UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2014/2015 Academic Session

June 2015

EAG442/4 – Advanced Geotechnical Engineering
[*Kejuruteraan Geoteknik Lanjutan*]

Duration : 3 hours
[*Masa : 3 jam*]

Please check that this examination paper consists of **FOURTEEN (14)** pages of printed material including **TWO (2)** appendixes before you begin the examination.

[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **EMPAT BELAS (14)** muka surat yang bercetak termasuk **DUA (2)** lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.

[***Arahan** : Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan.*]

All questions **MUST BE** answered on a new page.

[*Semua soalan **MESTILAH** dijawab pada muka surat baru.*]

In the event of any discrepancies, the English version shall be used.

[*Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.*]

1. (a) The parameter values associated with a fill material are given in **Figure 1**. Determine the cost of material purchase to meet the requirements at fill site. The unit price of fill is RM50 per cubic meter based on volume while on the trucks.

*Nilai-nilai parameter bagi tanah isi diberi di **Rajah 1**. Tentukan kos pembelian tanah isi bagi memenuhi keperluan di tapak bina. Harga tanah RM50 bagi setiap meter padu di atas lori.*

[8 marks/*markah*]

(b) Again based on the parameter values given in **Figure 1**, determine the required volume of borrow in order to meet the requirements at fill site.

*Sekali lagi, menurut nilai-nilai parameter di **Rajah 1**, tentukan isipadu tanah yang perlu diambil daripada tempat korekan bagi memenuhi keperluan di tapak bina.*

[4 marks/*markah*]

(c) Determine the straight line equation relating relative density and void ratio for soil used in this work.

Tentukan persamaan garis lurus yang mengaitkan antara ketumpatan relatif dengan nisbah lompang bagi tanah isi ini.

[4 marks/*markah*]

(d) Discuss the various types of fill soils available in Nibong Tebal and Parit Buntar, their availability, and prices. This discussion must be limited to one page only.

Bincangkan jenis-jenis tanah isi yang terdapat di kawasan Nibong Tebal dan Parit Buntar dari segi harga dan kebolehsediaan. Perbincangan ini perlu dihadkan ke satu mukasurat sahaja.

[4 marks/*markah*]

