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## **Oskarshamn site investigation**

### **Borehole KLX04A**

### **Tilt testing**

Panayiotis Chryssanthakis  
Norwegian Geotechnical Institute

October 2004

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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.

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## Summary

The Norwegian Geotechnical Institute (NGI) has carried out tilt testing on joint surfaces of drill cores from borehole KLX04A at Simpevarp, in October 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 6.0. The mean value of the joint wall compressive strength ( $JCS_o$ ) from Schmidt hammer testing of all the joint samples is 62.4 MPa. The mean values of the basic friction angle ( $\Phi_b$ ) and residual ( $\Phi_r$ ) friction angles of all the tested samples are 31.4 and 25.2 degrees respectively.

# Sammanfattning

Norges Geotekniska Institut (NGI) har gjort s k tilttester på öppna sprickor i borrhäror från borrhål KLX04A i Simpevarp i oktober 2004. Utifrån en sammanlagd borrhörnelängd på ca 900 m utvaldes 18 prover för tilttester på tre sprickgrupper.

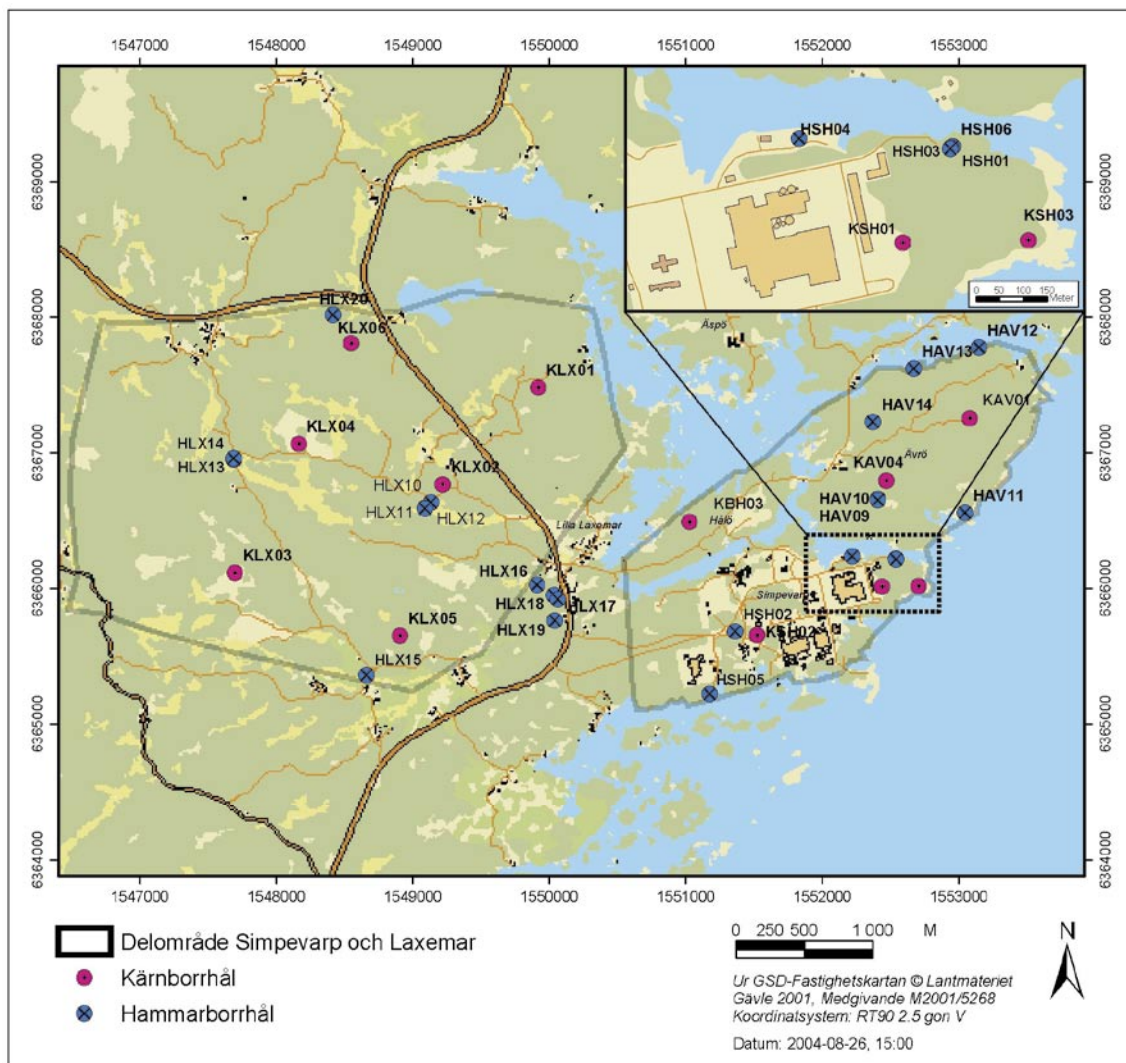
Resultaten är relativt enhetliga för samtliga sprickor och uppvisar inga stora variationer. Medelvärdet för råhetskoefficienten,  $JRC_0$ , för alla sprickor är 6,0. För sprickväggens tryckhållfasthet,  $JCS_0$ , som uppmättes med Schmidthammarmprovning, uppgår medelvärdet till 62,4 MPa. Medelvärdet för basfriktionsvinkeln ( $\Phi_b$ ) och residualfriktionsvinkeln ( $\Phi_r$ ) beräknat utifrån alla testade prover, är 31,4 respektive 25,2 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 KLX04A at Simpevarp, see Figure 1-1, according to SKB activity plan AP PS 400-04-078, version 1.0 (SKB internal controlling document). The work has been carried out by Panayiotis Chryssanthakis and Pawel Jankowski in October 2004, in accordance with SKB's method description MD 190.006, version 1.0 (SKB internal controlling document).



