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Study the Relationship of various Geotechnical Factors with Electrical Resistivity of soil

Suraj Sukhadev Vankamble[1], Sumit Sukhdev Vhankamble [2], Santosh Mohan Pawar[3]

[1]Assistant Professor, Civil Engineering Department, SBGI Miraj.
[2]Quality Incharge, ACC Pvt. Ltd, Hyderabad.
[3]Junior Engineer, Beri Architects & Engineers Pvt. Ltd, Kolhapur.

Abstract - The use of Electrical Resistivity (ER) in subsurface investigation has increased in recent years. Resistivity imaging (RI) is a non-destructive method and provides a continuous image of the subsurface. By performing different lab test we get the various geotechnical parameters such as moisture content, degree of saturation, dry unit weight, cohesion and angle of internal friction. In this study we introduce the relation between the some geotechnical parameters and electrical resistivity of soil.A geotechnical factors such as cohesion & angle of internal friction values are obtained from large box- direct shear test by conducting laboratory test. After the performing the electrical resistivity test in actual field we get that there is some relation between these cohesion and angle of internal friction with electrical resistivity of soil.

The field results reveal that a higher angle of internal frictionof soil results in a higher electrical resistivity. The electrical resistivity increases gradually with increasing cohesion value of soil of soil. A correlation among resistivity, cohesion of soil and angle of internal friction was developed based on the test results.

Key Words: Electrical Resistivity, Cohesion of soil, Angle of internal friction & Large box direct shear test.

1.INTRODUCTION

Electrical resistivity of soil, is the resistance offered by the soil against the conduction of electricity through it. This property of soil is mostly useful get information beneath or subsurface of the soil. Resistivity Imaging (RI) gives the continuous and unbreakable image of subsurface, which is mostly useful to study the different properties of soil. The various geotechnical factors such as water content, degree of saturation, dry unit weight and so on can be get without disruption of soil.

Electrical Resistivity mainly Work on Ohm's Law. The applied current value gives us the potential difference generated there. There are different methods but in this study:

A) Schlumberger method

B) Wenner alpha method

Are used mostly.

The values get with this above method are compared with two geotechnical factors of soil, those are cohesion and angle of internal friction mainly. Then a relation is established between them which is actually useful to future soil investigation.

In this study the two number of sites are selected from the state of Maharashtra. The soil samples are collected from those sites for conduct the test in laboratory such as large box shear test and get various geotechnical properties such as cohesion value of soil and angle of internal friction.

2 . PROCEDURE (IN LABORATORY)

There are two different field sites are selected at Maharashtra. From this sites three soil samples are selected where the Electric resistivity test are performed. Sample collected is bring to the laboratory for measuring properties of soil such as different values of moisture content, cohesion value and angle of internal friction of that different soil at different sites.

Oven dry test is done to determine the water content in soil by oven drying method as per IS: 2720(part 2) - 1973.

Soil sample from site 1 shows the Moisture content of 20%, from site 2 shows an Moisture content of 40% & from sample 3 contain moisture content of 60%.

Soil sample	Moisture content (%)
1	20.00
2	40.00
3	60.00

Table 1 : Soil with Moisture Content

A large direct shear apparatus was used to test coarse granular soil. By performing this Large-box shear test, we get values of Cohesion (kn/m2) and Angle of internal friction.

Table 2 : Soil with cohesion and phi-values.

Soil sample	Moisture content (%)	Cohesion (kn/m^2)	Angle of internal friction (phi)
1	20.00	33.15	41.23
2	40.00	22.15	33.32
3	60.00	19.18	24.21

3. PROCEDURE (ON FIELD)

For lateral profiling and sounding on the ground the plane surface of ground is selected which is having length of near about 100 to 200 meter and width of 20 to 50 meter for conducting the Electrical Resistivity in the field. The Schlumberger method and Wenner alpha method is used in this field study.

Difference between Wenner method and Schlumberger method is about spacing between the electrodes placed over the plane ground with constant span. The spacing kept is 4 meter in this field study. In Wenner method the electrodes are equally spaced but in Schlumberger method spacing between the current electrodes is three times the spacing between the potential electrodes.

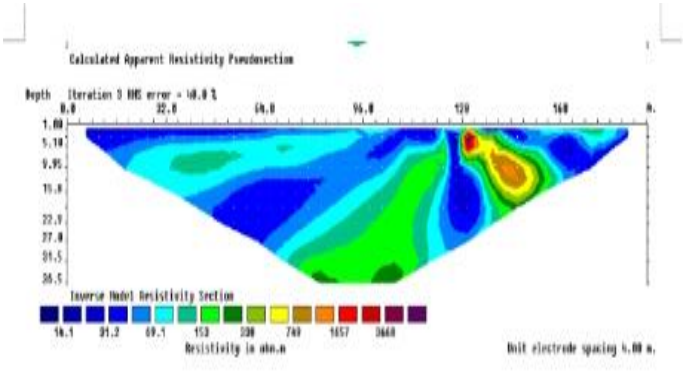
Fig.1 Site selected at Maharashtra for the conduction of ER test of soil.

