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Oskarshamn site investigation

Borehole KLX03A

Tilt testing

Panayiotis Chryssanthakis
Norwegian Geotechnical Institute

February 2005

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Keywords: Rock mechanics, Joint properties, JRC100, JCS100, Angles of joint friction and tilt test.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author and do not necessarily coincide with those of the client.

A pdf version of this document can be downloaded from www.skb.se

Summary

The Norwegian Geotechnical Institute (NGI) has carried out tilt testing on joint surfaces of drill cores from borehole KLX03A in Simpevarp, in November 2004. From a total drill core length of about 900 m, 18 tilt tests were performed on three 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 6.3. The mean value of the joint wall compressive strength (JCS_o) from Schmidt hammer testing of all the joint samples is 70.7 MPa. The mean values of the basic friction angle (Φ_b), and the residual friction angle (Φ_r), of all the tested samples are 32.2 and 27.1 degrees respectively.

Sammanfattning

Norges Geotekniska Institut (NGI) har gjort s k tilttester på öppna sprickor i borrhäror från borrhål KLX03A i Simpevarp. Utifrån en sammanlagd borrhörnelängd på ca 900 m utvaldes 18 prover för tilttester på tre sprickgrupper.

Resultaten är relativt enhetliga för samtliga sprickor och uppvisar inga stora variationer. Medelvärdet för råhetskoefficienten, JRC_0 , för alla sprickor är 6,3. För sprickväggens tryckhållfasthet, JCS_0 , som uppmättes med Schmidthammarmprovning, uppgår medelvärdet till 70,7 MPa. Medelvärdet för basfriktionsvinkeln, Φ_b , och residualfriktionsvinkeln Φ_r , beräknat utifrån alla testade prover, är 32,2 respektive 27,1 grader.

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1 Introduction

The Norwegian Geotechnical Institute (NGI) has carried out 18 tilt testing on joint surfaces of drill cores from borehole KLX03A at Simpevarp, see Figure 1-1, in Sweden according to SKB Activity Plan AP PS 400-04-107, Version 1.0 (SKB internal controlling document). The work has been carried out by Panayiotis Chryssanthakis and Pawel Jankowski in November 2004, in accordance with SKB's method description MD 190.006, Version 1.0 (SKB internal controlling document).

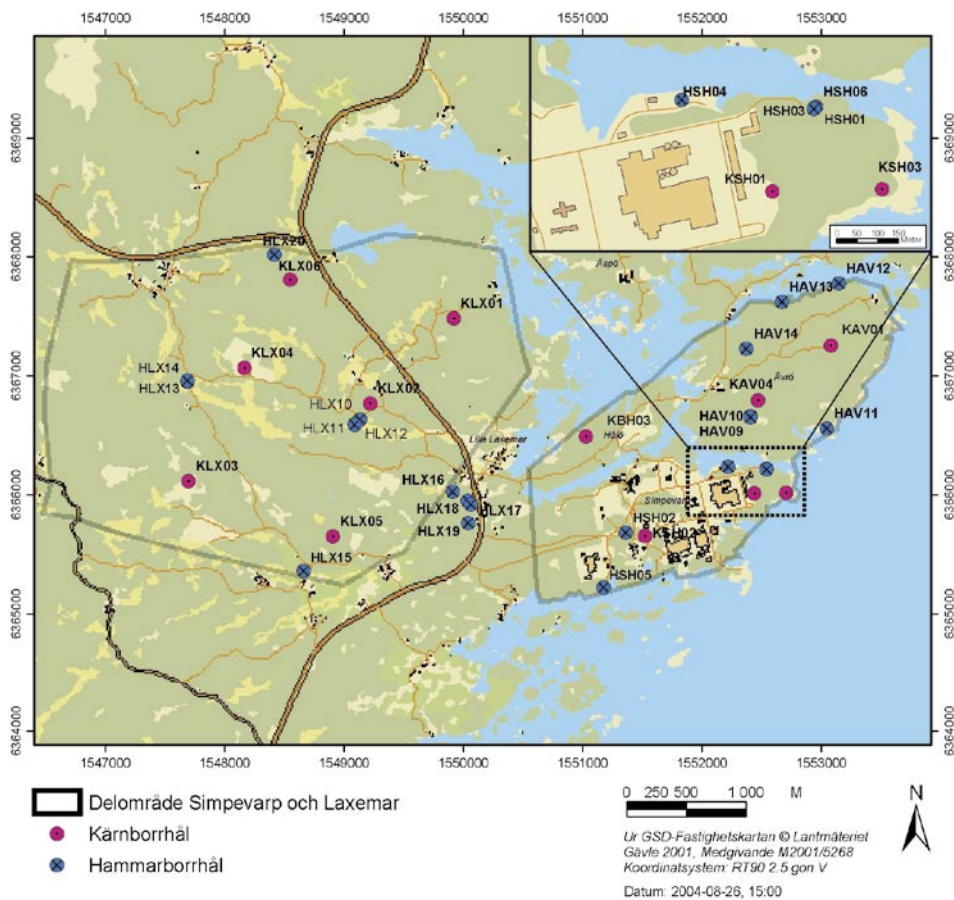


Figure 1-1. Location of drill hole KLX03A at the Oskarshamn site.

2 Objective and scope

The purpose of the testing is to determine the joint properties JRC and JCS as well as the basic and residual friction angles. 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 number of tests performed and the number of joint sets are given in Table 2-1.

Table 2-1. Total number of tilt tests.

Borehole	Tilt tests	No of joint sets
KLX03A	18	3

The results from the tilt tests are presented in this report by means of tables, figures and spreadsheets. The results are also reported to SICADA (field note no Simpevarp 567).

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. Usually such joints, that are well preserved and considered representative of a joint set to which they belong, are selected for testing. 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 to a simple workshop clamp fastened upon 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.

