ASSESSMENT OF FACTORS AFFECTING COLLAPSIBILITY OF UNSATURATED SANDY SOIL

By

Mohamed Abubakr Nazmi Alassal

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
CIVIL ENGINEERING – PUPLIC WORKS

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Key Words:
Collapsible Soil, Unsaturated Soil, Matric Suction, Sandy Soil, Fines Effect.

Summary:

In this thesis, an experimental program is performed to illustrate the influence of different parameters on the collapsibility of ten sandy soils. Moreover, the collapse potential (CP) of these samples is determined using the single Oedometer Test. Then, the effect of related parameters including fine content, type of fines (silt/clay), initial water content, pre-wetting pressure, and wetting/drying process have been investigated. Also, the initial and pre-wetting matric suction values are measured using the filter paper method (ASTM D5298) to investigate its role on collapsibility. The soil water characteristic curves (SWCCs) could be generated, which can be used in numerical modeling of these types of soils. Scanning Electron Microscope (SEM) is conducted to illustrate the role of fine type in the collapsibility mechanism. Finally, different correlations suggested by literature and the Egyptian Code to determine the susceptibility of soil to collapse are studied.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Mohamed Abubakr Nazmi Alassal Date: .../.../…

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Dedication

To the most loving and caring parents,

Abubakr Alassal and Samira Ibrahim

Thank you for giving me the support to be successful in life

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Abstract

During the construction of new urban areas in desert, new geotechnical challenges are encountered, among which is dealing with collapsible soil formations. Collapsible soils are metastable unsaturated soils that experience a radical rearrangement of particles and a significant reduction of volume upon wetting with or without loading.

In this study, an experimental program is conducted to investigate the influence of various parameters on the collapsibility of sandy soils. The collapsible soil is represented by an artificial soil mixture consisting of 50% to 90% of sand and 50% to 10% of fines. These soil mixtures are classified as SM, SC, and SP-SC according to unified soil classification system (USCS). All the soil specimens are prepared at 35% relative density (D_r), approximately. In addition, the procedure of preparing an artificial collapsible soil specimen in laboratory is explained in details. Afterwards, the collapse potential (CP) of ten sandy soils containing different types and percentages of fines is determined using the single Oedometer Test. Next, the effect of related parameters including fine content (10% - 50%), type of fines (silt/clay), initial water content (5% - 15%), initial degree of saturation (8% - 50%), pre-wetting pressure (0 – 200 kPa), and wetting/drying process have been studied. Furthermore, the initial and pre-wetting matric suction values are measured using the filter paper method (ASTM D5298).

Results show that matric suction and plasticity index of fines have a direct impact on the soil collapse potential (CP). In order to further examine the effect of fines, Scanning Electron Microscope (SEM) is used. It is verified that collapsibility of silty sand formations is better described in light of skeleton void ratio (e_s) whilst the collapsibility of clayey sand formations can be explained based on the formation of clay balls within the voids between sand particles. Furthermore, the matric suction measurements are used to generate soil water characteristic curves (SWCCs), which can be used in numerical modeling of collapsible soils using common application in geotechnical field, such as Abaqus and Plaxsis. The SWCCs are based on the work of Brooks and Corey (1964), Van Genuchten (1980) and Fredlund and Xing (1994). Moreover, the value of initial matric suction could be used as an indicator to assess collapsibility of soil and define the degree of problem that occurs due to soil collapsibility. Finally, different correlations suggested by literature and the Egyptian Code to determine the susceptibility of soil to collapse are studied and compared to current research work.