PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON ROCK JOINTS
LOEN / NORWAY / 4-6 JUNE 1990

Rock Joints

Edited by
NICK BARTON
Norwegian Geotechnical Institute, Oslo
OVE STEPHANSSON
Luleå University of Technology

A.A. BALKEMA / ROTTERDAM / BROOKFIELD / 1990
# Table of contents

**The Loen rockslides**

The Loen rockslides – A historical review  
*E.Grimstad & S.Nesdal*  
3

1. **Characterization**

Characteristics of joints and faults  
*R.H.Gabrielsen*  
11

Identification and characterisation of sets of fractures and faults in rock  
*M.C.Bridges*  
19

Joint roughness (JRC,) characterization of a rock joint and joint replica at 1 m scale  
*P.Chryssanthakis & N.Barton*  
27

Natural hydraulic fracturing  
*T.Engelder & A.Lacazette*  
35

Characteristics of pre- and syn-consolidation structures and tectonic joints and microfaults in fine to medium-grained sandstones  
*R.H.Gabrielsen & R.-K.Aarland*  
45

Application of borehole image processing system to survey of tunnel  
*S.Kamewada, S.Taniguchi, H.S.Gi & H.Yoneda*  
51

Evaluating material properties of faulted zones by image analysis and numerical methods  
*T.Kawamoto, T.Kyoya & Y.Ichikawa*  
59

Three dimensional stochastic joint geometry modelling including a verification: A case study  
*P.H.S.W.Kulatilake, D.N.Wathugala & O.Stephansson*  
67

Analysis of structural homogeneity of rock mass around ventilation drift Stripa mine  
*P.H.S.W.Kulatilake, D.N.Wathugala & O.Stephansson*  
75

Sheared bedding joints in rock engineering: Two case histories in Italy  
*A.Lembo Fazio, R.Ribacchi & P.Tommasi*  
83

Joint origin as a predictive tool for the estimation of geotechnical properties  
*K.D.Rawnsley, S.R.Hencher & A.C.Lumsden*  
91
Sub-horizontal discontinuities of large extension in the basaltic lava-flows nucleus of the Paraná basin (Brazil)
N.N. Souza Jr. & J.O. Campos

Study of rock joint surface feature and its classification
Sun Zongqi & Xu Fang Ming

Two types of mechanisms in bedding translation
T. Uemura

Characterizing joint spatial correlation using geostatistical methods
E. Villaescusa & E.T. Brown

2. Mechanical properties

Mechanical properties of rock joints
S.C. Bandis

Experimental investigations for an algorithm simulating the effect of variable normal stiffness on discontinuities shear strength

Discontinuities and their effect on rock mass
O. Aydan & T. Kawamoto

Shear strength of rock joints reinforced with flexible bolts based on physical modeling
K. Bakhtar, T. Zahra & D. Chitty

Self-similar distribution of macroscopic fractures at depth in crystalline rock in the Cajon Pass scientific drillhole
C.A. Barton & M.D. Zoback

Experimental and numerical investigation on rock joints
Z.H. Benjelloun, M. Boulon & D. Billaux

Shear behaviour of shale joints under heat in direct shear
H. Aydin Bilgin & A. Günhan Paşamethmetoğlu

Scale effects in the shear behavior of joints in welded tuff
T.E. Blejwas & F.D. Hansen

Behaviour of reinforced jointed models under multiaxial loadings
P. Egger & F. Pellet

The role of tension in failure of jointed rocks

Normal joint stiffness as a function of spatial geometry and surface roughness
D.L. Hopkins, N.G. W. Cook & L.R. Myer

Anisotropic shear strength of rock joints
T.H. Huang & Y.S. Doong
A study on the shear strength of rock joint of partial continuity
JJ.Hung & T.T.Lee

A photoelastic investigation of the stress state close to rock joints
A.J.Hyett & J.A.Hudson

