

# Assessments of swelling anisotropy of Ankara clay

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## ABSTRACT

Determination of swelling pressure exerted by expansive soils is important for designing structures such as shallow foundations, shallow tunnels, retaining walls, canal linings and underground conduits in such soils. The axial deformation and swelling pressure under zero lateral deformation can be determined by conventional oedometer using two identical samples. However, this test doesn't permit a synchronized measurement of both the axial and lateral swelling pressures on the same sample. The Ankara clay, which is an overconsolidated clay, rich in smectite group clay minerals, and partly covers the southern part of Ankara, the capital of Turkey, causes damage to light structures located at the surface and at shallow depths. A comprehensive study was conducted (i) to determine the swelling parameters (swelling pressure and swelling percentage) of Ankara clay both in vertical and lateral directions using a thin wall oedometer ring (providing synchronized measurement of swelling parameters in both directions), (ii) to compare lateral and vertical swelling parameters of the clay for the assessment of swelling anisotropy, and (iii) to investigate the effect of microstructure of Ankara clay on its swelling behavior using Scanning Electron Microscope (SEM). The experimental results revealed that the swelling parameters measured in vertical direction were greater than those measured in lateral direction. The ratio between the swelling pressures in lateral and vertical directions was found between 0.34 and 0.98. The results of the SEM analyses suggested that the clay minerals in Ankara clay show horizontal and/or nearly horizontal sheeting and have stepped face-to-face structure. This arrangement indicates that the swelling parameters in vertical direction should be greater than those in lateral direction. It also confirms the experimental results and shows the influence of the microstructure of the clay on swelling anisotropy.

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## 1. Introduction

In many countries, particularly in regions where arid or semi arid climate prevails, partially saturated and dry clays, which lie above the water table, cause severe damage to overlying and buried structures due to swelling and shrinkage. The damage to structures ranges from minor cracking of pavements to irreparable displacements of footings. Numerous reports of expansive soil problems and related damages have been documented in different countries (e.g. [Chen, 1988](#); [Basma, 1991](#); [Bell and Maud, 1995](#); [Al-Homoud and Al-Suleiman, 1997](#); [Papa, 1997](#); [Derriche and Iguechtal, 2000](#); [Al-Shamrani and Dhowian, 2003](#); [Erguler and Ulusay, 2003a](#)). The structures subject to damage affected by swelling soils are low rise buildings, roads and pavements, airports, shallow buried underground structures such as sewerage systems and pipelines, retaining and garden walls, watering canals and walls of lodges. Clays may also show anisotropic behavior with its lateral swelling pressure exceeding the vertical swelling pressure in some cases. However, most of the previous studies concentrated on vertical swelling pressure. Due to this, determination of the swelling

