UNIVERSITI TEKNOLOGI MARA

CHEMICAL MODIFIED SAND SOIL USING POLYURETHANE (PU) FOR FOUNDATION IMPROVEMENT

NORBAYA BT HAJI SIDEK

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor Of Philosophy
(Civil Engineering)

Faculty Of Civil Engineering

January 2018

CONFIRMATION BY PANEL OF EXAMINERS

I certify that a panel of examiners has met on 24th November, 2017 to conduct the final examination of Norbaya Bt Haji Sidek on her **Doctor of Philosophy** thesis entitled "Chemical Modified Sand Soil Using Polyurethane (PU) For Foundation Improvement" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of Examiners is as follows:

Datin Ir. Zainab Bt Mohamed, PhD
Professor
Faculty of Civil Engineering
Universiti Teknologi MARA, Malaysia
(Chairperson)

Mazidah Binti Mukri, PhD
Senior Lecturer
Faculty of Civil Engineering
Universiti Teknologi MARA, Malaysia
(Internal Examiner)

Ir. Ramli Bin Nazir, PhD
Professor
Faculty of Civil Engineering
Universiti Teknologi Malaysia, Malaysia
(External Examiner)

Stephen Fityus, PhD
Professor
Centre for Geotechnical and Materials Modelling,
University of Newcastle, Australia
(International Examiner)

PROF SR DR HJ ABDUL HADI

HJ NAWAWI

Dean
Institute of Graduates Studies
Universiti Teknologi MARA
Date: 22 January 2018

AUTHOR'S DECLARATION

I declare that the work in this thesis is carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Norbaya Binti Haji Sidek
Student I.D. No.	:	2012273766
Programme	:	Doctor of Philosophy (Civil Engineering) -EC990
Faculty	:	Civil Engineering
Thesis Title	:	Chemical Modified Sand Soil Using Polyurethane (PU) For Foundation Improvement
Signature of Student	:	.....
Date	:	January 2018

ABSTRACT

Roads are important assets to a country and need a maintenance programme to ensure that the longest life is achieved. Roads have to be cared for and without any maintenances they will lose their intrinsic value. Construction of road pavement generates instability to the naturally subsoil which encounters numerous engineering problems such as settlement, depression, sinkhole and faulting of subsoil. Conventional method of soil remediation work in subsoil such as crack sealing, patching potholes, overlays and grouting technique provide short term solutions to address those symptoms, but not underlying problem. This study permits a novel technique to solve the subsoil foundation problem precisely in sand that exists in the current pavement designs using Polyurethane (PU) grout. PU is a chemical substance that normally used in polymer industries for instance resilience foam seating, rigid foam insulation panels and microcellular foam seals. The study includes four main parts: the first part aims to optimize the composition of PU by varying the mixture of polyol and isocynate under Unconfined Compression Test (UCT). Two hundred fifty two (252) PU samples with different ratio of PU are tested using UCT and the ideal composition of polyurethane foam with 1:1 ratio is obtained. In addition, an empirical model is derived through the compressive strength of PU foam using numerical analysis (ABAQUS). Based on numerical analysis, the average difference between experimental and numerical results ranging between 3 to 5 % which is satisfactorily. The second part addresses the physical and mechanical properties of treated sand with different percentages of PU. The compressive strength of treated sands are determined by conducting the UCT in accordance with BS 1377: 1990: Methods of Test for Soils for Civil Engineering Purposes: Part 7–Shear Strength Test. The stress-strain relationship of the treated sand is presented. The third phase is to conduct a field evaluation on plate bearing test and mackintosh probe to evaluate the bearing pressure in treated soil. It is found that the performance of the bearing pressure in treated soil has improved almost twice as compared to natural soil. In addition, a great reduction in void ratio and swelling index are found in the treated soil as compared to the natural soil. The last part focuses on a laboratory sample sand model to determine and evaluate the performance of polyurethane in treated sand. Conclusively, this study has presented the reliable results and predictions on behavior of treated sand with PU. This study able to address as alternative remediation method whereby its shorten the time of implementation and eliminate the excavation works. In conclusion, this study is proven beneficial for a better environment and can be used as benchmark of ground improvement technique. This study can contribute to the improvement of pavement rehabilitation and ground modification works in Malaysia.

TABLE OF CONTENTS