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Stabilization of Expansive Soils with Milk of Lime: the Case of Clays of *Tlemcen*, Algeria

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ABSTRACT

Clay soil is the foundation for many buildings. Some families have the characteristic to be swelling or shrink. However, construction on this type of soil requires a good companion for the recognition of identification and characterization of their swelling potential. In this work the stabilization by the addition of milk of lime is used. This use is explained by the fact that this technique is that which provides the maximum benefit, particularly regarding the cost and methods of executions. In this work we are interested by two aspects:

- The first is on the tests recommended for the identification of four expansive soils in the region of *Tlemcen* in the north western Algeria.
- The second is to assess the influence of the addition of milk of lime has different percentages on the physico-chemical Compression shear strength, characteristics of compaction versus, swelling pressure and swelling potential of these soils.

This study shows that the stabilization by the addition of lime milk modifies the physicochemical characteristics of the soil, Compression shear strength and the results are quite satisfactory in significantly reducing the phenomena of swelling.

KEYWORDS: Clay, milk of lime, plasticity index, optimum density of dry, swelling, swelling pressure, swilling potential, stabilization, PH, Compression shear strength.

INTRODUCTION

The expansive soils are very thin soils whose elements are composed of layers. In times of drought, they lose their saturation, when they hydrated again; the water penetrates the cracks and tends to its initial volume. This is the phenomenon of swelling (Derriche *et al*., 1994).

The presences of expansive soils pose disorders of the works on the surface and underground structures. In Algeria in many cases very damaging disorders, associated with swelling have been reported. We include two pathological cases the first in the east and the second in South of Algeria:

- Sidi Aissa Hospital in Msila

- Ain-Amenas oil refinery

To resolve this problem in practice, many stabilization methods are available, we are interested in the stabilization by the addition of milk of lime. This use is explained by the fact that this technique has several advantages, especially regarding the cost and ease of implementation.

1. Localization of the site and geotechnical identification

The soils objects of this study are reworked clays coming from different regions of Tlemcen (north west of Algeria), in an active area of swelling perspective (Figure 1).

Whatever the objectives sought in geotechnical study, the rule is to make initial identification of concerned soils. This procedure is used to guide further geotechnical analysis and especially to make a classification of encountered materials. The parameters required for this classification are both physico-chemical and granulometric.

The results of all tests performed on the four soils studied are listed in Table 1.

The identification tests and physico-chemical classification of the GTR (Technical Design Guide Earthworks and Subgrade; LCPC, SETRA 1992) , show that soil 1 and 2 are very plastic clays marls, Class A 3. About soils 3, 4 they are pure clay, very plastic with very little calcium carbonate, and belong to the classA4.

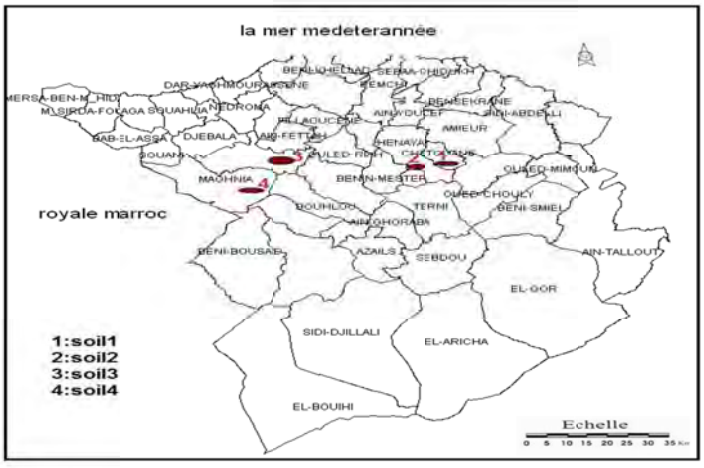

Figure 1: The geographical situation of studied sites geographical situation of studied sites

