# THE CORRELATIONS OF ENGINEERING CHARACTERISTICS OF JOHOR COASTAL CLAY

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# ABSTRACT

The characteristics of coastal clay soil are different compared to other soils due to their low strength and high compressibility. It is also difficult to get an undisturbed sample of this type of soil for laboratory testing. Hence, the correlation between engineering characteristics and basic properties or between engineering characteristics itself will be useful to engineers especially for preliminary design purposes. This paper presents some correlations of engineering characteristic of coastal clay in Johor that is the clay taken from Port of Tanjung Pelepas and Pontian. An attempt was made to correlate the Atterberg limits with the shear strength and also the shear strength with depth. In general, the correlations show that the liquid limit and plasticity index increase with moisture content. The plasticity index also tends to increase with liquid limit. For the undrained shear strength it is found to increase with depth, and decreases with moisture content, liquid limit, and plasticity index. An attempt was also made to get correlation between the liquid limit with the clay content. It is found that the liquid limit increases with the increase of clay content, probably due to the clay particles tend to pull or absorb water to the surface of soil particle, making the liquid limit to be much higher. The results give an alternative for engineers to use the basic soil properties to predict the strength of soil. One can also determine the shear strength of the soil at certain depth below ground level. This will allows a quick and economic design for construction on soft clay.

# ABSTRAK

Ciri-ciri tanah liat pantai adalah berbeza dibandingkan dengan tanah jenis lain kerana kekuatan yang rendah dan kebolehmampatan yang tinggi. Adalah diketahui bahawa amat sukar untuk mendapatkan sampel tak terganggu bagi tanah jenis ini untuk ujian makmal. Maka, korelasi antara ciri-ciri kejuruteraan dan sifat asas atau antara ciri-ciri kejuruteraan itu sendiri amat berguna untuk para jurutera terutamanya untuk tujuan merekabentuk di peringkat awal. Laporan ini mempersembahkan beberapa korelasi bagi ciri-ciri kejuruteraan tanah liat pantai di Johor, iaitu tanah liat diambil dari Pelabuhan Tanjung Pelepas dan Pontian. Satu percubaan telah dilakukan untuk membuat korelasi antara had Atterberg dengan kekuatan ricih dan kekuaatan ricih dengan kedalaman. Secara amnya, korelasi-korelasi menunjukkan had cecair dan indeks keplastikan meningkat dengan kandungan lembapan asli. Indeks keplastikan juga akan meningkat dengan had cecair. Manakala bagi kekuatan ricih tak tersalir didapati meningkat dengan kedalaman, dan menurun dengan peningkatan kandungan lembapan asli, had cecair, dan indeks keplastikan. Satu percubaan telah dilakukan untuk mendapatkan korelasi antara had cecair dengan kandungan tanah liat. Didapati had cecair meningkat dengan peningkatan kandungan tanah liat, mungkin disebabkan kecenderungan zarah tanah liat lembut untuk menarik atau menyerap air kepada permukaan zarah tanah, menjadikan had cecair menjadi lebih tinggi. Keputusan yang diperolehi memberikan alternatif kepada jurutera untuk menggunakan ciri-ciri asas tanah bagi meramal kekuatan tanah. Kekuatan ricih tanah juga boleh diperolehi pada kedalaman tanah yang tertentu di bawah aras bumi. Ini akan membolehkan proses rekabentuk yang cepat dan ekonomi untuk pembinaan di atas tanah liat lembut.

