International Journal of Advanced Technology in Civil Engineering

Volume 2 | Issue 2 Article 8

April 2013

DETERMINATION OF PORESIZE AND PERMEABILITY BY INDUCED POLARIZATION TECHNIQUES IN CLAY SAMPLES OF COASTAL ANDHRA PRADESH

E. V. RAGHAVARAO
Visakha Technical Campus, Visakhapatnam, India, E.V.RAGHAVARAO@gmail.com

R. P. DAS
Madhira Institute of Technology and Sciences, Kodada, India, R.P.DAS@gmail.com

MADHU CHANDRA POPURI
Pydah College of Engineering & Technology, Visakhapatnam, India,
MADHUCHANDRAPOPURI@gmail.com

Follow this and additional works at: https://www.interscience.in/ijatce

Recommended Citation

RAGHAVARAO, E. V.; DAS, R. P.; and POPURI, MADHU CHANDRA (2013) "DETERMINATION OF PORESIZE AND PERMEABILITY BY INDUCED POLARIZATION TECHNIQUES IN CLAY SAMPLES OF COASTAL ANDHRA PRADESH," *International Journal of Advanced Technology in Civil Engineering*: Vol. 2 : Iss. 2 , Article 8.
Available at: https://www.interscience.in/ijatce/vol2/iss2/8

This Article is brought to you for free and open access by Interscience Research Network. It has been accepted for inclusion in International Journal of Advanced Technology in Civil Engineering by an authorized editor of Interscience Research Network. For more information, please contact sritampatnaik@gmail.com.

DETERMINATION OF PORESIZE AND PERMEABILITY BY INDUCED POLARIZATION TECHNIQUES IN CLAY SAMPLES OF COASTAL ANDHRA PRADESH

E. V. RAGHAVARAO[1], PROF. (DR.) R. P. DAS[2], MADHU CHANDRA POPURI[3]

[1]Professor, Dept. of Civil Engg., Visakha Technical Campus, Visakhapatnam, India
[2]Director, Madhira Institute of Technology and Sciences, Kodada, India
[3]Assistant Professor, Pydah College of Engineering & Technology, Visakhapatnam, India

Abstract- Using the similarity between poresize and IP relaxation time a cost effective method of determining permeability in coastal Andhra Pradesh has been worked out. The results have found greater matching in the medium grade.

Keywords*-Induced Polarization; poresize; resistivity; permeability;*

I. INDUCED POLARIZATION TECHNIQUE

Time domain induced polarization techniques are useful for studying resistivity and chargeability. The electrodes, as in Fig. 1, can be turned around for taking horizontal and vertical measurements. The focused electric field can penetrate deep into the formations of soil [1]. The signal to noise ratio is quite large so that logging can be done without intra-receptions. As the ions polarized by this method move in the direction of applied electric field we can separate horizontal and vertical permeability.

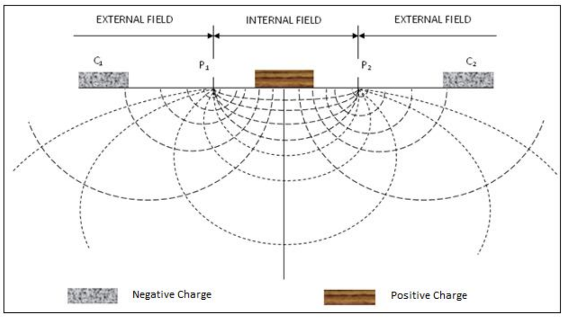

Figure 1. Electric field pattern in IP measurement (Horizontal / Vertical)

Additionally, unlike NML (Nuclear Magnetic Logging), IP method is sensitive to water only. Oil is out of picture being substantially insulating in nature. Contrasted to NML, response is measured only along conducting paths. So, disconnected (or Dead-End) pores which have no effect on permeability are not measured in case of IP logging [3].

II. PRINCIPLE OF OPERATION

The time-domain decay curve can be decomposed into a set of exponential decays with different time constants. With respect to each set of amplitude and time constant poresize pattern can be constructed. It is based on the diffusion relation, $D=R^2/\tau$, where D is the diffusion constant of sodium chloride (cm^2/sec), R is the displacement length (m) and τ is the time factor. D can be taken to be $1.5x10^{-5}$ cm^2/sec at room temperature. For all practical purposes R can be equated with poresize leading to IP decay curve yielding distribution of poresize.

From the distribution of poresize a rough value of permeability can be predicted using geometric models. Through a relative calibration we can also show that IP instrument can be used to show the value of permeability.

Pores can be thought of as series of clay rich and clay free zones. Clay rich zones act as cation selective membranes [4]. These reduce the flow of cations. So, after some time gap, a gradient is formed across cay-free zones because of increase in electrolyte concentration at the edge of the clay-rich zone. During the turn-off phase, concentration gradient is disturbed and electrolyte ions diffuse back to their equilibrium position. Subsequently, IP gradient is reduced in the decay pattern.

III. EXPERIMENTAL SETUP

The C_1 and C_2 electrodes are kept at different orientation for the purpose of horizontal/vertical measurements. The timer is adjusted for 2 sec / 4 sec / 8 sec operations [Figure 2]. Let V_0 be the equilibrium voltage after the application of electric filed. Let V' (t) be the IP decay voltage so that at t=o decay starts in V (t). For porous medium consisting of same size, IP decay curves ideally should be having single exponential pattern.

