The University of Iowa
Department of Civil & Environmental Engineering
SOIL MECHANICS 53:030
Final Examination
2 Hours, 200 points

Fall 2002 **Instructor: C.C. Swan**

Problem #1: (25 points)

a. What is meant by the term “plasticity index” or PI of a soil, and what is its general significance.

b. What is the expression for the liquidity index of a fine-grained soil?

c. If as a geotechnical engineer, you were asked to consider building a structure on a clayey soil deposit with a liquidity index value of 1.20, how might you respond, and why?

d. 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.

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

Problem #2: (25 points)

An embankment for a highway will use a 20m wide and 1.5m thick layer of compacted soil. The soil is to be trucked in from a borrow pit. The water content of the sandy soil in the borrow pit is 12 percent, and its void ratio is 0.80. The specification requires the soil in the embankment be compacted to a dry unit weight of 17.5 kN/m^3. For a 100 meter length of embankment, determine:

a. the weight of sandy soil from the borrow pit required to construct the 20m by 1.5m layer in the embankment;

b. the number of $15m^3$ truck loads of sandy soil required for construction;

c. the weight of water per truck load of sandy soil; and

d. the degree of saturation of the sandy soil in the embankment if the water content remains at 12 percent.

Assume that $\gamma_w = 9.81 kN \cdot m^{-3}$ and that G_s for the soil grains is 2.68.

Problem #3: (50 points)

To build an underwater foundation, a temporary sheetpile wall system has been constructed as shown in Figure 1, and the soil has been excavated to a depth of D=4m. The water level H on the back side of sheetpile is 3m. The corresponding flownet for this problem is also shown in Figure 1.

a. At what rate is water being pumped out of the excavation to maintain the water level shown?

b. What is the vertical effective stress at point A?

c. What is the factor of safety against heaving in the critical regions around the sheetpiles?

d. How high H would water have to be on the back side of the sheetpile wall to create an unstable situtation in the critical regions? (Assume that the water level in the excavation remains as shown in Figure 1.)

e. Assume that if for this problem the soil had an anisotropic permeability with $k_{xx} = 16k_{zz}$. How would one go about computing the flow rate into the excavation in that case? (You needn't actually do it, just explain the process.)

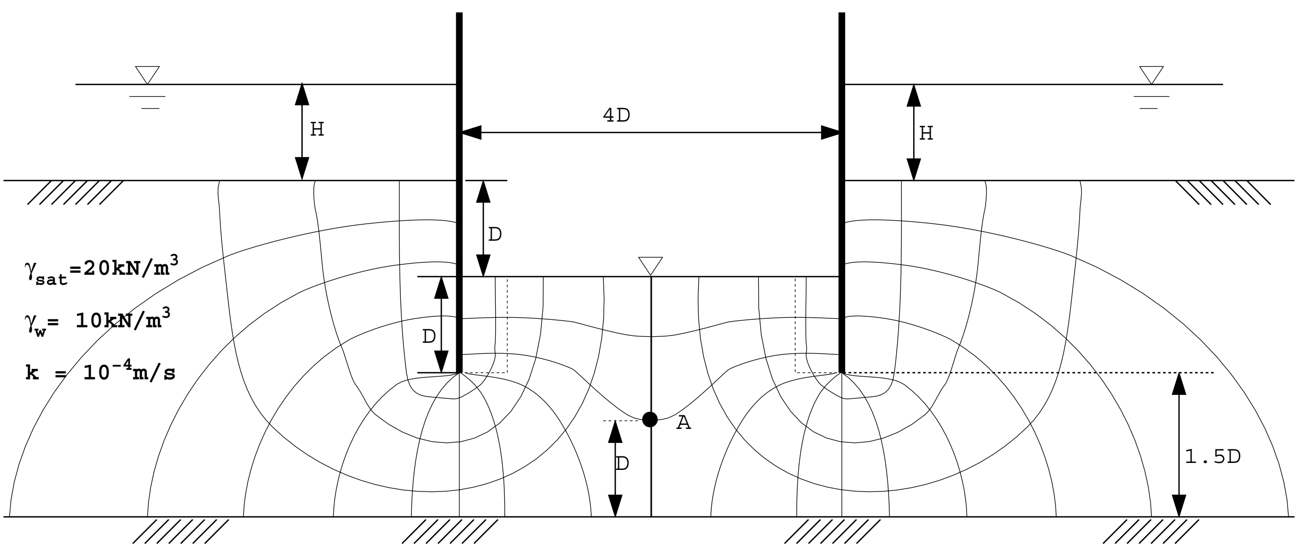

Figure 1. Seepage around sheetpile walls.

