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EFFECT OF NONWOVEN GEOTEXTILE COMBINATION WITH STEEL MESH ON ELECTROKINETIC DEWATERING OF SOFT SOIL USING GEO-DRAINS

Mansi Parmar[1], Dr.L.S.Thakur[2], Dr.D.L.Shah[3]

[1]Assistant Professor,Civil Engineering Department, Sigma Institute of Engineering-Vadodara
[2] Associate Professor, Civil Engineering Department, Babaria Institute of Technology-Vadodara
[3]Professor, Applied Mechanics Department, Faculty of Tech. & Engg., M. S. U, Vadodara

Abstract — *In the current era, civil engineers are mainly indulged in the construction sector for improving infrastructure of our country. This in turn alarms geotechnical engineer to go for building structure even in weaker soils leading to the need of improvement of such soils. Electro kinetic process is one of the best methods of soil improvement by dewatering, decontaminating and enhancing soil-chemical interactions. The present research work envisaged to study various factors affecting dewatering using nonwoven conductive geotextiles with help of different nonwoven material and steel mesh. The objective of paper is to evaluate the moisture content parameter and to study the effect of various factors during the process of dewatering. The present study, for vertical dewatering four laboratory scale cylindrical models were prepared for the experimental work. With the help of carbon rods acting as an anode and nonwoven conductive geotextile which acts as a cathode current is applied to the soil for obtaining the required outcome. The different parameters studied include effect of using different nonwoven geotextile and effect of preloading. The results were taken for the moisture content for the preloading as well as using EKG on daily basis at fixed time.*

Keywords- *Electrokinetics, Electrokinetic Geosynthetics (eKG), Electrokinetic dewatering, Vertical Geo-drains, Electrically conductive vertical drains.*

I. INTRODUCTION

Electro kinetic is a process that has shown a great potential for remediating soil with low shear strengths and strengthening of deep seated soil layers under the existing structure. It is the term applied to a group of physicochemical phenomena involving the transport of charges, action of charged particles, effects of applied electric potentials, and fluid transport in various media. It is an emerging technique, which uses direct current (DC), or a low electric potential difference to an array of electrodes placed in the soil, for removing organic, inorganic and heavy metal particles from low permeable soils, mud, sludge, slurries, sediments and groundwater by electric potential. This technique is effective for the treatment of low permeable clays and/ or heterogeneous soils. Electro kinetic techniques use the combined effect of electric, chemical and hydraulic potential for remediation of expansive problematic soil. The ability of electro kinetic phenomena to transport water, charged particles and free ions through fine grained soils has been well established following their discovery by Reuss (1809). He discovered that, under the influence of an applied electrical potential, water moves through the soil capillaries from the positive side to the negative side of the cell. The phenomenon of electro-osmotic flow was presented by Helmholtz in 1879, modified by Pellat in 1904, and refined by Smoluchowski in 1921. The theory presented by Smoluchowski is widely known as the Helmholtz-Smoluchowski theory. This theory deals with the electro-osmotic velocity of a fluid in soil media under the application of an electrical gradient. In 1930's, electro-osmosis was applied to fine grain materials for soil stabilization in earthworks and foundation engineering (Gent, 1998). In 1939, Casagrande demonstrated that applying electro kinetics to fine grained soils with high water contents resulted in an increase in the effective stress within the soil through the generation of negative pore water pressures. He used this to increase soil shear strength and thus stabilize steep railway cuttings.

II. EXPERIMENTAL PROGRAMME

2.1 Soil Sample

The index properties of the black cotton soil are listed in table 1. The soil sample for the work has been collected from Parekha village, Kayavarohan, Vadodara, Gujarat.

