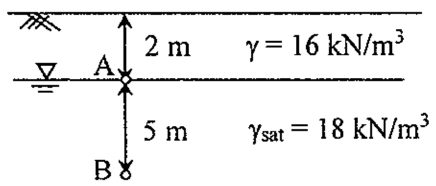
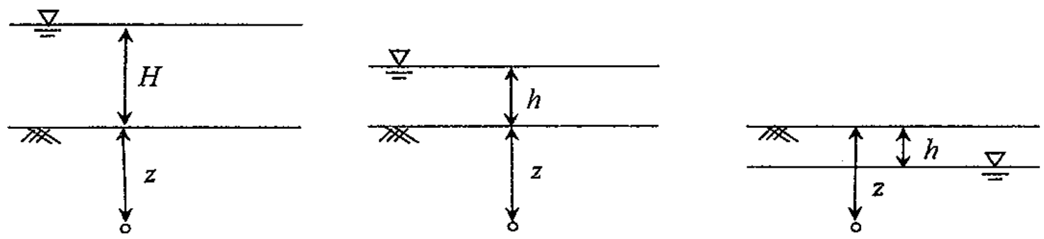
1. Answer the following questions related to soil effective stress (25%)

a. Define soil effective stress, discuss the physical meaning of soil effective stress, and use soil effective stress to explain why saturated soil could be liquefied under earthquake. (5%)

b. Calculate the soil total stress, pore water pressure, and soil effective stress of Points A and B in the following figure. (5%)

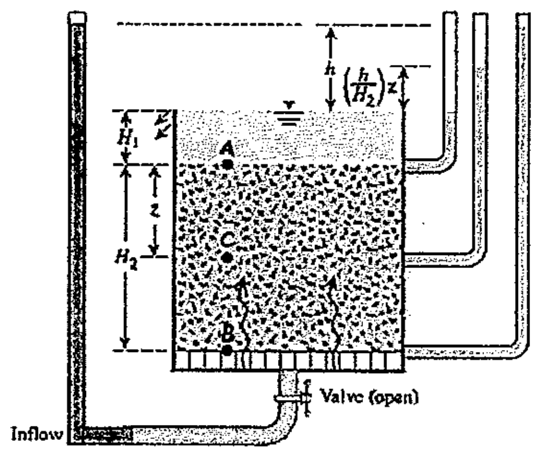


c. Compare the soil effective stress at a depth of z below ground among the following three cases with different water levels. Note $h < H$. (5%)



Case 1: Water level is H above ground　　Case 2: Water level is h above ground　　Case 3: Water level is h below ground

d. A soil specimen is subjected to upward seepage as shown in the following figure. The height of the soil specimen is H_2. Calculate the soil total stress, pore water pressure, and soil effective stress of Points A, B, and C using the provided symbols (i.e., H_1、H_2、h、z、γ_w、γ、γ'). (10%)



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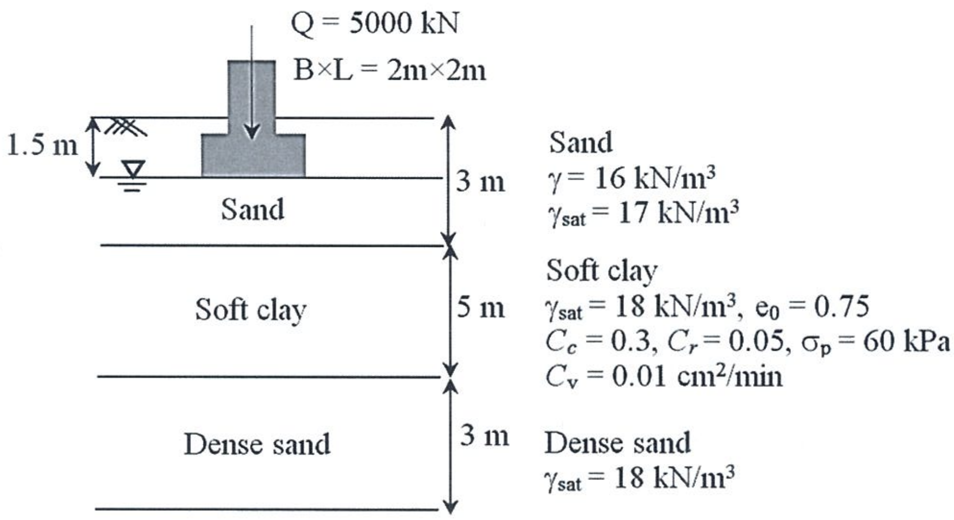
2. Answer the following questions related to soil consolidation (25%)

a. Please discuss the difference between soil consolidation and compaction. (5%)

b. Estimate the stress increment in the middle of the soft clay layer using the 2:1 method and calculate the settlement in the soft clay layer due to consolidation. The soft clay has field void ratio e_0 = 0.75, compression index C_c = 0.3, recompression index C_r = 0.05, pre-consolidation pressure σ_p = 60 kPa, and coefficient of consolidation C_v = 0.01 cm^2/min. (10%)



c. Continuing Problem b, an array of wick drains at a horizontal spacing of 1 m are installed to accelerate the consolidation rate of soft clay, as shown in the following photo. Please provide a drawing to illustrate how the pore water pressure is dissipated through wick drains in the field. Calculate the ratio of consolidation time of the original case (only soft clay) to that of the improved case (soft clay with wick drains). (10%)

