COMPARATIVE STUDY OF BRITISH AND MALAYSIAN PEAT SOILS PERTAINING TO GEOTECHNICAL CHARACTERISTICS

Adnan[1], Z, Wijeyesekera[2], D.C. and Masirin[3], M.I.

1. Research Student, School of Computing and Technology, University of East London, e-mail:adnan@uel.ac.uk
2. Professor, School of Computing and Technology, University of East London, e-mail: chitral@uel.ac.uk
3. Associate Professor, University Tun Hussein Onn Malaysia (UTHM), e-mail: idrus@yahoo.co.uk

ABSTRACT: Peat soils occur in many countries and are described differently at times from both a qualitative and quantitative perspective. Peats are formed naturally through the decomposition of plant and animal matter under anaerobic conditions that take place over long periods of time. While the estimated and reported extent of Malaysian peat was approximately 2.6 million hectares respectively [12], there is an estimated 1.6 million hectares (minimum) of peat land available in British [6]. In British, peat soils are classified as Bog and Fen Peat. However in Malaysia, peat soil is described and generally termed as basin and valley peat [4]. The behaviour and composition of these peats are different from each other, accentuating the need for a useful engineering geological classification of peat soils. These soils are known for their low shear strength and high compressibility characteristics leading to unstable ground conditions. This paper focuses on comparative study an overview of the characteristic geotechnical properties for these soils. It also examines and discusses the effect of basic properties and behaviour of composition of each soil with case studies that had been done by one of the authors at Western Johore, Malaysia.

Keywords: peat; British peat soil; Malaysian peat soils; geotechnical basic properties

1. INTRODUCTION

The consequent rapid development within the country, coupled with a strong economic performance has resulted in vast infrastructure development. These developments are hindered by a dearth of suitable land for development and as a consequence, an area with adverse ground conditions such as peat soil is being considered for infrastructure construction such as roads, housing, drainage and others.

Peat is commonly known as materials with high compressibility and bearing capacity and being not suitable as foundation materials for any construction works. Researches have been done for this type of soil [1][3][5][14]. It is also known with several names which in turn indicate to characterise its differences resulting from the effect of climate and type of plant materials that constitute the peat. Although the definition of this soil has similarity but the characterization of this soil normally is defined by its inherent locality. This paper presents the comparative study between peat soil from Britain and Malaysia.

2. DEFINITIONS AND CLASSIFICATION

Literature review showed that peat soils have accumulated since the last 20 000 years. Some of buried peats may have been developed during inter-glacial periods. As peat is a type of soil which contains high proportion of dead organic matter, the factors which cause peat to accumulate may be its similar the world over however different types of peatlands develop because of differences in climate, soil type and plant species. Peat is included in soil classification systems under names such as ‘peat soil’,‘muck soils’, ‘bog soil’, and ‘organic soils’, ‘moors’, ‘muskegs’, ‘mires’, ‘tropical swamp forests’ and ‘fens’. [13]

One of the issues still facing peat engineering is the lack of satisfactory and internationally accepted definitions and classification. Most common definition of peat is based on ash (or organic) content [1][10]. Peat is geotechnically is described as soils with more than 75% organic content. It is mainly governed by the quantity and the quality of organics it contain, as well as its physical properties. However the definition and descriptions of peat between soil scientists and engineers are diverse. Soil scientists have described peat as soil with an organic content greater than 25%. This forms a fundamental difference between the views of a soil scientist from that of a geotechnical engineer.

Current classification systems for peat and organic soils use organic and ash content as the sole

