論 文 の 内 容 の 要 旨

論文題目　Elastic wave propagation through unsaturated soils concerning early warning of rain-induced landslides
（降雨による斜面崩壊の早期警報のための不飽和土内の弾性波速度の研究）

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Rapid growth in world's population is pressing its inhabitants to uncover the unexplored avenues of accommodation and transportation. Under these severe demographic and economic pressures, widespread construction projects are being carried out in hilly areas and thus are exposed to landslides. Landslides cause severe damage to infrastructure and life all around the globe every year. Citing the vast aerial spread of such disasters, typical landslide remediation approaches of constructing retaining structures or soil improvement are not economically feasible anymore. Rather, there is a need for more robust and economically viable solutions like real-time landslide early warning systems. Current landslide early warning systems rely on monitoring slope movements by means of inclinometers or tilt sensors, in combination with soil moisture monitoring by means of dielectric moisture sensors or tensiometers, etc. This study is an attempt to improve the currently available landslide early warning systems by introducing a new technique to predict landslide movements by means of elastic wave propagation in soil.

The fundamental understanding of behavior of elastic wave velocities (compression wave velocity (*Vp*), and shear wave velocity (*Vs*)) during landslides was envisaged through laboratory element tests. An advanced triaxial apparatus with independent controls of axial, and lateral stress (required for replicating field stress path during landslides), and capable of measuring elastic wave velocities in unsaturated soil specimens was developed. Measurement of elastic wave velocities was made possible by means of a novel disk shaped piezoelectric transducer, which was able to generate and measure both compression and shear wave velocities. Separate series of triaxial tests were conducted to explore the effects of soil moisture, and soil yielding on elastic wave velocities. In another series of tests, field stress path during rain-induced landslides was reproduced to study the behavior of corresponding wave velocities.

Through the aforementioned test series, sensitivity of elastic wave velocities (*Vp* and *Vs*) to soil moisture as well as soil yielding, was confirmed. It was concluded that, both compression and shear wave velocities decrease with a nearly uniform rate as soil becomes wet. Compression wave velocity however, approached sonic wave velocity in water, for fully saturated soil. These observations are useful to monitor the saturation state of an actual soil slope. Soil yielding was also found to cause a decrease in elastic wave velocities. Also, the rate of decrease of wave velocities was observed to be consistent with rate of soil yielding. This finding is of practical importance with reference to real-time slope monitoring, as the actual slope movements in a slope surface can be identified by monitoring the rate of decrease of wave velocities.

Keywords: Landslide monitoring; early warning; wave velocity; unsaturated soil.