CRACK DETECTION ON RETAINING WALL BY USING THERMAL CAMERA AND IMAGE PROCESSING TECHNIQUE

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

Monitoring on geotechnical structure such as retaining wall, beams and dams is an essential task to retain its serviceability. One of the necessary component to be monitored is the presence of crack. In this paper, the potential of infrared thermography (IRT) as an operational tool for detecting cracks was tested and demonstrated on retaining wall. Two main work phase is employed in this study. First phase is focused on fieldwork which involve capturing the image by using infrared thermal (IRT) camera and digital single lens camera (DSLR). Second phase is focused on image processing technique by using a MATLAB numerical software. Targeted crack sample from the retaining wall have been scratched to observe the deformation of the crack before and after scratching. Analysis of the infrared thermal (IRT) image show that crack stand as cold area (low temperature) with respect to surrounding area. Disturbance of the heat flow allow the thermal camera to detect the presence of crack on retaining wall. Processing of the image extracted allows geometric characterization and direction of propagation of the crack through the wall to be determine. Within limited testing, detection and analysis of cracks is better with the proposed method because it is economical, can reduce time and involve no contacts. This paper presents a preliminary study for further inspection development on retaining wall.

ABSTRAK

Pemantauan terhadap struktur geoteknik seperti dinding penahan tanah, empangan dan juga tiang pengukuh struktur adalah penting bagi memastikan fungsinya untuk mengekalkan kestabilan dapat berjalan lancar. Antara komponen yang perlu diperhatikan pada struktur geoteknik adalah kehadiran retakan. Penggunaan kamera berdasarkan sinar haba inframerah digunakan dan diuji bagi mengesan retakan pada dinding penahan. Terdapat dua fasa kerja dalam kajian ini. Fasa pertama tertumpu pada kajian lapangan di mana gambar struktur dinding penahan akan diambil menggunakan kamera sinar inframerah dan juga kamera digital. Kawasan retakan yang terdapat pada dinding penahan ditoreh bagi menguji dan melihat perbezaan sebelum dan selepas retakan itu dibesarkan. Fasa kedua tertumpu kepada kaedah memproses data dan maklumat yang dikumpulkan. Gambar yang telah ditangkap akan diproses menggunakan perisian MATLab. Keputusan sinar haba inframerah terhadap retakan yang terdapat pada dinding penahan menujukkan kawasan retakan mempunyai suhu yang rendah dan dikategori sebagai kawasan yang sejuk manakala permukaan dinding penahan yang lain menunjukkan suhu yang lebih tinggi dan dikategori sebagai kawasan yang panas. Gangguan terhadap pengaliran haba menyebabkan retakan dapat dikenalpasti. Selain itu, hasi analisis gambar menunjukkan arah retakan dan perubahan yang berlaku pada dinding penahan. Hasil kajian ini membuktikan kaedah berdasarkan sinar haba inframerah dan teknik memproses gambar memudahkan proses mengenalpasti retakan dan mengetahui perubahan yang berlaku pada retakan.Kaedah ini lebih menjimat masa, tidak memerlukan sentuhan dengan subjek yang diuji dan juga lebih ekonomi. Kertas kerja ini merupakan kajian permulaan dalam melakukan pemantauan terhadap dinding penahan.

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LIST OF ABBREVIATIONS

IR	-	Infrared Thermography
DSLR	-	Digital Single Lens Camera
PIV	-	Particle Image Velocimetry
NDT	-	Non Destructive Testing

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

This chapter outline the objectives, methodology and arranged plan for a research project that will be carried out as a partial fulfilment for the Master of Civil Engineering (Geotechnics), University Technology Malaysia. This project will be conducted during second and third semester of 2018/2019 session. The title of the proposed project is "Evaluation of Cracks on Retaining Wall by using Thermal Camera and Image Processing Technique".

Monitoring and maintenance of geotechnical structure such as retaining wall, earth-fill dams and beams is an essential task to retain its serviceability. Mageswari, Divakar & Aravind (2016) stated that it is effective to monitor the structural health of a building, so that the life cycle cost of a building can be reduce from construction to maintenance. One of the necessary component to be monitored is the presence of cracks. This is because a structure will develop cracks whenever the stress in the components exceeds its strength. Traditionally, visual inspection has been done to monitor the cracks on building. However, this method need specialist knowledge and experience, lacks objective and time consuming. Automation of this process was suggested by researchers to increase the productivity, efficiency and also the inspection cycles.

