CORRELATION OF ENGINEERING CHARACTERISTICS OF MARINE CLAY FROM CENTRAL WEST COAST OF MALAYSIA

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil – Geotechnics)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

NOVEMBER 2007

DEDICATION

For my dearest mum and dad

Ramamoorthy & Apiamah

My success is your gift and prayers…

To my beloved husband

Renganathan

Your support and courage is my success…

and to my children

Hemantkumar & Tirishaanth

To my sisters, brother and relations

Everyone and friends whom are the best…

Success of mine is success of all of yours…

ACKNOWLEDGEMENT

I would like to thank God for giving me enough knowledge and time to conclude this program. I would also like to express my sincere thanks to my lecturer cum supervisor Prof. Madya Dr. Aminaton bt Marto, for the time she has allocated and all her guidance in preparation of this thesis. I wish to acknowledge the encouragement and advice I have received from her.

All the help rendered by the lectures and friends are appreciated. My special thanks to Mr Balakrishnan from GCU Geotechnics Sdn Bhd and Mr Ismail Abd. Rahman from Jabatan Kerja Raya, Malaysia for being helpful to me in gathering all the data and information related to this study. The time spent in doing this program gives memories that would last forever.

I am grateful to my beloved husband whom always encourages and supports me in my studies. Thanks for his care and love.

ABSTRACT

Quaternary erosion induced by climatic and sea level changes have produced widespread and thick deposits of soft marine clays in the coastal areas and major river valleys on the west coast of Malaysia. These areas of poor ground condition have been attracting increasing attention as land reclamation, strengthening of the reclaimed ground and coastal development projects, which have gained momentum in recent years. A study was conducted mainly to establish the geotechnical properties of marine clay from the central west coast region of Malaysia. The data's are obtained from four completed project sites comprising about 48 nos. of borehole. Correlations and geotechnical parameters are established to assist in the preliminary design process. From the study, it can be concluded that the marine clay from central west coast of Malaysia have high natural moisture content (w) which reaches 125%. Other physical parameters such as liquid limit (w_L) is between 50 to 125%, unit weight (γ) is in the range of 13 to 18 kN/m^3 and the average specific gravity (G_s) is 2.6. The strength parameters are also established; the effective friction angle (ϕ') is in the range of 15 to 25^o and the effective cohesion (c') is 2 to 20 kPa. The undrained shear strength obtained from vane shear test shows that the value is ranging from 4 to 65 kPa. Based on the oedometer test, the compressibility parameters have been produced, such as range of void ratio (e_o) is 1.5 to 3.0. Range of compressibility index obtained is 0.2 to 1.5 and for compression ratio (CR) is 0.1 to 0.4. The pre consolidation pressure (P_c') is 20 to 125 kPa and for coefficient of volume compressibility (m_v) is 0.25 to 1.5m^2/MN is also have been established. From the correlation derived, it shows that the undrained shear strength decreases with the increase in natural moisture content and liquidity index. The same trend also found with the effective friction angle where it is decreases with the increase in plasticity index. The correlation for effective cohesion is increases with the increase in liquidity index. From the correlation derived on compressibility parameters, it shows that compressibility index increases with natural moisture content, plasticity index, liquid limit and void ratio, whereas compression ratio is also increases with void ratio and liquid limit.

