Eastern Australia Ground Control Group

Australian Geomechanics Society

ISRM

The Q System workshop with Nick Barton

February 2 and 3, 2012, 8.30am – 4.30pm
Hotel Windsor, 11 Spring Street, Melbourne

Thursday 2nd February 2012

Start	End	Session	Presentation
07:45	08:30	Registration	Tea and coffee will be available on arrival
		Session 1	
08:30	09:00	Workshop Opening	Welcome / House Keeping / Opening Addresses
09:00	10:20		From empiricism through theory to problem solving in rock engineering (Müller Lecture 2011, given in ISRM Congress Beijing)
10:20	10:45	Morning tea	
		Session 2	
10:45	12.15		Introduction to the Q-system of rock mass characterization with examples of the parameter ratings
12:15	13:00	Lunch	
		Session 3	
13:00	14:30		Tunnel support selection from Q-classification, support element properties, water control methods, cost of NMT
14:30	15:00	Afternoon tea	
		Session 4	
15.00	16:30		Weathering effects, rock core logging, Q-parameter linkages, engineering examples
16:30	16:45	Discussion Session	

Friday 4th February 2012

Start	End	Session	Presentation
		Session 5	
08:30	08:45		Welcome
08:45	10:15		Pre-injection and Q-parameter and rock mass improvement
10:15	10:40	Morning tea	
		Session 6	
10:40	12:00		Shear strength of rock joints (B-B model), Rockfill and rock masses, deformability, permeability and seismic attributes: an overview
12:00	12:45	Lunch	
		Session 7	
12:45	14:15		Slope stability theory and Q_{slope} method (preliminary)
14:15	14:40	Afternoon tea	
		Session 8	
14:40	16:00		TBM open-gripper or double shield tunnelling, prognosis with QTBM method, problem of faulting and high stress.
16:00	16:15	Workshop closing	

#1 FROM EMPIRICISM, THROUGH THEORY, TO PROBLEM SOLVING IN ROCK ENGINEERING (Müller Lecture 2011, given in ISRM Congress Beijing)

This personal journey through simple methods gradually developed by the lecturer and then used around the world, also by others, can serve as a compressed introduction to many of the topics and techniques described in more detail during this two days course.The emphasis is on discontinuous behaviour caused by jointing, with limited respect for continuum modelling, even though recently used in an unusual way to model a mining scenario.

#2 INTRODUCTION OF Q-SYSTEM OF ROCK MASS CHARACTERIZATION, WITH EXAMPLES OF THE PARAMETER RATINGS

This introduction to the Q-system of rock mass characterization takes the form of illustrated examples of each of the six parameters in turn. It also lists the Q-parameter tables in an appendix. Most detail is on the stress/strength component of SRF, with examples from highly stressed tunnels, with consequences of jointing (Peck equations) and consequences of mining near mine access/declines. The ratio Jn/Jr and its link to over-break, and Frazer/CSIRO studies of Q-parameter links to cavability. The tenuous relation between RMR and Q is also discussed, and a 'new' (25 years old) method of Q-logging is 'introduced', called Q-histogram logging.

#3 TUNNEL SUPPORT SELECTION FROM Q-CLASSIFICATION, SUPPORT ELEMENT PROPERTIES, WATER CONTROL METHODS, COST OF NMT

Original case records for Q-development in 1974 were mostly using B+S(mr) for permanent support. A major update mostly by Grimstad in 1993 brought the Q-system support recommendations into line with 10 to 15 years of B+S(fr) single-shell permanent support in Scandinavia, with bolted and steel reinforced ribs of shotcrete RRS for worst conditions. Differences between single-shell NMT and concrete-lined NATM are emphasised. When compared in volumes of support, the Norwegian NMT is mostly air, and NATM mostly concrete, and may be five times more expensive. Reinforcement and support components are described by means of testing. Various water control methods are compared. Finally a cost/span/Q chart is shown emphasising the possible economies of hybrid NATM in portal areas and NMT in central better quality rock, where rock cover is larger.

#4 WEATHERING EFFECTS, ROCK CORE LOGGING, Q-PARAMETER LINKAGES, ENGINEERING EXAMPLES

Weathering has dramatic effects on all the Q-parameters. Core logging of weathered and jointed core are illustrated. Boreholes are 1D samples, but some interpolation between holes is possible with seismic refraction. Links between Q and velocity and deformation modulus, both shallow and at depth are illustrated from a nuclear waste disposal URL facility in Sweden. Empirical links between Q and tunnel or cavern deformation are described.

#5 PRE-INJECTION AND Q-PARAMETER AND ROCK MASS IMPROVEMENT

High pressure pre-injection ahead of tunnel faces is increasingly used to ensure dry or almost dry conditions for NMT-designed rail tunnels and major road tunnels. A final line of defense against water could be sprayed membranes covered by a second layer of S(fr). Methods of interpreting Lugeon tests for estimating the spacing of conducting joints, and for converting hydraulic to physical apertures are described. Pre-grouting design then depends on physical aperture and particle size comparison, using the empirical/theoretical criterion $E \geq 4.d95$. Ore -passes in mines follow the same rule at 10,000-100,000 times larger scale. Pre-grouting improves many of the Q-parameters, and velocity, deformability and of course permeability are effected in a positive way.

#6 SHEAR STRENGTH OF *ROCK JOINTS (Barton-Bandis), ROCKFILL, AND ROCK MASSES*. ALSO DEFORMABILITY, PERMEABILITY AND SEISMIC ATTRIBUTES: AN OVERVIEW

The shear strength, deformability, permeability of joints and rock masses are discussed. The Barton-Bandis scale effects on shear strength due to block size, and coupled modelling involving changing permeability are each addressed. The shear strength of rockfill and interfaces is also presented. Rock masses can be characterised by Q-logging and by various seismic methods. Some examples are given of the effect of stress, de-stress, degradation-with-time, on seismic velocity. Use of cross-hole velocity in ore-body characterization of geometries, and across yielding pillars in longwall mining is also shown.

#7 SLOPE STABILITY THEORY AND Q_{SLOPE} METHOD (PRELIMINARY)

Some rock slope stability basics are shown, including conventional treatment of wedges, and a discussion of the effects of water pressure during storms is also used as an introduction to a new application of a modified Q-method called Q-slope. This is preliminary and unpublished. The method employs all the familiar parameters, but is tailored to slopes, including wedges and weighting for orientation, with different Jr/Ja accepted on adjacent sides of wedges. The Q_{slope} value is designed to still correlate roughly with P-wave velocity, and an example of the use of just core logging and seismic refraction for motorway slope design through virgin territory is given from Panama.

#8 TBM OPEN-GRIPPER or DOUBLE-SHIELD TUNNELLING, PROGNOSIS WITH Q_{TBM} METHOD, PROBLEMS OF FAULTING AND HIGH STRESS

Some fundamentals of TBM include the deceleration with time and/or tunnel length following the 'learning curve' when PR and AR gradually improve with the contractor's familiarity. Decisions of whether open-gripper or double-shield, or even drill-and-blast are discussed. The challenges of fault zones and the absolute need for pre-injection in worst cases is explained by means of a very elementary equation. The challenges of high cover and rock bursting is also addressed with examples.