P-04-44

Oskarshamn site investigation

Borehole: KLX02

Results of tilt testing

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March 2004

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Keywords: Rock mechanics, Joint properties, JRC_{100}, JCS_{100}, Angles of joint friction and tilt test.

Summary

Norwegian Geotechnical Institute (NGI) has carried out tilt testing on joint surfaces of drill cores from the borehole KLX02 at Simpevarp. From a total of about 1700 m of cores, 29 tilt tests have been carried out on two sets of joints.

The main results from the tilt tests are rather uniform throughout the joint surfaces and they do not show strong variations. The mean value of the joint roughness coefficient (JRC_o) obtained from tilt testing of all the joint samples is 6.8. The mean value of the joint wall compressive strength (JCS_o) from Schmidt hammer testing of all the joint samples is 66.0 MPa. The mean values of the basic (Φ_b) and residual (Φ_r) friction angles of all the tested samples are 31.4 and 25.6 degrees respectively.

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1 Introduction

Norwegian Geotechnical Institute (NGI) has carried out tilt testing on joint surfaces of drill cores from borehole KLX02 at Simpevarp in Sweden according to SKB's Aktivitetsplan AP PF 400-03-087 (SKB internal controlling document). The work has been carried out by Panayiotis Chryssanthakis and Pawel Jankowski during the period 3–9 December 2003 in accordance with SKB's method description MD 190.006 version 1.0 (SKB internal controlling document).

KLX02 is an earlier borehole and was drilled at year 1992. Revaluation of the core logging made it easy to take joints for Tilt testing. The core diameter is about 47.5 mm, which could be compared with the core diameter of about 51 mm for the new boreholes in the site investigation.

2 Objective and scope

The purpose of the testing is to determine the joint properties JRC, JCS as well as the basic and residual friction angle. The joint properties are parameters used in the rock mechanical model which will be established for the candidate area selected for site investigations at Simpevarp.

The following tests shown in Table 2-1 have been carried out:

Table 2-1. Total number of tilt tests and number of joint sets.

Borehole	Tilt tests	Number of joint sets
KLX02	29	2

The results from the tilt tests are presented in this report by means of tables, figures and spreadsheets.

3 Equipment and methods

The tilt angles (α and Φ_b) are measured by a simple tilt apparatus, see Figure 3-1.

The tilt test apparatus is a self-weight tilt testing machine used for predicting the peak shear strength of a joint. Joints that are well preserved and that are considered representative of a joint set to which they belong are usually tested. The test consists of forcing the upper half of a jointed specimen to slide under its own weight.

The tilt test table consists of a hand driven rotating apparatus attached to an aluminium frame which is able to rotate 90 degrees in both directions (see Figure 3-1). The specimen is attached on a simple workshop clamp fastened to the tilt test table. The joint area is then levelled to zero degrees before the tilt testing can start, (see Figure 3-1) The angle of tilting (α) can be read from a protractor attached to the rotating apparatus. The mass of the upper joint half and the fracture surface area are measured before tilt testing.

Figure 3-1. *NGI's tilt test apparatus.*

For measurements of JCS, r and R, a Schmidt hammer with a clamp to fasten the samples is used, see Figure 3-2.

Joint profiling is carried out by means of a profilometer, see Figure 3-3. In addition a planimeter is necessary to measure the area of the fracture face.

***Figure 3-2**. Clamp for the Schmidt hammer tests.*

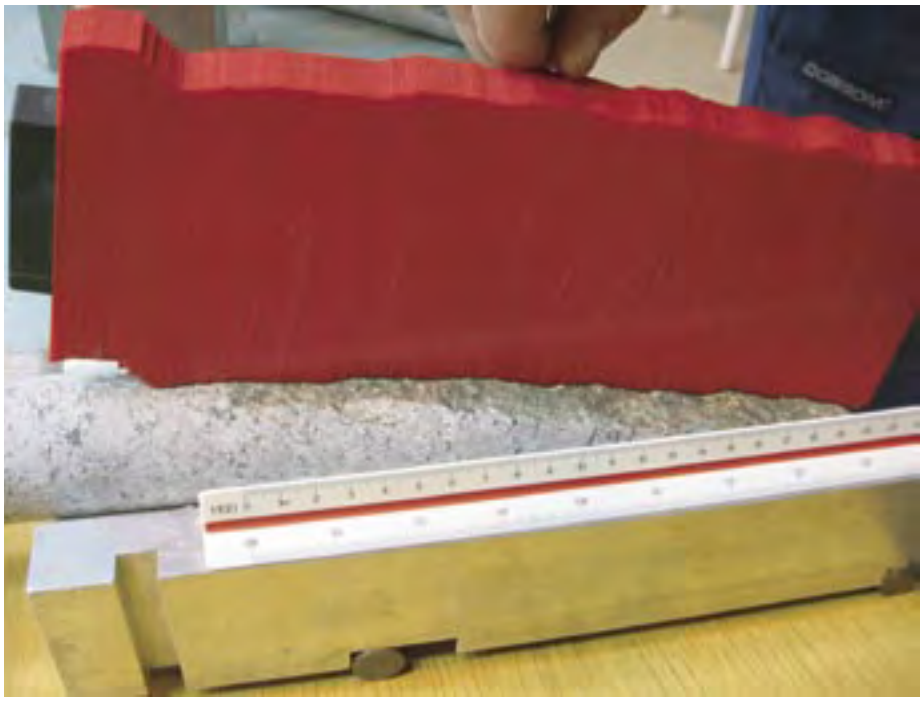

***Figure 3-3.** Profilometer applied on a joint surface.*

4 Execution

4.1 Sampling

The samples were taken from drill cores with a diameter of 47.5 mm in that way that each sample contained both faces of a joint, see Figure 4-1. To prepare the sample, sawing is usually necessary.

