Study on Seepage Law of Surrounding Rock in Karst Tunnels Under Various Influencing Factors: Postprint

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Abstract

To investigate the seepage law of surrounding rock in karst tunnels, the Yesanguan Tunnel of the Yichang-Wanzhou Railway is taken as the engineering background. Based on engineering data and literature review, key factors influencing surrounding rock seepage were identified. A finite element calculation model for karst tunnel seepage based on elastic damage was established using RFPA software to analyze the influence of surrounding rock fracture patterns, permeability coefficient, and water pressure loading rate on seepage. The research results demonstrate that the surrounding rock permeability coefficient, fracture pattern, and water pressure loading rate exert significant effects on seepage, with their influence diminishing sequentially in that order. As water pressure increases, the fracture evolution process in surrounding rock primarily exhibits three stages: stable latent stage, sudden failure stage, and accelerated development stage. Fracture propagation generally manifests as divergent extension from the crack tip along the crack orientation. Upon reaching a critical water pressure threshold, the number of damaged elements around the crack tip surges dramatically, continuously forming dense interconnections and creating new fractures, thereby transforming the original resistant elements into weak elements and ultimately establishing preferential seepage pathways.

Full Text

Seepage Characteristics of Surrounding Rock in Karst Tunnels Under Various Influencing Factors

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Abstract

To investigate the seepage characteristics of surrounding rock in karst tunnels, this study employs the Yesanguan Tunnel of the Yiwan Railway as an engineering case. Key factors influencing rock mass seepage were identified through comprehensive analysis of engineering data and literature review. A finite element computational model for karst tunnel seepage based on elastic damage theory was developed using RFPA software to analyze the effects of fracture patterns, rock mass permeability coefficient, and water pressure loading rate on seepage behavior. The results demonstrate that the permeability coefficient, fracture pattern, and water pressure loading rate exert significant influence on seepage, with their impact diminishing in that order. As water pressure increases, the fracture evolution process in surrounding rock primarily undergoes three distinct stages: a stable latent phase, a sudden failure phase, and an accelerated development phase. Fracture propagation typically initiates from fracture tips and extends divergently along fracture orientations. Upon reaching a critical pressure threshold, the number of damaged elements around fracture tips increases dramatically, forming dense, interconnected networks that create new fractures. This transformation converts originally resistant elements into weak elements, ultimately establishing preferential seepage pathways.

Keywords: Karst tunnel; influencing factors; seepage law; evolution process

Note: Figure translations are in progress. See original paper for figures.