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# Effect of Cationic exchange Capacity of Soil on Strength of Stabilized Soil

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**Abstract**

Consumption of Ca and OH in soil may cause the pore solution in the stabilized soil $Ca(OH)_2$ unsaturated, and thus reduces the amount of cementious hydrates generated by the cement hydration, which impedes strength growth of the stabilized soil. It is not clear that what kinds of factors have influence on $Ca(OH)_2$ saturation in the stabilized soil. In this research, a set of soil samples with different cationic exchange capacity were selected, stabilized soil specimens are prepared by mixing the soil samples with different proportions of cement and $Ca(OH)_2$. The influence of soil cationic exchange capacity on the strength of the stabilized soil are investigated by means of measuring the concentrations of main ions in the pore solutions squeezed from the stabilized soil specimens and the strength of the stabilized soil. It is revealed that: cationic exchange of the soil samples depresses the $Ca(OH)_2$ saturation of the stabilized soil. When the cationic exchange capacity of the soil samples is high enough, the $Ca(OH)_2$ concentration of the pore solution in the stabilized soil cannot get saturated, under these conditions, further cationic exchange depletes $Ca^{2+}$, $OH^-$ which shall be used to generate calcium silicate hydrate, so the amount of calcium silicate hydrate decreases, which results in the poor strength of the stabilized soil.


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*Keywords:* Stabilized Soil, Soil Strength, Cationic Exchange Capacity, Pore Solution, Ionic Concentration.

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## Introduction

Using silicate cement series to treat soft soil foundation is a very widely used foundation reinforcement techniques. However, different with concrete, using the same cement to stabilize soils with similar physical and mechanical properties, the strength of the stabilized soil varies greatly. Even some soils with better physical and mechanical properties obtain less soil strength than those with poor properties. It is difficult to design mixing ratio of stabilized soil in engineering application. Therefore, acquisition of factors other than physical and mechanical properties is significant to engineering practice.

Reference [16] claims that cement and soil mixing, cement hydration produces calcium hydroxide (CH), calcium silicate hydrate (CSH) and other hydrates. Clay absorbs CH until saturation, and then pozzolanic reaction and physical improvement takes place between CH and clay. Effect of hydration and hardening of cement is not affected by clay and CH reaction, but controlled by pozzolanic reaction ability of clay and CH. This theory cannot explain the phenomenon that the same amount of cement cannot get same strength. It is reported that, in clay minerals, hydration of cement can be normally carried out. CH consumption of kaolinite, illite, is kind of small, so the strength of cement soil is high. CH consumption of montmorillonite is kind of large, so the strength of cement soil is reduced. In clay, other cations are adsorbed and exchanged with calcium ion. Therefore, the higher cationic exchange capacity (CEC) is, the lower strength of cement soil will be, and vice versa. Organic matter in the soil has the stronger adsorption ability about calcium ion. When the absorption is greater than a certain value, the cement soil cannot achieve a satisfied strength. Presence of soluble salt in soil has a great influence on the strength of cement soil. That study noticed that there is relationship between this phenomenon and the strength of stabilized soil. Reference [12] claims that, in the cement soil, CH is unsaturated usually. In this condition, further absorption of CaO, $Ca^{2+}$, and $OH^{-}$ leads to reducing of formation of cementation of hydrate like CSH. As a result, cement with same properties and amount produces different amount of hydrates, which means different strength of stabilized soil. However, it hasn't told exactly that what factors affects CH saturation of soil and then affects soil strength.

This study selected several groups of soils with similar physical properties but different soil CEC. Add different proportion of cement and CH to prepare stabilized soil. Attempt to analyze the effect of soil CEC on the strength of stabilized soil through the determination of relationship between pore solution ion concentration and the strength of stabilized soil.

## Testing materials and methods

**Testing Materials.** This test uses ordinary portland cement 32.5(Jingdu brand, production of Beijing Cement Factory), water, reagent grade calcium hydroxide (production of Beijing Yili Fine Chemical Products Co., Ltd.). The soil samples are kaolin (GT), Sodium montmorillonite (NT) and artificially screened silty soils (FT). All of them are production of the Beijing Chemical Plant Second Factory. Soil specimens are NT1, NT2, NT3, NT4 and GT, which are prepared according to proportion shown in Table 1.The physical and chemical properties are shown in Table 1, which indicates that the soil specimens have similar density and porosity. In Table 1, the pH value and cationic exchange capacity CEC are measured by the China University of Geosciences Chemical Testing Center, and the testing method is referenced to Reference [13].

Table 1 Proportion and Properties

| Specimens | Proportion | | | Physical Properties | | | | pH | CEC mmol/kg |
|---|---|---|---|---|---|---|---|---|---|
| | GT | NT | FT | ρ/g.cm-3 | w/% | n/% | Ip | | |
| NT1 | 0 | 87.5 | 12.5 | 1.53 | 92.50 | 52.15 | 61.11 | 6.9 | 86 |
| NT2 | 30 | 60.0 | 10.0 | 1.54 | 81.00 | 52.38 | 53.68 | 6.9 | 65 |
| NT3 | 50 | 42.5 | 7.5 | 1.55 | 72.50 | 53.05 | 50.15 | 6.9 | 48 |
| NT4 | 70 | 24.5 | 5.5 | 1.57 | 60.00 | 53.49 | 46.76 | 6.9 | 32 |
| GT | 100 | 0 | 0 | 1.52 | 52.50 | 50.50 | 33.06 | 6.9 | 4 |