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Investigation of Geotechnical Parameters affecting Electrical Resistivity of Compacted Clay

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Abstract – Electric Resistivity is used to study the sub-surface investigation of soil. Resistivity imaging (RI) is a non-destructive method and provides a complete image of the subsurface. The Geotechnical properties of soil obtained from laboratory tests such as Oven Dry test and Standard Proctor Compaction Test. The effects of moisture content, unit weight and degree of saturation on soil resistivity were investigated. Resistivity tests were conducted on the actual field on Composite soil at varying moisture contents, temperature and unit weights.

The field results shows that a higher degree of saturation results in a lower electrical resistivity. The electrical resistivity increases gradually with increasing dry unit weight of soil. Test results indicated that soil resistivity decreased with an increase in moist unit weight. A correlation among resistivity, moisture content, dry unit weight and degree of saturation was developed based on the test results.

Key Words: Electrical Resistivity, Moisture content, Degree of saturation, Void ratio, Dry unit weight and Standard proctor compaction test.

1.INTRODUCTION

Electric Resistivity is the method which is used world wide to investigate the geotechnical properties of soil. The geotechnical properties such as moisture content, degree of saturation and many others. It is also possible to find out such properties by boring methods by using different equipments. But such methods are less economical as compare to Electric Resistivity method, also this are time consuming methods. That's why ER is used to study the actual relation of geotechnical properties and Electrical Resistivity of soil .

In this study the different sites are selected at Narayan Gaon, Pune district in Maharashtra. The soil samples are collected from those sites to conduct the test in laboratory and get various geotechnical properties.

2. METHODOLOGY

2.1 SAMPLE COLLECTION:

There are diffeternt field sites are selected at Narayan gaon, pune. From this sites the the soil samples are selected where the Electric resistivity test are performed . Sample collected is bring to the laboratory for measuring properties of soil.

2.1.1Lab tests: Oven Dry test:

This test is done to determine the water content in soil by oven drying method as per IS: 2720(part 2) - 1973.The water content (w) of a soil samples is equal to the mass of water divided by the mass of solids. Two soil samples are taken from site A and from site B. Samples collected in air tight container made of non-corrodible material with lid. The test is conducted Thermostatically controlled oven maintained at temperature of 110°c.

Soil sample from site A shows the Moisture content of 54% and from site B shows an Moisture content of 12%.

Table 1 : Soil with Moisture Content

Soil sample	Moisture content (%)
A	54.00
B	12.00

Standard Proctor compaction test:

The standard proctor compaction tests were carried out according to the Indian standard method (IS: 2720 Part 7). Three soil samples are taken from site A, site B and site C for conducting Standard proctor test, to measure dry unit weight (kn/m3).

Table 2 : Soil with Dry Unit Weight

Soil sample	Dry Unit Weight (kn/m3)	Optimum Moisture content (percentage)
A	12.45	24.5
B	14.96	23.0
C	16.23	21.5

For lateral and vertical profiling of soil using resistivity technique, Resistance (ohm) is calculated in the field using the Wenner method and Schlumberger method, using Instrument Electric Resistivity Imaging (ERI). In these methods four electrodes are use in which inner electrodes are potential electrodes and outer electrodes are current electrode. DC (direct current) is applied at the current electrodes and potential difference is measured at potential electrodes.

Difference between Wenner and Schlumberger method is only about spacing between the electrodes. 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.

2.2 SITE SELECTION :

For taking readings and well set up of ERI instrument, the plain terrain should be there.Such sites are helpful for placing the electrodes with suitable span.

A site at Narayan Gaon at Pune district, Maharashtra is selected for field experimentation.

Fig.1 Site selected for conduction of ER

Fig.2 Electrode with acceptor connection

After the placing the electrodes the Acceptors that having two ends which are connected to electrode and main connection cable of acceptor. This are connected to each electrodes mainly with tight Rubber band, as shown in above fig.2. After that the acceptor cable conneced with the Electric resistivity imaging instrument and the ERI instrument also connected to the Battery of 220 Ah.

After the confirmation, start the battery and set the inputs regarding the imformation of site to the instrument by using numerical and function keys of instrument.

