P-06-25

Forsmark site investigation

Borehole: KFM09A

Tilt testing

Panayiotis Chryssanthakis
Norwegian Geotechnical Institute, Oslo

April 2006

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Keywords: Rock mechanics, Joint properties, JRC_{100}, JCS_{100}, Angles of joint friction and tilt test, AP PF 400-05-110.

Summary

The Norwegian Geotechnical Institute (NGI) has carried out tilt testing on joint surfaces of drill core samples from borehole KFM09A in Forsmark, Sweden, during the period December 12th–15th, 2005. KFM09A has a diameter of 77.3 mm, is inclined c. 60° from the horizontal plane and has a total length of c. 800 m. Nine tilt tests were performed on three sets of joints on core samples from the level range 200 to 400 m.

The main results from the tilt tests are rather uniform for all fractures and 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 5.8. The mean value of the joint wall compressive strength (JCS_o) from Schmidt hammer testing of all the joint samples is 76.4 MPa, whereas the mean values of the basic (Φ_b) and residual (Φ_r) friction angles of all the tested samples are 31.1 and 26.7 degrees respectively.

Sammanfattning

Norges Geotekniska Institut (NGI) har gjort s k tilttester på öppna sprickor i borrkärneprover från borrhål KFM09A i Forsmark. KFM09A har en diameter på ca 77,3 mm, är ansatt med en gradning av ca 60° från horisontalplanet samt har en total längd på nästan 800 m. Nio kärnprover i intervallet 200–400 m utvaldes för tilttester på tre sprickgrupper.

Resultaten är relativt enhetliga för samtliga sprickor och uppvisar inga stora variationer. Medelvärdet för råhetskoefficienten, JRC_o, för alla sprickor är 5,7. För sprickväggens tryckhållfasthet, JCS_0, som uppmättes med Schmidthammarprovning, uppgår medelvärdet till 76,4 MPa. Slutligen är medelvärdet för basfriktionsvinkeln, Φ_b, och residualfriktionsvinkeln Φ_r, beräknat utifrån alla testade prover, 31,1 respektive 26,6 grader.

Contents

1 Introduction

The Norwegian Geotechnical Institute (NGI) has carried out nine tilt testings on joint surfaces of drill cores from borehole KFM09A at Forsmark, Sweden. KFM09A is a conventional core drilled borehole, inclined c. 60° from the horizontal plane and with a total length of 799.67 m and a diameter of 77.3 mm. The drill core diameter is c. 50.5 mm. The samples selected for tilt testing were collected within the interval c. 200–400 m borehole length. All deep boreholes drilled in Forsmark up to December 2005 are shown in Figure 1-1. The SKB internal controlling documents for performance of this activity are presented in Table 1-1.

The activity has been carried out by Panayiotis Chryssanthakis and Pawel Jankowski during the period December 12th–15th, 2005.