The frequency of the tilt test samples was determined by choosing one specimen for approximately 18 to 22 m in the depth range between 201.0 m and 994.5 m from borehole KLX02. From depth 994.5 m to 1700.5 m five samples were chosen. A total of 29 tilt samples were chosen in co-operation with SKB. The depths quoted in the tables, can be directly correlated with the SKB database SICADA for the first 994.5 m. In the range from 994.5 until 1700.5 m core box depths are quoted. During the tilt tests, the real orientation of fractures was not known, and therefore the various joints, fractures were classified according to their angle of intersection with the core in the way it is displayed in Table 4-1.

***Figure 4-1**. Sample for tilt testing in the tilt apparatus.*

Table 4-1. Joint set numbers and orientations.

Joint set number	Angle of intersection in degrees	Number of tilt tests
Set 1 (steep joints)	0–30°	14
Set 2 (ca 45 degrees joints)	30–60°	15

Because of the smaller core diameter (47.5 mm) compared to usual site investigation boreholes (about 51 mm), it was decided not to perform any tilt tests on the so-called horizontal joints, which correspond to set 3 (intersection angle 60–90°).

Three profiles on each tilt joint surface have been also carried out. The rocks can be classified as mainly metamorphic rocks which include mainly granite-monozodiorite rock of coarse to medium grained granodiorite with some areas of medium grained granite, and some veins of fine grained darker diorite. The most common minerals on the tested joint surfaces are mainly chlorite and calcite and to a lesser extent epidote and pyrite. Since geological logging of the core has been carried out by SKB, no detailed geological description has been attempted by NGI. The 24 tilt joint tests from the depth range 201.0 to 994.4 can be directly identified within the database Sicada at SKB. Five tilt tests in the depth range 994.5 to 1700.5 can only be identified by their core box depths. At the time of sampling the core had been exposed to the atmosphere at room temperature for an extended period and may be presumed to be air-dried, though no measurements of the moisture content were made.

4.2 Testing

The tilt test consists of tilting, Schmidt hammer measurements and profiling of the joint faces.

The measuring of the tilt angle α is performed on wet (humid) joint surfaces. The sample is then fixed to the tilt apparatus and tilted. At least three tilts are carried out on each sample, the tilt angle should not vary more than 3° in these tests. However, in some cases the characteristics of the sample changes during the testing, for example fracture coating may be removed, and therefore variation of more than 3° may be accepted.

The same procedure is used for determining Φ_b which is the tilt angle core to core, but here the cores shall be dry.

The Schmidt hammer measurements for JCS were performed on wet (humid) joint surfaces (r value) with 10 blows on each test sample. The lower five blow values were then eliminated.

For measuring of R-value Schmidt hammer readings on fresh, dry cores near the joint for tilting were performed with 10 blows. The lower five blow values were again eliminated.

The weight of the tilting block and the rock density are measured, and the fracture surface area is measured with a planimeter as seen in Figure 4-2.

Profiling of the tilt tested fractures is carried out by means of a profilometer, and the profiles are drawn on a paper by pulling a pencil along the edge of the profilometer. For each fracture three parallel profiles are drawn; one along the centre of the sample and, one to the

