THE IN-SITU PROPERTIES OF CLAY SOIL IN PEKAN USING CONE PENETRATION TEST

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ABSTRACT

Construction project for civil structures always experience big challenges in order to ensure no conflict to the foundation. As we know, foundation is an important initial work in a construction of civil structure. if a foundation is not designed according to its requirement and properly, collapse to the building might be occurred. The construction of foundation needs to take account for the strength (bearing capacity) of the site area. Here, site investigation plays an important role. Through the results of site investigation, the choosing for suitable type of foundation can be accomplished. This study had covered important aspects towards the choosing of foundation for a building construction. The objectives of this study is to determine the parameters of soil at site study and to determine the soil profile for site study using the method of Piezocone's Cone Penetration Test. This method had been chosen as it is the most reliable method to obtain dynamic pore pressure parameter at site study among all site investigation method. Through this method, data obtained had been tabulated and graphs had been plotted. The conclusions obtained from these data are for the parameters; cone resistance is 12.07 MPa, sleeve friction is 0.06 MPa and dynamic pore pressure is 0.65 MPa. The site study (Pekan) also had been concluded to be classified in clays type of soil with clays-clayey to silty clay. From above data, further analysis and calculation to obtain the suitable foundation for clay type of soil can be proceed.

ABSTRAK

Projek pembinaan bagi struktur awam sering menghadapi cabaran besar dalam memastikan tiada masalah terhadap asas tapak. Seperti yang kita ketahui, asas tapak merupakan permulaan yang paling penting dalam pembinaan sesebuah bangunan. Jika asas tapak bangunan tidak direkabentuk mengikut standard dan dengan baik, keruntuhan bangunan berkemungkinan besar akan berlaku. Pembinaan asas tapak haruslah melihat kepada kekuatan tanah di kawasan pembinaan. Di sini,aspek penyiasatan tapak amatlah penting. Melalui dapatan keputusan penyiasatan tapak terhadap kawasan kerja, pemilihan jenis asas tapak yang sesuai mengikut jenis pembinaan bangunan dapat dilaksanakan. Kajian ini telah merangkumi aspek-aspek penting dalam menuju kepada pemilihan asas tapak yang sesuai untuk pemilihan sesebuah pembinaan bangunan. Objektif kajian ini ialah mengetahui parameter-parameter tanah di tapak kajian dan mengetahui jenis profil tanah di tapak kajian melalui kaedah Piezocone's Cone Penetration Test. Prosedur kaedah penyiasatan telah dipilih berdasarkan kemampuan kaedah tersebut untuk mencari parameter bagi tekanan liang dinamik (dynamic pore pressure) tapak kajian berbanding kaedah penyiasatan tapak yang lain. Melalui kaedah penyiasatan di atas, data-data telah dijadualkan dan graf telah diplotkan. Rumusan telah mendapati bahawa, nilai parameter bagi cone resistance ialah 12.07 MPa, sleeve friction ialah 0.06 MPa dan dynamic pore pressure ialah 0.65 MPa. Kawasan tapak kajian (Pekan) juga telah didapati tergolong dalam jenis tanah liat. Melalui dapatan data-data tersebut, dapatlah dilakukan analisis pengiraan selanjutnya bagi mendapatkan jenis asas tapak yang sesuai bagi kawasan jenis tanah liat.

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LIST OF SYMBOLS

A	-	Activity
c	-	Cohesion
c_u	-	Undrained shear strength
c'	-	Effective cohesion
CPT	-	Cone Penetration Test
wL	-	Liquid limit
wP	-	Plastic limit
ws	-	Shrinkage limit
q_c	-	Cone resistance
f_s	-	Sleeve friction
u2	-	Dynamic pore pressure
R_f	-	Friction ratio

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Soil is a natural property of earth which is formed by a small pieces of mineral particle and it may contain three properties; water, air and organic material. Soil is the oldest and the most complex of the construction materials used by engineers. More generally, soil is a three phase system comprised of various combinations of naturally-derived solids including fine to coarse-grained rock and minerals organic matter, weathered rock and precipitates, liquid primarily water solutions and gases (Rosnah, 2008). The behavior of soil itself is very important in civil engineering field design. Properties of soil are an essential prior to any geotechnical design. Due to the different situation at every field, properties of the soil need to be determined and tested first before constructing any structure at the site. The soil classification systems that are commonly used are AASTHO (American Association of State Highway and Transportation Officials), Unified Soil Classification System and British Soil Classification System. Besides, ASTM (American Standard Testing Method) also play a major role in classify and determine soil properties.

