Properties of clayey soils stabilized by Liquid Ionic Stabilizer

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ABSTRACT: The improvement of soil properties is one of the main branches of geotechnical science that has been considered by researchers in different countries. Fine clayey soils properties due to high swelling, known as a problematic soil that is necessary to improve the geotechnical properties. Pavement subgrade soil stabilization has traditionally relied on chemical additive such as lime, cement, bitumen, and sometimes fly ash. Liquid ionic stabilizer is marketed by some companies as alternative to these conventional soil stabilizers. CBR SUPER 4+ stabilizing anionic soils can improve the load bearing of clayey soils. This stabilizer controls dust and improves its density, permeability, adhesion and compaction and decreases curing time. By the way, the hydrophobic property of this product causes the soil to be less sensitive to moisture, increases efficiency and to better compaction of soil particles by construction machinery. In this study, clay content soils stabilization with CBR SUPER 4+ has been studied along with applying laboratory tests. The results of laboratory studies show that stabilizing of clay content soils with CBR SUPER 4+ improved physical properties and can be as an alternative and economic method in the civil projects.

1 INTRODUCTION

Iran is a country in which we can face different geological events. Therefore, the government spends some parts of its annual budget on controlling these events. Some of these measures includes managing some roads that have expensive clay. When the amount of moisture is increased in this roads, clay swells and the pavement lifts up. In addition, when moisture is decreased the clay shrinks, so some cracks appears on pavement. The incompatibility of mechanical and physical is usually caused by adsorbed water in clay particles. Study on adsorbed water and layers of adsorbed water not only has remarkable academic value but also has some positive effect on safety and stability of roads.

Soil stability is usually done by some materials in forms of powder, such as, lime, cement and fly ash. But field experiences has been shown that treatment of some soils that has so much sulfate with

calcium-based stabilizers such as lime and cement can cause extreme swelling of soil (Kota et al. 1996).

This failures happens when sulfate and free alumina in natural soils react with calcium in the stabilizer and this causes crystalline minerals that has so much expansion (Rauch et al. 2002).

In recent years experts used some new types of soil stabilizer which are suitable and economical under the title of liquid soil stabilizers and good for treatment of clayey soils. These products with no calcium and without causing to extreme expansion can be used in soil containing Sulfate. Producers and factories actively provide some different kinds of product in the form of liquid soil stabilizers. Scholen provided a list of these products in the form of electrolytes and Enzymes acrylic polymers and mineral pitches (Scholen 1992).

Liquid chemical stabilizers can work in different ways, such as: encapsulation of clay minerals, exchange of interlayer cations, breakdown of clay minerals with expulsion of water from the double layer, interlayer expulsion with subsequent moisture entrapment (Petry & Das 2001).

One form of such products is Ionic Soil Stabilizer (ISS). ISS is a kind of liquid composed of active ions that is suitable for reinforcing of different clay soils where its percent of clay fraction is more that 25% (Dong et al. 2004).

Because ISS has advantages such as low costs, simple structure, use of local materials in project, they are widely used in roads (Xiang et al. 2010).

2 MATERIALS

Sand

Sand which is used in experiments are 0-4. This means that the size of sand particles is between 0 to 4 mm. Its grain size has been shown in Figure 1. Features of sand are: coefficient of uniformity (C_u), coefficient of curvature (C_c). $C_u = 2.74$ and $C_c = 1.54$
According to unified classification the sand called poorly-graded (SP).