Laboratory simulation of joints and their influence on rock mass behaviour
B.Indraratna

Influence of parallel and cross joints on shear behaviour of rock discontinuities
H.K.Kutter & F.Otto

Characteristics of acoustic emissions during shearing of rock joints
C.Li & E.Nordlund

Behaviour of rock joints and rock bridges in shear testing
C.Li, O.Stephansson & T.Savilahti

Shear behaviour of physical models of rock joints under constant normal stiffness conditions
Y.Ohnishi & P.G.R.Dharmarane

Shear strength of modelled filled rock joints
T.Papaliangas, A.C.Lumsden, S.Manolopoulos & S.R.Hencher

Shear strength of filled discontinuities
J.Paulino Pereira

Effect of infill thickness on shear behavior of rock joints
N.Phien-wej, U.B.Shrestha & G.Rantucci

Shear box testing and modelling of joint bridges
T.Savilahti, E.Nordlund & O.Stephansson

Experimental investigations and modelling of rock joint behaviour under constant stiffness
C.A.Skinas, S.C.Bandis & C.A.Demiris

Shear behaviour of cement grout filled artificially created planar joints

Geomechanical characteristics of a pulverised infilling material of a shear zone
F.T.Suorineni & K.E.N.Tsidzi

Shear tests of model rock joints under stiff normal loading
M.L.Van Sint Jan

Determination of shear strength of rock joints at two dam sites and at Stripsa Research Mine
G.Vik & P.M.Johansen

In-situ study of strength and strain characteristics of a rock mass based on sign-variable deformations in a pillar
N.P.Vlokh, A.V.Kritikov & Y.P.Shoupletsov

The complete shear stress -vs- shear displacement behaviour of clean and infilled rough joints
Shulin Xu & M.H.de Freitas
3. Hydraulic properties

Hydraulic behaviour of rock joints
J.Gale

Groundwater behaviour in jointed rock mass during the excavation of underground crude oil storage caverns
K.Aoki, Y.Shiogama & T.Kobuchi

Numerical and laboratory studies of flow in a fracture
D.Billaux & S.Gentier

Quantitative description and modelling of joints morphology
S.Gentier & J.Riss

Aperture measurements and flow experiments using transparent replicas of rock joints
E.Hakami & N.Barton

Hydraulic characterization of jointed rock masses using the 'Pulsation test'

Laboratory studies of transport within a single rock fracture
A.R.Piggott & D.Elsworth

Fluid flow through single fractures

A parameter study of the influence of aperture variation on fracture flow and the consequences in a fracture network
R.G.Stratford, A.W.Herbert & C.P.Jackson

Hydrological characterization of variable-aperture fractures
Y.W.Tsang & C.-F.Tsang

4. Dynamic properties

Dynamic behaviour of rock joints
B.E.Hobbs, A.Ord & C.Marone

Direct shear testing of single joints under dynamic loading
G.Barla, M.Barbero, C.Scavia & A.Zaninetti

Simulation and in-situ study of rock behaviour around mining opening approaching to a tectonic discontinuity
Y.Lihipin & A.V.Zoubkov

Scale model experiments of a rock joint under dynamic loads
S.A.Miller, J.W.Simons & A.L.Florence

Effects of single fractures on seismic wave propagation
L.R.Myer, L.J.Pyrak-Nolte & N.G.W.Cook

The effects of shear and normal stress paths on rock friction
W.A.Olsson
5. Coupled behaviour

Coupled behavior of rock joints
C.-F. Tsang

The pressure dilation of a deep, jointed region of the earth
D.W. Brown & B.A. Robinson

Channeling and stiffness effects on fluid percolation in jointed rocks
J. Desroches & F.H. Cornet

Joint conductivity variation due to normal and shear deformation
A. Makurat, N. Barton, N. S. Rad & S. Bandis

The measurement of the mechanical and hydraulic properties of rock joints at different scales in the Stripa project
A. Makurat, N. Barton, L. Tunbridge & G. Vik

