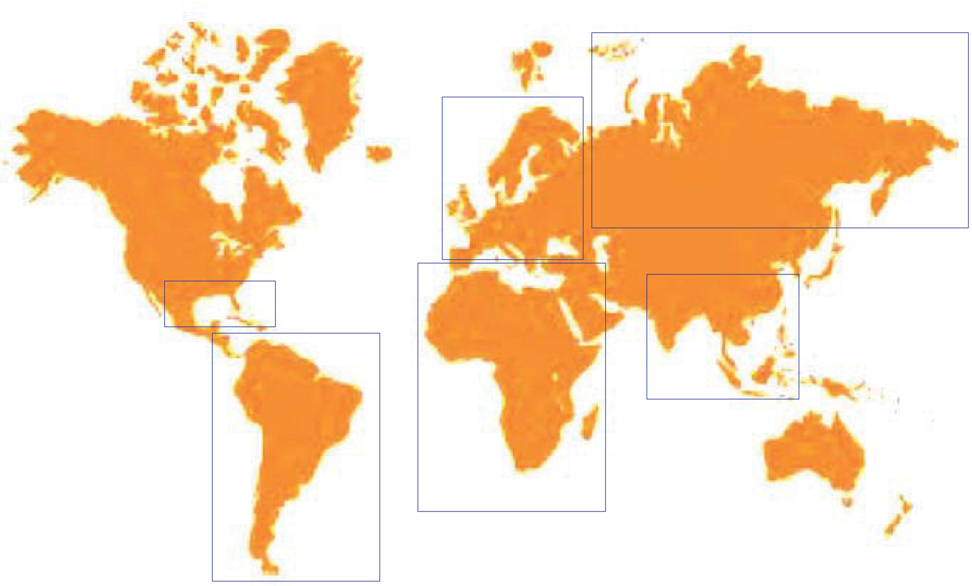
stabilization and waterproofing

all types of soils in the Word

Scientific explanations



Summary

Theatrical study of the chemical effects of
QUATERNARY SALTS with ADDITIVES* stabilize clayed soils

MSc. Engineer professor Juan Mario Junco del Pino
Doctor Engineer Eduardo Tejeda Pieusseaut

(*)ROCAMIX®

1 THEATRICAL STUDY OF THE CHEMICAL EFFECTS OF QUATERNARY SALTS WITH ADDITIVES* FOR THE STABILIZATION OF CLAYED SOILS

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J. M. junco del Pino.

The chemical stabilization is one of the techniques that are used for the sub rasantes improvement, using chemical substances that modify the characteristics of the soils, reducing plasticity and increasing the cohesion and its support capacity.

An investigation was developed that as a result gave the creation of a procedure of stabilization of soils using quaternary salts of ammonium + additives*, which has as advantages its economy and simplicity in its employment, besides getting the resistance increment and permeability reduction in the soils.

It Samples up the way in that the quaternary salts produce the changes in the clayey soils, as well as the behavior of the physical and mechanical properties of the stabilized soils with the system, comparing the physical and mechanical properties of the soils in their natural state and after having improved, as well as the evolution of the characteristics in the time of the stabilized soils.

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1 0 CHEMICAL STABILIZATION OF SOILS

It is denominated stabilization of soils to the process of subjecting the natural soils to certain treatments to take advantage of their best qualities, so that they can support the adverse conditions of climate, surrendering in all time the appropriate service that is expected from them. (Frizzy, 1998: 325).

The stabilization procedures, in a general way, consist on mixtures of soils with others of different characteristic or with preservatives; the compaction for mechanical means; the use of waterproof membranes; electric means, among other. The stabilization of soils has as main objectives to increase the resistance, to provide or to diminish the permeability and as much as possible, to reduce the volumetric (establishments or expansions) changes.

In the sub-leveling of highways, the stabilization pursues to be able to use natural soils with a low support quality, near to the work, not capable for itself for the construction, to improve them and to make them appropriate in an economic way.

For the option of improvement of the soil they exist different procedures or stabilization methods at the moment:

a) Stabilization for mechanical means;
b) Stabilization for drainage;
c) Stabilization for electric means;
d) Stabilization for employment of heat and calcinations;
e) Stabilization for chemical, stabilizing agent's addition.

The chemical stabilization of soils consists on the employment of chemical substances to improve the engineering properties of the soils, reducing its plasticity and making them more resistant, before the action of the traffic and environmental conditions. In general the use of chemical preservatives increases in the sub grade the capacity to support loads without deformation, and it improves or reduces the cost of rolling layer for erosion for heavy traffic or for strong rains.

It is important for the engineer to know the varied options that exist for the stabilization of soils for chemical means, since each one of them is effective for certain types of soils.

In the design of the stabilization of a soil with stabilizing chemical agents present the variations, that is expected to achieve the volumetric stability, mechanical resistance, permeability, durability and compressibility.

The procedures of chemical stabilization of good known soils and the method employees are: soil- cement; soil - lime; soil – asphalt; stabilization with salts; stabilization with polymers, enzymes, compound resinous and others. Each one of these procedures pursues objectives and they provide from modifications different to each soil.

In recent dates and impelled by the Technological Development of the chemical Industry different preservatives were created with objective of obtaining improvements in the engineering's properties of the soil starting from chemical diverse reactions, for example: CBR+, RoadPacker Bonus, Base. Seal, Minedur, Consolid, Permazyme, ISS 2000, Claycrete, and others.

1 1 Brief characterization of clay

Clays consist essentially of hydrated aluminum silicates and danscertains cases also present, silicates of magnesium, iron or other metals, also hydrated. These minerals almost always have a definite crystal structure, the atoms are structured blades. There are two varieties of these plates: the silica and alumina.

The first of these sheets is formed by a silicon atom surrounded by four oxygen, positioning tetrahedron shaped, as shown in **fig 1**.
These tetrahedrons agroupent into hexagonal units, using an oxygen atom as the link between each tetrahedron.

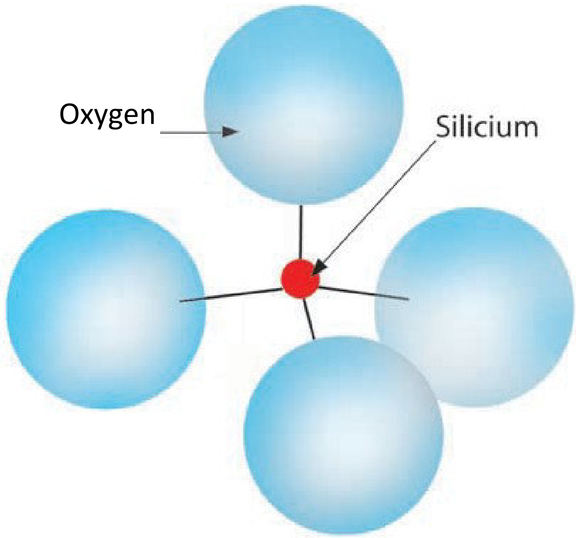


Fig 1

A diagram of a hexagonal unit is shown in **fig 2**.

These hexagonal units repeated indefinitely, is a laminar network.

