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ORIGINAL ARTICLE

Experimental Study on Physical Properties of Peat in Sibu, Sarawak

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ABSTRACT - Peat is well known for its extremely soft, wet, unconsolidated surficial deposits that are integral part of the wetland systems. Peat can sustain a lot of water because of its low physiography and water holding capacity, which is 20 to multiple times its own weight. Due to its long-term consolidation settlements, even when subjected to low loads, peat creates major issues in the construction sector [1]. This is why peat is one of the most challenging types of soil to handle with when it comes to sustain the load from various types of constructions. The objective of this study is to review the physical properties of peat in Sungai Bidut, Sibu, Sarawak, Malaysia.

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INTRODUCTION

Soil is defined as any loose surface material overlying solid rock [2]. Organic content as a percentage of the total product determines that organic soil is classified as moderately organic soil (3% - 20% organic content), organic soil (20% - 75% organic content) and peat (over 75% organic content) which is stated in Table 1 [3].

Peat soil is the result of disintegration and partially decomposed of plant materials that occur in the environment which consists of low oxygen and can be described as naturally high in percentage of fibrous organic matters [4]. When peat exposed to very wet environment, it will absorb the moisture very well. Compared to the other types of soil, peat soil acts as a good water retention. For this reason, peat contains very high in moisture content up to more than 1000% [5].

Peat soil bearing capacity is significantly reduced as a result of increasing in moisture content and this condition poses problems in construction process because peat soil does not provide suitable support in the construction of infrastructures. In its natural untreated condition, peat soil is characterized a non-plastic because it contains of high foreign material and very little clay content in soil body [4].

Peat soils are the soil produced from decaying and decomposed vegetations. Once plants and animals have been decomposed, they experience an anaerobic process, where oxygen has been used for decomposition for a very long time. Decomposition is a process that disintegrates the original structure of peats, apart from modifying the chemical composition. The type of decomposition will depend on the possibility of the oxygen supply that regulates the rate of process [5].

However, the content of peat may vary from location to location due to factors such as origin of fiber, temperature, and degree of humification [3]. For instance, bog and fen peats normally developed at northern temperature regions of the world. Bog peats receive water from rain falling on its surface only while fen peats receive water and nutrients from the soil, rock and groundwater as well as rain [6].

The types of peat can be determined with degree of humification by referring to the Von Post classification system. The Von Post test involves squeezing the fresh peat soil by hand. Then, by observing the quantity of peat soil left on the palm after squeezing and the colour of water escape from the fingers are required to determine the degree of humification. The scale range for the humification of peat is 1-10. H1 has the lowest degree of humification while H10 is the highest [7].

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Malaysia has more than 3 million hectors of land are peatland [1]. Peat can be spotted throughout the world, especially in Malaysia. Malaysia occupies approximately 25,000km2 of peatland [8]. [5] There was about 228,960ha of peat in Johor. Peat is a type of soil that is not suitable to withstand loads and incapable of accomplishing in engineering activity in their natural condition [9].

The peat soil has the compressibility of within the range of 0.9 – 1.5, moisture content (may up to 1000%); high organic content (>75%) and high fiber content which faces serious settlement problems [2]. Apart from that, Malaysia is located in tropical and subtropical areas [10]. [8] Tropical peats in Malaysia can then be classified into three main groups; fibrous peat, hemic peat and sapric peat [11].

Table 1 Type of soil depends on their organic content [3]

Type of soil	Organic content
Moderately Organic Soil	3% - 20%
Organic Soil	20% - 75%
Peat Soil	>75%

MATERIALS AND METHODS

There are two types of tests to be carried out on peat samples which are field test and laboratory test. Field test typically conducted on the location of peat sampling in accordance to Von Post Classification Test. Laboratory test can be further subdivided into three types of tests; physical properties, engineering properties, and microscopic tests. Only physical tests will be covered in this study.

RESULTS AND DISCUSSIONS

Field Tests

The peat samples are collected by utilizing peat sampler. The samples are collected from Jalan Sungai Bidut and samplings are taken from three different points which are point 1, point 2 and point 3 (Figure 1) with four different depths (below ground level) each; 0.5m, 1.0m, 1.5m and 2.0m. All the samples collected are stored and sealed in zipped plastic bags in order to minimize the moisture lost. The peat sampler used for sampling is Eijkelkamp Peat Sampler Set as shown in Figure 2.

Figure 1 Peat sampling points

Figure 2 Peat sampling

The only in-situ test that involved in the study is Von Post classification test and the test is carried out in accordance to ASTM D5715 standard [13]. The test covers a system for visual inspection of peat and other highly organic soils on the basis of degree of humification. Degree of humification as defined by Von Post classification refers to any one out of ten categories which indicated by the letter "H" with H1 being the least humified and H10 being the most humified.

The procedures for estimating the degree of humification of peat by observe the color of water expelled between the fingers upon squeezed and the amount of amorphous material expelled between the fingers during the test as shown below in figure 3, which is identified as Hemic peat (H4 - H5).

