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Analysis soil investigation of railway reactivation Km. 28+980 to 50+450 (North Sumatera, Indonesia)

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Abstract. Soil investigation working is a sub division of railway reactivation project of km 28 + 980 to 50 + 450 located in Binjai-Besitang, North Sumatera, Indonesia. Soil investigation was undertaken is sondir (cone penetration test / CPT) with the amount of 15 (fifteen) sections. Sondir test results to obtain soil parameters so that can be determined the type of compatible foundation and deepness so is obtained economics construction

1. Introduction

The National Railway Master Plan, or abbreviated RIPNas, contains the Indonesian railway development plan until 2030. With this RIPNas, it is expected that the purpose of railway operation as mandated in Law no. 23 of 2007 on Railways and Government Regulation no. 56 of 2009 on Railway Implementation can be done well. In Sumatera, the targets to be achieved are the realization of the Trans Sumatra Railways linking existing railway lines in Nanggroe Aceh Darussalam, North Sumatra, West Sumatra, South Sumatra and Lampung. Railways facilities and infrastructure covering railways, stations and railway operations are planned to be built in six phase until 2030.

The function of railway on the island of Sumatra has long time ago, since the colonialism of the Dutch East Indies government. The beginning of railway development has been done in Aceh (1874), North Sumatra (1886), West Sumatra (1891) and South Sumatra (1914). In that era, railways were used to transport the archipelago's existing products on the island of Sumatra, Aceh and also for military purposes by the Dutch East Indies government.

A Due to the massive use of public vehicles and private cars around the year 1970, the use of rail transport vehicles is not a priority by passengers. However, due to the increasingly severe traffic jam in Sumatera area, which resulted in the high cost of goods delivery in the inter-Sumatra region, the train became the main priority of local government in Sumatra today. The function of toll roads that have been planned by the government is not sufficient to overcome the congestion that occurred in Sumatra and Aceh. All modes of transportation need to be built in an integrated way if they want to accelerate the movement of people and goods. The comparison between the cost of toll road construction and the cost of building a railway is cheaper for each kilometer. Railway construction averages Rp20 billion per kilometer, while toll roads are around Rp120 billion per kilometer. Another alternative is the reactivation of old railways including replacing rails of different sizes whose cost per kilometer could be about half the cost of building a new railroad. Part of this long-term project is also the reactivation of the Binjai-Besitang railway line which is the border of North Sumatra and Aceh in Langkat. The 85 km line was rebuilt at a cost of Rp640 billion from the

state budget, and is expected to be completed by 2017. Since July 2015, 50 of the 85 km of the Binjai-Besitang railway line is still being undertaken which become a research of soil.

Soil investigation working is a sub part of reactivation project of railway road Km 28 + 980 until Km 50 + 450. The soil investigation aims to find out soil parameters that can be represented local soil conditions for use in project planning. In order to fulfill the calculation of planning, field investigation was undertaken to obtain soil parameters in the form of cone resistance and skin friction of sondir result. Sondir test was undertaken to obtain data of soil parameters, soil type, whether soft soil, medium soil or hard / solid soil, and this will determine the type of foundation soil and foundation depth to be used. Determination of soil parameters by using soil classification by Robertson and Campanella method.

2. Literatur Review

2.1 Cone Penetration Test (CPT) or Sondering Test

The methode and equipment refer to ASTM D 3441, standard test method for mechanical cone penetration test of soil. This test is done before the foundation construction such as pile foundation etc. The test sondir was done to know such as determining type or type of foundation to be used, calculate the bearing capacity of the original soil, determining how deep the foundation should be put later.

Cone Penetration Test (CPT) or sondir is a soil test that is widely used in Sumatra and Aceh. Generally this soil testing is used since the Dutch East Indies era and was first used in 1935 (Ahmad, 2012). This sondir test predicts a correction between the penetration resistance of the constants and the shear strength parameters. The result of the manometer reading on the sondir device ie cone-resistant or CR resistance is expressed in kg / cm2 and total resistance is expressed in kg / cm2, the calculation of skin friction or SF is expressed in kg / cm, and the total skin resistance or TSF is expressed in kg / cm. The relative densities levels of the soil test layer of sondir penetrate are:

- CR (kg/cm^2): 0-10 very loose
- CR (kg/cm^2): 16-40 loose
- CR (kg/cm^2): 40-120 medium
- CR (kg/cm^2): 120-200 solid
- CR (kg/cm^2): > 200 very solid

