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Evaluation of the Predictive Ability of Simplified Deformation Analysis of Embankment Foundation Using Physical Properties of Soils Only

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ABSTRACT

This paper describes a simple procedure for evaluating deformation behavior of clay foundation under embankment, using a soil-water coupled finite element method based on finite deformation with an elasto-plastic model. The simplified method for determining the soil parameters and ground modeling is estimated using liquid limit, plasticity index and natural water contents only. Reasonable agreements have been obtained between measured and computed values for vertical deformation and excess pore pressure of the well documented case history of the Kanda trial embankment built on a deep soft ground. Lateral displacement, however, is notoriously difficult to predict even approximately, to overcome this, we also investigate the effects of Poisson's ratio on the deformation analysis. The analytical results obtained by the present methods are found to be reasonable, considering the idealized assumptions made.

KEY WORDS: plasticity; finite deformation; soft ground; settlement; lateral flow

INTRODUCTION

In recent years, as highway networks are becoming more extensive, highway embankments are constructed on complex topographical sites, particularly in plain covered with soft ground. For this reason, analytical techniques which make it possible to more precisely predict the behavior of soil structures related to actual construction work are required. Geotechnical researchers have developed theoretical soil mechanics, sophisticated laboratory and *in-situ* testing devices, and finite element method (FEM) with the powerful computers. They also developed the complementary approaches to performance for predicting prototype mechanical behavior with any real confidence.

It was also found that the computed deformations are governed by selected soil parameters for constitutive equations. It appears, however, that in practice, the selection of soil parameters from tests is not easy task. Kamei (1985) and Nakase *et al.* (1988) proposed simplified procedure to estimate the soil parameters for constitutive models. The simplified procedure can determine all the soil parameters using plasticity index (PI) only. This index can be obtained from technical reports and standard penetration test samples. Finite element analysis using the simplified procedure (simplified deformation analysis) has been conducted extensively, and its reliability have been demonstrated (Kamei, 1985; Nakase *et al.*, 1988; Kamei and Sakajo, 1993, 1995a, 1995b, 1998; Sakajo and Kamei 1996).

However, previous studies has been reported that a number of comparisons between predicted and observed lateral displacements have shown considerable lack of agreement, despite the agreement between predicted and observed settlements was quite good (e.g. Poulos, 1972; Tavenas *et al*. 1979). The reason for poor lateral displacements prediction may be attributed to several factors, including accuracy of Poisson's ratio, anisotropy, principal stress rotation under the toe of embankment, etc (e.g. Poulos, 1972). Lateral displacement, therefore, is notoriously difficult to predict even approximately, despite the sophistication of the analytical tools available. Surprisingly few numerical simulations have been made to investigate the effects of Poisson's ratio on such analyses.

Deformation theory, on the other hand, can be divided into two type, infinitesimal and finite deformations. Infinitesimal deformation theory has been used on a number of previous studies about deformation analysis (e.g. Kamei and Sakajo, 1993, 1995a, 1995b, 1998; Sakajo and Kamei, 1996). In this theory, strains with loading are extremely small, and they are ignored accordingly. Equilibrium equations are then easily given because deformations are ignored during loading. Consequently, infinitesimal deformation theory is inadequate to evaluate the stability of structure with large deformation. In these situations, deformation analysis based on finite deformation theory should be used.

Recently, finite deformation analysis has been applied to various types of problems, such as localization of strain in clay specimens (Asaoka and Noda, 1995; Shibi *et al.*, 2000), large settlement of embankment foundation (Noda *et al.*, 2005), and failure of embankment foundation (Kamei *et al.*, 2006). In addition, Asaoka *et al*. (1997) reported that the lateral deformations computed using finite deformation analysis were always lower than these using the infinitesimal deformation analysis.

In this paper, deformation behavior of the Kanda trial embankment on a deep soft ground with a well-documented case history was simulated using soil-water coupled finite element method based on finite deformation theory with the soil parameters for the constitutive model estimated from plasticity index (PI). To easily evaluate the deformation behavior of embankment foundation, the Cam-clay model for finite deformation is used as constitutive model of soil. The Cam-