LABORATORY EVALUATION OF HORIZONTAL COEFFICIENT OF CONSOLIDATION. c_h OF FIBROUS PEAT SOIL

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To my beloved mother and father

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ABSTRACT

Encountered extensively in wetlands, fibrous peat is considered as problematic soil because it exhibits unusual compression behaviour. When a mass of fibrous peat soil with both vertical and horizontal drainage boundaries is subjected to a consolidation pressure, rate of excess pore water dissipation from the soil in the horizontal direction is higher than that in the vertical direction. The rates of excess pore water dissipation from the soil in the vertical and horizontal directions are measured by vertical and horizontal coefficient of consolidation (c_v and c_h) respectively. This project report presents laboratory findings on the consolidation behaviour of fibrous peat from Bahru village, Pontian, Johor with respect to one-dimensional vertical and radial consolidation. Results from hydraulic consolidation tests indicate that the c_h/c_v ratio of the soil is greater than 1 when the soil is subjected to consolidation pressure of 50 kPa, 100 kPa, and 200 kPa. This implies that the utilization of horizontal drain maybe suitable for soil improvement to accelerate the settlement of fibrous peat soil.

ABSTRAK

Ditemui secara meluas di kawasan paya, tanah gambut berfiber merupakan tanah bermasalah kerana ia mempunyai sifat pengukuhan yang luar biasa. Apabila sesuatu jisim tanah gambut berfiber yang terdedah kepada sistem saliran air secara menegak dan mendatar dikenakan tekanan, kadar lesapan air terlebih secara mendatar adalah lebih tinggi berbanding dengan kadar lesapan air terlebih secara menegak daripada tanah tersebut. Kadar lesapan air terlebih secara menegak dan mendatar daripada tanah tersebut ditentukan oleh kadar pengukuhan tanah secara menegak dan mendatar (c_v dan c_h) masing-masing. Laporan projek ini membincangkan hasil kajian di dalam makmal tentang sifat pengukuhan tanah secara menegak dan mendatar bagi sampel-sampel tanah gambut berfiber yang didapati dari kampung Bahru, Pontian, Johor. Hasil ujian pengukuhan hidraulik menunjukkan bahawa nisbah c_h/c_v untuk tanah tersebut adalah lebih daripada 1 apabila tanah itu dikenakan tekanan 50 kPa, 100 kPa, dan 200 kPa. Ini menandakan bahawa penggunaan sistem saliran air secara mendatar mungkin sesuai bagi mempercepatkan proses pemendapan tanah gambut berfiber.

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LIST OF SYMBOLS

A	-	Area of sample
AC	-	Ash content
B	-	Pore pressure parameter
c_c	-	Compression index
c_h	-	Horizontal coefficient of consolidation
c_r	-	Recompression index
c_v	-	Vertical coefficient of consolidation
c_α, $c_{\alpha 1}$	-	Coefficient of secondary compression
$c_{\alpha 2}$	-	Coefficient of tertiary compression
D	-	Diameter of sample
e	-	Void ratio
e_o	-	Initial void ratio
FC	-	Fiber content
G_s	-	Specific gravity
H, H_o	-	Initial thickness of consolidating soil layer
h	-	Head loss due to the height of water in the burette
i	-	Hydraulic gradient
k_h	-	Horizontal coefficient of permeability
k_{ho}	-	Initial horizontal coefficient of permeability
k_v	-	Vertical coefficient of permeability

k_{vo}	-	Initial vertical coefficient of permeability
L	-	Longest drainage path in consolidating soil layer; equal to half of H with top and bottom drainage, and equal to H with top drainage only
m	-	Secondary compression factor
m_v	-	Coefficient of volume compressibility
OC	-	Organic content
p	-	Consolidation pressure
p_o	-	Initial pressure
p_1	-	Inlet pressure
p_2	-	Outlet pressure
Q	-	Cumulative flow
q	-	Rate of flow
r	-	Radius of sample
T_r	-	Radial theoretical time factor
T_v	-	Vertical theoretical time factor
t	-	Time
t_s	-	Time to reach end of secondary compression
t_p	-	Time to reach end of primary consolidation
U_r	-	Average degree of consolidation due to radial drainage
U_v	-	Average degree of consolidation due to vertical drainage
u	-	Excess pore water pressure at any point and any time
u_o	-	Initial excess pore water pressure
w	-	Natural moisture content
ΔH_s	-	Change in height of soil layer due to secondary compression from time, t_1 to time, t_2

