Effects of Peak Ground Acceleration on Landslide Susceptibility in Japan

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INTRODUCTION

In Japan, great earthquakes have caused many landslides, slope failures and landslide dams, resulting severe damages in the past. National Institute for Land and Infrastructure Management (NILIM) developed an empirical equation to assess the seismic landslide susceptibility through the study on factors of landslides in the Rokko Mountains triggered by the 1995 Great Hanshin Earthquake (M7.3). Hereinafter this method is referred to as "Rokko method". After that, a large number of seismometers has been installed in Japan, and some stronger earthquakes (for example, the 2004 Mid Niigata Earthquake (M6.8) and the 2008 Iwate-Miyagi Earthquake (M7.2)) occurred with many deep-seated landslides being triggered. These enabled us to examine the effects of peak ground acceleration on seismic landslide susceptibility in detail.

In this study, the relationship between landslide distribution and slope gradient or peak ground acceleration of Mid Niigata Earthquake and Iwate-Miyagi Earthquake was analyzed.

OUTLINE OF THE ROKKO METHOD

NILIM analyzed correlation between topography (elevation, slope gradient, slope direction, over-ground and under-ground openness, mean curvature, etc.), seismic wave characteristics (peak ground acceleration, peak ground velocity, etc.) and landslide distribution using the data in the Rokko Mountains with study area of about 175 km^2. NILIM showed that the seismic landslide susceptibility can be quantified using the following empirical equation:

F=0.075I-8.9C+0.0056a-3.2 (1)

where, F: score of landslide susceptibility level, I: slope gradient in degree, C: mean curvature, a: peak ground acceleration (m/s^2). It is noted that peak ground acceleration in the study area was 200-350 gal approximately.

STUDY OF MID NIIGTA EARTHQUAKE AND IWATE-MIYAGI EARTHQUAKE

The study areas of the Mid Niigata Earthquake and Iwate-Miyagi Earthquake are 739 km^2 and 590 km^2, respectively. Estimation of the spatial distribution of peak ground acceleration (PGA in a 1km*1km grid) was done by the Kriging method with the recorded seismometer data (K-NET). Slope gradients before the earthquakes were estimated from digital elevation model (DEMs) of 10 m resolution.

Fig.1 shows relationship between slope gradient and landslide ratio on the semi-log graph. Consequently, landslide ratios of every 100 gal are approximated as below:

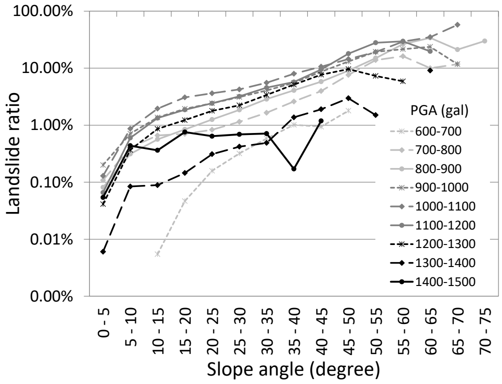

Fig.1 Relationship between slope gradient and landslide ratio (Mid Niigata Earthquake)

$$\mathrm{Log}(P)=kI+b \quad (2)$$

where, P: landslide ratio (area of landslides/area of study area), k: slope of fitted line, b: intercept of fitted line.

Figs.2 (a) and **(b)** show the relationship between slope (k) and intercept (b) of fitted line and acceleration, respectively. In the Mid Niigata Earthquake, value k is almost constant from 600 to 1400 gal; whereas, in the Iwate-Miyagi Earthquake, value k is almost same as the Mid Niigata Earthquake even though it is only from 700 to 1100 gal.

Fig.2 (b) shows that intercept of fitted line of both earthquakes increases with the increase of acceleration until about 1000 gal. While, in the Mid Niigata Earthquake, intercept does not increase with keeps constant with the acceleration more than 1100 gal. According to the **Fig.1**, landslide ratio is very high as about 10% with slope gradient about 40 degree and ground acceleration about 1100 gal. It is assumed that the landslide ratio is saturated with PGA more than 1100 gal.

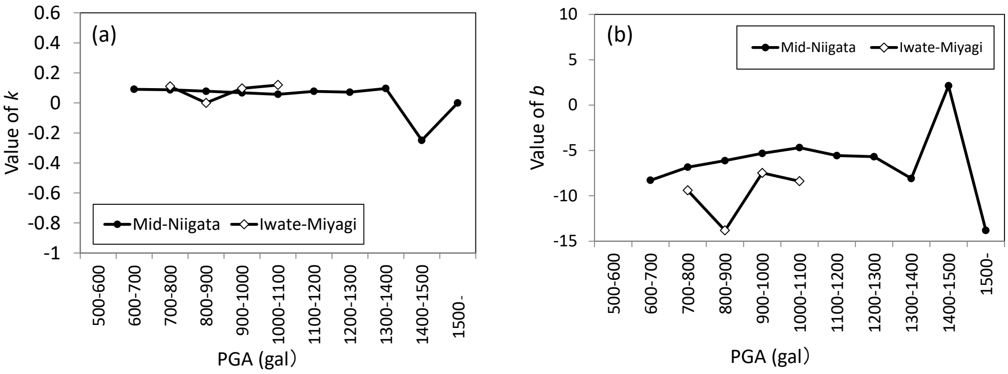

Fig.2 (a) Relationship between PGA and slope of fitted line and (b) relationship between PGA and intercept of fitted line

CONCLUSIONS

There is a good relationship between landslide ratio and slope gradient on the semi-log graph as described in the Equation 2. Value k (slope of fitted line) is almost constant regardless of PGAs or places. It means that slope gradient may affect landslide ratio with no relationship with PGA or seismic wave characteristics. On the other hand, value b (intercept of fitted line) increases with the increase of PGA, but it reaches the limit at high intensities.

Keywords: landslide susceptibility, earthquake, topography, seismic wave