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Non–destructive assessment of Hot Mix Asphalt density with a Step Frequency Radar – Case study

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The density of Hot Mix Asphalt (HMA) layers is a key parameter for assessing newly paved roads. It allows the quality control and ensures the time performance of the road layers. The standard methods for measuring the in-place HMA density are destructive and based on cores testing. Knowing the specific gravity of the HMA (data provided by builder), the bulk density can be determined in the laboratory either by weighting cores methods or by measuring the absorption ratio of gamma rays through road samples.
Non destructive (ND) methods are highly needed in order to gain time and to avoid the strong constraints due to the nuclear gauges use. The Step Frequency Radar (SFR) is an electromagnetic method based on wave propagation in matter, similar in its principle to the Ground Penetrating Radar (GPR). It can use wide band and higher frequencies than GPR, allowing a thinner spatial resolution, but with a lower speed of acquisition. It is used in the present work as a tool providing the dielectric constant of HMA. Recent results in the laboratory have shown that the density can be relied on HMA dielectric constant with the use of a dielectric model (Complex Refractive Index model, or CRI model) taking into account the volume concentration and the dielectric constant of each HMA component. In this approach, the knowledge of the rock dielectric constant that composes the main part of HMA is required. If not, the in-place measurements can be calibrated according to one or more core drillings and the previous approach is still available.
The main objective of this paper is to apply the methodology developed in the laboratory on a new HMA layer (case study located on A13 highway, nearby the city of Cagny, Normandie, France) for assessing the HMA density. The SFR system is composed of a vector network analyser sweeping a large frequency band [1.4 GHz – 20 GHz] and an ultra wide band antenna placed above the HMA surface. The whole system is pc-controlled and embedded in a vehicle allowing 0.5 m step measurement at 5 km/h speed. Then, the dielectric constant is calculated and the density is estimated via the CRI model. Compared with lab experiment, improvements were achieved by taking into account the antenna trembling due to vehicle displacement during the survey. Results are compared with standard nuclear test. These measurements show that ND electromagnetic method based on wave propagation can assess HMA density with a high output. The main advantage is that the SFR system safely provides density assessment as accurate as nuclear methods.