POSSIBLE CONSEQUENCES OF CLASSIFICATION METHODS APPLICATION, COUNTRY BY COUNTRY, IN THE CASE OF ROCK SLOPE FAILURE MODELS

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Rock masses are by definition assemblies of rock blocks separated by joint sets and less frequent faults. Of course they can be very massive too. Over the years quite accurate methods have been developed for numerical modelling of what are often 'block assemblies', both in 2D (UDEC-MC, UDEC-BB) and in 3D (3DEC-MC). Many have used them for studying how tunnels, caverns and slopes might perform when excavated in these challenging media. Empirical characterization methods have also been developed which can assist in such activities as tunnel and cavern support, choosing stable slope angles, and mining stope dimensioning. These can complement the numerical modelling.

The apparently most frequent geographic application of various rock mass classification methods in numerous countries, thanks to the questionaires circulated and synthesised by Erharter et al. 2023 are summarized in Figures 1 and 2. Two potential problems caused by the geographic 'spread' of slope-related methods seem to be the over-simplified and difficult to quantify GSI, and the black-box complexity of Hoek-Brown et al. equations if these are applied following GSI estimation. In the opinion of the author of this 'possible consequences' discussion, a return to joint and rock mass characterization for application in discontinuum models is needed if we are to return closer to reality. Do colourful continuum models have a place in actual engineering in rock?

We made good progress in rock engineering many decades ago, until too many chose GSI and H-B, the easy way to lose sight of real behaviour since actually there is hardly any application of geology involved despite the 'G' in GSI. Any subsequent continuum modelling will mean a regrettable loss at least of structural geology.

On the subject of rock slope stability (Figure 2 empirical methods), the behaviour and occasional failures in open pit slopes in jointed rock are actually not very well related to modelled slopes in unjointed model simulations. We are readily able to observe the differences between real failures, often involving capable joint sets and faults, and the idealized modelled failures, typically 'spoon-shaped', if using currently popular (GSI, c, ϕ, H-B) methods.

In the writer's humble opinion it is remarkable that so many, perhaps mostly young people, are trusting the use of GSI, H-B, and continuum models – both for tunnels and caverns and slopes. The critique of the H-B equations presented in Barton, 2023 and partly reproduced in Figure 3 and its caption, should be noted.

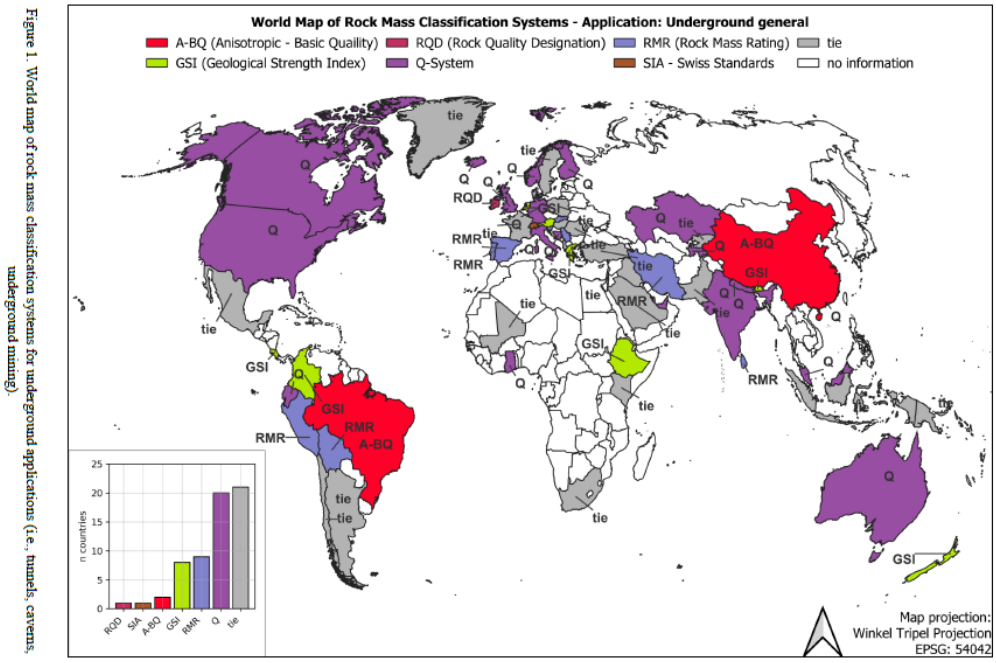

Figure 1. World map of rock mass classification systems for underground applications (i.e., tunnels, caverns, underground mining).