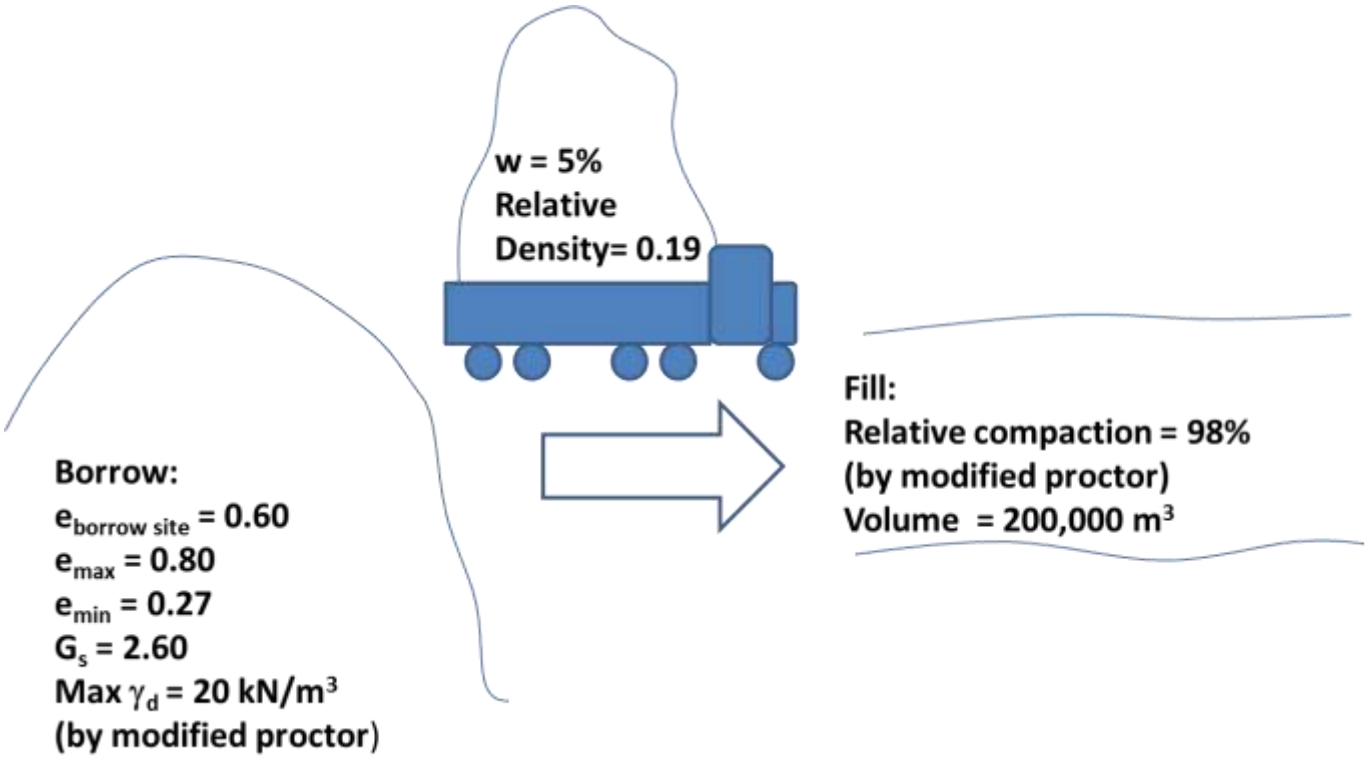


Figure 1/Rajah 1

2. (a) Describe how pre-loading and use of vertical drains are done in the field.

Terangkan bagaimana pra-pembebanan dan penggunaan saliran tegak dijalankan di tapak pembinaan.

[4 marks/*markah*]

(b) A uniform fill work has been assigned as given in **Figure 2** together with the parameter values. The pre-loading period in case of not using any vertical drain has been specified as 2 years. The objective is to achieve 90 % consolidation of the clay layer within this period. Determine the thickness of pre-loading surcharge (design fill + extra load) that would deliver the objective. The compression curve for the clay is given in **Figure 3**.

Suatu kerja penambakan sekata telah dirancang seperti diberi di ***Rajah 2,*** *dan nilai-nilai parameter ada disertakan sekali. Tempoh pra-pembebanan tanpa menggunakan saliran tegak adalah selama 2 tahun. Tujuan pra-pembebanan ialah supaya 90% enapan pengukuhan lapisan lempung dicapai. Tentukan ketebalan beban pra-pembebanan (ketebalan isi + ketebalan tambahan) yang diperlukan bagi mencapai tujuan di atas. Lengkung pemadatan diberi di* ***Rajah 3***.

[8 marks/*markah*]

(c) In order to shorten the pre-loading period down to 1 year, the use of PVD is considered. Determine the required distance between PVDs if the surcharge is specified as 6 m thick. Assume the PVD chosen is 100 mm wide and 9 m thick thus giving an equivalent diameter of 70 mm. **(Refer to Appendix 1**).

Bagi memendekkan tempoh pra-pembebanan kepada 1 tahun, PVD digunakan. Tentukan jarak antara PVD yang diperlukan sekiranya ketebalan pra-pembebanan (ketebalan isi + ketebalan tambahan) 6 m. Andaikan PVD yang dipilih mempunyai kelebaran 100 mm dan ketebalan 9 mm yang menjadikan diameter setaranya 70 mm. ***(Rujuk Lampiran 1)***

[8 marks/*markah*]

