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Landslide Investigation of Earthquake Induced Landslide during Rainfall in Tandikat, West Sumatra, Indonesia

Fikri Faris[1*], Fawu Wang[1]

[1]Shimane University

Indonesia is an archipelagic country which extends on one of the most active seismicity area in the world. In geological perspective, the west and south coast of the archipelago takes apart into Pacific Ring of Fire makes it numerously contains active volcanic mountains which extensively supplies loose volcanic material. The tropical climate brings consequence of high precipitation of the most area. These facts make Indonesia has high vulnerability against geo-disaster which induced by combination of earthquake and rainfall on volcanic areas.

One of the most devastating earthquakes in Indonesia struck West Sumatra Province on September 30, 2009, at 5:16 p.m. with MW 7.6 magnitudes, caused about more than 1000 deaths. The earthquake excited number of landslides which took more than 60% of total earthquake death toll. The most extensive landslides which occurred in Tandikat, Padang Pariaman Regency, buried hundreds of people and flattened some villages (Fig.1). These landslides occurred on loose pumice layered mountain during rainfall. The combination of intensive rainfall and strong earthquake is considered to decreases the slope stability dramatically. This study attempts to reveal contributory factors which involved on the event.

Integrated study of the landslide elaborating field investigation, laboratory work and numerical modelling were conducted. Geological investigation on the landslide area and laboratory investigation had been performed to examine geological features and mechanical properties of sliding material. The field investigation consisted of soil sampling, Standard Penetration Test (SPT), geological logging, in-situ permeability and density test. Further examination about mechanical properties of landslide deposit samples subsequently performed in laboratory. Several static and dynamic tests using cyclic triaxial apparatus had been conducted to study about stress-strain history of the soil under dynamic condition. The mechanical parameters of the material were then derived from both geological investigation and laboratory test by correlating SPT values and taking laboratory tests result. These parameters were then used into numerical model using finite element method software ABAQUS to analyze earthquake effect by considering time-historical acceleration from actual earthquake record.

Field investigation revealed that, particularly in the area, impermeable clay stratum is overlain by porous pumice layer. The difference of permeability may cause the saturation of lower part of the pumice layer when rainfall percolates. Both static and stress-controlled dynamic triaxial test showed the contractive behaviour of pumice deposit. This behaviour brought the consequence of excess pore water pressure increase at small strains. Immediate liquefaction occurred when specimen was conditioned as fully saturated and initial pore water pressure was given as to simulate ground water table after rainfall.

Finite element modelling using ABAQUS software indicated amplification phenomena of earthquake Finite element modelling using ABAQUS software indicated amplification phenomena of earthquake acceleration in the landslide area. The contributing factor of the amplification was the thick clay stratum and weathered andesitic sandstone layer below the pumice material deposit that was considered have low stiffness. Another possibility causing of amplification was the topographical aspect involving sloping surface. The numerical model and laboratory tests clarified that the amplification effect on the area caused the collapse of the pumice material. Immediate liquefaction was considered as the mechanism of the landslide due to the combination of earthquake amplification effect and soil saturation by rainfall during earthquake.

Keywords: Landslide, earthquake, rainfall, cyclic triaxial test, ABAQUS