Experimental Studies on the Effects of Density and Moisture content on Resistivity of Soils

by

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Introduction

Electrical resistivity technique is one of the geophysical methods which is frequently being used by civil engineers for sub-surface explorations. Electrical resistivity values, though differ over a wide range for various soils and rocks, also depend largely on various other factors. In layered soil deposits the electrical resistivity survey provides the values of apparent resistivity and one has to obtain values of absolute resistivities of each of the layers to identify them. It is well known that the factors such as density and moisture content affect the resistivity values. In view of this, it is necessary to study the effects of these factors on resistivity, so that the outcome of these studies may aid the interpretations. The present experimental investigations were done in the laboratory to study the effect of density and moisture content and in turn degree of saturation on resistivity values of soils.

Literature Review

For field investigations, various methods and electrode configurations are in use. It is assumed that current flows along the part of the spherical surface below the ground. These methods in layered system give apparent resistivity values of the soil upto the depth equal to the depth of penetrtion of current below the ground. Apparent resistivity is the resistivity value indicating cumulative effects of resistivities of different layers upto the depth of current penetration. It depends upon absolute resistivities of each layer and their thicknesses. The absolute resistivity of a soil will be equal to the resistance offered to the flow of current by a soil cylinder of unit cross sectional area and unit length.

$$\rho = \frac{R.\ A.}{L} \qquad \text{... (1)}$$

where

ρ = *Resistivity of the soil*

R = Resistance offered by a cylindrical soil specimen.

A = Cross-sectional area of the specimen

L = Length of the specimen.

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Experimental Programme

Equipment used : Following equipment and accessories were used to conduct the experiment.

(*i*) Perspex mould—A perspex mould was selected since the resistivity of perspex is infinity for all practical purposes. The internal dia of the mould was 3.77 cm. and length 7.57 cm. One end of the mould was sealed with a copper plate. Another copper plate of dia equal to the inner dia of the mould was used to pass the current through the soil specimen.

(*ii*) Multimeter—A multimeter which could read up to 200 k-Ohm was used to measure resistance of soil specimen.

(*iii*) Jack and plunger —A brass cylinder of dia equal to the inner dia of the mould was used as a plunger to compact the soil up to desired densities with the help of a hydraulic jack.

Soils studied—Total six soils were tested for their resistivity values under different conditions of density and moisture content. These soils were Bentonite, Dhanauri clay, Farakka soil, Ghaggar clay , Delhi silt and Malanjkhand soil. Their properties are given in Table 1.

TABLE 1

Properties of Soil

Property	Soil					
	Malanjkhand soil	Delhi silt	Ghaggar clay	Farakka soil	Dhanauri clay	Bentonite
Liquid limit (%)	—	33	50	44	51	320
Plastic limit %	—	23	25	23	30	70
Sand (%) (2 to 0.075 mm)	40	29	4	4	1	Nil
Silt (%) (0.075 to 0.002 mm)	60	54	58	65	64	5
Clay (%) (< 2 micron)	0	14	38	31	35	95
Activity	—	0.71	0.66	0.66	0.60	2.63
Specific gravity	2.77	2.67	2.77	2.76	2.81	2.82

The soils so selected for study were ranging from highly plastic clay to non plastic sandy silt.

Experimental Procedure—Soil specimens were prepared in the perspex mould at desired density and moisture contents. The copper plate was pushed into the mould and resistance of the soil specimen were measured. Exact values of moisture content were determined after each test. The specimen were prepared at dry densities 1.0, 1.10, 1.20, 1.30, 1.40 and 1.50 gm/cc. and at moisture contents ranging from 5 to 35 per cent. Figure 1 shows the view of experimental set up. The resistivity values are calculated from the observed values of resistances using equation 1.

Results and Discussions

The typical results of variation between electrical resistivity and dry density for different moisture contents are shown in Figure 2. It can be seen from the figure that decrease in resistivity values with increase in density is significant for lower moisture contents while for higher moisture contents decrease is not much. Figure 3 indicates resistivity tests results at constant density and different moisture contents. It also shows that decrease in resistivity is considerable at low densities while at higher densities resistivity values do not change much. The experiments conducted on totally dry soil showed that these are non conductive. Degree of Saturations were calculated corresponding to the different dry densities and moisture contents. Typical results for the variation of resistivity with degree of saturation is shown in Figure 4. An interesting point to note is that resistivity values decrease with increase in dry density upto a certain degree of saturation beyond which the resistivity increases with increase in density. More or less similar results were obtained for all the soils studied.

