Failure characteristics and stress wave propagation of red sandstone under explosion with varying gas energies

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Abstract

The blasting excavation process during underground rock mass engineering can induce severe stress disturbance, resulting in spalling and damage to the surrounding rock mass in the tunnels, which can seriously compromise the underground engineering construction. In the present work, an experimental blast loading device was developed to study the dynamic response of rocks under explosive loads, which could vary the utilization of explosive gas energy by changing the constraint conditions. The device employed a high-speed camera to record the stress wave propagation and failure characteristics on the surface of the specimen and verified the reliability of the experimental results using an ultra-dynamic strain gauge. The developed apparatus was used to explore the failure characteristics and stress wave propagation laws in red sandstone under different explosion gas energies. The complete process of stress wave propagation in red sandstone was captured under different explosive gas energies, from an intact form to failure, and the attenuation law of stress waves was obtained. The experimental results showed that when the explosive stress wave traversed through the specimen, it primarily experienced tensile strain, with maximum tensile strain observed at the free surface. The stress wave propagation in the specimen varied under different explosive loads, leading to varying overall failure characteristics of the specimen. The larger the amplitude of the stress wave, the greater the spatial attenuation coefficients of the compression wave and the tensile wave. The thickness of the spalling fracture was determined based on the wave width of the stress wave λ_1, the attenuation coefficient of the stress wave α, and the longitudinal wave velocity C_0. The closer the crack is to the bottom of the specimen, the smaller the thickness. The experimental results provide theoretical guidance to understand the strong dynamic disturbance behavior and progressive instability failure phenomenon in deep underground engineering.

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