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Oskarshamn site investigation

Borehole: KAV01

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.

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

Norwegian Geotechnical Institute (NGI) has carried out tilt testing on joint surfaces of drill cores from the borehole KAV01 at Simpevarp. From a total of about 746 m of cores, 26 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 6.5. The mean value of the joint wall compressive strength (JCS_o) from Schmidt hammer testing of all the joint samples is 55.8 MPa. The mean values of the basic (Φ_b) and residual (Φ_r) friction angles of all the tested samples are 30.8 and 26.3 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 KAV01 at Simpevarp in Sweden according to SKB's Activity Plan AP PF400-03-72 (SKB internal controlling document). The work has been carried out by Panayiotis Chryssanthakis and Pawel Jankowski during the period 4–10 November 2003 in accordance with SKB's method description MD 190.006 version 1.0 (SKB internal controlling document).

KAV01 is an earlier borehole and has been drilled in three stages; year 1977, 1986 and 1997. Revaluation of the core logging made it easy to take joints for Tilt testing. The core diameter is about 41.5 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 number of tests performed and the number of joint sets is given in Table 2.1

Table 2-1. Total number of tilt tests.

Borehole	Tilt tests	Number of joint sets
KAV01	26	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 collected from drill cores with a diameter of 41.5 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 198.0 m and 717.0 m from borehole KAV01. A total of 26 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 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°	13
Set 2 (ca 45 degrees joints)	30–60°	13

Due to the small core diameter (41.5 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, with the main part of the borehole lying in Ävrö granite, with some intersecting veins of gabbrodiorite and dioritoid. Most common minerals on the joint surfaces are chlorite, calcite, pyrite, epidote and laumontite. Since geological logging of the core has been carried out by SKB, no detailed geological description has been attempted by NGI. All 26 tilt joint surfaces 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 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 (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. 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.

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 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 0.01 g. 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 26.74–27.37 kN/m³ or 2.67–2.37 g/cm³. In the calculations the following densities as listed in Table 4-2 have been used:

Table 4-2. Depth ranges in borehole KAV01 with the relevant unit weight used.

Interval in the borehole m	m	Unit Weight kN/m ³
200.00	304.10	27.09
304.10	404.50	27.08
404.50	504.88	26.75
504.88	609.95	26.74
609.95	701.40	26.81
701.40	750.00	27.37

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 178).

The 26 tilt test specimens have been chosen from the total of 746 m of core material from borehole KAV01 in the depth range between 198 m and 717 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 KAV01

In the depth range 198.0 to 717.0 m from borehole KAV01, 26 tilt tests and 26x3 profilings on joints have been performed. Complete input data and output data from tilt tests and profiling are found in Appendix A. Figures 5-1, 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 KAV01.

Fracture set	JRC _o (tilt)	JCS _o MPa	Φ_b (o)	Φ_r (o)	Number (tilt)	Number (profiles)
Set 1	6.90	58.85	30.7	26.28	13	13
Set 2	6.04	52.72	30.9	26.24	13	13
Mean/Total	6.47	55.79	30.8	26.26	26	26