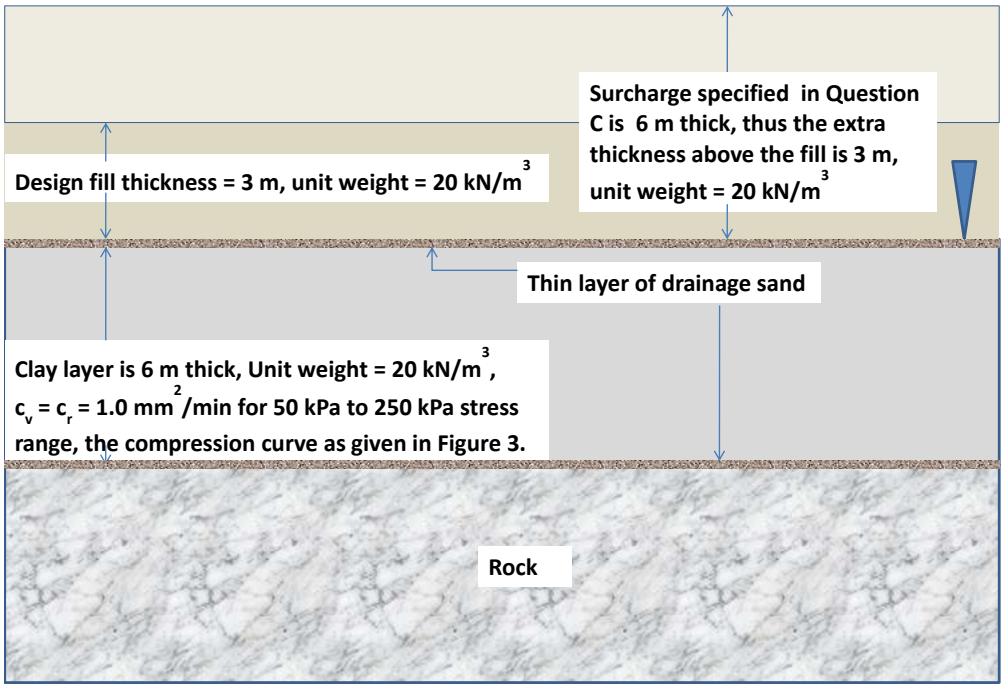


Figure 2 / Rajah 2

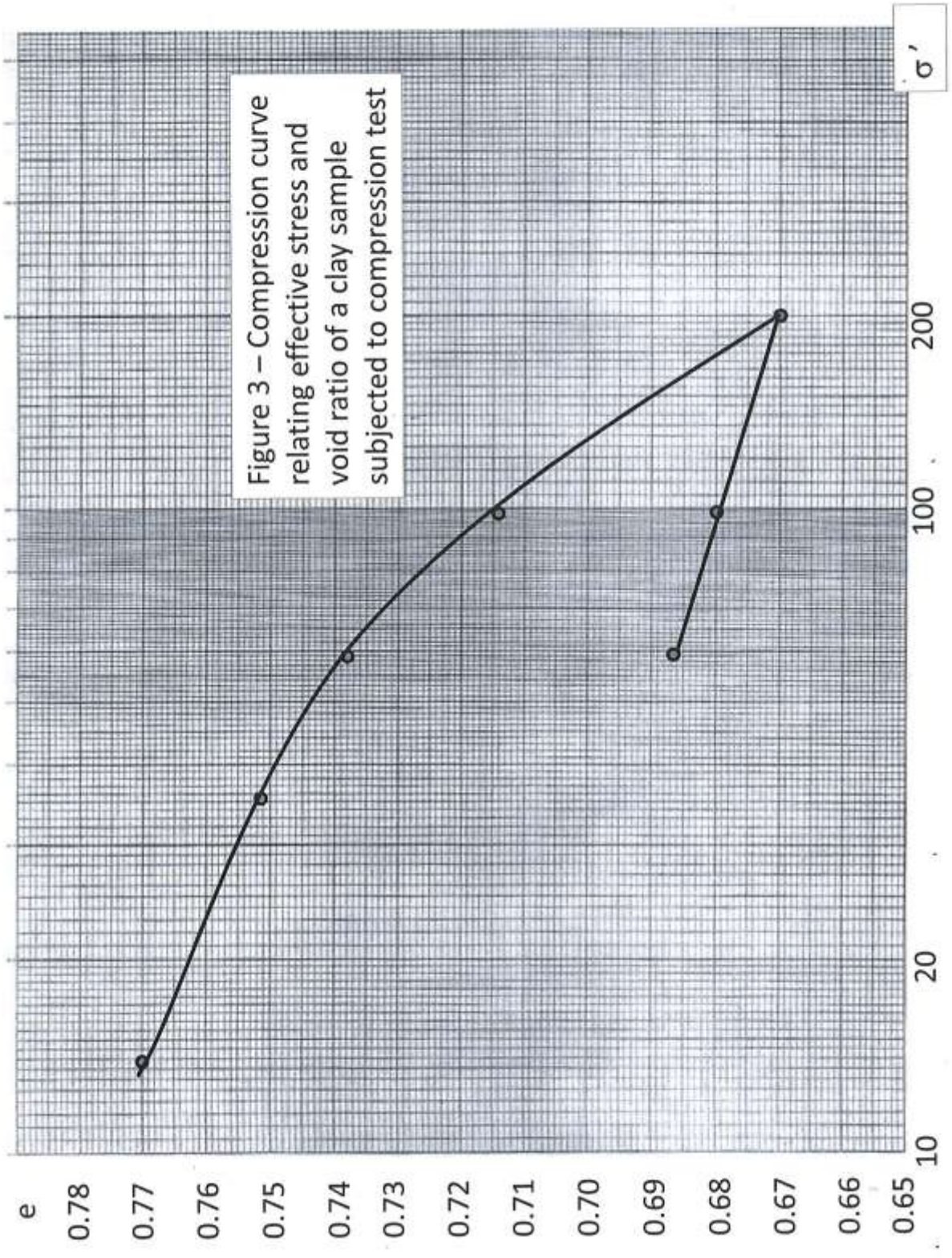


Figure 3 / Rajah 3

3. (a) Erosion and landslide are mechanisms of failure. Using sketches, explain the differences between these two mechanisms.

Hakisan dan tanah runtuh adalah mekanisma-mekanisma kegagalan. Dengan menggunakan lakaran jelaskan perbezaan diantara dua mekanisma ini.

[6 marks/*markah*]

(b) What are the **FIVE (5)** preventive measures against the possibility of erosion and landslide failures.

*Apakah **LIMA (5)** langkah pencegahan yang biasa digunapakai bagi melindungi tanah daripada hakisan dan keruntuhan.*

[5 marks/*markah*]

(c) Name **THREE (3)** types of landslides, sketch them, and give the reasons why they happen.

*Namakan **TIGA (3)** jenis tanah runtuh, lakarkan dan berikan punca ianya terjadi.*

[9 marks/*markah*]

4. (a) Explain at least **FIVE (5)** functions of geosynthetic material that affect field performance in any geotechnical application and sketch them according to its functions.

*Terangkan sekurang-kurangnya **LIMA (5)** fungsi bahan geosintetik yang mempengaruhi prestasi di lapangan dan lakarkan maklumat berkaitan menurut fungsinya.*

[5 marks/*markah*]

(b) Describe with sketches aspects that are considered in the planning and design of a geosynthetic application.

Terangkan dengan menggunakan lakaran perkara-perkara yang diambil kira dalam suatu perancangan dan rekabentuk melibatkan penggunaan geosintetik

.

[7 marks/*markah*]

(c) Specify the requirements and criteria for any one application of geosynthetics. Propose one application and design accordingly.

Nyatakan keperluan dan kriteria bagi mana-mana penggunaan geosintetik. Cadangkan suatu penggunaan dan rekabentuk penggunaan tersebut sewajarnya.

[8 marks/*markah*]