Table 1 Index Properties of Soil

Type of Soil	LL*	PL*	SL*	FSI*	Specific Gravity	MDD (g/cc)	OMC (%)
Black Cotton Soil	62%	31%	7%	90.5 %	2.45	1.51	24.92

*LL = liquid limit, PL = Plastic Limit, SL = Shrinkage Limit, FSI = Free Swell Index

2.2 Laboratory Model

Four laboratory scale drum model were prepared or the experimental work. Two models were having size of 19'' diameter and 3' height and another two models were having size of 19'' diameter and 2'6'' height. These drum models were made up of 6mm plywood sheet and 12mm plywood sheet at the bottom side. Before using these models, coating was done inside the models for its long term use. (Fig. 1).

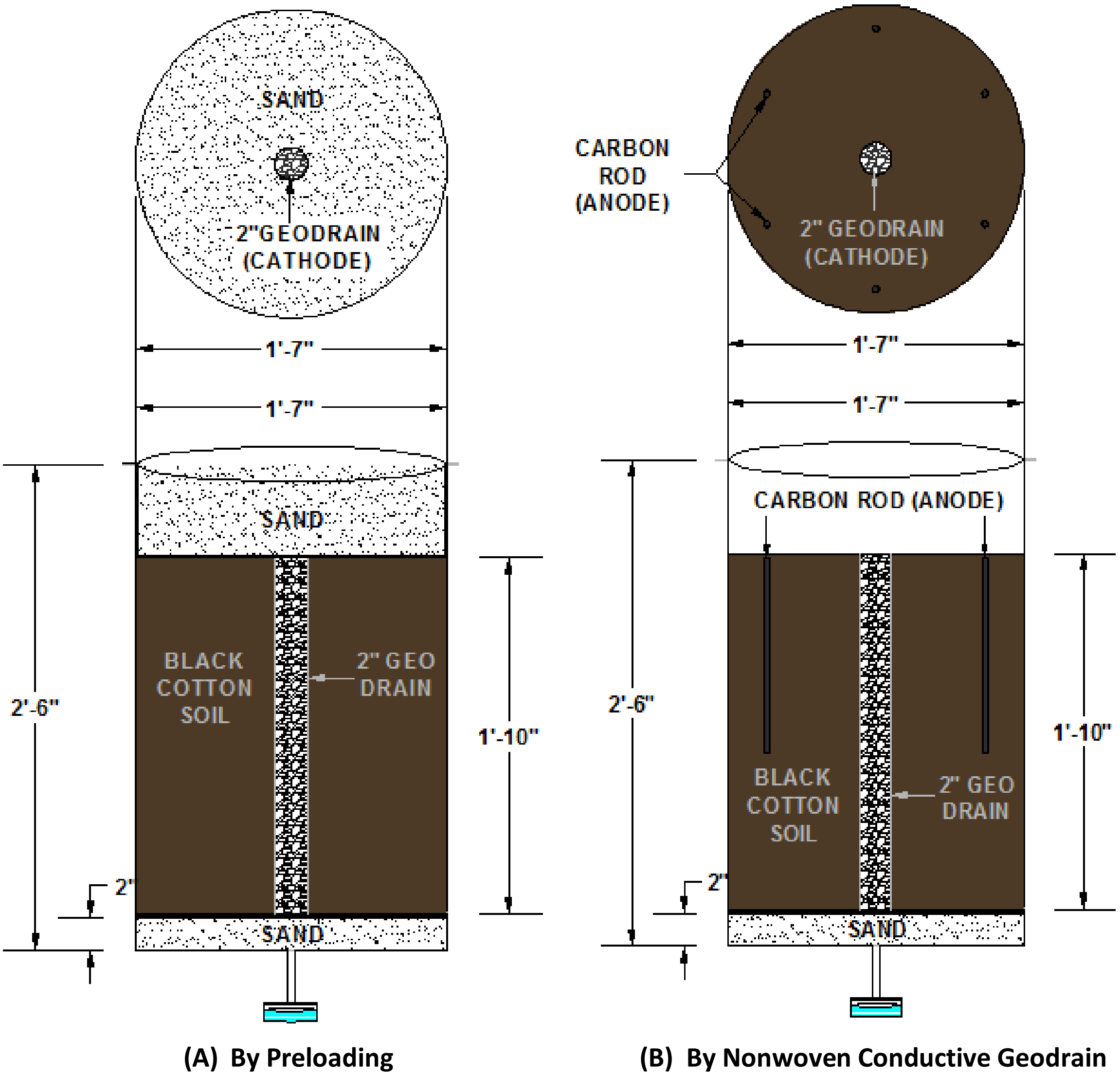

Fig. 1 Setup diagram of Vertical Geodrain

2.3 Development of Conductive Textiles

In the experimental work, for the vertical model 2 types of sample with a different combination were developed. In the vertical model total 4 samples have been prepared, two samples for preloading and two samples for conductive geodrain. This different combination as shown in the Table 2. To develop this vertical geodrain, the samples were prepared by stitching a steel mesh in between two identically cut nonwoven geotextiles and rounded up so that the inner diameter remains of 2'' for experimental study. (Fig. 2)

Table 2 Different types of Conductive geotextile (CG) for Vertical model

Geotextile	Top	Middle	Bottom	Thickness
CG 1	*PE	SM	PE	3
CG 2	*PP	SM	PP	2.5

*PE- Polyester, PP- Polypropylene

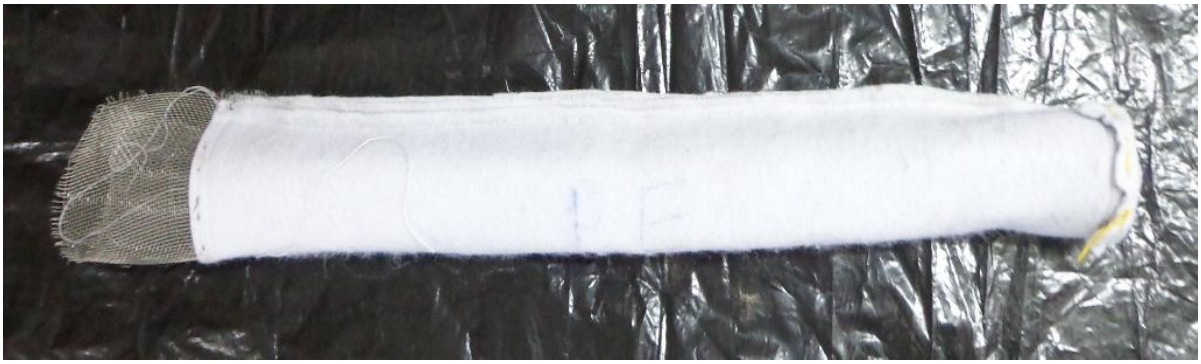

Fig.2 Conductive nonwoven Geodrain

III. SETUP AND EXPERIMENTAL DEVELOPMENT

3.1 Preloading

