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Analysis of Soil Characteristics by Layer Based on the Robertson Et Al and Schmertmann Method from CPT (Cone Penetration Test)

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Abstract: Soil is the sub-base where the building structure is located, and the soil classification differs for each layer. There are many cases of failure in building construction due to poor soil, causing the building structure to crack and even collapse, which causes damage to the building - material and also dangerous for the building occupants. For this reason, soil investigation is significant to conduct before constructing the upper structure. One of them is the Sondir test. However, when the sondir data analysis of the qc and FR values are obtained, the Robertson et al method and the Schmertmann method will show the result of soil layer classification before construction begins. The research was located in a specific area, Bengkalis Road, Belawan Medan City, and North Sumatra. The research suggests that the soil in this location is predominantly soft with low shear resistance (qc ranging from 0 - 5 kg/m^2), clay type, and depths of 6 - 7 meters. Due to these soil conditions, there are certain considerations and precautions that need to be taken into account if you plan to build on this land. One of them, soil improvement is given the soft and low shear resistance characteristics of the soil, its techniques may be necessary before construction. The suggested depth for the pile foundation is 10 - 20 meters. The actual depth would depend on factors such as the specific characteristics of the soil layers and the weight of the planned structure.
Keywords: Bengkalis road, construction, soil layer, pile foundation, structure

1. Introduction

Soil is a geological material that is part of the earth's crust and is used as a working medium or to build buildings. One of the most important things before constructing a building is knowing the characteristics of the soil itself due to the different characteristics of each layer, thus it is necessary to investigate the soil first before starting construction on the ground. There are many cases of damaged buildings and even collapsing on the ground, which is not only a disadvantage in terms of finances but also human life.

Figure 1. Collapsed soil under the road

From Figure 1, it can be seen that the road has collapsed, this creates a separation between the road and the bridge, making it impassable for vehicles, and the soil may have the characteristics of sandy silt which has high shear resistance, resulting in the soil it cannot withstand the load of the road structure above, thus road collapse/damage occurs. Likewise in the picture below, cracks extend along the length of the house, causing the house to be tilted.

Figure 2. Collapsed soil in the retaining wall

Soil investigation is very much needed in development planning, be it the construction of roads, retaining wall, bridges, multi-storey buildings, and residential houses. Soil generally consists of gravel, sand, silt and clay, which have different characteristics. One of the ways to get the soil data is by using a sondir, which later the results of the sondir test can be analyzed to obtain the characteristics of the soil layers.

Soil classification based on the sondir test on the embankment of the reservoir in Jakarta, using the Robertson et al (1986) method, from the soil classification data obtained, can be analyzed the problems in water structures that will be studied, a nd how to overcome them [1]. From soil investigations in the form of sondir tests, not only can the soil carrying

capacity for the piles be obtained, but also the types of soil based on depth, which will significantly affect the erection of the pile foundation itself, where the method used is soil classification by the Schmertmann method with analysis of sondir data [2].

At the Gorontalo State University auditorium building, the researchers also use sondir testing for piling foundations, while determining soil type or depth soil classification using the Robertson et al method [3]. Not only for buildings but also, soil testing using sondir (Cone Penetration Test) can be carried out on roads, for example on the Solo - Kertasono toll road to determine the carrying capacity of the soil using sondir data and the Scmertmann method to obtain the type of layered soil. This study aims to increase bearing capacity of the soil based on soil classification obtained [4].

2. Material and Methods

2.1. Materials

The material used is a set of sondir tools to get the bearing capacity of the soil. Soil investigation with Cone Penetration Test is carried out with the following equipment and materials included sondir machine with a capacity of 2.5 tons (according to the capacity requested), sondir rods by the needs, with a length of 1 meter each, gauge pressure, bikonus (Beugemen Friction Jacket Cone), spiral-shaped anchors and 4 (four) turning tools, pipe wrenches, cleaning tools, sastrol oil, sae 10 oil, plucker, 2 pieces of 3m channel steel, 2 pieces of 1m channel steel and a locking device.