5. An open cut for 2 new MRT box stations will be constructed deep into the Kuala Lumpur Karst Limestone and also into the Granite Formation. From the Lugeon test carried out in two different geological formations, the intact granite rock has an a hydraulic conductivity, K, of 1 x 10^{-12} m/s and the limestone has a hydraulic conductivity, K, of 1 x 10^{-4} m/s. Since the main requirement of an underground box station is to remain completely dry during the operation, it is important to analyze the water flow into the rocks.

Suatu potongan terbuka bagi 2 stesen kotak baru MRT akan dibina jauh kedalam Batu Kapur Karst Kuala Lumpur dan Formasi Batuan Granit. Daripada ujian 'Lugeon' yang dijalankan di kedua-dua formasi geologi yang berbeza, batuan utuh granit mempunyai kekonduksian hidraulik, K, 1 x 10^{-12} m/s dan batuan kapur mempunyai kekonduksian hidraulik, K, 1 x 10^{-4} m/s. Sebagai keperluan utama untuk stesen kotak bawah tanah kekal kering sepanjang beroperasi, adalah penting untuk menganalisis aliran air ke dalam batuan-batuan tersebut.

(a) Define the meaning of Lugeon Test and describe its main objective.

Berikan definisi ujian 'Lugeon' dan jelaskan objektif utama ujian tersebut.

[4 marks/*markah*]

(b) Calculate the time required for water subjected to 10 m head difference to pass through horizontally a 5 m length of the intact granite and the limestone surrounding the underground box station.

Kirakan masa diperlukan oleh air yang tertakluk kepada perbezaan turus sebanyak 10 m untuk melepasi panjang 5 m secara ufuk bagi batuan granit dan batu kapur yang mengelilingi stesen kotak bawah tanah tersebut.

[6 marks/*markah*]

(c) Based on the results obtained in (b), discuss if groundwater control is needed in order to minimize the groundwater movement into the underground box station.

