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Probabilistic analysis of rock slope stability using terrestrial LiDAR

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Probabilistic analysis has been considered as an appropriate method dealing with uncertainty in the slope stability problems. In addition the probabilistic analysis can be effectively used in the decision making process as well as the stability analysis while the deterministic analysis provides only information about slope stability. However, the probabilistic analysis requires a large amount of information for uncertain parameters but in many practical conditions, the amount of data is limited. Especially, the discontinuity characteristics such as roughness and joint wall strength are difficult to obtain a large amount of information and analyze their random properties. Therefore, in order to overcome this limitation LiDAR has been utilized to obtain the discontinuity characteristics in this study. The advantage of utilizing terrestrial LiDAR is that a considerable amount of discontinuity data such as joint roughness profile can be readily obtained from digital surface model. Accordingly, the random properties of discontinuity characteristics can be analyzed with data obtained from terrestrial LiDAR, and the probabilistic analysis can be applied. In this approach, a large amount of the joint roughness profiles for slope surface were obtained using terrestrial LiDAR and then, joint roughness profiles have been transformed to JRC (joint roughness coefficient) by using statistical parameters such as Z2 or Ai. Then the probabilistic stability analysis was carried out with Barton's equation.

This approach has been applied to practical examples. Two failed slopes (slope-A and slope-B) have been selected and approximately one hundred of roughness profiles for each slope are extracted from digital surface model. The joint roughness profiles were transformed to JRC with two different parameters, Z2 and Ai. Subsequently the statistical parameters of JRC such as mean, standard deviation and probability density function are acquired. The Monte Carlo simulation has been implemented in the probabilistic slope stability analysis with random properties of JRC. The probabilities of failure for slope A and slope B with JRC values based on Z2 are calculated as 29.2% and 78.3% respectively. And the probabilities of failure for slope A and slope B with JRC based on Ai are calculated as 19.7% and 59.6% respectively. The analysis results show that the probability of slope failure evaluated with Ai is lower than the probabilities with Z2. This is because JRC values from Ai were higher than JRC values from Z2. In order to compare the probabilistic results with the traditional analysis results, the representative roughness profiles for each slope were obtained from the field and the deterministic analysis was carried out. The deterministic analysis results show the factors of safety for slope A and slope B were 0.96 and 1.21, respectively. These results are different from the probabilistic analysis results that show quite high probability of failure. This means that the variability and uncertainty involved in data are quite important and sufficient amount of data should be obtained. Consequently, the proposed process using LiDAR in this study is an effective way to acquire a considerable amount of data and thus, makes it possible to enhance the usefulness and reliability of the probabilistic slope stability analysis.