ORIGINAL ARTICLE

Probabilistic analysis of underground rock excavation stability using point estimate method

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Abstract

Accurately assessing the stability of an underground excavation poses a crucial problem to rock engineers due to variou sources of uncertainties inherent in the rock mass mechanical parameters. Ignoring uncertainties in rock mass properties ca lead to over-conservatism and based on the distributive character of the rock property, may sometimes produce misleadin results. There is therefore the need for probabilistic approaches that systematically account for uncertainties in undergroun stability assessment. This study analyzed the effect of uncertainties in the peak and post-peak rock mass mechanical param eters on the displacement and the plastic zone depth for a section of the Pahang-Selangor Raw Water Tunnel (PSRWT Malaysia. The uncertainties in the rock mass parameters were quantified using Monte Carlo Simulation, and the best-f probability distribution function was verified by the Kolmogorov–Smirnov (K–S) test at a 95% confidence level. The poir estimate method (PEM) incorporated in RS2 was used to model two case scenarios. In case 1, uncertainties in both pea and post-peak rock mass strength parameters were considered whereas in case 2, only uncertainties in the peak parameter were considered. A comparison of the two cases with the measured displacements revealed that the predicted displacemer and probability of failure were significantly underestimated when the uncertainties in the post-peak rock mass parameter were ignored and rock mass is assumed as elastic-perfectly plastic. A parametric study of the various input rock parameter revealed that the most sensitive parameter to the total displacement and yield zone depth is the UCS, followed by the residua Hoek–Brown frictional constant (m_b^r), and peak Hoek–Brown frictional constant (m_b^p).

Keywords Uncertainties · Probabilistic analysis · Rock tunnels · Post-peak strength · Point estimate method

Introduction

A crucial aspect of tunnel design is accurately assessing tunnel deformation and ensuring rock mass stability. The widely used techniques applied in the design of support systems for underground excavations include analytical, empirical, an numerical methods. Zhang and Mitri (2008) indicated tha the analytical methods are ineffective in addressing comple mining problems. The analytical methods were develope solely for circular tunnels and are based on the assumptio that in-situ stress conditions are hydrostatic. These assump tions, however, in most cases are not entirely true since di ferent stress conditions can be encountered (Tiwari et al 2018a). The empirical or stability graph-based approac developed by Mathews et al. (1981) and subsequentl modified by Potvin (1988) is site-specific and thus cann be applied to all projects. The stability zone defined by th stability graph method is based on historical data, henc making it an ineffective tool for analyzing the stability of stope with no prior historical data. The numerical method have over the years gained popularity due to their superiorit in handling complex problems associated with hydrostati or high differential in-situ stresses, complex geometries, an

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