In order to ascertain the effect of rate of draining of water, two experiments were conducted alternately. The first experiment was done by preloading using sandbag whereas the second experiment was carried out using a nonwoven conductive vertical geodrain without loading. The experimental drum model was installed at some elevation from the floor surface with a bottom central hole for collection of water (Fig.3). The opening was fitted with a brass nipple of appropriate size to connect a flexible PVC pipe was collecting the drained water. The bottom of the drum was laid with a 5cm sand drain layer (passing 10mm retained 4.75mm) overlain with a perforated disc to act as a separator and drain media. The disc made of PVC of 6mm thickness was levelled using a level tube and the sides then sealed using bentonite to have proper water insulation between the filter and soil.

The separator disc was overlain with two Whatman filter paper discs before filling up with 600μm sieved black cotton soil at its liquid limit see Fig.4 (Step-1). In the middle of the drum nonwoven conductive geotextile was put, which is surrounded by the black cotton slurry. The water content reading was noted once the slurry was placed. The soil was then overlain with a solid PVC disc of 18mm thickness so as to distribute the loading to be applied on the clay uniformly (Step-2). The load was applied using a plastic bag filled with sand which was increased gradually at the rate of 5kg/day and the amount of water collected from the base was noted (Step-3). At the end of day 1,3,7,14,21 and 28 the moisture content was measured using sample taken. In the first step of sampling procedure 5cm diameter PVC pipe inserted up to perforated disc so as to run the complete depth of the sample and to place the nonwoven conductive geotextile into the drum up to the perforated disc. The sample was taken at various depths for standard water content determination using over drying method.

