INFLUENCE OF POST-CYCLIC LOADING ON HEMIC PEAT

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This thesis is dedicated to my loving parents and to my whole family members for their unconditional love and support.

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ABSTRACT

Construction on peat soils has proven to be a challenging task to civil engineers since this soil type has a significant issue that arises from common problems construction of roads, housing and embankment construction with regard to peat are stability, settlements and major problems were encountered especially on deep peat. For many years, in road design as an example, static loading method was applied in road designed by considering soil shear strength through static load and do not take into account the vehicular dynamic loading and shear strength thereafter. This fact is related to the shear strength of peat soil after dynamically loaded. The aim of this research is to establish the post-cyclic behaviour of peat soil after cyclically loaded and to assess the effect of parameters changes on static and post-cyclic behaviour of peat soil. 200 specimens are tested, and prepared under consolidated undrained triaxial with effective stresses at 25kPa, 50 kPa, and 100 kPa with different location from Parit Nipah, Johor, Parit Sulong, Batu Pahat, Johor and Beaufort, Sabah. These specimens tested using GDS Enterprise Level Dynamic Triaxial Testing System (ELDYN) apparatus. Whereas, dynamic load tests are carried out in different frequencies to simulate the loading type such as vibration of machineries, wind, traffic load and earthquake in field from 1.0 Hz, 2.0 Hz and 3.0 Hz with 100 numbers of loading cycles. Post-cyclic monotonic shear strength results and then compared to the static monotonic results. Significantly, showed some vital changes that leads to the changes of stress-strain behaviour. Apparently, the result shows that post-cyclic shear strength decreases with the increase of frequencies. Prior to critical yield strain level, the peat specimen experience a significant deformation. The deformation of peats triggers changes in soil structures that causes reduction in stress-strain behaviour. Thus, it can be concluded that the stress-strain behaviour of peat soil decreased after 100 numbers of cyclic loading in post-cyclic test as compared to the static tests, and it decreased substantially when frequencies were applied. The post-cyclic specimen had a lower undrained parameters than did the static. Reduction of cohesion value in post-cylic compared to static almost 70% and reduction of friction angle is about 46.34%.

ABSTRAK

Pembinaan di tanah gambut telah terbukti menjadi tugas yang mencabar kepada jurutera awam kerana jenis tanah ini mempunyai masalah penting yang timbul daripada masalah umum pembinaan jalan, perumahan dan pembinaan tambak yang berkaitan dengan tanah gambut adalah kestabilan dan masalah utama yang dihadapi terutamanya gambut dalam adalah mendapan. Sebagai contoh, kaedah beban statik digunakan di jalan yang direka dengan mempertimbangkan kekuatan ricih tanah melalui beban statik dan tidak mengambil kira beban dinamik kenderaan dan kekuatan ricih selepas itu. Tujuan penyelidikan ini adalah untuk mewujudkan tingkah laku pasca-kitaran tanah gambut selepas dibebankan secara kitaran dan untuk menilai kesan perubahan parameter terhadap tingkah laku statik dan pasca-kitaran tanah gambut. 200 spesimen diuji, dan disediakan di bawah ujian tiga paksi yang tidak terkawal dengan tekanan berkesan pada 25kPa, 50 kPa dan 100 kPa dengan lokasi yang berbeza dari Parit Nipah, Johor, Parit Sulong, Batu Pahat, Johor dan Beaufort, Sabah. Spesimen-spesimen ini diuji dengan menggunakan sistem Pengujian *Triaxial Dynamic Triaxial Level Enterprise* (ELDYN). Sedangkan ujian beban dinamik dijalankan dalam frekuensi yang berbeza untuk mensimulasikan jenis pemuatan seperti getaran mesin, angin, beban lalu lintas dan gempa bumi di lapangan dari 1.0 Hz, 2.0 Hz dan 3.0 Hz dengan 100 bilangan kitaran beban. Hasil kekuatan ricih monotonik pasca-kitaran kemudian dibandingkan dengan keputusan monotonik statik. Secara ketara, menunjukkan beberapa perubahan penting yang membawa kepada perubahan tingkah laku. Keputusan menunjukkan bahawa kekuatan ricih pasca kitaran menurun dengan peningkatan frekuensi. Sebelum tahap ketegangan hasil kritikal, spesimen gambut mengalami ubah bentuk yang ketara. Oleh itu, dapat disimpulkan bahawa tingkah laku tekanan tegangan tanah gambut berkurangan selepas 100 bilangan beban kitaran dalam ujian pasca-kitaran dibandingkan dengan ujian statik, dan ia berkurangan dengan ketara apabila frekuensi digunakan. Spesimen pasca-kitaran mempunyai parameter yang lebih rendah daripada yang statik. Pengurangan kejelikatan dalam pasca selepas kitaran berbanding dengan statik hampir 70% dan pengurangan sudut geseran adalah kira-kira 46.34%.