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

The 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.

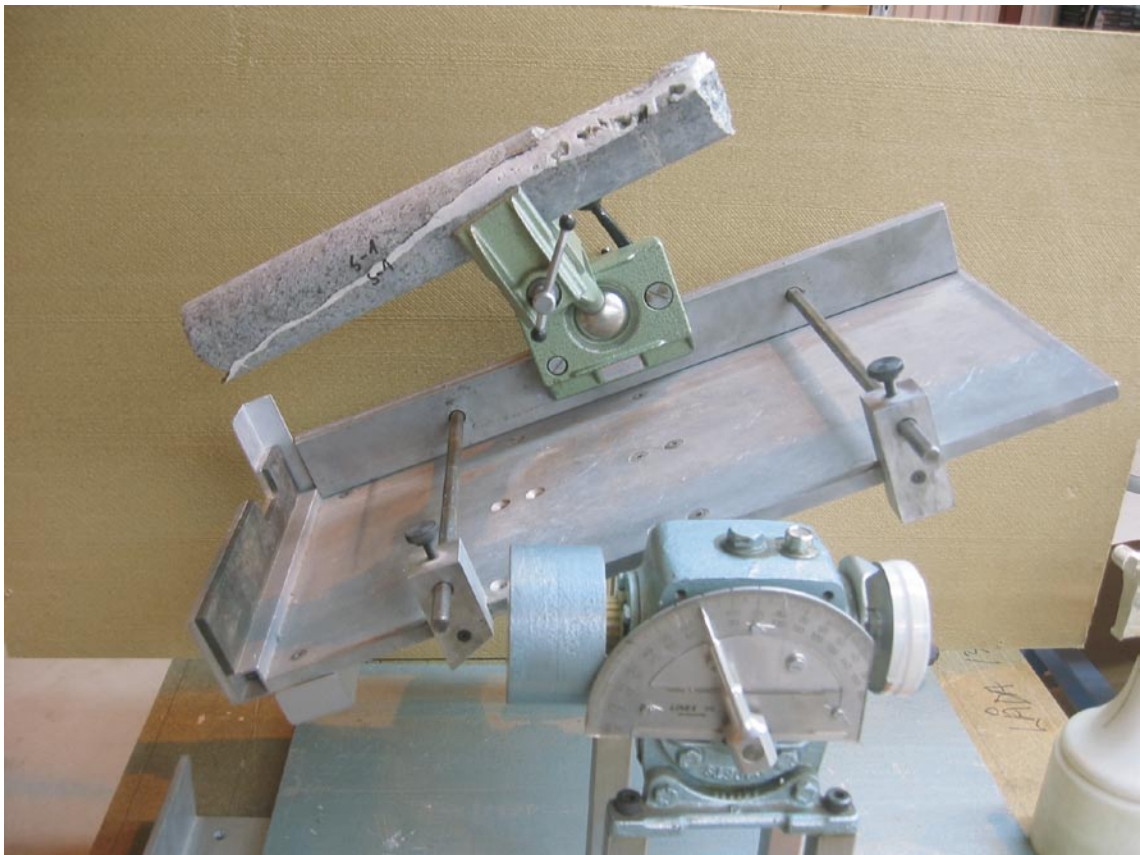


Figure 3-1. NGI's Tilt test apparatus.

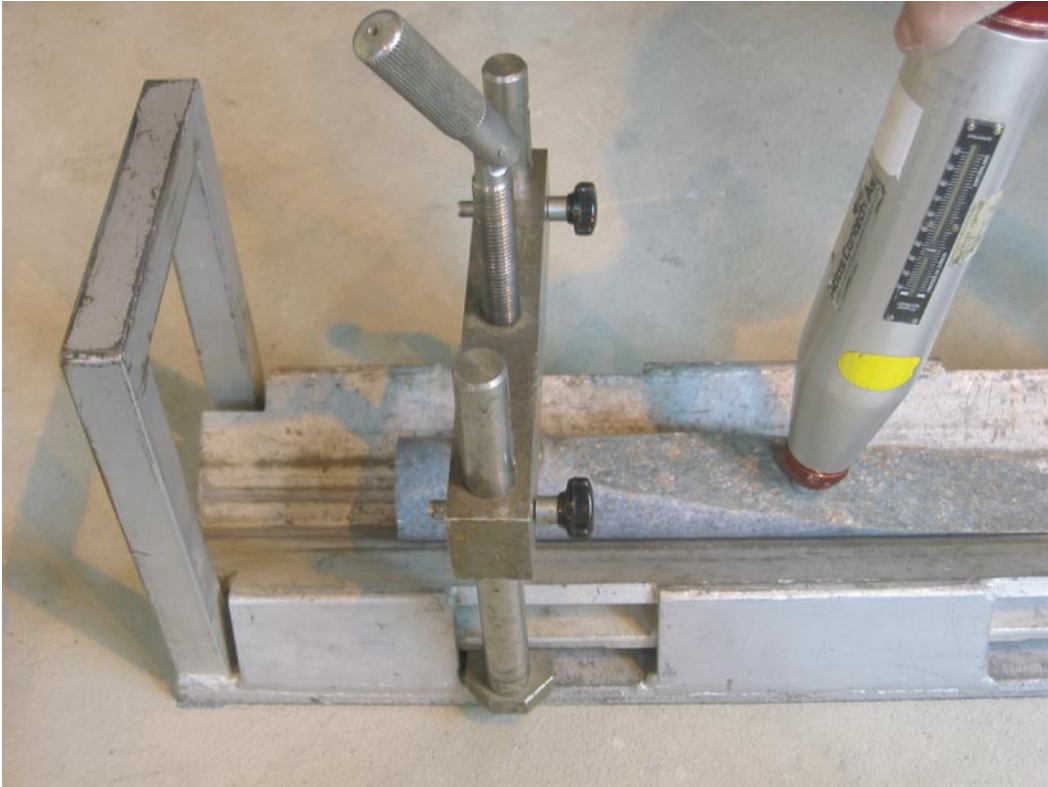


Figure 3-2. Clamp for the Schmidt hammer tests.

