Questions 1 to 10 are worth 3 points each. Problems 11, 12, 13, and 14 are worth 20, 10, 20, and 20 points respectively.

1. Define the hydraulic gradient?
2. Define the coefficient of hydraulic conductivity?
3. Can a saturated clay swell?
4. Is an elevated structural slab on piers a good solution for houses on shrink swell soils?
5. Is the elevated slab on piers less expensive than the stiffened slab on grade?
6. Briefly explain the process of consolidation.
7. If it takes two years for a 5 m high embankment to settle, how long does it take for a 10 m embankment according to the consolidation theory?
8. What is the range of values for the effective stress cohesion intercept \( c \) for a normally consolidated clay?
9. Give the equation for the shear strength of a soil.
10. What is the first step in the procedure to find a failure load?

11. Calculate
   a) the total head, the elevation head, and the pressure head at the top and the bottom of soil 1 in Figure 1.
   b) The hydraulic gradient in soil 1
   c) The pore pressure at the boundary between soil 1 and soil 2.

12. A house is resting on a 5 m thick layer of high plasticity clay underlain by a non swelling and non shrinking soil. The house goes up and down each year by 0.1 m. The shrink-swell modulus of the plastic clay is equal to 0.8. Calculate the yearly average change in water content in the layer.

13. Calculate the required diameter of a shallow foundation to safely (factor of safety of 3) carry a 15000 kN tower if the soil is a clay with an undrained shear strength equal to 100 kPa. What is the elastic settlement of that tower if the modulus of elasticity of the clay is 100,000 kPa and the Poisson’s ratio 0.35.

14. A concrete retaining wall is 3 m high and has a rectangular cross section with a width equal to \( B \). It rests on a clay with an effective stress cohesion equal to 10 kPa and an effective stress friction angle equal to 25 degrees. The wall is backfilled with sand with a unit weight equal to 20 kN/m³ and an effective stress friction angle of 30 degrees. The water table is very deep. Calculate
   a) The push against the wall and its point of application
   b) The required width of the wall to prevent sliding; use a factor of safety of two, a unit weight of concrete of 25 kN/m³ and assume that the failure takes place in the clay along the bottom of the wall.

BONUS (5 points): Is it a good idea to get a Masters degree?
Formulas:
\[ Q = k \Delta H L \frac{N_f}{N_d} \]
\[ F = \frac{F_{\text{max}}}{F_d} \]
\[ Q = v A \]
\[ h_t = h_c + h_p \]
\[ \Delta H = 0.33 H \frac{\Delta w}{E_w} \]
\[ \Delta \sigma = \frac{Q}{(B+z)^2} \]
\[ \Delta \sigma = \frac{Q'}{(B+z)} \]
\[ \Delta H = H (\varepsilon_b - \varepsilon_a) \]
\[ t = T \frac{H^2}{c_v} \]
\[ \sigma' = \sigma - \alpha u \]
\[ s = 0.88 pB \left(1 - v^2\right)/E \]
\[ V = k i \]
\[ s = 0.78 pB \left(1 - v^2\right)/E \]
\[ p_u = 6 s_u \]
\[ h_t = h_t(\text{beg}) + n_d \left(h_t(\text{beg}) - h_t(\text{end})\right)/N_d \]
\[ p_u = 9 s_u \]
\[ s = c + \sigma' \tan \phi \]
\[ Q_u = f_u A_p + p_u A_p ; p_u = 9 s_u ; f_u = \alpha s_u \]
\[ F = M_{\text{max}} / M_d \]
\[ \sigma_{\text{ah}} = K_a \sigma'_{\text{ov}} - 2c K_a^{0.5} + \alpha u \]
\[ \Delta \sigma = 4Q/\pi(D+z)^2 \]
\[ K_a = \frac{(1 - \sin \phi)}{(1 + \sin \phi)} \]
\[ \Delta H = H C_s \log(\sigma'_{\text{vo}} + \Delta \sigma v/\sigma'_{\text{vo}}) / 1 + \epsilon_o \]
\[ F = (s LR) / (Wa) \]