Consideration to the Early Warning Rainfall Criteria of Landslides after Strong Earthquake in Japan

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INTRODUCTION

The research on the warning rainfall criteria for landslides after strong earthquakes is conducted associated with the great earthquake in Eastern Japan (M=9.0). After this kind of strong earthquake, soil strength of the slopes in the region that were exposed to the strong seismic forces are generally reduced by seismic activity (vibration) or disturbance by certain slope deformation. In this situation, the revised rainfall criteria for landslides are required. On this point of view, we are intrigued to elucidate the response of landslide to rainfall under this deteriorated soil condition. Hence, the impact of rainfall events on the specific landslide slopes that experienced the strong seismic vibration is analyzed using numerical simulation method i.e. finite element method (FEM) in order to evaluate the critical rainfall for landslide occurrence.

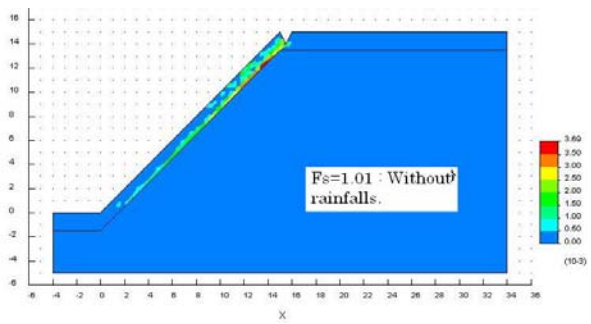

Fig.1 An example of the FEM slope stability analysis on a disturbed slope by the earthquake (maximum increment of the shear stress, tension crack at slope top)

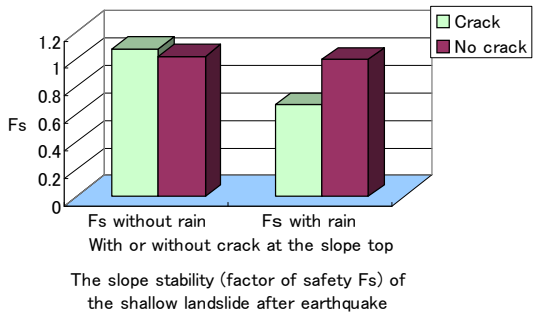

Fig.2 The influence of cracks by the earthquake on the shallow landslide stability Fs

METHOD

Field investigation and geotechnical test with samples from the landslide slopes are conducted to obtain the basic data for FEM analysis such as hydraulic conductivity "k" and soil shear strength at the slopes that experienced strong earthquake, as well as hourly rainfalls. Then, FEM(GUSLOPE) analysis which is combination of rain seepage analysis and slope stability one with the rain data at nearest meteorological observatory is conducted under the earthquake impact i.e. the slope condition with cracks which are located at the top of the slope and have high "k" or reduced soil strength.
The position and scale of cracks were identified with field investigation in some earthquakes. From the FEM results, the influence of the earthquake impact on the landslide slopes is estimated. Some soil samples of weathered schist were also prepared for shear tests with roots

and without roots, to clarify the influence of seismic vibration on soil strength. The seismic impact was generated by mechanical shaker up to 1500gal.

RESULT AND CONSIDERATION

In the result of FEM analysis, the cracks induced by the earthquake are effective to increase the seepage and render the slopes instable (Fig.1, Fig.2). Also, reduced soil strength such as 4% decrease in internal friction angle caused instability of the slope. The earthquake vibration can cause 40~50% reduction of critical rainfall (cumulative rainfall) for landslide occurrence temporally (decrease in "safety factor Fs" of the slopes from 1.02~1.04 to 0.83~0.95: Fig.3, Fig.4). However, the influence of the seismic impact on soil strength is not obvious in cases with tree roots and ones without them (Fig.5). Experiments with different soils and various geotechnical conditions suggested that the soil strength were increased in some cases by the seismic vibration. In this situation, father geotechnical tests are required to clarify it.

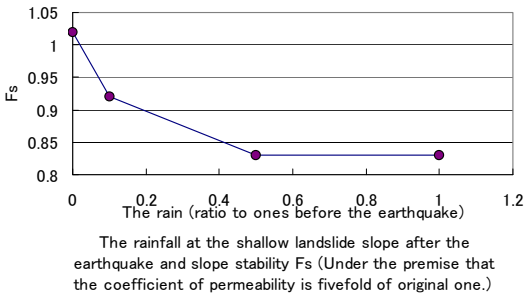

Fig.3 The influence of the increase in hydraulic conductivity "k" on the shallow landslide

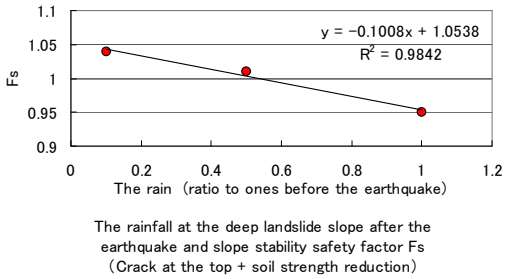

Fig.4 The influence of cracks and reduction in soil strength on the deep landslide

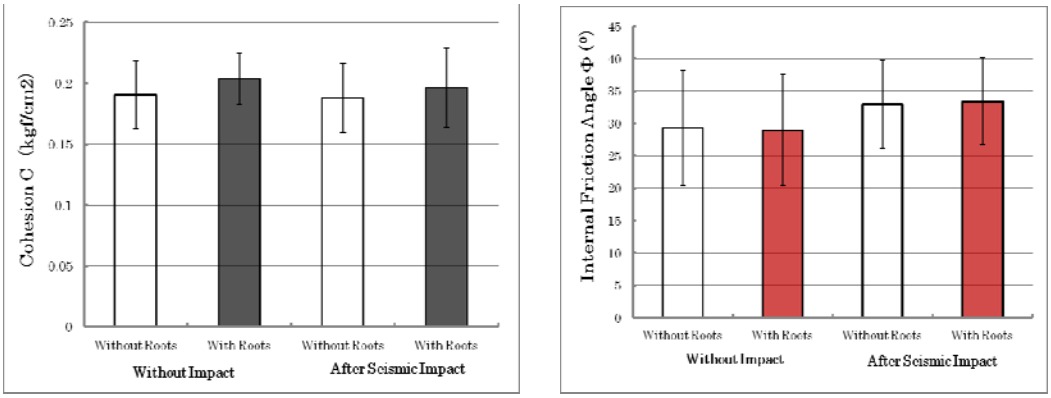

Fig.5 Influence of seismic vibration on the soil strength (Left: cohesion C, Right: internal friction angle Φ)

CONCLUSIONS

Consequently, the impact of strong earthquake can cause reduction of landslide critical rainfalls (cumulative rainfalls) in its aftermath. On the other hand, the influence of the seismic vibration on soil strength is not obvious.

Keywords: slope stability, landslides, earthquake, crack, critical rain