

Analytical Solution and Factors Influencing the Tunnel Plastic Zone under a Nonuniform Stress Field

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Abstract The size of the plastic zone around a tunnel is a crucial parameter for determining the surrounding rock stability. In actual cases, the initial rock environment is dominated by a nonuniform stress field, especially in regions with high tectonic stresses. To explore the plastic zone distribution in tunnel surrounding rock under a nonuniform stress field, a new analytical solution for the plastic zone radius is proposed, and the reliability of the analytical results is verified with FLAC3D. Moreover, the influence of initial stress and rock mass parameters on the plastic zone distribution is explored. Finally, the presented solution is verified with several existing engineering cases. The results show that under a nonuniform stress field, the cohesion, friction angle, and vertical stress strongly affect the plastic zone size and that the lateral pressure coefficient dominates the plastic zone shape. The average error of the size of the plastic zone determined with the new analytical method is 14.6%, which is 36.1% and 49.9% more accurate than that of the point criterion method and the stress construction method, respectively. This study offers a valuable reference for predicting the plastic zone distribution and guiding tunnel engineering support for nonuniform stress fields.

Key words: tunnel surrounding rock, plastic zone, nonuniform stress field, approximate implicit method.