Table 1: Physicochemical characteristics of Tlemcen clays

Symbol	Soil 1	Soil 2	Soil 3	Soil 4
Thickness (m)	3	4	8	6
γ_d (kN/m^3)	15,82	16,19	16,5	13,33
W_{opm} (%)	24,6	23	21,4	33
< 80µ(%)	90	94	90	85
organic matter (%)	1.22	1.67	1.91	1.77
< 2µ (%)	44	48	44.8	50
w_l (%)	67	66,3	68,45	136
w_p(%)	29,58	30	26,41	48,06
I_p (%)	37,42	36,2	42,04	87,94
W_R(%)	4,2	2,3	7.01	11
I_R (%)	62,8	64	59,55	125
A_C	0,850	0,754	0,938	1,107
Vbs	8.4	6.15	9.6	43.22
S.S.T (m^2/g)	176.4	129.15	201,6	907.62
TCaCo3 (%)	13,84	16,45	2,469	1.89
Class GTR	A3	A3	A4	A4

Soil 1 : Mansourah ; Soil 2 : Boujlida, Soil 3: Bougherara; Soil 4: Bentonite of Maghnia

Microscopic analysis of the studied soils

To better appreciate our study we examined the microstructure, using observation in scanning electron microscope with an x-ray detector. Figures 2 and 3 show an example of this analysis.

The quantitative X-ray performed analysis showed the presence of several essential minerals calcium aluminum silicium (table2). In Table 2 we assumed that the soil analysis 1, 2, we see that both soils have almost the same quantities of aluminum, calcium and silicium.
For SOL1 we observe the presence of iron 30.4%, that mineral is absent in the soil 2. With regard soil 2 there are also traces of potassium 8.6.%.

Figure 2: MEB with X-ray spectrum, Soil 1

Figure 3: MEB with X-ray spectrum, Soil 2

Preparing samples

The methodology for this study is primarily to make soil-milk of lime mixtures in well determined percentages (2%, 4%, 6%, 8%.) Of these mixtures, the physico-chemical parameters will be determined then, samples will be reworked into a mold de75mm reconstituted 75mm in

diameter and 20mm in height, compacted in press at low speed (1.14mm/min) at water contents and optimum density.

Table 2: Quantitative analysis of X-rays Soil 1, 2

Soil 1		**Soil 2**	
Element	% mass	Element	% mass
Aluminium	15.5	Aluminium	16.3
Silicium	37.2	Silicium	53.0
Calcium	16.9	Potassium	8.6
Iron	30.4	Calcium	22.1

Evolution of physicochemical characteristics

The swelling of soils is sometimes correlated with some physico-chemical parameters in order to study the influence of stabilization on these parameters, measurements of Atterberg limits and VBS were made with milk of lime at different percentages.

Figure 5 shows the path followed by the clays of *Tlemcen* after treatment with 2% -4% - 6% - a8% milk of lime.

We notice that the clays which high plasticity seen after treatment with milk of lime, consistence progress to low plasticity. This change in the consistence related to the percentage of milk of lime, translates into a decrease of plasticity index which partly due to ionic reactions of milk of lime (excess of cations calcium) with clay minerals which causes a flocculation of the soil, and partly by an exchange of calcium with other cations in the structure of the clay. We also note a continued decrease in blue value and the index of shrinkage according to the increased percentage of milk of lime.

Evolution of characteristics of compaction

Soils treated with different percentages of milk of lime are compacted to the normal energy Proctor 30 min after the addition of milk of lime. Proctor curve obtained flattens as the percentage of milk of lime increases (Fig. 4). We verify that the use of milk of lime resulted in an increase in optimum water content and a decrease in dry density at first but from 6% dry density begins to increase (Fig. 4). This increase is due to the pozzolanic reaction and the reaction products are presented in formed agglutinative and increase the capacity to resist of the soil. (Agglutinating main products are silicates and calcium aluminates, Mateos, 1963).

