International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Correlation of Geoelectrical Resistivity (Ωm) to the Number of Collisions (N) of Standard Penetration Test (N-SPT)

Yusuf Kurniawan[1], Lies Kurniawati Wulandari[2], Maranatha Wijayaningtyas[3], Nusa Sebayang[4]
[1,2,3,4]Department of Civil Engineering, National Institute of Technology, Malang, Indonesia - 65140

Abstract*— Analysis of soil bearing capacity in receiving loads is an important step in the construction of building structures, namely as a basis for planning types, materials, material quality, and foundation dimensions. This study aims to analyze the minimum resistivity (Ωm) of soil or rock material that is correlated with the Standard Penetration Test (N-SPT) value of ≥ 50. This is done as the basis for estimating the depth of drilling in the Standard Penetration Test (SPT) test. This study applies a geolytic approach to study soil and rock specifications. The research data includes descriptions of soil types, depth and thickness of each soil layer, material resistivity which is interpreted as soil density, minerals, to the presence of water content in the soil layers. The results of the data correlation analysis show that the higher the resistivity value of the soil or rock material (Ωm), the greater the number of collisions (N). The minimum resistivity value of soil material is more than (>) 121.27 Ωm obtained from the number of (N) collisions of the Standard Penetration Test (N-SPT) of more than (≥) 50. Thus, further estimation of the drilling depth can be carried out. The depth of drilling for each location varies, depending on the carrying capacity of the soil, which ultimately determines the amount of drilling costs.*

Keywords*— Geoelectrical Resistivity, SPT collisions, Correlation.*

I. INTRODUCTION

Engineering geology is a science that studies geological phenomena from the aspects of geological strengths and weaknesses, which are applied in infrastructure development such as the stages of determining the location, design, construction, construction implementation and maintenance of engineering work. Every infrastructure generally has a foundation as the most basic part in maintaining the stability of the building. According to Hardiyatmo (2020), the foundation is the lowest part of the building which transmits the building's load to the soil or rock below. Another definition according to Hanafiah, et al. (2020) the foundation is part of the structural system that functions to transfer the load from the upper structure to the subsoil below, without causing soil shear failure and excessive settlement.

Determination of the type of foundation depends on the soil conditions and properties obtained from the results of soil investigations either directly on the spot, as well as inspections and experiments in the laboratory. The methods and equipment used in soil investigation are of various types and forms. The selection of methods and equipment used depends on the situation and field conditions. According to Hatmoko and Suryadarma (2020) if a good soil location is at an elevation far from the ground surface, a pit foundation or pile foundation is usually used.

The subsurface investigation method is generally carried out by destructive methods, namely by dismantling the site location to determine its condition or by non-destructive methods, namely by not destroying the site location to determine subsurface conditions. One of the destructive methods is geotechnical drilling for the Standard Penetration Test (SPT) test, namely by drilling the soil, pounding and taking soil samples. While one of the non-destructive methods is to use the geoelectric method. The output generated from this geoelectric method can be in the form of material resistivity, soil or rock type, hardness, depth and thickness of each layer, groundwater type, and so on.

By utilizing the output of the geoelectric method, the geoelectric method can be used as an initial reference for soil investigation, especially in estimating the depth of the Standard Penetration Test (SPT) test. Therefore, this study presents a geoelectrical correlation analysis in estimating the plan into the Standard Penetration Test (SPT) test at the Papua Province Public Works Office. Geologically, the island of Papua is a manifestation of the confluence of several micro continents. In the northern part of the island of Papua is the boundary between the oceanic crust which subducts towards the continent in the north of Papua and moves from the northeast-southwest which stretches from the Sarmi Regency area to the Jayapura City area. This tectonic condition causes rock conditions in the Jayapura City area to become unstable in several places due to fault activity or faults that pass through the Jayapura City area. Indications of the existence of these faults can be found clearly in several places in the Jayapura City area as according to Suwarna and Noya (1995). This is why the planning of infrastructure development in the City of Jayapura is obliged to carry out engineering geological investigations to ensure the level of security and minimize the risk of disasters in the future.

