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Analytical solution for the stress and deformation of rock surrounding a cold-regional tunnel under unequal compression

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Abstract: Frost damage is one of the main factors to affect the stability of cold-regional tunnels. It often occurs in the tunnel portal where the horizontal stress and vertical stress are generally not equal. To ensure the construction safety of cold-regional tunnels and to propose new theoretical insights for their analysis and design, an analytical calculation model for a cold-regional tunnel under unequal compression is established in this paper. During the analysis process, this model is decomposed into an excavation model and a frost heaving model. The excavation model is solved using a complex variable function method. Combining the supplemental equation built by the numerical results, the frost heaving model is also addressed using an iteration method. The total stress and deformation are obtained by the superposition of the results of the two models. An example is introduced to obtain the stress field of the lining and surrounding rock of cold-regional tunnels. The reason for the size relation between the radial stress and the circumferential stress at different angles is explained. Then, the range for the negative circumferential stress at different angles is determined. Moreover, the conclusion is also drawn that the radius of zero frost heave displacement is independent of the linear strain induced by frost. Finally, it is found that frost heave induced an incremental stress difference in the lining, which results in damage to lining. The calculation method and results can provide a guide for the construction of cold-regional tunnels.

Keyword: cold-regional tunnels; frost heaving force; supplemental equation; unequal compression.