According to Wesley (2012), type in terms of economy i.e: The advantages of testing sondir are: 1). quite economical, 2). what if the boring soil sample cannot be taken (soft soil / sand), 3). can be used to determine the bearing capacity of the soil well, 4). empirical correlation is more reliable, 5). can help determine or position on the boring, 6). in the implementation of the sondir test is strongly recommended to be accompanied by other tests both field testing and lab testing so that the test results can be verified sondir or compared with other tests, 7). can quickly determine the hardness of the skin friction (SF) soil layer, 8). can be estimated layer difference, 9). can be used on fine grained layers, 10). either used to determine ground water level.

The disadvantages are: 1). If there are regular loose rocks giving an indication of the wrong hard layer, 2). If the tool is not straight and does not work well then the results obtained can be detrimental, 3). Cannot know the soil directly.

2.2 Robertson and Campanella soil classification

Classifying the soil there are many types, one of them by Robertson (1986). In this classification used by plotting between qc value with FR. The results of plotting showed the type of soil in the area. Before plotting, the qc value must be changed first from kg / cm2 to MPa or Mega pascal. For a value of 1 kg / cm2 = 0.0980665 MPa (Robertson, 1990).

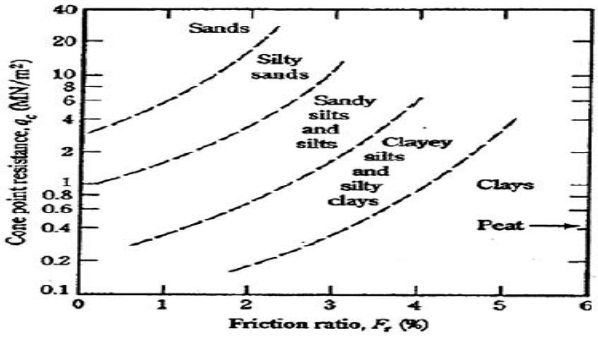

Figure 1. Graph classification of soil type based on CPT measurement Robertson and Campanella (bowles)

Accepting the Robertson (1990) normalization, Figs. 2a and 2b show the envelopes of the Robertson (1990) chart (Fig.3) converted to a Begemann type chart. The ordinate is the same and the abscissa is the multiplier of the normalized cone resistance and the normalized friction factor of the original chart (the normalized sleeve friction is the sleeve friction divided by the effective overburden stress). Where needed, the envelopes have been extended with a thin line to the frame of the diagram (Fellenius, 2018).

