Dielectric modeling of cementitious specimens using an open-ended coaxial probe in the frequency range of 1 GHz to 4.5 GHz

Jones Owusu-Twumasi and Tzuyang Yu
Department of Civil and Environmental Engineering
University of Massachusetts Lowell
One University Avenue, Lowell, MA 01854, U.S.A.

ABSTRACT

Modeling the dielectric properties of cementitious materials (e.g., cement paste, concrete) is important to the success of nondestructive evaluation (NDE) of civil engineering infrastructure using electromagnetic sensors. Information regarding material composition, aging, cracking, and chemical deterioration of cementitious materials can jointly affect the dielectric properties of the material. Reliable and accurate condition assessment of concrete structures using electromagnetic sensors cannot be achieved without the capability and knowledge of dielectric modeling of cementitious materials. Among existing dielectric measurement techniques, open-ended coaxial probe is convenient for in-situ measurement and superior for field applications than other techniques. Nonetheless, quality of coaxial probe measurements is dependent on the contact condition between the probe and the specimen. In this paper, our measurement and modeling efforts on the dielectric properties of cementitious specimens using an open-ended coaxial probe in the microwave frequency range (0.5 4.5 GHz) are reported. Fluctuation of dielectric data curves (dielectric constant and loss factor) due to the contact condition between the probe and the specimen was investigated using frequency analysis. It is found that the presence of surface pores/cavities can introduce high frequency noises into the measured dielectric data curves.

Keywords: : Dielectric dispersion, cementitious composites, frequency, water-to-cement ratio

1. INTRODUCTION

2. SPECIMEN DESCRIPTION

(*The following needs to be revised. -TY*)

Twelve 1ft-by-1ft-by-1in hydrated cement paste (hcp) (Portland cement Type I/II plus water) panels with six water-to-cement (w/c) ratios (0.35, 0.40, 0.42, 0.45, 0.50, and 0.55; by weight) were manufactured, moist-cured for 28 days and conditioned in two different environments (room temperature and oven dried). In the room temperature environment, six hcp panels were conditioned at a temperature of 23°C and 50% RH (relative humidity) for seven days, while the other six hcp panels were oven dried at a temperature of 110°C and 0%RH. Plexiglass molds were used in casting the hcp panels to ensure a smooth surface for the accurate measurement of the coaxial probe. Fig. 1 shows the twelve hcp panels. Hcp panels are denoted by their w/c ratio and conditioning environment. For example, CP35rt is a hcp panel of w/c = 0.35 conditioned in room temperature and CP50od is an oven dried hcp panel of w/c = 0.50. (*Need a table to describe the design of specimens. -TY*)

3. EXPERIMENTAL SYSTEM

Contact dielectric measurements of hcp specimens were conducted by using an open-ended coaxial probe system and a series network analyzer (Agilent E5071C) in the frequency range of 0.5GHz to 4.5GHz. Fig 2 shows the experimental setup of the measurement system and the dimensions of hcp panels. Contact dielectric measurements were calibrated by a E-cal module and using reference materials (water and perfect electric conductor) before each measurement. Relative, complex permittivity (dielectric constant ϵ_r' and loss factor ϵ_r'') was converted from the S11 measurement using the Agilent 85071E Material Measurement software.

Further author information: (Send correspondence to T. Yu)
E-mail: tzuyang_yu@UML.EDU, Telephone: 1 617 230 7402

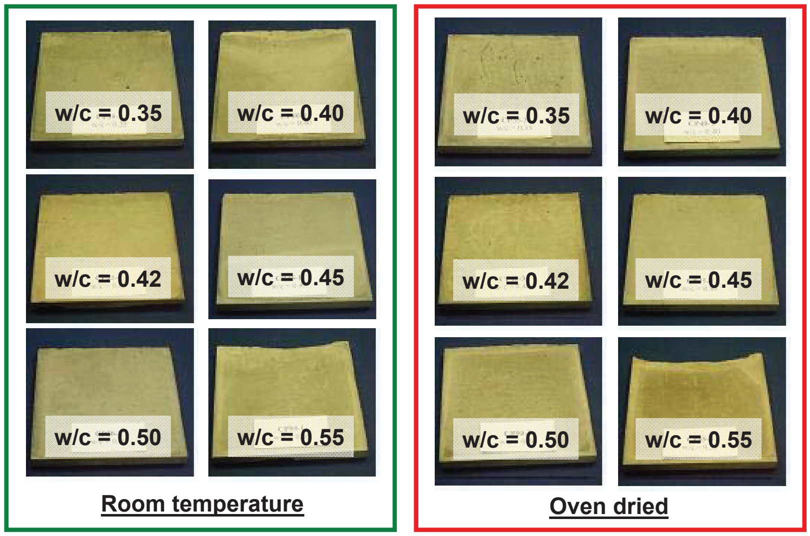

Figure 1. Manufactured and conditioned hcp panels

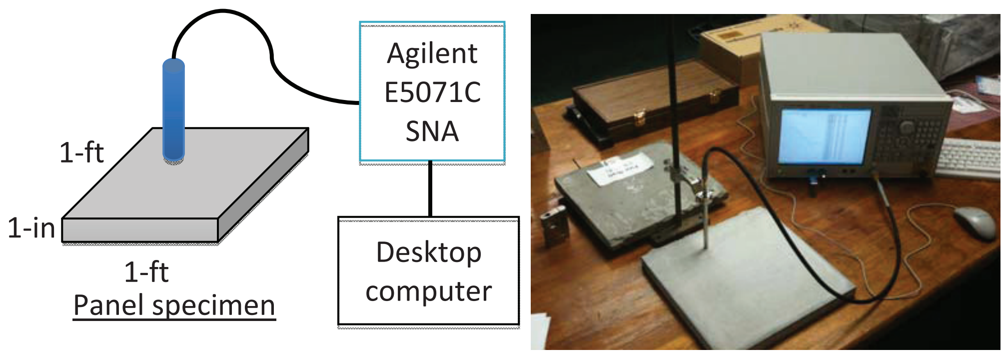

Figure 2. Contact dielectric measurement system and dimensions of hcp panels

4.

5. SUMMARY

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