Digital Mapping of Hard Soil Depth in Banjarmasin City

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Abstract—**In the area of Banjarmasin City, a lot of data has been obtained well based on CPT data or SPT data. But for now, there is no information that summarizes the depth of hard soil in the city of Banjarmasin, especially in the form of digital maps. In in the field of civil engineering, the use of GIS has been widely applied to help map depth and type of soil. There has been a lot of research done using the CPT data and the GIS application. This kind of map holds important value for field work practice, especially in civil engineering. Therefore, it is necessary to make an initial concept of a digital map that can later be used as a starting point for foundation work in the city of Banjarmasin. The result of this study is a map of the depth of hard soil in the city of Banjarmasin with the help of GIS software. From the results of soil depth data based on CPT and SPT point test, the depth distribution of hard soil in the city of Banjarmasin varies from 28 m to 42.4 m. For areas that are not covered by the test location, a linear interpolation method is used. This depth varies in each region, between 30-40 m in Banjarmasin Utara, 36-42.4 m in Banjarmasin Barat, Banjarmasin Selatan, and Banjarmasin Tengah, and 28-40 m in Banjarmasin Timur.**

Index Terms—**Depth, hard soil, CPT, map.**

I. INTRODUCTION

The city of Banjarmasin is the capital of South Kalimantan province, Indonesia. Banjarmasin city, dubbed the City of Thousand Rivers, has an area of 98.46 km² whose territory is a delta or an archipelago consisting of about 25 small islands (deltas) [1] which are separated by rivers including Tatas Island, Kelayan Island, Rantau Keliling Island, Insan Island and others. Alluvial soil dominated by clay structure is the type of land that dominates the area of Banjarmasin City. Whereas the bedrock or hard soil is formed in the basin area originates from metaphoric rocks whose surface is covered by greasy, gravel, sand and clay which settles on the river and swamp environment.

Because of that, high rise building in Banjarmasin ussually use deep pile foundation, which is design based on CPT or SPT data. In the city of Banjarmasin, there has been a lot of hard soil depth data based on CPT or SPT data. But for now, there is no information that summarizes the depth of hard soil in the city of Banjarmasin, especially in the form of digital maps.

Digital mapping (also called digital cartography) is the process by which a data set is compiled and formatted into a digital image. The main function of this technology is to produce maps that provide an accurate representation of a particular area, detailing the main roads and other points of interest. This technology also allows for the calculation of distances from one place to another.

In in the field of civil engineering, the use of GIS has been widely applied to help map depth and type of soil. There has been a lot of research done using the CPT data and the GIS application. A simmilar research is previously done in Surakarta, Central Java, Indonesia. That research is done by compiling all existing CPT data, analyzed, plotted on a map, and make the soil profile throughout the region Surakarta using the software ArcGIS 9.2. The results of this research indicated that depth hard stratum in the city is dominantly 3-5 meters from the soil surface [2]. Another mapping research conducted in Pontianak, West Kalimantan, Indonesia, was based on the CPT data in the City of Pontianak. This research conducted to map the consistency of the type of land represented by the parameters obtained from CPT data. This map presents the results of CPT data analysis to determine soil conditions in Pontianak City then describe the spread of soil consistency in Pontianak City. In general, the consistency of soil in Pontianak City shows that at a depth of 0-14 meters is classified as very soft soil and at a depth of 14-20 meters classified as soft soil in terms of soil consistency [3].

Another research using ArcGIS software established a pre-map of soil resources of Caia Irrigation Perimeter. Based on the work of verification, correction, and reinterpretation of the preliminary soil map, a final soil map for the Caia Irrigation Perimeter is developed, which is characterized by enormous heterogeneity, typical of Mediterranean soils, containing 23 distinct cartographic units, the most representative being the Distric Fluvisols with inclusions of Luvisols Distric occupying 29.9% of the total study area, and Calcisols Luvic with inclusions of Luvisols endoleptic with 11.9% of the total area. Considering the obtained information on soil properties; ArcGIS was used to develop a map in which it was possible to ascertain the impact of the continuous practice of irrigation in this area. This allows us to put forward relevant conclusions on the need to access and monitor specific Mediterranean soils in order to mitigate the environmental impact of irrigation practices [4].

