Moisture Measurement for Green Civil Engineering Materials Using Dielectric Spectroscopy

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Abstract. A dielectric spectroscopy approach is proposed to characterize the moisture in new materials used for green civil engineering. The method relies on reflectometry measurements using an open ended coaxial probe. We report preliminary dielectric spectroscopy characterization of Hempcrete, a material used as an insulator and a moisture regulator in green buildings, carried out over the 30 MHz – 3GHz frequency range for samples featuring different moisture content levels.

Keywords. Dielectric spectroscopy, civil engineering materials, open ended probe

1. Introduction

Non destructive evaluation (NDE) of moisture in civil engineering materials such as concrete is useful either at early stage of construction or for ageing works, since moisture is a key element involved cracks generation. NDE of moisture may also be useful regarding new materials like Hempcrete which is used as an insulator and a moisture regulator in green buildings. Electromagnetic methods are good candidates for moisture characterization since the dielectric permittivity of porous materials is greatly influenced by moisture. In this paper we propose a dielectric spectroscopy approach relying on reflectometry measurements [1], which may represent a suitable alternative to time domain reflectometry (TDR) [2], as far as NDE is concerned. Indeed, thanks to the use of an open ended coaxial probe to be simply put in contact with the material to characterize, the method is non invasive, conversely to measurements implementing TDR probes.

We report preliminary broadband reflectometry measurements carried out over the 30 MHz – 3GHz frequency range for Hempcretes featuring different moistures.

2. Dielectric spectroscopy based on reflectometry measurements

The experimental set-up proposed to characterize moisture in materials such as Hempcrete (Figure 1) implements an open ended coaxial probe based on an N type RF connector put in contact with the sample to characterize, and a vector network analyzer

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(VNA) (Anritsu MS2026C) connected to the probe via a coaxial cable. The VNA enables measuring the probe input reflexion coefficient (i.e. the S_{11} scattering parameter), provided calibration of the attenuation and phase shift in the cable.

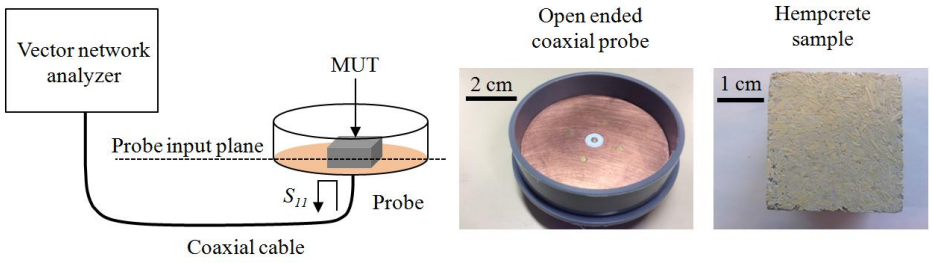

Figure 1. (a) Dielectric spectroscopy experimental set-up.

Preliminary measurements have been carried out over the 30 MHz – 3 GHz frequency range with a view to verify the sensitivity of the experimental NDE approach to moisture variations in Hempcrete. So far, two samples have been tested, which featured R_H water relative humidities of 50% and 100% respectively (Figure 2), the temperature being set at 296 K.

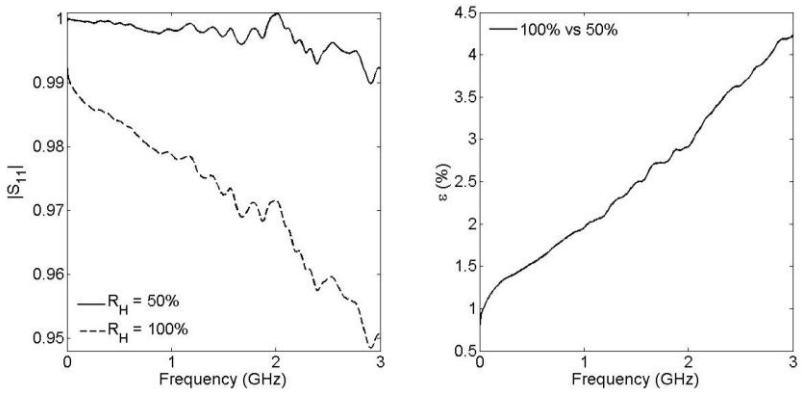

Figure 2. Measured probe $|S_{11}|$ parameter for Hempcrete samples featuring 50% and 100% R_H respectively and relative absolute error $\varepsilon = \left|\left|S_{11}^{R_H 100\%}\right| - \left|S_{11}^{R_H 50\%}\right|\right| / \left|S_{11}^{R_H 50\%}\right|$.

Conclusions

The obtained preliminary experimental results show that the moisture influences the probe input signal which lets the proposed experimental approach to be envisaged with NDE of new green civil engineering materials in view. To confirm this point, the next step of the study will consist in dielectric spectroscopy experiments involving Hempcrete samples featuring a variety of water contents at different temperatures, thanks to appropriate conditioning.

References

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