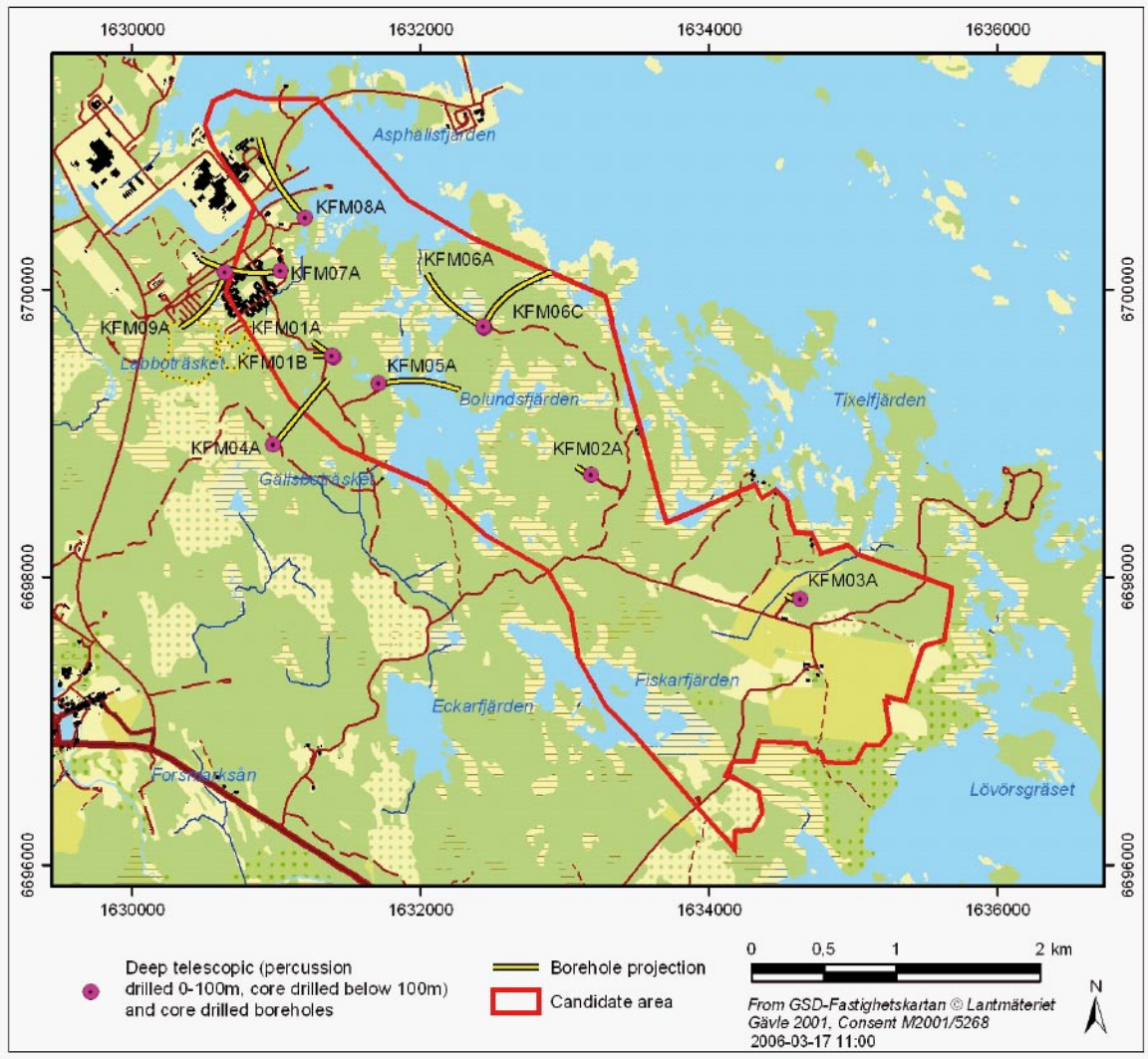

***Figure 1-1**. Location of all deep boreholes, including borehole KFM09A, drilled up to December 2005 at the Forsmark site.*

Table 1-1. Controlling documents for performance of the activity.

Activity Plan	Number	Version
KFM09A – Bergmekaniska parameter-bestämningar	AP PF 400-05-110	1.0
Method descriptions	**Number**	**Version**
Bestämning av sprickegenskaperna: råhetskoefficient, ytans tryckhållfasthet och den residuala friktionsvinkeln	SKB MD 190.006	1.0

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 Forsmark.

The number of tests performed and the number of joint sets are given in Table 2-1.

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

Table 2-1. Total number of tilt tests.

Borehole	Tilt tests	No. of joint sets
KFM09A	9	3

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.

