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RAPID METHODOLOGY TO DETERMINE DIFFUSION CHARACTERISTICS OF GEOMATERIALS

Dr.Solly George[1], Ahsan.K.A [2], Balu.B[3], Jestine.J.Thannickal[4], Nanda Kishor.V.S[5]

[1] Professor, [2,3,4,5] Undergraduate student, Mar Athanasius College of Engineering, Kothamangalam, India

Abstract: **Accelerated diffusion methodology was proved to be an efficient and sustainable method to determine the diffusion characteristics of geomaterials. In comparison to the time consuming conventional methods, this method proved to be a better and viable alternative. To establish the validity of the method studies were performed on clayely soil of 20 micron size. The influence of different electric potentials on diffusion characteristics of this geomaterial was studied**.

Keywords: **contaminant transport, diffusion, accelerated diffusion tests, clayey soils, electric field.**

I. INTRODUCTION

Population explosion and rapid industrialization have resulted in the generation of large amount of solid and liquid wastes, which contain high concentrations of toxic heavy metals, volatile organic compounds and radio active elements. The safe disposal and containment of these wastes is a matter of concern to engineers and planners. Currently the most widely accepted method is land disposal. However this method gives enough leeway for ground water pollution. To diminish severity of environmental degradation, present modern day landfills are provided with low permeability clay liners. In case of clay liners the diffusion phenomenon is the dominant mechanism of contaminant transport.

Migration of contaminants by diffusion mechanism takes place only due to concentration gradient. Consequently, obtaining the diffusion characteristics of various geomaterials using conventional laboratory studies is quite challenging and time consuming. In geomaterials like clay it would take months to obtain some appreciable results related to diffusion characteristics. In addition to the time constraint there exist the difficulty in maintaining environmental conditions practically constant throughout the experiment.

As a novel alternative to overcome these difficulties researchers have and intact rock mass. Previous researchers have come up with the idea of applying electric potential difference across the sample successfully employed the electromigration process to obtain contaminant transport parameters of various porous materials like concrete to expediate the migration of ions from one side of the specimen to the other side. However the efficiency and suitability of the electromigration to enhance the diffusion mechanism have not been addressed by the previous researchers in the literature.

The electromigration process is quite independent of pore size distribution and application of electrokinetics does not alter both pore and soil structure. It permits a more uniform flow distribution and high degree of control of direction of flow.

The electromigration method can be applied in both saturated and unsaturated soil. Contaminant removal is easy, and could be done by collecting liquids at electrodes. This technique is non destructive and can be applied to inaccessible places such as under structures or underground tanks.

The scope of the present work is the literature review of various methodologies related to diffusion characteristics of porous materials. It also compares the test results of both types of tests and validation of the accelerated test results with those of conventional tests and existing values in literature.

II. LITERATURE REVIEW

Rowe (1987) has reviewed the various methods employed to predict the contaminant transport through both saturated and unsaturated clay barriers. The study highlights the soil properties that control the transport mechanism of the contaminant in saturated as well as unsaturated soils and migration of contaminant through barriers into adjacent aquifers .Casey (1989) have studied the influence of pore geometry and their orientation on diffusion characteristics of the intact rock. A 2 dimensional mathematical model was proposed to stimulate the transport mechanism through dolomite intact rock sample and hence to estimate the effective diffusion coefficients. Incidentally the obtained diffusion coefficient using the mathematical model is found to be quite comparable with those obtained from complex experiments.

Gurumoorthy and Singh (2003) have presented an experimental method to monitor diffusion of contaminants through the intact and fractured rock mass. The authors used two types of diffusion cells one where migration will be in vertical direction and the other one horizontal direction. Electrical conductivity is sensed in the form of digital pulse frequency, later which was converted into concentraton of chloride ion. The calculated values are found to be in line with those values obtained from ion chromatography.

Boving and Grathwohl (2001) have measured the effective diffusion coefficients using the time log method for 49 mm diameter and 4 to 15 mm thick rock samples. The results indicated a close relationship between total porosity and the effective diffusiuon coefficient of the rock. From the experimental results it has been observed that porosity influences the diffusion characteristics.

Shackelford (1989) has studied diffusion of anions such as bromide, chloride and iodide and cations such as cadmium , potassium and zinc through compacted kaolinite and lufkin clay samples. The effect of molding water content and method of compaction on diffusion coefficient of kaolinite was evaluvated.it has been observed that diffusion coefficient values of chloride ion through kaolinite are relatively insensitive to molding water content and compaction method employed. The measured diffusion coefficients of kaolinite for cations are found to be relatively high as compared to anions.

