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Investigation of engineering characteristics of marly soils treated by lime and nanocomposite (case study: marly soil of Sonqor region)

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Abstract

The presence of marly soils causes various problems in the implementation of engineering projects. Therefore, treatment of these soils, using various types of additives, has become to one of the most important research topics in the field of geotechnics. Hence, this study has been done with aim of investigating the effect of treatment by lime and nanoparticle on the engineering behavior of marly soils located around the Sonqor city. After taking marly soil samples from the study area, the samples were transferred to the laboratory and their physical, chemical and mechanical properties have been investigated before and after stabilization by the lime and nanocomposite additives. Based on the obtained results, the soil plasticity index decreases by increasing lime percentage due to pozzolanic reactions. Also, with increasing lime percentage and curing time, the modulus of elasticity and the uniaxial compressive strength have been increased. The results showed that with increasing the percentage of nanocomposite up to 4%, due to the filling of the soil's pore space by nanocomposite particles, the compressive strength of the soil increases, and after that a decreasing trend is observed as a result of the flocculation of the particles. Finally, it was found that addition of lime has more efficiency in improving the strength properties than the nanocomposite.

Keywords: *Marly soil, Stabilization by lime and nanoparticles, Physical, chemical and mechanical properties*

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Extended Abstract:

1. Introduction

Marl is one of the weak rocks due to its high swelling potential and slaking property. It has a short half-life and in exposed to environmental factors it is rapidly converted to marly soils. Expansive marly soils create various problems in engineering projects such as highway embankments, dams, building foundations and etc. Application of lime or cement, as conventional additives, to soil is considered as an effective stabilization method. In result of the hydration process due to addition of the stabilization agents, agglomeration of particles occurs, and it leads to formation of a soil with coarser particle size distribution, lower plasticity and higher permeability (Lin et al., 2007). Also, in recent years, the use of a variety of nanoparticles in the stabilization of clayey and even sandy soils is growing (Kermani et al., 2018). In the meantime, the nanoparticle of clay due to its small size, high cation exchange capacity and fast and complete reactivity, has become one of the most commonly used nanoparticles in improving engineering properties of clay soils (Calbi-Floody M., 2009). Many studies have been carried out in field of stabilization of clay soils with conventional and nanoparticle additives (e.g. Dang et al., 2016; Garzón et al., 2016; Harichane et al., 2018; Roshan Bakht et al., 2015; Majeed et al., 2014; Khalid et al., 2015; Changizi and Haddad., 2017).

Marly soils are significantly expanded throughout the world, including Iran. In Iran, Kermanshah Province like some other provinces such as Qom, Lorestan, Khuzestan and Hamadan, has a significant distribution of marl deposits. Therefore, in this research, we tried to investigate chemical, physical and mechanical properties of marly soil samples, taken from the Sonqor city (east of Kermanshah province), before and after treatment by lime and nanoparticles with aim of assessing changes in their strength parameters.

2. Materials and methods

Chemical properties including mineralogy, percentages of oxides and purity of calcium carbonate were studied through microscopic studies of thin sections and some experiments such as XRD and XRF. Physical and mechanical properties were also measured for the samples according to standards of American Society for Testing and Materials (ASTM). In the next step, the soil samples were stabilized by different weight percentages of lime and nanocomposite with different curing times (1, 7, 14 and 24 days). Then, the stabilized soil samples were tested to measure their physical and mechanical properties. Finally the effect of each of the additives on the improvement of the soil sample properties was evaluated.

3. Test results

The obtained results indicated that both the additives used in this study have reduced the plasticity index (PI) of the soil samples. But the important point is the greater ability of lime additive to decrease the soil PI compared to the nanocomposite. The addition of lime up to 6% led to a 43% loss in the PI. However, the addition of nanocomposite in its optimum weight percentage (4%) only caused 12.5% loss in the PI. The study of the effects of the additives on the compressive strength of the soil samples also indicates the superiority of lime in increasing the compressive strength (the rate of increase of UCS value is 3.5 and 1.5 for the lime and the nanocomposite additives during 28-days curing time, respectively).

4. Conclusion

Based on the results, with increasing lime percentage, an increasing trend (linear form) was observed in the uniaxial compressive strength (UCS) values of the soil samples. Also, it can be concluded that by increasing weight percentage of lime and curing time, the UCS and the elasticity modulus of the soil samples increase in response to decrease of the soil's plasticity (swelling potential). Also, the results showed that with increasing the weight percentage of nanocomposite up to 4%, UCS values of the soil samples increase and by passing this amount, a decreasing trend is observed. This is due to an increase in the weight percentage of the nanocomposite and the accumulation of that in the soil composition. The results of the experiments showed that the nanocomposite particles due to small size have high specific surface area and show more active reaction with soil particles compared to lime. So that the presence of small amounts of nanocomposite compared to lime, has led to improvement of the soil engineering properties. Whereas, contrary to the use of more lime additive than nanocomposite, the overall lime efficiency in improving the soil properties was higher than that of nanocomposites. Therefore, it is proposed to investigate the effect of different nanoparticles with different weight percentages on the engineering properties of marl and clay soils in the future studies with aim of evaluation of their performance compared to traditional additives such as lime.

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