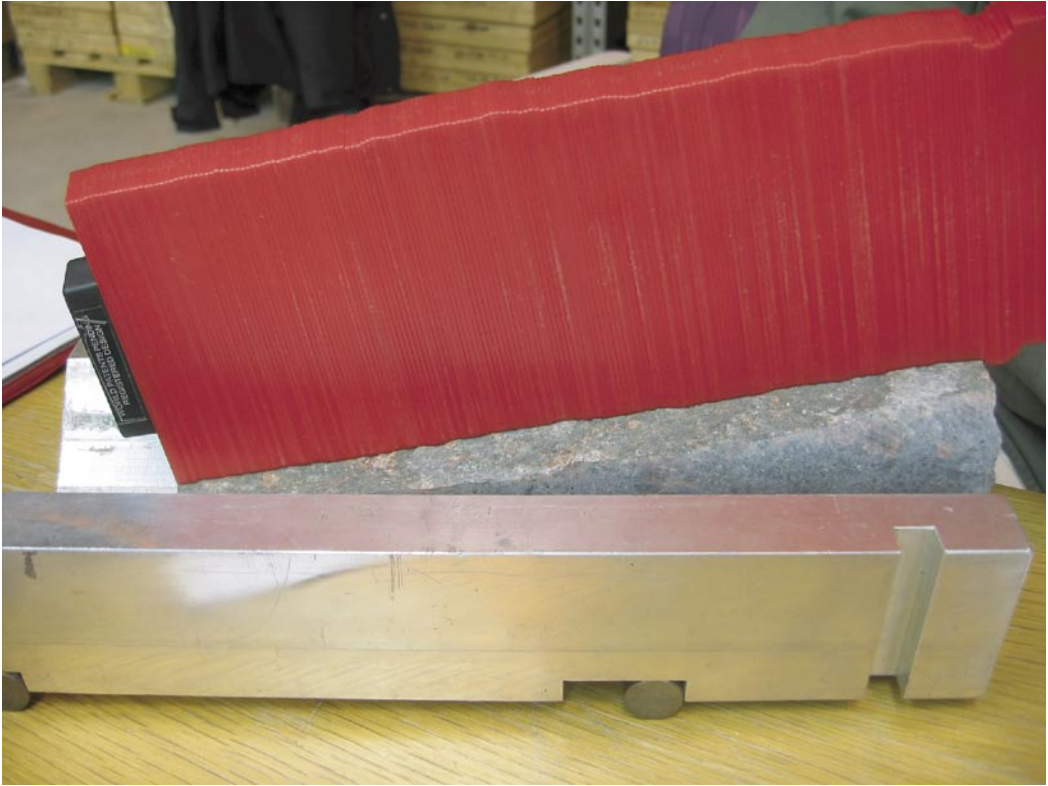


Figure 3-3. Profilometer applied on a joint surface.

4 Execution

4.1 The sampling

The samples were taken from drill cores with a diameter of approximately 50 mm in such a way that each sample contained both faces of a joint, see Figure 4-1. To prepare the sample, sawing was usually necessary.

The frequency of the tilt test samples were determined by choosing one specimen for approximately 18 to 22 m in the depth range between 240 m and 700 m. A total of 18 tilt samples were chosen in co-operation with SKB. The depths quoted in the tables can be directly correlated with the SKB database SICADA. During the tilt tests, the real orientation of joints was not known, and therefore the various joints, were classified according to their angle of intersection with the core in the way it is displayed in Table 4-1.



Figure 4-1. Upper and lower joint surfaces used in the tilt test 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°	6
Set 2 (ca 45 degrees joints)	30–60°	6
Set 3 (sub-horizontal joints)	60–90°	6

Three profiles on each tilt joint surface have also been carried out. The rocks can be classified mainly as Ävrö granite, with veins of quartz monzodiorite and fine grained granodiorite. However, since core logging has been carried out by SKB, no detailed geological description has been attempted by NGI. Most common minerals on the joint surfaces are chlorite, calcite, pyrite, epidote, laumontite and clay minerals. All 18 tilt joint surfaces from borehole KLX03A can be directly identified within the database SICADA at SKB. At the time of sampling, the core had been exposed to the atmosphere at room temperature for an extended period of time 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 the tilting, Schmidt hammer measurements and profiling of the joint faces.

The measuring of the tilt angle α is performed on wet joint surfaces. The sample is then fixed to the tilt apparatus and tilted. At least three tilts are carried out on each sample, and the tilt angle should not vary more than 3° in these tests. However, in some cases the characteristics of the sample change during testing. For example fracture coating may be removed, and therefore variation of more than 3° may (in some cases) 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 joint surfaces (r value) with 10 blows on each test. 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 on dry cores 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.

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, one to the 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 taken 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 accuracy of the calliper used for measuring the size (height and diameter) of the specimens is of 0.01 mm.

The results were in the range 2,751–2,814 g/cm³. In the calculations the densities listed in Table 4-2 have been used.

Table 4-2. Depth ranges in borehole KLX03A with the relevant unit weight used.

Depth Interval m	m	Unit Weight kN/m ³
0.00	301.50	27.55
301.50	401.00	27.51
401.00	552.35	27.68
552.35	800.00	28.14

4.3 Nonconformities

None.

