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The Study of Uncertainty in the Effect of Oil Contamination on Geotechnical Behavior of Sandy Soil beneath Oil Storage Tanks

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ABSTRACT: A leakage from oil storage tanks result in pollution of a large amount of soil by gasoil. Physical and chemical reactions between soil and the contaminant lead to a change in the geotechnical soil behavior. If it yields a negative effect, the strength of the soil may decrease and the stability of the storage tanks may weaken and resulting in the seeping of a large amount of the contaminant in the soil and groundwater. In concern with lack of information about precise leakage of oil, the precise level of pollution and changes in geotechnical parameters couldn't be accessible. So, the application of the certain analysis together with the probability analysis could be helpful. In this study, the direct shear test was conducted on silica sand samples contaminated with 2, 4, 6, 12 and 16% of gasoil and the stability probability analysis was evaluated by Monte Carlo method. The results showed that increasing the contaminant fraction led to reduction of internal friction angle and bearing capacity of the soil. This trend was observed with a slight reduction up to 6% and then with a sharper decline. In addition, two probability criteria of reliability and rapture probability (RP) were studied by Monte Carlo and then compared with factor of safety (FS).

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1- Introduction

The oil contaminated soils have been recently considered by many researchers. The contamination of soil could be caused by oil leakage during various stages of storage, refinement, loading and discharge of the oils [1]. In addition to different environmental concerns, the effects of the oil contamination on the geotechnical properties of the soil is of great importance which could finally lead to the changes in bearing capacity and settlement of the soil [1, 2]. Uncertainty is a fact in geo-environmental engineering. Nature, due to its complexity, offers soil profiles often very different from those assumed in analysis and design; loads and environmental condition also defy precise prediction; and limited sampling, measurement errors [3]. Accordingly, using a probabilistic method like Monte Carlo simulation besides a certain analysis method could be more efficient for getting results with more safety.

Although many studies have been done on the effect of contaminant on soil, but still the effect of gasoil on sand and also the application of uncertainty on the contaminated soils haven't been worked. In this study, the direct shear test was conducted on silica sandy soil samples contaminated by gasoil with 2, 4, 6, 12, 16 percent of gasoil and the stability probability analysis was evaluated by Monte Carlo method.

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2- Methods and Material

2- 1- Direct shear test and Bearing capacity calculation

In this study, the silica sandy soil of a mine in Garmsar, Iran was used. The preparation of soil samples was started by screening for uniformity. The soil was dried in 105°C for 24 hours in the oven. The dried soil then was mixed with gasoil to have 2, 4, 6, 12, 16 percent contaminant samples. The samples were maintained in room temperature for 10 days. To obtain the changes in the shear strength of the samples, the direct shear test under ASTM D3080-72 standard was conducted. The considering parameters are internal friction angle (Φ) and cohesion (c). The bearing capacity is a general term to describe the load that a foundation can bear. The ultimate bearing capacity of soil in foundations depends on the soil characteristics and the other specifications of the foundation like the dimensions and shape of it [4]. In this study the bearing capacity was calculated by the equations presented by Terzaghi, Meyerhof.

For a specific compaction and contamination content, the amount of change in bearing capacity is calculated by the following equation:

$$\Delta Q(\%) = \frac{Q - Q_w}{Q} \times 100$$

ΔQ= Reduction in ultimate bearing capacity
Q = Ultimate bearing capacity in the clean sample
Q_w=Ultimate bearing capacity in w% content sample

2- 2- Probabilistic Analysis

Many of soil properties have some elements of uncertainty in soil analysis which leads to obscurity in applications [5]. Monte Carlo simulation is wildly used for numerical reproduction without any further experiments. In this method, at first, a random number is produced and then an event probability is compared with the random number. If the obtained number meets the probability measure, a chain of processes proceeds. This chain could be repeated and it each time a measurable output is produced.

To evaluate the foundation stability to more parameters, i.e. fracture probability and reliability coefficient were applied. Fracture probability is defined as the probability number when the safety factor is 1 or less that 1. Reliability coefficient (β) is calculated by the following equation:

$$\beta = \frac{\mu - 1}{\sigma}$$

μ= the mean of safety factors
σ= the standard deviation of safety factors

3- Results and Discussion

3- 1- Results of direct shear test

Figure 1 shows the internal friction angle changes in different gasoil content.

