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Behaviour of Clayey Soil Existing in the Portoviejo Canton and Its Neutralization Characteristics

Eduardo Humberto Ortiz Hernandez [a]
Eduardo Humberto Ortiz Moncayo [b]
Lucia Katherine Macias Sanchez [c]
Ramona Panchana de Calderero [d]

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Abstract

An investigation has been carried out on soil characterization and behavior in the canton of Portoviejo province of Manabí, in the Eloy Alfaro street sector of the Andrés de Vera Parish; where pits or open-air surveys were carried out and experimental laboratory tests of soils. It was demonstrated that soils have expansive properties of different characteristics, from medium to high degree of expansively according to the results of Laboratory of Soil Mechanics, where samples were tested analyzing the behavior according to the soil type. In this context, the results obtained by incorporating lime into the mixture are presented in 3 and 6%, thus obtaining a reduction by contraction to the volumetric change of the soil between 8 and 13%, allowing to improve its physical and mechanical properties; as well as its increase to bearing capacity by the California Bearing Ratio (CBR) test method from 9 to 16%, thus improving soil plasticity. With the results obtained, a description of the soil could be elaborated to determine the variations and changes according to the lime content, which was added to the soil, which allowed to reduce the deformations and damages caused to the superficial and structural pavement caused by the clays expansive, because in contact with the water the soil expands and at the same time when it drains the water contracts, proving that stabilizing the expansive clays with hydrated lime would improve the conditions of the pavement and its useful life.

Author correspondence:
Eduardo Humberto Ortiz Hernandez,
The aspirant to Ph.D., Civil Engineering,
Faculty of Science, Mathematics, Physics, and Chemistry,
Universidad Técnica de Manabí, Portoviejo, Ecuador
Email address: eduardohumberto1983@hotmail.com

[a] Universidad Tecnica de Manabi, Ecuador
[b] Universidad Tecnica de Manabi, Ecuador
[c] Universidad Tecnica de Manabi, Ecuador
[d] Universidad Tecnica de Manabi, Ecuador

1. Introduction

The state of Chiapas in the southern region of Mexico in the Tuxtla Gutierrez valley is geologically framed by a sequence of marine sediments (Alvarado & Torres, 2002). Structural damages caused by expansive clays to engineering works, foundations or pavements cause substantial economic losses and inadequate service of works. This problem has been and is the subject of experimental research focused on the characterization and mitigation of geotechnical risks.

The factors influencing the expansion can be divided into two groups. The first includes the stratigraphic conditions and the intrinsic properties of the soil: type of clay mineral, size and specific surface of particles, clay content and water content depending on the height of the region, also depends on the environmental conditions: precipitation, evaporation, and temperature. Alvarado & Torres (2002), Geotechnical risk maps of these parameters were constructed. In addition, criteria were proposed to identify and classify the type and level of hazard.

Usually, in the field, some undesirable properties that experience materials are volumetric changes in the presence or absence of water (expansion and contraction respectively); loss of bearing capacity and shear strength when the water content (humidity) is increased. In the above-mentioned studies, it has not been measured in the laboratory if the properties of the clays analyzed, which change with temperature, recover again after being re-moistened and remelted (thixotropy phenomenon). In this study, it will be evaluated whether the clays analyzed has the capacity to recover their index and resistance properties after being submitted for 1, 7 and 15 days at temperatures between 150 and 300 ° C.

Some studies on the subject can be consulted in de grado, Angarita & Díaz (1995). These investigations have worked to find the optimum percentages of stabilizing material that should be added to a particular soil type to improve a particular feature, usually Jorge *et al.*, (2015) its resistance to cutting and decrease the degree of susceptibility to volumetric change. In some provinces of the Costa del Ecuador region there are expansive soils that generate constant instability in civil works; For this reason, it is necessary to look for an alternative of stabilization for this type of soil, which presents serious geotechnical problems for Sánchez Albán (2014) its use in the construction of infrastructures due to its high plasticity and volume instability due to humidity.

