EXPERIMENTAL STUDY OF ACOUSTIC EMISSION TECHNIQUE FOR CONCRETE DEFECT DETECTION

HEADER ALI A.

UNIVERSITI TEKNOLOGI MALAYSIA

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To Family

"To my beloved family, especially my parents, brothers and sisters for supporting me all the way"

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First of all, gratefulness of thanks to our creator, “ALLAH” for this continuous blessing, which make this work neither the first nor the last.

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ABSTRACT

The process of structural health monitoring (SHM) involves monitoring a structure over a period of time using appropriate sensors, extracting damage sensitive features from the measurements made by the sensors and analysing these features to determine the current state of the structure. Various techniques are available for structural health monitoring of structures and acoustic emission (AE) is one technique that is finding an increasing use. Acoustic emission waves are the stress waves generated by the mechanical deformation of materials. AE waves produced inside a structure can be recorded by means of sensors attached on the surface. Analysis of these recorded signals can locate and assess the extent of damage. This project describes studies on the AE technique for health monitoring of concrete structures. Crack initiation or structural damage will result in wave propagation in solid and this can take place in various forms. Propagation of these waves is likely to be affected by the dimensions, surface properties and shape of the specimen. This, in turn, will affect source localization. Various laboratory test results will be presented on source localization, using pencil lead break tests. The results from the tests can be expected to aid in enhancement of knowledge of acoustic emission process and development of effective concrete structure diagnostics system.

ABSTRAK

Proses pemantauan kesihatan struktur (SHM) melibatkan pemantauan struktur dalam tempoh masa dengan menggunakan sensor yang sesuai, mengekstrak ciri-ciri sensitif kerosakan dari ukuran yang dibuat oleh sensor dan menganalisis ciri-ciri ini untuk menentukan keadaan semasa struktur. Pelbagai teknik boleh didapati untuk pemantauan kesihatan struktur bagi struktur dan pancaran akustik (AE) adalah salah satu teknik yang semakin meningkat penggunaannya. Gelombang pancaran akustik adalah gelombang tegasan yang dihasilkan oleh perubahan bentuk mekanikal bahan. Gelombang AE yang dikeluarkan dalam struktur boleh dirakam melalui sensor yang dipasang di permukaan. Analisis isyarat yang direkodkan ini boleh mengesan dan menilai tahap kerosakan. Projek ini menerangkan kajian tentang teknik AE untuk pemantauan kesihatan struktur konkrit. Permulaan retak atau kerosakan struktur akan menyebabkan perambatan gelombang dalam pepejal dan ini boleh berlaku dalam pelbagai bentuk. Perambatan gelombang ini berkemungkinan terjejas oleh dimensi, ciri-ciri permukaan dan bentuk spesimen. Ini seterusnya, akan memberi kesan kepada penyetempatan sumber. Pelbagai keputusan ujian makmal akan dibentangkan tentang penyetempatan sumber, dengan menggunakan ujian patah mata pensil. Keputusan dari ujian boleh dijangkakan untuk membantu dalam peningkatan pengetahuan proses pancaran akustik dan pembangunan sistem diagnostik struktur konkrit yang berkesan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The Nondestructive testing (NDT) techniques were widely applied to detect the internal situation of materials and structures. The link between physics and other applied sciences promote the development of the NDT techniques. When it comes to the classifications of the NDT techniques, they include but are not limited to acoustic emission technique, infrared/thermal testing, visual inspection, penetrating testing, magnetic particle testing, electromagnetic or eddy current testing, radiography, and ultrasonic testing.

All of these non-destructive testing approaches can work individually; however, more efficiently if multiple NDTs are employed in the meantime. It is favorable to apply the NDT techniques into heavy industry like power plants, aerospace and aircraft industry, leakage detection of pipelines, damage inspection of dams, construction and maintenance of bridge structure, to name a few (Shiotani, Aggelis *et al.*, 2007). This research principally discussed the utilizations of the Acoustic Emission (AE) technique in concrete damage detection.

Once the elastic wave is generated, it then travels throughout the material and can be detected at considerable distances from its point of origin. Traveling from its source to the point of detection, the wave is subjected to all the characteristics and variations of its acoustic path. Its energy is attenuated by geometric spreading and scattering by both microscopic and macroscopic variations in the material's structure.

Other kinds of attenuations may also be present. The wave's frequency content is generated by the source and modified as it travels the acoustic path. The primary information carried by the wave is the time of arrival and the elastic energy detected at each sensor on the structure. The excitation of a sensor indicates that something happened in the specimen at a specific time, while the amplitude indicates the level of the disturbance. The apparent location of the source and all other characteristics of the detected signal are modified by the characteristics of the wave's path to each sensor as well as the characteristics the sensor. As a result, in a highly controlled laboratory experiment, a reasonable estimate can be made of the characteristics of the emission source; however, in a test on an actual structure, we are limited to what are basically statistical estimates from multiple emissions to tell us what is happening in the specimen. Statistical analysis is not generally used in the study of acoustic emissions, but the state of the specimen and the location coordinates of the sources are inferred from averages of calculated values from multiple emissions.

1.2 Problem Statement

The loss of signal amplitude when AE signals transmit through the material. It is a common phenomenon, which has been witnessed in the AE technique test. The amplitude of AE signals will decline rapidly in the material with high attenuation. Attenuation dampens a stress wave as the wave front propagates away from its source and spreads over a larger volume. Attenuation of a stress wave in an infinite medium causes the wave amplitude to decrease proportional to the distance from the wave source.

The concrete has unique characteristics due to heterogeneity, porosity and presence of cracks. Besides internal damping, AE waves travelling in concrete members undergo reflection, scattering, mode conversion and diffraction, all of which influence the propagation of stress waves. Wave attenuation limits sensor distance, which, in turn, limits the area that can be accurately monitored by a lead

pencil test. Therefore, attenuation is considered as having the major influence on the accuracy of data collected from concrete members.

1.3 Objectives of Study

1. To investigate the reliability and performance of acoustic emission technique that used to localization the active defects in a concrete plane.
2. To prevent wave signal attenuation which effect on the acoustic emission system.

1.4 Scope of Study

1. Experiment the range that can be measured using the defined AE sensor.
2. Test the localization capability of the defined AE sensor in concrete.
3. Analysis the data using Matlab programming.

1.5 Thesis Organization

This thesis consists of five chapters summarized as follows:

Chapter two: presents the literature review about the acoustic emission in term of the experimental methods.

Chapter three: describes the methodology that has been used to predict the damage location using acoustic emission technique.

Chapter four: provides the results of the process for the experiment speed sound through the concrete experiment signal wave attenuation and damage source location, where the damage location with exact damage position then with calculated damage position.

Chapter five: summarizes the conclusion of the work and the recommendations for the future works.

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