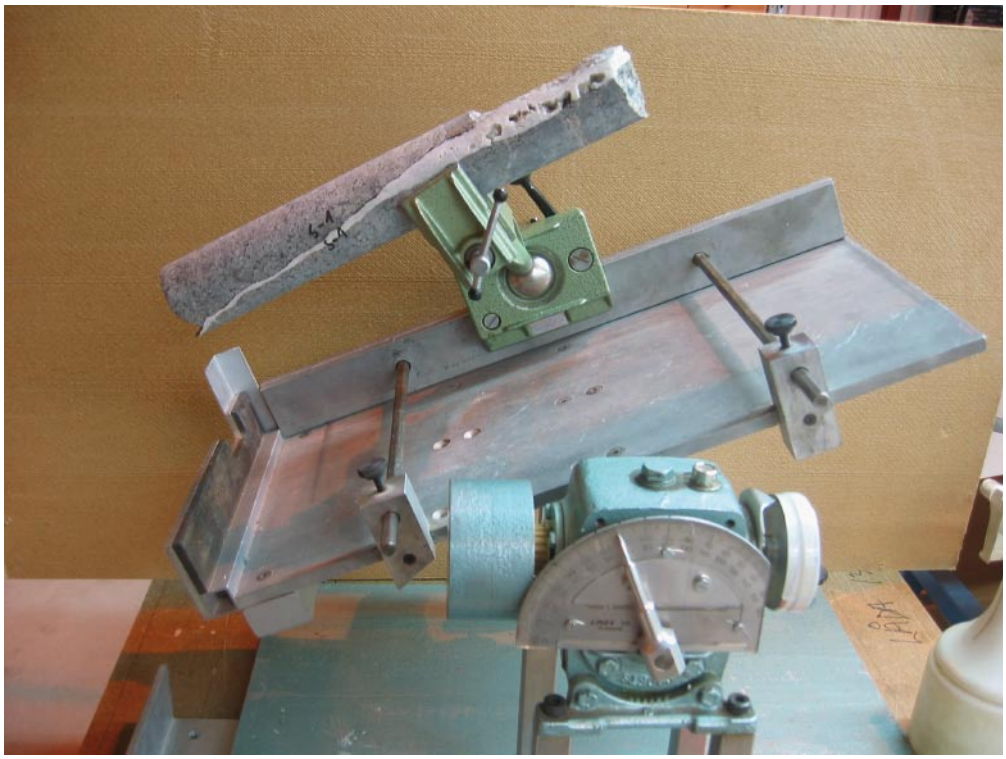

Figure 3-1. *NGI's Tilt test apparatus.*

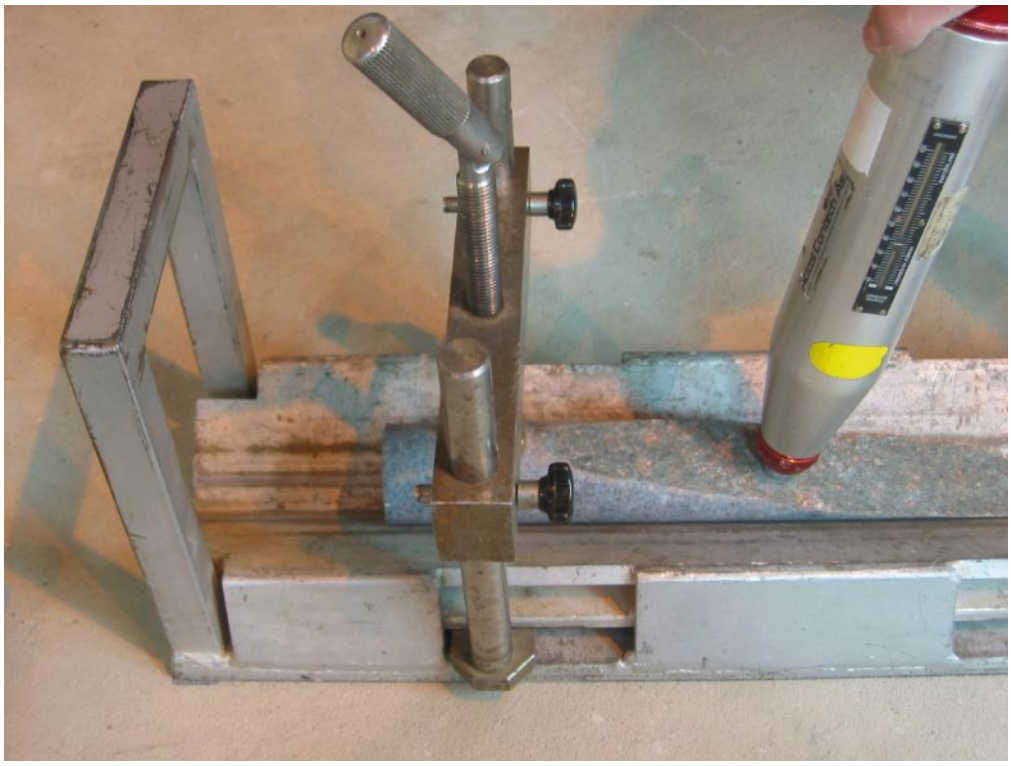

Figure 3-2. *Clamp for the Schmidt hammer tests.*

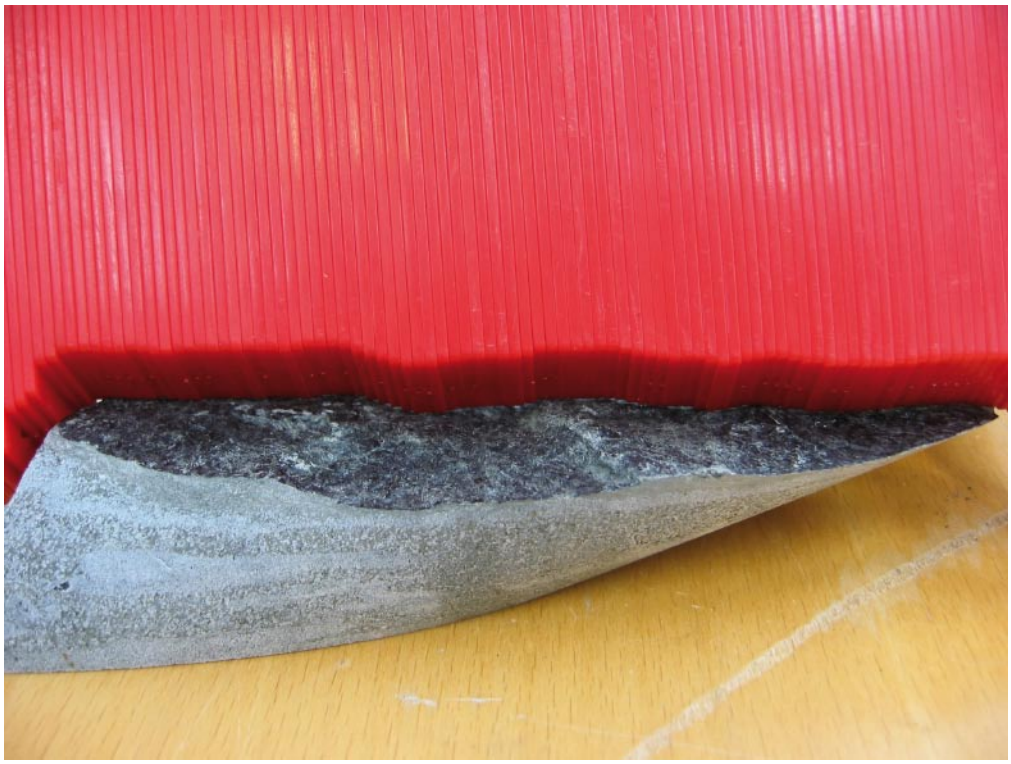

Figure 3-3. *Profilometer applied on a joint surface.*

4 Execution

4.1 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 was determined by choosing one specimen for approximately 18 to 22 metres in the interval between 200 m and 400 m borehole length. A total of nine tilt samples were selected in co-operation with SKB. The levels 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.

Three profilings on each tilt joint surface have also been carried out. The rock types dominating the major part of the borehole can be classified as foliated metamorphic granite, fine to medium-grained granite or granodiorite respectively tonalite with some veins of amphibolite and pegmatite,. 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, epidotite and laumontite. All nine tilt joint surfaces from borehole KFM09A 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.

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°	3
Set 2 (ca 45 degrees joints)	30–60°	3
Set 3 (sub-horizontal joints)	60–90°	3

4.2 Testing

The tilt tests include tilting, Schmidt hammer measurements and profiling of the joint faces.

The measurement 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, 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 (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 on dry cores with 10 blows. The lower five blow values were again eliminated. The core surface wall could be considered as non-uniform (straight). It was rather wavy with a typical wave length varying between 20 and 100 cm and a wave depth of up to 1.5 mm. Placing such a wavy core on the clamp, the Schmidt hammer readings can be influenced depending on whether one hits a valley or a peak with the Schmidt hammer. However, it is believed that this influence on the R-value measurements is rather limited.

The weight of the tilting block and the rock density were measured, and the fracture surface area was determined with a planimeter.