These types of soils are called expansive because they are exposed to shrinkage and expansion processes due to volumetric changes that are caused by variations in soil moisture and internal stresses affected by water. This material has mineral components such as kaolinites, elites and montmorillonites, the particularity of these minerals is that they are able to absorb water molecules within their own molecular structure, which causes volumetric changes in the soil. To be able to use these soils it is necessary to modify their properties to avoid that the constructions settled on this type of material undergo deformations that are caused by the change of volume of the floor; among the effects caused by the expansion of the ground are cracks on walls and the rising of floors.

The great variety of soils and their composition makes each stabilization method applicable to a certain number of them; therefore it is necessary to carry out an analysis to determine the characteristics of the material that is required to stabilize, in order to find Rondón (2013), Sánchez Albán (2014) the most appropriate treatment method. The durability and long-term operation of a structure or a construction project depend on the quality of the foundation floors. Unstable soils can create significant problems in both structures and pavements. The chemical treatment of soils by means of the addition of Arias (2002), lime and cement transforms unstable soils into usable materials. The stabilization of the soil achieves a considerable change of the characteristics of the same, producing resistance and stability in the long term, in particular as far as the action of the water, besides saving money

It will be necessary to take into account the direct relationship between the characteristics that improve the soil and the effort and Díez & Montes (2002) money invested in the treatment to make the right decision when carrying out a large-scale stabilization. In the construction of roads and highways it is important to achieve a stabilization of the soil in each of the layers of the pavement, such as the subfloor, base, and subbase, because the pavement is a light structure, when settling on an expansive soil this can suffer great damage, as has been seen especially in the province of Manabí, this generates economic losses to be able to rebuild them.

2. Materials and Methods

For the development of this investigative work, soil samples were taken in the Eloy Alfaro street of the parish of Andres de Vera, Canton Portoviejo, Province of Manabí. MOP-001 - F-2002 was applied to perform the soil paving of the clays of the site under study. It was made an open sky well of a square meter of the surface in distant points with a length of the street of 700 meters although the technical norm indicates every 500m, to different depths of

0.50, 1.00 and 1.50 meters from the level of the subgrade, taking the respective soil samples for analysis. A sampling of 3 pits per 200 meters was carried out, making a technical analysis of the samples in their natural state, applying the technical standards MOP-001 - F-2002. Hernández *et al.*, (2017) the applied methodology allows using lime with different percentages to stabilize the clay and to diminish the degree of soil swelling. This method allows observing the degree of expansivity and behavior that exist in clay soils. The tests were carried out applying the technical standards according to MOP-001 - F-2002, where the expansive properties were characterized as Fine Granulometry, Consistency Limits, Liquid Limit, Plastic Limit, Shrinkage Test, CBR-Sponge.

3. Results and Discussions

To determine the expansion of the clay, 3 different sites were selected and from which soil samples were extracted by making a test pit shown in Figure 1 (a), the area of study of 1 m2 of open test pit, in figure (b) we can see Eloy Alfaro Street where the samples were extracted.