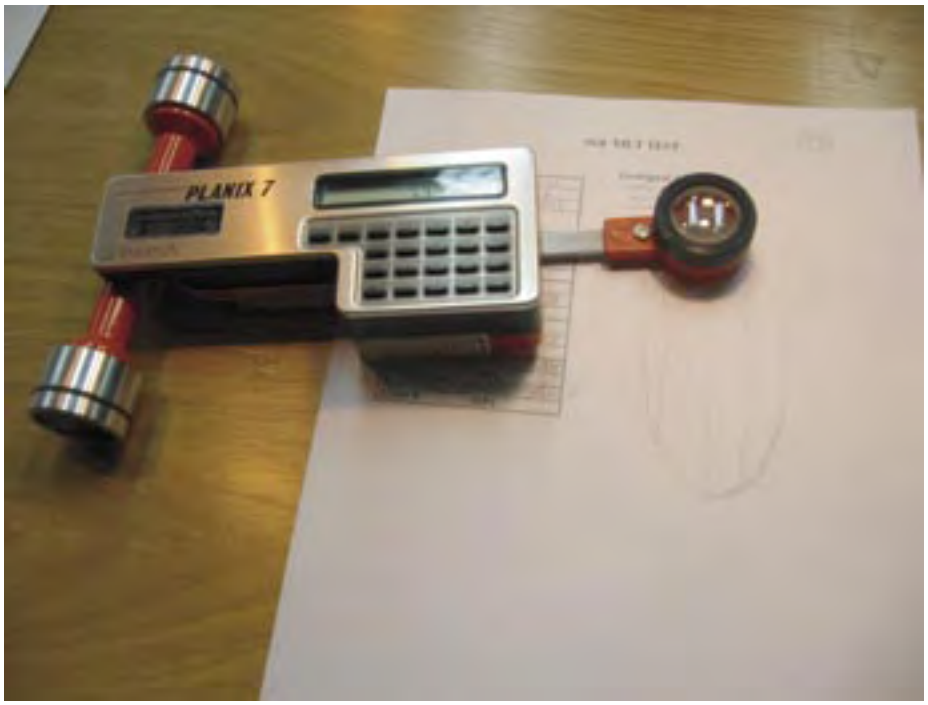

***Figure 4-2**. Planimeter for measuring the fracture surface area.*

left and one to the right of the centre line. From the profile the roughness amplitude (a) and the profile length (L) are measured.

Several density measurements of the rock were carried out during tilt testing. The samples were take directly from the racks in the core shed and consequently the measurements were done on air-dried samples. The unit weight specimens are chosen at approximately 100 m intervals. The specimens are cut as perfect cylinders from which the volumes are calculated. The balance used for weighing the specimens has an accuracy of 0.01g. The calliper used for measuring the size (height and diameter) of the specimens has an accuracy of 0.01 mm.

The results were in the range of 26.76–28.20 kN/m^3 or 2.67–2.82 g/cm^3. In the calculations the densities as listed in Table 4-2 have been used:

Table 4-2. Depth ranges in borehole KLX02 with the relevant unit weight used.

Interval in the borehole m	m	Unit Weight kN/m3
200.00	300.55	26.87
300.55	403.65	26.93
403.65	496.40	26.82
496.40	595.25	27.77
595.25	701.50	26.99
701.50	806.40	26.76
806.40	912.35	27.20
912.35	994.46	26.86
1500.00	1585.75	28.20
1585.75	1685.00	27.50

5 Results

5.1 General

The results from the different measurements are put into an Excel spreadsheet (Input data). Excel then calculates the different parameters which are shown in another sheet (Output data).

Tables showing all the input and output data are shown in Appendix A. Separate tables are presented for each of the two joint sets. A table showing the two joint sets is also presented in the Appendix A.

Complete input and output data from the tilt tests such as JRC, JCS, Schmidt hammer readings, and roughness amplitudes are shown in the tables in Appendix A.

The results are also reported to SICADA (FN 234).

The 29 tilt test specimens have been chosen from the total of 1700.5 m of core material from borehole KLX02 in the depth range between 200.9 m and 1700.5 m. As mentioned earlier, the fractures have been classified in two sets according to the angle of intersection with the core. Each set may, however, consist of fractures with different dip, dip directions and different mineralization.

5.2 Results from borehole KLX02

In the depth range 200.9 to 994.5 m from borehole KLX02, 24 tilt tests and 24x3 profilings on joints have been performed. In the depth range 994.5 to 1700.5 m five tilt tests and 5x3 profiles were performed. Complete input data and output data from tilt tests and profiling are found in Appendix A. Figures 5-1 and 5-2 show the variation of the parameters JCS_o, JRC_o, Φ_r and Φ_b with depth for each of the two joint sets respectively. Table 5-1 shows the arithmetic mean values of these parameters. A summary of the tilt tests and profiling is also given in Table 5-1.

Table 5-1. Arithmetic mean JCS_o, JRC_o, Φ_r and Φ_b -values, Borehole KLX02.

Fracture set	JRCo (tilt)	JCSo MPa	Φb (o)	Φr (o)	Number (tilt)	Number (profiles)
Set 1	6.79	68.19	30.9	25.29	14	14
Set 2	6.73	63.98	31.8	25.85	15	15
Mean/Total	6.76	66.01	31.4	25.58	29	29

