

Parameter Estimation and Numerical Analysis of Self-Weight Consolidation of Slurried Marine Clay

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ABSTRACT

The methods to determine the parameters needed for a self-weight consolidation analysis of slurried marine clay are described in this study. The relationship between volume ratio (f) and effective stress (p) is needed for the estimation of the final settlement in a numerical analysis. The relationship between the coefficient of permeability (k) and volume ratio (f), together with the f - p relationship are needed for the estimation of the settling rate in a numerical analysis. The f - p relationship was determined by the centrifugal model test using a small centrifuge by two methods, and the k - f relationship was determined by the centrifugal model test and the standard oedometer test. The determined parameters were then evaluated in comparison between the self-weight consolidation settlement measured in cylinder tests and the settlement calculated from the numerical analysis.

INTRODUCTION

The settling rate of dredged clay is an important factor to consider in land reclamation planning and for the use of reclaimed land. The settling types of the dredged clay in seawater are mainly of zone settling and consolidation settling (Imai, 1980). In zone settling, discrete flocs are formed from clay or colloid particles, and a clear solid-liquid interface develops at the top of the settling mass. Then, the interface settles at a constant rate. In consolidation settling, no discrete flocs are formed, and the settling rate of the solid-liquid interface is very slow, compared to the zone settling. This type of settling is caused by self-weight consolidation.

The settling type of slurried marine clay in seawater shifts from zone settling to self-weight consolidation when the initial water content decreases to less than about 1000% (Imai, 1980; Kondo et al., 1996). The zone settling rate of a clay suspension with high water content and high salt concentration, as in seawater, is so rapid that the estimation of the settling rate by the self-weight consolidation of slurried clay becomes the main problem during land reclamation. However, it has been found that Terzaghi's classic consolidation theory, in which the self-weight of clay does not affect the consolidation process, can generally not be applied.

The fundamental mechanism of self-weight consolidation was successfully interpreted by Mikasa (1963) in his consolidation theory. He defined the volume ratio f as $f = 1 + e$, where e is the void ratio. The relationship between the volume ratio (f) and

effective stress (p) is needed for the estimation of the final settlement, and the relationship between the coefficient of permeability (k) and volume ratio (f) is needed for the estimation of the settling rate in the numerical analysis of self-weight consolidation based on Mikasa's consolidation theory (Mikasa, 1963; Takada, 1983). Nishimura et al. (1992) reported that these parameters significantly influence the results of numerical analysis in consolidation settlements. The f - p and the k - f relationships, for numerical analysis of the self-weight consolidation of slurried clay, can be determined by the hydraulic consolidation test (Imai, 1979) or by the centrifugal model test (Mikasa and Takada, 1984). On the other hand, Umehara and Zen (1980) determined these relationships by the consolidation test with a constant rate of strain. Toriyama (1981) has also determined these relationships by the consolidation test using a triaxial test device. However, very special devices, which are commonly unavailable, are needed for the hydraulic consolidation test, the constant rate of strain consolidation test and the triaxial consolidation test. Moreover, the procedures of these tests are also very complicated; these tests are not commonly used. On the contrary, while a special device is needed for the centrifugal model test, its experimental procedure is simple and the experiment can be finished in a short time. The centrifugal model test is also useful not only for the determination of parameters, but also the model simulation of the self-weight consolidation procedure.

Therefore, this study describes the methods to determine the parameters needed for self-weight consolidation analysis of slurried marine clay with high water content in seawater. The f - p relationship was determined by the centrifugal model test using a small centrifuge by two methods, and the k - f relationship was determined from the centrifugal model test and the standard oedometer test. The parameters determined were then evaluated in comparison with the self-weight consolidation settlement measured in cylinder tests, and the settlement calculated from the

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KEY WORDS: Self-weight consolidation, slurried marine clay, centrifugal model test, oedometer test.