Effect of different adsorbents in shear resistance of lead heavy metal contaminated soil

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Abstract

In past few decades, the expansion of industrial areas and increasing the effluents has led to increase the contamination of heavy metal in soil and groundwater resources. Adsorption is one of the most important processes that affecting in the leakage of contamination. In this study, with triaxial tests, the behavior of mixed sandy clay (base composition) with 10% of different low plasticity (kaolinite and zeolite) and high plasticity (bentonite) adsorbents is studied in both contaminated and uncontaminated states. As the type of adsorbent mineral changed, the resistance parameters of contaminated soil show different trend. Increasing the concentration of lead in the soil with bentonite adsorbent, has led to form the flocculation structure and it cause shear strength and internal friction angle increase a bout 18% than uncontaminated state. Also, cohesion in compositions with low and high adsorbent increases and decreases by about 30% and 19%, respectively.

Keywords:

Lead nitrate, Sandy clay, Zeolite, Triaxial test, Bentonite.

1- Introduction

Heavy metal are the most important and dangerous contamination that are important to study both environmentally and geotechnically. According to the World Health Organization, the concentration of heavy metals such as lead (Pb), zinc (Zn) and mercury (Hg) in the soils of agricultural and industrial areas is higher than other heavy metals. Chu et al. studyed the shear strength parameters in heavy metals contaminated soils with the lead, zinc and cadmium. Direct shear test was performed after curing the contaminated samples. According to the results, increasing the concentration of heavy metals increased the shear strength and cohesion in the soil. Also, increasing the concentration of contaminants has an inverse effect on the electrical resistance of contaminated samples [1]. Li et al. Investigated the behavior of lead-contaminated soils. The results showed as the concentration of heavy metal increased, the water thickness of the dual layer reduced and it caused the flocculated structure [2]. The main purpose of this study is to increase the adsorption capacity of the base soil by mixing different adsorbents with low and high plasticity in both contaminated and non-contaminated states. Another purpose of this study is the effect of adsorbent plasticity properties and the study of microstructural changes in various clay minerals in heavy metal contaminated state. For this purpose, three types of adsorbents, zeolite and kaolinite with low plasticity and bentonite with high plasticity properties were used as adsorbents. Although many studies have used kaolinite compounds in contaminated soils [10], but its adsorption capacity is lower compared to bentonite and zeolite. Thus, due to the extension of kaolinite in natural and in order to compare the resistance

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parameters in both contaminated and uncontaminated states with bentonite composition, kaolinite has been used as an adsorbent.

2- Soil and the performed tests

As mentioned in this study, combination of sand and 15% kaolinite was named base composition. Also, in order to improve the adsorption performance of heavy metals in the base composition, three types of adsorbents with low plasticity properties (zeolite and kaolinite) and high plasticity properties (bentonite) have been used. [3]. Zeolites contain large number of equilibrium cations in the group of alkaline and alkaline metals (Na^+,K^+, Mg^{+2} and Ca^{+2}) [4]. Another adsorbent that is studied in this research is bentonite, which is the van der Waals force is predominant bond between montmorillonite mineralogy in bentonite. In order to investigate the effect of different adsorbents, 10% of each adsorbent was added to the base soil composition. Different concentrations of lead nitrate ($Pb(NO_3)_2$) were added to the soil for preparation of heavy metal contaminated samples. Firstly, the lead nitrate was dissolved in distilled water and solutions with concentration of 10,000 and 20,000 ppm were prepared. Then, test samples were constructed in 95% maximum density. 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.

Table 1. Physical properties of the used clay minerals

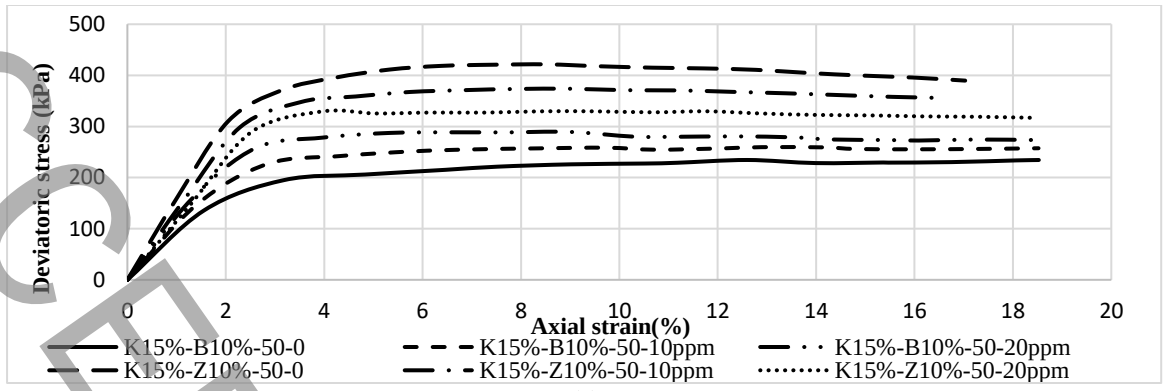
	Kaolinite	Bentonite	Zeolite
Gs	2.59	2.6	2.58
LL (%)	43.8	135.5	40.9
PL (%)	32	51.9	29.8
PI (%)	11.8	83.6	11.1
USCS	CL	CH	CL

