請依題號順序作答。中文或英文作答皆可。

(1) (25%) Define clearly the following 12 terms (using equations or diagrams where possible). When equations are used, the symbols in the equations should also be specified.

(i)	(2%) 2:1 clay mineral	(vii)	(2%) recompression index
(ii)	(2%) Atterberg limits	(viii)	(2%) SPT (standard penetration test) N-value
(iii)	(2%) zero air voids line	(ix)	(2%) compaction
(iv)	(2%) sand cone test	(x)	(2%) flow net
(v)	(2%) capillarity	(xi)	(2%) consolidated undrained (CU) triaxial test
(vi)	(2%) Skempton's pore pressure parameter A	(xii)	(3%) Rankine's coefficient of active earth pressure (In addition to definition and equation, please specify two assumptions of Rankine's earth pressure theory.)

(2) (25%) A site profile is given in Figure 1.

(i) (3%) Calculate the saturated unit weight for the soil at location A.

(ii) (5%) Evaluate the vertical and horizontal total stresses, vertical and horizontal effective stresses, and pore pressure for the soil at location A.

(iii) (2%) Estimate the friction angle for the soil at location A. Explain how you obtain this estimation.

(iv) (5%) Plot the effective stress Mohr's Circle for the soil element at location A. Label your plot clearly (e.g. axis titles, major and minor principal stresses). Also, put the Mohr Coulomb failure envelop on the plot. For this question, you may assume that cohesion is negligible.

(v) (4%) Explain how particle shape, gradation, void ratio and confining stress control the friction angle of sand.

(vi) (6%) Suggest a laboratory test that is suitable for determining the hydraulic conductivity (k) of the CL layer. Explain how the test works. Provide a sketch of the experimental setup and the equation that can be used to find k. Lastly, explain how temperature and degree of saturation affect k.

