Doctoral Dissertation
Doctoral Program in Civil Engineering (34^{th}cycle)

A novel methodology for the evaluation of low temperature failure properties of asphalt binders

The Monotonic Torsional Loading (MTL) test

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Politecnico di Torino
2022

Declaration

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2022

* This dissertation is presented in partial fulfillment of the requirements for **Ph.D. degree** in the Graduate School of Politecnico di Torino (ScuDo).

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Low temperature cracking represents one of the main distress modes affecting flexible pavements, particularly in cold regions. Thermally induced stresses arise inside the mixture, when the temperature decreases, leading the pavement structure to prematurely fail, when exceed the mixture strength. The asphalt binder plays a key role in controlling and preventing the crack initiation and propagation, since its response can change from a ductile to an extremely brittle one, within the temperature range the pavement experiences during its service life. Therefore, a proper selection of the binder, considering low temperature cracking resistance, represents a critical issue to consider for the mix design of the mixtures. The SuperPave Performance Grade (PG), developed during the Strategic Highway Research Project (SHRP), is one of the most used parameter to address low temperature cracking performance of binders. However, the methodology may not be always reliable to represent the materials field performance, in particular for the increasingly new modified binders. In such context, there is the need of a simple and reliable procedure to address the binders failure properties at low temperatures, both in terms of strength and brittleness. A novel methodology, involving the use of the DSR, is proposed in this thesis. The use of the DSR has been limited to high and intermediate temperatures during the SHRP project, due to the arise of significant compliance errors for low temperatures. This limitation was recently overcome for linear viscoelastic measurements by the introduction of a new measurement system of 4 mm diameter. The Monotonic Torsional Loading (MTL) test proposed in this research project aims to extend the use of the 4 mm DSR to the high strain domain, leading the specimen to its failure point. A cylindrical specimen, designed to be higher than the standard geometry to reduce the torsional stiffness, is subjected to a torsional load, which increases monotonically at a fixed strain rate until failure, while the temperature is kept constant. A simple parameter was proposed to synthetically characterize each material in terms of brittleness, for a selected combination of temperature and strain rate, allowing to determine a representative cracking temperature. The methodology developed was successfully applied to characterize a set of unaged binders, three unmodified and one SBS-modified. The same materials were, subsequently, characterized through the Local Fracture Test (LFT) methodology, which involves subjecting a thin film of asphalt binder placed between two steel protuberances to a tensile load, applying a constant displacement rate, until failure. The LFT results were compared to the MTL results, showing that the two procedures lead to the same results in terms of materials ranking for thermal cracking performance. Even though further investigations on the proposed protocol are certainly needed, it appears to be a promising methodology to characterize binders at low temperatures through easy and short laboratory testing.