Mechanical Characterization of Asphalt Concrete for Pavements with Reduced Transport Emissions

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This project is in extension of the project Innoenergi, run by the Danish Road Directorate (DRD), concerning itself on mainly the reduction of rolling resistance and thus CO_2 reduction, as the tested asphalt mixtures derive from here. The project has been done in collaboration with the Danish Road Directorate.

Currently most pavement models operate with linear elastic models while asphalt is not an linear elastic material. Asphalt is a viscoelastic plastic material that behaves differently under changing load scenarios and temperatures. In the work done in this project, a test method for obtaining material functional properties were found. Properties which may be used for future linear viscoelastic calculations in pavement design, reflecting the physical responses in asphalt pavements.
This, and helping to test asphalt material that may help reduce CO_2 emissions, is the motivation and background for this project.

In the project, a cyclic uniaxial compressive test was conducted on cylindrical asphalt concrete (AC) specimens. The results were analysed and the characteristic parameters of the response functions were determined. Results were then used in further analysis where influences of especially void contents and polymer modification of bitumen in the AC mixtures, were related to the representative response functions.
The AC specimens were created from AC mixtures, which had been previously developed by the DRD (Danish Road Directorate) in a process of developing AC wearing course materials that will help reduce transport emissions of noise and CO_2 related pavement surfaces. In this project, two mixtures designed for low Rolling Resistance, two mixtures designed for reduced noise emissions, along with a reference mixture, will be investigated.
The first AC property determined in the mechanical characterization was the Creep Compliance. The Creep Compliance is a property that describes the relationship between time dependent strain and applied stress in viscoelastic materials. The test involved in the determination of the Creep Compliance was a non-destructive uniaxial compressive test, which was called Creep and Recovery test. In the test all deformations, which the AC specimens were exerted to, were kept in the linear viscoelastic (LVE) range. During the test the strain deformation and applied force was measured.
The cycles in the test were of the form of load-unload-rest, where the rest period was made long enough to ensure a strain recovery in the specimens that would show which parts of the total strain that was recoverable and which parts that were permanent. Other tests, such as a Static Creep Test, does not allow for this. Here the recoverable and permanent strain components are enveloped in a total strain where there are no rest periods and thus no recovery periods.
From this uniaxial Creep and Recovery test the parameters for a modified power law representation of the Creep Compliance was determined, by fitting numerical representations of theoretical constitutive equations for the elastic and viscous strain components (the recoverable and permanent strain) to the measured strain data. This meant that it was possible to arrive at Creep Compliance parameters that had been derived while taking regards of permanent deformations.
Once one of the material response functions has been determined, it is possible to determine the remaining response functions by interconversion. The interconversion method used was a numerical approach based on Prony series as introduced by (Park & Schapery, 1999).
The material response functions determined from the interconversion method were the Relaxation Modulus and the Dynamic Modulus. The Phase Angle was also found.