Thermally Induced Consolidation of Soft Bangkok Clay

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Introduction:

Thermal effects in geotechnical problems become important for many specific applications in soil mechanics. Some facilities, for example: nuclear waste disposal and heat storage are going to cause significant changes in the temperature of soil surrounding them. Therefore, the existing geotechnical engineering experience may not be sufficient to handle it with certainty. In Bangkok, the consolidation settlement of soft clay subsoil creates a lot of problems in the integrity of the foundations and the infrastructures. Several techniques are used to improve soft ground foundations. Thermal stabilization is another technique that can be used to improve the soft clay properties at shorter time. However, the behavior of soft Bangkok clay due to temperature effects has not been well studied. This work has been formulated to obtain the volume change behavior, using oedometer test, of soft Bangkok clay subjected to increase in temperature.

Objectives:

The specific objectives of this study are as follows:

1.)To determine the thermal effects on the compressibility characteristics such as compression index, C_c, recompression index, C_r and preconsolidation pressure.

2.)To investigate the effects on the overconsolidation ratio (OCR) by thermally induced and volume change under heating.

3.)To investigate the effects of the stress level on the volume-change behavior during heating of soft clay.

Apparatus and Testing:

The main apparatus was standard consolidation cell which was modified to provide heat and control the temperature to the specimen. The heat was provided to the specimen by heater which was attached around the consolidation cell. The thermocouple was also attached to consolidation cell to measure the temperature of the specimen. Both heater and thermocouple were connected to the thermo-controller which can control the temperature of the specimen. In order to prevent desiccation, the consolidation cell was kept filled with water by using automatic water supply unit. The schematic diagram of test equipment is illustrated in Fig.1.

Development of Preconsolidation and Consolidation Characteristics due to Temperature Increase

For this study, consolidation tests are divided into two parts, namely: a) those specimens subjected with initial stress of 100 kPa, and b) those specimens subjected under initial stress of 200 kPa. Specimens were firstly loaded to the certain pressure then unloaded to OCR of 12 and reloaded again in different higher temperature conditions

The preconsolidation pressures obtained at various temperatures compared in Fig.2 which shows a non-linear decrease of preconsolidation pressure with increased temperature. For the specimen subjected with initial stress100 kPa, the preconsolidation pressure decreased from

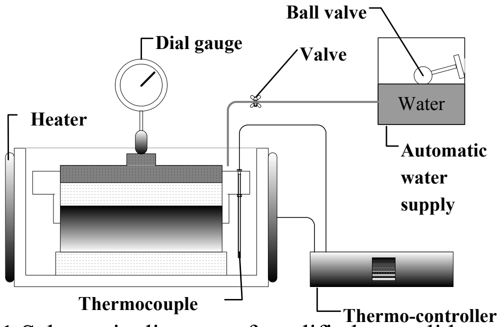

Fig.1 Schematic diagram of modified consolidometer used in this study

100 to 75 kPa when the temperature increased to 90°C. Also for the specimen subjected with initial stress 200 kPa, the preconsolidation pressure decreased from 200 to 157 kPa when the temperature increased to 90°C. The trends of decreasing preconsolidation pressure are the same despite the different initial values of preconsolidation pressures. These results are in agreement with those obtained from Moritz (1995) and Cekerevac et al. (2002).

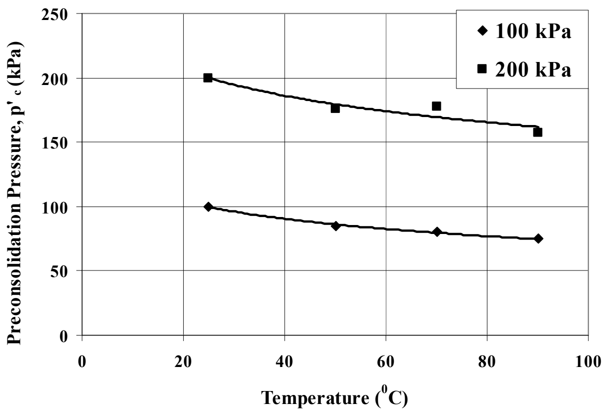

Fig.2 Influence of temperature on preconsolidation pressures at different initial stresses

Figure 3 shows that the value of compression index (C_c) and recompression index (C_r) are about 1.1 and 0.15, respectively. These compressibility indices are found to be more or less independent of temperature. Similar results were obtained by Campanella and Mitchell (1968).

Volume change due to heating

This part of this study was performed to determine the amount of thermally induced volume change of the specimens which have different stress histories. The specimens were roughly separated into two parts, namely: a) those specimens subjected with initial stress of 100 kPa, and b) those specimens subjected with initial stress of 200 kPa. The specimens having each initial stress were unloaded to the different OCR values and subjected to the higher temperatures.

Figures 4 and 5 present the effect of temperature on thermally induced volume change at initial stress 100 and 200 kPa, respectively. As can be seen in these figures, in normally consolidated condition, the volume changes of specimens are significantly effected by temperature. Higher temperature can induce more contraction to the specimens. In overconsolidated condition, less significant effect of temperature on volume change was observed. In other words, the effect of temperature on volume change tends to be reduced when the OCR increased. Similar results were observed by Sultan et al. (2001).