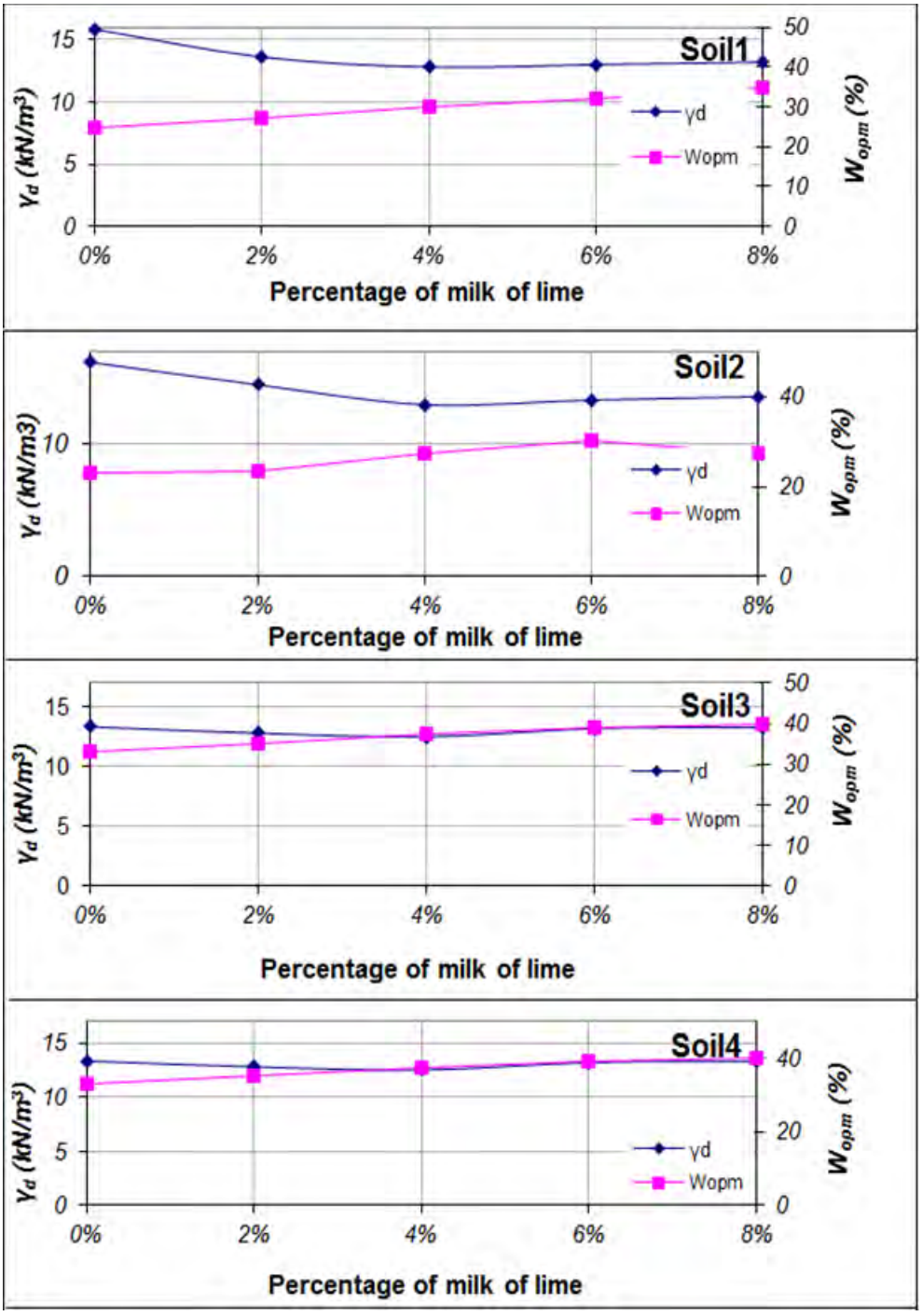

Figure 4: Evolution of characteristics of compaction versus milk of lime Percentage

Evolution PH according to percentage of milk of lime

To study the influence of milk of lime on the pH, measuring and test with the phmeter were made to soils studied with different percentages of milk of lime. The obtained results are shown

in Figure 6; we find that the addition of milk of lime increases the pH value. as an example for the soil 3 pH changes from 8 before treatment to 11 after treatment with 8% of milk of lime.

