

Supplementary Appendix 1. Rock Engineering Properties and the Measured ROP along the Tunnel

No	Tunnel Station (m)	UCS (MPa)	BTS (MPa)	BI (kN/mm)	DPW (m)	Alpha (degree)	Measured ROP (m/h)
1	269	199.7	9.3	55	0.8	25	2.19
2	280	199.3	9.3	55	1.6	21	2.12
3	302	199	9.1	55	2	20	1.88
4	473	189.7	9	56	0.2	42	2.81
5	560	189	9	56	2	40	2.2
6	929	168.3	9.8	58	1.6	41	2.37
7	989	174.1	9.9	58	2	35	2.34
8	1021	177.9	10.1	58	0.4	61	2.9
9	1027	180.7	10.1	57	0.2	55	3.04
10	1045	184.1	10.2	57	0.4	49	3.07
11	1179	192.4	10.3	54	0.4	32	3.04
12	1183	191	10.4	54	0.4	34	2.95
13	1213	191	10	53	0.1	23	2.66
14	1258	194.5	10	52	0.4	33	2.3
15	1262	195.2	10	52	0.4	30	2.17
16	1529	188.3	10.6	46	0.2	29	2.87
17	1538	188.4	10.6	45	0.2	24	2.48
18	1606	193.1	11	43	0.8	41	2.02
19	1756	182.8	10.2	39	0.8	20	1.87
20	1757	182.4	10.2	39	0.8	66	2
21	1768	182.4	10.3	39	0.4	55	2.45
22	1960	192.7	11.4	42	0.4	55	2.18
23	2011	192.6	11.4	42	0.2	59	2.17
24	2477	164.1	9.4	46	0.8	19	2.09
25	2517	160.7	9.2	46	1.6	66	2.1
26	2521	160.7	9.2	46	1.6	31	2.05
27	2559	144.8	8.9	42	0.2	67	2.6
28	2577	140	8.9	43	0.1	46	2.46
29	2643	137.2	8.8	42	1.6	70	2.2
30	2665	136.6	8.8	41	0.8	62	2.14
31	2691	135.2	9.1	41	0.4	29	2.78
32	2741	136.2	9.2	40	0.4	32	2.03
33	2772	137	9.2	39	1.6	21	2.05
34	2792	137.4	9.2	39	0.8	46	2.47
35	2772	137	9.2	39	1.6	21	2.05
36	2792	137.4	9.2	39	0.8	46	2.47
37	2872	139.3	9.2	38	2	41	1.83
38	2878	139.4	9.2	38	2	40	2.08
39	2928	141	9.1	38	1.6	10	1.87
40	2946	140.7	9.1	38	1.6	28	2.1
41	2961	139.7	9.2	37	1.6	36	2.31
42	2972	138.9	9.2	37	0.8	47	2.43
43	3005	136.5	9.3	35	1.6	14	1.79
44	3032	134.2	9.4	34	2	41	2.17
45	3061	131.4	9.6	34	2	44	2.17
46	3078	130	9.8	34	1.6	15	1.65
47	3107	128.6	9.9	32	1.6	10	1.75
48	3135	130	9.9	32	1.6	15	1.87
49	3152	131	9.9	32	0.4	2	1.78
50	3152	131	9.9	32	0.4	11	1.78
51	3152	129	10	31	0.8	39	2.39
52	3198	130	10.2	31	0.8	2	1.28
53	3271	130.1	10.3	31	0.8	26	1.85

