American Journal of Materials Science and Engineering, 2013, Vol. 1, No. 3, 60-64
Available online at http://pubs.sciepub.com/ajmse/1/3/6

DOI:10.12691/ajmse-1-3-6

Behavior of the Grounds Inflating of Algiers by Incorporation of Lime "Case of Ouled Fayet and Cheraga"

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Received December 29, 2012; Revised November 21, 2013; Accepted December 15, 2013

Abstract The ground heaving is a very complex phenomenon which utilizes a great number of intrinsic and surrounding parameters. It is the response of the ground to a gradient of potential of the water of this last. It appears initially by a water run-off within the meaning of Darcy, in the large pores of the ground, then by the hydration of the particles of clay. This phenomenon is related to two parameters of great importance: it water content initial of the ground which expresses the state of suction of the ground and which controls the rate of swelling that it is for the altered or intact grounds. it initial dry density or the index of the vacuums, which measures the quantity of material likely to inflate. Indeed, the curve which giving swelling according to time, reveals two quite distinct phases, one fast which starts with the flood of the sample, the other slow one which evolves/moves in time. According to Chen (1988), the first phase would be the result of a relaxation partial of the constraints in the partially saturated vacuums. This phase would correspond to a macroscopic swelling, compared to a water run-off within the meaning of Darcy, which is governed by the permeability of the medium and the gradient of suction, i.e. a water filling of the large pores separating the grains. The second phase would represent the process of progressive hydration of argillaceous minerals starting from water existing in the pores. Thus starting from this direction, our work, consists in plotting the curves of kinetics of swelling according to time for two natural clay soils of Algiers "Ouled Fayet and Cheraga" with the calculation of the pressures and rates of swelling of the latter in a first place, then by studying the behavior and the improvement of this swelling in this kind of the grounds by adding a hydraulic binder as being one stabilizing which is the lime of Saida.

Keywords: *lime, clay soil, swelling, kinetics, pressure, stabilization*

Cite This Article: F. Z. Aissiou, A. Nechnech, and H. Aissiou, "Behavior of the Grounds Inflating of Algiers by Incorporation of Lime "Case of Ouled Fayet and Cheraga"." *American Journal of Materials Science and Engineering* 1, no. 3 (2013): 60-64. doi: 10.12691/ajmse-1-3-6.

1. Introduction

The swelling of clays is a notable phenomenon in many grounds like the marnes, the molasses or the schists argillaceous containing illite, smectites in particular which account for approximately 2,5% of the surface of the grounds in the world and are present mainly in the climatic zones where strong seasonal variations of precipitation and temperature are observed [2]. The phenomenon of swelling is likely d' to induce very important disorders on the level of the structure of the work from where the annual cost of the damage binds to the geotechnical dryness is regard much higher than that of all the other natural disasters.

2. Mechanism of the Phenomenon of Swelling

The swelling of a clay is the result of an introduction of water molecules between the layers. If the interfoliaceous distance is higher than 3A° (dimension of the water molecule), the access of water is possible .les attraction forces between the layers are then weakened because of presence of water , it is this weakening which gives to the layers clay a tendency to move away from/to each other by increasing interfoliaceous space, which causes consequently the phenomenon of swelling. According to Tessier quoted by [4] The mechanisms of swelling of clays were the subject of many assumptions, (Terzaghi, 1948) and (Bolt, 1956) quoted by [4] subdivided the phenomenon of swelling in two distinct processes, one mechanical and the other physicochemical one.

2.1. Mechanical Mechanism

The phenomenon of swelling, just as compressing, can come from a modification state of stresses in the ground in the presence of water. If the pore water pressure becomes negative (in the field of suctions) and opposed to the variation of total constraint. Under conditions of freedom of movement of water, a phenomenon of swelling then will develop, expressing the absorption of water and the transfer of negative constraint of water on the solid skeleton, until the final state. It is thus possible to affirm that if the consolidation expresses a pressure decrease Interstitielle until its cancellation, swelling expresses as for him the reduction in Suction (- U) until its cancellation.