Wesley (2010) states that soil bearing capacity is a term that expresses the ability of the soil to withstand loads on the soil surface and to withstand loads at depth below the surface as is the case with foundations. The calculation of soil bearing capacity can be used to ensure the stability of the foundation, which depends on the shear strength of the soil and its bearing capacity, and to ensure that the settlement of the foundation does not exceed the permissible limit. Fahriani and Apriyanti (2015) stated that the estimated carrying capacity of a single pile with vertical loads is determined based on sondir data and the physical properties of the soil. Engineering Geological Mapping for the creation of Technical Geological Capability Zoning will greatly assist in justifying the type of electrode configuration in a geoelectrical survey which will lead to determining standardized prices for the drilling technical services to be used.

Therefore, for the safety of a building it must be strong and safe as a whole, starting from the structure, the foundation to the carrying capacity of the soil. To determine the carrying capacity of the soil, soil investigation is required. There are several soil investigation methods, including groundwater level measurement, Cone Penetration Test (CPT) or Sondir, Standard Penetration Test (SPT), Dynamic penetration test, Pressure meter test, Dilatometer test, Plate loading test, Field propeller shear test, Permeability test, etc. The most common and frequently performed tests are the Cone Penetration Test (CPT) or Sondir and the Standard Penetration Test (SPT).

Testing with the Cone Penetration Test (CPT) or Sondir has several weaknesses. Among other things, the achievement of limited depth, generally 20 meters and cannot penetrate the lens/border/hard soil insert even though it is relatively thin. Thus, for high-risk buildings, such as tall buildings and or large structures, a Standard Penetration Test (SPT) is used which is able to cover the deficiencies of the Cone Penetration Test (CPT) or Sondir.

II. Method

The scientific method applied in this study is a geoelectrical method to identify soil specifications, namely to describe the type of soil, the depth of each layer of soil and its thickness, the resistivity of the material which can be interpreted from the density of soil, minerals, to the water content in each layer of soil. The independent variable is the Standard Penetration Test (SPT), the dependent variable is the geoelectric test, while the control variable is N-SPT ≥ 50 and the thickness of the aquifer with resistivity $< 16.7\ \Omega$m. This research was conducted at the Office of Public Works, Spatial Planning, Housing and Settlement Areas (PUPRPKP) of Papua Province. The research location is shown in Figure 1. The primary data collected in this study included geoelectric test data and Standard Penetration Test (SPT) test data. Meanwhile, the data analysis method applied is quantitative analysis using the data correlation method.

Fig. 1. Research Location

III. Results and Discussion

The data analysis discussed in this paper is the correlation between point 1 and N-SPT point 4 geoelectric data, as well as point 2 and point 3 N-SPT geoelectrical data correlation. Correlation analysis was performed with the Microsoft Excel program. Geoelectrical data point 4 and N-SPT point 3 are presented as follows:

Furthermore, in order to be able to correlate the initial geoelectrical data point 04 (PU04), it needs to be modified based on depth intervals every 2 meters (Table 2). Table 2 is a modified table from table 1, with the intention that the Y (Geoelectric) variable data can be used in data processing based on 2 meter depth intervals. Furthermore, correlation analysis can be performed to determine the relationship between X and Y.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

TABLE 1. Tabulation of geoelectrical data point 1 and N-SPT point 4

No.	Ground Depth (m)	N-SPT (X)	Ωm (Y)	XY	X^2	Y^2
1.	2	35	1,78	62,30	1.225,00	3,1684
2.	4	57	259,80	14.808,60	3.249,00	67496,04
3.	6	35	5,80	203,00	1.225,00	33,64
4.	8	35	5,80	203,00	1.225,00	33,64
5.	10	50	231,00	11.550,00	2.500,00	53361
6.	12	50	231,00	11.550,00	2.500,00	53361
7.	14	38	27,50	1.045,00	1.444,00	756,25
8.	16	35	27,50	962,50	1.225,00	756,25
9.	18	50	116,00	5.800,00	2.500,00	13456
10.	20	31	116,00	3.596,00	961,00	13456
11.	22	37	116,00	4.292,00	1.369,00	13456
12.	24	40	98,70	3.948,00	1.600,00	9741,69
13.	26	50	98,70	4.935,00	2.500,00	9741,69
14.	28	45	546,00	24.570,00	2.025,00	298116
15.	30	50	546,00	27.300,00	2.500,00	298116
∑		638,00	2427,58	114.825,40	28.048,00	831.884,37

