A Comparison of Physical Parameters of Sri Lankan Organic Soils and Peats

M. Thivaskar
Civil Engineer, Central Engineering Consultancy Bureau, Sri Lanka

H.G.P.A. Ratnaweera
Senior Lecturer, Department of Civil Engineering, The Open University of Sri Lanka, Sri Lanka

ABSTRACT: This study compares physical properties of Sri Lankan organic soils and peats in relation to tropical peats. Peats are classified as fibric, hemic and sapric; the classification is based on a) Fibre Content (ASTM D4427, 2007), b) degree of humification (von-Post, 1922), or c) based on visual observation and feel. Organic content quantifies the amount of organic and inorganic matter, however does not quantify the state of humification. Organic matter in plant fibres and organic matter in humified peat may yield different physical parameters. Classification of organic soils and peat should be based on standardised test methods performed on undisturbed specimens. This study examines correlations dry density versus natural water content, organic content versus specific gravity, and organic content versus natural water content, based on published data. Results show both conformity and divergence, against expected trends.

1 INTRODUCTION

1.1 *Formation of peat*

Tropical peats are formed under high precipitation and high temperature conditions. Cooray (1984) identifies peat deposits along the coastal wet zone of Sri Lanka as recent, and such deposits are nourished by inorganic sediments supplied by perennial rivers located in this region. These deposits are water-logged and hence anaerobic conditions exist. Though these reservations are important buffer zones that store and transmit storm-water, several such regions are reclaimed and developed.

1.2 *Classification of peat*

Fibric peats are characterized by relatively unaltered plant tissues such as wood blocks, grasses, leaves, and roots. Hemic peat contains fragments of plant tissues which are partially disintegrated and decomposed. Sapric peat is characterized by black organic fragments and brown amorphous materials of unidentifiable botanical origin (Sabiham 1990).

Classification systems used in geotechnical engineering applications differentiate peat from other inorganic soils (Carlsten 1988). Landva, *et al.* (1983) defines organic soils and peat based on organic content (OC): peat (OC>80%), organic peat (OC between 60-80%), and organic soils (OC<60%). ASTM D4427 (2007) broadly classifies peats based on their fibre content: fibric peat >67%; hemic peat 33–67%; sapric peat <33%.

Von Post (1922) proposed a method to classify peats, based on colour of water squeezed out when a handful of saturated peat is compressed. It uses the scale H_1–H_{10} to describe varying degrees of humification. ASTM D5715 (2006) uses von Post's scale to classify the three peat types; namely, fibric (H_1–H_3), hemic (H_4–H_6) and sapric (H_7–H_{10}).

Peaty soils have the potential for further humification resulting from changing environment (Deboucha *et al.* 2008). These changes cause changes in the water phase, i.e. free water and water entrapped within its fibres.

Accurate quantification of physical properties of organic soils and peat remains a challenge due to changes to soil fabric during sampling and handling, and due to spatial variations observed within the soil deposit.

The aim of this study is to compare physical parameters of Sri Lankan peats with data and correlations as reported by other researchers. This enables researchers to compare measured properties with those of similar peat types, thereby make better predictions.

1.3 *Parameters representing physical properties*

Natural water content of peaty soils is computed based on a) mass of water to oven-dried mass of peat or as b) mass of water to 'as received' mass of peat. ASTM D2974 (2007) recommends measuring dry solid mass by oven-drying at 105°C for Geotechnical purposes and air-drying at room temperature when determining Nitrogen, pH and cation exchange capacity. Oven-drying at 105°C may cause a loss of organic matter, hence Method B allows the computation of natural water content based on air dried weight and oven-dried weight.

Ash content is computed as the ratio of mass of ash to oven dried mass of peat. Organic content is the complement of ash content. Ash is produced by burning the soil in a muffle furnace, at 440°C or 750°C (ASTM D2974 2007).

Fibre content is defined as the ratio of mass of fibres retained on 0.15mm sieve, during wet sieving to the original dry mass of soil. Fibres and inorganic matter are washed with a gentle stream of water. Mass of fibers is determined by oven drying the specimen at 105 ± 5°C for a period of 24 hrs and later burning all organic matter in a muffle furnace (ASTM D1997 2008).

The specific gravity of solid matter is recommended to be measured relative to the density of water at 20°C. BS 1377-2 (1990) recommends the use of water or kerosene as wetting agents. Chiet, (2010) discusses the use of small pyknometer method, to accommodate particle sizes finer than 2mm. Specific gravity of inorganic soils is around 2.65–2.72; values lower than this range indicates a high organic content. Davis (1997) observes that specific gravity ranges between 1.3–1.8, when organic content is greater than 75%. Dry density of saturated peats quantifies the state of compactness.

