WATER ABSROPTION EFFECT ON ELECTRICAL RESISTIVITY OF KAOLINITE-SUPERABSORBENT POLYMER MIXTURE

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STUDENT'S DECLARATION

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

Satu kajian mengenai campuran Kaolin - Superabsorbent Polymer (SAP), yang merupakan sejenis tanah liat mendominasi di Malaysia. Deposit utama kaolin berkualiti tinggi di semenanjung Malaysia yang terdapat berhampiran Bidor dan Tapah, Perak. Tanah liat kaolinit ini digunakan sebagai bahan alternatif untuk menggantikan bentonit dalam sistem pembumian. Kajian ini dijalankan untuk membina Lengkungan Ciri Air Tanah (SWRC) dan menentukan sifat elektrik Kaolinite - SAP. Penyiasatan terhadap kakisan elektrod tanah juga telah dipertimbangkan dalam kajian ini. Penyelidikan ini hanya memberi tumpuan kepada ujian makmal di bawah Teknik Wap Keseimbangan (VET), ujian kaedah kotak tanah dua-elektroda dan kaedah jisim kerugian untuk penyiasatan sifat elektrik tanah. Kajian ini menunjukkan lengkungan ciri air tanah (WRC) untuk campuran Kaolin - SAP. Penambahan SAP meningkatkan kelakuan pengekalan air Speswhite, FMC dan S300 kaolin. Kaolin tanpa SAP mempunyai daya tahan yang tinggi di keadaan keringnya. Walau bagaimanapun, sifat elektrik berkurangan dengan cepat dengan peningkatan kandungan air. Kaolin dengan SAP juga mempunyai keadaan yang sama di mana sifat elektrik tinggi pada keadaan kering dan berkurang dengan kandungan air meningkat. Hasil eksperimen dari kaedah jisim kerugian menunjukkan kadar kakisan elektrod tembaga untuk kaolin dengan campuran SAP lebih besar daripada kaolin tanpa SAP. Air adalah salah satu faktor yang mempengaruhi kakisan tanah.

ABSTRACT

A research on the Kaolinite – Superabsorbent Polymer (SAP) mixture, which is a type of clay that dominated in Malaysia. The main high quality kaolin deposits in peninsular Malaysia that is found near Bidor and Tapah, Perak. This kaolinite clay soil used as an alternative material to replace bentonite in grounding system. The study was conducted to establish Soil Water Retention Curve (SWRC) and to determine the resistivity behaviour of the Kaolinite – SAP. The investigation on the corrosion of earthing electrode also has been considered in this study. The research focuses only on laboratory tests under Vapour Equilibrium Technique (VET), Wenner Four – Point test and mass – loss method for corrosion investigation. This study showed the water retention curve (WRC) for Kaolinite – SAP mixture. The addition of SAP increased the water retention behaviour of Speswhite, FMC and S300 kaolin. Kaolin without SAP has a high resistivity at its dry states. However, the resistivity decreases abruptly with increasing water content. Kaolin with SAP also has the same situation where resistivity is high at its dry states and get decrease with the water content is increase. Experimental result from the mass – loss method showed that the copper electrode corrosion rates for kaolin with SAP mixture are greater than kaolin without SAP. Water is one of the factors that affect soil corrosion.

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LIST OF SYMBOLS

Ψ	Total suction
u_v	Partial pressure of water vapour
u_{v0}	Saturation pressure of pure water vapour
v_{w0}	Specific volume of water
ω_r	Molecular mass of water
R	Universal gas constant
T	Absolute temperature
RH	Relative humidity
G_s	Specific gravity
w_1	Mass of the density bottle and stopper
w_2	Mass of the density bottle, stopper and dry soil
w_3	Mass of density bottle, stopper, soil and water
w_4	Mass of density bottle, stopper and water
w	Water content
M_D	Mass of the dry soil
M_S	Mass of the wet soil
SL	Shrinkage limit
W	Moisture content of the wet soil sample
V_s	Volume of the dry soil sample
V	Volume of wet soil sample
W_s	Weight of the oven dried sample
K	A constant
T	Time of exposure
A	Area
W	Mass loss
D	Density
w_i	Hygroscopic water content
w_L	Liquid limit
w_P	Plastic limit
w_s	Shrinkage limit

CHAPTER 1

INTRODUCTION

1.1 Background

Earthing plays a huge role as a shield for power systems especially against lightning. To shorten the time for the dispersion of charge flow to the mother earth at the event of lightning or fault are the aim of an earthing system. It is vital to ensure a proper earthing installations, to avoid damage of equipment or improper operation, especially within solid-state equipment (Drive et. al., 2001). The current transmission is limited by the earth's resistance.

