SUBSURFACE DAMAGE DETECTION OF A MULTI-LAYER LOSSY MEDIUM USING SIMULATED MONOSTATIC GPR RESPONSES

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ABSTRACT

Detecting subsurface damages in multi-layer lossy media has been an important topic in the application of GPR (ground penetrating radar) on civil infrastructure systems such as bridges and roadways. In these systems, the presence of subsurface damages including interlayer delaminations, air voids, and material cracking can result in a premature failure of the systems and, thus, must be inspected and removed for the safety of the systems. Multi-layer, lossy, dispersive media are usually encountered when modeling construction materials (e.g., concrete) in bridges and roadways. Attenuation of radar signals is expected in the wave transmission and scattering in lossy media, leading to the reduction of damage detectability of GPR, especially in the case of monostatic operation.

The objective of this paper is to study the effects of material properties (complex permittivity), damage features (geometry, location), and signal frequency on the damage detectability of monostatic GPR using FDTD (finite difference time domain) methods. Dielectric half-space, two-dimensional dispersive models are considered, along with the use of TE (transverse electric) plane waves at 1 GHz, 5 GHz, and 10 GHz. Lorentz-medium model is applied in modeling the material dispersion. Dimensionless indices (dielectric contrast ratio and loss contrast ratio) are defined in order to investigate the influence of surface layer on the detectability of a subsurface, artificial damage. Artificial damages are modeled by a rectangular air void which is characterized by void geometry and embedment depth in this paper. Simulated transient responses are generated, and near-field reflections are analyzed. An example layout of the considered research problem is provided in Figure 1.

From the simulated results it is found that the presence of a surface layer reduces the amplitude of reflected signals representing the presence of subsurface damages, owing to the loss of

reflection energy at the surface layer. Higher loss contrast ratios can result in lower detectability values, while higher dielectric contrast ratios of damage can lead to higher detectability values. In the meantime, the increase of embedment depths reduces damage detectability, especially in the presence of dielectric loss.

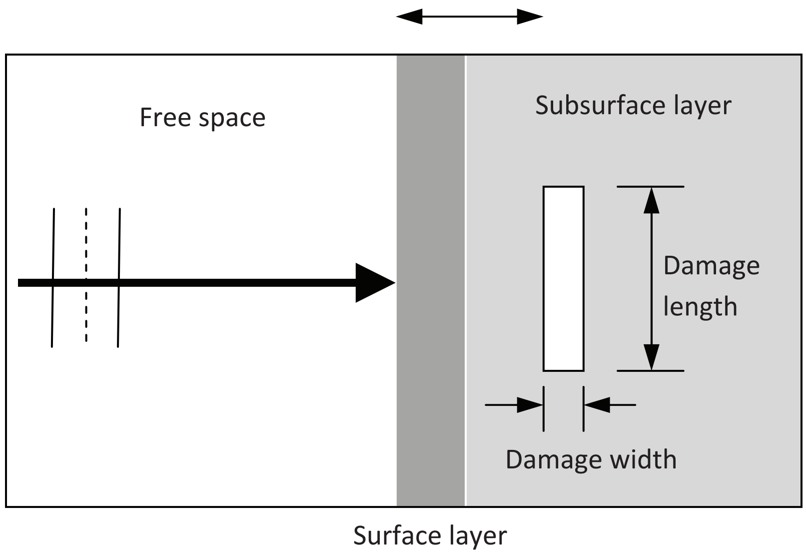

Figure 1. Layout of the 2D FDTD domain

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