# TABLE OF CONTENTS

**CHAPTER 2 LITERATURE REVIEW**

**CHAPTER 3 METHODOLOGY**



**CHAPTER 4 CASE STUDY**

**CHAPTER 5 RESULTS AND DISCUSSIONS**



**CHAPTER 6 CONCLUSIONS**

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF SYMBOLS

| | | |
|---|---|---|
| °C | - | Degree Celcius |
| A | - | Activity |
| c | - | Cohesion |
| $c_u$ | - | Undrained shear strength |
| c’ | - | Effective cohesion |
| CID | - | Isotropically consolidated drained |
| CIU | - | Isotropically consolidated undrained |
| $I_L$ | - | Liquidity index |
| $I_P$ | - | Plasticity index |
| UU | - | Undrained unconsolidated |
| w | - | Natural moisture content |
| $w_L$ | - | Liquid limit |
| $w_P$ | - | Plastic limit |
| $w_s$ | - | Shrinkage limit |
| σ | - | Stress |
| ϕ | - | Internal angle of friction |
| ϕ’ | - | Effective internal angle of friction |
| $R^2$ | - | Correlation of determination |
| $s_u/\sigma'_{vo}$ | - | Soil strength ratio |
| $\sigma'_{vc}$ | - | Preconsolidation pressure |
| $\sigma'_{vo}$ | - | Overburden pressure |

# CHAPTER 1

# INTRODUCTION

## 1.1 General

The emergence of development in construction industry has minimized the preferred site of geotechnical quality for construction although these sites are known to reduce technical problems and thus the cost associated with their construction. By that, socio-economic and political considerations have forced the use of sites of lower quality and in particular, the sites covered by compressible soils. In developed country such as Malaysia, the chances to have good quality construction sites become rarer and it is necessary to choose sites that include compressible soils, especially for industrial structures and transportation projects. Therefore, the tasks to do constructions on these compressible soils have become a challenge for geotechnical engineers all over the world.

This study presents the characterization of coastal clay in Johor and developed a fundamental understanding of engineering properties of this type of

clay. In particular, some important correlations have been established for key engineering properties.

Soils with characteristics of low strength and compressible exist all over the world. One of the most significant problem arises because of its characteristics that is difficulties in supporting loads on such foundation. The problem arises with low strength is that it leads to difficulties in guaranteeing the stability of the structure on this type of soil. On the other hand, this type of soil also associated with high compressibility which leads to large settlements and deformations of the structure.

Clays, referring to the United Soil Classification System, are fine-grained soils with more than 50% by weight passing No.200 US Standard sieve (0.075 mm). Soft clay is defined as clay with shear strength below 25 kPa (Brand & Brenner, 1989). Soft soils have weak compressibility and known to engineers as very complex, problematic, and treacherous materials. That is why many structures constructed on soft clay experiencing failure.

Because of this, it is important to continue research effort on this problem in order to resolve the problems posed by construction on soft clay.

## 1.2 Background of Problem

The construction on soft cohesive soil is increasing lately because there are not too many suitable sites for construction of infrastructures and other development. The problems that related to this type of soil are stability and settlement. Due to that, the understanding and knowledge of engineering characteristics of soft clay soil are critical and should be understand by people

related in this field. The selection of construction method on this formation is restricted by costs, duration of completion, and benefits.

The development in South East Asia had been so rapid that studying the soft clay soil is very important. However, the studies that been done mostly concentrated on major cities, such as Bangkok, Kuala Lumpur, Jakarta, Singapore, and others. Because of that, the coastal areas in Johor are chosen in this study in order to develop correlations that hopefully will be used in the design of structure on soft clay.

It is difficult to get samples from soft clay for laboratory testing, such as shear strength. Some of the tests take a long time to complete and also need a careful analysis. So correlations with basic properties play an important role to overcome this problem. Besides that, the correlation of shear strength with depth could also help the engineer to make prediction of the shear strength soil at certain depth below ground level.

## 1.3 Objectives

The objectives of this study are:

a) To determine the engineering properties and design parameters for soft clay soil.
b) To produce correlations between engineering characteristics and basic properties of soft clay soil for design purposes.
c) To produce correlations between engineering characteristic and basic properties with depth of soft clay soil for design purposes.