TABLE 2. Modification of geoelectric data point 4

Interval of Ground Depth (m)	Resistivity (Ωm)
2	17,00
4	83,40
6	83,40
8	10,40
10	10,40
12	120,00
14	120,00
16	120,0
18	2,26
20	2,26
22	56,10
24	56,10
26	56,10
28	56,10
30	395,00

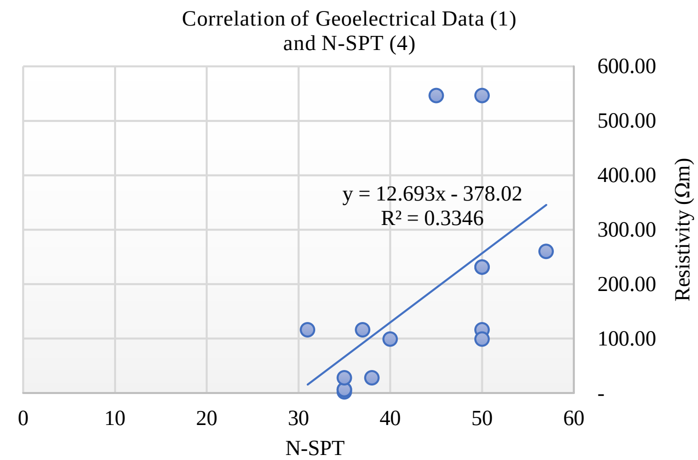

Fig. 2. Correlation of geoelectrical point 1 and N-SPT point 4

In the table above, N-SPT is denoted as X or independent variable. Meanwhile, geoelectrical data is denoted as Y or the dependent variable. Column XY is the multiplication of N-SPT data and geoelectrical data, while column X2 is the squaring of N-SPT data, and Y2 is the squaring of geoelectrical data. Regression analysis shows a t-statistics value of 2.5567, where the value is greater than the t-table value of 2.1604. This means that there is a significant correlation between N-SPT and geoelectricity. Furthermore, the analysis graph is displayed in Figure 2. Figure 2 shows a positive and linear correlation, with an R2 value of 0.3346.

Furthermore, geoelectrical data point 4 and N-SPT point 3 are explained as follows:

TABLE 3. Tabulation of geoelectrical data point 4 and N-SPT point 3

No.	Ground Depth (m)	N-SPT (X)	Ωm (Y)	XY	X^2	Y^2
1.	2	21	17,00	357,00	441,00	289
2.	4	50	83,40	4.170,00	2.500,00	6955,56
3.	6	50	83,40	4.170,00	2.500,00	6955,56
4.	8	27	10,40	280,80	729,00	108,16
5.	10	26	10,40	270,40	676,00	108,16
6.	12	50	120,00	6.000,00	2.500,00	14400
7.	14	50	120,00	6.000,00	2.500,00	14400
8.	16	50	120,00	6.000,00	2.500,00	14400
9.	18	31	2,26	70,06	961,00	5,1076
10.	20	36	2,26	81,36	1.296,00	5,1076
11.	22	43	56,10	2.412,30	1.849,00	3147,21
12.	24	53	56,10	2.973,30	1.809,00	3147,21
13.	26	38	56,10	2.131,80	1.444,00	3147,21
14.	28	50	56,10	2.805,00	2.500,00	3147,21
15.	30	53	395,00	20.935,00	2.809,00	156025
∑		628,00	1.188,52	58.657,02	28.014,00	226.240,50

Furthermore, in order to be able to correlate the initial geoelectrical data point 03 (PU04), it needs to be modified based on depth intervals every 2 meters (Table 4). Table 4 is a modified table from table 3, with the intention that the Y (Geoelectric) variable data can be used in data processing based on 2 meters depth intervals. Furthermore, correlation analysis can be performed to determine the relationship of X and Y.

