Elastic wave propagation of ultrasound in bituminous road surfaces – simulations and measurements

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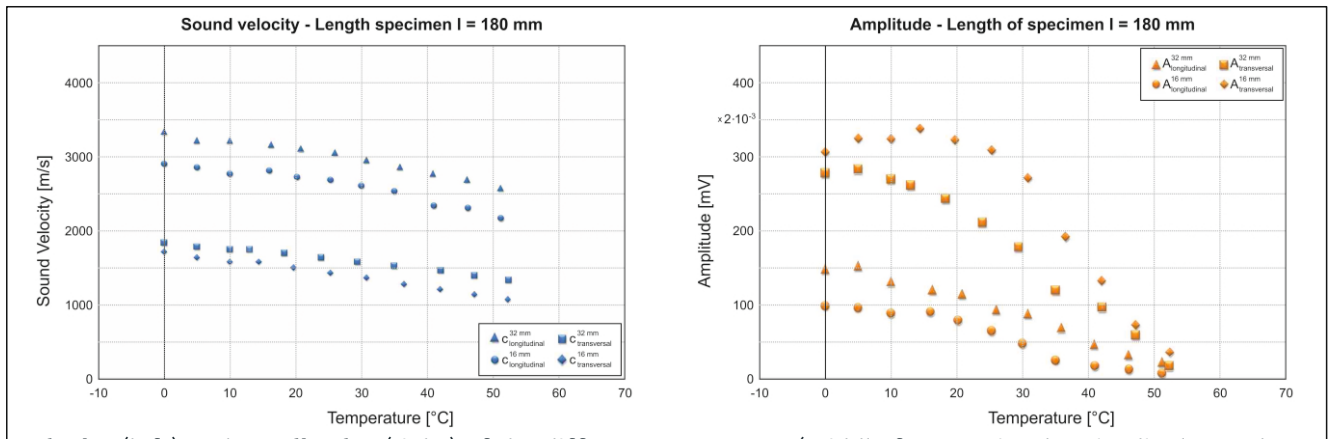
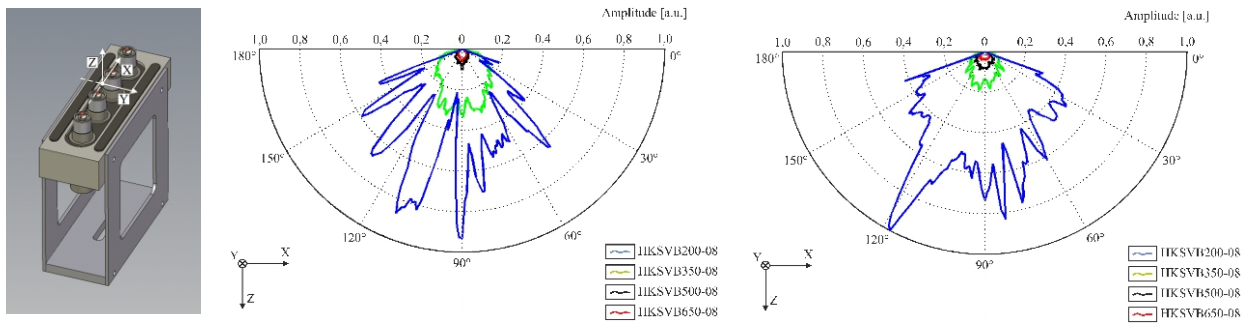
Introduction

Maintenance costs of road infrastructure are increasing steadily. Adverse environmental impacts on infrastructure get more and more important as well. Therefore, it is important to determine how limited financial resources can be directed with an optimum pay-out. The present study takes first steps towards the usage of low-frequency ultrasound as a tool to evaluate the road condition.



Velocity (left) and **amplitudes** (right) of the different wave types (Middle frequencies: longitudinal - 100 kHz, transversal - 50 kHz) in relation to **material temperature** [1]



Ultrasonic array comprised of **4 single probes** (left) **Directivity pattern** for longitudinal (middle) and transversal (right) excitation on bituminous specimens with different radii [1]

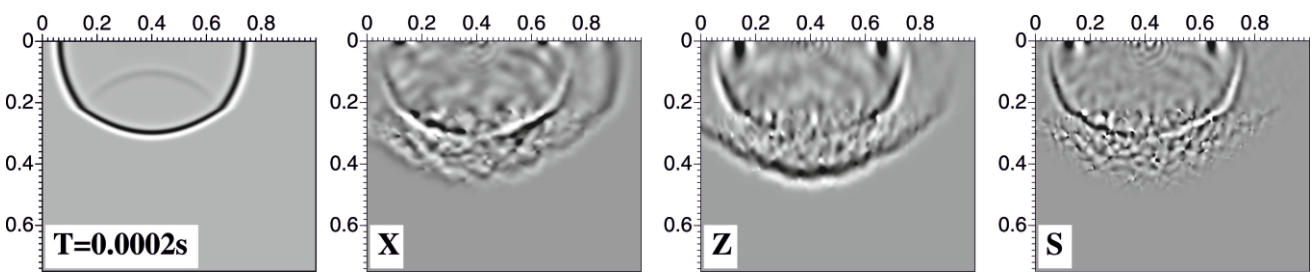
Labratory investigations

Simulations of elastic wave propagation require elastic material models of the velocities of longitudinal and transversal waves and of the density. Apart from differences in material composition the temperature dependence of the material is most important. In a first step the propagation times of four asphalt specimen with different compositions were determined. The temperature in a climatic chamber has been increased from 0° C in steps of 5° C up to 50 °C. The **temperature**-dependent **velocities** and **amplitudes** of longitudinal and transversal waves are presesented in diagrams on left. Besides the material parameters the geometry of the wave field radiation is important. The **polar diagrams of directivity patterns** for used **probes** on different specimens are shown.