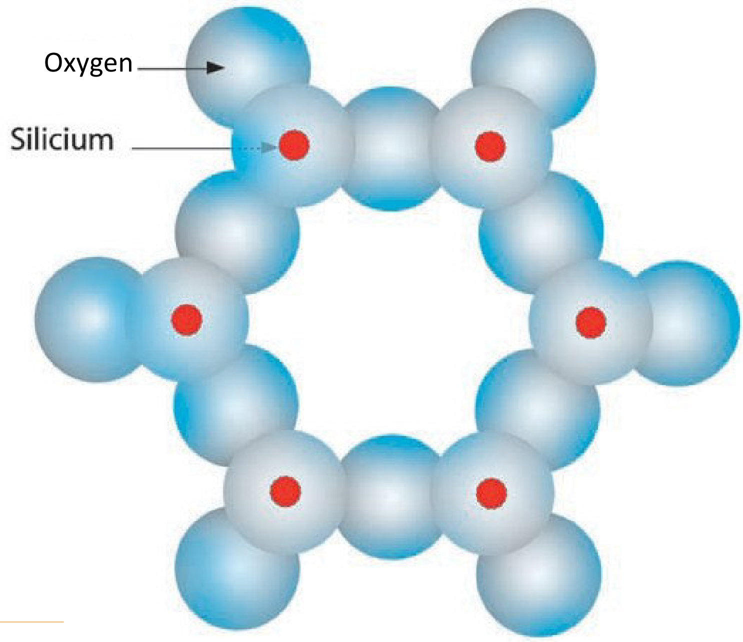


Fig 2

1 1 Continue

The aluminum-blades are formed by a lattice of octahedra arranged with an aluminum atom at the center and six oxygen around, as shown in **fig 3**. So now is the oxygen that makes the link between each neighboring octahedra forming the grid.

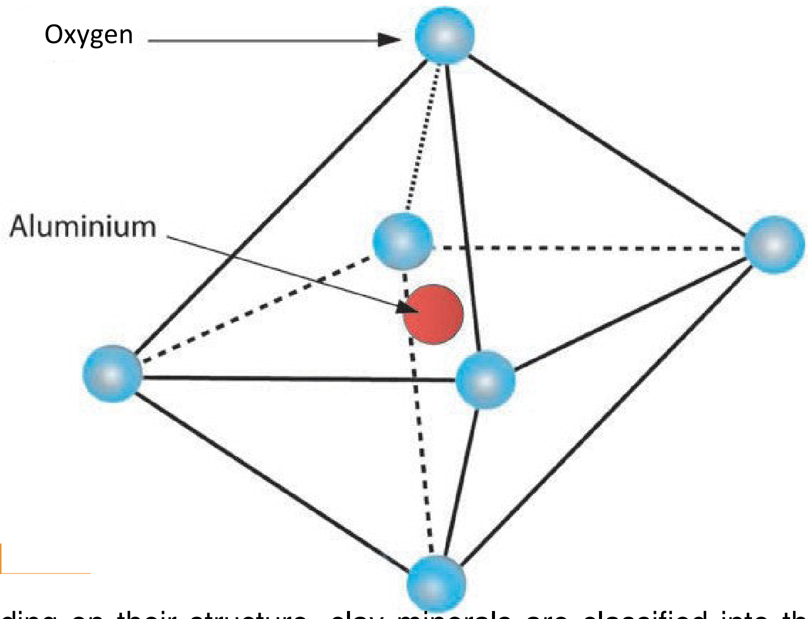


Fig 3

Depending on their structure, clay minerals are classified into three groups: kaolinite, montmorillonite and illite. To better understand the response of soils for the stabilization it is important to know the physical and chemical aspects of these. In general, we consider that the clay particles have a size of about 2 microns or less and have a high electrical activity, which governs its behavior due to its large surface area relative to its volume and mass. One of the most widely accepted to explain the internal structure of clays is developed theories which states that the surface of each soil particle has a negative electrical charge. The load intensity depends on the structure and composition of the clay. The particle attracts positive ions from water (H +) and cations of different chemical elements, such as Na +, K +, Ca + +, Mg + +, Al + + +, Fe + + +, ... etc. The fact is that each individual particle of the clay is set in a defined manner and connected to the structure (adsorbed water).

The water molecules are polarized, ie they no longer correspond to the centers of gravity of their positive and negative charges, but function as small permanent dipoles, by binding to the particle by the load (+) the pole (-) charge is able to act as a source of positive attraction for other cations. Own cations attract water molecules through the polarization thereof, so that each can have a cation volume of water around it. The adsorbed water increases each cation with its electric charge and its ionic radius (Peck, RB, Hanson, WE and Thorburn, TH 1957)
.
Therefore, when soil particles attract cations the water film due to the particle increases.

The thickness of the water film absorbed by the crystals of the soil is not only on the nature there of, but also the type of cation attracted function.

The clay crystals can modify absorbed on the surface of film cations. For example, a hydrogenated clay (H + cations) can be transformed into sodium, if circulation is achieved through the mass of water containing sodium salts dissolved. In reality what happens is a cation exchange between water and dandruff absorbed by mineral particles, sometimes very fast reaction. The most common exchangeable cations are Na +, K +, Ca + +, Mg + +, H + and (NH4) +.

Correctly understand the properties of clay and water, and the attrac-tion forces between them resulting from the "diffuse double layer" of water surrounding the particles of clay is essential for good read how to work-er stabilized clay soils or Gravo clay. The water molecules are dipoles, which signi-fies that they have a negative pole at one end, where there is oxygen, and a positive pole where the hydrogen, so each water molecule acts as a magnet which can be aligned with the forces or electromagnetic fields. It is this property which gives the surface tension of water. It is this property that allows water to be electrostatically attracted to the surface charges of clay particles. In some clays pressure achieved by the electrostatic attraction between water and clay can reach values of more than 10,000 atmospheres. This is one reason why the expansion of certain clays can raise buildings and push them off their foundations and also the reason for excessive humidity and drying of the subgrade under roads may be the cause of many strains.

In the graph below (**fig 4**) you can see a special interchangeable ion in montmorillonite