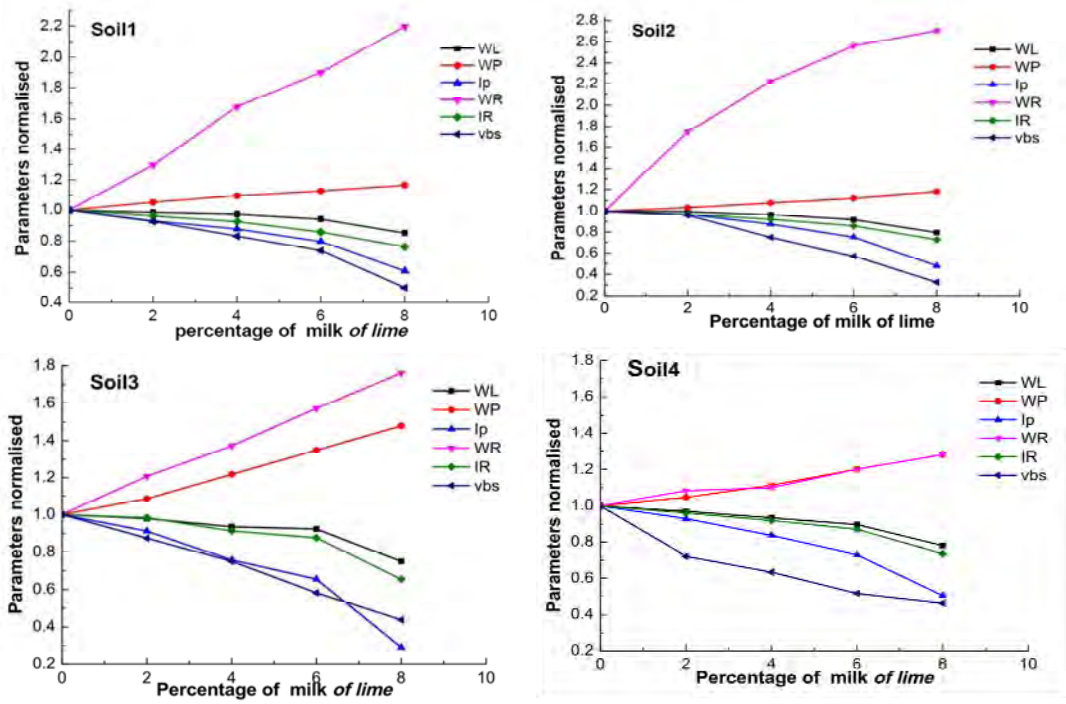

Figure 5: Evolution of characteristics of compaction versus milk of lime Percentage

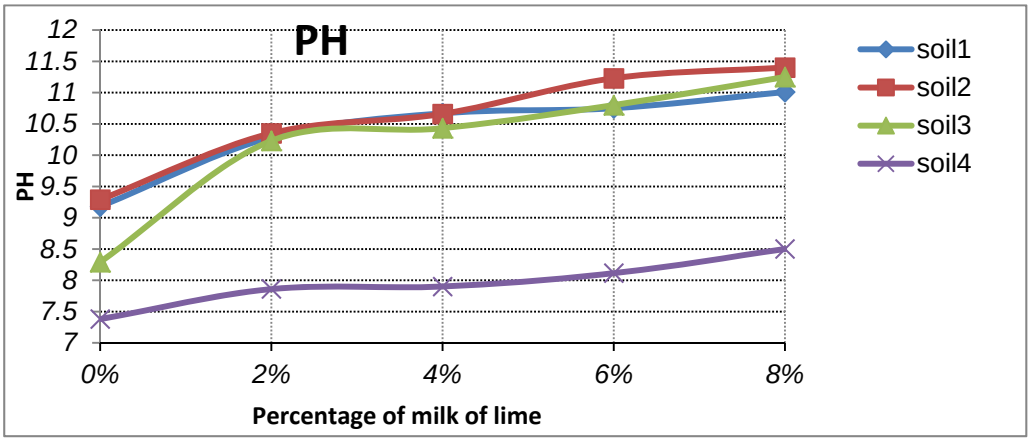

Figure 6: Evolution PH versus milk of lime Percentage

Evolution of compressive strength according to milk of lime

For a simple compression and to determine compression shear strength. The test is to measure the resistance to compression of the soil made up of cylindrical (30/30mm) (fig 7) and with the optimal characteristics that were obtained by compaction proctor kept at 28 days and treated with doses of milk of lime 0% 2% 3% 4% 6% 8%.