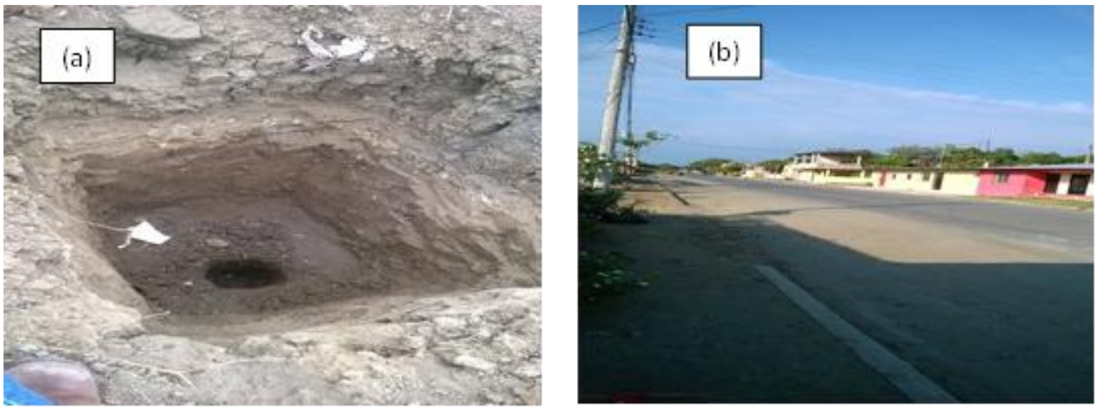

Figure 1. Open pit test of $1m^2$ (a) at Eloy Alfaro Street (b)

Laboratory tests of the soil in its natural state yielded the results of the 3 test pits, if any stabilization component, reaching to determine that the soils have an expansive behavior from high to very high, affecting the surface of the structure with the presence of deformations. We have analyzed the results of natural soil moisture, determined for test pits N°1 to the depths of indicates of 050, 1.00, 1.50 obtaining natural humidity corresponding to the values of 40.51%, 49.48%, 54.44%. For the test pit N°2, at the same depths indicated above, humidities of 34.5%, 41.5%, 43.58% were obtained. For the test pit N°3, and at the same depths, natural moisture values of 35.56%, 38.49%, 40.56%, were obtained as shown in figure 2.

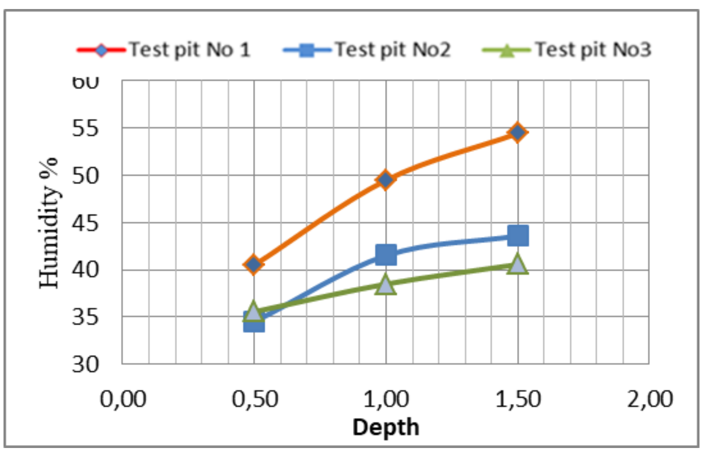

Figure 2. Moisture values for natural clay

Figure 3 shows the values of the liquid limits of consistency, where it was verified that the soil has as particularity high values of plasticity with existing liquid limits that can be considered in a weighted of 104.10% for the depth of research indicated of 1.50m, this for the pit test identified as 1, for the pit 2 test liquid limit has been obtained in a value that reaches 92.97%, and for pit test N ° 3, a net limit of 92.97%.

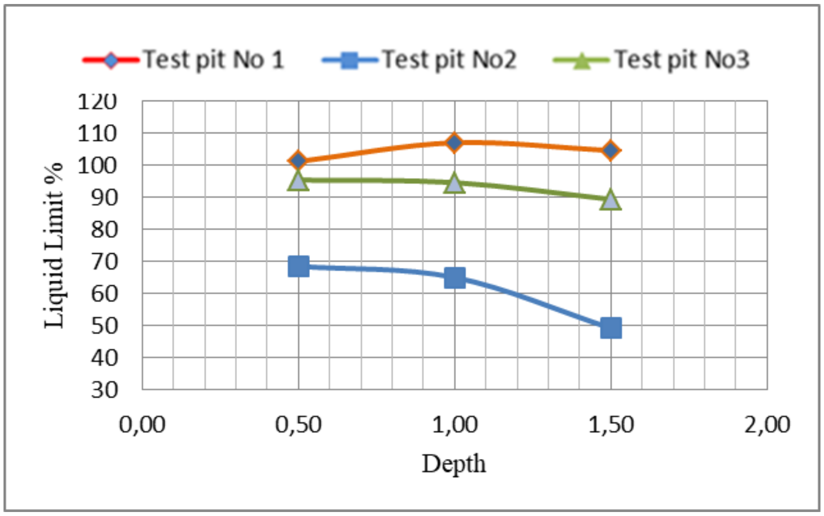

Figure 3. Values of liquid limits

Figure 4 shows the results of the plasticity indices of the soil samples tested in the natural state of the clays, obtaining values for the pit 1 test, a plasticity index of 71, 65% higher than for the 2 and 3.