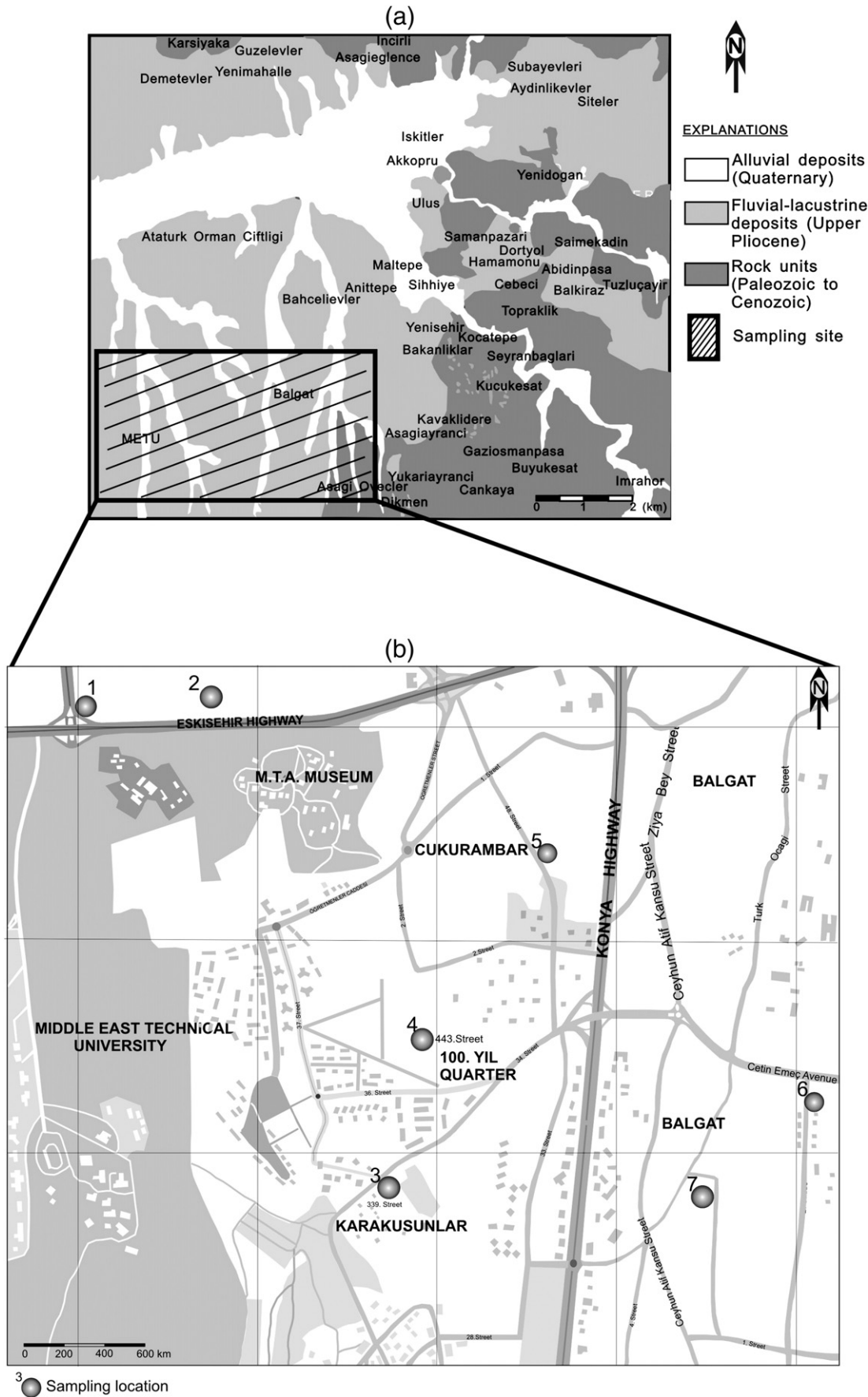
anisotropy by defining both vertical and lateral swelling of soil is very important for the stability of low rise and buried structures.

There is limited amount of research on lateral swelling of clays. [Chen and Huang \(1987\)](#) pointed out that walls of low rise buildings (buried walls in soil) in Denver, USA, experienced damage due to lateral swelling and observed that there was almost 15 cm of lateral movement. Similarly, [Joshi and Katti \(1984\)](#) studied the effect of swelling on retaining walls, roads, canals and drainage systems in India. They indicated that the dominant factor in causing damage to these structures was the swelling in the lateral direction, and that swelling anisotropy has a prime importance in clays.

A few attempts have been made on the synchronized measurement of the swelling pressures both in vertical and lateral directions on the same sample. [Komornik and Zeitlen \(1965\)](#) modified the classical consolidation cell unit to measure the lateral swelling pressure and developed a consolidation ring with a thin wall section allowing the use of electrical strain gauges to determine the applied internal pressure. [Parcher and Liu \(1965\)](#) used a device measuring swelling percentages both in vertical and lateral directions. A lateral swelling pressure ring, which is a modified thin-walled oedometer ring instrumented with strain gauges and is similar in principle to that of [Komornik and Zeitlen \(1965\)](#), was developed by [Ofer \(1980\)](#). [Ofer](#)

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**Fig. 1.** (a) Geological map showing the distribution of the soil and rock units in the city of Ankara (modified and simplified from Kasapoglu, 1980), (b) location map of the study site and sampling locations.

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