5 Results from the tilt testing

5.1 General

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

Tables showing all the input and output data are given in Appendix A. Separate tables are presented for each of the three joint sets. A table displaying all the joint sets is also presented in 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 18 tilt test specimens have been selected from KLX03A in the depth range between 240 m and 700 m. As mentioned earlier, the fractures were classified in three 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 KLX03A

In the depth range 240–700 m from borehole KLX03A, 18 tilt tests and 18×3 profilings on joints were performed. Complete input data and output data from tilt tests and profiling are found in Appendix A. Figures 5-1, 5-2 and 5-3 show the variation of the parameters JCS_o , JRC_o , Φ_r and Φ_b versus depth for each of the three joint sets respectively. All the results from borehole KLX03A are presented together in the plots. 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 KLX03A.

Fracture set	JRC_o (tilt)	JCS_o MPa	Φ_b (°)	Φ_r (°)	Number (tilt)	Number (profiles)
Set 1	6.84	75.54	32.3	27.64	6	6
Set 2	6.40	72.54	32.3	27.49	6	6
Set 3	5.83	64.04	32.1	26.18	6	6
Mean/Total	6.35	70.71	32.2	27.10	18	18

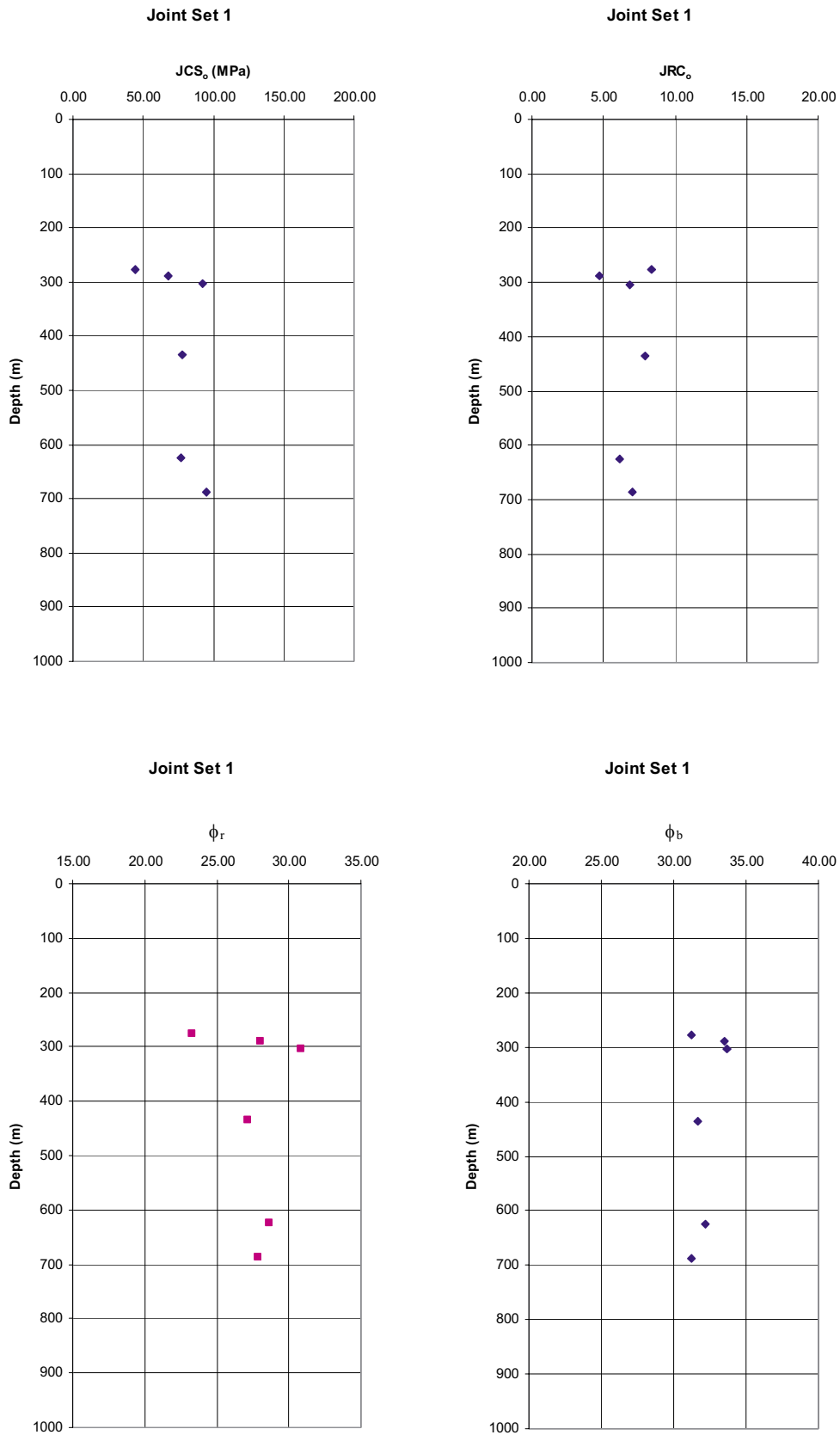


Figure 5-1. Variation of joint parameters with depth for Set 1.