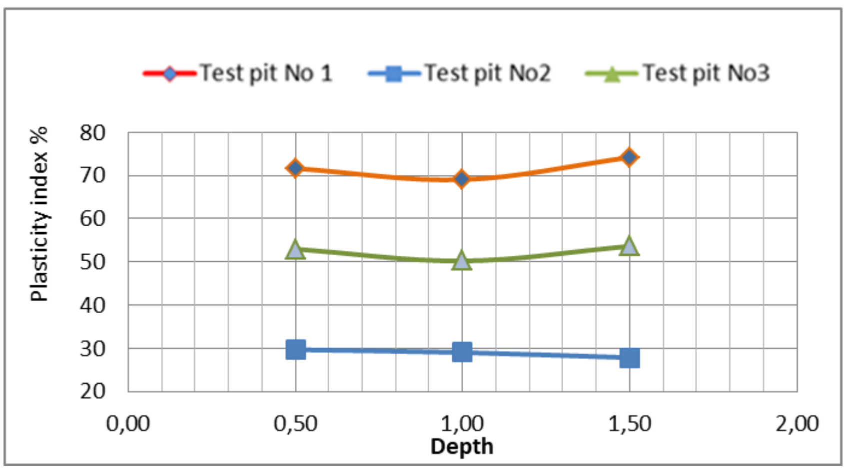

Figure 4. Values of plasticity indices

The table 1 shows the values correlating the contraction limits according to their graduation of soil expansion comparing with the results of the normative of (Adapted from Holtz 1969 a Gibbs 1969).

Table 1
Holtz and Gibbs method to determine soil expansivity

Expansion potential	Contract limit	Plasticity index	Liquid limit
Low	> 15	0 - 18	39
Medium	10-16	15 - 28	39-50
High	7-12	15-41	50-63
Very high	0-11	>35	Más de 63

In figure 5 shows the degree of expansion of the clay, for which the contraction test was performed and compared to the percentage of CBR swelling, results are obtained for the pit 1 test, an average contraction limit of 9.44% with a sponge of up to 16%; for the Pit test No. 2, an average contraction limit of 10.98% is obtained with a percentage of up to 15% of the sponge, and for the pit 3 test there is an average contraction limit of 9.77% with a percentage of 16 %.

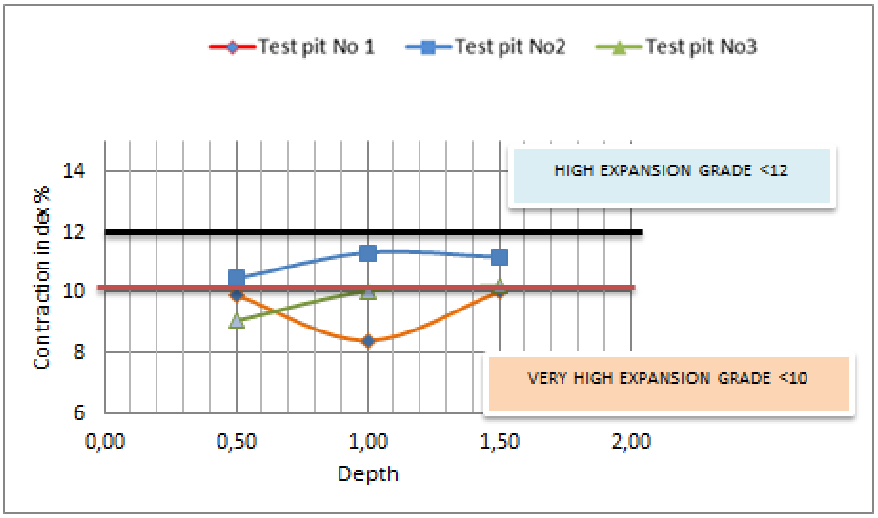

Figure 5. Shrinkage Limit Values

The results of the soil bearing capacity by the CBR test have obtained low values estimated from 1 to 2.06% as shown in figure 6.