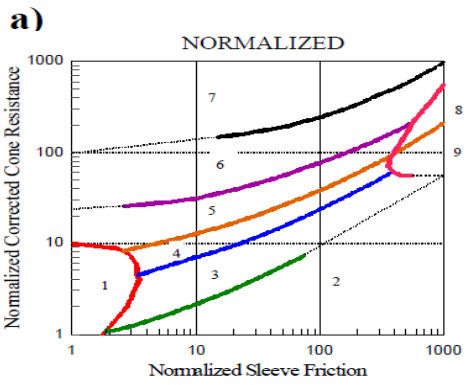

Fig. 2a. Normalized corrected cone resistant VS normalized sleeve friction

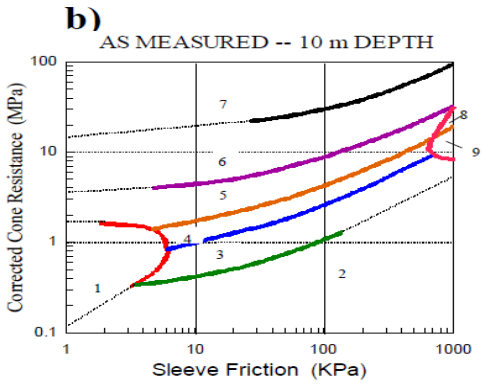

Fig. 2b. Corrected cone cone resistant VS sleeve friction

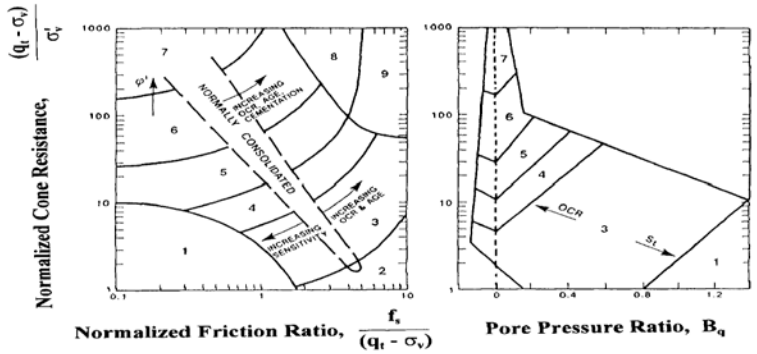

Fig 3. Profiling chart per Robertson

3. Methodology

This soil research working is a subdivision of a reactivation railway construction project Km. 28 + 980 to 50 + 450. The soil investigation aims to find out technical data or soil parameters that can represent local soil conditions for using in project planning. In order to fulfill the planning stage, a field of soil exists to obtain soil parameters in the form of cone resistant and skin friction of sondir testing results.

The purpose of this research is to obtain the data of soil parameters on the soil layer. The attainment of these data is expected to obtain a safe and optimal planning in terms of technical and economical. From the results of testing sondir is found the type of foundation to be used, whether the foundation is shallow or deep foundation. In terms of economics can determine the depth of the foundation.

The scope of this soil investigation working is soil investigation in field area which consists in penetration testing sondir as much as 15 sections**.** The duration of field soil investigation was for 7 days ie on 24 July 2017 until 30 July 2017. The location of this soil investigation working was located in Binjai to Besitang. Sondir testing sections include:

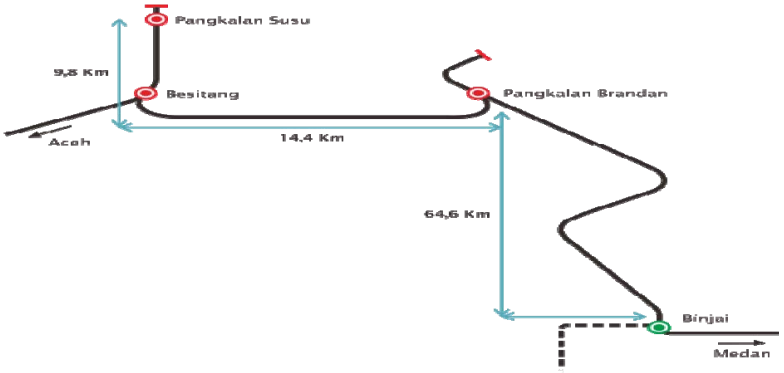

Fig. 4 Research Location

Table 1. Research Location (STA.Km)

NO	Sondir Sections	STA Km
1	Sondir 1	STA Km50+450
2	Sondir 2	STA Km 50+450
3	Sondir 3	STA Km 49+770
4	Sondir 4	STA Km 49+770
5	Sondir 5	STA Km 36+650
6	Sondir 6	STA Km 36+650
7	Sondir 7	STA Km 36+850
8	Sondir 8	STA Km 36+850
9	Sondir 9	STA Km 36+850
10	Sondir 10	STA Km 35+925
11	Sondir 11	STA Km 35+925
12	Sondir 12	STA Km 30+220
13	Sondir 13	STA Km 30+220
14	Sondir 14	STA Km 28+980
15	Sondir 15	STA Km 28+980

4. Result and Discuss

4.1 Result

A. Data 1 : Sondir 1 (STA Km 50 + 450)
Soil Classification Sondir Section Km 50 + 450 (at kilometre 50 plus 450 meters) as shown below figure 5.

Depth	qc	fr	Keterangan
-1	4	5	Clay
-2	11	1,82	Sandy silt
-3	12	1,67	Sandy silt
-4	32	0,63	Silty sand
-5	31	0,65	Silty sand
-6	25	0,8	Silty sand
-7	24	0,83	Silty sand
-8	35	0,57	Silty sand
-9	30	0,67	Silty sand
-10	33	0,61	Silty sand
-11	31	0,65	Silty sand
-12	28	0,71	Silty sand
-13	35	0,57	Silty sand
-14	50	0,40	Sand
-15	150	0,33	Sand
-16	125	0,4	Sand
-17	115	0,43	Sand
-18	130	0,54	Sand

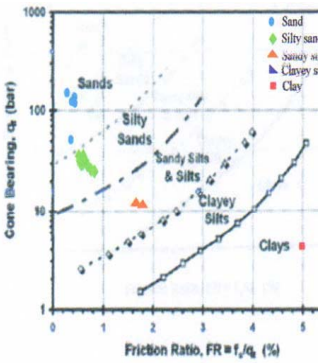

Figure 5. STA Km 50 + 450

B. Data 2 : Sondir 8 (STA Km 36 + 850)
Soil Classification Sondir Section Km 36 + 850 (at kilometre 36 plus 850 meters) as shown below figure 6.