## 1.4 Scope

This study was conducted on Johor coastal clay. The samples were taken from the construction project sites at the coastal area of Port of Tanjung Pelepas and Pontian. The soil samples were tested by Geolab (M) Sdn. Bhd. and the analysis carried out in this study was from the results obtained from this company. Figure 1.1 shows the location of the sites, while Figure 1.2 and 1.3 show the location map of Port of Tanjung Pelepas and Pontian, respectively.

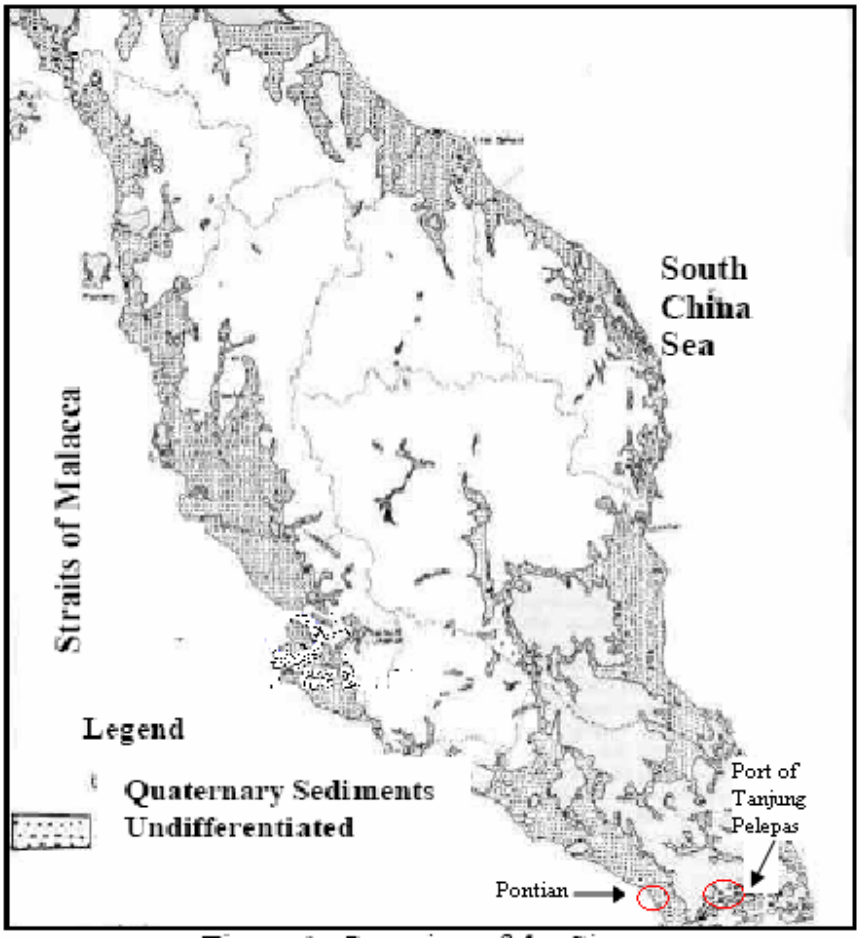


**Figure 1.1: Location of the sites (After Brand and Brenner, 1981)**

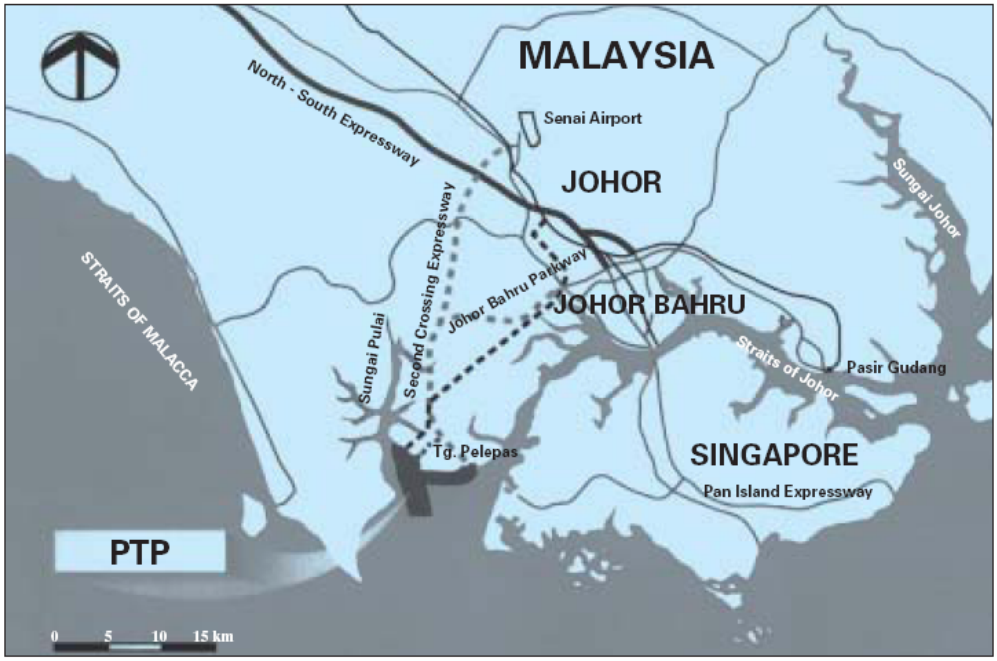


**Figure 1.2: Location map for Port of Tanjung Pelepas (PTP)**

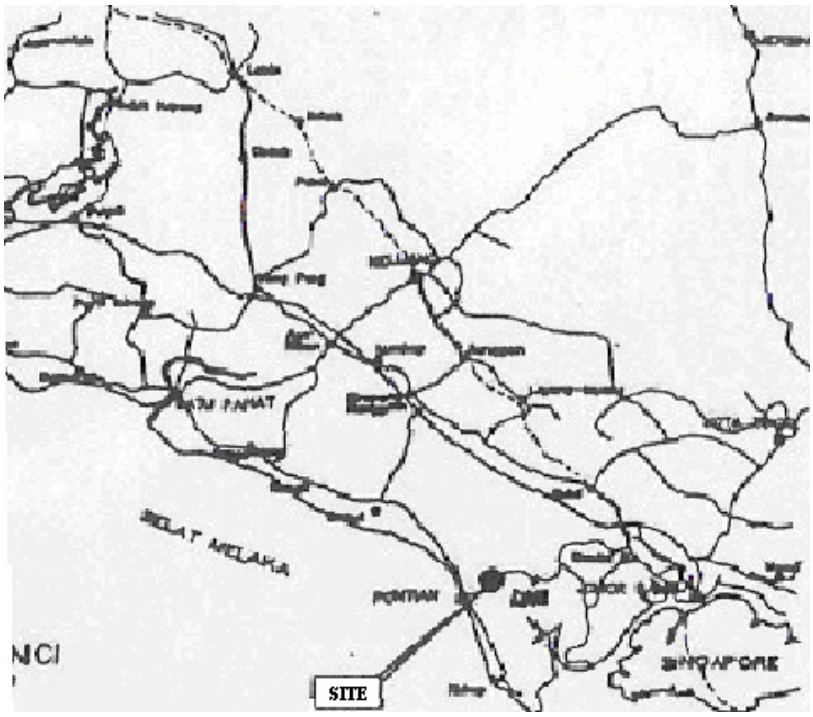


**Figure 1.3: Location map for Pontian**

## 1.5 Importance of Study

To overcome the problem encountered in soft clay, knowledge and deep understanding about the engineering characteristics of soft clay are very important. The data that obtained are analyzed will hopefully become a part of soft clay database in Malaysia. This is because there still lack of studies in soft clay properties and engineering characteristics in Malaysia. The result from this study can be referred by engineers as useful guidance for them to apply in construction on soft clay soil. The correlations produced could be used as preliminary design of structure on soft clay soil.

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