2.2. Methods

2.2.1. Sample collection and preparation

The soil investigation used to determine soil data is the sondir test (Cone Penetration Test). The test location is Jalan Bengkalis, Medan, Belawan City, Medan City, North Sumatra (Figure 3). Sondir testing was carried out in as many as three drill points, coded Point 01, Point 02, and Point 03, representing the 6 test points.

Figure 3. Locations of the Sondir drill point
Source: Google Maps

Figure 4. Cone Penetration Test

2.2.2. Cone Penetration Test Procedure

The procedure for implementing Cone Penetration Test (Figure 4) is carried out in the following way:

1. The anchor is planted into the ground using the rotating device.
2. The sondir machine is installed and arranged vertically at the place to be tested using canal steel, supported on the ground with the anchor mentioned above.
3. The bikonus is installed at the lower end of the first pipe
4. Install the hydraulic hose on the sondir machine.
5. After everything is ready, the pipe is pressed along with the stem inside to insert the bikonus 20 cm deep into the ground.
6. At the time of each reading, the pressure will only press the rod inside the sondir pipe, which will only move the cone tip and the shear cover.
7. The reading is done two times after the first reading, namely the second reading after approximately 4 cm of the pipe it enters the soil again after the first reading.
8. On the first reading, only the cone tip is depressed in the ground, so the first reading is the cone pressure. On reading both ends of the cone and shear blanket are stressed, thus the second reading is the cone resistance plus the shear resistance.

2.3. Flowchart of research

The test procedure can be seen in the flowchart below (Figure 5).

2.4. Data Analysis

The data obtained from the sondir test results in the form of qc and FR values, will later be analyzed using the Schmertmann method and the Robertson et.al method for soil classification for each layer, at each drill point.

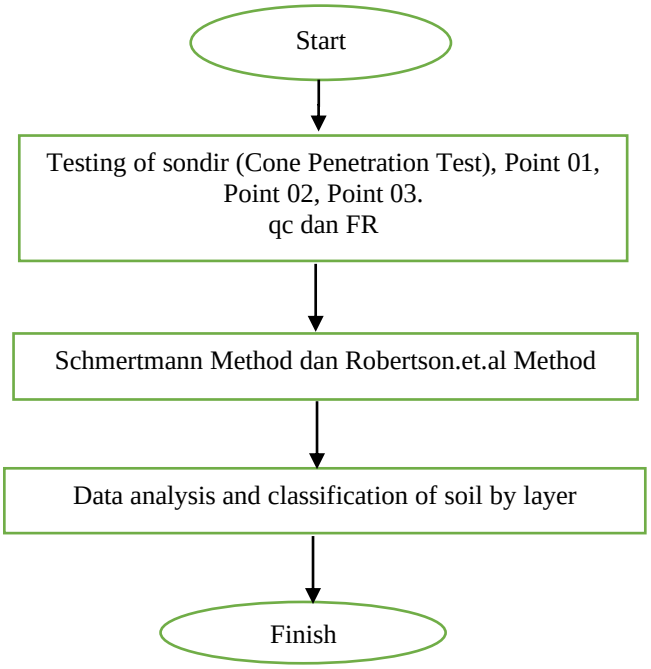

Figure 5. Flowchart of Research

2.4.1. Schmertmann Method

This method can be used for soil classification from sondir data, which is processed to obtain **qc** values and FR values. Later these values will be entered into the graph in Figure 6, and soil types per depth layer are obtained.

