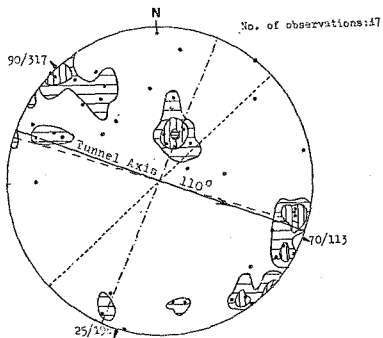


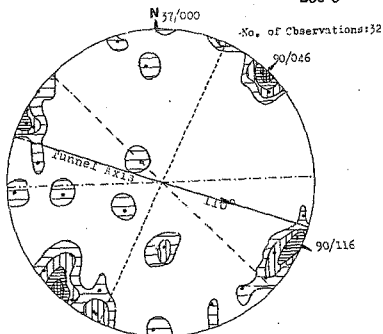
Bos 5



PERCENT OF POLES

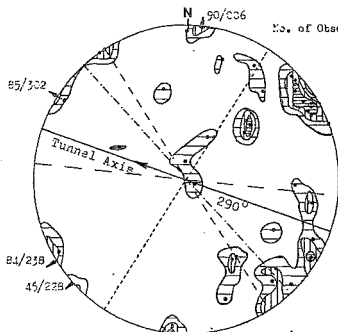


Bos 6



Bos 7

No. of Observations: 38

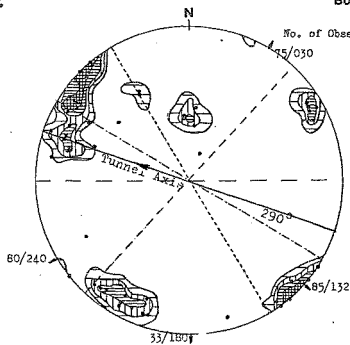


PERCENT OF POLES



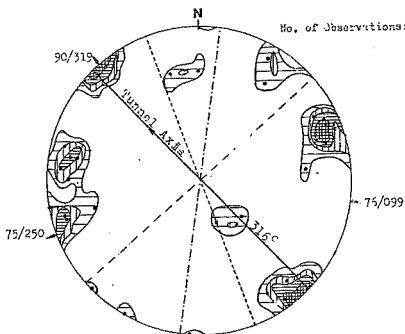
Bos 8

No. of Observations: 50



Bos 9

No. of Observations: 34

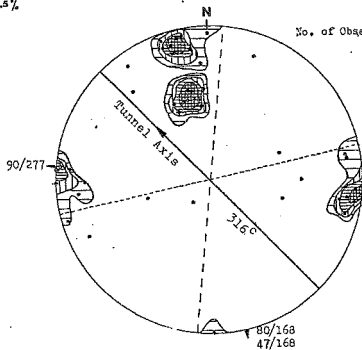


PERCENT OF POLES



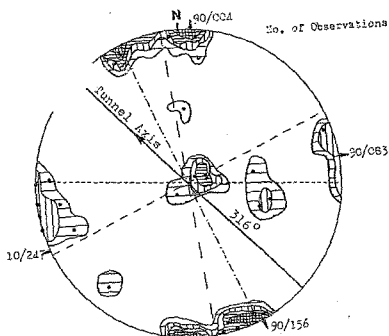
Bos 10

No. of Observations: 43



Bos 11

No. of Observations: 32

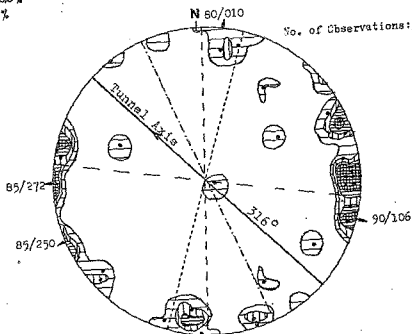


PERCENT OF POLS-

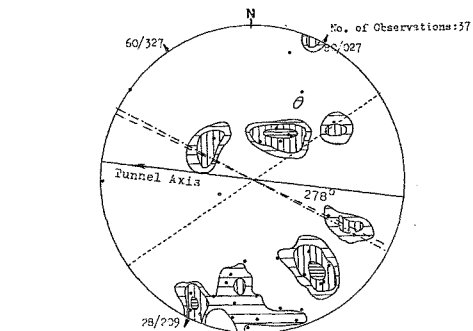
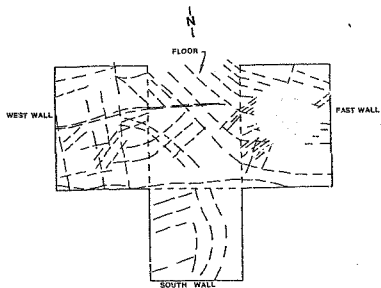


Bos 12

No. of Observations: 35

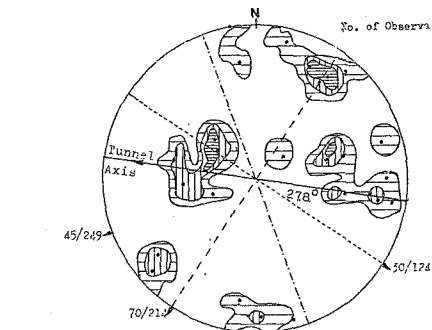
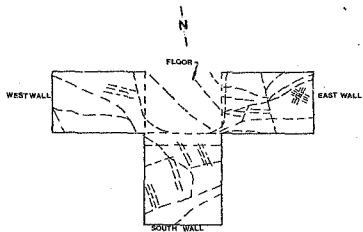


Dut 1

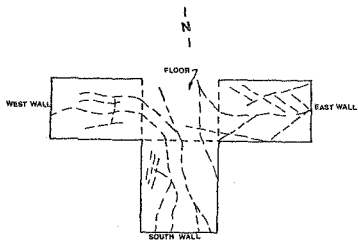
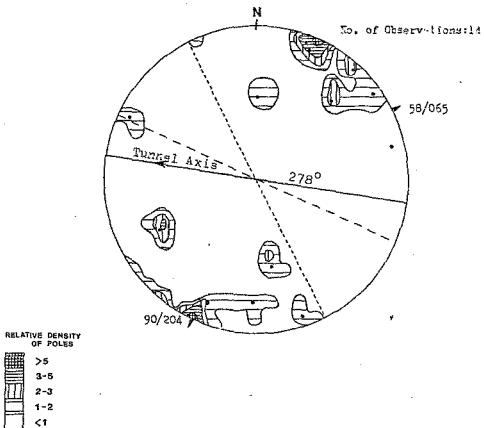
RELATIVE DENSITY
OF POL'S

Dut 2

No. of Observations: 27

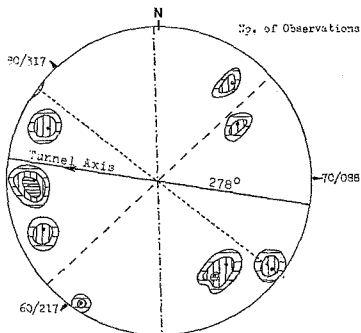
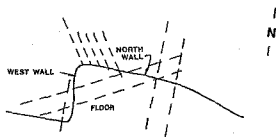
RELATIVE DENSITY
OF POLES

Dut 3



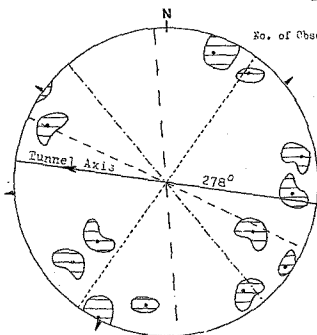
Dut 4

No. of Observations: 10

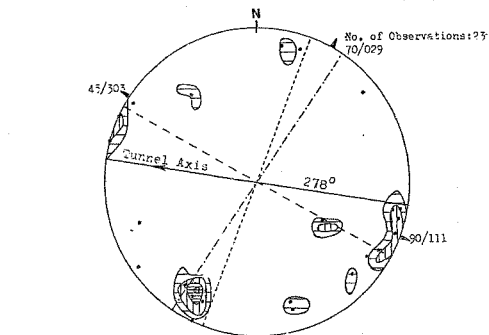
RELATIVE DENSITY
OF POLES

Dut 5

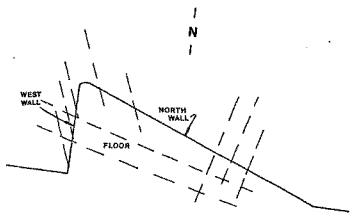
No. of Observations: 12

RELATIVE DENSITY
OF POLES > 1
 < 1

Dut 6

RELATIVE DENSITY
OF POLES

>8
5-8
3-5
2-3
<2



APPENDIX IV

POINT LOAD STRENGTH TEST RESULTS

POINT LOAD STRENGTH INDEX TEST RESULTSProject: BUSHKOPPIES TUNNEL

BOREHOLE NUMBER	NUMBER OF SPECIMENS TESTED	Is(54) MEAN	Is(54) MEDIAN	U.C.S.(MPa) 24Is(54)	UNIAXIAL TEST RESULTS*	
					No. of Tests	U.C.S. (MPa)
Bos. 1	4	4,5	4,2	101	2	334,4
Bos. 2						
Bos. 3	3	2,5	2,5	60		
Bos. 4	6	12,7	13,8	331		
Bos. 5	3	3,8	4,1	98	2	278,3
Bos. 6						
Bos. 7	5	12,9	12,8	307		
Bos. 8	6	12,4	12,2	293		
Bos. 9	4	9,5	9,8	235	2	477,2
Bos. 10	2	2,75	2,75	66		
Bos. 11						
Bos. 12						

* - A.B.A. BRINK AND ASSOCIATES

POINT LOAD STRENGTH INDEX TEST RESULTSProject: DELVERS TUNNEL

BOREHOLE NUMBER	NUMBER OF SPECIMENS TESTED	Is(54) MEAN	Is(54) MEDIAN	U.C.S. (MPa) 24Is(54)	UNIAXIAL TEST RESULTS	
					No. of Tests	U.C.S. (MPa)
Del. 1	5	1,0	1,0	24		
Del. 2	11	2,8	2,2	53		
Del. 3	13	0,9	0,8	19		
Del. 4	10	6,1	6,3	151		
Del. 5	6	1,5	1,0	24		
Del. 6	9	1,7	1,6	38		

POINT LOAD STRENGTH INDEX TEST RESULTS

Project: DU TOITSKLOOF TUNNEL

BOREHOLE NUMBER	NUMBER OF SPECIMENS TESTED	Is(54) MEAN	Is(54) MEDIAN	U.C.S.(MPa) 24Is(54)	UNIAXIAL TEST RESULTS*	
					No. of Tests	U.C.S. (MPa)
Dut. 1-H	12	8,2	7,3	175	1	299
Dut. 1-V	5	5,7	4,2	101		
Dut. 2-H	12	4,8	4,2	101	3	85
Dut. 2-V	8	3,7	3,8	91		
Dut. 3-V	7	1,4	1,5	36		
Dut. 4-H	12	1,3	1,2	29		
Dut. 4-V	8	1,4	1,3	31		
Dut. 5-V	2	1,9	1,9	46		
Dut. 6-H	11	5,7	6,5	156		
Dut. 6-V	7	7,2	6,9	166		

