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Effects of Material Heterogeneity on the Blast-Induced Rock Crack Initiation and Propagation

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ABSTRACT

Material heterogeneity plays an important role in the blasting induced rock fracture. However, the investigation of the effects of material heterogeneity is limited by the numerical methods for dynamic fracture. In the work, we propose a peridynamic model for brittle rock with heterogeneous micro-modulus and critical stretch to investigate the effects of material heterogeneity on the blast-induced rock crack initiation and propagation. The discretization in polar coordinates is introduced into the proposed model to avoid the fallacious directional guidance to the crack initiation around the hole. The proposed model satisfies the m-convergence, and its results are consistent with experimental results. For the locations of blast-induced rock crack initiation, the results show that the crack initiation locations are determined by the type of material heterogeneity, which always correspond to the local minimum of the heterogeneous material properties. The blasting load just makes cracks initiate in the given sequence by material heterogeneity. The multiple cracks initiate and propagate with a tendency to bisect the circumference. For the blast-induced crack propagation, the results suggest that there is a strong correlation between the crack propagation speed and the behavior of each crack. The initiated cracks around the hole are more likely to propagate and form main cracks as the material properties become more heterogeneous. We also explore the effects of blasting load parameters on the crack propagation. The decay rate of the blasting loads just affects the crack propagation while the load peak affects both the crack initiation and propagation. The results of this work can offer a useful reference for the optimization of the blasting loads and outcomes.

KEYWORDS

Blast-induced crack; crack initiation; crack propagation; material heterogeneity; peridynamic theory

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