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Analysis of Soil Layer Characteristics on PT. Mining Roads Vale Indonesia Bahudopi Morowali Site Based on Cone Penetration Test (CPT)

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ABSTRACT

The location of this research was carried out in the mining concession area of PT. Vale site Bahudopi at 22 observation points. This research aims to analyze the characteristics of the soil and rock layers of the research area based on the Cone Penetration Test (CPT). The location of this research was carried out in the mining concession area of PT. Vale site Bahudopi at 22 observation points (Figure 1). The method used in this research is descriptive quantitative, namely, research that describes the conditions of a particular project with existing data, where the results obtained are data in the form of numbers. Meanwhile, data analysis uses quantitative descriptive analysis methods. The characteristics of the soil and rock layers of the research area based on the Cone Penetration Test (CPT) are: In the CPT data group in the northern part, it can be seen that the majority of rocks up to a depth of 4 meters have quite low friction sleeve and cone resistance values, namely below 20 kg/cm2. which indicates that the soil thickness is quite high in most parts of the area. In the CPT data group in the Southern part, it can be seen that the majority of rocks can be seen to have experienced several changes in hardness or pressure values, which can be seen from changes in qc and fs/FR values. From this, it can be concluded that the soil around the CPT data collection area is not homogeneous but still shows a tendency to be composed of the same type of rock but differs in friction sleeve and cone resistance values which could be caused by a high level of weathering so that the composition of the soil layers /soil is quite thick.

Keywords: Cone Penetration Test (CPT); quantitative descriptive; PT. Vale Bahudopi.

INTRODUCTION

Mining activities cannot be separated from the construction of road infrastructure which is usually referred to as a hauling road, where this road infrastructure has a function as a link between locations, including mining locations and Stockpiles, Disposal, Offices, Ports and other important locations. The mine road infrastructure that is built must be strong and sturdy so that it can function as it should. Therefore, before building a mining road, it is very important to carry out an assessment of the soil structure that will be used as a mining road.

A road infrastructure construction can stand firmly if it is supported by soil bearing capacity that meets safety requirements. In this case the soil will support the load from a construction through the building foundation. If the load transmitted by the foundation to the ground does not exceed the strength (bearing capacity) of the soil then the building is safe regarding the bearing capacity of the soil. However, if the strength of the soil is exceeded, excessive settlement or collapse of the soil will occur. (Martini, 2009).

Therefore, before building a construction, it is necessary to investigate the soil to determine the properties and characteristics of the soil layers, especially the mechanical characteristics of the shear strength of the subsurface soil to determine the type of foundation and calculate the bearing capacity of the foundation. Determination and calculation of the bearing capacity of the foundation is based on soil test data either in the field or in the laboratory. Sondir or in civil terms called Cone

Penetration Test (CPT) is a soil testing method (soil test) which aims to determine the shear resistance of the soil against the biconus sheath with units of force per unit length.

The bearing capacity of the soil needs to be known to calculate and plan the load dimensions of the structure to be built. If the soil's bearing capacity is unable to accept the load of the planned structure, with known soil bearing capacity data we can carry out certain treatments so that the soil's bearing capacity value can reach the desired value. Piling and compacting is one particular treatment to obtain the bearing capacity value of the soil.

Investigation of underground conditions is a prerequisite for planning underground construction elements. It is also necessary to obtain sufficient information for an economical design for a proposed project. One of the experiments used to determine the bearing capacity of soil is by using an experiment, CPT (Cone Penetration Test). Cone Penetration Test (CPT) or more commonly called sondir is a field survey that is useful for estimating the location of hard soil layers. This test is best done on clay soil. From this test, the cone penetration resistance value is obtained. Cone penetration resistance is the resistance of the soil to the tip of the cone expressed in terms of force per unit area. Meanwhile, adhesive resistance is the shear resistance of the soil against the biconus sheath in a force per unit length. The value of cone penetration resistance and sticking resistance can be determined from the manometer reading. (Ridhayani I., Saputra I., 2021).

Soil bearing capacity in highway or airport planning is an important element, because the soil bearing capacity value greatly influences the thickness of the subgrade pavement layer. To determine the bearing capacity of the subgrade, there are several test methods used, such as sondir testing using the Dutch Cone Penetration Test tool. (CPT) The sondir test, also known as the static cone penetration test, is widely used in Indonesia. This test is a test used to calculate the bearing capacity of the soil. The static cone resistance or cone resistance (qc) values obtained from testing can be directly correlated with the soil bearing capacity (Hardiyatmo, 2010).

