

## SOIL INVESTIGATION DUTCH PENETRATION TEST IMPLEMENTATION OF NORTH SUMATRA POLDA FLAT HOUSES

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### Abstract

From the results of drilling tests with machine drills, standard penetration tests (SPT), and DCPT or sondir tests, several conclusions can be taken as follows: 1). The results of boring tests show that the soil layer has medium soil consistency at a depth of 0 - 9.85 meters with NSPT value 10 – 30. 2). The soil layer consists of sandy clay, fine sand pumice stone, and fine sand. 3). Test results for the depth of solid soil at a depth of 18.6 – 19.00 meters. 4). The cone tip resistance at point S-01 is 200 kg/cm<sup>2</sup> and S-02 is 173 kg/cm<sup>2</sup> 5). Calculation of the vertical Bearing Capacity (Qi) of the pile foundation from SPT data using a safety factor for tip penetration resistance = 3, for sticky resistance used = 5. 6). For large construction loads using deep foundations, it is necessary to check to a depth of > 10 meters or attain NSPT 60 in a row 3 times.

### Abstrak

*Dari hasil uji pengeboran dengan bor mesin, uji penetrasi standar (SPT), dan uji DCPT atau sondir, beberapa kesimpulan dapat diambil sebagai berikut: 1). Hasil uji bor menunjukkan bahwa lapisan tanah memiliki konsistensi tanah sedang pada kedalaman 0 – 9,85 meter dengan nilai NSPT 10 – 30. 2). Lapisan tanah terdiri dari tanah liat berpasir, batu apung pasir halus, dan pasir halus. 3). Hasil pengujian untuk kedalaman tanah padat pada kedalaman 18,6 – 19,00 meter. 4). Resistansi ujung kerucut pada titik S-01 adalah 200 kg / cm<sup>2</sup> dan S-02 adalah 173 kg / cm<sup>2</sup> 5). Perhitungan Daya Dukung (Qi) vertikal pondasi tiang pancang dari data SPT menggunakan faktor keamanan untuk ketahanan penetrasi ujung = 3, untuk ketahanan lengket yang digunakan = 5. 6). Untuk beban konstruksi besar menggunakan pondasi yang dalam, perlu diperiksa hingga kedalaman > 10 meter atau mencapai NSPT 60 berturut-turut 3 kali*

## INTRODUCTION

The implementation of soil investigation work constitutes a sub-activity of the North Sumatra Polda Flats Construction, which necessitates soil investigation, particularly at the location of the structural design. In the process of designing building construction foundations, a soil investigation is imperative to ascertain the soil parameters that will be employed in calculating the soil's bearing capacity [1][2]. The bearing capacity of the soil exerts a substantial influence on the shape and dimensions of the foundation, thereby ensuring that the foundation structure is designed with optimal dimensions. The foundation constitutes a component of the lower building construction (sub-structure), the primary function of which is to distribute the load from the upper construction section (upper structure/superstructure)[3][4][5]. This upper structure must be robust and secure to support the load from the upper construction, as well as the foundation's own weight[6]. To this end, soil investigations are conducted both in the field and in the laboratory. This final report presents the field results, with the objective being the acquisition of soil layer stratigraphy and NSPT at 2-meter intervals[7]. The overarching aim and purpose of this soil investigation is to ascertain the physical condition of the soil at the building location. The purpose of the SPT (Standard Penetration Test) is to determine the number of hits in a layer, which is reflected in the SPT value[8].

### Scope of investigation

The scope of this land investigation work is undertaken testing work in the field (field investigation), including:

- DCPT/Sondir working
- Boring work Measurement of SPT values at 2-meter intervals Tests in the laboratory are undertaken based on 2 (two) tube UDS samples to determine soil properties and soil engineering properties

### Location of investigation

The location of the soil investigation work is located on Jalan Bhayangkara, Indra Kasih, Medan Tembung District, Medan City, North Sumatra,



Figure 1. Soil investigation location

The objective of this study is to ascertain the depth of the solid soil layers and the nature of the bearing capacity at each depth. Additionally, SPT testing can provide parameters of resistance to penetration of landfill layers that have been previously conducted by the contractor. This parameter is derived from the number of blows to the cone penetration, which can be used to identify the density of soil layers, which is part of the design requirements.