Problem #4: (50 points)

Figure 2a shows a two-layered soil system in which a dry sandy soil overlies a normally consolidated silty-clay soil, which in turn overlies a layer of low-permeability, undrained bedrock. A strip foundation load of 150 kPa is to be applied to the soil as shown in Figure 2b.

a. What is the *average vertical stress increase* in the silty clay layer directly beneath the centerline of the strip loading?

b. Neglecting any and all deformations in the sand layer, compute the settlement beneath the center of the strip foundation due to primary consolidation of the clay:

   1. after 1 year has passed;
   2. after 10 years have passed; and
   3. after consolidation is complete.

c. If instead of being normally consolidated in the initial state before the foundation load was applied, the clay soil instead had a mean preconsolidation stress level of 300 kPa, how would the ultimate consolidation settlement differ?

For all computations, assume $\gamma_{water} = 10 kN \cdot m^{-3}$.

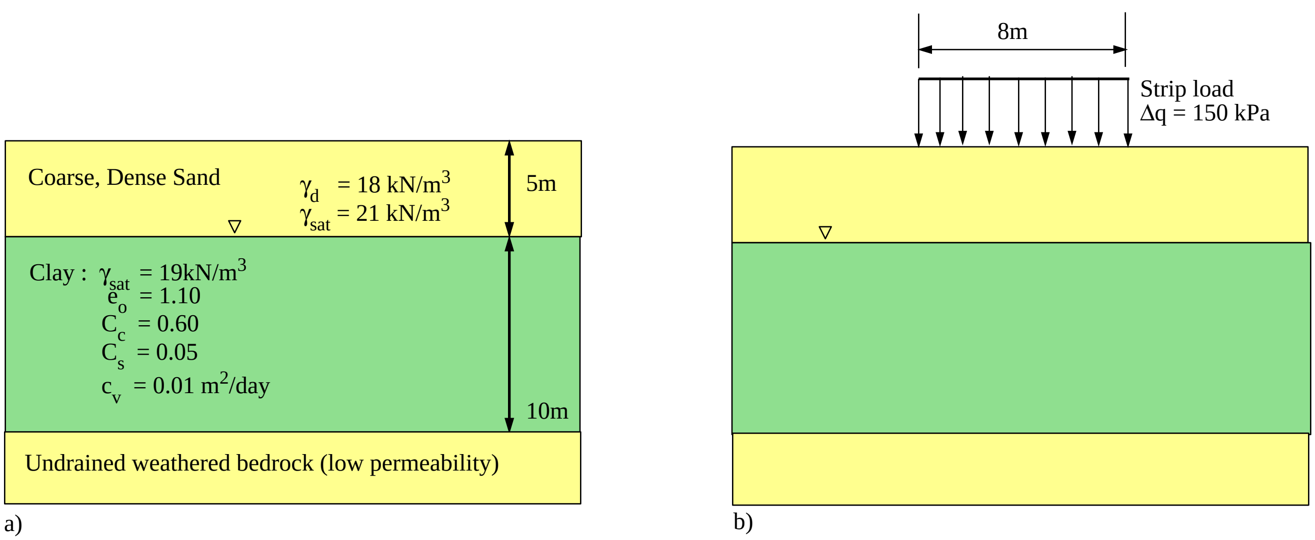

Figure 2: a. Two-layered soil system before load is applied; and b. Strip load applied to the soil system.

