The University of Iowa
Department of Civil & Environmental Engineering
SOIL MECHANICS 53:030
Final Examination
2 Hours, 100 points

Fall 1995 **Instructor: C.C. Swan**

Problem #1: (10 points)

In a few sentences, explain the differences between consolidation of soil as discussed in Chapter 8 and compaction of soil as discussed in Chapter 4. Since both can be used to improve the engineering properties of soil for construction projects, please mention one or two applications where one might use consolidation and one or two where one would use compaction.

Problem #2: (10 points)

a. List two or three of the major differences in engineering properties (permeabilities, strength behaviors, compressibilities, etc.) between clay soils and sands/gravels. Briefly, explain why these differences exist based on fundamental physical differences between the soil types.

b. What is the difference between a soil that is normally consolidated and one that is over-consolidated?

Problem #3: (20 points)

Steady state seepage is occurring in the soil profile shown in Figure 1. Note the standpipes inserted at points B and C.

a. How high (h) is the water standing in the standpipe located at B?

b. Compute the magnitude of the hydraulic gradient in the sand layer.

c. Compute the vertical effective stress at point A in the sand layer.

d. What is the magnitude (per unit volume) and direction of the seepage force exerted by the fluid on the gravel soil?

e. How high (h) would the water have to stand in the standpipe at B to cause a quick (boiling) condition in the silty sand layer? (Note that the height of water in the standpipe at C will change from its original height.)

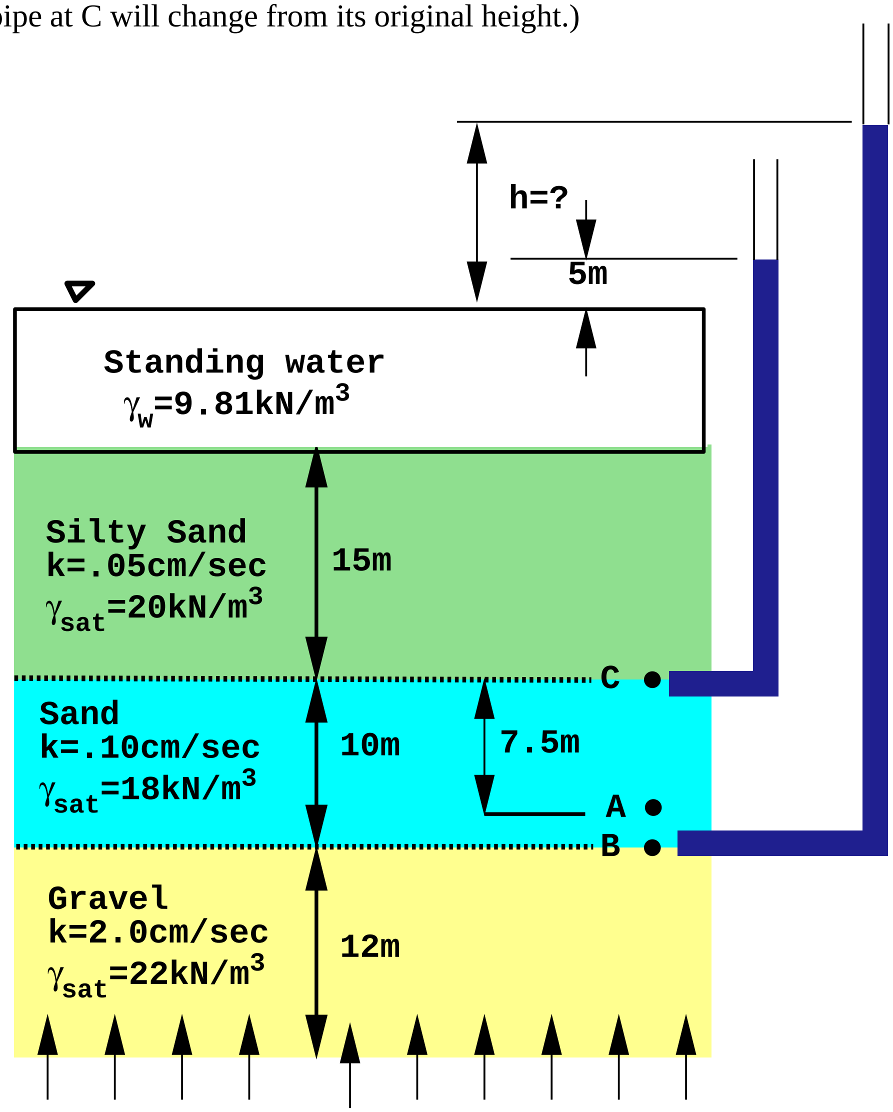

Figure 1. Uniform upward seepage in a multi-layered soil deposit.

