



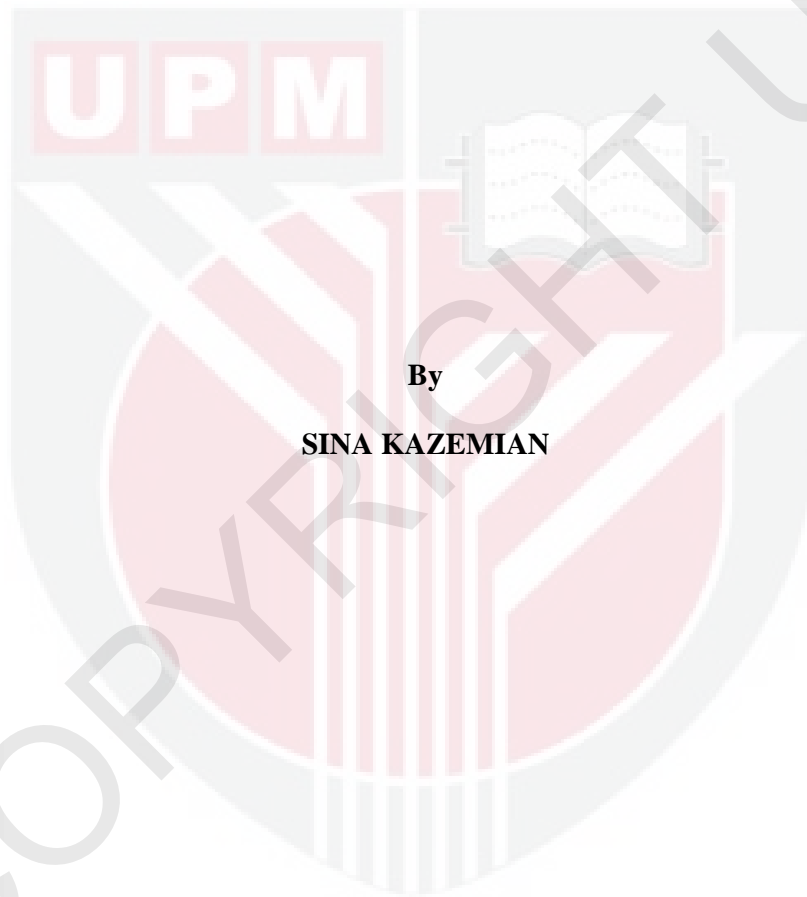
**UNIVERSITI PUTRA MALAYSIA**

***STABILIZATION OF PEAT BY CEMENT-SODIUM SILICATE  
GROUT USING INJECTION-VACUUM TECHNOLOGY***

**SINA KAZEMIAN**

**FK 2011 12**

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USING INJECTION-VACUUM TECHNOLOGY**

