Evaluation of the uniaxial compression strength and Atterberg limits of metakaolin-treated sandy clay soil

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Abstract

Improvement of soil as an inescapable an important role in civil engineering projects. Adding some of the additives to the soil has always been considered by geotechnical engineers as one of the effective methods for improving soil behavioral characteristics. In the present study, the effect of adding metakaolin on the soil engineering parameters such as Atterberg and unconfined compressive strength have been investigated. For this purpose, unconfined compressive strength tests were carried out on unpackaged and stabilized 5%, 10%, 15%, 20% and 25% metakaolin soil samples at instant curing times of 7, 14 and 28 days. Also, the Atterberg limits were tested at 5, 15, and 25 at instantaneous curing time. The results show that increasing the percentage of metakaolin increases the LL and PL of the soils. So that the amount of soil loss is less than the upper limit and thus the soil paste has increased. Stabilized samples with 25% metacaolein increased by 1.33 and 1.40 times, respectively, for the LL and PL, respectively. Also, with increasing the percentage of metakaolin and the processing time increases the compressive strength of the SC soil. The highest resistance rate for 25% of metacaolein occurred at 28 days. Also, studying the failure levels and the failure rate of the tested specimens shows that with increasing metacaolein, the failure of the specimens occurs faster after reaching the final strength.

Keywords: *Atterberg Limits, unconfiend compressive strength, SC soil, metacaolein, ground improvement*

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Extended Abstract:

1. Introduction

The use of additives for soil stabilization has always been of interest to researchers. In the meantime, the use of cheap and environmentally friendly additives such as natural pozzolans is important. In recent years, the use of metacaolein has been considered for the synthesis of geopolymers. The results of the synthesis of geopolymers with metalaole and the combination of metakaolin with other materials, such as zeolite, Nano-silica, kaolin, cement materials, etc., show that metakaolin improves physical, chemical and environmental properties and, in general, improves the performance of geopolymers. The result is that the use of material-based geoplolymers such as metakaolin in the manufacture of concrete, mortar and soil improvers will extend to their increased resistance and efficiency (Sudagar et al., 2018; Avent et al., 2018; El-Eswed et al. al., 2017). A review of past studies has shown that the use of cement has been used as an appropriate additive for soil stabilization. In recent years, although the effect of mixing metakaolin and cement on soil stabilization has been limited, but so far, metakaolin alone has not been used to stabilize the soil. In this study, considering the unique properties of metakaolin, the effect of different metakaolin percentages on the results of Atterberg range tests and unconfined compressive strength of sandy clay soils should be investigated.

2. Materials and methods

In this research, sandy clay soil with mixture of clay sand with 52% clay and 48% of sand 161 Firoozkooh has been used. The percentage of the sand passing through the sieve is less than 1. The specific gravity of metakaoilin used in this study is 2.63 gr/cm^3 and its specific surface area is 9169 cm^2/gr. In this study, in order to prepare the sample, the clay and sand were first mixed dry together and then the additive was added to the soil and the mixture was added to the soil in proportion to the dry weight of the soil in various percentages. Further, Atterberg and unconfined compressive strength tests were performed on fixed and unspecified samples according to existing standards.

3. Tests results

By increasing the percentage of metakaolin, the soil PI is first reduced and then increased. In addition, by increasing the percentage of metakaolin, the PL and LL of the samples increase. Stabilized samples with 25% metakaolin with an increase of 1.33 times the PL and 1.4 times the LL caused the most change in the Atterberg volume of the SC soli.

Also, by increasing the percentage of metakaolin up to 25%, the soil resistance increases. At the time of curing, the resistance of non-additive samples reaches 5.5 kg/cm^2 with an increase of 1.84 times to 9.9 kg/cm^2. The reason for this increase in resistance during immediate treatment can be attributed to the change in the physical texture of the soil. In fact, the finer amounts of metakaolin seeds and the higher activity of this additive than the soil, increases the uniaxial resistance of the fixed samples during instantaneous processing. Over time, the resistance of metakaolin stabilized specimens increases substantially. In addition, long term pozzolan reactions between soils and metakaolin as natural pozzolan in the presence of moisture and free lime can lead to the production of calcium silicate hydrates (CSH) and calcium aluminate hydrates (CAH), which itself increases soil resistance.

4. Conclusion

The results of the Atterberg range test showed that by increasing the percentage of metakaolin additive, the PL increased and the PI was initially reduced and then increased. Adding metakaolin to the soil causes physical and chemical changes in the soil. Physical modifications of the addition of metakaolin, such as the increase of fine particulate matter, result in a reduction in soil bulk density, and chemical changes in the addition of metakaolins, such as cationic reactions and clotting, increase the amount of LL. The interaction of the physical and chemical effects of the addition of metakaolin increases the soil's PL.

Uniaxial compressive strength test results show that by increasing the percentage of metakaolin, the uniaxial stength of the samples increases to 2 times. Increasing curing time also increases the resistance of single samples of samples. By increasing the percentage of metakaolin, the effect of processing time increases. Increasing the percentage of metakaolin causes the samples to become brittle and the samples in the constant strain can withstand more stress. Also, studying the failure levels and the failure rate of the tested specimens shows that by increasing the percentage of metakaolin and the time of the rcuring of the samples, the faster the resistivity is achieved after reaching the final strength.

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