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The susceptibility analysis of landslides induced by earthquake in Aso volcanic area, Japan, scoping the prediction

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Kumamoto earthquake on April 16th 2016 in Kumamoto prefecture, Kyushu Island, Japan with intense seismic scale of M7.3 (maximum acceleration = 1316 gal in Aso volcanic region) yielded countless instances of landslide and debris flow that induced serious damages and causalities in the area, especially in the Aso volcanic mountain range. Hence, field investigation and numerical slope stability analysis were conducted to delve into the characteristics or the prediction factors of the landslides induced by this earthquake. For the numerical analysis, Finite Element Method (FEM) and CSSDP (Critical Slip Surface analysis by Dynamic Programming theory based on limit equilibrium method) were applied to the landslide slopes with seismic acceleration observed. These numerical analysis methods can automatically detect the landslide slip surface which has minimum Fs (factor of safety).

The various results and the information obtained through this investigation and analysis were integrated to predict the landslide susceptible slopes in volcanic area induced by earthquakes and rainfalls of their aftermath, considering geologic-geomorphologic features, geo-technical characteristics of the landslides and vegetation effects on the slope stability.

Based on the FEM or CSSDP results, the landslides occurred in this earthquake at the mild gradient slope on the ridge have the safety factor of slope Fs=2.20 approximately (without rainfall nor earthquake, and Fs>=1.0 corresponds to stable slope without landslide) and 1.78 $\sim$ 2.10 (with the most severe rainfall in the past) while they have approximately Fs=0.40 with the seismic forces in this earthquake (horizontal direction 818 gal, vertical direction -320 gal respectively, observed in the earthquake). It insists that only in case of earthquakes the landslide in volcanic sediment apt to occur at the mild gradient slopes as well as on the ridges with convex cross section.

Consequently, the following results are obtained. 1) At volcanic hillside, mild slopes of 7-10 ° gradient with volcanic sediment such as pumice are prone to collapse to be landslide by strong earthquake. 2) The slopes at the mountain ridge with convex cross section where the seismic vibration tends to concentrate are prone to form landslides in case of earthquake. 3) Due to the most severe precipitation of the past or in the aftermath of earthquake, no landslides occurred in these mild gradient slopes or on the mountain ridges with convex cross section.
This information will be a great help in the aspect of landslide prediction.