* - VAN NIEKERK, KLEYN & EDWARDS

APPENDIX V

RESULTS OF THE STEPS FOR EVALUATING
THE BOREHOLE CORE MEASUREMENTS

THE NUMBER OF JOINTS WITH SIMILAR INCLINATION
ANGLES RECORDED IN EACH BOREHOLE

Project: BUSHKOPPIES TUNNEL

STEP 1

BOREHOLE NUMBER	α°	0	10	20	30	40	50	60	70	80	90	TOTAL CORRECTED JOINTS
	$1/\sin \alpha$	∞	5,77	2,92	2,0	1,56	1,31	1,15	1,06	1,02	1,0	
Bos 1	A	1	5	2	1	2	3	8	1	2	0	45
	B	1	17	6	2	3	4	9	1	2	0	
	C	2	38	14	4	7	9	20	2	4	0	
Bos 2	A	1	1	3	0	1	0	1	7	1	0	27
	B	1	6	9	0	2	0	1	7	1	0	
	C	4	22	33	0	7	0	4	26	4	0	
Bos 3	A	1	2	4	1	4	4	1	1	1	1	42
	B	1	12	12	2	6	5	1	1	1	1	
	C	2	29	29	5	15	12	2	2	2	2	
Bos 4	A	0	0	2	3	3	4	0	3	0	0	25
	B	0	0	6	6	5	5	0	3	0	0	
	C	0	0	24	24	20	20	0	12	0	0	
Bos 5	A	0	1	0	3	1	1	2	6	0	0	23
	B	0	6	0	6	2	1	2	6	0	0	
	C	0	26	0	26	9	4	9	26	0	0	
Bos 6	A	1	1	0	2	2	1	8	1	0	0	25
	B	1	6	0	4	3	1	9	1	0	0	
	C	4	24	0	16	12	4	36	4	0	0	
Bos 7	A	2	4	3	3	3	0	1	0	0	4	50
	B	2	23	9	6	5	0	1	0	0	4	
	C	4	46	18	12	10	0	2	0	0	8	
Bos 8	A	0	3	6	1	2	1	4	1	4	0	51
	B	0	17	18	2	3	1	5	1	4	0	
	C	0	33	35	4	6	20	10	2	8	0	
Bos 9	A	0	1	2	0	0	0	0	0	0	0	12
	B	0	6	6	0	0	0	0	0	0	0	
	C	0	50	50	0	0	0	0	0	0	0	
Bos 10	A	1	5	5	3	0	1	2	3	2	0	59
	B	1	29	15	6	0	1	2	3	2	0	
	C	2	49	26	10	0	2	3	5	3	0	
Bos 11	A	0	3	8	0	2	1	3	2	1	0	50
	B	0	17	23	0	3	1	3	2	1	0	
	C	0	34	46	0	6	2	6	4	2	0	
Bos 12	A	0	0	1	3	0	1	0	1	1	1	13
	B	0	0	3	6	0	1	0	1	1	1	
	C	0	0	23	45	0	8	0	8	8	8	

A - No. of joints recorded in the borehole.

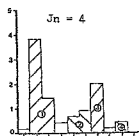
B - No. of joints corrected for intersection angle α .

C - Corrected no. of joints expressed as percentages.

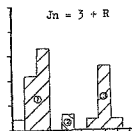
HISTOGRAMS SHOWING THE NUMBER OF JOINTS IN EACH BOREHOLE
WITH SIMILAR DIRECTIONAL ANGLES

Project: BUSHKOPPIES TUNNEL

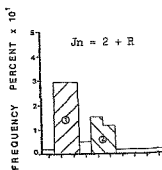
STEP 2



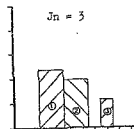
Bos 1



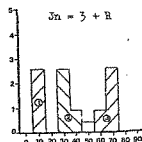
Bos 2



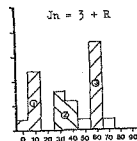
Bos 3



Bos 4



Bos 5



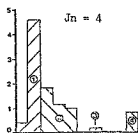
Bos 6

DIP ANGLE (degrees)

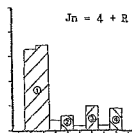
HISTOGRAMS SHOWING THE NUMBER OF JOINTS IN EACH BOREHOLE
WITH SIMILAR INCLINATION ANGLES

Project: BUSHKOPPIES TUNNEL

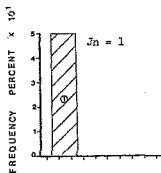
STEP 2



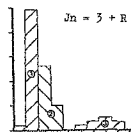
Bos 7



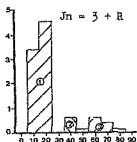
Bos 8



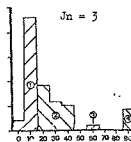
Bos 9



Bos 10



Bos 11



Bos 12

DIP ANGLE (degrees)

THE AVERAGE SPACING OF EACH JOINT SET

Project: BUSHKOPPIES TUNNEL

STEP 3

BOREHOLE NUMBER	COAL LENGTH L (m)	DIP OF JOINT SET (°)	CORRECTED JOINT NUMBER N ¹	JOINT ² SPACING L/N ¹ (m)	JOINT SPACING CATEGORY *
Bos 1	2,5	70 - 80	23	-	-
		40 - 50	7	0,3	0,05 - 0,3
		30	9	0,3	0,05 - 0,3
		10	2	1,25	1 - 3
Bos 2	8,0	70 - 80	15	-	-
		50	2	4,0	3
		10 - 30	9	0,9	0,3 - 1
Bos 3	8,0	70 - 80	24	-	-
		40 - 50	11	0,7	0,3 - 1
Bos 4	8,0	60 - 70	12	0,7	0,3 - 1
		40 - 50	10	0,8	0,3 - 1
		20	3	2,6	1 - 3
Bos 5	3,0	80	6	-	-
		50 - 60	8	0,4	1 - 3
		20 - 30	8	0,4	1 - 3
Bos 6	7,5	80 - 90	7	-	-
		50 - 60	7	1,1	1 - 3
		30	9	0,8	0,3 - 1
Bos 7	6,0	80 - 90	25	-	-
		50 - 70	20	0,3	0,3 - 1
		30	1	6,0	3
		0	4	1,5	1 - 3

*after Bieniawski

THE AVERAGE SPACING OF EACH JOINT SET

Project: BUSHKOPPIES TUNNEL

STEP 3

BOREHOLE NUMBER	CORE LENGTH L (m)	DIP OF JOINT SET (°)	CORRECTED JOINT NUMBER N ¹	JOINT SPACING L/N ¹ (m)	JOINT SPACING CATEGORY *
Bos 8	6,5	70 - 80	35	-	-
		50	3	2,2	1 - 3
		30	5	1,3	1 - 3
		10	4	1,6	1 - 3
Bos 9	8,0	70 - 80	12	0,7	0,5 - 1
Bos 10	6,5	80	29	-	-
		60 - 70	21	0,3	0,05 - 0,3
		10 - 30	7	0,9	0,3 - 1
Bos 11	4,0	70 - 80	40	-	-
		50	3	1,3	1 - 3
		20 - 30	5	0,8	0,3 - 1
Bos 12	6,5	60 - 70	9	0,7	0,3 - 1
		40	1	6,5	3
		0 - 20	3	2,2	1 - 3

*after Bieniawski

THE NUMBER OF JOINTS IN EACH SET WITH SIMILAR CUTFACE ROUGHNESS AND ALTERNATION CHARACTERISTICS

Project: BUSHROPPETS TUNNEL

Data Source: MORE CORE

*MEASURED FROM CORE AXIS

STEP 4

SAMPLE SITE NUMBER	JOINT SET ANGLE (°)	SURFACE ROUGHNESS				SURFACE ALLOCATION				None or Staining only	Closed	None or Staining only	City or Rural	County or State
		Undulating		Planar		Rough		Smooth						
		Rough	Smooth	Rough	Smooth	Rough	Smooth	Rough	Smooth					
Pos 8	10 - 20	5	1	1	2	1	1	1	1	3	5			
	40									2				
	60				4	2	1	1	1		3			
Pos 9	30							4			2			
	10 - 20	3							3					
	40	5	1		1				1		4			
Pos 10	20 - 30	4	1		1	2	3	3	3	5				
	40	4			2	1	1	1	3	3				
	60 - 80										3			
Pos 11	10 - 20	1	2			8	1	1	4	6				
	40	2							2					
	60 - 70								5					
Pos 12	20 - 30	4					1	1	1	3				
	40				1		1	1						
	70 - 90				2	1			1	2				

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: MUSHOPPE'S TUNNEL			Data Source: CORE CORE		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J slip)*	REASONS FOR SELECTION OF (J slip)
Bos 1	70 - 80	Undulating and rough.	None or surface staining.		One of the most common joint sets and only one with some clay coating.
	40 - 50	Undulating/planar and rough.	None or staining only.		
	30	Planar and rough.	Clay coatings and stain.		
Bos 2	10	Undulating and rough.	Non-softening mineral coatings.	*	Most commonly recorded orientation.
	70 - 80	Planar and rough.	Closed.		
	50	Undulating and rough.	None or staining only.		
Bos 3	10 - 30	Planar and rough.	Non-softening mineral coatings.	*	One of the most common joint sets with slicken-sides and clay in fragmented sections of core.
	70 - 80	Undulating and rough.	Non-softening mineral coatings.		
	40 - 50	Planar and rough or smooth with occasional slicken-sides.	None or staining only with some clay and chlorite coatings.	*	
Bos 4	60 - 70	Undulating and rough.	None or staining.		Most commonly recorded joint set.
	40 - 50	Undulating and rough.	None or staining.		
	20	Planar and rough.	Non-softening mineral coatings.	*	
*With respect to Tunnel Stability					STEP 5

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: EUCKOPPIES TUNNEL					
Data Source: ROSE CORE					
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J sig)*	REASONS FOR SELECTION OF JOINT SET
Ros 5	80	Undulating and rough.	Closed.		
	50 - 60	Undulating and rough.	Closed.		
	20 - 30	Undulating and rough.	Closed or with softening mineral coatings.	*	Well-developed joint set with evidence of clay coatings.
Ros 6	80 - 90	Undulating/planar and rough with slickensides.	Non-softening mineral coatings.		
	50 - 60	Undulating and rough with some slickensides.	Non-softening mineral coatings.	*	Not well presented owing to vertical orientation but has poorest surface conditions.
	30	Planar and rough.	Non-softening mineral coatings and staining.		
Ros 7	80 - 90	Planar and smooth.	None or staining.		
	50 - 70	Planar and smooth.	None or staining.		
	30	Undulating and rough.	None or staining.	*	Both sets are well represented and both show some evidence of clay coatings.
Ros 8	70 - 80	Undulating and rough with occasional slickensides.	Non-softening mineral coatings and staining.		
	50	Planar and smooth with some slickensides.	None or staining.		
	30	Planar and rough with slickensides.	Non-softening mineral coatings.	*	Most frequently recorded despite low intersection angle, although not poorest surface conditions.
	10	Planar and rough.	Closed or non-softening mineral coatings.		
*With respect to Tunnel Stability					STEP 5