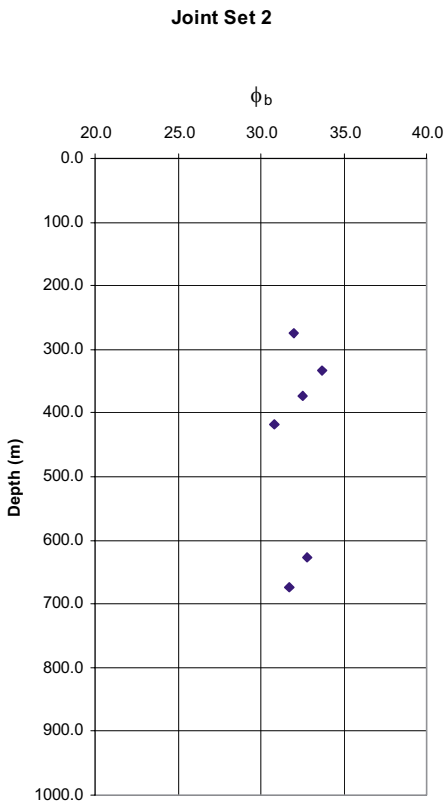
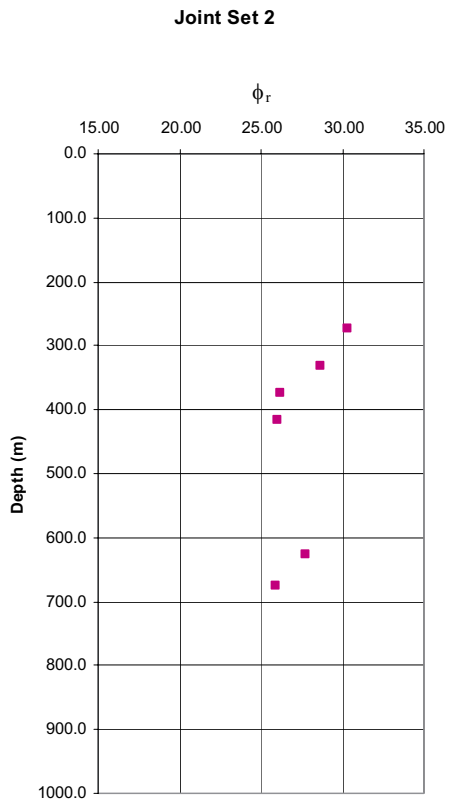
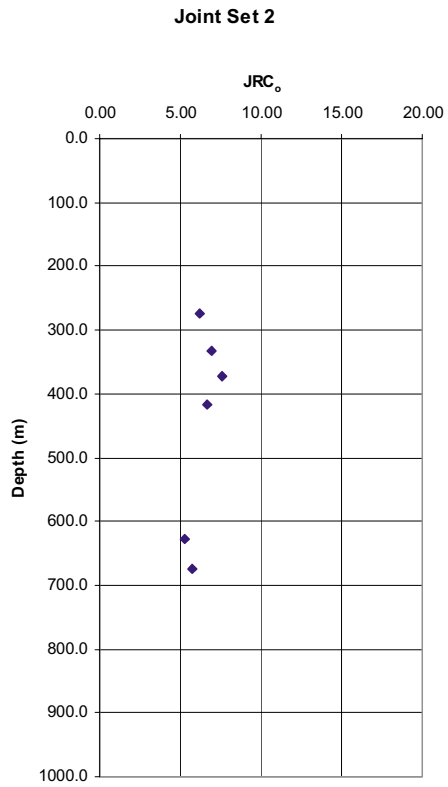
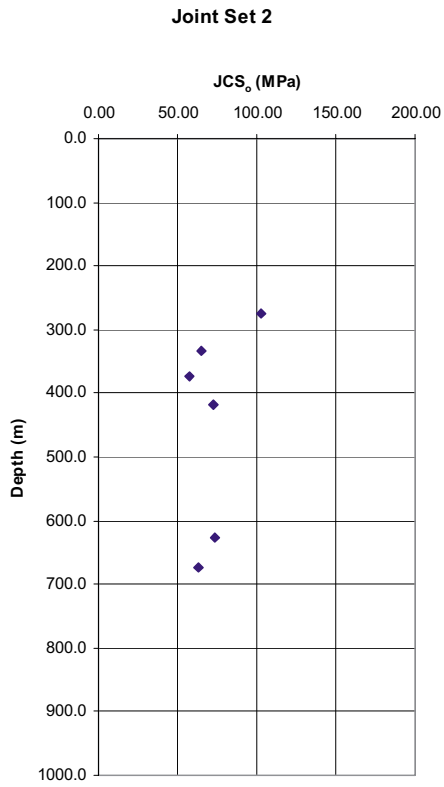


Figure 5-2. Variation of joint parameters with depth for Set 2.

