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Calculation of Maximum and Minimum Plastic Zone Radius Around Circular Tunnels; New Emprical Relation

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Abstract

This paper discusses the calculation of plastic zone radius around the circular tunnel which were based on the Hoek-Brown failure criterion. The importance of plastic zone radius calculation for different stress ratio can be illustrated by knowing that for each stress ratio, the shape of failure zone will get changed. The calculation of plastic zone radius was done for five stress ratio with numerical modeling by defining the factor of d. The maximum and minimum of plastic zone radius were determined for each stress ratio and after that by fitting the curve to the data, the emprical relations were obtained. New emprical relations are the results of this paper which can be used for calculation of maximum and minimum plastic zone radius in different condition.

Keywords: Plastic zone radius, Hoek Brown criterion, Stress ratio

1. INTRODUCTION

when a circular tunnel is excavated in the rock mass, re-distribution of stresses on the tunnel walls and in the surrounding rock mass occur. By developing the plastic zone around the tunnel, radial convergence sets in, resulting in the reduction of stresses in the rock mass. An analysis of interaction between rock and the support system enable to evaluate the convergence of the tunnel face, the extent of plastic zone around the tunnel, the required support pressure and it's rigidity. This convergence confining analysis has been applied to circular tunnels in an hydrostatic stress field. The convergence confining method was attempted by many researchers. Plastic zone shape around the tunnel changes from the horizontal butterfly to horizontal parabolic, circular ,vertical parabolic and vertical butterfly shapes. By using two-dimensional elasto-plastic finite element method, stress analysis for divided cases of stress ratio at specific angles, the non-hydrostatic plastic zone equations has been explored.

2. CALCULATION OF PLASTIC ZONE AND DISPLACEMENT IN HYDROSTATIC CONDITION

The analytical methods was carried out to determine the size of the plastic zone surrounding a circular tunnel subjected to a hydrostatic condition is dependent on the kind of failure criterion that defined by:
•based on the Mohr-Coulomb failure criterion
•based on the Hoek-Brown failure criterion
the analysis that is based on the Mohr-Coulomb failure criterion gives a very simple solution for the progressive failure of the rock mass surrounding a circular tunnel.
In this analysis Duncan Fama (1993) was assumed that the surrounding heavily jointed rock mass behaves as an elastic-perfectly plastic material in which failure involving slip along intersecting discontinuities is assumed to occur with zero plastic volume change.
In the present work, an analytical solution derived by Carranza-Torres and Fairhurst (1999) is based on the 'general' form of the Hoek-Brown criterion proposed by Londe (1988).