### Standard Penetration Test (SPT)

Standard Penetration Test (SPT) is a type of soil test that is frequently utilized to ascertain the bearing capacity of soil in addition to CPT. SPT is conducted concurrently with drilling to evaluate both the dynamic resistance of the soil and disturbed samples employing pounding techniques[9]. The SPT test involves the impact of a thick wall split tube into the soil, accompanied by the measurement of the number of blows required to insert the split tube to a depth of 300 millimeters (1 foot) vertically. This procedure entails the impact of a standard tube into a 450 millimeter deep drilled hole using a 63.5 kilogram hammer, which is released from a height of 760 millimeters. The number of blows required to penetrate 150 mm is calculated, with the final 300 mm of penetration utilizing the same number of blows. In the context of core drilling, once the drilling depth has reached the

soil layer under investigation, the drill bit is removed and replaced with a tool known as a standard split barrel sampler[10]. After the installation of this tube, in conjunction with the drill pipe, the tool is lowered until its tip rests on the subgrade layer and then hits from above[11]. This tool can be used to identify soil types visually and to obtain qualitative soil parameters through empirical correlation. The merits of SPT lie in its ability to generate a soil strength profile distinct from that of the falling load system, wherein a hammer weighing 140 lb (63.5 kg) is repeatedly dropped from a height of 30 in (0.76 m)[12]. The implementation of the test is segmented into three stages, with each stage comprising 6 in (150 mm) of soil thickness. The first stage is recorded as a seat, while the number of strokes required to insert the second and third stages is summed to obtain the N-value, or SPT resistance (expressed in strokes per 0.3 m or strokes per foot). The SPT test is conducted at 2 m intervals during drilling and is terminated when the SPT N-value exceeds 60 N on three consecutive occasions [13].

This abbreviation stands for "standard penetration test," which is one of the most frequently performed soil tests. The test involves dropping an iron rod (beater) onto a drill in the soil and counting the number of blows required to deepen the drill hole to a depth of 15 centimeters. The greater the number of blows needed to achieve this depth, the more solid the soil being studied. This can be interpreted as indicating a higher "phi" or cohesion of the soil.

The Standard Penetration Test (SPT) is a method for estimating the relative density of the soil layer under consideration. The SPT test is performed using a primary tool known as a Standard Split Barrel Sampler or standard split tube, which is inserted into the bore hole after the drilling process. This tool is lowered in conjunction with the drill pipe until its tip rests on the subgrade. Subsequent to this, the tool is subjected to a hammer blow (weighing 63.5 kg) from the superior aspect. In the initial leathering stage, the tool is struck to a depth of 15 centimeters. Subsequent to this, the second stage

of leathering is initiated, continuing to a depth of 30 centimeters, and finally, to a depth of 45 centimeters. In the second and third blows, the value "N" emerges, signifying the number of blows necessary to attain a depth of 45 centimeters in the standard tube. The SPT test involves the impact of a hammer (63.5 kilograms) on a thick wall split tube in the soil, accompanied by the measurement of the number of blows required to insert the split tube 300 millimeters vertically[14]. In this falling load system, a hammer weighing 63.5 kilograms is utilized, which is dropped repeatedly from a height of 0.76 meters. The test implementation is divided into three stages, with each stage involving the drilling of 150-millimeter-thick tubes. The first stage is designated as the seat, while the number of strokes required to reach the second and third stages is summed to obtain the N-stroke value or SPT resistance (expressed in strokes/0.3 m). Ensuring the implementation of effective drilling techniques is paramount for obtaining reliable SPT test results. Common drilling techniques include wash drilling, core drilling, and auger boring[15]. The equipment utilized in each drilling technique must be capable of producing a clean drill hole to ensure the validity of the test. SPT is typically conducted on relatively undisturbed soil. If the rinse drill technique is employed, the drill bit must have water flowing through the side of the drill bit and not through the tip of the drill bit.