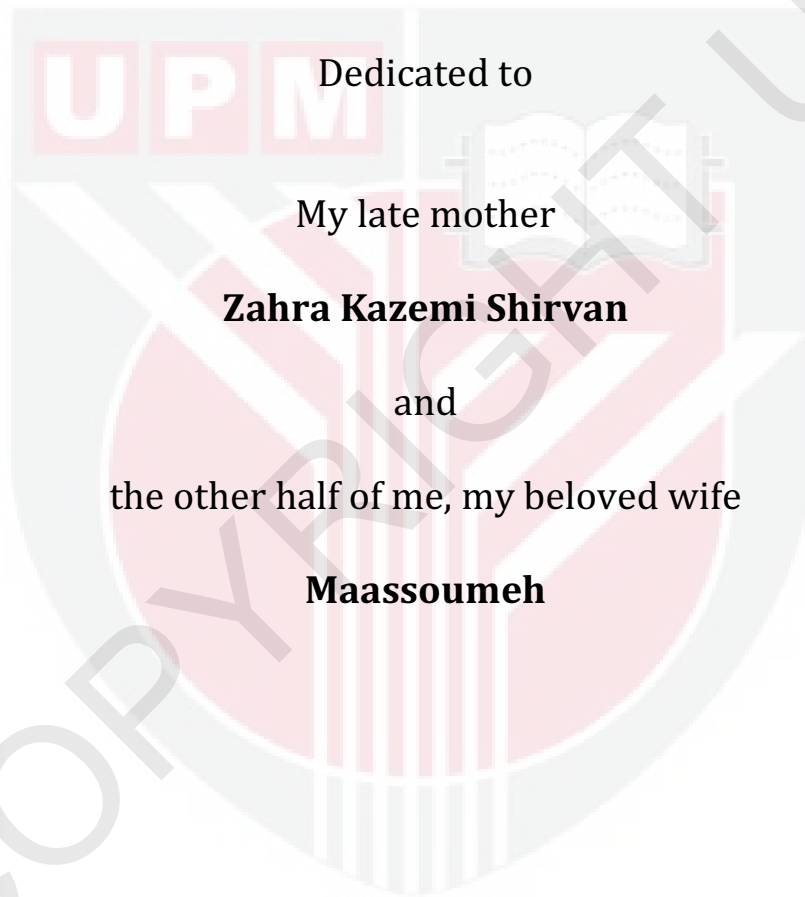


**By**

**SINA KAZEMIAN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**February 2011**



Dedicated to

My late mother

**Zahra Kazemi Shirvan**

and

the other half of me, my beloved wife

**Maassoumeh**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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By

**SINA KAZEMIAN**

**February 2011**

**Chairman : Professor Bujang Bin Kim Huat, PhD**

**Faculty : Engineering**

Peat is a naturally occurring unconsolidated material; with high organic matter, high moisture content, and extremely soft in consistency. Due to its high compressibility and low shear strength, such soils are geotechnically problematic. The objective of this study was to stabilize peat, collected from different locations in Kampung Jawa, Selangor (West Malaysia), by using a new binder and adopting a new approach for mixing peat and binder i.e., a combination of injection and vacuum method.

Grouting and chemical grouting technologies have grown over the last few decades. This study was carried out to investigate the influence of different amount of cement, sodium silicate, calcium chloride and kaolinite on the cement-sodium silicate grout with kaolinite for the stabilization of peat. The effectiveness of the grout was studied in terms of an increase in the shear strength of peat by performing vane shear test and

a decrease in the moisture content of the samples after curing time. Scanning electron microscopy (SEM) and energy dispersive X-ray spectrometer (EDX) tests were performed to evaluate the microstructural changes taking place due to the interaction of peat and grouts. Calcium chloride seemed to have different effects on the shear strength of peat. Experimental results showed that kaolinite has crucial role in increasing the shear strength of peat. It was observed that cement have favorable effects on the shear strength of peat and also lead to favorable changes in the microstructure. The rheology properties (viscosity, shrinkage, pH, and specific gravity) of the grouts were also examined.

The effect of peat characteristics [ $\text{CO}_2$ , Nitrogen (N), and pH] over time after treating with cement, cement-slag, and the new binder was evaluated. The mechanical properties of the samples were determined by performing unconfined compressive strength (UCS) test and the microstructure was studied by SEM. It was observed that the  $\text{CO}_2$  dissolved in peat water caused an increase in the depth of carbonation. The presence of an increasing amount of N had no tangible effect on cementation or pozzolanic reactions in the treated peats. Acidic media (pH) had a negative effect on cementation and pozzolanic reactions whereas the strength of peat treated with the new binder had no effect in the acidic media.

In the concluding part of this study, the effect of the new binder on peat was evaluated by using the specially designed and fabricated deep mixing method (DMM) equipment. In this method, the new binder was injected in peat and a constant flow was achieved by a vacuum applied through a series of interconnected

tubes installed in peat, which in turn were connected to a vacuum pump. The efficiency of this method was evaluated by studying the dispersion of grout. Due to the high permeability of peat, the binder could disperse homogeneously in peat with negative pressure. Finite element analysis was also carried out using the commercially available software (PLAXIS 2D v8.2) to study the effectiveness of the new DMM technique in comparison with conventional method i.e. injection method by using the results of the laboratory tests as input parameters.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai mementuhi keperluan untuk ijazah Doktor Falsafah.

**STABILISASI GAMBUT DENGAN NAT KIMIA DAN KOMBINASI  
TEKNOLOGI SUNTIKAN DAN VAKUM**

Oleh

**SINA KAZEMIAN**

**February 2011**

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Tanah gambut merupakan bahan alam yang biasanya terjadi tak terkukuh; dengan bahan organik tinggi, kadar air tinggi, dan sangat lembut dalam konsistensi. Oleh sebab kebolehmampatan tinggi dan kekuatan ricih yang rendah, tanah tersebut dikategorikan sebagai tanah bermasalah dalam geoteknik. Tujuan kajian ini adalah untuk menstabilkan tanah gambut, yang dikumpul dari lokasi yang berbeza di Kampung Jawa, Selangor (Malaysia Barat), dengan menggunakan pengikat baru dan mengadoptasi pendekatan baru untuk pencampuran tanah gambut dengan pengikat, iaitu satu kombinasi kaedah suntikan dan vakum.