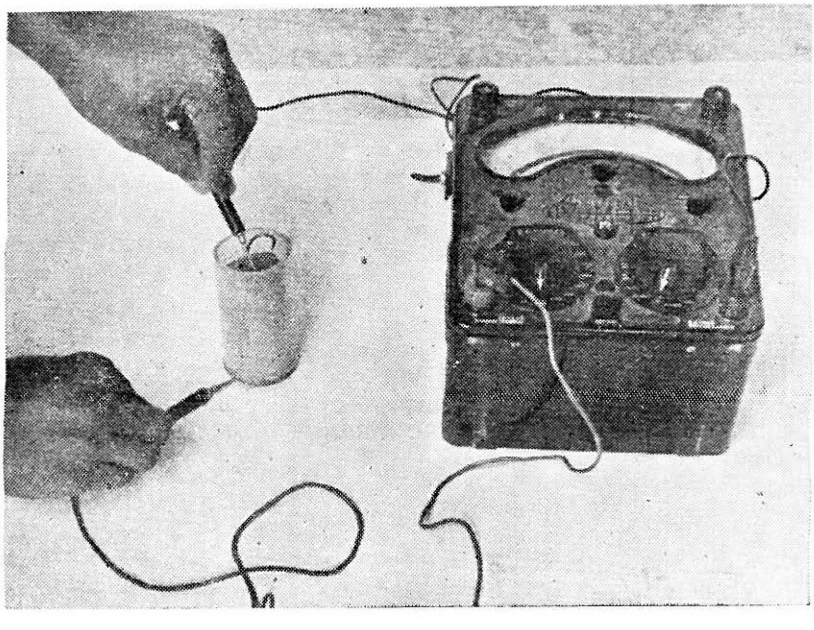

FIGURE 1 View of the experimental arrangement

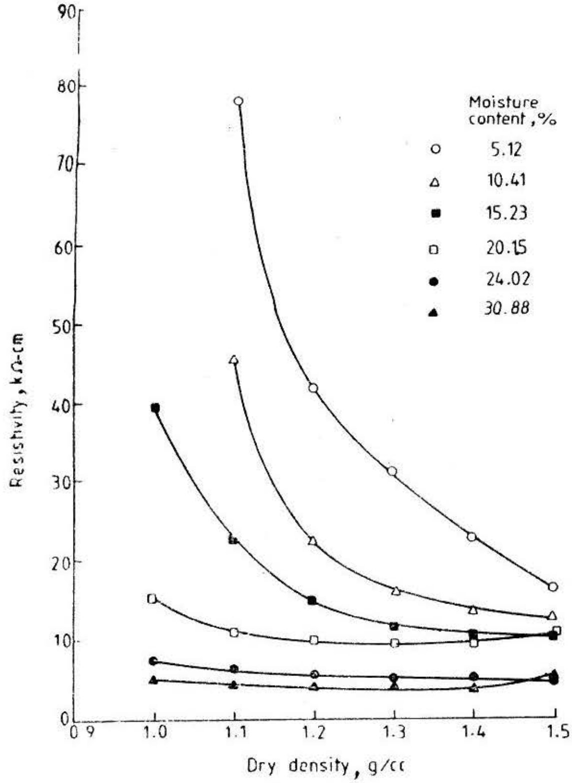

FIGURE 2 Electrical resistivity of soils versus dry density

Since dry soils were found to be non conductive to the flow of current it can be assumed that flow of current takes place through the moisture present in the soils. Entire behaviour can best be explained by resistivity versus degree of saturation curves in Figure 4. Resistivity of the soils decreases as the water filled voids become close and interconnected. Resistivity is more if there are air voids or the water filled voids are not interconnected and are dispersed in the soil medium as can be seen that resistivity increases with increase in density after a certain limit of degree of saturation.