2.2. Physicochemical Mechanism

It appears d' important physicochemical interactions between an argillaceous particle and l' water, generally illustrated by the model of the double-layer. With very precise assumptions, this theory makes it possible to quantify the phenomenon of swelling compared to the various parameters of l' water.

2.3. Model of Double-Layer

The clay particle generally presents a negative clear load due to isomorphous Substitutions for the level of the layers. This deficit of loads is translated by the fixing of cations and the orientation of the polar molecules (of water, for example) in the peripheral space of the particle and possibly between the layers. With l' attraction of the cations by the surface of the particles d' clay s' oppose the tendency of the ions to diffuse and to distribute d' a homogeneous manner in l' water. The result of this interaction is a cloud d' ions surrounding the particle, called electric double-layer diffuse. There is thus, around each particle, formation of a double-layer of origin electric, known as "layer of Gouy-Chapman".

3. Identification of the Samples

3.1. Choice of Materials Used

For this part, we took two samples of clay soil coming from "Cheraga (Sample n°1) of 4,70m of depth" and of "Ouled Fayet (Sample n°2) of 5,40m of depth", these two sites belong to the same area which profits from a local climate of Mediterranean type semi - wet. Precipitations annual averages are between 700 mm and 800 mm, strongest extend from October in February and one records no precipitation in August and July. This area is known also by these marnes plaisancians covering a broad surface in the south-west of the Sahel of Algiers. The physical properties of the two grounds are presented in Table 1.

Table 1. Physics soil characteristics studied

Basic characteristic	Sample n°1	Sample n°2
Depth [m]	4.70	5.40
Water content natural [%]	7.08	6.38
Apparent densities (wet) [g/cm3]	2.07	2.04
Content of organic matter [%]	0.84	0.31
Passing to sieves 80 µm [%]	99.44	99.66
Content of clay (< 2µm) [%]	59.24	56.76
Liquid limit [%]	65.20	81.87
Plastic limit [%]	30.01	34.23
Index of plasticity [%]	35.19	47.64
Activity of clay	0.59	0.84
Water content optimum [%]	15.3	16.9
Density dries maximum [g/cm3]	1.64	1.61

All the tests geotechnics were carried out according to standards AFNOR. Lime used is an extinct lime produced in the town of Hassasna, Unité Erco, wilaya of Saida, where the data sheet chemical and physical properties of the lime quoted by [5] is presented in Table 2.

Table 2. The data sheet of the Physical properties and chemical of lime Saida

Basic characteristics	The data sheet of lime
Physical appearance	White powder dries
CaO [%]	> 73.3
MgO [%]	< 0.5
Fe_2O_3 [%]	< 2
Al_2O_3 [%]	< 1.5
SiO_2 [%]	< 2.5
SO_3 [%]	< 0.5
Na_2O [%]	0.4 - 0.5
CO_2 [%]	< 5
$CaCO_3$ [%]	< 10
Specific density [g/cm^3]	2
More than 90 µm [%]	< 10
More than 630 µm [%]	0
Insoluble material[%]	< 1
Apparent density [g/l]	600-900

4. Gonflment of the Grounds

4.1. The Free Test of Swelling In Solution

The standards used now, in the United States (ASTM D5890) and in project in France (NF P 84-703) describe a test making it possible to appreciate the capacity of swelling of one clay to water or with all other liquidates. It is more especially intended for the quality control of a smectite which is clay present usually in the structures of sealings. The test envisages the use of clay 2g which is put in a graduated test-tube container 100ml of distilled water, after 24:00 one measures the volume occupied by clay, measurement is expressed in cm3/2g. This test is of the interest to be rather simple and reproducible Our natural clays gave volumes of free swelling respectively of 6,3ml for the 1st sample (Clay of Cheraga) and 15,56ml louse the 2nd sample (Clay of Ouled Fayet) these values are very close to the values found for various bentonites studied in the world such as Dixon et al. (1996) found values between 7et 16ml for a sodic bentonite coming from Japan, 9ml for same bentonite of Canada and between 12et 26ml for bentonite American and Debiéche (2006) found an average of 23ml for calcic bentonite of mostaghanem in Algeria.