Depth	qc	fr	Keterangan
-1	7	2,86	Clayey silt
-2	12	1,67	Sandy silt
-3	10	2	Sandy silt
-4	12	1,67	Sandy silt
-5	13	1,54	Sandy silt
-6	22	0,91	Silty sand
-7	20	1	Silty sand
-8	30	0,67	Silty sand
-9	20	1	Silty sand
-10	31	0,65	Silty sand
-11	34	0,59	Silty sand
-12	39	0,51	Sand
-13	39	0,51	Sand
-14	53	0,57	Sand
-15	65	0,46	Sand
-16	78	0,38	Sand
-17	90	0,33	Sand
-18	77	0,39	Sand

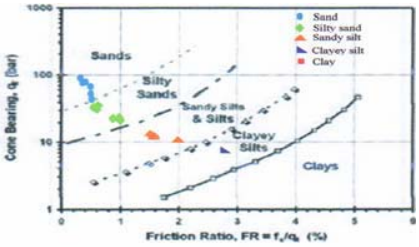

Figure 6. STA Km 36 + 850

C. Data 3. Sondir 14 (STA Km 28 + 980)
Soil Classification Sondir Section Km 28 + 980 (at kilometer 288 plus 980 meters) as shown below figure 7.

Depth	qc	fr	Keterangan
-1	14	1,43	Sandy silt
-2	10	2	Sandy silt
-3	13	1,54	Sandy silt
-4	15	1,33	Sandy silt
-5	37	0,54	Silty sand
-6	50	0,4	Sand
-7	51	0,39	Sand
-8	35	0,57	Silty sand
-9	60	0,33	Sand
-10	60	0,33	Sand
-11	67	0,3	Sand
-12	70	0,29	Sand
-13	72	0,28	Sand
-14	30	0,67	Silty sand

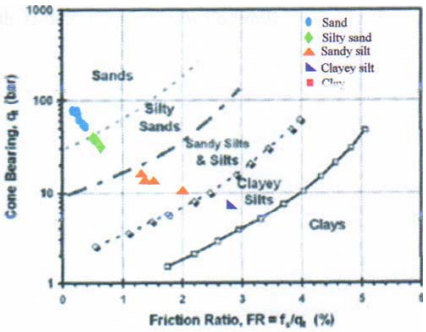

Figure 7. STA Km 28 + 980

D. Data 4: Sondir 15 (STA Km 28 + 980)
Soil Classification Sondir Section Km 28 + 980 (at kilometers 28 plus 980 meters) as shown below figure 8.

Depth	qc	fr	Keterangan
-1	5	4	Clay
-2	7	2,86	Clayey silt
-3	15	1,33	Sandy silt
-4	53	0,38	Sand
-5	64	0,31	Sand
-6	82	0,24	Sand
-7	75	0,27	Sand
-8	91	0,22	Sand
-9	103	0,19	Sand
-10	117	0,17	Sand
-11	135	0,15	Sand
-12	157	0,13	Sand
-13	177	0,11	Sand