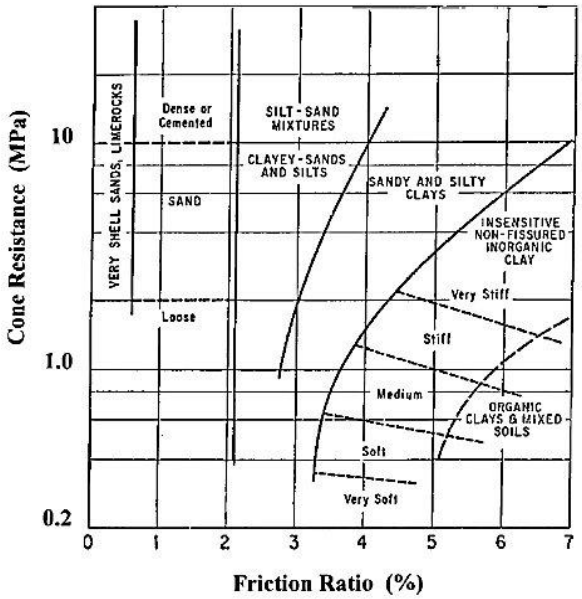

Figure 6. Schmertmann's Graph

2.4.2. Robertson et al Method

This method is used to classify soil based on qc, FR sondir data, and in the graph below (Figure 7), the type of layered soil can be determined based on the soil zone code in Table 1. In the graph with the Robertson et al method, the soil zone is divided into 12 soil types, which compared to the Schmertmann method, the Robertson et al method, is more able to classify the soil in more detail since, the higher the numbering of the soil zones obtained, the soil type coarser or commonly called sand and gravel.

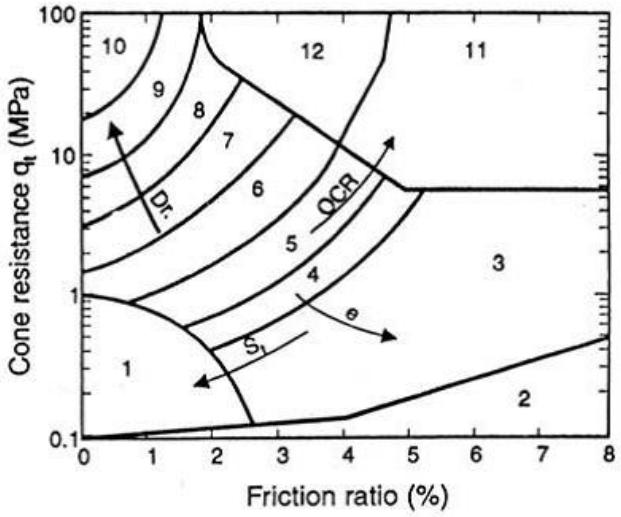

Figure 7. Robertson et al Graph

Table 1. Zone type of soil qt - FR (Robertson et al, 1986)

Zone	Soil Behavior Test
1	Sensitive Fine Grained
2	Organic Material
3	Clay
4	Silty Clay to Clay
5	Clayey silt to silty clay
6	Sandy Silt to Clayey Silt
7	Silty Sand to Sandy Silt
8	Sand to Silty Sand
9	Sand
10	Gravelly Sand
11	Very Stiff Fine Grained
12	Sand to Clayey Sand

3. Results and Discussion

From the 3 sondir-test-points that were carried out and analyzed using the Robertson et al and Schmertmann method. The results of the soil classification for each layer can be seen in the Table 2. At each drill point, the layering depth taken is 20 meters deep, with a range of soil classifications every 2 meters deep.

Besides the classification of soil types, the reader can also see a graph of sondir values by depth with a comparison of qc values and FR values, at each drill point.

From this soil classification per layer, it can also determine the type of sub structure to be used, if the desired depth of the foundation to plan is less than 4 meters, a shallow foundation design can be used, from the results of Tables 3 and 4 the depth range of 2-6 meters is clay soil, then The recommended foundation design is a shallow foundation, while for table 1 the clay soil depth ranges from 2 – 14 meters, the foundation design used can use a deep foundation or commonly called a pile foundation.

Meanwhile, the qc and FR values from sondir data, can also be analyzed for the bearing capacity of the foundation, which is very influential in designing the foundation for a building structure, namely to find out the safety of the foundation, whether it is safe for the bearing capacity of the foundation with the building structure above it, the style overturning and shearing of the foundation and soil. From the sondir test at Point 01, it was found that from a depth of 2 - 6 meters it was a type of clay soil, while from a depth of 8 - 14 meters it was dominated by silty clay or sandy silt, and at a depth of 16 - 20 meters it was a type of sandy soil.

