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Investigation of mechanical properties of pavement through electromagnetic techniques

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Ground-penetrating radar (GPR) is considered as one of the most flexible geophysical tools that can be effectively and efficiently used in many different applications. In the field of pavement engineering, GPR can cover a wide range of uses, spanning from physical to geometrical inspections of pavements. Traditionally, such inferred information are integrated with mechanical measurements from other traditional (e.g. plate bearing test) or non-destructive (e.g. falling weight deflectometer) techniques, thereby resulting, respectively, in time-consuming and low-significant measurements, or in a high use of technological resources. In this regard, the new challenge of retrieving mechanical properties of road pavements and materials from electromagnetic measurements could represent a further step towards a greater saving of economic resources.

As far as concerns unpaved and bound layers it is well-known that strength and deformation properties are mostly affected, respectively, by inter-particle friction and cohesion of soil particles and aggregates, and by bitumen adhesion, whose variability is expressed by the Young modulus of elasticity. In that respect, by assuming a relationship between electromagnetic response (e.g. signal amplitudes) and bulk density of materials, a reasonable correlation between mechanical and electric properties of substructure is therefore expected.

In such framework, a pulse GPR system with ground-coupled antennae, 600 MHz and 1600 MHz centre frequencies was used over a 4-m×30-m test site composed by a flexible pavement structure. The horizontal sampling resolution amounted to 2.4×10-2 m. A square regular grid mesh of 836 nodes with a 0.40-m spacing between the GPR acquisition tracks was surveyed.

Accordingly, a light falling weight deflectometer (LFWD) was used for measuring the elastic modulus of pavement at each node. The setup of such instrument consisted of a 10-kg falling mass and a 100-mm loading plate so that the influence domain of the elasticity measure could be comparable to that of the radar signal. Good agreement were found between high Young modulus values and repaved zones, whereas damaged areas were characterized by lower values of E.

Tomographic maps of amplitudes along the z axis were extracted up to a depth of z <200 mm, consistent with the depth domain of the LFWD, and some values on the nodes were randomly selected and thus related to the corresponding elastic modulus both for calibration and validation of the model.

Comparison between predicted and measured elastic modulus showed relatively good results. Percentage errors ranging from -44% and +34% demonstrated an overall underestimate of the model with respect to the real truth. Future research activities could be addressed towards an improvement of the model by calibrating in laboratory environment under controlled conditions, and by using different GPR centre frequencies of investigation.

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