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Theoretical Analysis and Numerical Simulation of Surrounding Rock Damage under Staged Blasting in Upper Bench Tunneling: Post-Print

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Abstract

To thoroughly investigate the degree of surrounding rock damage during the staged blasting process of the upper bench in tunnel engineering, this study takes a Grade II rock mass as an example, beginning with the mechanism of crack generation in a single blasthole, explores the interaction mechanisms between adjacent blastholes and the cut blasting mechanism of multiple holes, thereby establishing an analytical framework for the damage mechanism of surrounding rock. Numerical simulations using ANSYS/LS-DYNA are conducted for the staged blasting process of the upper bench in this Grade II rock mass, examining the damage conditions of surrounding rock under the combined action of stress waves and explosion gases from cut holes, as well as the damage conditions across the entire upper bench cross-section. The findings reveal: there exists a significant correlation between the degree of surrounding rock damage and crack propagation; cut holes produce lower strain rates in the surrounding rock compared to other sections, yet cause damage to develop initially at pre-existing cracks, which is conducive to improving rock fragmentation efficiency; under reverse initiation conditions, the surrounding rock damage around the upper bench cross-section is well controlled, and the cut contour formation quality meets expectations; blasthole spacing directly influences crack development during blasting—smaller spacing leads to initial crack formation between holes, while excessively large spacing results in non-uniform rock fragmentation, introducing a certain “space effect”.

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Full Text

Theoretical Analysis and Numerical Simulation of Surrounding Rock Damage under Upper Bench Section Blasting in Tunnel Engineering

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Abstract

To thoroughly investigate the extent of surrounding rock damage during upper bench section blasting in tunnel engineering, this study takes Grade II surrounding rock as an example and establishes a comprehensive damage mechanism analysis framework. This framework begins with the mechanism of crack initiation in single blastholes, then examines the interaction mechanisms between adjacent blastholes, and finally addresses the cutting action mechanism of multiple blastholes. Numerical simulations of the upper bench section blasting process in this Grade II surrounding rock were performed using ANSYS/LS-DYNA to analyze the damage to surrounding rock under the combined effects of stress waves and explosion gases from cutting holes, as well as the overall damage distribution across the entire upper bench section. The research findings demonstrate a clear correlation between the degree of surrounding rock damage and crack propagation. Although cutting holes produce lower strain rates in the surrounding rock compared to other sections, they promote damage development initially at pre-existing cracks, thereby enhancing rock fragmentation efficiency. Under reverse initiation conditions, the surrounding rock damage around the upper bench section is effectively controlled, and the cutting contour achieves the desired formation. Furthermore, blasthole spacing directly influences crack development during blasting; smaller spacing facilitates initial crack formation between holes, while excessive spacing leads to non-uniform rock fragmentation, introducing a certain "spatial effect."

Keywords: upper bench section blasting; surrounding rock damage; initial crack; numerical simulation; "spatial effect"

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

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