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Increasing of Fine-Grained Soils Drainage using Electrokinetic Method in Laboratory Scale

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ABSTRACT: Every year, many structures are being constructed on fined-grained soils. Drainage of these soils is necessary for constructing new or maintaining existing structures. Considering low drainage capacity of these soils, it is required to use appropriate methods. Electrokinetic is one of these methods, which can be used for increasing drainage in fine-grained soils effectively. In this method, two electrodes are placed in the soil and then electrical current is established in the electrodes using a power source. As a result, charged particles move to the electrodes with opposite charge. This mechanism causes rapidly drainage of the soil. In this research, soil's drainage investigated using electrokinetic method. The charged particles moving, was investigated within the soil using mathematical equations and soil drainage was tested in a laboratory reservoir with dimension of 180×60×60 cm3 serving electrokinetic method. This was made by applying different voltage levels in the soil and acidic environment. Results showed that soil bearing capacity, drainage and consolidation were increased in the Saturated fine soil by applying electrokinetic method.

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1- Introduction

Drainage in the coarse-grained soils is done easily, but in the fine-grained soils the drainage rate is very low, and the use of appropriate methods is necessary to increase the drainage. One possible method is electrokinetic method. This method aims to increase drainage in fine-grained soils or remove heavy metal contaminants from low permeable contaminated soils under the influence of an applied direct current. This method were used in many researches [1-12] to increase the fine-grained draining. In this research, the effect of electrokinetic process on fine-grained draining rate is investigated in laboratory scale.

2- Electrokinetic Method

The surface tension in a liquid can be calculated using equation 1:

$$\gamma_L \approx \frac{\frac{1}{6}\varepsilon}{L_{mol}^2} \approx \frac{1}{6}\frac{hm}{L_{mol}^2} \approx \frac{1}{6} h\rho L_{mol} \qquad (1)$$

In which, γ_L is surface tension, is binding energy in a molecule, L_{mol} is the distance between molecules, h is the specific heat of evaporation, m is the mass of a single molecule and ρ is the density of molecules. Young presented equation 2 for computing surface tension between a liquid and a solid surface as follow:

$$\gamma_L \cos\theta = \gamma_S - \gamma_{SL} \qquad (2)$$

In which, γ_S is the solid surface tension, γ_{SL} is the surface tension between the liquid and the solid and θ is contact angle between the liquid and the solid.

The γ_{SL} can be easily calculated using Young equation if the other parameters to be known. The γ_{SL} have high value in the fine-grained soils. Electrokinetic method is used to reduce the value in the fine-grained soils by increasing soil drainage. Electrokinetics refers to the relationship between electrical potential and the movement of water and charged particles. Effects directly related to the application of a voltage via electrodes include: heating, electrolysis of water and other electrochemical processes (Figure 1).

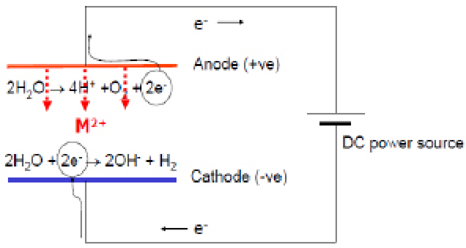

Figure 1. Electrokinetic phenomena

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3- Material and methods

In this research, a device with two copper electrodes (anode and cathode), variable voltage power source, extension cord and a container with dimensions of 180×60×60 cm^3 were constructed (Figure 2).

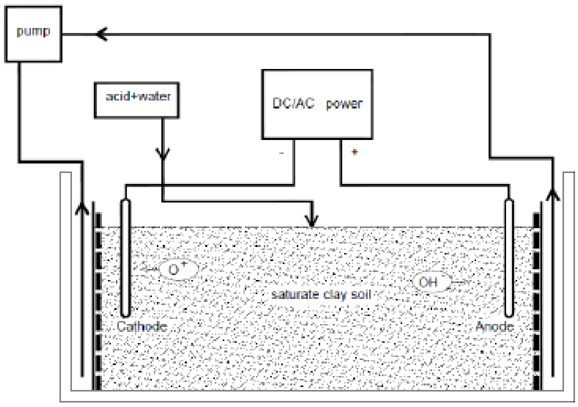

Figure 2. Electrokinetic device

In the first step of experiments, the soil was poured into the container and saturated with water. Then, six experiments were performed in two (soil and water) and three phases (soil, water and acid) environment in saturated and partially saturated conditions which was taken placed electrodes directly or indirectly. The voltage of 4, 6, 8, 10, 15, 20, 30, and 40 V were applied in each experiment and observations were made. The effect of acid presence were investigated in some of the mentioned experiments. The acid used in this research was sulfuric acid with molecular weight of 98 gr/mol, density of 1.28 gr/cm^3, melting point of 10℃ and boiling point of 337℃. The experiment time was varied between 1 and 7 day.

4- Results and Discussion

Six experiments were performed in this research for saturated and partially saturated soils. Here, results of saturated condition were presented (experiments 1-3). In experiment 1, electrodes were placed inside a polika pipe within the soil. In the experiment 2, electrodes were placed in the soil directly. In the experiment number 3, electrodes were directly placed in the soil which blended with sulfuric acid. The diagram of obtained results is shown in Figure 3 in which the amount of drained water is drawn versus applied voltage for three experiments. The voltage varied between 4 and 40 V.