In the sondir test, complex changes in soil stress occur during penetration, making theoretical interpretation difficult. Thus, even though theoretically there is an interpretation of sondir test results, in practice the sondir test remains empirical (Rahardjo, 2008). The important value measured from the sondir test is the cone tip resistance (qc). The magnitude of this value often indicates identification of the type of soil and its consistency.

In the world of considerations, before construction of mining infrastructure and facilities such as offices, warehouses, mining roads, disposal sites, etc., it is necessary to investigate the carrying capacity of the soil and rocks at the location where construction will be carried out. The option of using this CPT method in investigating the strength of soil and rock materials is widely chosen, this is because CPT is a simple tool so that the mobilization is quite short, the time duration used in data collection is faster, and of course the costs used are cheaper compared to other methods which involves more complex tools such as drilling methods. Based on the background that has been described, the aim of this research is to analyze the characteristics of the soil and rock layers of the research area based on the sondir test/Cone Penetration Test (CPT) where the location of this research is the mining location of PT. Vale Indonesia at the Bahudopi Morowali Site, Central Sulawesi

RESEARCH METHODS

The location of this research was carried out in the mining concession area of PT. Vale site Bahudopi at 22 observation points (Figure 1). The method used in this research is descriptive quantitative, namely research that describes the conditions of a particular project with existing data, where the results obtained are data in the form of numbers. Meanwhile, data analysis uses quantitative descriptive analysis methods. Analysis means processing existing data in such a way as to obtain final results that can be concluded. Meanwhile, descriptive means describing events and problems that already exist in the research object.

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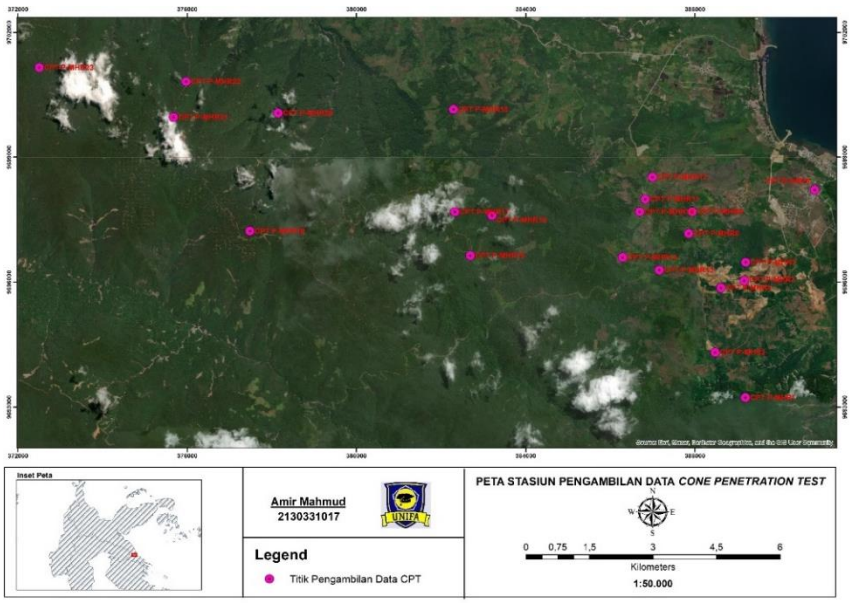

Figure 1. Map of cone penetration test (CPT) data collection locations

There are two types of data, namely primary data and secondary data.

1. Primary Data is data obtained directly from the source. This data explains the relationship between depth and cone value (qc) and the total friction value which is presented in tabular form and in curve form.
2. Secondary Data is data obtained from the project indirectly. In the form of secondary data obtained from intermediary media. In general, data is in the form of evidence, documents, or notes.

After the data collection stage is complete, the data analysis and processing are then carried out in the following way:

1. Calculating joint reactions using SAP 2000.
2. Calculate data from sondir testing results.
3. Calculating cone resistance (qc)
4. Calculating shear resistance (fs)
5. Calculate the shear appeal number (Rf)
6. Calculate total displacement (Tf)
7. Describe a graph of the relationship between variations in cone resistance (qc) and depth (meters)
8. Analyze the soil bearing capacity using the Terzaghi equation (1943). Analyze the soil bearing capacity using the Schmertmann equation (1978).
9. Analyze the bearing capacity of the soil using the Skempton (1951) equation.