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: BUSHKOPPIES TUNNEL			Data Source: BORE CORE		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J set)*	REASONS FOR SELECTION OF (J set)
Bos 9	70 - 80	Undulating and rough.	Closed.	*	Only set recorded in bore core.
Bos 10	80	Undulating and rough.	Non-softening mineral coatings.		Well-developed throughout core and only set with planar surface - could also be unfavourably orientated.
	60 - 70	Undulating and rough.	Non-softening mineral coatings and closed.		
	10 - 30	Undulating and rough, also planar.	Non-softening mineral coatings and staining.	*	
Bos 11	70 - 80	Planar and smooth.	Clay or softening mineral coatings and staining.	*	Well-developed joint set with poorest surface conditions.
	50	Undulating and rough.	None or staining.		
Bos 12	20 - 30	Planar and smooth.	None or staining.		Well-developed joint set and possibly unfavourably orientated.
	60 - 70	Undulating and rough.	Non-softening mineral coatings.		
	40	Planar and rough.	Closed.	*	
	0 - 20	Planar and rough.	Non-softening mineral coatings.		
*With respect to Tunnel Stability					
STEP 5					

GEOCHEMICAL CLASSIFICATION SYSTEM - DATA FORM										
Project: MURKOPPIES TUNNEL										
Data Source: BORE CORE.										
SAMPLE NUMBER	ROCK TYPE	IMPACT ROCK STRENGTH W.C.S./P.L.S. (best)	BQD %	GROUND WATER	JOINT DESCRIPTION				JOINT ORIENTATION	
					Top (ft)	Spacing (ft)	Continuity	Condition	Joint Roughness	Joint Orientation
Bos 1	LAVA		4,2	0 Moist	40-50 30 10	0,05-0,3 0,05-0,3 1,0-3,0	-	0,1-1 0,1-1 1-5	Hard Rough Rough	Pair Hard Unfav.
Bos 2	LAVA	334		95 Moist	70-80 50 10-30	> 3,0 0,3-1,0	-	< 0,1 0,1-1 1-5	Rough Rough Rough	Pair Hard Unfav.
Bos 3	DIABASE		2,5	0 Moist	70-80 40-50	0,5-1,0	-	1-5 0,1-1	Rough Smooth	Wed. Hard Wed. Hard
Bos 4	DIABASE	13,8	80	Dry	60-70 40-50 20	0,3-1,0 0,3-1,0 1,0-3,0	-	0,1-1 0,1-1 1-5	Rough Rough Rough	Pair Hard Unfav.
Bos 5	LAVA	4,1	100	Moist	50-60 20-30	0,3-1,0 0,3-1,0	-	< 0,1 0,1-1	Rough Rough	Pair Hard
Bos 6	LAVA	278	80	Moist	80-90 50-60 30	1,0-3,0 0,3-1,0	-	0,1-1 0,1-1 0,1-1	Rough Rough Rough	Pair Hard With slicks. With slicks.
Bos 7	LAVA	12,8	10	Moist	80-90 50-70 0	0,05-0,3 1,0-3,0 1,0-3,0	-	0,1-1 0,1-1 0,1-1	Smooth Smooth Rough	Pair Hard Unfav.
Bos 8	LAVA	12,2	80	Moist	70-80 50 10	1,0-3,0 1,0-3,0 1,0-3,0	-	1-5 0,1-1 1-5	Rough Smooth Rough	With slicks. Hard Unfav.
Bos 9	LAVA	9,8	100	Dry	70-80	0,3-1,0	-	< 0,1	Rough	Pair
Bos 10	LAVA	2,7	50	Moist	60-70 10-30	0,05-0,3 0,3-1,0	-	1-5 0,1-1 0,1-1	Rough Rough Rough	Pair Hard Unfav.

STEP 6

R.O.I. CLASSIFICATION SYSTEM - DATA FORM
 Project: EUGROPPES TUNNEL Data Source: BORE CORE.

S&S-15 SITE NUMBER	CROWN SECTION NUMBER	ROCK Type	EXCAV- ATION SPAN (m/ft)	ESR	RQD %	JOINT DATA			STRESS RELATION FACTOR	REMARKS
						Joint Number	Roughness	Alteration		
Bos 1	18.75	LAVA	2890	3.35	1.6	0	4	Planner & Rough stain & clay coating	Minor	Heavily jointed rock.
Bos 2	40.75	LAVA	2890	3.35	1.6	95	3+R	Planner & Rough Non-softening mineral coating	Minor	Low stress.
Bos 3	64.50	DIAZUR	-	3.35	1.6	0	2+R	Planner & Smooth stain with clay with siliceous & chlorite coat	Medium	Multiple shears with clay 50m.
Bos 4	64.50	DIAZUR	2890	3.35	1.6	80	3	Undulating & None or stain	Minor	Medium stress.
Bos 5	61.00	LAVA	2890	3.35	1.6	100	3+R	Undulating & Softening mineral coating	Minor	Medium stress.
Bos 6	42.50	LAVA	2890	3.35	1.6	100	3+R	Planner & Rough Non-softening with siliceous mineral coating	Minor	Single clay free shears in competent rock (< 50m).
Bos 7	27.50	LAVA	2890	2.6	1.6	100	4	Planner & smooth None or stain	Minor	Heavily jointed rock.
Bos 8	41.25	LAVA	2890	2.6	1.6	80	4+R	Undulating & Rough stain with siliceous minerals	Minor	Single clay free shears in competent rock (< 50m).
Bos 9	48.50	LAVA	2890	2.6	1.6	100	1	Undulating & Closed	Dry	Medium stress.
Bos 10	32.00	LAVA	2890	2.6	1.6	50	3+R	Planner & Rough stain & non-softening minerals	Minor	Single clay free shears in competent rock (< 50m).
Bos 11	21.50	LAVA	2890	2.6	1.6	15	3+R	Planner & Rough stain & occ. clay coatings	Minor	Single clay free shears in competent rock (< 50m).
Bos 12	4.5	LAVA	2890	2.6	1.6	80	3	Planner & Rough Non-softening clay	Minor	Low stress.

STEP 6

N.G.I. CLASSIFICATION SYSTEM - CALCULATION SHEET									
Project: SUBROCKIES TUNNEL				Data Source: BOLD COLE					
SAMPLE SITE NUMBER	CROWN DEPTH (m)	$\sigma'v$ (kPa)	CLASSIFICATION: J.W. PARAMETER RATINGS				Q	SPAN $\frac{L}{B}$	SUPPORT CATEGORY
			$\frac{RQD}{J_n}$	$\frac{J_x}{J_a}$	$\frac{J_v}{J_{sz}}$				
Pos 1	19,75	531	$\frac{10}{15} = 0,67$	$\frac{1,5}{5,0} = 0,3$	$\frac{1,0}{5,0} = 0,2$		6,07	$\frac{2,32}{1,6} = 2,1$	34
Pos 2	40,75	1143	$\frac{25}{12} = 7,92$	$\frac{1,5}{2,0} = 0,75$	$\frac{1,0}{2,5} = 0,4$		2,39	"	21
Pos 3	64,50	1829	$\frac{10}{6} = 1,67$	$\frac{0,5}{4,0} = 0,13$	$\frac{0,05}{10,0} = 0,07$		0,02	"	34
Pos 4	64,50	1829	$\frac{80}{9} = 8,89$	$\frac{1,0}{1,0} = 1,0$	$\frac{1,0}{2,0} = 0,5$		26,67	"	13
Pos 5	61,0	1729	$\frac{100}{12} = 8,33$	$\frac{1,0}{4,0} = 0,25$	$\frac{1,0}{1,0} = 1,0$		6,25	"	17
Pos 6	42,50	1199	$\frac{80}{12} = 6,67$	$\frac{0,5}{2,0} = 0,25$	$\frac{1,0}{5,0} = 0,2$		0,33	"	29
Pos 7	27,50	780	$\frac{10}{15} = 0,67$	$\frac{1,0}{1,0} = 1,0$	$\frac{1,0}{5,0} = 0,2$		0,13	$\frac{2,6}{1,6} = 1,6$	29
Pos 8	41,25	1169	$\frac{80}{15} = 5,33$	$\frac{1,5}{2,0} = 0,75$	$\frac{1,0}{5,0} = 0,2$		0,8	"	25

[illegible]

THE NUMBER OF JOINTS WITH SIMILAR INCLINATION
ANGLES RECORDED IN EACH BOREHOLE

Project: DELVERS TUNNEL

STEP 1

BOREHOLE NUMBER	α°	0	10	20	30	40	50	60	70	80	90	TOTAL CORRECTED JOINTS
	$1/\sin \alpha$	∞	5,77	2,92	2,0	1,56	1,31	1,15	1,06	1,02	1,0	
Del 1	A	1	6	0	0	1	1	2	1	16	1	59
	B	1	35	0	0	2	1	2	1	16	1	
	C	2	59	0	0	3	2	3	2	27	2	
Del 2	A	1	9	3	3	6	5	6	4	3	0	98
	B	1	52	9	6	9	7	7	4	3	0	
	C	1	54	9	6	9	7	7	4	3	0	
Del 3	A	1	0	2	3	10	26	34	24	7	5	139
	B	1	0	6	6	16	34	39	25	7	5	
	C	1	0	4	4	12	24	29	18	5	4	
Del 4	A	1	0	3	5	7	2	6	5	2	5	53
	B	1	0	9	10	11	3	7	5	2	5	
	C	2	0	17	19	21	6	13	9	4	7	
Del 5	A	0	2	5	2	1	3	8	0	4	0	50
	B	0	12	15	4	2	4	9	0	4	0	
	C	0	24	30	8	4	8	18	0	8	0	
Del 6	A	3	1	8	3	2	5	9	14	11	5	89
	B	3	6	23	6	3	7	10	15	11	5	
	C	3	7	26	7	3	8	11	17	12	6	
	A											
	B											
	C											
	A											
	B											
	C											
	A											
	B											
	C											
	A											
	B											
	C											
	A											
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	A											
	B											
	C											

A - No. of joints recorded in the borehole.

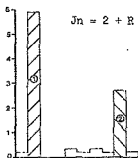
B - No. of joints corrected for intersection angle α .

C - Corrected no. of joints expressed as percentages.

