B-03

Relationship between land use and landslides during the Chuetsu earthquake

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1. Introduction

The Chuestu earthquake on 23 October 2004 was comprised of a series of shocks, the strongest with a magnitude of 6.6 on the Richter scale (6.8 on the JMA, Japan Meteorological Agency scale). The three strongest earthquakes (M > 6.2 on JMA scale) occurred within a period of less than 40 minutes with epicenters spread across Ojiya city and Hirokami and Yamakoshi villages in Niigata Prefecture. These earthquakes were characterized by a shallow focal depth (13 km) that generated strong levels of ground motion, resulting in thousands of landslides throughout the region.

2. Characteristics and distribution of landslides

Most of the earthquake–induced landslides on natural slopes were located near Ojiya city and Yamakoshi village; these occurred in regional sandy siltstone and interbedded sandstone-siltstone. Even though ≈ 100 mm of rain fell in the area 3 days prior to the earthquake, our field survey just after the earthquake indicated that shallow soil mantles were quite dry. Many types of hillslope failures occurred, ranging from large deep-seated coherent and disrupted landslides to small shallow landslides in highly weathered material.

One of the more conspicuous and highest impact landslides triggered by the Chuetsu earthquake was a large block glide that initiated in Yamakoshi village. The sliding mass traveled relatively undisrupted across the Imokawa River, where it created a dam blocking the confluence of the Imokawa and Maesawa rivers. During the impact of the block glide with the river, the landslide displaced alluvial sediments onto the opposite bank, as evidenced by freshwater fish and alluvial cobbles found in the landslide deposits. This large landslide may have been exacerbated by the antecedent heavy rainfall; water inputs to the deep failure plane at this site may have partially destabilized this land mass, although during the actual failure, the block glide moved intact. In the vicinity of the Shinano River, most of the shallow landslides were located close to the crest of the mountain ridge emphasizing the importance of topography in the amplification of seismic waves.

3. Effects of land use

Near the major earthquake epicenters, as well as in nearby towns, we observed many landslides affected by road cuts and fills, paddy fields on slopes, and residential fills. Hundreds of road cut- and fillslope failures occurred near Yamakoshi village. Much cut and fillslope material remained tenuously unstable awaiting failure during forthcoming rainstorms or periods of snowmelt. A fillslope failure along the local road to Yamakoshi village deposited directly into Maesawa River contributing to the dam formation. Such failures cause rather severe environmental problems, especially when the debris reaches streams.

Many earthquake–induced failures occurred in terraces and slopes around rice paddy fields near Yamakoshi village. Often, the paddy field berm ruptured due to shaking of the wet soil. In spite of their small magnitude, such failures may affect the occurrence of future landslides and debris flows. Water draining from damaged rice paddy fields can infiltrate into cracks and saturate hillslope soils, thereby increasing the landslide hazard.

Numerous landslides occurred in residential fill slopes constructed on reclaimed land in Otoyoshi development, Nagaoka city, inflicting much damage to homes and roads. This development was actually built on an old earthflow that was reactivated during Chuetsu earthquake. Tension cracks in fills are evidence of the reactivation of the earthflow during the earthquake.