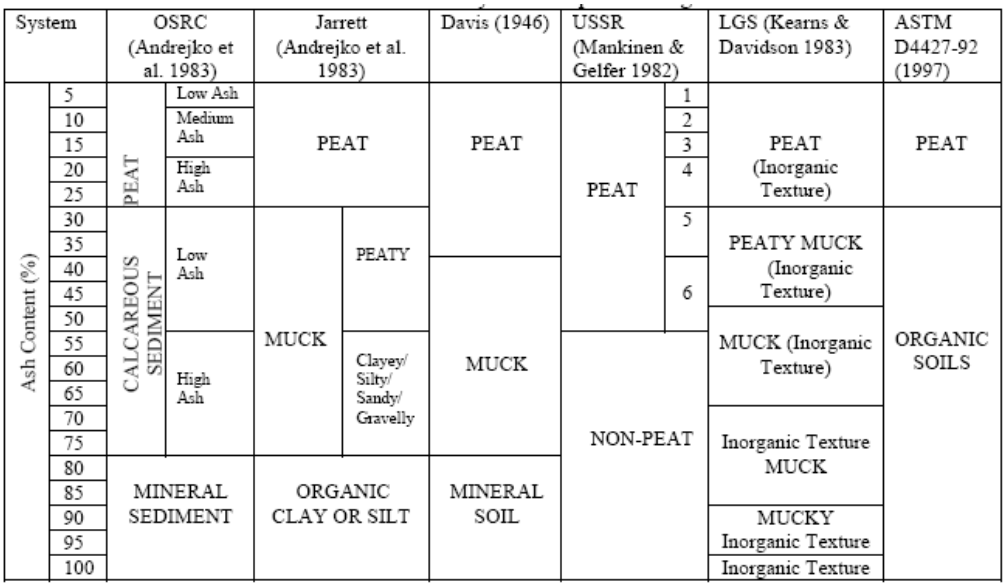

Figure 1: Comparison of classification systems used for peat and organic soils [11]

parameter in classification [1][10]. This, however, has resulted in a wide variation in the definition of peat which is compared in Figure 1. The threshold organic contents in peat that separate the various types usually differ, depending on the classification system adopted.

In Malaysia classification of peat and organic soils is based on the British Standard 5930:1981. However, this classification has been improved by Public Work Malaysia & Jarret [7] to make this system more explicit to the Malaysian environment. The MSCS system introduced the state of decomposition (or the degree of humidification) as the second important parameter to be considered after organic content. This defines the state of decomposition/decay of the organic plant remains which give rise to peats and organic soils. A further factor that has been considered in MSCS is the percentage of fiber content. There are three-point scales for fiber content is used in the classifications for Malaysian peat shown in Table 1.

3. GEOGRAPHICAL DISTRIBUTION OF PEAT SOILS IN BRITISH AND MALAYSIA

Peat is found worldwide and occurs in many different climatic zones from arctic to tropical in both northern and southern hemispheres [13][14]. The physical and chemical properties of peat and the vegetation which supports vary with geographical location, climate, topography, hydrology and hydrochemistry. Peat in northern temperate regions of the world is formed normally from the remains of grasses, sedges and bog mosses [14]. However, tropical peats like Malaysia, it consists mainly of sediments from woody remains such as roots, branches and tree trunks [2][16].

Hobbs [14] gave excellent summaries of the development and properties of British peat. There are two types that are fen and bog peat. The morphological differences between fen and bog are attributable to the types of plant remains which occur in the peat and their mode of origin. He found that the differences involve degree of humification, structure, fabric and proportion of mineral material contained in the peat, and this in turn affects their engineering behaviour. Bog receives water solely from rain and/or snow falling on its surface meanwhile fen receives water and nutrients from the soil, rock and groundwater as well as rain and/or snow.

In Malaysia, there is approximately 26,000 km^2 of peat that accounting for about 8% of the country's land area [12]. Bujang [4] observed the depths for peat deposits in Malaysia were varying from 1m to 20m. The colour of peat soils in Malaysia is generally dark reddish brown to black. It consists of loose partly decomposed leaves, branches, twigs and tree trunks with a low mineral content. The ground water table in these areas is always high and occurs at or near the surface [9]. In its

Table 2 Malaysian Soil Classification Systems (MSCS) for Organic and Peat. [7]

Soil Group	Organic Content	Group Symbol	Degree of Humidification	Subgroup name	Field Identification
Peat	>75%	Pt	H1-H3	Fibric or Fibrous Peat	Dark brown to black in color. Material has low density so seems light. Majority of mass is organic so if fibrous the whole mass will be recognized plant remains. More likely to smell strongly if highly humidified
			H4-H6	Hemic or Moderately Decomposed Peat	
			H7-H10	Sapric or Amorphous Peat	