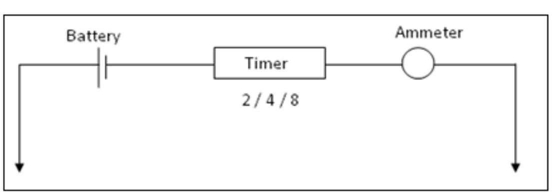

Figure 2. Block diagram of the proposed model

It is found that observed exponential decay consists of series of exponential decay with different time constants. The pattern can be formed by decomposing the decay obtained. In this case, there are at least 5 patterns of pore distances. The shortest time constant in the decay curve is contributed by those ions with shorted relaxation distance. In case of long time constants, ions may have enough time to return to their equilibrium positrons so that final IP decay voltage goes to zero in a limiting case [2].

It is experimentally found that [Figure 3] clay free-relaxation dimensions are approximately the same as pore size. This is so because the clay occurs as a pore living substance. This interesting factor can be used in IP plots to determine the effective pore size.

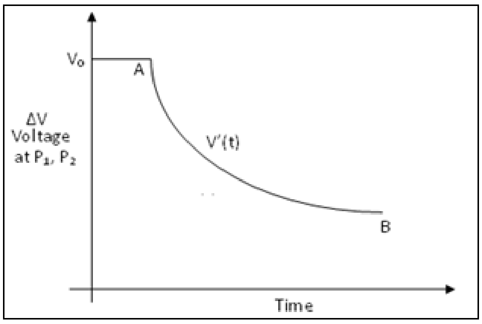

Figure 3. Graph showing the relationship between Voltage and time

In the proposed setup, the IP logging arrangement is made to apply constant current, as in Fig. 3, until equilibrium is reached. The time required varies from few ms to tens of seconds. The ratio of the voltage from V' (t) /V_0, eq. 1,can be expressed in terms of exponentials such that

$$V'(t)/V_o = F_1e^{-t/\tau 1} + F_1e^{-t/\tau 2} + F_1e^{-t/\tau 3} + F_1e^{-t/\tau 4} \quad (1)$$

can be made to match the ratio. (Here F's are the fraction of total pore volume in which time constant is equal to τ). Pore size can be determined by

$$r_i = \sqrt{(DC_i\tau_i)} \quad (2)$$

where r_i is the radius of i^{th} pore and C_i is the correction factor.

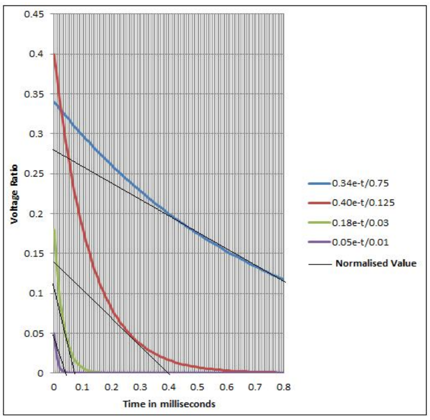

Figure 4. Graph between Voltage and time obtained from the experiment

IV. RESULTS

Basically we are decomposing the voltage decay curve into a number of relaxation times which are a function of poresize pattern. Permeability can be easily worked out from free poresize. These results can be extended to frequency domain studies. In these cases, phase shift with frequency can be correlated with previous core measurements to obtain pore size distribution.

A particular pattern of normalized decay has been broken into four components as shown in the Figure 4. From the various τ values we can obtain the poresize. Poresize calculations are shown in table 1.

TABLE I. TABLE SHOWING PORESIZE CALCULATIONS

Length	Fine Sand	Medium Sand	Coarse Sand
10 mm	0.122 (0.12)	0.143 (0.14)	0.78 (0.75)
50 mm	0.172 (0.17)	0.212 (0.21)	0.995 (0.99)

The bracketed values are as per conventional standards. The computed values are as per our method come extremely close to these values and justify the usage of IP based calculations.

V. CONCLUSION

The relationship between poresize and IP response has been established. The domain analysis has been used so far. Frequency domain method is likely to bring out closer relation between soil parameters and IP quantities. However, time domain analysis being easier, this method is likely to be of greater value to the field engineering.

REFERENCES

[1] KuanZheng; Pirjola, R.J.; Boteler, D.H.; Lian-guang Liu; , "Geoelectric Fields Due to Small-Scale and Large-Scale Source Currents," Power Delivery, IEEE Transactions on , vol.28, no.1, pp.442-449, Jan. 2013.

[2] Jianping Xiang; Jones, N.B.; Schlindwein, F.S.; , "Theoretical analysis and experimental investigation of induced polarization effect of rocks/minerals," Electrical Insulation and Dielectric Phenomena, 2001 Annual Report Conference on Electrical Insulation and Dielectric Phenomena, vol., no., pp.58-62, 2001.

[3] Attia, M.F.; , "Interpretation of time-domain induced polarization and resistivity data for Earth modeling," Geoscience and Remote Sensing Symposium, 1994. IGARSS '94. Surface and Atmospheric Remote Sensing: Technologies, Data Analysis and Interpretation, International, vol.4, no., pp.2499-2501 vol.4, 8-12 Aug 1994.

[4] E.V. Raghava Rao; Prof. (Dr.) R.P. Das; Madhu Chandra Popuri;, "Variation of Moisture Content as a Parameter of Study by Induced Polarization Technique in Soil Sample of Coastal Andhra Pradesh", International Journal Of Advanced Civil Engineering And Architecture Research 2012, Volume 1, Issue 1, pp. 1-5.

◈◈◈