

**มหาวิทยาลัยสงขลานครินทร์**  
**คณะวิศวกรรมศาสตร์**

การสอบปลายภาค ประจำภาคการศึกษาที่ 1

ปีการศึกษา 2554

สอบวันที่ 5 ตุลาคม 2554

เวลา 13:30-16:30 น

วิชา 220-526 Unsaturated Soil Mechanics

ห้องสอบ A201

Instruction:

1. There are 3 problems with total of 160 points, students are asked to do all of them.
2. This is an open-book exam.
3. All types of calculators are allowed.
4. Answers can be written in Thai.

Name.....Code.....

Question	Full score	Score received
1	40	
2	55	
3	65	
Total	160	

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Instructor

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1. Flow in Unsaturated Soils. (40 points)

1.1. (5 points) For any given soil, please briefly explain why its hydraulic conductivity decreases with decreasing water content.

1.2. (5 points) Briefly explain volumetric water content determination using Time Domain Reflectometer (TDR).

1.3 (20 points) Properties of a soil sample obtained in the lab are as follows:  $K_{sat} = 1e-2$  cm/s, air entry suction ( $\psi_a$ ) = 8 kPa,  $\lambda = 0.6$ ,  $\theta_r = 0.14$ ,  $\theta_s = 0.46$ , and porosity ( $n$ ) = 0.34. Determine unsaturated hydraulic conductivities ( $K_{\psi}$ ) using Wyllie-Gardner method when degrees of saturation of the soil is 70%.

1.4. (5 points) Briefly explain a concept and procedure of unsaturated hydraulic conductivity determination using instantaneous profile method. Sketch the sample set-up and graphs if necessary.

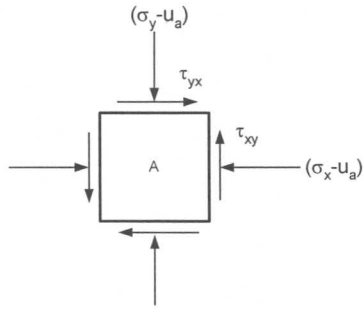
1.5. (5 points) A dielectric constant of an unsaturated sandy soil measured by TDR is 26. Estimate the volumetric water content of the soil.

2. Shear Strength of Unsaturated soils. (55 points).

2.1 (5 points) Briefly explain the shear strength equation for unsaturated soils proposed by Fredlund et al. (1978).

2.2 (5 points) Does  $\phi^b$  have a linear relationship with matric suction? Please explain.

- 2.3. (20 points) Soil element A with matric suction of 20 kPa, has stresses as shown in figure below;  $(\sigma_x - u_a) = 60$  kPa,  $(\sigma_y - u_a) = 100$  kPa, and  $\tau_{xy} = \tau_{yx} = 45$  kPa. Sketch an extended Mohr circle and estimate major and minor principal stresses. Also indicate the pole point.



2.4 (20 points) A series of triaxial tests was conducted for four identical specimens of unsaturated soil silty soil. Data in table 1 are stresses at failure for each test. Determine the shear strength parameters  $c'$ ,  $\phi'$ , and  $\phi^b$ . Also, determine  $\chi_r$ .

Table 1. Triaxial test results of an unsaturated silty soil.

Test No.	$(\sigma_1 - u_a)$	$(\sigma_3 - u_a)$	$(u_a - u_w)$
1	115.5	30	20
2	175.5	50	20
3	141.2	20	80
4	261.2	60	80

Note: Stress unit in kPa

2.5 (5 points) Explain the work of Vanapalli et al. (1996) on shear strength, matric suction, and degree of saturation.



3. Limit Equilibrium Problems Related to Unsaturated Soils. (65 points)

- 3.1. (20 points) An homogeneous soil layer with bulk unit weight of  $16 \text{ kN/m}^3$ , has thickness of 10 m, and ground water table is 6 m below the ground surface. Compute net vertical and horizontal stresses at rest of a soil element at depth of 2 meter below ground surface. Also estimate the depth of cracking. Hint: Poisson ratio of the soil is 0.35.

- 3.2. (20 points) A 4-meter high retaining wall with unsaturated soil backfill is being design. The properties of the soil backfill are:  $\gamma = 16 \text{ kN/m}^3$ ,  $c' = 2 \text{ kPa}$ ,  $\phi' = 30^\circ$ , and  $\phi^b = 10^\circ$ . The ground water table is 2 meter below the base of the retaining wall. Determine coefficient of earth pressures ,  $K_a$  and  $K_p$ , and passive lateral earth pressure at the base of the wall.

- 3.3 (25 points) A free body diagram of an infinite slope is shown in figure below. The slope has soil properties as follows:  $\gamma$ ,  $c'$ ,  $\phi'$ . Derive an equation for computing factor of safety (FS) of the slope that incorporating suction and  $\phi^b$  for unsaturated soil. Hint:  $W = \gamma LH$ .