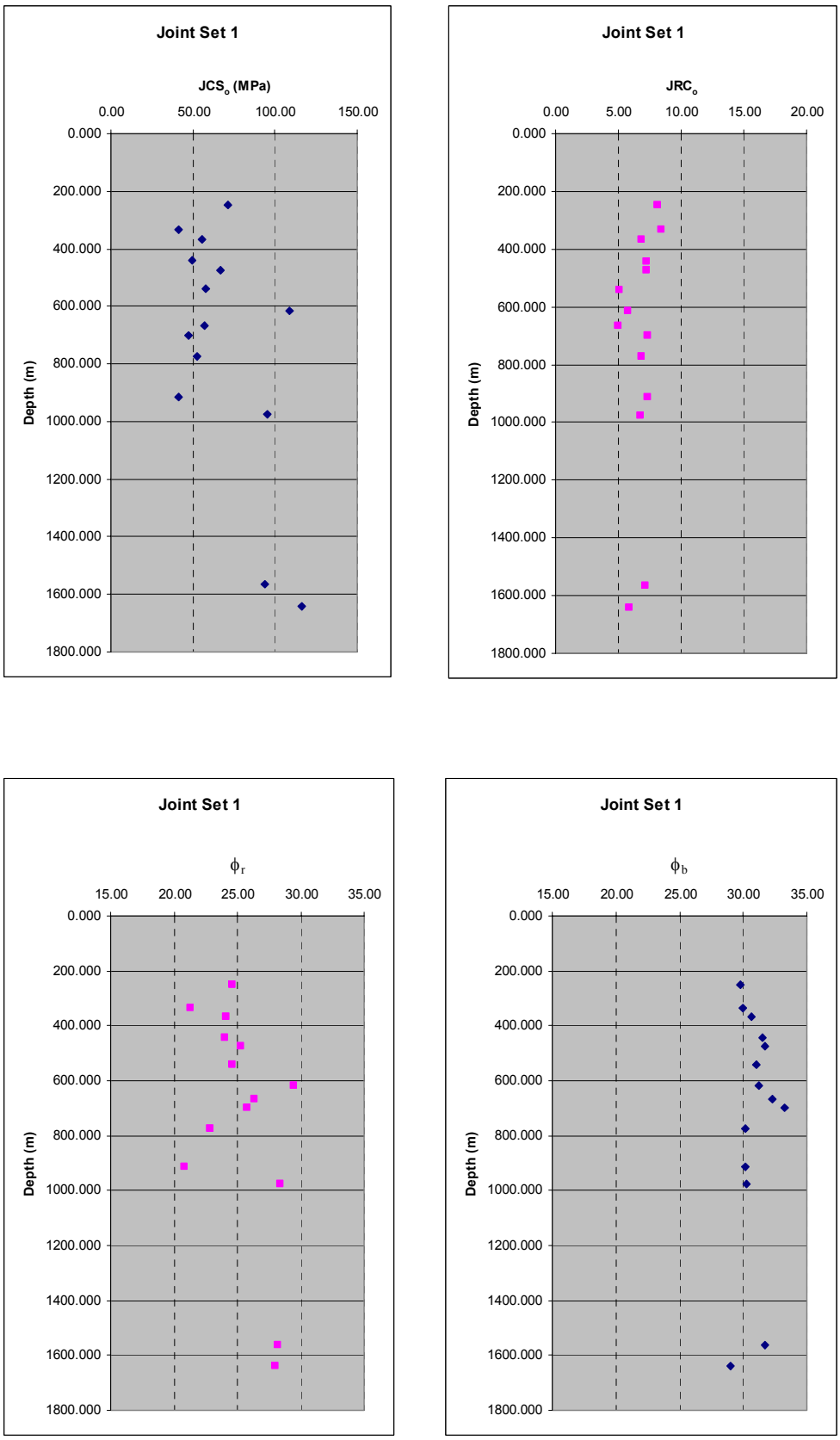

Figure 5-1. *Variation of joint parameters with depth for Set 1.*

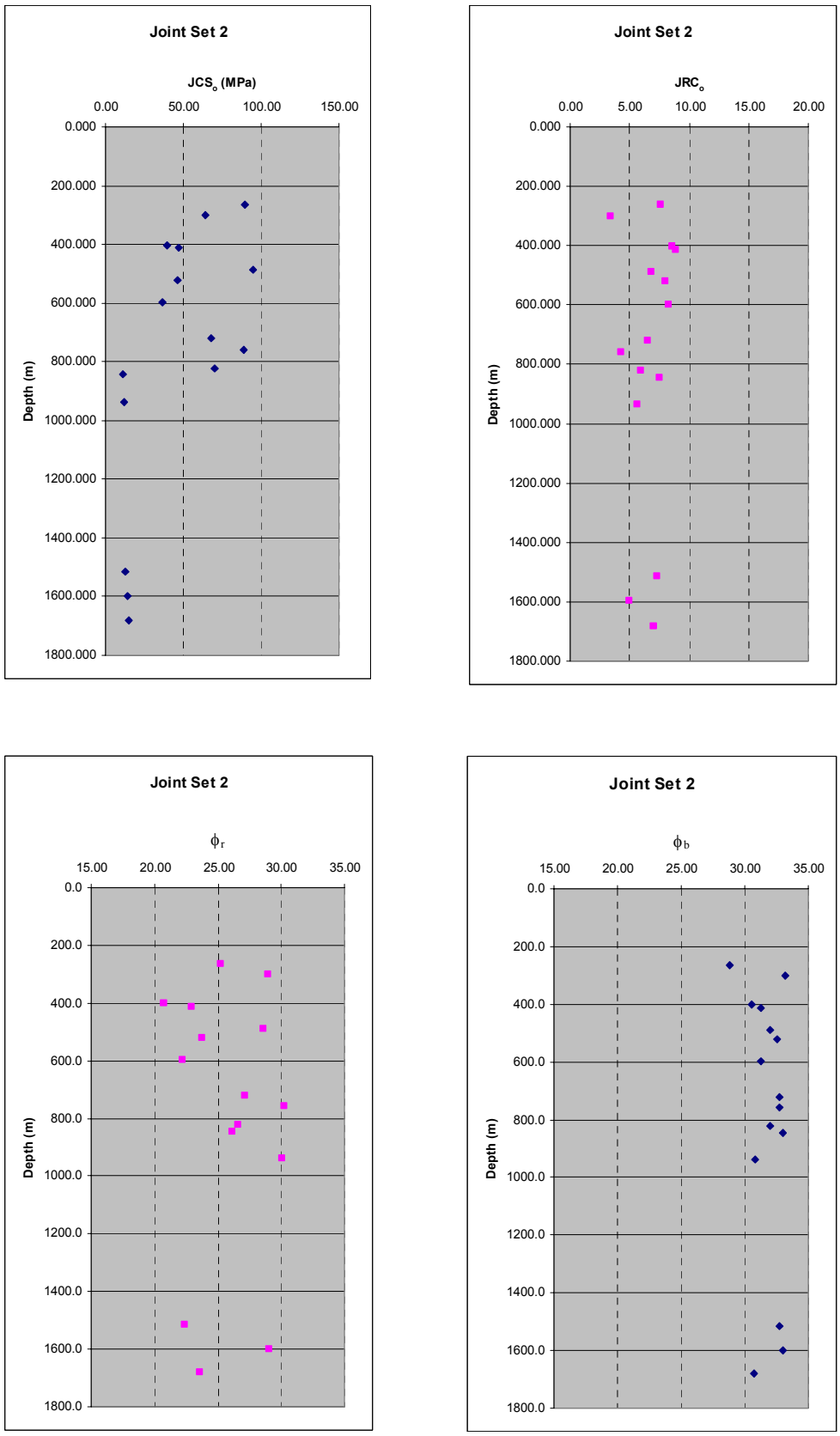

Figure 5-2. *Variation of joint parameters with depth for Set 2.*

5.3 Discussion

The joint faces are rather similar concerning mineralisation, and the tilt tests show rather uniform JRC and JCS values. Because of the small core diameter the results are associated with some uncertainty since the standard length for such tests is 100 mm i.e. L_{100}. Tilting of samples with relatively high JRC-values is sometimes impossible because toppling takes place before sliding. However, the selection of the tilt test samples did not take into account the possible toppling before the sliding. In case of toppling only profiling would have been carried out, but it did not proved to be necessary. All profiling is therefore taken in order to compare them with the tilt test results. If joints are too rough to reach shear failure by tilting "pull test" should be performed using a calibrated equipment attached to the tilt table. The pull test is performed on a horizontally-placed joint sample.

In general, the joint roughness on the two joint sets varied between 3.5 and 8.9. This means that the sample selection for tilt testing is representative for the borehole KLX02.

Appendix A

The main results from tilt testing

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

	PAGE 1
	Operator: PC
	Date: 15.12.2003
	Borehole: KLX02

INPUT DATA Depth zone: 0 - 1700,6 m

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT AMP. a (mm)	MEAN JOINT LENG. L (mm)	MASS m (g)	AREA A (cm^2)	MEAN TILT ANGLE (°)	JOINT REBOUND NUMBER (r)	ROCK REBOUND NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m^3)
1	set 1	249,522	Sicada	3,6	193,0	427,00	92,1	77,8	35,6	48,0	29,8	26,87
2	set 2	263,288	Sicada	2,3	59,7	141,30	25,1	72,7	39,9	48,6	28,8	26,87
3	set 1	334,677	Sicada	4,8	191,3	465,20	85,5	70,8	25,6	45,2	30,0	26,93
4	set 2	300,767	Sicada	1,8	58,3	154,00	24,4	47,5	33,7	42,6	33,2	26,93
