UNIVERSITI PUTRA MALAYSIA

REDUCTION OF EARTH RESISTANCE BY APPLICATION OF CHEMICAL AND NATURAL MATERIALS

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MASTER OF SCIENCE

ELECTRICAL POWER ENGINEERING

FACULTY OF ENGINEERING

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By

BUBA, SANI DAHIRU

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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DEDICATION

To my Parents for the burden of bringing me up from childhood and also for the moral values and discipline they have instilled in me,

And

To my beloved family

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science

REDUCTION OF EARTH RESISTANCE BY APPLICATION OF CHEMICAL AND NATURAL MATERIALS

By

BUBA, SANI DAHIRU

May 2012

Chair: Wan Fatinhamamah Wan Ahmad, PhD

Faculty: Faculty of Engineering

Earthing systems provide continuous and conductive electrical path to the ground for dissipation of fault currents, lightning transient charges and ensures the safety of humans against contact with energised circuits and systems. Earthing systems also provide a zero signal reference for electronic systems and ensures reliable operation of power system both under normal and fault conditions. Local and international earthing standards have recommended minimum values of earth resistance required for earthing systems to provide adequate protection. However, it is difficult to achieve low earth resistance in ordinary soil conditions due to variation of soil resistivity from one location to the other. Hence, the objective of this study is to determine the performance of chemical and natural materials for reduction of earth resistance of vertically installed earth electrodes.

A combined experiment based on soil enhancement and electrode enhancement was conducted in UPM, Serdang, Selangor, Malaysia (Latitude 2.99^0 N, longitude 101.71^0 E). The experiment based on soil enhancement was installed by driving five earth electrodes made of solid copper into the soil to a depth of 1.4m separated at intervals of 3m from each other. Five circular trenches of dimension 0.2m wide by 0.15m deep were dug around each of the earth electrodes for placement of 10kg each of chemical materials such as sodium chloride, sodium thiosulphate, magnesium chloride, calcium chloride and calcium-magnesium carbonate (dolomite) in separate trenches. The experiment based on electrode enhancement was installed by drilling five holes with dimension of 0.13m diameter and 1.5m deep which were each filled with different natural materials such as palm kernel fibre, kenaf fibre, paddy dust (rice husk), bentonite and Sungai Besar Marine Clay and compacted. Five earth electrodes made of solid copper were driven at the centre of each hole to a depth of 1.4m. Another earth electrode was installed without any enhancement material around it as a reference. All copper earth electrodes used were of similar dimensions of 0.013m diameter and 1.5m length. For all 11 earthing installations, 0.1m length of the earth electrode was allowed above grade for clamping of earth resistance meter. Plastic earth chambers were placed on all earthing installations to serve as inspection boxes. Earth resistance measurement was conducted using 3-point fall of potential method on daily basis for a period of one year using a Megger Digital Earth Tester, model DET3TC.

After 365 days, results of earth resistance measurements indicated that the earth resistances have reduced from their initial values by 78.30%, 74.65%, 68.61%,

64.49%, and 29.16%, for sodium chloride, calcium chloride, magnesium chloride, sodium thiosulphate, and calcium-magnesium carbonate installations, respectively when compared to the reference installation. Similarly, earth resistance for bentonite, palm kernel fibre, Sungai Besar Marine Clay, kenaf fibre and paddy dust (rice husk) installations over the same period have reduced by 56.43%, 34.65%, 17.32%, 16.81% and 2.92%, respectively. It is concluded from the study that chemical materials are a better choice for reduction of earth resistance compared to natural materials.

The cost of installing earthing systems with natural materials is averagely 65% cheaper than earthing systems with chemical materials. In terms of installation technique, earthing systems with chemical materials are easier to install as earthing systems with natural materials require more equipment and operators during the installation process. It is also easier and cheaper to maintain earthing systems with chemical materials. Considering the impact on environment, the study did not reveal any effect from the two installations as the grasses germinated at the same rate and maintained similar colour. The only discolouration of grass that was observed is specifically at water logged spots.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENGURANGAN RINTANGAN BUMI DENGAN MENGGUNAKAN BAHAN KIMIA DAN BAHAN SEMULA JADI

Oleh

BUBA, SANI DAHIRU

Mei 2012

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Sistem pembumian menyediakan laluan elektrik yang berterusan dan konduktif ke tanah untuk pelesapan arus rosak, muatan kilat sementra dan memastikan keselamatan manusia terhadap hubungan dengan litar dan sistem bertenaga. Sistem pembumian juga menyediakan rujukan isyarat nol untuk sistem elektronik dan memastikan operasi sistem kuasa yang dipercayai kedua-dua di bawah normal dan keadaan rosak. Standard pembumian tempatan dan antarabangsa telah mengesyorkan nilai minimum rintangan bumi yang diperlukan untuk sistem pembumian untuk menyediakan perlindungan yang mencukupi. Walau bagaimanapun, adalah sukar untuk mencapai rintangan bumi yang rendah dalam keadaan tanah biasa disebabkan perubahan kerintangan tanah dari satu lokasi ke lokasi yang lain. Seterusnya, objektif kajian ini adalah untuk menentukan prestasi kimia dan bahan-bahan semula jadi untuk mengurangkan rintangan bumi elektrod bumi yang dipasang secara menegak.

