ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

The Physical Properties of Peat Soil in Palangka Raya

[1]Fatma Sarie, [2]Mohammad Bisri, [2]Achmad Wicaksono and [3]Rustam Effendi

[1]*University of Brawijaya, Doctoral Program of Environmental Studies, Graduate School, Veteran Malang 65145, Malang, Indonesia.*
[2]*University of Brawijaya, Faculty of Engineering, Veteran Malang 65145, Malang, Indonesia.*
[3]*Lambung Mangkurat University, Faculty of Engineering, Brigjen H. Hasan Basri 70123, Banjarmasin, Indonesia*

ARTICLE INFO

Article history:
Received 10 November 2015
Accepted 30 December 2015
Available online 18 January 2016

Keywords:
Fibrous peat, low ash peat, moderately absorbent, hemic

ABSTRACT

Background: Road damages in some places of Indonesia are often found in regions with peat soil types. Peat is often referred as a problem in the construction of infrastructure in a region due to its low shear strength, high compressibility and high water content. **Objective:** The physical properties assessment of peat is required to determine characteristics and effect of peat soil as subgrade layer on the highways. **Methodology:** Peat soils were sampled from some sites in Palangka Raya, Central Borneo i.e. Mahir Mahar street, Bukit Keminting street, and Sisingamaraja street. Peat soils were sampled by using a soil sampler and then the physical and chemical properties of the samples were analyzed in the laboratory. **Results:** The results showed that the peat soils in this study are classified as fibrous-hemic peat soil (fiber content ranging 33.15 to 38.33%), dominated by medium fiber size, moderately absorbent (water content ranging 412.16 to 531.33%), low ash content (2.31 - 3.22%), high acidity (pH ± 3.5), and peat depth ranging 1-3 meters. **Conclusion:** Comparing of Palangka Raya peat soil with some peat soils from other locations such as Riau, Banjarmasin, Sarawak, and Klang showed similarities in peat classification although the value and percentage of measured parameters showed differences.

To Cite This Article: Fatma Sarie, Mohammad Bisri, Achmad Wicaksono and Rustam Effendi., The Physical Properties of Peat Soil in Palangka Raya. ***Aust. J. Basic & Appl. Sci.,*** *9(36): 77-81, 2015*

INTRODUCTION

In general, the highway damage can be caused by the water flow, pavement construction material, climate, unstable soil conditions and poor compaction process on layer above the subgrade. Unstable soil conditions are commonly found in areas with peat soil type. Peat is a mixture of fragmented organic materials formed in wetlands under appropriate climatic and topographic conditions and it is derived from vegetation that has been chemically changed and fossilized (Dhowian and Edil, 1980). According to Van de Meene (1984) peat soils formed as result of the accumulation of remains plants such grass, ferns, mangroves, *Pandanus*, nuts, and other plants. The organic contents of peat are remains of partially decomposed and destroyed plant. These occurred in a condition where the rate of accumulation is more than the rate of decay.

Mesri and Aljouni (2007) reported that peat covers a total area of 30 million hectare in US including 42 states. Said and Taib (2009) reported that in Malaysia, peat covers 3 million hectares or approximately 8% of the land. Among these lands, 6,300 hectares of the peat lands are found in Pontian, Batu Pahat and Muar in West Johore (Yulindasari, 2006). Sarawak has about 13% of the state area or 1.66 million hectares (Said and Taib, 2009). Peat in Indonesia is the tropical peat soil type with peat area reached approximately 20.6 million hectares or approximately 10.8% of the land areas (Subagjo, 1998). These mostly found in Sumatra, Kalimantan and Papua with various depths and approximately 5.7 hectares or 27.8% is found in Kalimantan (Wahyunto *et al*., 2004).

Peat is often referred as a problem in the construction of infrastructure in a region, such as highways, due to its low shear strength, high compressibility and high water content. If the ability to support the load is lower than the weight of the construction, the soils will subsidence (failure on bearing capacity). Likewise, the decrease of compressibility will cause cracks or tilt the structure of existing construction. Roads were built on peat potentially damaged by unstable soil conditions. This study aim to analyze the physical properties of peat as road subgrade and classification as well as comparing it with peat soils from other studies. The results of this study can be used as initial information for determining appropri-

Corresponding Author: Fatma Sarie, University of Brawijaya, Doctoral Program of Environmental Studies, Graduate School, Mayjen Haryono No. 169, 65145, Malang. Indonesia.
Tel: +62 341-571260; E-mail: fatmasarie50@yahoo.com

ate strategy and planning in infrastructure development, especially roads in Palangka Raya.