3- Results and discussion

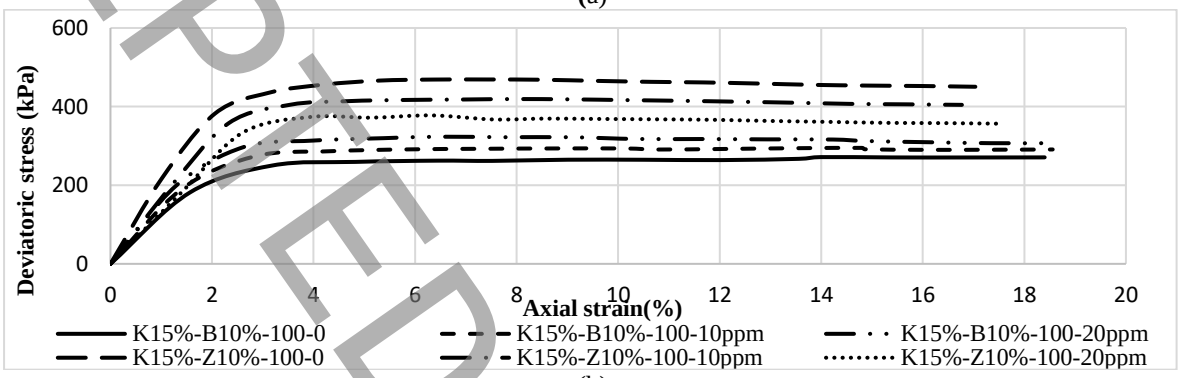
Figure 1 shows the ultimate strength changes for the base soil composition with 10% of bentonite and zeolite adsorbents in various confining pressure. In uncontaminated state, the results show in all different confining pressure, by changing the type of adsorbent from zeolite to bentonite, the final strength decreases by about 68%. As the concentration of lead nitrate increases, the ultimate shear strength for the base composition with zeolite decreased while in the case of base composition with bentonite shear strength increased. The results indicated in the base soil composition with 10% adsorbent which contaminated with 10000 ppm lead nitrate, by changing adsorbent mineral From zeolite to bentonite, the difference between the final strengths is reduced to about 40%. Also, in the contaminated state with a concentration of 20000 ppm, the final strength in the composition of the base soil with 10% bentonite is reduced by about 17% compared to the composition of the base soil with 10% zeolite in various confining pressure. The main reasons for changing the behavior of contaminated base composition with bentonite and zeolite is the structural differences .Reducing the thickness of this layer causes the flocculated structure in bentonite while in zeolite the structure became dispersed.

4- Conclusion

1- Adding zeolite to the base soil, in addition to increasing the cation exchange capacity, increases the resistance parameters to the base soil in both contaminated and non-contaminated states.
2-Although the results showed that by changing the type of adsorbent mineral from zeolite to bentonite, the shear strength in non-contaminated state decreases, nevertheless, with increasing the concentration of lead nitrate in base composition with bentonite, the shear strength increases while with zeolite the reduction observe.



(a)



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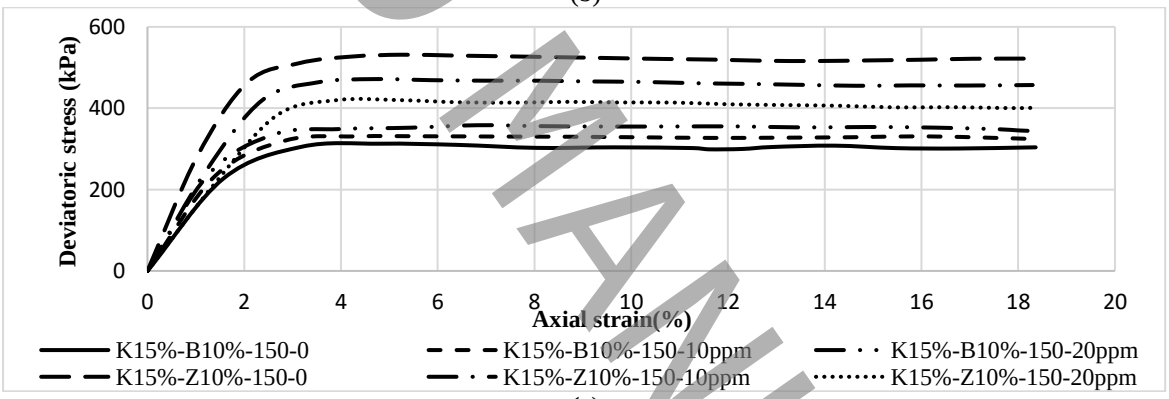

(c)

Fig 1: Stress-strain behavior for base composotion with 10% zeolite and bentonite adsorbent in two cases of contaminated an uncontaminated at different confining pressure of (a)50 KPa, (b)100 KPa and (c)150 Kpa

5- References

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