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FIELD HYDRAULIC CONDUCTIVITY OF SOME MALAYSIAN PEAT

by

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ABSTRACT

Field measurements on the hydraulic conductivity (K) of several developed and undeveloped peat soils using auger hole method were conducted. Developed deep peat has hydraulic conductivity values in the range of 6.32×10^{-4} to 4.44×10^{-3} (0.55 to 3.84 m/d). The studies also indicated that developed shallow peat has a conductivity value of 5.55×10^{-4} to 5.67×10^{-3} cm/s (0.48 to 4.90 m/d), while shallow undeveloped peat K value was in the range of 9.24×10^{-4} to 1.92×10^{-3} cm/s (0.80 to 1.66 m/d). The values of peat hydraulic conductivity's were found to be difficult to relate with their depth and development stages. This is because a number of uncertain variables such as the capillary potential, the existence of macro and micro-pores and their tortuosity are difficult to measure. These variables can definitely contribute to the K value of peat.

INTRODUCTION

Hydraulic conductivity of soil (K) has been recognized as one of the most important soil parameter in any drainage design and investigation. The K value of soil is needed for calculating open drain spacing using steady state equation. It is also a very useful design parameter in most of soil-water related studies such as solute movement study in the soil, groundwater investigation, capillary rise study of soil, irrigation application and many others.

In peatland reclamation project, drainage is the first activity to be employed to reduce water logging problem and hence to improve soil strength for mechanical operation. On developed or established peatland drainage plays a much more important role to accommodate a control of proper water table, subsidence rate, soil oxidation and subirrigation. Although the K value of peat has been investigated and been used extensively for the design of drainage project and other related reclamation works in the developed countries such as in the USA, Canada and EEC, little has been done in Malaysia. Realising that Malaysia has more than 2 million hectares of peatland that can potentially be developed for both agriculture and non-agriculture, the urgency of getting more information on the water behaviour of peat such as its hydraulic properties is therefore obvious. The distribution of the peat land in Malaysia is presented in *Table 1*.

Table 1: Distribution of peat in Malaysia

State	Area (Ha)
Sarawak	1 657 600
Johor	228 960
Pahang	219 561
Selangor	194 300
Perak	107 500
Terengganu	81 245
Sabah	86 000
Kelantan	7 400
Negeri Sembilan	6 300
Total	2 588 866

Source: Mutalib et al 1991

This paper reports the finding of field measurement of K value of peat soil located in several major peat areas in Semenanjong Malaysia.

MATERIAL AND METHODS

The K measurements were conducted in two locations, i.e. at Pontian in Johor and at Klang in Selangor, using the auger hole method. Peatland in Pontian is classified as a developed deep peat where the peat depth is about 3m from the ground surface. The area has been developed and planted with oil palm trees. Peatland in Klang is classified as a shallow for both developed and virgin peat. The peat depth found in Klang was about 60-80cm deep. Both peat sites in Pontian and Klang were located in the major peat areas found in Peninsular Malaysia.

The auger hole method is a common method used to determine saturated K of soil under the presence of shallow water table. Results from this method would represent the field K value with consideration of both lateral and horizontal flow of water in the soil. The detail procedure of this method is found in Amoozegar and Warrick (1986). The equipment setup of the auger test is shown in *Figure 2*. In this study auger hole of 5 cm radius (r) of different depths below water table (H) were used. The distance of the auger hole base to the impermeable layer or subsoil layer(S) is varied according to the geometrical dimension of the respective hole. The typical geometry of the auger hole is shown in *Figure 1*. The positions of the water table were determined manually using sounding measuring tape. In each of the auger holes, three running tests were carried out from which the K value was calculated by the following equation:

$$K = \frac{4.63\, r^2}{y\,(H + 20r)\,[2 - (y / H)]}\,(dy / dt) \qquad (1)$$

for the case where the auger hole is sufficiently above the impermeable layer ($S > 0.5$ H), while

$$K = \frac{4.17\, r^2}{y(H + 10r)\ [2 - (y / H)]}\,(dy / dt) \qquad (2)$$

for the case where the auger hole is extended to the impermeable layer (S=0)

where

r	=	radius of the hole in cm
H	=	depth of the groundwater in the hole in cm
y	=	different between the depth of groundwater and the depth of water in the hole in cm
dy/dt	=	rate of change of y with respect to time in cm/s
K	=	hydraulic conductivity in cm/s