Table 3 Comparison geotechnical properties for Britain and Malaysian peat

Soil Deposit	West Malaysia Peat	East Malaysia Peat	Johore Hemic Peat	British Peat	
				Bog	Fen
Natural water content, W (%)	200-700	200-2200	230-500	200-1000	500-600
Liquid limit, LL (%)	190-360	210-550	220-250	800-1500	200-600
Plastic Limit, PL (%)	100-200	125-297	-	-	-
Plasticity Index, PI (%)	90-160	85-297	-	-	-
Specific gravity (G_s)	1.38-1.70	1.07-1.63	1.48-1.8	1.40-1.60	1.80
Organic content (%)	65-97	50-95	80-96	>98	>98
Unit weight (kN/m^3)	8.3-11.5	8.0-12.0	7.5-10.2	9.5-10.5	8.5-11.0
Undrained Shear strength (kPa)	8-17	8-10	7-11	-	-
Compression Index,C_c	1.0-2.6	0.5-2.5	0.9-1.5	-	-
Refs.	[3][4]	[3][4]	[17]	[14]	[14]

state, the peat will transform to a compact soil mass consisting partially of large wood fragment and tree trunks embedded in it.

4. GEOTECHNICAL CHARACTERISTICS REVIEW OF BRITISH AND MALAYSIAN PEAT SOILS

The study of peat has been done by many researchers especially engineers to ensure that any construction on peat based grounds are safe after completion. The main aspects of these studies were focused on geotechnical characteristics when the application in engineering is concerned. Some parameters studied were the moisture content, liquid limit (LL), plastic limit (PL), plastic index (PI), specific gravity (Gs), shear strength and others. As discussed earlier, there are still challenges in peat engineering especially when understanding of peat soils and utilizing it for engineering purposes. In this section, a review on some of these geotechnical characteristics and properties were discussed and indicated in Table 2. Variations of those geotechnical properties of peat in British and Malaysia by some engineers are also summarized and later discussed in this section.

To analyze geotechnical characteristics and properties of peat, there are several techniques and methods. A common and useful method of determining organic content is to burn a small soil specimen in a furnace after drying at 105^0C for 24 hours. Comparison of measured mass before and after *burning* yields the ash content or loss on ignition (N). The organic content is then determined as the followings:

Organic content (%): 100-C (100-N)

Where, C is correction factor for oven temperatures in excess of 450^0C (C=1.0 for 450^0C).

When similar tests were conducted on Malaysian peat soil, the natural water content indicated ranges from 200% to 2200% [4]. These values are for east Malaysian peat soil. However Zainorabidin et al [17] conducted several testing on Johore Hemic peat and found that the natural water content ranges from 230% to 500%. Other researchers on these properties for West Malaysian peat soil include Al-Raziqi et al. [3] who found some properties of Malaysian peat soils as interesting similar to values indicated in Table 3. All these figures indicated that Malaysian peat soil varies from different geographical locations when natural water content is consent. This is due to the influence of different agricultural background of the area and rainfall intensity.

Furthermore the sampling location might differ as some were taken from coastal area and others from midlands. As in the case British peat soil, there are two types of peat namely bog and fen (See Table 3). The natural water contents for bog seems to be similar with sample taken from east Malaysia peat soil where as for fen it characteristics if not the same is similar to some West Malaysia and Johore peat soil.

In the drying process to determine water content of peat, the technique employed should be carefully selected as it would lead to unnecessary charring of the organic component in peat does producing in consistent water content value. Some researchers uses a lower temperature between 50^0C to 95^0C whereas the standard drying technique of soil where at 105^0C for twenty four hours [17]. Skempton & Petley [15] and Kabai & Farkas [8] conducted some test and found that the lost of organic matter at 105^0C was insignificant while drying at lower temperature retained small amount of moisture.

Zainorabidin & Ismail [17] further investigated the effect of drying temperature on hemic peat soil and suggested that Figure 2 shows that the drying duration decreases as temperature increases. For drying temperature of 60^0C, drying duration needed is 96 hours while for drying temperature of 400^0 C, the duration is only 5 hours. However, from laboratory observations, suitable temperature for hemic peat soil is between 100^0C to 200^0C for drying durations between 24 hours to 60 hours.

The ability for peat soil to retain moisture in its unique structure is quite different any others soil such as clay, this might due to the presence of organic matter and botanical remains. The existence of these elements might further contribute towards *free-water* movement in the soil thus; higher water content might be computed or indicated when moisture content test is carried out on peat soil.