Figure 1. Underground application of rock mass classification methods in selected countries. based on Erharter et al. 2023 syntheses of questionaires. Q and RMR are widespread. The apparent widespread application of the Chinese method A-BQ in Brazil shown here is a surprise. The application of RMR is not a surprise. One may wonder if there were many respondents who chose A-BQ for underground application in Brazil?

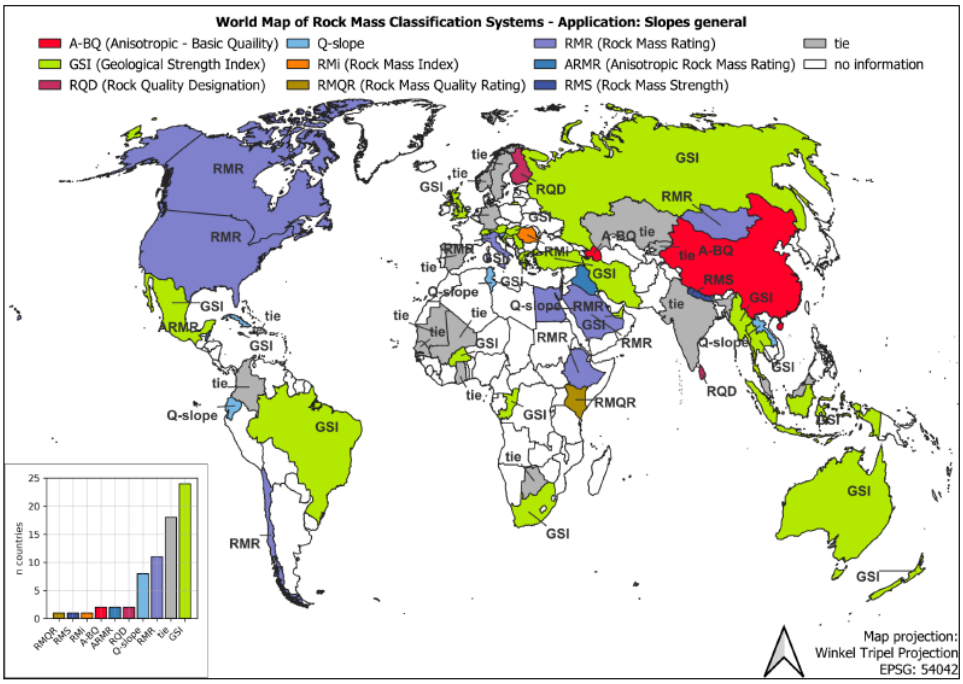

Figure 2. World map of rock mass classification systems for rock slopes, comprising slopes for civil engineering, mining and natural slopes.

Figure 2. Application of 'rock mass classification' methods for slopes based on Erharter et al. 2023 synthesis of questionaires. Does the predominance of GSI mean that the 'green' countries believe in circular ('spoon-shaped') failure modes for rock slopes?

$c' = \dfrac{\sigma_{ci}\left[(1+2a)s+(1-a)m_b\sigma'_{3n}\right](s+m_b\sigma'_{3n})^{a-1}}{(1+a)(2+a)\sqrt{1+\left(6am_b(s+m_b\sigma'_{3n})^{a-1}\right)/(1+a)(2+a)}}$		
$\phi' = \sin^{-1}\left[\dfrac{6am_b(s+m_b\sigma'_{3n})^{a-1}}{2(1+a)(2+a)+6am_b(s+m_b\sigma'_{3n})^{a-1}}\right]$		
$m_b = m_i \exp\left(\dfrac{GSI-100}{28-14D}\right)$	$s = \exp\left(\dfrac{GSI-100}{9-3D}\right)$	$a = \dfrac{1}{2}+\dfrac{1}{6}\left(e^{-\frac{GSI}{15}}-e^{-\frac{20}{3}}\right)$

Figure 3. The Hoek-Brown equations for supposedly representing the shear strength of rock masses when modelled as continua. These were derived from their valid empirical model of intact rock, not from actual rock joint behaviour. GSI actually appears sixteen times in the H-B equation for 'c' and twelve times in the H-B equation for 'φ'. This can be confirmed by using the above supporting equations. Is this a sensible focus on the guessed values of GSI? (Guessed because of the doubts with disturbance factor 'D'). An error in GSI – whatever this parameter actually represents – is not going to go unnoticed in subsequent modelling.

References

Erharter, G. H., Hansen, T. F., Qi, S., Bar, N. and T. Marcher, 2023. A 2023 perspective on Rock Mass Classification Systems. Proc. Of ISRM congress, Salzburg.

Barton, N. 2023. GSI or JRC – continuum or discontinuum modelling – some suggestions and some critique. Proc. Of ISRM congress, Salzburg.