

CVG 3106: SOIL MECHANICS II

FINAL EXAMINATION

Time: 3 hours

8th August, 2009 (STE G0103) (13:00 to 16:00)

Professor: Sai Vanapalli

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Family Name: _____

Other Names: _____

Student Number: _____

Signature _____

- (i) **This is an OPEN BOOK exam. Textbooks on Soil Mechanics and Foundation Engineering allowed: Recommended Book: Principles of Foundation Engineering by Braja M. Das**
- (ii) Formula sheet permitted. **Class Notes NOT permitted**
- (iii) If you do not understand a question, clearly state an assumption and proceed.
- (iv) Non programmable calculators are permitted
- (v) Questions have the values shown next to the question.
- (vi) Marks will be taken out for missing units and labels.
- (vii) **IMPORTANT: PLEASE SUPPLEMENT YOUR ANSWERS WITH SKETCHES WHEREVER NECESSARY**

At the end of the exam, when time is up:

- Stop working and turn your exam upside down.
- Please remain silent.
- Do not move or speak until ALL exams have been picked up, and a TA or the Professor gives the go-ahead to leave.

<u>Question</u>	<u>Max Marks</u>	<u>Marks Awarded</u>
1. Objective (SECTION A)	10	
2. Subjective (SECTION A) (Answer only 4/6 Questions)	20	
3. (Foundation Design)	20	
4. (Retaining Wall)	20	
5. (Earth Pressures)	12	
6. (Elasticity)	12	
7. (Consolidation)	6	
Total	100%	

SECTION A (30 Marks)

Question 1(a)

(0.5 x 10 = 5 marks)

Circle the correct answer.

1	The pore-water pressures in overconsolidated clay can be positive when it is subjected to a stress higher than its pre-consolidation pressure.	T	F
2	At $t = 0$ (i.e., immediately after the stress is applied), the excess pore-water pressure, Δu at any depth, Δh will be equal to the applied loading $\Delta \sigma$, or $\Delta u = (\Delta h)(\gamma_w) = \Delta \sigma$	T	F
3	Two fine-grained soils; A and B have liquid limit, w_L values equal to 50 and 60 respectively. Note that the plastic limit, w_P values for the soils A and B are 25 and 35 respectively. For such fine-grained soils, the compression index, C_c of will not be the same; however, the swelling index, C_s will be the same. Assume Soil A is normally consolidated clay and Soil B is over consolidated clay.	T	F
4	Rankine's theory is used widely in comparison to Coulomb's theory because of its simplifying assumption, in which the wall is assumed smooth, that yields conservative results and prompts safer designs in engineering practice.	T	F
5	The bearing capacity of a fine-grained soil such as clay for long term condition depends on the effective shear strength parameters c' and ϕ' values and the location of the ground water table.	T	F
6	The passive earth pressure coefficient is always greater than active earth pressure coefficient and also equal to unity or greater than unity.	T	F
7	Excavations in clayey soils loose strength with time.	T	F
8	A sand with a higher angle of internal friction, ϕ' exerts a higher P_a on a retaining structure compared to a saturated clay with no angle of internal friction (i.e., $\phi_u = 0$).	T	F
9	Elastic settlements predominantly occur below foundations constructed on sands rather than saturated clays	T	F
10	For design of shallow foundations on sand, a weighted averaging has to be made after correction of the measured N -values from SPT from the zone between the base of the foundation and a depth of twice the width of the foundation with greater weightage being to values closer to the base of the foundation.	T	F

Multiple choice questions

Question 1(b):

5 marks

1. To determine the short term stability of an embankment constructed with clay, the total shear strength parameters (i.e. c_u and ϕ_u) can be determined by:
 - (i) Conducting consolidated drained direct shear tests on identical specimens
 - (ii) Conducting consolidated drained triaxial shear tests on identical specimens
 - (iii) Conducting consolidated undrained ($C\bar{U}$) triaxial shear tests with pore-pressure measurements during the shearing stage on identical specimens
 - (iv) Conducting any one of the above tests (i.e., (i), (ii) or (iii))
 - (v) None of the above