Profiling of the tilt tested fractures was carried out by means of a profilometer, and the profiles were drawn on a paper by pulling a pencil along the edge of the profilometer. For each fracture, three parallel profiles were 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) were 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 made on air-dried samples. The unit weight specimens were chosen at approximately 100 m intervals. The specimens were cut as perfect cylinders from which the volumes were calculated. The balance used for weighing the specimens has an accuracy of 0.01 g. The accuracy of the calliper used for measuring the size (height and diameter) of the specimens is 0.01 mm.

The results were in the range 2.665–2.671 g/cm^3. In the calculations the densities listed in Table 4-2 have been used.

Table 4-2. Depth ranges in borehole KFM09A with the relevant unit weight used.

Level Interval (borehole length) m	m	Unit Weight kN/m³
0.00	250.00	26.65
250.00	345.00	26.68
345.00	400.00	26.71

4.3 Nonconformities

None.

5 Results

5.1 Structure of result presentation

The nine tilt test specimens were selected within the interval 200–400 m from the total of about 800 m of drill core material from borehole KFM09A (c. 7–799.67 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.

The results from the different measurements were inserted into Excel spreadsheets (Input data). Excel then calculated the different parameters which are exposed in other Excel sheets (Output data). 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.

5.2 Results from borehole KFM09A presented in a table and in parameter plots versus depth

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 respective joint sets. All results from borehole KFM09A are presented together in the plots. Table 5-1 presents the arithmetic mean values of these parameters together with a summary of the tilt tests and profiling.

Table 5-1. Borehole KFM09A. Arithmetic mean of JRC_o, JCS_o, Φ_b and Φ_r–values together with number of tilts and profiles.

Fracture set	JRC_o (tilt)	JCS_o MPa	Φ_b (°)	Φ_r (°)	Number (tilt)	Number (profiles)
Set 1	4.74	67.09	31.1	25.86	3	3
Set 2	6.03	73.84	31.7	26.75	3	3
Set 3	6.46	88.23	30.6	27.35	3	3
Mean/Total	5.80	76.39	31.1	26.70	9	9