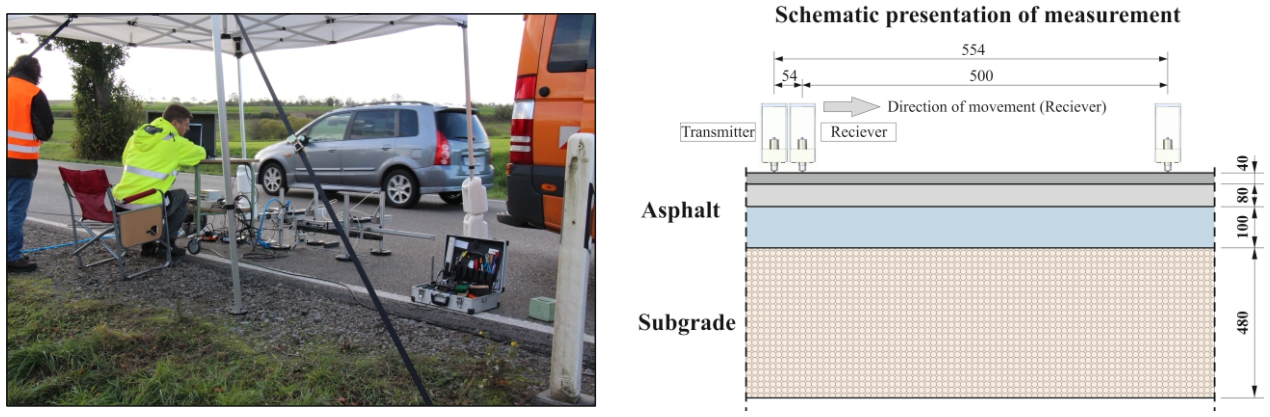
Data analysis and comparative simulations

In order to better understand the recorded wave fields and to interpret the observed events it is very useful to perform simulations of wave propagation. A Snapshot of **wave propagation** after 200 µs for **isotropic homogeneous** layers and of simulations through the **granular 2-D model** with the different components are shown.

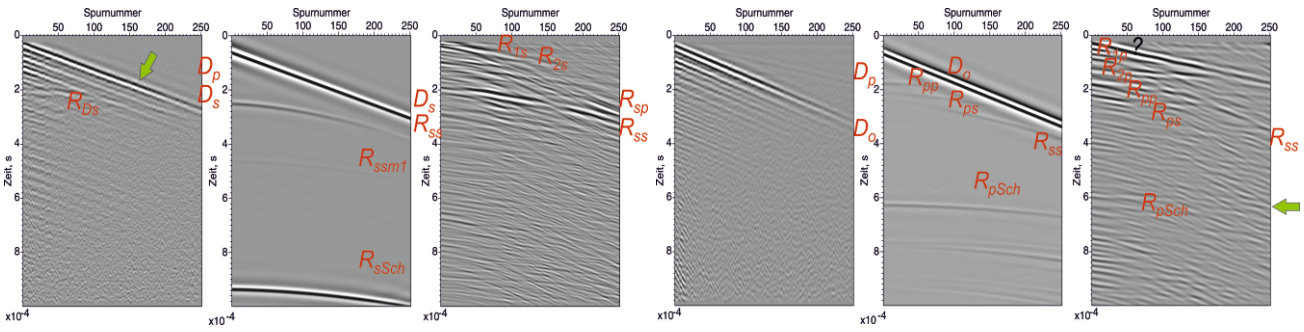
In studying the snapshots and the corresponding synthetic time-space records it is possible to interpret the **measurement results** from the **highway B35** in detail and to annotate certain events. Shown are filtered **raw data** from the field test after **longitudinal** (left) and **transversal** (right) excitation of the probes, the corresponding **simulation result** (center) and the **final processed** shot record (right). Note that the simulation is based on a simplified model with a homogeneous asphalt body.



A snapshot of the simulation in **isotropic homogeneous** (left, horizontal x-component) and in the **granular 2-D model** (right) after 200 µs. In the granular model are shown the horizontal x-component, the vertical z-component and the shear component [1].



Schematic presentation of road structure with different layers and of the **measuring procedure** (right). Measurement on **highway B35** near Illingen (Germany) with the automatic scanner system [1] (left).



Filtered **raw data** from the field test after **transversal** (right side) and **longitudinal** (left side) excitation of the probes (left in figures), the corresponding **simulation result** (center) and the final **processed shot record** (right) [1].

Reference

[1] Kneib, G., Maack, S., Forschungsbericht: Innovative zerstörungsfreie Untersuchungen des Schichtaufbaus von Straßen, Bundesanstalt für Straßenwesen (BASt), FE04.0267/2012/BRB (in print, german)

Acknowledgements

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