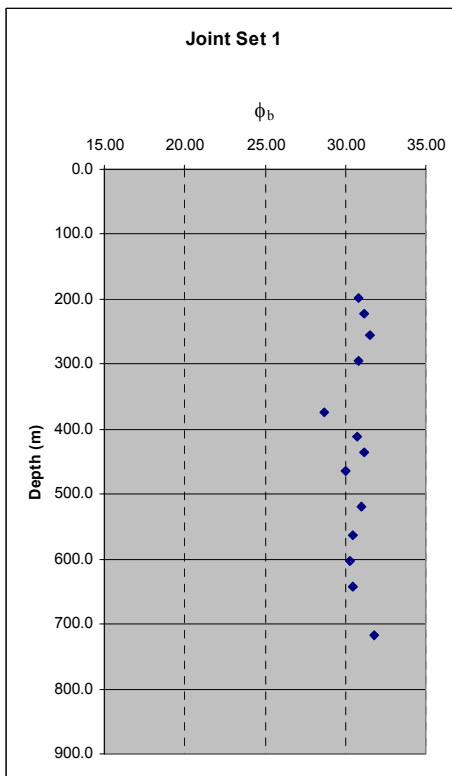
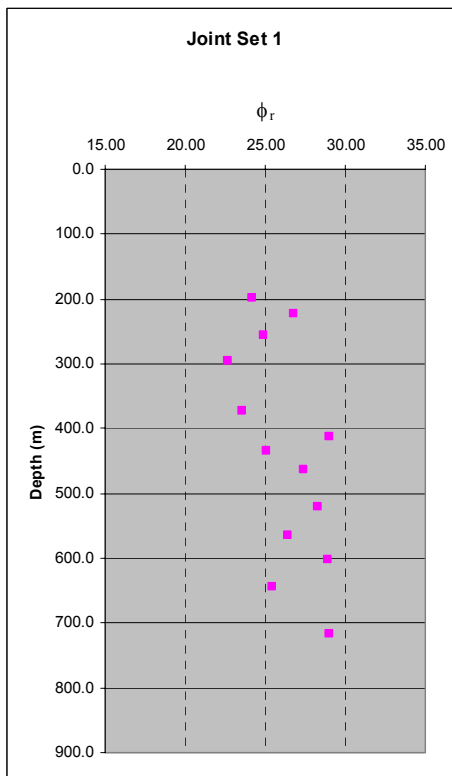
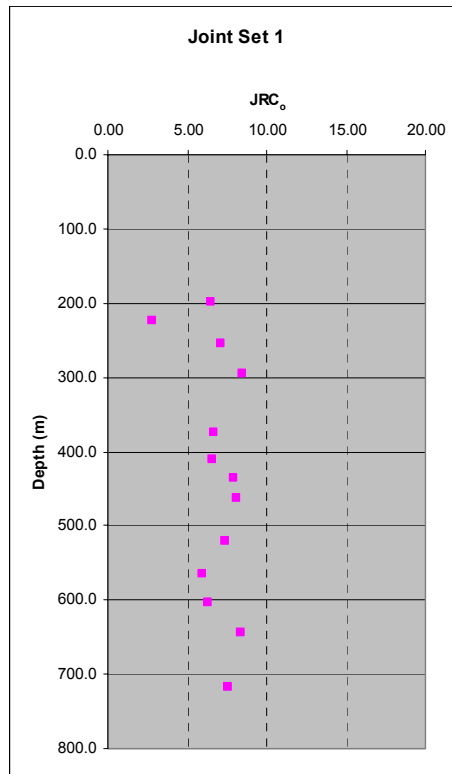
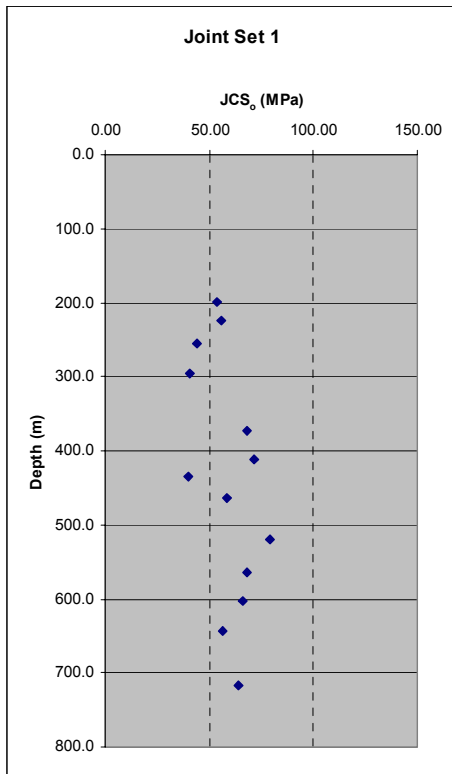


Figure 5-1. Variation of joint parameters with depth for Set 1.

