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On the seismic responses of a deep-seated landslide: Insights from field monitoring

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1. Introduction

In recent years, earthquakes have triggered numerous landslides, resulting in severe damage to local properties and sometimes great loss of lives directly. To prevent or at least to mitigate this kind of geohazards, great efforts had been paid to the study on understanding the properties of co-seismic landslides, and many research results had been obtained. By now, the co-seismic site responses on landslides had been analyzed by means of various methods and evidences showed that the seismic responses of landslide can be affected by various factors especially in those deep-seated landslides, where the geological and slope structural conditions can be more complicated (Bozzano et al, 2008; Del Gaudio et al, 2011; Massa et al, 2014; Gischig et al, 2015). However our understanding on the co-seismic response of deep-seated landslides is still very poor. To better understand the co-seismic response of deep-seated landslides, we then performed long-term seismic monitoring on a landslide, and analyzed the co-seismic response features of this landslide. Some insights were obtained and will be presented here.

2. Method

Five high-sensitivity seismometers were installed on different locations of an old deep-seated landslide on Azue area, Tokushima prefecture, which were reactivated by heavily rainfall in 2004, with the purpose of analyzing the landslide stability and the relationship between variation of site responses and status of slip mass (Fig. 1). Through long-term real time monitoring, many earthquake events with different magnitudes and epicentral distances were recorded. By using these records, we analyzed the site responses, especially the amplification effects, were analyzed in time and frequency domains.

3. Results

The results showed that the amplified responses are different for differing locations of the landslide.

(1) The spectral ratios from coda waves showed that the amplifications on the location of talus (P2) present obvious peak in 7.7Hz with amplified factor about 8 and amplified direction pointing toward 40°N; however these on block B (P3) of the landslide are inconspicuous, and multiple peaks emerge in 10-20Hz and arrange between 30°N-70°N. Differing from former results, one evident peak appears in low frequency band near 3Hz along 50°N on block A (P4). In addition, the amplifications on bedrock (P1) outside of the landslide area present relatively small values in frequency bands and distribute in wide azimuth bands (Fig. 2).

(2) The amplification factors in different periods in approximated one year also present various characteristics on different locations of the landslide. The predominant peak values maintain stably in a narrow frequency band on P2 around the whole year, but they scatter in different frequency bands on P3 around the same periods (Fig. 3).

3. Conclusion

The co-seismic site responses at different locations on Azue landslide revealed that the amplification effects on the landlside mass areas are more complicated than the deposit areas or bedrock. These phenomena may result from the complex geological settings and/or ground water level, or other reasons that could lead to seismic energy redistribute in the landslide mass. Because we just have performed the analyses by only using relatively strong motion records that may be insufficient, multidisciplinary approaches will be adopted for analyzing the co-seismic responses on this landslide in the future.

Reference

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(a)

(b)