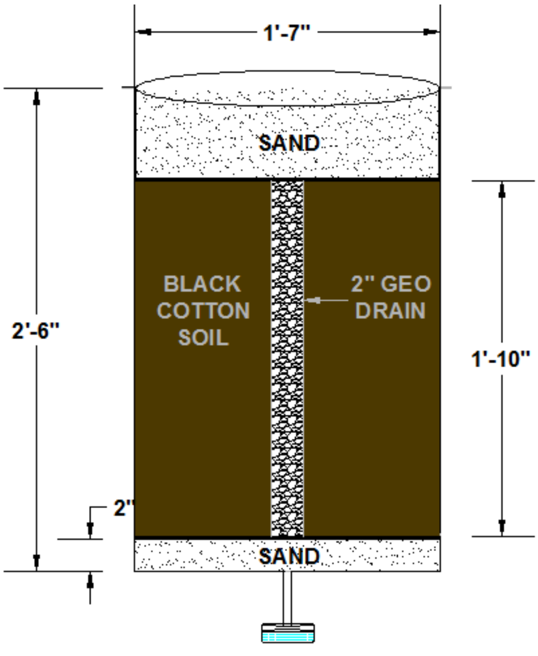

Fig. 3 Line diagram of preloading

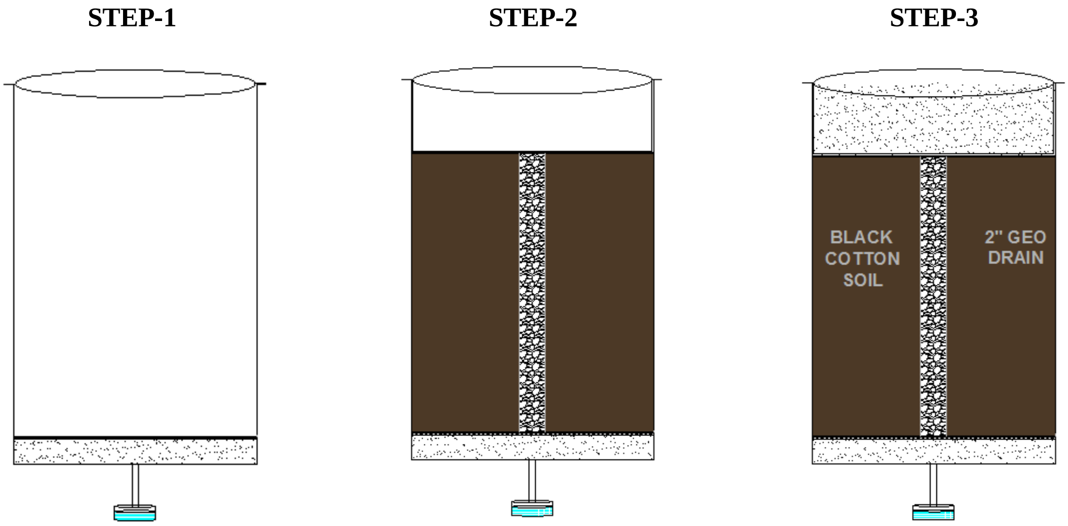

Fig. 4 Stepwise Procedure for Experiment Setup (Preloading)