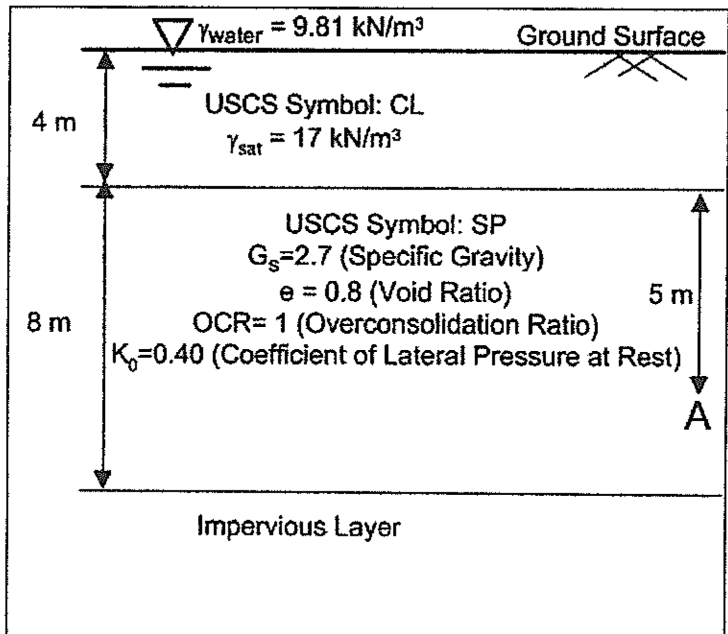

Figure 1. Site profile for **Question 2**

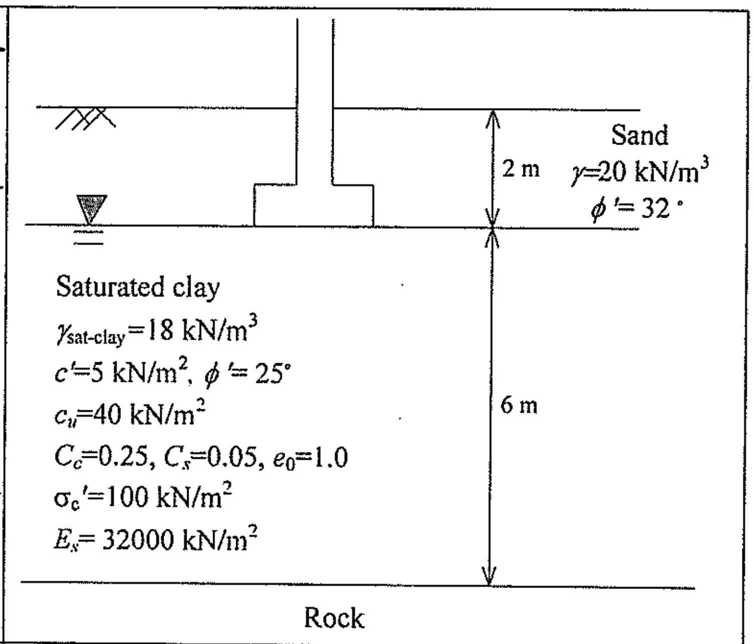

Figure 2. Site profile for **Question 3**

(3) (25%) A site is located at a 2m-thick dry sand layer underlain by an 8m-thick saturated clay. A 2m×2m footing is founded on the top of the clay layer, as displayed in Figure 2. The footing supports 400 kN column load (including the weight of the footing). Given that sand: γ_{sand}=20 kN/m^3, drained friction angle ϕ'=32°; clay: $\gamma_{sat\text{-}clay}$=18 kN/m^3, undrained shear strength c_u=40 kN/m^2, drained shear strength parameters c'=5 kN/m^2 and ϕ'=25°, modulus of elasticity E_s=32000 kN/m^2, preconsolidation stress σ_c'=100 kN/m^2, compression index C_c=0.25, swell index C_s=0.05, and initial void ratio e_0=1.0, answer the following questions:

(i) (10%) Applying Meyerhof's bearing capacity equation, evaluate the **short-term** and **long-term gross** ultimate bearing capacities of the footing.

(Note: bearing capacity factors: $N_c = (N_q - 1)\cot\phi$, $N_q = \tan^2(45+\frac{\phi}{2})e^{\pi\tan\phi}$, $N_\gamma = (N_q - 1)\tan 1.4\phi$; considering shape factors only)

(ii) (5%) Based on (i), in terms of net ultimate bearing capacity, calculate the **minimum** factor of safety of the footing against vertical loading.

(iii) (10%) Estimate the **short-term** and **long-term** settlements of the footing. (Note: Can use 2(V):1(H) method for the increase in stress)

Table 1. Meyerhof's shape 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}	$1 + 0.2\,(B/L)\tan^2(45 + \phi'/2)$
$F_{qs} = F_{\gamma s}$	$1 + 0.1\,(B/L)\tan^2(45 + \phi'/2)$

