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Experimental study on the effect of acid and alkaline rains on geotechnical properties of fine-grained soil

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Abstract

Loess is a kind of collapsible soil that in saturated conditions, its volume will rapidly drop. Iran is one of the countries in which these types of soils are spread. The purpose of this study is to improve the strength parameters of Gorgan loess (North of Iran) using different ratios of geopolymer (a combination of loess and metakaolin). For this purpose, , in addition to conducting index tests, a series of uniaxial compressive strength, Brazilian tensile strength, compressive wave velocity and modified compaction tests have been done. Furthermore, SEM, EDX and XRD tests have been conducted to investigate micro-structural features of non-stabilized and stabilized soils. In the stabilized samples with geopolymer, by increasing the ratio of loess to metakaolin and the curing time (with fix alkaline activator solution), uniaxial compressive strength, tensile strength and compressive wave speed decreases. So that, by increasing curing time, the uniaxial compressive strength of the specimens decreased to 0.83 and the rate of this decrease was greater in the first 7 days. The results of XRD analysis and SEM images show that the dispersed structure of loess soil is altered by the addition of geopolymer and the production of alumina-silicate gel will result in increasing the strength and decreasing the porosity and homogenizing the soil structure.

***Keywords**: Gorgan Loess, Geopolymer, Metakaolin ,SEM, XRD*

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Extended Abstract

1. Introduction

Being considered as a type of collapsible soil, loess soil always has numerous geotechnical issues such as soil settlement and a low bearing capacity. In a dry state, these types of soils have a relatively high resistance, but they lose their resistance to a great extent as soon as water is absorbed and in conditions of near saturation. Reviewing the study literature indicates that despite the extensive research having been done on loess soil stabilization (utilizing cement, lime, Clinker, ammonium sulfate salts, rice husk ash, etc.), few studies been conducted on improving the loess soils found in the city of Gorgan using geopolymers [1 & 2]. Due to the limited number of studies carried out on the geopolymer additive and its effect on loess soil improvement, this matter has been assessed and compared regarding loess soil stabilization in Gorgan.

2. Materials and methods

The type of soil studied in this research is the loess soil found in Gorgan (north of Iran). Intact samples of this soil were prepared based on the ASTM D1587 standard utilizing a Shelby sampler. In this study, samples of geopolymer mortar were prepared by combining Metakaolin with Sodium Hydroxide (NaOH) and Sodium Silicate (Na2SiO3). The main objective of this study is to improve the resistive parameters of the loess soil in Gorgan (north of Iran) using different ratios of geopolymer (a combination of loess and Metakaolin). For this purpose, in this study, in addition to identification experiments, a series of uniaxial compressive strength tests, Brazilian tensile strength, compressional wave velocity and modified density, as well as the SEM, EDX and XRD tests were performed in order to assess the unstabilized and stabilized soil microstructure.

3. Results and Discussion

The results of the uniaxial compressive strength tests indicate that the uniaxial compressive strength of the samples decreased by increasing the curing time and soil to Metakaolin ratio with a constant alkaline activation solution. So that by increasing the curing time, the resistance of samples decreases by 83% and the rate of resistance decrease is higher within the first 7 days. Also, samples with a higher percentage of Metakaolin content become friable.

The results of the tensile strength test on a soil sample stabilized with geopolymer with a 14-day curing time indicated that by increasing the soil to Metakaolin ratio, with a constant alkaline activation solution, the tensile strength of the sample decreased. The sample containing 100% Metakaolin and 0% soil has a tensile strength of 1.30 MPa and the sample containing 100% soil and 0% Metakaolin has a tensile strength of 0.26 MPa. In addition, the results of compressional wave velocity test on soil stabilized by geopolymer with a 14-day curing time indicated that by increasing the soil to Metakaolin ratio, with a constant alkaline activation solution, the compressional wave velocity has decreased by 0.62. Assessing the SEM images indicates that adding geopolymer to loess soil leads to a pozzolanic reaction and the production of calcium hydrate silicates (CSH) and aluminosilicate gel products between the soil particles and the ultimate strength of the soil increases and the porosity of the soil decreases through the formation of a complex structure. Also, the 28-day curing time changes the loess soil structure and makes it more complex compared to an immediate curing time.

4. Conclusion

In this study, the effect of a geopolymer additive on the resistive parameters of the loess soil found in the city of Gorgan (north of Iran) was scrutinized. For this purpose, uniaxial compressive strength tests were performed on loose soil samples that had been stabilized with geopolymer at immediate, 7-day, 14-day and 28-day curing times. Also, tensile strength and compressional wave velocity tests were performed on samples of loess soil that had been stabilized with geopolymer during a 14-day curing time. Also, in order to analyze the causes of the obtained results and to investigate the microstructure of the soil, SEM photography and XRD & EDX analysis were performed on the soil samples. The most significant results are as follows:

- The results of the uniaxial compressive strength tests indicate that the uniaxial compressive strength of the samples decreased by increasing the curing time and soil to Metakaolin ratio with a constant alkaline activation solution.

- The results of the tensile strength test on a soil sample stabilized with geopolymer with a 14-day curing time indicated that by increasing the soil to Metakaolin ratio, with a constant alkaline activation solution, the tensile strength of the sample decreased.

- Also, the results of compressional wave velocity test on soil stabilized by geopolymer with a 14-day curing time indicated that by increasing the soil to Metakaolin ratio, with a constant alkaline activation solution, the compressional wave velocity has decreased by 0.62.

- Assessing the SEM images indicates that adding geopolymer to loess soil leads to a pozzolanic reaction and the production of calcium hydrate silicates (CSH) and aluminosilicate gel products between the soil particles and the ultimate strength of the soil increases and the porosity of the soil decreases through the formation of a complex structure.

References:

Dassekpo, J.B.M., Zha, X., Zhan J., 2017.Synthesis reaction and compressive strength behavior of loess-fly ash based geopolymers for the development of sustainable green materials, 141: 491-500.

Hosseini, S.E., Alizadeh, M.K., Mesbah, A. 2012. Evaluation of Shear Strength Parameters of Amended Loess through Using Common Admixtures in Gorgan, Iran. In: 7th Asian Rock Mechanics Symposium. International Society for Rock Mechanics and Rock Engineering.