

Rockfall Hazard Map Using Digital Elevation Model

Takuya URAKOSHI

Assistant Senior Researcher, Geology, Disaster Prevention Technology Division

1. Introduction

We have developed a method to make a rockfall hazard map, using the digital elevation model (DEM). This method enables mapping a “reach probability,” that is, the probability that falling rocks will reach railway facilities. This hazard map will be helpful to screen rock outcrops and to plan measures against a potential rockfall disaster.

2. Hazard mapping

This hazard mapping method consists of three components as shown in Fig.1: an estimation of the distribution of rock outcrops, an analysis of the pathway of a falling rock from each rock outcrop, and an evaluation of the reach probability using rockfall simulation. In this method, these estimations and evaluations are carried out using DEM. The DEM is raster data where analysis area is divided into squares, namely cells, with each cell consisting of an appropriate elevation value. The width of a cell, i.e. spatial resolution, is up to one meter when it is created from airborne light detection and ranging (Lidar) data.

The estimation of the distribution of rock outcrops (Fig.2(A)) is based on two characteristics, namely the slope angle and the curvature of the ground surface calculated using DEM. We selected these two properties as indices for this estimation based on statistical comparison between the properties and the results of field investigations.

The pathway of a falling rock from each rock outcrop [Fig.2(A)] is analyzed with the assumption that the falling rock moves in the direction of maximum downward gradient, DMDG. The DMDG is determined by comparing slope angles between the cell where the rock exists and the surrounding eight cells.

To evaluate the “reach probability,” an existing simulation^[1] using the Monte Carlo method is conducted (Fig.2(B)). The pathway analysis and the rockfall simulation are implemented for all estimated rock outcrops, and in this analysis, each rock outcrop is regarded as an individual source of rock fall.

Finally, the reach probability is mapped along railway lines using a geographic information system (Fig.2(C)). Additionally, the distribution of rock outcrops and the pathways are also mapped.

3. Merits of the rockfall hazard map

This map can be used as a screening tool to identify rock outcrops to be given high priority in investigation by engineers, among the vast number of rock outcrops along railway facilities. Moreover, this map enables users to find the region where the reach probability is high, which helps users to make a decision where they should prioritize counter-measures.

[1] Yoshida, H., T. Ushiro, H.Masuya and T. Fujii, 1991. An Evaluation of Impulsive Design Load of Rock Sheds Taking into Account Slope Properties, Journal of structural engineering. A., 37A, 1603-1616. (In Japanese with English abstract)

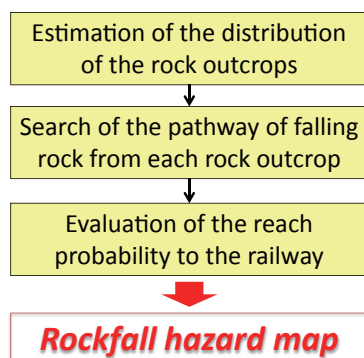
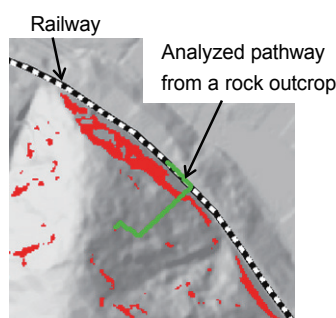
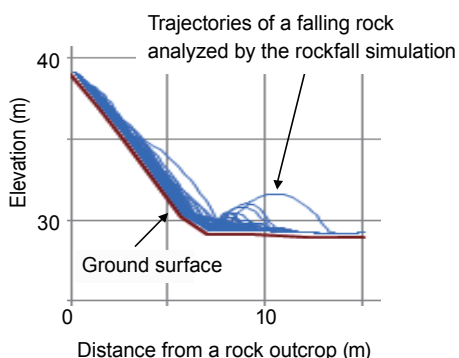


Fig.1 The process of the proposed hazard mapping method

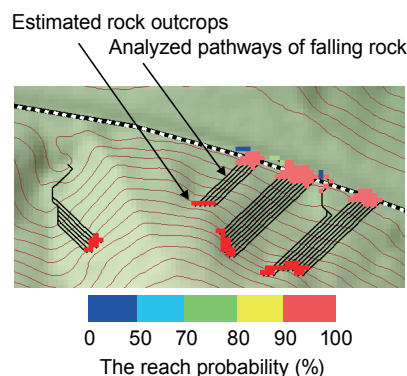


■ The estimated rock outcrops

(A) Distribution of rock outcrops and pathway of falling rock



(B) Rock fall simulation on pathway



(C) Reach probability of falling rocks

Fig.2 Examples of estimation results