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Analytical and Statistical Study of the Parameters of Expansive Soil

A. Medjnoun, R. Bahar

***Abstract*—**The disorders caused by the shrinking-swelling phenomenon are prevalent in arid and semi-arid in the presence of swelling clay. This soil has the characteristic of changing state under the effect of water solicitation (wetting and drying). A set of geotechnical parameters is necessary for the characterization of this soil type, such as state parameters, physical and chemical parameters and mechanical parameters. Some of these tests are very long and some are very expensive, hence the use or methods of predictions. The complexity of this phenomenon and the difficulty of its characterization have prompted researchers to use several identification parameters in the prediction of swelling potential. This document is an analytical and statistical study of geotechnical parameters affecting the potential of swelling clays. This work is performing on a database obtained from investigations swelling Algerian soil. The obtained observations have helped us to understand the soil swelling structure and its behavior.

***Keywords*—**Analysis, estimated model, parameter identification, Swelling of clay.

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I. Introduction

NORTHERN Algerian is known by the dominance of clay formation and semi arid climate, hence the presence of the phenomenon of shrinking and swelling.

A database is collected as part of development projects in several sites around the national territory. These data will be used in analyzing the parameters affecting this phenomenon, and in the confirmation of some prediction models. There are a variety of estimation methods, mainly based on the physical and chemical identifications simple testing, carried out on undisturbed or remodeled samples. Some methods use a maximum of three parameters considered to have a direct relation with the swelling of clays. Among these methods we have: the classification of [4], based on the liquid limit and plasticity index, the classification of [1], which is based on the percentage of clay fraction and plasticity index and the classification of [3], which is based on the percentage of the clay fraction, the corrected activity and plasticity.

The present work is based on a set of parameters such as the natural water content, dry and wet density, Atterberg limits, the clay fraction and the swelling parameters.

A. Medjnoun is with the University of Sciences and Technology Houari Boumediene, LEEGO, BP 32 El-Alia,16111 Bab Ezzouar, Algiers, Algeria (Corresponding author, Phone: 0213-253-379; e-mail: medjnounamel@yahoo.fr).

R. Bahar is with is with the University of Sciences and Technology Houari Boumediene, LEEGO, (e-mail: rbahar@usthb.dz).

II. Presentation of the Geotechnical Results

Swelling risk is suspected in 14 investigated sites. The geotechnical results are shown in Figs. 1-3. In the studied sites, the percent of clay fraction (F) is, the dry density and the water content are medium to high. The abacus of Casa grande shows the presence of low plastic and very plastic types of clay. The oedometer tests, carried out on intact clays samples, show different swelling potentials from one site to another and so different at the same site; Example site Medea [2]. His observation shows that in the same site, the soil is heterogeneous, and the presence of the swelling risk.

The number of identification results is more important than oedometric results, because of duration of oedometric test.

III. Analysis of the Different Parameters

A. States Parameters

Observation of state parameters shows a relation between the water content (w) and dry density (γ_d). This relationship is similar to that of wet density (γ_h)

$$\gamma_h = \frac{\gamma_d}{1+w} \tag{1}$$

where γ_d is dry density and w is initial water content. Except that, the knowledge of wet density (γ_h) is not necessary for the determination of dry density (γ_d).

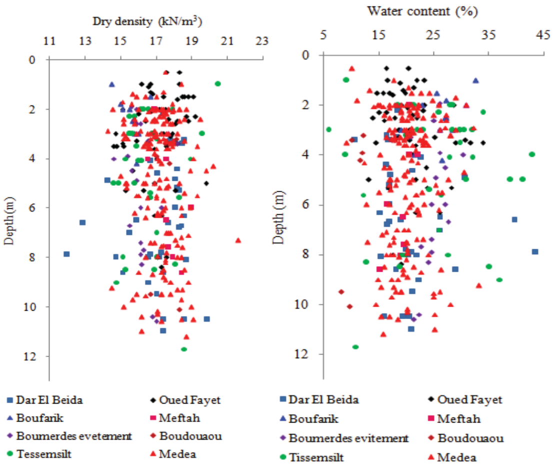
The correlation study is performed on 360 undisturbed clay samples taken sites studied. The results show a good correlation between these two parameters, and the correlation coefficient is $R^2 = 0{,}88 \cong 1$ (Fig. 4).The number of samples is quite sufficient to validate this correlation. This relationship has a form of simple linear regression model, the variable “a” and “b” represent respectively the slope and the ordinate-axis as shown in (2):

$$\mathrm{Y} = \mathrm{a\,X} + \mathrm{b} \tag{2}$$
$$\text{or} \quad \mathrm{Y} = \gamma\mathrm{d} \;\; ; \mathrm{X} = \mathrm{w}$$

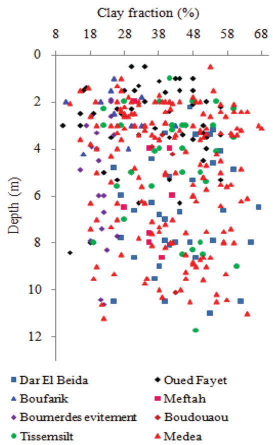
The statistical method of lesser square programmed in Excel can estimate the values of these two variables as:

$$\gamma_d = -0{,}221\, w + 21{,}74 \tag{3}$$

This model is also tested on 56 values of dry density and water content of remodeled and intact samples of Romainville green clay, studied by [5]. Fig. 4 shows the applicability of this model.



