INVESTIGATION ON SUPERABSORBENT POLYMER (SAP) WITH KAOLINITE AS GROUNDING MATERIAL

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Dalam rangkaian penghantaran dan pengedaran, sistem pembumian penyumbang terpenting untuk operasi keselamatan mana-mana pemasangan elektrik. Salah satu aplikasi penting bahan pembumian adalah keupayaan mengurangkan keberintangan asas. Bentonit adalah salah satu bahan yang biasa digunakan sebagai bahan penambahbaikan tanah kerana keberintangan yang rendah dan keupayaan untuk mengekalkan air. Walau bagaimanapun, tiada pengeluaran bentonit di Malaysia manakala kaolinit boleh didapati dengan banyak. Oleh itu, kaolinit menggantikan bentonit sebagai bahan penambahbaikan tanah. Walau bagaimanapun, pengekalan ciri plastik dan air adalah terhad berbanding dengan bentonit. Oleh itu, untuk meningkatkan prestasi ciri keplastikan dan kerintangan kaolinit, superabsorbent polymer (SAP) mempunyai pertalian air yang tinggi, bengkak yang tinggi dan mempunyai kapasiti pengekalan air yang tinggi ditambah dalam kaolinit. Dalam kajian ini, tiga kaolinit digunakan iaitu FMC, S300 dan Speswhite dengan penambahan 0%, 5% dan 10% daripada SAP. Tujuan kajian ini untuk mengenalpasti kesan superabsorbent polymer (SAP) terhadap ciri plastik kaolinit, untuk membentuk lengkung pengekalan air (SWRC) dan untuk membandingkan keberintangan kaolinit dengan penambahan SAP pada peratusan yang berlainan. Untuk menentukan penambahbaikan keplastikan kaolinit, sifat fizikal dan kimia dijalankan. Teknik titik embun cermin telah digunakan dalam kajian ini untuk membina tanah serapan air lengkung (SWRC). Selain itu, keberintangan kaolinit dengan penambahan SAP pada peratus yang berbeza akan dikaji dengan menggunakan kaedah kotak tanah. Hasil yang diperoleh daripada ujian makmal menunjukkan bahawa sifat keplastikan kaolinit meningkat. SWRC kaolinit dengan penambahan SAP telah dibentuk dan lengkung didapati adalah antara sedutan rendah hingga nilai sedutan yang tinggi. SWRC menunjukkan bahawa kandungan air untuk semua sampel tanah berkurang dengan peningkatan sedutan tanah. Resistensi FMC, S300 dan Speswhite dengan 10% adalah 8.80 Ω.m, 6.24 Ω.m dan 6.10 Ω.m. Oleh itu, penambahan SAP akan mengurangkan ketahanan tanah.

ABSTRACT

In transmission and distribution network, grounding system contributes significantly for the safety operation of any electrical installation. One of important application of ground enhancing material is the ability reduce the grounding resistance. Bentonite is one of commonly used as ground enhancing material due to its low resistance and ability to retain water. However, there is no production of bentonite in Malaysia whereas kaolinite can be found abundantly. Thus, kaolinite is used as a substitute for bentonite as ground enhancing material. However, the plasticity and water retention are limited as compared to the bentonites. Thus, to enhance the performance of kaolinite in plasticity and resistivity, superabsorbent polymer (SAP) which has high affinity for water, high swelling and have high water retention capacity is added in kaolinite. In this study, three kaolinites are used which are FMC, S300 and Speswhite with addition of 0%, 5% and 10% of SAP. The aims of this study to determine the effect of superabsorbent polymer (SAP) on the plasticity characteristic of kaolinite, to establish soil-water retention curve (SWRC) and to the compare the resistivity of kaolinite with addition of SAP at different percentages. To determine the plasticity of the enhanced kaolinite, physical and chemical properties are conducted. The osmotic and chilled-mirror dew-point methods were used in this study to establish soil-water retention curve (SWRC). Besides that, the resistivity of kaolinites with addition of SAP at different percentages are studied by using soil box method. The obtained results from laboratory tests showed that the plasticity characteristic of enhanced kaolinite is increased. SWRC of kaolinite with addition of SAP are establish and the curve ranging from low suction to high suction value. SWRC shows that water content for all soil samples decrease with increasing of soil suction. The resistivity of FMC, S300 and Speswhite with 10% are 8.80 Ω.m, 6.24 Ω.m and 6.10 Ω.m. Thus, the addition SAP decreases the resistivity of the soil and may be used as ground enhancement material.

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LIST OF SYMBOLS

$\Omega.m$	Ohm.meter
T_s	Sample temperature
T_b	Chamber temperature
K	Kelvin
C	Celsius

LIST OF ABBREVIATIONS

ASTM	Simple Boost Pulse Width Modulation
BS	British Standard
BET	BET Brunauer-Emmett-Teller
CEC	Cation Exchange Capacity
EGME	Ethylene Glycol Monoethyl Ether
IEEE	Institute of Electrical and Electronics Engineers
MPa	Megapascal
SAP	Superabsorbent polymer
SWRC	Soil-Water Retention Curve
WP4C	Water Potential Meter

