EXPERIMENTAL STUDY FOR IDENTIFYING UNSTABLE ROCK BLOCKS

BY MEASURING MICRO-TREMORS AND VIBRATION ON ROCK SLOPES

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INTRODUCTION

Rock failure occurs far less often than slope failure[, but when this failure does occur, it causes severe damage. On cliffs facing roads or human habitations in particular, a rock failure claims human lives. So it is important to prevent a disaster caused by rock falling from a rock cliff by accurately identifying unstable rock blocks on a rock cliff to monitor them and take countermeasures to prevent their failure. However, unstable rock blocks are usually identified by studying the distribution and aperture of cracking visible on the rock cliff by a surface survey, but it is difficult to reliably perform such a survey visually from the ground surface, which means that accurately identifying unstable rock blocks is extremely difficult. And it is also very expensive to perform a priority survey in order to increase the precision of unstable rock block identification.

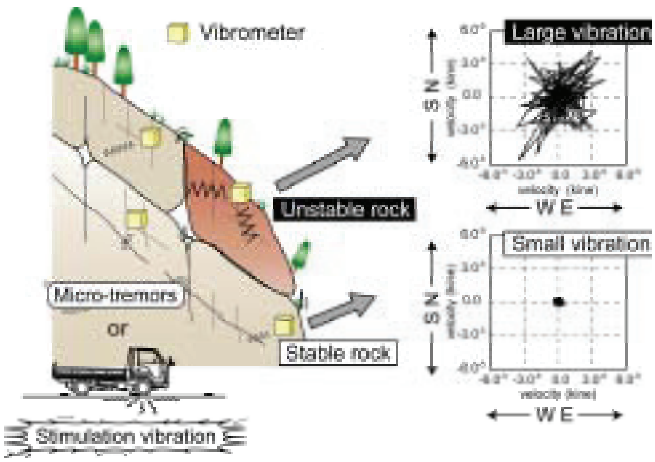

Fig. 1: Unstable bed rock and Stablerock

Fig. 2: Vibrometer shape and its installation

So we carried out a field test to develop a method of simply and precisely identifying unstable rock blocks by measuring vibrations of a rock cliff. This method of identifying unstable rock blocks is based on the idea that in contrast to stable rock in which surrounding cracks adhere closely and are integrated with the foundation, in unstable rock blocks, the cracks have opened and deteriorated, causing separation from the foundation, with the result that unstable rock vibrates more than stable rock (Fig. 1).

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OUTLINE OF THE MEASURING TECHNOLOGY

To apply this measuring technology, a number of vibrometers are installed on a rock cliff to measure the micro-tremors (micro-tremors occurring at all times) of rock blocks and the vibrations produced in reaction to stimulation vibrations, and the amplitudes or wave lengths (frequencies) are compared to evaluate the stability of the rock blocks. At this time, the amplitude of vibrations applied to the cliff is not constant, so in principle, one measurement point is set on a known stable baserock to measure its vibrations. The vibrometers that are used can measure vibrations in three dimensions, and their size is approximately 8 x 8 x 4 cm. Each vibrometer is equipped with an approximately 8cm long spike and is installed by drilling a hole in the rock, inserting the spike in the hole, then fixing it in place with putty (Fig.2). They were installed by rock climbers.

The vibration that has been measured is analyzed to evaluate the stability of rock blocks as shown in Fig.3. First, the vibration wave form is output and its amplitude and the way it declines, and other characteristics are visually observed to judge the unstability at the measurement point. Secondly, a Fourier transformation of the vibration wave form is performed to obtain the frequency spectrum. The results of the frequency spectrum analysis are applied to judge whether or not measurement points are on the same rock block, based on characteristics such as the existence/non-existence of a dominant frequency, its value, etc. Third, because the vibration is measured in three dimensions, combinations of two dimensions are formed to output the vibration particle trace in a total of three directions: one horizontal direction and two vertical directions. The vibration particle trace visually shows the amplitude of the vibration, but also permits observation of the direction of the vibration and allows the evaluation of the instability of each measurement point accompanied by a judgment of whether or not they are on the same block. Fourth, trace accumulation length (cumulative length of the trace of the vibration of a measurement point within a fixed period of time) is obtained to represent the vibration amplitude numerically based on the vibration particle trace. This value is used to establish the priority of relative instability of unstable blocks. Trace accumulation length is a new concept applied by this measurement technology, and is a value obtained by accumulating the lengths of traces moved by vibration at the measurement points on rock during a fixed period of time.

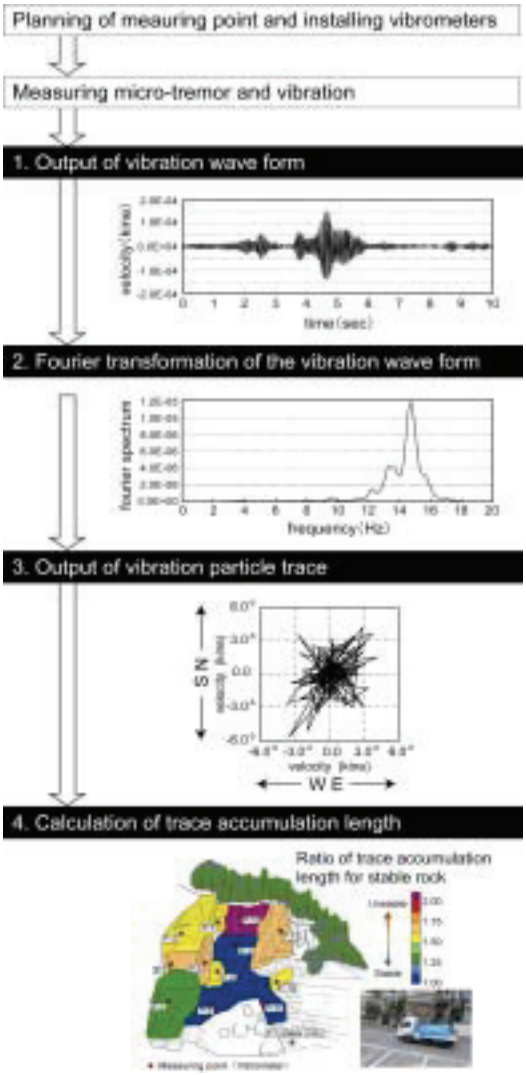

Fig. 3: Flow of analysis

Keywords: Identifying Unstable Rock Blocks, Micro-tremors, Vibration