(a) Dry density (b) Water content (w)



(c) Clay fraction

Fig. 1 Results of identification parameters

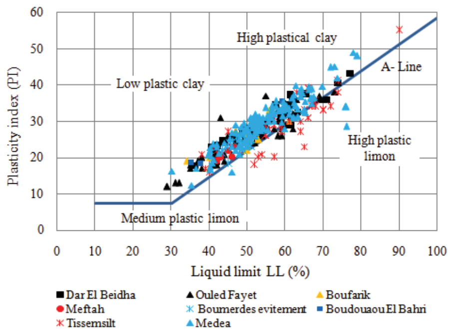
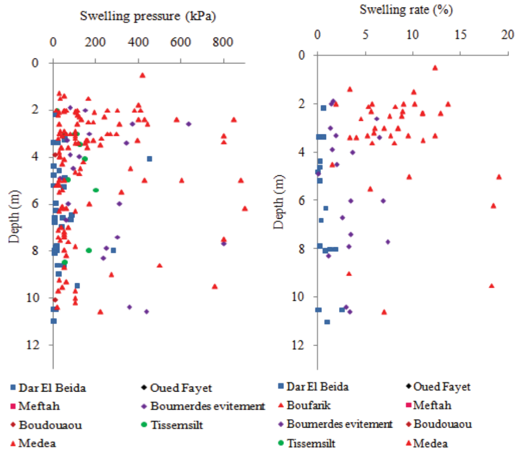
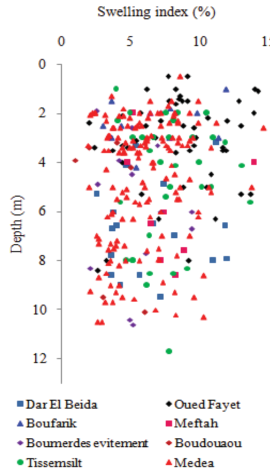


Fig. 2 Casa grande abacus



(a) Swelling pressure (b) Swelling rate



(c) Swelling index

Fig. 3 Oedometric parameters

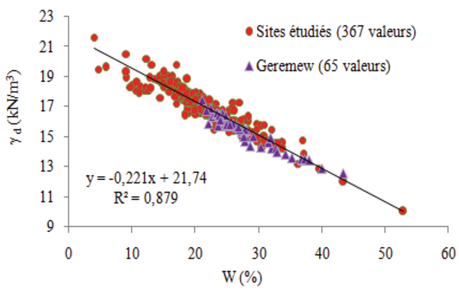


Fig. 4 Correlation between the dry density and the water content measured in the laboratory

Linear regression between the estimated values and the measured values of (γ_d), Fig. 5, shows a regression line passing through the origin, of a mathematical form: X = Y. The calculation of error shows that the majority of the values are between a percentage error of -5% and + 5%. From this model, the estimation of the water content or the dry density become possible, knowing that the obtaining the water content results, require at least 24 hours to fine soils.

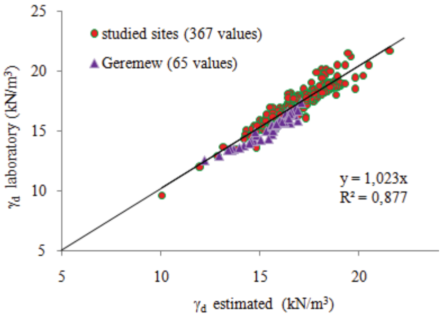


Fig. 5 Correlation between dry densities measured at the laboratory and estimated dry densities

The estimate of potential swelling recommends the use of independent parameters. In the last years, the dry density and the water content have been considered independent by several researchers. Now that their dependency is verified by the model (3), a rewrite of the estimated swelling potential models is necessary.

B. Analysis of Swelling Parameters

The mechanical behavior of soils is just the result of physical and chemical characteristics. Grain size, dry density, water quantity occupying pores between grains and liquidity and plasticity limits, are information that predicts approximately the behavior of soil and orients the geotechnical investigation to swelling tests, taking account the nature of the project.