2. It is more reliable to determine the FS for long term stability conditions for an expansive soil slope using:
 - (i) Peak shear strength parameters
 - (ii) Residual shear strength parameters
 - (iii) Critical state shear strength parameters
 - (iv) None of the above. The long term FS is not dependent on the shear strength parameters

3. Vane shear apparatus can be used for determining the in-situ shear strength of
 - (i) Soft clays only
 - (ii) Soft clays and soft sands
 - (iii) All types of clayey soils but not for sands
 - (iv) All soils

4. Lateral earth pressure under active conditions on the back of a smooth vertical retaining wall with a horizontal slope clay backfill under saturated conditions and loaded under undrained conditions will be zero at a depth of
 - (i) $z = \frac{4c_u}{\gamma} \tan\left(45 + \frac{\phi_u}{2}\right)$
 - (ii) $z = \frac{3c_u}{\gamma} \tan\left(45 + \frac{\phi_u}{2}\right)$
 - (iii) $z = \frac{2c_u}{\gamma} \tan\left(45 + \frac{\phi_u}{2}\right)$
 - (iv) $z = \frac{c_u}{\gamma} \tan\left(45 + \frac{\phi_u}{2}\right)$

5. The bearing capacity theory proposed by Skempton is valid for
 - (i) sands under undrained loading conditions
 - (ii) sands under both drained and undrained loading conditions
 - (iii) saturated clays under both drained and undrained loading conditions
 - (iv) saturated clays under undrained loading conditions only

Short Questions

Answer any FOUR of the following SIX questions: $5 \times 4 = 20$ marks. PLEASE NOTE THAT ONLY THE FIRST FOUR ANSWERED QUESTIONS WILL BE MARKED. EXTRA QUESTIONS ANSWERED WILL NOT BE CONSIDERED)

Question 2 (a):

With a practical example detail when you would design a foundation using undrained shear strength parameters? **(5 marks)**

Question 2 (b):

The **factor of safety** used in the **design of slopes** is conventionally **higher for short term stability** conditions in comparison to long term stability conditions. Explain with reasons. **(5 marks)**

Question 2 (c):

Derive an expression for factor of safety and also detail how critical height of excavation depth can be determined using the information in the **Figure 1** below. (5 marks)

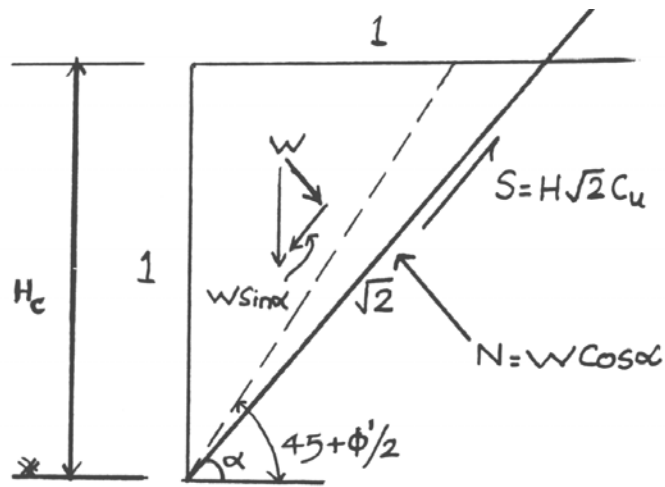


Figure 1

Question 2 (d):

Explain in your own words about the Shanghai Apartment Complex failure and lessons learned by the Geotechnical Engineers from this experience **(5 marks)**

Question 2 (e):

Explain the test below (i.e., see Figure 2) and detail what is the information that can be derived and how it is useful? (5 marks)