ABSTRAK

Hakisan pantai banyak berlaku di pesisiran pantai Malaysia. Ini disebabkan oleh pasang surut air, angin, ombak, arus air, suhu dan juga perubahan cuaca, dimana proses geologinya telah berlaku sejak dahulu lagi. Dengan ini, mendapan kuartenari yang tebal banyak terdapat di tepi-tepi pantai di bahagian dataran barat Malaysia. Pada dekad kebelakangan ini, disebabkan perkembangan teknologi yang pesat dan pertambahan penduduk yang cepat menyebabkan masalah kekurangan tanah mula dirasai di merata tempat. Masalah ini, menyebabkan kebanyakan projek utama yang dilaksanakan mula tertumpu di kawasan mendapan tanah liat. Walau bagaimanapun, pembinaan bangunan di atas kawasan tanah liat lembut ini sering mengalami masalah kestabilan dan enapan. Oleh yang demikian, adalah sangat penting untuk para jurutera awam untuk membuat kajian lanjutan terhadap tanah liat lembut tersebut untuk mengetahui ciri-cirinya. Data untuk kajian ini diperolehi dari empat lokasi projek yang telah siap dengan 48 bilangan lubang jara. Korelasi serta parameter geoteknik bagi tanah liat lembut telah diterbitkan sebagai rujukan untuk digunakan semasa membuat rekabentuk awal. Hasil kajian terhadap tanah liat lembut dari bahagian pantai barat Malaysia, didapati kandungan lembapan (w) yang tinggi diperolehi iaitu mencapai sehingga 125%. Beberapa parameter lain yang penting juga diperolehi iaitu, nilai had cecair (w_L) adalah di antara 50 hingga 125%, berat unit (γ) adalah di antara 13 hingga 18 kN/m^3 dan nilai purata bagi graviti tentu (G_s) adalah 2.6. Bagi penentuan kekuatan ricih, nilai sudut rintangan ricih berkesan (ϕ') dan nilai kejelikitan berkesan (c') adalah masing-masing berjulat di antara 15–25^o dan 2-20 kPa. Bagi nilai kekuatan ricih tak terganggu adalah di antara 4–65 kPa. Berdasarkan keputusan ujian odometer, parameter tanah seperti kebolehmampatan juga diperolehi. Nilai nisbah lompang asal (e_o) adalah di antara 1.5–3.0, indeks mampatan (C_c) adalah di antara 0.2–1.5 dan nilai nisbah mampatan (CR) adalah di antara 0.1–0.4. Nilai tekanan pra pengukuhan (P_c') dan pekali kebolehmampatan isipadu (m_v) yang diperolehi adalah masing-masing berjulat di antara di antara 20–125 kPa dan 0.25- 1.5m^2/MN. Dari korelasi yang diterbitkan, didapati kekuatan ricih tak terganggu berkurangan apabila kandungan lembapan semulajadi dan indeks kecairan meningkat. Manakala sudut geseran dalam berkesan juga berkurangan apabila indeks keplastikan meningkat. Korelasi yang diterbitkan di antara kejelikatan berkesan dan indeks kecairan pula menunjukkan kejelikatan berkesan bertambah apabila indeks kecairan meningkat. Bagi korelasi yang diterbitkan di atas parameter kebolehmampatan, didapati indeks mampatan meningkat apabila kandugan lembapan semulajadi, indeks keplastikan, had cecair dan nilai nisbah lompang asal meningkat, manakala nisbah mampatan juga meningkat apabila had cecair dan nisbah lompang asal meningkat.

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C_c	-	Compression index
CR	-	Compression ratio
c	-	Cohesion
c'	-	Effective cohesion
d	-	Diameter
e_o	-	Initial void ratio
G_s	-	Specific gravity
h	-	Height
I_L	-	Liquidity index
I_p	-	Plasticity index
m_v	-	Coefficient of volume compressibility
P'_c	-	Pre consolidation pressure
S_c	-	Consolidation settlement
S_u	-	Undrained shear strength
T	-	Torque
w	-	Natural moisture content
w_L	-	Liquid limit
w_p	-	Plastic limit
ϕ'	-	Effective frictional angle
γ	-	Unit weight
σ'_v	-	Effective overburden pressure

CHAPTER 1

INTRODUCTION

1.1 Background of Problem

In many cases, clay deposit layers which are widely distributed over the seaside show various aspects according to the type of base rock or distribution characteristics. Especially very soft ground composed of marine clayey deposit which is mostly distributed over the west and south east coast part of Malaysia, is considerably affected by the numerous factors such as components of the deposit, particle size distribution, the shape of the particles, properties of the absorbed ion and pore water, tidal current, temperature and so on (Yoon *et al*, 2006). Figure 1.1 shows the general location of the deposits. Moreover, after the deposit process, geotechnical characteristics of the ground show great complexity by its history, the variation of pore water, leaching process, gas generation and many more.

Recently in Malaysia, the increasing attention on coastal development projects have gained momentum as it is expected for the utilization of the soft ground to be increased hereafter. Therefore, technical backgrounds for the effective utilization of soft ground are to be highly demanded. For these reasons, as a fundamental stage, the collected data have been analyzed to establish various correlation and design parameters. The locations of the project sites considered are superimposed on Figure 1.1 and Figure 1.2.

