UNIVERSITI PUTRA MALAYSIA

DETECTION OF CAVITIES IN KUALA LUMPUR LIMESTONE USING GEO-ELECTROMAGNETIC METHOD

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By

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February 2015

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Cavities in Kuala Lumpur Limestone have been known to have caused problems, such as sinkholes, subsidence, slump zone, and other geohazards. Hence, the main purpose of this study had been to detect cavities in limestone with the application of Geo-Electromagnetic Method using EM 34-3 equipment in Kampung Baru Batu Caves and Kampung Wira Damai. EM 34-3 has the capability to map high conductivity anomalies from a minimum of 7.5 meters to a maximum of 60 meters depth. On top of that, the electrical conductivity could detect the soil or rock material as the electric current can be made to flow through it. Meanwhile, ArcGIS 9.3 Software had been the tool used in this study to produce 2-Dimensional and 3-Dimensional Subsurface Mapping by using Inverse Distance Weighted (IDW) Interpolation technique. In addition, four subsurface mappings were plotted at the depths of 7.5 meters, 15 meters, 30 meters, and 60 meters.

Based on the plotted maps, the presence of cavities was detected in some parts of the study areas. Apart from that, borehole log and resistivity data were used to support the geo-electromagnetic mapping for verification purpose. The results from this study could provide essential information for engineering purpose, as well as to prevent disastrous failures of structures and other related geohazard complications.

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

PENGESANAN RONGGA DI KUALA LUMPUR LIMESTONE MENGGUNAKAN KAEDAH GEO-ELEKTROMAGNETIK

Oleh

MOHAMMAD YUNUS NASIB

Februari 2015

Pengerusi : Prof. Husaini Omar, PhD
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Rongga di Kuala Lumpur Limestone telah dikenalpasti dalam menyebabkan masalah seperti lubang benam, penenggelaman, terhenyak zon, dan lain-lain kebahayaan-geo. Tujuan utama kajian ini adalah untuk mengesan rongga di batu kapur dengan aplikasi Kaedah Geo-Elektromagnetik menggunakan peralatan EM 34-3 di Kampung Baru Batu Caves dan Kampung Wira Damai. EM 34-3 mempunyai kemampuan untuk memeta anomali kekonduksian tinggi pada kedalaman minimum sebanyak 7.5 meter sehingga maksimum 60 meter. Kekonduksian elektrik boleh mengesan jenis tanah atau batuan melalui arus elektrik yang mengalir melaluinya. Tambahan pula, perisisan ArcGIS 9.3 adalah satu alat yang digunakan dalam kajian ini untuk menghasilkan 2 Dimensi dan 3 Dimensi Peta Permukaan Bawah Tanah dengan menggunakan teknik interpolasi Inverse Distance Weighted (IDW). Sebanyak empat peta permukaan bawah tanah telah diplot pada kedalaman 7.5 meter, 15 meter, 30 meter, dan 60 meter.

Berdasarkan peta-peta yang diplot, kehadiran rongga telah dikesan di beberapa bahagian kawasan kajian. Data daripada log lubang gerek dan kerintangan telah digunakan untuk menyokong pemetaan geo-elektromagnetik untuk tujuan pengesahan. Keputusan daripada kajian ini boleh memberi maklumat yang penting bagi tujuan kejuruteraan dan mencegah daripada kegagalan struktur dan kerumitan kebahayaan-geo yang lain.

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I certify that a Thesis Examination Committee has met on 16 February 2015 to conduct the final examination of Mohammad Yunus bin Nasib on his thesis entitled "Detection of Cavities in Kuala Lumpur Limestone using Geo-Electromagnetic Method" 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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LIST OF ABBREVIATIONS

EM	Electromagnetic Method
GIS	Geographic Information System
IT	Information Technology
GPS	Global Positioning System
DGPS	Differentiate Global Positioning System
IDW	Inverse Distance Weighted
2D	Two Dimensional
3D	Three Dimensional
SPT-N	Standard Penetration Test Value
MTD-RC	Mountainous Terrain Development Research Centre
JKR	Jabatan Kerja Raya
YTL Sdn Bhd	Yeoh Tiong Lay Sdn Bhd

CHAPTER 1

INTRODUCTION

1.1 Introduction

Large parts of Kuala Lumpur are underlain by carbonate rocks, such as dolomite and limestone, which are susceptible to solution in our humid climate. Besides, the movement of ground water along the joints and the fractures in these soluble rocks results in solution of the rocks and the development of cavities or openings in the rock. In fact, a prerequisite for subsidence is the presence of underground openings in rocks or unconsolidated materials. On top of that cavities may form naturally or they may be manmade. The most significant cavities in terms of subsidence in Kuala Lumpur are solution cavities in carbonate rock terrains. Karst is an earth feature formed in limestone, marble, gypsum or salt carbonate rocks; showing distinctive landforms arising from a combination of high rock solubility and well-developed secondary porosity (Derek et al., 2007). Karst is a unique landscape feature formed by the underground erosion of limestone by water. Karst landscapes are distinguishable in terms of landforms and hydrology; arising from the solubility of rock and well-developed secondary porosity. Besides, groundwater movement through the joints and the fractures of the carbonate rock is the cause of karst terrain development, cavities, and sinkholes. This kind of circumstance has attributed to geological hazards and has created huge annual costs every year. It is also a potential danger to human life and properties.