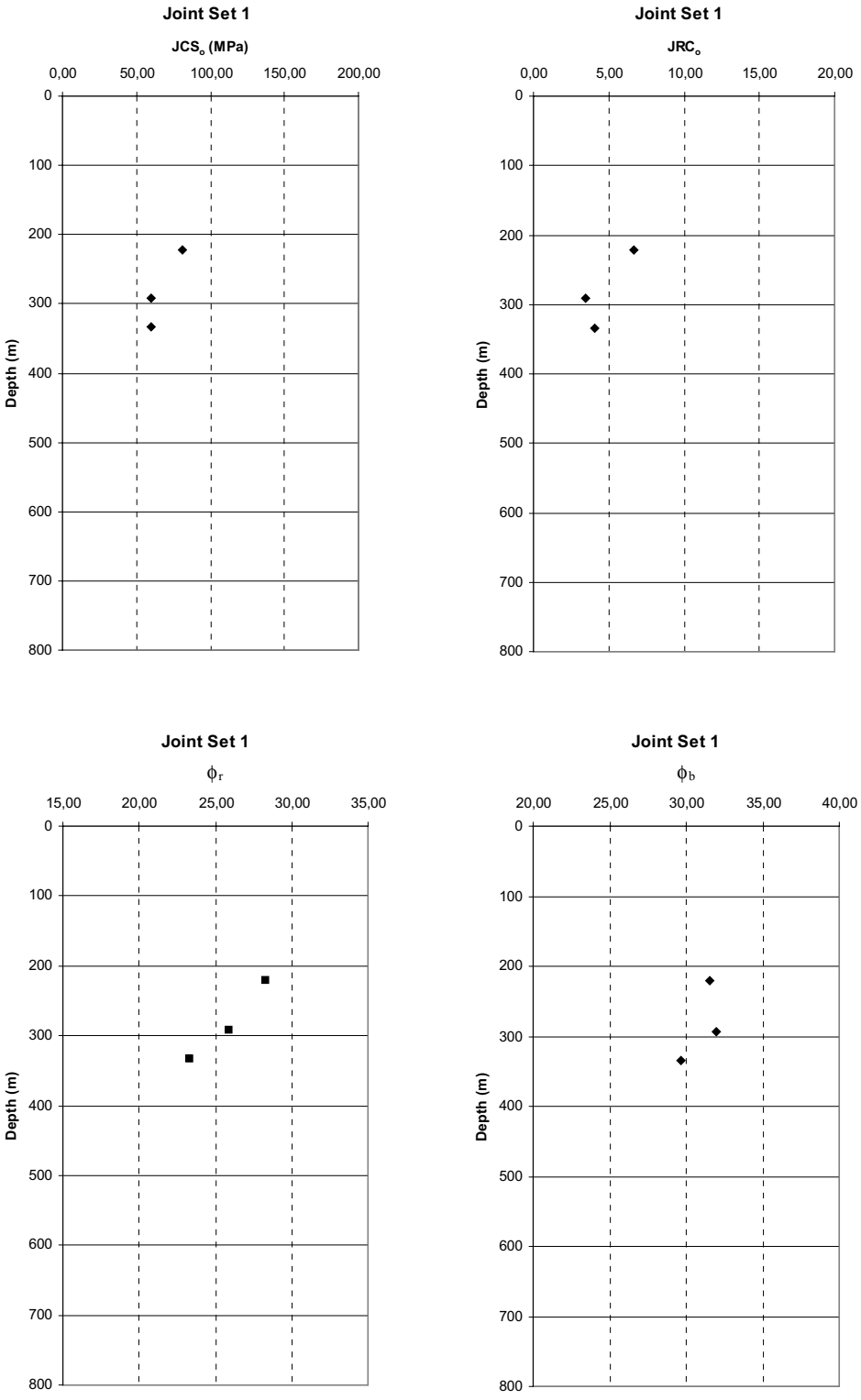

Figure 5-1. *Variation of joint parameters with depth for Set 1.*

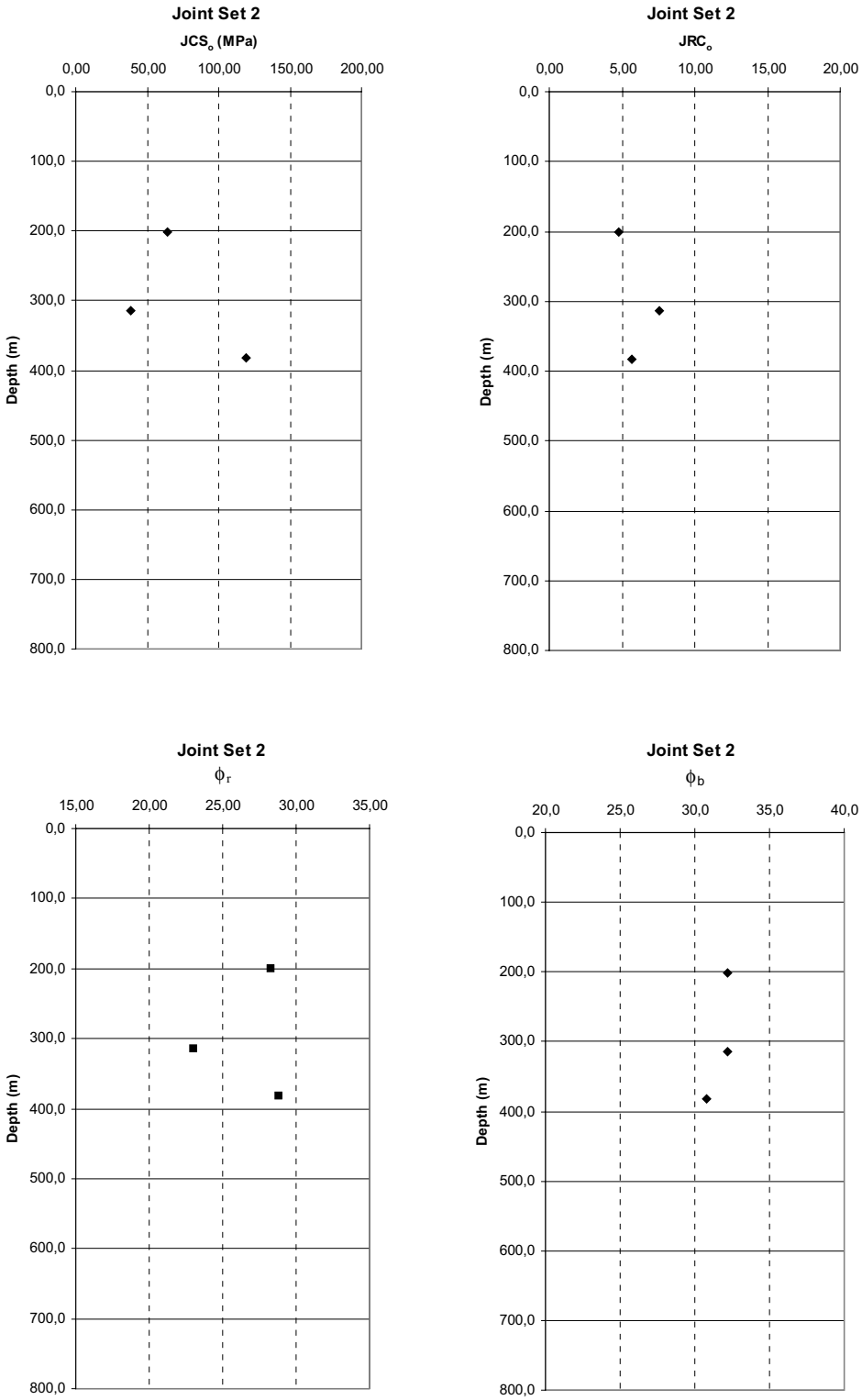

Figure 5-2. *Variation of joint parameters with depth for Set 2.*

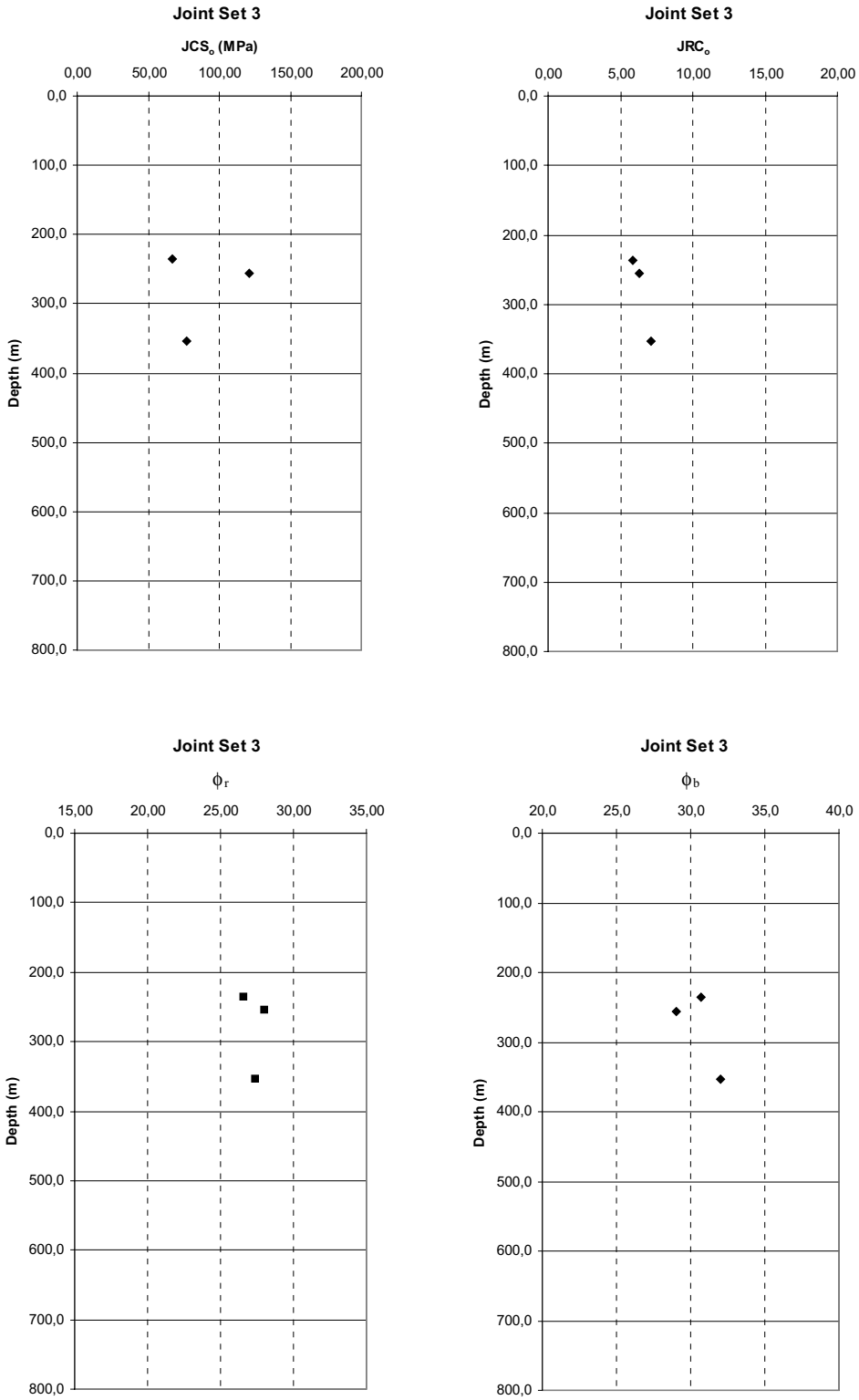

Figure 5-3. *Variation of joint parameters with depth for Set 3.*

5.3 Discussion

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 dimension for such tests is 100 mm, i.e. L_{100}. In terms of uncertainty level, the small number of tests for this borehole must also be 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 consider 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 3.4 and 7.6. This means that the sample selection for tilt testing is representative for borehole KFM09A.

Appendix A

The main results from tilt testing

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

	PAGE 1
Operator:	PC
Date:	15/12/2005
Borehole:	KFM09A