RESULTS AND DISCUSSION

A hydraulic portable Cone Penetration Test (CPT) unit with a capacity of 5 tons was used for this geotechnical investigation. The aim of CPT is to identify the condition of in situ soil materials and to determine their likely geotechnical properties. During the test, cone resistance (qc) and friction sleeve resistance (fs) were continuously measured at 20mm intervals during a penetration rate at a

constant speed of 20mm/sec. Resistance was recorded using a capacity of 500 kg/cm2. CPT testing was stopped at a maximum cone resistance of 400 kg/cm2 to 500 kg/cm2.

The CPT test results are in table 1 and presented in Figure 1, Figure 2 and Figure 3. Analysis of the results of CPT data collection/sondir tests is grouped into three area groups, so that it can be carried out easily. These groups include the northern CPT data group (MHR12, MHR11, MHR10, MHR9 and MHR8), the southern CPT data group (MHR1, MHR2, MHR3, MHR5, MHR7, MHR13 and MHR14) and the western CPT group (MHR15, MHR16 , MHR18, MHR19, MHR20, MHR21, MHR22 and MHR23) In the CPT data group in the northern part, it can be seen that the majority of rocks up to a depth of 4 meters have quite low friction sleeve and cone resistance values, namely below 20 kg/cm2 which indicates a high soil thickness. quite high in most parts of the area, then at a depth of 4 meters to 5 meters the soil turns into rock with hardness measured in cone resistance and sleeve friction which is quite high, at MHR8 it reaches 140 kg/cm2 while at MHR9 it reaches 160 kg/cm2. CPT data collection ended on rocks with pressure strengths reaching 300 kg/cm2 (Figure 2). In the CPT data group in the southern part (Figure 3), it can be seen that the majority of rocks can be seen to have experienced several changes in hardness or pressure values, which can be seen from changes in qc and fs/FR values.

From this, it can be concluded that the soil or rocks found around the CPT data collection area are not homogeneous but still show a tendency to be composed of the same type of rock but differ in the friction sleeve and cone resistance values which can be caused by a high level of weathering so that the composition a fairly thick layer of soil (MHR2, MHR3, MHR4, MHR5, MHR13 and MHR14) or the presence of boulders (MHR4) at different depths. At a depth of 3 – 3.5 meters there is an increase in the qc and fs/FR values for MHR7 by 200 kg/cm2 and MHR1 by 150 kg/cm2, after that there is a slow decrease in the qc and fs/FR values for the CPT holes MHR1, MHR7, MHR5 and MHR14, the qc and fs/FR values decreased not significantly because the sondir/CPT tool had already hit the bedrock that makes up the area. The CPT data group in the western part (Figure 1) shows that the qc and fs/FR values are relatively almost the same as the values obtained in each CPT hole. This indication can be interpreted as meaning that apart from experiencing high levels of weathering on the surface of the land, along with increasing depth, the bedrock is then exposed and because it is still close to the surface, around 2-3 meters from the ground surface, the bedrock is weathered or has quite a cracked condition. intense so that the resistance value does not experience spikes, so that the graph reading all CPT data tends not to be too erratic.

It can be said that from the results of cone penetration test measurements in the research area, it shows that the majority of the soil content is a type of residual soil material originating from the intense weathering of bedrock which has undergone changes due to weathering and laterization processes, apart from in several parts of the research location this shows soil composition originating from sedimentary rock fragments or a mixture of sedimentary rock and ultramafic rock.

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No	Test Point	Easting	Northing	RL	Date of test
1	CPT P-MHR1	389194	9693227	229	24-Mar-23
2	CPT P-MHR2	388476.783	9694315.57	351	13-Jan-23
3	CPT P-MHR3	389168	9696037	178	10-Oct-22
4	CPT P-MHR4	388614.625	9695865.3	178	8-Sep-22
5	CPT P-MHR7	389198	9696477	178	17-Oct-22
6	CPT P-MHR8	387852	9697169	152	6-Oct-22
7	CPT P-MHR9	387937	9697693	120	7-Oct-22
8	CPT P-MHR10	386694	9697691	0	14-Oct-22
9	CPT P-MHR11	386825	9697993	178	9-Nov-22
10	CPT P-MHR12	386997	9698522	178	10-Nov-22
11	CPT P-MHR13	387156	9696291	178	12-Nov-22
12	CPT P-MHR14	386291	9696595	224	23-Jan-23
13	CPT P-MHR15	382691.02	9696638.9	560	23-Feb-23
14	CPT P-MHR16	383204.526	9697596.82	560	18-Feb-23
15	CPT P-MHR17	382,326	9,697,688	687	15-Feb-23
16	CPT P-MHR18	382293.209	9700148.51	430	23-Mar-23
17	CPT P-MHR19	377483.596	9697227.43	1026	22-Feb-23
18	CPT P-MHR20	378148.856	9700059.28	558	17-Mar-23
19	CPT P-MHR21	375676	9699960	853	25-Feb-23
20	CPT P-MHR22	375973	9700814	752	2-Mar-23
21	CPT P-MHR23	372503.044	9701153.46	905	24-Mar-23
22	CPT P-HRP5	390827	9698215	178	18-Oct-22