<u>Problem #4</u>: (20 points)

Figure 2 shows a three-layered soil system. Note that the preconsolidation vertical effective stress σ'_{vc} at the center of the clay layer is 300 kPa.

a. Just after the uniform load q = 250kPa is applied to the soil (assuming that it could be applied instantaneously), how high h would water rise above the existing water table level in the standpipe?

b. Considering only primary consolidation, how much will the clay layer have compressed three years after the load is applied?

Assume $\gamma_{water} = 10 kN \cdot m^{-3}$.

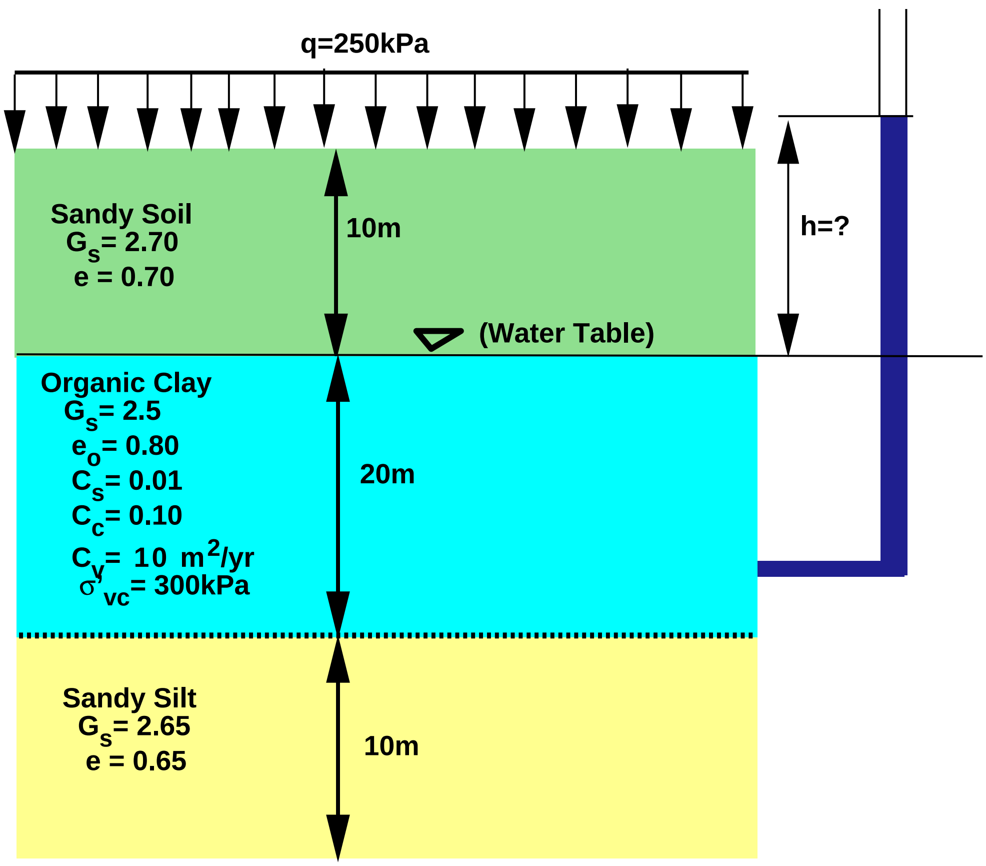

Figure 2. Three-layered soil system with standpipe.

Problem #5: (20 points)

In preparing a sandy soil for a drained triaxial compression test, a specimen (c = 0, ϕ = 40°) has uniform atmospheric pressure acting on it $\sigma_1 = \sigma_3$ = 100kPa. The pore pressure (air pressure) in the voids is also atmospheric as well, u = 100kPa.

a. Draw the Mohr's Circle for the soil's stress state in terms of
   1. total stresses; and
   2. effective stresses.

b. Why can't the soil in this state support any shear stress?

