Post-print: 3D Modeling and Stability Analysis of Dangerous Rock Masses Based on Close-range Photogrammetry and Ground-penetrating Radar Technology

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Date: 2025-09-02T14:54:22+00:00

Abstract

To address issues of low work efficiency, high safety risks, and survey blind spots in the investigation of high-steep dangerous rock masses, a survey system specifically for such rock masses was established using close-range photogrammetry and ground-penetrating radar technologies, with the No. 1 high-elevation dangerous rock mass from a hydropower project serving as a case study. Technical means were employed to construct a three-dimensional oblique photogrammetric model of the dangerous rock mass, enabling precise determination of its boundary conditions and engineering geological characteristics. Based on the acquired data, the instability mechanism and failure mode were analyzed, and stability evaluation was performed. The results indicate that No. 1 dangerous rock mass has a thickness of approximately 14.1 m, a length of about 27.1 m, a maximum concave cavity depth of 4.6 m, and a volume of 2210 m^3, classifying it as a large-scale dangerous rock mass. The development depth of tension cracks at the rear edge ranges from 7.6 to 9.0 m, with a falling-type failure mode. Under natural, seismic, and rainstorm conditions, the stability coefficients are 1.16, 1.08, and 1.04, respectively, corresponding to stable, basically stable, and marginally stable states. The non-contact measurement technology of oblique photogrammetry and the tension crack detection capability of ground-penetrating radar compensate for the limitations of single-technology information acquisition, resolving the problems of low efficiency, high safety risks, and survey blind spots inherent in traditional investigation methods. This approach provides novel ideas and methods for the identification and detection of high-steep dangerous rock masses and offers valuable reference for the investigation and evaluation of similar rock mass hazards.

Full Text

Construction of Three-dimensional Model and Stability Analysis of Unstable Rock Mass Based on Nap-of-the-object Photogrammetry and Ground Penetrating Radar Technology

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Abstract

To address the challenges of low efficiency, high safety risks, and investigation blind spots in the exploration of high and steep unstable rock masses, this study establishes a comprehensive investigation system using nap-of-the-object photogrammetry and ground penetrating radar (GPR) technologies. Taking the No. 1 high-position unstable rock mass at a hydropower project as a case study, we constructed a 3D oblique photogrammetry model to accurately determine the boundary conditions and engineering geological characteristics of the rock mass. Based on the acquired data, we analyzed the failure mechanism and failure mode, and conducted a stability evaluation.

The results demonstrate that the No. 1 unstable rock mass has a thickness of approximately 14.1 m, a length of about 27.1 m, and a maximum concave cavity depth of 4.6 m, with a total volume of 2210 m^3, classifying it as a large-scale unstable rock mass. The development depth of tension cracks at the rear edge ranges from 7.6 to 9.0 m, and the failure mode is classified as toppling-falling. Under natural, seismic, and rainstorm conditions, the stability coefficients are 1.16, 1.08, and 1.04, respectively, corresponding to stable, basically stable, and marginally stable states.

The integration of non-contact oblique photogrammetry measurement and GPR-based tension crack detection compensates for the limitations of single-technology approaches. This combined methodology effectively resolves the issues of low efficiency, high safety risks, and investigation blind spots inherent in traditional exploration methods. The approach provides new insights and techniques for the identification and detection of high and steep unstable rock masses, offering valuable reference for the investigation and evaluation of similar geological hazards.

Keywords: Nap-of-the-object photogrammetry; Ground penetrating radar; Unstable rock mass; Fracture development depth; Stability

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