54	3282	130.2	10.3	31	0.8	32	2.2
55	3290	138.6	10.1	31	0.4	58	2.43
56	3321	138.8	10	31	0.8	55	2.13
57	3350	138.8	10	30	0.4	8	1.71
58	3377	138.7	10	30	0.8	17	2.04
59	3396	138.6	10	30	0.2	50	2.39
60	3415	137.4	10.1	30	1.6	69	2.14
61	3440	137.2	10.2	30	0.8	67	1.88
62	3449	136.2	10.2	30	0.4	45	1.88
63	3469	135.2	10.3	30	1.6	7	1.27
64	3490	134.8	10.4	30	0.4	62	2.14
65	3515	134.1	10.4	30	1.6	76	1.77
66	3545	133.3	10.5	30	0.8	47	2.14
67	3557	133.4	10.5	30	1.6	18	1.6
68	3576	134.1	10.5	32	0.8	19	2.05
69	3580	134.3	10.5	32	0.4	30	2.44
70	3581	134.3	10.4	32	0.4	40	2.42
71	3641	134.3	10.4	33	1.6	4	1.67
72	3664	133.9	10.3	33	0.4	81	2.12
73	3673	133.8	10.1	33	0.4	60	2.17
74	3754	143.4	9.4	33	1.6	33	2.28
75	3813	145.4	9.1	34	1.6	71	2.12
76	3840	146.2	8.8	35	0.4	32	2.47
77	3858	145.9	8.6	35	0.8	61	2
78	3983	137.5	8	36	1.6	10	1.5
79	4046	140.7	7.7	36	0.1	15	2.47
80	4087	145.5	7.7	38	0.8	52	2.35
81	4209	158.6	8.7	37	0.1	36	2.07
82	4224	159	8.7	36	0.2	74	2.28
83	4239	159.3	8.8	36	0.8	35	2.16
84	4241	159.3	8.8	36	0.8	78	2.61
85	4298	160.3	9	35	0.8	26	1.91
86	4382	159.6	9.3	36	0.4	20	2.26
87	4437	153.8	9.6	35	0.8	52	1.85
88	4497	154.5	10.1	33	2	52	1.58
89	4542	157.9	10.2	33	1.6	10	1.51
90	4625	160.3	10.2	32	0.1	70	2.36
91	4707	163.2	9.9	32	0.8	21	1.82
92	4741	164.3	9.6	32	0.4	4	1.5
93	4860	166.4	9.8	30	0.4	74	2.05
94	4991	173.1	9.8	31	0.8	33	1.84
95	4999	173.1	9.8	31	0.8	11	1.38
96	5012	174.1	10	31	0.8	37	1.96
97	5026	174.5	10.1	31	0.1	4	1.85
98	5042	175.2	10.2	30	0.4	56	1.95
99	5056	176	10.3	30	2	71	1.6
100	5080	176.8	10.6	30	1.6	88	1.88
101	5080	176.8	10.6	30	1.6	77	1.88
102	5099	177	10.6	30	0.4	89	2.11
103	5120	175.9	10.6	30	2	66	1.64
104	5128	175.2	10.5	30	2	79	1.51
105	5162	173.1	10.6	30	1.6	63	2.17
106	5230	156.9	10.7	30	0.8	51	2.16
107	5298	150.7	10.8	30	1.6	81	1.98
108	5333	147.6	10.8	30	2	44	2.09
109	5378	147	10.8	29	2	86	1.77
110	5409	145.6	10.7	29	1.6	72	2
111	5421	144.8	10.7	29	2	70	1.84

112	5481	140.7	10.3	28	1.6	68	2.15
113	5551	125.5	10.3	29	2	70	1.7
114	5579	123.1	10.2	29	0.8	10	1.46
115	5591	122.3	10.2	29	0.8	57	2.23
116	5602	121.7	10.1	29	0.8	36	1.87
117	5653	121.7	9.9	30	0.8	56	1.82
118	5672	121.7	9.8	30	0.8	80	2.64
119	5717	120.7	9	29	0.8	68	1.94
120	5750	119.7	8.8	29	0.2	60	1.97
121	5799	118.3	8.7	29	0.8	71	2.01
122	5806	118.3	8.6	29	0.8	57	2.22
123	5916	119	8.1	27	1.6	22	1.68
124	6141	124.5	8.3	27	1.6	82	1.78
125	6190	125	8.3	27	1.6	83	2.21
126	6201	125.2	8.3	27	1.6	64	2.22
127	6212	125.2	8.3	27	0.2	88	2.22
128	6368	129.2	8.2	29	0.8	28	1.98
129	6381	129.2	8.2	29	0.8	69	1.84
130	6411	129	8.2	29	1.6	50	1.67
130	6447	126.9	8.4	29	2	59	1.52
132	6488	125.1	8.6	28	1.6	25	1.65
133	6530	122.9	8.8	27	0.05	66	2.36
134	6577	123.4	8.9	27	1.6	86	2.08
135	6600	123.4	8.9	27	2	57	2
136	6771	129.7	9	26	0.4	64	2.02
137	6820	134.5	9	26	0.2	73	2.01
138	6833	136.2	9	26	1.6	62	1.56
139	6897	139.3	9.2	26	2	11	1.27
140	6933	141.4	9.4	26	1.6	52	1.74
141	6944	142.1	9.4	26	0.4	49	1.87
142	6957	142.3	9.4	26	0.05	50	1.87
143	6957	142.3	9.4	26	0.05	21	1.87
144	7082	153.4	9.1	26	0.8	89	1.94
145	7082	153.4	9.1	26	2	28	1.94
146	7109	154.1	8.9	25	0.4	48	1.93
147	7182	155.9	9	25	1.6	45	1.8
148	7273	169	8.7	26	1.6	20	1.81
149	7328	170.3	8.1	27	2	26	1.77
150	7347	168.2	7.9	27	2	11	1.4
151	7521	153.4	7.6	29	0.8	21	1.51
152	7639	154.2	7	30	1.6	61	2.03
153	7654	152.8	6.7	30	1.6	60	1.6