In the table below, N-SPT is denoted as X or independent variable. Meanwhile, geoelectrical data is denoted as Y or the dependent variable. Column XY is the multiplication of N-SPT data and geoelectrical data, while column X2 is the squaring of N-SPT data, and Y2 is the squaring of geoelectrical data. Regression analysis shows a t-statistics value of 2.6351, where the value is greater than the t-table value of 2.1604. This means that there is a significant correlation between N-SPT and geoelectricity. Furthermore, the analysis graph is displayed in Figure 3. Figure 3 shows a positive and linear correlation, with an R2 value of 0.3482.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

TABLE 4. Modification of geoelectric data point 3

Interval of Ground Depth (m)	Resistivity (Ωm)
2	26,80
4	133,40
6	23,40
8	23,40
10	222,50
12	189,90
14	189,90
16	66,80
18	122,20
20	122,20
22	56,10
24	88,60
26	88,60
28	387,00
30	387,00

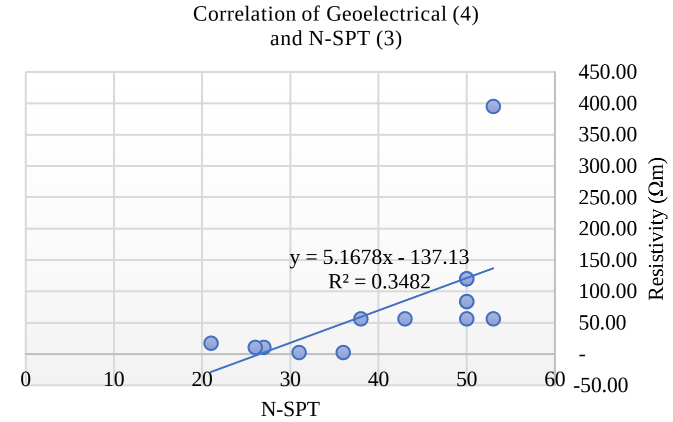

Fig. 3. Correlation of geoelectrical point 4 and N-SPT point 3

If a soil investigation using the Geoelectrical method finds a resistivity value of > 121.27 Ωm (taken from the minimum resistivity value in this study), then the resistivity depth of the soil or rock can be used as a reference for drilling depth plans with a value of (N) Standard Penetration Test (N-SPT). This applies if the layer of soil or rock with that resistivity has a thickness of > 6 meters. If the thickness of the layer is <6 meters, it is necessary to be aware that the layer of soil or rock is a lens or insertion of boulder. In addition, the structure of the subsoil which is a type of sandy soil containing a relatively thick aquifer layer needs special attention. Even though it has a resistivity of <16.7 Ωm (soil or rock containing aquifers), this type of soil layer provides collision resistance because it has hydrostatic pressure, especially sandy soil material. And this layer of soil is not recommended as a foundation end support that relies on end bearings. It is feared that if there is a decrease in groundwater, then the soil will lose its carrying capacity, this also raises the potential for liquefaction when an earthquake with a sufficient magnitude occurs.

IV. Conclusion

This study presents an overview of the importance of knowing the specifications of the soil/rock that will be the construction site. The accuracy of the analysis also determines the feasibility of the building structure. Based on the results of the analysis and discussion, it can be concluded that there is a correlation between the geoelectrical resistivity data (Ωm) and the number of collisions (N) of the Standard Penetration Test (N-SPT). The higher the resistivity value of the soil or rock material (Ωm), the greater the number of collisions (N). Field observations showed that the minimum resistivity value of soil material > 121.27 Ωm was obtained from the number (N) of collisions of the Standard Penetration Test (N-SPT) ≥ 50.