It has been discussed that soil is formed by the process of physical and chemical weathering. The individual size of the constituent parts of even the weathered rock might range from the smallest state to the largest possible. This implies that all the weathered constituents of a parent rock cannot be termed as soil. According to their grain sizes, soil particles are classified as cobbles, gravel, silt and clay (Murthy V.N.S, 2002). In order to build a structure on top of the ground, some experimental method should be done to determine the strength of the soil. Otherwise, structure built will fail and even will collapse. There are two type of soil testing method which is field testing (in-situ testing) and laboratory testing to gain data and test soil sample. Soil which is not suitable enough in term of property, such as strength of soil need to be treat well if structures are intended to be built at the site.

Shear strength is one of the most important geotechnical parameter which used by engineers in designing foundation, slope stability, dam and structure. Shear strength of soil is measured and determined depending on type of soil tested. The undrained shear strength of clay soil in Pekan will be studied in this report.

Kuala Pekan is one of several places in peninsular Malaysia which has an availability of soft soil existence. Soft soil in this area is reaching until the 40 meter depth. Accordingly, the other places are Johor, Melaka, Pelabuhan Klang, Alor Star, some part of Terengganu and some part of east coast peninsular Malaysia (Ting and Ooi, 1976). The undrained shear strength of this area, Pekan will be determined by in-situ testing method and the result will show that whether treatment of soil is need to be done when a structure is intend to be built.

1.2 Problem statement

Since the soft soils have a low shear strength and high compressibility, the constructions on this soft soil is a challenge to engineers (Mitchell, 1993). The geotechnical properties of clay soil are proved to have high cohesive value and friction ratio. The clay soil at Pekan will be tested by in-situ method which is Piezocone's Cone Penetration Test (ASTM D5778).

Strength of soil need to be determined in order to analyze which foundation is suitable to be applied on site area. A foundation needs to be build as its function is to transmit the weight of the structure. Without foundation as a base, a structure can not be built on site. By revising the strength of soil, we can notice whether it is competent enough to support loads from structure. If the strength of soil shows that it is unable to support loads, reinforcement on soil can be made or foundation can be made deeper into the earth layer.

The existence of pore water pressure can influenced the soil stability. The pore water pressure will produce the seepage in the soil layer which is has connection with the depth below the groundwater table. The profile of clay soil is known to have excessive pore water pressure and seepage in soil layer due to its particle size which can be classified as finer.

The significance of knowing the clay's physical properties is engineers will get to know the condition of the soil. Such as the condition of pore water pressure, the consistency of soil, the seepage and the testing suitable to determine the strength of soil.

1.3 Objective

The objectives of this study of soil analysis are as stated below:

i. to determine soil parameters using Piezocone Cone Penetration Test at Pekan.

ii. to determine the soil profile based on the in situ testing (Piezocone's Cone Penetration Test (ASTM D5778).

1.4 Scope of study

This study will focus on the specific scope which has been determine to ensure that research done is precise with the study area chosen. The scope of study has been narrowed down so the study will not exceed the limit stated. Below are the narrowed scopes of study:

i. Location of study

Pekan is the location chosen which is located at the bank of Pahang River and 50 km south from Kuantan town. Pekan is also located approximately 6500km from South China Sea. Exact location will be chosen is Kuala Pahang and Langgar (Pekan's subdistricts)

ii. Scope of work

The scope of work involved in this study is in-situ soil testing. Testing is involving the piezocone's cone penetration test apparatus (Piezocone's Cone Penetration Test (ASTM D5778)). The testing method will be done on the field as for this test, there is no laboratory testing.

iii. Properties of material (soil)

The properties of the soil is said to be categorized as soft soil as Pekan is situated at the river bank of Pahang River. Usually area which is stated is near a river or sea.