Literature reports that liquid limit increases with increasing organic content. Atterberg consistency limits are meant to quantify the physico-chemical interaction between inorganic fines and the pore-fluid, and not water retention and interlocking abilities of organic fibres. Kolay *et al.* (2011) notes an increase in water absorption with an increase in fibre content. Liquid limit increases due to high water absorption with increasing organic matter and decrease due to low water absorption due to aggregation of inorganic fines within organic matter (Huang *et al.* 2009).

2 METHODOLOGY

This study compares secondary data on tropical organic soils and peat, and trends proposed by previous researchers. Secondary data that identified organic soils as fibric, hemic and sapric were reported in this study; other data were identified as 'unclassified'. These data were used to correlate between a) dry density versus natural water content, b) organic content versus specific gravity, and c) organic content versus natural water content.

3 RESULTS AND DISCUSSION

Fig. 1 plots the variation of dry density with natural water content. It also shows the zero air-void curves corresponding to G_s values equal to 2.7 and 1.4, typical of inorganic and organic peaty soils, respectively. The plot shows good agreement even with some data outliers. The measured water content of the specimen may not represent its natural water content due to loss of moisture during sampling and handling. This however, may not affect the dry density since it is usually computed based on bulk density of the specimen. For saturated specimens, degree of saturation may help establish the true natural water content.

Fig. 2 plots organic content with specific gravity of solids. Skempton & Petley (1970) expresses $OC = 290.8 / G_s - 107.7$. The two parameters measured are inter-related; hence variations observed can be attributed to deviations in standard procedures or due to measurement errors.

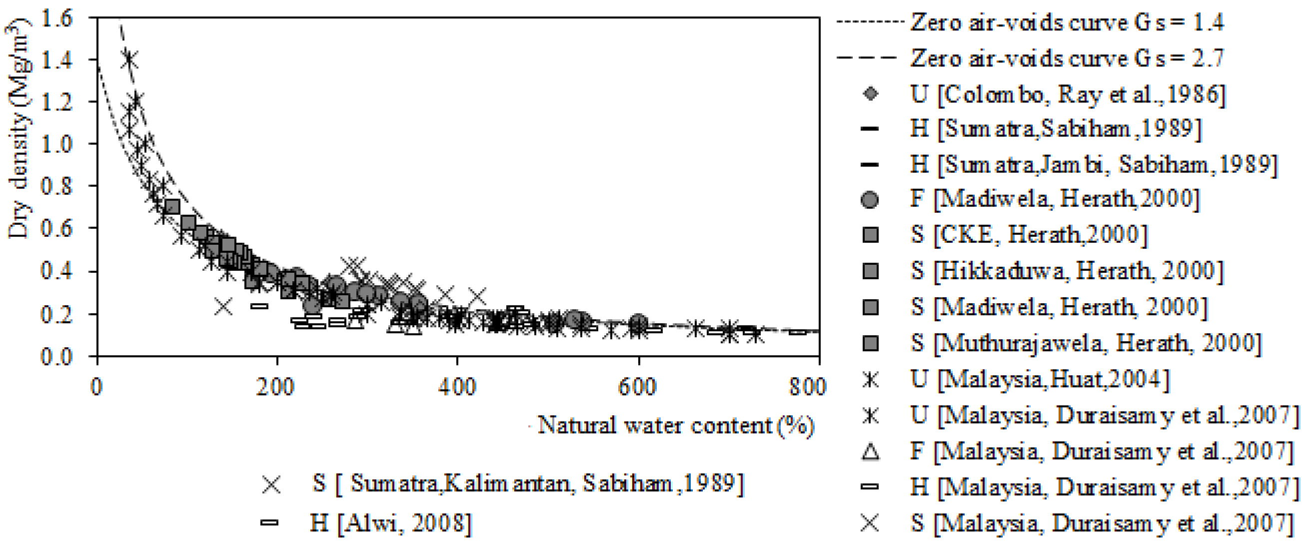

Fig. 1 Dry density versus natural water content for ucliassified (U), fibric (F), hemic (H) and sapric (S) peats.

