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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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## 4-The Effect of the Distance between Core and Casing on the Behavior of Concrete Frame Reinforced with Buckling Restrained Brace

In order to investigate the effects of changing of the parameter of the distance between core and steel casing on the behavior of concrete frame reinforced with buckling-restrained brace, models having the distance parameters of 1, 2, 3, and 4 mm and model without distance have been prepared and analyzed for which the obtained results are presented. For examining the behavior of the finite element models, nonlinear static analysis under increasing lateral load has been used. The loading is gradually applied to the structure, starting from zero, and it increases to an extent until the structure reaches the stage of collapsing. The analysis results are shown in Figure 4.

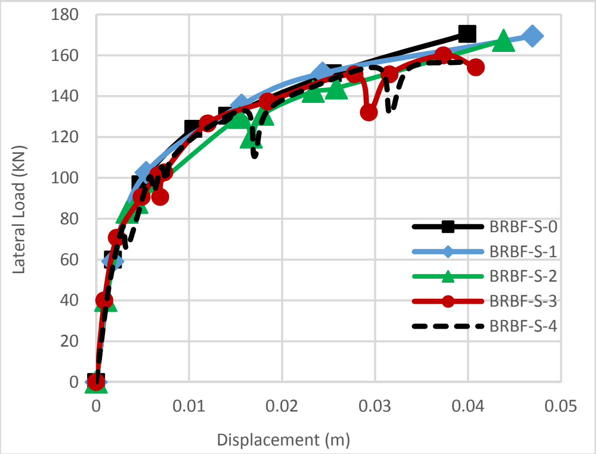

**Fig 4. Load-displacement curve of frame models reinforced by buckling-restrained brace having distance between core and casing**

**Table 1. Analysis results of models having distance between core and casing**

| Model Name | Distance between core and casing | Pu (KN) | δu (m) | E (KN.m) |
|---|---|---|---|---|
| BRBF-S-0 | 0 | 170 | 0.04 | 5.43 |
| BRBF-S-1 | 1 | 171 | 0.044 | 6.06 |
| BRBF-S-2 | 2 | 167 | 0.043 | 5/5 |
| BRBF-S-3 | 3 | 154 | 0.041 | 5/2 |
| BRBF -S-4 | 4 | 157 | 0.04 | 4/65 |

Table 1 represents the amount of deformation, strength, and energy dissipation of models with different distances between core and casing.

## 5- Conclusion

The amount of energy dissipation by the structure has a direct relation with the number of buckling half waves and consequently, the number of core-to-casing contacts. Thus, the more the number of contacts, the greater is the amount of energy absorption by the structure.

The less the distance between core and casing, the more the core-to-casing number of contacts. However, greater displacements are required for the formation of half-waves as the distance between core and casing increases. Therefore, because of the lack of contacting of core to the casing in some displacements, the structure energy dissipation drops down and remains until contacting of the core with the casing.

In the case of no space between core and casing (S=0), it is reduced from the structure lateral deformation.

At the distances of 1 to 2 mm between core and steel casing, the core is of the best behavior in terms of ductility and it has the maximum number of buckling half-waves, which lead to more energy absorption, itself. Moreover, by increasing the distance between core and casing, the number of vibrations is reduced and it is reduced from energy absorption by the brace.