The graph (Fig. 8) shows the significant improvement in tensile pressure based on the addition of milk of lime 28days of maturation, we see that The addition of milk of lime with clay soils make them more resistant to compression because we see that more we increase the percentage of milk of lime in the mixture (milk of lime + clay) and we get more a little bigger strength ,and the clay soil becomes more compact and harden over into several what we found as we get a good strength and very meaningful increase to 6% milk of lime for the four soils, So we can say that the compression shear strength has been greatly improved with the addition of milk of lime and 6% is a sufficient level to ameliorate the mechanical properties of soils.

Figure 7: Compression Test

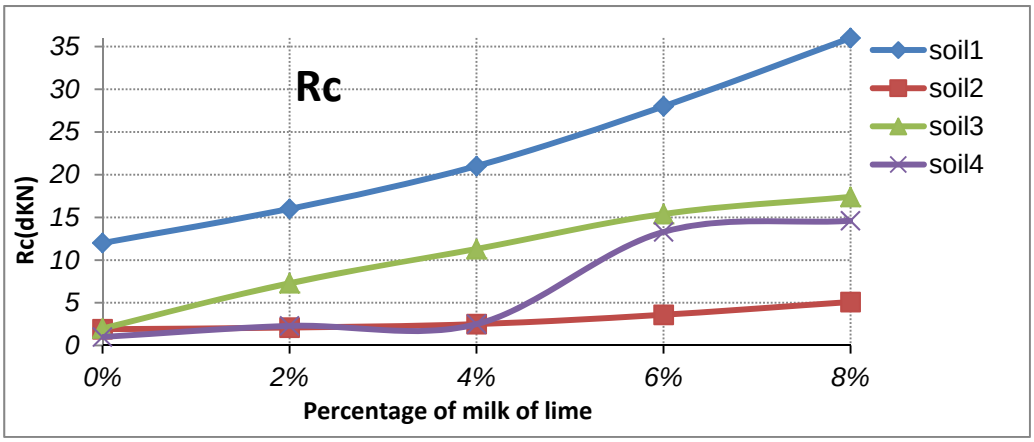

Figure 8: Evolution of compression shear strength of soils versus Percentage of milk of lime (28 days).

Influence of milk of lime on the amplitude of swelling and pressure

To study the effect of the milk of lime on the swelling of studied clays, we mixed the samples with the necessary additions to a different percentage.

Immediately after mixing the clay and milk of lime, it is carried into the preparation of specimens in a cell for testing odometer swelling.

The chosen method in this study is in accordance with standard ASTM d-4546-90-méthode A this choice is explained by the fact that the method adopted to correct the effect of realignment by applying a charge-discharge cycles, the final pressure of the cycle is the equivalent weight of the land before extraction of the sample. Swelling of the latter, obtained by imbibitions, will follow until stabilization. The swelling pressure is equal to the pressure that would have handed the sample to its original height. The amplitude of swelling corresponds to the maximum deformation between the beginning and the end of the swelling phase (fig9).

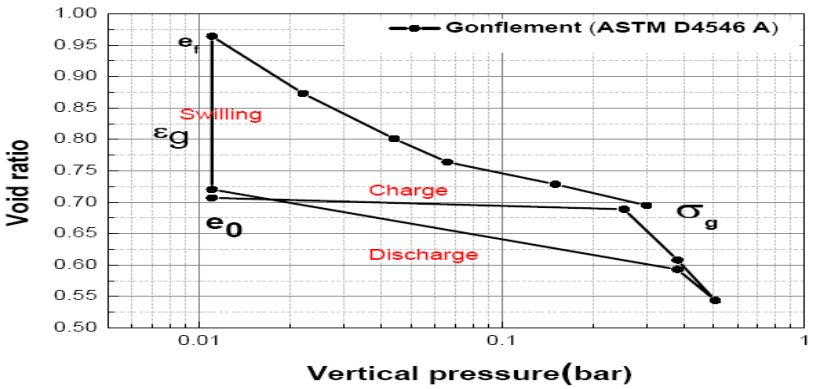

Figure 9: Method of swelling according to the standard ASTM D-4546-90- method A.