This kind of map holds important value for field work practice, especially in civil engineering. Therefore, it is necessary to make an initial concept of a digital map that can later be used as a starting point for foundation work in the city of Banjarmasin. Essentially, this map can give some additional information to estimate the depth of pile foundation in building structure in Banjarmasin City.

II. METHODOLOGY

There are several ways to determine the depth of hard soil, one of which is to conduct testing with Cone Penetration Test

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(CPT) [5], to the area where the depth will be measured. CPT test, also known as Dutch Cone Penetration, is a method of stratigraphic estimation of the subsurface layer that is related to soft material, lens, and soil consistency.

The CPT test set consists of a series of tools with a principal part called a biconus that can work double. Among them: 1) When the conus tip is pressed, the ground below will provide resistance which amount can be read on the pressure gauge manometer. This is called the conus penetration value (qc). 2) The soil around the biconus will provide a friction resistance (Fs) to the biconus mantle whose magnitude can also be read from the manometer, if the biconus is pressed through the soil [6].

From the CPT test, the value of conus resistance (qc) and friction resistance (Fs) are obtained. Based on the value of the conus resistance value (qc) we can determine the soil classification based on the value in table I. If the value of conus (qc) is bigger than 150 kg / cm^2, then the soil is classified as hard soil.

TABLE I: SOIL CLASSIFICATION BASED ON CPT TEST

CPT data		Classification
qc (kg/cm^2)	*Fs(kg/cm^2)*	
6	0.15 – 0.40	Very soft clay
6 – 10	0.20	Silty sand loose or sand loose
	0.20 – 0.60	Soft clay or Soft Silty clay
10 – 30	0.10	Gravel loose
	0.10 – 0.40	Sand loose
	0.40 – 0.80	Clay or Silty clay
	0.80 – 2.00	Clay medium stiff
30 – 60	1.50	Silty sand, Sand medium dense
	1.00 – 3.00	Stiff clay or Stiff Silty clay
60 – 150	1.00	Sandy gravel loose
	1.00 – 3.00	Sand dense, Silty sand or Clay dense or Silty Gravel
	3.00	Stiff Gravel clay
150 – 300	1.00 – 2.00	Sand dense, Sandy gravel dense, coarse sand dense, Silty sand very dense

(Source: [7])

The other method is Standard Penetration Test (SPT). SPT is a test carried out by drilling to find out whether the dynamic resistance of the soil or sampling takes place with a collision technique. The SPT test consists of a test of beating a thick wall split tube into the ground and accompanied by a measurement of the number of blows to insert a 300 mm (1 ft) vertical split tube

In this fall load system, a hammer with a load of 140 lb (63.5 kg) was dropped repeatedly with a height of 30 in (0.76 m). The testing is divided into three stages, which are 6 in a row (150 mm) for each stage. The first stage is recorded as a stand, while the number of blows to enter the second and third stages is summed to get the value of punch N or SPT resistance (expressed in blows / 0.3 m or punches per foot (ft)). The SPT test was carried out every 2m drilling and was stopped when the SPT N test was above 60 N in a row 3 times [8].

TABLE II: SOIL CLASSIFICATION BASED ON SPT TEST

SPT, N_{60}	Consistency	Unconfined Comp Stregth (ton/m^2)
0 - 2	Very soft	0 – 2.50
2 – 4	Soft	2.5 – 5.0
4 – 8	Medium stiff	5 – 10
8 – 16	Stiff	10 – 20
16 – 32	Very Stiff	20 – 40
> 32	Hard	> 40

(Source: [9])

From this test we can determine the type of soil. Based on table II below we can determine the type of soil. If the test results obtained the value of SPT, N_{60} is bigger than 32, then it is is classified as hard soil.

After obtaining soil depth data, the CPT location is checked on the GPS. This information is then analyzed and compiled in order to create a map that provides the easiest and most efficient way to reach the destination.

The data is then poured into digital maps with the help of ArcGis 10.30 software. ArcGIS is a software package produced by Esri (Environment Science & Research Institute) which consists of several GIS software products such as desktop GIS, server, and web-based GIS. The Main Product From ArcGIS is ArcGIS desktop, where arcgis desktop is a comprehensive professional GIS software [10].

