Experimental study of thermal effects on the hydro-mechanical behaviour of kaolin clay

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Summary

The need for an improved understanding of the effects of elevated temperature on the soil behaviour is important in many applications such as disposal of high-level nuclear wastes, burial of high voltage cables, drilling of deep offshore wells, and clay liners used on landfills.

This research presents the results of an experimental study of thermal effects on the mechanical behaviour of an unsaturated soil. The study was performed on kaolin clay samples at different initial condition using temperature-controlled oedometer apparatus.

A comprehensive experimental program was carried out, in order to: (1) examine collapse potential of the soil samples when statically compacted to different initial dry densities; (2) examine the influence of compaction moisture content on the collapse potential of the compacted soil samples; (3) examine the influence of temperature on the soil response, and (4) obtain the correlation between the aforementioned effects.

Material

This study was performed on kaolin clay with properties shown in Table 1. The particle size distribution revealed that about 98% by weight was smaller than 0.02 mm and 42% was smaller than 0.002 mm. The mineralogical content of the material obtained from x-ray diffraction analysis was found to be 82% Kaolinite, 15% Quartz, and 3% Illite and/or Mica.

Property	Value
Liquid limit	55.0%
Plastic limit	31.4%
Specific gravity	2.64
Silt fraction	58%
Clay fraction	42%

Table 1: Engineering properties of kaolin clay

Figure 1 shows the compaction curve obtained following the British Standard BS-1377, where w_{opt} (the optimal water content) is equal to 23.7% and γ_{max} (the maximum dry density) is equal to 1.556 Mg/m3.

Experimental Programme

(a) Sample preparation

Test specimens were obtained by mixing distilled water into the dried clay powder to reach the required moisture content, and then statically compacted into the ring to give the required dry unit weight. The soil samples had 50 mm diameter and 19 mm height.

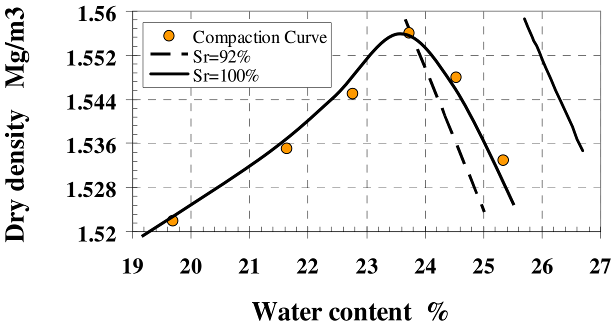

Figure 1: Compaction curve

(b) Single and double oedometer test

The single-oedometer method consists of incrementally loading a test specimen to reach the desired vertical stress, waiting for the vertical deformation to cease, and then wetting the specimen with water. The double-oedometer method consists of testing two nominally identical samples. One sample is initially saturated with water under a small seating load and allowed to collapse. The sample is subsequently loaded in standard incremental loading procedure. The other sample is tested at the initial water content using standard incremental loading procedure.

(c) Obtained results

In this study, a series of single and double-oedometer test has been performed, in order to investigate the collapse potential of the material, over a wide range of stress levels.

Temperature effects are identified by comparing the results of tests performed at 50ºC with the results of the same type of test carried out at 20ºC.

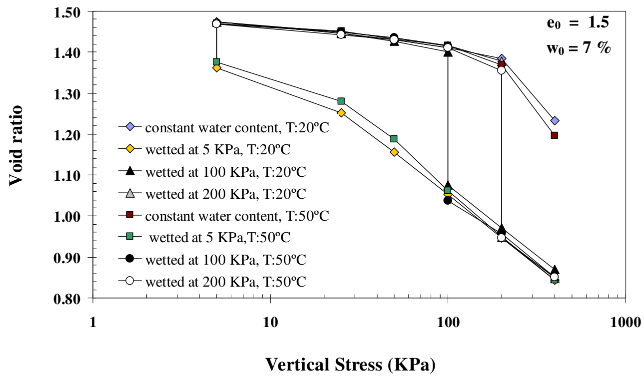

Figure 2: Single and double oedometer test

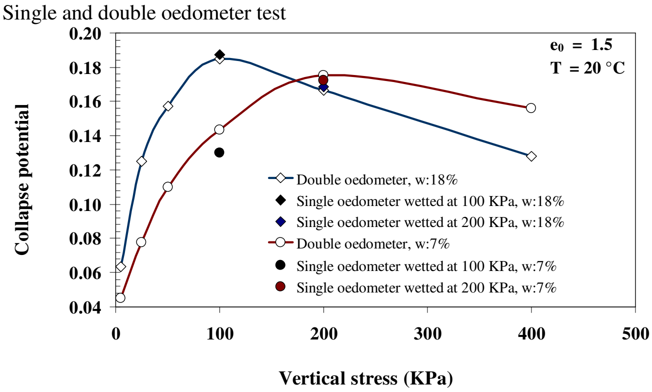

Figure 3: Collapse potential of the samples with different initial water content

Final Consideration

From figure 2 it can be recognized that collapse potential of the soil decreases with an increase in temperature. This observation was confirmed for the soil samples with different initial void ratio and water content. In addition it was observed that collapse potential of the soil increases with increasing initial water content at low stress level. In contrast, the collapse potential decreases with increasing initial water content for high stress level.