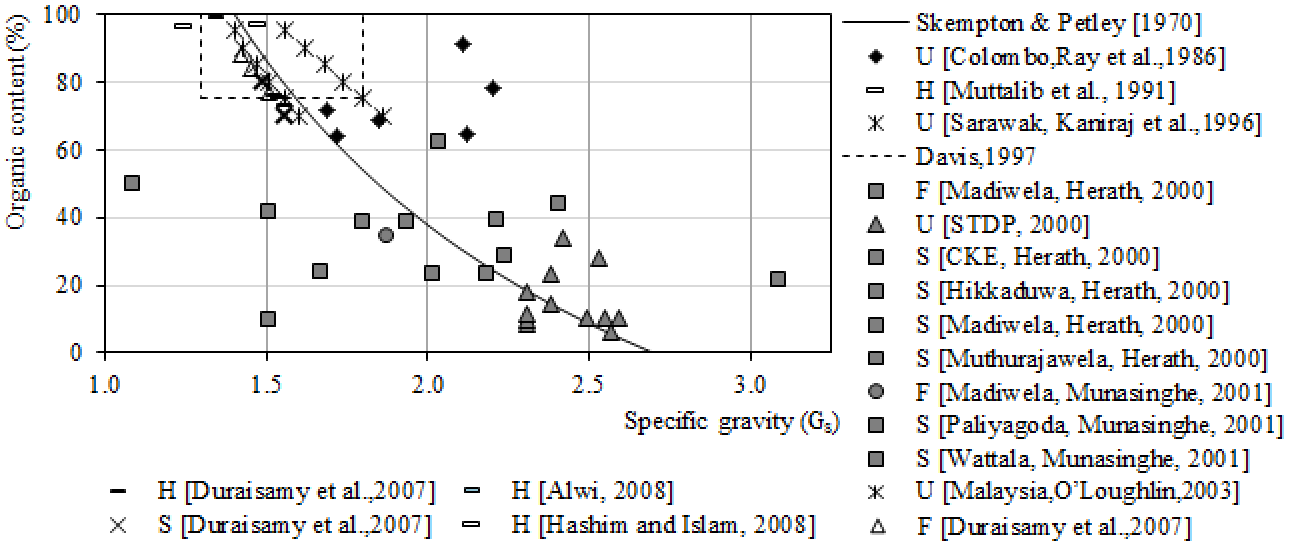

Fig. 2 Organic content versus specific gravity for fibric (F), hemic (H) and sapric (S) and uncliassified (U) peats.

Fig. 3 plots the variation of organic content with Natural Water Content for observed secondary data. MacFarlane & Rutka (1962) suggests an increase in Organic Content with Water Content (the solid line). Landva *et al.* (1983) identifies soil type based on organic content (i.e. organic soils: 0-60%, organic peats: 60-80% and peat: > 80%) and regions where data points are expected to plot (represented by dash-dot lines). Data do not seem to correlate well with the two measured parameters, even though they seem to follow trends proposed by researchers.

Physical properties of organic soils and peat are influenced by type and amount of organic matter present in the soil mix. Plant fibres undergo humification while inorganic fines penetrate deeper during this transformation. These changes influence absorption and adsorption of pore water to plant fibres and clayey fines, respectively. This influences the structure and mechanical properties. Classifying peats as fibric, hemic and sapric based on fibre content or based on the method described in Von-Post (1922) seems more reliable than depending on visual observation and feel.