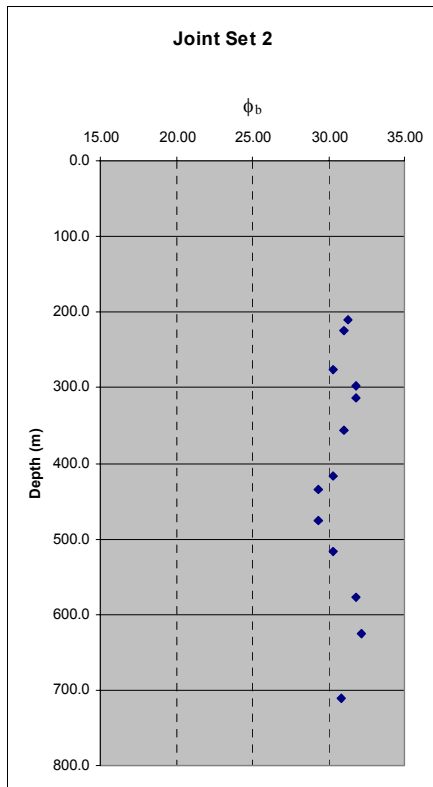
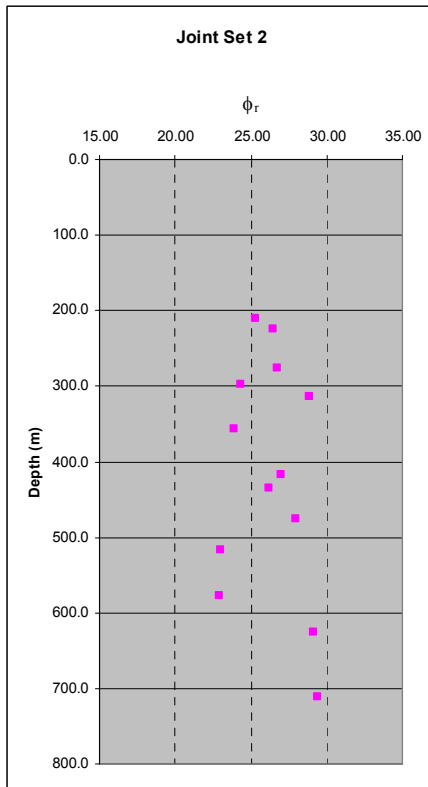
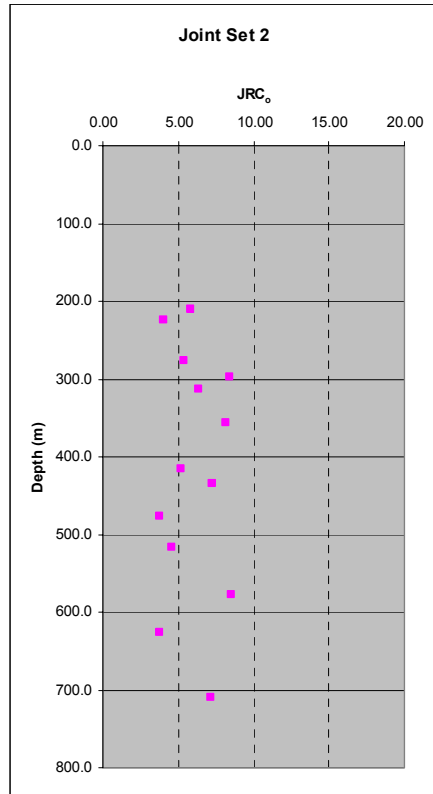
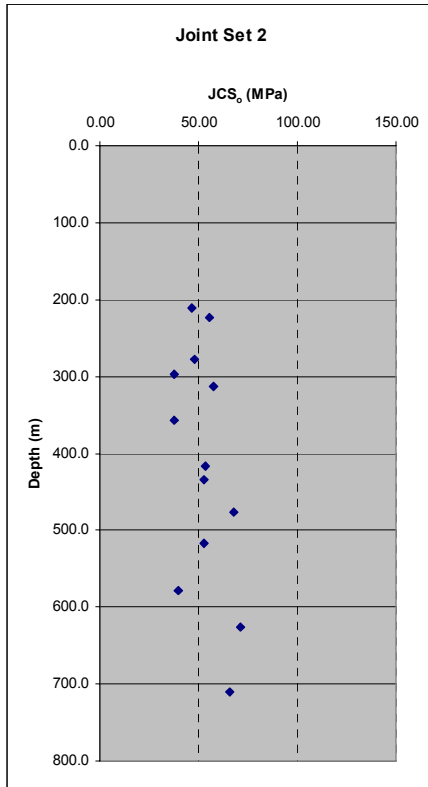


