Exercise 6 – 13/11/2025 - Solution

Parameter determination based on data from in-situ tests

1. Standard Penetration Test (SPT)

In order to estimate the Dr, the value of N'_{70} has to be computed according to the following procedure:

$$N'_{70} = C_N \eta_1 \eta_2 \eta_3 \eta_4 N \quad (1)$$

where η_i are adjustment factors defined below and C_N is a coefficient that considers the overburden vertical stress:

$$C_N = \left(\frac{95.76}{\sigma'_{v0}}\right)^{0.5} \quad (2)$$

with $\boldsymbol{\sigma'_{v0}}$ is the effective vertical overburden stress at the given depth $\sigma'_{v0} = \sigma_{v0} - p_w = \gamma z - \gamma_w z$

- $\eta_1 = \frac{Er}{70} = \frac{60}{70} = 0.857$ (energy efficiency coefficient)
- $\eta_2 = 1$ (rod length correction)
- $\eta_3 = 1$ (sampler correction)
- $\eta_4 = 1$ (borehole diameter correction)

Once the values of N'_{70} are computed for the sand layer at the different depth, the mean values are calculated above and below the GWT. They are respectively 11.59 and 7.31 (see table below).

According to the Table of Problem 1, relative density can be estimated D_r = 0.35.

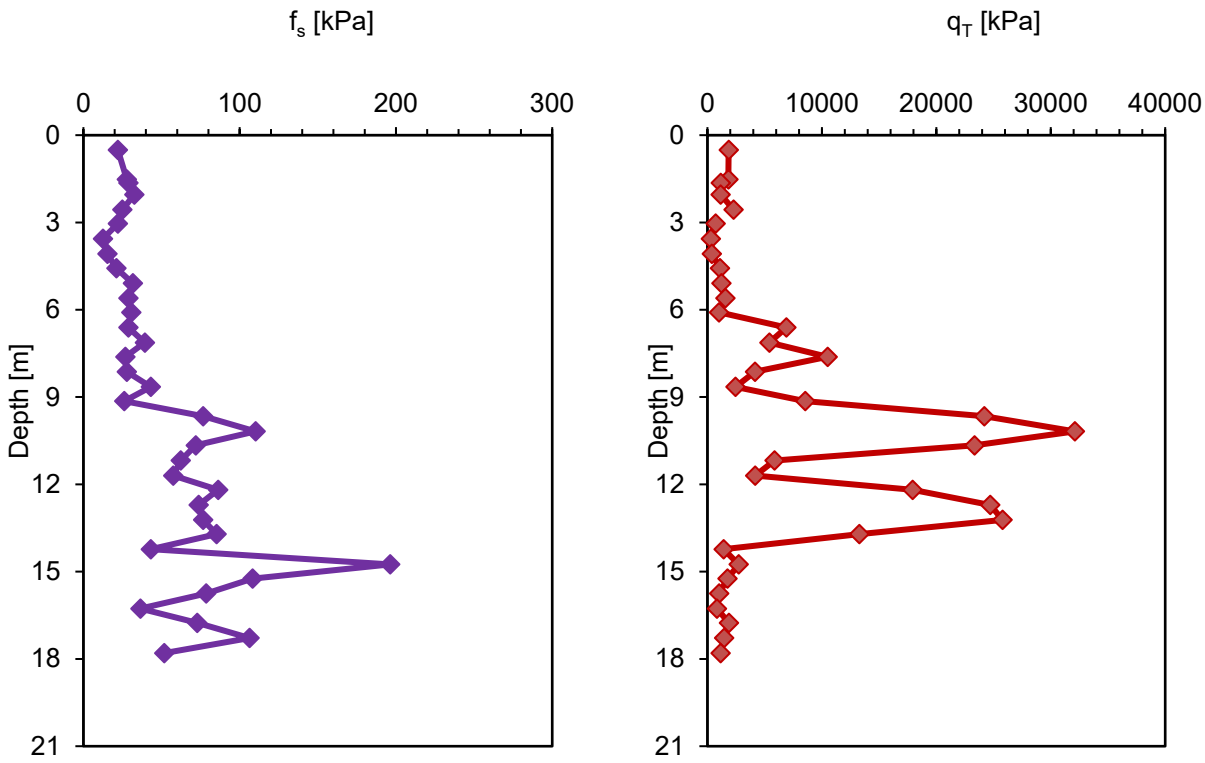
Finally, the shear strength angle can be estimated by using the following formula:

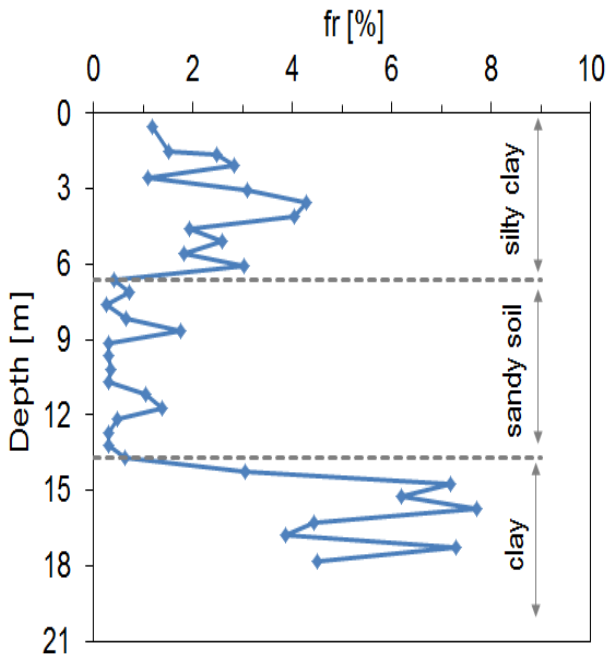
$\varphi' = 28° + 15° D_r = 33.25°$

Depth [m]	N_{SPT} [-]	γ [kN/m³]	σ_0 [kPa]	p_w [kPa]	σ_0' [kPa]	C_N [-]	N'_{70} [-]	N'_{70} Mean [-]	Dr [%]	φ' [°]
1	6	15.705	15.70	0.00	15.71	2.47	12.70			
2	9	16.410	31.76	0.00	31.76	1.74	13.39	11.59	35	33.25
3	10	17.115	48.52	0.00	48.53	1.40	12.04			
4	8	17.820	65.99	0.00	65.99	1.20	8.26			
5	7	19.750	84.78	5.89	78.89	1.10	6.61	7.31	35	33.25
6	9	19.750	104.53	15.70	88.83	1.04	8.01			

2. Cone Penetration Test (CPT)

- Plots of tip resistance ($\mathbf{q_T}$), the sleeve friction ($\mathbf{f_s}$), and friction ratio ($\mathbf{f_r=f_s/q_T\%}$) with respect to depth:





- *Sands usually have* f_r *lower than 1 while clays have larger values; peat (organic soils) can have values greater than 5%.*

- The undrained shear strength s_u is calculated by using the formula:

$$s_u = \frac{q_T - \sigma_{v0}}{N_k}$$

At 5.6 m, $q_T = 1570\ kPa,\ \ \sigma_{v0} = 101\ kPa$

$$s_u = 97.93\ kPa$$

The shear strength angle φ' at depth z = 7.62 m is calculated by using the formula:

$$\varphi' = 29° + \sqrt{q_T} = 29° + \sqrt{10.5} = 32.2°$$

3. The Pressuremeter Test (PMT)

$$\sigma_{vo} = \gamma_{sat} z = 4x19.81 = 79.24\ kPa\ \textit{(in situ)}$$

$$\sigma'_{v0} = \sigma_{v0} - p_w = \gamma_{sat} z - \gamma_w z = 79.24 - 1x10 = 69.24\ kPa$$

$$\sigma'_h = \sigma_h - p_w = p_h - p_w = 0.38\ x\ 98.07 - 1x10 = 27.27\ kPa$$

Note: $\left(1\ \frac{kg}{cm^2} = 98.07\ \frac{kN}{m^2}\right)$

$$K_o = \frac{\sigma'_h}{\sigma'_{vo}} = \frac{27.27}{69.24} = 0.39$$

$$V'_o = V_0 + V_c = V_0 + \frac{\Delta V}{2} = 88 + \frac{44}{2} = 110\ cm^3$$

$$G = \frac{E_{sp}}{2(1+v)} = V'_o \frac{\Delta p}{\Delta V}$$

$$E_{sp} = E_s = 2G(1+v) = 2(1+v)V'_o \frac{\Delta p}{\Delta V} = 2(1+0.5)110\frac{1.4}{44}98.07 = 1030\ kPa$$

$$G = \frac{E_{sp}}{2(1+v)} = \frac{1030}{3} = 343.3\ kPa$$