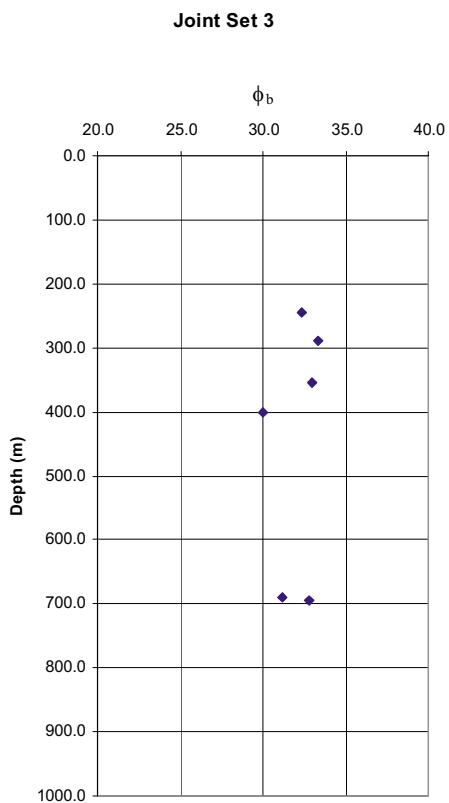
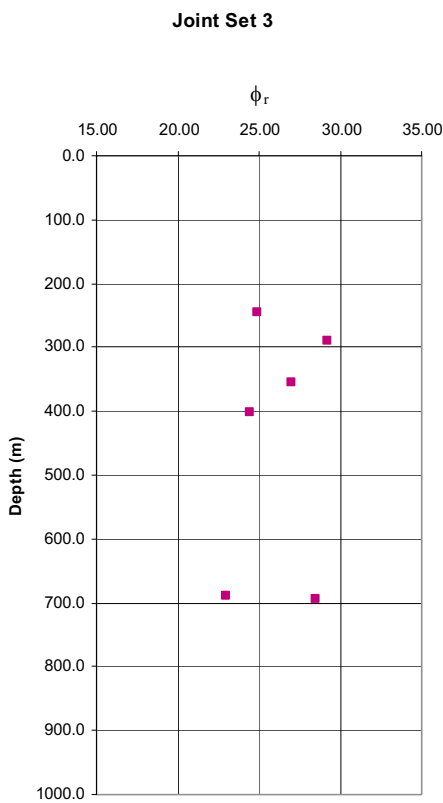
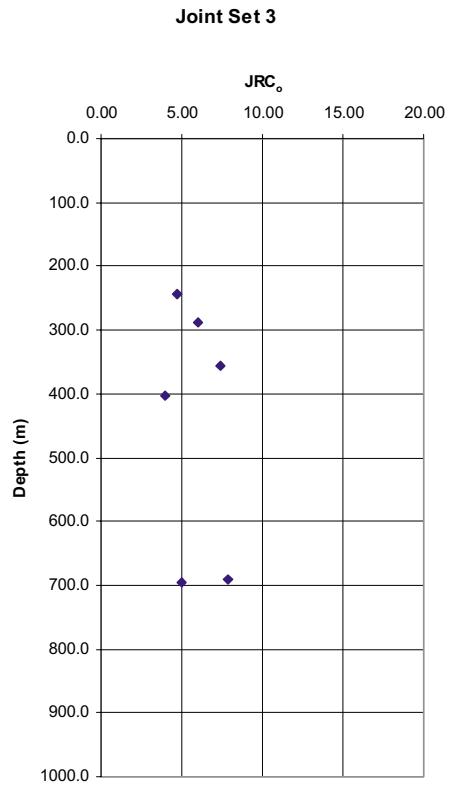
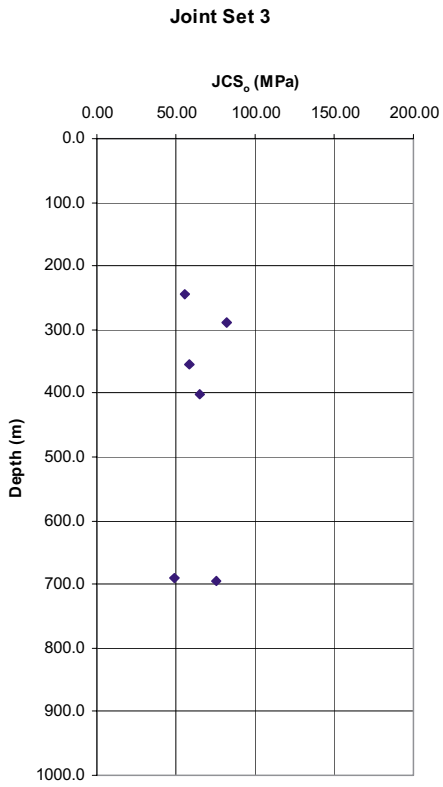


Figure 5-3. Variation of joint parameters with depth for Set 3.

5.3 Evaluation of the results

The joint faces are rather similar concerning mineralization, and the tilt tests show rather uniform JRC-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} . In terms of uncertainty level, the small number of tests for this borehole must be also taken into account. 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 sliding. In case of toppling, only profiling would have been carried out, but it did not prove 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 all three joint sets varied between 3.9 and 8.3. This means that the sample selection for tilt testing is representative for the KLX03A borehole.

The main results from tilt testing

ROCK JOINT CHARACTERISATION													PAGE 1	
CLIENT: SKB- Tilt tests													Operator:	PC
INPUT DATA													Date:	06.12.2004
Depth zone: 101.4 - 1000.4 m													Borehole:	KLX03
F:\p\2003\10\20031089\Reports\Rap KLX03\alljoints KLX03.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 REBOUN NUMBER (r)	ROCK REBOUN NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m ³)		
1	set 1	276.733	SICADA	4.4	217.0	525.10	89.3	72.8	26.2	43.4	31.2	27.55		
2	set 2	273.797	SICADA	2.1	56.0	134.40	24.5	68.7	41.3	45.0	32.0	27.55		
3	set 3	244.605	SICADA	1.9	45.7	164.20	20.1	49.8	30.2	47.8	32.3	27.55		
4	set 1	288.731	SICADA	3.7	87.0	211.90	38.0	54.3	33.8	46.6	33.5	27.55		
5	set 2	332.650	SICADA	2.1	70.3	201.70	32.7	70.3	33.2	44.4	33.7	27.51		
6	set 3	289.157	SICADA	2.7	49.3	157.80	21.2	63.7	37.2	46.8	33.3	27.55		
7	set 1	303.536	SICADA	3.1	96.0	269.80	43.2	74.0	39.4	46.0	33.7	27.51		
8	set 2	373.327	SICADA	2.2	73.7	199.70	32.5	71.8	31.0	45.2	32.5	27.51		
9	set 3	355.033	SICADA	1.9	49.3	112.30	21.5	72.2	31.2	44.6	33.0	27.51		
10	set 1	435.064	SICADA	3.1	255.7	713.80	106.5	78.7	36.2	46.8	31.7	27.68		
11	set 2	416.815	SICADA	1.9	62.3	138.60	27.4	65.3	35.0	46.0	30.8	27.68		
12	set 3	402.062	SICADA	2.6	52.7	124.00	22.4	45.7	32.9	45.6	30.0	27.68		
13	set 1	624.262	SICADA	3.9	166.0	408.00	77.4	64.8	35.4	43.0	32.2	28.14		
14	set 2	626.512	SICADA	5.2	92.3	211.60	41.8	57.8	34.6	46.2	32.8	28.14		
15	set 3	694.625	SICADA	2.0	44.3	149.30	20.1	56.0	35.0	44.6	32.8	28.14		
16	set 1	686.700	SICADA	5.3	169.0	346.90	76.8	73.0	39.0	46.8	31.2	28.14		
17	set 2	674.665	SICADA	1.7	55.0	157.90	24.6	57.6	32.0	45.0	31.7	28.14		
18	set 3	689.816	SICADA	2.1	48.3	147.50	21.4	67.8	27.5	46.6	31.2	28.14		
Arithmetic av.				2.9	93.9	243.0	41.2	64.7	34.0	45.6	32.2	27.8		
minimum val.				1.7	44.3	112.3	20.1	45.7	26.2	43.0	30.0	27.5		
maximum val.				5.3	255.7	713.8	106.5	78.7	41.3	47.8	33.7	28.1		

