Flow behavior of asphalt mixtures under compaction

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Abstract

Asphalt compaction is one of the most important phases of road construction, being the decisive phase when the structure of the asphalt pavement layer is formed. In spite of its importance, the knowledge about this construction phase is still based on empirical and technological background and therefore surprisingly limited. This lack of knowledge is also due to the fact that the existing laboratory scale compaction devices for mix design are not fully capable of simulating the field compaction. The simulation of asphalt compaction in the laboratory is normally focused on the vertical rearrangements of asphalt particles whereas the flow behavior of these particles in other directions is mostly neglected. However, existing literature suggests that the neglected flow is one of the most important factors for the quality of the road construction, particularly in special cases such as asphalt joints. Therefore, building up a better understanding of the flow behavior of asphalt mixtures subjected to compaction loads is needed for improving the quality of the pavements.

In this study, a new test setup, the so called Compaction Flow Test (CFT), was developed to simulate the flow behavior of asphalt mixtures at early stages of compaction. In the first step, feasibility tests were performed, substituting asphalt mixtures by model materials with simple geometries and less complex properties. X-ray Computed Tomography (CT) was utilized for capturing 2D radiography images of the flow patterns in the model material during the test. Results of the CFT showed the capability of the new test setup to clearly distinguish between model mixtures with different characteristics. Hence, in the next step, the CFT was applied to real asphalt mixtures and the obtained results were found to support the findings of the feasibility tests with the model materials.

The results from the feasibility tests encouraged examining the possible use of an ultrasonic sensor as alternative to the complex and costly X-ray imaging for flow measurements during the CFT. Hence, the CFT was used along with a distance measuring ultrasonic sensor for testing asphalt mixtures with different characteristics. The test results confirmed that an ultrasonic sensor could be effective for capturing the differences of the flow behavior of asphalt mixtures tested by the CFT.

In addition, a parametric study with the X-ray setup was carried out to examine the capability of the CFT in reflecting the possible changes of the flow behavior in asphalt mixtures due to the change of construction parameters such as lift thickness, bottom roughness and compaction modes. The results obtained also confirmed the capability of the CFT in showing the possible differences in the flow behavior of the mixtures under the chosen conditions.

The encouraging results suggested that the CFT may have potential to become a simple but effective tool for assessing compactability of the mixtures on-site, right after production in an asphalt plant or before placing the mixture on the road. Hence, discrete element method (DEM) was utilized to understand both the influence of selected boundaries of the CFT and the effect of its design on the results.

As one specific example of application, an investigation was carried out using the CFT to find the most suitable tracking method for flow measurements in the field. Based on the literature review and feasibility tests, a tracking method with the highest potential for conducting flow measurements during field compaction was introduced. X-ray radiography confirmed the validity of the results obtained with the suggested method.

The overall results obtained from this study suggest that the recommended CFT along with the suggested field tracking method may be helpful in building up a comprehensive basis of knowledge on the flow and compaction behavior of asphalt mixtures thus helping to close the gap between the field and laboratory.

Key words: Asphalt compaction, Asphalt joint, Laboratory production, Discrete Element Method (DEM), X-ray radiography, Compaction Flow Test (CFT), Compactability