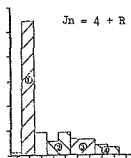
HISTOGRAMS SHOWING THE NUMBER OF JOINTS IN EACH BOREHOLE
WITH SIMILAR INCLINATION ANGLES

Project: DELVERS TUNNEL

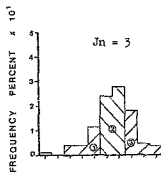
STEP 2



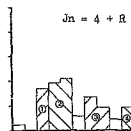
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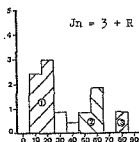
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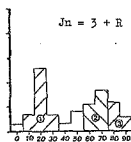
Del 3



Del 4



Del 5



Del 6

DIP ANGLE (degrees)

THE AVERAGE SPACING OF EACH JOINT SET

Project: DELVERS TUNNEL

STEP 3

BOREHOLE NUMBER	CORE LENGTH L (m)	DIP OF JOINT SET (°)	CORRECTED JOINT NUMBER N ¹	JOINT SPACING L/N ¹ (m)	JOINT SPACING CATEGORY *
Del 1	4,5	80	-	-	-
		10	26	0,173	0,05 - 0,3
Del 2	6,6	80	-	-	-
		50 - 60	15	0,44	0,3 - 1
		30 - 40	14	0,47	0,3 - 1
		10 - 20	7	0,94	0,3 - 1
Del 3	10,9	5 - 25	20	0,55	0,3 - 1
		75 - 85	52	0,21	0,05 - 0,3
		45 - 65	27	0,40	0,3 - 1
Del 4	8,1	70	-	-	-
		50 - 60	40	0,20	0,05 - 0,3
		20 - 30	22	0,37	0,3 - 1
		0	9	0,9	0,3 - 1
Del 5	4,75	70 - 80	-	-	-
		30 - 40	26	0,18	0,05 - 0,3
		10	8	0,59	0,3 - 1
Del 6	8,5	60 - 80	-	-	-
		20 - 30	28	0,30	0,05 - 0,3
		0 - 10	18	0,47	0,3 - 1

*after Bieniawski

NB. Del 3 - Inclined at 45°N.

THE NUMBER OF JOINTS IN EACH SET WITH SIMILAR SURFACE ROUGHNESS AND ALTERATION CHARACTERISTICS												
Project: DELVERS TUNNEL					Data Source: ROME CME							
SAMPLE SITE NUMBER	JOINT SET ANGLE (°)*	SURFACE ROUGHNESS				Closed	SURFACE ALTERATION			Gauge		
		Unculating		Planar			None or Staining only	Non-metallic Coatings	Poly or Epoxy Coatings			
		Rough	Smooth	Rough	Smooth							
Del 1	10	1	4	1			2			4		
	80	4		12			16					
	10	5		3	1		1			8		
Del 2	30 - 40	8		1			3			6		
	50 - 60	11					6			5		
	70 - 80	5		2			6			1		
Del 3	20 - 40	13	2	1	17		5			10		
	50 - 60	17	20	1			19	5		5		
	70 - 90	24	5	2	5		1	1	1	16		
Del 4	20	3					1			1		
	30 - 40	7		3	2		4	5		3		
	60 - 70	10		1			11					
Del 5	90	4		1			5					
	10 - 20	6		1			6	1				
	50 - 60	11					8			3		
Del 6	80	4					1			3		
	10 - 30	7	3	1	1		2	1		9		
	60 - 70	20	1	1	1		10	1		12		
	80 - 90	11		4	1		5			11		
*MEASURED FROM CORE AXIS												
										STEP 4		

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					Data Source: CORE CORE	
Project: DELVERS TUNNEL						
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J set)*	REASONS FOR SELECTION OF (J set)	
Del 1	60 10	Undulating and smooth. Planar and rough.	Clay or softening coatings. None or staining.	*	Appears to be the poorest set although possibly favourably orientated.	
Del 2	50 - 60 30 - 40 10 - 20	Undulating and rough. Undulating and rough. Undulating and rough.	Clay or softening mineral coatings. Clay or softening mineral coatings. Staining and clay coatings.	* ?	Poorest surface conditions.	
Del 3	5 - 25 75 - 85 45 - 65	Undulating and rough. Undulating and smooth/rough. Undulating and rough.	None or staining. Clay or softening mineral coatings. Clay or softening mineral coatings. Stain and clay or softening minerals.	*	Most unfavourably orientated.	
Del 4	70 50 - 60 20 - 30 0	Undulating and rough. Undulating and rough. Undulating and rough. Undulating and rough.	Stain and both softening and non-softening coatings. Non-softening mineral coatings with staining and clay coatings. None or staining. None or staining.	*	One of most common joint sets and poorest surface conditions.	

*With respect to Tunnel Stability

STEP 5

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: DELVERS TUNNEL			Data Source: FINE CORE		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	NOT STONIFIED CANT JOINT SET (3 sig)*	REASONS FOR SELECTION OF (3 sig)
Del 5	70 - 80	Undulating and rough. (Pinnar and slickensided joints of this orientation in fragments)	None or staining (clay coatings).	*	Often apparent in fragmented sections of core.
	30 - 40	Undulating and rough.	None or staining with occasional clay coatings.		
	10	Undulating and rough.	Clay or softening mineral coatings.		
Del 6	60 - 80	Undulating and rough with occasional slickensides.	Clay or softening mineral coatings.		All joint sets similar: C-10° set possibly unfavourably orientated.
	20 - 30	Undulating and rough with occasional slickensides.	Clay or softening minerals and stain.		
	0 - 10	Undulating and rough with occasional slickensides.	Clay or softening minerals.	*	
*With respect to tunnel stability					STEP 5

Project: DELVER'S TUNNEL												
Data Source: BORE CODE.												
SHEET NUMBER	SECTION NUMBER	SHEET DEPTH (ft)	ROCK TYPE	DENSITY (g/cm ³)	RQD %	ESR	RQD	JOINT DATA			REMARKS	
								Joint Number	Roughness	Alteration		
Del 1	6.7		AGGILL. QUATITE.	-	2.6	1.6	0	2-R	Undulating & smooth	Clay & softening mineral coatings.	Dry	Multiple weaknesses zones with clay (< 50m)
Del 2	6.5		AGGILL. QUATITE.	-	2.6	1.6	36	4-R	Undulating & rough	Clay or softening mineral coatings.	Dry	Multiple weaknesses zones with clay (< 50m)
Del 3	6.5		AGGILL. QUATITE.	-	2.6	1.6	38	3	Undulating & rough	Clay & softening mineral coatings.	Dry	Multiple weaknesses zones with clay (< 50m)
Del 4	7.2		AGGILL. QUATITE.	-	2.6	1.6	66	4-R	Undulating & rough	Non-softening mineral coat.	Dry	Low stress.
Del 5	5.2		AGGILL. QUATITE.	-	2.6	1.6	11	3-R	Planar & slicken.	Clay & softening mineral coatings.	Dry	Multiple weaknesses zones with clay (< 50m)
Del 6	4.8		AGGILL. QUATITE.	-	2.6	1.6	43	3-R	Undulating & rough	Clay & softening mineral coatings.	Dry	Multiple weaknesses zones with clay (< 50m)

STEP 6

N.G.I. CLASSIFICATION SYSTEM - CALCULATION SHEET									
Project: DELVENS TUNNEL									
Data Source: BORE CORE									
SAMPLE SITE NUMBER	CHORN DEPTH (m)	σ _v (kPa)	CLASSIFICATION PARAMETERS			Q	SPAN ESR	SUPPORT CATEGORY	
			RQD/J _n	J _r /J _a	ΣV/ΣV				
Del 1	6,6	169	$\frac{10}{8} = 1,67$	$\frac{2,0}{4,0} = 0,5$	$\frac{1,0}{10,0} = 0,1$	0,08	$\frac{2,6}{1,6} = 1,6$	33	
Del 2	6,6	160	$\frac{26}{15} = 2,4$	$\frac{2,0}{4,0} = 0,75$	$\frac{1,0}{10,0} = 0,1$	0,18	"	29	
Del 3	6,6	149	$\frac{28}{9} = 4,22$	$\frac{2,0}{4,0} = 0,75$	$\frac{1,0}{10,0} = 0,1$	0,32	"	29	
Del 4	7,2	176	$\frac{66}{15} = 4,4$	$\frac{2,0}{3,0} = 1,0$	$\frac{1,0}{2,5} = 0,4$	1,76	"	21	
Del 5	5,2	120	$\frac{12}{12} = 0,92$	$\frac{0,5}{4,0} = 0,13$	$\frac{1,0}{10,0} = 0,1$	0,012	"	33	
Del 6	4,8	118	$\frac{47}{12} = 3,58$	$\frac{2,0}{4,0} = 0,75$	$\frac{1,0}{10,0} = 0,1$	0,27	"	29	
* From:		Kirsten, Stacey and Warwick, Nov. 1976.							
STEP 7									

THE NUMBER OF JOINTS WITH SIMILAR INCLINATION
ANGLES RECORDED IN EACH BOREHOLE

Project: DU TOITSKLOOF TUNNEL

STEP 1

BOREHOLE NUMBER	α°	0	10	20	30	40	50	60	70	80	90	TOTAL CORRECTED JOINTS
	1/Sine α	∞	5,72	2,92	2,0	1,56	1,31	1,15	1,0	1,02	1,0	
Dut 1-H	A	1	0	1	2	14	14	15	18	7	2	93
	B	1	0	3	4	22	18	17	19	7	2	
	C	1	0	5	4	24	20	18	20	8	2	
Dut 1-V	A	3	3	1	6	4	6	3	7	0	0	59
	B	3	17	3	12	6	8	3	7	0	0	
	C	5	29	5	20	10	14	5	12	0	0	
Dut 2-H	A	3	5	0	1	2	7	6	15	3	0	72
	B	3	29	0	2	3	9	7	16	3	0	
	C	4	40	0	3	4	13	10	22	4	0	
Dut 2-V	A	2	2	1	3	3	2	3	1	4	0	39
	B	2	12	3	6	5	3	3	1	4	0	
	C	5	31	8	15	13	8	8	2	10	0	
Dut 3-V	A	3	0	5	3	3	0	0	1	0	0	30
	B	3	0	15	6	5	0	0	1	0	0	
	C	10	0	50	20	17	0	0	3	0	0	
Dut 4-H	A	0	0	1	3	1	1	7	7	1	0	28
	B	0	0	3	6	2	1	8	7	1	0	
	C	0	0	11	21	7	4	25	24	4	0	
Dut 4-V	A	2	1	0	2	2	5	1	5	0	0	28
	B	2	6	0	4	3	7	1	5	0	0	
	C	7	21	0	14	11	25	4	18	0	0	
Dut 5-V	A	2	0	0	1	4	0	0	0	0	0	10
	B	2	0	0	2	6	0	0	0	0	0	
	C	20	0	0	20	60	0	0	0	0	0	
Dut 6-H	A	0	0	0	0	5	0	2	1	0	0	11
	B	0	0	0	0	8	0	2	1	0	0	
	C	0	0	0	0	73	0	18	9	0	0	
Dut 6-V	A	0	0	2	0	4	1	0	1	1	0	15
	B	0	0	6	0	6	1	0	1	1	0	
	C	0	0	39	0	39	8	0	7	7	0	
	A											
	B											
	C											
	A											
	B											
	C											

A - No. of joints recorded in the borehole.

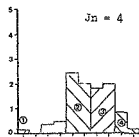
B - No. of joints corrected for intersection angle α .

C - Corrected no. of joints expressed as percentages.

