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ESTABLISHINGA RELATIONSHIP BETWEEN ELECTRICAL RESISTIVITY MEASUREMENTS AND SOIL PENETRATION TEST VALUES – A CASE STUDY

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ABSTRACT

Electrical resistivity survey and SPT blow count (corrected N value) for majestic site in Bangalore region are analyzed to establish their relationships. In the present study, the apparent resistivity and corrected N values are interpreted with depth to understand the relation between the two properties. From the results, it is found that zone showing low apparent resistivity values generally have low corrected N value and vice versa.

Also apparent resistivity and transverse resistance are correlated with corrected N values. The apparent resistivity is correlated with corrected SPT-N value, it can be concluded that relationship between corrected SPT-N value and apparent resistivity is not significant (R^2=0.394), it shows the apparent resistivity is non-linearly varying with corrected SPT-N values.The transverse resistance is correlated with corrected SPT-N value, it can be concluded that there is linear relationship between corrected SPT-N value and transverse resistance (R^2=0.7256), it shows good correlation between these two parameters.

Keywords: Electrical Resistivity, Corrected N values, Apparent Resistance, Transverse resistance.

I. INTRODUCTION

1.1 GENERAL

Careful design of an engineering structure is not completed unless full information about the type and condition of the strata, on which the structure is to be build up is available. Intelligent design for safe and economical construction requires through knowledge of subsurface condition. The study is being carried out mainly in majestic site Bangalore, Karnataka. An attempt is made here to delineate subsurface lithology, and conduct geophysical surveys to find the depth to bed rock and to establish relationship between electrical resistivity and SPT-N values. Electrical resistivity sounding (ERS) have been conducted at the places where the standard penetration test (SPT) for geotechnical investigation has been carried out. The electrical resistivity data has been used to correlate the transverse resistance and apparent resistivity of soil with the number of blow counts (N values) obtained from SPT data. The demonstrate the usefulness of the ERS method in geotechnical investigation, which is economic, efficient and less time consuming in comparison to the other geotechnical method, such as SPT and DCPT, used for the purpose. The result of this investigation will be valuable information in civil engineering projects.

Geotechnical tests are time-consuming and expensive. On the other hand, geoelectrical methods are faster and comparatively cheap. The use of Electrical Resistivity

Tomography (ERT) technique provides the electrical image of subsurface soil and has become an important tool for the electrical characterization of soil.

Correlation between electrical parameters and soil strength, derived from geotechnical tests, can be studied by choosing different electrical parameters. The relationship between the electrical parameters such as charge ability, resistivity and N-values is poor [6]. We try to make an interpretation by combining resistivity and geotechnical standard penetration test (SPT) blow counts, named the N value, for the safety assessment of a fill dam. The SPT is known as an effective and direct method to analyze the soil stiffness. If the resistivity has positive correlation with the soil stiffness, then it should also show the same relation tendency with the N value [8]. In this study, we compare the N value from SPT and the resistivity information to interpret how the resistivity pattern is related with the subsurface soil condition [12]. Stability of natural and engineered structures such as building, roads, tunnels, slopes, bridges, dams etc, is the most vital aspect of geotechnical engineering. Precise determination of engineering properties of soil is essential for proper design and successful construction of any structure [5].

1.2 Objective of the Project

1. To calibrate resistivity meter available in the department.
2. The main objective of the present study is to use electrical resistivity method to get more details of soil/rock beneath, so that it is more economical, efficient and less time consuming to get the engineering properties of soil or rock.
3. An attempt is made to correlate the electrical resistivity results with the SPT N values, by carrying out the electrical resistivity sounding at the same point where the SPT have been already conducted.
4. To study and compare the variation of resistivity and spt obtained in the field with respect to depth.

II.GEOLOGICAL DETAILS OF THE STUDY AREA AND METHODOLOGY

2.1 GENERAL

Geology of majestic site, Bangalore discussed keeping in mind, the geology of Bangalore district of Karnataka State (of which the study area is a part) The Latitude of majestic Bangalore metro station is $12^0$58’32.95” N and Longitude of majestic Bangalore metro station is $77^0$34’22.74” E. Granite Gneiss are the major lithological units.