The site should be free of obstructions , that is it should plane and continuous. In this study the 48 electrode method is used in which 48 number of electrodes are used with constant span of 4 meter. For proper bonding of electrode and soil the water is pour to that electrode point. The connection of battery source and ER instrument is checked. At the time of starting the instrument various inputs are placed over the numerical keyboard of ER instrument. The input data is useful for future working of electrical resistivity of same site and store the record of the electrical resistivity values which we get as output.

4. RESULTS

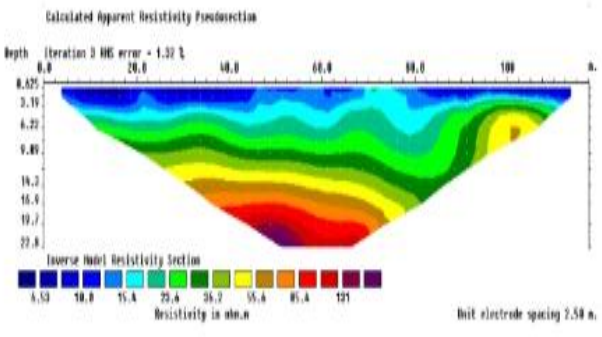
4.1 SOIL PROFILE (resistivity pseudo section) :

Calculated apparent resistivity pseudo section at site 1, in the state of Maharashtra. The Laboratory results obtained from soil sample selected from this site give the Moisture content of 20% and cohesion value of 33.15 kn/m2 and the angle of internal friction of 41.23.



Site No. 1

Calculated apparent resistivity pseudosection at site 2, in the state of Maharashtra. The Laboratory results obtained from soil sample selected from this site give the Moisture content of 60% and cohesion value of 19.18 kn/m2 and the angle of internal friction of 24.21.



Site No. 2

4.2 RELATIONSHIP OF ANGLE OF INTERNAL FRICTION WITH ELECTRICAL RESISTIVITY OF SOIL

Angle of internal friction (friction angle) A **measure of the ability of a unit of rock or soil to withstand a shear**

stress. It is the angle (φ), measured between the normal force (N) and resultant force (R), that is attained when failure just occurs in response to a shearing stress (S).

The variations of soil resistivity with the angle of internal friction are presented in below table for the soil Samples 1, 2 and 3. To obtain the angle of internal friction, a specific gravity of soil is 2.6 was considered to be constant. Soil resistivity increases with an increase of angle of internal friction. As degree of saturation or moisture content increases the value of angle of internal friction gets reduced.

At site-1, 2 and 3 the soil sample is taken which gives the value of moisture content of 20, 40 & 60%. The graphical representation showing the relationship of angle of internal friction with electric resistivity as x-axis representing electrodes span in meter and y-axis representing electric resistivity in ohm-meter.

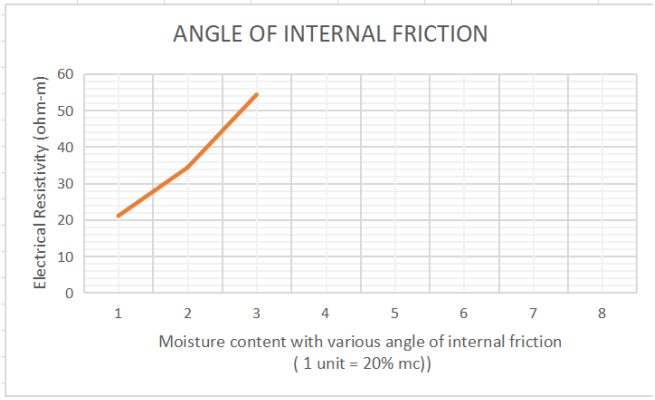
On the basis of geology obtained, we can identify the soil with various angle of internal friction.

Table 3. Soil with angle of internal friction with various moisture content and EWR values

Moisture content with different angle of internal friction (%)	Resistivity (ohm-m)
60	21.06
40	34.18
20	54.28

After the study of table given above shows that as angle of internal friction increases , the value of ER also gets increased.

By using the values given in the above table no. 3, the graph is plotted as x-axis as moisture content with various angle of internal friction and y-axis as Electrical resistivity (ohm-meter).