Berdasarkan kepada keputusan yang diperolehi di (b), jelaskan samaada kawalan airbumi perlu dilakukan untuk mengurangkan pergerakan airbumi ke dalam stesen kotak bawah tanah tersebut.

[4 marks/*markah*]

(d) With the help of sketches, proposed a suitable groundwater control method that can be used to minimize the groundwater movement in the rock mass.

Dengan berbantukan lakaran, cadangkan kaedah kawalan airbumi yang dapat digunakan untuk meminimumkan pergerakan airbumi di dalam bongkah batuan.

[6 marks/*markah*]

6. (a) From an initial investigation carried out on the rock mass for the excavation of a large underground cavern, the fracture frequency is one fracture per meter with fracture aperture of 0.01 mm and hydraulic conductivity of 8.3 x 10^{-10} m/s. However, during the tunnel face mapping immediately after the excavation work, the side wall of the large cavern has ten fractures per meter with an average fracture aperture of 1 mm.

Daripada siasatan awal yang dijalankan terhadap bongkah batuan bagi pengorekan gua besar bawah tanah, didapati frekuensi rekahan adalah satu per meter dengan bukaan rekahan, 0.01 mm dan kekonduksian hidraulik 8.3 x 10^{-10} m/s. Walau bagaimanapun, semasa pemetaan permukaan terowong sejurus selepas kerja pengorekan bawah tanah, dinding sisi gua besar tersebut mempunyai 10 rekahan per meter dengan purata bukaan rekahan, 1 mm.

i. Determine the hydraulic conductivity of the rock mass at the side wall of the large cavern.

Tentukan kekonduksian hidraulik bongkah batuan pada dinding sisi gua besar tersebut.

[6 marks/*markah*]

ii. Discuss the main factors contributing to the difference in the hydraulic conductivity of the rock mass obtained during the initial investigations and after the excavation work of the large cavern.

Bezakan faktor utama yang menyumbang kepada perbezaan diantara kekonduksian hidraulik bongkah batuan yang diperolehi semasa siasatan awal dan juga selepas kerja pengorekan gua besar tersebut.

[4 marks/*markah*]

(b) One of the tunnel face at the Hulu Terengganu Hydropower project has been rated using the Q rock mass classification system. From the tunnel face mapping information obtained, joint set number, Jn = 4, joint roughness number, Jr = 3, joint alteration number, Ja = 1 and joint water reduction, Jw = 1. The major principal stress for the tunnel section is 70 MPa and uniaxial compressive strength of intact rock obtained by using the Rock Schmidt Hammer is 120 MPa.

Salah satu permukaan terowong projek hidro kuasa Hulu Terengganu dinilai dengan menggunakan sistem pengelasan batuan Q. Daripada maklumat pemetaan permukaan terowong yang diperolehi nombor set kekar, Jn = 4, nombor kekasaran kekar, Jr = 3, nombor perubahan kekar, Ja = 1 dan pengurangan air kekar, Jw = 1. Tegasan utama major yang diperolehi bagi keratan terowong tersebut adalah 70 MPa dan kekuatan mampatan ekapaksi batuan utuh yang diperolehi dengan menggunakan `Rock Schmidt Hammer' adalah 120 MPa.

i. Determine the Rock mass quality rating using the Q classification system. **(Refer to Appendix 2**).

Tentukan nilai kualiti batuan tersebut dengan menggunakan sistem pengelasan Q. ***(Rujuk Lampiran 2).***

[6 marks/*markah*]

ii. From the same tunnel face mapping of Questions (i) above, the RMR rating was determined to be 82 (Very good rock). Describe the major differences in rating and results coming from the Q and RMR classification systems.

Berdasarkan kepada maklumat pemetaan permukaan terowong yang sama dengan soalan (i), nilai RMR yang ditentukan adalah 82 (batuan sangat bagus). Jelaskan perbezaan utama nilai dan deskripsi yang diperolehi daripada sistem pengelasan Q dan RMR.

