

Assignment 2

(Due: 6 February, 2020 by 17:00)

- Q1.** A BX core specimen of sandstone is 8 cm-long and has a dry mass of 250 g. If the specific gravity of the sandstone is 2.65, determine the following index properties of the rock:
- dry density;
 - void ratio;
 - porosity;
 - water content when fully saturated.

Hint: Use the phase relationships table on the last page of this assignment.

- Q2.** Laboratory **slake durability tests** were performed on samples of sandstone and dolomite and the results are summarized below. Calculate the **slake durability index** and **estimate the durability of both rocks**.
- Mass of sample (dry) + drum = 902 g (sandstone);
 - Mass of sample (dry) + drum = 928 g (dolomite);
 - Mass of empty drum = 432 g (sandstone);
 - Mass of empty drum = 434 g (dolomite);
 - Mass of sample (dry) + drum after 1st weathering cycle = 871 g (sandstone);
 - Mass of sample (dry) + drum after 1st weathering cycle = 926 g (dolomite);
 - Mass of sample (dry) + drum after 2nd weathering cycle = 821 g (sandstone);
 - Mass of sample (dry) + drum after 2nd weathering cycle = 921 g (dolomite).

Q3. Twenty **point-load tests** were carried out on intact rock samples and the results are summarized in the following table. The tested samples were either NX rock core specimens (samples 1 to 10), HQ rock core specimens (samples 11 to 15), or irregular lumps (samples 16 to 20). Tests were performed perpendicular and parallel to the planes of weakness, as indicated in the table. Estimate:

- the **point load strength index**, I_s ;
- the **size-corrected point load strength index**, $I_{s(50)}$;
- the **point load strength anisotropy index**, $I_{a(50)}$;
- the **uniaxial compressive strength**.

Hint: Summarize your results in a spreadsheet similar to that presented on p.28, Ch.3 of the Lecture Notes. Assume $\sigma_c \approx 24I_{s(50)}$.

Test #	Type	W_1	W_2	D	P
		(mm)	(mm)	(mm)	(kN)
1	a//	53.90	53.87	25.23	2.14
2	a//	53.73	53.65	25.00	2.29
3	a//	54.12	54.01	25.07	2.44
4	a//	53.72	53.86	25.06	2.75
5	a//	53.89	53.92	25.04	1.84
6	d//	-	-	54.13	3.41
7	d//	-	-	53.86	2.85
8	d//	-	-	53.77	3.12
9	d//	-	-	54.05	3.02
10	d//	-	-	53.38	3.18
11	a⊥	63.42	63.57	45.28	5.11
12	a⊥	63.45	63.34	30.15	2.87
13	a⊥	63.68	63.81	30.38	3.68
14	a⊥	63.43	63.38	29.83	2.54
15	a⊥	63.59	63.47	31.25	3.41
16	i⊥	37.14	28.89	18.98	1.52
17	i⊥	55.13	29.58	27.22	2.19
18	i⊥	29.89	37.14	17.63	1.93
19	i⊥	45.69	39.61	24.59	2.31
20	i⊥	19.89	33.26	14.36	1.24

a = axial

d = diametrical

i = irregular lump

⊥ = loaded perpendicular to plane of weakness

// = loaded parallel to plane of weakness

Q4. The results provided in the table below were obtained from a **direct shear test** conducted in the lab along an open bedding plane. The tested specimen was **square** in shape and **0.06 m-wide**. The **normal load** applied on the specimen during the test was 660 N.

- Plot a graph of **shear stress vs. shear displacement**. Determine the peak and residual shear strength on this rock surface.
- Plot a graph of **shear displacement vs. normal displacement** and comment of the volumetric **behaviour of the rock specimen during shear**.
- Assuming a **zero cohesion** along the bedding plane, determine the **peak and residual friction angles** from a plot of **shear stress vs. normal stress**.

Shear force	Shear displacement	Normal displacement	Shear force	Shear displacement	Normal displacement
(N)	(mm)	(mm)	(N)	(mm)	(mm)
0.00	0.0000	0.0000	465.21	3.1750	-0.0203
195.72	0.1980	-0.0356	470.67	3.4925	0.0102
217.96	0.2540	-0.0457	473.23	3.8100	0.0483
258.00	0.3810	-0.0635	467.85	4.1275	0.0830
280.24	0.5080	-0.0762	457.61	4.4450	0.1219
298.03	0.6350	-0.0914	446.67	4.7625	0.1626
315.82	0.7755	-0.1067	441.10	5.0800	0.2083
338.06	0.9629	-0.1219	438.37	5.3975	0.2437
360.31	1.1565	-0.1270	436.64	5.7150	0.2870
382.55	1.3970	-0.1270	435.37	6.0325	0.3277
391.44	1.5240	-0.1245	431.67	6.3500	0.3785
409.24	1.7780	-0.1194	429.39	6.6675	0.4216
426.37	2.0320	-0.1092	427.78	6.9850	0.4674
439.78	2.2860	-0.0914	423.37	7.3025	0.5077
448.37	2.5400	-0.0737	421.87	7.6200	0.5382
457.91	2.8575	-0.0486			