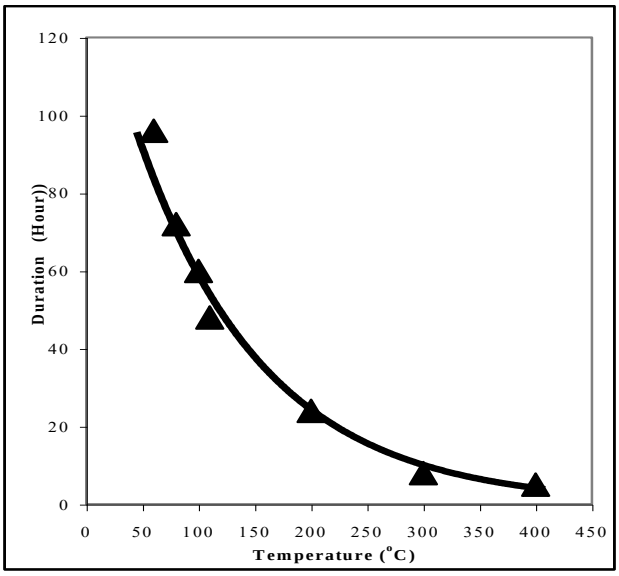

Figure 2: Duration versus drying temperature (^{0}C) [17]

As for the consistency limits values, Malaysian peat varies from 100% to 550%, depending on their locations whereas for British peat ranges from 200% to 1500% depending on whether it's of bog or fen type. However, the most important analyses here are its suitability in engineering application. From these results, they indicated that peat have a very high plasticity and liquidity which if taken direct from its natural habitat, they are not suitable for any engineering purposes.

With these characteristics and understanding, engineering may be able to make appropriate decisions and conduct soil improvements where necessary for any construction project on soft soil. The existence of higher liquid limit values of peat soils in British especially in bog shows that if

construction is to be done on it, serious consideration to the type of soil improvement must be taken into account. As for peat soil in Malaysia, tests seem to give consistent values and this may further contribute towards common approach in improving peat soils for construction purposes.

As for LL and PL properties, they showed higher values ranging from 190 to 550% and 100 to 297%, respectively. However, the authors have previously encountered problems when attempting to determine the plastic limit of Malaysian hemic peat. The presence of the fibres in peat makes the process of determining the Atterberg limits difficult and less accurate.

Hobbs [14] determined the differences in liquid limit which he identify that peat's liquid limit depended on the type of plant detritus, the degree of humidification and the clay content. Accordingly, the liquid limit for the Malaysian peat is much less than that reported by Hobbs [14] of 200-600% for fen peat and 800-1500% for bog peat. Specific gravity of peat is influenced by that of cellulose (1.58) and of lignin (1.40). Edil [5] and Hobbs [14] reported the values in the range of 1.1 to 1.9.

As for organic content in peat, Malaysian peat contains 50% to 97% whereas British peat contains more than 98%. The reason for the difference might be the types of plants cultivated or grown in the peat areas in Malaysia and British. The Malaysian peat might originate or formed from a less denser agricultural land area than the British peat. Thus, the percentages of organics are different.

The unit weights of both peat soils in Malaysia and British seem to indicate similarities with values ranging from 8.0 to 12.0kN/m^2. However, no comparison can be made in terms of shear strength and compression index as there are no results for these parameters for British peat soil. As for Malaysian peat, the undrained shear strength were 8 to 17 kN/m^2 (West Malaysian peat), 8 to 10 kN/m^2 (East Malaysian peat) and 7 to 11 kN/m^2 (Johore Hemic peat). The compression indices values for the above were 1.0 to 2.6, 0.5 to 2.5 and 0.9 to 1.5 respectively. The performance of peat is assumed hypothetically being dominated by its macro and micro structure which continuously changes with the digenesis of the material.

Further research is being carried out at the University of East London to determine and identify the soil properties based on macrostructure and microstructure to the strength characteristics as they are important for future research.

5. CONCLUSION AND SUMMARY

In conclusion, this paper has given properties overview of British and Malaysian peat. It has discussed and emphasized some pertinent matters such as mentioned below:

- Closing the gap between soil scientist and engineers in peat definition should be a continuous effort.
- Different geographical location in different climate will generate different and unique properties of peat.
- Botanically different peat properties will give different engineering characteristics and behaviour.
- Thus, peat by virtue of its heterogeneity is a problematic soil.
- Research leading to a better understanding of the performance of peat is urgently required for better geotechnical design.

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