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Finite Difference Analysis of Dilatory Dissipation on Piezocone Test in Overconsolidated Cohesive Soil

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ABSTRACT

For a commonly used piezocone with a shoulder filter element, dilatory dissipation behavior, which shows an initial temporary increase in pore pressure, has been observed in overconsolidated cohesive soils. In this study, dilatory dissipation with a wide range of OCRs was investigated in order to provide its theoretical and substantial grounds. Finite difference analyses on the dissipation after cone penetration were performed with the initial distribution of the excess pore pressure derived by the empirical modification of a solution proposed by the cavity expansion theory and critical state concept. It was found that in lightly overconsolidated soils, the upward propagation of the excess pore pressure from the lower cone face to the shoulder filter could lead to dilatory dissipation. Meanwhile, in heavily overconsolidated soils, the horizontal propagation of excess pore pressure in the inward direction to the cone, in addition to the upward propagation, increase the significance and possibility of dilatory dissipation. In addition, a parametric study showed that increases of OCR and the ratio of hydrostatic pressure to mean principle effective stress (u_0/p_0'), as well as the decrease of rigidity index (I_r), resulted in more probable and significant dilatory dissipation.

KEY WORDS: Dilatory dissipation; piezocone; overconsolidated cohesive soil; coefficient of consolidation; finite difference analysis.

INTRODUCTION

Piezocone penetration test (CPTu) is a widely utilized technology for the in-situ investigation of the ground, which operates by measuring the cone and sleeve resistances and pore pressure developed by cone penetration. In addition, a dissipation test carried out by measuring the pore pressure change with time after halting cone penetration, provides the determination of the coefficient of consolidation, which controls the time dependent deformation of cohesive soils.

For a commonly used piezocone with a shoulder filter element immediately behind the cone tip, a dissipation test performed in normally consolidated cohesive soils shows monotonically decreasing pore pressure, as shown in Fig. 1(a). However, in overconsolidated cohesive soils, a dissipation test records dilatory pore pressure behavior, showing an initial temporary increase in pore pressure followed by a decrease to hydrostatic pressure (Lunne et al., 1986; Battaglio et al., 1986; Sully et al., 1988; Chen & Mayne, 1994; Burns & Mayne, 1998). An example of the dilatory dissipation is shown in Fig. 1(b). Fig. 1 was obtained from the dissipation test results at Yangsan, located in a deltaic area of the southern part of the Korean peninsula, where the soil deposit was divided into two layers of upper lightly overconsolidated soils with OCR=2.3, and lower normally consolidated soils. Although this unusual dissipation behavior was reported mostly in heavily overconsolidated ground (OCR≥10) in previous research, it has also been observed in lightly overconsolidated ground (1<OCR≤4) in the western and southern seaside districts of the Korean peninsula, as presented in Table 1. 19 cases out of 39 test results showed that the maximum pore pressure (u_{2max}) was at least 10 % larger than the initial pore pressure (u_{2i}). Currently, in the dissipation test of the piezocone, the coefficient of consolidation is estimated on the basis of the monotonic decrease of the excess pore pressure (Torstensson, 1977; Baligh & Levadoux, 1986; Teh & Houlsby, 1991). In the case of a dilatory dissipation response, there is no appropriate way to estimate a consolidation parameter. Furthermore, the mechanism of dilatory dissipation has not been established and its governing parameters have not been clarified.

This paper is concerned with the mechanism and influencing parameters for the dilatory dissipation on piezocone tests in cohesive soils with a wide range of OCRs, in order to provide theoretical and substantial grounds to develop an appropriate method for the evaluation of the coefficient of consolidation from the dilatory dissipation curve of the piezocone test. Finite difference analyses on the dissipation after cone penetration were conducted with various ground conditions. The