53:030 SOIL MECHANICS

Department of Civil & Environmental Engineering
The University of Iowa
Fall Semester 2003
Final Exam, 2 hours
5 questions, 100 points

Note: To receive proper credit for your answers, show all of your work in your exam booklet. Credit will not be given for work submitted on the exam handout.

Question #1: (20 points)

An ethanol storage tank of diameter 30m and gross weight 100MN is to be constructed on the site shown below in Figure 1a. To construct the tank, 5m of the dense sand layer will be excavated and the tank will be built as shown in Figure 1b. For the values provided for the soil:

a. Compute the increased average vertical stress in the clay layer directly beneath the center of the tank;
b. Calculate the ultimate consolidation settlement that would be expected to occur under the net additional loading created by the tank;
c. How much settlement would be expected 1 year, 5 years, and 20 years after the tank is completed? (Assume the one-dimensional consolidation model is valid.)
d. Assume that the silty clay were originally overconsolidated (OCR=1.40), how would the ultimate consolidations settlements computed in part b. be different?

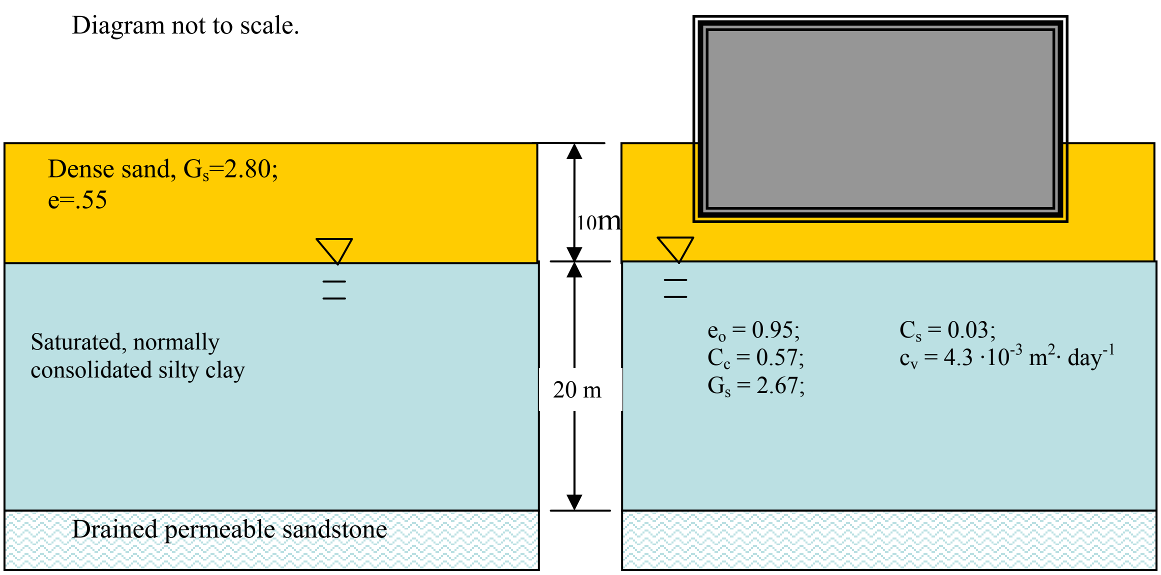


Fig. 1a   Fig. 1b

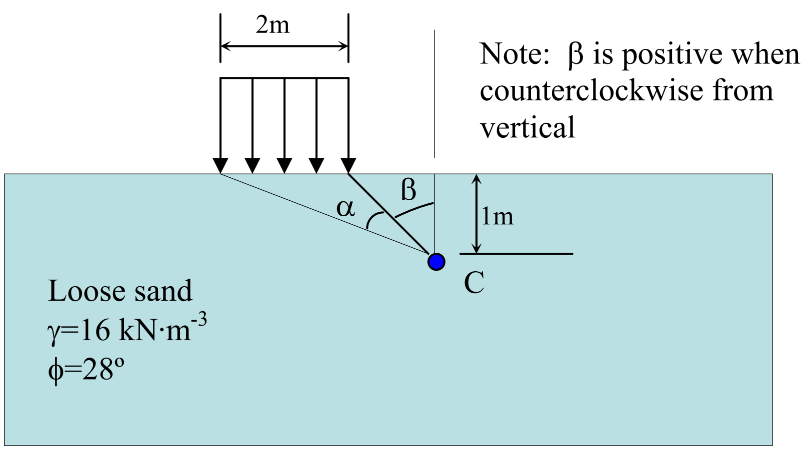
Note: $\Delta\sigma_v = q\left\{1-\left[\left(R/z\right)^2+1\right]^{-1.5}\right\}$ where R is the radial dimension of the loaded area and z is the distance below the center of the loaded area.

Question #2: (20 points)

At a point C in the soil mass before any loads are applied, the vertical effective stress σ_v' and horizontal effective stress σ_h' are 16 kPa and 8 kPa, respectively. Subsequently, a strip load of magnitude q=25 kPa and width B=2m is applied **directly over** point C.

a. What is the maximum shear stress at C **before** the strip load is applied?
b. **After** the strip load is applied, what are the vertical and horizontal stresses at point C?
c. What magnitude of strip load would be required to generate shear failure in the soil at point C?
d. If failure were to occur at C due to the strip loading, what would be the orientation of the plane(s) on which shear failure might be expected? (Use Pole method).
e. What would be the magnitude of the shear and normal stresses at failure? (Use Pole method)