Methods:

Study Site:

Palangka Raya is located at 113°3'-114°07' East Longitude and 1°35' North Latitude to 2°24' South Latitude covered 2,678.51 km^2 (267,851 hectares). This research was conducted in three locations i.e. Mahir Mahar Street (Bereng Bengkel Area), Bukit Keminting Street, and Singamangaraja Street, Palangka Raya, Central Borneo (Figure 1). These locations have been selected to represent the condition of the road which damaged significantly. This research used quantitative methods for data collection in the field and laboratory.

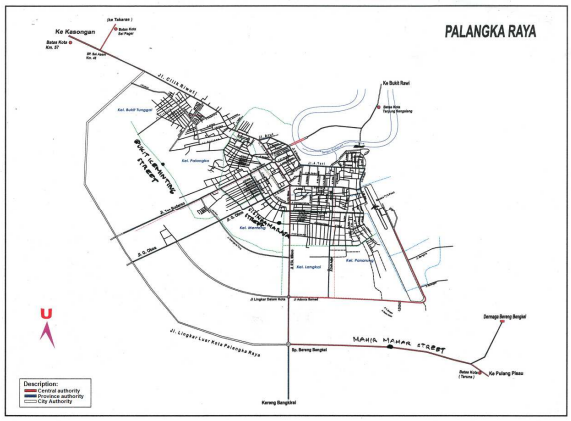

Fig. 1: Study Site.

Soil Sampling and Data Analysis:

Peat soil was observed visually before sampling. Water and peat samples were taken from disturbed and undisturbed peat lands in each study site with depth of 30-100 cm by using soil sampler. Furthermore, water and peat samples were analyzed in the laboratory of Soil Mechanics and Geology, Faculty of Engineering. University of Brawijaya. Soil sampler which is used has diameter of 10.9 cm with a length of 70 cm. Some of parameters measured were pH (acidity), peat depth, natural water content, bulk density, specific gravity, fiber content, fiber size, ash content, and organic content. In this study, the average of water table was found at the depth of 30 cm.

Field and laboratory data obtained were used as the basis for peat classification and as compared to peat from the other locations. Data from the field observation and laboratory analysis were classified to evaluate the peat soil as common quality classification. We also compare the results with the previous studies on peat soil in other areas.

RESULTS AND DISCUSSION

Common Physical Properties Of Peat Soil:

The characteristic of peat is different than the other inorganic soils which are made up by the soil particles because the main component of peat is organic matter so the peat poses its own distinctive geotechnical properties. Peat compositions are different with locations as its content is greatly depending on temperature and degree of decomposition (Deboucha *et al*., 2008).

According to Muhamad *et al*. (2010), the peat is a type of soil with high content of fibrous organic matters so peat can be defined as an accumulation of 100% pure organic matter which contains less than 35% mineral content or at least 65% organic matter. The chemical properties of peat are affected by the chemical composition of peat's components, the environment in which they were deposited and the extent of decomposition. In this research pH (acidity) is 3.5. It is more acid than the other research. Generally, peat is in an acidic condition and the pH value often lies between 4 and 7. Peat has high Cation Exchange Capacity (CEC). The main exchangeable sites are the functional acid groups which is named humic acids. The most common exchangeable cations in peat are Ca^{2+}, Mg^{3+}, Al^{3+}, K^{+}, Na^{+}, and NH_4^{+}. The CEC will increase with an increase of pH value and the exchangeable cation concentration. Among the peat, the CEC for fibrous peat is larger than others (Moayedi *et al*., 2011a; Moayedi *et al*., 2011b). The acidity of peat is decreasing with depth and the decrease depending on the type of the underlying soil, the decrease may be larger near the bottom layer (Kazemian and Huat, 2009, Kazemian *et al*., 2010).

