UNIVERSITI PUTRA MALAYSIA

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By

BEHZAD KALANTARI

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

(February 2010)

Dedicated to my daughter

"Kimia"

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

STABILIZATION OF TROPICAL FIBROUS PEAT USING ORDINARY PORTLAND CEMENT AND ADDITIVES

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BEHZAD KALANTARI

February 2010

Chairman: **Bujang B. K. Huat, PhD**

Faculty: **Engineering**

One of the most troublesome of soft and organic soils is fibrous peat due mainly to their high compressibility, and their low shear strength. In this study, fibrous peat has been stabilized with ordinary Portland cement (OPC), as well as OPC and five different types of additives namely; polypropylene fibers, steel fibers, silica fume, blast furnace slag, and fly ash.

Shallow and deep stabilizations have been studied to improve strengths, as well as to reduce compressibility of fibrous peat. For shallow stabilization of fibrous peat, strength evaluation tests (un-soaked and soaked) were unconfined compressive strength (UCS), and California bearing ratios (CBR), and for deep stabilizations were, consolidation undrained triaxial (CU), and Rowe cell consolidation tests.

Three types of curing technique have been studied for their effectiveness, as well as their ease of applications in the field. Curing techniques were; moist curing, moist curing with surcharge load, and air curing. Curing periods used were continued up to 180 days. Based on the results obtained from various curing techniques, air curing technique was chosen to be used for the entire shallow stabilization process. Optimum dosage rates for polypropylene fibers, silica fume, blast furnace slag, and fly ash as additives to be used in the research either in shallow or deep stabilization was determined through UCS tests.

In-order to examine the effectiveness of stabilization method used in the research in the field, fibrous peat with its field moisture contents has been used for stabilized samples. Also, in-order for shallow stabilization process to be more effective, stabilized samples were tested for their strength at their optimum moisture contents (OMC) found from compaction curves.

For deep stabilization of fibrous peat deposits, precast stabilized columns were developed and tested for their effects to improve shear strength parameters, as well as reducing compressibility of fibrous peat. The process of making precast stabilized peat columns included mixing fibrous peat with a specified amount of OPC, (with or without additives) at their optimum moisture contents. Each type of mixture was then compacted in to molds and left to dry. When drying was completed, they were taken out of their molds and inserted in the pre-drilled holes within the undisturbed fibrous peat, and tested for their strength as well as their deformation through CU triaxial, and Rowe cell consolidation tests respectively. Precast stabilized peat columns that were made of

hemic or sapric peats were also tried for their strengths and deformations evaluations as well. The columns were tested for their load bearing capacities in a larger scale test tank. Untreated fibrous peats as well as six different types of precast stabilized fibrous peat columns were tested in the test tank.

As the curing period were increased, more strength obtained by the stabilized peat samples. Among various types of additives used in this research, the most effective dosage rates for polypropylene fibers was found to be 0.15%, and for silica fume 10, and 5% when lower amount of OPC (< 25%) and higher amount of OPC (> 25%) were used respectively. As the amount of steel fibers increased from 2 to 4% in the OPC treated samples, the stabilized samples gained further strength. Joint uses of polypropylene and steel fibers, use of polypropylene fibers, and use of silica fume in OPC treated fibrous peat provide the highest strength during curing period respectively. Use of blast furnace slag and fly ash as chemically active additives to stabilize fibrous peat were positive but the degree of effectiveness was not as effective as when OPC alone was used.

Test results in this study indicate that, stabilization procedures used in either shallow (mass), or deep stabilization improve the load bearing capacities of untreated fibrous peat by increasing its load bearing capacity, as well as decreasing its deformations upon imposed loads.

Abstrak tesis yang dikemukakan kepada Senta Universti Putra Malaysia sebagi memenuhi keperluan untuk ijazah Doktor Falsafah.

PENGUKUHAN TANNAH GAMBUT TROPIKA BERGENTIAN DENGAN MENGGUNAKAN SIMEN PORTLAND DAN BAHAN TAMBAH

Oleh

BEHZAD KALANTARI

Februari 2010

Pengerusi: **Bujang B.K. Huat, PhD**

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Salah satu masalah utama bagi tanah lembut dan tanah organik adalah tanah gambut gentian yang disebabkan oleh kebolehmampatan yang tinggi dan kekuatan ricih yang rendah. Dalam kajian ini, tanah gambut gentian telah distabilkan dengan simen Potland biasa (OPC) serta lima bahan tambahan; iaitu gentian polipropilena, gentian keluli, wasap silika, sanga relau bagas dan abu cerobong.

Penstabil cetek dan dalam telah dikaji untuk membuktikan kekuatan seperti mengurangkan kebolehmampatan gambut gentian. Bagi penstabil cetek tanah gambut gentian, ujian penilaian kekuatan (rendaman dan tidak direndam) adalah seperti kekuatan mampatan tidak terhad (UCS) dan nisbah galas California (CBR), manakala kestabilan dalam pula adalah ujian pengukuhan tak bersalir tiga paksi (CU) dan ujian pengukuhan Sel Rowe.

