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Comparing the Influence of Kinds of Lime on Time and Swelling Pressure of Bentonite

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1- Introduction

Expansive soils are soils that expand in volume due to increase in moisture. One of the most effective methods for reducing the swelling characteristics of clayey soils is use of lime in the soil. Despite the fact that many research studies have been done on this subject for a long time in the past, it is still of interest to many researchers in the world. Lime mainly consists of Calcium Oxide (CaO) or quick lime and Calcium hydroxide [Ca(OH)2] or hydrated lime. When at least 3 % of lime is mixed in clayey soils in the presence of water, the pH of soil increases to 12.4 and in this condition silicates (SiO2) and aluminates (Al2O3) are detached from the clay minerals into soil water solution. These species then react with Calcium cation from the lime and as a result hydrated Calcium silicate (CSH) and hydrated Calcium aluminates (CAH) are formed which are then hardened with time and cause cementation between clay particles. The amount of 3 to 8 % lime in terms of dry weight of soil is the proper amount for stabilization of expansive soil. However, determination of the least amount of lime necessary for pozollanic reaction to begin in soil depends on the quality of lime, temperature and the volume of water present.

2-Materials

Bentonite used in this research was obtained from Kashan Doreen Co. Its index properties are given in Table 1.

Industrial and traditional limes used were obtained from Lorestan and Haftkel, respectively.

Table 1 Characteristics of Bentonite

8	W (%)	ASTM
79	CF (%)	D422-63
2.65	G_s	D854
25	SL (%)	D4318
36	PL (%)	D4318
155	LL (%)	D4318
119	PI (%)	D4318
1.5	A	D4318
CH	Class	D2488-06

3.Tests

In this research three groups of test were performed:

1-Index tests consisted of Atterberg limits and standard Proctor compaction ASTM D698.

2- Constant volume swelling pressure tests according to ASTM 4546

3-Unloading tests using stress and strain controlled methods

Three groups of samples were prepared for testing

-Untreated soil samples

- Soil samples wet mixed with both hydrated industrial (IL) and traditional (TL) lime with 0,1,7,28 and 90 days of curing period
- Soil samples dry mixed with both quick IL and TL with 0,1,7,28 and 90 days of curing period.

Constant Volume Swelling Pressure – Unloading test. In constant volume swelling pressure test the objective is to find the highest pressure required to maintain the initial height of the sample after inundation. In this method after the soil sample is placed into oedometer and water is added surcharge loads are added in stages in order to maintain the initial height of the sample until ultimate swelling pressure is reached. In this method small surcharge load of about 10 kPa is applied to the sample until compression in the sample occurs (due to air removal), immediately after completion of compression, soil sample begins to swell upon water absorption. Swelling of the sample is allowed until the initial volume (initial height of sample) is reached. At this time, the next surcharge load is added (about 10 kPa) to the sample. The process is repeated until the ultimate swelling pressure is reached. This ultimate swelling pressure is called swelling pressure. After completion of constant volume swelling pressure measurement, in order to obtain swelling index of the soil sample, the sample is unloaded. For all samples tested unloading was performed using both stress and strain controlled method.

4. Test Results

According to Atterberg limits test, all samples had high swelling potential. Liquid limit for treated soil with IL and TL quick lime was increased as compared to untreated soil. The reason for that could be the tendency of quick lime to absorb water.

Compaction curves for all treated soil samples with all four kinds of lime were lower than that for

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untreated soil (lower max. dry density) and shifted to the right (higher optimum water content) as shown in Fig.1. Addition of lime (all 4 types of lime) to bentonite soil caused a decrease in swelling pressure as shown in F. In fact addition of lime to the soil causes increase in calcium ion in the soil that replaces sodium and potassium ions in the clay and those replaced cations have lesser tendency to absorbed water and cause improvement in the plastic properties and decrease in swelling pressure of soil. For treated soil samples with increase in curing period, the amount of swelling pressure and the time to reach primary swelling pressure decreased. This means that treated soil samples in comparison to untreated soil showed faster rate of swelling pressure development with time. This could be due to increase in the permeability of samples as the result of flocculation of soil particles in the presence of calcium cation. Hardening of soil with curing period could be another reason for faster rate of swelling pressure development with time with increase in curing period.

5- Conclusion

1- Both quick lime (IL and TL) showed better behavior in decreasing of swelling pressure. Most decrease in swelling pressure was for traditional quick lime sample with 90 days of curing period.

2- The increase in curing period for all four types of lime caused decrease in swelling pressure.

3- Addition of all four lime to soil caused a decrease in $C_{\alpha ps}$

4- Addition of all four lime caused decrease in $C_{sstrain}$ and $C_{sstress}$

5- According to test results obtained, the addition of quick lime with high percentage of CaO and with 28 days of curing is most economical and better behavior in lowering the swelling pressure and swelling index.

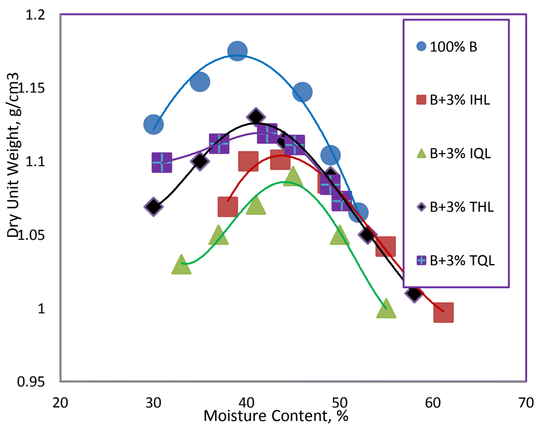

Fig. 1 Compaction Curves for Different Samples.

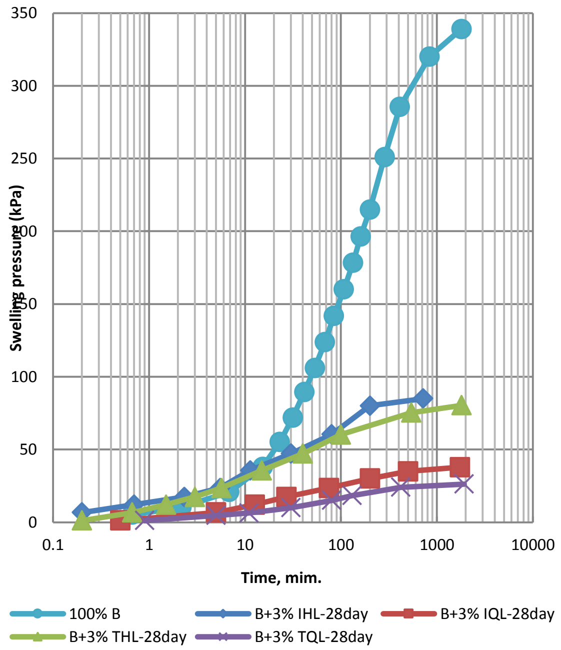

Fig. 2 Time Rate of Swelling Pressure Development for Different Samples