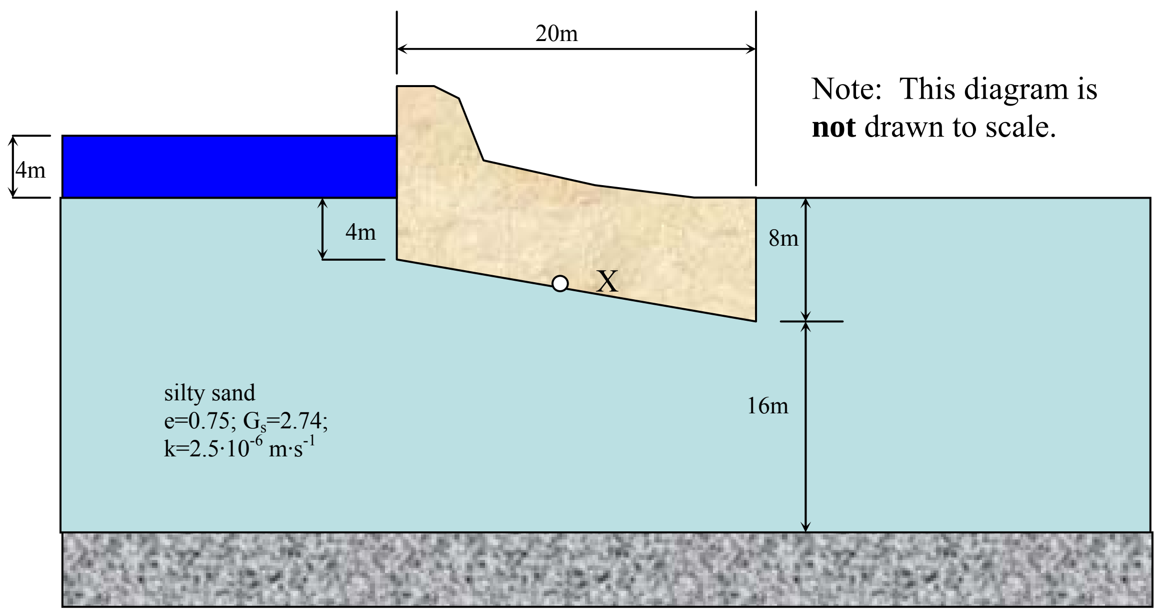
$$\Delta\sigma_v = \tfrac{q}{\pi}\left[\alpha + \sin(\alpha)\cos(\alpha + 2\beta)\right]$$
$$\Delta\sigma_h = \tfrac{q}{\pi}\left[\alpha - \sin(\alpha)\cos(\alpha + 2\beta)\right]$$



Question #3: (20 points)

Consider the reservoir, a portion of which is shown in the diagram below.

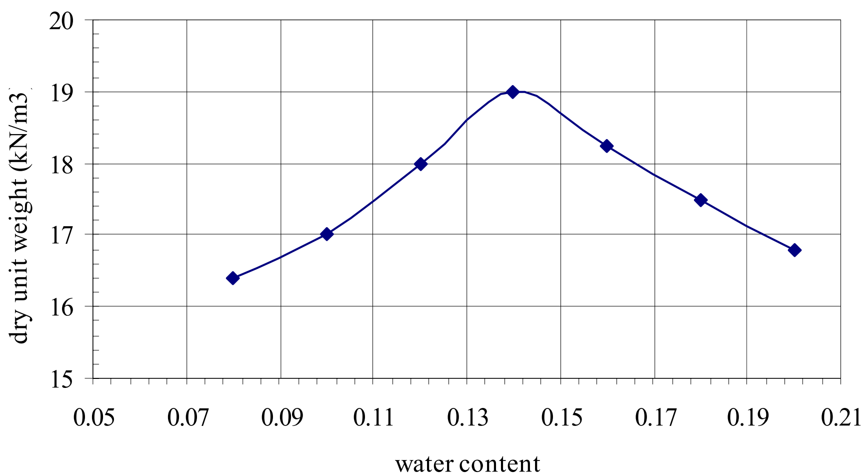
a. In your exam booklet, draw the flow domain to scale and then draw a good, neat flownet that satisfies all of the necessary requirements.
b. Based on your flownet and the soil properties, what is the rate of fluid seepage out of the reservoir, per unit length in the out-of-plane direction?
c. Based on your flownet, compute the fluid pressure at a point X midway along the base of the retention structure.
d. Based on your flownet, what is the factor of safety against liquefaction in the critical region of the flow domain?
e. What depth of water in the reservoir would be necessary to cause liquefaction in the critical region?



Question #4 (20 points)

A standard Proctor Test (see results below) was performed on a soil (G_s=2.70) being considered for grading work at a high-tech business park. The soil is to be brought in from a borrow pit where its void ratio is 0.80 and degree of saturation is 0.40. At the business park site the soil will be compacted to a dry density that exceeds 95% of the standard Proctor maximum, and the dimensions of the compacted fill region are approximately 250m by 250m by 4m deep.

a. What is the moisture content of the soil in the borrow pit?
b. What volume of soil must be taken from the borrow pit?
c. How many 5-ton truckloads of the soil will need to be hauled to the business park site? (assume 1 ton = 1000 kg)
d. If the optimum moisture content from the standard Proctor Test is to be used in the field compaction, how much water must be added to each ton of moist soil from the borrow pit?



Question #5 (20 points):

a. What are the benefits of carefully controlled compaction of soils imported to construction sites?
b. What type of soils generally receive the highest ratings in the AASHTO Classification system, and why are such soil types preferred for highway applications?
c. If you had to estimate the hydraulic conductivity of a soil based on only one piece of information, would it be more helpful to know that soil's void ratio, or its grain-size distribution? Explain.
d. For fine-grained soils, what is the general significance of the PI (plasticity index) measurement?

Tabulated values of degree of consolidation U(%) versus non-dimensional time factor T_v in the one-dimensional consolidation model.

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	∞
33	.0855	67	.364		