

Lecture Notes in Electrical Engineering 921

Norhaliza Abdul Wahab
Zaharuddin Mohamed *Editors*

Control, Instrumentation and Mechatronics: Theory and Practice

 Springer

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Preface

The 3rd International Conference on Control, Instrumentation and Mechatronics Engineering, CIM 2022 is organized by the School of Electrical Engineering, Universiti Teknologi Malaysia and supported by the Malaysian Simulation Society (MSS) and Malaysian Society for Automatic Control Engineer (MACE). The 1st and 2nd CIM have traditionally been held physically. However, the COVID-19 pandemic affects the lives and activities of many people, and this has made it necessary to organize the 3rd CIM 2022 as an online event.

The CIM 2022 conference provides a platform for knowledge-sharing and research activities in Control, Instrumentation and Mechatronics. The conference aims to bring together researchers, building a strong networking and research collaboration in the listed areas. In bringing CIM 2022 into reality, the organizing committee have made an enormous effort to maximize opportunities for our virtual discussions. Our technical program is rich and varied with five technical sessions providing key research topics in realizing Industry 4.0 vision. CIM 2022 technical program also strives for prestige by inviting distinguished speakers who are expert in their fields. We have one keynote speech and two invited speeches from three different countries, together with 73 technical papers. Furthermore, the high impact of CIM is also ensured through the spread of authors from different parts of Malaysia, as well as from other countries.

The success of the conference depends ultimately on the hard work, support and dedication of numbers of parties, who have worked with us in planning and organizing both the technical program and supporting social arrangements that make CIM 2022 a successful online event. The organizing committee have been working throughout the year to make the conference successful. Recognition should go to all CIM 2022 committee members who have all worked extremely hard for the details of important aspects of the conference programs and social activities, virtually. Special thanks to the Ministry of Science, Technology and Innovation (MOSTI) for the support and to our sponsors, SYNAPSE, MSS, AR Mechatronics, DF Automations & Robotics, JEOL and Worldbay Network System and, last but not least, to all the submitters and reviewers who are the backbone of this conference.

This Lecture Notes in Electrical Engineering entitled Control, Instrumentation and Mechatronics: Theory and Practice is a compilation of all the accepted and presented papers at CIM 2022. All the papers were peer reviewed by a minimum of two reviewers from different institutions to ensure the quality of the papers. The conference received 135 paper submissions, and only 73 papers were accepted after the review process. The articles published in this proceeding are divided into three parts which are Mechatronics (22 articles), Control Systems (27 articles) and Measurement and Instrumentation (24 articles).

We hope that the proceeding will benefit readers, in particular, researchers, academicians and practitioners in the area of Control Engineering, Mechatronics and Instrumentation.

Thank you.

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A Study on the Arrival Time of Ultrasonic Waves in Concrete Material

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Abstract. Concrete is one of the most critical materials being used in construction project. Ultrasonic testing is a conventional non-destructive test method, that is adopted to evaluate the condition and quality of concrete structure. This is important to ensure the strength and resilience of built structures. This paper aims to assess the arrival time of the ultrasonic waves in concrete structure by employing ultrasonic through-transmission method. A simulation study was performed in COMSOL Multiphysics software. Data were collected and structured into three sections, including in homogenous concrete model, as well as concrete model with inclusion of air voids and cracks. This study investigates the influence of size of air voids and position of cracks on the arrival time of the received ultrasonic signal. The waves diffraction at the defects increase the arrival time of the received signal.

Keywords: Arrival time · Concrete · Through-transmission · Ultrasonic

1 Introduction

Concrete is mainly composed of Portland cement and aggregates (gravel, sand, or rock) that mixed together with water to form a workable paste that solidifies and hardens over time. It is the most reliable manmade material which has been extensively used in the construction, such as buildings, roads, bridges, dams, and other structures. It is used to provide strength, durability, and versatility during the construction process [1]. However, concrete may degrade over time due to various reasons, including mechanical overloading, high-temperature exposure, environmental factors, deicing salts

application, and freeze-thaw cycles [2–4]. These factors can then lead to major flaws in concrete, including fine cracks and concrete voids. Therefore, the assessment of concrete structures is very important to determine their quality as well as provide assurance that the structures are structurally safe and fit.

For practical reasons, researchers focus on developing non-destructive testing (NDT) for the fast and economical assessment of a concrete structure with better accuracy, efficiency, and sensitivity to internal damage [5]. NDT refers to a set of inspection techniques on a material, system, or component, without destroying or permanently altering their surface or internal structure [6]. It is conducted to detect defects and variations in structures, as well as the presence of cracks and other physical discontinuities that may contribute to the loss of structure strength. NDT is carried out by using several methods considering the type of materials to be tested, the type of flaws, and the position of the occurring defects [7].

Ultrasonic testing is an NDT technique that employs the use of sound energy to identify changes in materials' properties. This technique requires the use of high range frequency to be emitted into the material. The principle of ultrasonic testing is based on the detection and analysis of received ultrasonic waves or their signal at the receiver [8]. It is possible to locate defects in all type of materials, by employing either straight line or angle beam testing technique. Ultrasonic testing is widely used for evaluation and defect detection in concrete structures. Karaiskos et al. [9] introduced an embedded aggregate-size piezoelectric transducers to monitor the hydration process of the new *in situ* concrete structures. On the other hand, Bui et al. [10] presented an ultrasonic travel time shift to evaluate distributed cracks in concrete. This technique used high frequency elastic wave to probe the tested concrete, while low frequency wave was used to disturb it to create a time delay. From the study, time shift technique is much sensitive and able to detect the initiation and growth of cracks in the concrete. A new technique known as Recurrence Plot Quantification Analysis (RQA) has been proposed by Carrion et al. [11] for characterizing concrete damage. RQA quantifies the non-coherent ultrasonic waves generated by the echoes from the edges and faces of tested specimen, as well as the scattering effects caused by aggregates. Slonski et al. [12] conducted a study on concrete-defect detection by combining ultrasonic tomography technique and convolutional neural network. The results showed promising agreement between both techniques with very high accuracy obtained in detecting defects.

Pulse echo, through-transmission and resonance, are the three basic techniques adopted in ultrasonic testing. The main objective of this paper, therefore, to evaluate the arrival time of ultrasonic waves in concrete structure by employing the ultrasonic through-transmission method. The influence of size of air void and position of crack on the arrival time of ultrasonic wave were studied.

2 Ultrasonic Through-Transmission Method

Ultrasonic through-transmission method is adopted to detect and locate voids, honeycombing, cracks, delaminations, and other failures in concrete. It can also be used to evaluate the condition and quality of metal, stone, masonry and ceramics [13]. This

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