Figure 1. Components of the mould oedometric

4.2. The Test Oedometric of Free Swelling (NF P 94-091)

The test oedometric with free swelling consists in placing the sample of ground in a cylindrical cell between two porous stones. Then, following the imbibition, it is authorized to inflate vertically under the pressure of the piston during several days until stabilization (Serratrice J.F, B.Soyez, 1996). The end value makes it possible to calculate the relative variation of the volume of the sample which represents the rate of swelling noted per G, that one expresses as a percentage often it is given according to the following formula:

$$G\% = \left[\left(H_f - H_0\right) / H_0\right] \times 100 \quad (1)$$

H_f : The final height after swelling
H_0 : The initial height before swelling

4.3. Results and Discussion

The curve which gives the percentages of swelling obtained according to time indicates the presence of two phase the first phase of swelling, dependent on the migration of water in the test-tube starting from its ends, concerns a process of diffusion. It is more or less slow according to nature and the state of material, and according to the loading, and hard a few hours the percentages recorded for primary education swelling are given in Table 3.

Figure 2. Site of the mould

Table 3. Values of the free test swelling for the two samples

Parameters	Rate of swelling (%)	Pressure of swelling (bars)	Swelling number (%)	Primary swelling (%)	Secondary swelling (%)
Marly clay of cheraga (Sample n°1)	50,76	2,08	5,06	4,42	8,31
Marly clay of Ouled Fayet (Sample n°2)	37,76	4,49	5,56	3,51	6,31

The secondary phase of swelling is more problematic, because the direction of the deformation of swelling is opposed to that of the loading, contrary to the creep which produces deformations of compression under loads of compression. The kinetics of secondary swelling is very slow and depends on the level of loading and, for weak loads, it is often impossible to reach a balance under reasonable conditions of realization of the laboratory tests the percentages of swelling obtained are definitely higher than that of primary education swelling (see Figure 3, Figure 4), therefore a phase of primary education swelling (corresponding to the diffusion of water in the pores) and a phase of secondary swelling of hydration of argillaceous minerals.

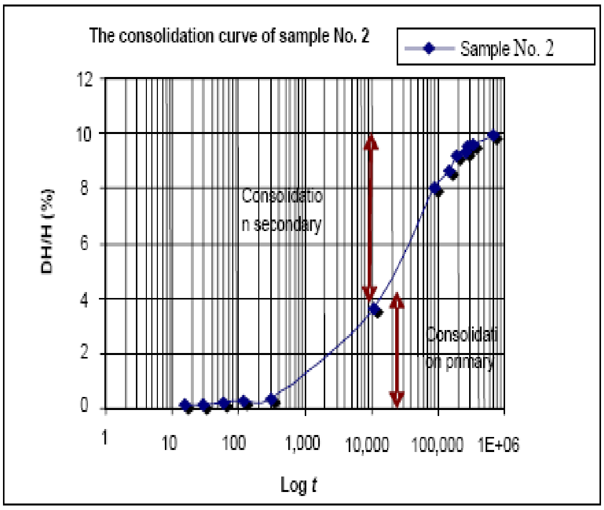

Figure 3. The primary education curve of swelling and secondary of the clay of Cheraga