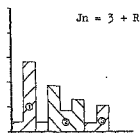
HISTOGRAMS SHOWING THE NUMBER OF JOINTS IN EACH BOREHOLE
WITH SIMILAR INCLINATION ANGLES

Project: DU TOYIKLOOF TUNNEL

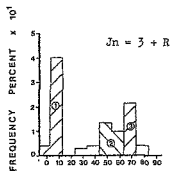
STEP 2



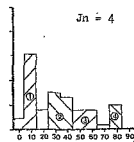
Dnt 1-H



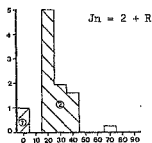
Dnt 1-V



Dnt 2-H



Dnt 2-V



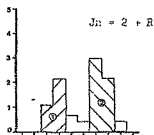
Dnt 3-V

DIP ANGLE (degrees)

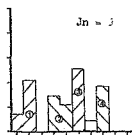
HISTOGRAMS SHOWING THE NUMBER OF JOINTS IN EACH BOREHOLE
WITH SIMILAR DIRECTION ANGLES

Project: DU TOPSKLOPP TUNNEL

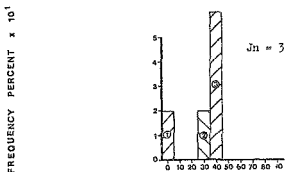
SHEET 2



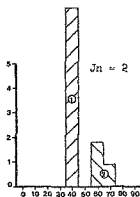
Dst 4-H



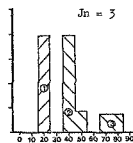
Dst 4-V



Dst 5-V



Dst 6-H



Dst 6-V

D.P. ANGLE (degrees)

THE AVERAGE SPACING OF EACH JOINT SET

Project: DU TOITSKLOOF TUNNEL

STEP 3

BORSHOLE NUMBER	CORE LENGTH L (m)	DIP OF JOINT SET (°)	CORRECTED JOINT NUMBER N ¹	JOINT ² SPACING L/N ² (m)	JOINT SPACING CATEGORY *
Dut 1-H	10,5	0	-	-	-
		40 - 50	40	0,3	0,05 - 0,3
		60 - 70	35	0,3	0,05 - 0,3
		80 - 90	9	1,2	1 - 3
Dut 1-V	4,0	20 - 30	10	0,4	0,3 - 1
		40 - 60	25	0,2	0,05 - 0,3
		80 - 90	-	-	-
Dut 2-H	14,7	0 - 10	-	-	-
		50 - 60	16	0,9	0,3 - 1
		70	16	0,9	0,3 - 1
Dut 2-V	5,6	10	4	1,4	1 - 3
		30 - 40	6	0,9	0,3 - 1
		50 - 60	11	0,5	0,3 - 1
		80 - 90	-	-	-
Dut 3-V	5,3	50 - 70	26	0,2	0,05 - 0,3
		90	-	-	-
Dut 4-H	5,8	20 - 30	9	0,6	0,3 - 1
		60 - 70	15	0,4	0,3 - 1
Dut 4-V	5,20	20	5	1,2	1 - 3
		40	7	0,8	0,3 - 1
		50 - 60	7	0,8	0,3 - 1
		80 - 90	-	-	-

*after Bieniawski

THE NUMBER OF JOINTS IN EACH SET WITH SIMILAR CLASPE ROUGHNESS AND ALTERNATION CHARACTERISTICS											
Project: DU FOITSLOOP TUNNEL											
Data Source: BORE CORE											
SAMPLE SITE NUMBER	JOINT SET ANGLE (°) #	SURFACE ROUGHNESS				Closed	SURFACE ALTERNATION				Grade
		Undulating		Rough	Smooth		None or Staining only	Non-undulating Mineral Coatings	Clay or Silt Particulate		
		Rough	Smooth								
Dat 1-H	0	1					1				
	40 - 50	15		10	3		23	5			
	60 - 70	14		19		5	17	16			
	80 - 90	9					9				
Dat 1-V	20 - 30	4		6			1	4			
	40 - 60	14		2			11	2			
	80 - 90	6					3				
	0 - 10	1		2	5	1	2	1	2		
Dat 2-H	30 - 60	9	1	1	2		12	1			
	70	12			3		15				
	10	3	1					1		3	
	30 - 40	3		1	1	1	3	1			
Dat 2-V	50 - 60	4			1	1	6				
	80 - 90	1	1	2			4				
	50 - 70	7	3	1			8				
	90	2	1	3			2		1		
Dat 3-V	20 - 30	4		2					3		
	60 - 70	7	2	4	1	1	11		3		
	80	5				2	2		3		
	40	4	1				2		3		
Dat 4-V	50 - 60	4									
	80 - 90	2	1	2		1					

STEP 4

* MEASURED FROM CORE AXIS

*MEASURED FROM CORE AXIS

STEP 4

[illegible]

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: W TOUTSKLOOF TUNNEL			Data Source: BORE CORE		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROCKFACES	ALTERATION	MOST SIGNIFICANT JOINT SET (J sig)*	REASONS FOR SELECTION OF (J sig)
Dut 1-H	0	Undulating and rough.	None or staining.		
	40 - 50	Undulating/planar and rough.	None or staining.		
	60 - 70	Planar/undulating and rough with occasional slickensides.	Staining with non-softening mineral coatings.	*	Well-developed joint set and poorest surface conditions.
	80 - 90	Undulating and rough with occasional slickensides.	None or staining.		
Dut 1-V	20 - 30	Planar/undulating and rough.	Staining with non-softening mineral coatings.	*	Well-developed joint set and poorest surface conditions.
	40 - 60	Undulating and rough.	None or staining.		
Dut 2-H	50 - 90	Undulating and rough with occasional slickensides.	Staining with non-softening mineral coatings.		
	0 - 10	Planar & smooth with occasional slickensides.	Staining with some clay coatings.		
	50 - 60	Undulating and rough.	None or staining.		
Dut 2-V	70	Undulating and rough.	None or staining.	*	Most common joint set.
	10	Undulating and rough.	Gouge.	*	Poorest surface conditions.
	30 - 40	Undulating and rough.	None or staining.		
	50 - 60	Undulating and rough.	None or staining.		
	80 - 90	Planar/undulating & rough.	None or staining.		
*With respect to Tunnel Stability					
STEP 5					

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: DU TUNISKLOOF TUNNEL			Data Source: BOM CORE		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J set)*	REASONS FOR SELECTION OF (J set)
Dat 6-H	40	Undulating and rough.	Non-softening mineral coatings.	* ?	Both joint sets similar.
	60 - 70	Undulating and rough.	Non-softening mineral coatings and stain.		
Dat 6-V	10 - 20	Undulating/planar and rough.	Stain and non-softening mineral coatings.	*	Most common joint set.
	40 - 50	Undulating and rough.	Non-softening mineral coatings.		
	70	Undulating and rough.	Non-softening mineral coatings.		
*With respect to Tunnel Stability					STEP 5

Geomechanics Classification System - Data Form											
Project: MD TOLSON/40 TUNNEL Data Source: BURE CORB.											
SAMPLE NUMBER	ROCK TYPE	INITIAL ROCK STRENGTH (psi)	U.C.S. P.L. (psi)	RQD (%)	GROUND WATER	N ₁₀ (%)	JOINT DESCRIPTION				REMARKS
							Specimen (in)	Continuity	Separation (mm)	Joint Condition Roughness	Joint Wall Orientation Rock
Dat 1-H	MAFICIC SANDSTONE	7.3		30	Moist	0 40-50 60-70 80-90	- 0.05-0.3 0.05-0.3 1.0-5.0	-	< 0.1 0.1-1 0.1-1 0.1-1	Rough Hard Rough Hard	Unfav. Fair
Dat 1-V	MAFICIC SANDSTONE	4.2		18	Moist	20-30 40-50 60-70 80-90	0.3-1.0 0.05-0.3 -	-	< 0.1 0.1-1 0.1-1	Rough Hard Rough with Slicks.	Fair
Dat 2-H	MAFICIC SANDSTONE	4.2		20	Moist	0-10 50-60 70	- 0.3-1.0 0.3-1.0	-	0.1-1 0.1-1 0.1-1	Smooth & Slicks Rough Rough	Unfav. Fair
Dat 2-V	MAFICIC SANDSTONE	3.8		40	Moist	10 30-40 50-60 80-90	1.0-3.0 0.3-1.0 0.3-1.0 -	-	< 0.5 0.1-1 0.1-1 0.1-1	Rough Hard Rough Hard	Unfav. Fair
Dat 3-V	MAFICIC SANDSTONE (weathered & brecc.)	1.5		43	Moist	50-70 90	0.05-0.3 -	-	1-5 1-5	Rough with Slicks & Smooth & Slicks.	Fair
Dat 4-H	GRANITE (sheared)	1.2		55	Moist	25-30 60-70	0.3-1.0 0.3-1.0	-	0.1-1 0.1-1	Slicks.	Fair
Dat 4-V	GRANITE (sheared)	1.3		28	Moist	20 40 50-60 80-90	1.0-5.0 0.3-1.0 0.3-1.0 -	-	0.1-1 0.1-1 0.1-1	Rough & Slicks. Slicks. Slicks.	Unfav. Fair

The rock shows evidence of internal shearing.

STEP 6

STEP 6

GEOMECHANICS CLASSIFICATION SYSTEM - CALCULATION SHEET									
Project: DU TUNNEL TUNNEL Data Source: BURE CORE									
SAMPLE SITE NUMBER	CLASSIFICATION AND OTHER DATA						RM.	ROCK CLASS	
	Intact Rock Strength	RQD	Joint Spacing	Joint Condition	Ground Water	Orientation Adjustment			
Dat 1-H	12	8	15	20	7	- 6	55	III	
Dat 1-V	12	3	15	15	7	- 5	47	III	
Dat 2-H	12	3	20	15	7	- 7	50	III	
Dat 2-V	7	8	21	17	7	- 6	54	III	
Dat 3-V	4	8	10	6	7	- 5	30	IV	
Dat 4-H	4	13	20	6	7	- 5	45	III	
Dat 4-V	4	8	21	12	7	- 6	46	III	
Dat 5-V	4	13	23	20	10	- 6	64	II	
Dat 6-H	12	17	15	20	10	- 5	69	II	
Dat 6-V	12	17	22	20	10	- 7	74	II	