1.5 Significant of study

This study will give information on the properties of clay soil at Pekan especially the properties of soil parameter. This information is beneficial to student who wanted to do further research about the properties of clay soil at Pekan. Site investigation is carried out and determination of soil properties at in-situ condition, which can give actual condition of natural condition of soil. The Piezocone's Cone Penetration Test is less at cost and time value as it is done right at the site area. It is also produce more result for the soil properties. It is very significance as engineers will be able to determine other properties of soil at the site area. Moreover, Cone Penetration Test is also a fastest way to get data at site area as the testing is not taking a long time to come out with soil data.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The shear strength of a clay soil can be influenced by the particle size of the soil, the pore water pressure, total stress of soil and many more. This chapter will discuss the important element that influenced the shear strength of soil. The clay soil of the site area of Pekan, Pahang will be studied for its shear strength by the in-situ testing.The important element in this chapter which have to be taken note is the testing method; the Piezocone's Cone Penetration Test (ASTM D5778). This test will also be discussed at the end of this chapter, reviewing for its previous data result, previous graph presented and the significance of the testing.

2.2 Study location

The location chosen for this study is Pekan district. Pekan is located in Pahang state. Pekan is located on the banks of the Pahang River and it is a royal town of the Malaysian state of Pahang Darul Makmur. Pekan is of 3805 km^2 with a population of 120 000 people. Pekan is at the map coordinate of 3°30'00"N and 103°25'00.12"E. Pekan has 11 subdistricts which are Bebar, Penyor, Lepar, Pulau Manis, Pekan (capital), Temai, Ganchong, Langgar, Kuala Pahang, Pahang Tua and Pulau Rusa. The study location is covered for subdistrict Kuala Pahang and Langgar. Geography of the Kuala Pahang and Langgar is shown to be near to the Pahang River. Figure 2.1 below shows the geographical map of the Kuala Pahang and Langgar, the subdistrict of Pekan.

