

**MEASUREMENTS OF ELECTROMAGNETIC PROPERTIES  
OF CEMENT CONCRETE FOR NONDESTRUCTIVE  
EVALUATION AT MICROWAVE FREQUENCIES**

This thesis is presented in partial fulfillment for the award of the  
Bachelor in Electrical Engineering (Hons) of  
INSTITUT TEKNOLOGI MARA



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**APRIL 1998**

*Buku ini adalah milik*

## ABSTRACT

Electromagnetic properties such as complex permittivities of concrete are a functions of moisture content, fequency, temperature and concrete mix constituents. By using an appropriate model ( e.g. effective medium theory ), it is possible to determine the moisture content from dielectric measurements of dry and wet specimens of concrete. A fre-space microwave measurement system will be used for reflection coefficient measurements of metal-backed specimens in the frequency range of 7.5 - 14.5 GHz. Complex permittivities of concrete specimens will be determined from reflection coefficient values using two minima method and infinite sample method. The key components of the measurements system are a pair of spot-focusing horn lens antennas, mode transition, coaxial cables and microwave network analyzer. The inaccuracies in dielectric measurements using this set up is due to diffraction effects at the edges of the specimens and the multiple reflection between two horns.

The spot-focusing horn lens antenna are used for minimizing diffraction effects and free-space LRL ( line, reflect and line ) calibration method eliminates errors due to multiple refelctions. Complex permittivities and moisture contents is reported for cement concrete specimens of grades 25, 30, 40 and 50. These grades have different values of water to cement ratio and concrete mix constituents. We have calculated moisture content of cement concretesamples using dielectric mixture theory.

## **ACKNOWLEDGEMENT**

In the name of ALLAH, the Beneficent and the Merciful, it is the deepest sense of gratitude to the Al-Mighty ALLAH who gives strength and ability to complete this project as it is today.

I would like to take this opportunity to express my most gratitude to my project supervisor, Dr. Deepak Kumar Ghodgaonkar for his guidance, assistance, advice and effort in completing my project.

My gratitude also goes to, Prof. Wan Mahmood bin Wan Abdul Majid for their support, and cooperation.

I also would like to express my special thanks to staff of Schools of Civil and Mechanical Engineering, technicians of Material Science lab, and also staff of CADEM Centre for their full cooperation.

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# CHAPTER 1

## 1.0 INTRODUCTION

The term microwaves is used to define all electromagnetic radiation waves whose frequencies lie between 0.3 and 300 GHz. These frequencies correspond to a range of free-space wavelengths in vacuum from one meter to one millimeter. Microwaves travel at the velocity of light,  $c$  in vacuum or air[1].

$$c = 2.997 \times 10^8 \text{ m/s} \quad (1)$$

Microwaves are commonly used in our daily lives. In recent years, microwaves are being used in communication links generally referred to as a microwave links. Telephone and communication circuits use microwaves relay stations to transmit signals over distances of many miles. Microwave is also used in space communication and radio astronomy. To a much lesser degree, microwaves are used for non-destructive testing. Electromagnetic waves are used to nondestructively evaluate properties of materials. Nondestructive evaluation of material has shown to be a valuable science which has produced probes and methods by which flaws, cracks, defects and voids[3].