An isotaches-type compression model for predicting long term consolidation of KIA clays

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ABSTRACT
At the Phase-I island of the Kansai International Airport (KIA) opened in 1994, unexpected large settlements are still taking place due to special consolidation characteristics peculiar to the Pleistocene marine clays deposited at the site with more than 200m thickness. In order to predict long-term consolidation settlements at the site which will further take place, a variety of studies have been carried out at Port and Airport Research Institute (PARI) and Yokohama National University (YNU). The main results of these studies are here summarized, and a new isotaches-type compression model for predicting long-term consolidation of the KIA clays is proposed as an effective tool for practical use.

1 INTRODUCTION

The Phase-I island of the Kansai International Airport (KIA) was constructed as a typical big project in the Osaka area, 5 km offshore from the coastal line. Although 10 years have passed since the opening of its facilities, it is still observed at the island that the rate of settlement is as much as 15 cm per year. Such a large amount of settlement rate couldn't be predicted before construction, but now we understand that it must result from special consolidation characteristics peculiar to the Pleistocene marine clays deposited in the Osaka basin. Based on this understanding, Port and Airport Research Institute (PARI) and Yokohama National University (YNU) have focused their efforts on making consolidation characteristics of the KIA clays clear from various viewpoints, in order to finally constitute a consolidation model which can numerically predict future long-term settlements of the KIA islands.

Consolidation behavior of a clay layer in the ground is in general characterized as a complex result of the actions of many factors such as physicochemical nature of the clay and its geological history, its hydraulic conductivity and compression characteristics in-situ, and so on. In this paper, these fundamental natures and mechanical characteristics obtained at PARI will be first summarized, especially paying special attention to the mechanical quality of samples retrieved from deep depths of 300m at the maximum.

Before formulating a new consolidation model for the intact KIA clays of which characteristics were thus grasped, the compression model formulated at YNU for the completely reconstituted clay without cementation will be reviewed. According to the author's understanding, any intact clay under increasing or a constant effective stress necessarily consolidates approaching a more stable state of the reconstituted clay. This type of consolidation behavior can never be explained as long as elasticity or elasto-plasticity is applied to the clay skeleton as its compression model, rather the behavior may be explained only when unknown effects of strain rate on the compression are appropriately clarified on the basis of experimental results.

Based on such an idea stated above, experimental results obtained at PARI for the intact KIA clays and at YNU for both of intact and reconstituted KIA clays will be analized for the purpose to formulate a new consolidation model for the intact KIA clays. In this analysis, the original isotaches-method proposed by Šuklje(1957) will be further developed to a general compression law, in which a consolidation state (e, σ') is determined by the current strain rate $\dot{\varepsilon}$, that is to say, $e = \mathrm{F}(\sigma', \dot{\varepsilon})$.

A new consolidation model for the intact KIA clays thus formulated will be finally evaluated by comparing its numerical solutions with the results of long-term consolidation tests carried out for 400 days at the longest.

2 PHYSICAL AND CHEMICAL PROPERTIES OF THE KIA CLAYS

From the viewpoint of soil mechanics, the consolidation behavior of clay is determined by the combination of two different mechanical characteristics of the clay, compressibility and permeability. Therefore, if a mechanical model for compressibility and a model for permeability were both given to clay, consolidation behaviors of the clay could be predicted only by use of the two models and associated soil constants.

Before establishing such a couple of mechanical consolidation models for the KIA clays, it should be confirmed whether a model of the same functional type can be commonly applied or not to all of the different KIA clay layers with different deposition ages, different sedimentation environments, and different geological histories. In order to get a sound engineering judgment about this subject, physical and chemical properties of the KIA clays are summarized in this section, based on the experimental results obtained at PARI.

2.1 *Soil profiles at the KIA islands*

As shown in Figure 1, the KIA islands are constructed on the very thick sea bed materials which had been deposited during the past 1.1 million years (Itoh et al., 2000). During that time, a cycle of a glacial period followed by a warm period had been many times repeated, and its changes are inscribed on the soil profiles shown in Fig.1. Each of the layers "Ma0" to "Ma13" is marine sediment deposited during a corresponding warm period. The other layers are judged to be fluvial deposits formed in cold climates during the corresponding glacial period. They are generally quite rich in coarser materials as silt and sand or occasionally gravel, but several fluvial layers are exceptionally rich in clay fractions. Those fluvial clay layers are denoted by