Characterizing normal stiffness and hydraulic conductivity of a major shear zone in granite
C. D. Martin, C. C. Davison & E. T. Kozak

Theoretical and field investigations of fracture hydromechanical response under fluid injection

Permeability variation around underground openings in jointed rock masses: A numerical study
L. Wei & J. A. Hudson

Hydromechanical coupling between stress, stiffness, and hydraulic conductivity of rock joints and fractures

6. Constitutive models

Constitutive models of rock joints
B. Amadei & S. Saeb

Studies on interfaces and discontinuities and an incremental elasto-plastic constitutive law
Ö. Aydan, Y. Ichikawa, S. Ebisu, S. Komura & A. Watanabe
Review of predictive capabilities of JRC-JCS model in engineering practice
N.Barton & S.Bandis

Numerical investigation of the boundary conditions effect on rock joint behaviour
F.D.E.Cuisiat, A.J.Hyett & J.A.Hudson

Rheological behaviour of a contact layer – Field measurements, constitutive modelling and
back analysis by FEM
M.Doležalová & V.Herle

Failure mechanism and shear strength of joint wall asperities
Yu.A.Fishman

A two-dimensional constitutive model of rock joints with pre- and post-peak behaviour
Lanru Jing

Three dimensional flow model in fractured rock mass
A.Kobayashi & R.Yamashita

Jointed rock mass modelling
A.Makurat, N.Barton, G.Vik, P.Chryssanthakis & K.Monsen

Evaluation of mechanical characteristics of rock joints under shear loads
J.Muralha

An experience on the application of fractal theory to basic shear strength studies
J.Muralha & J.G.Charrua-Graça

Development and verification of a numerical technique for coupled hydromechanical
phenomena in rocks
J.Noorishad & C.-F.Tsang

Probabilistic mapping of rock joint surfaces
W.J.Roberds, M.Iwano & H.H.Einstein

Mechanical behaviour of joints of cliff and open pit
N.Rode, F.Homand-Etienne, R.Hadadou & V.Soukatchoff

A variance on the Ladanyi and Archambault's shear strength criterion
S.Saeb

Finite element implementation of a new model for rock joints
S.Saeb & B.Amadei

Geomechanical modelling of joints in rock foundations of structures
D.D.Sapegin, N.M.Karpov & A.A.Nikitin

Fracture-induced stress heterogeneity: Examples from the Cajon Pass scientific drillhole near
the San Andreas Fault, California
G.Shamir, M.D.Zoback & F.H.Cornet

Cyclic loading characteristics of joints and rock bridges in a jointed rock specimen
B.Shen & O.Stephansson

Forward and backward discontinuous deformation analyses of rock block systems
Gen-hua Shi
Seepage flow under dams with jointed rock foundations – A discrete hydraulic model with respect to laminar and turbulent flow
R. Soyeaux

The modelling of water flow through fissure matrix and major joints of a dam foundation rock
D. Stematin

The discrete element method and its application in jointed rock stability of hydropower projects
Wei Qun, Liu Guangting & Chen Xinhua

Kinematic mechanisms of shear deformation and the validity of Barton’s shear models
Shulin Xu & M.H. de Freitas

Continuum modelling of rock joints and its application to three dimensional excavation analysis
T. Yamabe, M. Oda, Y. Ishizuka, H. Kumasaka & H. Tada

Joint profiles and their roughness parameters
Xianbin Yu & B. Vayssade

A fuzzy-set-theoretic interpretation of strength of rock joints
Qing Zhang

Strength properties of rock mass with bidirectional intermittent cross joints
Zhu Keshan, Fan Jingwei & Liu Dongyan

Late papers

Estimating the shear stiffness of rock joints
N. Infanti Jr. & M.A. Kanji

Correlation of rock joints at surface and subsurface for support assessment in a Himalayan tunnel
V.D. Choubey & G. Dhawan

Author index