- Q5.** The following results were obtained from a single-stage **triaxial compression test on a cylindrical rock specimen**, conducted at a **confining stress of 25.0 MPa**. The specimen was 59 mm in diameter and 126 mm long. The pore water pressure was not measured during the test. Estimate:
- the **peak triaxial compressive strength**;
 - the **residual triaxial compressive strength**;
 - the **tangent Young's modulus**, $E_{t,50}$ at 50% peak deviator stress; and
 - the **tangent Poisson's ratio** at 50% peak deviator stress.

Total Axial Load, P	Axial Deformation ΔL	Lateral Deformation ΔD	Total Axial Load, P	Axial Deformation ΔL	Lateral Deformation ΔD
(kN)	(mm)	(mm)	(kN)	(mm)	(mm)
68.35	0.00	0.000	188.35	2.55	-0.340
72.35	0.12	-0.040	201.35	2.65	-0.350
76.35	0.25	-0.060	226.35	2.85	-0.370
80.35	0.38	-0.090	240.35	2.95	-0.390
84.35	0.51	-0.110	256.35	3.10	-0.420
91.35	0.74	-0.140	267.35	3.20	-0.450
96.35	0.93	-0.150	276.35	3.30	-0.480
100.35	1.06	-0.170	283.35	3.40	-0.510
105.35	1.22	-0.190	289.35	3.50	-0.550
112.35	1.45	-0.210	294.35	3.60	-0.580
117.35	1.61	-0.220	296.35	3.65	-0.600
122.35	1.75	-0.230	299.35	3.77	-0.640
126.35	1.85	-0.240	300.35	3.90	-0.680
134.35	2.00	-0.260	299.35	4.10	-0.710
144.35	2.15	-0.280	297.35	4.25	-0.750
154.35	2.27	-0.290	295.35	4.40	-0.770
165.35	2.38	-0.310	294.35	4.60	-0.810



Various Forms of Relationships for γ , γ_d , and γ_{sat}

Moist unit weight (γ)		Dry unit weight (γ_d)		Saturated unit weight (γ_{sat})	
Given	Relationship	Given	Relationship	Given	Relationship
w, G_s, e	$\frac{(1 + w)G_s\gamma_w}{1 + e}$	γ, w	$\frac{\gamma}{1 + w}$	G_s, e	$\frac{(G_s + e)\gamma_w}{1 + e}$
S, G_s, e	$\frac{(G_s + Se)\gamma_w}{1 + e}$	G_s, e	$\frac{G_s\gamma_w}{1 + e}$	G_s, n	$[(1 - n)G_s + n]\gamma_w$
w, G_s, S	$\frac{(1 + w)G_s\gamma_w}{1 + \frac{wG_s}{S}}$	G_s, n	$G_s\gamma_w(1 - n)$	G_s, w_{sat}	$\left(\frac{1 + w_{sat}}{1 + w_{sat}G_s}\right)G_s\gamma_w$
w, G_s, n	$G_s\gamma_w(1 - n)(1 + w)$	G_s, w, S	$\frac{G_s\gamma_w}{1 + \left(\frac{wG_s}{S}\right)}$	e, w_{sat}	$\left(\frac{e}{w_{sat}}\right)\left(\frac{1 + w_{sat}}{1 + e}\right)\gamma_w$
S, G_s, n	$G_s\gamma_w(1 - n) + nS\gamma_w$ $Se = G_s w$	e, w, S	$\frac{eS\gamma_w}{(1 + e)w}$	n, w_{sat}	$n\left(\frac{1 + w_{sat}}{w_{sat}}\right)\gamma_w$
		γ_{sat}, e	$\gamma_{sat} - \frac{e\gamma_w}{1 + e}$	γ_d, e	$\gamma_d + \left(\frac{e}{1 + e}\right)\gamma_w$
		γ_{sat}, n	$\gamma_{sat} - n\gamma_w$	γ_d, n	$\gamma_d + n\gamma_w$
		γ_{sat}, G_s	$\frac{(\gamma_{sat} - \gamma_w)G_s}{(G_s - 1)}$	γ_d, G_s	$\left(1 - \frac{1}{G_s}\right)\gamma_d + \gamma_w$
				γ_d, w_{sat}	$\gamma_d(1 + w_{sat})$