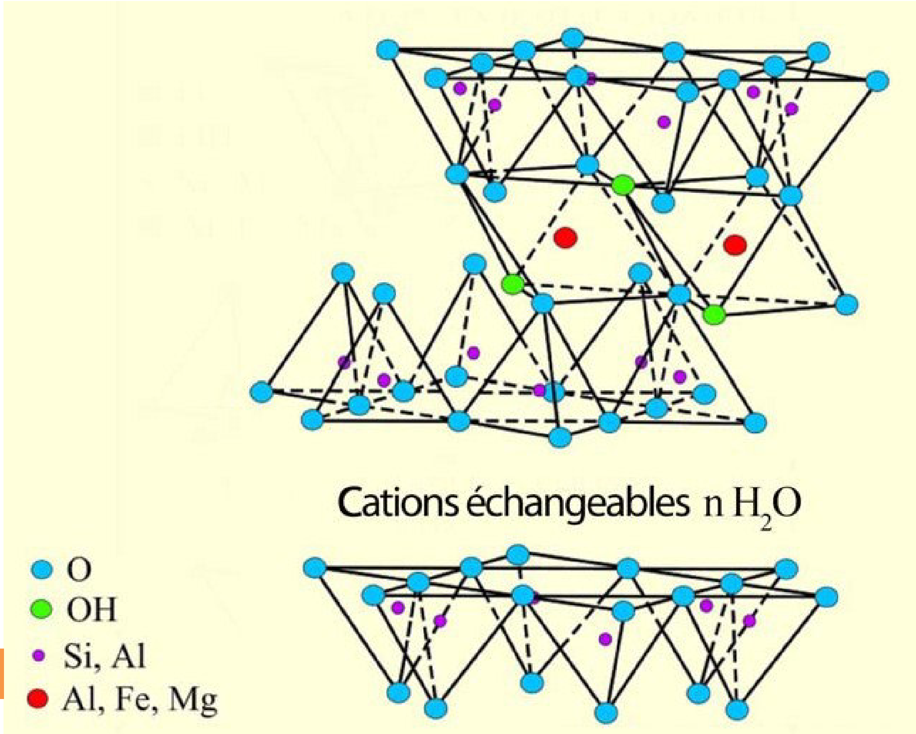


Fig 4

1.2 Influence of the Adsorbed Organic Molecules

Gieseking has reported that the Clays Montmorillonitas loses its tendency to swell by means of the absorption of water until the saturation with a variety of organic cationes. These Cationes is absorbed on the flat basal surface of the montmorillonita. Hendricks demonstrates that the quantity of water absorbed by the montmorillonita dragging certain ions of absorbed amina makes that the difference between the extended total flat basal surface and the probable part of this covered surface for the amine ions is minimum. Hendricks also aims that the reduction in the absorbed water is not exactly correlative with the size of the organic Ion, because the form of the organic Ion can be such that it can destroy the configuration of the molecules of water in the layers of the absorbed water.

1.3 Influence of interchangeable Cations in the Clays

The ions absorbed in the surface of the loamy minerals can affect the absorbed water in different ways:

- A cation can be good as a link to sustain the united mineral particles of clay or to limit the distance to which they can be separate.
- The Ion ammonium has a great tendency to maintain united the loamy minerals, due to its size and I number of coordination that allows him/her to notice with the net of I oxygenate of the surface of the three layers of the loamy minerals.

The size of the absorbed cations and their tendency to be moisturized can influence the natural classification of group of the molecules of water and the thickness to which the orientation can be developed. Depending on the distribution of the loads in the molecules of water, it can be expected that the ions loaded in the ionic solutions attract the molecules of water electrostatically.

Example of this is that the thickness of the layers of water among the silicate units depends the nature of the interchangeable cations. Experiments carried out by Mering, with montmorillonita in the presence of big quantities of water suggest that with certain absorbed cations, for example Na+, the layers separate completely, but with other such cations as Ca +, H+, and the organic cations the separation is not complete **Fig 5**

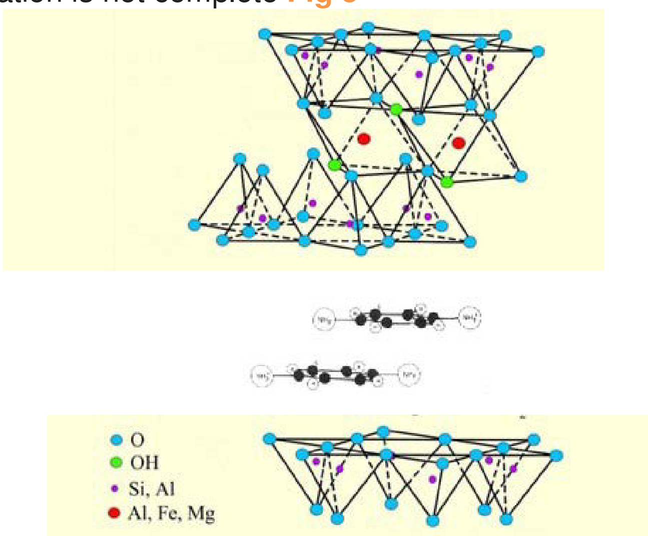


Fig 5

13 Continue

In the **Chart 1** that Samples up the certain capacity of exchange of cations of the montmorilonita next can be observed with certain organic cationes, that which will be important for our work, because it Samples the high thing that it is before QACS..

Certain capacity of exchange catiónico of a montmorillonita with certain organic cationes (Hewdricks)

Base	Capacity of exchange catiónico (meq/100g)
Benzidine	91
Aminodimethylaniline	90
Phénylènediamine	86
Naphtylamine	85
Diaminofluorene	95
Piperedine	90
Baryum	90-94

Chart 1

14 Characterization of the Quaternary Salts and Paper of the same ones in the Process of Stabilization

The quaternary (QACs) compounds of ammonium are composed organic that contain four groups united functional covalently to a central (R_4N +) atom of nitrogen. These functional (R) groups include a long chain of group alkyl and the rest at least they are alternating methyl groups or benzyl. QACs are among the Chemical Productions of High Volume (HPVs). QACs possesses activating superficial properties, characteristic of own conformation, detergents and antimicrobial properties. The physical chemical unique properties of QACs have been in a variety of uses and a high level of popularity in domestic and industrial applications as surfactants, emulsifiers, smoothing, disinfectant, pesticides and inhibitors of corrosion, among other.

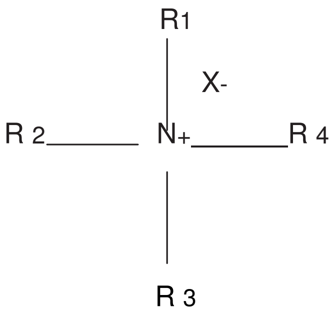


Fig 6 General molecular structure of a QAC (R represents a functional group, X is a negative ion such as Cl-, Br-or NO3-)

15 Influence of ionic Surfactant in the behavior of the Clays

The presence of Surfactants increases the Plastic viscosity and the intensity from the electric field to ionic level. This demonstrated that Surfactant Polarized head of the group, anchors in the surface of the badge tetrahedral, leaving the chain extended alkaline outside in the faces and corner. For consequence, the chain alkaline receives interactions hydrophobias that hydrophobias that facilitate the association among the badges and it increase the physical structure inside the suspension fig. 7.

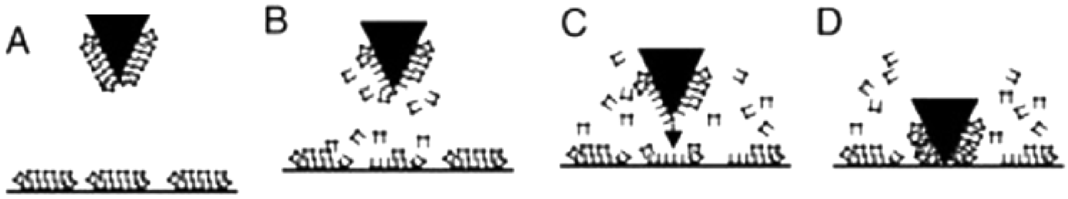


Fig 7

The stereo chemicals differences among the polar groups they can take to differences in the way of associating with the badge tetrahedral and it can influence this way in the finishing effect of the rheological behavior. A significant interaction exists among these surfactants and the clays montmorillonites, and the rheological changes that happen they can have impact in the doses to use in the stabilization processes. Diverse studies have investigated the effect of the intercalation among the badges of ionic surfactants in the behavior of the clays montmorillonites.