The soil sample is then sealed in a rubber membrane and the pore space is evacuated with a vacuum pump reducing the absolute pore pressure to u = 0kPa. Atmospheric pressure $\sigma_1 = \sigma_3$ = 100kPa continues to act externally on the soil.

c. Draw the Mohr's Circle for the soil's effective stress state.

The soil is then subjected to an axial compression test in which the horizontal stress remains atmospheric σ_3 = 100kPa; the vertical stress σ_1 is increased until shear failure occurs; and the pore pressure is maintained at a vacuum u = 0kPa.

d. Draw the Mohr's Circle for the effective stresses at shear failure.

e. What is the orientation of the shear failure plane in the soil?

f. What are the effective shear and normal stresses on the failure plane?

Problem #6: (20 points)

Consider the jointed stone mass resting on a level bed of sand as shown in Figure 3. To maintain stability of the sand layer against erosion, a concrete retaining wall was constructed as shown. Unfortunately, the retaining wall blocks drainage of the sand layer and over the years, rainfall has been accumulating in the fissure.

a. How high would water have to rise in the fissure shown to initiate a **sliding** instability of the jointed stone mass caused by shear failure in the sand layer? Neglect the resistance to sliding provided by the retaining wall.

b. If as an engineer you became responsible for this situation, how would you increase the stability of the stone mass?

Sand properties are: G_s=2.68; e=0.72; c=0; ϕ=25°
Stone properties: $\gamma_{\text{stone}} = 25 kN \cdot m^3$.

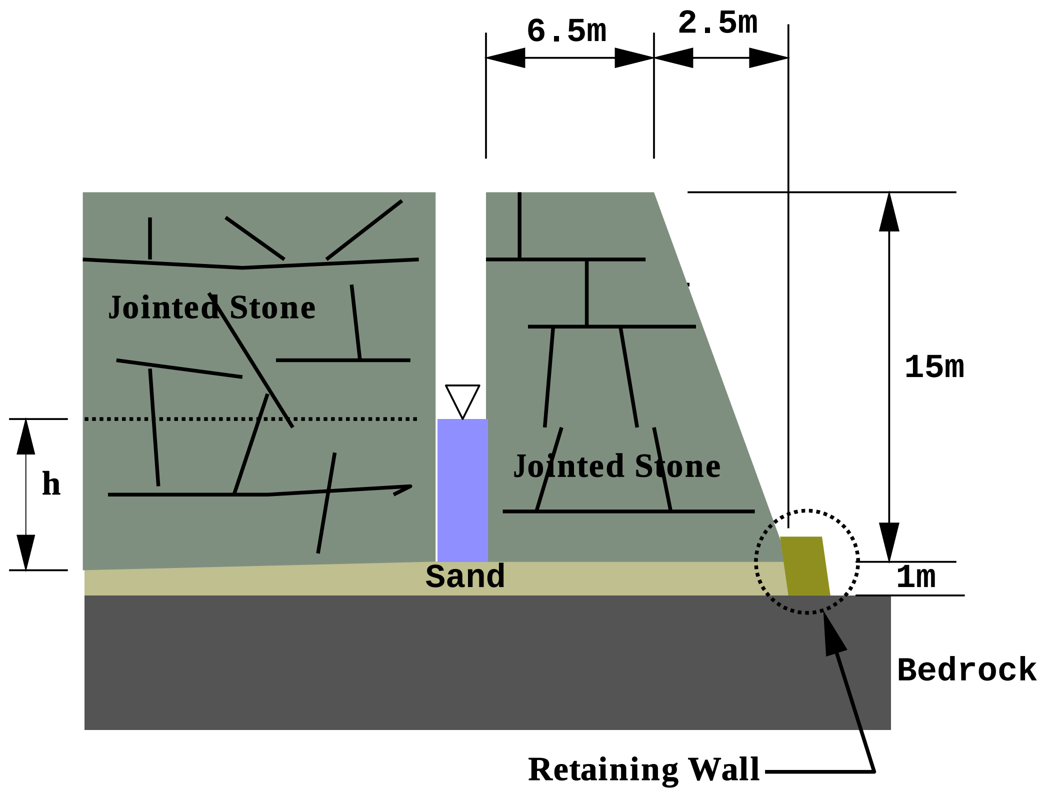

Figure 3. Jointed stone mass on an undrained sand layer.