Critical Appraisal:

Many efforts were made by the previous researchers to understand diffusion mechanism and idealise it ti framework both mathematical and experimental.

In all the above mentioned works, the time involved in attaining the desired breakthrough was large and the difficulty to maintain the test conditions practically constant was reported widely. To overcome this electomigration concept were employed where electric potential is applied across the porous media of interest to accelerate the migration of ions. Having applied this concept successfully in concrete, researchers have extended the electro migration concepts for geomaterials like intact rocks.

From the above precise of work it would be coherent that time involved in completion of the diffusion process is really large. On an average these tests in compacted soil specimen under normal testing conditions would take months to complete .So the concept of accelerating these conventionally long duration tests has of late caught the imagination of researchers .This has successfully been applied and validated in case of rocks where inorganic solvents were used as model contaminants. The results obtained in all these works would testify the fact that electro migration tests are reliable and fast.

However not many efforts were been made by the previous researchers to understand the electro migration of various heavy metals through compacted fine grained soils. With this in view the present study made to develop the methodology to determine the diffusion characteristics of various geomaterials using accelerated diffusion tests.

III. EXPERIMENTAL SETUP

Although previous researchers have made tremendous efforts to develop testing methodologies to obtain the diffusion characteristics of porous materials , still the area of research need constructive and systematic efforts to resolve some of the unattended experimental issues. Hence the author has attempted the development of new methodology by fabricating the accelerated diffusion test setup to determine the diffusion characteristics of geomaterials effectively in a very short duration.

Components of Test Setup:

Source Reservoir: The source reservoir is intended to house the known solution of known concentration of a chosen model contaminant.

Receiving Reservoir: To impose the zero flux boundary condition on one one side of the sample the receiving reservoir is made up of acrylic is filled with distilled water. This reservoir also facilitates the collection of diffused ions through the sample.

Sample Holding Cube: The soil sample is compacted to different unit weight and moisture content in the sample holding cube. This sample holding cube is sandwiched between source and receiving reservoir.

Tie Rods : To hold all individual parts of the diffusion test setup together with the help of wing nuts.

Porous plates: to test compacted soils on the setup there need to be confinement on either side of sample so that there is no slipping of soil to cause side wall leakage of the contaminant.

Regulated DC Power Supply: The regulated DC power supply capable of supplying a constant potential difference of 0 to 100 V was chosen. The applied voltage could be maintained for long periods without any hindrance.

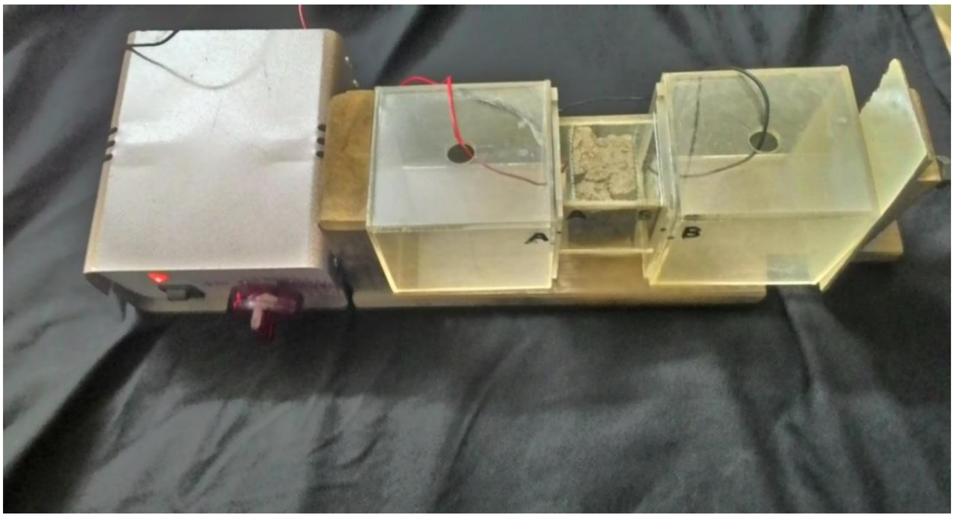

Fig 1: Diffusion Characteristics test setup

IV. EXPERIMENTAL STUDY AND MATERIAL CHARACTERISATION

The fabricated experimental test setup is employed to determine the diffusion characteristics of chosen geomaterial.

