Geotechnical Characteristics of Miocene Marl in the Region of Medea North-South Highway, Algeria

Y. Yongli, M. H. Aissa

Abstract—The purpose of this paper aims for a geotechnical analysis based on experimental physical and mechanical characteristics of Miocene marl situated at Medea region in Algeria. More than 150 soil samples were taken in the investigation part of the North-South Highway which extends over than 53 km from Chiffa in the North to Berrouaghia in the South of Algeria. The analysis of data in terms of Atterberg limits, plasticity index, and clay content reflects an acceptable correlation justified by a high coefficient of regression which was compared with the previous works in the region. Finally, approximated equations that serve as a guideline for geotechnical design locally have been suggested.

Keywords—Correlation, geotechnical properties, Miocene marl, north-south highway.

I. INTRODUCTION

The North-South Highway in Algeria (Chiffa-Berrouaghia section) is an important part which comes within the framework of the National Road 01 upgrade (RN°01). The project extends along 53 km, the layout of the road cross plains, but the most part passes through a mountainous region. Thus, topographical and geological conditions along the project where marl formations occupy a very large field are complex and unfavorable. All these factors are a real challenge for the geotechnical practitioners and designers of different construction projects in the region.

In the literature, we can find several works dedicated for the marls study and their characterization thus the factors influencing their behavior. Pejon et al. [1] studied the effect of water on the clay-marl rocks and the contribution of the mineralogy and texture in the swelling process.

Klotz [2], as well as Monnet et al. [3] studied the role of wetting-drying cycles on the degradation of marl. Additionally, the influence of freeze-thaw is also investigated by [4].

Extensive studies were carried out on marl in the Algerian Tell (see for example: [5], [6]). Other researchers have shown that the type of marl is a determining factor in the erosion of soils in Algeria [7], [8], whereas [9] showed that the marl is highly vulnerable to gully.

In the geological and geotechnical point of view, many research fields can be found in the marly soils of Algeria, including the pliocencennes marls of Algiers [10]-[12]. Aïssou and Nechnech [13] conducted an analysis of the withdrawal swelling potential of the clay marl soils of Plaisancien age in Algiers region, while [14] conducted a study of the marly schist formations subjected to the landslides.

In the eastern region of Algeria, [15] conducted a study on the marl in the region of Tizi Ouzou to use as a filling material in roads while [16] also conducted an analysis of clays and marl of Miocene in the Mila region exactly the risk of withdrawal swelling of these formations and also the data from the geotechnical researches in the region [17]-[19]).

In the target area (Medea), the Miocene marls are very sensitive to erosion [8]. In the literature there is a gap in studies and geotechnical research on Miocene marl of Medea, except a recent study achieved by [20] which serves as a reference document for validation of the present study.

This article aims at studying the Miocene marl exposed in the region of Medea based on the analysis of the results of laboratory tests, executed as a part of the geotechnical investigation of the North-South Highway between Chiffa and Berrouaghia, to establish correlations between physical and mechanical parameters of marl in question.

II. GEOLOGICAL SETTING OF THE STUDY AREA

The area between Chiffa and Hamdania begins with medium and lower Cretaceous formations consisting mainly of fractured and weathered schists. The gray marl of Cretaceous age experiences a high alteration with the exposition to the air in the less steep slopes where water causes very slowly. Thereafter, we encounter the Turonian calcareous formations and calcareous marl of Vraconian between Hamdania and Medea.

Marls are greenish, non-laminated, hard enough, brecciated, and hard marls which have a violet color with amygdaloide texture, accompanied by compact calcareous of homogenous grain of the same color [21].

Medea region is constituted by a tray, which exceeds altitude of 900 m. This tray is formed of the tertiary fields [21] of Middle Miocene age (Helvetian) based on Cretaceous (Senonian-Cenomanian). This Helvetian is all most constituted of marl and becomes sandstone in the top and constituting the plate of Medea. This plate is syncline, oriented N.W-S.E, and divided into three compartments by faults N.E-S.W with a rejection of 25 meters. To the South of this plate between Medea and Damiette, a layer of sand and clay separates the sandstone in two levels.

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Between Medea and Berrouagha extends the Middle Miocene, characterized by a large amount of marine fossils, and especially by the shells of oyster genres, comb, bucarde, and various polyparities. Two main formations dominate:

- Lower Miocene: Formed by a clayey sandstone series, and a series of marl of light gray color, little important.

At Berrouagha city, we encountered a series of Cenomanian-Turonian-Vracano formations consists of: Black limestones with Ammonites and Belemnites. Marls with a few large Calcareous shoals at the top. Calcareous rocks with phitanites locally.

Beyond Berrouagha, the Miocene land gradually fades, except for the summits and hills: it gives way to a formation composed of bluish or blackish marl, almost everywhere gypsum, alternating with gray calcareous marl, and generally has layers inclined at 45 degrees.

III. TECTONIC CONTEXT OF THE REGION

The tectonic units are Autochton and Telliens displaced during the lower Miocene from the North to the South exhibiting many lower Cretaceous facies, and this superposition is followed by posttablecloth formations of Miocene age, which is the basin of Medea. This tectonisation manifests by folding, faults, and erosions which reveal the windows of Tellian tablecloths infra-Miocene. Towards Medea, we encountered marl facies of lower Miocene, and marl and clay of upper Miocene.

IV. SITE CHARACTERISTICS OF MIocene MARL

In this study, we are interested in the marl formations of Miocene age, which are generally located in the layout of the North-South Highway between PK20 and PK40 (Fig. 1). These marls have a grey-bluish color, locally in greyish-green and yellowish-green, homogeneous, and contain fissures where water circulates and the permeability is low (The permeability coefficient $k = 10^{-11} \text{ m/s}$, containing a large fossil crustacean and a fossil fragment). With adding 5% of hydrochloride, effervescence of the marly rock occurs.

