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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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14.528 Drilled Deep Foundations
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Homework No. 3

Drilled Shaft Axial Loading Design

The attached Figure 1 and Table 1 refer to the site and subsurface conditions you were provided with as part of homework no. 2. Using the attached subsurface and strata parameters, you are required to design two drilled shafts following O'Neill and Reese design procedures (also examine the AASHTO (2007) Horvath and Kenney procedure).

1. The design addresses two axial loads having the magnitude of 3850kips and 2700kips.

2. The shaft is to be constructed in the vicinity of boring NVB-B

3. The shaft is designed using WSD and assumed global F.S. = 2.5.

4. The drilled shaft is uniform 7ft in diameter. You need to establish the length of the shafts required to support the above loads.

5. The shaft reinforcement cage steel area (related to cross-section) is A_s = 1.0% and the concrete used is of f_c' = 4000psi.

6. A casing is used along the fill and organic silt layers, and hence, the friction along these layers is neglected.

7. Remember to examine the structural limit of the shaft such that the resistance (capacity) you assign does not exceed the structural allowable limit.

8. Evaluate the axial settlement/shortening of the shaft using the attached Paikowsky et al. (2008) equation. Examine the estimated settlement of each shaft knowing that the service limit state at the shaft's top is 0.5in of axial movement.

9. Provide organized calculations and summary tables with all requested solutions.

Item #8 Equation

Estimated vertical deformation of the drilled shafts at the shaft top (below the columns) was analyzed using an equation developed by Paikowsky et al. (2008) for the evaluation of settlement of deep foundations:

$$S_{DL} = \frac{X}{6} + \frac{2}{3}\frac{P_{DL}L}{EA}$$

For which
- S_{DL} = Pile settlement under the design load
- P_{DL} = Design Load (e.g. 3850kips)
- X = 0.15 + B/120, where B = 84in (7ft)
- A = $\pi B^2/4$
- E = $E_{composite}$

Paikowsky, S.G., Gurbuz, A., Ye, L. and Canniff, M. (2008). "Summary of the Uncertainty in Settlement Evaluation of Deep Foundations and Settlement Multipliers Recommendations for SLS Analysis of Axially Loaded Deep Foundations", Report submitted to National Cooperative Highway Research Program (NCHRP) for project NCHRP 12-66, Geosciences Testing and Research, Inc., North Chelmsford, MA

Table 1: Summary of Soil Strata and Properties Determined from Correlations with SPT-N Values

Stratum	$N_{corrected}$ [1,2]	γ [4,5]	D_R [6]	ϕ' [7]	S_u(psf) [8] q_u (ksf)	E_s [9,10] or RQD
						(ksi)
	(bpf)	(pcf)	(%)	(deg.)		Drilled Shafts
Granular fill	32	125	62	35	N/A	6.1
Organic Silt[3]	N/A	100	N/A	0	500	0.7
Clay - BBC	13	120	N/A	0	2700	3.8
Glacial Deposits	44	135	64	39	N/A	6.7
Weathered Rock	>100	145	N/A	44	N/A	N/A
Fractured Rock	N/A	150	N/A	N/A	535[11]	RQD = 28%
Competent Rock	N/A	172	N/A	N/A	1300[11]	RQD = 73%

1. SPT-N values in cohesionless soils corrected for overburden, hammer efficiency, and rod length $[(N_1)_{60}]$.
2. SPT-N values in cohesive soils corrected for hammer efficiency and rod length (N_{60}).
3. No SPT-N values available for organic silt layer (observed only in NVB-B). Soil properties assumed based on description of stratum and local geology.
4. Cohesionless soil: $\gamma = 0.88[(N_1)_{60}]+99 \leq 145$ pcf [see Paikowsky et al. (NCHRP 12-66) based on Bowles (1996)].
5. Cohesive soil: $\gamma = 9.33LN(N_{uncorrected})+99 \leq 140$ pcf (see Terzaghi and Peck, 1967).
6. For correlations between D_R (%) and $(N_1)_{60}$ see Das (2007), Table 2.5 (pg 80 of 6th Ed. textbook).
7. $\Phi' = 54\text{-}27.6034e^{[-0.014(N1)60]}$ [see Paikowsky et al. (NCHRP Report 651) based on PHT (Kulhawy & Mayne, 1990)].
8. For correlations between S_u (psf) and N_{60} see Das (2007), Table 2.4 (pg 79 of 6th Ed. textbook). Su average of borings A,B and C.
9. Cohesionless soil: $E_s/p_a = 112*e^{(0.07)}LN[(N_1)_{60}]$ for drilled shafts.
10. Cohesive soil: $E_s = 200*S_u$ (see Paikowsky et al. NCHRP Report 651 for correlations with E_s).
11. q_u – average of borings A, B and C in ksf.