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LIST OF SYMBOLS AND ABBREVIATIONS

BSpt	-	Beaufort, Sabah peat
PRpt	-	Penor peat
PNpt	-	Parit Nipah peat
POpt	-	Pontian peat
$\Delta\sigma'$	-	Effective pressure
CTX	-	Cyclic triaxial
CT	-	Computed Tomography
Cu	-	undrained shear strength
N	-	Number of cyclic
CIU	-	Consolidated isotropic undrained
CU	-	Consolidated Undrained
q	-	Deviator stress
u	-	Pore pressure
ε_a	-	Axial strain
Gs	-	Specific Gravity
LL	-	Liquid Limit
PL	-	Plastic Limit
r_{ur}	-	Pore Pressure Ratio
S_u	-	Normalized Undrained Shear Strength
Δu_{max}	-	Maximum excess pore water pressures
p’	-	Mean effective stress
UTHM	-	Universiti Tun Hussein Onn Malaysia
RECESS	-	Research Center for Soft Soil Malaysia

LIST OF PUBLICATION

CHAPTER 1

INTRODUCTION

1.1 Preamble

Malaysia, comprising the regions of Peninsular, Sabah and Sarawak, supports some of the most extensive tropical peatlands in the world. Tropical peat forest is found mainly in Southeast Asia (Phillips, 1998) it was estimated at about 20 million hectares, two-third of the total area of the world's tropical peat swamps (Kyuma, 1992). In Peninsular Malaysia, they are found in the coastal areas of the east and west coast, especially in the coastal areas of west Johore, Kuantan and Pekan district, the Rompin-Endau area, northwest Selangor and the Trans-Perak areas in the Perak Tengah and Hilir Perak district.

In Sarawak, peat occurs mainly between the lower stretches of the main river course (basin peat) and in poorly drained interior valleys (valley peats). They are found in the administrative division of Kuching, Samarahan, Sri Aman, Sibu, Sarikei, Bintulu, Miri, and Limbang. In Sabah, the organic soils are found on the coastal areas of the Klias peninsula, Krah swamps in Kota Belud, Sugut and Labuk centuries and Kinabatangan floodplains. The peat swamp forest is well represented in Borneo (Phillips, 1998). The Klias Peninsular contained the largest pieces of peat swamp forest at the northern end of Borneo. However, peat is in the category of problematic soil because it has low shear strength and high compressibility, which are not suitable for construction (Said and Taib, 2009). Peat soil is not suitable for the construction of embankment, highway, building or any other load bearing engineering structures due to the fact that it is having extreme low shear strength and bearing capacity. In natural state, peat consists of water and decomposed plant fragment with virtually no measurable strength (Munro, 2004).

Therefore, it is essential to find an alternative to improve the strength since nowadays lands are very expensive and very limited. Peat soil is not only soft, it is compressible to where this characteristic will lead to excessive settlement which is a very serious problem. Generally, peat soil is considered as a soft soil as it has high settlement value even under moderate loading condition.

Peat swamps cover about 2.7 million hectares in Malaysia. Nearly 63% of this area or about 1.7 million hectares are in the East Malaysian state of Sarawak according to Shenbaga and Huong (2009). Construction of road networks and other infrastructural facilities on the peat land fairly difficult and the maintenance issue after construction often rise up as major topic. Table 1.0 shows the proportionate distribution status of peat soil areas in Malaysia. Values in parentheses are the percentage proportion of total peat soil area and the data for peat swamp forest from the year 2000 (Wong, 2003). The total for moderately and severely disturbed peat land comprise Wong's classes of medium and low density peat swamp forest.

Table 1.1: Status of peat soil areas in Malaysia.
(Wetlands International – Malaysia. March 2010)

Regions	Total peat soil area (ha)	Undisturbed/ relatively undisturbed (ha)	Moderately Disturbed (ha)	Peat soils under infrastructure (ha)
Peninsular Malaysia	642, 857	226, 026 (35)	66, 353	15, 512
Sabah	116, 965	21, 000 (18)	27, 757	17, 767
Sarawak	1, 697, 847	223, 277 (13)	488, 357	nd
Total	2, 457, 730	470, 303 (19)	582, 528	33, 633 (1)

*nd - not defined

Construction on peat soil will experience significant short-term and long-term settlement with regard to stability and long-term settlements. In road design as an example, conventional method used where the vehicular traffic on the roadway, treated as static loads and the vehicular dynamic loading and shear strength thereafter that related to the earthquake, rail transit or vibrating machinery that called post-cyclic are not considered. Thus, Erken and Ulker (2008) has stated that, in laboratory investigation, the post-cyclic monotonic shear strengths were evaluated using various numbers of cycles of dynamic loading. This method was applied in this research which is the generation of shear strength referred closely.

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