Experimental Evaluation and Stabilization of Regional Kaolinite Clay and Mineral Soil by Use of Lime and Cement

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Abstract: Soil stabilization is a set of measurements and treatment which apply to soils. The main reason of the measurements is to prepare a soil type which covers the geotechnical engineering necessities like shear resistance, bearing capacity, compressibility, etc.. Stabilization methods are generally limited into mechanical and chemical properties of Kaolinite soil. Actually, the first method is by use of stabilization binding agents and the second one is done via construction machines like rollers and tampers. Generally, civil projects or earth projects are mostly getting along with clay soils. Therefore, a sufficient knowledge about the soil property is needed due to their special behavior beside sufficient stabilization methods. In the research, a comparison between lime and cement stabilization agents via proctor standard test is conducted to evaluate mechanical and chemical stabilization methods encountered clay soil sample with kaolinite mineral from Fars region, Iran.

Key words: Stabilization, lime, cement, chemical stabilization.

1. Introduction

1.1 Stabilization

1.1.1 Definition

Soil stabilization is a set of measurements and treatment which apply to soils. The main reason of the measurements is to achieve a soil which fulfills the engineering necessities in each geotechnical engineering aspects like shear resistance, bearing capacity, compressibility, etc.. In fact, these treatments are using to enhance geotechnical engineering quality of a base or sub base layer in a road way project, earth dams or embankments, instead of removing poor soil which is not only economically sufficient but also impossible for time allocation or time limits in a project [1].

1.1.2 Methods

Nowadays there are so many methods to stabilize soils; but all of the methods are restricted to juts two

main groups which are mechanical and chemical. These two methods are illustrated at the following paragraphs.

1.1.2.1 Mechanical Method

The most common stabilization method is mechanical. The concept of the method is formed by biological (growing plants) and soil compaction approaches [2]. In order to stabilize the soil using the biological method which is a kind of mechanical method, a combination of agricultural and geotechnical engineering is deeply required. The plant roots and leafs (mostly grass with different roots length) act like a binder in order to improve soil shearing resistance at sharp slopes with poor or insufficient soil shear engineering satisfaction (Fig. 1).

Another stabilization method is using compressive property of soils [3] to modify or actually improve soil mechanical features (Fig. 2). The method is normally applies by rollers or rammers [4, 5]. In addition, this approach may be used by adding and mixing some chemical stabilizer agents with grader stabilizer

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Fig. 1 Biological soil stabilization.

which are explained in the following. As a matter of fact, applying gavia forces in order to decrease air part of the three phase soil to prepare and stabilize the problematic soil for required bearing capacity [6, 7].

1.1.2.2 Chemical Method

Due to some elaboration, this method of stabilization requires special engineering supervision. Decision making about mixing design and applicable agent which should be used are the main factors that must be considered in this method [8]. On the other side, agents that called binders are divided in two main groups of hydraulic and non-hydraulic materials. The main stabilization binders are lime, cement and soil.

1.2 Clay Soils as a Problematic Soil

In general, clay soils are special among other kinds of earth soils. The sentence is proved due to their behavior which has been seen in every civil project. Swelling features, drainage system and permeability are a few involved parameters of the clay soil which in some cases are totally different from other soils [9]. On the other words, clay soils existence in our project is a strict engineering calculation governor. Microscopic view of clay is demonstrated using SEM (electron micrograph scanning) and some minerals such as montmorillonite, illite, kaolinite, etc. [10]. are the base part of its structure (Fig. 4). Each of clay

minerals structure shows a special characteristic of the clay soil [11]. Actually, problematic cohesion of the soil

Fig. 2 Mechanical soil stabilization by compaction method.

Fig. 3 Chemical soil stabilization sequence.

Fig. 4 Microscopic view of clay soil minerals.

is because of sudden property changes of clay soils and the afterward process in order to find the right clay mineral in our project [12].

2. Experimental

2.1 Main Goal of the Research

This article is tried to have a comparison between two stabilization agents beside clay soil compaction characteristics. As mentioned before, clay soils are a firm determinant of engineering calculations. So, their behavior knowledge in every situation is crucial. Besides that, the research domain is not only limited to some civil engineering measurements but also involves every angels of engineering calculations that deal with soil parameters.

2.2 Soil Mechanics Laboratory

In this section laboratory apparatus and sampling procedure were taken into account. In this research, both mechanical and chemical soil stabilization methods were used. In order to fulfill mechanical soil stabilization method, proctor standard compaction apparatus was conducted and chemical method was performed using cement and lime beside clay with specially kaolinite mineral features. Lime is more common and has been used in construction activities so far. Lime reaction with kaolinite is shown in Eq. (1) which is a kind of pozzolanic reaction.

Fig. 5 Comparison curves.

Moreover, clay soil sample is from Fars (a province of Iran) soil with PI (plastic Index) = 24, LL (liquid limit) = 41 from liquid and plastic Atterberg limit laboratory test, and lime and cement were sampled from FARS Construction Material Factory which was type two of cement. Agents were mixed in 0, 3, 5, 7 and 9 percent of cement and lime substances. Each agent mixture met five complete proctor standard tests; it means liquid and plastic Atterberg limit tests, totally 25 complete standard proctor tests were performed. Maximum dry density was calculated via the equation bellow:

$$\gamma_d = \frac{\gamma}{1 + \frac{w(\%)}{100}} \quad (2)$$

in which:

γ_d = maximum dry density (kN/m³);

γ = wet density (kN/m³);

$w(\%)$ = optimum moisture content.

After all the tests were performed, results were evaluated and calculated as Table 1 and Fig. 5 that clearly depict a comparison between the stabilization binder agents and clay soil with special kaolinite mineral.

3. Conclusion

The curves and the charts are depicting an interesting comparison between lime and cement binding stabilization agents encounters clay soil with kaolinite mineral (Fig. 5a). As seen from maximum drydensity curve and chart, it shows a light decrease of the curve (Fig. 5b) even for cement and lime in parallel

Table 1 Comparison charts.

MDD (maximum dry density) (kN/m ³)	OMC (optimum moisture content) (%)	Cement (%)
16.34	21.78	0
16.02	21.70	3
15.52	24.04	5
15.06	26.51	7
14.87	26.33	9

MDD (maximum dry density) (kN/m ³)	OMC (optimum moisture content) (%)	Lime (%)
16.34	21.78	0
15.23	25.37	3
15.14	26.16	5
14.75	27.01	7
14.44	28.50	9

with increase of stabilization agent. In addition, a dramatic constant rate of maximum dry density is seen approximately from 3.5 to 5 stabilization agent percent of lime. As a result, compaction performance energy is generally increasing. On the other side, increasing rate is started from initial stage of the optimum moisture content that is concluded, the more stabilization agent added, the more optimum moisture content is required.

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