5	set 1	366,251	Sicada	4,6	180,7	239,70	73,1	65,0	31,0	46,2	30,7	26,93
6	set 2	402,149	Sicada	1,3	69,3	172,10	29,6	70,3	24,9	48,4	30,5	26,93
7	set 1	441,827	Sicada	2,2	111,0	116,80	47,5	69,0	29,0	46,2	31,5	26,82
8	set 2	413,051	Sicada	2,4	73,3	190,30	34,1	83,0	28,2	48,4	31,3	26,82
9	set 1	472,459	Sicada	2,9	134,3	250,00	61,2	69,7	34,6	51,0	31,7	26,82
10	set 2	487,360	Sicada	2,4	69,0	192,30	32,0	70,7	40,9	49,2	32,0	26,82
11	set 1	540,299	Sicada	3,8	129,7	308,80	59,5	52,7	30,8	45,2	31,0	27,77
12	set 2	521,867	Sicada	4,5	89,0	246,00	37,7	70,3	26,9	47,8	32,5	27,77
13	set 1	615,721	Sicada	2,2	94,3	223,10	43,8	64,3	43,2	47,2	31,2	26,99
14	set 2	598,027	Sicada	3,2	51,3	145,10	21,2	69,2	23,4	42,8	31,3	26,99
15	set 1	665,899	Sicada	2,3	83,0	223,10	36,7	53,3	31,4	44,6	32,3	26,99
16	set 2	720,568	Sicada	0,9	49,3	140,50	22,7	65,3	34,9	48,4	32,7	26,76
17	set 1	700,213	Sicada	3,5	97,7	243,10	43,3	68,7	28,0	45,0	33,3	26,99
18	set 2	758,455	Sicada	2,5	63,0	164,80	27,6	54,7	39,9	45,4	32,7	26,76
19	set 1	772,803	Sicada	3,1	117,3	321,30	50,8	61,3	30,2	47,6	30,2	26,76
20	set 2	821,526	Sicada	1,7	52,3	146,30	22,5	60,2	34,9	47,8	32,0	27,20
21	set 1	914,279	Sicada	2,4	80,3	247,10	34,9	60,2	25,6	48,0	30,2	26,86
22	set 2	844,533	Sicada	2,4	69,0	214,60	29,7	70,0	30,4	46,2	33,0	27,20
23	set 1	975,460	Sicada	2,3	185,0	236,20	79,5	72,5	41,0	45,4	30,3	26,86
24	set 2	936,590	Sicada	1,7	46,0	133,80	20,8	63,7	42,7	44,4	30,8	26,86
25	set 2	1515,420	Core box	2,2	55,0	126,40	23,3	62,7	22,3	45,8	32,7	28,20
26	set 1	1563,400	Core box	2,3	125,0	275,00	54,3	73,7	38,8	47,0	31,7	28,20
27	set 2	1598,000	Core box	1,3	53,0	133,20	22,6	56,7	31,6	39,4	33,0	28,20
28	set 1	1641,000	Core box	2,8	86,0	249,40	38,4	63,0	43,6	45,8	29,0	27,50
29	set 2	1681,500	Core box	1,9	53,0	146,00	23,7	63,3	30,6	47,4	30,7	27,50
			Arithmetic av.	2,6	93,8	216,3	41,3	65,6	32,9	46,4	31,4	27,1
			minimum val.	0,9	46,0	116,8	20,8	47,5	22,3	39,4	28,8	26,8
			maximum val.	4,8	191,3	465,2	85,5	83,0	43,6	51,0	33,3	28,2