Material:

The chosen geomaterial was locally available clayey soil. It was collected from a field near Vaikom.The material was characterised for its physical and geotechnical characteristics.to obtain these characteristics series of experimental discussions were carried out and the details are presented in the following . Lead nitrate in its solution form was used as a model contaminant in the diffusion tests to stimulate the contaminant transport through these materials. The concentration of the lead ions in the receiving reservoir is determined using an atomic absorption spectrometer, AAS.

TABLE I: Geotechnical properties of Clayey soil

Sl No	Properties	Values Obtained
1.	Specific gravity	2.43
2.	Index property (Liquid Limit in %)	56
3.	Grain size distribution: Clay size (%)	30

	Silt size (%) Sand size (%) Gravel size (%)	45 25 0
4.	Standard proctor test: Optimum moisture content(%) Dry density(kN/m3)	 30 1.16

Diffusion Characteristics:

The basic principle of accelerated diffusion methodology is that under yhe influence of applied electric field , anions and cations migrate towards respective anode and cathode of the diffusion test setup as a result diffusion mechanism will get accelerated.

The accelerated diffusion test were performed by applying an electric potential difference directly across the sample. This was achieved by placing the two stainless steel porous plates electrodes adjacent to the sample and connecting them to a regulated DC power supply.this arrangement also helps in minimising the loss of electric potential acting across the sample.

To monitor the variation of concentration value in the receiving reservoir, solution was sampled at close regular intervals of time. This was done by drawing approximately 10 cc of the solution with the help of a microlit Micro pipette.The samples were analysed for the concentration of lead ions with the help of AAS.

The Ct values obtained were used for developing the break through curve, BTC, which is a graphical representation of concentration variation in the receiving reservoir with time.

V. RESULTS

The break through curves BTC for different soil samples in the form of Ct versus t were obtained from accelerated diffusion tests as per different applied electrical potential.

The concentration values are very low during initial testing periods and gradually increased upto a certain time and followed by a rapid linear increase. The initial portion of the curve is corresponding tio the unsteady state of diffusion phenomenon .After overcoming the initial unsteady state the concentration values follows exponential form .This kind of behaviour can be represented by steady state portion of the BTC.

As experimentation time increases BTC will give a distinct steady and unsteady portion which is quite helpful for obtaining the diffusion characteristics. A straight line is fitted into the exponential steady state portion of the BTC and slope value of this is directly proportional to effective diffusion coefficient of soils .The diffusion time is the intercept that the linear portion of the BTC makes with the abscissa.

TABLE: II. Test Sample Results

Sl No	SampleID	Analyte	Mean
1.	Sample 20 V 70 Hr	Pb 269.9	NIL
2.	Sample 20 V 190 Hr	Pb 269.9	21.30 mg/L
3.	Sample 20 V 210 Hr	Pb 269.9	86.27 mg/L
4.	Sample 20 V 350 Hr	Pb 269.9	144.6 mg/L
5.	Sample 40 V 70Hr	Pb 269.9	44.42 mg/L
6.	Sample 40 V 190 Hr	Pb 269.9	86.13 mg/L
7.	Sample 40 V 210 Hr	Pb 269.9	184.9 mg/L
8.	Sample 40 V 350 Hr	Pb 269.9	493.5 mg/L

VI. CONCLUSIONS

i. The diffusion characteristic of locally available clay was determined efficiently in a very short duration by employing a rapid methodology

ii. The result obtained from the rapid methodology was comparable to those obtained from conventional methods. Thus its validity was established.

iii. The concentration values are very low during initial testing periods and gradually increased up to a certain time and followed by a rapid linear increase. After overcoming this unsteady initial portion the concentration values follows exponential form.

iv. The diffusion time is the intercept that the linear portion of BTC makes with abscissa. With increase in voltage the time of diffusion reduces appreciably .

v. The slope of linear portion of BTC can be used as diffusion characteristic of geomaterial. With increase in the applied voltage the value of the slope increases.

REFERENCES

[1] Thevanayagam, S. and Rishindran, T. (1997). "Injection of Nutrient and TEAs in Clayey Soils using Electrokinetics", Journal of Geotechnical Engineering.

[2] Tang, L. and Nilsson, L. (1992). "Rapid determination of the chloride diffusivity in concrete by applying an electric field", ACI Materials Journal, 89(1), 49-53.

[3] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," journal name., vol. 20, pp. 569–571, Nov. 1999.

[4] Probstein, R. F. and Hicks R. E., (1993). "Removal of contaminants from soils by electric fields", Science, 260, 121-134.

[5] Witthüser, K., Dalinaidu, A., and Singh, D. N. (2004). "Determination of diffusion characteristics of the rock mass", Indian Geotechnical Journal, 34(1), 95-105.