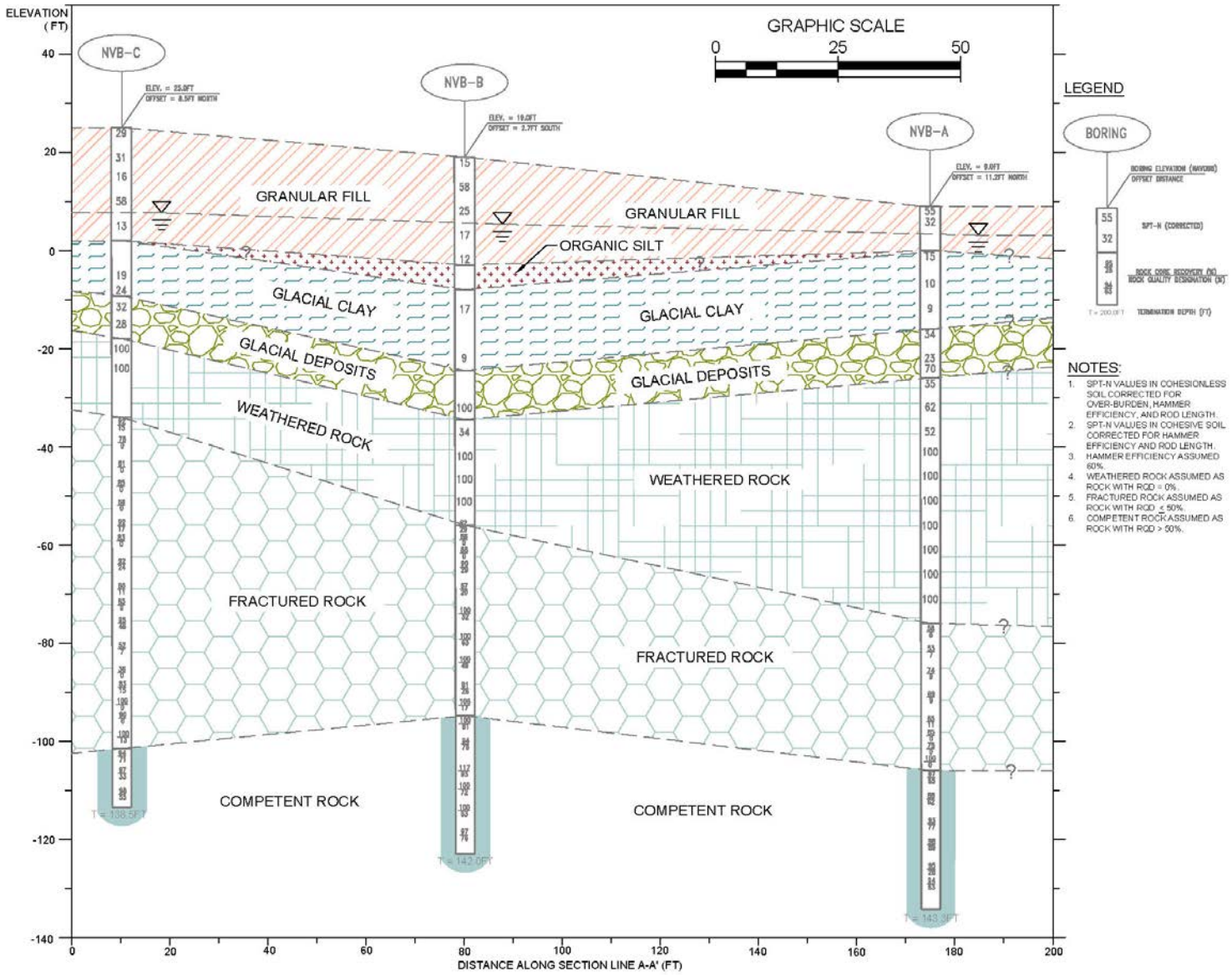

Figure 1. Subsurface Conditions