Consolidation characteristics of clay under various heating conditions

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1. Background and objectives

Since underground temperature from 10 m to 200 m is almost constant at approximately 15 °C through the year, this shallow geothermal energy is expected as a new renewable energy source in these decades. Vertical drain method, which can accelerate settlemenet of soft clay ground for strengthening the strength, can be potentially sophisticated by heating the ground, because high temperature has a positive effect on consolidation settlement; however, the effect of temperature on consolidation has not been generalized. The main objectives of this study are to investigate temperature effects on consolidation of clay with two different soils by two types of the consolidation test under didfferent heating conditions. In addition, spatial heat transfer and corresponding 2D consolidation behavior was investigated by the large tank test.

2. Materials and methodologies

In this study, kaolin clay (liquid limit is 77%, and plastic index is 47%) and kasaoka clay (ditto, 58% and 34%) were used as clay samples. Three types of consolidation tests under diffirent heating conditions were conducted as follows; 1) the element-scale consolidation test under constant temperature, 2) the element-scale consolidation test in which heating starts after precedence consolidation, and 3) the large-scale tank test associated with horizontal heating from a cartridge heater at the center. The specimen size of test (1) and (2) was 6 cm in diameter and 10 cm in height and that of test (3) was 80 cm in diameter and 20 cm in hight of clay layer.

3. Main achievements

1) Comparing with ones under a room temperature, consolidation coefficient of kaoline increased by 1.2, 1.5, 1.6 times at 35 °C, 50 °C, 65 °C, respectively (Fig-1). That of kasaoka clay at 65 °C increased by 2.2 times which means temperature significantly affected.
2) An average value of consolidation coefficient increase ratio at consolidation pressure from 10 kPa to 120 kPa tended to decrease with liquid limits, analyzing the results of consolidation tests under different constant temperature for 5 types of clay material including previous research works (Fig-2).
3) Thermal volumetric strain tended to increased with heating temperature. Thermal volumetric strain by 50 °C heating of kaolin was larger than that of kasaoka clay. This can be due to the difference of plasticity index between the two clay materials. Thermal volumetric strain was relatively less affected by consolidation pressure, which was the same result as previous studies.
4) The large-scale tank test revealed that dissipation of excess pore water pressure at higher temperature point was faster. On the other hand, the effect of temperature on consolidation coeffient was not clear as the result obtained from test (1) and test (2).

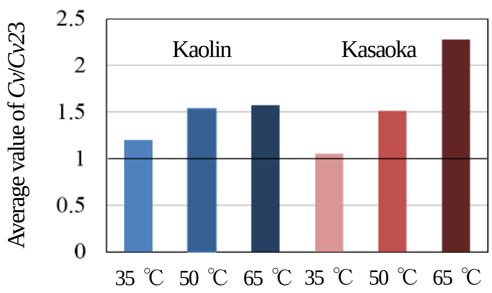

Fig-1 Temperature effect on consolidation coefficient

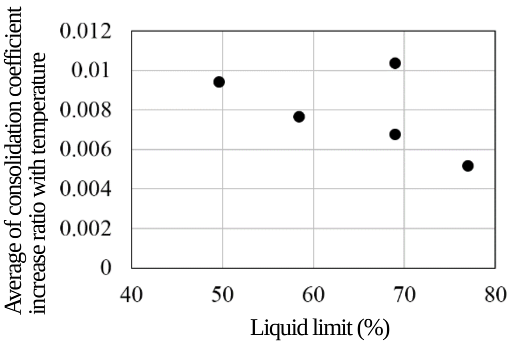

Fig-2 Average of consolidation coefficient increase ratio with temperarure