Turapan dan teknologi turapan kimia telah berkembang selama beberapa dekad terakhir. Penelitian ini dilakukan untuk menyiasat pengaruh daripada perbezaan jumlah simen, natrium silikat, kalsium klorida dan kaolinit pada turap simen-

natrium silikat untuk stabilisasi tanah gambut. Keberkesanan turap dikaji dalam peningkatan kekuatan ricih daripada tanah gambut dengan melakukan ujian kekuatan ricih bilah dan penurunan pada kadar air daripada sampel selepas waktu pemeraman. Ujian mikrograf elektron imbasan (SEM) dan tenaga dispersi spektrometer sinar-X (EDX) dilakukan untuk menilai perubahan struktur mikro yang terjadi daripada interaksi antara tanah gambut dengan turap. Kalsium klorida dilihat mempunyai kesan yang berbeza pada kekuatan ricih tanah gambut. Keputusan kajian menunjukkan kaolinit mempunyai pengaruh yang penting dalam peningkatan kekuatan ricih tanah gambut. Diamati bahawa simen mempunyai kesan yang menguntungkan pada kekuatan ricih tanah gambut dan juga membawa perubahan yang menguntungkan dalam struktur mikro. Sifat reologi (kelikatan, penyusutan, pH, dan graviti) tentu turap juga diperiksakan.

Pengaruh daripada ciri-ciri tanah gambut [ $\text{CO}_2$ , Nitrogen(N), dan pH] selepas diperbaiki dengan simen, simen-jermang, dan pengikat baru dinilai dari masa ke masa. Sifat-sifat mekanik daripada sampel tersebut telah ditentukan dengan pelaksanaan ujian bebas kekuatan mampatan (UCS) dan struktur mikro tersebut dipelajari dengan SEM.  $\text{CO}_2$  diperhatikan terlarut dalam air tanah gambut dan kejadian tersebut menyebabkan peningkatan dalam pengkarbonatan. Kewujudan peningkatan dalam jumlah N tidak berpengaruh ketara terhadap penyimenan atau reaksi pozzolan dalam tanah gambut yang diperbaiki. Medium yang asid mempunyai pengaruh negatif terhadap penyimenan dan reaksi pozzolan sedangkan kekuatan tanah gambut yang diperbaiki dengan pengikat baru tidak berkesan dalam medium asid.



Pada bahagian penutup penyelidikan ini, pengaruh daripada pengikat baru kepada tanah gambut dinilai dengan menggunakan peralatan DMM yang khusus direka dan dibuat. Dalam kaedah ini, pengikat baru dipam ke dalam tanah gambut dan aliran malar dicapai oleh vakum diterapkan melalui siri tabung yang dipasang di tanah gambut, yang dihubungkan ke pam vakum. Kecekapan kaedah ini dinilai dengan mempelajari dispersi turap. Oleh kerana ketelapan tanah gambut yang tinggi, pengikat boleh dibubarkan dengan homogen dalam tanah gambut dengan tekanan negatif. Analisis unsur terhingga juga dilakukan dengan menggunakan perisian komersial yang sedia ada (PLAXIS 2D v8.2) untuk mempelajari keberkesanan teknik DMM baru melalui perbandingan dengan kaedah konvensional iaitu kaedah suntikan dengan menggunakan hasil ujian makmal.

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First of all, my utmost gratitude goes to Allah. An effort such as undertaking postgraduate studies for a Ph.D. needs the direct and indirect help of several people. This is an opportunity to remember their help and acknowledge their contribution to enlighten, educate and enable me to complete this piece of work.

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**Sina Kazemian**

**10 Dec. 2010**

I certify that a Thesis Examination Committee has met on Feb. 2011 to conduct the final examination of Sina Kazemian on his thesis entitled “Stabilization of Peat by Cement-Sodium Silicate Grout Using Injection-Vacuum Technology” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, or is not concurrently, submitted for any other degree at Universiti Putra Malaysia (UPM) or at any other institution.

**SINA KAZEMIAN**

Date: 18 February 2011



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