

Remote Identification and Stability Evaluation of Falling-type Unstable Rock Masses on High-steep Slopes: Postprint

Authors: Zhang Xueliang

Date: 2025-07-18T00:00:00+00:00

Abstract

High-steep slopes, characterized by their steep inclinations, complex rock mass structures, and intense weathering and unloading, often host dangerous rock masses situated on high-altitude scarps or within zones of well-developed unloading fissures. Under the influence of multiple complex triggering factors, such dangerous rock masses are prone to high-disaster-potential high-altitude remote collapses, constituting severe safety hazards. However, due to the difficulties in close-range investigation, challenges in accurately identifying boundary conditions, and obstacles in obtaining key mechanical parameters, traditional methods exhibit significant limitations in the identification and stability assessment of dangerous rock masses on high-steep slopes.

To address the aforementioned challenges, this study focuses on falling-type dangerous rock masses. Based on vibration dynamics theory and through theoretical derivation and laboratory model testing, the relationship between bedrock-dangerous rock dynamic indices and dangerous rock mass stability is investigated, and a dangerous rock mass stability evaluation method based on dynamics-PSO-SVM is proposed. Integrating unmanned aerial vehicle (UAV) and laser vibrometry technologies, research on remote identification and stability evaluation of dangerous rock masses on high-steep slopes was conducted, with demonstration applications implemented on high-steep slopes of hydropower projects in southeastern Tibet. The principal contributions and conclusions of this paper are summarized as follows:

- (1) Through theoretical derivation and experimental investigation, the differential evolution characteristics of key dynamic indices between bedrock and dangerous rock mass during the destabilization process were analyzed, revealing the correlation between bedrock-dangerous rock amplitude ratio, frequency ratio indices and stability evolution. A dynamics-PSO-SVM

dangerous rock mass stability evaluation method was proposed, achieving basic identification of dangerous rock mass stability states through training and deep learning with experimental data.

- (2) Utilizing high-steep slopes of hydropower projects in southeastern Tibet as the engineering background, remote identification of dangerous rock masses based on UAV photogrammetry and remote laser vibrometry technologies was proposed. Combined with the dynamics-PSO-SVM dangerous rock mass stability evaluation method, stability assessment applications for high-steep slope dangerous rock masses were performed. The practicality and effectiveness of the dynamics-PSO-SVM stability evaluation method were verified through traditional stereographic projection method and numerical simulation analysis of dangerous rock mass stability.

Full Text

Preamble

Study on Remote Sensing Identification and Stability Evaluation of Falling Dangerous Rock on High-steep Slope

Xueliang Zhang

School of Resources and Security Engineering, University of Science and Technology Beijing, Beijing 100083

Abstract

High-steep slopes, characterized by steep surfaces, complex rock mass structures, and intense weathering and unloading, often host dangerous rock masses located at high elevations or in areas with well-developed unloading fissures. Under the influence of various complex triggering factors, these dangerous rock masses are prone to high-altitude, long-runout collapses with high disaster potential, posing serious safety hazards. However, traditional methods for identifying and evaluating the stability of dangerous rock masses on high-steep slopes have significant limitations due to difficulties in close-range investigation, challenges in accurately identifying boundary conditions, and obstacles in obtaining key mechanical parameters.

To address these issues, this study focuses on falling-type dangerous rock masses. Based on vibration mechanics theory and through theoretical derivation and laboratory model tests, the relationship between bedrock-dangerous rock dynamic indicators and the stability of dangerous rock masses is investigated. A stability evaluation method for dangerous rock masses based on dynamics-PSO-SVM is proposed. Combining UAV and laser vibration measurement technologies, research on remote identification and stability evaluation of dangerous rock masses on high-steep slopes is conducted, with a demonstration application on high-steep slopes of a hydropower project in southeastern Tibet.

The main contributions and conclusions of this paper are as follows:

- (1) Through theoretical derivation and experimental research, this study analyzes the differential evolution characteristics of key dynamic indicators of bedrock and dangerous rock during the destabilization process of dangerous rock masses, reveals the correlation between bedrock-dangerous rock amplitude ratio and frequency ratio indicators and stability evolution, proposes a dynamics-PSO-SVM stability evaluation method for dangerous rock masses, and achieves basic identification of dangerous rock mass stability states through training and deep learning of experimental data.
- (2) Taking the high-steep slopes of a hydropower project in southeastern Tibet as the engineering background, this study proposes a remote identification method for dangerous rock masses based on UAV photogrammetry and remote laser vibration measurement technologies. Combined with the dynamics-PSO-SVM stability evaluation method, the stability evaluation of dangerous rock masses on high-steep slopes is applied. The stability of dangerous rock masses was analyzed using traditional stereographic projection and numerical simulation methods, thereby verifying the practicality and effectiveness of the dynamics-PSO-SVM stability evaluation method.

Keywords: High-steep slope dangerous rock mass; Amplitude ratio; Frequency ratio; Remote identification; Stability evaluation

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

Source: ChinaXiv – Machine translation. Verify with original.