SLOPE FAILURE HAZARD ASSESSMENT CONSIDERATION WITH SOIL DEPTH AND RAINFALL INFILTRATION

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論 文 名　：SLOPE FAILURE HAZARD ASSESSMENT CONSIDERATION WITH SOIL DEPTH AND RAINFALL INFILTRATION
（土壌深さと降雨浸透を考慮した斜面崩壊危険度評価）

区　　分　　：甲

論 文 内 容 の 要 旨

Landslides and debris flows are sources of severe natural disasters and societal hazard in mountainous regions throughout the world. Landslide and debris-flow are the main types of slope-mass movements when slopes fail. Therefore, landslide hazard assessment study, which is commonly used for hazard mitigation, should give answers to the three key questions: the magnitude, the location and the occurrence time of the dangerous process. However, so far, there are few reliable methodologies available for giving the answers. As mentioned above, the qualitative analyses are totally subjective and dependent on the experience of the earth scientist, can not assess slope stability quantitatively. Therefore, an easy implementation method of 3D analysis for practical issues is urgently required. Furthermore, 3D deterministic model should be applied to a wide mountainous area for the purpose of landslide hazard assessment with accurate prediction of the magnitude, the location and the occurrence time of the dangerous process. Concerning the occurrence time of slope failure, the trigger factors of the occurrence of landslide, such as soil depth and rainfall, should be taken into account. Therefore, the combining the 3D slope stability analysis with hydrological model ,which considering the cohesion model (Montrasio et al.2008) were conducted to define a correlation between the safety factor of the slope and the rainfall depth. Furthermore, the verification of the slope failure probability has been considered with slope failure in the past. The purpose of slope failure hazard evaluation are: (1) understand the development a GIS-aided methodology to implement the 3D limit equilibrium model in natural slope failure assessment; (2) to assess the soil depth by process based model as one of factor controlling the occurrence and distribution of shallow slope failure; (3) combine the 3D slope stability model with a infiltration model to evaluate the variation of slope stability during rainfall event; and (4) to predict and assess the stability of slopes under soil depth influenced and rainfall infiltration effect in Sangun mountainus area by combine the 3D slope stability model with a infiltration model.

In Chapter 1, some background knowledge about landslide hazard are described. Finally, the objective of this thesis is proposed. Three widely used landslide hazard assessment approaches: landslide inventory based probabilistic approach, statistical approach and deterministic approach are reviewed in Chapter 2. All these approaches are considered valid in certain contexts. Most of deterministic models are based on limit equilibrium approach for a one-, two-, or three-dimensional model. For natural slopes, 3D model is preferred because it considers the spatial distributions of slip body, stratum, and groundwater table. Moreover, the effect of rainfall in the slope stability analysis has to be considered.

In Chapter 3, a process based model analysis to simulate soil depths of mountainous area are introduced. The soil depth model simulations were carried out by utilizing Geographic Information System (GIS) function. Soil depth is one of the most important parameters for controlling shallow landslides. The easiest and most accurate way to measure soil depth is through field measurements. For large-scale areas, especially in mountainous areas, this method is not cost effective or practical as some places are not accessible. To overcome this difficulty, a process based model analysis is used to evaluate soil depths. The effectiveness of this method has been tested by applying it to Sangun mountainous area in Japan. The result shows a consistency between predicted soil depths and samples from field investigation. In the simulation, the third of soil production rate (*Po*) values, such as 0.019, 0.022, and 0.025 cm/yr had been used. Results from the simulation analysis indicated that topographic variables, soil production rate (*Po*), and a soil production time (year) provide the reasonable model for distribution of soil depth. Therefore, the soil depth ranged from 0.51 to 1m has the largest area of soil distribution.

In Chapter 4, the methodology of GIS-based 3D analysis for rainfall infiltration effect has been provided. Firstly, the homogeneous layer is considering to assume that the varying of the uncertainty of geotechnical parameter is important in the slope stability to get the best performance. Furthermore, I concern in the soil depth and rainfall effect in the analysis. Therefore, the combining of GIS-based 3D model and hydrological model are presented. Such as, saturation degree and matric suction of the soil texture has been used in the hydrological model. Furthermore, this model provide the effect of rainfall intensity on the slope failure probability.

In Chapter 5, aiming to apply 3D deterministic model with combining of hydrological model to predicting the location of slope failure with soil depth and rainfall effect is given. The 3D slope stability analysis for homogeneous and multi layer (consideration of weathered layer) model based on verification of the results will be conducted by considering the inventory slope failure in the past. As results, due to the cohesion (*c*) values gave the similar values in homogeneous and multi layer (consideration of weathered layer) model, therefore the cohesion value in 1 kN/m^2 gave a best performance compare to similar cohesion values performed by other cohesion values. It is about 72.73% of the ratio of the number of slope failure in the past and the number of slope unit $\leqq$ 1.0 in simulation. Moreover, the internal friction angle (ϕ) value of 25^0 is a best performance in the both homogeneous and multi layer (consideration of weathered layer) model. Furthermore, the effect of rainfall, there are three case; (1) infiltration parameter for soil weathering and the occurrence of groundwater level (5m); (2) infiltration parameter for soil + organic materials (10%) and groundwater level (5m); and (3) infiltration parameter for soil + organic materials (10%) and groundwater level (0m). As results, the number of slope failure probability in case 2 is increases than the case 1. However the validation is not reasonable for the both case 1 and 2. Therefore, the assuming of the groundwater level is 0m have been changed. Furthermore, the result shows 76.36% of the ratio of the number of slope failure in the past and the number of slope unit $\leqq$ 1.0 in simulation after 20 hours.

In Chapter 6, conclusions of this thesis are summerized.