Effect of Sodium Silicate on The Unconfined Compressive Strength of Crushed Concrete

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Abstract. Various building infrastructure projects worldwide have resulted in a significant rise in the production of waste materials such as concrete, fly ash, plastic, rice husk, foundry sand, and other materials, raising disposal issues. Crushed concrete is abundant and comes from the removal of old buildings as well as waste concrete from new construction. As a result, construction waste recycling is essential, both in reducing the amount of open land needed for landfilling and environmental protection by resource conservation. The research's main objective is to study the effect of adding sodium silicate on the cohesion strength of crushed concrete and its behavior. The concrete cubes are grinded with a hammer to get crushed concrete which passing sieve no.4. The results show that the cohesion strength increase as a percentage of sodium silicate increase (addition 6% Sodium silicate show the higher strength where the strength increased at 10 days by 246% and at 14 days by 250% as compared with strength at 5 days) and the cohesion between crushed concrete particles increase until 8% sodium silicate the cohesion began to decrease (10% same cohesion at 2%). As well, the cohesion strength increase when curing time increase.

Keywords: Soil stabilization; sodium silicate; crushed concrete; and unconfined compressive strength.

1. Introduction
There are hundreds of thousands of tons of concrete blocks used as security fences in Iraq that are now considered waste after being removed, so it’s necessary to take an interest in recycling these materials for use in improving Iraq’s soft soils throughout the country [1]. The self-cementing properties of crushed concrete layers recycled from old demolished structures [2]. Soft clayey soils were stabilized by mixing with 5-15 percent crushed concrete measured by soil weight [1]. The study found that crushed concrete aggregates would increase soft soils' bearing capacity by rehydrating the remaining unhydrated cement in the cement mortar, causing soil particles to self-cement. The addition of crushed concrete to soft soil improves soil cohesion, decreases soil compression and swelling, and reduces fine particles in the soil. Haut et al. [3] The effectiveness of various percentages of Ordinary Portland Cement, like 0%, 40%, and 50% as a conventional binder, sodium silicate, including 0%, 1%, 2.5%, and 5.0% sodium silicate as chemical binders, and kaolinite, including 0%, 30%, and 40% on peat stabilization and shear strength testing under unconsolidated undrained (UU) condition, kaolinite was used as filler. The findings showed that 2.5 % sodium silicate had the highest shear strength, and 50% cement had the highest strength value.
However, the effective dosage has yet to be calculated because the strength gain from 0% to 40% is better than 40% to 50%. The shear strength increased as the percentage of kaolinite increased. As compared to kaolinite and sodium silicate, Ordinary Portland Cement provides a better strength benefit. Kaolinite's purpose is to serve as a pozzolanic material for cement and to bind with peat. The active dose of sodium silicate added to the peat significantly improves the undrained shear strength.

Ransinchung et al. [4] The effectiveness of fines collected from demolished concrete slabs as a soil stabilizer was tested. Shabzi Mandi in Roorkee provided the demolished concrete slabs. Besides FDCS, ordinary Portland cement 43 grade was chosen as a base stabilizer so that the effects of FDCS admixed soil could be compared to those of ordinary Portland cement 43 grade. According to IS: 1498 classification, the clayey soil used in this study belongs to the CI soil group. In equal increments of 3% to 15%, separate cement and FDCS were mixed with clayey soil. As cement and FDCS were mixed together, the dry densities and plasticity indices decreased. When FDCS is added to the mix, the soaked CBR value, unconfined compressive strength, and split-tensile strength increase. The effect of mixing limes and sodium silicate on shear strength was investigated [5]. CBR and other soil properties. The study aimed to reduce the cost of bitumen by using surface layer stabilizers. Highly plastic light brown silt clay from south of Kark/Jordan was obtained for the study. Direct shear, free swell, Atterberg limit, and CBR tests were used. The research's main findings can be summarized as follows:

- The maximum dry density has been increased by using 4% lime and 2.5% sodium silicate.
- As the lime concentration rises to 4%, shear strength increases as well.
- As the concentration of sodium silicate rises, so does the shear strength.
- The CBR improved when the soil was treated with lime and sodium silicate at a ratio of 6% lime to 2.5 molar sodium silicate.

Soft clay soil can be improved by adding small percentages of sodium silicate (by weight), which leads to better building material and an improvement in many of the soil's engineering properties. Moayedi studied the effect of adding 3 different molarities; 1, 3, and 5 mol/L sodium silicate on kaolinite compressive strength treated kaolinite measured in unconfined compressive strength machine at 1, 7, 14 days. As a result, adding 3 or 5 mol/L caused fairly similar UCS, temperature and curing time had a significant effect on the amount of strength developed, and sodium silicate is still one of the best secondary additives for increasing pH and creating a suitable environment for other stabilizers such as cement and lime [6].

2. Material and methods

2.1 Crushed concrete
Waste concrete cubes were milled after being tested in a concrete testing laboratory (compressive strength of concrete mix) and sieved with sieve number 4 to produce relatively fine aggregates. Figure 1 shows crushed concrete.

2.2 Sodium silicate
In this experiment, liquid sodium silicate (water glass) was used, as shown in Figure 2. Table 1 lists the properties of sodium silicate.

![Figure 1. Crushed concrete.](image)
3. Test procedure
The tests were carried out in cubes with dimensions of 50×50×50 mm³. Figure 3 shows the preparation of samples. Cubes of crushed concrete and sodium silicate were prepared as follows.

- The concrete was first crushed with a hammer to small sizes and then sieved.
- Mold was coated with grease oil.
- After mixing with different percentages of sodium silicate (2%, 4%, 6%, 8%, and 10%) by weight. The mixture was placed in layers inside the mold, and each layer was tamped.
- After the completion of the preparation of the cubes of the sample, it was covered tightly with nylon sheets and left for (3, 5, 10, and 14 days) as curing period.
- Finally, the strength of the samples is determined through unconfined compressive strength test.
4. Results

Figures 4 and 5 show the effect of adding a different percentage of sodium silicate on the cohesion strength of crushed concrete, and the effect of curing time on the action of crushed concrete is also significant. The strength is at its highest after 14 days of curing, according to the results. It means that using 6% sodium silicate for 10 or 14 days produced approximately the same cohesion strength.

**Figure 4.** Effect of different percentage of sodium silicate on strength of crushed concrete at different curing time.

**Figure 5.** Effect of curing time on compressive strength of crushed concrete with 6% sodium silicate.

5. Conclusion

The following are the main conclusions drawn from this study:

- The cohesion strength of crushed concrete increases as the percentage of sodium silicate increases until it reaches the ultimate strength at 6%.
- After 6%, the cohesion strength decreases as the percentage of sodium silicate increases, and sodium silicate becomes a lubricant rather than a cementing agent.
• The higher cohesion strength was obtained when adding 6% sodium silicate at 14 days, where the strength increased at 10 days by 246% and at 14 days by 250% compared with strength at 5 days.
• When curing time increase the cohesion strength of crushed concrete increase. Between 10 and 14 days the amount of strength gained was significantly influenced by curing time, since it is the most suitable in terms of time, the appropriate time for treatment may be selected at 10 days.

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