ROCK JOINT CHARACTERISATION

PAGE 3

CLIENT: SKB- Tilt tests

Operator: PC

Date: 15.12.2003

OUTPUT DATA

Depth zone: 0 - 1700,6 m

Borehole: KLX02

F:\P\2003\10\20031089\Reports\Rap KLX02\[alljoints.xls]OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS_0 (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC_0 AT JOINT LENGTH TESTED	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL`D JRC_{100}- VALUES 100 mm	EXTRPL`D JCS_{100}- VALUES 100 mm (MPa)
1	set 1	249.522	71.09	2.03E-05	24.6	8.12	0.52	9.04	83.44
2	set 2	263.288	89.84	4.88E-05	25.2	7.58	1.68	7.01	79.90
3	set 1	334.677	41.37	5.77E-05	21.3	8.45	0.52	9.43	48.76
4	set 2	300.767	64.19	2.82E-04	29.0	3.45	1.72	3.33	60.70
5	set 1	366.251	55.55	5.74E-05	24.1	6.83	0.55	7.40	62.70
6	set 2	402.149	39.71	6.49E-05	20.8	8.56	1.44	8.04	36.14
7	set 1	441.827	49.48	3.10E-05	24.1	7.25	0.90	7.36	50.62
8	set 2	413.051	47.38	8.13E-06	23.0	8.88	1.36	8.40	43.62
9	set 1	472.459	67.08	4.83E-05	25.3	7.23	0.74	7.55	71.52
10	set 2	487.360	94.47	6.45E-05	28.6	6.82	1.45	6.49	87.56
11	set 1	540.299	57.90	1.87E-04	24.6	5.11	0.77	5.25	60.26
12	set 2	521.867	46.49	7.27E-05	23.8	8.02	1.12	7.87	45.21
13	set 1	615.721	108.66	9.39E-05	29.5	5.74	1.06	5.70	107.56
14	set 2	598.027	36.69	8.46E-05	22.2	8.34	1.95	7.46	31.05
15	set 1	665.899	56.99	2.13E-04	26.4	4.96	1.20	4.87	55.43
16	set 2	720.568	67.71	1.06E-04	27.1	6.58	2.03	6.00	58.89
17	set 1	700.213	47.32	7.26E-05	25.7	7.39	1.02	7.36	47.08
18	set 2	758.455	89.04	1.96E-04	30.3	4.32	1.59	4.15	83.87
19	set 1	772.803	52.62	1.43E-04	22.9	6.90	0.85	7.06	54.39
20	set 2	821.526	69.85	1.57E-04	26.6	5.95	1.91	5.51	62.21
21	set 1	914.279	41.22	1.71E-04	20.9	7.31	1.25	7.08	39.28
22	set 2	844.533	54.66	8.29E-05	26.2	7.53	1.45	7.12	50.26
23	set 1	975.460	95.30	2.64E-05	28.4	6.73	0.54	7.31	107.91
24	set 2	936.590	104.54	1.24E-04	30.0	5.68	2.17	5.20	91.58
25	set 2	1515.420	36.59	1.12E-04	22.4	7.30	1.82	6.69	32.10
26	set 1	1563.400	93.94	3.91E-05	28.2	7.13	0.80	7.36	98.53
27	set 2	1598.000	62.26	1.74E-04	29.0	4.98	1.89	4.68	56.62
28	set 1	1641.000	116.18	1.31E-04	28.0	5.88	1.16	5.78	113.13
29	set 2	1681.500	56.30	1.22E-04	23.6	7.01	1.89	6.41	49.27
		Arithmetic av.	66.01	1.03E-04	25.58	6.76	1.29	6.65	64.47
		maximum val.	116.18	2.82E-04	30.28	8.88	2.17	9.43	113.13
		minimum val.	36.59	8.13E-06	20.77	3.45	0.52	3.33	31.05