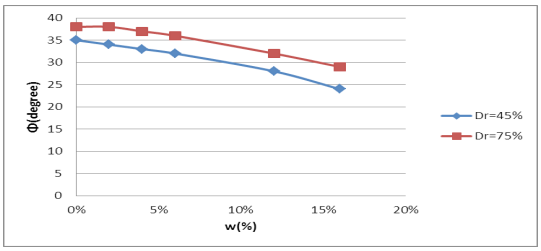

Figure 1. The changes of the internal friction angles in different gasoil content

It could be seen that as the gasoil content is increased, the internal friction angle will have a decreasing trend. This trend in 6% and higher contents of contamination is more obvious. It also could be realized that in higher compaction, the friction angle is increased.

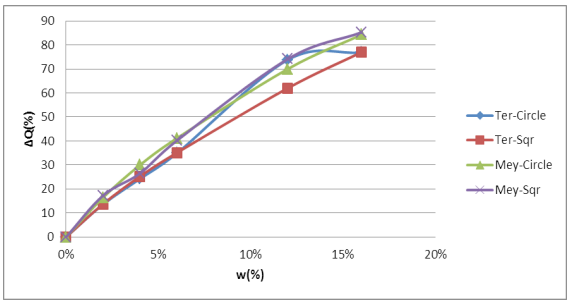

Figure 2. Relative reduction in ultimate bearing capacity in 45% compaction

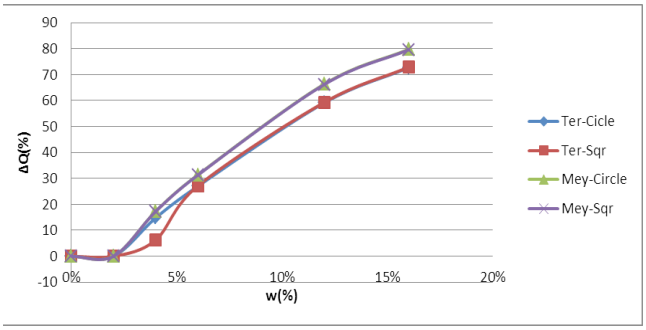

Figure 3: Relative reduction in ultimate bearing capacity in 75% compaction

Figures 2 and 3 demonstrate that bearing capacity changes follow a descending trend. It also could be realized that in higher contents of contamination, these changes get more change. This could be because of decrease in internal friction angle.

3- 2- Results of probabilistic analysis

Based on Monte Carlo simulation, by increasing compaction from 45% to 75%, mean safety factor and reliability coefficient increase and fracture probability decreases.

There isn't any direct relationship between safety factor and reliability coefficient. Practically, the foundation with higher safety factor may be less safe than that of lower safety factor. So, the safety factor couldn't be determining alone.

4- Conclusion

Making a comparison between certain and probabilistic analyses, it could be realized that the factor of safety resulting of certain analysis may not show the fracturing, while the probabilistic analysis may show it more likely. Because of uncertainties in soil parameters and lack of adequate data of other elements, engineers may not be able to evaluate and calculate the risk of fracture properly.

However, since in probabilistic analysis, the safety is assigned by a probabilistic distribution, it is possible to obtain different safety factors and fracture probabilities.

References

[1] Khosravi, E, Ghasemzadeh, H, Sabour, M.R, Yazdani, H, "Geotechnical properties of gasoil-contaminated kaolinite." Engineering Geology 166 (2013): 11-16

[2] Shin, E.C., Das, B.M., "Bearing Capacity of Unsaturated Oil-Contaminated Sand", Offshore and Polar Engineering, Vol.11, 2001, pp. 220-226.

[3] Fenton, G.A., Griffiths, D.V., 2007, Probabilistic Methods in geotechnical engineering, CISM courses and lectures, Springer Wien New York, http://www.springer.com/gp/book/9783211733653

[4] Das, B.M., Sobhan, Khaled., 2010, Principles of geotechnical engineering, 8st ed. , CENCAGE Learning, www.cengage.com

[5] Jones,A., Kramer, S., Arunio, P., "Estimation of uncertainity in Geotechnical Properties for Performance-Based Earthquake Engineering", University of California, Berkeley, 2002.

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