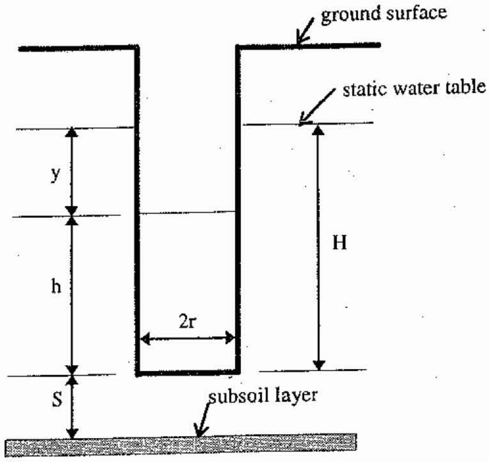

Figure 1. Geometry of an auger hole

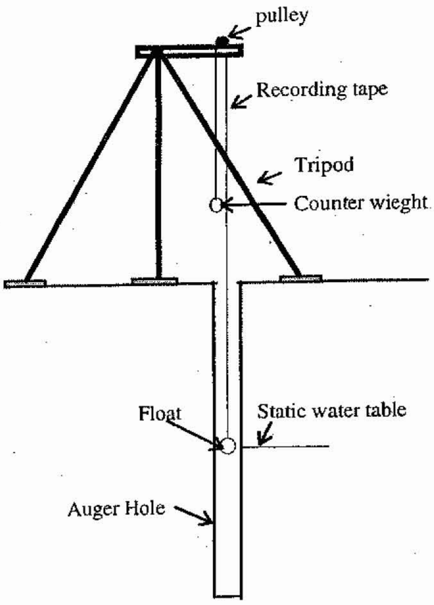

Figure 2. Equpment setup for the auger hole test

RESULTS AND DISCUSSION

The range of K value of peat obtained from the study is summarized in *Table 2*. At Pontian site, where the peat is classified as a deep peat, K values in the range of $4.44x10^{-3}$ to $6.32x10^{-3}$ cm/s were obtained. In the case of deep peat where the auger hole was sufficiently above the subsoil layer, *Equation 1* was used to compute the K value. The height of H recorded was between 65-90cm while the average S value was about 170 cm.

Table 2 : Measured hydraulic conductivity of peat from the tested sites

Site No.	Peat class, peat depth	Hydraulic conductivity, K, values x 10^{-3} cm/s				
		N	Mean	Min	Max	Std
1	developed, 3 m depth	27	5.49	4.44	6.32	6.47
2	developed, 60 - 80 cm	33	2.82	0.55	5.67	1.65
3	virgin, 1-2 m	9	1.37	0.92	1.92	0.40

Site number 1: Pontian Johor, Site number 2 and 3: Klang, Selangor
N = total number of test made, Std = standard deviation

On the developed shallow peat as found at Klang in Selangor, a quite similar K values to those of previously determined ones were obtained. Their values were in the range of $5.55x10^{-4}$ to $5.67x10^{-3}$ cm/s. Similarly for the virgin shallow peat at Klang site a K value of $9.24x10^{-4}$ to $1.92x10^{-3}$ cm/s was recorded. Because of very little data on tropical peat K values, it is very difficult to make comparison with others. However McLay et al (1992) indicated that the values of K reported for developed and undeveloped peat soil elsewhere range over several orders of magnitude which makes it very difficult to make comparison. Data on K value from non-tropical countries however are plenty. *Table 3* presents some of the K value of peat found from locations throughout the world.