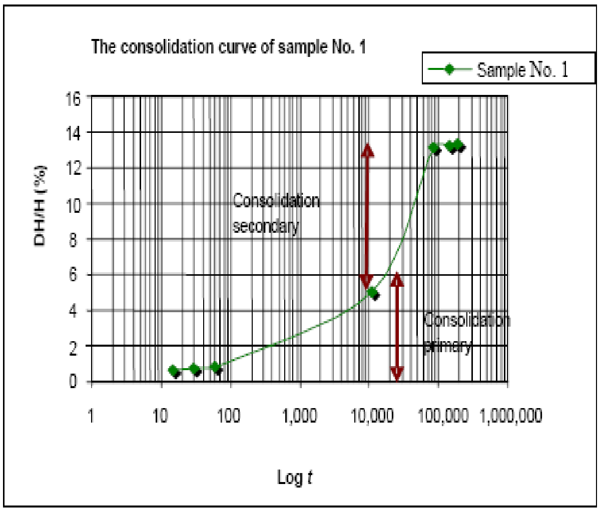

Figure 4. The primary education curve of swelling and secondary of the clay of Ouled Fayet

5. Stabilization of Swelling by Incorporation of Lime

5.1. The Effect of Lime on The Kinetics of Swelling

For the preparation of the samples, the conditions of tests used for the treatment are the same ones (static compaction and optimal characteristics) with the contents lime according to; 2%, 4%, 6% the deformations relating to swelling for the two samples before and after the treatment are registered with Table 4.

Table 4. Influence contents lime on the kinetics of swelling of the two samples

Sample used	Sample n°1		Sample n°2	
Parameters	Deformation relating to swelling in the secondary consolidation Gs (%)	Reduction of the deformations relative to swelling in the secondary consolidation ΔGs/Gs (%)	Deformation relating to swelling in the secondary consolidation Gs (%)	Reduction of the deformations relative to swelling in the secondary consolidation ΔGs/Gs (%)
Lime proportioning				
0%	13.36	-	10	-
2%	1.99	67.36	6.26	37.46
4%	1.63	87.79	6.47	35.30
6 %	1.37	89.74	5.79	42.10