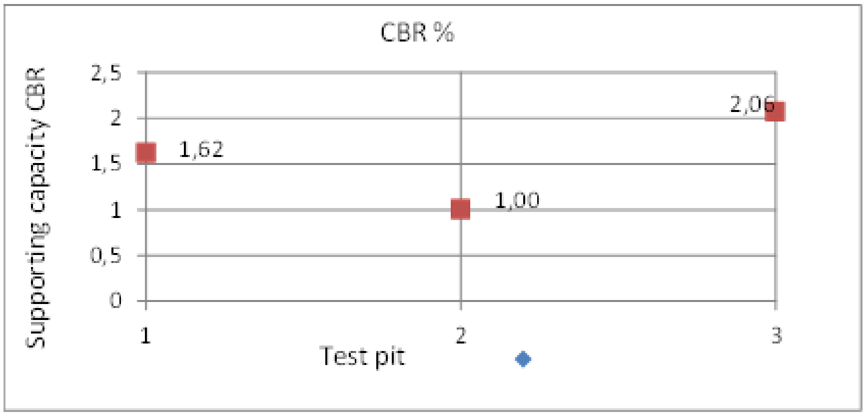

Figure 6. Load capacity (CBR) of natural soils

In addition, the soil-free expansion tests were carried out in the natural state, where the expansion index was determined by the differences between the final and initial height of the specimen divided by the initial height, the results obtained are categorized by the degree of expansion ASTM D4829-03, as shown in table 2. The tests of free expansion of the soil in the natural state reached an expansion index of 97.41 with an expansion percentage of 9.74% for the pit 1 test; for pit test 2 of 98.93 with expansion percentage 9.89% and pit test of 102.76 with an expansion percentage of 10.28%.

Table 2
Classification of soil expansion potential ASTM D4829-03

Expansion Rate	Expansion Potential
0-20	Very low
21-51	Low
51-90	Medium
91-130	High
More 130	Very high

Laboratory results of stabilized soils with 3% and 6% of lime for the neutralization of expansion in the clays. After obtaining the laboratory results of the soil in the natural state, it was stabilized to neutralize the expansive properties of the clay, so that two scores, one with 3 and 6% of lime, were programmed. The average soil moisture content of the soil with 3% lime for the test pit 1 was 25.3%, the test pit 2 was 31.59 and the test pit 3 was 34.6% as shown in Figure 7 (A) and for the stabilization with lime of 6%, natural humidity was determined for the test pit 1 of 20.97%, test pit 2 20.96% and for the test pit 3 of 23.63% as indicated in figure 7 (B).