Problem #5: (50 points)

A strip load is applied to a soil as shown in Figure 3 below. Neglecting any initial stresses in the soil:

a. Use the formulas provided, compute the stress increases ($\Delta\sigma_{zz}$, $\Delta\sigma_{xx}$,$\Delta\tau_{xz}$) at point A in terms of the applied strip load magnitude q:

b. Compute the magnitude of the principal stresses σ_1' and σ_3' at point A using Mohr's circle analysis:

c. Using the pole method, compute the respective orientations of the principal planes passing through point A. (Clearly identify your results with a labeled sketch.)

d. If the soil has a drained friction angle of $\phi' = 20°$ and a cohesion c=30 kPa, compute the magnitude q_u of the strip loading that initiates shear failure at point A.

$$\Delta\sigma_{zz} = \frac{q}{\pi}\left[\alpha + sin(\alpha)cos(\alpha + 2\beta)\right]$$

$$\Delta\sigma_{xx} = \frac{q}{\pi}\left[\alpha - sin(\alpha)cos(\alpha + 2\beta)\right]$$

$$\Delta\tau_{xz} = \frac{q}{\pi}\left[sin(\alpha)sin(\alpha + 2\beta)\right]$$

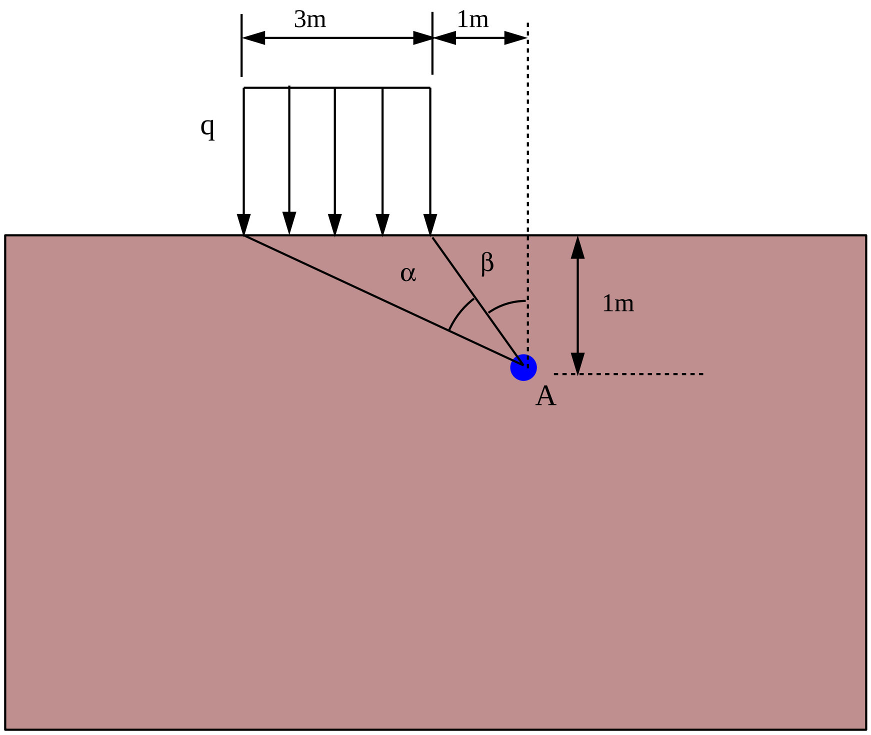

Figure 3: Strip loading applied to the the soil.

U(%)	T_v	U(%)	T_v	U(%)	T_v
0	0	34	.0907	68	.377
1	.00008	35	.0962	69	.390
2	.00030	36	.102	70	.403
3	.00071	37	.107	71	.417
4	.00126	38	.113	72	.431
5	.00196	39	.119	73	.446
6	.00283	40	.126	74	.461
7	.00385	41	.132	75	.477
8	.00502	42	.138	76	.493
9	.00636	43	.145	77	.511
10	.00785	44	.152	78	.529
11	.00950	45	.159	79	.547
12	.01130	46	.166	80	.567
13	.0133	47	.173	81	.588
14	.0154	48	.181	82	.610
15	.0177	49	.188	83	.633
16	.0201	50	.197	84	.658
17	.0227	51	.204	85	.684
18	.0254	52	.212	86	.712
19	.0283	53	.221	87	.742
20	.0314	54	.230	88	.774
21	.0346	55	.239	89	.809
22	.0380	56	.248	90	.848
23	.0415	57	.257	91	.891
24	.0452	58	.267	92	.938
25	.0491	59	.276	93	.993
26	.0531	60	.286	94	1.055
27	.0572	61	.297	95	1.129
28	.0615	62	.307	96	1.219
29	.0660	63	.318	97	1.336
30	.0707	64	.329	98	1.500
31	.0754	65	.340	99	1.781
32	.0803	66	.352	100	8
33	.0855	67	.364		