As we have seen the clays montmorillonites are characterized to alternate layers silica tetrahedral with aluminum octahedral coordinated with atoms of I oxygenate. The substitution isomorphic of AT THE 3 + for If 4 + in the layer tetrahedral and Mg 2 + or Zn 2 + for At the 3 + in the layers octaedricas it is in a net of loads superficial negatives on this type of clays. These loads desbalanceadas are compensated by interchangeable (typically Na + or Ca 2 +) cationes in the surface of the clays. The structural layers of the clays allow the expansion (swelling) after having humidified. These factors in combination with the small size of their particles, it provokes that the montmorillonite exhibits a high capacity of exchange cationic compared with other natural soils.
In a half watery one, the cations of quaternary ammonium can be retained by both surfaces: the external one and the interlayer of an expansible clay for a process of exchange cationic and they are not easily displaced by cations but small as H+, Na + or Ca 2 + .Las properties of absorption of the surface of the modified clay can be significantly altered for this substitution reaction.
The surfactants reduce the superficial tension of the water largely, that which increases the capacity of the water ionized to penetrate the soil largely. This increases the capacity of compaction of the soil tried with ROCAMIX largely, because for example the clay particles are able to move more easily inside the gravel. In the floors tried with the System the ionized solution the double it penetrates it castrates diffuse of water that it surrounds the loamy particles. This brings more ions near the surface of the particles of the clay, replacing the water of previously loaded suspension electrostatic ally, that which provokes that a lot of quantity of the water that previously was united it is untied and be like free water.
Through the ionizing powerful action of QACS, the ionic exchange is induced in the surface of the clay particles. This means that great part of the water that usually this united one, after the application lifting to the surface like free water,

for that reason acts as a dehydrating agent.

To the being able to liberate previously to the subject water, ROCAMIX provides to the particles of clays the possibility to be placed but united during the compaction. After the treatment, the "cushion" of water electro statically united that it usually surrounds particles of the clay and it impedes the good compaction, it is discharged now by the physical compaction facilitating a realignment of the clay particles, therefore it acts as a support to the extremely efficient compaction. That is to say believe the possibility that the good compaction is reached reducing the empty spaces and the quantity of water in the clay.

The maximization of the compression is achieved by means of an increase of the linkage among the clay particles, that which is been of the realignment of the particles, being united strongly. The induced process of ionic exchange is permanent, the one which permanently it reduces the attraction between water and clay, and consequently it reduces the possibility of the Numbness and the Shrink permanently. Permanently it reduces the Index of Plasticity of the clay. Several actions of cohesion (cementing) take place in the soils tried with QACS, but these actions are not immediate, and they take place during several weeks, as masses, which continue during months.

QACS only alters the clay in the soil because the clays only have the molecular structure with an electrostatic load in the surface (the sands, slimes and the rock don't possess this characteristic). Consequently determining when a soil responds to the treatment with ROCAMIX it is a way to determine the quantity of clay, and the nature of the clay in the soil. The determination of the soil percentage that passes the sieve of 75 microns, and the index of plasticity of the soil, will give us an indication of the quantity and the clay type in the soil.

1 CASES OF STUDY
OF THE CHEMICALS EFFECTS OF THE QUATERNARY SALTS WITH ADDITIVES'* FOR STABILIZATION OF CLAYED SOILS

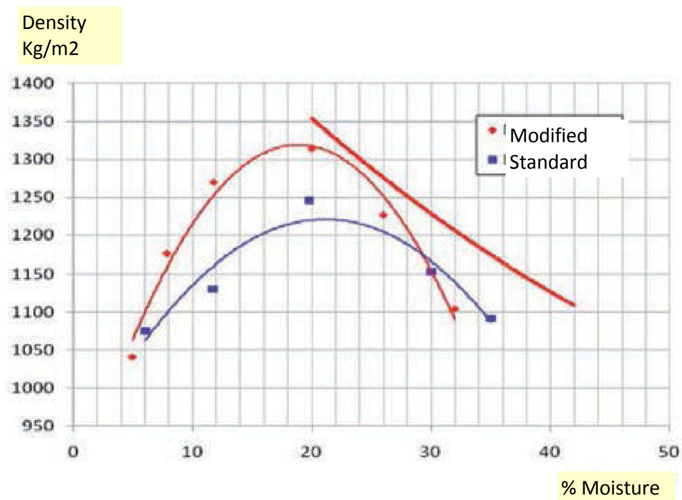
A ANALYSIS OF RESULTS

Studying carried out with the extracted material of the quarry Manuela, in Mariel

1 Classification of the soil
The material of the quarry Manuela, in Mariel has a high plasticity, given by the values means of the determinations in the laboratory; Limit Liquid of 41%, Plastic Limit of 16,3% and a Plastic Index of 24,7%.
The granulometric analysis Samples a smaller high percentage of particles that the sieve No. 4, however low percentage of finer material that the 200.
The soil classifies as an A-2-7 (0), uniform sand with discontinuous graduation. It presents very few fines inferior to the sieve 200, with clay of high plasticity.

2 Test Proctor
We offer the results of the tests Proctor, Normal and Modified, in the fig **8**.

Fig 8



3 Index CBR
The results of Index CBR have been obtained for the energies standard and Modified, with the natural soil and the treated soils. The results are Sample in the **Chart 2**, where you can appreciate the increment of the resistance for both compaction values. The compacting natural soil to standard energy presents an index first soil of CBR (1,7%), however compacting with the one Modified elevates its resistance until 11,4%, but although it could be used as material of sub grade in a natural way, it would not be advisable for heavy traffic.

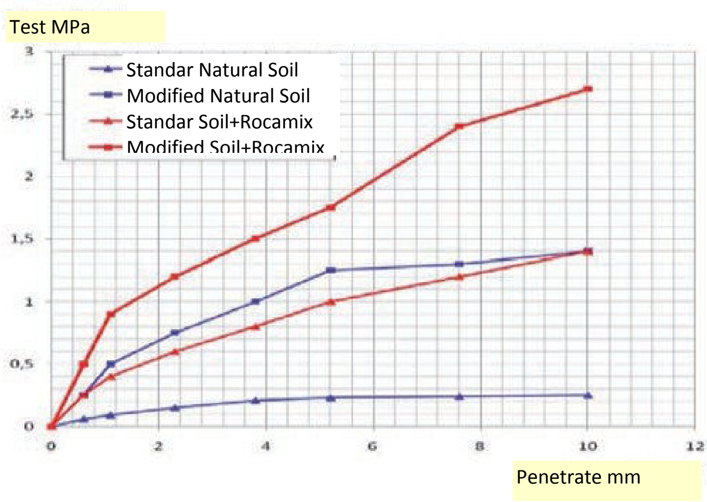
A

The incorporation of the preservative provokes a similar effect that the increment of the energy, registering an increase of CBR until 11,4%, alone adding preservative. When preservative is added and you compact with the one Modified, then CBR reaches acceptable values for heavy (19,9%) traffic..