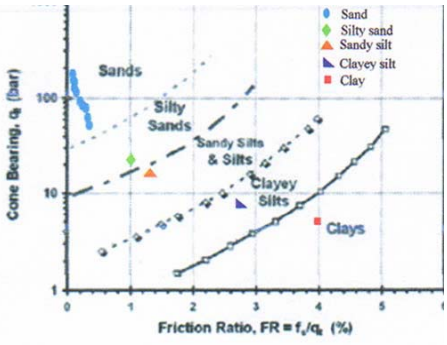

Figure 8. STA Km 28 + 980

E. Data 5: Relative value chart of constant resistance (CR) with depth

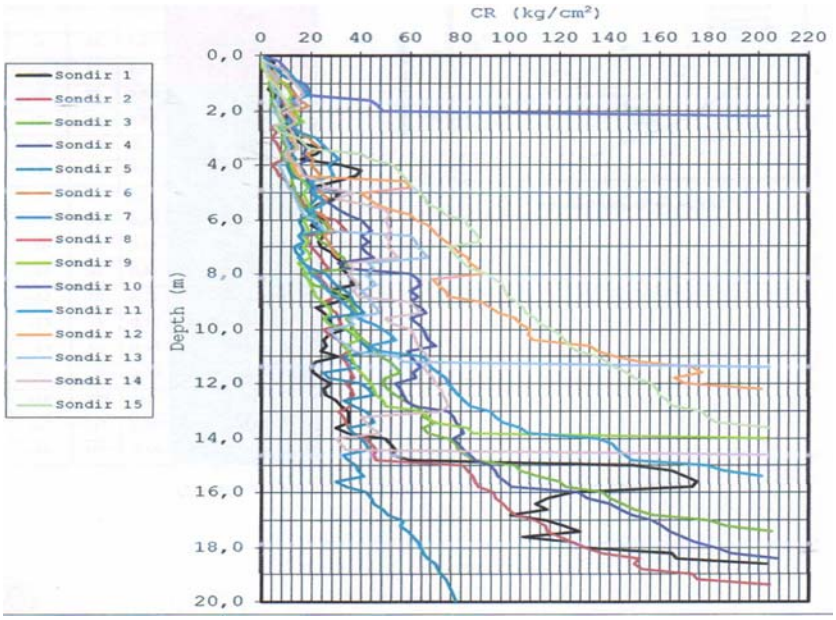

Figure 9. Sondir Test (CPT)

4.2 Discuss

The relative density level of the soil test layer of sondir penetration are:

- CR (kg/cm^2): 0-10 very loose
- CR (kg/cm^2): 16-40 loose
- CR (kg/cm^2): 40-120 medium
- CR (kg/cm^2): 120-200 solid
- CR (kg/cm^2): > 200 very solid

Based on the above specifications obtained the results of testing sondir as in table 4.1

Table 1. Sondir Test Result

Sondir Sections (STA Km)	**Depth (m)**	**Cone Resistant CR (kg/cm^2)**	**Total Skin Friction (TSF) (kg/cm^2)**	**Density Level**
Sondir 1 (STA Km 50+450)	18.6	203	546	Very solid
Sondir 2 (STA Km 50+450)	19.4	304	570	Very solid
Sondir 3 (STA Km 49+770)	17.4	205	450	Very solid
Sondir 4 (STA Km 49+770)	18.4	207	380	Very solid
Sondir 5 (STA Km 36+650)	20.0	78	492	Medium
Sondir 6 (STA Km 36+650)	20.0	89	718	Medium
Sondir 7 (STA Km 36+850)	17.6	205	450	Very solid
Sondir 8 (STA Km 36+850)	18.6	204	416	Very solid
Sondir 9 (STA Km 36+850)	14.0	203	434	Very solid

Sondir 10 (STA Km 35+925)	2.2	204	56	Very solid
Sondir 11 (STA Km 35+925)	15.4	201	316	Very solid
Sondir 12 (STA Km 30+220)	12.2	201	270	Very solid
Sondir 13 (STA Km 30+220)	11.4	204	236	Very solid
Sondir 14 (STA Km 28+980)	14.6	203	300	Very solid
Sondir 15 (STA Km 28+980)	13.6	204	262	Very solid

5. Conclusions

1. Sondir test results at sections 5 and 6 on STA Km 36 + 650 at a depth of 20 meters, is obtained soil parameters the soil layer are medium.
2. In testing of sondir 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, with varying depth, is obtained very solid soil layer.
3. Sondir test results at sections 5 and 6 on STA Km 36 + 650 at a depth of 20 meters, is obtained soil parameters layer are medium .
4. There are several Robertson & Campanella soil classifications in this research, i.e:
   a) Robertson & Campanella's soil classification graph obtain results on average detect silty sand on sondir 1,5.
   b) Robertson & Campanella's soil classification detect sand and silty sand on sondir 2, 6, 8, 10, 11.
   c) Robertson & Campanella's soil classification detect sand on sondir 3, 4, 12, 13, 14, 15.
   d) Robertson & Campanella's soil classification graph obtain results on average detect silty sand and sandy silt on sondir 7.
   e) Robertson and Campanella soil classification obtain results average sandy silt detect on sondir 9.

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