2.2 GEOLOGY AND SOIL TYPES OF STUDY AREA

2.2.1 GEOLOGY:

The area has mature topography with scattered isolated hillocks around, where rocks are exposed. The rock type exposed in the district belong to Saugar Group, Charnockite Group, Peninsular Gneissic Complex (PGC), Closepet granite and basic younger intrusive. Saugar group comprises ultramorphic rocks, amphibolites, Quartzite banded magnetites, quartzite occurring as small bands and lenses within the magmatites and gneisses. PGC is the dominant unit and covers about two-thirds of the area, which includes granites,

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gneisses and magmatites. The bed rocks essentially consist of granites and gneisses intruded by number of basic dykes. The soils of Bangalore district consist of red laterite and red fine loamy to clayey soils.

2.2.2 CLIMATE

The district enjoys a very agreeable climate free from extremes. The climate of Bangalore is classified as the tropical wet and seasonally dry with four seasons. The dry season with clear bright weather is from December to February. The summer season from March to May is followed by South-West monsoon from June to September. The temperature varies from a mean maximum of 33.4^{0}C in April/May to the mean minimum of 15^{0}C in December/January. The mean monthly relative humidity ranges from 44% (min) in March to 85% (max) in October. Rainy season is characterized by spells during June to September and October to November, corresponding to South-West and North-East monsoon. The mean annual rainfall is reported to be 889 mm. The surface winds in Bangalore have a seasonal character with clear cut easterly and westerly predominant directions.

2.2.3 SOILS:

The soils of the districts can be broadly grouped into red loamy soil and lateritic soil. **Red loamy soils** generally occur on hilly to undulating land slope on granite and gneissic terrain. It is mainly seen in the eastern and southern parts of Bangalore. **Laterite soils** occur on undulating terrain forming plain to gently sloping topography of peninsular gneissic region.

2.3 Methodology

- To use the resistivity meter the instrument should be set up on the ground with preliminary connections i.e, Ref 1of power supply-unit should be connected to the Ref 1 of measuring unit. Ref 2 of the power supply-unit to the Ref 2 of the measuring unit.
- We use four electrodes and connecting cable. here in this survey the 4 electrodes are laid in a line on the ground in such a way that the spacing between potential electrode is 0.5m,1m, and so on (inner electrodes) and spacing between current electrodes is 1.5m, 3m,4.5m,6m and so on upto desired depth.
- After connecting the electrode with cable the power supply unit is switch on, and the resistivity readings are taken with number of stacks is equal to 4.
- This procedure is continued till the desired depth is reached this can be achieved by increasing horizontal spacing between current and potential electrode.

Fig2.1Measuring Unit Fig2.2 Powersupply

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2.4 Electrical Resistivity and Borehole Details

Characterization subsurface soil and determination of soil strength prerequisite for the foundation design of important civil engineering structure. Electrical characterization of soil was done by conducting surface electrical resistivity measurements and subsequently translating these data in terms of electrical properties of subsurface soil as apparent resistivity and transverse resistivity of the soil. Alternatively, in geotechnical study, Standard Penetration Test (SPT) furnishes data about the resistance of soils to penetration, which can be used to evaluate the soil strength in terms of number of blows (N values). The details of sub soil profile condition of study area discussed in the following sections.

2.4.1 Geophysical investigation by Electrical Resistivity technique

The electrical resistivity method is highly useful to investigate the nature of subsurface formations by studying the variations in their electrical properties. This method assumed considerable importance in subsurface exploration because of very good resistivity contrasts among the lithological units, controlled depth of investigation, ease of field operations and low cost of instrumentation and operation.

The resistivity values obtained after conducting the vertical electrical sounding (VES) at majestic site, Bangalore. It is found that area is having a significant variation of resistivity of soil at different depths along the profile line.