STEP 7

N.C.I. CLASSIFICATION SYSTEM - CALCULATION SHEET									
Project: BU TOINSLIP TUNNEL					Data Source: FORM CODE				
SAMPLE SITE NUMBER	CROWN DEPTH (m)	σ_v (kPa)	CLASSIFICATION PARAMETER RATINGS			Q	SPAN $\frac{L}{B}$	SUPPORT CATEGORY	
			RQD/J_n	J_r/J_a	J_w/S_{wy}				
Dat 1-H	200	3200	$\frac{30}{15} = 2,0$	$\frac{1,5}{1,0} = 1,5$	$\frac{1,0}{2,5} = 0,4$	1,2	$\frac{3,0}{1,6} = 1,9$	21	
Dat 1-V	200	3200	$\frac{18}{12} = 1,5$	$\frac{1,5}{1,0} = 1,5$	$\frac{1,0}{2,5} = 0,4$	0,9	"	25	
Dat 2-H	210	3400	$\frac{20}{12} = 1,7$	$\frac{3,0}{1,0} = 3,0$	$\frac{1,0}{2,5} = 0,4$	2,04	"	21	
Dat 2-V	210	3400	$\frac{40}{15} = 2,7$	$\frac{2,5}{8,0} = 0,38$	$\frac{1,0}{2,5} = 0,4$	0,41	"	25	
Dat 3-V	150	4800	$\frac{52}{6} = 7,2$	$\frac{1,5}{4,0} = 0,38$	$\frac{1,0}{2,5} = 0,4$	1,1	"	21	
Dat 4-H	200	5100	$\frac{55}{6} = 9,2$	$\frac{1,5}{1,0} = 1,5$	$\frac{1,0}{7,5} = 0,13$	1,8	"	21	
Dat 4-V	200	5100	$\frac{28}{15} = 1,9$	$\frac{1,5}{4,0} = 0,38$	$\frac{1,0}{7,5} = 0,13$	0,09	"	33	
Dat 5-V	150	3600	$\frac{58}{9} = 6,4$	$\frac{3,0}{1,0} = 3,0$	$\frac{1,0}{2,5} = 0,4$	7,7	$\frac{5,0}{1,6} = 3,1$	17	

STEP 7

APPENDIX VI

RESULTS OF THE STEPS FOR EVALUATING
THE IN SITU MEASUREMENTS

TABLE SHOWING THE INTERSECTION ANGLES (α) BETWEEN JOINT SETS AND THE TUNNEL AXIS: THE NUMBER OF JOINTS IN EACH SET CORRECTED FOR ORIENTATIONAL BIAS: JOINT SPACINGS AND RQD ESTIMATES													
Project: KESKOPLES TUNNEL													
SHAFT NUMBER	TUNNEL ADVANCE DIRECTION	JOINT SURVEY LENGTH (m) L	JOINT STRIKE DIRECTION (°)	α (°)	$1/\sin \alpha$	SURFACE OF JOINTS N	CORRELATED NUMBER OF JOINTS $N_c = N/\sin \alpha$	JOINT SPACING L/N_c	JOINT CATEGORY*	NO. OF JOINTS PER METER	NO. OF JTS/M.	RQD # (115 - 3, 3, 1)	AVERAGE NO. OF JOINTS/ METER RQD %
Bos 1	132	9.05	102	30	2.00	15	30	0.3	0.3-1.0	3.3	8.6	87	3.3
			216	84	1.01	9	9	1.0	1.0-3.0	1.0			
			166	34	1.79	1	-	-	0.3-1.0	3.3			
			355	43	1.47	2	-	-	1.0-3.0	1.0			
Bos 2	177	10.0	225	48	1.35	12	16	0.6	0.3-1.0	1.6	7.3	91	4.9
			153	24	2.46	6	15	0.7	0.3-1.0	1.4			
			155	24	2.46	8	20	0.5	0.3-1.0	2.0			
			R			23		0.4	0.3-1.0	2.3			
Bos 3	177	10.0	128	49	1.33	6	11	0.9	0.3-1.0	3.2			
			213	36	1.70	5	9	1.1	1.0-3.0	0.9	6.9	92	5.1
			161	16	3.63	4	15	0.7	0.3-1.0	1.4			
			046	49	1.33	2	3	3.3	> 3.0	0.3			
			R			32		0.3	0.3-1.0	3.2			
Bos 4	177	10.0	090	87	1.00	4	6	1.7	1.0-3.0	0.6			
			254	77	1.03	4	4	2.5	1.0-3.0	0.4	4.6	100	4.3
			146	31	1.94	6	12	0.8	0.3-1.0	1.2			
			R			24		0.4	0.3-1.0	2.4			
Bos 5	110	10.0	173	2	-	7	-	-	0.3-1.0	2*	5.6	97	4.7
			47	63	1.1	8	8	1.2	1.0-3.0	0.8			
			023	87	1.0	3	3	3.3	> 3.0	0.3			
			R			25		0.4	0.3-1.0	2.5			
* AFTER DISINTEGRATION													STEP 3

* Visual estimation.

NB: 3x Random joints not included.

TABLE SHOWING THE RELATION BETWEEN THE TUNNEL DIRECTION AND THE ORIENTATION OF THE JOINT SETS						
Project:		ROSEKOPPESS TUNNEL			STEP 4	
SAMPLE SITE NUMBER	TUNNEL ADVANCE DIRECTION (°)	JOINT SET DIP ANGLE (°)	DIP DIRECTION (°)	STRIKE (°)	STRIKE wrt TUNNEL DIRECTION	EFFECT ON TUNNEL STABILITY*
Bos 1	132	68	192	102	Parallel	V. Unfav.
		85	306	216	Perpend.	Fair
		30	256	166	Parallel	Fair
		85	085	355	Parallel	V. Unfav.
Bos 2	177	90	315	045	Perpend.	Fair
		90	243	153	Parallel	V. Unfav.
		20	243	153	Parallel	Fair
Bos 3	177	90	218	128	Perpend.	V. Fav.
		85	123	033	Parallel	V. Unfav.
		25	251	161	Parallel	Fair
		90	136	046	Perpend.	V. Unfav.
Bos 4	177	70	000	000	Perpend.	Fair
		80	344	254	Perpend.	Fair
		80	256	146	Parallel	V. Unfav.
Bos 5	110	25	198	108	Parallel	Fair
		90	317	227	Perpend.	Fair
		70	113	023	Perpend.	V. Fav.
Bos 6	110	90	046	136	Parallel	V. Unfav.
		90	116	206	Perpend.	V. Fav.
		37	000	090	Parallel	Fair
Bos 7	290	84	238	148	Parallel	V. Unfav.
		85	302	212	Perpend.	V. Fav.
		45	228	138	Parallel	V. Unfav.
		90	006	096	Parallel	V. Unfav.
Bos 8	290	85	132	042	Perpend.	Fair
		80	240	150	Parallel	V. Unfav.
		75	030	120	Parallel	V. Unfav.
		33	180	270	Parallel	Fair

* AFTER BIENIAWSKI

THE NUMBER OF JOINTS IN EACH SET WITH SIMILAR SURFACE ROUGHNESS AND ALLOCATION CHARACTERISTICS									
Project: BUSHKOPPIES TUNNEL									
Data Source: IN SITU JOINT SURVEY									
SAMPLE SITE NUMBER	JOINT SET ANGLE (°)*	SURFACE ROUGHNESS				SURFACE ALTERATION			
		Undulating		Pleasant		Closed	None or Staining only	Non-softening Mineral Contingents	Clay or Softening Mineral Contingents
		Rough	Smooth	Rough	Smooth				
Pos 7	84	2		5	1		6	1	1
	85				4		1		1
	45	2		1	2		1	2	
	80								
Pos 6	87	1		7	7	12	2	1	
	80	2		1	1	3	1		
	75				11	11			
	33			3	1	2		1	1
Pos 9	90	6		3	1	5		4	
	72	3		2	1	6			
	76	4		1	1	5			
	90	2		4	2	4	2		2
Pos 10	47			9	1	1	2	2	4
	80	4		5		1	8		
	90			4	4	1	5		2
	90	1		2	4	1	5		2
Pos 11	10	1		2		1	1	1	1
	10	1		2	3	2	3		1
	85	3		2	2	2	2		3
	90	2		2	1	3	1		1
Pos 12	85	1	1	2	1	3	2		
	80	1		3	1	4	4		

* DIP

STEP 5

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: BUSHKOPPIES TUNNEL			Data Source: IN SITU JOINT SURVEY		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J sig)*	REASONS FOR SELECTION OF (J sig)
Bos 1	68	Undulating and rough.	Clay coatings with staining and non-softening minerals.		
	85	Undulating and rough.	Clay coatings.		
	30	Planar/undulating and rough.	Gouge (up to 10 cm thick).	*	Most unfavourably orientated joint set - has caused main crown failure.
	85	Undulating and rough.	Clay coatings.		
Bos 2	90	Planar and rough.	Closed.		
	90	Undulating/planar and rough.	Closed.	*	Most unfavourably orientated joint set.
	20	Undulating and rough.	Closed.		
Bos 3	90	Planar and rough/smooth.	Closed but with occasional staining and clay coatings.		
	85	Undulating and rough.	Closed.		
	25	Planar and rough.	Closed but also staining and clay coatings.	*	Poor orientation but poor surface characteristics.
	90	Undulating/planar and rough.	Closed or with calcite and chlorite coatings.		
Bos 4	70	Planar and rough.	Closed.		
	80	Planar and rough or smooth.	Closed.		
	80	Planar and rough or smooth.	Closed.	*	Very unfavourably orientated.
*With respect to Tunnel Stability					STEP 6.

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE						
Project: BUSHKOPPIES TUNNEL						
Data Source: IN SITU JOINT SURVEY						
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFI- CANT JOINT SET (J sig)*	REASONS FOR SELECTION OF (J sig)	
Bos 5	25	Undulating and rough.	Closed.	x	Appeared to be most un- favourably orientated joint set.	
	90	Undulating/planar and rough.	Closed.			
	70	Undulating/planar and rough.	Closed and non-softening mineral coatings.			
Bos 6	90	Undulating/planar and rough.	Closed.	x	Most unfavourably orient- ated joint set.	
	90	Undulating and rough.	Closed and with non- softening mineral coatings.			
	37	Undulating and rough or smooth.	Closed.			
Bos 7	84	Planar and rough.	Staining with occasional clay and non-softening and softening mineral coatings.	x	Poor orientation and poorest surface characteristics.	
	85	Planar and smooth.	Closed with occasional staining and clay coatings.			
	45	Undulating/planar and rough.	Closed.			
	90	Planar and smooth/rough.	Non-softening mineral coat- ings.			
*With respect to Tunnel Stability					STEP 6	

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: EUSKOPPEX TUNNEL			Data Source: IN SITU JOINT SURVEY		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J slip)*	REASONS FOR SELECTION OF JOINT SET (J slip)
Bos 8	85	Planar and rough/smooth.	Closed with some staining.		
	80	Undulating and rough.	Closed with some staining.		
	75 73 33	Planar and smooth. Planar and rough.	Closed. Closed but with some non-softening and clay coatings.	*	Most common unfavourably orientated joint set.
Bos 9	90	Undulating and rough.	Closed and non-softening mineral coatings.		
	75	Undulating/planar and rough.	Closed.		
	76	Undulating and rough.	Closed.	*	Most unfavourably orientated joint set.
Bos 10	90	Planar and rough/smooth.	Closed and with occasional clay coatings and stain.		
	47	Planar and rough.	Clay coatings with some stain and non-softening minerals.	*	Poorest surface characteristics.
	80	Planar/undulating and rough.	Staining.		
Bos 11	90	Planar and smooth/rough.	Staining with occasional clay coatings.		
	90	Planar and smooth/rough.	Staining with occasional clay coatings.		
	10	Planar and rough.	Staining and clay coatings.		
	90	Planar and smooth/rough.	Staining and occasional clay coatings.	*	Most unfavourably orientated joint set.
* With respect to Tunnel Stability					
STEP 6					