[4 marks/*markah*]

APPENDIX 1
LAMPIRAN 1

Table 7.3 Solution for radial drainage

Degree of consolidation, U_r (%)	Time factor, T_r, for values of n				
	5	10	15	20	25
0	0	0	0	0	0
1	0.0012	0.0020	0.0025	0.0028	0.0031
2	0.0024	0.0040	0.0050	0.0057	0.0063
3	0.0036	0.0060	0.0075	0.0086	0.0094
4	0.0048	0.0081	0.0101	0.0115	0.0126
5	0.0060	0.0101	0.0126	0.0145	0.0159
6	0.0072	0.0122	0.0153	0.0174	0.0191
7	0.0085	0.0143	0.0179	0.0205	0.0225
8	0.0098	0.0165	0.0206	0.0235	0.0258
9	0.0110	0.0186	0.0232	0.0266	0.0292
10	0.0123	0.0208	0.0260	0.0297	0.0326
11	0.0136	0.0230	0.0287	0.0328	0.0360
12	0.0150	0.0252	0.0315	0.0360	0.0395
13	0.0163	0.0275	0.0343	0.0392	0.0431
14	0.0177	0.0298	0.0372	0.0425	0.0467
15	0.0190	0.0321	0.0401	0.0458	0.0503
16	0.0204	0.0344	0.0430	0.0491	0.0539
17	0.0218	0.0368	0.0459	0.0525	0.0576
18	0.0232	0.0392	0.0489	0.0559	0.0614
19	0.0247	0.0416	0.0519	0.0594	0.0652
20	0.0261	0.0440	0.0550	0.0629	0.0690
21	0.0276	0.0465	0.0581	0.0664	0.0729
22	0.0291	0.0490	0.0612	0.0700	0.0769
23	0.0306	0.0516	0.0644	0.0736	0.0808
24	0.0321	0.0541	0.0676	0.0773	0.0849
25	0.0337	0.0568	0.0709	0.0811	0.0890
26	0.0353	0.0594	0.0742	0.0848	0.0931
27	0.0368	0.0621	0.0776	0.0887	0.0973
28	0.0385	0.0648	0.0810	0.0926	0.1016
29	0.0401	0.0676	0.0844	0.0965	0.1059
30	0.0418	0.0704	0.0879	0.1005	0.1103
31	0.0434	0.0732	0.0914	0.1045	0.1148
32	0.0452	0.0761	0.0950	0.1087	0.1193
33	0.0469	0.0790	0.0987	0.1128	0.1239
34	0.0486	0.0820	0.1024	0.1171	0.1285
35	0.0504	0.0850	0.1062	0.1214	0.1332
36	0.0522	0.0881	0.1100	0.1257	0.1380
37	0.0541	0.0912	0.1139	0.1302	0.1429
38	0.0560	0.0943	0.1178	0.1347	0.1479
39	0.0579	0.0975	0.1218	0.1393	0.1529
40	0.0598	0.1008	0.1259	0.1439	0.1580
41	0.0618	0.1041	0.1300	0.1487	0.1632
42	0.0638	0.1075	0.1342	0.1535	0.1685
43	0.0658	0.1109	0.1385	0.1584	0.1739
44	0.0679	0.1144	0.1429	0.1634	0.1793
45	0.0700	0.1180	0.1473	0.1684	0.1849
46	0.0721	0.1216	0.1518	0.1736	0.1906
47	0.0743	0.1253	0.1564	0.1789	0.1964
48	0.0766	0.1290	0.1611	0.1842	0.2023
49	0.0788	0.1329	0.1659	0.1897	0.2083
50	0.0811	0.1368	0.1708	0.1953	0.2144