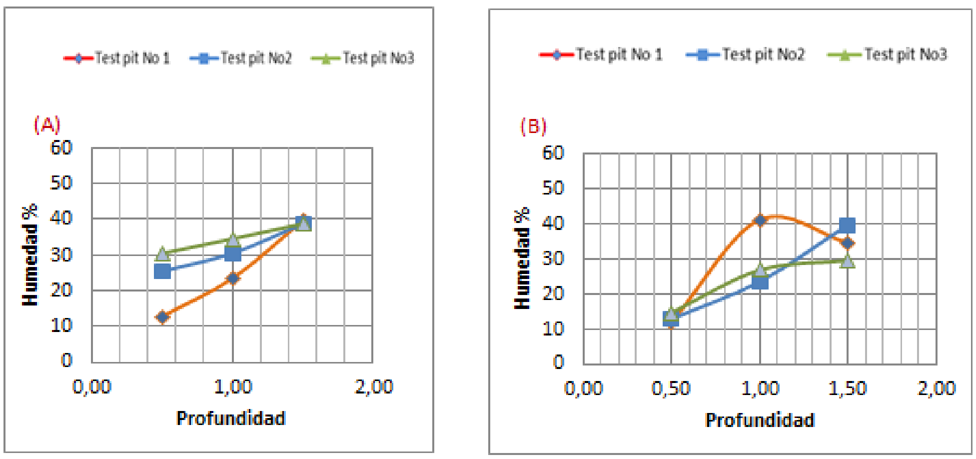

Figure 7. Natural soil moisture values stabilized with 3% lime (A) and 6% lime (B).

The liquid limits after mixing with 3% reach average values of: 53.97, 44.49, 46.34% as seen in Figure 8 (A); and with 6% of added lime, values of: 39.71, 33.60, 34.18% as indicated in figure 8 (B), corresponding to test pit No 1, 2 and 3 respectively.

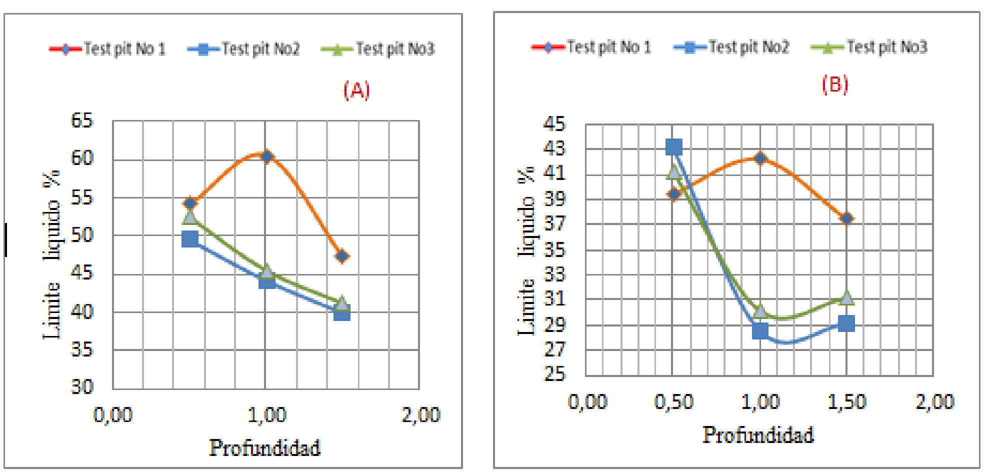

Figure 8. Values of liquid limits stabilized with 3% lime (A), 6% (B)

Subsequently, the plasticity index was calculated, whose results obtained for the stabilization with 3% of lime have values of 18.20, 15.33, and 15.84%, which correspond to the test pits 1-2-3 respectively as shown in Figure 9 (A). For the mixture with 6% lime added, values of 15.27, 11.78 and 10.30% are obtained for test pits 1-2 and 3 respectively in 9 (B).

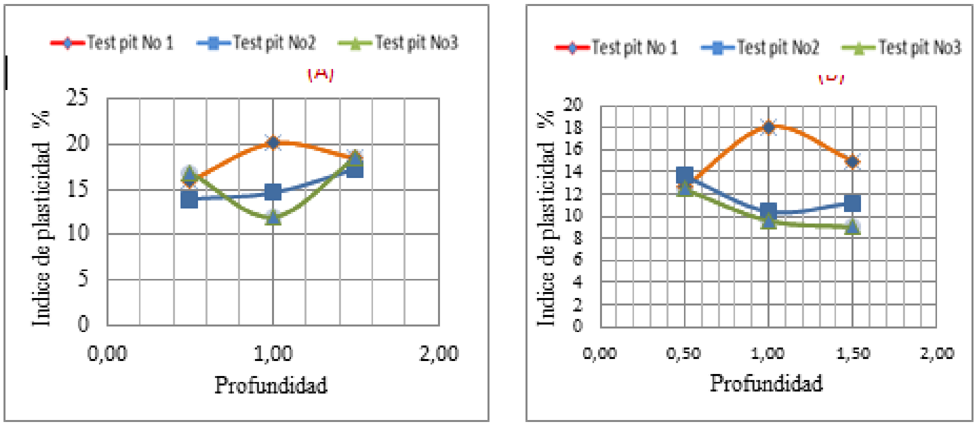

Figure 9. Values of plasticity index stabilized with 3% lime (A) and 6% (B)