In the event that the water pumped through the pile to the bottom of the hole exits from the drill bit tip, the resultant flow of water from the drill bit tip may cause softening or disruption at the bottom of the drill hole. This, in turn, may yield an N value that is lower than anticipated[16].

#### **Dutch Cone Penetration Test (DCPT)**

The sondir tool, a static soil solid penetrometer of Dutch origin, functions by applying constant pressure (0.5–1 cm/second) to the tip (cone) of the tool, which is inserted into the soil. The resistance force ( $q_c = \text{Kg/cm}^2$ ) is measured, and the resulting data are used to assess the solidity of the soil. This information is crucial for

determining the foundation's capacity to support the building's load. The solid of the soil at a certain depth can be determined through the use of a sondir, a tool characterized by a cone-shaped tip at an angle of 60° and an area of the tip equal to 10 cm<sup>2</sup> (equivalent to 1.54 in<sup>2</sup>). Two types of penetrometer tips are commonly utilized: the Standard Type, which is analogous to an ordinary cone, and the Friction Sleeve or Adhesion Jacket Type, which functions as a bonus. The sondir tool is composed of the following elements. A cone section is a section that has a cone-shaped tip at an angle of 60 degrees. Above this part of the cone, there is a layer of bedding with a length of 10 cm. This part can move up or down due to resistance (friction) from the soil when we measure the amount of resistance [17].

- The Sondir Handlebar Section is composed of a casing, which is a cover shaped like a steel pipe, and a "rod" section, which is an iron rod that is inserted into the casing.
- The manometer part is the component that is connected to the piston, which contains oil. This component is referred to as the plunger. This plunger part establishes a connection between the rod part of the Sondir handlebar and the piston.

Sondir is a geotechnical experiment that aims to determine cone penetration resistance (qc), local shear resistance (Lf), and total shear resistance (JHP). The classification of Sondir is determined by its compressive capacity, which is further divided into three distinct categories:

- a) Lightweight sondir which has a capacity of 2.5 tons and a maximum piercing force of 20 m, maximum manometer reading of 150 kg/cm<sup>2</sup>.
- b) Medium sondir which has a capacity of 5 tons a maximum piercing force of 40 m, maximum manometer reading of 350 kg/cm<sup>2</sup>.
- c) Heavy sondir 1 machine (hydraulic power) which has a force capacity of 10 tons a maximum thrust of 60 m, maximum manometer reading of 500 kg/cm<sup>2</sup>.

Soil that is continuously pressed by the cone will resist (qc). And the resistance was measured at every 20 cm interval, the readings are

- Observed are (C) as the initial reading and (C+F) as the second reading.
- Cone penetration resistance (qc) is calculated using the formula

$$\text{Cone force} = \text{Plunger force}$$

$$q_c \cdot A_c = C_w \cdot A_{pl}$$

$$q_c = \frac{A_{pl}}{A_c} \cdot C_w \quad (\text{kg/cm}^2)$$

wherein: qc = Cone style      Apl = Plunger cross-sectional area  
Cw = Plunger style      Ac = The cross-sectional area of the cone

Plunger force + Bedding force = Plunger force  
Local friction (Lf) is the vertical resistance of the soil against the head of the cone and the resistance/friction of the soil against the upper biconus highest force per unit length. It is calculated using the formula:

$$\text{Plunger force} + \text{Blanket force} = \text{Plunger force}$$

$$C_w \cdot A_{pl} + L_f \cdot A_{sel} = T_w \cdot A_{pl}$$

$$L_f = \frac{(T_w - C_w)}{A_{sel}} A_{pl} \quad (\text{kg/cm}^2)$$

Wherein: Apl = Plunger cross-sectional area  
Tw = Two manometer readings

Asel = The area of the cone bedding  
Cw = First manometer reading

- Total friction (Tf) or total adhesion resistance (JHP) is the shear resistance of the soil against the biconus sheath by multiplying it by a certain depth at a specific depth for each cone piercing (performed at each interval = 20 cm).
- Friction ratio (Fr) is a comparison of Local friction (Lf) for Cone resistance (qc).