Figure 3 Very dark brown in colour and pasty residue left on hand after squeezed

Laboratory Tests

To investigate the properties of peat at Jalan Sungai Bidut, a series of laboratory tests are carried out to determine its physical properties. The physical properties tests to be carried out in the laboratory are moisture content, ash content, organic content, fibre content, specific gravity, liquid limit, pH value test, and particle size distribution.

A moisture content test is carried out to determine the percentage of water content in nature peat. Generally, peat has a very high moisture content in its nature. However, the percentage of water content might be slightly different between peat depends on their origin and degree of humification. In this study, the moisture content of peat is determine based on the procedures as stated in ASTM D2974 standard [16].

Table 2 Moisture Content of peat at Sungai Bidut, Sibu

Point	Depth (m)	Avg Moisture Content (%)	Avg Moisture Content for each point (%)
1	0.5	991.93	986.44
	1.0	1091.19	
	1.5	939.97	
	2.0	922.66	
2	0.5	990.34	1071.55
	1.0	1016.53	
	1.5	1005.22	
	2.0	1074.12	
3	0.5	893.53	985.38
	1.0	1046.29	
	1.5	954.54	
	2.0	1047.16	

Table 2 shows that the peat at point 2 has the highest moisture content, 1071.55% while peat at point 3 has the lowest moisture content, 985.38%. The peat at point 2 has the highest moisture content compared to point 1 and 3 due to its large amount of undecomposed organic matters and fibrous materials present in the peat.

Regarding Table 2, it shows that different points give different percentage of moisture content due to the relation to the ground water table [17]. Apart from that, [17] also mentioned that moisture content increases due to the decreasing in particle density.

Ash content test is conducted in the laboratory on peat as the pre-requirement test to determine the organic content of peat, and the ash content of peat can be determined based on the procedures stated in ASTM D2974 standard [16]. There are five samples for each point and Table 3 shows that the ash content for peat in Sungai Bidut is around 8.42 - 10.09.

Organic content in peat is one of the important parameters that need to be determined for the classification of peat or other organic soil. As mentioned earlier, the organic content in peat is determined based on the results from the ash content test. According to Table 4, the organic content of peat in Sungai Bidut is high (89.91% - 91.58%). Peat in Sungai Bidut contains a high amount of fiber (Table 5), which gives a high amount of organic content as well.

The level of maturity of peat decomposition influences the organic content of peat soil. The carbon content of soils decreases as a result of the decomposition process. The organic content of peat soil in the maturity levels hemic and sapric is lower than that of peat soil in the maturity level fibric [18].

Table 3 Ash Content of peat at Sungai Bidut, Sibu

Point	Ash Content (%)	Avg Ash Content for each point (%)
1	9.22 8.56 9.73 7.68 6.89	8.42
2	9.66 9.95 10.32 10.57 9.97	10.09
3	9.61 9.57 10.18 10.07 9.74	9.83

Table 4 Organic Content of peat at Sungai Bidut, Sibu

Point	Organic Content (%)	Avg Organic Content for each point (%)
1	90.78 91.44 90.27 92.32 93.11	91.58
2	90.34 90.05 89.68 89.43 90.03	89.91
3	90.39 90.43 89.82 89.93 90.26	90.17

The fibre content of samples is determined based on the procedures as described in ASTM D1997 standard [13]. In this standard, the results from the test are expressed as the fibre content as the percentage by dry mass.

Table 5 shows that the fibre content in Sungai Bidut is high, 50.93% - 64.56% which can be seen in figure 4. As reported by [19], high fibre content gives high water content and high initial void ratio, where the water content in Sungai Bidut is high as well.

Figure 4 Fiber retained and oven-dried

Table 5 Fibre Content of peat at Sungai Bidut, Sibu

Point	Depth (m)	Avg Fibre Content (%)	Avg Fibre Content for each point (%)
1	0.5	70.64	63.58
	1.0	67.01	
	1.5	59.28	
	2.0	57.38	
2	0.5	88.54	64.56
	1.0	58.15	
	1.5	54.63	
	2.0	56.92	
3	0.5	55.76	50.93
	1.0	44.70	
	1.5	47.54	
	2.0	55.73	

The specific gravity of soil solids can be defined as the ratio of the mass of a unit volume of soil solids to the mass of the same volume of gas-free distilled water at 20°C [16]. The results from the specific gravity test can be used to determine the density of soil solids by just multiplying its specific gravity by the density of water.

For the study, the specific gravity of peat is determined by using the pycnometer method based on procedures stated in ASTM D854 standard [16] as shown in figure 5. The specific gravity for this study is 1.08 - 1.21 (Table 6) which is low due to the organic constituents; cellulose and lignin [20].