III. RESULT AND DISCUSSION

To determine hard soil depth based on secondary data by reviewing the value of sondir data. From the test with CPT test, the value of conus resistance (qc) and sticky resistance (f) are obtained. If the value of the conus resistance is bigger than 150 kg / cm2, then the soil is classified as hard ground.

The city of Banjarmasin which is the focus of observation consists of five region as can be seen in Fig. 1, where each region is represented by at least one CPT test or SPT test data. An example is for the Banjarmasin Tengah Region represented by the CPT test data from Global Hotel Banjarmasin as shown in Fig. 1.

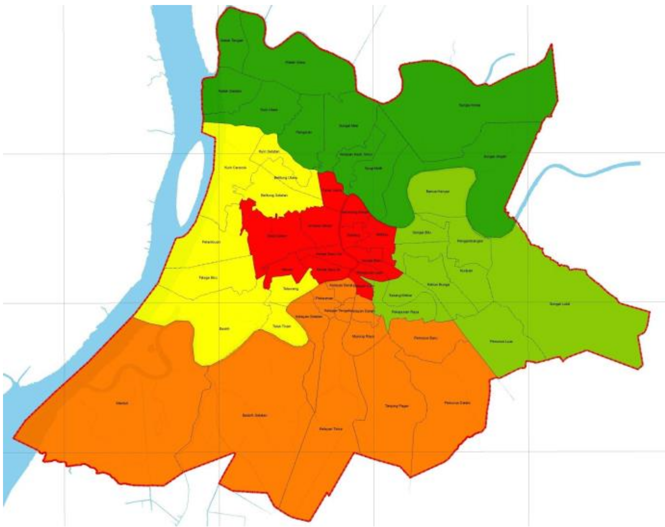

Fig. 1. The borderline of each rigion in Banjarmasin City

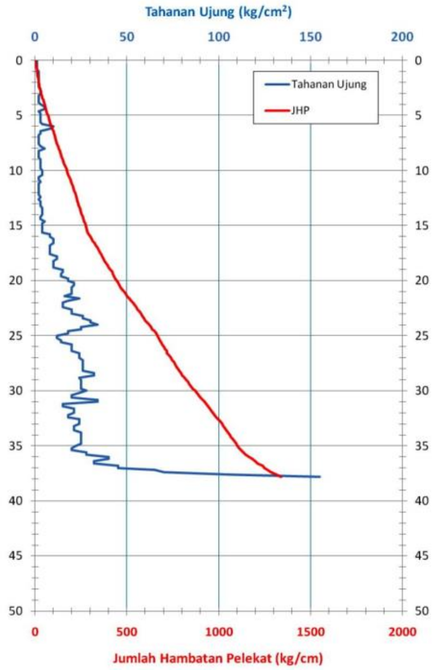

Fig. 2. CPT result of global hotel Banjarmasin.

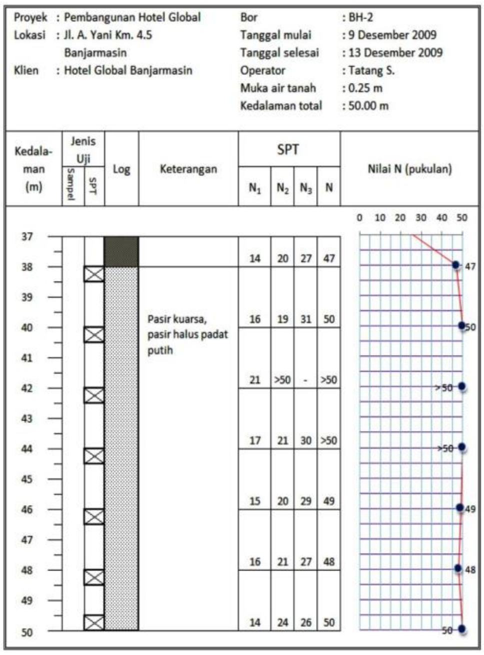

Fig. 3. SPT result of global hotel Banjarmasin.

