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Studying field-scale dam breach due to overtopping by using seismic signals

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A dam is the natural damming of a river by the geohazards, such as landslides and debris flows. When the dam materials are eroded or washed away due to scour, erosion, and/or an increasing in water level of dam lake, leading dam breach and catastrophic outburst of flooding, which affect the downstream area. Therefore, real-time monitoring of dam failure would facilitate relevant early warning message for the impending floods. The conventional approach using image-based analysis and hydrological measurements is for providing timely warnings of breach; however, landslide dams often occur in mountainous areas, where the methods may face limitations of in-situ measurement. Additionally, the observations of landslide dam breach process are rare and cause the large uncertainties in scientific research. Hence, this study utilizes seismic signals to study the overtopping breach process of field-scale dams. Seismic signals serve as a monitoring tool while simultaneously monitoring the seismic characteristics of overtopping failure in the field-scale dams. In fact, there is a scarcity of observed seismic signal records related to dam breach process in field. Even if some observational data is available, there is a lack of corresponding image analysis or hydrological information for comprehensive discussions. Thus, this study aims to observe and understand overtopping failure through a series of field-scale dam breach experiments. In this study, we first investigate the time-frequency characteristics of seismic power spectral density (PSD) corresponding to the dam breaches primarily involves retrogression erosion, longitudinal and lateral erosion, and the stabilization period. Then, the results of photographic analysis (surface flow velocity, breach geometry), discharge measurements and the time-frequency characteristics of PSD are integrated to discuss the phenomena associated with dam breach. Finally, a series of comparison between compacted and non-compacted dams for PSD spectrogram patterns. The time-series of mean PSD and flow discharge data for the compacted dam exhibit a single-peak and short-term signal duration. Notably, the mean PSD time-series recorded by the seismic station located at the left bank showed a similar trend with flow discharge. Furthermore, during the retrogression erosion period, significant high-frequency PSD energy can be observed only in a case of the compacted dam. In contrast, the PSD energy for the non-compacted dam is concentrated in a relatively lower frequency range (between 10 to 30 Hz). The PSD and flow time series data for the non-compacted dam present a bimodal shape with longer time duration. Based on the flow velocity of breach notch, both in the compacted and non-compacted dams, the maximum velocity occurred during the transition from longitudinal to lateral

erosion. In practical application, the results of seismic characteristics for the non-compacted dam case can be applied to the monitoring of dams formed by natural landslides in the field. Our results not only advance in understanding of the field-scale dam breach process but also can be directly applied to breach flooding warnings.
Key words : field-scale dam breach experiments, overtopping breach, power spectral density, time-frequency characteristic