Figure 5-2. Variation of joint parameters with depth for Set 2.

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 2.8 and 8.5. This means that the sample selection for tilt testing is representative for the borehole KAV01.

Appendix A

The main results from tilt testing

ROCK JOINT CHARACTERISATION													PAGE 1	
CLIENT: SKB- Tilt tests													Operator: PC	
INPUT DATA													Date: 14.11.2003	
Depth zone: 0 - 745,6 m													Borehole: KAV01	
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)	#/VT	
				AMP. a (mm)	LENG. L (mm)									
1	set 1	198,608	Sicada	2,7	91,0	196,82	34,1	60,3	30,2	45,0	30,8	27,09		
2	set 2	210,954	Sicada	1,8	46,7	106,52	16,1	56,5	27,6	39,4	31,3	27,09		
3	set 1	223,309	Sicada	6,1	199,3	504,00	73,7	41,0	30,8	39,6	31,2	27,09		
4	set 2	224,105	Sicada	1,6	45,0	107,86	16,0	47,8	30,8	39,8	31,0	27,09		
5	set 1	254,838	Sicada	4,3	88,0	134,20	53,4	68,7	26,6	39,8	31,5	27,09		
6	set 2	277,053	Sicada	2,7	48,3	196,73	17,6	54,3	28,2	34,4	30,3	27,09		
7	set 1	295,356	Sicada	3,0	121,3	223,11	47,3	74,2	25,0	42,2	30,8	27,09		
8	set 2	297,894	Sicada	2,1	50,7	137,45	19,7	73,8	23,8	38,0	31,8	27,09		
9	set 1	373,767	Sicada	1,3	81,0	227,10	28,6	60,5	34,6	46,6	28,7	27,08		
10	set 2	312,775	Sicada	1,8	58,7	150,19	20,4	64,7	31,4	36,8	31,8	27,08		
11	set 1	411,442	Sicada	4,9	158,3	272,30	64,6	69,8	35,8	39,0	30,7	26,75		
12	set 2	357,148	Sicada	1,6	53,7	123,55	19,4	70,5	23,8	36,8	31,0	27,08		
13	set 1	435,376	Sicada	3,8	80,0	224,87	29,5	69,8	25,0	36,0	31,2	26,75		
14	set 2	416,389	Sicada	0,6	42,3	97,64	15,9	55,5	30,6	36,6	30,3	26,75		
15	set 1	463,585	Sicada	4,1	111,3	285,94	41,7	79,2	32,2	37,0	30,0	26,75		
16	set 2	433,937	Sicada	2,6	46,3	108,09	16,2	68,3	30,2	35,8	29,3	26,75		
17	set 1	520,261	Sicada	2,1	64,3	186,53	24,3	73,5	37,8	43,6	31,0	26,74		
18	set 2	475,851	Sicada	1,7	49,7	111,07	18,0	48,3	34,9	37,4	29,3	26,75		
19	set 1	564,327	Sicada	3,0	100,7	109,80	38,0	62,7	35,0	44,0	30,5	26,74		
20	set 2	516,904	Sicada	1,9	46,5	100,66	13,1	46,7	30,2	47,6	30,3	26,74		
21	set 1	602,424	Sicada	3,2	152,0	233,76	62,2	67,2	34,4	37,0	30,3	26,74		
22	set 2	577,901	Sicada	1,7	54,0	133,43	19,5	72,8	25,0	44,8	31,8	26,74		
23	set 1	643,529	Sicada	3,9	163,7	313,30	62,6	82,0	31,4	42,0	30,5	26,81		
24	set 2	626,037	Sicada	1,6	62,7	177,21	21,2	49,2	35,7	42,0	32,2	26,81		
25	set 1	717,049	Sicada	1,9	60,3	133,70	22,5	77,2	33,0	38,4	31,8	27,37		
26	set 2	710,220	Sicada	2,2	50,7	127,00	20,0	73,0	33,5	36,0	30,8	27,37		
			Arithmetic av.	2,6	81,8	181,6	31,4	64,1	30,7	39,8	30,8	26,9		
			minimum val.	0,6	42,3	97,6	13,1	41,0	23,8	34,4	28,7	26,7		
			maximum val.	6,1	199,3	504,0	73,7	82,0	37,8	47,6	32,2	27,4		