Several statistical tests are realized, using "Statistica 7" program, to analysis the effect of the identification parameters on the swelling parameters. The results are showing in Figs. 6-9.

The dry density (γ_d) informs on the state of compaction of a soil, and the clay fraction (F) gives the percent of each grain fraction. Fig. 6 shows the effect of these two parameters on the swelling pressure. When the clay fraction is compact, the swelling pressure is important.

In Fig. 8, the analysis of the swelling pressure (Sp) is made, from, dry density and clay activity. The parameter of clay activity involves the clay fraction (F) and plasticity index (PI). The plasticity index provides information on the Atterberg limits of the soil. Finally the analysis is performed from four parameters. Fig. 8 shows that swelling pressure is important, when the clay activity and the dry density are important.

The parameters studied in Figs. 6 and 7 affect in the same manner on the Swelling rate (S_{rate}). However, the swelling index (S_{index}) is not dependent on the same parameters, because it is a parameter determined from the unloading phase of oedometer curve. At this step of test the soil lost these initial state (in situ characteristics), the reason for which the relationship between the swelling index and the dry density is non-existent, Fig. 8. However, the clay fraction (F) and clay activity (CA) have a relationship with this parameter, but it is not sufficient for the prediction of the swelling index, Fig. 9. It still depends on the state of soil stress and the texture of the clay sheets; it is directly related to the quality and quantity of swelling clay particles (Mineralogy).

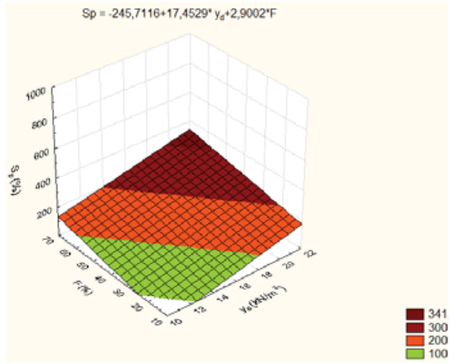


Fig. 6 The effect of the dry density, and the clay fraction, on the swelling pressure

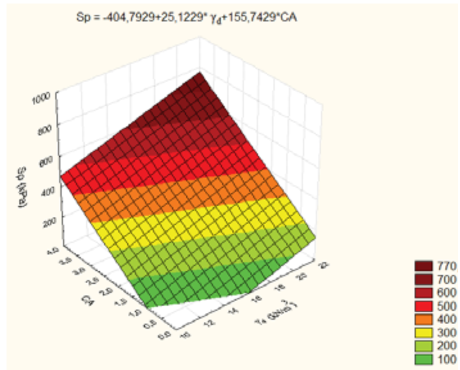


Fig. 7 Effect of dry density and clay activity on the swelling pressure

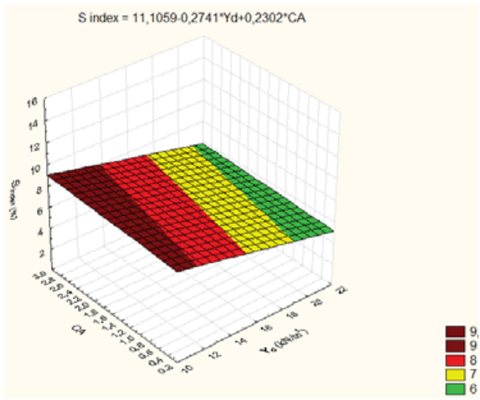


Fig. 8 Effect of dry density and the clay fraction on the swelling index

IV. Conclusion

The swelling of clays depends on three important parameters: mineralogy (quality and quantity of swelling clay), clay texture (history of clay) and state parameters (γ_d et w). The quantity and quality of swelling minerals can be represented by the clay activity, methylene blue values and limits of withdrawals. The clay texture stills an unknown parameter to be determined. The accuracy in the estimation of the swelling potential can be achieved by increasing the number of independent parameters and make the relationship between them. From estimated models, the prediction of soil behavior is possible and geotechnical tests are well oriented.

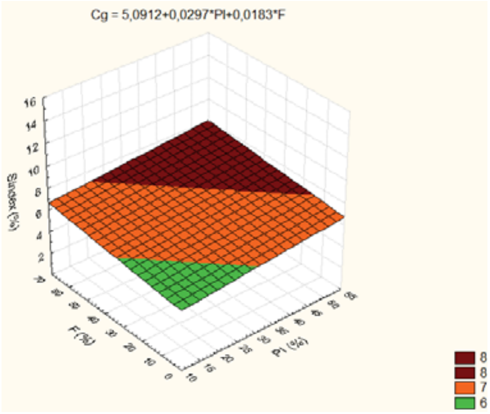


Fig. 9 Effect of the plasticity index and the clay fraction on the swelling index

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