: Inputs consist of the imformation regarding:

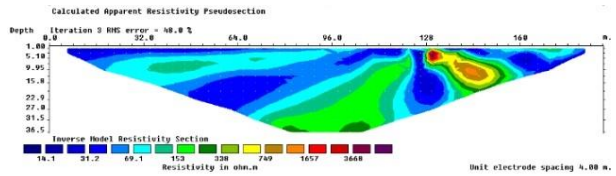
- ✓ Name of the site
- ✓ Lattitude and Longitude of lacation
- ✓ Near by site
- ✓ Span between electrodes
- ✓ Number of electrodes
- ✓ Method used on site

Etc. Data will set on the instrument for the future identification of site and there relevent results.

3. OBSERVATION AND RESULTS

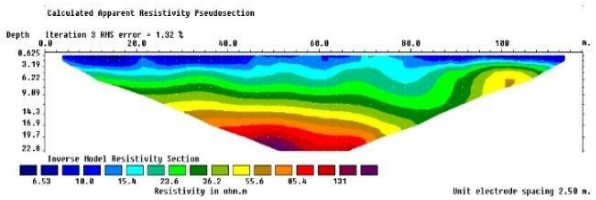
3.1 Soil profile apparent resistivity inversion

Calculated apparent resistivity pseudosection at Khodad site, Narayan gaon, Pune district, Maharashtra.The Laboratory results obtained from soil sample selected from this site give the Moisture content of 54% and Dry unit weight of 12.45 kn/m3.



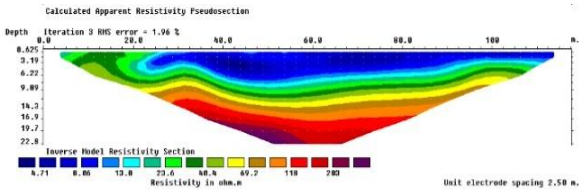
Khodad

Calculated apparent resistivity pseudosection at Kurwandi site, Narayan gaon, Pune district, Maharashtra. The Laboratory results obtained fromil sample selected from this site give the Moisture content of 27% and Dry unit weight of 14.96 kn/m3.



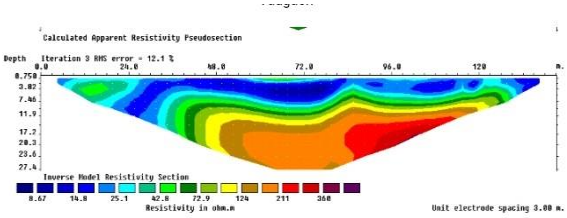
Kurwandi

Calculated apparent resistivity pseudosection at Vadgaon site, Narayan gaon, Pune district, Maharashtra. The Laboratory results obtained from soil sample selected from this site give the Moisture content of 12% and Dry unit weight of 16.23kn/m3.



Vadgaon

Calculated apparent resistivity pseudosection at Vaishnabdham site, Narayan gaon, Pune district, Maharashtra.The Laboratory results obtained from soil sample selected from this site give the Moisture content of 28% and Dry unit weight of 14.98kn/m3.

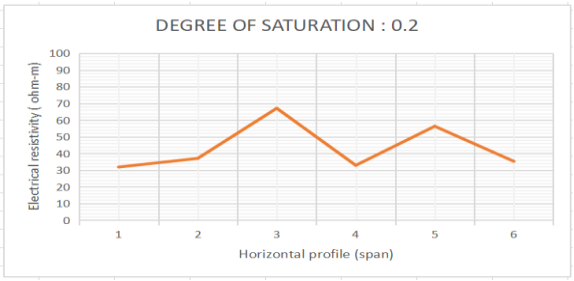


vaishnabdham

3.1 Soil Resistivity with Degree of Saturation:

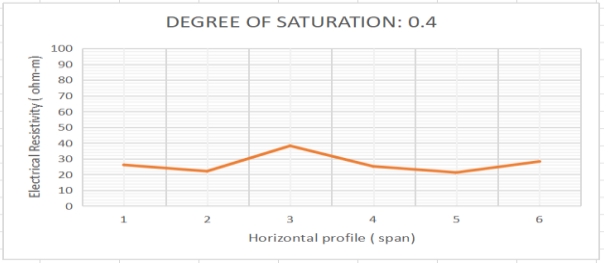
The water content and dry unit weight can be combined to a single geotechnical parameter called degree of saturation. The degree of saturation increases with the increase of water content or dry unit weight (Abu-Hassanein et al. 1996). The variations of soil resistivity with the degree of saturation are presented in above figure for the soil Samples A, B and C. To obtain the degree of saturation, a specifific gravity of 2.6 was considerd to be constant. Soil resistivity decreased with an increase of degree of saturation. Average soil resistivity of the samples was 28.56 Ohm-m at 40% degree of saturation. However, soil resistivity decreased to 15.26 Ohm-m at 60% degree of saturation. An increase in degree of saturation yields changes in orientation of clay particles. Therefore, soil resistivity decreased with the increase in degree of saturation, as presented in graphical representation of 3 different sites.

