Shear Characteristics of Boston Marine Clay

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1. INTRODUCTION

The city of Boston is underlayed by a deposit of marine clay ground. This clay is refered to as "Boston Blue Clay" . This clay varies in thickness from 10m-40m, and exhibts significant relationships in stress-history strength and deformation charactristics. This paper presents the behavior of the geological outline of the Boston area, summarizes the typical clay profiles and gives experimental results from laboratory K_o -consolidated undrained shear tests, field vane data etc.

2. GEOLOGICAL AND PHYSICAL PROPERTIES

For geological properties, soft rock consist of slates and sandstones distributed in the central Boston area. Hard rock consists of conglomerates and volcanic rocks distributed along the Charles River. Very thick glacial deposits overlie the bedrock. These deposits include drumlin till, ablation till, sand, gravel, silt, and clay. Most of the clay is marine and referred to as the " "Boston blue clay " " (BBC). But the color of the clay is typically light greenish-gray to medium-gray (Barosh, Kaye & Woodhouse 1989).Initial physical data is $G_s=2.80$, $w_0=35.84\%$, $e_0=1.015$, $k_{v0}=2.33\times10^{-7}$cm/sec .

3. K_o -CONSOLIDATED UNDRAINED SHEAR TEST

3.1 Method of Experiment

The specimen used was a test sample of undisturbed marine clay(BBC). The test sample for this soil experiment came from a sampling depth of 20.74 - 21.35m(68.00or70.00ft). The sample with steel tube was inspected by X-ray photography in order to examine without shell, gap, and grain in the sample clay. The specimen shape is d=35.87cm (1.5in.), h= 10.00cm(3.50in.).

For saturation : Back pressure (σ_b=3.5ksc) was used in order to raise the B value for 5 hours and then loading the cell pressure to σ_c=3.75 ksc.

For K_0-Consolidation : K_0-dimensional consolidation requires 105 hours in loading vertical stress σ_v by axial force, and it must be equalized between the decrease in volumetric strain ΔV and decrease of axial strain $\Delta\varepsilon_a$. The K_o - value is measured simultaneously. The effective stress limit was 6ksc with a strain rate of 0.15 %/hr. Consolidation was stopped after10% axial strain.

For Undrained Shear Test : A strain rate was selected , based on an estimate of the coefficient of consolidation. A strain rate of 0.5 %/hr was used, because the coefficient of permeability of BBC is $k_v = 1.0\times10^{-7} \sim 1.0\times10^{-10}$ cm/sec. Loading continued to shear until a failure plane developed or 20 % total strain achieved (A.J. Whittle 1994)

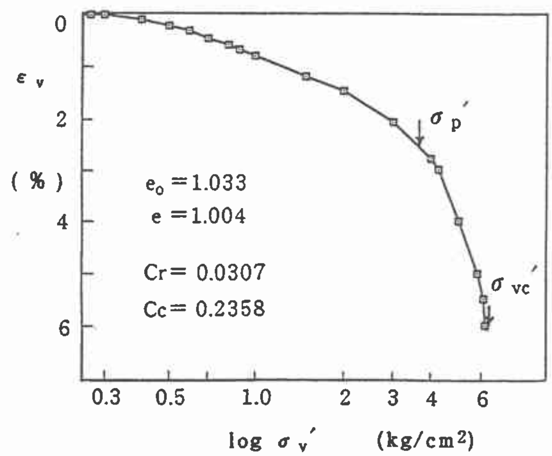

FIG. 1. $\varepsilon_v \sim \log\sigma_v'$ of K_0-Consolidation

3.2 Properties of Consolidation

We used both back pressure and carbon dioxide until the B · value increased to 0.94.

Figure- 1 shows ε_a- log σ_v' curve of K_0- consolidation. We obtained the vertical consolidaton effective stress σ_{vc}' = 6.13 ksc and the volumetric strain ε_a = 5.95 % . And we calculated OCR = 1.05 from σ_p' of Figure-1 and overburden pressure σ_v . The recompression index Cr of this curve had slope Cr = 0.0307 of initial stress σ_{v0}' and compression index was Cc=0.2358. Therefore from this figure . the magnitude of displacement of void ratio is in proportion to log-p for normalized consolidation clay receiving proportional loading.