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: BUSHKOPPIES TUNNEL			Data Source: IN SITU JOINT SURVEY		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J sig)*	REASONS FOR SELECTION OF (J sig)
Pos 12	85	Planar and rough/smooth.	Clay coatings and staining.		
	90	Planar and undulating and rough.	Closed but with occasional staining and clay coatings.		
	85	Planar and rough/smooth.	Closed and stained.		
	80	Planar and rough.	Staining.	*	Unfavourably orientated joint set.
* With respect to Tunnel Stability					STEP 6

GEOMECHANICS CLASSIFICATION SYSTEM - DATA FORM										
Project: BUSHOPPIES TUNNEL										
Date source: IN SITU JOINT SURVEY.										
SAMPLE NUMBER	ROCK TYPE	UNFRACT. ROCK STRENGTH (M.P.S.)	RQD %	GROUND WATER	JOINT DESCRIPTION				JOINT ORIENTATION	REMARKS
					DIP (°)	Spacing (m)	Continuity	Joint Condition		
									Joint Wall	
									Rock	
Boe 1	LAVA	4.2	87	Moist	85 90 90 85	0.3-1.0 0.3-1.0 0.3-1.0 1.0-3.0	Continuous Continuous Continuous Continuous	Rough Rough Rough Rough	Hard Hard Hard Hard	Max. joint thickness estimated.
Boe 2	LAVA	3.4	51	Moist	90 90 80	0.3-1.0 0.3-1.0 0.3-1.0	Continuous Continuous Continuous	Rough Rough Rough	Hard Hard Hard	
Boe 3	LAVA & DIABASE	2.5	92	Moist	90 85 85 90	0.3-1.0 0.3-1.0 0.3-1.0 0.3-1.0	Continuous Continuous Continuous Continuous	Rough/Smooth Rough Rough Rough	Hard Hard Hard Hard	* Joints in diabase have soft wall rock.
Boe 4	DIABASE	13.8	100	Dry	70 80 80	1.0-3.0 0.3-1.0 0.3-1.0	Continuous Discontinuous Discontinuous	Rough/Smooth Rough/Smooth Rough/Smooth	Hard Hard Hard	
Boe 5	LAVA	4.1	97	Dry	95 90 70	0.3-1.0 0.3-1.0 0.3-1.0	Continuous Continuous Continuous	Rough Rough Rough	Hard Hard Hard	
Boe 6	LAVA	27.6	100	Dry	90 90 37	0.3-1.0 1.0-3.0 1.0-3.0	Continuous Continuous Discontinuous	Rough Rough Rough/Smooth	Hard Hard Hard	
Boe 7	LAVA	12.6	98	Moist	84 85 45 90	0.3-1.0 1.0-3.0 1.0-3.0 0.3-1.0	Continuous Continuous Discontinuous Discontinuous	Rough Smooth Rough Rough/Smooth	Hard Hard Hard Hard	
Boe 8	LAVA	12.2	82	Dry	85 85 75 33	0.3-1.0 0.3-1.0 0.3-1.0 0.3-1.0	Continuous Continuous Continuous Continuous	Rough/Smooth Rough/Smooth Rough Rough	Hard Hard Hard Hard	
Boe 9	LAVA	9.8	100	Moist	90 75 76	1.0-3.0 0.3-1.0 1.0-3.0	Continuous Discontinuous Continuous	Rough Rough Rough	Hard Hard Hard	

STEP 7

GEOMECHANICS CLASSIFICATION SYSTEM - CALCULATION SHEET									
Project: BUSHOPPTES TUNNEL					Data Source: IN SITU				
SAMPLE SITE NUMBER	CLASSIFICATION RATINGS						RSL	ROCK CLASS	
	Intact Rock Strength	RQD	Joint Spacing	Joint Condition	Ground Water	Orientation Adjustment			
Bos 1	12	17	23	15	7	- 9	65	II	
Bos 2	15	20	20	20	7	- 7	75	II	
Bos 3	7	20	24	20	7	- 4	74	II	
Bos 4	15	20	23	20	10	- 7	81	I	
Bos 5	12	20	25	20	10	- 3	84	I	
Bos 6	15	20	23	20	10	- 6	82	I	
Bos 7	15	20	23	19	7	- 9	75	II	
Bos 8	25	17	19	19	10	- 9	71	II	
Bos 9	15	20	23	20	7	- 6	79	II	
Bos 10	7	20	20	19	7	- 3	70	II	
Bos 11	15	20	24	20	7	-10	84	I	
Bos 12	15	20	24	20	7	- 7	87	I	
									STEP 8

DELYERS TUNNEL

STEP 4

* AFTER BIENIAWSKI

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Data Source: IN SITU JOINT OBSERVATIONS					
Project: DELVERS TUNNEL					
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J set) *	REASONS FOR SELECTION OF (J set)
					Least favourably orientated for stability.
Del 1	Vertical or steep south (E-W strike). Subhorizontal Flat North.	Planar and rough. Planar and rough.	Clay or softening mineral coatings. Clay coating (1-5 mm).	×	
Del 2	Vertical or steep south (E-W strike). Flat North.	Undulating and irregular.	Fine coating and sandy clay fill up to 5 cm thick.	×	Most common Joint Set.
Del 3	Vertical (E-W). Vertical (N-S). Flat South	Undulating and rough. Undulating and rough. Undulating and rough.	Clay fill. Staining. Staining.	×	Unfavourably orientated.
Del 4	Vertical (N-S strike). 60° SW	Undulating and rough. Planar and rough.	Clayey sand and stain. Stain	×	Poor orientation and surface condition.
Del 5	80-85° N Flat North. Vertical (N-S strike)	Undulating and rough. Planar and rough. Undulating and smooth.	Staining or clayey layers Staining Sandy clay 5-10 cm thick.	×	Poor orientation - worst surface conditions.
* With respect to Tunnel Stability					
STEP 6					

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE						
Project: DELVERES TUNNEL			Data Source: IN SITU JOINT OBSERVATIONS			
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J sig)*	REASONS FOR SELECTION OF (J sig)	
Del 6	70° N 20-25° S 80° E	Planar and rough. Planar and rough. Planar and rough.	Clay coatings (1-5 mm) Clay coating (1-5 mm) None	x	Most common joint set - poor surface conditions.	
*With respect to Tunnel Stability						STEP 6

OF MECHANICS CLASSIFICATION SYSTEM - DATA FORM									
Data Source: IN SITU JOINT OBSERVATIONS.									
Project: DELVERS TUNNEL									
SAMPLE SITE NUMBER	ROCK TYPE	JUNCTION STRENGTH P.C.S. 30, 1.5 P.C.S. 30, 1.5	RCD #	JOINT DESCRIPTION				JOINT CONDITION	REMARKS.
				MP [°]	Spacing (m)	Continuity	Surface Condition	Joint Condition	
Del 1	2011L GABBROITE	1,0	92	85-90 0-20	0.05-0.3 0.3-1.0	Continuous Continuous	1-5 Rough	Soft Soft	Random joints present Rocks soften on exposure to moist air.
Del 2	2011L GABBROITE	2,2	92	85-90 0-20	0.05-0.3 Irreg. +	Continuous Discontinuous	> 5 Rough	Soft Soft	Foss. random jts.
Del 3	2011L GABBROITE	0,8	65	90 20	0.05-0.3 0.3-1.0	Continuous Continuous	0.1-1 Rough	Soft Soft	Fav. v. Unfav.
Del 4	2011L GABBROITE	6,3	95	90 80	0.3-1.0 1-3	Continuous Discontinuous	0.1-1 Rough	Hard Hard	Fav. v. Unfav.
Del 5	2011L GABBROITE	1,0	92	85-90 0-20	0.1-1.0 0.3-1.0	Continuous Continuous	1-5 Rough	Soft Soft	* Clay gouge up to 10cm thick.
Del 6	2011L GABBROITE	1,5	69	70 25	0.05-0.3 1-3	Continuous Discontinuous	1-5 Rough	Soft Soft	Stiff clay gouge.

STEP 7

N.C.I. CLASSIFICATION SYSTEM - CALCULATION SHEET									
Project: DELVERS TUNNEL			Data Source: IN SITU JOINT OBSERVATIONS						
SAMPLE SITE NUMBER	CROWN DEPTH (m)	σ_v (kPa)	CLASSIFIC-TION. PARAMETER RATINGS				Q	SPM -30	SUPPOT CATEGORY
			RQD / J_n	J_r / J_a	J_v / SIF				
Del 1	6,6	169	$\frac{92}{6} = 15,3$	$\frac{1,2}{4,0} = 0,30$	$\frac{1,0}{10,0} = 0,1$	0,59	$\frac{2,6}{1,6} = 1,6$	25	
Del 2	6,6	160	$\frac{92}{3} = 27,3$	$\frac{3,0}{4,0} = 0,75$	$\frac{1,0}{10,0} = 0,1$	2,05	"	21	
Del 3	6,6	149	$\frac{62}{3} = 7,67$	$\frac{1,0}{1,0} = 1,0$	$\frac{1,0}{1,5} = 0,67$	2,52	"	22	
Del 4	7,2	176	$\frac{95}{12} = 7,92$	$\frac{1,5}{1,0} = 1,5$	$\frac{1,0}{2,5} = 0,4$	4,75	"	17	
Del 5	5,2	180	$\frac{92}{3} = 30,2$	$\frac{1,0}{4,0} = 0,25$	$\frac{1,0}{3,0} = 0,33$	1,02	"	21	
Del 6	4,0	118	$\frac{62}{12} = 5,75$	$\frac{1,2}{4,0} = 0,30$	$\frac{1,0}{10,0} = 0,1$	0,22	2	29	
From:	Kivsten,	Macey and Wardick, Nov. 1976.							
SHEET 8									

TABLE SHOWING THE INTERSECTION ANGLES (A) BETWEEN JOINT BEARS AND THE TUNNEL AXIS;
THE NUMBER OF JOINTS IN EACH SET CONNECTED FOR ORIENTATIONAL BLDG; JOINT SPACINGS AND RQD ESTIMATES