Sondir results ( kg/cm <sup>2</sup> )		Classification
q <sub>c</sub>	L <sub>f</sub>	
0 - 6	0.15 - 0.40	Humus, very soft clay
6 - 10	0.20	Loose silt sand, very loose sand
	0.20 - 0.60	Soft clay, soft silty clay
10 - 30	0.10	Loose gravel
	0.10 - 0.40	Loose sand
	0.40 - 0.80	Clay or silty clay
	0.80 - 2.00	The clay is a bit chewy
30 - 60	1.50	Silty sand, rather dense sand
	1.00 - 3.00	Clay or silt clay is chewy
60 - 150	1.00	Loose sandy gravel
	1.00 - 3.00	Dense sand, silty sand or dense clay and clayey gravel
	3.00	Chewy gravel clay
150 - 300	1.00 - 2.00	Dense sand, dense gravel sand, dense coarse sand, very dense silty sand

Friction ratio (Fr) is the ratio of Local friction (L<sub>f</sub>) to Cone resistance (q<sub>c</sub>).

By getting the Fr value, we can also estimate the type of soil by looking at the Fr table.

$$Fr = \frac{L_f}{q_c} \times 100 \%$$

**Table 1.** Soil Classification of Qc and Lf Values  
Soil consistency according to QC

q <sub>c</sub> ( kg/cm <sup>2</sup> )	Konsistensi
< 6	Very soft
6 - 12	Soft
12 - 24	Medium
24 - 45	Stiff
45 - 75	Very stiff
> 75	Hard

## TEST RESULTS

### 1. Standard Penetration Test Test Results (SPT)

Based on the test results of Standard 1. Standard Penetration Test (SPT) Test Results Penetration Test (SPT), the relative density level of the sand layer can be determined, i.e

**Table 2.** Relative density of sand layers

N	:	0 - 4	VERY LOOSE
N	:	4 - 10	LOOSE
N	:	10 - 30	MEDIUM
N	:	30 - 50	SOLID
N	:	> 50	VERY SOLID

The relative density level of the clay soil layer can be determined, i.e:

**Table 3.** Relative density of clay layers

N	:	0 - 2	VERY SOFT
N	:	2 - 4	SOFT
N	:	4 - 8	MEDIUM
N	:	8 - 15	RIGID/STIFF
N	:	15 - 30	VERY HARD
N	:	> 30	SOLID

The results of the standard penetration test (SPT) at every 2 m interval in the drill hole at each drill point can be shown in Table 3 below.

**Table 4.** Value Standard Penetration Test (SPT)

No.	Depth (m)	N-SPT
		BH-01
1	2.00 - 2.45	10
2	4.00 - 4.45	28
3	6.00 - 6.45	21
4	8.00 - 8.45	20
5	10.00 - 10.45	30
6	12.00 - 12.45	28
7	14.00 - 14.45	11
8	16.00 - 16.45	45
9	18.00 - 18.45	57
10	22.00 - 22.45	>60
11	24.00 - 24.45	>60
12	26.00 - 26.45	>60
13	28.00 - 28.45	50

14	30.00 - 30.45	42
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## 2. Dutch Cone Penetration Test (DCPT)

This test provides information in the form of a graph showing the bearing capacity of the biconus relative to depth. The bearing capacity of the biconus consists of the end bearing capacity and the friction bearing capacity. The reading is usually stopped if :

1. The  $Q_c$  reading has achieved the maximum engine capacity, i.e light sondir  $\leq 200 \text{ kg/cm}^2$
2. The entire connecting rod has been used, i.e. for light sondir 20 bar (20 m).