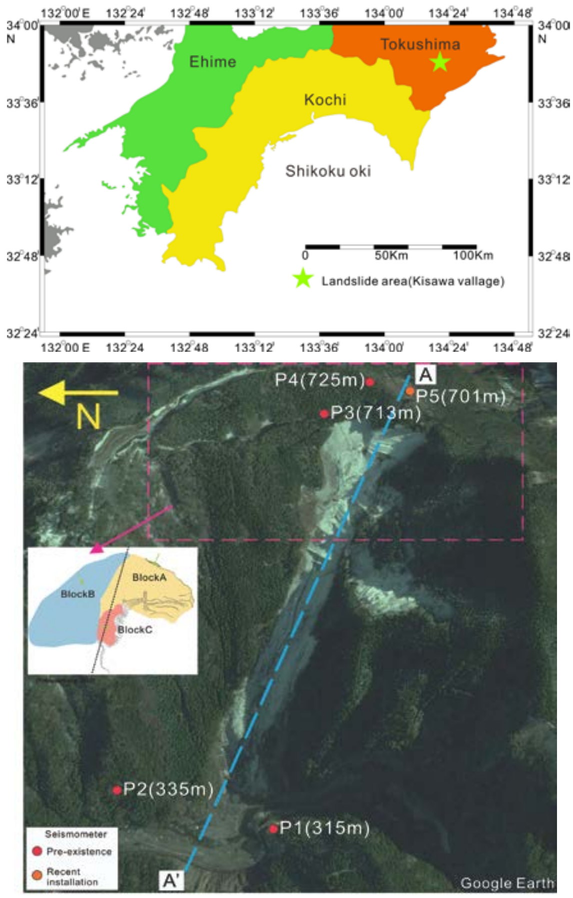

Fig. 1. (a) Location of study area in Tokushima prefecture; (b) View of Azue landslide and locations of installed seismometers.

(a)

(b)

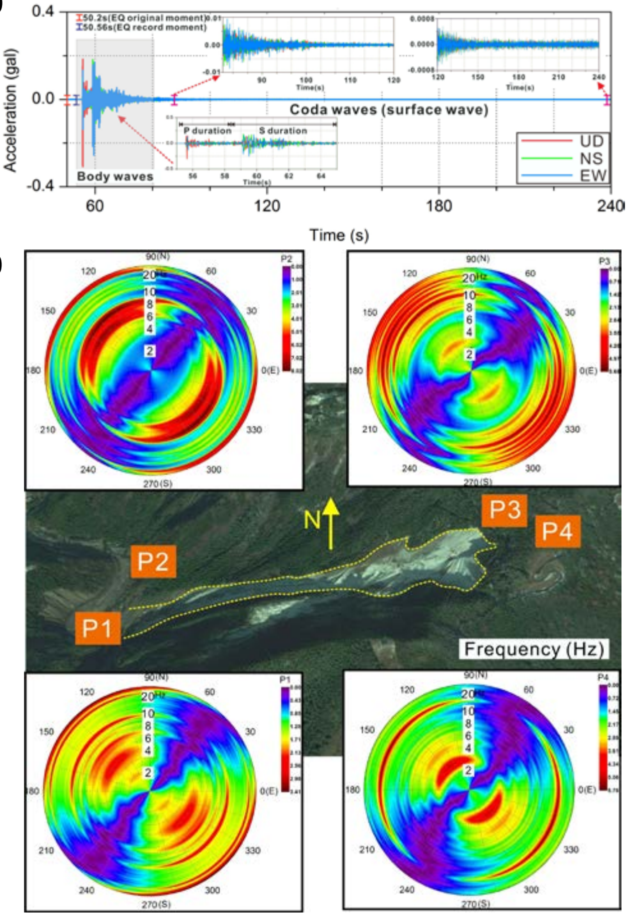

Fig. 2. (a) Time history data for the 3-component acceleration recorded on position P1 from one earthquake event; (b) The amplification effects (average of all the recorded earthquake events in 2015) in frequency domain on different locations. Note: the color scales represent amplified values and the azimuths show the amplified directions.

(a) (b)

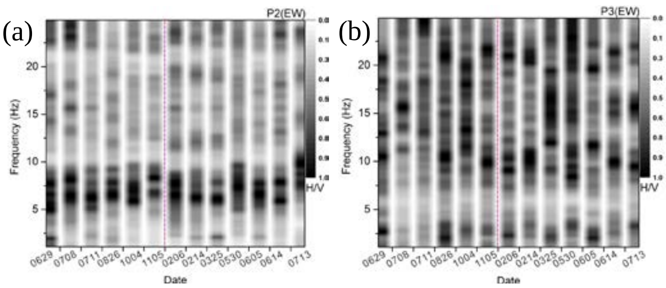

Fig. 3. (a) and (b) the seasonal H/V amplitudes from EW component in frequency bands on landslide deposit area (P2) and slip mass block B (P3), respectively in one year events