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ASSESSMENT OF BLAST-INDUCED GROUND VIBRATION AND ITS IMPLICATIONS FOR FINAL HIGHWALL STABILITY IN AN OPEN-PIT COAL MINE

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ABSTRACT

Blast-induced ground vibration is a major geotechnical concern in open-pit coal mining, particularly where repeated production blasting occurs near final pit slopes. Although peak particle velocity (PPV) is widely used to evaluate vibration intensity, its implications for long-term highwall stability remain insufficiently understood due to geological heterogeneity and cumulative blasting effects. This study investigates the relationship between blasting vibration and final highwall stability using field monitoring data and numerical slope analysis. A database of 162 production blasting events was compiled, including blast distance, charge per delay, and three-component PPV measurements. Statistical analysis and logarithmic regression were employed to develop an empirical vibration attenuation model and identify the dominant factors influencing ground vibration. The results indicate that blast distance and charge per delay are the primary variables controlling vibration attenuation. The developed empirical model achieved a coefficient of determination (R^2) of 0.549, suggesting moderate predictive capability and highlighting the influence of additional geological factors on vibration propagation. To evaluate the geotechnical implications of blasting vibration, representative vibration scenarios were incorporated into a three-dimensional slope stability model using laboratory-derived geomechanical properties of mudstone, sandstone, and coal strata. The numerical simulations indicate that increasing vibration intensity is associated with greater slope deformation and a reduction in stability margins, particularly within weaker lithological units. The integration of field vibration monitoring, empirical prediction, and numerical slope assessment provides a practical framework for evaluating blast-related risks in open-pit coal mines. The proposed approach can support blasting optimization and contribute to safer final highwall management.

Keywords: blast-induced vibration; peak particle velocity; final highwall; slope stability; empirical model; open-pit coal mining.