...12/-

Degree of consolidation, U_r (%)	Time factor, T_r, for values of n				
	5	10	15	20	25
51	0.0835	0.1407	0.1758	0.2020	0.2206
52	0.0859	0.1448	0.1809	0.2068	0.2270
53	0.0884	0.1490	0.1860	0.2127	0.2335
54	0.0909	0.1532	0.1913	0.2188	0.2402
55	0.0935	0.1575	0.1968	0.2250	0.2470
56	0.0961	0.1620	0.2023	0.2313	0.2539
57	0.0988	0.1665	0.2080	0.2378	0.2610
58	0.1016	0.1712	0.2138	0.2444	0.2683
59	0.1044	0.1759	0.2197	0.2512	0.2758
60	0.1073	0.1808	0.2258	0.2582	0.2834
61	0.1102	0.1858	0.2320	0.2653	0.2912
62	0.1133	0.1909	0.2384	0.2726	0.2993
63	0.1164	0.1962	0.2450	0.2801	0.3075
64	0.1196	0.2016	0.2517	0.2878	0.3160
65	0.1229	0.2071	0.2587	0.2958	0.3247
66	0.1263	0.2128	0.2658	0.3039	0.3337
67	0.1298	0.2187	0.2732	0.3124	0.3429
68	0.1334	0.2248	0.2808	0.3210	0.3524
69	0.1371	0.2311	0.2886	0.3300	0.3623
70	0.1409	0.2375	0.2967	0.3392	0.3724
71	0.1449	0.2442	0.3050	0.3488	0.3829
72	0.1490	0.2512	0.3134	0.3586	0.3937
73	0.1533	0.2583	0.3226	0.3689	0.4050
74	0.1577	0.2658	0.3319	0.3795	0.4167
75	0.1623	0.2735	0.3416	0.3906	0.4288
76	0.1671	0.2816	0.3517	0.4021	0.4414
77	0.1720	0.2900	0.3621	0.4141	0.4546
78	0.1773	0.2988	0.3731	0.4266	0.4683
79	0.1827	0.3079	0.3846	0.4397	0.4827
80	0.1884	0.3175	0.3966	0.4534	0.4978
81	0.1944	0.3277	0.4090	0.4679	0.5137
82	0.2007	0.3383	0.4225	0.4831	0.5304
83	0.2074	0.3496	0.4366	0.4922	0.5481
84	0.2146	0.3616	0.4516	0.5163	0.5668
85	0.2221	0.3743	0.4675	0.5345	0.5868
86	0.2302	0.3879	0.4845	0.5539	0.6081
87	0.2388	0.4025	0.5027	0.5748	0.6311
88	0.2482	0.4183	0.5225	0.5974	0.6558
89	0.2584	0.4355	0.5439	0.6219	0.6827
90	0.2696	0.4543	0.5674	0.6487	0.7122
91	0.2819	0.4751	0.5933	0.6784	0.7448
92	0.2957	0.4983	0.6224	0.7116	0.7812
93	0.3113	0.5247	0.6553	0.7492	0.8225
94	0.3293	0.5551	0.6932	0.7927	0.8702
95	0.3507	0.5910	0.7382	0.8440	0.9266
96	0.3768	0.6351	0.7932	0.9069	0.9956
97	0.4105	0.6918	0.8640	0.9879	1.0846
98	0.4580	0.7718	0.9640	1.1022	1.2100
99	0.5391	0.9086	1.1347	1.2974	1.4244

...13/-

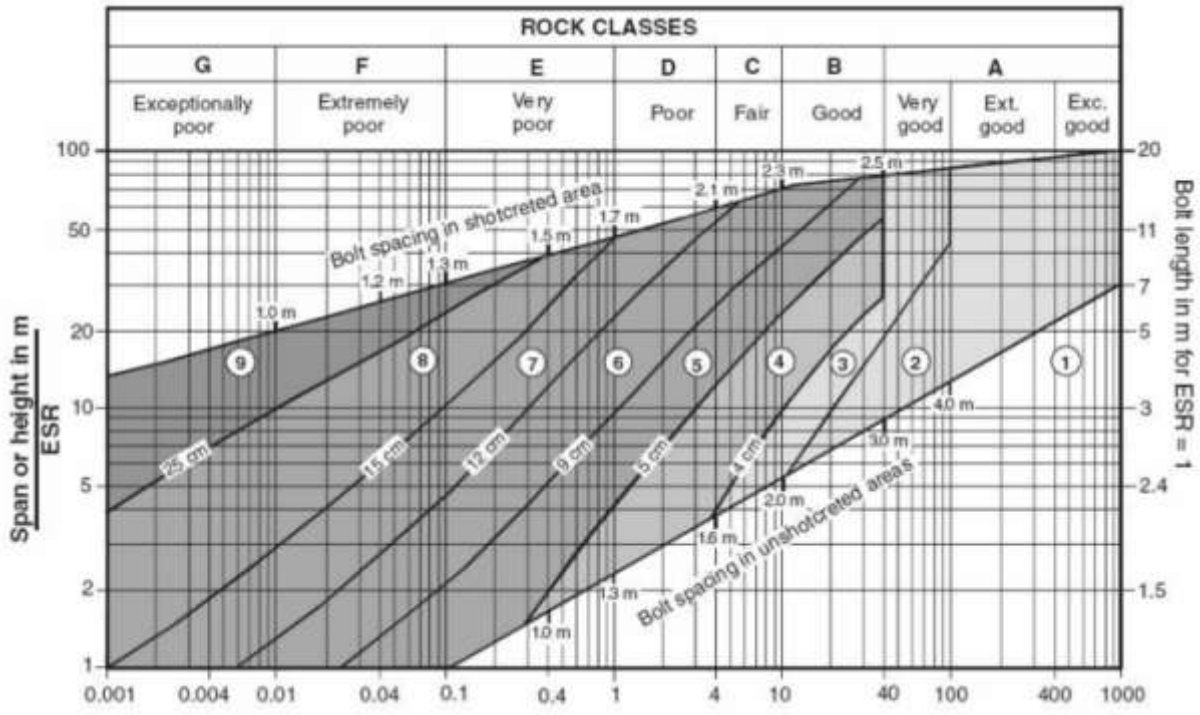
Table 7.1 Variation of time factor with degree of consolidation*

