PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Midterm Examination: Semester 1 Academic Year: 2016

Date: October 8, 2016 Time: 9.00-12.00 pm

Subject: 235-402 Geotechniques Room: R 201

หมายเหตุ

1. ข้อสอบมีทั้งหมด 2 ส่วน 5 ข้อใหญ่ ในกระดาษคำถาม .....9..... หน้า (อนุญาตให้เขียนหน้าหลังได้)
2. ห้ามการหยิบยืมสิ่งใดๆ ทั้งสิ้น จากผู้อื่นๆ เว้นแต่ผู้คุมสอบจะหยิบยืมให้
3. ห้ามนำส่วนใดส่วนหนึ่งของข้อสอบออกจากห้องสอบ
4. ผู้ที่ประสงค์จะออกจากห้องสอบก่อนหมดเวลาสอบ **แต่ต้องไม่น้อยกว่า 30 นาที** ให้ยกมือขออนุญาตจากผู้คุมสอบก่อนจะลุกจากที่นั่ง
5. เมื่อหมดเวลาสอบ ผู้เข้าสอบต้องหยุดการเขียนใด ๆ ทั้งสิ้น
6. ผู้ที่ปฏิบัติเข้าข่ายทุจริตในการสอบ ตามประกาศคณะวิศวกรรมศาสตร์ **มีโทษ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา**
7. ให้นักศึกษาสามารถนำสิ่งต่อไปนี้เข้าห้องสอบได้

   ☐ Textbook ☐ Book
   ☑ Calculator (no programming) ☐ Paper A4 …… sheet
   ☑ Dictionary
   ☐ Others .....
8. Do this examination by

   ☑ Pencil for drawing only ☑ Pen

No.	Full Scores	Assigned Scores	No.	Full Scores	Assigned Scores
1	20		4	30	
2	25		5	20	
3	50		Total	145	

Instructors: Associate Professor Danupon Tonnayopas

Arj Hathaichanok Vattanasak

Student Signature .....

Bonne chance et bon courage

Part 1 (Aj. Hathaichanok)

Problem 1 (20 points)

A soil sample has a weight of 0.7 kg and the volume was found to be 3.5×10^{-4} m^3. After drying out, the weight was reduced to 0.6 kg. The particle specific gravity test gave 2.60. Determine the following

(a) Moisture content

(b) Dry density

(c) Bulk density

(d) Void ratio

(e) Porosity

(f) Degree of saturation

Part 2 (Assoc.Prof.Dr.Danupon)

Problem 2 (25 points)

a) The average vertical stress in a coal pillar of a Mae Tha mine is found to be 8 MPa. The depth of the pillar and the average density of overburden rock is 200 m and 2500 kg/m^3, respectively. Assuming pillar stress to be same in all coal pillars of that panel, find out the safety factor of the panel. (8 points)

b) A sandstone core specimen composed of quartz and feldspar grains with calcite cement is 82 mm in diameter and 169 mm long. On saturation in water, its wet weight is 21.42 N; after oven drying its weight is 20.31 N. Calculate its wet unit weight, its dry unit weight, and its porosity. (17 points)

Problem 3 (50 points)

The following table shows data obtained from a single-stage triaxial compression test on a cylindrical rock sample, conducted with closed-loop servo-control, at a confining stress of 10.0 MPa, and at zero pore pressure. Estimate values from plotted graph for the following:

a) Yield strength; (5 points)
b) Peak strength, (5 points)
c) Residual strength, (5 points)
d) Tangent Young's modulus E_{tan} at 50% peak axial stress; and (10 points)
e) Tangent Poisson's ratio at 50% peak axial stress. (10 points)

No.	Axial Load (kN)	Sample high (mm)	Sample diameter (mm)
1	0	100.80	50.200
2	19.89	100.76	50.201
3	39.60	100.73	50.203
4	63.40	100.70	50.205
5	88.67	100.63	50.208
6	116.18	100.64	50.212
7	144.68	100.61	50.216
8	162.00	100.59	50.222
9	185.23	100.54	50.236
10	190.62	100.52	50.246
11	191.99	100.5	50.253
12	180.22	100.48	50.258
13	137.56	100.45	50.265
14	115.79	100.42	50.271
15	101.93	100.39	50.277
16	97.97	100.36	50.283
17	96.98	100.33	50.283

Problem 4 (30 points)

Relocation of the tunnel outlet with span 8 meters and is 20 meters below the surface which has bulk density of 2660 kg/m^3. Perform the following tasks:

a) Classify the rock mass condition in accordance with RMR method (15 points)

b) Determine modulus of deformability and pressure for support roof in RMR (15 points)

Item	Value	Rating
Intact rock strength	50 MPa	.....
RQD	55-85%	.....
Spacing discontinuities	50 mm to 0.9 m	.....
Condition of discontinuities	separation 0.8 to 1.1 mm, slightly weathered, roughness surfaces	.....
Groundwater	dripping water, low pressure, Flow 25-125 liters/min	.....
Discontinuity orientation	strike perpendicular to tunnel axis with dip 20%	.....