CHAPTER 1

INTRODUCTION

1.1 Background

The role of grounding system is very important in the area of lightning protection, and communication systems and power (Lim et al., 2012). The function of grounding system is to disperse the transient current to the soil masses as soon as possible (Gomes et al., 2010). Thus, preventing undesired voltage from passing through personnel, critical equipment and other nearby metallic objects which is hazards and can cause damage (Adegboyega and Odeyemi, 2011). The accomplishment of grounding system is verified by its earth resistance (Gomes et al., 2010) which follow in accordance to the IEEE standard. The resistance is dependent on the size and type of electrode, the depth of electrode is buried and soil resistivity (Adegboyega and Odeyemi, 2011). Therefore, surround the electrodes in ground enhancement material also known as backfill materials which an accepted practice of attaining low earth resistance, especially for site that have extremely high resistivity. Such materials have distinct advantage in producing good earth resistance at space restricted sites and sites with ultra-high soil resistivity (Gomes et al., 2010; Lim et al., 2012). A good ground enhancement material must provide lower resistance compared to the local soil while maintaining it for a long time, and non-reactive with the electrode material (Gomes et al., 2010). Based on Gomes et al. (2010), majority of the good ground enhancement material has higher resistivity value under dry conditions although it has lower values under wet conditions. The lower the resistivity the fewer the electrodes required to achieve the desired earth resistance value (Adegboyega and Odeyemi, 2011).

Based on previous studies, bentonite is an ideal as ground enhancement material which able to reduce the ground resistance (Lim et al., 2015). Apart from that, it has high absorption capacity, swelling capability and retention capacity which enables it to maintain resistance at low levels for long period due to its high water absorption and retention tendency (Lim et al., 2013). In Malaysia, bentonite deposits can be found in several areas such as Mansuli, Segama, and Andrassy (Irawan and Samsuri, 2005). To date, there is no production of bentonite meanwhile only five processing plants located two in Selangor and one each in Perak, Johor and Sabah. As stated in Malaysian Minerals Yearbook (MYB, 2013), Malaysia imports most of raw bentonites from India and China at around 32,668 tonnes of bentonites in 2013 which significantly increased from 20,113 tonnes in 2012.

In Malaysia, another type of clay, the kaolinite dominated most of the mineral composition of tropical residual soils in Malaysia which takes place from the process of weathering (Muhammad, 2013). Main kaolin deposits are found in Malaysia which located at Perak, Johor, Kelantan, Selangor, Pahang and Sarawak (MYB, 2013). Based on (Baioumy and Ibrahim, 2012), kaolin reserves are identified around 112 million tons in Malaysia. According to JMG Basic Data & Information Compendium (2017) estimated kaolin reserves in Malaysia are 80,150,000. In fact, Malaysian Minerals Yearbook 2016 stated the production of kaolin is 392,932 tonnes in 2016, which mainly produced kaolin came from Perak around 32%. Swelling is related to the hydration of clays but not all clays swell when hydrated. Kaolinite is non-swelling clay whereas bentonite is high-swelling clays which swells and expand up to ten or more times their clay volume when presents in water (Murray, 1999). Kaolinite has a relatively low surface area and a low surface charge compared to bentonite, so it exhibits low absorption and adsorption (Murray, 1999). Unlike kaolinite, the bentonite provides high bonding strength and plasticity. As has been proven that plasticity index of kaolinite lower compared to bentonite (Horpibulsuk et al., 2011). In addition, bentonite possessed high optimum content in contrast to kaolinite (Fattah and Al-Lami, 2016). Therefore, superabsorbent polymer is added into kaolinites to improve its plasticity and water absorption.

Superabsorbent polymer (SAP) is defined as materials that are hydrophilic that have the ability to absorb and hold large quantity of water or aqueous solutions (Zohuriaan and Kabiri, 2008). Due to its water-absorbing properties and high-water retention (Kiatkamjornwong, 2007), SAPs have been widely adopted in agriculture as new water-saving materials and soil conditioners (Bai et al., 2010). Based on Xie et al.

(2012) stated that, SAP capable of absorbing water or fluids hundreds to thousands their own weight and the absorbed water is hardly removed under some pressure. The presence of SAP in the soil makes it possible to increase the water-absorption capacity the soil and preserve water in soil longer (Bakass et al., 2002). According to Guilherme et al., (2015), SAPs are normally used as soil condition due to its ability to retain soil moisture, enhance the stability of soil and prevent soil erosion as soil conditioner in agriculture. Bai Furthermore, SAP amendments can reduce soil penetration resistance (Busscher, Bjorneberg and Sojka, 2009). Apart from that, it can increase soil aggregation and soil-water holding capacity, and helps the protection of soil organic matter (Goebel et al., 2005; John et al., 2005).

In this study, three different kaolinites were used as ground enhancement material. The resistivity and the water retention behaviour were assessed to perform as grounding material. In addition, SAP were incorporated into the kaolinite to improve the water retention and resistivity characteristic.

1.2 Problem Statement

Soil type is a primary factor to determine the ground resistance. Different soil possesses different resistivity and not all soil have low resistivity. Bentonite is commonly used ground enhancement material because of the ability to retain water and having low resistivity. However, bentonite is hardly found in Malaysia, so it needs to be imported from foreign countries such as USA, China and Australia. Another type of clay, namely the kaolinites are more common in Malaysia. However, the plasticity and water retention are limited as compared to bentonites. The used of SAP has shown to increase the water retention capacity of soils. Thus, it is anticipated that the plasticity and water retention of kaolinites will improve by adding SAP. As the plasticity of kaolinites improve, it is expected that kaolinites can be a substitute of bentonite as a ground enhancement material.

1.3 Research Objectives

The objectives of this study are:

1. to determine the effect of superabsorbent polymer (SAP) on the plasticity characteristic of kaolinite.

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