Figur 1-1. Simpevarp investigation area.

## 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.

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 (FN 507).

**Table 2-1. Total number of tilt tests.**

Borehole	Tilt tests	No of joint sets
KLX04A	18	3

### 3 Equipment and methods

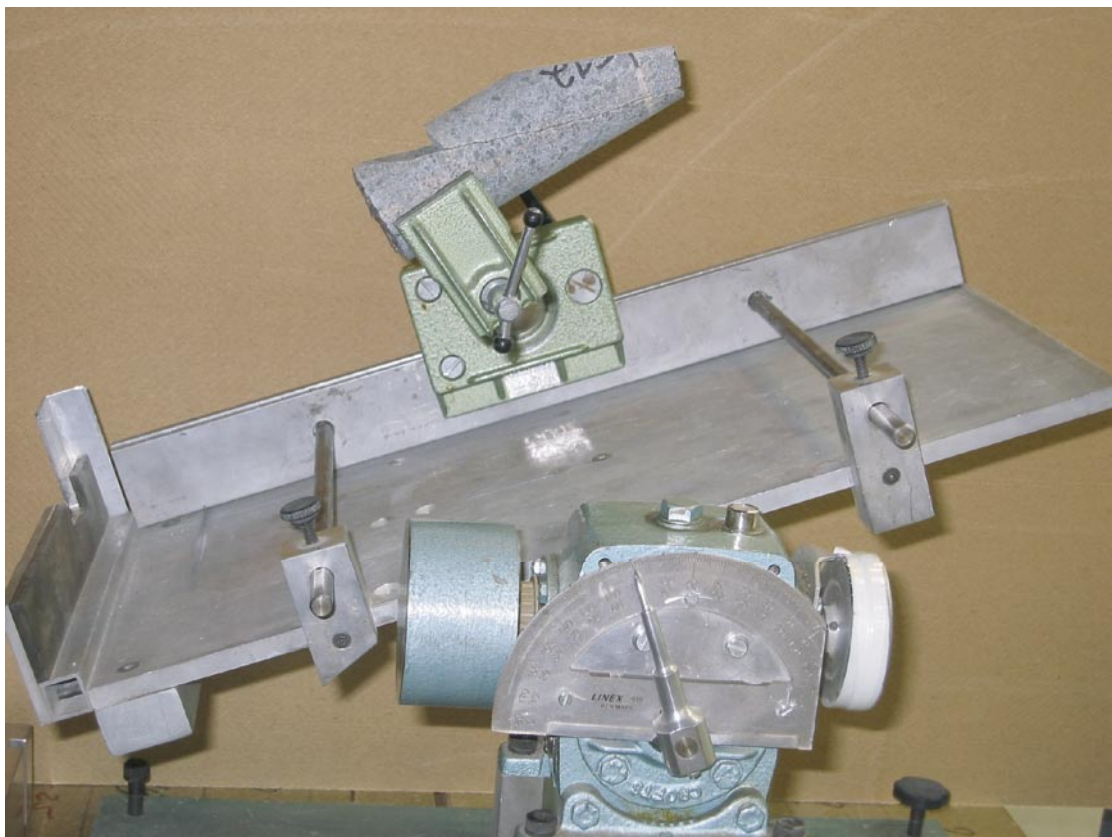
The tilt angles ( $\alpha$  and  $\Phi_b$ ) are measured by a simple tilt apparatus, see Figure 3-1.

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 ( $\alpha$ ) 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 metres in the depth range between 200 m and 600 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 some veins of quartz monzodiorite and fine grained granitoid. 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 KLX04A 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  $\alpha$  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  $\Phi_b$  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 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 0.01 g. 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 2,646–2,722 g/cm<sup>3</sup>. In the calculations the densities listed in Table 4-2 have been used.

