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Investigation of antenna frequency impact on assessing voids of asphalt pavements using GPR

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Ground Penetrating Radar (GPR) is a Non Destructive Testing (NDT) technique that has been developed and improved upon over the past 30 years. The technique is frequently utilized in order to evaluate and assess pavement structures. GPR, for pavement evaluation purposes, can be described as a remote sensing system that emits a short pulse, of electromagnetic energy, into the pavement, with a central frequency varying from 10 MHz up to 2.5GHz. The two most commonly utilized setups are air-coupled and ground-coupled antenna systems. For air-coupled systems, the antennas are suspended above the pavement surface and can operate at normal traffic speeds (up to $\sim$ 80 Km/h). The major drawback of the air-coupled antenna is that penetration depth is limited. On the other hand, for ground-coupled systems the antennas are in direct contact with the pavement surface, providing for better signal penetration into the pavement structure; however ground coupled systems can achieve only limited operational speeds. As a generalized rule, increasing the GPR central operating frequency, increases the investigation resolution, while decreasing the overall depth of investigation

In the light of the above, air-coupled systems have become increasingly popular for the evaluation of the part of the pavement structure, especially for the asphalt layers, while ground-coupled systems are utilized mostly in order to gather information from the entire pavement structure (up to $\sim$ 3 m depth). The majority of GPR pavement studies are carried out with air-coupled horn antennas, as they can be implemented at driving speeds without need for road closures. For instance, the 1 GHz air-coupled horn antenna is commonly used for the estimation of pavement layer thickness. However signals generated by horn antenna systems must have sufficient quality to allow the performance of automated signal processing and qualitative data analysis, especially when pavement data more sensitive to the analysis parameters, such voids or moisture, is concerned.

The implementation of the horn antenna method is dependent upon, amongst others, the resolution of the antenna in use. The present research work investigates the application of the GPR sensor technique to assess voids within the asphalt layers, with a focus on the air-coupled antenna penetration depth and resolution. For this purpose the dielectric properties of asphalt layer materials were estimated and related voids contents were evaluated based on data collected by an air-coupled GPR system, operating at a 1 GHz and alternatively a 2 GHz central frequency. The collected data is analyzed comparatively for the two antennas. Comparison results indicate differences between the voids determined from the 1 GHz and 2GHz antennas. These differences are further analyzed and evaluated for pavement quality control purposes. The indication of a relationship between the measured voids is also evaluated, while ground truth data is used for the validation of the GPR data analysis results. The above is presented and discussed thoroughly with the aim to assist pavement quality assurance systems