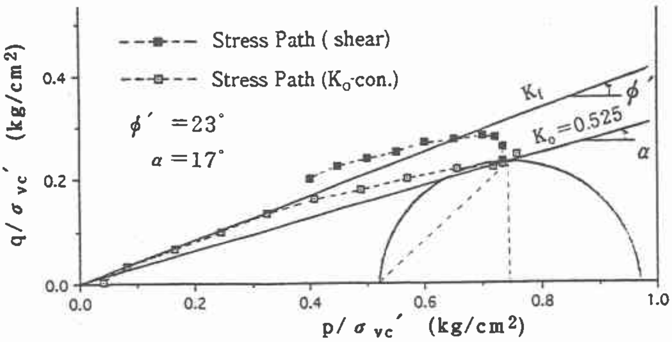

FIG. 2. Effective Stress Path of BBC

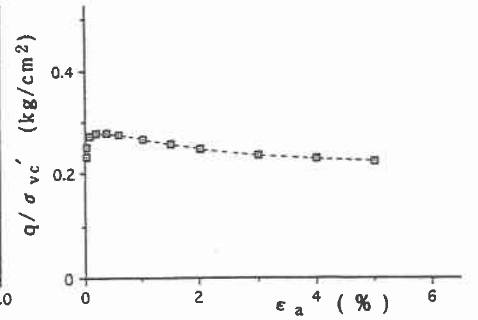

FIG. 3. Stress ～ Strain Curve of Undrained Shear Test

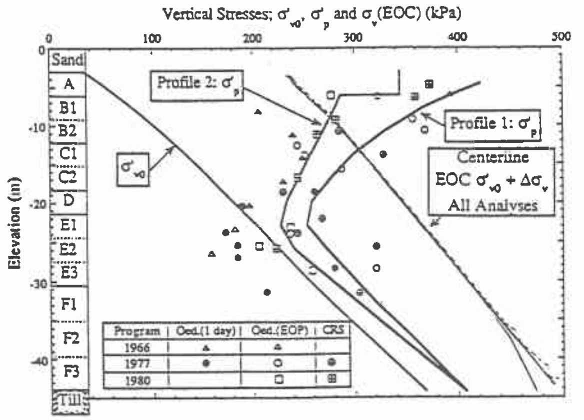

FIG. 4. BBC Layers and Stress History Data

3.3 Properties of Shear Figure-2 and Figure-3 show the stress strain curve of undrained shear test during and after K_0- consolidation. We had a peak strength $q/\sigma_{vc}' = 0.28$ ksc with the least volumetric strain of $\varepsilon_a = 0.2$ % .Our results agree with the peak stress path of undrained shear and peak of $q'/\sigma_{vc}' \sim \varepsilon_v$ curve , and had continuous agreement with the stress path of the K_0-consolidation process and stress path of undrained shear process. Pore pressure was measured correctly too , therefore we can calculate the effective stress . From the measured result of pore pressure . there is a large effect caused by shear stress.

3. 4 Stress History Fig.-4 shows the stress history of underground stress of a constructed embankement model on test section of an Interstate Highway extention during 1966 to 1980. This figure shows the calculated effective overburden stress σ_{vo}' and this stress plus the increment of total vertical stress $\Delta\sigma_v$ at the centerline at the end of construction (EOC) obtained from the finite element analyses method (FEM). The figure also plots values of preconsolidation pressure σ_p' estimated from the compression curves measured in the three consolidation test programs. and two σ_p' profiles selected for the FEM. The upper bound Profile 1 emphasized the σ_p' data from the 1966 and 1977 programs above El.-30 m and assumed a constant amount of precompression ($\sigma_p' - \sigma_{vo}'$) at greater depths. The lower bound Profile 2 emphasized the 1980 σ_p' data and considered the fact that su(FV)/ σ_{vo}' increased with depth from 0.18 to 0.21 below El.23 m. The soil profile was divided into 3.05 or 4.6 m(10or15 ft) intervals for the FEM and are designated as layers A,B1,…,through F3 in Fig.4 (C.C. Ladd, A.J. Whittle & D.E. Legaspi 1994)

4. CONCLUSIONS

(1) BBC is mostly glacial deposits and most of the clay is marine .

(2) We had good continious agreement with the stress path.

(3)The stress history was divided into smaller sections for the FEM which are used to designate the layers.

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