Figure 10 show the evolution of swelling according to the percentage of milk of lime to the tested soil, we find that the pressure and the amplitude of swelling decreased significantly, beyond 6%, the swelling becomes negligible; the decrease is due to reactions between the milk of lime and clay minerals.

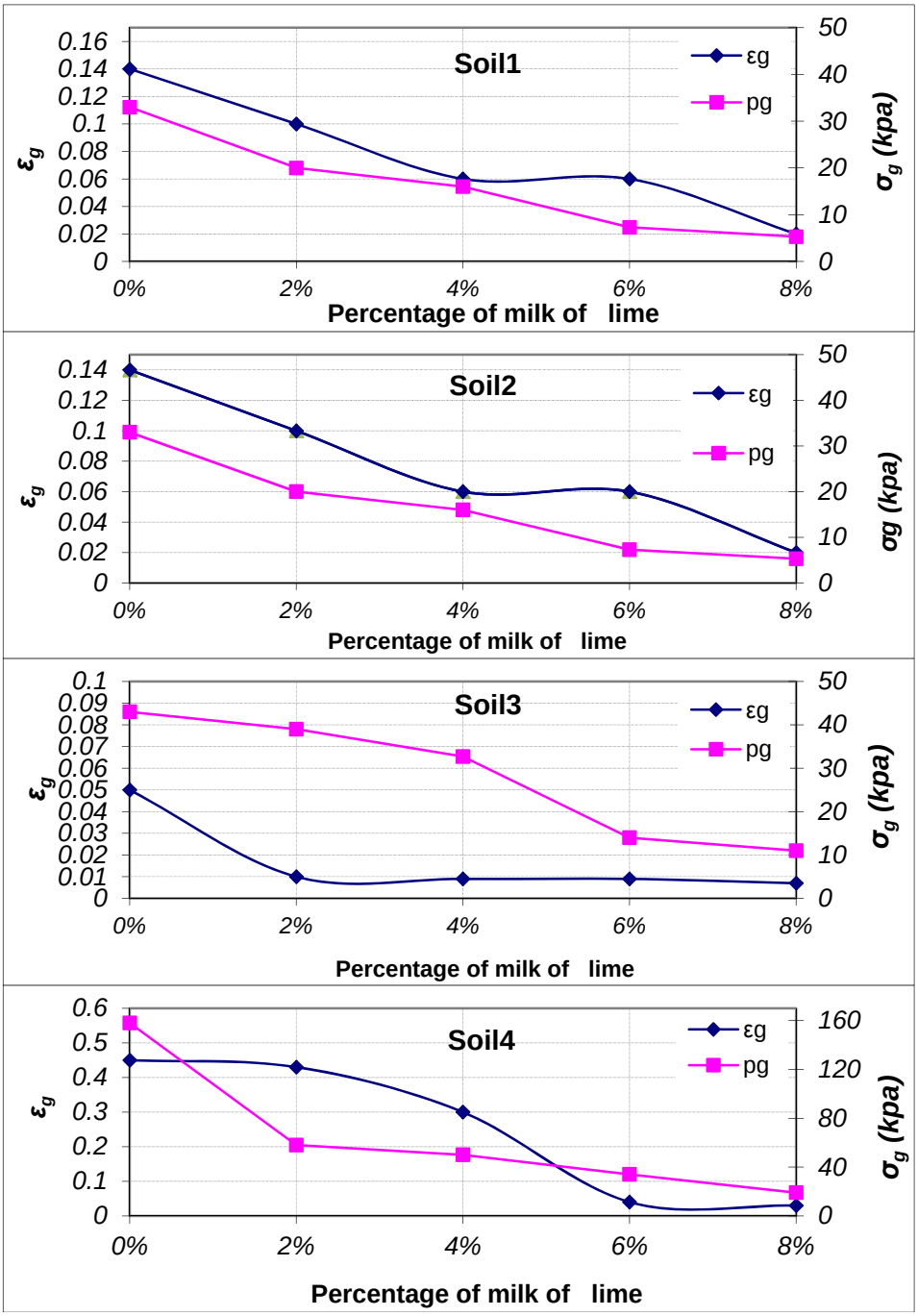

Figure 10: Swelling pressure and amplitude versus milk of lime percentage

Evolution in swell potential with percentage of milk of lime

The study of the swelling potential examined the natural clays and clays treated milk of lime that been the subject of our research.

The kinetics of obtained swelling was approached by the hyperbolic law proposed by Dakshanamurty (1978) and Vayssade (1978):

$$\frac{\Delta h}{h_0}=\left[\frac{\Delta h}{h_0}\right]_{\infty}\frac{1}{B+t} \quad (1)$$

where B is the half swelling, *t* is time;

$\frac{\Delta h}{h_0}$ is swelling and $\left[\frac{\Delta h}{h_0}\right]_{\infty}$ is the final swelling.

In writing Eq. (1) in the coordinate system (t, t / Δh / h) we get a straight line enabling the determination of the final potential of swelling and half-swelling. The results for the studied soils are given in Figure 10 and 11.

An examination of the plots in these figures (Fig. 11) shows that the variation in swelling potential corresponding to the variation of percentage of milk of lime follows similar trends as those observed in soils tests. For untreated soils a decrease in swell behavior is observed as the percentage of milk of lime number increase.