**Table 4-2. Depth ranges in borehole KLX04A with the relevant unit weight used.**

Depth interval m	m	Unit weight kN/m <sup>3</sup>
200.00	305.13	26.70
305.13	402.18	26.46
402.18	504.45	27.01
504.45	600.00	27.22

### **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 KLX04A in the depth range between 200 m and 600 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 KLX04A

In the depth range 200–600 m from borehole KLX04A, 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  $JCS_o$ ,  $JRC_o$ ,  $\Phi_r$  and  $\Phi_b$  versus depth for each of the three joint sets respectively. All the results from borehole KLX04A 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  $JCS_o$ ,  $JRC_o$ ,  $\Phi_r$  and  $\Phi_b$ -values, borehole KLX04**

Fracture set	$JRC_o$ (tilt)	$JCS_o$ MPa	$\Phi_b$ (°)	$\Phi_r$ (°)	Number (tilt)	Number (profiles)
Set 1	6.89	61.80	31.5	25.28	6	6
Set 2	5.78	58.95	31.4	24.61	6	6
Set 3	5.26	66.34	31.4	25.75	6	6
Mean/Total	5.98	62.36	31.4	25.21	18	18

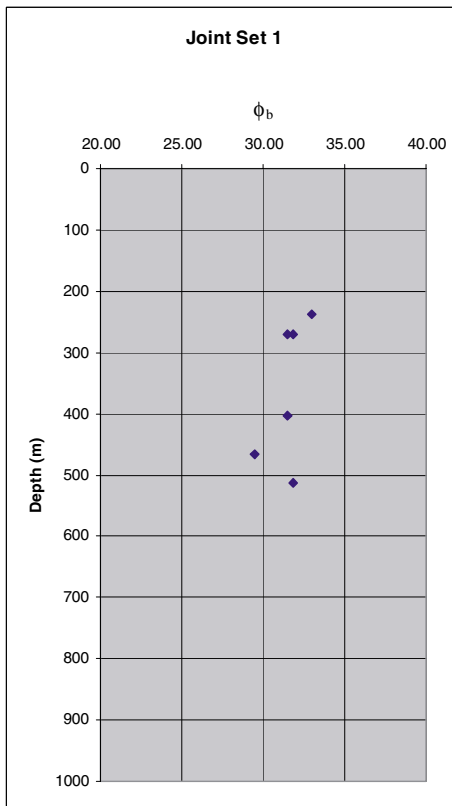
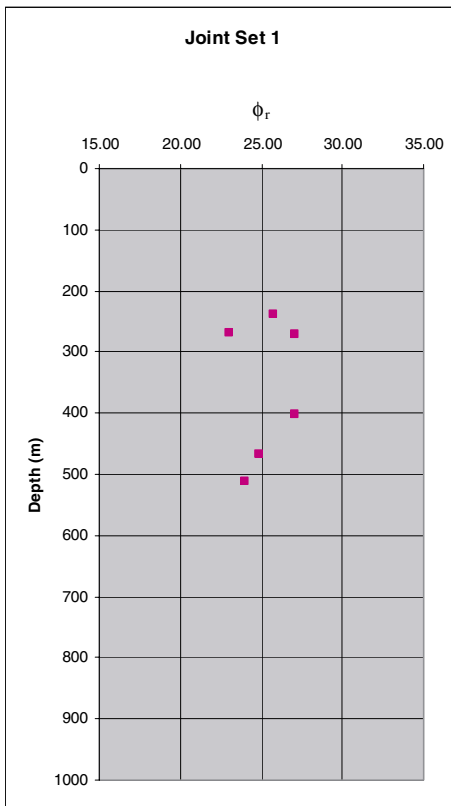
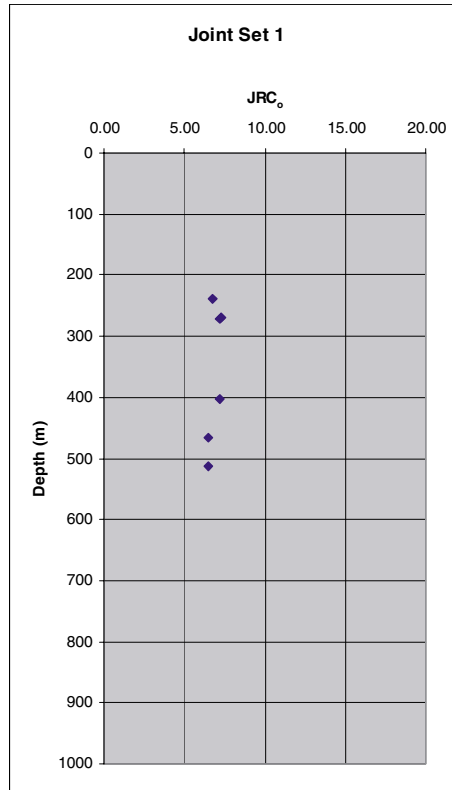
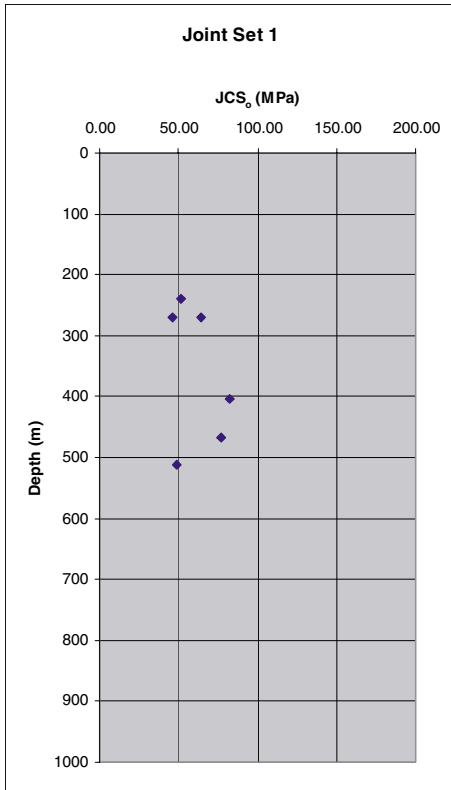
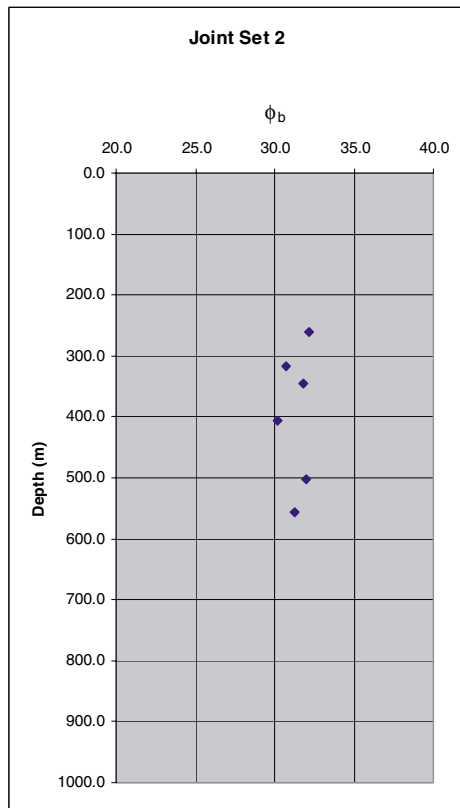
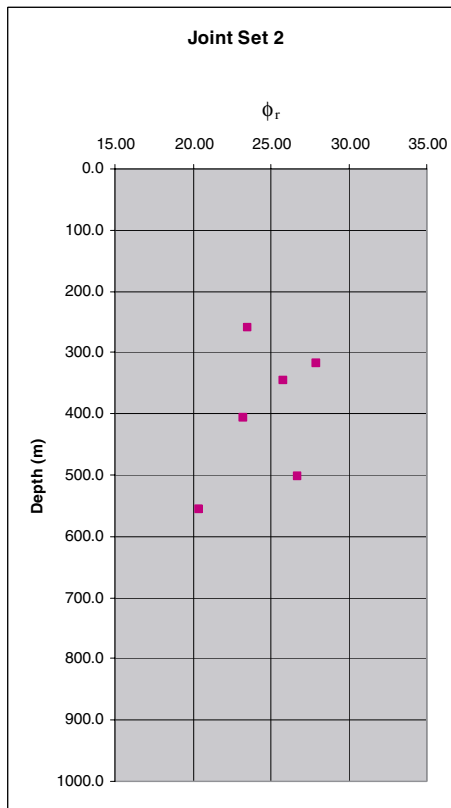
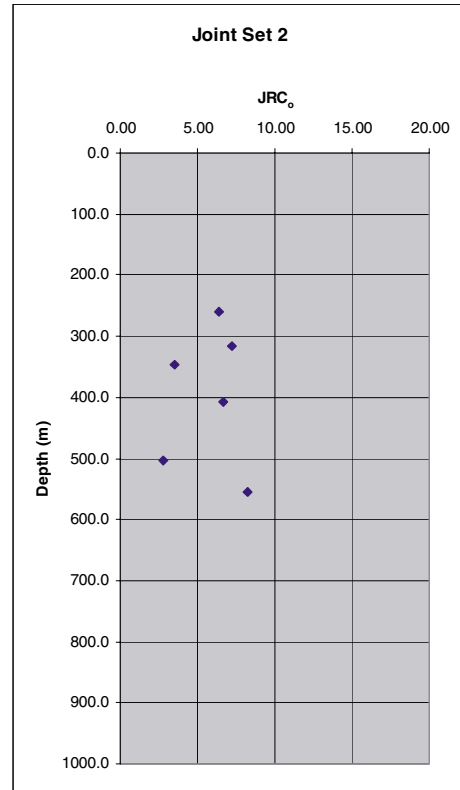
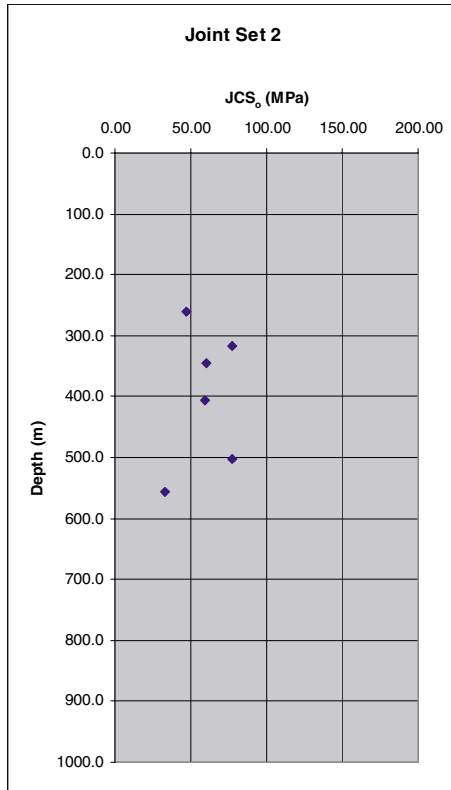
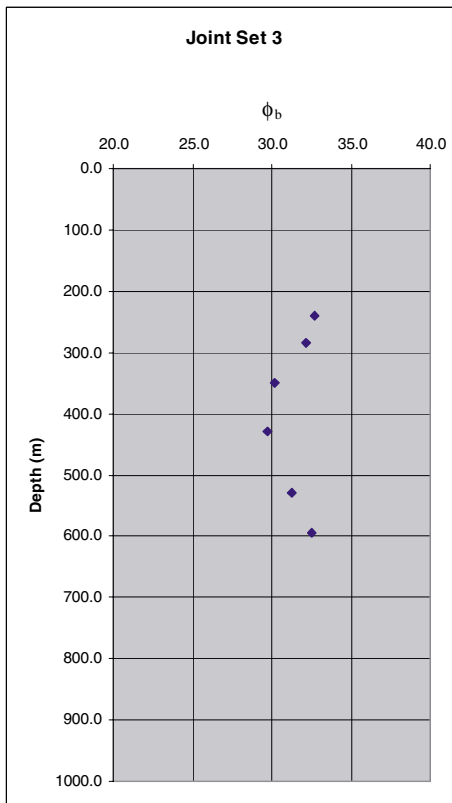
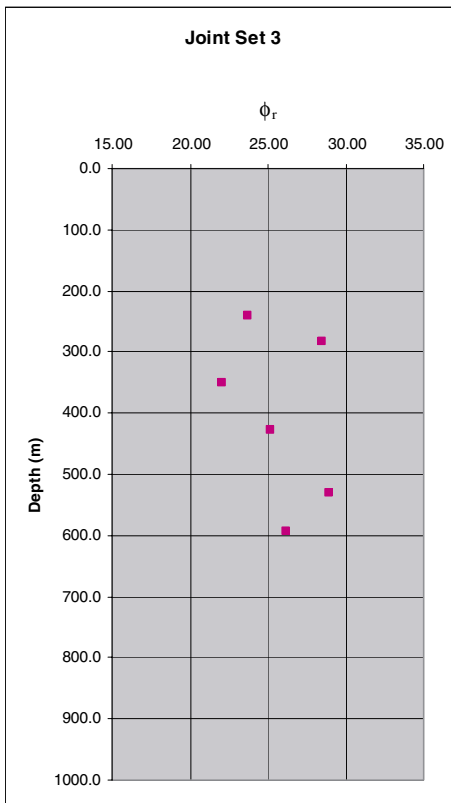
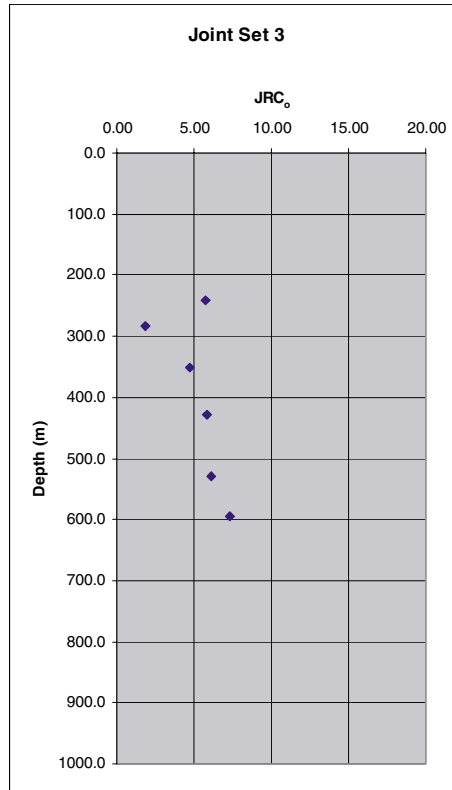
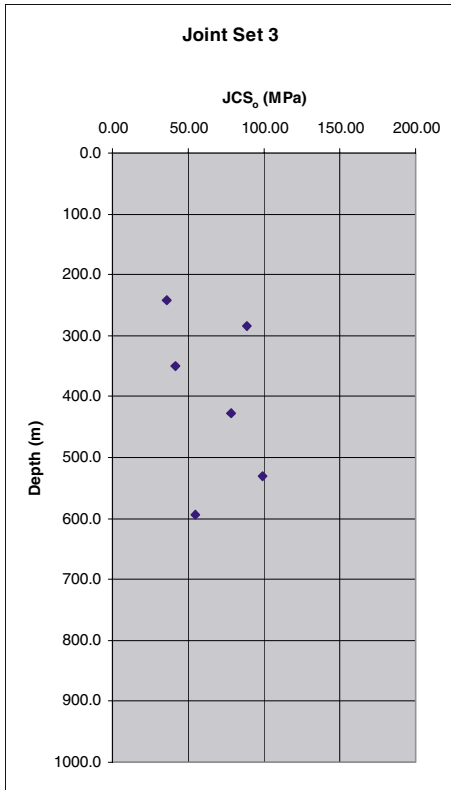