Tiga jenis teknik pemulihan yang telah diuji keberkesanannya adalah sangat mudah diaplikasikan di lapangan. Teknik pemulihan tersebut adalah pemulihan kelembapan, pemulihan kelembapan dengan lebihan beban dan pemulihan udara. Tempoh pemulihan yang dilaksanakan dilanjutkan sehingga 180 hari. Berdasarkan keputusan yang diperolehi daripada pelbagai teknik pemulihan, teknik pemulihan udara dipilih untuk digunakan pada keseluruhan proses penstabilan cetek. Pada kadar sukatan optimum, bahan tambah iaitu gentian polipropilena, wasap silika, sanga relau bergas dan abu cerobong digunakan untuk penstabilan cetek atau dalam melalui ujian percubaan dan kesilapan UCS.

Bagi menguji keberkesanan kaedah penstabilan yang digunakan dan kajian di lapangan, gambut gentian beserta kandungan kelembapan asalnya digunakan untuk menstabilkan bahan contoh. Begitu juga untuk proses penstabilan cetek yang lebih berkesan, contoh bahan penstabil diuji kekuatannya pada tahap kandungan kelembapan optimum (OMC) yang diperoleh dari mampatan kelok.

Sementara itu, kaedah tiang penstabil pratuang dihasilkan dan diuji kesannya untuk membuktikan parameter kekuatan ricih juga mengurangkan kebolehmampatan tanah gambut gentian. Proses pembuatan tiang penstabil gambut pratuang termasuk campuran gambut dengan OPC telah yang telah ditetapkan jumlahnya (ditambah bahan tambah atau tanpa bahan tambah) pada kandungan kelembapan yang optimum. Setiap campuran dimampatkan dalam molds dan dibiarkan sehingga kering. Apabila proses pengeringan lengkap, campuran diambil daripada mold dan dimasukkan ke dalam lubang separuh

tebuk di dalam tanah gambut gentian tak terganggu dan diuji kekuatannya melalui ujian pengukuhan tak bersalir tiga paksi (CU) dan ujian pengukuhan Sel Rowe.

Tiang tersebut diuji keupayaan galas bebannya di dalam tangki ujian ukuran besar. Tanah gambut gentian yang tak terurai beserta enam jenis tiang penstabil gambut gentian pratuang juga diuji di dalam tangki ujian.

Keputusan ujian menunjukkan, proses penstabilan yang telah digunakan sama ada bagi penstabil cetek atau dalam telah memperbaiki bearing beban muatan tanah gambut gentian tak terhurai. Penggunaan gentian polipropilena, penggunaan bersama polipropilena dan gentian keluli, atau wasap silica memberi kekuatan yang lebih. Antara lima jenis bahan tambahan tersebut, sanga relau bagas dan abu cerobong adalah paling sedikit berkesan.

Apabila tempoh kuring meningkat, kekuatan sampel tanah gambut yang distabilkan juga bertambah. Diantara semua jenis bahan tambah yang digunakan, kadar dos efektif bagi gentian polypropylene ialah 0.15% dan gentian silica 10% (kandungan OPC < 25%) atau 5% (kandungan OPC > 25%). Apabila kandungan gentian besi meningkat dari 2% ke 4% dalam sampel OPC terawat, sampel yang distabilkan akan peroleh lebih kekuatan. Kombinasi penggunaan gentian polipropilena dan gentian keluli, penggunaan gentian polipropilena dan penggunaan wasap silica di dalam tanah gambut terawat memberikan kekuatan yang tinggi semasa tempoh kuring. Penggunaan sanga relau bagas dan abu cerobong sebagai bahan tambah untuk menstabilkan tanah gambut adalah positif, akan tetapi darjah keberkesanannya tidaklah begitu baik.

Keputusan dari kajian ini menunjukkan, prosedur penstabilan yang digunakan sama ada bagi penstabilan cetek atau dalam mampu memperbaiki keupayaan galas tanah gambut tak terawat dengan meningkatkan keupayaan galas beban dan mengurangkan perubahan bentuk terhadap beban yang dikenakan.

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I certify that a Thesis Examination Committee has met on 5th February 2010 to conduct the final examination of Behzad Kalantari on his PhD thesis entitled "Stabilization of tropical fibrous peat, using ordinary Portland cement and additives" in accordance with the Universities and University College 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 Degree of Doctor of Philosophy.

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This thesis was submitted to the Senate Universiti Putra Malaysia (UPM) and has been accepted as fulfilment of the requirement for the degree of Doctor of philosophy (PhD). The members of the supervisory committee were as follows:

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Date: 8 April, 2010

DECLARATION

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

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BEHZAD KALANTARI

Date:

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