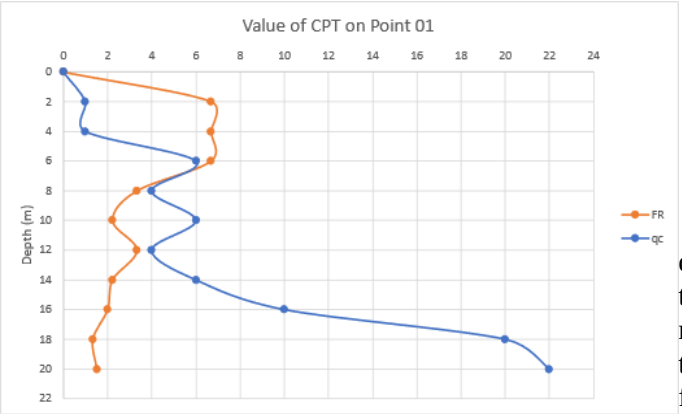

Figure 8. Sondir Graph of qc and FR in Point 01

In the graph in Figure 8, the largest qc value is at a depth of 16 – 20 meters with a value > 10 kg/cm2, and the largest FR value is at a depth of 2 – 6 meters with a value of 6.69%, where for the bearing capacity of the foundation used is a deep foundation with a depth of 16 - 20 meters since, the soil layer has a high qc value thus the soil pressure is also high and is very good for driving pile foundations.

The sondir test at Point 02 (Table 3), found that the soil classification from a depth of 2 - 10 meters was clay soil, while from a depth of 12 - 20 meters, it was dominated by sandy soil.

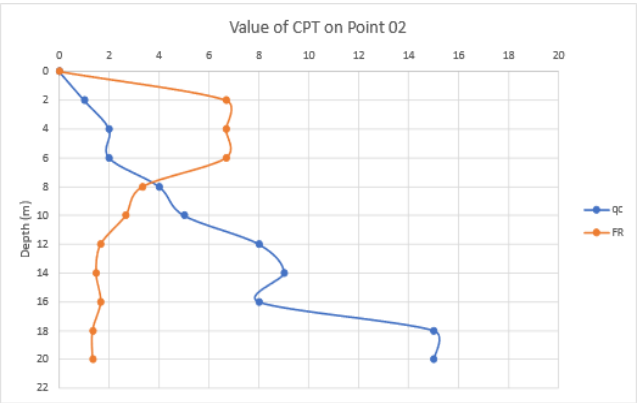

Figure 9. Sondir Graph of qc and FR in Point 02

Table 3. Value of CPT in Point 02

Depth (m)	qc	FR (%)	Schmertmann Method	Robertson.et.al Method
0	0	0	0	0
2	1	6,69	Organic Clay	Clay
4	2	6,69	Organic Clay	Clay
6	2	6,69	Organic Clay	Clay
8	4	3,34	Clay	Clayey Silt
10	5	2,67	Clay	Clayey Silt
12	8	1,67	Sand	Silty Sand
14	9	1,49	Sand	Sand
16	8	1,67	Sand	Silty Sand
18	15	1,34	Sand	Sand
20	15	1,34	Sand	Sand

And then, the largest qc value (Figure 9) is at a depth of 18-20 meters with a value of > 10 kg/cm2, and the most considerable FR value is at a depth of 2-6 meters with a value of 6.69%, where for the analysis of the bearing capacity of the foundation is a deep foundation at a depth of 18 – 20 m, if you want to plan a shallow foundation at a depth of 6 m, soil improvement must be carried out first. From the sondir test at Point 03 (Table 4), the soil classification from 0 - 10 meters is loamy soil, while from a depth of 12 - 20 meters, it is dominated by sandy soil.