3.2 Vertical nonwoven conductive Geodrain

Black cotton soil was air dried, pulverized and kept at 100˚C for 24hrs. Black cotton soil was sieved through a 600µm sieve prior to use. The various factors considered for study in the work included temperature and optimization of experimental duration. The experiment was performed to study the effect of conductive vertical geodrain using the basic principle of electro kinetics i.e. application of DC supply. The setup used is similar to preloading experiment only difference being the installation of the nonwoven conductive vertical geodrain in the centre surrounded by carbon electrodes. For installing the conductive vertical geodrain a PVC pipe of 5 cm diameter was inserted and the slurry was filled all around its sides (Fig.5). The PVC pipe was so kept so as to fall on the lower drain in the bottom of the drum. The vertical geodrain was stitched in the form of a long sock and filled with coarse aquarium quality stone and then installed inside the pipe. Once the complete length was dropped down to the bottom the pipe was gently removed and the drain came into contact with the slurry (Fig.6 & 7). This vertical conductive geodrain was designated to work as cathode, whereas six carbon rods of 10mm diameter with 30cm length were used as anode all around the vertical geodrain (Fig.8).

Fig. 5 Insertion of PVC pipe

Fig. 6 Conductive drain with PVC pipe

Fig. 7 Drain filled with aquarium stone

Fig. 8 Nonwoven Conductive drain (Cathode)

IV. EXPERIMENTAL RESULTS

4.1 Effect of Moisture Content

Different combination of nonwoven conductive Geodrain was used at the constant voltage gradient as 12 V for the experimental work. Moisture content was measured at the time of filling the model and at the end of the day. For preloading moisture content was observed up to 28 days and for electrokinetic sample run for 3 days at 12 V and moisture content for theses 3 days was noted. The Moisture content was noted for preloading and using EKG. The result between moisture content (Initial and Final) and sample run is illustrated below.

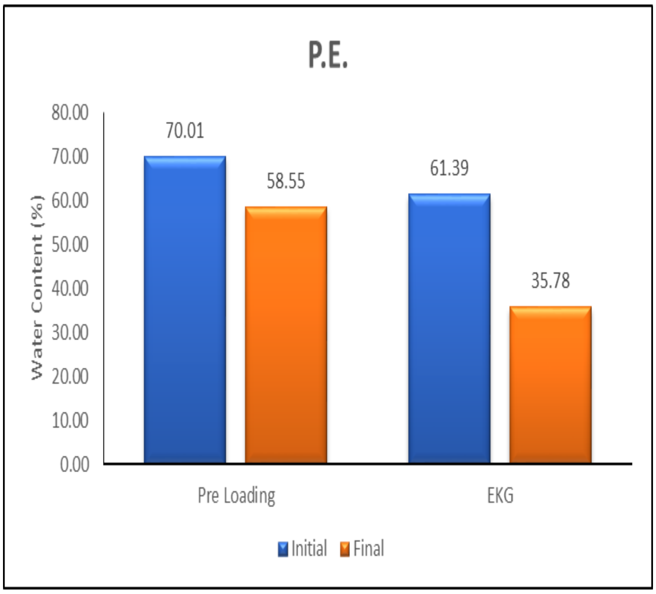

Fig. 9 Moisture Content v/s Conductive Geotextile run for P.E. (Polyester)

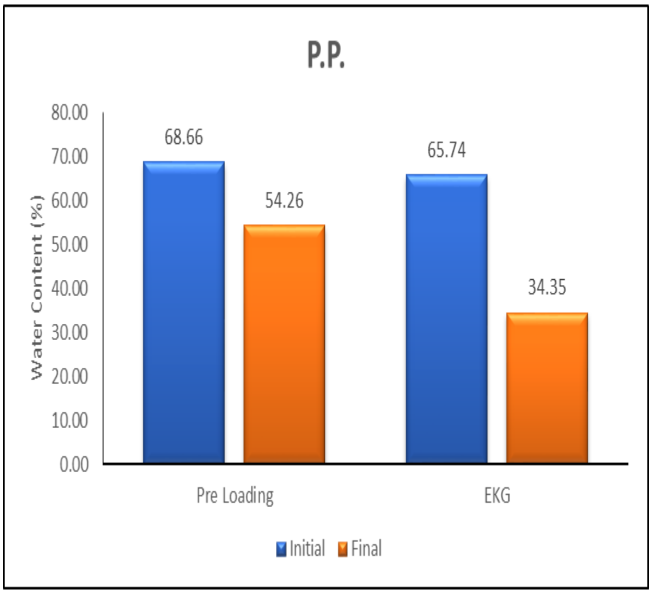

Fig. 10 Moisture Content v/s Conductive Geotextile for P.P. (Polypropylene)