Chart 2

		Natural soil ProctorStandard		Soil+Rocamix Proctor Standard		Natural soil Proctor Modified		Soil+Rocamix ProctorModified	
mm 2,54	Mpa 6,9	1,15	2,2	0,7	10,1	0,7	10,1	1,3	18,8
5,04	10,3	0,2	1,9	1,2	11,7	1,02	9,9	1,8	17,5
Value Proctor			**1,7**		**11,0**		**11,4**		**1 9,9**

Fig 9



4 Norms

The Standard 6.1 IC, of the 2003, it establishes three sections different from firm (pavements) that must use depending on the type of project traffic: E1; E2 AND E3

The **chart 3**, it Samples the values demanded for these categories of esplanades and the values of the module of compressibility in the second load cycle, obtained of the load test with badge (NLT-357).

Cuban Standard 334-2004 also establishes three categories of embankment, according to CBR obtained in the sub grade like design value. They are classified in: Acceptable, mediate and good, like one can see in the **chart 4**.

Chart 3

Category of Embankmen	E1	E2	E3
EV2 (MPa)	≥ 60	≥ 120	≥ 300

Chart 4

Classification of the base	Resistance
Acceptable	5% ≤ CBR < 10%
Mediate and good	10% ≤ CBR
Good	CBR ≥ 15%

5 Capillary rising

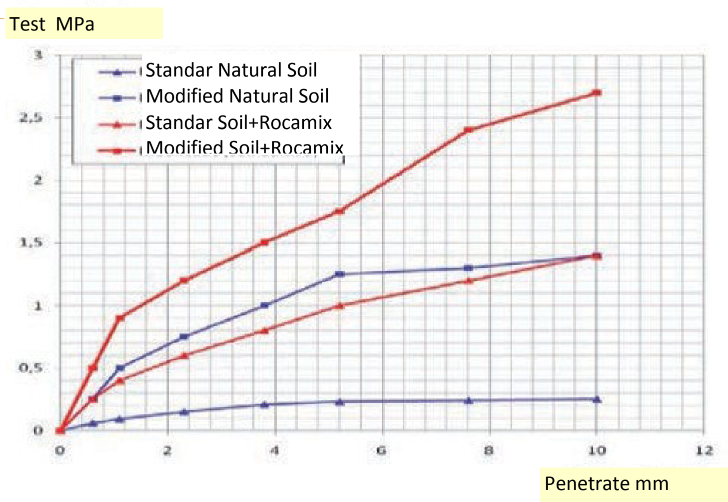
We got ready a test to measure the water capillary rising that takes place in the stabilized mixtures. It is a simple test that pursues to know like it ascends the water through the material and the time that can remain under the influence of the water without to crumble or to suffer important affectations. The test was executed with samples of different times of cured: 7, 14 and 28 days. The **fig 10** contains some of these results, after being subjected to the action of the water for 24 hours.

Fig 10

The samples of natural soil disintegrated at the two hours, while the samples with preservative resisted the influence of the water. They were subjected to the test after having been cured to 7, 14 or 28 days, and in all the cases they increased their weight, for the presence of humidity, without disintegrating. They were not appreciated, however, it influences significant of the time of cured, for what is supposed that, although capillary ascension, the cured of 7 days exists it is an enough time so that the samples have acquired the necessary resistance to the action of the humidity.

The **fig 11** represents the increment of weight that you/they have had the test tubes stabilized chemically that have been subjected to the process of capillary ascension. As it is observed clearly, the slope of variation of the weight the humidity decreases with the days of cured, what evidences the importance of the time of having cured in the improvement of the characteristics of the mixture.

Fig11



A

6 Resistance to axial compression

The floor coming from the Quarry Manuela that classifies as an A-2-7 (0), in Mariel; it improved their mechanical properties in a significant way, with the application of the preservative. It was demonstrated with these works that, besides a resistant mixture, it is also obtained appreciable reduction in the absorption for capillarity, with that which the floor becomes more resistant to the destructive effects of the water. fig 12 and fig 13