Figure 2. Cone Penetration Test (CPT) Collection Locations

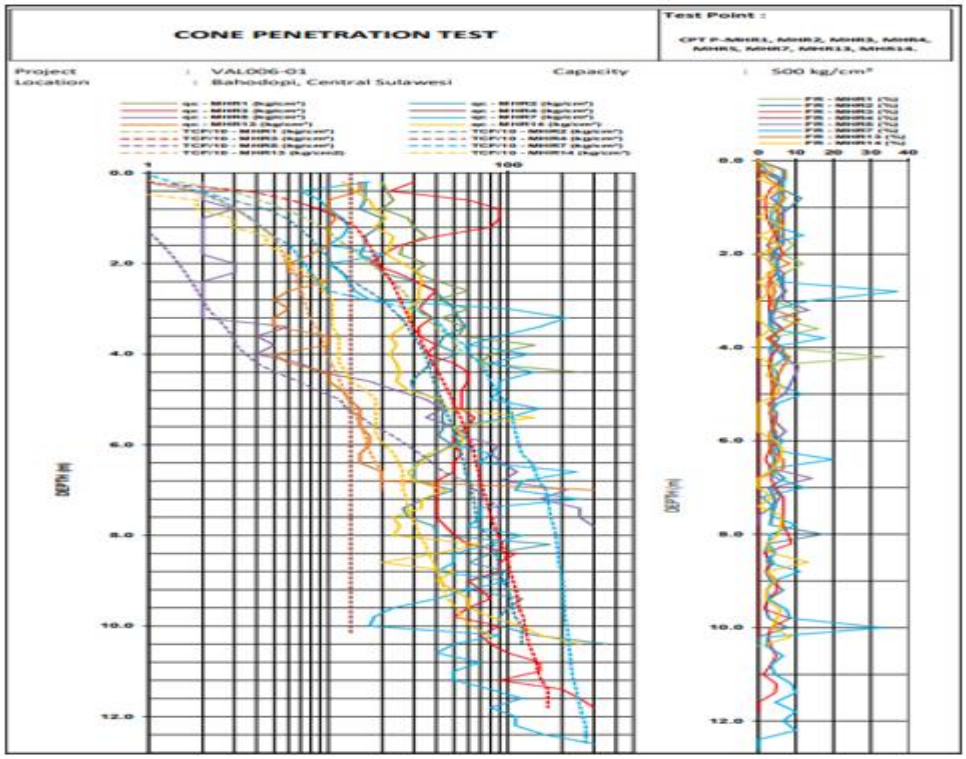

Figure 3. CPT data with qc and Fs/FR values in the southern part of the CPT/sondir test data group. The reading value plot is carried out on a graph with a log scale.