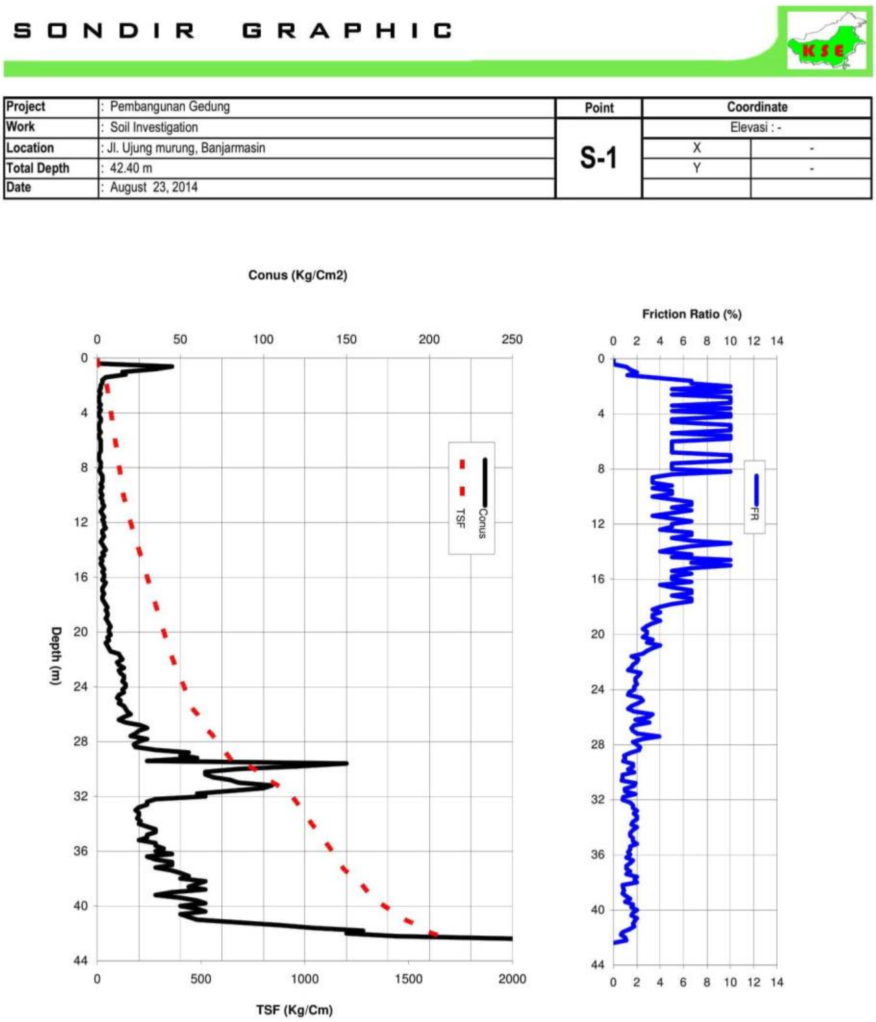

Fig. 4. CPT result of ujung murung street banjarmasin.

From Fig. 2 shows the qc value for hard soil is at a depth of 38.4 m. While from the SPT data for the same location the hard soil depth where the N-SPT value for hard soil is 38 m, as shown in Fig. 3.

Other locations in the Banjarmasin Tengah region are represented by CPT test points on Ujung Murung Street, Banjarmasin as shown in Fig. 4. From Fig. 4 shows the qc of the 150 kg / cm^2 is at a depth of 29 m and 42.4 m. From the two depth values, the value of hard soil depth was 42.4 m because the qc value at a depth of 30 m decreased before rising back to a depth of 34 m.

The results of the data obtained from several sample points that can represent each region in the area of Banjarmasin City then compiled in Table III as shown.

From the results shown in table III, the distribution of hard soil depth in the City of Banjarmasin varies from 28 m to 42.4 m. This depth varies in each region, between 30-40 m in Banjarmasin Utara, 36-42.4 m in Banjarmasin Barat, Banjarmasin Selatan, and Banjarmasin Tengah, and 28-40 m in Banjarmasin Timur. For areas that are not covered by the sample point location, a linear interpolation method is used to obtain a digital map of the soil depth of Banjarmasin City.Tthe data is then plotted into digital maps with the help of ArcGIS 10.3 software.