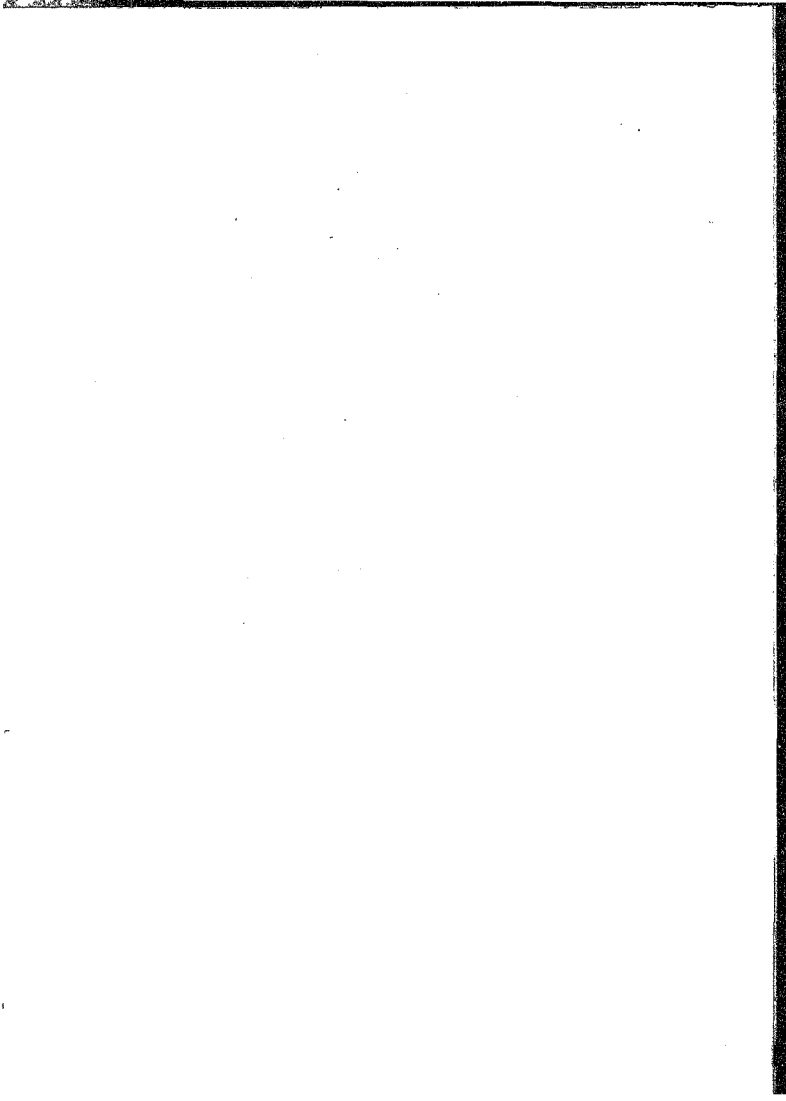
TABLE SHOWING THE INTERSECTION ANGLES (α) BETWEEN JOINT SETS AND THE TUNNEL AXIS; JOINT SPACINGS AND RAD ESTIMATES THE NUMBER OF JOINTS IN EACH SET CORRECTED FOR ORIENTATIONAL BIAS; JOINT SPACINGS AND RAD ESTIMATES													
Project: IN ROUTED GROUP TUNNEL													
SAMPLE NUMBER	TUNNEL DATE ADVANCE METERS TIME	JOINT NUMBER 1	JOINT DIP DEG	JOINT DIP DEG	α ($^\circ$)	NUMBER OF JOINTS N	CORRECTED NUMBER OF JOINTS Nc = N/sin α	JOINT SPACING M	JOINT CATEGORY	NO. OF JOINTS PER METRE	SUM OF SPACINGS M	EQD λ (115 - 5.3 λ) M/MTRE	AVERAGE JOINTS [cos α] ^{0.44} M/MTRE
Dat 1	278	7.4	119	21	2.79	5	14	0.5	0.3-1.0	2	7.5	90	5
			129	41	1.52	6	0.6	0.3-1.0	1.3	91			
Dat 2	278	5.4	117	19	3.07	3	9	0.8	0.3-1.0		0.9	10	82
			098	0	-	7	1.1	1.0-3.0	2	91			
Dat 3	278	2.5	119	21	2.79	5	14	0.5	0.3-1.0		2	7.5	90
			129	41	1.11	5	6	0.9	0.3-1.0	1.1	91		
Dat 4	278	8.15	124	26	2.28	4	9	0.6	0.3-1.0	1.7		10	82
			159	63	1.14	2	2.7	1.0-3.0	0.4	91			
Dat 5	278	2.5	198	90	1.10	5	5	1.1	1.0-3.0		0.9	10	82
			050	8	7.19	5	36	0.2	0.05-0.3	91			
Dat 6	278	2.5	R	-	-	5	5	1.1	1.0-3.0		0.9	10	82
			125	57	1.19	1	2	2.6	2.0-3.0	0.4	91		
Dat 7	278	2.5	234	16	3.55	4	15	0.2	0.05-0.3	5		9.9	82
			137	39	1.59	3	5	0.5	0.3-1.0	2	91		
Dat 8	278	2.5	R	-	-	6	6	0.4	0.3-1.0	2.5		10	82
			227	51	1.29	-	-	-	-	0.05-0.5	6		
Dat 9	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 10	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 11	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 12	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 13	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 14	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 15	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 16	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 17	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 18	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 19	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 20	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 21	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 22	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 23	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 24	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 25	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 26	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 27	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 28	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 29	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 30	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 31	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 32	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 33	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 34	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 35	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 36	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 37	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 38	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 39	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 40	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 41	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 42	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 43	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 44	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 45	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 46	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 47	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 48	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 49	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 50	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 51	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 52	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 53	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 54	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 55	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 56	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 57	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 58	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 59	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 60	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-	-	-	0.05-0.5			
Dat 61	278	2.5	307	29	2.09	-	-	-	0.05-0.3	10	10	82	5
			178	80	1.02	-	-	-	-	0.3-1.0			
Dat 62	278	2.5	R	-	-	-	-	-	-	-	10	82	5
			227	51	1.29	-	-						

TABLE SHOWING THE INTERSECTION ANGLES (α) BETWEEN JOINT SETS AND THE TUNNEL AXIS: THE NUMBER OF JOINTS IN EACH SET CORRECTED FOR ORIENTATIONAL BIAS; JOINT SPACINGS AND RQD ESTIMATES													
Project: BUWITZKAMP TUNNEL													
SAMPLE HOLE NUMBER	TUNNEL DIAMETER FT	JOINT LENGTH (m) L	JOINT DIRECTION (ϕ)	α ($^\circ$)	$1/\sin \alpha$	NUMBER OF JOINTS N	CORRECTED NUMBER OF JOINTS $N/\sin \alpha$	JOINT SPACING $1/H$	JOINT SPACING CATEGORY*	NO. OF JOINTS IN CATEGORY	SUM OF JTS/M. Σ	RQD % (115 - 1.3 J.)	AVERAGE RQD NO. OF JOINTS PER FOOT [100 * (ave.)]
Dut 5	278	7.6	295	17	3.42	-	-	-	0.3-1.0	3	8-28	89-56	*
			215	63	1.12	-	-	-	0.05-0.3	10			
			175	77	1.05	-	-	-	0.3-1.0	2			
			141	43	1.47	-	-	-	0.3-3.0	3			
			R	-	-	-	-	-	> 3.0	1			
Dut 6	278	11.5	119	21	2.79	4	11	1.0	0.3-1.0	1.0	2.8	100	2.4
			201	77	1.33	7	7	1.6	1.0-3.0	0.6			
			213	65	1.10	1	1	11.5	> 3.0	0.1			
			1	-	-	12	12	0.9	0.3-3.0	1.1			
* Joint spacing and RQD based on visual estimates because joint survey data insufficient.													

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: DU TOTTEKIDOP TUNNEL					
Data Source: IN SITU JOINT SURVEY					
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J sic)*	REASONS FOR SELECTION OF (J sic)
Dat 1	28	Undulating/planar and rough.	None and clay coatings.		
	60	Undulating and rough.	None or staining.		
	80	Planar and rough/smooth with slickensides.	None or staining.	*	Most unfavourably orientated and poorest surface conditions.
	60	Undulating/planar and rough.	None or staining.		
Dat 2	30	Undulating/planar and rough.	Stain with some clay coatings.	*	Unfavourably orientated and poor surface conditions.
	70	Undulating and rough.	None or staining.		
	45	Planar and rough.	None or staining.		
	60	Planar and smooth/rough.	None or staining.		
Dat 3	60	Undulating and rough.	None or staining.		
	58	Planar and rough.	None or staining.		
	90	Undulating and rough/smooth with slickensides.	Clay or softening minerals.	*	Very unfavourably orientated and most common joint set.
	75	Planar and smooth with slickensides.	Clay or softening minerals.		
*With respect to Tunnel Stability					STEP 6

GENERAL SURFACE CONDITIONS OF THE JOINT SETS RECORDED AT EACH SAMPLE SITE					
Project: DU TUNISKLOOF TUNNEL			Data Source: IN SITU JOINT SURVEY		
SAMPLE SITE NUMBER	DIP ANGLE OF JOINT SET (°)	ROUGHNESS	ALTERATION	MOST SIGNIFICANT JOINT SET (J sig)*	REASONS FOR SELECTION OF (J sig)
Dat 4	80	Undulating/planar and smooth with slickensides.	Clay or softening minerals,		
	60	Planar and smooth with slickensides.	None and some clay coatings.	*	Very unfavourably orientated and poor surface conditions.
	70	Undulating/planar and smooth with slickensides.	None with some clay.		
Dat 5	0				
	85	Undulating and smooth with slickensides.	Staining or non-softening minerals.	*	Very unfavourably orientated and poor surface conditions.
	75	Planar and rough/smooth with some slickensides.	Staining or none.		
	75	Planar and rough.	None or staining only.		
Dat 6	40	Planar and rough/smooth with slickensides.	Stain or non-softening minerals.		
	70	Undulating and rough.	Non-softening minerals.	*	Unfavourably orientated.
	90	Planar/undulating and rough.	None or staining.		
Dat 6	45	Planar and rough.	None or staining.		
*With respect to Tunnel Stability					STEP 6

N.G.I. CLASSIFICATION SYSTEM - DATA FORM												
Project: DIO TOIRISLOOP TUNNEL												
Data Source: IN SITU.												
SAMPLE SIZE DEPTH NUMBER	ROCK Type Density (g/cm ³)	EXCAV- ATION SPAN	ESR	RQD %	JOINT DATA			STRESS REDUCTION FACTOR	REMARKS			
					Joint Number	Roughness	Alteration					
Dat 1 200	221210 2640 2.640	3.0	1.6	90	4	Tamar & smooth with slicks.	None or stain	Minor	Single weakness zones in compe- tent rock. Gen- erally clay free (> 50m).			
Dat 2 210	221810 2704	3.0	1.6	82	4	Plaster & rough	Stain & clay coating.	Minor	Single weakness zones with clay (> 50m).			
Dat 3 190	221210 2460 2.460	3.0	1.6	82	3-R	Undulating & smooth with slicks.	Clay & soft- ening minerals.	Minor	Single weakness zones with clay (> 50m).			
Dat 4 200	221210 2570 2.570	3.0	1.6	56	3-R	Plaster & smooth with slicks.	None but minor clay	Minor	Heavily jointed rock.			
Dat 5 150	221210 2650 2.650	3.0	1.6	73	4	Undulating & smooth with slicks.	Non-softening mineral cement.	Dry	Joints usually closed.			
Dat 6 280	221210 2650	3.0	1.6	100	3-R	Undulating & rough	Non softening mineral cement.	Dry	Medium stress.			
										STEP 7		



Author Cameron-clarke Ian Stuart

Name of thesis An Evaluation Of The Reliability Of Borehole Core Data In Engineering Rock Mass Classification Systems.
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