References

[1]. Chin, W. W. 1998. *The Partial Least Squares Aproach to Structural Equation Modeling*. Modern Methods for Business Research, 295, 336

[2]. Fahriani, Fera dan Apriyanti, Yayuk, 2015, *Analisis Daya Dukung Tanah dan Penurunan Pondasi pada Daerah Pesisir Pantai Utara Kabupaten Bangka*, Jurnal Fropil, Vol.3, Juli-Desember

[3]. Ghozali, I. 2016. *Aplikasi Analisis Multivariete Dengan Program IBM SPSS 23. Edisi 8*, Semarang: Badan Penerbit Universitas Diponegoro

[4]. Hanafiah, H.,Z., Jaya, Zairipan., Reza, Muhammad. 2020. *Rekayasa Fondasi Untuk Program Vokasi*. Yogyakarta: Penerbit Andi

[5]. Hardiyatmo, Hary, Christadi. 2020. *Analisis dan Perencanaan Fondasi I*. Yogyakarta: Gadjah Mada University Press

[6]. Hardiyatmo, Hary, Christadi. 2020. *Mekanikan Tanah II*. Yogyakarta: Gadjah Mada University Press

[7]. Hatmoko, Tri, John dan Suryadharma, Hendra. 2020. *Teknologi Perbaikan Tanah*. Yogyakarta: Penerbit Andi

[8]. Irianto dan Karma, Georgiana. 2017. *Kajian Daya Dukung Pondasi Bored Pile pada Pembangunan Gedung Bank Indonesia, Jayapura, Papua*, Jurnal Teknik Sipil USTJ, Vol.6 No.1 Bulan Juni

[9]. Loke, M.H. 1999. *Electrical Imaging Surveys for Environmental and Engineering Studies*. Edgbaston: The University of Birmingham

[10]. Pamungkas, Anugrah dan Harianti, Erni. 2013, *Desain Pondasi Tahan Gempa*, Yogyakarta: Penerbit Andi.

[11]. S, V.D., W, N.R., Pranatya, A., Saragih, D. A & Nababan, R.N, *Identifikasi Lapisan Bawah Permukaan Menggunakan Metode Geolistrik Di Kawasan Komersial*, Abhinaya Mappindo Bumitala

[12]. Suharso dan Retnoningsih, Ana. 2011. *Kamus Besar Bahasa Indonesia*. Semarang: Widya Karya

[13]. Suwarna, N., dan Noya, Y. 1995. *Peta Geologi Lembar Jayapura (Peg. Cycloops) Irian Jaya*, Bandung: Pusat Penelitian dan Pengembangan Geologi (P3G)

[14]. Syukri, Muhammad. 2020. *Dasar-dasar Metode Geolistrik*, Banda Aceh: Syiah Kuala University Press

[15]. Telford, W.M., Geldart, L.P. dan Sheiff, R.E. 1990. *Applied Geophysics 2nd Edition*. Cambridge: Cambrige University

[16]. Terzaghi, Karl and Peck, B., Ralph. 1960. *Soil Mechanics in Engineering Practice, Modern Asia Edition*, New York: John Wiley & Sons, Inc

[17]. Vebrianto, Suhendra. 2016. *Eksplorasi Metode Geolistrik*. Malang: Uversitas Brawijaya Press

[18]. Virman. 2013. *Analisis Data Geolistrik dan Data Uji Tanah untuk Menentukan Struktur Bawah Tanah Daerah Skyland Distrik Abepura*, Papua, Jurnal Fisika UNNES, Vol.3 No.1 Bulan Mei

[19]. Wesley, L.D. 2010. *Mekanika Tanah Untuk Tanah Endapan dan Residu*, Yogyakarta: Penerbit Andi

[20]. Wesley, L.D. 2017, *Mekanika Tanah (Edisi Revisi)*, Yogyakarta: Penerbit Andi.

[21]. Wulandari, Lies, Kurniawati. 2017. *Pengolahan Limbah Domestik Septictank Komunal Blackwater Menjadi Air Pertanian dengan Metode Filtrasi*, Universitas Brawijaya Malang.

Yusuf Kurniawan, Lies Kurniawati Wulandari, Maranatha Wijayaningtyas, and Nusa Sebayang, “Correlation of Geoelectrical Resistivity (Ωm) to the Number of Collisions (N) Standard Penetration Test (N-SPT),” *International Research Journal of Advanced Engineering and Science*, Volume 8, Issue 1, pp. 103-106, 2023.