Islam and Hashim (2008a, 2008b) reported that in Peninsular Malaysia, the ash content and organic content of peat are at an average of 3.55 and 96.45% respectively. It shows that the peat the peat has very high content of organic matter that indicates exceeding 90% of the loss of ignition value. The permeability of the peat is dependent on the void ratio, mineral content, degree of decomposition, chemistry, and the presence of gas. The degree of permeability is determined by applying a hydraulic pressure difference across the sample of fibrous peat that fully saturated then measuring the consequent rate of water flow. The coefficient of permeability is used to de-

termine the water flow through fibrous peat (Wong *et al*., 2008).

Physical Properties of Peat Soil in Palangka Raya:

In this study, peat soils showed highly organic content, more than 95%, in each sites. As known, high organic content was special characteristic of peat. Mankinen and Gelfer (1982) suggested that organic soil will be known as peat if the organic content reached greater than 50%, while according to Landva *et al*. (1982), Kearns *et al*. (1982), and ASTM (1985;1992) organic content of peat soil was more than 75%.

Peat soils in the study sites had relatively similar fiber content ranges from 33-38%. Based on the content of fiber, peat soils are classified into fibrous peat (with ≥ 20% of fiber content) and amorphous peat (with <20% of fiber content) (MacFarlane and Radforth, 1965). Peat soil with the fiber content of 33-67% is classified into hemic peat type (ASTM D4427-84, 1992). Thus, peat soils in the study sites were grouped into fibrous – hemic peat type. Fibrous peat is peat with high organic and fiber content with low degree of humification. Landva and Pheeney (1980) continued by Landva and La Rochelle (1983) described fibrous peat particles consist of fragments of long stems, thin leaves, rootlets, cell walls, and fibers often quite large. Stem diameters of 20 to 500µm, leaf thicknesses of 10 to 15 µm, and width and length of 100 to 1,200 µm are commonly found.

According to ASTM D4427-84 (1992), based on ash content, peat soils are classified into three classes, i.e. low peat ash (<5%), medium peat ash (5-15%), high peat ash (>15%). In the study sites, the peat soils showed low ash content ranges from 2-3%. Based on the criteria of ASTM D4427-92 (1992), the peat soils were moderately absorbent with the ability to store and absorb water ranging 300-800% and high acidity (pH <4.5).

Table 1: Physical properties of peat soil in Palangka Raya City.

Parameter	Street			
	Mahir Mahar	Bukit Keminting	Sisingamangaraja	Description
Water content (%)	531.33	457.38	412.16	moderately absorbent: w=300-800%
Unit Weight (γ) g/cm³	1.06	1.07	1.04	Bulk density: 0.9-1.25 g/cm3
Density (Gs)	1.74	1.69	1.42	Specific Gravity: 1.3-1.9
Organic Matter (%)	96.86	97.69	96.78	
Ash Content (%)	3.14	2.31	3.22	Low ash peat: < 5%
Fiber Content (%)	34.46	33.15	38.33	Hemic peat : 33-67%
Particle Size (%)				
- Rough fiber	11.14	5.34	36.14	
- Medium fiber	73.06	63.25	39.00	
- Smooth fiber	15.80	31.41	24.86	
Acidity (pH)	3.5	3.5	3.5	High acidity: pH<4.5

Physical Properties of Peat Soil in Several Sites:

Table 2 informed characteristics of peat soil from several locations. Peat soils derived from Klang (Selangor) and Matang (Sarawak), Malaysia are classified into fibrous peat soil with organic content of greater than 75%, moderately absorbent, low ash content and high acidity. The pH of peat soils which sampled from Palangkaraya were lower than the peat soil were studied by Kazeiman *et al.* (2009) in Klang. But in general, the peat soils from Palangka Raya showed similar characteristics to other locations such as from Malaysia. It is the same as the research of Gofar and Sutejo (2007) showed that the typical peat found in Peninsular Malaysia is classified as fibrous peat with low to medium degree of decomposition, it is very high organic and fiber contents.

Table 2: Physical properties of peat soil in previous studies.