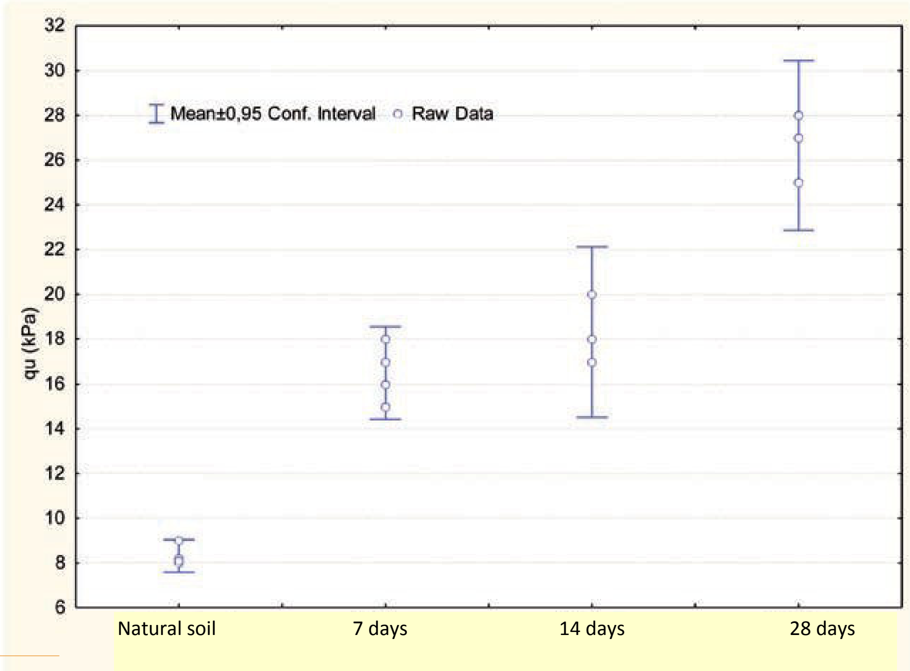


Fig 12

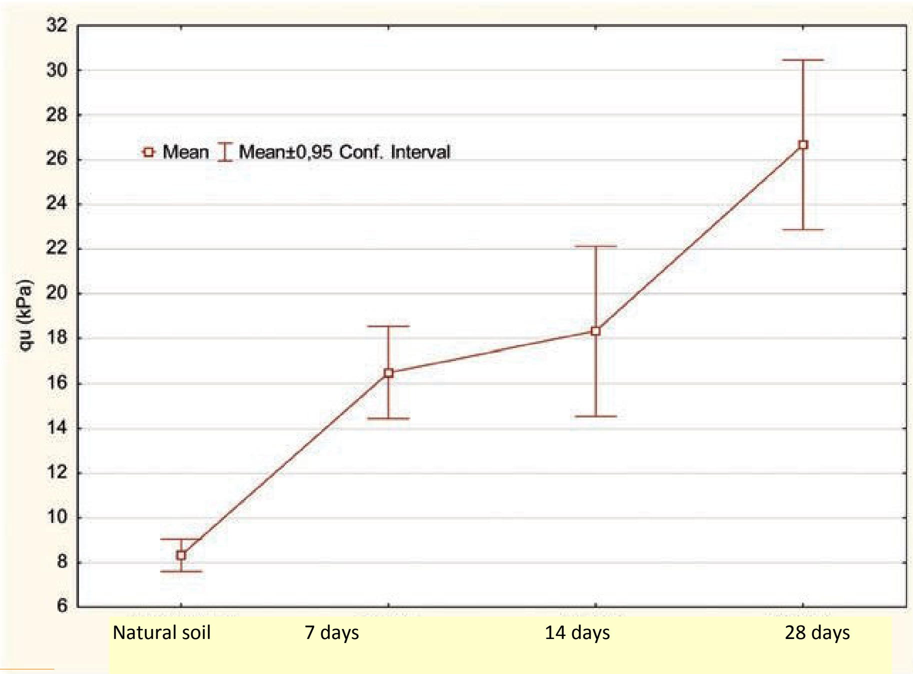


Fig 13

A

Study of the soil of Formation Via Blanca

1 Classification of the soil

In another investigation the results of the application of the preservative were compared in loamy floors. For them tests were made with the employment of Rocamix in a floor of the Formation Via Blanca, with a grain and such plasticity that allow to **classify it as a floor A-7-6 (20), according to the System of Classification AASTHO.**
clay of high compressibility and high change of volume and according to the System SUCS, as a floor CH, clay of high compressibility. LL average of the rehearsed samples is of 68%, while LP is of 29%, for an IP of 39%.
The results of the test of the Hydrometer, 0,074mm, is Sampled in the chart 5. As it is observed, the clay content is in an order of 25%.

Diameter (mm)	% real fine Sample 1	Sample 2	Sample 3	Mean
0,055	74.3	75.4	75.0	74.9
0,040	70.2	72.5	71.0	71.2
0,023	68.5	68.9	69.0	68.8
0,018	67.0	67.8	67.4	67.4
0,013	66.7	62.7	65.0	64.8
0,011	64.4	65.0	64.7	64.7
0,008	60.0	60.0	60.0	60.0
0,006	53.5	54.0	54.0	53.8
0,004	43.9	50.0	47.0	47.0
0,003	36.7	36.7	37.0	36.8
0,001	24.3	23.9	24.0	24.1

Chart 5 Analysis to the smallest particles to the sieve 200.

In the investigation he/she incorporated a percentage of preservative of 1,5% and 2 cement% regarding the floor weight. The influence of the compaction energy was also analyzed, using different, standard and modified two energies.

2 Tests of CBR

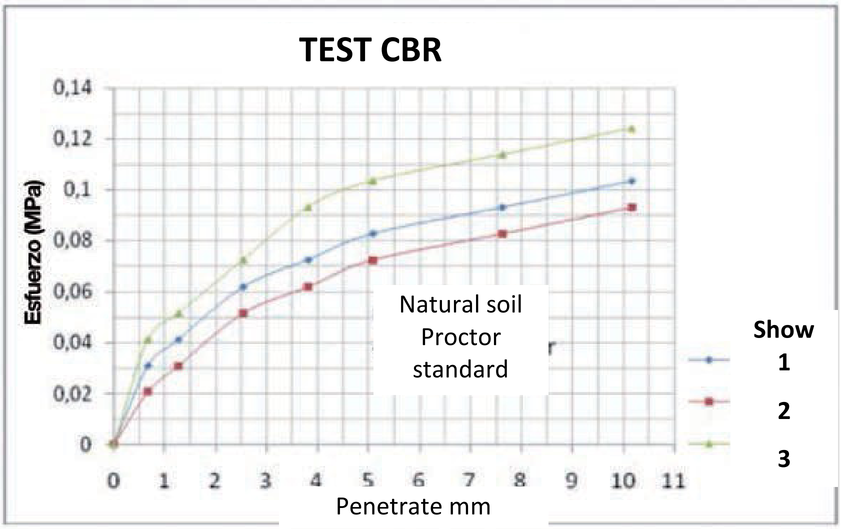
The Charts 15 and 15.1 Sample the results of CBR, for the natural floor, with the energies standard and modified. As it can be proven the resistance of the floor it is very low, inferior at the levels demanded for sub rasante, still with the energy of the one Modified. It is even a floor that doesn't complete the material values for nucleus of embankments. (To mention Spanish norm of embankments).

B

The values of CBR with the addition of Rocamix can be seen in the **fig 15.1**. Notice you that the values of CBR have been increased until acceptable values, passing from 1,2% with the natural floor until 5,6% of CBR, when it has been stabilized, using the energy of the one modified..

Fig15

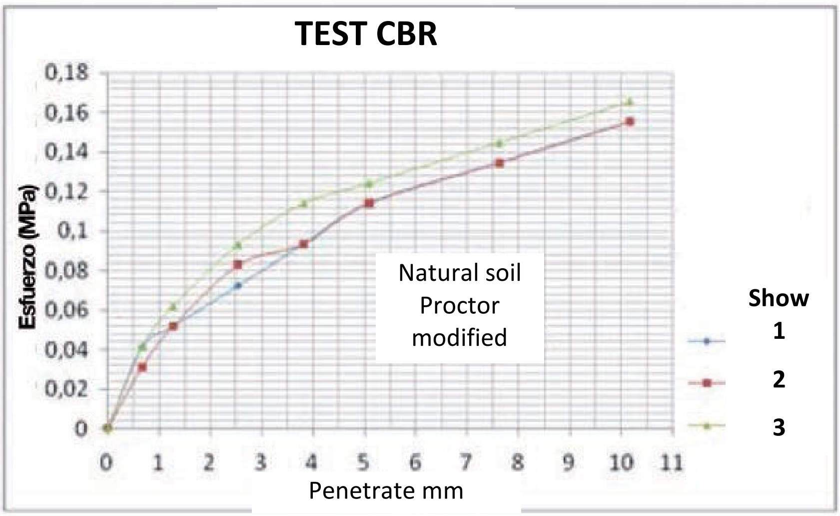
Test CBR natural soil Proctor standard



Sample	1	2	3
Indice CBR (2,54)	0,87	0,43	1,01
Indice CBR (5,08)	0,78	0,68	0,97
Indice CBR	0,87	0,68	1,01

Fig 15.1

Test CBR natural soil Proctor modified



Sample	1	2	3
Indice CBR (2,54)	1,01	1,16	1,30
Indice CBR (5,08)	1,07	1,07	1,17
Indice CBR	1,07	1,16	1,30

B

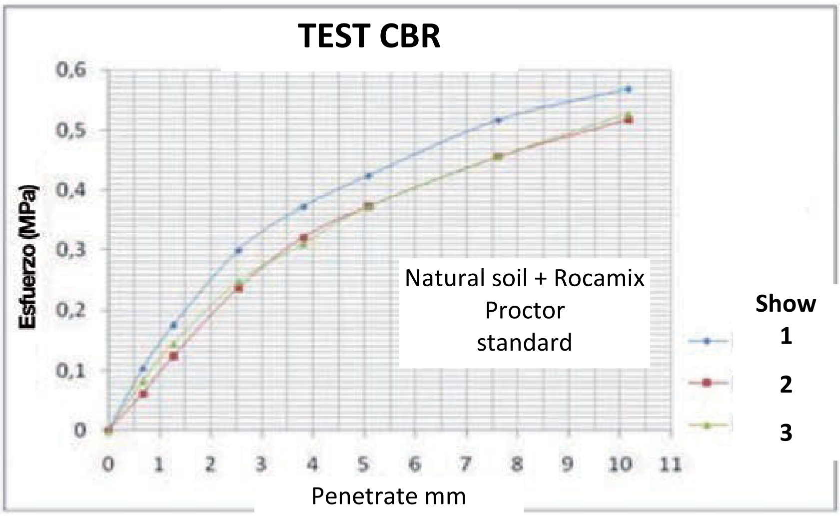


Figure 16

Test CBR
Soil+Rocamix
Proctor Standard

Sample	1	2	3
Indice CBR (2,54)	4,20	3,48	3,62
Indice CBR (5,08)	4,08	3,59	3,59
Indice CBR	4,20	3,59	3,62