ΔH_t	-	Change in height of soil layer due to tertiary compression from time, t_3 to time, t_4
Δp	-	Pressure difference
ε_i	-	Instantaneous strain
ε_p	-	Primary strain
ε_s	-	Secondary strain
ε_t	-	Tertiary strain
γ_w	-	Unit weight of water
σ'_v	-	Effective vertical stress
δ	-	Total compression
δ_p	-	Primary consolidation settlement
δ_s	-	Secondary compression

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CHAPTER 1

INTRODUCTION

1.1 Background

When a load is applied to a saturated soft soil, it is initially carried by the pore water within a soil mass. The resulting pore water pressure, in excess of the hydrostatic water pressure is termed excess pore water pressure. As water dissipates from the soil pores, the applied load is gradually shifted from water to soil particles. The load transfer is accompanied by a volume change. This process is generally known as consolidation.

Depending on the packing of the soil mass and the drainage boundary condition, the dissipation of excess pore water would naturally take either vertical or horizontal flow path. The packing of the soil mass is usually governed by the soil fabric, the shape of soil particles, and other material content. The term *fabric* describes the geometrical arrangement of soil particles with respect to each other. Generally, the greater the range of particle sizes, the smaller the total volume of void spaces there will be.

Fibrous peat soil has many void spaces existing between the solid grains. Due to the irregular shape of individual particles, fibrous peat soil deposits are porous and the soil is considered a permeable material. Flow of water is occurring not only through the inner voids within organic particles but also the outer voids between organic particles and soil particles in the soil mass. Hence, for saturated fibrous peat soil, the actual path taken by pore water as it flows through void spaces is tortuous and erratic because of the random arrangement of the soil particles and organic coarse particles. In this case, velocity of pore water varies considerably with the flow direction.

The discussion in the preceding paragraph shows that the dissipation of excess pore water pressure would follow a flow path which is dependent on the packing of soil mass and the velocity of flow varies considerably with flow direction. Despite of this fact, conventional consolidation theory developed by Terzaghi (1925) considers that consolidation process takes place in vertical direction only. Up to recently, analysis of consolidation is very often based on this theory where horizontal consolidation of soil is ignored.

The importance of horizontal consolidation emerges with the development of soil stabilization method especially the use of preloading system with vertical drains. Vertical drains are used to provide horizontal drainage system in compressible soil layer so that water would flow radially from the soil into the vertical drains. With the use of surcharge and vertical drains, the consolidation process is accelerated by shortening the length of the drainage path for the pore water escaping from the soil layer. In this case, horizontal drainage flow plays an important role in the consolidation process. Thus, an economic design of vertical drains depends on a rational assessment of the horizontal coefficient of consolidation, c_h (Berry and Wilkinson, 1969).

Horizontal drainage becomes even more important in view of the fact that for most transported soils, horizontal coefficient of consolidation, c_h is normally greater than vertical coefficient of consolidation, c_v. Thus, the knowledge of horizontal coefficient of consolidation, c_h is very important in the selection of suitable soil stabilization method for soft organic soils and peat.

1.2 Aim of project

The project focuses on the study of horizontal coefficient of consolidation, c_h of fibrous peat soil and to compare the results with it's vertical coefficient of consolidation, c_v through laboratory investigation. This is important to emphasize the applicability of knowledge of horizontal coefficient of consolidation, c_h on the development of soil improvement method for construction on fibrous peat soil.

1.3 Objectives of study

In order to achieve the aim of the project, the study consists of the following objectives:

1. To study the compressibility characteristics of fibrous peat soil based on the consolidation curves obtained from hydraulic consolidation tests for vertical and horizontal drainage
2. To study the effect of secondary compression on the determination of vertical and horizontal coefficient of consolidation (c_v and c_h) of fibrous peat soil
3. To compare the vertical and horizontal coefficient of consolidation (c_v and c_h) of fibrous peat soil under a range of consolidation pressures
4. To compare the vertical and horizontal coefficient of permeability, (k_h and k_v) of fibrous peat soil under a consolidation pressure
5. To outline the use of knowledge of horizontal coefficient of consolidation, c_h on the development of soil improvement method for construction on fibrous peat soil

1.4 Scope of project

The project is concentrated on the laboratory measurement of consolidation parameters for fibrous peat soil found in Bahru village, Pontian, Johor with the primary focus on the comparison of vertical and horizontal coefficient of consolidation (c_v and c_h) measured by Rowe consolidometer in laboratory using 'identical' sample. Since creep deformation is significant in fibrous peat soil, laboratory investigation is also carried out to analyze the long term compression behaviour of the soil.

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