TABLE III: DEPTH OF HARD SOIL BASED ON CPT AND SPT

No.	Location	Region	CPT (m)	SPT (m)	Depth (m)
1	Belitung Street	Banjarmasin Barat		36	**36**
2	Trisakti Port	Banjarmasin Barat	42.4		**42.4**
3	Ujung Murung Street	Banjarmasin Tengah		40	**40**
4	Global Hotel	Banjarmasin Tengah	38	38	**38**
5	Grand Fortune Hotel	Banjarmasin Tengah	38.4	38	**38,4**
6	Magister Deegre ULM	Banjarmasin Utara		37	**37**
7	Polytechnic	Banjarmasin Utara	28		**28**
8	Booster Pdam Banua Anyar	Banjarmasin Timur	36		**36**
9	Booster Gerilya	Banjarmasin Selatan		37	**37**

The output product obtained from this study is a digital map of the soil depth of Banjarmasin city as can be seen in Fig. 5. This map can provide hard soil depth information for the Banjarmasin city area in accordance with the color zoning which describes the range of each depth.

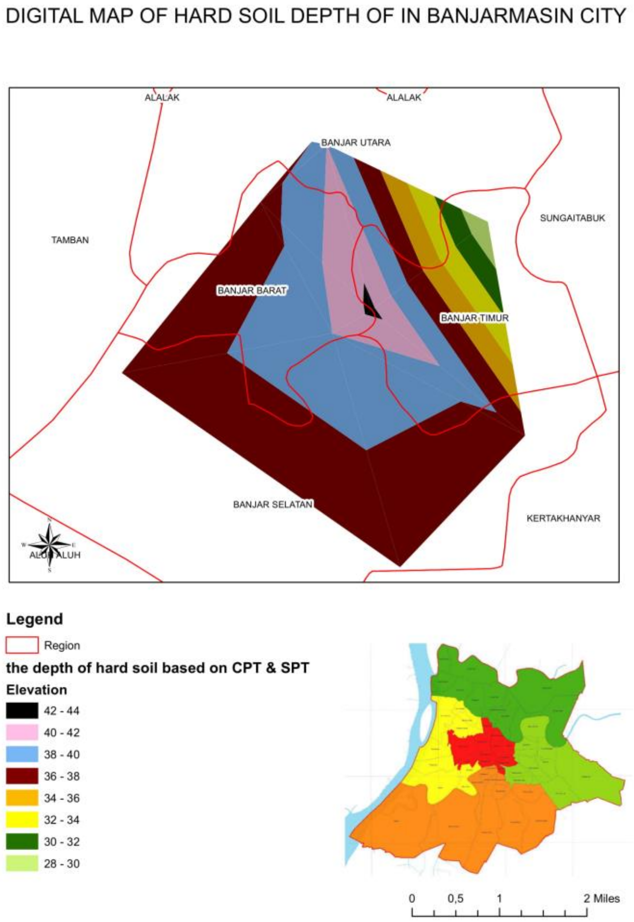

Fig. 5. Digital map of the soil depth of banjarmasin city.

IV. CONCLUSION

From the results of soil depth data based on CPT and SPT data obtained, the distribution of hard soil depth in the city of Banjarmasin varies from 28 m to 42.4 m. This depth varies in each region, between 30-40 m in Banjarmasin Utara, 36-42.4 m in Banjarmasin Barat, Banjarmasin Selatan, and Banjarmasin Tengah, and 28-40 m in Banjarmasin Timur. For areas that are not covered, a linear interpolation method is used to obtain a digital map of the soil depth of Banjarmasin City

A map of soil depth in the city of Banjarmasin is as the final product of this research. Essentially, this map can give some additional information to estimate the depth of pile foundation in building structure in Banjarmasin City. This map can provide hard soil depth information for the Banjarmasin city area in accordance with color zoning which describes the range of each depth.

For future study, it is important to add more CPT and SPT point test to add some more detail. And also possible to add the physical and mechanical soil properties in each point to make the map more advance and informatif, especially for civil engineering practition.

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