Limb shrinkage tests were performed, where it was stabilized with lime added at 3%, obtained as mean values of 15.84, 15.33, 16.83% for test pit 1, 2, 3 respectively, as shown in figure 10 (A) and with 6% yields 22.37, 21.34, 23.06%, corresponding to the pit 1, 2 and 3 test as shown in 10 (B).

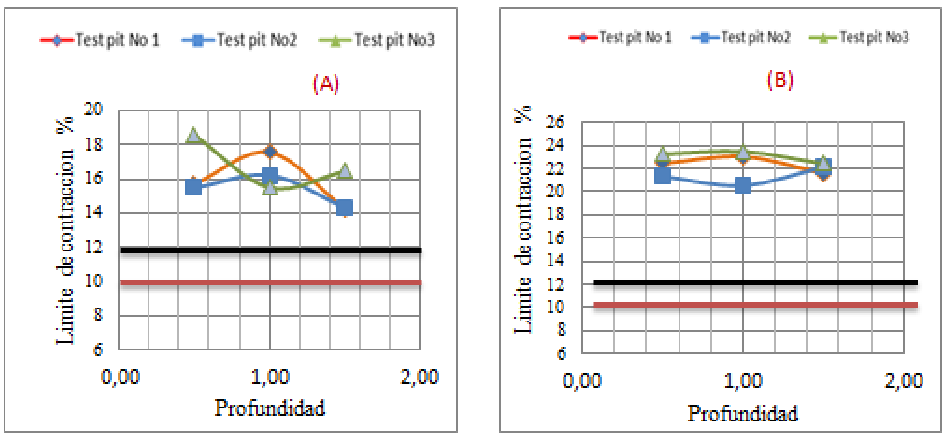

Figure 10. Shrinkage Limit values stabilized with 3% (A) of lime and 6% in (B)

Then, the CBR tests were carried out to determine the bearing capacity that would reach the soil with the 3% lime shown in Figure 11 (A), which were 11.88, 12.56, and 14.49%: for test pits 1, 2 y 3 respectively, as shown in Figure 11 (B), and with 6% results of 18.98, 17.58, 18.98 are obtained for pits 1, 2 and 3.

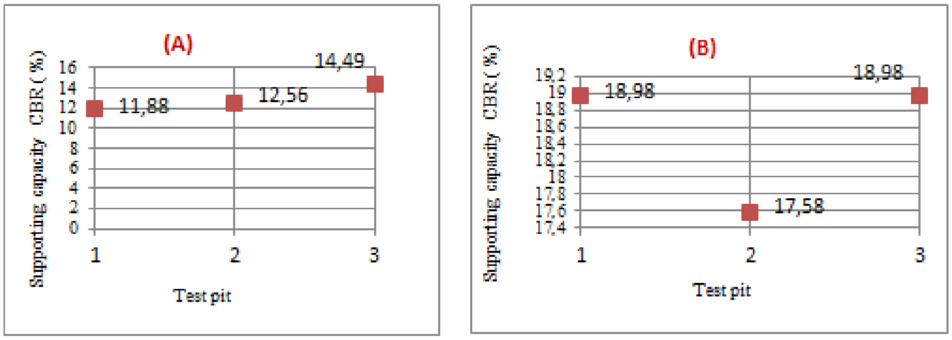

Figure 11. CBR values stabilized with 3% lime (A) and 6% in (B)

The free expansion that was determined with the mixture between 3 and 6% of lime, through the tests carried out it was determined that according to the lime added with 3% it reduces a degree of expansion with an expansion index of 65% and with lime added at 6%, an expansion index of 30% was obtained according to ASTM D4829-03. There is a low degree of expansion and it may be concluded that it is appropriate to introduce lime into the process.