INPUT DATA Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[alljoints KFM09A.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 1	221,346	Sicada	2,1	81,7	147,90	37,6	70,2	38,4	45,8	31,5	26,65
2	set 2	200,568	Sicada	1,5	67,7	164,20	30,7	55,0	33,9	42,1	32,2	26,65
3	set 3	236,180	Sicada	2,6	53,0	160,00	22,8	59,5	34,8	43,7	30,7	26,65
4	set 1	292,748	Sicada	2,3	108,3	195,50	55,7	45,0	32,6	46,8	32,0	26,68
5	set 2	313,971	Sicada	2,0	66,3	187,50	30,8	65,5	24,6	45,2	32,2	26,68
6	set 3	259,655	Sicada	1,2	47,0	153,70	21,4	66,3	45,7	48,0	29,0	26,68
7	set 1	333,981	Sicada	2,8	108,3	295,50	53,8	45,2	32,8	48,0	29,7	26,68
8	set 2	382,745	Sicada	2,1	59,7	160,10	26,5	63,0	45,4	50,2	30,8	26,71
9	set 3	353,266	Sicada	1,4	48,0	137,90	22,7	70,8	37,1	48,4	32,0	26,71
			Arithmetic av	2,0	71,1	178,0	33,6	60,1	36,1	46,5	31,1	26,7
			minimum val	1,2	47,0	137,9	21,4	45,0	24,6	42,1	29,0	26,7
			maximum va	2,8	108,3	295,5	55,7	70,8	45,7	50,2	32,2	26,7

ROCK JOINT CHARACTERISATION TESTED

CLIENT: SKB- Tilt tests