1.2 Problem Statement

Concrete retaining walls are the most common type of geotechnical structures that function to control lateral pressure and resist the back soil or other materials when there is a change in elevation. It is used for stabilizing the slope and provide space at

highway, structures below the ground level and around the building. However in Malaysia, there are quite numbers of issues related to the failure of retaining wall such as on 2017 at Tanjung Bungah, Penang and same year occur at Bangsar, Kuala Lumpur. There are also 8 failures in rapid rail transit works that were related to retaining walls and strutting works and the failures resulted in economic loses and collapsed building (Moh & Hwang, 2007). When concrete retaining wall fail, it will not only cause an extensive damage of the landscape but the price to repair is also costly. Thus, preventive measures or regular inspection need to be taken to prevent this kind of problem to be happen.

To prevent subsequent damage, early detection of growing cracks is one of the major concerns in engineering. Crack usually initiate at the microscopic level on the structure surface. When cracks in these structures are created, the stability may be enforced and causes to defeat. Cracking can be result of one or a combination factors, all of which involve some form of restraint. The factors include drying and shrinkage, thermal contraction or expansion, settlement, differential bearing capacity and stresses from applied force or load. Due to some limitations in manual inspection, automatic crack detection have been suggested to give better analysis. Recently, non-destructive testing (NDT) techniques is proposed as a method in detecting crack such as ultrasonic testing, infrared and thermal testing, laser testing and radiographic testing (Mohan and Poobal, 2017).

Among these technologies, thermography testing is seen as a possible approach in provide an easy visualisation data for crack studies. Thus, the scientific interest of this paper is to apply the infrared (IR) thermography camera in detecting the crack on retaining wall. A thermal camera detects radiation in the infrared range of the electromagnetic spectrum and produces images of that radiation. According to the black body radiation law, all objects emit the infrared radiation with intensity related to their temperatures. The amount of radiation emitted by an object increases with temperature. Therefore, the thermography allows to see the area as variations in temperature of the target objects.

In 2008, thermographic testing has been applied by STARMANS electronic s.r.o in determine crack on square steel bars used in automotive industry. Starman (2008) mentioned that the system show faster inspection times, excellent detection sensitivity and it has ability to detect hidden, subsurface cracks. Besides, Martin et al., (2016) also used thermal images to predict different depth of cracks on steel and the results demonstrate good precision of the method in predict depth values of crack with 15% of maximum deviation. Since thermal camera can be used to inspect the heat loss, it may suitable to be apply in detecting the location of the cracks on the geotechnical engineering structure.

1.3 Research Goal

The aim of this study is to apply the thermal testing method to detect and analyse crack on geotechnical structure.

1.3.1 Research Objectives

The objectives of the research are:

(a) To detect cracks on retaining wall by using infrared thermography method.

(b) To determine displacement and orientation of the cracks on retaining wall by using image processing technique

(c) To establish a thermal model representing temperature distribution of retaining wall with propagation of the cracks.

1.4 Scope of Project

This study was undertaken to capture the retaining wall image by using thermal camera and subsequently processing them using computer to detect and analyse the characterization of crack. Therefore, the scope of this thesis can be summarized as:

(a) Capture the image of retaining wall by using thermal camera and transfer it into the computer to identify the cracks.

(b) Develop suitable image processing technique in classifying and quantifying different type of cracking based on width, length or other properties.

(c) Establish a thermal model of the structure with the surface temperature.

(d) Assessing the performance of the proposed method against existing methods in term of accuracy and practicality.

1.5 Limitations

The research will be limited to :

(a) The distance between the sensor (thermal camera) and the crack.

(b) Weather conditions (light, wind and surrounding temperature).

(c) Time for the data collection.

(d) The location of the structure of study.

1.6 Significance of the project

(a) Propose a two dimensional analysis with both quantitative and qualitative data extraction.

(b) Provide an alternative method in crack detection system, which is viable to be apply in maintenance the geotechnical structure.

Replace the existing manual inspection due to several limitations.

1.7 Thesis Outline

This paper will be consist of five chapters. Presentation of the findings of the present investigation begins in chapter two with a literature review describing the background of study. The type and causes of cracks, the non-destructive methods, existing image processing techniques for crack detection are reviewed. Besides, the theory involved in thermography are also discussed.

Chapter three explains the processes to be followed using the thermal testing technique. In addition, this chapter will describes the image processing developed including, how to detect the cracks and cracking classification. Simple manual method assessments are discussed.

Chapter four present the result obtained from the proposed method. The results are compared and validated using a visual inspection.

Chapter five discusses and concludes the findings of the project. Future work of this topic is also suggested.

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