The joints are developed vertically and often there to thin bands of iron oxide, fragile, extremely easy to disintegration, and diagenetic processes are low, also marls have a low wind resistance capacity. The morphology of the terrain is often flat. The slope is less than 20° generally (Fig. 2).

### Table 1: Mineralogical Composition of Marl

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Statistical Property</th>
<th>Samples Number</th>
<th>Maximum Value</th>
<th>Minimum Value</th>
<th>Average Value</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albite</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>13</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td>Dolomite</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Gypsum</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Orthose</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Quartz</td>
<td>7</td>
<td>24</td>
<td>20</td>
<td>20</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>7</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Kaolinite</td>
<td>7</td>
<td>11</td>
<td>8</td>
<td>8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Montmorillonite</td>
<td>7</td>
<td>21</td>
<td>18</td>
<td>18</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Ferruginous</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

![Fig. 1 Location of Miocene Marl in the plan](image1)

![Fig. 2 Overview on the Morphology of Miocene Marl in Medea region](image2)
Table I reflects a complex mineralogical composition of Miocene Marl. The most abundant clay minerals are: illite, kaolinite, and montmorillonite, totally they can reach 42%, followed by the quartz silica with 24%, and finally calcium carbonate with about 20%. The cement material is calcareous.

V. CHARACTERISTICS OF THE MIOCENE MARL IN LABORATORY

A. Mineralogical Composition of Marl

The determination of the mineralogical composition of Miocene marl is verified by the analysis of the X-ray diffraction spectrum. The results obtained are in Table I.

The plasticity index $I_p$ is plotted as a function of liquidity limit $W_L$ of 150 samples on the plasticity Abacus of Casagrande (Fig. 3). The blue line on the abacus has the following equation: $I_p = 0.73(W_L - 20)$. Note that the cloud points are above the blue line. For this purpose, the marl is classified as a little plastic clay to a very plastic clay ($A_p - A_t$).

B. Physical Properties of Marl

The study of the physical properties of Miocene marl focuses on the particle size, Atterberg limits, soil density (dry and wet) and the void ratio of the soil. The test results are in Table II and note that the liquid limit is measured according to the French standard NF P94-052-1 [23].

Subsequently, the proportion of clay less than 0.002 mm $P_{0.002}$ is drawn as a function of Liquidity limit $W_L$ (Fig. 4). A linear relationship between the liquidity limit and the clay content can be seen and this relationship follows this equation: $P_{0.002} = 1.26W_L - 24.52$ with a regression coefficient $R^2 = 0.7063$. Similarly, the plasticity $I_p$ index is drawn as function of clay content $P_{0.002}$ by using data of the present study and the data from the study conducted by [20] for comparison (Fig. 5). For the present study: $I_p = 0.36P_{0.002} + 11.84$ with a regression coefficient $R^2 = 0.61$. For the study conducted by [20]: $I_p = 0.1P_{0.002} + 21.87$ with a regression coefficient $R^2 = 0.23$. 
D. Mechanical Characteristics of Marl

A strength shear tests were performed by using 20 undrained unconsolidated samples of marl and 52 drained consolidated samples of marl. The analysis of Table IV shows that the values of cohesion with the two procedures cited above reflect a wide discretion, whereas the values of the internal friction angle reflect a small discretion.

The swelling coefficient $C_g$ is drawn as a function of compression index $C_c$ (Fig. 6). The fitted equation is: $C_g = 0.2689C_c + 0.0021$ with $R^2 = 0.63$.

### E. Swelling Index of Marl

The swelling test was carried out following the French standard NF P94-091 [25]. Statistical analysis of the swelling test results of all 16 samples is in Table V. The results show that the values are quite discrete.

### VI. DISCUSSION OF THE RESULTS

Through our study, the following notes can be concluded:

- According to the plasticity index $I_p = 23.2$, the Miocene marls are plastic.
- According to the BRE method (1980) [26], $18 < I_p < 35$ and $30 < P_{0.002} < 60$, the swelling potential is medium to high.
- According to the undrained cohesion $C = 89$ kPa, the soil is firm.
- According to the compression index $C_c = 0.123$, soil minerals are kaolinites.
- According to swelling coefficient $C_g = 0.035$, the swelling risk is high.

Thereafter, correlations are made between the clay content $P_{0.002}$ as function of liquidity limit $I_p$, between plasticity index $I_p$ as function of clay content $P_{0.002}$ in a hand, and between the swelling coefficient $C_g$ as function of compression index $C_c$ in the other hand. Correlations reflect a linear relationship between parameters with a high regression coefficient $R^2$. For this purpose, equations are suggested:

$$P_{0.002} = 1.26 \omega_L - 24.52 \text{ with } R^2 = 0.7063$$

$$I_p = 0.36P_{0.002} + 11.84 \text{ with } R^2 = 0.61$$

$$C_g = 0.2689C_c + 0.0021 \text{ with } R^2 = 0.63$$

### VII. CONCLUSION

Through the statistical analysis of geotechnical results performed on the Miocene marl as part of the recognition of the North-South Highway crossed the Medea region fitted equations, and notes were proposed between the geotechnical parameters with a good accuracy justified by the value of the regression coefficient.

The equations proposed in this study will help to better understand the geotechnical properties of Miocene marl of Medea region, and a fast tool of design when obtaining these...
settings seems difficult, while there is some guidance and reference for the geotechnical investigation on the local scale. This work is of paramount importance since it enabled to provide an invaluable data to be served first in future research works in the Medea region and second a way to geotechnical engineers and practitioners in the conception projects.

REFERENCES