	PAGE 3
Operator:	PC
Date:	15.12.2005
Borehole:	KFM09A

OUTPUT DATA Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[alljoints KFM09A.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	221,346	81,39	4,43E-05	28,3	6,69	1,22	6,51	78,15
2	set 2	200,568	63,83	1,73E-04	28,3	4,79	1,48	4,62	60,35
3	set 3	236,180	67,01	1,77E-04	26,6	5,89	1,89	5,47	59,89
4	set 1	292,748	59,62	1,72E-04	25,9	3,44	0,92	3,46	60,11
5	set 2	313,971	38,58	1,03E-04	23,1	7,61	1,51	7,15	35,13
6	set 3	259,655	121,05	1,14E-04	28,0	6,35	2,13	5,77	104,84
7	set 1	333,981	60,27	2,67E-04	23,4	4,08	0,92	4,11	60,86
8	set 2	382,745	119,11	1,22E-04	28,9	5,70	1,68	5,37	109,05
9	set 3	353,266	76,21	6,44E-05	27,3	7,16	2,08	6,44	65,10
		Arithmetic av.	76,34	1,37E-04	26,65	5,75	1,54	5,43	70,39
		maximum val.	121,05	2,67E-04	28,87	7,61	2,13	7,15	109,05
		minimum val.	38,58	4,43E-05	23,07	3,44	0,92	3,46	35,13

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	15/12/2005
Borehole:	KFM09A