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	15.12.2003
Borehole:	KLX02

INPUT DATA

Depth zone: 0 - 1700,6 m

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT AMP. a (mm)	MEAN JOINT LENG. L (mm)	MASS m (g)	AREA A (cm^2)	MEAN TILT ANGLE (°)	JOINT REBOUND NUMBER (r)	ROCK REBOUND NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m^3)
1	set 1	249,522	Sicada	3,6	193,0	427,00	92,1	77,8	35,6	48,0	29,8	26,87
2	set 1	334,677	Sicada	4,8	191,3	465,20	85,5	70,8	25,6	45,2	30,0	26,93
3	set 1	366,251	Sicada	4,6	180,7	239,70	73,1	65,0	31,0	46,2	30,7	26,93
4	set 1	441,827	Sicada	2,2	111,0	116,80	47,5	69,0	29,0	46,2	31,5	26,82
5	set 1	472,459	Sicada	2,9	134,3	250,00	61,2	69,7	34,6	51,0	31,7	26,82
6	set 1	540,299	Sicada	3,8	129,7	308,80	59,5	52,7	30,8	45,2	31,0	27,77
7	set 1	615,721	Sicada	2,2	94,3	223,10	43,8	64,3	43,2	47,2	31,2	26,99
8	set 1	665,899	Sicada	2,3	83,0	223,10	36,7	53,3	31,4	44,6	32,3	26,99
9	set 1	700,213	Sicada	3,5	97,7	243,10	43,3	68,7	28,0	45,0	33,3	26,99
10	set 1	772,803	Sicada	3,1	117,3	321,30	50,8	61,3	30,2	47,6	30,2	26,76
11	set 1	914,279	Sicada	2,4	80,3	247,10	34,9	60,2	25,6	48,0	30,2	26,86
12	set 1	975,460	Sicada	2,3	185,0	236,20	79,5	72,5	41,0	45,4	30,3	26,86
13	set 1	1563,400	Core box	2,3	125,0	275,00	54,3	73,7	38,8	47,0	31,7	28,20
14	set 1	1641,000	Core box	2,8	86,0	249,40	38,4	63,0	43,6	45,8	29,0	27,50
			Arithmetic av.	3,1	129,2	273,3	57,2	65,9	33,5	46,6	30,9	27,1
			minimum val.	2,2	80,3	116,8	34,9	52,7	25,6	44,6	29,0	26,8
			maximum val.	4,8	191,3	465,2	85,5	73,7	43,6	51,0	33,3	28,2

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 3	
Operator:	PC
Date:	15.12.2003
Borehole:	KLX02

OUTPUT DATA

Depth zone: 0 - 1700,6 m

F:\P\2003\10\20031089\Reports\Rap KLX02\[set1.xls]OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS_0 (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC_0 AT JOINT LENGTH TESTED	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL`D JRC_{100}- VALUES 100 mm	EXTRPL`D JCS_{100}- VALUES 100 mm (MPa)
1	set 1	249.522	71.09	2.03E-05	24.6	8.12	0.52	9.04	83.44
2	set 1	334.677	41.37	5.77E-05	21.3	8.45	0.52	9.43	48.76
3	set 1	366.251	55.55	5.74E-05	24.1	6.83	0.55	7.40	62.70
4	set 1	441.827	49.48	3.10E-05	24.1	7.25	0.90	7.36	50.62
5	set 1	472.459	67.08	4.83E-05	25.3	7.23	0.74	7.55	71.52
6	set 1	540.299	57.90	1.87E-04	24.6	5.11	0.77	5.25	60.26
7	set 1	615.721	108.66	9.39E-05	29.5	5.74	1.06	5.70	107.56
8	set 1	665.899	56.99	2.13E-04	26.4	4.96	1.20	4.87	55.43
9	set 1	700.213	47.32	7.26E-05	25.7	7.39	1.02	7.36	47.08
10	set 1	772.803	52.62	1.43E-04	22.9	6.90	0.85	7.06	54.39
11	set 1	914.279	41.22	1.71E-04	20.9	7.31	1.25	7.08	39.28
12	set 1	975.460	95.30	2.64E-05	28.4	6.73	0.54	7.31	107.91
13	set 1	1563.400	93.94	3.91E-05	28.2	7.13	0.80	7.36	98.53
14	set 1	1641.000	116.18	1.31E-04	28.0	5.88	1.16	5.78	113.13
		Arithmetic av.	68.19	9.23E-05	25.29	6.79	0.85	7.04	71.47
		maximum val.	116.18	2.13E-04	29.51	8.45	1.25	9.43	113.13
		minimum val.	41.22	2.03E-05	20.87	4.96	0.52	4.87	39.28