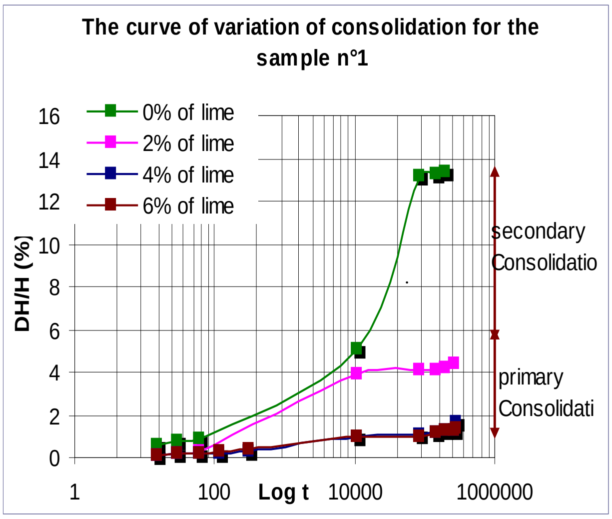

Figure 5. Influence contents lime on kinetics of swelling of the 1st sample

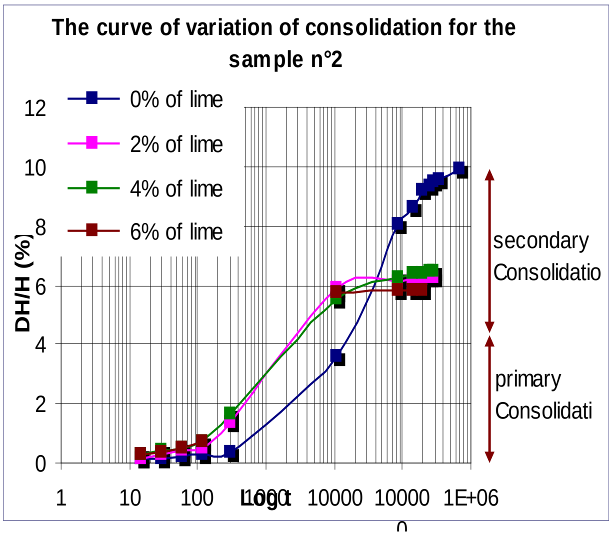

Figure 6. Influence contents lime on kinetics of swelling of the 2nd sample

From Figure 5, Figure 6 which gives the curves of variation of the deformations relating to swelling according to time, one notes the effect of lime on free swelling, by reducing the deformation relating to secondary swelling in an important way, the settling time of swelling in the second part (secondary consolidation) became short. The shape of various curves are identical and almost confused, lime 2% made it possible to reduce this secondary swelling of 67% (1st sample) and 37% (2nd sample) still better with lime 6% secondary swelling were tiny room of 89,76% for the 1st sample (Clay of Chéraga) and of 42,10% of reduction for the 2nd sample (Clay of Ouled Fayet).

5.2. The Effect of Lime on the Pressures of Swelling

Table 5. Influence contents lime on the pressures of swelling of the two samples

Sample used	Sample n°1		Sample n°2	
Parameters	Pg [bars]	ΔPg /Pg [%]	Pg [bars]	ΔPg /Pg [%]
Lime proportioning				
0%	2.08	-	4.49	-
2%	1.35	35.10	3.89	13.36
4%	1.30	37.50	3.53	21.38
6 %	1.20	42.31	3.45	23.16

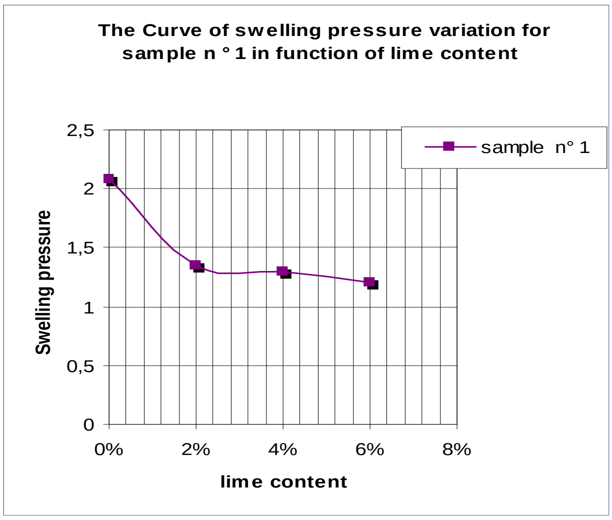

Figure 7. Curve of the variations of pressures of swelling of the sample 1 in function of proportionings lime

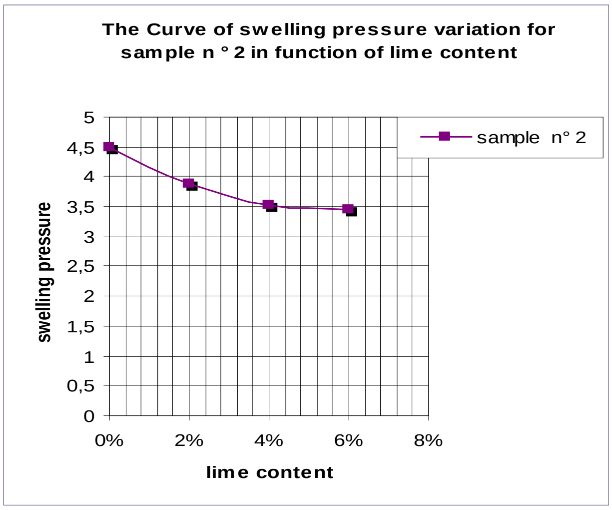

Figure 8. Curve of the variations of pressures of swelling of the sample 2 in function of proportionings lime

The pressure of swelling for the sample n°1 was reduced as soon as lime was incorporated, with the first proportioning 2%, one noticed a decrease in pressure by 35,10% then that decreases further and with 6% the pressure decreased by 42,31%, and then the pressure becomes stable whereas for the sample n°2 the reduction of the pressures of swelling is not large with 2% the reduction was of 13,36% and with the increase in lime proportionings the reduction evolves/moves jusqu' to 23,16% per lime 6%, therefore one can say that lime reacted well with the first sample that with the second, simply lime from 4% of its proportioning mixed with the clay of Chéraga and Ouled Fayet could stabilize the pressure of swelling of these last.

