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EXTENDED ABSTRACT

Investigating the Effect of Zeolite and Rice Husk Ash with Different Clay Minerals on the Behavior of Contaminated Soils

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1. Introduction

Heavy metal contaminants are the most important and most hazardous type of pollution that needs to be studied both environmentally and geotechnically. There are different concentrations of heavy metals in the soils (Zhang et al, 2019). Engineering properties of contaminated soil tend to significantly change due to chemical reactions between the soil mineral particles and the contaminants (Arasan and Yetimoglu 2008). Chu et al. estimated the shear strength parameters of contaminated soil by lead, zinc and cadmium. The direct shear experiment was performed and results indicated that increase of heavy metal concentration increases shear strength and cohesion. Also, the electrical resistivity of soils decreased with the increase in concentration (Chu et al, 2016). Based on the spreading of the heavy metals such as Lead and Zinc in the most parts of China, Li et at. conducted research on lead contaminated soil in these areas. Samples were made in OMC and MDD and cured for 2 days. Obtained results showed that the increase of the concentration decreased the thickness of diffuse double layer (DDL) and particles were in a flocculated micro structure form. Increasing the flocculation, increased the permeability coefficient of samples (Li et al., 2015). In this study, the effects of zeolites and rice husk ash were investigated. It should be noted that the soil mixture was sand with 20% kaolinite and also sand with 20% bentonite. After determining the performance of these two types of clay minerals in contaminated and uncontaminated conditions, 10% of the fine-grained fraction were reduced and the equivalent of 10% of zeolite or rice husk adsorbents were added.

2. Methodology

2.1. Soil and The performed Tests

In this study, 72 consolidated-non-drained triaxial experiments were performed on a mixture of sandy soils with different percentages of kaolinite, bentonite and zeolite and rice husk ash in different concentrations of zinc nitrate. The used sand was a poorly graded (SP) sand (161 Firoozkooh). The characteristics of kaolinite, bentonite and Zeolite, which were prepared from the Iran China clay, Iran Barite and Negin powder of Semnan, respectively, are presented in Table 1. According to the unified soil classification system, kaolinite and Zeolite were clasified CL and bentonite was CH. To prepare contaminated specimens, different concentrations of zinc nitrate were added to the soil. To this purpose, specific amounts of zinc nitrate were dissolved with deionized water (DW) to make solutions with 1000, 2000 and 5000 ppm of concentration to mix with the soil. The reason for choosing this range of contamination is that according to previous research studies, there may be higher amount of contamination encountered in urban or industrial areas (Nasab and Keykha, 2021).

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Table 1. Physical properties of the used fine grains

Soil	Specific Gravity, G_s	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Plasticity index, PI (%)	Classification (USCS)
Zeolite	2.59	48.8	31.5	17.3	CL
Bentonite	2.61	140.3	54.2	86.1	CH
Kaolinite	2.58	40.9	29.8	11.1	CL

3. Results and discussion

In Fig. 1, the ultimate strength changes for the replacement of 10% kaolinite with 10% zeolite in both contaminated and uncontaminated state has shown. The results show that the replacement of zeolite with kaolinite has increased the ultimate strength in both cases rather than soils without adsorbent. Accordingly, by adding zeolite, as well as increasing the adsorption capacity, the ultimate strength also increases. The results show that the average amount of strength in the composition of kaolinite-zeolite sand has increased by about 50% compared to the strength of kaolinite soil without adsorbent in both contaminated and uncontaminated conditions. Fig. 2 shows the ultimate strength changes in both contaminated and uncontaminated states by replacing zeolite with bentonite in a bentonite-containing sand composition. The results show increasing of about 50 to 60% in uncontaminated resistance in bentonite-zeolite composition compared to purely bentonite composition. The heavy metals in sand with bentonite cause a reduction in the thickness of DDL and this leads to the more packing structure and the interlocking of the particles increases. On the other side, with the addition of heavy metals into the sand with kaolinite, Zeolite and Rice husk ash, solutions the particles become more dispersed due to the dissolution of hydrogen bonds between the them.

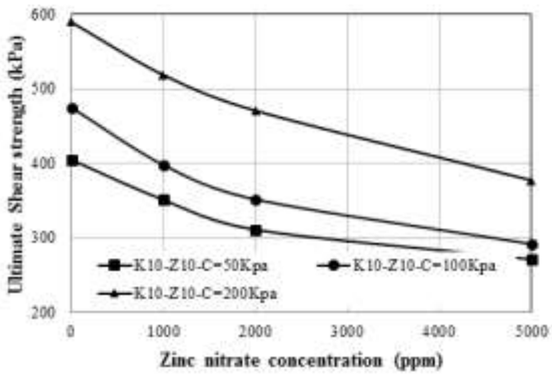

Fig. 1. The changes of ultimate shear strength of contaminated sand with 10% kaolinite and 10% zeolite

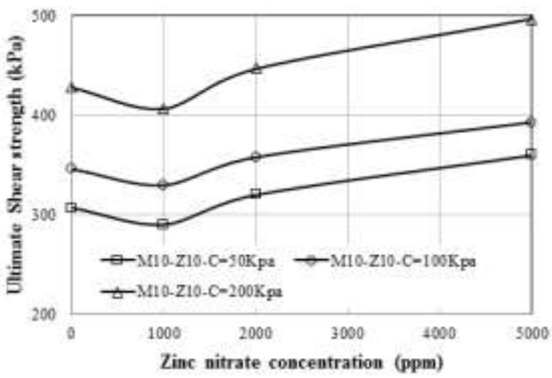

Fig. 2. The changes of ultimate stress of contaminated sand with 10% kaolinite and 10% zeolite mixture

4. Conclusions

use of heavy metal adsorbents to prevent the spread and transfer of heavy metal contaminants in groundwater as well as soil is one of the most common and economical methods in recent years. Some of the most important results obtained in this research, based on triaxial experiments, are as follows:

1) In the uncontaminated state, the ultimate strength of kaolinite-rice husk ash mixture was about 15% higher than bentonite with rice husk mixtures. However, with increasing zinc nitrate concentration, the final strength in the bentonite-rice husk mixture increased and, in the kaolinite-rice husk composition decreased.

2) The shear strength of bentonite with zeolite adsorbent was higher than kaolinite-zeolite mixture and due to the higher adsorption capacity of bentonite-zeolite mixture, its environmental effect is also stronger.

3) In fine-grained particles, with the addition of zinc nitrate and the entry of heavy metal into the soil, soil particles tended from the flocculent structure to a dispersed structure, which decreased the ultimate strength in the contaminated state of the mixtures containing low plasticity clays.

4) The reduction of the thickness of the double layer in contaminated bentonite reduced the dispersed structure in the soil and increased the flocculation structure, thus, the ultimate strength increased.

5) Replacement of zeolite with kaolinite or bentonite increased the ultimate strength. The results in both contaminated and uncontaminated conditions showed that the strength in the soil mixture (with kaolinite or bentonite) with zeolite adsorbent is about 50% higher than that of the shear strength of the soil without adsorbent in both contaminated and uncontaminated.

6) With the addition of rice husk ash to the mixture of sand with 10% kaolinite, the ultimate strength in uncontaminated soil decreased compared to the sand with kaolinite and zeolite, while due to the greater stability of rice husk than kaolinite, the strength in the kaolinite-rice husk mixture increased by about 20% to 30% compared to the sand mixture with 20% kaolinite.

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