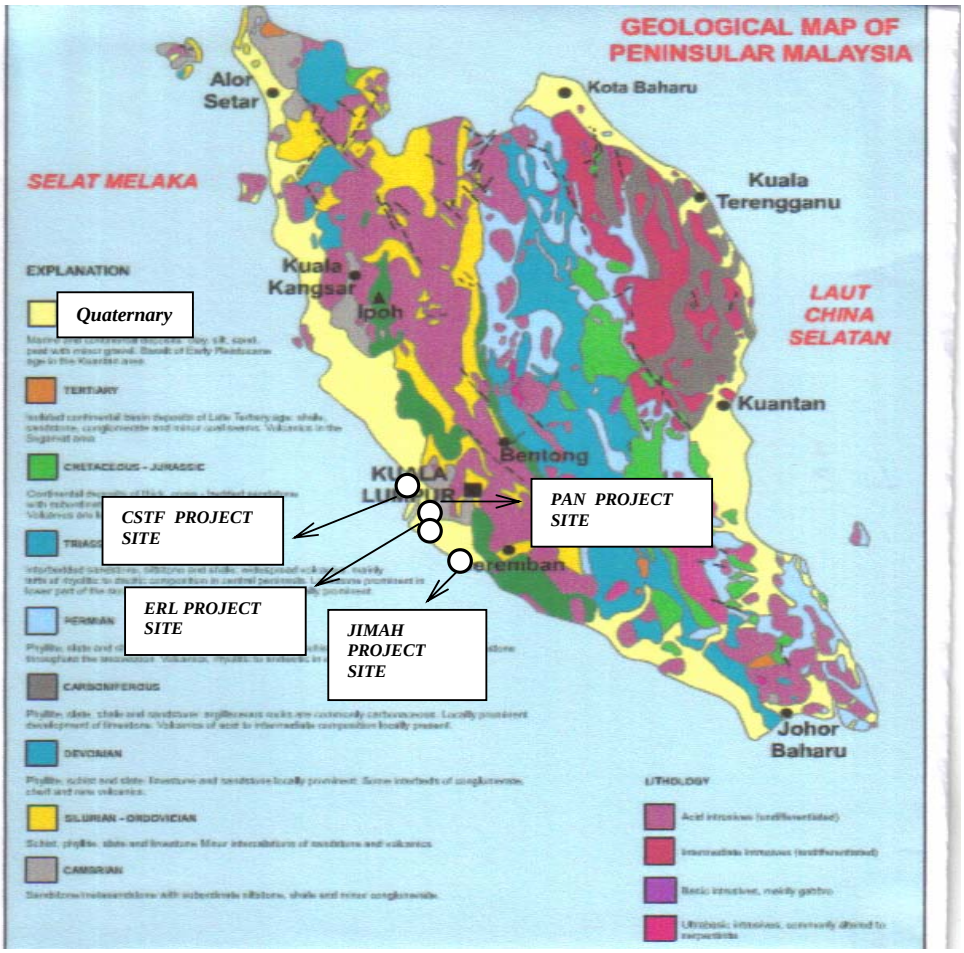

Figure 1.1 Quaternary deposits at Peninsular Malaysia and the locations of the site (Geological Map of Peninsular Malaysia, 8th Edition, 1985)

