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Density measurements of road overlays samples with nuclear gauges and a Step Frequency Radar

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The density of Hot-Mix Asphalt layers (HMA) and thin overlays is an important parameter for the pavement quality and its long time performance. In the laboratory, the density could be measured with nuclear gauges based on the gamma rays absorption through cores samples drilled from the pavement. However, it is a destructive testing. For in-place control, the density could be measured with nuclear gauges based on the back-scattered gamma rays. But it is limited to overlays thickness greater than 3 cm. For both cases, nuclear gauges require specific training and certification for users. The use of a nuclear source (generally Cesium 137) is a major constraint for transportation and is a threat for operator safety.

This work proposes a laboratory density measurement with an electromagnetic method, the Step Frequency Radar developped in our institute (Fauchard et al, 2009). It is based on the same physical principle than the Ground Penetrating Radar, but the used frequencies allow the study of very thin asphalt overlays less than 3 cm and the possible non-destructive measurement of in-place density with high performance. For this study, the dimensions of the device are designed to measure the density of slab samples (40*60*8 cm) in laboratory. The results are compared to the nuclear density measurement used in French Labs.

Three kinds of slabs are implemented with four various degrees of compaction (88, 90, 92 and 94%) according to the French norm. Their composition is known and differs mainly with the nature of the aggregates (basalt, quartzite and limestone) that represent the main part of the mix materials. Then the permittivity of the samples is measured according to the reflected waves on surface and bottom slabs. A Complex Refractive Index Model gives the measured permittivity of the tested mix as a function of the compaction and the content, permittiviy and density of each component (filler, aggregates and bitumen). The obtained density is very closed to the density measured by nuclear gauges. Nevertheless, the dimensions of slabs limit the results to a small surface compared to the nuclear results and improvements are needed to adapt the method to cylindrical cores samples. These two drawbacks are not encountered on roads and we currently carry out some experiments for in-place density measurement with the Step Frequency Radar.

Fauchard C., Li B., Mazari B., "Estimation of compaction of bituminous mixtures at microwave frequencies", NDTCE'09, Nantes, France, Juillet 2009