Parameter	Klang Peat[a]	Matang, Sarawak Peat[b]	Kampung Jawa, Klang Peat[c]	Description
Level of ground water (%)	668	598,5	504	moderately absorbent: w=300-800%
Weight (γ) g/cm³	-	-	-	0.9-1.25
Density (Gs)	1.4	1.21	1.21	1.3-1.9
Organic Content (%)	96.00	90.47	88.23	
Ash Content (%)	4.00	-	-	Low ash peat < 5%
Fiber Content (%)	90.00	79.33	-	Sapric peat < 33 %
Particle Size (%)				
- Rough fiber	-	-	-	
- Medium fiber	-	-	-	
- Smooth fiber	-	-	-	
Acidity (pH)	3.51	3.75	4.9	High acidity: pH<4.5

Note: a: Wong *et al.*, 2008; b: Kolay *et al.*, 2011; c: Kazemian *et al.*, 2009.

Physical Properties of Peat Soil Compare to Mochtar (1999):

The peat soils are studied by Mochtar (1999) were fibrous peat soil type with organic content of greater than 75%, moderately absorbent and low ash contents. There are similarities between the classification which studied by Mochtar with peat soils under study although the value and percentage

of measured parameters showed differences. The physical properties of peat soils has some uniqueness including the main components such as minerals, organic matter content, naturally water content and air. When one component changed, it will alters the overall physical properties of peat soils (Huat *et al*., 2011).

Onuoha and Onwuka (2014) concluded that the geotechnical characteristic like as soil properties is a caisative factor of the road failure. Based on this research the subgrade of the three roads is peat soils so it has the very low bearing capacity. Its need several treatment before used as a subgrade of the road.

Table 3: Physical properties of peat soil in three areas.

Parameter	Banjar Masin	Palangka Raya	Pekanbaru	Range
Level of ground water (%)	449.84	536.33	616.08	moderately absorbent: w=300-800%
Weight (γ) g/cm³	0.964	1.000	1.043	0.9-1.25
Density (Gs)	1.381	1.439	1.520	1.3-1.9
Organic Matter (%)	95.38	98.91	95.55	
Ash Content (%)	4.62	1.09	4.45	Low ash peat:< 5%
Fiber Content (%)	61.33	53.33	39.26	Hemic peat:33-67 %
Particle Size (%)				
- Rough fiber	49.69	35.35	38.88	
- Medium fiber	31.94	35.84	32.12	
- Smooth fiber	18.37	28.81	29.00	
Acidity (pH)	-	-	-	-

Source: Mochtar (1999)

Conclusion:

In general, Palangka Raya's peat soil is type of fibrous peat soil (fibrous peat-hemic) with high organic content (more than 75%), moderately absorbent and low ash content. There is a similarity in classification of peat under study with the other studies although the value and percentage of measured parameters showed differences. As we know that peat has a very low bearing capacity so if the peatland is used as a subgrade of the road so that several suitable soil stabilization methods must be applicated.

ACKNOWLEDGMENT

This work was supported by a scholarship grant from Directorate General of Higher Education (DIKTI), Ministry of Education and Culture, Republic of Indonesia.

REFERENCES

ASTM Annual Book, 1985. Standard classification of peat samples by laboratory testing (D4427). ASTM Section, 4: 883-884.

ASTM Annual Book, 1992. Standard classification of peat samples by laboratory testing (D4427-92 Reapproved). ASTM, 596-597.

Deboucha S., R. Hashim and A. Alwi, 2008. Engineering properties of stabilized tropical peat soils. Journal of Geotechnical Engineering, 13E: 1-9.

Dhowian, A.W. and T.B. Edil, 1980. Consolidation behavior of peats. Geotechnical Testing Journal, 3:105-114.

Huat, B.B.K., S. Kazemian, A. Prasad and M. Barghchi, 2011. State of an art review of peat: general perspective. International Journal of The Physical Sciences 6(8): 1988-1996.

Islam, M.S. and R. Hashim, 2008a. Use of macintosh probe test for field investigation in peat soil. Proceeding of the International Conference, May 26-27, Best Western Premier Seti Pacific Kuala Lumpur, Malaysia, pp 27.

Islam, S. and R. Hashim, 2008b. Engineering properties of peat soils in Peninsular, Malaysia. Journal of Applied Science, 8(22): 4215-4219.

Kazemian, S., A. Asadi and B.B.K. Huat, 2009. Laboratory study on geotechnical properties of tropical peat soils. International Journal of Geotechnics and Environment, 1: 69-79.

Kazemian, S. and B.B.K. Huat, 2009. Compressibility characteristic of fibrous tropical peat reinforced with cement column. Electronic Journal of Geotechnical Engineering, 14E: 1-8.