This test is useful for obtaining values for variations in soil density. In very dense sandy soil, gravelly and rocky soil, the use of sounding equipment becomes ineffective when it has difficulty penetrating the soil. The values of cone resistance ( $q_c$ ) and cone resistance obtained from testing can be directly correlated with the bearing capacity of the soil in shallow foundations and pile foundations[18].

Wherein:

- $q_c$  : Measured Cone Resistance ( $\text{kg/cm}^2$ )
- $q_c + q_f$  : Measured Total Resistance from cone & shaft ( $\text{kg/cm}^2$ )
- $q_f$  : Shaft Friction Resistance ( $\text{kg/cm}^2$ )
- $f_s$  : Skin Friction (local)( $\text{kg/cm}^2$ )
- $f_d$  : friction per each 20 cm unit depth settlement reading ( $\text{kg/cm}$ )
- $T_{fd}$  : Total friction per unit depth ( $\text{kg/cm}$ )
- $R_f$  : Friction Ratio (%)

The results of the DCPT were undertaken at 2 (two) points are described in the following table 5:

No.	Point number	Depth (m)	Cone Resistant Max ( $q_c$ ) ( $\text{kg/cm}^2$ )	Total Skin friction Max ( $T_{fd}$ ) ( $\text{kg/cm}$ )
1	S -01	18.60	200	920
2	S -02	19.00	173	876

## 3. Soil Layer Analysis

Soil layering is based on the end and bedding resistance values was undertaken using the Robertson and Campnella (1983) method. The soil layering is as follows:

