University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2022), Issue 2 (Summer), 121-128

EXTENDED ABSTRACT

Effect of Temperature on the Hydraulic Conductivity of Compacted Clayey Soil and Geosynthetic Clay Liner (GCL)

Mahdi Gholikhany, Kazem Badv *

Department of Civil Engineering, Urmia University, Urmia, Iran

Received: 23 January 2020; **Accepted:** 16 February 2021

Keywords:
Hydraulic Conductivity, Temperature, Compacted clay, GCL, Effective stress, Density

1. Introduction

In most studies, the increase in hydraulic conductivity with temperature has been considered due to the decrease in the viscosity of fluid (Habibagahi, 1977; Cho et al., 1999; Delage et al., 2011). However, the changes in hydraulic conductivity with temperature are not only influenced by the changes in water properties, but also by the thermal effect on soil-water interaction at the microstructure level (Towhata et al., 1993; Romero et al., 2001; Villar and Lloret, 2004). In the present study, results of temperature effects on the hydraulic conductivity of compacted clay from the Nazlou region of Urmia City (Iran), and geosynthetic clay liner (GCL) are presented. In this research, experiments were conducted by flexible-wall triaxial permeability apparatus. In order to increase the temperature of the permeability cell to a desired level, a heater and a temperature sensor were used. Results showed that by increasing the temperature, the viscosity of fluid decreases, the soil pore size increases, cross-section of effective flow increases and hence, the soil hydraulic conductivity increases. Increasing the effective stress causes the rate of increase in soil permeability due to temperature to decrease. Results showed that temperature increase does not have a significant effect on the hydraulic conductivity increase of geosynthetic clay liners.

2. Methodology

Clay samples with 5 cm height and 7 cm diameter and the GCL samples with 7cm diameter were used in order to investigate the effect of temperature on the hydraulic conductivity of clay and GCL samples. For clay samples, permeability tests were conducted with 30 and 65 kPa of effective stresses and at different temperatures ranging from 23 ˚C to 50 ˚C. Also, the permeability tests on the clay samples were conducted at three various soil densities (1.5, 1.7 and 1.9 gr/cm^3). For GCL samples permeability tests were conducted with 30 kPa effective stress, and at the same temperature levels as clay samples.

3. Results and discussion

3.1. Effect of temperature on the hydraulic conductivity of compacted clay

In order to investigate the effect of temperature on the hydraulic conductivity of compacted clay, permeability tests were conducted on the clay samples with 30 kPa of effective stress and a hydraulic gradient of 10. For each temperature level, two permeability tests were conducted. The results showed that hydraulic conductivity at 50 ˚C is about 2.3 times larger than that at room temperature (23 ˚C).

* Corresponding Author
E-mail addresses: m.gholikhany@gmail.com (Mahdi Gholikhany), k.badv@urmia.ac.ir (Kazem Badv).

3.2. Effect of effective stress on the hydraulic conductivity of compacted clay with temperature increase

In order to investigate the effect of effective stress on the hydraulic conductivity, two series of permeability tests were conducted on the compacted clay with 30 and 65 kPa effective stress and hydraulic gradient of 10. The results of these tests are shown in Fig 1. By increasing the effective stress from 30 to 65 kPa, hydraulic conductivity and the hydraulic conductivity increasing rate, are reduced. The ratio of average hydraulic conductivity for each temperature with 65 kPa effective stress, to average hydraulic conductivity with 30 kPa effective stress was 0.4.

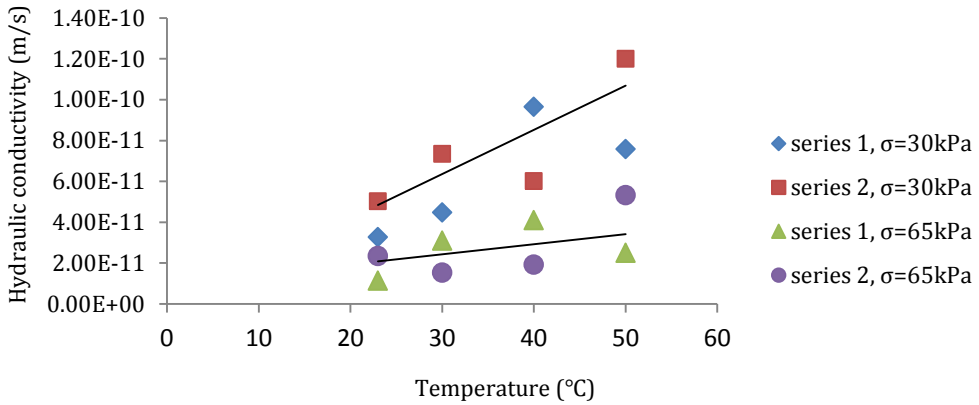

Fig. 1. Hydraulic conductivity of clay samples versus temperature with 30 and 65 kPa effective stress

3.3. Effect of density on the hydraulic conductivity of compacted clay with temperature increase

Permeability tests with three various densities (1.5, 1.7 and 1.9 gr/cm^3) were conducted on the clay samples, in order to investigate the effect of density on the hydraulic conductivity of compacted clay with temperature increase. The results showed that as the density of clay samples reduces, the hydraulic conductivity and increase the rate of hydraulic conductivity increases.

3.4. Effect of temperature on the hydraulic conductivity of GCLs

Results of permeability tests on the GCL samples are presented in Table 1. Results showed that when the temperature level increases from 23 ˚C to 50 ˚C, the hydraulic conductivity of GCL increases by about 20%.

Table 1. Results of permeability tests on the GCL samples

T (°C)	23	30	40	50
K (m/s)	2.10×10^{-11}	2.22×10^{-11}	2.38×10^{-11}	2.49×10^{-11}

4. Conclusions

For clay samples, temperature increase causes an increase in clay hydraulic conductivity. Hydraulic conductivity at 50 ˚C is about 2.3 times greater than at 23 ˚C room temperature. By increasing the effective stress from 30 to 65 kPa, hydraulic conductivity and the hydraulic conductivity increase rate, are reduced. The ratio of average hydraulic conductivity for each temperature with 65 kPa effective stress to average hydraulic conductivity with 30 kPa effective stress is 0.4. As the density of clay samples reduces, hydraulic conductivity and increase the rate of hydraulic conductivity increases. Results showed that when temperature level increases from 23 ˚C to 50 ˚C, the hydraulic conductivity of GCL increases about 20%.

5. References

Cho Wj, Lee Jo, Chun Ks, “The temperature effects on hydraulic conductivity of compacted bentonite”, Applied Clay Science, 1999, 14 (1), 47-58.

Delage P, Sultan N, Cui YJ, Ling LX, “Permeability change in Boom Clay with temperature”, arXiv preprint arXiv, 2011, 1112, 6396.

Habibagahi K, “Temperature effect and the concept of effective void ratio”, Indian Geotechnical Journal 1977, 7 (1), 14-34.

Romero E, Gens A, Lloret A, “Temperature effects on the hydraulic behavior of an unsaturated clay”, Geotechnical & Geological Engineering, 2001, 19 (3-4), 311-32.

Towhata I, Kuntiwattanakul P, Seko I, Ohishi K. “Volume change of clays induced by heating as observed in consolidation tests”, Soils and Foundations 1993, 33 (4), 170-83.

Villar MV, Lloret A, “Influence of temperature on the hydro-mechanical behavior of a compacted bentonite”, Applied Clay Science, 2004, 26 (1), 337-50.