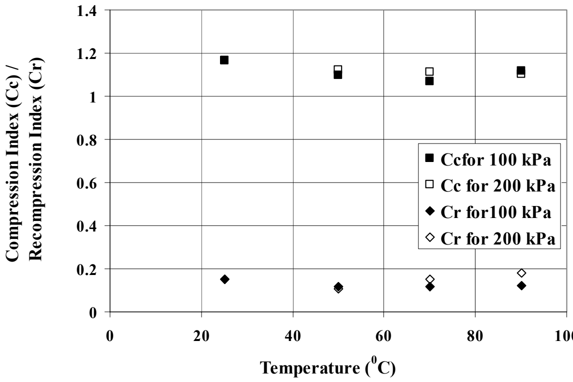

Fig.3 Influence of temperature on compression index and recompression index at initial stress of 100 kPa and 200 kPa

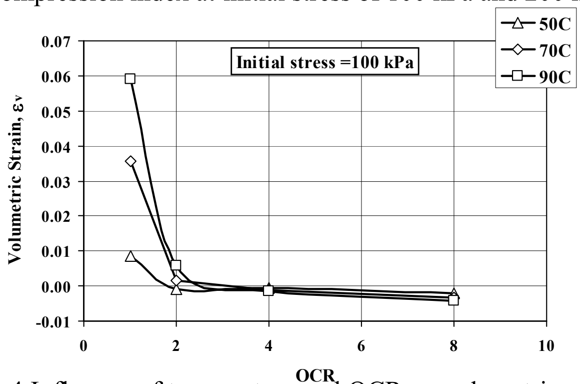

Fig.4 Influence of temperature and OCR on volumetric strain of the specimens at initial stress of 100 kPa

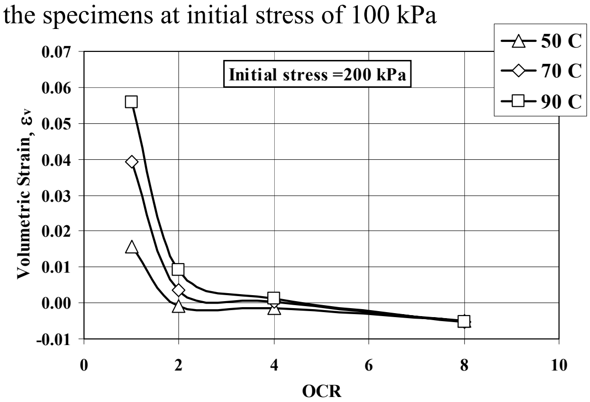

Fig.5 Influence of temperature and OCR on volumetric strain of the specimens at initial stress of 200 kPa

Effects of Stress Level on the Thermally Induced Volume Change

In this section, the temperature of the specimens which were tested at different stress levels were increased from 25°C to 90°C in order to compare the temperature induced volume change of each specimen. Twelve specimens were tested and were roughly separated into 3 parts. The 3 portions were tested at initial stresses of 100 kPa, 200 kPa and 300 kPa, respectively. After subjecting with initial stress the specimens were unloaded to different OCR and subjected to the increasing temperature.

Figure 6 shows the corresponding results of specimens subjected with different initial stresses. These results reveal that for a given increase in temperature and OCR, the change in volume caused by heat considerably similar for all stress levels. Therefore, it can be concluded that the thermally induced volume change is independent of the stress level. This observation is in agreement with the results obtained Demars and Charles (1982) and Sultan et al. (2001).

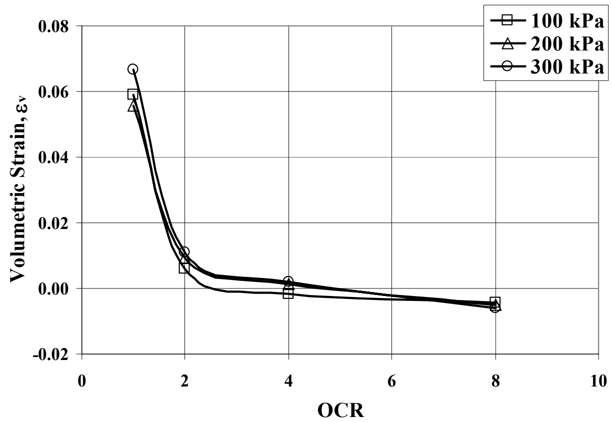

Fig.6 Influence of stress level on thermally induced volume change

Conclusions:

The studies described aboved have demonstrated the observed effects of elevated temperature on the behavior of Bangkok clays. From the results of the tests, the following conclusions can be made:

1) Normally consolidated specimens exhibit a non-linear volume contraction upon heating because heating induced sliding between clay particles. This contraction is dependent on temperature magnitude but independent of stress level.

2) Overconsolidated specimens exhibit a small volume contraction upon heating. However, this contraction decreases with increasing overconsolidation ratio and become an expansion at high overconsolidation ratio. The decrease of contraction occurs because of the expansion of pore water and clay particles induced by heating.

3) Preconsolidation pressure of overconsolidated clays decreases non-linearly with increasing temperature because the reduction of shear resistance between clay particles making specimens can resist less pressure.

4) Consolidation properties, compression index (C_c) and recompression index (C_r) are independent of temperature.

References:

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