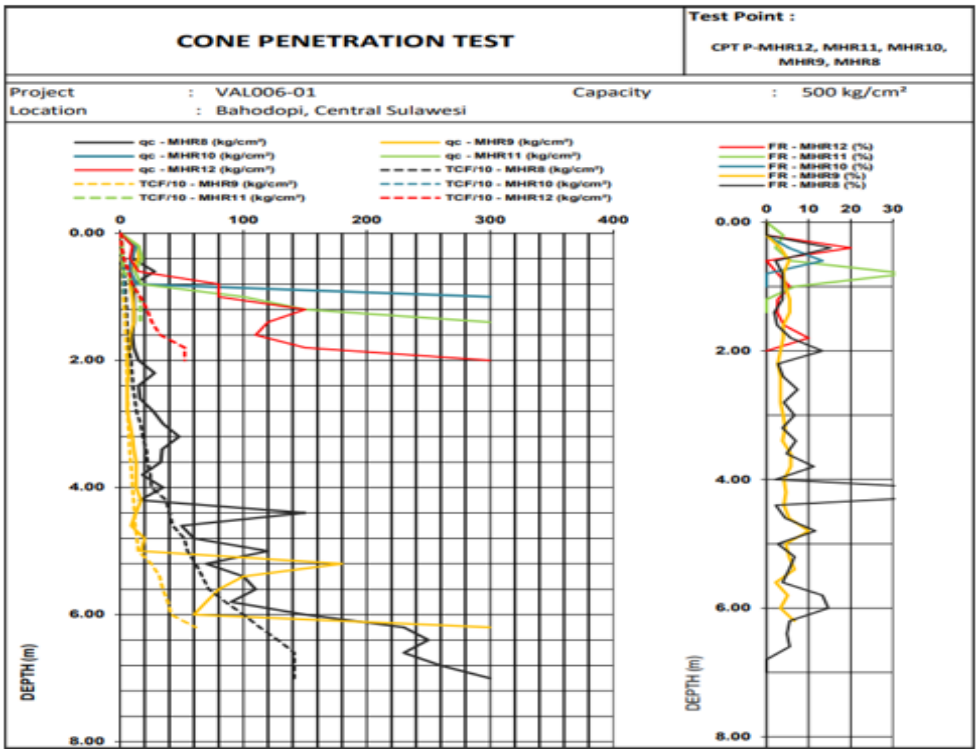

Figure 4. CPT data with qc and Fs/FR values in the western part of the CPT/sondir test data group. The reading value plot is carried out on a graph with a log scale.

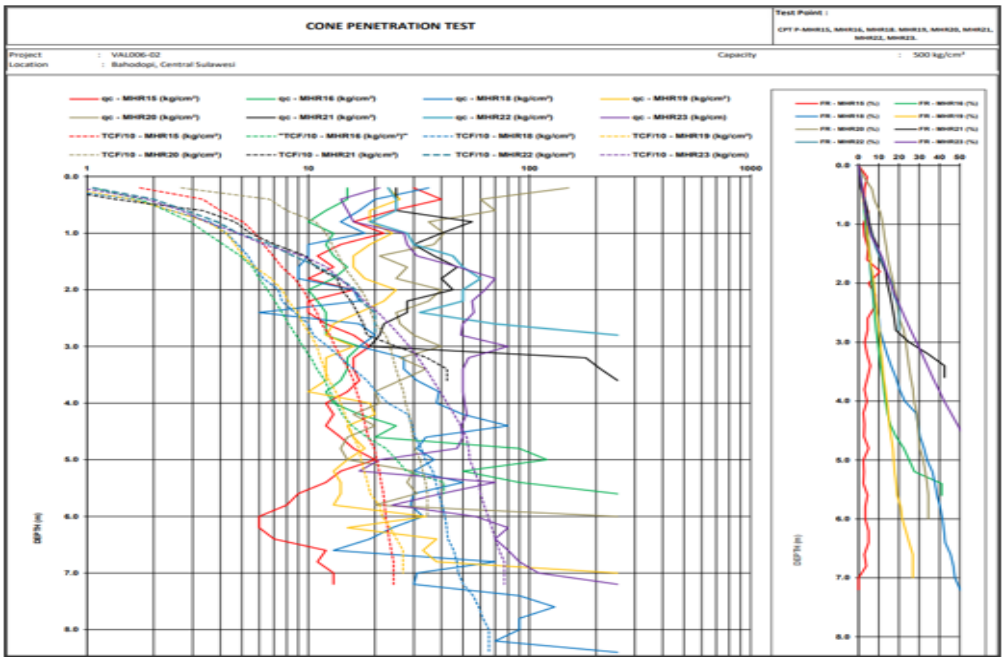

Figure 5. CPT data with qc and Fs/FR values in the northern part of the CPT/sondir test data group. The reading value plot is carried out on a graph with a normal scale.

CONCLUSION

The characteristics of the soil and rock layers of the research area based on the Cone Penetration Test (CPT) are: In the CPT data group in the northern part, it can be seen that the majority of rocks

up to a depth of 4 meters have quite low friction sleeve and cone resistance values, namely below 20 kg/cm2. which indicates that the soil thickness is quite high in most parts of the area. In the CPT data group in the Southern part, it can be seen that the majority of rocks can be seen to have experienced several changes in hardness or pressure values, which can be seen from changes in qc and fs/FR values. From this, it can be concluded that the soil around the CPT data collection area is not homogeneous but still shows a tendency to be composed of the same type of rock but differs in friction sleeve and cone resistance values which could be caused by a high level of weathering so that the composition of the soil layers /soil is quite thick. planning for the construction of a mine road can be continued by continuing to monitor if other supporting data is needed that is adjusted to the purpose of the mine road.

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