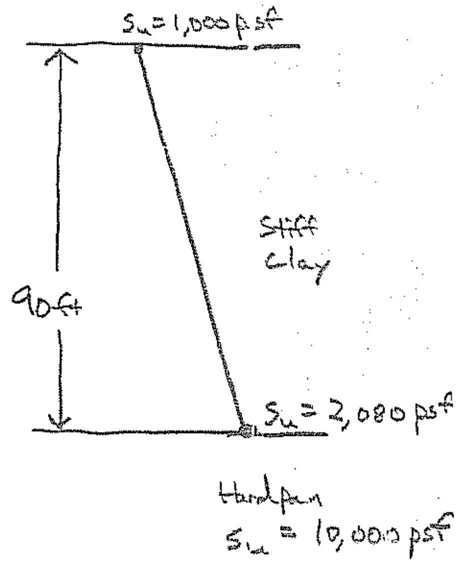
The axial capacity for two alternative drilled shaft designs has been estimated.

Straight Shafts: For the straight shafts that are 36 inches in diameter and 100 feet long, the total axial capacity is 1,640 kips, giving an allowable design capacity of 650 kips. Of the total capacity, 40 percent of it is carried in end bearing. The compressive stresses in this shaft are all less than allowable compressive stress in the concrete if 5,000-psi concrete is used.

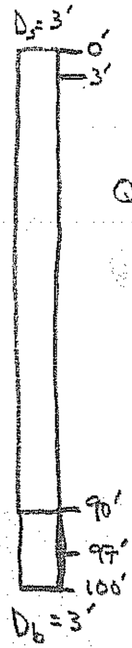
Belled Shafts: For the belled shafts that are 36 inches in diameter, 100 feet long, and tipped with a 5-foot diameter bell, the total axial capacity is 2,680 kips and the allowable design capacity is 1,070 kips. Of the total capacity, 66 percent is carried in end bearing. The compressive stresses in this shaft are all greater than the allowable compressive stress in the concrete if 5,000-psi concrete is used. Therefore, either higher strength concrete or substantial reinforcement will be required to mobilize the total axial capacity in these shafts.

Calculations supporting this report are attached. If you need additional information, or have further questions, please do not hesitate to contact me.

[redacted] | Homework No. 3 | [redacted]



1.



$Q_s = 0$

$$Q_s = \int_3^{90} 0.55(1{,}000 + 12z)\,\pi\,3\,dz$$

$$= 0.55(1{,}000)\pi\,3\,z\Big|_3^{90} + 0.55\left(\tfrac{1}{2}12z^2\right)\pi\,3\Big|_3^{90}$$

$$= 0.55(1{,}000)\pi\,3(87) + 0.55\left(\tfrac{1}{2}12\right)\pi\,3\,(90^2 - 3^2)$$

$$= 703 \text{ kips}$$

$$Q_s = 0.45(10{,}000)\pi\,3\,(7) = 297 \text{ kips}$$

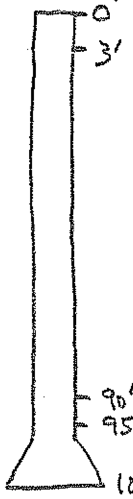
$Q_s = 0$

$$Q_b = 9(10{,}000)\tfrac{\pi}{4}(3)^2 = 636 \text{ kips}$$

$$Q = 703 + 297 + 636 = 1{,}640 \text{ kips}$$

$$P_{design} = 1{,}640^k/2.5 = 650 \text{ kips}$$

2.



$Q_s = 0$

$Q_s = 703$ kips

$Q_s = 0.45(10{,}000)\pi\,3(5) = 212$ kips

$Q_b = 9(10{,}000)\frac{\pi}{4}(5)^2 = 1{,}770$ kips

$Q = 703 + 212 + 1{,}770 = 2{,}680$ kips

$P_{design} = 2{,}680^k/2.5 = 1{,}070$ kips

3. Straight Shaft

$\downarrow Q = 1{,}640^k$

$\uparrow Q_{butt} = 1{,}640^k$ $\qquad \sigma_{butt} = \frac{1{,}640{,}000\text{ lb.}}{\pi/4\,(36\text{ in})^2} = 1{,}610$ psi

$\downarrow Q = 1{,}640^k$

0'

$\uparrow Q_s = 0.55(1{,}000)\pi\,3(47) + 0.55(\frac{1}{2}12)\pi\,3(50^2 - 3^2) = 244 + 78 = 322$ kip

50'

$\uparrow Q_{mid} = 1{,}640 - 322 = 1{,}320$ kips

$\sigma_{mid} = \frac{1{,}320{,}000\text{ lb.}}{\pi/4\,(36\text{ in})^2} = 1{,}290$ psi

$\downarrow Q_{tip} = 636$ kips

$\uparrow Q_b = 636$ kips $\qquad \sigma_{tip} = \frac{636{,}000\text{ lb.}}{\pi/4\,(36\text{ in})^2} = 625$ psi

Belled Shaft

$\downarrow Q = 2{,}680$ kips

$\uparrow Q_{butt} = 2{,}680$ kips $\qquad \sigma_{butt} = \dfrac{2{,}680{,}000 \text{ lb.}}{\pi/4\,(36\text{in})^2} = 2{,}630$ psi

$\downarrow Q = 2{,}680$ kips

$Q_s = 322$ kips

$\uparrow Q_{mid} = 2{,}680 - 322 = 2{,}360$ kips $\qquad \sigma_{mid} = \dfrac{2{,}360{,}000 \text{ lb.}}{\pi/4\,(36\text{in})^2} = 2{,}320$ psi

$\downarrow Q_{tip} = 1{,}770$ kips

$\uparrow Q_b = 1{,}770$ kips $\qquad \sigma_{tip} = \dfrac{1{,}770{,}000 \text{ lb.}}{\pi/4\,(36\text{in})^2} = 1{,}740$ psi

Note: Check at top of bell - critical location.

4. $\sigma_{all} = \frac{1}{3}(5{,}000 \text{ psi}) = 1{,}670$ psi

Straight Shaft: $\sigma_{max} = 1{,}610 \text{ psi} < \sigma_{all} = 1{,}670$ psi ✓

Belled Shaft: $\sigma_{butt}, \sigma_{mid}, \sigma_{tip} > \sigma_{all}$ Not OK