ROCK JOINT CHARACTERISATION								PAGE 3	
CLIENT: SKB- Tilt tests								Operator:	PC
OUTPUT DATA								Date:	#####
								Depth zone:	
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	198,608	53,70	1,39E-04	24,2	6,46	1,10	6,38	52,72
2	set 2	210,954	46,55	1,98E-04	25,3	5,81	2,14	5,31	40,77
3	set 1	223,309	55,49	3,82E-04	26,8	2,76	0,50	2,87	58,75
4	set 2	224,105	55,49	2,98E-04	26,5	4,05	2,22	3,79	50,37
5	set 1	254,838	44,07	3,25E-05	24,9	7,15	1,14	7,02	42,88
6	set 2	277,053	48,11	3,73E-04	26,7	5,40	2,07	4,99	42,76
7	set 1	295,356	40,36	3,43E-05	22,6	8,49	0,82	8,77	42,40
8	set 2	297,894	37,69	5,34E-05	24,3	8,46	1,97	7,54	31,72
9	set 1	373,767	68,32	1,89E-04	23,5	6,65	1,23	6,46	65,51
10	set 2	312,775	57,32	1,32E-04	28,9	6,36	1,70	5,94	51,78
11	set 1	411,442	71,24	4,93E-05	29,1	6,61	0,63	7,03	78,04
12	set 2	357,148	37,67	6,96E-05	23,9	8,13	1,86	7,35	32,37
13	set 1	435,376	39,67	8,91E-05	25,1	7,92	1,25	7,64	37,63
14	set 2	416,389	53,74	1,93E-04	27,0	5,23	2,36	4,78	46,96
15	set 1	463,585	58,61	2,36E-05	27,4	8,10	0,90	8,24	60,16
16	set 2	433,937	52,59	8,95E-05	26,2	7,30	2,16	6,53	44,43
17	set 1	520,261	79,34	6,07E-05	28,3	7,38	1,56	6,92	71,94
18	set 2	475,851	67,67	2,68E-04	27,9	3,77	2,01	3,58	62,52
19	set 1	564,327	68,17	5,96E-05	26,4	5,99	0,99	6,00	68,26
20	set 2	516,904	52,56	3,54E-04	23,0	4,59	2,15	4,27	47,30
21	set 1	602,424	65,99	5,53E-05	28,9	6,30	0,66	6,65	71,43
22	set 2	577,901	39,55	5,87E-05	22,9	8,55	1,85	7,70	33,76
23	set 1	643,529	56,34	9,51E-06	25,5	8,35	0,61	9,07	63,74
24	set 2	626,037	70,97	3,50E-04	29,2	3,77	1,59	3,64	67,32
25	set 1	717,049	63,80	2,86E-05	29,0	7,59	1,66	7,03	56,86
26	set 2	710,220	65,41	5,32E-05	29,4	7,16	1,97	6,50	56,53
Arithmetic av			55,79	1,40E-04	26,26	6,47	1,50	6,23	53,03
maximum val			79,34	3,82E-04	29,38	8,55	2,36	9,07	78,04
minimum val.			37,67	9,51E-06	22,65	2,76	0,50	2,87	31,72