2.4.2 Geotechnical investigation by Standard Penetration Test

The SPT, which was developed around 1925, is a well established and unsophisticated method and currently one of the most popular techniques for evaluating the geotechnical characteristics of soils to weather rock all over the world.

Standard penetration test was conducted according to Indian Standard and necessary corrections were made for Overburden and dilatancy. A total of 18 SPT were conducted to a maximum depth of 15m. SPT tests were conducted in majestic site, Bangalore. Details of Borehole log shown in section 3.

2.4.3 SOIL STRATIFICATION IN THE STUDY AREA

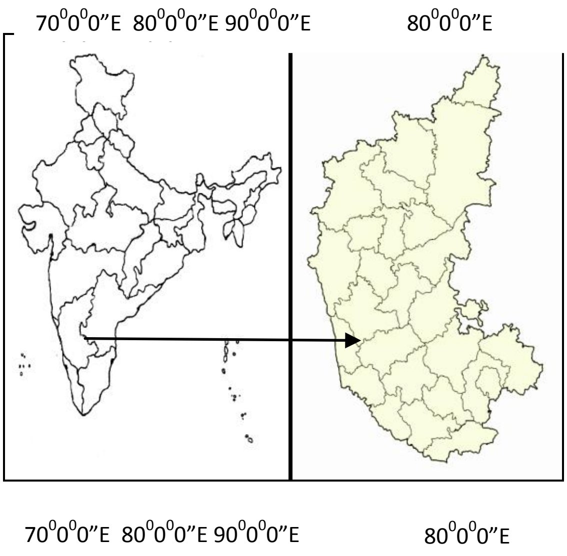

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Figure 2.3 Locations of VES testconducted and BH points at investigated site

Study area is located in Majestic site, Bangalore Karnataka. The SPT and electrical resistivity tests conducted are shown in Fig 3.4. For the investigation purpose, study area is divided into four zones Zone-I, Zone-II, Zone-III and Zone-IV. The bore holes covered in four zones are shown in following Borehole

Borehole Zones Region. TABLE 1

Zone-I	**Zone-II**	**Zone-III**	**Zone-IV**
BH-4 BH-5 BH-6 BH-15	BH-16 BH-17 BH-18	BH-9 BH-10 BH-11 BH-12 BH-13 BH-14	BH-1 BH-2 BH-3 BH-7 BH-8

Zone-I: This zone consists of filled up soil from 0 to 4.5m depth. Below the filled up soil, from 3 to 10.5m silty sandy soil is present in BH-4, BH-5 and BH-15. In BH-6 clayey sandy soil occurred at 3m to 10.5m. Weathered rock is found at depth of 7.5 ~ 13.5m.

Zone-II: This zone consists of filled up soil from 0 to 2m. Gravelly soil is found at depth of 2 to 9m and below gravelly soil, weathered rock occurred at 9m ~ 13.5m.

Zone-III: This zone is having 0 to 3m filled up soil in BH-9 and BH-10. In BH-11, BH-12, BH-13 and BH-14 consist of clayey sandy soil. From 3 to 9m clay sandy soil is occurred in BH-9, BH-12, BH-13 and BH-14. Gravelly soil of 3 to 9m is present in BH-10 and BH-11. Weathered rock is found at depth of 9m ~ 13.5m in all bore holes.

Zone-IV: This zone consists of filled up soil from 0 to 3m in BH-3, BH-7 and BH-8. In BH-1 and BH-2 of silty

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soil is present in 0 to 3m. From 3 to 12m silty soil is present in BH-1, BH-2, BH-3 and clay sandy soil in BH-7, BH-8. Weathered rock is found at depth of 12m ~ 13.5m

III. RESULTS AND DISCUSSIONS

3.1 GENERAL

In the present study, an attempt is made to correlate the electrical resistivity and the SPT- N value. For this Electrical Resistivity Sounding was conducted at the same point where SPT was done. The derived electrical resistivity values are first calibrated with the borehole data of subsurface soil and subsequently used to compute apparent and transverse resistance, which is correlated with SPT-N values recorded.

Analysis and Discussion of the test results have been done in this chapter and they are in the followingorder.