4. Conclusion

Different tests were carried out in the laboratory with natural soil introducing different percentages of lime, with the results being verified, that with 6% of lime is adequate since they achieve low values of expansivity, which ensures a good stabilization.

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Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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References

Alvarado, J. A., & Torres, C. A. (2002). *Estabilización de una arcilla blanca con cemento* (Doctoral dissertation, Tesis de grado (Ingeniería Civil), Pontificia Universidad Javeriana, Bogotá).

Angarita, H., & Díaz, H. I. (1995). *Uso de enzimas orgánicas como alternativa de estabilización de subrasantes y sub-bases en Santafé de Bogotá* (Doctoral dissertation, Tesis de grado (Ingeniería Civil), Pontificia Universidad Javeriana, Bogotá).

Arias, O. E. (2002). *Métodos de estabilización de suelos de sub rasante para pavimentos utilizados en Bogotá* (Doctoral dissertation, Tesis de grado (Ingeniería Civil), Universidad de los Andes, Bogotá).

Díez, L., & Montes, O. (2002). *Estudio de la estabilización de subrasantes con productos químicos* (Doctoral dissertation, Tesis de maestría (Ingeniería Civil), Universidad de los Andes, Bogotá, 2002.[Links]).

Hernández, E. H. O., Moncayo, E. H. O., Sánchez, L. K. M., & de Calderero, R. P. (2017). Behavior of Clayey Soil Existing in the Portoviejo Canton and Its Neutralization Characteristics. *International Research Journal of Engineering, IT and Scientific Research*, *3*(6), 1-10.

Jorge, O. R., Gabriel, A. G., & Moisés, J. C. (2015). Caracterización del subsuelo y análisis de riesgos geotécnicos asociados a las arcillas expansivas de la ciudad de Tuxtla Gutiérrez. *Ingeniería, investigación y tecnología*, *16*(3), 453-470.

Rondón, H. A. (2013). evaluación del comportamiento de arcillas sometidas a diferentes tiempos de exposición a altas temperaturas (behavior evaluation of clays subjected to different exposures times at high temperatures). *revista eia*, *8*(16), 175-187.

Sánchez Albán, M. A. (2014). *Estabilización de suelos expansivos con cal y cemento en el sector Cacical del cantón Tosagua provincia de Manabí* (Bachelor's thesis).

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Biography of Authors

	Magister in Construction of Road Works specialist in Soil Mechanics Pavement and Laboratory Professor of the Faculty of Physical and Chemical Mathematical Sciences of the Technical University of Manabí, Ecuador subjects taught are Soil Mechanics 1 and 2, Transit and Transport Engineering, Works Vials and Pavements. *Email: eduardohumberto1983@hotmail.com*
	Magister in Construction of Road Works specialist in Soil Mechanics Pavement and Laboratory Former Professor of the Faculty of Physical and Chemical Mathematical Sciences of the Technical University of Manabí, Ecuador subjects taught Soil Mechanics 1 and 2, Transit Engineering and Transport, Road Works and investments, Former Supervisor of Road Studies and Geotechnics at the Ministry of Transportation and Public Works Manabí - Ecuador.
	Civil Engineer, a specialist in Soil and Pavement Mechanics and Laboratory, he studied at the Faculty of Physical and Chemical Mathematical Sciences of the Technical University of Manabí, Ecuador. He currently works as a Consultant in Acolit, Ecuador.
	Civil Engineer, Professor of the Faculty of Physical and Chemical Mathematical Sciences of the Technical University of Manabi, subjects taught are Programming of Works and Formulation and evaluation of Ecuador Projects, position as Regional Director Manabí of the State Comptroller General, the latter on secondment.