At Vadgaon site, Narayan gaon the soil sample is taken which gives the value of degree of saturation of 0.2. The graphical representation showing the relationship of degree of saturation with electric resistivity as x-axis representing electrodes span in meter and y-axis representing electric resistivity in ohm-meter.



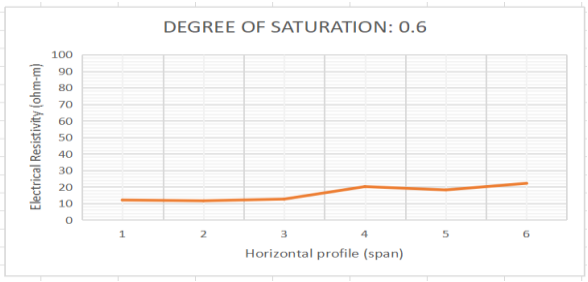
Graph 1. Relation of Degree of saturation with Electric Resistivity

At Kuruwandi site, Narayan gaon the soil sample is taken which gives the value of degree of saturation of 0.4. The graphical representation showing the relationship of degree of saturation with electric resistivity as x-axis representing electrodes span in meter and y-axis representing electric resistivity in ohm-meter.



Graph 2. Relation of Degree of saturation with Electric Resistivity

At Khodad site, Narayan gaon the soil sample is taken which gives the value of degree of saturation of 0.6. The graphical representation showing the relationship of degree of saturation with electric resistivity as x-axis representing electrodes span in meter and y-axis representing electric resistivity in ohm-meter.



Graph 3. Relation of Degree of saturation with Electric Resistivity

After the comparing all the graphs of degree of satiration with electrical resistivity , we get that the Electric Resistivity of soil decreases with increase in degree of saturation of soil, as shown in below figure.With the increase in dergree of saturation of soil as 20%, 40% and 60%, the soil shows the varition in electrical resistivity as decreasing the values as 48.23 ohm-m, 28.56 ohm-m and 15.26 Ohm-m. This study shows the inversely proportional relation of Degree of saturation and Electric resistivity.

3.2 Electric Resistivity with Dry Unit Weight of soil:

To determine the correlation of soil resistivity with Dry unit weight, resistivity tests were conducted at different sites having various values of dry unit weights while considering the moisture content constant. Tests were conducted on three sites at Narayan gaon, Pune. The soil

samples are collected from that respective sites and laboratory testings are done as mentioned above to find the proprties of soil, that are Samples A, Sample B and Sample C at optimum moisture contents of 24.5, 23.0 and 21.5% respectively.

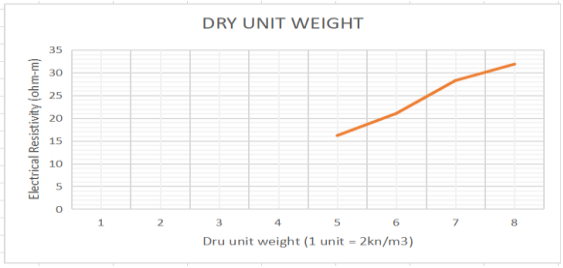
Dry unit weights were varied from site to site, as Site A, Site B and Site C having the value of Dry unit weight of 12.45, 14.96 and 16.23 kn/m3 respectively.Soil resistivity decreased with the increase of unit weight in each condition.

Table given below shows the soil with dry unit weight and there respective average ER value:

Table 3 : Soil with various Properties

Soil	Dry Unit Weight (kn/m3)	Optimum Moisture Content (%)	Electric Resistivity (ohm-m
Site A	12.45	24.5	21.02
Site B	14.96	23.0	28.25
Site C	16.23	21.5	31.83

Graphical representation having Dry unit weight (kn/m3) as x-axis and Electrical Resistivity (ohm-m) as y-axis.