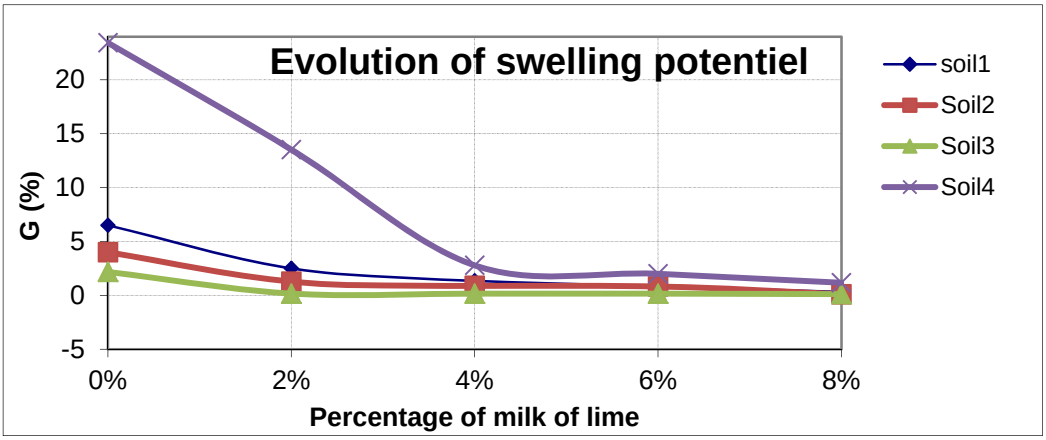

Figure 11: Swelling potential versus milk of lime percentage

Conclusions and perspectives

Across the tests on the effect of milk of lime on several parameters of studied soils, the limits of consistency, blue value, the pressure and the amplitude of swelling, the resistance of the compression a number of conclusions can be drawn:

The addition of milk of lime modifies the physico-chemical characteristics of treated clays and reduces its adsorption capacity. The treatment reduces the plasticity index, the blue value, the optimum density of dry soils decreases with the increase of milk of lime to 6% beyond this percentage, the density increases;

The compression shear strength has-been Significantly Improved 28days maturation with the addition of lime and 6% is a happy Sufficient to ameliorate the mechanical properties of soils;

The final amplitude of swelling and swelling potential and pressure decrease depends on the final percentage. 6% from the pressure and the amplitude becomes negligible;
Finally, it may indicate that the treatment of soil lime milk may be solution to consider.

As perspective, this study will be pursued through durability tests to understand the effectiveness of milk of lime over time.

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