



## Effect of Lead Nitrate on the Behavior and Shear Strength Parameters of clayey sand

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**ABSTRACT:** By the expansion of the industrial zones, heavy metals enter the environment, which contaminates the soil and groundwater. The leakage of heavy metals such as lead, zinc, copper, etc. is not only an environmental crisis but also causes changes in soil shear resistance parameters. In this research, with triaxial tests, the behavior of sandy soils with different percentages of kaolinite in two cases of non-contaminated and contaminated with lead is investigated. It was seen that by increasing the lead concentration, the hydrogen bonding between kaolinite particles and the resistance of contaminated soils reduces. Then, to investigate the effect of clay minerals on contaminated soils, the shear resistance parameters of soil with kaolinite and bentonite clay were compared. The results showed, clay minerals in contaminated soils, resulted in different shear behavior and resistance parameters, so that, increasing the lead concentration in bentonite causes the shear strength to increase.

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### 1- INTRODUCTION

Although some researches have represented the effect of heavy metal pollutants on the shear behavior of granular soils, most studies have been conducted on the effect of heavy metals on compounds that consist of clay fine grains [1]. Therefore, the existence of clay fine grains has a more significant effect on the behavior of contaminated soils. On the other hand, by changing the type of mineral clay, the ability to absorb and react with heavy metals is changed [2]. Due to the extent of heavy metals such as lead and zinc in most parts of China, Li et al. investigated the behavior of contaminated soils with lead in these areas. The concentrations of lead nitrate have been chosen 1000, 5000, 10000, and 20000 ppm. The results have shown that the liquid limit and plastic limit decrease with increasing the concentrations of contaminants. Also, increasing the concentration of contaminants reduces the thickness of the double-layer water and reduces the flexibility limit [3]. Little researches on the resistance parameters of contaminated soils with heavy metals indicate the need for further study in this field. Therefore, in the first part of this research, the effect of fine-grained content on the shear behavior and resistance parameters of contaminated soils is investigated by triaxial tests. In the second part of this research, the behavior of contaminated soils with different clay minerals is studied. The clay minerals used in this research are kaolinite (with low plasticity) and bentonite (with high plasticity).

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### 2- SOIL AND THE PERFORMED TESTS

In this study, the heavy metal contaminant effect on clay minerals of kaolinite and sodium bentonite is investigated. The different behavior of contaminated soils is one of the main reasons for the variation of clay minerals. In other words, by changing the type of fine-grained mineral, the shear behavior and resistance of contaminated soil varied. Due to the wide application of kaolinite in scientific researches, two percent of kaolinite (15% and 25%) were specified. To compare the behavior of kaolinite and bentonite, the mixture of clayey sand with 15% bentonite is also prepared. Different concentrations of lead nitrate ( $Pb(NO_3)_2$ ) were added to the soil for the preparation of heavy metal contaminated samples. Firstly, the lead nitrate was dissolved in distilled water, and solutions with a concentration of 10,000 and 20,000 ppm were prepared. Then, test samples were constructed with a wet tamping method having optimum moisture content and 95% maximum density. The characteristics of kaolinite and bentonite, which were prepared from the Iran China clay and Iran Barite, respectively, are presented in Table 1. According to the unified soil classification system, kaolinite and bentonite were classified as CL and CH, respectively. The used sand is also 161 Firuzkoh sand in which is popular sand in Iran.

### 3- RESULTS AND DISCUSSION

In Fig. 1, the stress-strain behavior of uncontaminated and contaminated samples with lead nitrate is shown for two types



**Table 1. Physical properties of the used clay minerals**

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

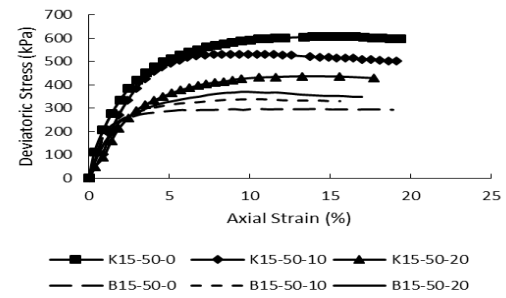
of sandy soils with 15% kaolinite and bentonite in different confining stresses. This figure shows by changing the type of clay minerals from kaolinite to bentonite, the shear strength has decreased. According to Fig. 1, by varying the clay minerals, the effect of the lead-heavy metal is different. In samples containing kaolinite, with increasing the concentration of lead nitrate, soil shear strength is decreased, while in samples containing bentonite, increasing the concentrations of heavy metals led to increased shear strength. One of the main reasons for changing the behavior of contaminated bentonite with heavy metals in comparison with contaminated kaolinite is the behavioral dependence of bentonite to the volume of the double layer water. Reducing the thickness of this layer causes more grain contact with each other, therefore the flocculated structure is made. As a result, it can be concluded that reducing the thickness of the double layer water increases the shear strength in clay soils with high plastic properties (such as bentonite). It should be noted that by increasing the concentration of lead nitrate, the cohesion of soils containing kaolinite increased, while the angle of internal friction has decreased due to changes in the grain arrangement. Also, the results show with increasing concentration of lead nitrate in bentonite samples, unlike kaolinite, internal friction angle increased slightly and cohesion decreased.

**4- CONCLUSION**

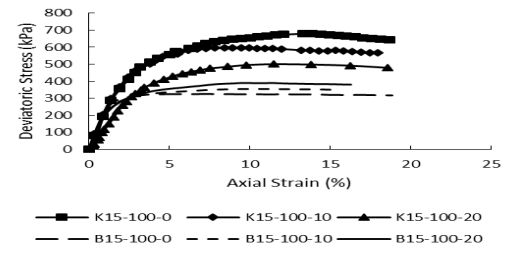
1- Increasing the amount of kaolinite from 15% to 25% reduced the clayey sand soil resistance up to 48%. Also, by increasing the amount of kaolinite from 15% to 25%, the soil angle of internal friction decreased by 20%, while enhancement the kaolinite caused the cohesion to increased by about 60%

2- In samples with 25% kaolinite, by increasing the concentration of lead nitrate up to 20,000 ppm, the shear strength of the contaminated sample decreased 24% compared to uncontaminated. In contaminated clayey sand (with 25% kaolinite) by increasing the concentration of lead nitrate to 10,000 and 20,000 ppm, the cohesion increased 42% and 52%, respectively. Also, the internal friction angle for the contaminated sample with 20,000 ppm was decreased by about 15% relative to the uncontaminated state.

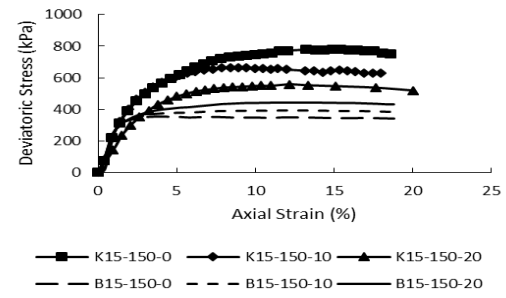
3- Changes in clay minerals caused variation in the



(a)



(b)



(c)

behavior of heavy metal contaminated clayey sand soils. By increasing the concentration of lead nitrate in clayey sand with high plasticity fine grains (like bentonite), the shear strength increased. In sand containing 15% bentonite, with an increasing concentration of lead nitrate to 10,000 and 20,000 ppm, the cohesion of contaminated soil is reduced by about 20% and 35%, respectively, compared to uncontaminated samples. Also, the internal friction angle increased about 16% and 26% respectively.

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