Letter to the Editor

18 February 2002

Dear Sirs,

We'd like to thank Dr. Nick Barton for his thoughtful response in Volume 7.1 of the ISRM News Journal (December 2001), to the report from the GeoEng2000 workshop on "The reliability of rock mass classification used in underground excavation and support design". We appreciate the opportunity to clarify some aspects of our original summary. Rock mass characterisation is a critical component to rock engineering and some debate on various aspects of characterisation is healthy for the rock mechanics community.

To begin with, we would like to state that we use the RMR, Q and other established rock classification systems. They are important systems that are the key to much of the engineering design work for excavations in rock. It seems that Dr. Barton may be under the false impression that the workshop suggested that the Q classification system should be truncated, omitting the parameters for stresses and ground water. This was never mentioned or suggested by any participant. The use of stresses and water in classification systems as well as in other calculations, such as the deformation modulus of rock masses, can be seen in Figure 1 of the workshop report. In this figure it is suggested that loading conditions such as stress and water be omitted from rock mass characterisation, but included in design applications such as rock classification.

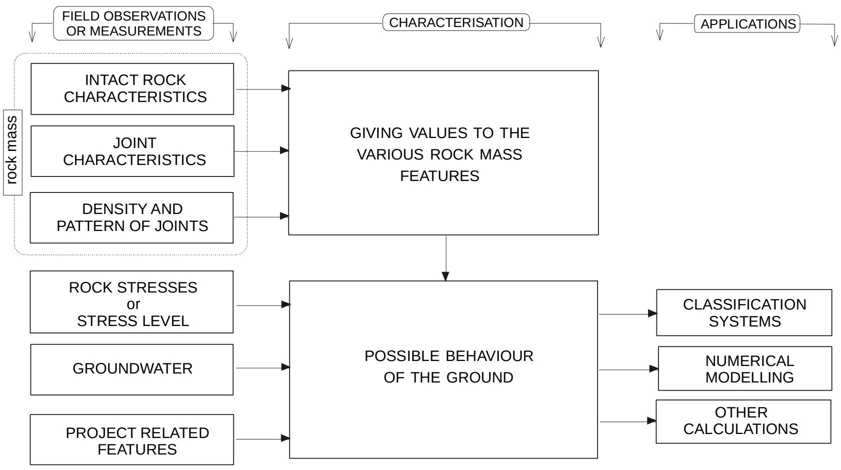

Figure 1. The use of stresses and water in design applications (from GeoEng2000 workshop)

The difference between Rock Mass Characterisation and Classification

The conference's organising committee gave us a very broad theme for the workshop and the discussion in the workshop concentrated on the various inputs to classification systems. The rock mass (the material in which the tunnel is excavated) was differentiated from the ground (the rock mass subjected to the forces acting from rock stresses and ground water). The groundwater condition and the rock stress can change markedly during the life of a deep mine, for example, and hence there is a corresponding change in ground behaviour as the mine is developed. It was suggested that the rock stress and groundwater factors represent loading or boundary conditions for the rock mass. This approach is used in other engineering fields, such as the design of concrete structures. First, the material properties are determined, then the reaction from loads or forces on the concrete structure is determined and the stresses in the structure calculated. Hence, rock mass characterisation (determining the material properties) was differentiated from rock classification systems that make design recommendations.

Stress and Rock Mass Characterisation

The authors - and the workshop attendees - suggested excluding a stress factor from rock mass characterisation to avoid accounting for the influence of stress twice in an analysis. Also, in a mining environment accounting for stress in rock mass characterisation can lead to a constantly changing rock classification for the same rock mass, which could lead to confusion. In mining applications, a computer model is required to assess the influence of complex mining geometries on maximum and minimum induced stresses. Rock mass characterisation is frequently used to determine a failure criterion for these stress modelling programs. Inclusion of a stress factor in this form of analysis results in assessing stress twice.

Dr. Barton also raised the point that the stress environment of a rock mass will affect rock mass properties, such as the seismic velocity and deformation modulus. We agree entirely with Dr. Barton's comments. Figure 1 (of the workshop report) shows that the suggested rock mass characterisation must be coupled with assessments of stress and groundwater conditions before the possible behaviour of the rock mass can be predicted.

Groundwater Conditions and Rock Characterisation

In the workshop it was also suggested to exclude the groundwater factor from characterisation of the rock mass, to avoid accounting for the influence of water twice in an analysis, as the influence of effective stress conditions is often accounted for in computer modelling design approaches. However, groundwater conditions are not assessed in many empirical mine design techniques, such as the Stability Graph Method (Potvin, 1988), which means replacing it in rock characterisation if the mine isn't dewatered. The authors recognise that inclusion or exclusion of groundwater effects in rock characterisation is not straightforward. Groundwater acts to both reduce the strength properties on a joint as well as reduce the effective stress clamping the rock mass together. At the same time ground water is often draining from the rock masses surrounding the underground opening. While modelling can account for the change in the stress state, the change in the properties of the joint must be assessed during the characterisation of the rock mass. This may be done by directly assessing the joint properties, or it may be done through the inclusion of some component of a groundwater factor. This area needs further thought.

RQD/Jn as an Estimate of Block Size

Dr. Barton also disagreed with the viewpoint that RQD/Jn does not adequately quantify intact block size in all ground conditions. Generally, volumetric or 3D (block size) measurements should be preferred over one dimensional (RQD) assessments.

The two well-established rock classification systems (RMR and Q) were first published in the mid 70's and use RQD, plus joint spacing or the number of joint sets present. These parameters can be reasonably estimated based on limited field work and interpretation. Since then, some practitioners have been collecting extensive line mapping data and undertaking detailed block size analysis which, by definition, does a better job of estimating block size than block size parameters such as RQD/Jn. The RMi characterisation system was briefly mentioned as an example of a system that incorporates a more detailed assessment of joint block size. For this system, Palmstrom (1996) has shown that stresses and, when necessary, groundwater, are incorporated prior to using RMi for support estimates.

The workshop leaders, and many of the attendees, were strong proponents of rock mass characterisation. The belief is that underground design can be improved if characterisation methods are developed to take advantage of technology in areas of improved measurement of rock mass properties. Also, rock characterisation can be coupled with realistically modelled induced maximum and minimum stresses and effective stresses, only if empirical assessments of stress and ground water conditions are not already incorporated in the rock characterisation system.

Finally, it was unfortunate that neither Dr. Barton nor Dr. Bieniawski were able to attend the GeoEng2000 Conference, as their attendance would have made the active debate even more lively. The conference organisers had initially invited Dr. Barton to lead the workshop but, as he could not attend, the organisers then passed that role over to us.

– Douglas Milne, Arild Palmstrom, Warren Peck

References

Potvin, Y. 1988. *Empirical open stope design in Canada*. Ph.D. Thesis, Dept. Mining and Mineral Processing, University of British Columbia, 343 p.

Palmstrom A. 1996: *Characterizing rock masses by the RMi for use in practical rock engineering. Part 2: Some practical applications of the rock mass index (RMi).* Tunnelling and Underground Space Technology, Vol. 11, No. 3, pp. 287-303.