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Investigation the Effect of Freezing-Thawing cycles on Quick Lime Stabilized Soils in Faghire area, Hamedan

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Abstract

The purpose of this research is investigation the effect of lime on the residual soils in the southern area of the Faghireh village of southern Hamadan. The study area is located in the mountain range of Alvand and Kyvarstan in south of Hamadan. The topography of the region is hilly and formed from the weathered units. To investigate of lime effect on studied soils, maximum dry unit weight, optimum water content, pH and uniaxial compressive strength of stabilized soils with different percentages of lime was determined. The results show that increasing lime percentage and curing time, increases optimum water content and decreases maximum dry unit weight, and also improved the resistance properties of stabilized soil.
According to the results, optimum lime percentages were 5% and 7%, and the curing time for the stabilized soils in the Faghireh area of Hamedan were obtained for 28 days. Then, the effects of freez-thaw cycles were investigated by using uniaxial compressive strength tests, direct shear, weight loss due to freezing and determining the swelling of samples.
The results show a reduction in uniaxial compressive strength in freez-thow cycles. Also, the cohesion of the samples are decreased and the internal friction angle of the samples are increased, and the weight loss and swelling due to the freezing of the stabilized samples are less than the base soil.

Key words: *Soil cohesion, soil internal friction angle, swelling, weight loss, curing time.*

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Extended Abstract:

1. Introuduction

To Improve of engineering characteristics of soils, various techniques are used that each one has special technical and economic features. Regarding to this features, the use of lime has long been considered. Adding lime to soil causes interactions that in some aspects of geotechnical engineering will actually improve the quality and characteristics of the soil (Bell, 1996).

Cold weather and freezing-thawing cycles are important issues in engineering. The freezing-thawing cycles, that is, the presence of water and ice in porosity of soils that can be created in thermodynamic conditions at temperatures below zero degrees, change the engineering characteristics of soils(Ghazavi and Roustaei, 2013).

Swelling by freezing, causes an increase in the total volume of the soil and the thawing, which increases porosity, increases moisture content and finally decreases soil strengt. When the soil and lime are combined and exposed to freezing-thawing cycles, these cycles reduce compressive strength. Also, with increasing curing time, the soil particles do not tend to absorb water and then, the percentage of compressive strength of the samples is reduced (Yıldız and Sogancı, 2012).

2. Material and Mothods

To conduct this research, after investigating the geological map of the area, the field study and sampling was carried out. Various experiments in the laboratory were carried out including water content, specific gravity, standard proctor compaction, the Atterberg limits, calcimetry tests, uniaxial compressive strength test and direct shear test in CU conditions on the base soil. The soil samples of the studied area are located in the CL, SM, and SC classes at USCS classification.

To determine the optimum amount of quick lime in the soils of the studied area, two methods of compressive strength and pH were used. Regarding to the results of these methods, for stations 1 and 3, the optimum amount of quick lime was 5% and for stations 2 and 5, the optimum amount of quick lime was 7%, and due to the lack of mixing with lime, the soil of station 4 were eliminated from the experiments.

Remolded samples from each station were stored in a nylon bag until the 28-day curing times. Each sample was then placed in a freezer at -20 ° C and then 6 hours at + 20 ° C according to the freezing-thawing cycle's standard (Ghazavi and Roustaei, 2013) and then was tested.

3. Results and discussion

3.1 Soil stabilization results

3.1.1 Uniaxial Compressive strength of stabilized soils

The results of uniaxial compressive strength tests show that the compressive strength and elasticity modulus of stabilized soil were increased with adding quick lime to the optimum quick lime content and increasing of curing time, which can be attributed to the progression of Pozzolanic reactions.

In order to obtain suitable relationships for determination of uniaxial compressive strength for the stabilized soil samples with different percentages of quick lime (L%) and different curing time (D), linear multiple regression were used using Minitab17.0 software. Regarding that, the following relationships were obtained.

For station 1 of studied area:

$$UCS = 89.79 + 8.25\ L + 6.973\ D \quad (1)$$

$$\omega\ (\%) = 13.675 + 0.4442\ L + 0.14683\ D \quad (2)$$

$$\gamma_d = 1.89870 - 0.01442\ L - 0.003922\ D \quad (3)$$

For station 2 of studied area:

$$UCS = 121.8 + 16.41\ L + 12.748\ D \quad (4)$$

$$\omega\ (\%) = 17.833 + 0.4942\ L + 0.17563\ D \quad (5)$$

$$\gamma_d = 1.69587 - 0.014042\ L - 0.002349\ D \quad (6)$$

For station 3 of studied area:

$$UCS = 99.6 + 15.14\ L + 8.26\ D \quad (7)$$

$$\omega\ (\%) = 16.412 + 0.4500\ L + 0.16655\ D \quad (8)$$

$$\gamma_d = 1.82684 - 0.01367\ L - 0.002271\ D \quad (9)$$

For station 5 of studied area:

$$UCS = 129.0 + 14.80\ L + 8.909\ D \quad (10)$$

$$\omega\ (\%) = 18.338 + 0.3475\ L + 0.16441\ D \quad (11)$$

$$\gamma_d = 1.83143 - 0.011225\ L - 0.002619\ D \quad (12)$$

which, UCS is Uniaxial Compressive Strength in term of kPa, ω is percentage of optimum water content and γ_d is maximum dry unit weight in term of gr/cm^3.

It should be noted that the provided relationships for all stations in the studied area are valid up to 28-days curing time and for quick lime percentage, optimal lime amount should be considered for each station. In this regards, the relationships provided for stations 1 and 3 are valid for an optimum quick lime amount range of up to 5% and for stations 2 and 5 are valid for a range of optimum quick lime amounts up to 7%.

3.1.2 pH results

By using the pH meter device, the pH of the soil extracts is measured. The optimum amount of lime in this method is the percentage of lime, in which the pH of the soil extracts reaches up to 12.4. In this paper, the optimum amount of quick lime obtained from pH results was similar to the other test results.

3.2 Freezing-thawing cycles test results

3.2.1 Uniaxial Compressive strength of stabilized soils under the freezing-thawing cycles test

Based on uniaxial compressive strength test results of stabilized soils under the freezing-thawing cycles test, the compressive strength was decreased. This decreasing was obvious in the first cycles of freezing-thawing test and then the strength was increased, which can be due to the recovery of strength after thawing in a few initial cycles. Finally, the strength was decreased again, which can be due to the formation of micro fractures in the soil samples.

3.2.2 Direct shear test of stabilized soils under the freezing-thawing cycles test

The results of direct shear test on stabilized soils under the freezing-thawing cycles test show that the angle of internal friction of soils was increased and the cohesion of stabilize soils was decreased.

3.3.3 Free swelling due to freezing-thawing cycles test

The free swelling of stabilized soils in the freezing-thawing cycles test was lower than the base soil. The important effect of lime on soil was increasing efficiency, reducing soil swelling and soil shrinkage.

4. Conclusion

By adding a percentage of quick lime, samples from stations 1 and 3 with 5% of lime reached to the peak strength. At stations 2 and 5, samples with 7% of quick lime reached to the peak strength. Generally, uniaxial compressive strength of stabilized soils under the freezing-thawing cycles test was decreased. The results of freezing-thawing cycles test on basic and stabilized soil samples showed a decrease in cohesion and an increase in the internal friction angle of soils. The free swelling of stabilized soil in freezing-thawing cycles test was lower than the free swelling in the basic soil (unstabilized soils).

The percentages of weight loss in the stabilized soil samples under freezing-thawing cycles test was lower than the basic soils which indicates the optimal effect of quick lime stabilization on soil strength.

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