ROCK JOINT CHARACTERISATION													TESTED		PAGE 3	
CLIENT: SKB- Tilt tests													Operator:	PC		
OUTPUT DATA													Date:	06.12.2004		
Depth zone: 101.4 - 1000.4 m													Borehole:	KLX03		
F:\p\2003\10\20031089\Reports\Rap KLX03\alljoints KLX03.xls\OUTPUT DATA																
SAMPLE No	JOINT SET NO	DEPTH (m)	JCS ₀ (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC ₀ AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC ₁₀₀ VALUES 100 mm	EXTRPL'D JCS ₁₀₀ VALUES 100 mm (MPa)							
1	set 1	276.733	44.18	5.04E-05	23.3	8.33	0.46	9.48	53.62							
2	set 2	273.797	102.63	7.10E-05	30.4	6.22	1.79	5.79	92.10							
3	set 3	244.605	55.23	3.34E-04	24.9	4.76	2.19	4.42	49.38							
4	set 1	288.731	67.52	1.86E-04	28.0	4.73	1.15	4.67	66.20							
5	set 2	332.650	65.12	6.87E-05	28.7	6.97	1.42	6.63	60.50							
6	set 3	289.157	81.64	1.43E-04	29.2	5.99	2.03	5.51	71.89							
7	set 1	303.536	92.01	4.65E-05	30.8	6.86	1.04	6.82	91.24							
8	set 2	373.327	57.61	5.88E-05	26.2	7.61	1.36	7.26	53.73							
9	set 3	355.033	58.25	4.79E-05	27.0	7.43	2.03	6.69	49.76							
10	set 1	435.064	77.94	2.52E-05	27.2	7.94	0.39	9.22	97.48							
11	set 2	416.815	72.87	8.66E-05	26.0	6.63	1.61	6.23	66.32							
12	set 3	402.062	64.77	2.65E-04	24.4	3.95	1.90	3.75	60.04							
13	set 1	624.262	77.02	9.37E-05	28.7	6.11	0.60	6.50	84.52							
14	set 2	626.512	73.59	1.41E-04	27.8	5.25	1.08	5.21	72.67							
15	set 3	694.625	75.29	2.28E-04	28.5	4.98	2.26	4.60	66.66							
16	set 1	686.700	94.57	3.79E-05	27.9	7.05	0.59	7.60	105.68							
17	set 2	674.665	63.45	1.81E-04	25.9	5.71	1.82	5.34	57.27							
18	set 3	689.816	49.09	9.65E-05	23.0	7.85	2.07	7.00	41.36							
Arithmetic av.			70.71	1.20E-04	27.10	6.35	1.43	6.26	68.91							
minimum val.			44.18	2.52E-05	23.00	3.95	0.39	3.75	41.36							
maximum val.			102.63	3.34E-04	30.83	8.33	2.26	9.48	105.68							

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	07.12.04
Borehole:	KLX03

INPUT DATA Depth zone: 101.4 - 1000.4 m

F:\p\2003\10\20031089\Reports\Rap KLX03\set 1 KLX03.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 REBOUN NUMBER (r)	ROCK REBOUN NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m ³)
1	set 1	276.733	SICADA	4.4	217.0	525.10	89.3	72.8	26.2	43.4	31.2	27.55
2	set 1	288.731	SICADA	3.7	87.0	211.90	38.0	54.3	33.8	46.6	33.5	27.55
3	set 1	303.536	SICADA	3.1	96.0	269.80	43.2	74.0	39.4	46.0	33.7	27.51
4	set 1	435.064	SICADA	3.1	255.7	713.80	106.5	78.7	36.2	46.8	31.7	27.68
5	set 1	624.262	SICADA	3.9	166.0	408.00	77.4	64.8	35.4	43.0	32.2	28.14
6	set 1	686.700	SICADA	5.3	169.0	346.90	76.8	73.0	39.0	46.8	31.2	28.14
Arithmetic av.				3.9	165.1	412.6	71.9	69.6	35.0	45.4	32.3	27.8
minimum val.				3.1	87.0	211.9	38.0	54.3	26.2	43.0	31.2	27.5
maximum val.				5.3	255.7	713.8	106.5	78.7	39.4	46.8	33.7	28.1

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

TESTED

PAGE 3

Operator:	PC
Date:	07.12.04
Borehole:	KLX03

OUTPUT DATA Depth zone: 101.4 - 1000.4 m

F:\p\2003\10\20031089\Reports\Rap KLX03\set 1 KLX03.xls\OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS ₀ (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC ₀ AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC ₁₀₀ -VALUES 100 mm	EXTRPL'D JCS ₁₀₀ -VALUES 100 mm (MPa)
1	set 1	276.733	44.18	5.04E-05	23.3	8.33	0.46	9.48	53.62
2	set 1	288.731	67.52	1.86E-04	28.0	4.73	1.15	4.67	66.20
3	set 1	303.536	92.01	4.65E-05	30.8	6.86	1.04	6.82	91.24
4	set 1	435.064	77.94	2.52E-05	27.2	7.94	0.39	9.22	97.48
5	set 1	624.262	77.02	9.37E-05	28.7	6.11	0.60	6.50	84.52
6	set 1	686.700	94.57	3.79E-05	27.9	7.05	0.59	7.60	105.68
Arithmetic av.			75.54	7.33E-05	27.64	6.84	0.71	7.38	83.12
minimum val.			44.18	2.52E-05	23.27	4.73	0.39	4.67	53.62
maximum val.			94.57	1.86E-04	30.83	8.33	1.15	9.48	105.68