Graph 1. Relation of Angle of internal friction with Electric Resistivity of soil.

After the analytical study of the graphs of Angle of internal fraction with electrical resistivity , we get that the Electric Resistivity of soil increases with increase in angle of internal friction of soil.

As values of angle of internal friction increases as 24.21, 33.32 and 41.23, then the values of Electrical Resistivity also get increases as 21.06, 34.18 and 54.28 ohm-meter respectively.

4.3 RELATIONSHIP OF COHESION OF SOIL WITH ELECTRICAL RESISTIVITY OF SOIL

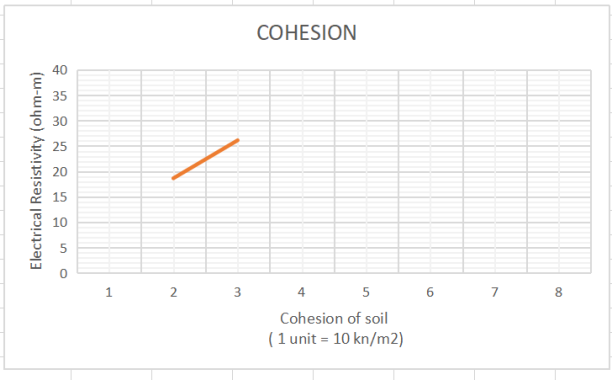
To determine the correlation of soil resistivity with Cohesion of soil, resistivity tests were conducted at different sites having various values of moisture content. From site 1 and 2 we get 3 different soil samples having the Cohesion value of 33.15, 22.15 and 19.18 kn/m2 respectively.

Table 4. Soil with cohesion and respective ER values.

Type of soil with cohesion (kn/m2)	Electrical Resistivity (ohm-meter)
33.15	33.12
22.15	26.12
19.18	18.02

After study the table of values of corresponding Cohesion and ER values, we get that cohesion of soil increases, the ER also gets increases.

By using the above table Graphical representation having Cohesion of soil (kn/m2) as x-axis and Electrical Resistivity (ohm-m) as y-axis is plotted as shown below:



Graph 2. Relation of Cohesion of soil with Electric Resistivity.

As Cohesion value of soil increases as 19.18, 22.15 and 33.15 kn/m2, the respective Electric resistivity values also get increased as 18.02, 26.12 and 33.12 ohm-m. This shows that the relation between ER and Cohesion of soil is Directly proportional.

5. CONCLUSIONS

- After the complete study of Electrical Resistivity of soil with different geotechnical parameters such as Moisture content, Cohesion of soil and angle of internal friction of soil, results shows the relation is exist between them.
- These relations are useful for further future study of the electrical resistivity of soil at different sites of having same Geological conditions as in this respective study.
- To study the effects of geotechnical fctors on soil resistivity will help to obtain the relationship between Electric Resistivity results and geotechnical parameters of soil.
- With the increase Angle of internal friction of soil as 24.21, 33.32 and 41.23, the soil shows the variation in electrical resistivity as increasing the values as 21.06 ohm-m, 34.18 ohm-m and 54.28 Ohm-m. Directly proportional relation is exist between the Angle of internal friction and electric resistivity of soil.
- As Cohesive values of soil increases as 19.18, 22.15 and 33.15 kn/m2, the respective Electric resistivity values also get increased as 18.02, 26.12 and 33.12 ohm-m. This shows that the directly proportional relation exist between Cohesion of soil and electrical resistivity of soil.
- However, the current study presents the effects of different soil parameters on resistivity. Similar trends are expected to be observed for other sites with different composition of soils.

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BIOGRAPHIES

1. MR. SURAJ SUKHADEV VANKAMBLE.

- ASSISTANT PROFESSOR, CIVIL ENGINEERING DEPARTMENT, SBGI, MIRAJ.
- M-TECH (GEOTECHNICAL ENGINEERING), COLLEGE OF ENGINEERING PUNE, COEP.
- B-TECH (CIVIL ENGINEERING), DR. JJMCOE, JAYSINGPUR, (SHIVAJI UNIVERSITY).

2. MR. SUMIT SUKHDEV VHANKAMBLE.
- QUALITY INCHARGE, ACC PVT. LTD. , HYDERABAD.
- B-TECH (CIVIL ENGINEERING), DR. JJMCOE, JAYSINGPUR, (SHIVAJI UNIVERSITY).

3. MR. SANTOSH MOHAN PAWAR
- JUNIOR ENGINEER, BERI ARCHITECTS & ENGINEERS PVT. LTD. KOLHAPUR.
- B-TECH (CIVIL ENGINEERING), DR. JJMCOE, JAYSINGPUR, (SHIVAJI UNIVERSITY).