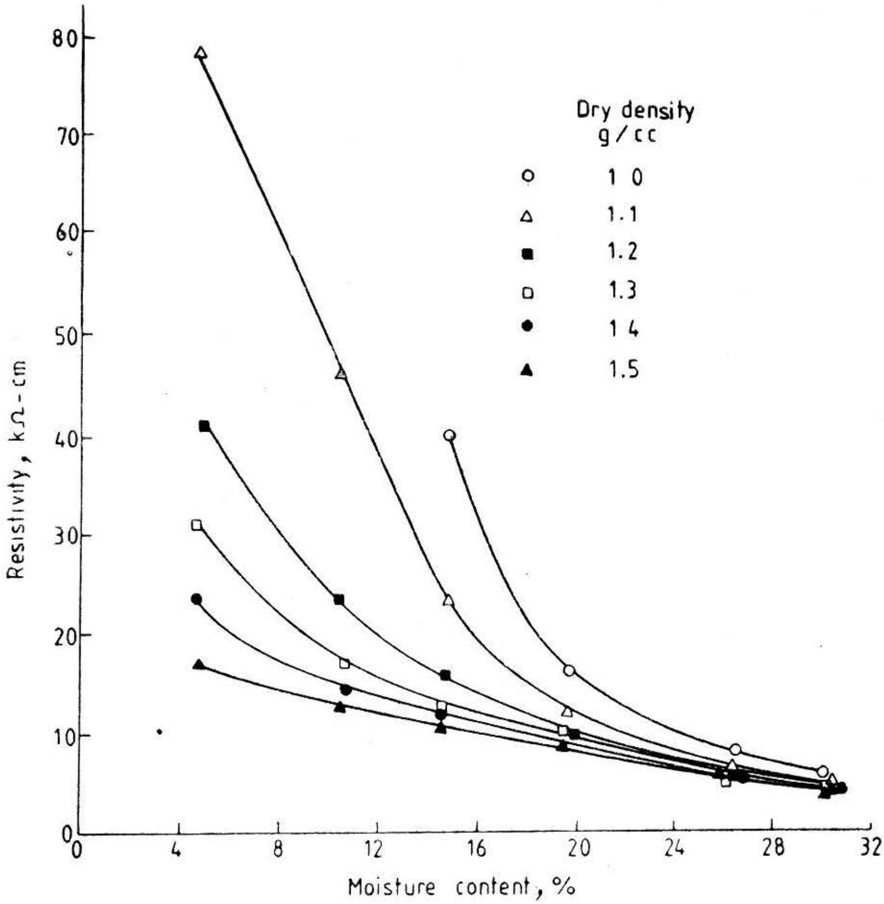

FIGURE 3 Variation between resistivity and moisture content

Attempts were also made to correlate absolute resistivities with properties given in Table 1. But within the scope of these experimental studies no specific correlations could be established.

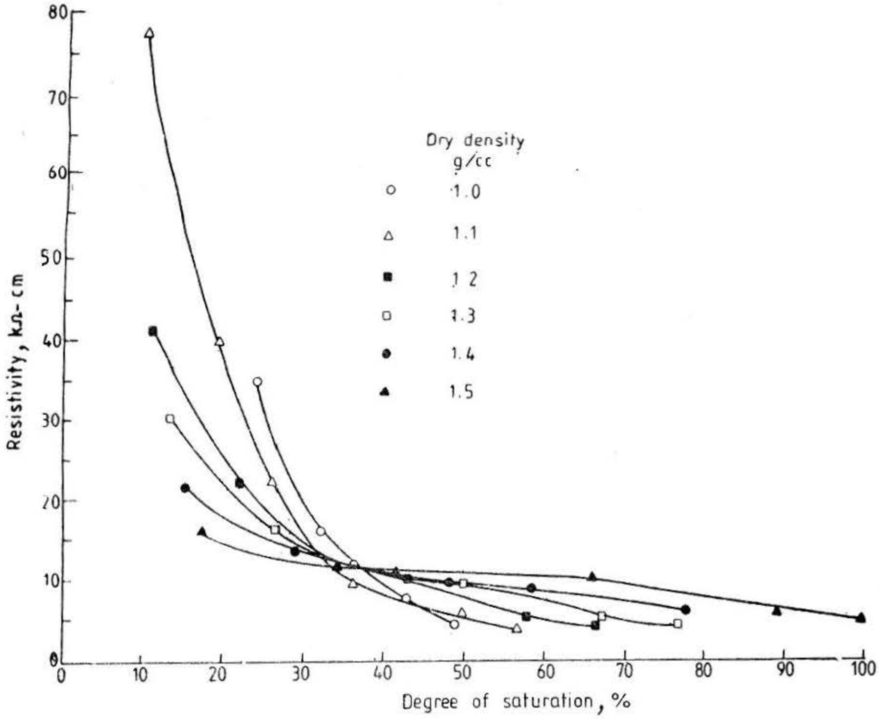

FIGURE 4 Resistivity Variation with degree of saturation

Conclusions

The conclusions drawn are summarized below :

(*i*) Both density and moisture content affect the resistivity of soils significantly.

(*ii*) Degree of saturation is an important parameter affecting the resistivity of soils, since it incorporates the effect of both density and moisture content.

(*iii*) The results of these studies may prove to be useful for interpreting absolute resistivity from apparent resistivity data.

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