The graph was plotted for moisture content v/s conductive geotextile behaviour for P.E. which is shown in Fig.9. For preloading at 28 days, the initial moisture content was 70.01% and final moisture content was 58.55% at the end of 28 day. So the percentage water removal at the end of 28 day was 16.38%.By using electrokinetic geosynthetics (EKG) initial moisture content observed was 61.39 % and final moisture content was 35.78 % and water reduction in moisture content was 41.72%.

In the similar manner the graph was plotted for moisture content v/s conductive geotextile behaviour for P.P. which is shown in Fig.10. For preloading at 28 days, the initial moisture content was 68.66% and final moisture content was 54.26% at the end of 28 day. So the percentage water removal at the end of 28 day was 20.97%. By using electrokinetic geosynthetics (EKG) initial moisture content observed was 65.74 % and final moisture content was 34.35 % and water reduction in moisture content was 47.75 %.

V. CONCLUSIONS

Based on the results, we can conclude that preloading was not effective alone for faster dewatering of soil. The percentage water removal were 16.38 % and 20.97 % for P.E. and P.P. geotextiles laid as filters respectively at the end of 28 days. Instead of that if we are using electrokinetic method from that the percentage water removal were 41.72% and 47.75% for P.E. and P.P. respectively. So as compare to preloading, EKG method is effective.

REFERENCES

[1] Black, J. L.; Glendinning, S.; Colin J. F. P. Jones And David T. Huntley, "Electrokinetic Processes For The Management Of Natural Sports Turf", Manuscript Of A Presentation To The National Turfgrass Foundation Annual Conference 2003.

[2] Gray, D.H. And J.K.Mitchell, "Fundamentals Aspects Of Electroosmosis In Soils," ASCE Journal Of Soil Mechanics And Foundations Division, 93 (6), 209, 1967.

[3] Acar, Y. B. And A. N. Alshawabkeh, "Principles Of Electrokinetic Remediation," Environmental Science And Technology, 27(13), 2638, 1993.

[4] Lamont-Black J, Glendinning S,Jones C,Huntley D, And Smith R, "The Development Of Lagooned Sewage Sludge Using Electrokinetic Geosynthetics(EKG)".

[5] Glendinning, S. & Jones, C.J.F.P, Lamont-Black, J. & Huntley, D.T. The Use Of Electrokinetic Geosynthetics (EKG) In Enhanced Performance Of Sports Turf.

[6] Thakur Lalit S., Remediation And Enhancement Of Heavy Metal Contaminated And Problematic Soils Using Electrokinetics, (2013) Faculty Of Technology And Engineering, The Maharaja Sayajirao University Of Baroda, Vadodara.

[7] Gray D. H.; Schlocker J., (1969), "Electrochemical Alteration Of Clay Soils," Clays And Clay Minerals, (309-322).

[8] Dr. Bipin J Agrawal, Recent Trends Of Technical Textiles & Geotextiles In Engineering & Technology.

[9] Lee EC, Douglas RS (2007), "Performance Of Electro-Osmosis In Ground Treatment Of Soft Clay Using Electro-Osmotic Vertical Drains", 16th Southeast Asian Geotechnical Conference, Kuala Lumpur, Malaysia, Pp 609–612.

[10] Esrig, M.I.; Gemeinhardt, J.P. (1967), Electrokinetic Stabilization of an Illitic Clay, Journal Of The Soil Mechanics And Foundations Division, Proceedings Of The American Society Of Civil Engineers 93(SM3): 109-128.

[11] Huntley, D.T. & Lamont-Black, J. Glendinning, S. & Jones, C.J.F.P, Dewatering Of Sewage Sludge Using Electrokinetic Geosynthetics.