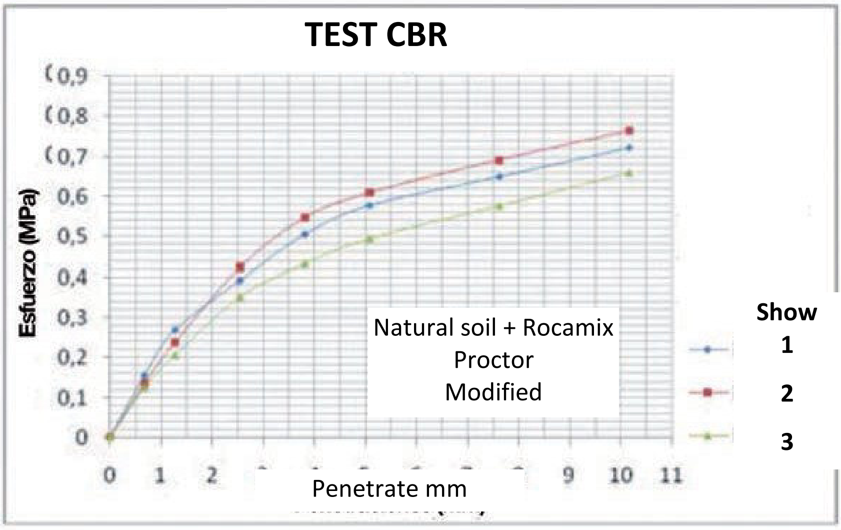


Figure 16.1

Test CBR
Soil+Rocamix
Proctor modified

Sample	1	2	3
Indice CBR (2,54)	5,51	6,23	4,93
Indice CBR (5,08)	5,36	5,92	4,80
Indice CBR	5,51	6,23	4,93

He/she was proven that the addition of Rocamix the floor increases its resistance in an appreciable way and that the applied energy favors these results, in the same way that it happens in other stabilization systems, being observed that in the case of the Stabilization of the one Modified this loamy floor of carrying low capacity as Natural, it ends up reaching a CBR that allows him/her its employment as Sub rasante for highways.

B

Capillary Test

Results of the Tests of Capillary Ascent in floor samples prepared with the miniproctor and compacted with **standard energy** Chart 6

Chart 6

Results of the Test of Capillary Ascension (measured weight in grams)						
Time (hours)	After 7 days		After 14 days		After 28 days	
	Sample 1 natural	Sample 2 + Rocamix	Sample 3 natural	Sample 4 + Rocamix	Sample 5 natural	Sample 6 + Rocamix
1	188,25	146,41	168,52	146,60	160,04	145,93
2	188,25	146,47	174,03	146,62	161,98	146,01
3	188,25	146,51	174,03	146,65	162,30	146,21
4	188,25	146,62	174,03	146,67	162,57	146,87
5	188,25	146,74	174,03	146,70	162,60	146,91
6	188,25	146,84	174,03	146,79	164,42	147,02
7	188,25	147,18	174,03	146,83	169,44	147,17
8	188,25	147,51	174,03	147,18	170,27	147,31
24	188,25	152,54	174,03	152,18	170,27	147,62

The Samples made with the miniproctor applying the energy Standard Proctor that don't contain preservative are saturated immediately and they collapse offering insignificant difference as for the cured one because they collapse finally, to observe that all the samples with preservative offer a bigger resistance to the since capillarity they weigh less..

Results of the Tests of Capillary Ascent in floor samples prepared with the miniproctor and **compacted with energy of the modified proctor** Chart 7

Chart 7

Results of the Test of Capillary Ascension (measured weight in grams)						
Time (hours)	After 7 days		After 14 days		After 28 days	
	Sample 1 natural	Sample 2 + Rocamix	Sample 3 natural	Sample 4 + Rocamix	Sample 5 natural	Sample 6 + Rocamix
1	167,12	167,79	167,97	165,48	146,08	166,10
2	167,38	168,17	168,53	165,98	149,69	166,23
3	167,64	168,23	168,70	166,05	151,22	166,33
4	167,71	168,34	168,80	166,25	151,93	166,65
5	167,75	168,47	168,97	166,61	152,24	166,84
6	167,88	168,66	170,28	166,86	152,31	167,16
7	168,79	168,93	171,37	167,13	152,38	167,34
8	170,26	169,25	172,37	167,60	152,63	167,64
24	178,58	174,79	179,22	174,09	153,35	168,12

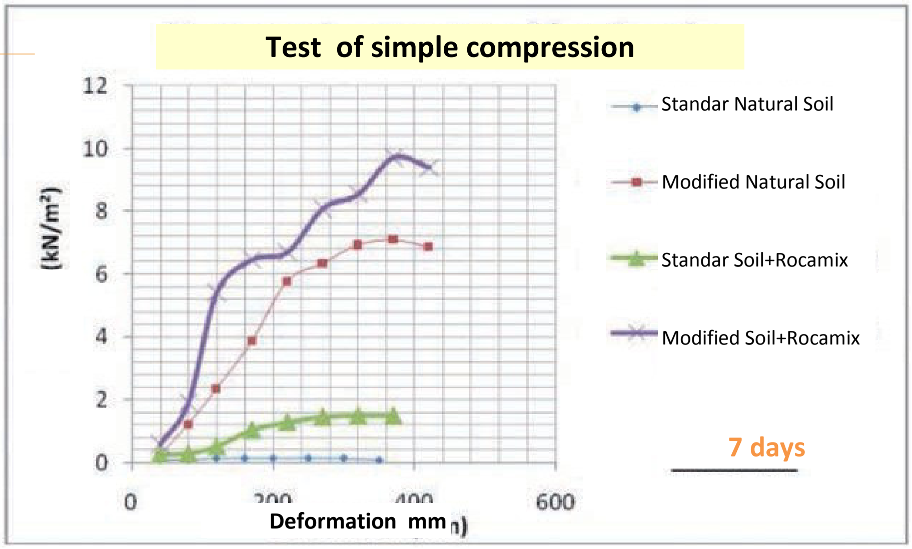
One can observe that the samples with preservative absorb less water than the samples without preservatives, observe that in the case the cured sample to 28 days the results indicate that as the cured one is bigger in time the samples absorb less water and that with the addition of the product pending happiness he/she goes diminishing the samples then with more time of cured they offer bigger resistance to the capillary ascension.