Table 3 : Some of the field data on peat K values from various location

Location	K values cm/s	Reference
Minnesota, USA	Order of 10^{-3}	Chason and Seigel, 1986
Canada	Order of $10^{-4} – 10^{-3}$	Andriesse, 1988
Dun Mos, England	Order of $10^{-3} – 10^{-5}$	Rycroft et al, 1975
Zegvelderbroek, Netherland	Order of $10^{-3} – 10^{-4}$	Schothorst, 1982
Hauraki, New Zealand	Order of 10^{-4}	McLay et al, 1992

In terms of water transmissibility in peat, comparing our data with those obtained from the non-tropical countries as presented in *Table 3*, it can be said that Malaysian peat does not deviate significantly from other peat even though their physico-chemical properties may differ considerably. Lucas (1982) as quoted by Andriesse (1988), indicated that, in general, fibrous peats have moderate rate of water movement while decomposed peats often have low values.

K value and the degree of decomposition

The degree of decomposition of peat is a very important parameter in evaluation the structural and chemical changes that occur in peat during the development process and may directly affect the K value. Fibre content and bulk density are two measures used to estimate the degree of decomposition from peat material. Generally a higher decomposed peat has a higher bulk density value while lower fibre content has a lower K value. Andriesse (1988) classified that peat material found in Sarawak, Malaysia, with bulk densities of about 0.15 g/cm^3 and 0.13 g/cm^3 at depths 0-15 and 15-30cm respectively is considered as well decomposed peat. *Table 4* presents the bulk densities of the peat profile in the study site. It is noted that the first 20-30 cm soil profile for developed peat is more dense that the lower one. It has to be expected because the upper layer of peat is more exposed to development activities that may generate a faster decomposition process. A review given by Baden and Eggelsmann (1963), as quoted by Rycroft et al (1975), indicated that there was a marked decrease in K with increasing humification. In graphical presentation, a hyperbolic relationship between K and humification stage of peat was reported.

Table 4 : Measured bulk densities of the peat profile

Site		Bulk density (g/cm^3)					
	Depth (cm)	10	20	30	40	50	60
Pontian, developed		0.17	0.17	0.17	0.13	0.13	0.13
Klang, developed		0.29	0.13	0.11	0.10	0.09	0.43
Klang, virgin		0.15	0.16	0.13	0.10	0.07	0.08

CONCLUSION

The hydraulic conductivity value, K, of soil is the most single design parameter to be considered in any drainage design. It shows the drainability of soil and the transmissibility of water in the soil thus the effectiveness of the drainage works. Field experiments were conducted to determine K value of some Malaysian peat. It is found that under the presence of water table Malaysian peat has a K values in the order of 10^{-4} to 10^{-3} cm/s for both developed and virgin peat.

However in many civil engineering works where soil compaction and modification are normally required, the K value of that particular soil condition has to be measured first before the drainage status can be assessed.

REFERENCES

[1] Amoozegar, A. and Warrick,A.W. (1986). Hydraulic conductivity of saturated soils: Field methods of soil analysis. Part 1. 2nd edition Klute, A.(ed) SSSA Monograph No 9, p 735-770. USA: Madison

[2] Andriesse, J.P. (1988). Nature and management of tropical peat soils. FAO Bulletin No 59, pp 165. Italy: Rome

[3] Chason, D.B. and Diegel, D.I. (1986). Hydraulic conductivity and related physical properties of peat, lost peat, Northern Minnesota. Soil Science 42(2): 91-99

[4] McClay, C.D. , Allbrook, R.F. and Thompson, K. (1992). Effect of development and cultuvation on physical properties of peat soils in New Zealand. Geordema 54: 23-37

[5] Mutalib, A.A., Lim, J.S., Wong, M.H. and Koonvai, L. (1991. Characterization, distribution and utilization of peat in Malaysia. Proc.of the Int.Symp.on Tropical Peat. p 7-16. Aminuddin, B.Y. (ed). Kuching, Sarawak.

[6] Rycroft, D.W., William, D.J.A. and Ingram, A.P. (1975). The transmission of water throuhg peat. 1. Review. J.Ecol. 63: 535-556

[7] Schothorst, C.J. (1982). Drainage and behaviuor of peat soils. Proc on the symposium on peat lands below sea level. Bakker and Van den Berg (ed s). p 130-163. The Netherlands: Wagenningen