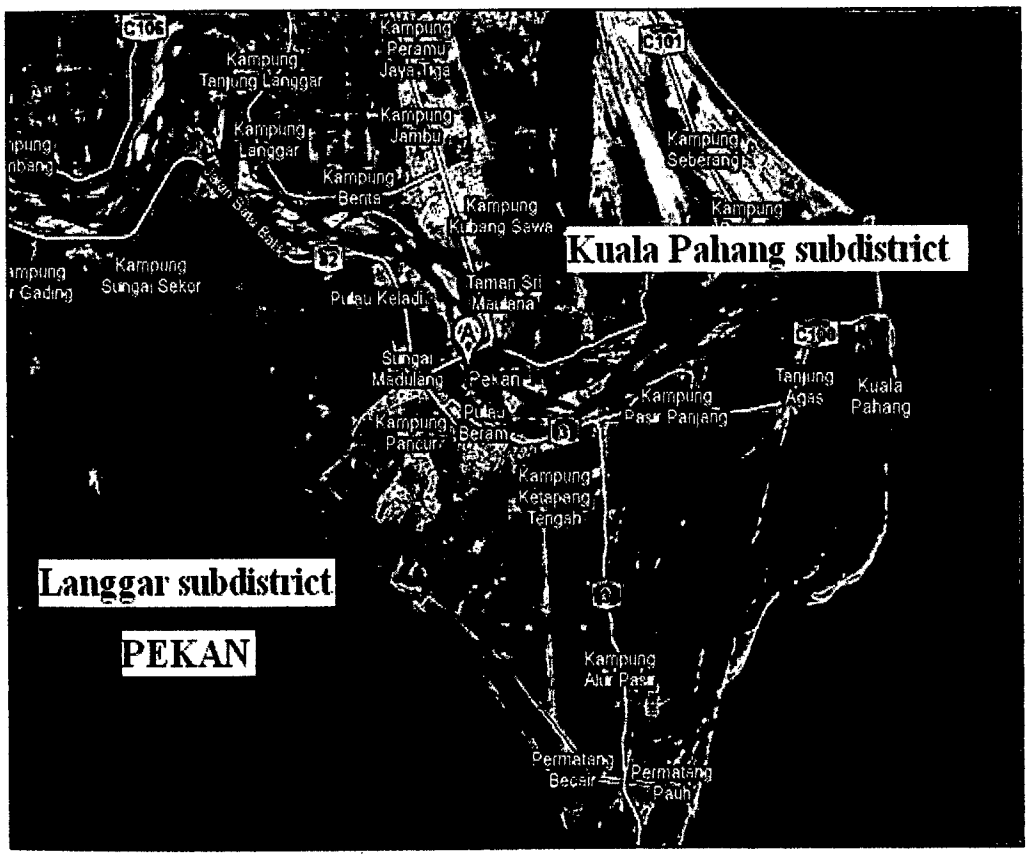

Figure 2.1: Geographical map of site study.

The borehole testing will be held around Langgar and Kuala Pahang subdistricts for all 15 numbers. For detail of boreholes location on map, refer the appendix.

2.3 Soil

In this world, there is an element called soil which is covered the earth approximately at 30%. Soil can be divided into several groupings according to the system of classification which has been revised all around the world by geologists and soil scientists. Soil can be grouped through its physical properties. Soils consist of grains (mineral grains, rock fragments, etc.) with water and air in the voids between grains. The water and air contents are readily changed by changes in conditions and location: soils can be perfectly dry (have no water content) or be fully saturated (have no air content) or be partly saturated (with both air and water present). Although the size and shape of the solid (granular) content rarely changes at a given point, they can vary considerably from point to point. Generally, soil can be classified into cohesion less soil and cohesive soil. Soils as we know are sand, clay soil, peat soil, silt and gravel. Each one of the group soil has different physical properties with other soil's groups. This shows the uniqueness of every soil group as an important element in the civil engineering field. This study will focus on clay soil as a main subject.

It is very important for one to have skill on differentiate among types of soil referring to their plasticity analysis and gradation in fields. Even though this information is available in the laboratory testing, engineers should be able to differentiate among soils in the field. Such situation involving the excavating process which needed one to excavate until the certain layer will need an engineer to give a stop order whenever the excavation process has reached to the selected soil layer. This is a reason why all major construction projects require on-site inspection. Granular soil, fine-grained soil and coarse-grained soil are needed to be differentiated

among them. In this project study, the fine-grained soil properties will be discussed as the clay is classified as fine-grained soil.

2.3.1 Definition of clay

Cohesive soil or clay soil is a group of soil, determined through the classification system by soil scientists. Basically, clay particles are flaky and their thickness is very small relative to their length and breadth. They therefore have high to very high specific surface value. These surfaces condition somehow electrochemically causes a lot of water whether held or absorbed within clay mass. Clay or fine-grained soil will not crumble and is in a plastic condition when is moisture. Cohesive or clay soil is hard to break up when it is in dry condition. Clay can be grouped as clayey silt, sandy clay, silty clay, clay and organic clay. Clays are produced mainly from the chemical weathering and decomposition of feldspars, such as orthoclase and plagioclase, and some micas. They are small in size and very flaky in shape. The structure of clay itself is the key to clay main properties, such as plasticity, compressibility and shrinkage/swell potential. Clay is defined as having very small particle sizes, sticky and plastic. This is due to its properties which has high content of moisture in the soil structure.

Clay is consist of several minerals such as Silica Tetrahedron and Alumina Octahedrons as the basic mineral units; composing the clay minerals. Particle size of clay is very small which is less than 2μm and electrochemically is very active. Minerals of clay are produced mainly from the chemical weathering and decomposition of feldspars such as Orthoclase and Plagioclase (Rosnah, 2008).

In Malaysia, clay soil or soft soil are available along the west coast of Peninsular Malaysia such as Johor, Malacca, Port Klang and some part of east coast

of Peninsular Malaysia for examples, Port Kuantan and Kuala Pekan. The depth of soft soil or clay soil is reaching 40 meter at these areas, supporting the fact that clay soil is much easier to be found near sea or river (Ting and Ooi, 1976). Clay soils also can be found at wet area such as mines and beach. The depth also is depending on area such as Table 2.1 shown below (Abdullah and Chandra, 1987).

Table 2.1: Thickness of clay soil at several places.