U (%)	T_v	U (%)	T_v	U (%)	T_v
0	0	34	0.0907	68	0.377
1	0.00008	35	0.0962	69	0.390
2	0.0003	36	0.102	70	0.403
3	0.00071	37	0.107	71	0.417
4	0.00126	38	0.113	72	0.431
5	0.00196	39	0.119	73	0.446
6	0.00283	40	0.126	74	0.461
7	0.00385	41	0.132	75	0.477
8	0.00502	42	0.138	76	0.493
9	0.00636	43	0.145	77	0.511
10	0.00785	44	0.152	78	0.529
11	0.0095	45	0.159	79	0.547
12	0.0113	46	0.166	80	0.567
13	0.0133	47	0.173	81	0.588
14	0.0154	48	0.181	82	0.610
15	0.0177	49	0.188	83	0.633
16	0.0201	50	0.197	84	0.658
17	0.0227	51	0.204	85	0.684
18	0.0254	52	0.212	86	0.712
19	0.0283	53	0.221	87	0.742
20	0.0314	54	0.230	88	0.774
21	0.0346	55	0.239	89	0.809
22	0.0380	56	0.248	90	0.848
23	0.0415	57	0.257	91	0.891
24	0.0452	58	0.267	92	0.938
25	0.0491	59	0.276	93	0.993
26	0.0531	60	0.286	94	1.055
27	0.0572	61	0.297	95	1.129
28	0.0615	62	0.307	96	1.219
29	0.0660	63	0.318	97	1.336
30	0.0707	64	0.329	98	1.500
31	0.0754	65	0.304	99	1.781
32	0.0803	66	0.352	100	∞
33	0.0855	67	0.364		

$$U_{v,r} = 1-(1-U_r)(1-U_v)$$

APPENDIX 2
LAMPIRAN 2

DESCRIPTION	VALUE			NOTES
6. STRESS REDUCTION FACTOR			***SRF***	
b. Competent rock, rock stress problems				
	σ_c/σ_1	$\sigma_t\sigma_1$		2. For strongly anisotropic virgin stress field
H. Low stress, near surface	> 200	> 13	2.5	(if measured): when $5 \le \sigma_1/\sigma_3 \le 10$, reduce σ_c
J. Medium stress	200 - 10	13 - 0.66	1.0	to $0.8\sigma_c$ and σ_t to $0.8\sigma_t$. When σ_1/σ_3 > 10,
K. High stress, very tight structure	10 - 5	0.66 - 0.33	0.5 - 2	reduce σ_c and σ_t to $0.6\sigma_c$ and $0.6\sigma_t$, where
(usually favourable to stability, may				σ_c = unconfined compressive strength, and
be unfavourable to wall stability)				σ_t = tensile strength (point load) and σ_1 and
L. Mild rockburst (massive rock)	5 - 2.5	0.33 - 0.16	5 - 10	σ_3 are the major and minor principal stresses.
M. Heavy rockburst (massive rock)	< 2.5	< 0.16	10 - 20	3. Few case records available where depth of
c. Squeezing rock, plastic flow of incompetent rock				crown below surface is less than span width.
under influence of high rock pressure				Suggest *SRF* increase from 2.5 to 5 for such
N. Mild squeezing rock pressure			5 - 10	cases (see H).
O. Heavy squeezing rock pressure			10 - 20	
d. Swelling rock, chemical swelling activity depending on presence of water				
P. Mild swelling rock pressure			5 - 10	
R. Heavy swelling rock pressure			10 - 15	



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