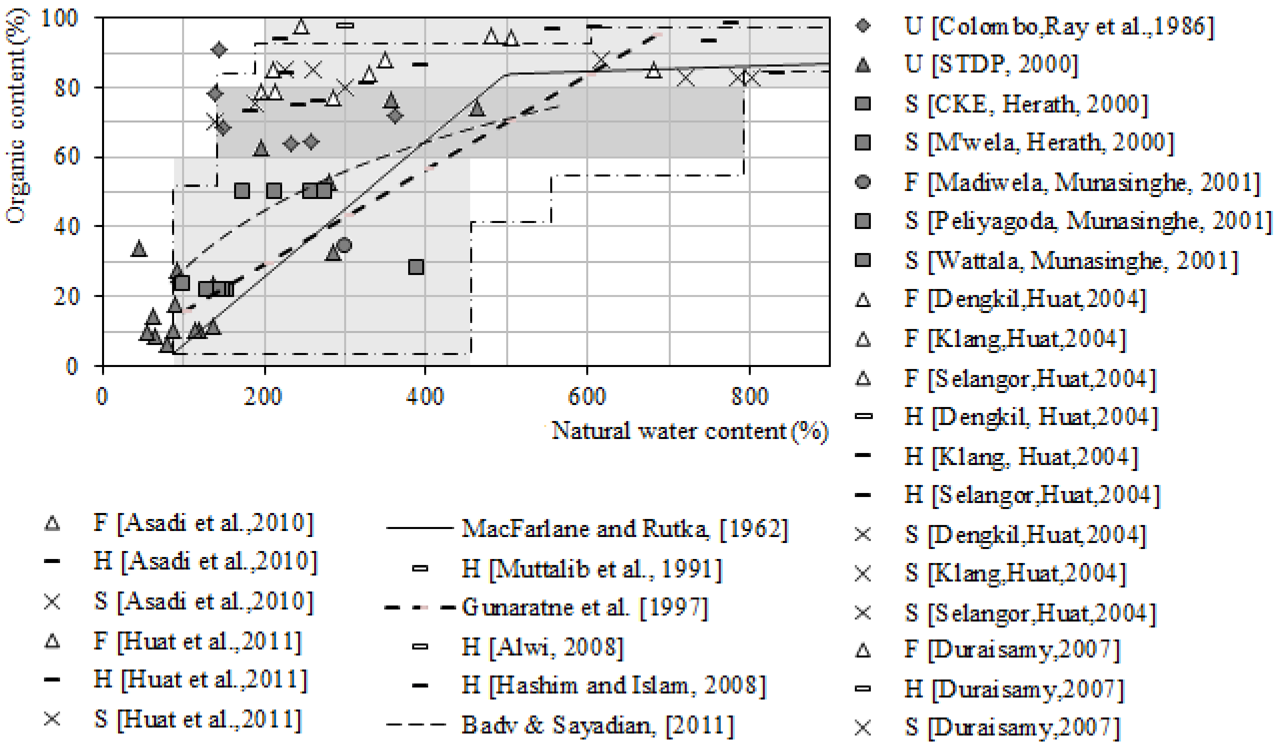

Fig. 3 Organic content versus natural water content for fibric (F), hemic (H), sapric (S) and uncliassified (U) peats.

4 CONCLUSIONS

Measurement of Natural Water Content, Organic Content, Fibre Content, Specific Gravity Dry Density and Degree of Saturation based on standardised test methods help confirm the accuracy of measured physical parameters.

REFERENCES

Alwi A. (2008). "Ground improvement on Malaysia peat soils using stabilized peat-column techniques." *PhD thesis*. University of Malaya.

Asadi, A., Huat, B.B.K., Hanafi, M., Mohamed, T., and Shariatmadari, N., (2010)., Physico-chemical sensitivities of tropical peat to electro-kinetic environment, Journal of Geosciences, 14(1):67-75.

ASTM Standard D1997 (2008). "Standard test method for laboratory determination of the fiber content of peat samples by dry mass." ASTM International, West Conshohocken, PA, 2007, DOI: 10.1520/D1997-91R08, <www.astm.org>.

ASTM Standard D2974, (2007). "Standard test methods for moisture, ash and organic matter of peat and other organic soils." ASTM International, West Conshohocken, PA, 2007, DOI: 10.1520/D2974-07A, <www.astm.org>.

ASTM Standard D4427, (2007). "Standard classification of peat samples by laboratory testing." ASTM International, West Conshohocken, PA, 2007, DOI: 10.1520/D4427-07, <www.astm.org>.

ASTM Standard D5715, (2006). "Standard test method for estimating the degree of humification of peat and other organic soils." (Visual/Manual Method), ASTM International, West Conshohocken, PA, 2007, DOI: 10.1520/D5715-00R06, <www.astm.org>.

Badv K., Sayadian T. 2011 Physical and geotechnical properties of Urmia peat.14th Pan-American Conference on Soil Mechanics and Geotechnical Engineering, Toronto, Canada, pp. 3-8.

BS1377-2, (1990). "Methods of test for soils for Civil Engineering purposes Classification tests." Copyright by the British Standards Institution, 2000.

Carlsten, P., (1988)., Peat geotechnical properties and up-to date methods for design and construction. Varia 215 Swedish, Geotechnical institute, Linkoping.

Chiet, K. T .P. (2010). "Geochemistric property of organic soil." *Master thesis*, University Teknologi Malaysia, pp. 31-32.

Cooray, P. G. (1984). "Introduction to the geology of Sri Lanka."

Davis, J.H., (1997)., The peat deposits of Florida their occurrence, development and uses. Florida Geological Survey, Geological Bulletin, 3.