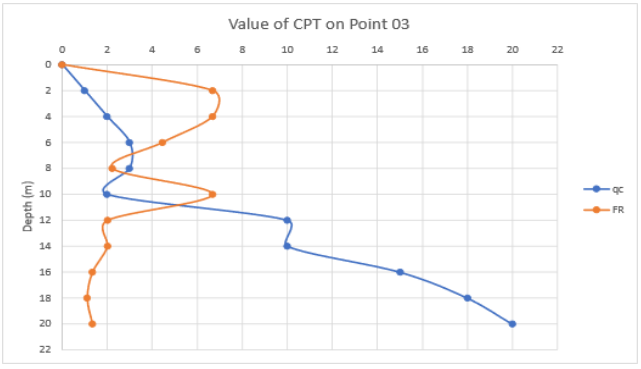

Figure 10. Sondir Graph of qc and FR in Point 03

Meanwhile, from the graph (Figure 10), the largest qc value is at a depth of 12-20 meters with a value > 10 kg/cm2, and the largest FR value is at a depth of 2-4 meters with a value of 6.69%, where the carrying capacity of the planned foundation is a deep foundation at a depth of 12 – 20 m, which is obtained from the soil classification value and the soil resistance value / qc value in the Cone Penetration Test.

Table 4. Value of CPT in Point 03

Depth (m)	qc	FR (%)	Schmertmann Method	Robertson.et.al Method
0	0	0	0	0
2	1	6,69	Organic Clay	Clay
4	2	6,69	Organic Clay	Clay
6	3	4,46	Clay	Clayey Silt
8	3	2,23	Clay	Clayey Silt
10	2	6,69	Organic Clay	Clay
12	10	2,01	Sand	Silty Sand
14	10	2,01	Sand	Silty Sand
16	15	1,34	Sand	Sand
18	18	1,11	Sand	Sand
20	20	1,34	Sand	Sand

4. Conclusion

The conclusion that can be drawn from the sondir test and soil classification based on two analysis using the Schmertmann and Robertson.et.al method, the soil contain that is located on Jalan Bengkalis, Medan Kota Belawan, Medan City North Sumatra is dominated by clay, with an average depth of up to 6 meters. From a depth of 8 - 20 meters is sandy soil. Meanwhile, based on the strength value of the soil itself, the soil is soft soil which is highly avoided for building construction. From the results of the soil analysis based on data from the field, the type of foundation that can be used is a deep foundation, which on average starts from a depth of 12 - 20 meters, with a range of qc/soil resistance values between 10 - 15 kg/cm^2. The soil type classification is sandy silt and if you want to use a shallow foundation for the construction of simple houses, it can be 4 - 6 meters deep, with the classification of clay soil, with the suggestion that the soil is repaired first by adding embankment soil thus the qc value becomes higher and the foundation is safe from settlement. Other soil improvements can be done using the vacuum method, or dewatering, where this method is used to remove groundwater, so that the soil does not settle in the construction buildings above it.

References

[1] Pranantya, P. A., Sukiyah, E., Utomo, E. P., Hendarmawan. Korelasi Nilai Sondir Terhadap Parameter Geoteknik Dan Rembesan Pada Pondasi Tanggul Fase E, Kalibaru, Jakarta Utara. *Jurnal Sumber Daya Air*, Vol. 14 No.2, 2018, p 73 – 86.

[2] Noor, A., Octaviani, S. Evaluasi Perkiraan Daya Dukung Teoritis Terhadap Daya Dukung Aktual Tiang Berdasarkan Data Sondir Dan Loading Test. *Jurnal INTEKNA*, No. 1, 2014, p 1 – 101.

[3] Kadarningsih, R., Achmad, F. Evaluasi Penurunan Pondasi Gedung Auditorium Universitas Negeri Gorontalo Berdasarkan Data Sondir. *Laporan Penelitian Dana Pnbp Tahun Anggaran 2014.*

[4] Arsy, A. A. Analisis Stabilitas Timbunan Pada Konstruksi Badan Jalan Dengan Perkuatan Geotekstil Menggunakan Metode Fellenius (Stability Analysis Of Embankment Of Road Construction With Geotextile Reinforcement Using Fellenius Method) (Studi Kasus: Proyek Jalan Tol Solo-Kertosono Sta 4 +175). *Program Studi Teknik Sipil Fakultas Teknik Sipil Dan Perencanaan Universitas Islam Indonesia, 2018.*

[5] Robertson, P. K., Campanella, R. G. Interpretation of Cone Penetration Tests: Sands and Clays. *Canadian Geotechnical Journal*, Vol.20, No.4, 1983, p 734-745.

