

ON SHEARING BEHAVIOUR OF JOINTED ROCKS

CONTENTS

Synopsis	..	..	..	
Certificate	..	..	..	
Acknowledgements	..	..	..	
Notations	..	..	..	
CHAPTER				Page
I INTRODUCTION	..	..	..	1-7
1.1.0 General	..	..	..	1
1.2.0 Intact rocks	..	..	..	2
1.3.0 Jointed rocks	..	..	..	3
1.4.0 Analysis and design		..	..	6
1.5.0 Concluding remarks		..	..	7
II MECHANICAL BEHAVIOUR OF JOINTED ROCKS			..	8-83
2.1.0 General	..	..	..	8
2.2.0 Theory of friction		..	..	9
2.2.1 Concept of friction	..		..	9
2.2.2 Classical laws of friction			..	9
2.2.3 Friction in jointed rocks			..	11
2.3.0 Strength of intact and jointed rocks	..		..	12
2.3.1 Strength of intact rocks			..	12
2.3.2 Strength of jointed rocks			..	15

CHAPTER		Page
2.4.0	Sliding behaviour of rock joints ..	31
2.4.1	Types of joints ..	31
2.4.2	Sliding along a single joint system ..	32
2.4.3	Double or multiple joint system ..	38
2.5.0	Factors influencing failure of jointed rocks ..	38
2.5.1	Influence of roughness of the surface ..	38
2.5.2	Influence of normal stress ..	43
2.5.3	Influence of water ..	45
2.5.4	Influence of filling material ..	51
2.6.0	Mechanism of sliding between joint surfaces ..	59
2.6.1	Physical process of sliding of joint surface ..	59
2.6.2	Phenomenon of dilatation ..	63
2.6.3	Phenomenon of stick-slip ..	67
2.7.0	Constitutive modelling of rock joints ..	76
2.7.1	Physical models ..	76
2.7.2	Joint elements ..	78
2.8.0	Concluding remarks ..	81
III	EXPERIMENTAL INVESTIGATIONS FOR JOINTED ROCKS..	84-151
3.1.0	General ..	84
3.2.0	Testing techniques ..	86
3.2.1	Slider sliding over another surface ..	86

CHAPTER		Page
3.2.2	Conventional direct shear test ..	86
3.2.2.1	Locher setup ..	88
3.2.2.2	Krsmanovic setup ..	88
3.2.2.3	Patton setup ..	91
3.2.2.4	Desai, Drumm and Zaman setup	91
3.2.2.5	Double shear test ..	94
3.2.3	Triaxial test	94
3.2.3.1	Conventional triaxial test	94
3.2.3.2	True triaxial test ..	95
3.2.4	Rotation of cylinders. ..	100
3.2.5	Insitu testing	101
3.3.0	Strength investigations for jointed rocks	103
3.3.1	Strength of jointed rocks in uniaxial compression test ..	103
3.3.2	Strength of jointed rocks in tension	116
3.3.3	Strength of jointed rocks in direct shear	126
3.3.4	Strength of jointed rocks in multiaxial compression ..	133
3.3.4.1	Biaxial condition ..	133
3.3.4.2	Triaxial condition ..	135
3.4.0	Concluding remarks	148

CHAPTER				Page
IV	SCOPE OBJECTIVES AND SCHEME		..	152-164
	4.1.0 General	..	..	152
	4.2.0 Scope	..	..	153
	4.3.0 Objectives	..	..	153
	4.4.0 Scheme	..	..	154
	4.4.1 Materials.	..	..	154
	4.4.1.1 Basalt rock cores	..	..	154
	4.4.1.2 Gouge materials	..	..	154
	4.4.2 Equipments	..	..	156
	4.4.2.1 Conventional triaxial setup			156
	4.4.2.2 Servo controlled testing system	..	..	156
	4.4.3 Special jobs	..	..	159
	4.4.4 Test series	..	..	159
	4.5.0 Concluding remarks	..	..	159
V	THEORETICAL CONSIDERATIONS	..	..	165-178
	5.1.0 General	..	..	165
	5.2.0 Mechanistic concept of sliding for jointed rocks	..	..	166
	5.3.0 Failure criterion for jointed rocks	..	..	166
	5.4.0 Constitutive relations for jointed rocks	..	..	177
	5.5.0 Concluding remarks	..	..	178
VI	EXPERIMENTAL INVESTIGATIONS	..	..	179-240
	6.1.0 General	..	..	179
	6.2.0 Testing system..	..	..	180
	6.2.1 Conventional triaxial test system.			180

CHAPTER	Page
6.2.2 Closed loop material testing	
system	181
6.3.0 Preparation of jointed specimens ..	184
6.3.1 General	184
6.3.2 Development of rock joint ..	184
6.4.0 Observations	186
6.4.1 Category-I	186
6.4.2 Category-II	199
6.4.3 Category-III	217
6.4.4 Category-IV	230
6.4.4.1 Monotonic loading ..	230
6.4.4.2 Triangular loading ..	236
6.4.4.3 Sinusoidal loading ..	238
6.5.0 Concluding remarks	240
VII ANALYSIS, DISCUSSIONS AND CONCLUSIONS ..	241-282
7.1.0 General	241
7.2.0 A failure criterion for jointed rocks ..	251
7.3.0 Stress-deformation characteristics of jointed rocks	263
7.4.0 Phenomenological parameter of dilatancy.	264
7.5.0 Influence of joint orientation ..	267
7.6.0 Influence of gouge material ..	271
7.7.0 Influence of scale	278
7.8.0 Conclusions	278
VIII SUMMARY OF FINDINGS	284-288
BIBLIOGRAPHY	289-304