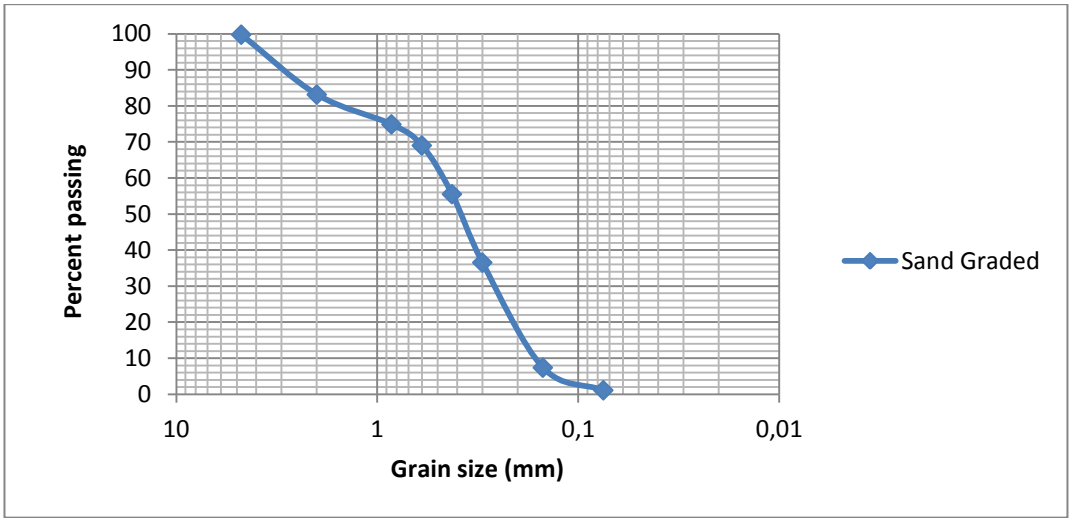


Figure 1: Grading Diagram of Sand

Clay

Required clay is available from northern area of Iran, Region of Rasht in Guilan province from 2-3 m depth. After carrying out Atterberg limits test on soil, soil features are determined in this way: Plastic Limit = 32.7, Liquid Limit = 64.4 and its Plasticity Index = 31.7
According to unified classification clay with high plasticity is called (CH).

Ionic Soil Stabilizer (ISS)

ISS is a kind of liquid surfactant composed of active ions. The hydrophilic and hydrophobic group of ISS remarkably can reduce the surface tension of water (xiang 2010).

In this research CBR SUPER 4+ is used as stabilizer. CBR SUPER 4+ is a synthetic thio compound which forms protective, oily layers on the surfaces of soil and clay particles. It reduces ion mobility and ion exchange and simultaneously makes the material hydrophobic by eliminating the adsorption of water.

The result is a soil material that is much less sensitive to moisture, more workable and can be compacted to a better particle-interlock state by equipment and traffic forces. Better particle-interlock means higher internal friction and improved bearing capacity.

3 LABORATORY PROCEDURES

In this research, three kinds of soil for carrying out experiments were considered such as:

Soil A- 0% weight sand + 100% weight clay soil
Soil B- 50% weight sand + 50% weight clay soil
Soil C- 70% weight sand + 30% weight clay soil

Then for easy process, soils are classified according to soil numbers order A, B, C. Standard proctor compaction experiment was used for determining dry unit weight and optimum moisture content.

Then Atterberg limits tests were carried out on soil before treatment and after treatment, and finally unconfined compression tests before and after treatment were carried out too.

CBR SUPER 4+ will further analyze the soil for reactivity with the CBR SUPER 4+ product, to ensure compatibility and determine the correct application or dosage rate for the particular soil to be treated.

All soils are different and react differently with the CBR SUPER 4+. This test ensures the optimum application rate for each soil type and also ensures highest performance possible.

In addition, it was decided that direct shear, CBR, socked CBR, triaxial tests are used.

4 RESULTS AND DISCUSSIONS

Compaction Test

This experiment is carried out based on ASTM D-698 on each three soils combination to obtain percent of optimum moisture content and Dry unit weight. Related diagram to this experiment has been shown in Figure 2.