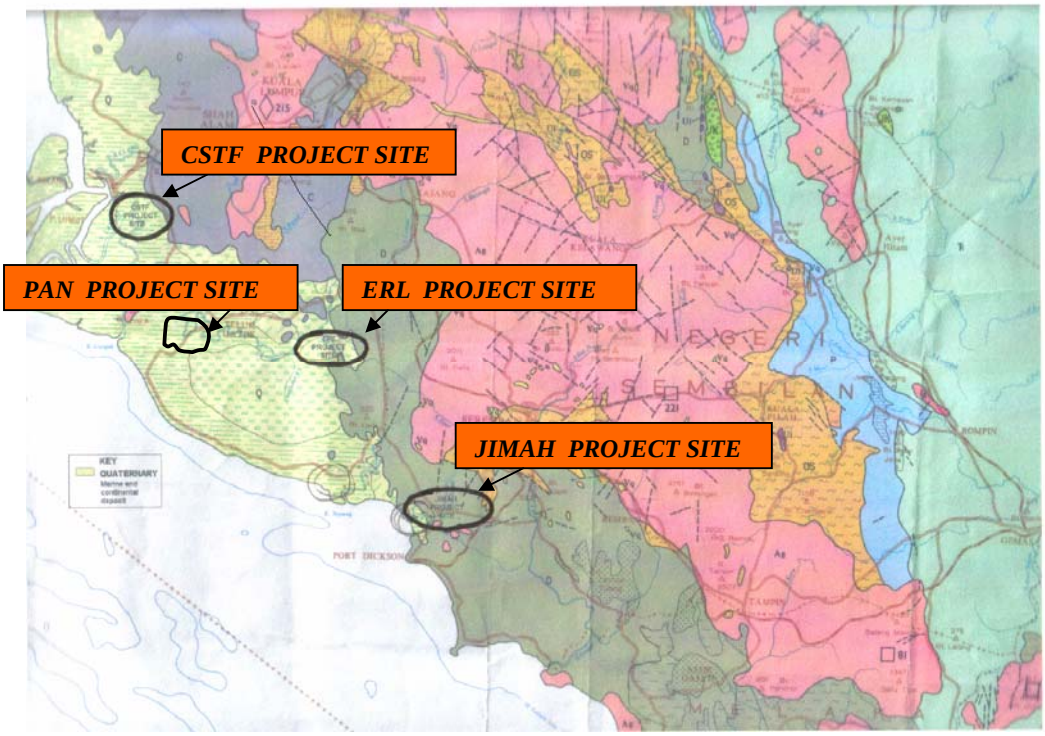

Figure 1.2 Project site locations: Central Sludge Treatment Facility (CSTF) in South Klang Valley, Express Rail Link (ERL) in Sungai Labu Sepang, Jimah Power Station (JIMAH) in Port Dickson and Pusat Angkasa Negara in Mukim Kelanang, Daerah Kuala Langat.

1.2 Statement of Problem

The solutions of many geotechnical issues on construction are very much directly or indirectly related to the understanding of the problematic soil. Marine clay is one of the problematic soils which are commonly found along the coastal area of west Malaysia. Thus, it is very important to understand the characteristic and behaviour of marine clays. However, in many situations geotechnical engineers are often expected to provide prediction of the subsoil behaviour during and after construction. To provide a satisfactory prediction, geological knowledge and

understanding of subsoil are essential in order to use the reliable correlations developed by the researcher based on the existing data.

This master project attempts to compile information's obtained from site investigation works for better understanding of the marine clay properties of this area. In addition, as geotechnical engineers are often expected to provide their estimation of soil behaviour even when there is no relevant test results are available, this master project attempts to develop empirical correlations for estimating the engineering characteristic of shear strength properties. Such correlations included undrained shear strength (S_u), cohesion (c) and clay effective soil friction angle (ϕ') with basic properties and compressibility parameters. Compressibility parameters are equally important in the design of land reclamation and building structures on soft clay, therefore some of the compression parameters are also correlated, such as compression index (C_c), coefficient of volume compressibility (m_v), void ratio (e_o) and compression ratio (CR) with basic properties.

1.3 Aim and Objective of the Study

The aim of the study is to develop correlations between engineering characteristics of marine clay taken from central west coast of Malaysia. In order to achieve the aim of study, three objectives have been identified:

(i) To determine the characteristic of marine clay in particular the basic properties, strength and compressive characteristics.

(ii) To obtain the correlations between strength with basic properties and compressibility parameters of marine clay.

(iii) To obtain the correlations between compressibility parameters and basic parameters of marine clay.

1.4 Scope of Study

The study are conducted based on data collection from three construction sites, which are Central Sludge Treatment Facility (CSTF) in South Klang Valley, Jimah Power Station (JIMAH) in Port Dickson and Express Rail Link (ERL) in Sungai Labu Sepang. This covers only the central west coast of Malaysia.

Site and laboratory tests had not been carried out thus, all the soil information and test results were obtained from the existing soil investigation that have been done by contractors and commercial laboratories.

The correlations reviewed and analysed in this study are limited to shear strength and compressibility parameters, such as undrained shear strength (S_u), effective frictional angle (ϕ'), compression index (C_c), coefficient of volume compressibility (m_v), void ratio (e_o) and compression ratio (CR).

1.5 Importance of Study

Basic knowledge and understanding of geotechnical properties of marine clay is very important due to many projects are developed along the coastal area, where this will overcome the problems related to settlement and also the stability.

Correlations obtained not only will be used at the study area but also at other places with similar soil condition. This will allow the engineers to use the correlations obtained for design purposes without having to do strength or compressibility tests, hence will be able to save cost and also to reduce the time.