INPUT DATA

Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[set 1 KFM09A.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 NUMBEF (r)	ROCK REBOUND NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m^3)
1	set 1	221,346	Sicada	2,1	81,7	147,90	37,6	70,2	38,4	45,8	31,5	26,65
2	set 1	292,748	Sicada	2,3	108,3	195,50	55,7	45,0	32,6	46,8	32,0	26,68
3	set 1	333,981	Sicada	2,8	108,3	295,50	53,8	45,2	32,8	48,0	29,7	26,68
			Arithmetic av	2,4	99,4	213,0	49,0	53,5	34,6	46,9	31,1	26,7
			minimum val	2,1	81,7	147,9	37,6	45,0	32,6	45,8	29,7	26,7
			maximum va	2,8	108,3	295,5	55,7	70,2	38,4	48,0	32,0	26,7

ROCK JOINT CHARACTERISATION

TESTED

CLIENT: SKB- Tilt tests

PAGE 3	
Operator:	PC
Date:	15/12/2005
Borehole:	KFM09A

OUTPUT DATA

Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[set 1 KFM09A.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	221,346	81,39	4,43E-05	28,3	6,69	1,22	6,51	78,15
2	set 1	292,748	59,62	1,72E-04	25,9	3,44	0,92	3,46	60,11
3	set 1	333,981	60,27	2,67E-04	23,4	4,08	0,92	4,11	60,86
		Arithmetic av.	67,09	1,61E-04	25,86	4,74	1,02	4,69	66,37
		maximum val.	81,39	2,67E-04	28,27	6,69	1,22	6,51	78,15
		minimum val.	59,62	4,43E-05	23,37	3,44	0,92	3,46	60,11

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

	PAGE 1	
	Operator:	PC
	Date:	15/12/2005
	Borehole:	KFM09A

INPUT DATA

Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[set 2 KFM09A.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	200,568	Sicada	1,5	67,7	164,20	30,7	55,0	33,9	42,1	32,2	26,65
2	set 2	313,971	Sicada	2,0	66,3	187,50	30,8	65,5	24,6	45,2	32,2	26,68
3	set 2	382,745	Sicada	2,1	59,7	160,10	26,5	63,0	45,4	50,2	30,8	26,71
			Arithmetic av	1,9	64,6	170,6	29,3	61,2	34,6	45,8	31,7	26,7
			minimum val	1,5	59,7	160,1	26,5	55,0	24,6	42,1	30,8	26,7
			maximum va	2,1	67,7	187,5	30,8	65,5	45,4	50,2	32,2	26,7

ROCK JOINT CHARACTERISATION

TESTED

CLIENT: SKB- Tilt tests

	PAGE 3	
	Operator:	PC
	Date:	15/12/2005
	Borehole:	KFM09A

OUTPUT DATA

Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[set 2 KFM09A.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 2	200,568	63,83	1,73E-04	28,3	4,79	1,48	4,62	60,35
2	set 2	313,971	38,58	1,03E-04	23,1	7,61	1,51	7,15	35,13
3	set 2	382,745	119,11	1,22E-04	28,9	5,70	1,68	5,37	109,05
		Arithmetic av.	73,84	1,32E-04	26,75	6,03	1,55	5,71	68,18
		maximum val.	119,11	1,73E-04	28,87	7,61	1,68	7,15	109,05
		minimum val.	38,58	1,03E-04	23,07	4,79	1,48	4,62	35,13

ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

	PAGE 1	
	Operator:	PC
	Date:	15/12/2005
	Borehole:	KFM09A

INPUT DATA

Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[set 3 KFM09A.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 3	236,180	Sicada	2,6	53,0	160,00	22,8	59,5	34,8	43,7	30,7	26,65
2	set 3	259,655	Sicada	1,2	47,0	153,70	21,4	66,3	45,7	48,0	29,0	26,68
3	set 3	353,265	Sicada	1,4	48,0	137,90	22,7	70,8	37,2	48,4	32,0	26,71
			Arithmetic av	1,7	49,3	150,5	22,3	65,5	39,2	46,7	30,6	26,7
			minimum val	1,2	47,0	137,9	21,4	59,5	34,8	43,7	29,0	26,7
			maximum va	2,6	53,0	160,0	22,8	70,8	45,7	48,4	32,0	26,7

ROCK JOINT CHARACTERISATION

TESTED

CLIENT: SKB- Tilt tests

	PAGE 3	
	Operator:	PC
	Date:	15/12/2005
	Borehole:	KFM09A

OUTPUT DATA

Depth zone: 0.00 - 799.67 m

F:\p\2003\10\20031089\Reports\Rap KFM09A\[set 3 KFM09A.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 3	236,180	67,01	1,77E-04	26,6	5,89	1,89	5,47	59,89
2	set 3	259,655	121,05	1,14E-04	28,0	6,35	2,13	5,77	104,84
3	set 3	353,265	76,63	6,44E-05	27,4	7,15	2,08	6,44	65,47
		Arithmetic av.	88,23	1,18E-04	27,35	6,46	2,03	5,89	76,73
		maximum val.	121,05	1,77E-04	28,04	7,15	2,13	6,44	104,84
		minimum val.	67,01	6,44E-05	26,63	5,89	1,89	5,47	59,89