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	14.11.2003
Borehole:	KAV01

INPUT DATA Depth zone: 0 - 745,6 m

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT		MASS m (g)	AREA A (cm ²)	MEAN TILT ANGLE (°)	JOINT REBOUNDE NUMBER (r)	ROCK REBOUNDE NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m ³)
				AMP. a (mm)	LENG. L (mm)							
1	set 1	198,608	Sicada	2,7	91,0	196,82	34,1	60,3	30,2	45,0	30,8	27,09
2	set 1	223,309	Sicada	6,1	199,3	504,00	73,7	41,0	30,8	39,6	31,2	27,09
3	set 1	254,838	Sicada	4,3	88,0	134,20	53,4	68,7	26,6	39,8	31,5	27,09
4	set 1	295,356	Sicada	3,0	121,3	223,11	47,3	74,2	25,0	42,2	30,8	27,09
5	set 1	373,767	Sicada	1,3	81,0	227,10	28,6	60,5	34,6	46,6	28,7	27,08
6	set 1	411,442	Sicada	4,9	158,3	272,30	64,6	69,8	35,8	39,0	30,7	26,75
7	set 1	435,376	Sicada	3,8	80,0	224,87	29,5	69,8	25,0	36,0	31,2	26,75
8	set 1	463,585	Sicada	4,1	111,3	285,94	41,7	79,2	32,2	37,0	30,0	26,75
9	set 1	520,261	Sicada	2,1	64,3	186,53	24,3	73,5	37,8	43,6	31,0	26,74
10	set 1	564,327	Sicada	3,0	100,7	109,80	38,0	62,7	35,0	44,0	30,5	26,74
11	set 1	602,424	Sicada	3,2	152,0	233,76	62,2	67,2	34,4	37,0	30,3	26,74
12	set 1	643,529	Sicada	3,9	163,7	313,30	62,6	82,0	31,4	42,0	30,5	26,81
13	set 1	717,049	Sicada	1,9	60,3	133,70	22,5	77,2	33,0	38,4	31,8	27,37
Arithmetic av.				3,4	113,2	234,3	44,8	68,2	31,7	40,8	30,7	26,9
minimum val.				1,3	60,3	109,8	22,5	41,0	25,0	36,0	28,7	26,7
maximum val.				6,1	199,3	504,0	73,7	82,0	37,8	46,6	31,8	27,4

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 3	
Operator:	PC
Date:	14.11.2003
Borehole:	KAV01

OUTPUT DATA Depth zone: 0 - 745,6 m

F:\P\2003\10\20031089\Reports\Rap KAV01\set1a.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)
2	set 1	223.309	55.49	3.82E-04	26.8	2.76	0.50	2.87	58.75
3	set 1	254.838	44.07	3.25E-05	24.9	7.15	1.14	7.02	42.88
4	set 1	295.356	40.36	3.43E-05	22.6	8.49	0.82	8.77	42.40
5	set 1	373.767	68.32	1.89E-04	23.5	6.65	1.23	6.46	65.51
6	set 1	411.442	71.24	4.93E-05	29.1	6.61	0.63	7.03	78.04
7	set 1	435.376	39.67	8.91E-05	25.1	7.92	1.25	7.64	37.63
8	set 1	463.585	58.61	2.36E-05	27.4	8.10	0.90	8.24	60.16
9	set 1	520.261	79.34	6.07E-05	28.3	7.38	1.56	6.92	71.94
10	set 1	564.327	68.17	5.96E-05	26.4	5.99	0.99	6.00	68.26
11	set 1	602.424	65.99	5.53E-05	28.9	6.30	0.66	6.65	71.43
12	set 1	643.529	56.34	9.51E-06	25.5	8.35	0.61	9.07	63.74
13	set 1	717.049	63.80	2.86E-05	29.0	7.59	1.66	7.03	56.86
Arithmetic av.			58.85	8.87E-05	26.28	6.90	1.00	6.93	59.25
maximum val.			79.34	3.82E-04	29.06	8.49	1.66	9.07	78.04
minimum val.			39.67	9.51E-06	22.65	2.76	0.50	2.87	37.63