[6] SNI 2827. Cara Uji Penetrasi Lapangan dengan Alat Sondir Indonesia. Badan Standarisasi Nasional, 2008.

[7] Terzaghi, K., Peck, R.B. Mekanika Tanah dalam Praktek Rekayasa Jilid 2. 1993, Jakarta : Erlangga.

[8] Terzaghi, K, Peck, R.B., dan Mesri. Soil Mechanics in Engineering Practice. 1996, New York: John Wiley.

[9] Oktoviar, E. Studi Kapasitas Dukung Tiang Pancang Berbasis Korelasi Data Sondir dan Data NSPT di Kota Pekalongan. *Pena Jurnal Ilmu Pengetahuan dan Teknologi*, Vol. 36, 2022, p 78-86.

[10] Ghadafi, M. A., Toha, M. T., Setiabudidaya, D. Effect Of Ground Vibration To Slope Stability, Case Study Landslide On The Mouth Of Railway Tunnel, Gunung Gajah Village, Lahat District. *Sriwijaya Journal of Environment*, Vol. 2, No.3, 2017.

[11] Suroso, P., Tjitradi, D. Analisis Daya Dukung Pondasi Menggunakan Hasil Uji CPT Dan Uji Laboratorium Pada Bangunan Guest House. *Buletin Profesi Insinyur*, Vol.3, No.2, 2020.

[12] Fauziah, S., Muslim, D., Hardiyanto, A., Widyaningrum, R. Jenis Dan Konsistensi Tanah Bawah Permukaan Kecamatan Pekalongan Utara. *Jurnal Ilmiah PPSDM Geominerba*, Vol.7, No.2,

2022.

[13] Hidayat, B. R., Putra, P. P., Suyoso, H. Pemetaan Daya Dukung Fondasi Dangkal di Wilayah Universitas Jember Berbasis CPT (Cone Penetration Test). *Rekayasa Sipil*, Vol 14, No.3, 2020, p 179-186.

[14] Meyerhof, G. G. Penetration tests and bearing capacity of cohesionless soils. *Journal of the Soil Mechanics and Foundations Division*, Vol. 82, No. 1, 1956, p 866-1.

[15] Mulya, E. R., Darwis, F. Analisis Daya Dukung Pondasi Tower BTS Berdasarkan Uji Cone Penetrometer Test (CPT). *Jurnal Ilmiah Wahana Pendidikan*, Vol. 6, No.1, 2020, p 111-118.

[16] Das, B.M, 1985, "Mekanika Tanah Prinsip-Prinsip Rekayasa Geoteknis", Jakarta: Erlangga.

[17] Hakam, A. *Rekayasa Pondasi*. 1985, Padang: CV Bintang Grafika.

[18] Zhafirah, A. Karakteristik Tanah Kawasan Gedebage Kota Bandung Berdasarkan Hasil Uji Lapangan dan Laboratorium. *Jurnal Konstruksi*, vol. 17, no. 2, 2019, p 94 – 100.

[19] Hayumi, L. Analisis Stabilitas Timbunan Pada Badan Jalan Dengan Perkuatan Geotekstil Menggunakan Program Plaxis (Analysis of Road Embankment Stability with Geotextile Using Plaxis Program) (Studi Kasus: Jalan Tol Padang-Pekanbaru Seksi I). *Program Studi Teknik Sipil Fakultas Teknik Sipil Dan Perencanaan Universitas Islam Indonesia*, 2021.

[20] Rahman A. N., Yogaswara, D. Karakteristik Tanah di Daerah Tanjung Kamuning Garut. *Jurnal Konstruksi*, vol. 20, no. 2, 2022, p 348-354.