$$S = A_1 A_2 \frac{q_0 B}{E_s}$$

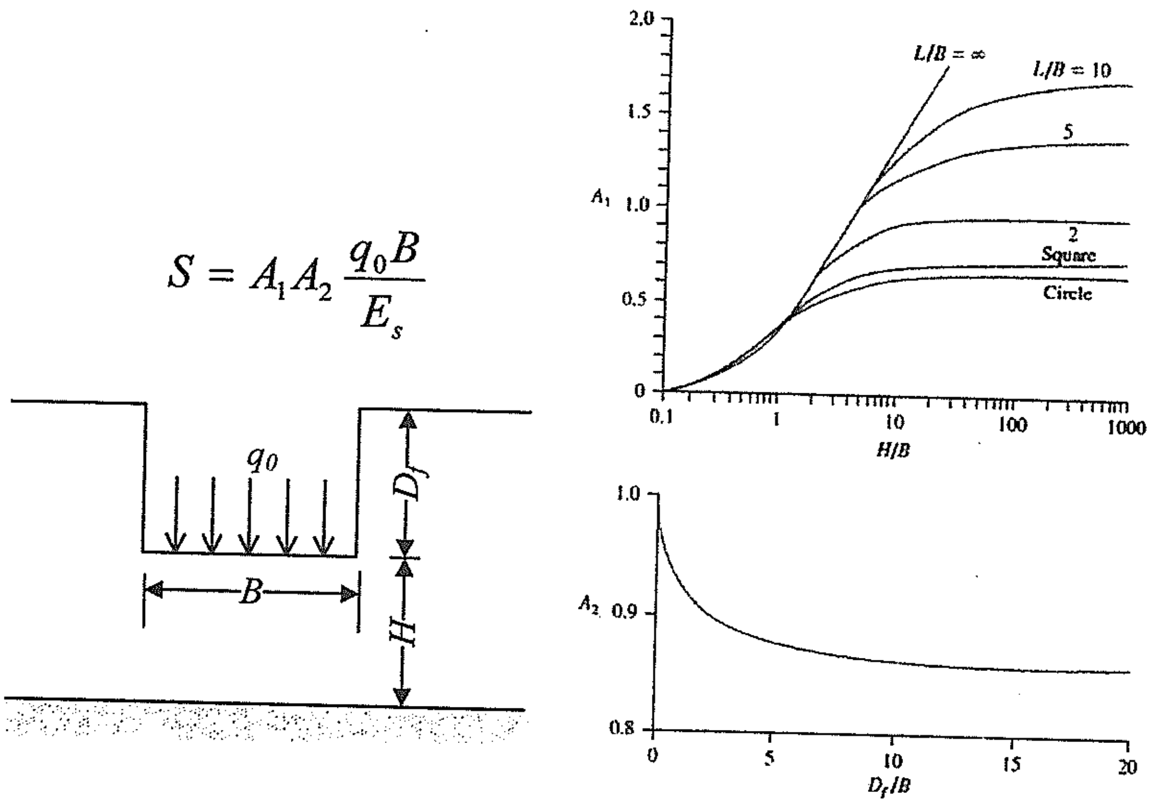

Figure 3. Shape factors for settlement calculation

(4) (25%) A driven prestressed concrete pile of diameter of 1 m and length 20 m embedded in **saturated sand**. Given that the unit weight of sand γ_{sand}=20 kN/m^3, drained friction angle of sand ϕ'=35° and the friction angle of sand-pile interface δ=28°. Answer the following questions:

(i) (5%) Estimate the ultimate frictional resistance Q_s of the pile. (Assume the effective earth pressure coefficient K=1.2).

(ii) (5%) Estimate the ultimate point load Q_p of the pile.

(iii) (6%) According to Taiwan building foundation design code, the total settlement of a pile under a vertical working load can be computed by $S_1+S_2+S_3$, in which S_1, S_2 and S_3 are expressed as in the following equations. Explain the meanings of the three equations.

$$S_1=\frac{(Q_p+\xi Q_s)L}{A_pE_p},\quad S_2=\frac{C_pQ_p}{Dq_{p(ult)}},\quad S_3=\frac{C_sQ_s}{Lq_{p(ult)}}$$

(iv) (9%) A working load on the pile is 3000 kN. Skin resistance carries 1800 kN of the load and point bearing carries the rest. Estimate the total settlement of the pile using the above equations. (Assume the modulus of elasticity of pile E_p=21×10^6 kN/m^2, and a uniform distribution of skin friction along the pile)

Table 2. Values of N_q* and N_q*

ϕ (degrees)	26	28	30	32	35	38	40
N_q* (driven pile)	10	15	21	29	50	86	145
N_q* (bored pile)	5	8	10	14	25	43	72

Table 3. Typical values of C_p

Type of soil	Driven pile	Bored pile
Sand (dense to loose)	0.02–0.04	0.09–0.18
Clay (stiff to soft)	0.02–0.03	0.03–0.06
Silt (dense to loose)	0.03–0.05	0.09–0.12

Equation 1. Evaluation of C_s

$$C_s=(0.93+0.16\sqrt{L/D})C_p$$

試題隨卷繳回