Location	**Thickness (m)**
Perlis-Kedah	5-12
Kedah River Dam	8-12
Alor Setar Airport	12
Prai and Pulau Pinang Bridge	12-25
Butterworth-Changkat Jering Highway	5-15
Kerian River	10
Bagan Datoh-Teluk Intan Road	5-11
Klang Port	8-30
Acheh Village-Marine Jetty	3-7
Farm Development Project West Johor	10-35
Kuantan	3-20
Kuantan River Brigde	5-12
Kuantan Port	3-15
Chukai	4-8
Semerak-Kemasin	3-90

2.3.2 Properties of clay soil

From the view of soil texture, soil scientists have proved that, clay soil have the smallest sized particles and sticky when held as mention at the paragraph earlier. Clay soil also show a character of hardly to be squeezed. The smallest sized particles of clay soil influenced the porosity, permeability, water holding capacity and soil particle surface. Clay soils show that for porosity properties, it dominantly has small pores and slow in permeability. Clay also capable of holding water in a very large capacity, same goes with the soil particle surface.

2.3.3 Consistency of cohesive soil

Soil classification is the arrangement of soils into various groups or subgroups to provide a common language, expressing briefly the general usage characteristics without any detailed descriptions. Currently, there are two major classification system, which are Unified Soil Classification System (USCS) and Association of State Highway and Transportation Officials (AASTHO).

Taken from the analysis of the USCS, clay soil/fine-grained soil is characterized based on its plasticity index and the liquidity if the soil itself. From the key word of plasticity index, we can notice that water content influences the plasticity of a soil. In other word, since clay soils/fine-grained soils content water in the structure, only fine-grained soil can be classified in plastic condition. The plastic consistency is then termed as Plasticity Index. Table 2.2 shows the plasticity chart ranges and the classification.

Table 2.2: Ranges of plasticity and classification.

Low plasticity	wL = <35%
Intermediate plasticity	wL = 35% - 50%
High plasticity	wL = 50% - 70%
Very high plasticity	wL = 70% - 90%
Extremely high plasticity	wL = >90%

Besides plasticity, liquidity also is a main property for clay soil. In fine-grained soil, especially clays, the current state is dependent on the water content with respect to the consistency limit. Liquidity or liquid limit is a condition where water influences changes of soil from plastic to liquid behaviour. The popular laboratory testing for liquidity is Atterberg Limit. For the relationship of liquid limit, plastic limit and shrinkage limit, the Figure 2.2 shows cohesive soil's consistency.

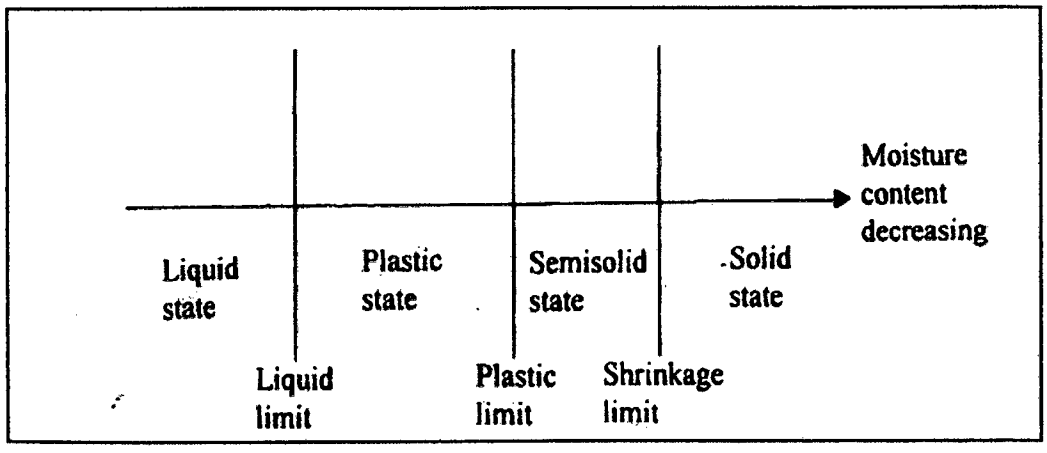

Figure 2.2 : Consistency of cohesive soil.