Rock mass characterization and use of empiricism to supplement modeling, design, and the verification of numerical results.

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Abstract

The writer has been in the privileged position of performing a wide range of rock mass characterization, and supervising a lot of numerical modeling in the past. In subsequent years requests to review a lot of similar work by others, has resulted in the possibility to observe the match or mismatch of numerical prognoses in relation to the finally monitored results. At this stage the actual underground conditions can be logged and compared with the assumptions different teams have made concerning the jointing, as interpreted from drill-core logging and surface mapping of exposures, where joint continuity may be exaggerated.

In this paper, continuum modeling is basically rejected for reasons that will be explained. These include the incorrect addition of cohesion and friction in the assessment of the shear strength of rock masses. These components are usually mobilized at different strains. If continuum modeling is the only viable option due to the scale of the problem, such as multiple mining stopes at variable depth, then at least attempts are made to improve upon existing methods, including the use of depth dependent deformation moduli, the use of degraded cohesion and mobilized friction, and the rejection of *a priori* non-empirical algebra for estimating c and φ for the rock mass.

Instead 'c' and 'φ' are estimated from the extended Q-system, where lack of cohesion and the need of shotcrete, and lack of internal friction and the need for bolting, have been provided by numerous *a posteriori* case records. These have conveniently suggested simple quantitative estimates for the needed cohesive and frictional strength. Since nobody knows what the actual c and φ of a given rock mass is going to be, simplicity and transparency is preferred to black box *a priori* algebra. Using CC and FC, the cohesive component and the frictional component, derived from pre-construction and post-construction logged Qc values, allows one to immediately observe the effect of for instance a poorly (vertically) sampled clay coated set of joints, or even just an additional set of joints, using formulae simple enough to be remembered. RMR and RMR-based GSI do not consider the number of joint sets, which are fundamental for determining over-break and need of rock reinforcement and support.

When applying the results of rock mass characterization, it is obviously preferable and more realistic to continue to treat the rock mass as a discontinuum, and use for example, UDEC-BB in a two-dimensional representation. As a result, non-linear, stress-dependent descriptions of shear strength and stiffness for the joint sets can be correctly represented. Potential response to excavation may then be more realistically observed, provided that modeled jointing is not unrealistically continuous as depth increases. Of course in bedded sedimentary rocks this warning may be unnecessary.

Observation of constructed caverns has shown that engineering geologists and numerical modellers have a tendency to exaggerate the continuity of jointing as depth is increased. This can result in an order of magnitude too large deformations, both in relation to monitored results, and in relation to empirical Q-based formulae for estimating deformations. It is therefore wise from the start, to integrate empiricism and the more sophisticated numerical modeling, if realism is to be achieved to an acceptable level for all parties concerned.