GNSS-Based Blasting Vibration Monitoring and Feature Recognition Method

Rao Xiaokang and Huang Shengxiang (China, PR)

Key words: Deformation measurement; GNSS/GPS; Remote sensing; GNSS; blasting; vibration monitoring; feature recognition; CEEMDAN-MPE-SSA; noise suppression

SUMMARY

Conventional blasting vibration monitoring suffers from unstable low-frequency performance, susceptibility to environmental interference, complicated operation, and vulnerability to damage. To address these limitations, this study proposes a novel monitoring and feature recognition method based on the Global Navigation Satellite System (GNSS). The method integrates complete ensemble empirical mode decomposition with adaptive noise (CEEMDAN), multiscale permutation entropy (MPE), and singular spectrum analysis (SSA). First, a GNSS-based monitoring framework tailored to blasting environments is established, providing a new reference for extending GNSS technology to vibration monitoring. Numerical simulations demonstrate that the proposed feature recognition approach effectively suppresses low- and high-frequency noise as well as trend components, enabling accurate extraction of the dominant vibration frequency compared with traditional methods. Field experiments, including open-pit and tunnel blasting, further validate the method against conventional blasting recorders. The results show accurate identification of key vibration features such as initiation time, peak particle velocity (PPV), initiation period, and dominant frequency. The RMSE of PPVs is 0.086, and errors in other indicators remain within 5%, showing strong agreement with conventional monitoring. The proposed GNSS-based vibration monitoring and feature recognition method enhances low-frequency stability, adaptability to field conditions, operational simplicity, and information richness. It provides a promising supplementary approach to existing blasting vibration monitoring techniques.