Figure 5-1. Variation of joint parameters with depth for Set 1.



**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 1.8 and 8.2. This means that the sample selection for tilt testing is representative for borehole KLX04A.

## The main results from tilt testing

ROCK JOINT CHARACTERISATION											PAGE 1	
CLIENT: SKB- Tilt tests											Operator:	PC
INPUT DATA											Date:	2004-10-12
Depth zone: 100.3 - 993.5 m											Borehole:	KLX04
SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT		MASS m (g)	AREA A (cm <sup>2</sup> )	MEAN TILT ANGLE (°)	JOINT REBOUND NUMBER (r)	ROCK REBOUND NUMBER (R)	BASIC FRICTION ANGLE (°)	#SAKNASI ROCK UNIT WEIGHT (kN/m <sup>3</sup> )
				AMP. a (mm)	LENG. L (mm)							
1	set 1	238,530	SICADA	4,0	137,7	343,40	66,5	64,2	30,0	47,2	33,0	26,7
2	set 2	259,772	SICADA	2,7	51,7	123,20	23,5	58,8	28,4	50,2	32,2	26,7
3	set 3	240,997	SICADA	1,4	53,3	97,00	20,7	54,2	23,0	41,8	32,7	26,7
4	set 1	269,301	SICADA	3,9	100,3	215,20	44,5	65,0	27,8	48,4	31,5	26,7
5	set 2	316,660	SICADA	2,4	76,7	180,90	33,6	72,7	37,7	43,8	30,7	26,46
6	set 3	283,729	SICADA	0,4	47,3	124,60	21,9	38,3	40,0	49,2	32,2	26,7
7	set 1	270,823	SICADA	5,8	269,3	484,60	113,1	71,5	34,0	44,6	31,8	26,7
8	set 2	345,497	SICADA	1,8	60,0	174,40	29,7	44,3	33,0	47,0	31,8	26,46
9	set 3	350,289	SICADA	1,3	44,0	129,70	20,7	46,5	26,1	44,0	30,2	26,46
10	set 1	402,692	SICADA	2,5	109,3	239,10	47,6	72,2	38,2	49,2	31,5	27,01
11	set 2	407,085	SICADA	2,1	51,0	160,60	24,5	60,2	32,0	49,0	30,2	27,01
12	set 3	428,081	SICADA	1,9	46,0	119,40	20,3	58,2	37,1	48,0	29,7	27,01
13	set 1	466,913	SICADA	4,5	139,3	125,00	56,7	65,7	36,8	47,8	29,5	27,01
14	set 2	502,937	SICADA	2,1	75,3	207,40	35,5	41,7	36,9	50,2	32,0	27,01
15	set 3	530,040	SICADA	1,0	46,3	117,30	21,8	66,0	41,2	46,8	31,3	27,22
16	set 1	511,984	SICADA	2,7	117,7	282,80	54,7	60,0	28,4	46,6	31,8	27,22
17	set 2	555,746	SICADA	2,5	63,7	139,90	29,5	67,0	21,1	46,2	31,3	27,22
18	set 3	594,462	SICADA	1,8	47,0	103,10	21,4	70,3	30,4	44,4	32,5	27,22
Arithmetic av.				2,5	85,3	187,1	38,1	59,8	32,3	46,9	31,4	26,9
minimum val.				0,4	44,0	97,0	20,3	38,3	21,1	41,8	29,5	26,5
maximum val.				5,8	269,3	484,6	113,1	72,7	41,2	50,2	33,0	27,2

ROCK JOINT CHARACTERISATION											TESTED		PAGE 3	
CLIENT: SKB- Tilt tests											Operator:	PC		
OUTPUT DATA											Date:	12.10.2004		
Depth zone: 100.3 - 993.5 m											Borehole:	KLX04		
SAMPLE No	JOINT SET NO	DEPTH (m)	JCS <sub>0</sub> (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC <sub>0</sub> AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC <sub>100°</sub> VALUES 100 mm	EXTRPL'D JCS <sub>100°</sub> VALUES 100 mm (MPa)	F:\p\2003\10\20031089\Reports\Rap KLX04[alljoints.xls]OUTPUT DATA				
1	set 1	238.530	51.87	9.59E-05	25.7	6.71	0.73	7.01	55.32					
2	set 2	259.772	47.56	1.38E-04	23.5	6.37	1.93	5.86	41.93					
3	set 3	240.997	35.51	1.57E-04	23.7	5.70	1.88	5.30	31.89					
4	set 1	269.301	46.05	8.47E-05	23.0	7.33	1.00	7.33	46.08					
5	set 2	316.660	77.24	4.67E-05	27.9	7.20	1.30	6.93	72.94					
6	set 3	283.729	89.09	3.44E-04	28.5	1.82	2.11	1.77	85.53					
7	set 1	270.823	64.40	4.23E-05	27.0	7.19	0.37	8.29	79.74					
8	set 2	345.497	60.03	2.95E-04	25.8	3.48	1.67	3.36	56.92					
9	set 3	350.289	41.47	2.91E-04	22.1	4.74	2.27	4.39	36.90					
10	set 1	402.692	82.79	4.60E-05	27.0	7.22	0.91	7.32	84.40					
11	set 2	407.085	58.97	1.59E-04	23.3	6.63	1.96	6.07	51.57					
12	set 3	428.081	77.95	1.60E-04	25.2	5.81	2.17	5.31	68.08					
13	set 1	466.913	76.68	3.66E-05	24.9	6.45	0.72	6.74	81.77					
14	set 2	502.937	77.10	3.19E-04	26.7	2.79	1.33	2.74	75.30					
15	set 3	530.040	99.29	8.73E-05	28.9	6.13	2.16	5.57	86.19					
16	set 1	511.984	49.01	1.27E-04	24.0	6.45	0.85	6.58	50.58					
17	set 2	555.746	32.77	7.10E-05	20.4	8.22	1.57	7.63	29.32					
18	set 3	594.462	54.73	5.37E-05	26.2	7.34	2.13	6.57	46.34					
Arithmetic av.			62.36	1.42E-04	25.21	5.98	1.50	5.82	60.04					
minimum val.			32.77	3.66E-05	20.43	1.82	0.37	1.77	29.32					
maximum val.			99.29	3.44E-04	28.91	8.22	2.27	8.29	86.19					

# ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	12.10.2004
Borehole:	KLX04

## INPUT DATA

Depth zone: 100.3 - 993.5 m

F:\p\2003\10\20031089\Reports\Rap KLX04\set 1 KLX04.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 <sup>2</sup> )	MEAN TILT ANGLE (°)	JOINT REBOUN NUMBER (r)	ROCK REBOUN NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m <sup>3</sup> )
1	set 1	238.530	SICADA	4.0	137.7	343.40	66.5	64.2	30.0	47.2	33.0	26.7
2	set 1	269.301	SICADA	3.9	100.3	215.20	44.5	65.0	27.8	48.4	31.5	26.7
3	set 1	270.823	SICADA	5.8	269.3	484.60	113.1	71.5	34.0	44.6	31.8	26.7
4	set 1	402.692	SICADA	2.5	109.3	239.10	47.6	72.2	38.2	49.2	31.5	27.01
5	set 1	466.913	SICADA	4.5	139.3	125.00	56.7	65.7	36.8	47.8	29.5	27.01
6	set 1	511.984	SICADA	2.7	117.7	282.80	54.7	60.0	28.4	46.6	31.8	27.22
Arithmetic av.				3.9	145.6	281.7	63.9	66.4	32.5	47.3	31.5	26.9
minimum val.				2.5	100.3	125.0	44.5	60.0	27.8	44.6	29.5	26.7
maximum val.				5.8	269.3	484.6	113.1	72.2	38.2	49.2	33.0	27.2

# ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

TESTED

PAGE 3

## OUTPUT DATA

Depth zone: 100.3 - 993.5 m

F:\p\2003\10\20031089\Reports\Rap KLX04\set 1 KLX04.xls\OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS <sub>0</sub> (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC <sub>0</sub> AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC <sub>100</sub> VALUES 100 mm	EXTRPL'D JCS <sub>100</sub> VALUES 100 mm (MPa)
1	set 1	238.530	51.87	9.59E-05	25.7	6.71	0.73	7.01	55.32
2	set 1	269.301	46.05	8.47E-05	23.0	7.33	1.00	7.33	46.08
3	set 1	270.823	64.40	4.23E-05	27.0	7.19	0.37	8.29	79.74
4	set 1	402.692	82.79	4.60E-05	27.0	7.22	0.91	7.32	84.40
5	set 1	466.913	76.68	3.66E-05	24.9	6.45	0.72	6.74	81.77
6	set 1	511.984	49.01	1.27E-04	24.0	6.45	0.85	6.58	50.58
Arithmetic av.			61.80	7.21E-05	25.28	6.89	0.76	7.21	66.31
minimum val.			46.05	3.66E-05	22.99	6.45	0.37	6.58	46.08
maximum val.			82.79	1.27E-04	27.05	7.33	1.00	8.29	84.40

# ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	12.10.2004
Borehole:	KLX04

INPUT DATA      Depth zone:      100.3 - 993.5 m

F:\p\2003\10\20031089\Reports\Rap KLX04\set 2 KLX04.xls\INPUT DATA 1

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT		MASS m (g)	AREA A (cm <sup>2</sup> )	MEAN TILT ANGLE (°)	JOINT REBOUND NUMBER (r)	ROCK REBOUND NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m <sup>3</sup> )
				AMP. a (mm)	LENG. L (mm)							
1	set 2	259.772	SICADA	2.7	51.7	123.20	23.5	58.8	28.4	50.2	32.2	26.7
2	set 2	316.660	SICADA	2.4	76.7	180.90	33.6	72.7	37.7	43.8	30.7	26.46
3	set 2	345.497	SICADA	1.8	60.0	174.40	29.7	44.3	33.0	47.0	31.8	26.46
4	set 2	407.085	SICADA	2.1	51.0	160.60	24.5	60.2	32.0	49.0	30.2	27.01
5	set 2	502.937	SICADA	2.1	75.3	207.40	35.5	41.7	36.9	50.2	32.0	27.01
6	set 2	555.746	SICADA	2.5	63.7	139.90	29.5	67.0	21.1	46.2	31.3	27.22
Arithmetic av.				2.3	63.1	164.4	29.4	57.5	31.5	47.7	31.4	26.8
minimum val.				1.8	51.0	123.2	23.5	41.7	21.1	43.8	30.2	26.5
maximum val.				2.7	76.7	207.4	35.5	72.7	37.7	50.2	32.2	27.2

# ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

TESTED

PAGE 3	
Operator:	PC
Date:	12.10.2004
Borehole:	KLX04

OUTPUT DATA      Depth zone:      100.3 - 993.5 m

F:\p\2003\10\20031089\Reports\Rap KLX04\set 2 KLX04.xls\OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS <sub>0</sub> (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC <sub>0</sub> AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC <sub>100</sub> VALUES 100 mm	EXTRPL'D JCS <sub>100</sub> VALUES 100 mm (MPa)
2	set 2	316.660	77.24	4.67E-05	27.9	7.20	1.30	6.93	72.94
3	set 2	345.497	60.03	2.95E-04	25.8	3.48	1.67	3.36	56.92
4	set 2	407.085	58.97	1.59E-04	23.3	6.63	1.96	6.07	51.57
5	set 2	502.937	77.10	3.19E-04	26.7	2.79	1.33	2.74	75.30
6	set 2	555.746	32.77	7.10E-05	20.4	8.22	1.57	7.63	29.32
Arithmetic av.			58.95	1.71E-04	24.61	5.78	1.63	5.43	54.66
minimum val.			32.77	4.67E-05	20.43	2.79	1.30	2.74	29.32
maximum val.			77.24	3.19E-04	27.91	8.22	1.96	7.63	75.30

# ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

PAGE 1	
Operator:	PC
Date:	12.10.2004

## INPUT DATA

Depth zone: 100.3 - 993.5 m

Borehole: KLX04

F:\p\2003\10\20031089\Reports\Rap KLX04\set 3 KLX04.xls\INPUT DATA 1

SAMPLE No	JOINT SET No	DEPTH (m)	ORIENT. DIP/ DIP DIR. (°)	MEAN JOINT AMP. a (mm) LENG. L (mm)		MASS m (g)	AREA A (cm <sup>2</sup> )	MEAN TILT ANGLE (°)	JOINT REBOUN NUMBER (r)	ROCK REBOUN NUMBER (R)	BASIC FRICTION ANGLE (°)	ROCK UNIT WEIGHT (kN/m <sup>3</sup> )
1	set 3	240.997	SICADA	1.4	53.3	97.00	20.7	54.2	23.0	41.8	32.7	26.7
2	set 3	283.729	SICADA	0.4	47.3	124.60	21.9	38.3	40.0	49.2	32.2	26.7
3	set 3	350.289	SICADA	1.3	44.0	129.70	20.7	46.5	26.1	44.0	30.2	26.46
4	set 3	428.081	SICADA	1.9	46.0	119.40	20.3	58.2	37.1	48.0	29.7	27.01
5	set 3	530.040	SICADA	1.0	46.3	117.30	21.8	66.0	41.2	46.8	31.3	27.22
6	set 3	594.462	SICADA	1.8	47.0	103.10	21.4	70.3	30.4	44.4	32.5	27.22
Arithmetic av.				1.3	47.3	115.2	21.1	55.6	33.0	45.7	31.4	26.9
minimum val.				0.4	44.0	97.0	20.3	38.3	23.0	41.8	29.7	26.5
maximum val.				1.9	53.3	129.7	21.9	70.3	41.2	49.2	32.7	27.2

# ROCK JOINT CHARACTERISATION

CLIENT: SKB- Tilt tests

TESTED

PAGE 3

Operator:	PC
Date:	12.10.2004

## OUTPUT DATA

Depth zone: 100.3 - 993.5 m

Borehole: KLX04

F:\p\2003\10\20031089\Reports\Rap KLX04\set 3 KLX04.xls\OUTPUT DATA

SAMPLE No	JOINT SET NO	DEPTH (m)	JCS <sub>0</sub> (MPa)	NORMAL STRESS (MPa)	RESIDUAL FRICTION ANGLE (°)	JRC <sub>0</sub> AT JOINT LENGTH	100mm DIVIDED BY JOINT LENGTH TESTED	EXTRPL'D JRC <sub>100</sub> -VALUES 100 mm	EXTRPL'D JCS <sub>100</sub> -VALUES 100 mm (MPa)
1	set 3	240.997	35.51	1.57E-04	23.7	5.70	1.88	5.30	31.89
2	set 3	283.729	89.09	3.44E-04	28.5	1.82	2.11	1.77	85.53
3	set 3	350.289	41.47	2.91E-04	22.1	4.74	2.27	4.39	36.90
4	set 3	428.081	77.95	1.60E-04	25.2	5.81	2.17	5.31	68.08
5	set 3	530.040	99.29	8.73E-05	28.9	6.13	2.16	5.57	86.19
6	set 3	594.462	54.73	5.37E-05	26.2	7.34	2.13	6.57	46.34
Arithmetic av.			66.34	1.82E-04	25.75	5.26	2.12	4.82	59.16
minimum val.			35.51	5.37E-05	22.06	1.82	1.88	1.77	31.89
maximum val.			99.29	3.44E-04	28.91	7.34	2.27	6.57	86.19