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	07.12.04
Borehole:	KLX03

INPUT DATA

Depth zone: 101.4 - 1000.4 m

F:\p\2003\10\20031089\Reports\Rap KLX03[set 2 KLX03.xls]INPUT DATA 1

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT		MASS m (g)	AREA A (cm ²)	MEAN TILT ANGLE (°)	JOINT REBOUND NUMBER (r)	ROCK REBOUND (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m ³)
				AMP. a (mm)	LENG. L (mm)							
1	set 2	273.797	SICADA	2.1	56.0	134.40	24.5	68.7	41.3	45.0	32.0	27.55
2	set 2	332.650	SICADA	2.1	70.3	201.70	32.7	70.3	33.2	44.4	33.7	27.51
3	set 2	373.327	SICADA	2.2	73.7	199.70	32.5	71.8	31.0	45.2	32.5	27.51
4	set 2	416.815	SICADA	1.9	62.3	138.60	27.4	65.3	35.0	46.0	30.8	27.68
5	set 2	626.512	SICADA	5.2	92.3	211.60	41.8	57.8	34.6	46.2	32.8	28.14
6	set 2	674.665	SICADA	1.7	55.0	157.90	24.6	57.6	32.0	45.0	31.7	28.14
Arithmetic av.				2.5	68.3	174.0	30.6	65.3	34.5	45.3	32.3	27.8
minimum val.				1.7	55.0	134.4	24.5	57.6	31.0	44.4	30.8	27.5
maximum val.				5.2	92.3	211.6	41.8	71.8	41.3	46.2	33.7	28.1

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

TESTED

PAGE 3

Operator: PC

Date: 07.12.04

OUTPUT DATA

Depth zone: 101.4 - 1000.4 m

Borehole: KLX03

F:\p\2003\10\20031089\Reports\Rap KLX03[set 2 KLX03.xls]OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS ₀ (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC ₀ AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC ₁₀₀ -VALUES 100 mm	EXTRPL'D JCS ₁₀₀ -VALUES 100 mm (MPa)
2	set 2	332.650	65.12	6.87E-05	28.7	6.97	1.42	6.63	60.50
3	set 2	373.327	57.61	5.88E-05	26.2	7.61	1.36	7.26	53.73
4	set 2	416.815	72.87	8.66E-05	26.0	6.63	1.61	6.23	66.32
5	set 2	626.512	73.59	1.41E-04	27.8	5.25	1.08	5.21	72.67
6	set 2	674.665	63.45	1.81E-04	25.9	5.71	1.82	5.34	57.27
Arithmetic av.			72.54	1.01E-04	27.49	6.40	1.51	6.08	67.10
minimum val.			57.61	5.88E-05	25.92	5.25	1.08	5.21	53.73
maximum val.			102.63	1.81E-04	30.36	7.61	1.82	7.26	92.10

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	07.12.04
Borehole:	KLX03

INPUT DATA

Depth zone: 101.4 - 1000.4 m

F:\p\2003\10\20031089\Reports\Rap KLX03[set 3 KLX03.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 REBOUN NUMBER (r)	ROCK REBOUN NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m ³)
1	set 3	244.605	SICADA	1.9	45.7	164.20	20.1	49.8	30.2	47.8	32.3	27.55
2	set 3	289.157	SICADA	2.7	49.3	157.80	21.2	63.7	37.2	46.8	33.3	27.55
3	set 3	355.033	SICADA	1.9	49.3	112.30	21.5	72.2	31.2	44.6	33.0	27.51
4	set 3	402.062	SICADA	2.6	52.7	124.00	22.4	45.7	32.9	45.6	30.0	27.68
5	set 3	694.625	SICADA	2.0	44.3	149.30	20.1	56.0	35.0	44.6	32.8	28.14
6	set 3	689.816	SICADA	2.1	48.3	147.50	21.4	67.8	27.5	46.6	31.2	28.14
Arithmetic av.				2.2	48.3	142.5	21.1	59.2	32.3	46.0	32.1	27.8
minimum val.				1.9	44.3	112.3	20.1	45.7	27.5	44.6	30.0	27.5
maximum val.				2.7	52.7	164.2	22.4	72.2	37.2	47.8	33.3	28.1

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

TESTED

PAGE 3

Operator: PC

Date: 07.12.04

OUTPUT DATA

Depth zone: 101.4 - 1000.4 m

F:\p\2003\10\20031089\Reports\Rap KLX03[set 3 KLX03.xls]OUTPUT DATA

Borehole: KLX03

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS ₀ (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC ₀ AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC ₁₀₀ -VALUES 100 mm	EXTRPL'D JCS ₁₀₀ -VALUES 100 mm (MPa)
1	set 3	244.605	55.23	3.34E-04	24.9	4.76	2.19	4.42	49.38
2	set 3	289.157	81.64	1.43E-04	29.2	5.99	2.03	5.51	71.89
3	set 3	355.033	58.25	4.79E-05	27.0	7.43	2.03	6.69	49.76
4	set 3	402.062	64.77	2.65E-04	24.4	3.95	1.90	3.75	60.04
5	set 3	694.625	75.29	2.28E-04	28.5	4.98	2.26	4.60	66.66
6	set 3	689.816	49.09	9.65E-05	23.0	7.85	2.07	7.00	41.36
Arithmetic av.			64.04	1.86E-04	26.18	5.83	2.08	5.33	56.51
minimum val.			49.09	4.79E-05	23.00	3.95	1.90	3.75	41.36
maximum val.			81.64	3.34E-04	29.20	7.85	2.26	7.00	71.89