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Problem 5 (20 points)

If $\sigma_1 = 4\times10^7$ N/m^2 and $\sigma_3 = 2\times10^7$ N/m^2 on serpentinite core specimen. and oriented at $\theta = 60°$. Find normal stress and shear stress by Mohr method. Draw a Mohr's circle showing stress system on serpentinite core with length to diameter of 2.

Available Equations and Tables for Midterm Examination'16

$$\upsilon_d = \frac{\left(V_p^2 - 2V_s^2\right)}{2\left(V_p^2 - V_s^2\right)} \; ; \qquad CI = \frac{W_L - w}{I_p}$$

$$\rho_b = \frac{G_s + eS_r}{1+e} \; ; \qquad \rho_d = \frac{G_s \rho_w}{1 + wG_s}\left(1 - A_v\right);$$

$$K = \frac{E}{3(1-2\upsilon)}$$

$$n = \frac{V_v}{V_t} \times 100 \; ; \; \lambda_d = \rho.\left(V_p^2 - 2V_s^2\right) \; ; \; I_L = \frac{w - W_p}{I_p}$$

$$\lambda = \frac{E\upsilon}{(1+\upsilon)(1-2\upsilon)} \; ; \qquad w = \frac{W_w}{W_s} \times 100$$

$$E_M = \rho.V_p^2.(1+\upsilon)(1-2\upsilon)$$

$$I_D = \frac{e_{\max} - e}{e_{\max} - e_{\min}} \qquad G = \frac{E}{2(1+\upsilon)} \; ; \sigma_c = 10^{A_0} \; ;$$

$$Y = \rho V_p^2 \; ; \qquad E = \frac{9KG}{3K+G} \; ; \qquad F = \left(\frac{D_e}{50}\right)^{0.45}$$

$$\sigma_t = \frac{2P}{\pi.t.d} \; ; \qquad E_d = \rho.V_s^2.\frac{\left(3V_p^2 - 4V_s^2\right)}{\left(V_p^2 - V_s^2\right)}$$

$$A_0 = 1 + 0.0065\rho.SHV \; ; \; I_{s50} = \left(\frac{D_e}{50}\right)^{0.45}.I_s$$

$$G_d = \rho.V_s^2 \; ; \qquad I_{s50} = \frac{P}{D_e^2}$$

$$K_d = \rho\frac{\left(3V_p^2 - 4V_s^2\right)}{3} \; ; \quad I_d = \frac{(C-D)}{(A-D)} \times 100 \; ; \; D_e^2 = 4A/\pi \; ; A = WD$$

$$C_u = d_{60}/d_{10}; \qquad C_z = d_{30}^2/d_{60}.d_{10}$$

$$\tau = c + \sigma_n.\tan\phi$$

$$P = \frac{100 - RMR}{100}\gamma B \qquad ; \qquad E_M = 2\mathrm{RMR} - 100 \qquad ; \qquad E_M = 10^{(\mathrm{RMR}-10)/40}$$

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

Parameter			Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality RQD		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6 - 2 . m	200 - 600 mm	60 - 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10 m tunnel length (l/m)	None	< 10	10 - 25	25 - 125	> 125		
		(Joint water press)/ (Major principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)

Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES

Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions

Discontinuity length (persistence) Rating	< 1 m 6	1 - 3 m 4	3 - 10 m 2	10 - 20 m 1	> 20 m 0
Separation (aperture) Rating	None 6	< 0.1 mm 5	0.1 - 1.0 mm 4	1 - 5 mm 1	> 5 mm 0
Roughness Rating	Very rough 6	Rough 5	Slightly rough 3	Smooth 1	Slickensided 0
Infilling (gouge) Rating	None 6	Hard filling < 5 mm 4	Hard filling > 5 mm 2	Soft filling < 5 mm 2	Soft filling > 5 mm 0
Weathering Ratings	Unweathered 6	Slightly weathered 5	Moderately weathered 3	Highly weathered 1	Decomposed 0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING

Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very favourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike*	
Fair	Unfavourable	Fair	

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly.

** Modified after Wickham et al (1972).