Kazemian, S., A. Prasad, B.B.K. Huat, T.A.M. Ali and F.N. Aznieta, 2010. Effect of cement, Sodium Silicate, Kaolinite and water on the viscosity of the grout. Scientific Research and Essay Journal, 5(22): 3434-3442.

Kearns, F.L., W.J. Autin and R.G. Gerdes, 1982. Geological society of america abstracts with programs. N.E. Sections, 14 (1 and 2).

Kolay, P.K., H.Y. Sii and S.N.I. Taib, 2011. Tropical peat soil stabilization using class F pond ash from coal fired power plant. International Journal of Civil and Environmental Engineering, 3(2): 79-83.

Landva, A.O. and P. La Rochelle., 1983. Compressibility and shear characteristics of radforth peats, testing of peat and organic soils, STP 820, ASTM, West Conshohocken, Pa., 157-191.

Landva, A.O. and P.E. Pheeney, 1980. Peat Fabric and Structure. Canadian Geotechnical Journal, 17(3): 416–435.

Landva, A.O., E.O. Korpijaakko, P.E. Pheeney and P.M. Jarret, 1982. Geotechnical classification of peats and organic soils. Testing of Peats and Organic Soils, ASTM, STP, 820.

MacFarlane, I.C. and N.W. Radforth, 1965. A study of the physical behavior of peat derivatives under compression. Proceeding of the 10th Muskeg Research Conference, National Research Council of Canada, Technical Memorandum No, 85.

Mankinen, G.W. and B. Gelfer, 1982. Comprehensive use of peat in the USSR. DOE Fifth Technical Conference on Peat.

Mesri, G and M. Aljouni, 2007. Engineering properties of fibrous peat. Journal of Geotechnical and Geoenvironmental Engineering, 133(7): 850-866.

Moayedi, H., A. Asadi, B.B.K. Huat and F. Moayedi, 2011a. Zeta potential of tropical soil in presence of polyvinyl alcohol. International Journal of Electrochemical Science, 6(5): 1294-1306.

Moayedi, H., A. Asadi, B.B.K. Huat and F. Moayedi, 2011b. Optimizing stabilizers enhanced electrokinetic environment to improve physico-chemical properties of highly organic soil, International Journal of Electrochemical Science, 6(5): 1277-1293.

Mochtar, N.E. and E.I. Imananto, 1999. Aplikasi model "Gibson dan Lo" untuk tanah gambut berserat di Indonesia. Jurnal Teknik Sipil, 6(1).

Muhamad, I.S., S. Gandaseca, O.H. Ahmed and N.M.A. Majid, 2010. Comparison of selected chemical properties of peat swamp soil before and after timber harvesting. American Journal of Environmental Sciences, 6(2).

Onuoha, D.C. and S.U. Onwuka, 2014. The place of soil geotechnical characteristic in road failure, a study of the Onitsha-Enugu Expressway, Southeastern Nigeria. Journal Civil and Environmental Research, 6(1): 55-67.

Said, J.M. and S.N.L. Taib, 2009. Peat stabilization with carbide lime. UNIMAS E-J. Civil Engineering, 1:1.

Subagjo, H., 1998. Karakteristik bio-fisik lokasi pengembangan sistem usaha pertanian pasang surut, Sumatera Selatan, Pusat Penelitian dan Agroklimat, Bogor (Unpublished).

Van de Meen, 1984. Geological Aspects Of Peat Formation In The Indonesian-Malaysian lowlands. Bulletin Geological Research and Development Centre, 9: 20-31.

Wahyunto, S.R. and H. Subagjo, 2004. Map of peatland distribution area and carbon content in Kalimantan, 2000-2002. Wetlands International-Indonesia Programme and Wildlife Habitat Canada (WHC).

Wong, L.S., R. Hashim and F.H. Ali, 2008. Strength and permeability of stabilized peat soil. Journal of Applied Science, 8(17): 1-5.

Wong, L.S., R. Hashim and F.H. Ali., 2008. Compression rates of untreated and stabilized peat soils, Electronic Journal of Geotechnical Engineering, 13F: 1-12.

Yulindasari, I., 2006. Compressibilty characteristic of fibrous peat soil. Master Thesis, Universiti Teknologi Malaysia, Malaysia.