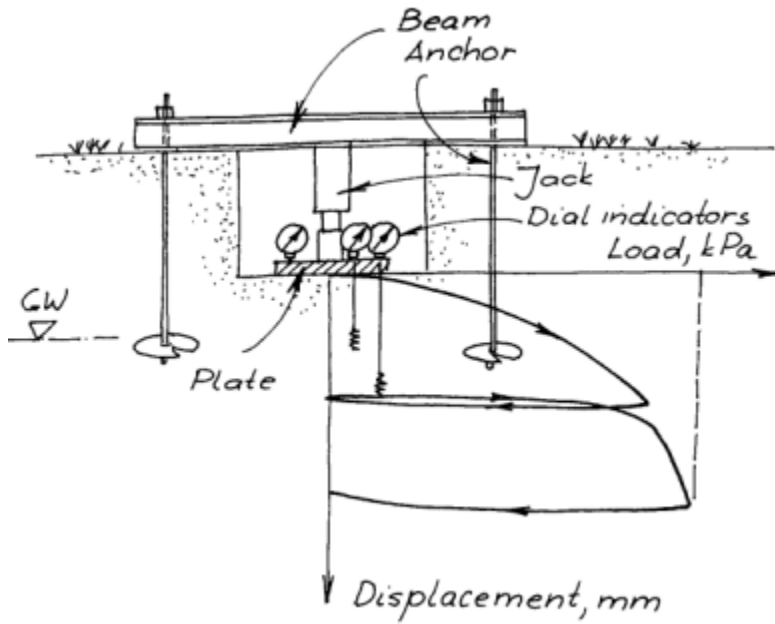


Figure 2

Question 2 (f):

What is the key information that can be derived from any FIVE tests listed below in **Figure 3**? Also, state how the information derived from these tests is useful for the design of geotechnical structures. Complete information asked in the table below. **(5 marks)**

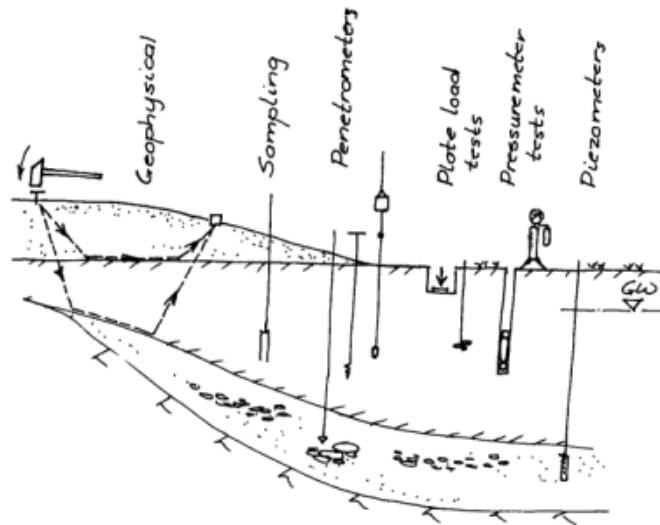


Figure 3

TESTS	WHAT IS THE INFORMATION DERIVED FROM THE TESTS	HOW ARE THESE RESULTS USEFUL IN ENGINEERING PRACTICE?
1.		
2.		
3.		
4.		
5.		

SECTION B

Question 3 (20 MARKS):

A shallow square foundation for a column is to be constructed. It must carry a net vertical load of 600 kN. The foundation soil is sand. The standard penetration numbers obtained from field exploration are summarized below. (i.e., N_{60} versus depth without any corrections) Assume that the depth of foundation will be 1.5 m and the tolerable settlement is 25.4 mm. Determine the size of the foundation.

Depth (m)	N_{60}
1.5	10
3.0	12
4.5	14
6.0	16
7.5	16
10.0	16
12.0	16
14.0	16
16.0	16

Question 4 (20 MARKS):

Details of a cantilever retaining wall are shown in **Figure 4**. The unit weight of the material is 23.5 kN/m^3 . Determine the factor of safety (FS) against (a) **overturning** and (b) **sliding**. (The friction between the base and the foundation soil, δ' is equal to $0.75\phi'$). Comment on the FS values determined.