Graph 4. Relation of Dry Unit Weight with Electric Resistivity

As Dry Unit Weight of soil increases as 12.45, 14.96 and 16.23 kn/m3, the respective Electric resistivity values also get increased as 21.02, 28.25 and 31.83 ohm-m. This shows that the relation between ER and Dry Unit Weight is Directely proportional.

3.3 Electric Resistivity with Moisture Content:

Soil resistivity tests were conducted at different sites having various moisture contents, Considering the dry unit weight constant. Moisture contents varied from 12 to 54% during field tests. two samples were considered to determine the variations of resistivity with moisture contents, that is, Sample at site A and site B. Soil resistivity in all soil samples decreased signifificantly with the increase of moisture content. The average reduction in soil resistivity was 7.0 Ohm-m for an increase of moisture from 12 to 22%. Maximum variation was observed in the soil Sample having 54% moisture content.

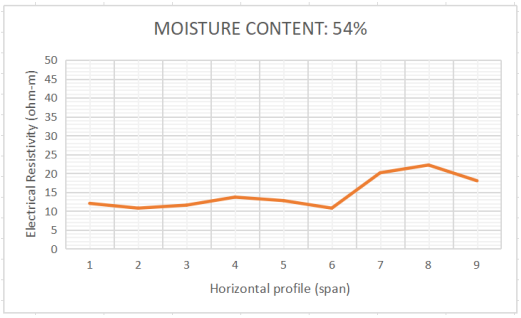
Moisture Content were varied from site to site, as Site A and Site B having the value of Moisture Content of 54 and 12 % respectively.Soil resistivity decreased with the increase of moisture content in each condition.

Table given below shows the soil with Moisture Content and there respective average ER value:

Table 4 : ER of soil with various Moisture Content

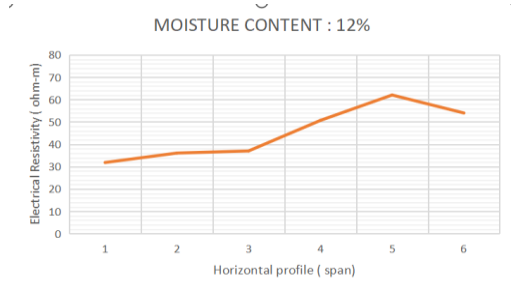
Soil Sample	Moisture Content (%)	ER (ohm-m)
Site A	54%	14.53
Site B	12%	44.16

Graphical representation having Mosture Content (%) as x-axis and Electrical Resistivity(ohm-m) as y-axis. For moisture content of 54% :



Graph 5. Relation of Moisture Content with Electric Resistivity

For moisture content of 12% :



Graph 6. Relation of Moisture Content with Electric Resistivity

After the comparing all the graphs of Moisture Content with electrical resistivity , we get that the Electric Resistivity of soil decreases with increase in degree of saturation of soil, as shown in below figure.

With the increase in Moisture Content of soil from 12% to 54%, the soil shows the varition in electrical resistivity as decreasing the values from 44.16 ohm-m to 14.53 ohm-m and 15.26. This study shows the inversely proportional relation of Moisture Content and Electric resistivity.

4. CONCLUSIONS

1. The objective of the current study was to determine the effects of some geotechnical parameters, that is, moisture content, unit weight and degree of saturation on the electrical resistivity conducted over different sites of Narayan gaon, Pune district, Maharashtra.

2. Understanding the effects of geotechnical parameters on soil resistivity will help to develop the correlations between ERI results and geotechnical properties.

3. By developing the correlations of electrical resistivity of soil with geotechnical parameters, ERI can be used extensively for geotechnical site investigation.

4. With the increase in dergree of saturation of soil as 20%, 40% and 60%, the soil shows the varition in electrical resistivity as decreasing the values as 48.23 ohm-m, 28.56 ohm-m and 15.260hm-m. This study shows the inversely proportional relation of Degree of saturation and Electric resistivity.

5. As Dry Unit Weight of soil increases as 12.45, 14.96 and 16.23 kn/m3, the respective Electric resistivity values also get increased as 21.02, 28.25 and 31.83 ohm-m. This shows that the relation between ER and Dry Unit Weight is Directely proportional.

6. With the increase in Moisture Content of soil from 12% to 54%, the soil shows the varition in electrical resistivity as decreasing the values from 44.16 ohm-m to 14.53 ohm-m and 15.26. This study shows the inversely proportional relation of Moisture Content and Electric resistivity.

7. 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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