B

3 Results of the Test of Simple Compression (fig 18, 19, 20)

Fig18

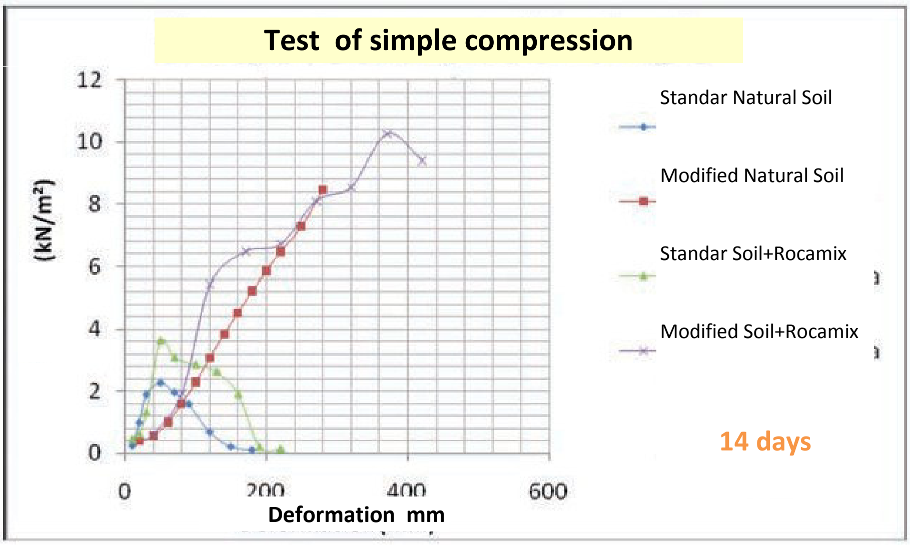
7 days



Test results with and without simple compression Rocamix after 7 days of drying.

Fig 19

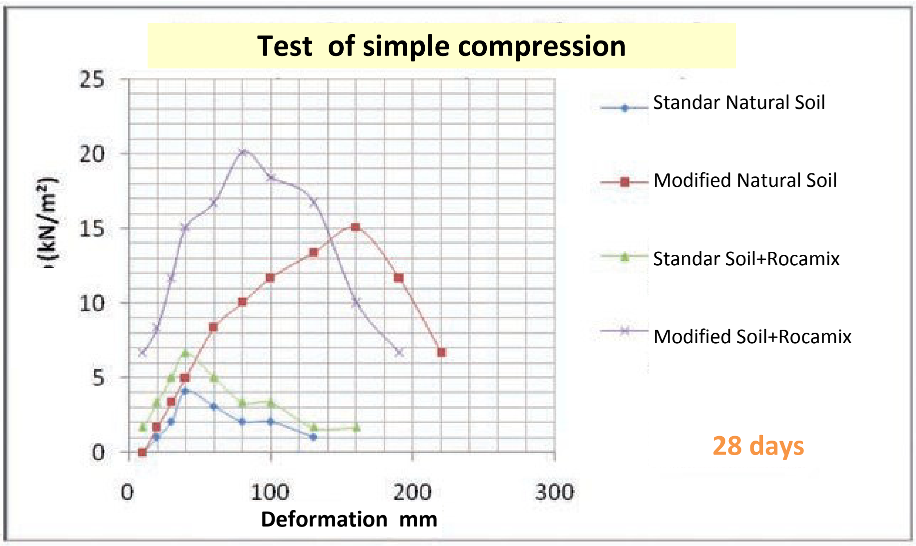
14 days



Test results with and without simple compression Rocamix after 14 days of drying.

Fig 20

28 days



Test results with and without simple compression Rocamix after 28 days of drying.

B

These results show that as we add the preservative Rocamix liquid the floor their resistance it increases to the axial compression and that it becomes also significant in the difference of energies of compaction of the sample, you conclude then:

a) In all the samples increase is observed from the resistance to axial compression with the addition of the product Rocamix liquid.

b) The resistance values to the axial effort increase from 0.5 kN/m2 to 3.8 kN/m2 from 7 to 14 days of cured and up to 7.0 kN/m2 to the 28 days of cured for the standard energy of making of the samples with preservative.

c) The resistance values to the axial effort increase from 9.5 kN/m2 to 10.5 kN/m2 from 7 to 14 days of cured and up to 20kN/m2 to the 28 days of cured for the modified energy of making of the samples with preservative.

d) The resistances increase with the addition of the product between 1.0 kN/m2 and 2.0 kN/m2 for the standard energy and enter 3.0 kN/m2 and 5.0 kN/m2 for the modified energy, the increase is more appreciable for the case of cured of 28 days.

4 Conclusions are accustomed to Formation Via Blanca

1. The floor study object after being properly examined by means of the tests of Grain and hydrometer and indexes of plasticity it classifies as a: SUCS Clay of high compressibility (CH) AASTHO TO-7-6 (20) Clay of high compressibility and high change of volume For what corresponds him/her a dosage corresponding to the manual of 2 cement% + 14.8ml of the product ROCAMIX for 1.0 kg of floor to stabilize.

2. The parameter CBR increases significantly with the addition of the product and with the increase of compaction energy with which the samples are made. This parameter is of great importance for the since design of highways in the projects of making of bases, sub bases and sub rasantes it is one from the conditions of more important design to measure.

3. In a general way the improvements in the properties of the floor with regard to their capillary ascension of a floor stabilized with System ROCAMIX Liquid are evidenced in the decrease of the level of capillary ascension that was measured by weight of the test tubes in this case. As the sample is carried out with more energy of less compaction it ascends the water, the addition of the product it demonstrates that it exists less possibility of capillary ascension and the increase of the time of cured it demonstrates this effect but in less measure.

4. It increases the resistance considerably to the axial compression with the presence of the preservative, it is more significant in this parameter the increase of the time of cured of 7, 14 to 28 days and equally it ascends the resistance with the increase of the compaction energy.

C

Conclusions

Of the studies and carried out analysis we can affirm that it is feasible the employment of the System of Stabilization and waterproofing of floors created starting from quaternary salts of ammonium in the stabilization of floors that you/they will be used in the conformation of the structural package of a flexible pavement. Their cash is demonstrated to be able to in the substantial improvement of the resistance properties and permeability of the fine-loamy floors that in general non capable floors are considered for the construction of flexible and rigid pavements.

The constructive processes and of maintenance of pavements using the proposed system doesn't require of special teams. We have been able to obtain in this study that its employment in two types of different floors allows to obtain parameters of supporting capacity that satisfy its employment as sub rasante of highways according to the Spanish, Cuban Norms and even AASHTO. It is even demonstrated that their employment reduces the Permeability of the floor, that which is very advantageous in the execution of works of vials, since with we can make sure that the future maintenance costs will be smaller. It is necessary to add that this Technology, contributes to be able to develop the protection of the environment, in moments in that the world demand in this sense is every bigger time because it reduces the necessity of use of sources of we lend that they force to carry out voluminous movements of lands that excessively make that the consumption of fuels increases and with the costs logically.

This work that we present is integral part of a Project of Investigation that is developed in Cuba, with a view to consolidating the concept of the advantages of this technique of chemical Stabilization of floors, like part of the efforts that today is carried out in function of the Protection of the environment and the necessity of reducing the costs of the investments, but even starting from the reduction of the consumption of fossil fuels.

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