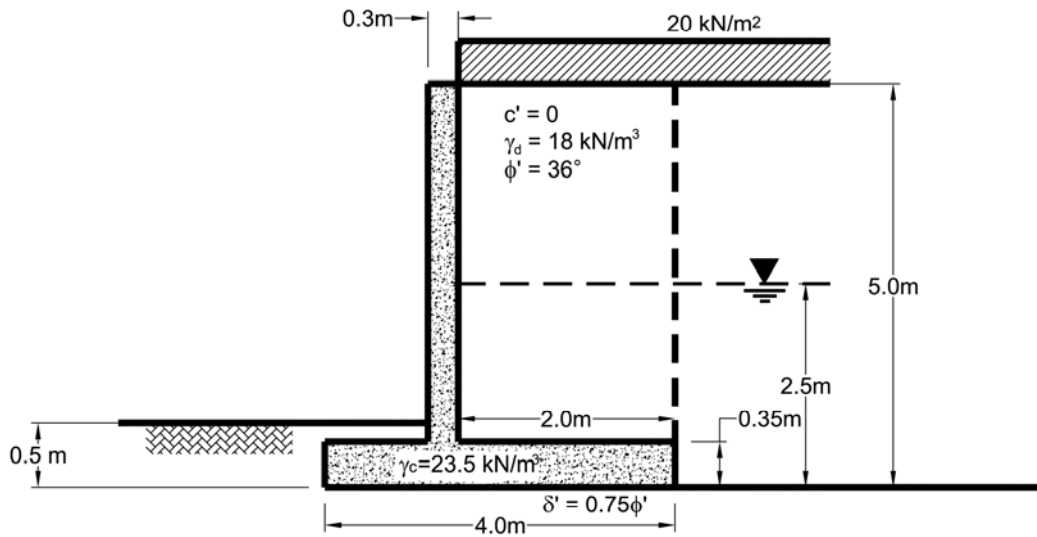


Figure 4

Question 5 (12 MARKS):

A 5-m high vertical wall supports a cohesive backfill ($\phi_u = 0$) with horizontal surface. The top 3 m of the backfill weighs 17.6 kN/m^3 and has an undrained cohesion, c_u of 15 kPa. The bulk density and undrained cohesion of the bottom 2 m are 19.2 kN/m^3 and 30 kPa respectively. What is the likely depth of tension cracks behind the wall?

- (i) If the tension cracks develop, what will be the net active pressure?
- (ii) Draw the pressure distribution diagram ONLY.

Question 6 (12 MARKS):

The elasticity with depth in an erratic sandy deposit varies considerably. Representative data of Elasticity versus depth is shown below:

Depth (m)	Data Set 1 Elasticity (kN/m ²)	Data Set 2 Elasticity (kN/m ²)	Data Set 3 Elasticity (kN/m ²)
0 to 2 m	5000	3000	8000
2 to 8 m	10000	6000	12000
8 to 12 m	15000	12000	20000
12 to 16m	12000	8000	15000

It is proposed to construct a continuous footing with $L/B > 20$, on this soil that has a foundation depth equal to 2m and width equal to 2.5m. Assume $\gamma = 20 \text{ kN/m}^3$ and creep time of 12 years for the correction factor C_2 . Use engineering judgement and calculate the expected **maximum elastic settlement** of the foundation using the given data. Use strain influence factor method for calculations. The stress at the level of foundation is equal to 150 kPa. **(Clue: You don't have to calculate settlement for all the three sets)**

Question 7 (6 MARKS)

A normally consolidated clay sample is obtained from the field to the Geotechnical Laboratory of the University of Ottawa. The sample collected was in a state of undisturbed condition without allowing its natural water content to change. The following stresses were measured in the field, over burden pressure (i.e., total stress), $\sigma = 300 \text{ kN/m}^2$, pore-water pressure, $u = 100 \text{ kN/m}^2$ and effective stress, $\sigma' = 200 \text{ kN/m}^2$. Answer the questions below.

#	Question
1	The sample collected from the field was placed in the University of Ottawa Geotechnical laboratory working desk. What are the σ , u and σ' ?
2	What is the over consolidation ratio of the sample placed on the laboratory working desk?
3	The sample is now placed in a consolidometer (i.e, oedometer) and a normal stress of 400 kN/m^2 is applied on it. What are the σ , u and σ' immediately after the application of this stress (i.e., 400 kN/m^2)
4	After 24 hours, what are the σ , u and σ' if water was not allowed to drain from the sample during the consolidation test?
5	This sample was now allowed to drain. Half of the total settlement in the soil sample occurred in a time period of 2 hours. Will the total settlement take place in the sample in 4 hours? State whether this statement is True or False.
6	What are σ , u and σ' acting on the specimen after the sample has completely consolidated.



Wish you a happy remainder of the summer (If it is really there this year!!)