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1

Operator: PC

Date: 14.11.2003

INPUT DATA

Depth zone: 0 - 745,6 m

Borehole: KAV01

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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 NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m ³)
				AMP. a (mm)	LENG. L (mm)							
1	set 2	210.954	Sicada	1.8	46.7	106.52	16.1	56.5	27.6	39.4	31.3	27.09
2	set 2	224.105	Sicada	1.6	45.0	107.86	16.0	47.8	30.8	39.8	31.0	27.09
3	set 2	277.053	Sicada	2.7	48.3	196.73	17.6	54.3	28.2	34.4	30.3	27.09
4	set 2	297.894	Sicada	2.1	50.7	137.45	19.7	73.8	23.8	38.0	31.8	27.09
5	set 2	312.775	Sicada	1.8	58.7	150.19	20.4	64.7	31.4	36.8	31.8	27.08
6	set 2	357.148	Sicada	1.6	53.7	123.55	19.4	70.5	23.8	36.8	31.0	27.08
7	set 2	416.389	Sicada	0.6	42.3	97.64	15.9	55.5	30.6	36.6	30.3	26.75
8	set 2	433.937	Sicada	2.6	46.3	108.09	16.2	68.3	30.2	35.8	29.3	26.75
9	set 2	475.851	Sicada	1.7	49.7	111.07	18.0	48.3	34.9	37.4	29.3	26.75
10	set 2	516.904	Sicada	1.9	46.5	100.66	13.1	46.7	30.2	47.6	30.3	26.74
11	set 2	577.901	Sicada	1.7	54.0	133.43	19.5	72.8	25.0	44.8	31.8	26.74
12	set 2	626.037	Sicada	1.6	62.7	177.21	21.2	49.2	35.7	42.0	32.2	26.81
13	set 2	710.220	Sicada	2.2	50.7	127.00	20.0	73.0	33.5	36.0	30.8	27.37
Arithmetic av.				1.8	50.4	129.0	17.9	60.1	29.6	38.9	30.9	27.0
minimum val.				0.6	42.3	97.6	13.1	46.7	23.8	34.4	29.3	26.7
maximum val.				2.7	62.7	196.7	21.2	73.8	35.7	47.6	32.2	27.4

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

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Operator: PC

Date: 14.11.2003

OUTPUT DATA

Depth zone: 0 - 745,6 m

Borehole: KAV01

F:\P\2003\10\20031089\Reports\Rap KAV01\set2a.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)
2	set 2	224.105	55.49	2.98E-04	26.5	4.05	2.22	3.79	50.37
3	set 2	277.053	48.11	3.73E-04	26.7	5.40	2.07	4.99	42.76
4	set 2	297.894	37.69	5.34E-05	24.3	8.46	1.97	7.54	31.72
5	set 2	312.775	57.32	1.32E-04	28.9	6.36	1.70	5.94	51.78
6	set 2	357.148	37.67	6.96E-05	23.9	8.13	1.86	7.35	32.37
7	set 2	416.389	53.74	1.93E-04	27.0	5.23	2.36	4.78	46.96
8	set 2	433.937	52.59	8.95E-05	26.2	7.30	2.16	6.53	44.43
9	set 2	475.851	67.67	2.68E-04	27.9	3.77	2.01	3.58	62.52
10	set 2	516.904	52.56	3.54E-04	23.0	4.59	2.15	4.27	47.30
11	set 2	577.901	39.55	5.87E-05	22.9	8.55	1.85	7.70	33.76
12	set 2	626.037	70.97	3.50E-04	29.2	3.77	1.59	3.64	67.32
13	set 2	710.220	65.41	5.32E-05	29.4	7.16	1.97	6.50	56.53
Arithmetic av.			52.72	1.92E-04	26.24	6.04	2.01	5.53	46.81
maximum val.			70.97	3.73E-04	29.38	8.55	2.36	7.70	67.32
minimum val.			37.67	5.32E-05	22.94	3.77	1.59	3.58	31.72