Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 115 (2017) 779–785

Procedia Computer Science

www.elsevier.com/locate/procedia

7th International Conference on Advances in Computing & Communications, ICACC-2017, 22-24 August 2017, Cochin, India

Microwave Reflectometry Study for Quality Monitoring of Asphalt Concrete

Dilip Mhaske, Sabarish Narayanan B*

Department of Electronics and Communication Engineering
Amrita School of Engineering, Coimbatore
Amrita Vishwa Vidyapeetham, Amrita University, India

Abstract

This paper proposes a system for classifying asphalt concrete (AC), based on the amount of asphalt binder used while preparing the concrete. ACs are classified using non-destructive, non-contact testing in laboratory on specimens of rectangular shape, which should be extended to test asphalt roads at highway speed. The testing utilizes reflected EM waves from the specimen in a laboratory setup consisting of EM source, waveguide and EM power measurement devices. The results of the laboratory testing on two AC specimens, a good specimen and a bad specimen, are discussed to conclude a possibility for quality monitoring of AC.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Advances in Computing & Communications.

Keywords: NDT, asphalt quality, permittivity, reflection coefficient

1. Introduction

Non-destructive techniques, hereafter referred to as NDT, is a wide group of analysis techniques used in science and industry to evaluate properties of a material, component or system without causing any physical damage. In destructive testing, the material is broken in order to determine mechanical properties such as strength, toughness and

* Corresponding author. Tel.: +91-422-2685721; fax: +91-422-2656274.
E-mail address: nb_sabarish@cb.amrita.edu

1877-0509
Peer-review under responsibility of the scientific committee of the 7th International Conference on Advances in Computing & Communications
10.1016/j.procs.2017.09.173

hardness. It becomes difficult to perform the conventional destructive testing if the system being tested is in service e.g. coring process for testing asphalt roads [1].

Ground penetrating radar (or GPR for short) is a non-destructive testing technique of non-metallic structure and it has been widely applied in engineering and environment surveys. GPR technique has been used for measurement of thickness of road surfaces and it can be used to make out assessment to the quality of concrete structure [2]. On condition that the concrete of road surface is symmetrical in thickness, the EM reflections from a road surface are essentially due the quality of the concrete. Currently available NDT methods including GPR assess quality of concrete of existing roads focusing mainly to detect unevenness of the road and to locate inhomogeneous concrete mixtures. This paper attempts to assess quality of AC before it is made into pavement. The objective is to identify asphalt mixtures with desired proportion of binder and aggregates, and to discard the unsuitable mixtures.

Rest of the paper is organized as follows. Section 2 explains AC and the desired properties of it. Section 3 describes previous work by other researchers for evaluating quality of AC using permittivity measurement technique. Section 4 mentions principle of the quality estimation of AC using microwaves. Sections 5 explains specimen and setup preparation for the experiment. In the end, results are presented in graphical format to conclude possibility of a NDT for quality estimation of asphalt mixtures. Type of microwave antenna suitable for the purpose of distinguishing AC based on asphalt content is investigated and mentioned as a conclusion.

2. Background

Asphalt is essentially a solid material at room temperature but a viscous fluid at elevated temperatures. It is equivalent to cement in RCC (reinforced cement concrete); it is referred to as bitumen in India and most Asian countries, and more commonly as asphalt in USA and Europe. Bitumen, a key ingredient for AC, acts as the binder holding aggregates such as crushed rock and pebbles together in pavements. The aggregate mixture for paving is produced by a method commonly known as hot-mix method (HMA – hot mixed asphalt) or SUPERPAVE (superior performing asphalt pavement) method, wherein a heated asphalt is mixed to produce a hot flowing composition.

AC is composed of suitably graded aggregates and the hard grade asphalt to form a coherent, void less, impermeable mass. The mixture is brought to sufficient temperature to be spread by means of float in manual construction [3]. It is required that the prepared mixture be stable yet flexible, durable, impermeable, fatigue resistant, skid resistant and workable. These requirements are affected by binder content, void content, viscosity of binder and aggregate properties. It is ensured that the mixture meets these requirements by specifying –

- minimum/maximum binder content
- minimum/maximum void content
- aggregate physical properties
- grading curve
- binder properties before and after ageing.

This paper focuses on binder and void content in AC. Also we attempt to address effect of aging on AC in laboratory situations. The aggregate physical properties, grading curve and binder chemical properties are currently not in the scope of the study.

Aggregate effective density, which is a measure of quality of AC, is not directly measurable in laboratory. Instead, it is calculated by knowing the maximum theoretical density of an AC and the asphalt content. Also voids filled with asphalt (VFA) affect the effective density of AC [4].

For a quality pavement, sufficient binder is necessary for coating the aggregates to provide adhesion. If it is low, the mixture becomes lean causing durability issues like fatigue cracking and raveling. If it is high, it acts as lubricant and reduces particle-to-particle contact between aggregates hampering the stability [5]. Also it is necessary to have just enough asphalt to provide flexibility to the concrete. Stability and flexibility are two conflicting properties to have at the same time. So, it is not always possible to optimize all the required properties of AC, and some compromises are made [6]. It is therefore, important to analyze and estimate quality of an asphalt mixture before it is made into pavement. The paper studies reflections of electromagnetic waves from a known good specimen of asphalt mixture and concludes quality of other specimens by comparing reflections with that of good samples.