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ScienceDirect
Engineering Geology 99 (2008) 85 – 90
ENGINEERING GEOLOGY
www.elsevier.com/locate/enggeo

Engineering properties of loess in Algeria

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Received 3 February 2007; received in revised form 10 November 2007; accepted 20 January 2008
Available online 16 February 2008

Abstract

Loess in North Africa has been investigated using samples from Algeria. The specific gravity, Atterberg limits, grain size distribution and dry density were determined. The hydro-collapsibility properties, due to wetting under different stress levels were measured in single-oedometer tests. The results of this investigation indicate that the properties of Algerian loess are similar to those of loess from many parts of the world, such as Iowa and Libya; they can be classified as silty loess.

Keywords: Algeria; Grain size; Engineering properties; Hydrocollapse; Loess; Oedometer tests

Contents

1. Introduction

The Sahara is one of the world's major sources of minerogenic dust (Prospero et al., 2002), many of the silty deposits in adjacent areas being attributed to aeolian processes. Loess is found in many parts of the worlds. In China, for example, it has been estimated that the area covered by loess exceeds 630,000 km^2, of which about 60% is collapsible (Derbyshire et al., 1995). Silt constituting 50–70% by weight is the predominant grain size fraction in loess, less than 5% of particles being greater than 1 mm, and clay particles making up only a few percent. Quartz and feldspar are the major mineral constituents of the coarser grades, while illite is the principal clay mineral. In addition, collapsible loess may contain relatively large amounts of calcium carbonate, as well as various soluble salts distributed on the surface of particles in solid or semi-solid state.

Loess deposits have certain distinctive characteristics (Rogers et al., 1994) that define the material. Two major defining features are particle size distribution and the susceptibility of the soil structure to collapse when loaded and wetted. Chen (1992) stated that the defining physical characteristics of loess in its natural state are low water content and high porosity.

It has been estimated that loess covers nearly 10% of the surface area of the earth (Pecsi, 1968). It is found in continental drylands on all continents, with the notable exception of Africa.

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doi:10.1016/j.enggeo.2008.01.013

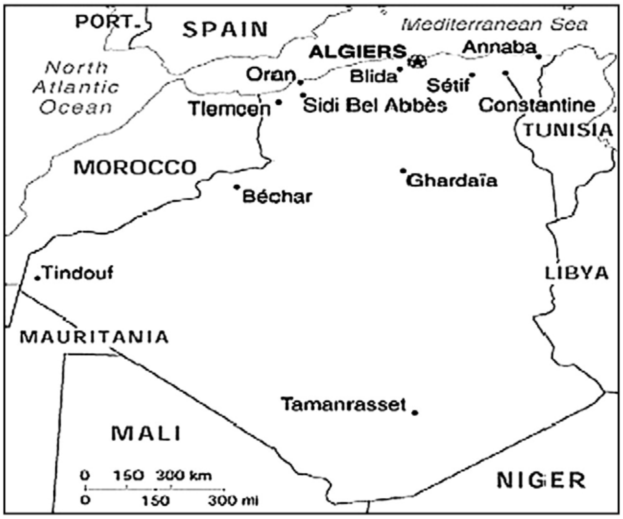


Fig. 1. Map of Algeria showing sampling location, Ghardaia.

Scheidig's (1934) map of world loess distribution recognizes only one loess region in Africa (North Libya). However, this conclusion was based on limited information, owing much to the work of Rathjens (1928) who described loess-like materials in Libya but found Tripolitanian loess to have a grain size >100 µm for loess. More recent work by Coudé-Gaussen (1987) has shown that North African loess may have larger modal sizes than better known loess deposits. In the Techine field-section (Matmata, Southern Tunisia), for examples, three series occur in a 17 m thick succession (Coudé-Guassen et al., 1982): an upper grey-beige loess, an intermediate series with altered reddish horizons; and a lower ochre loess. This work showed that Tunisian loess is coarser in granulometric composition than most other loess. Assallay et al. (1996) have recently justified Scheidig's classification of the North Libyan silty deposits as loess. They demonstrated that it has index properties and shows aspects of hydrocollapse behaviour similar to those found in loess from many parts of the world. They concluded that this material can be classified as silty loess in the Tripoli region and clayey loess in the Ghat area. Abdrabbo et al. (2000) have reported an extent of loess throughout the Western Desert of Egypt, especially at certain locations including Sidi Baranee, New El-America city, and El-Boustan. Despite the huge surface area of Algeria, no serious study has tackled the question as to whether or not loess is present in this vast area. In their study of Algerian duricrusts, Smith and Whalley (1982) concluded that these residual deposits contain quartz and feldspar grains, which exhibits evidence of limited aeolian abrasion and chemical weathering; they suggested a Holocene age for these deposits.

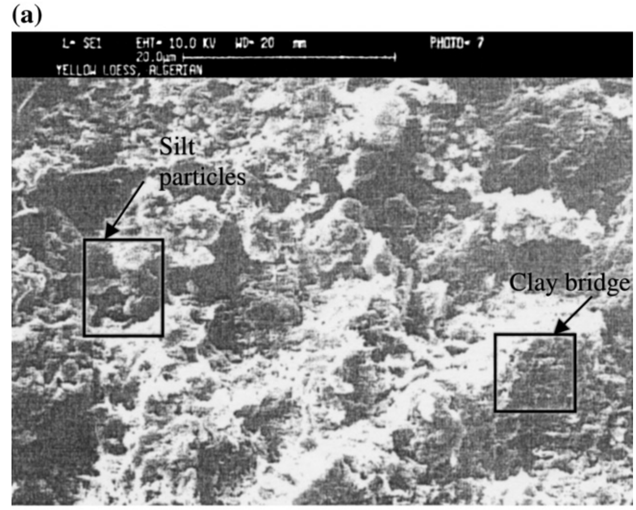
Because of the potential hazards posed to engineering structures with foundations on collapsible soils that undergo high volume change, it is important to identify such soils and to understand clearly their engineering properties. This paper is a first attempt to fill the gap in knowledge of the known loess-like silts of Algeria. Given the clear need for more careful analysis of North African silty sediments as a means of determining whether they constitute true loess, the main objective of this paper is to investigate the collapsibility characteristics and behaviour of selected Algerian materials with particular reference to their response to wetting at different stress levels. For this purpose, undisturbed soil samples representing two types of loess were collected from two locations: Daia Bendahoua and Metlili, Ghardaia (southern Algeria).

2. Materials and experimental programme

An experimental investigation was carried out to determine the index properties and the hydro-collapsibility characteristics and behaviour of the samples. Undisturbed block samples were obtained from depths of between 0.6 and 1 m, and then carefully trimmed, waxed and placed in boxes. The two samples sites lie 45 km apart in the Ghardaia region, some 600 km south of Algiers (Fig. 1), some soil assessment has already been undertaken in this region with a view to dam construction.

Specific gravity, and Atterberg limits were determined according to British Standard Procedure (BSI, 1990). Particle size analysis of material passing the 63 µm sieve was undertaken using Sedigraph Technique. The microstructure of loess particles was examined using a scanning electron an X-ray scanning system (Sedigraph). The collapsibility characteristics and behaviour of the

(a)



(b)

Fig. 2. Scanning electron micrograph of loess samples showing clay-coated silt grains of natural structure of (a) yellow loess and (b) grey loess.