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博　士　論　文　の　要　旨

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博士論文題名
（外国語の場合は，和訳を付記する。）

要旨（２，０００字程度にまとめること。）

Methods for Estimating OCR and Consolidation Properties of Soil from the Results of Piezocone Tests

(三成分コーン試験結果に基づく地盤の過圧密比および圧密特性の推定法)

This study focused on using the results of piezocone sounding (uCPT) and dissipation tests to estimate overconsolidation ratio (OCR) and consolidation properties (c_h and k_h) of soil. Currently, several existing methods for estimating OCR from uCPT results are ranging from empirical to theoretical approaches. Therefore, the methods for estimating OCR from uCPT results have been investigated. Moreover, the existing methods for estimating consolidation properties (c_h and k_h) of soil from uCPT results are investigated using laboratory model test results and the field cases.

The applicability of three (3) existing methods for estimating OCR from uCPT has been investigated with twelve (12) field cases around the world. All of existing methods have empirical parameters, and if the empirical parameters can be determined properly, reasonable values of OCR can be estimated. However for underconsolidated deposits, some of existing methods performed poorly. Therefore, a new method for estimating the value of OCR based on Modified Cam Clay theory has been proposed and modifications of existing method to be applicable for underconsolidated sites have been carried out. Finally, the proposed method and the modified existing methods have been evaluated using field data and it is shown that the proposed method can yield better results.

Totally fifteen (15) laboratory model tests on piezocone penetration (uCPT) and dissipation were conducted using five types of soil and over consolidation ratio (OCR) of 1, 2, 4, and 8. Four types of soil, namely, remolded Ariake clay, Ariake clay mixed with a sand with sand/clay ratios (by dry weight) of 50:50 (Mixed soil 1), 60:40 (Mixed soil 2), 70:30 (Mixed soil 3), and 20:80 (Mixed soil 4), respectively were used in the laboratory model tests. The laboratory model ground was prepared in a cylindrical container (chamber) made of PVC and has an inner diameter of 0.485 m and a height of 1.0 m. The soils were thoroughly mixed with a water content of about 1.2 times their liquid limits (LL), and carefully poured into the chamber layer by layer until the thickness of the model ground was 0.8 m. Piezometers were placed at pre-determined locations in the model to measure the pore water pressure during pre-consolidation process. An air pressure was applied to pre-consolidate the model ground. Once the degree of pre-consolidation was more than 95%, the air pressure was adjusted to achieve the desired value of OCR. After the pre-consolidation, the thickness of the model ground was about 0.6 m. In case of OCR > 1.0, unloading would induce negative pore pressure in the model ground. In this kind of case, the piezocone penetration and dissipation was conducted after the negative excess pore pressure dissipated. Two mini piezocones (u_2) have cone tip angle of 60° with diameters of 30 mm 20 mm were used in the laboratory test. The filter for pore pressure measurement is on the shoulder of the cones. The penetration rate adopted was 25 mm/min (0.4 mm/s).

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Based on dissipation test results, all measured dissipation curves are non-standard type where u_2 increased initially and then dissipated with time. Therefore, Chai *et al*. (2012a)'s method is used for estimating the coefficient of consolidation (c_h) from uCPT laboratory model test results. As a result, the method performed accurately for all soil types. Therefore, it is recommended that the method can be used in engineering practice of estimating c_h from the results of piezocone dissipation test. However, when applying the existing method (Chai *et al*. 2011) for estimating permeability (k_h) to the model test results indicates that the method performed poorly for overconsolidated soils. It can be seen that under the condition of a given maximum consolidation pressure the measured values of k_v slightly increased with OCR, while the estimated values of k_h decreased with OCR significantly for all the soil types.

Thus, Chai *et al*. (2011)'s method has been modified to be applicable for overconsolidated soils. Since in the method, k_h is a function of $\left(\Delta u / \sigma'_{v0}\right)$ (Δu is the measured excess pore water pressure and σ'_{v0} is the initial effective vertical stresses), the basic idea of the modified method is to include the effect of OCR on $\left(\Delta u / \sigma'_{v0}\right)$. To use the modified method to the field, four parameters are needed, namely, swelling index of soil, C_s, void ratio, e_0, OCR and a model parameter, α. It is suggested that C_s and e_0 have to be estimated based on local data-base about soil properties; and OCR can be estimated using the results of uCPT. As for α value, it is related to soil types. It is recommended to classify the soil type using Robertson's (1990) method. Finally, the modified method was evaluated to two (2) sites in Japan and one (1) site in China. By comparing the estimated values of k_h from the results of uCPT and the measured values of k_v, it shows that the modified method resulted in much better estimation of values of k_h.