- Combined interpretation of the apparent resistivity and corrected SPT-N values with respect to depth.
- Correlation of apparent resistivity and transverse resistance with corrected SPT-N values.

3.3.1 Overall Correlation Between Apparent Resistivity And Corrected Spt-N Values.

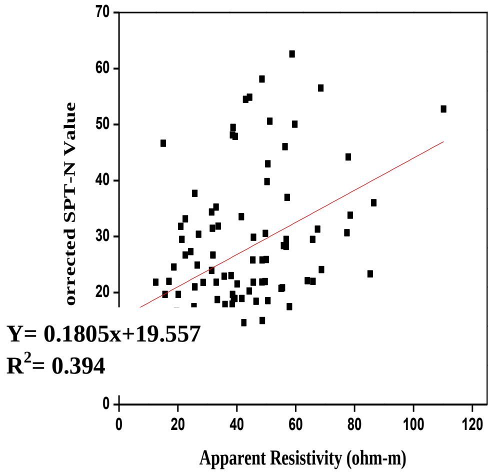

Figure 3.1 Overall correlations between Apparent Resistivity and Corrected SPT-N Values for all Boreholes.

- Fig **3.1** shows plot of all tests results of the corrected SPT-N values with their apparent resistivity values. It is observed that most of the values are not related to each other it indicating the non linear relationship between the apparent resistivity and corrected SPT-N values (i.e. R^2=0.394) and it shows poor correlation between these two parameters.

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3.3.2 Overall Correlation Betweentransverse Resistanceand Corrected Spt-N Values

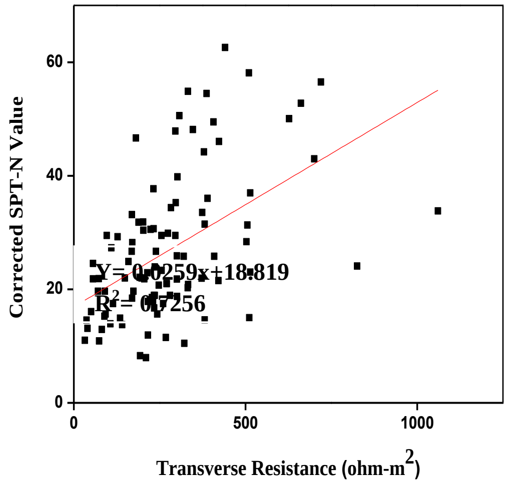

Figure 3.2 Overall correlations between Transverse Resistance and Corrected SPT-N Values for all Boreholes.

- Fig **3.1** shows plot of all tests results of the corrected SPT-N values with their transverse resistance values. It is observed that most of the values are positively related to each other indicating the linear relation between the transverse resistance and corrected SPT-N values (i.e.R^2=0.72) and it shows good correlation between these two parameters.

V. CONCLUSIONS

1. The results of resistivity survey and borehole tests are interpreted together to infer and to understand the relation between the resistivity and SPT-N value parameters.
2. The apparent resistivity and corrected SPT-N value are interpreted with depth to understand the relation between two parameters. According to the interpretation, the apparent resistivity and corrected SPT-N value show some correlated pattern as excepted. i.e., zone showing low apparent resistivity values generally have low corrected SPT-N value and vice versa.
3. The apparent resistivity is correlated with corrected SPT-N value. It can be concluded that relationship between corrected SPT-N value and apparent resistivity is not significant (R^2=0.394), it shows the apparent resistivity is non-linearly varying with corrected SPT-N values.
4. The transverse resistance is correlated with corrected SPT-N value. It can be concluded that there is linear relationship between corrected SPT-N value and transverse resistance (R^2=0.7256), it shows good correlation between these two parameters.
5. The empirical relation (0.0259x+18.819) obtained by regression analysis used to correlate corrected SPT-N value from transverse resistance value obtained in the field.
6. Therefore it is better to correlate with transverse resistance rather than apparent resistivity, the determination of soil strength using vertical electrical sounding (VES) is economic, fast and efficient in comparison to the other geotechnical methods.

