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Application of Flat DMT and ANN to Korean Soft Clay Deposits for Reliable Estimation of Undrained Shear Strength

Wi Yong Byeon and Seung Rae Lee
Department of Civil & Environmental Engineering, Korea Advanced Institute of Science and Technology
Daejeon, Korea

Y. S. Kim
Division of Ocean System, Yosu Nation University, Yeosu, Korea

The flat dilatometer test (DMT) is a geotechnical tool used to estimate in-situ properties of various types of ground materials. Undrained shear strength is known to be one of the most reliable and useful parameters that can be obtained by the flat DMT. However, a successful application of the existing relationships that have been established for other local deposits depends on regional geotechnical characteristics. In addition, although flat DMT data are interpreted using 3 intermediate indices—the material index (I_D), the horizontal stress index (K_D), and the dilatometer modulus (E_D)—undrained shear strength is estimated using only the horizontal stress index (K_D). In this paper, the applicability of the flat DMT to Korean soft clay deposits is investigated. An artificial neural network (ANN) model is developed to predict undrained shear strength, based on p_0, p_1, p_2 and σ'_v, without using the K_D. The ANN model adopts the back-propagation algorithm and is trained by using DMT data obtained from Korean soft clays. To investigate the feasibility of the ANN model, the prediction results were independently evaluated by data that had not been used to train the ANN model. They were also compared with data obtained using conventional relationships.

INTRODUCTION

The flat dilatometer test, first introduced by Marchetti (1980), is an in-situ testing device that measures the site characterization of soils. Data from flat DMT are normally interpreted using 3 intermediate indices: the material index (I_D), the horizontal stress index (K_D), and the dilatometer modulus (E_D). Several researchers have proposed various empirical correlations with these 3 intermediate indices to estimate in-situ properties: Chang (1991), Lacasse and Lunne (1988), Powell and Uglow (1988), and Roque et al. (1988). The feasibility of these flat DMT correlations has been examined in soil deposits all over the world (Coutinho and Oliveira, 1997; Cruz et al., 1997; Mello et al., 1997). So far, however, these relationships, which were intended to accurately measure local deposits from any site in the world, have been indiscriminately applied to Korean soils without regard to Korea's specific regional geotechnical characteristics. Further, the design parameters estimated by the flat DMT have been either underestimated or overestimated, compared with results obtained from laboratory tests (Byeon et al., 2004). Accordingly, it became necessary to examine if the specific regional geotechnical characteristics of Korean soils lead conventional empirical relationships to properly estimate design parameters.

In addition, the empirical relationships that have been derived were based on flat DMT data that include different site conditions and characteristics, and they cannot be easily and consistently applied to various geotechnical characteristics of ground materials. In such a situation, even just proposing an empirical relationship is very difficult, time-consuming and costly. Further, results estimated from a regression analysis that uses an empirical relationship are considerably affected, according to how well the mathematical relationship expresses the trend of data obtained from laboratory tests. The reliability of the estimation might thus vary according to the intension, knowledge and experience of the user.

Consequently, an artificial neural network (ANN) was applied to predict the undrained shear strength using data from a flat DMT, because the ANN is able to minimize intrinsic error in the existing statistical regression analysis model, and it reduces the variability of empirical estimations due to a variety of in-situ conditions. The ANN model does not need to specify a mathematical relationship between input and output variables, and it is capable of capturing complex nonlinear interactions between input and output variables. Additionally, as the neural networks are trained by actual field data, they deal with inherent noise or imprecise data (Goh, 1994).

Using the model, the applicability of a flat DMT to Korean soft clay deposits has been investigated. Results that had been estimated using conventional empirical relationships were compared with those obtained from laboratory tests. Factors influencing the relationships were examined, and the empirical expression was adjusted accordingly. Finally, an ANN model was developed to evaluate the undrained shear strength by flat DMT. The ANN model uses 3 original pressure data sets (p_0, p_1 and p_2) directly obtained from the flat DMT, instead of using the 3 intermediate indices that have been traditionally used.

GEOTECHNICAL CHARACTERISTICS OF TEST SITES

In this paper, flat DMT were carried out at 5 Korean soft clay deposit sites, with the results then compared to soil properties obtained by laboratory tests. Table 1 shows the soil characteristics. The soil properties are on both undisturbed and disturbed samples in the vicinity of sites in which the flat DMT were performed.

The material index (I_D) provides a profile of soil types, and Fig. 1 shows the profile of soil types interpreted from the flat DMT data at the 5 Korean sites (Marchetti, 1980). Fig. 1 shows a

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