Eksperimen gabungan yang berdasarkan peningkatan tanah dan peningkatan elektrod telah dijalankan di UPM, Serdang, Selangor, Malaysia (Latitude 2,990 N, longitud 101,710 E). Eksperimen yang berdasarkan peningkatan tanah telah dipasang dengan memandu lima elektrod bumi yang diperbuat daripada tembaga pepejal ke dalam tanah dengan kedalaman 1.4m yang dipisahkan pada selang 3m dari satu sama lain. Lima parit bulat selebar 0.2m dan sedalam 0.15m digali di sekeliling setiap elektrod bumi untuk menempatkan 10kg setiapnya bahan-bahan kimia seperti natrium klorida, natrium tiosulfat, magnesium klorida, kalsium klorida dan kalsium magnesium karbonat (dolomite) dalam parit yang berasingan. Eksperimen yang berdasarkan peningkatan elektrod dipasang dengan menggerudi lima lubang berdiameter 0.13m dan dalam 1.5m yang masing-masing diisi dengan bahan-bahan semulajadi yang berbeza seperti serat isirong sawit, serat kenaf, habuk padi (sekam padi), bentonit dan tanah liat Sungai Besar Marine dan dipadatkan. Lima elektrod bumi yang diperbuat daripada tembaga pepejal telah dipacu di tengah-tengah setiap lubang dengan kedalaman 1.4m. Satu elektrod bumi lain telah dipasang tanpa sebarang tambahanbahan di sekelilingnya sebagai rujukan. Semua elektrod bumi tembaga yang digunakan adalah sama dimensi dengan diameter 0.013m dan panjang 1.5m. Untuk kesemua 11 pemasangan pembumian, panjang 0.1m elektrod bumi telah dibenarkan di atas gred untuk pengapit meter rintangan bumi. Kotak plastik bumi telah diletakkan di atas semua pepasangan pembumian yang berguna sebagai kotak pemeriksaan. Pengukuran rintangan bumi telah dijalankan pada setiap hari dengan menggunakan 3-mata kejatuhan kaedah berpotensi untuk tempoh satu tahun menggunakan Penguji Megger Digital Bumi, model DET3TC.

Selepas 365 hari, keputusan pengukuran rintangan bumi menunjukkan bahawa rintangan bumi telah dikurangkan daripada nilai awal sebanyak 78.30%, 74.65%, 68.61%, 64.49% dan 29.16%, bagi pemasangan elektrod dengan natrium klorida, kalsium klorida, magnesium klorida, natrium tiosulfat, dan kalsium-magnesium karbonat masing-masing, apabila dibandingkan dengan pemasangan rujukan. Begitu juga, rintangan bumi untuk pemasangan electrod dengan bentonit, serat isirong kelapa sawit Tanah liat Sungai Besar Marine serat kenaf dan habuk padi (sekam padi) dalam tempoh yang sama telah masing-masing dikurangkan sebanyak 56.43%, 34.65%, 17.32%, 16.81% dan 2.92%. Kesimpulan daripada kajian ini didapati bahawa bahan-bahan kimia adalah pilihan yang lebih baik untuk mengurangkan rintangan bumi berbanding dengan bahan semula jadi.

Kos memasang sistem pembumian dengan bahan semulajadi didapati 65% lebih murah secara purata berbanding kos pemasangan sistem pembumian dengan bahan-bahan kimia. Dari segi teknik pemasangan, sistem pembumian dengan bahan-bahan kimia adalah lebih mudah berbanding pemasangan sistem pembumian dengan bahan semulajadi yang memerlukan peralatan dan pengendali semasa proses pemasangan. Ianya juga didapati mudah dan murah untuk mengekalkan sistem pembumian dengan bahan-bahan kimia berbanding bahan-bahan semula jadi. Dengan mengambil kira kesan ke atas alam sekitar, kajian ini tidak mendedahkan apa-apa perbezaan bagi kedua-dua pemasangan. Ini adalah kerana rumput yang tumbuh pada kedua-dua pemasangan adalah pada kadar dan warna yang sama. Perubahan warna pada rumput hanyalah diperhatikan kesan dan bintik log air.

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Approval Sheet 1

I certify that a Thesis Examination Committee has met on (24/5/2012) to conduct the final examination of (Buba, Sani Dahiru) on his thesis entitled "**Reduction of Earth Resistance By Application of Chemical and Natural Materials"** in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the (Master of Science).

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This Thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of **Master of Science.** The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

BUBA, SANI DAHIRU

Date: 24 May 2012

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