Development of risk evaluation system for slopes behind important cultural asset subjected to rainfall

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In Japan, slope disaster frequently occurs during typhoon and rainy season, thus, it is necessary to take countermeasures to protect lives and property from slope disaster. The countermeasures can be broadly classified into hardware (slope stability reinforcement measure) and software (improvement of warning and evacuation systems, limit new house construction in dangerous places, etc.). However, due to an immense amount of time and money of taking hardware for all areas of high slope failure risk, there are not enough countermeasures to maintain slopes. Consequently, it is desirable to develop slope risk evaluation system due to rainfall to improve warning and evacuation systems.

In order to protect lives and property from slope disaster due to rainfall, this study aims to develop slope risk evaluation for combination risk assessment of slope failure and real-time risk evaluation for a specific slope, and then two evaluating methods are examined. Moreover, several proposals toward advancement and efficiency of slope risk evaluation system are discussed. Here in, the subject of this research is slopes behind important cultural asset in Kyoto city. Because there are many important cultural assets on mountainsides of Kyoto city, setting standard for control tourists and locals during heavy rainfall is required.

In risk assessment of slope failure (see Chapter 2), it is evaluated using "quantification theory type II" considering the presence or absence of 24-hour rainfall. As a result, the accuracy of risk assessment using 24-hour rainfall is greatly improved (Failure: 68.8% → 87.5%, Non-Failure: 71.0% → 74.0%). Moreover, the risk of failure for the slopes behind important cultural asset in Kyoto city considering 24 hour rainfall can be ranked.

In real-time risk evaluation for a specific slope (see Chapter 3, Chapter 4), the field monitoring system located at a slope behind an important cultural asset in Kyoto city is examined. This system, which can predict surface slope failure due to rainfall, focuses on three factors: (1) increase in soil mass due to seepage, (2) shear strength reduction with rise of degree of saturation in soil and (3) increase of pore-water pressure and seepage force due to rising in groundwater; therefore, rainfall, pore-water pressure and ground displacement have been measured since July 2004. In order to make effective use of those data for the real-time risk evaluation, an evaluation method combining "principal component analysis (PCA)" and "neural network (NN)" is proposed. Then, by using the measurement results of the soil tank test and the field study of the slope, it is shows that "slope failure risk" as an evaluation index is correlated with the slope stability due to rainfall. Moreover, it can be configured more objective and concrete timing of dictating to evacuate and to release.

Finally, for the purpose of advancement and efficiency of slope risk evaluation system, (1) method for evaluating water behavior in unsaturated soil based on the ground temperature measurement results, (2) evaluating evaporation using bulk equation considering water behavior and (3) the efficiency of the field monitoring system using PCA are proposed (see Chapter 5). Results show that those new methods are beneficial to development of the efficient field monitoring system.