### Cross correlation between $q_c$ & $f_s$

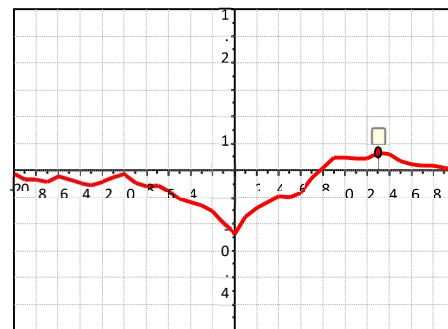
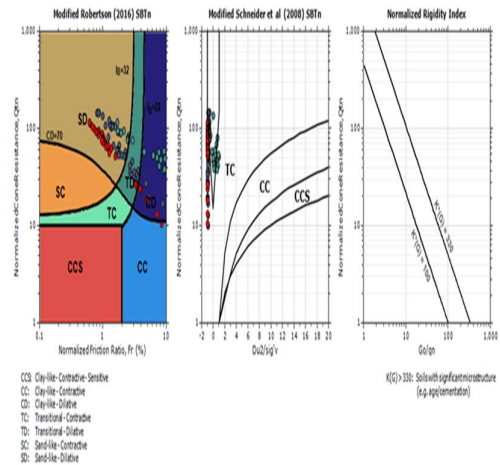
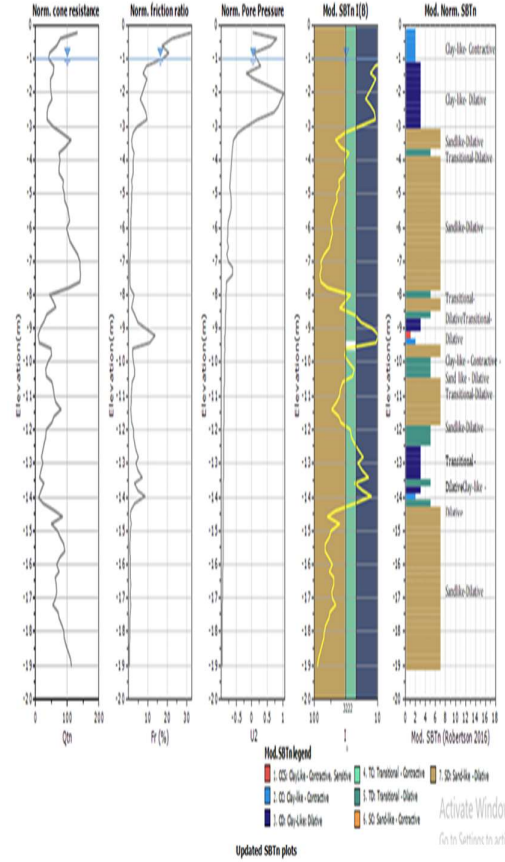
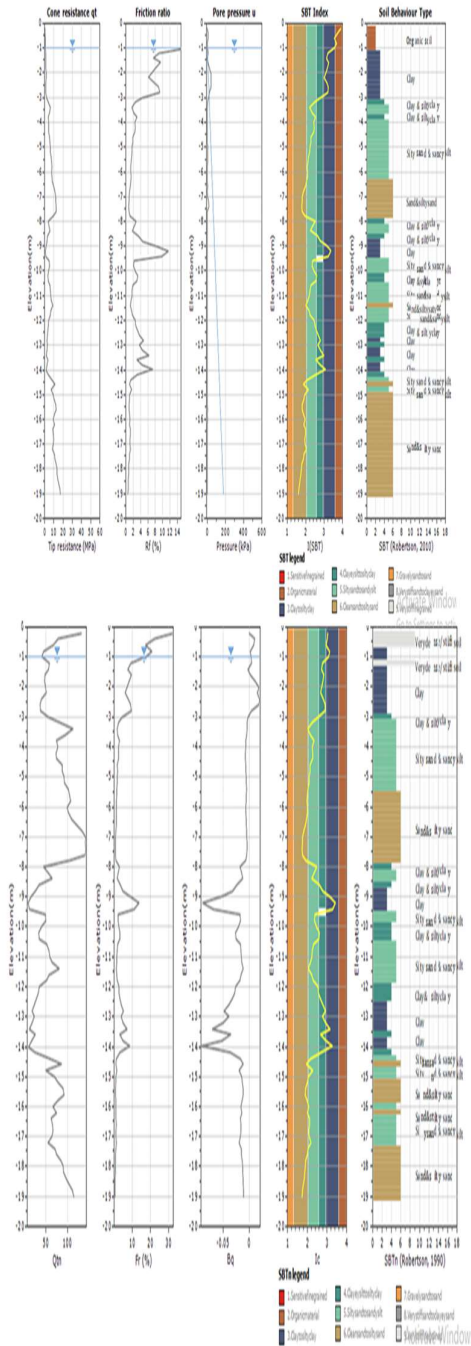
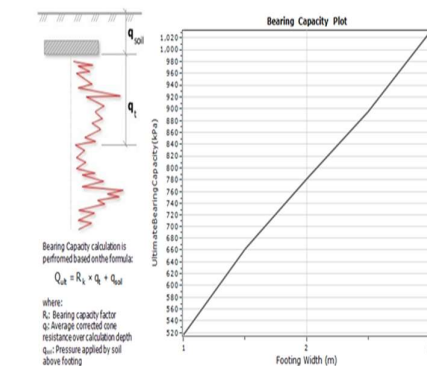
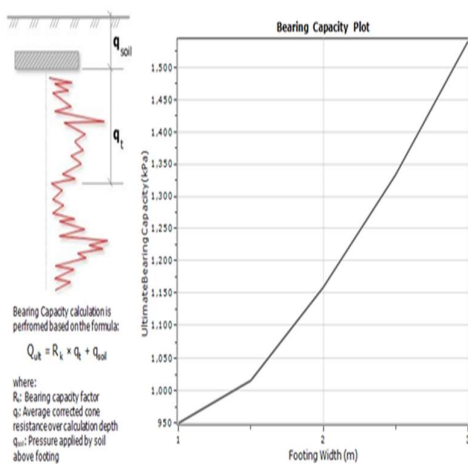
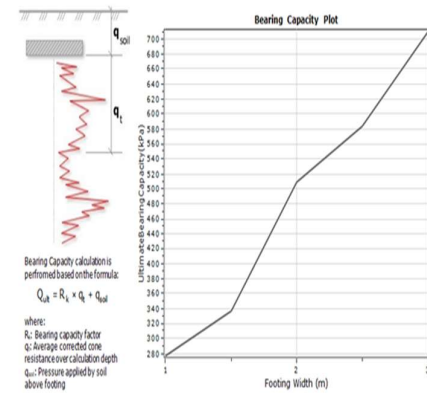
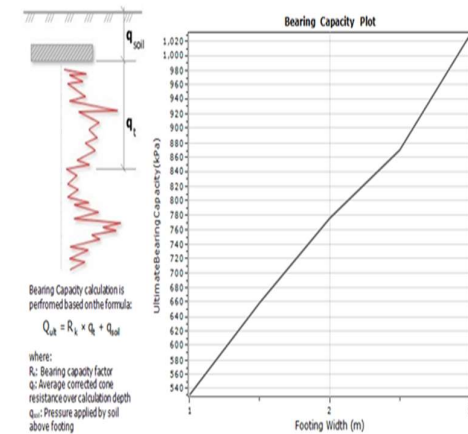
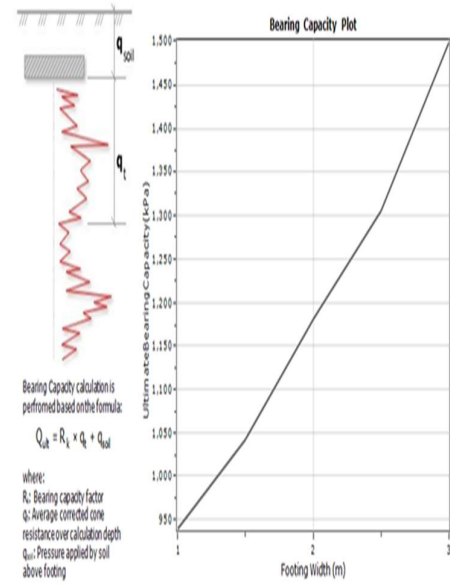
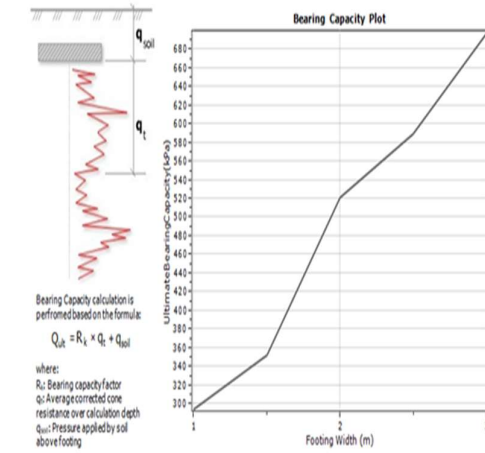


Figure 2. Combined Sondir Char





## CONCLUSION

From the results of drilling tests with machine drills, standard penetration tests (SPT), and DCPT or sondir tests, several conclusions can be taken as follows:

1. The results of testing using boring showed that the soil layer had medium soil consistency at a depth of 0 – 9.85 meters with an NSPT value of 10 – 30.
2. The soil layer consists of sandy loam, fine sand with pumice, and fine sand
3. Results of solid soil depth testing at a depth of 18.6 – 19.00 meters.
4. The resistance of the cone tip at point S-01 is 200 kg/cm<sup>2</sup> and S-02 is 173 kg/cm<sup>2</sup>
5. Calculation of the vertical allowable bearing capacity (Qi) of pile foundations from SPT data using a safety factor for tip penetration resistance = 3, for adhesive resistance = 5.
6. For large construction loads using deep foundations, it is necessary to check to a depth of > 10 meters or reach NSPT 60 3 times in a row.

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