Geophysical Research Abstracts
Vol. 18, EGU2016-18496-1, 2016
EGU General Assembly 2016

Calibration Methods for Air Coupled Antennas - COST Action TU1208

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This work focuses on the comparison of different methods for calibrating air coupled antennas: Coring, Surface Reflection Method (SRM) and Common Mid-Point (CMP) through the analysis of GPR data collected in a test site with different pavement solutions. Research activities have been carried out during a Short Term Scientific Mission (STSM) funded by the COST (European Cooperation in Science and Technology) Action TU1208 "Civil Engineering Applications of Ground Penetrating Radar" in December 2015.

The use of GPR in transport infrastructures represents one of the most significant advances for obtaining continuous data along the road, with the advantage of operation at traffic speed and being a non-destructive technique. Its main application has been the evaluation of layer thickness.

For the determination of layer thickness, it is necessary to know the velocity of the signal, which depends on the dielectric constant of the material, and the two-way travel time of the reflected signal that is recorded by the GPR system. The calculation of the dielectric value of the materials can be done using different approaches such as: using fixed values based on experience, laboratory determination of dielectric values, applying the SRM, performing back calculation from ground truth references such as cores and test pits, or using the CMP method.

The problem with using ground truth is that it is time consuming, labour intensive and intrusive to traffic, in addition, a drill core is not necessarily representative of the whole surveyed area. Regarding the surface reflection technique, one of the problems is that it only measures the dielectric value from the layer surface and not from the whole layer.

Recent works already started to address some of these challenges proposing new approaches for GPR layer thickness measurements using multiple antennas to calculate the average dielectric value of the asphalt layer, taking advantage of significant hardware improvements in GPR resolution and accuracy.

For this work, three experimental sections were tested with variable thickness of the asphalt layer. For each cell, two parallel survey lines were tested and two control points were defined for each profile.

Two pairs of air-coupled bistatic antennas with central frequencies of 1.0 GHz and 1.8 GHz were employed in the tests. The GPR data was acquired with both frequencies along the survey lines in a dynamic mode and also in static mode over the control points. After the GPR survey, drill cores were extracted at the control points in order to obtain real thickness data for the bituminous layer. This approach allowed obtaining the back calculation of the dielectric constant for asphalt.

For GPR calibration with the SRM, the dielectric constant was calculated comparing the amplitude from the pavement surface with the amplitude from a metal plate reflection, collected for each cell using a metal plate above the pavement surface acting as a perfect reflector of the GPR signals.

Using the CMP method, both antennas were simultaneously moved apart on either side of each control point and the velocity of propagation was calculated adjusting the hyperbolas of the reflection on the bottom of the bituminous layer. Prior to the hyperbola fitting, the start time for the GPR data was corrected based on the velocity of the waves in the air measured in the surface reflection.

The main results obtained so far and the comparison between the different calibration methods are presented in this study.

Acknowledgement

The Authors would like to thank COST for funding the Action TU1208 "Civil Engineering Applications of Ground Penetrating Radar" and supporting this STSM.