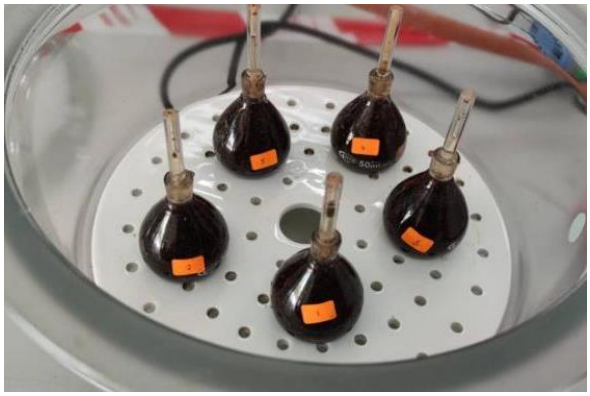

Figure 5 Specific gravity test by using pycnometer

Table 6 Specific Gravity of peat at Sungai Bidut, Sibu

Point	Specific Gravity	Avg Specific Gravity for each point
1	1.12 1.22 1.09 1.18 1.16	1.15
2	1.17 1.03 1.05 1.07 1.07	1.08
3	1.19 1.27 1.16 1.20 1.23	1.21

Table 7 Liquid Limit of peat at Sungai Bidut, Sibu

Point	Liquid Limit	Avg Liquid Limit for each point
1	235.45 352.73 243.91 228.46 356.84	283.48
2	337.64 361.25 381.70 283.49 351.42	343.10
3	367.40 380.04 371.66 370.09 365.83	371.00

The presence of fibers and negligible mineral content in peat make it difficult to perform the liquid limit test on peat. Thus, the coarse fibers in the sample need to be removed first before mixing the sample into a homogenous paste [21].

To determine the liquid limit of the sample, Casagrande liquid limit device is used as per guidelines based on ASTM D4318 standard [22]. Regarding Table 7, the liquid limit is high (283.48% - 371.00%) which is due to the high amount of fibre content and organic content which also gives high water-absorption capacity [20].

The pH test is carried out on peat in the study to express the degree of acidity or alkalinity of peat suspended in distilled water [23]. The pH test is carried out by the procedures mentioned in BS1377: Part 3: 1990 standard [24]. The pH value of peat in Sungai Bidut (Table 8) is low (3.76 - 4.01), also known as highly acidic (pH < 4.4) [25].

The geotechnical properties of fibrous peat are high in initial void ratio, low pH and high water-holding capacity [26], which can be concluded as the higher the amount of fibrous structure, the lower the pH of peat [27] and due to the presence of carbon dioxide during decomposition processes [28].

Table 8 pH Value of peat at Sungai Bidut, Sibu

Point	pH Value	Avg pH Value for each point
1	4.23 3.75 3.94 4.36 3.76	4.01
2	3.66 3.92 3.72 3.86 4.28	3.89
3	3.21 3.80 3.74 4.08 3.97	3.76

PEAT COMPARISON

Peat is generally comparable across places, although its composition varies according to its botanical features, which provide diverse characteristics [28]. Table 9 presents the comparison of peat properties in Sungai Bidut, Tun Zaidi Stadium and Jalan Lai Chee, Sibu.

Table 9 shows that the degree of humification for Sungai Bidut and Tun Zaidi Stadium is H4 - H5 while Jalan Lai Chee is categorized as H4, all of them represents Hemic peat. The values are differ depending on their origin [28], which clearly shows in Table 9, that moisture content in Sungai Bidut and Tun Zaidi Stadium are higher than Jalan Lai Chee.

The organic content of peat is greater than 75% [20], where in Table 9 gives organic content more than 90%, which leads by Tun Zaidi Stadium (96.29% in average). The fibre content in Jalan Lai Chee is slightly higher than Sungai Bidut and Tun Zaidi Stadium. This is because of the widely undecayed peat at the area.

On the other hand, Sungai Bidut has the lowest specific gravity compared to the other places due to the high amount of fibre content and organic content [28].

The liquid limit in Tun Zaidi Stadium is higher than the liquid limit Sungai Bidut and Jalan Lai Chee since it has the highest value of moisture content. The pH of the peat for both Sungai Bidut and Tun Zaidi Stadium is very low and acidic due to the numerous amount of organic content.

Table 9 Peat Comparison in Sibu, Sarawak

	Sungai Bidut	Tun Zaidi Stadium [28]	Jln Lai Chee [20]
Degree of Humifi-cation	H4 - H5	H4 - H5	H4
Moisture Content (%)	985.38 - 1071.55	964.52 - 1096.59	599
Organic Content (%)	89.91 - 91.58	96.22 - 96.35	90
Fibre Content (%)	50.93 - 64.56	43.45 - 48.23	79
Specific Gravity	1.08 - 1.21	1.16 - 1.2	1.21
Liquid Limit (%)	283.48 - 371.00	305 - 390	-
pH value	3.76 - 4.01	3.59 - 3.62	-

CONCLUSION

From the result of this study, it can be concluded that the peat in Sungai Bidut, Sarawak is Hemic fibrous peat (H4 - H5), has high water content (985.38% - 1071.55%), high organic content (89.91% - 91.58%), high fibre content (50.93% - 64.56%), low specific gravity (1.08 - 1.21), high liquid limit (283.48% - 371.00%) and low pH value (3.76 - 4.01).

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