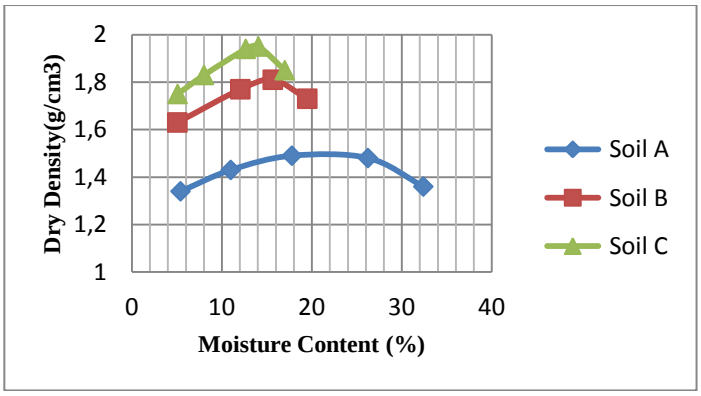


Figure 2: Compaction test results on Soils

Atterberg Limits Test

This experiment is consisting of Plastic Limit (PL) and Liquid Limit (LL) that was carried out on soil before and after treatment based on ASTM D-4318. Plasticity Index related to soil has been shown in Table 1.

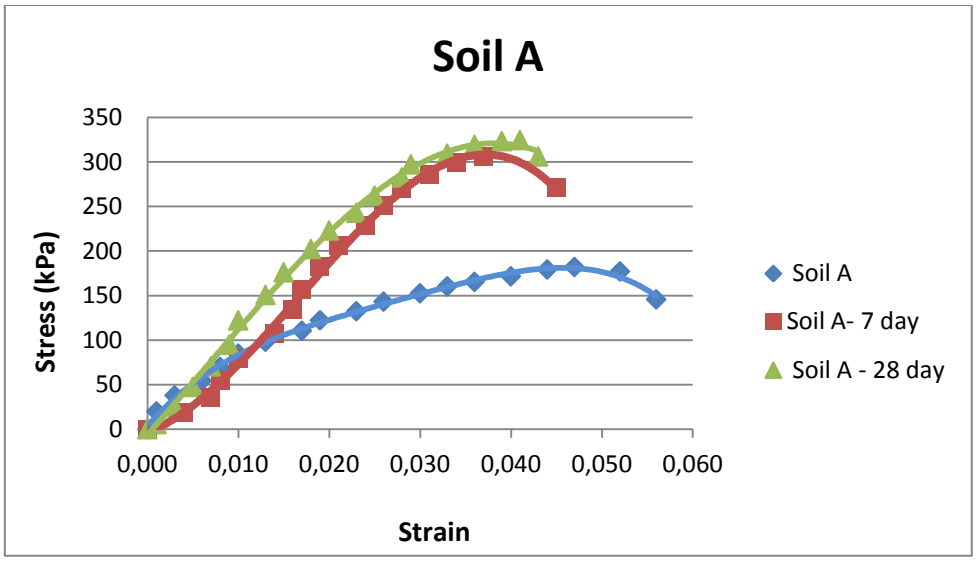
Table 1. Plastic Indexes of the Soils

Soil	Plastic Indexes	
	Before Treatment	After Treatment
A	31.7	24.9
B	16.0	11.5
C	9.1	6.7

As shown in table 1, adding CBR SUPER 4+ to soil causes to decrease PI. Addition of material decreases PI of soil A from 31.7 to 24.9 that shows 21% reduction. This reduction in soils B and C is 28% and 26%. The biggest reduction of PI is in soil B.

Unconfined Compressive Test

This experiment was carried out based on ASTM D-2166. Samples of untreated soils are provided in optimum moisture content and immediately were tested. Samples of treated soils are provided in optimum moisture content and for curing sample it was tested in forms of a 7-day and a 28-day sample. Samples for maintaining moisture were kept in plastic nylon and were curing under the laboratory temperature (20-25 °C). Diagram related to unconfined compressive test in Figure 3 has been shown.