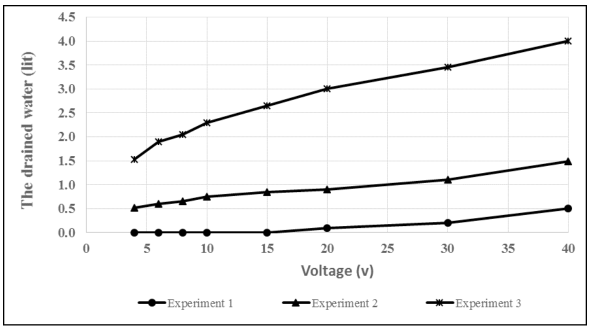

Figure 3. Electrokinetic phenomena

As shown in Figure 3, the drained water for voltages lower than 15 V were zero in the experiment 1. In the voltages of 20 and 40 V the drained water were 0.1 and 0.5 lit, respectively, which were low values and the presence of polika pipe was the main reason of this observation. In the experiment 2, drainage rate for applied voltages of 4 and 40 V were 0.52 and 1.49 lit, respectively. Also, the soil in the container was consolidated 10 cm (Figure 4). In the experiment 3, the drained water in voltages of 4 and 40 V were 1.53 lit and 4 lit, respectively, and the soil was consolidated 15 cm. Obtained results of partially saturated soils showed that the electrokinetic method haven't effect on the rate of water drainage in the soil and drained water was approximately zero.

Figure 4. Consolidation of the soil in experiment 2 and voltage of 40 V as a result of draining

5- Conclusion

The increase in the drainage rate and rapid movement of particles within a fine-grained soil using electrokinetic method was confirmed in this research. Results showed that soil bearing capacity, drainage and consolidation were increased in the fine-grained saturated soil by applying electrokinetic method and the soil drainage increases in the presence of sulfuric acid comparing with sample which sulfuric acid was not added to it.

References

[1] Mosavat, N., Oh, E., & Chai, G., "A review of electrokinetic treatment technique for improving the engineering characteristics of low permeable problematic soils", International Journal of GEOMATE, 2(2): 266-272, 2012.

[2] Pugh, R. C., "The application of electrokinetic geosynthetic materials to uses in the construction industry", 2002.

[3] Glendinning, S., Jones, C., Pugh, R., "Reinforced soil using cohesive fill and electrokinetic geosynthetics. International Journal of Geomechanics", 52: 138-146, 2005.

[4] Chew, S., G, Karunaratne, V. Kuma, L. Lim, M. Toh, A. Hee, "A field trial for soft clay consolidation using electric vertical drains. Geotextiles and Geomembranes", 221: 17-35, 2004.

[5] Lamont-Black, J., Jones, C., Glendinning, S., Huntley, D., Fourie, A., "Laboratory evaluation of the potential for Electrokinetic belt filter press dewatering of Kimberlite Slimes", 2007.

[6] Fourie, A., Johns, D., Jones, C. F., "Dewatering of mine tailings using electrokinetic geosynthetics. anadian geotechnical journal", 442: 160-172, 2007.

[7] Lamont-Black, J., Glendinning, S., Jones, C., Huntley, D., Smith, R., "The development of in-situ dewatering of lagooned sewage sludge using electrokinetic geosynthetics EKG", Proceedings of Tenth European Bio-solids and Bio-wastes Conference, 2005.

[8] Morefield, S. W., McInerney, M. K., Hock, V. F., Marshall, O. S., Malone, Jr, P. G., Weiss Jr, J, Sanchez, O. E. V. M. CORPS, "Rapid Soil Stabilization and Strengthening Using Electrokinetic Techniques. World Scientific", 2004.

[9] Makarchian, M. and Fardhajian, sh. 2011. Application of the Electro-Osmosis method for increasing the bearing capacity and reducing the negative skin friction on piles, "Road Journal", 69: 263-271.

[10] Doosti, M. R., Mansouri, N., Hassani, A. H. and Movaffagh. A. 2009. Zn Removal of Chemical Sludge using Electrokinetic, "Environmental Science and Technology Journal", 12(4):636-427.

[11] George, V. C., WALTER, W., LEONID, F. K., SIMON, A., "Electrobioremediation of soils contaminated with hydrocarbons and metals: progress report. Energy sources", 192: 129-146, 1997.

[12] Utchimuthu, N., Saravanakumar, K., and Joshuamarnath, D., "Removal or reducing heavy metal (lead) from soil by electrokinetic process", Engineering Research and Applications (IJERA), 2(3): 2367-2373, 2012.

[13] Rutigliano, L., Fino, D., Saracco, G., Specchia, V., Spinelli, P., "Electrokinetic remediation of soils contaminated with heavy metals", Journal of Applied Electrochemistry 387: 1035-1041, 2008.

[14] Jones, C., Lamont-Black, J., Glendinning, S., Bergado, D., Eng, T., Fourie, A., "Recent research and applications in the use of electro-kinetic geosynthetics'. Proceedings of 4th Euro-Geo Conference, Edinburgh, Scotland", 2008.

[15] Reddy, K. R., Donahue, M., Saichek, R. E., Sasaoka, R., "Preliminary assessment of electrokinetic remediation of soil and sludge contaminated with mixed waste", Journal of the Air & Waste Management Association, 497: 823-830, 1999.

[16] Sims, R. C., "Soil remediation techniques at uncontrolled hazardous waste sites", Journal of the Air & Waste Management Association, 405: 704-732, 1990.

[17] EPA, U., "Revised guidance document for the remediation of contaminated soils. S Environmental Protection Agency Annual Review", 1998.

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