(1) (25%) The cross section of a cantilever retaining wall with a height of 6 m and a base length of 4 m is shown in Figure 1. Given that the weight of the wall structure is 155 kN/m and its center of gravity is located at 2 m from the toe of the wall. Answer the following questions for the stability check of the wall.

(i) (5%) Compute and draw the distribution of lateral earth pressure and resultant force, and indicate their application locations and directions. (Using Rankine's theory).

(ii) (8%) Calculate the factor of safety with respect to sliding and overturning, ignoring the passive resistance of soil in front of the toe of the wall. (Assuming that the angle of friction of the soil-concrete interface δ is $2/3\phi$ and the adhesion of the soil-concrete interface c_a is $2/3c$).

(iii) (6%) Estimate the ultimate bearing capacity of the footing of the wall. (Using Meyerhof's formula; bearing capacity factors: $N_c=(N_q-1)\cot\phi$, $N_q=\tan^2(45+\frac{\phi}{2})e^{\pi\tan\phi}$, $N_\gamma=(N_q-1)\tan 1.4\phi$).

(iv) (6%) Calculate the factor of safety of the wall with respect to bearing capacity.

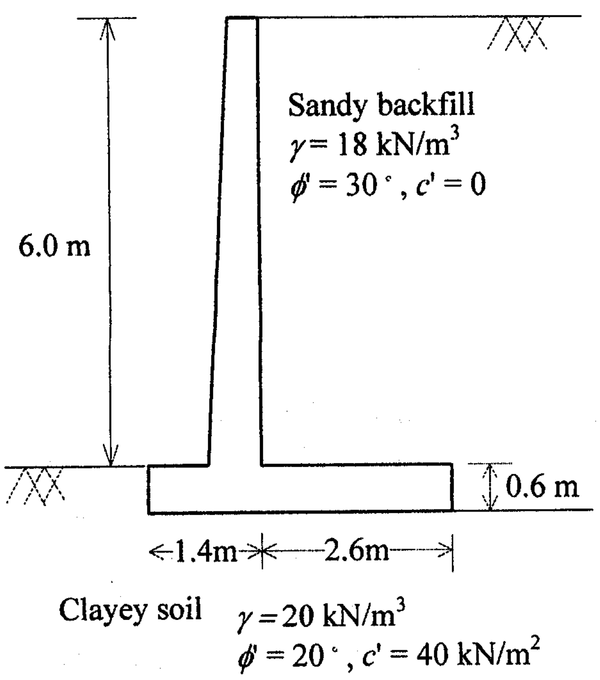

Figure 1. Site profile of the cantilever wall for Question 1.

Table 1. Meyerhof's shape, depth, and inclination factors

Factor	Relationship
Shape	
For $\phi = 0$.	
F_{cs}	$1+0.2\,(B/L)$
$F_{qs}=F_{\gamma s}$	1
For $\phi' \geq 10°$.	
F_{cs}	$1+0.2\,(B/L)\tan^2(45+\phi'/2)$
$F_{qs}=F_{\gamma s}$	$1+0.1\,(B/L)\tan^2(45+\phi'/2)$
Depth	
For $\phi = 0$.	
F_{cd}	$1+0.2\,(D_f/B)$
$F_{qd}=F_{\gamma d}$	1
For $\phi \geq 10°$	
F_{cd}	$1+0.2\,(D_f/B)\tan(45+\phi'/2)$
$F_{qd}=F_{\gamma d}$	$1+0.1\,(D_f/B)\tan(45+\phi'/2)$

Inclination

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

$$F_{\gamma i}=\left(1-\frac{\beta°}{\phi'}\right)^2$$

β = inclination of the load on the foundation with respect to the vertical

(2) (25%) Answer the following questions about foundations:

(i) (5%) Explain the difference between shallow and deep foundations in their bearing failure modes for vertical loading.

(ii) (5%) Explain the concept of compensated foundation design and the conditions of application.

(iii) (5%) Explain the short-term and long-term factors of safety of a footing on saturated soft clay subjected vertical loading.

(iv) (5%) What is the difference between driven and bored piles in estimating their ultimate vertical bearing capacities?

(v) (5%) Explain the mechanism of the group pile effects for vertical loading and their influences on the pile capacity and settlement.

(3) (25%) Answer the following questions related to liquid flow through soil.

(i) (5%) What is Darcy's law? (Define the parameters if you use an equation). When would Darcy's law be valid?

(ii) (6%) List three assumptions for using a flow net to solve a two-dimensional flow problem.

(iii) (4%) According to the filter design proposed by Terzaghi and Peck (1948), the particle size of the filter material and the particle size of the soil to be filtered have to satisfy the following criteria:

(a) $D_{15-filter}/D_{85-soil} \leq 4$

(b) $D_{15-filter}/D_{15-soil} \geq 4$

where $D_{15-filter}$ is the particle size at which 15% of the filter material is finer, $D_{85-soil}$ is the particle size at which 85% of the soil to be filtered is finer, and $D_{15-soil}$ is the particle size at which 15% of the soil to be filtered is finer.

Explain the concept/logic behind criterion (a) and criterion (b).

(iv) (10%) A soil deposit is composed of 3 layers. From top to bottom, the thickness and hydraulic conductivity is given below. Evaluate the equivalent horizontal and vertical hydraulic conductivities.

Layer	Thickness (m)	Hydraulic Conductivity (cm/sec)
1 (Top)	3	3.2×10^{-2}
2 (Middle)	1.5	2.5×10^{-3}
3 (Bottom)	2	1.0×10^{-4}

(4) (25%) Answer the following questions about laboratory and in-situ tests:

(i) (10%) A triaxial test is performed on a sand specimen. The specimen is first consolidated to a pressure of 450 kN/m^2. After the consolidation of the specimen is complete, the drain valve is kept open and the specimen is sheared until failure. At failure, the deviator stress is equal to 1050 kN/m^2. Determine the effective friction angle, the major and minor effective principal stresses at failure and the orientation (relative to the horizontal) of the failure plane. Draw the Mohr Circle associated with the failure state of stress. Make sure that you include the Mohr-Coulomb failure envelop, major and minor principal stresses on the plot.

(ii) (10%) A direct shear test is performed on a sand specimen. A normal stress of 450 is kN/m^2 is applied. The specimen is sheared until failure. The shear stress at failure is equal to 320 kN/m^2. Determine the effective friction angle, the major and minor effective principal stresses at failure and the orientation (relative to the horizontal) of the failure plane. Draw the Mohr Circle associated with the failure state of stress. Make sure that you include the Mohr-Coulomb failure envelop, major and minor principal stresses on the plot.

(iii) (5%) Cone penetration test is a common in-situ test. Describe how the test is performed and what parameters are measured during the test.