Cavity in the limestone bedrock is a major concern to geological and geotechnical engineers. The formation of cavities in the limestone bedrock has been related to the faults and the joints in the limestone and groundwater level. Moreover, cavities are mostly developed within the zone of groundwater level fluctuation and it is reasonable to expect that below the zone of active groundwater fluctuation cavity, formation would be limited (Tan, 1986; Smith et al., 1996). Apart from that, sinkhole is typically cylindrical or conical in shape and varies in depth from 1 to 50 meters and has a diameter from 1 to 100 meters, whereas the term 'subsidence' refers to a shallow 1 to 5 meters depth enclosed depression with a long axis up to a kilometer in length. A sinkhole is potentially more hazardous than subsidence as it usually manifests itself within a matter of time and without prior warning. The primary requirement for a sinkhole to develop is that parts of the dolomitic overburden are mobilized by gravity and/or water seepage into a receptacle that may be present either as a solution cavity within the bedrock or as disseminated openings within the overburden (Swart et al., 2003). Moreover, sinkhole hazard is a source of danger that can be categorized into three elements; risk of personal harm (death, injury disease or stress), risk to property and belongings (damage or economic loss), as well as risk of environmental damage (loss of flora and fauna, pollution or loss of amenity). Therefore, the acceptability of the hazard is a consideration of the degree of risk (Smith et al., 1996; Kovach et al., 1995).

1.2 Problem Statement

Cavities in Kuala Lumpur Limestone are known to have caused problems, such as sinkholes, subsidence, slump zone, and other geohazards. On 2nd July 2014, Malaysian was shocked due to the discovery of a huge sinkhole in the middle of Kuala Lumpur city. The area of the sinkhole was 19m stretch by 10 m depth. Nevertheless, no casualties were reported. This incident posed danger to the nearby buildings, congestion of traffic that caused massive traffic jam in the surrounding areas for almost two weeks, and loss of approximately RM1,000,000.00 for the rehabilitation of public facilities. (http://www.todayonline.com/world/asia/underground-tunnel-collapse-causes-sinkhole-kl). The major sinkhole hazards to civil engineering works had been due to the rapid failures of soil to form dropout or suffusion sinkholes. Instantaneous dropouts are the only karst hazard that frequently causes loss of life, and most soils normally have enough cohesion as arches may develop over growing voids until they collapse catastrophically. Furthermore, most cavities lie at the depths within the limestone where stable compression arches can develop within the roof rock so that they constitute no hazard to normal surface civil engineering works. In fact, sinkholes almost always occurs where cavities develop in unconsolidated deposits; overlying solutions opening in carbonate rocks (Lamoreaux, 1995).

Cavity Other than that, Seng et al., (1995) summarized a number of existing detection methods to detect cavity, such as collecting data using borehole log equipment, resistivity method, microgravity, gravity, and seismic method. These methods have its own advantages and disadvantages for the process of collecting data. Drilling borehole, for instance, is known to have reliable results, but it is very expensive. Meanwhile, the resistivity method is easy to handle, but it cannot be carried out in small area, whereas the microgravity method is not easy to interpret due to ambiguities. Therefore, EM34-3 is capable to replace the existing geophysical method as it is easy to handle in the field and practical in small area. Nonetheless, the output data need a new interpretation method for better and easy understanding. On top of that, the integration between EM 34-3 data and GIS technique had never been carried out for any subsurface mapping previously. Therefore, in this study, a geo-electromagnetic method was carried out using EM 34-3 to detect cavity by using GIS technique and the results were used to produce 2D and 3D subsurface mappings for engineering purpose.

1.3 Specific Objective

The detection and the definition of subsurface cavities are of considerable importance in the field of geological and geotechnical engineering. Cavities may occur naturally, such as those found in karstic terrain or they may be man-made as in the case with old abandoned mines, tunnels or underground nuclear explosion sites. Hence, the main objective of this research was to detect cavities in Kuala Lumpur limestone area using the geo-electromagnetic method. The specific objectives were:

1) to carry out field investigation

2) to analyze the EM 34-3 data

3) to integrate conductivity data and geological information using ArcGIS software

4) to produce 2D and 3D subsurface mappings

1.4 Scope of work

The study involved the development of geo-electromagnetic method, as well as analyses of the conductivity and the resistive properties of cavities in Kuala Lumpur limestone for engineering purposes. The study was carried out in two locations in Batu Caves, namely Kampung Baru Batu Caves and Kampung Wira Damai. The geo-electromagnetic equipment, EM 34-3, was used in this research for collection of data. The data collected were then used to analyze the conductivity and the resistive properties of the cavities to produce a detection and visualization model using the GIS technique. Finally, 2-Dimensional (2D) and 3-Dimensional (3D) maps were produced where cavities and volume of each were shown for usage in the future. The development of this guideline will give a lot of advantages and benefits to the study of the karstic areas. The major expected outcome from the study is a new and effective geo-electromagnetic guideline for detection of cavities in karstic area with the production of 2D and 3D mappings, which can be used to assist engineers, developers, scientists or decision makers in planning and developing these areas in Malaysia.

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