

## Characteristics of re-activated landslide induced by recent large earthquakes- Chuetsu earthquake and Chuetsu-offshore earthquake

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### 1. Introduction

The 2007 Chuetsu-offshore earthquake is another strong earthquake that attacked the Chuetsu region, Niigata prefecture, after 2004 Chuetsu earthquake. The Chuetsu earthquake was concerned densely due to that triggered a large number of slope failures, include re-activated landslides. The Chuetsu-offshore earthquake with M6.8 and focal depth of 17 km, is almost same as that of the Chuetsu earthquake (6.8, 13 km). The purpose of this study is to clarify the occurring mechanism of earthquake-induced re-activated landslide, so as to propose a risk assessment method for such landslide.

### 2. Characteristics of earthquake-induced re-activated landslide

#### (1) Chuetsu earthquake

Induced by this earthquake, 52 landslides occurred in the Imo river basin, in which 34 are re-activated within the pre-existing landslide. Some common features of these re-activated landslides are: (A) These tend to occur in part area of the pre-existing landslide area, and the size is smaller than that of the old one; (B) These tend to occur on the convex slope of pre-existing landslide, and the toe area of most of the pre-existing landslide slopes faced to river; (C) These tend to occur in the sandstone-mudstone alternation area with gentle slope bed rock; (D) The direction of re-activated landslide is same as that of pre-existing one; (E) The failure surface is same or shallower than that of the pre-exited landslide; (F) The failure surface of Shiotani-kamisawagawa landslide, the largest one induced by this earthquake, is deeper than that of the pre-existing landslide.

#### (2) Chuetsu-offshore earthquake

The slope failures triggered by this earthquake mainly concentrated along the costal area, the number is significantly less, and the size is smaller than those triggered by the Chuetsu earthquake. The Ozumi landslide is the only typical re-activated landslide occurred inland. The length is 90m, and width about 90m, the horizontal displacement is about 15.5m, depth of the failure surface is about 10m. This landslide slid in the toe area of a pre-existing large landslide, the base rock is consisted of sandstone-mudstone alternation, and the structure is almost gentle slope. The characteristics of this landslide are coincided with the re-activated landslides induced by the Chuetsu earthquake.

### 3. Summary and discussion

(1) Topographically, the landslides tend to occur within convex slope of pre-existing landslide, the size is smaller than the old one. This may relate to the activity history of the pre-existing landslide, due to the partition resulted by repeated sliding. Landslides tend to occur on the convex slope is coinciding with the result of seismic acceleration response amplified in the convex slope. (2) Geologically, landslides tend to sliding on the gentle slope which consisted of sandstone-mudstone alternation, may relate to the bedding surface acted as a weak surface under the strong motion. Dynamic ring shear test showed that the excess pore water pressure is easy to rise under strong motion, in the case of sand sample from re-activated landslides. (3) The direction of re-activated landslide is same as that of pre-existing landslide suggested that earthquake-induced re-activated landslide strongly controlled by the pre-existing landslide, especially by the topographical factors.

The significant difference of landslides number is mainly due to the different of seismic acceleration. The PGA of Chuetsu earthquake was recorded 2,516 gal at Kawaguchi, 1,132 gal in Yamakoshi-takezawa near the Imo river basin, while the Chuetsu-offshore earthquake recorded 1,019 gal in Kashiwazaki, 300-500gal was estimated around the Nishiyama terrain. Another reason may relate to the precipitation prior to the earthquake. In the case of Chuetsu earthquake, precipitation of 3-days period prior to the earthquake was 120mm, while only 20mm was recorded in Chuetsu-offshore earthquake.