Examples of the major parameters use to determine the performance of the grounding system is the resistivity of local soil. This resistivity of soil varies with a few factors such as soil type, moisture content, temperature, and size of soil particles, porosity and others (Fukue et al., 1999, Switzer, 1995). A good ground enhancement material should provide low earth resistance over a long period with little variation of resistivity value (Gomes et al., 2010).

Usually, bentonite has been used a backfill materials due to it is the most suitable example in decreasing the low grounding resistance of electrodes (Lim et al., 2015) for a long time due to its high water absorption and retention tendency (Lim et al.,2013).

Bentonite is not commonly available in most country. Another type of clay, largely found at the state of Perak, Johor, Kelantan, Selangor, Pahang and Sarawak is

kaolinite. However, kaolinite clays have lower plasticity behaviour than bentonite (Horpibulsuk et. al., 2011).

In this study, superabsorbent polymer (SAP) is used to increase the water absorption and retention behaviour. Superabsorbent polymer (SAP) is a hydrogel with three-dimensional polymer networks expand when absorb water. SAP able to absorb more than hundred times of water than its own weight rapidly and retain water well even at high temperature and pressure (Guan et al., 2017).

It is expected that increasing the water retention behaviour would improve the resistivity behaviour as well. The corrosion behaviour of the kaolinite is also generate to determine the effectiveness as grounding enhance material.

1.2 Problem Statement

There are several factors that governs the performance of earth enhancement material which include not all location is suitable for grounding. Field Emission Scanning Electron Microscopy (FESEM) is one of the used in order to check whether the backfill material is reacted with the clay soil or not.

Bentonite is recognized for its ability to hold water for a significant amount of time, contributing to its application as a backfilling materials (Lim et al., 2013a). Permeability of the earth enhancement material relates to its suction, which is its ability to store water (Nam et al., 2010). But unfortunately, bentonite is not commonly available in Malaysia.

Kaolinite clays is the most commonly found in Malaysia but there are several factors that holds the usage of kaolinite as an alternative material to replace bentonite. It is because some of the kaolinite soil does not show any plasticity characteristic with plasticity indices that varies according to grain size and some of the soil contain low plasticity characteristic which obtain from hydrothermal kaolin deposits where the clay is both coarse and well crystallized. For example the soil can be found in Swaziland, Cornwall and Nigeria (Bain, 1970).

In order to improve the plasticity characteristic of the kaolinite soil some method of applying the Superabsorbent Polymer (SAP) into the soil can be used. This is because SAP is the materials that can absorb and retain huge amounts of water as high as 100% which enhance the plasticity of soil itself. Superabsorbent Polymer (SAP) has been widely used in agriculture since improving the soil to absorb a huge amount of water that can helps plant to grow in stable condition.

1.3 Objective

The objectives of this study are:

1) to establish Water Retention Curve (SWRC) for Kaolinite-Superabsorbent Polymer (SAP) mixtures
2) to determine the resistivity behaviour of Kaolinite – Superabsorbent Polymer (SAP) mixtures
3) to investigate on the corrosion behaviour of earthing electrode induced by Kaolinite – Superabsorbent Polymer (SAP) mixtures.

1.4 Scope of Study

In this study, three different kaolin of kaolin are considered which are S300, FMC and Speswhite kaolin. The soil-water retention curves (SWRC) of these three types of kaolin are established by vapour equilibrium technique (VET) by applying suction from 3.60 to 262.75 MPa. Based on the water content of the SWRC, the electrical resistivity of S300, FMC and Speswhite kaolin were determined by means of Wenner four-point test using soil box. The corrosion of aluminium and copper electrode buried under S300, FMC and Speswhite is also determined using mass-loss method.

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