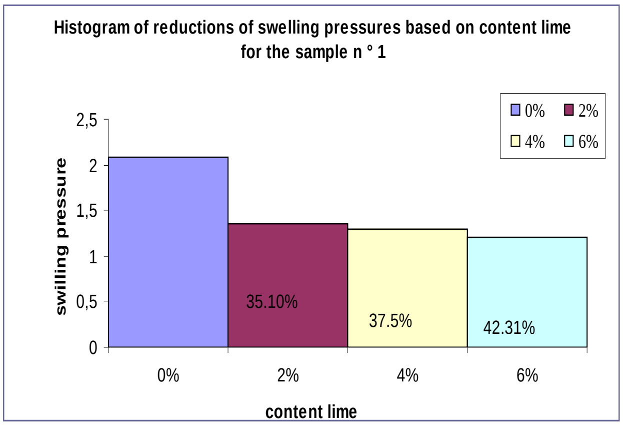

Figure 9. Histogram of the reductions of the pressures of swelling for the sample 1in function of lime proportioning

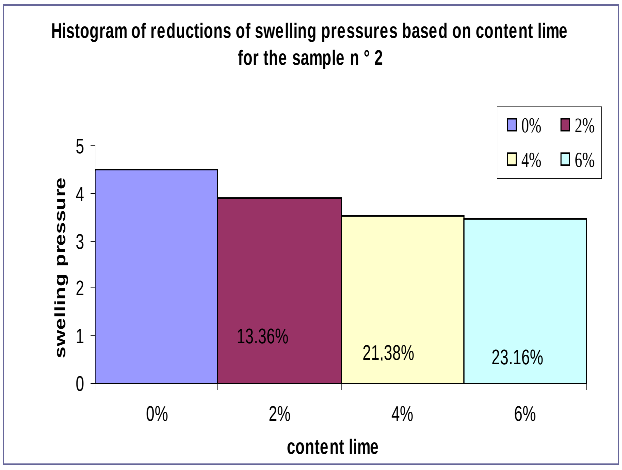

Figure 10. Histogram of the reductions of the pressures of swelling for the sample 2 in function of lime proportioning

6. Conclusion

The addition of lime to the samples (the clay of Chéraga and Ouled Fayet) gave its effect by reducing secondary swelling of the two grounds jusqu' with a certain stability (88% of reduction for the 1st sample and 35% of reduction for the 2nd sample). The free test of swelling revealed pressures of swelling of 2,08 bars for the 1st sample and 4,49 bars for the 2nd sample, with a rate of swelling of 51% for the 1st ground and 38% for the 2nd ground, the addition of lime on the ground allowed the reduction of 88% of rate of swelling for the 1st ground and 40% of reduction of rate of swelling for the 2nd ground, even thing were noticed for the pressures of swelling to lime 4% the pressure was tiny room of 37,5%, to lime 6% the pressure was tiny room of 42% for the 1st ground, the pressure of reduced swelling of 21% for the 2nd ground with lime 4% and 23% to lime 6%.

Acknowledgement

I would like to thank Mr Nechnech Ammar for his cooperation and his confidence in me, my gratitude goes to the mesieurs Aissa Mamoune, and Aboubekr (professors at the University of Tlemcen in Algeria) who participated in the large part of the development of this topic and not forgetting Mr Bouafia (Professor at the University of Blida in Algeria) that got much encourage and me help writing this article.

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