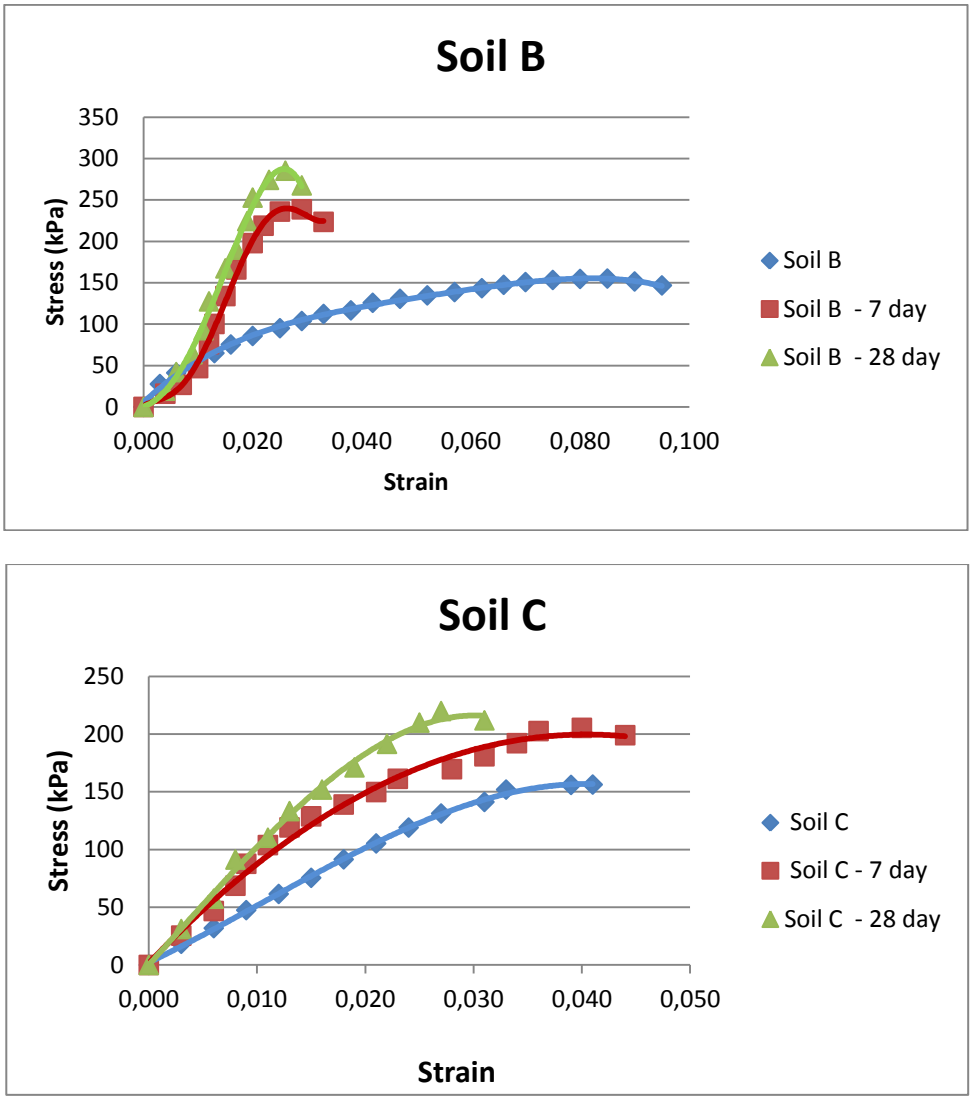


Figure 3: Unconfined Compressive Test Results on Treated and Untreated Soils

Regarding the diagrams in Figure 3, adding of CBR SUPER 4+ causes increasing of unconfined compression strength in soil. In soil A this increase in a 7-day sample is 1.7 times bigger and in a 28-day sample is 1.8 times bigger. In soil B increase in a 7-day sample and a 28-day sample are 1.5 and 1.84 times bigger. And finally in soil C in a 7-day sample and a 28-day sample are 1.32 and 1.42 times. The biggest increase in strength in soil B in a 28-day sample is equal 1.84 times.

5 **CONCLUSIONS**

According to concluded results we can consider CBR SUPER 4+ as stabilizers of clayey soil that causes reduction in PI and also causes increase in unconfined compression strength by 50-100%. The biggest reduction in PI is about 28% and the biggest increase in unconfined compressive strength is 1.84 times.

And finally it is essential to say that laboratory tests never can express natural state in soil. In the roads constructed with these materials, on field tests such as DCP, on field CBR, CPT and etc are recommended, since they are more trustful and reliable than laboratory tests.

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