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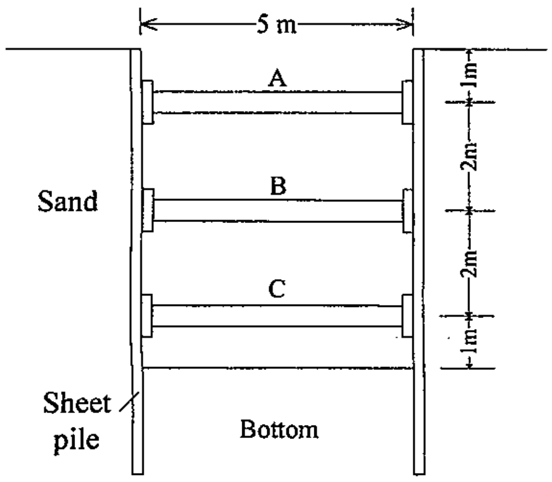
3. Answer the following questions related to braced cut (25%)

a. According to the Taiwan building foundation design code, explain all the analysis items for the stability of braced cut and their purposes. (10%)

b. Explain the meaning of the apparent pressure diagram and its use in the design of braced cut. (5%)

c. The figure below presents a braced cut system with sheep-pile wall. Given that the soil properties: $\phi' = 32°$, $\gamma = 18$ kN/m^3 and the horizontal spacing of struts is 3.0 m, apply Peck's apparent pressure diagrams to calculate (1) strut loads at levels A, B, and C; (2) maximum moment in the sheet pile. (10%)

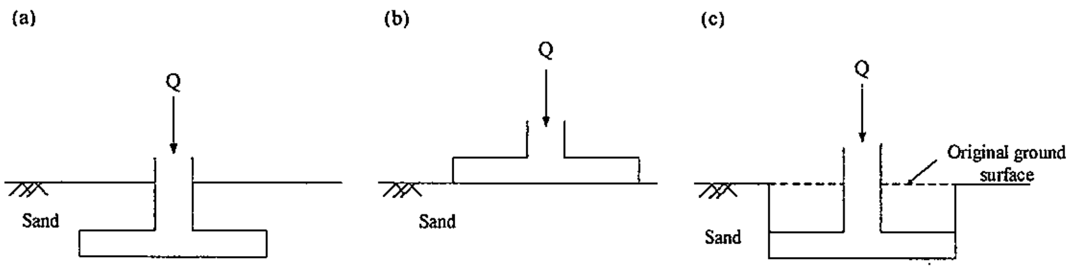


4. Answer the following questions related to foundation design (25%)

a. Compare the similarities and differences between the bearing mechanisms of shallow and pile foundations against vertical loading. (5%)

b. Explain the principle of compensated foundation design and how to design a fully compensated foundation. (5%)

c. The figure below displays three cases where a foundation located on homogeneous sandy ground. Given that the column load Q and footing size in the three cases are the same, compare the magnitudes of the foundation settlement of the three cases, and give your reasons. (5%)



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d. A rectangular footing of 4 m × 2 m in plan is situated on a saturated clay stratum with an embedded depth of 1 m. The groundwater table is located at the ground surface. The clay properties: saturated unit weight is 18 kN/m^3; effective friction angle and cohesion are 25° and 10 kN/m^2, respectively; undrained shear strength is 60 kN/m^2. Apply Meyerhof's bearing capacity equation to calculate the ultimate bearing capacities of the footing for long-term and short-term conditions, and give your comments on the results. (10%)

Note: $N_c = (N_q - 1)\cot\phi$, $N_q = \tan^2(45 + \frac{\phi}{2})e^{\pi\tan\phi}$, $N_\gamma = (N_q - 1)\tan 1.4\phi$

Shape factors	
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 factors	
For $\phi = 0$	
$F_{cd} = 1 + 0.2(D_f/B)$	
$F_{qd} = F_{\gamma d} = 1$	
For $\phi \geq 10°$	
$F_{cd} = 1 + 0.2(D_f/B)\tan(45 + \phi/2)$	
$F_{qd} = F_{\gamma d} = 1 + 0.1(D_f/B)\tan(45 + \phi/2)$	D_f: embedded depth of footing
Inclination factors	
$F_{ci} = F_{qi} = 1 - (\beta/90)^2$	β: inclination of the load on the footing with respect to the vertical
$F_{\gamma i} = 1 - (\beta/\phi)^2$	

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