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

	PAGE 1	
	Operator:	PC
	Date:	15.12.2003
	Borehole:	KLX02

INPUT DATA

Depth zone: 0 - 1700,6 m

F:\P\2003\10\20031089\Reports\Rap KLX02\[set2.xls]INPUT DATA 1

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT AMP. a (mm)	MEAN JOINT LENG. L (mm)	MASS m (g)	AREA A (cm^2)	MEAN TILT ANGLE (°)	JOINT REBOUND NUMBER (r)	ROCK REBOUND NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m^3)
1	set 2	263.288	Sicada	2.3	59.7	141.30	25.1	72.7	39.9	48.6	28.8	26.87
2	set 2	300.767	Sicada	1.8	58.3	154.00	24.4	47.5	33.7	42.6	33.2	26.93
3	set 2	402.149	Sicada	1.3	69.3	172.10	29.6	70.3	24.9	48.4	30.5	26.93
4	set 2	413.051	Sicada	2.4	73.3	190.30	34.1	83.0	28.2	48.4	31.3	26.82
5	set 2	487.360	Sicada	2.4	69.0	192.30	32.0	70.7	40.9	49.2	32.0	26.82
6	set 2	521.867	Sicada	4.5	89.0	246.00	37.7	70.3	26.9	47.8	32.5	27.77
7	set 2	598.027	Sicada	3.2	51.3	145.10	21.2	69.2	23.4	42.8	31.3	26.99
8	set 2	720.568	Sicada	0.9	49.3	140.50	22.7	65.3	34.9	48.4	32.7	26.76
9	set 2	758.455	Sicada	2.5	63.0	164.80	27.6	54.7	39.9	45.4	32.7	26.76
10	set 2	821.526	Sicada	1.7	52.3	146.30	22.5	60.2	34.9	47.8	32.0	27.20
11	set 2	844.533	Sicada	2.4	69.0	214.60	29.7	70.0	30.4	46.2	33.0	27.20
12	set 2	936.590	Sicada	1.7	46.0	133.80	20.8	63.7	42.7	44.4	30.8	26.86
13	set 2	1515.420	Core box	2.2	55.0	126.40	23.3	62.7	22.3	45.8	32.7	28.20
14	set 2	1598.000	Core box	1.3	53.0	133.20	22.6	56.7	31.6	39.4	33.0	28.20
15	set 2	1681.500	Core box	1.9	53.0	146.00	23.7	63.3	30.6	47.4	30.7	27.50
			Arithmetic av.	2.2	60.7	163.1	26.5	65.4	32.3	46.2	31.8	27.2
			minimum val.	0.9	46.0	126.4	20.8	47.5	22.3	39.4	28.8	26.8
			maximum val.	4.5	89.0	246.0	37.7	83.0	42.7	49.2	33.2	28.2

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

	PAGE 3	
	Operator:	PC
	Date:	15.12.2003
	Borehole:	KLX02

OUTPUT DATA

Depth zone: 0 - 1700,6 m

F:\P\2003\10\20031089\Reports\Rap KLX02\[set2.xls]OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS_0 (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC_0 AT JOINT LENGTH TESTED	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL`D JRC_{100}- VALUES 100 mm	EXTRPL`D JCS_{100}- VALUES 100 mm (MPa)
1	set 2	263.288	89.84	4.88E-05	25.2	7.58	1.68	7.01	79.90
2	set 2	300.767	64.19	2.82E-04	29.0	3.45	1.72	3.33	60.70
3	set 2	402.149	39.71	6.49E-05	20.8	8.56	1.44	8.04	36.14
4	set 2	413.051	47.38	8.13E-06	23.0	8.88	1.36	8.40	43.62
5	set 2	487.360	94.47	6.45E-05	28.6	6.82	1.45	6.49	87.56
6	set 2	521.867	46.49	7.27E-05	23.8	8.02	1.12	7.87	45.21
7	set 2	598.027	36.69	8.46E-05	22.2	8.34	1.95	7.46	31.05
8	set 2	720.568	67.71	1.06E-04	27.1	6.58	2.03	6.00	58.89
9	set 2	758.455	89.04	1.96E-04	30.3	4.32	1.59	4.15	83.87
10	set 2	821.526	69.85	1.57E-04	26.6	5.95	1.91	5.51	62.21
11	set 2	844.533	54.66	8.29E-05	26.2	7.53	1.45	7.12	50.26
12	set 2	936.590	104.54	1.24E-04	30.0	5.68	2.17	5.20	91.58
13	set 2	1515.420	36.59	1.12E-04	22.4	7.30	1.82	6.69	32.10
14	set 2	1598.000	62.26	1.74E-04	29.0	4.98	1.89	4.68	56.62
15	set 2	1681.500	56.30	1.22E-04	23.6	7.01	1.89	6.41	49.27
		Arithmetic av.	63.98	1.13E-04	25.85	6.73	1.70	6.29	57.93
		maximum val.	104.54	2.82E-04	30.28	8.88	2.17	8.40	91.58
		minimum val.	36.59	8.13E-06	20.77	3.45	1.12	3.33	31.05