5.1 Scope for Further Investigation

This phenomenon has influence this study to further some detail investigation in order to discover this unpredictable correlation. Therefore, this study has conduct an additional geotechnical laboratory test as known as particle size distribution test and water content test to discover and verify an assumption that the resistivity value was influenced by type of soils and water content intensity.

REFERENCE

1. A. Samoue¨lian (2005) "*Electrical resistivity survey in soil science: a review*" Soil & Tillage Research 83 (2005) 173–193.
2. Akintorinwa and Adeusi.(2009) "*integration of geophysical and geotechnical investigations for a proposed lecture room complex at the federal university of technology, akure, sw, Nigeria*" Ozean Journal of Applied Sciences 2(3), 2009 ISSN 1943-2429 © 2009 Ozean Publication.
3. E.A. Suryo,et al (2011) "*Application of electrical resistivity method to detect deep cracks in unsaturated residual soil slope*" Unsaturated Soils: Theory and Practice 2011 Jotisankasa, Sawangsuriya, Soralump and Mairaing (Editors) Kasetsart University, Thailand, ISBN 978-616-7522-77-7.
4. Ferhat Ozcep, et al (2010) "*Correlation between electrical resistivity and soil-water Content based artificial intelligent techniques*" International Journal of Physical Sciences Vol. 5 (1), pp. 047-056, January, 2010.
5. Fahad and Syed (2012), "*Integrating Geo-Electrical and Geotechnical Data for Soil Characterization*" International Journal of Applied Physics and Mathematics, Vol. 2, No. 2, March 2012.
6. Kumari Sudha, et al (2009). "*Soil characterization using electrical resistivity tomography and geotechnical investigations*."Journal of Applied Geophysics, Vol 67, No 1, pp 74-79.
7. Mahmut G. Drahor, et al (2006) "*Application of electrical resistivity tomography technique for investigation of landslides: a case from Turkey*" Environ Geol (2006) 50: 147–155 DOI 10.1007/s00254-006-0194-4.
8. Philippe C, et al (2006). "*Correlations between geotechnical and electrical data: A case study at Garchy in France*" Journal of Applied Geophysics, Vol 60 No 3-4, pp 165-178.
9. Rajiv khatri, et al(2011), "*correlation between vertical electric sounding and conventional methods of geotechnical site investigation*" (ijaest) international journal of advanced engineering sciences and technologies, vol no. 4, issue no. 2, 042 – 053.
10. Rajiv khatri, et al (2011) "*geophysical - vertical electrical sounding - method in the evaluation of difficult terrains*" (ijaest) international journal of advanced engineering sciences and technologies, Vol No. 3, Issue No. 2, 138 – 14.
11. S. Grellier, et al (2007) "*Correlation between Electrical Resistivity and Moisture Content of Municipal Solid Waste in Bioreactor Landfill*" Geotechnical Special Publication No. 163, ASCE Press, Reston, Virginia, 2007.
12. Seokhoon Oh, Chang–guk sun (2008). "*Combined analysis of electrical resistivity and geotechnical SPT*

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

blow counts for the safety assessment of fill dam" Environmental Geology, Vol 54, No 1, pp 31-42.

13. Syed and Zuhar (2010). "*Correlation of electrical resistivity with some soil properties in predicating factor of safety in slopes using simple multimeter*"Conference on Sustainable Building and Infrastructure, 15th-17th June, Kaulalumpur, Malaysia.
14. Seokhoon Oh (2012), "*Safety assessment of dams by analysis of the electrical properties of the embankment material*" journal of Engineering Geology 129 (2012) 76-90.
15. Indian Standard - IS: 2131-1981 Methods for standard penetration test for soil. New Delhi, India.
16. Soil mechanics and foundation (16th edition), Dr. B.C. Punmia, Ashok kumar jain, Arun kumar jain.
17. Ground water (second edition), H.M. Raghunath.
18. Signal stacking resistivity meter model –SSR-MP-AT-ME manual.
19. Report on geotechnical investigation at majestic station Bangalore.

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