Deboucha, S., Hashim, R., and Alwi, A., (2008)., Engineering properties of stabilized tropical peat soils. EJGE, 13(E).

Duraisamy, Y., Huat, B.B.K., and Aziz, A.A., (2007)., Engineering properties and compressibility behavior of tropical peat soil, American Journal of Applied Sciences, 4(10):768-773.

Gunaratne, M., Stinnette, P., Mullins, A.G., Kuo, C.L., and Echelberger, W.F., Jr., (1998)., Compressibility Relations for Peat and organic Soil, Journal of Testing and Evaluation, JTEVA, 26:1:1-9.

Hashim, R., and Islam, S., (2008)., A model study to determine engineering properties of peat soil and effect on strength after stabilization. European Journal of Scientific Research, .22(2):205-215.

Herath, H.M.S.D. (2000). "Use of Barden model for consolidation of Sri Lankan peaty soils." *M.Eng. Thesis*, University of Moratuwa, Moratuwa, Sri Lanka.

Huang, P., Patel, M., Santagata, M.C., Bobet, A., (2009). "Classification of organic soils." FHWA/IN/JTRP-2008/02. Joint transportation research program, Indiana DOT and Purdue University, West Lafayette, Indiana.

Huat, B.B.K (2004). "Organic and peat soil engineering." 1st Ed., University of Putra, Serdang, Malaysia.

Huat, B.B.K., Kazemian, S., Prasad, A. and Barghchi, M., (2011). "A study of the compressibility behaviour of peat stabilized by DMM." Lab Model and FE analysis, *Scientific Research and Essays* 6(1):196-204.

Kaniraj S.R., Joseph R.R. 1996 Geotechnical behavior of organic soils of North Sarawak. 4th International Conference on Soft Soil Engineering, Vancouver, Canada.

Kolay, P.K., Sii, H.Y., and Taib, S.N.L., (2011)., Tropical Peat Soil Stabilization using Class F Pond Ash from Coal Fired Power Plant. International Journal of Civil and Environmental Engineering 3:2.

Landva, A.O., Korpijaakko, E.O., and Pheeney, P.E., (1983). "Geotechnical classification of peats and organic soils." In: *Testing of peats and organic soils, ASTM STP 820* (eds. Jarrett P.M.), Philadelphia, PA, pp. 37-51.

MacFarlane I.C., Rutka A. 1962 An evaluation of pavement performance over muskeg in Northern Ontario, Highway Research Board, Bulletin 316:32-43.

Munasinghe, M.G.S. (2001). "Methods for improvement of engineering properties of peat a comparative study." *M.Eng Thesis*, University of Moratuwa, Sri Lanka.

Mutalib A.A., Lim J.S. Wang M.H. Koonvai L. 1991 Characterization,distribution and utilization of peat in Malaysia. Proceeding of International Symposium on Tropical Peatland, Kuching, Malaysia, pp. 7-16.

O'Loughlin C.D., Lehane B.M. 2003 A study of the link between composition and compressibility of peat and organic soils. Proceedings of 2nd International Conference on Advances in Soft Soil Engineering and Technology (ed. Huat*et al.*), Putrajaya, Malaysia,pp. 135-152.

Ray K., Senanayake K.S. Ganesamoorthy S. 1986 Some geotechnical properties of Colombo peats – A preliminary investigation. Asian regional symposium on geotechnical problems and practices in foundation engineering, Colombo. Sri Lanka February 25-27, pp. 44-50.

Sabiham, S., and Basuki, S., (1989)., Studies on peat in the coastal plains of Sumatra and Borneo II: the clay mineralogical composition of sediments in-coastal plains of Jambi and South Kalimantan. *Southeast Asian Studies,* 27(1):35–54.

Sabiham, S., (1990)., Studies on peat in the coastal plains of Sumatra and Borneo - Part-iv, A study of the floral composition of peat in coastal plains of Sumatra and Borneo. Southeast Asian Studies, Vol, 27, No. 4.

Skempton, A.W., and Petley, D.J., (1970)., Ignition loss and other properties of peats and clays from Avonmouth, King's Lynn and Cranberry Moss. *Geotechnique* 20(4):343-356.

STDP, (2000). "Southern transport development project soil investigation report." National Building Research Organisation, Sri Lanka.

Von Post, L., (1922). Sveriges Geologiska Undersoknings Torvinventering Och Nagre av Dess Hittills Vunna Resultat, Sr. Mosskulturfor. Tidskr , 1: pp. 1-27.