Doctoral Dissertation
Doctoral Program in Civil and Environmental Engineering (36th Cycle)

Workability of Asphalt Mixtures

Advanced Analogical Modeling and Development of an Innovative Testing Method

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SUMMARY

Densification curves obtained from the gyratory shear compactor (GSC) can be interpreted to extract synthetic parameters and indices related to the compaction process of asphalt mixtures. In particular, information can be obtained with respect to workability and compactability, regarded as crucial properties that affect pavement construction and field performance. In the study described in this thesis, following the explicit definition of workability and compactability, a comprehensive review of the methods and equipment for evaluating asphalt mixture workability are provided. An extensive experimental plan was designed, and tests were performed to examine different materials and to assess the effect on compaction of several properties. Based on the results obtained in the experimental campaign, the impact of trial compaction agents was investigated, and raw compaction data were extracted for modeling purpose.
An innovative analogical model is proposed to simulate the densification process of asphalt mixtures, incorporating densifier and delayer elements. The model is fitted to experimental data pertaining to 20 different dense-graded asphalt mixtures prepared in the laboratory to systematically assess the effects of binder type, binder content, binder viscosity, compaction temperature, maximum aggregate size, and aggregate particle size distribution. This model was also fitted to a wider GSC compaction database, which included 45 additional mixtures of the standard and non-standard type, containing reclaimed asphalt, fibers and plastic shreds. It was observed that the proposed model mimics the GSC compaction process with a high degree of accuracy and allows the identification of the different phases of densification associated with specific physical phenomena.

Furthermore, parameters and indices derived from the model can highlight the effects associated with changes of the explored variables and are in good agreement with other indices proposed in the literature to quantify workability and compactability. Given that the model is relatively simple and of straightforward implementation, the outcomes of the study suggest that its use may be included in the procedures adopted for the mix design and quality control / quality assurance (QC/QA) of asphalt mixtures. In particular, the newly proposed workability and

compactability indices can be jointly considered for the identification of asphalt mixtures which combine ease of construction with the achievement, in the compacted state, of a stable internal structure that prevents excessive densification. The final phase of investigation introduced an innovative method for evaluating the workability of asphalt mixtures. In this method, the force required to extrude material from a designed opening is considered as an alternative parameter to examine workability. To implement this approach, a laboratory-scale device was manufactured which simulates the process which materials go through in a paver machine. To assess the feasibility of the proposed method, this device was tested in three different scenarios in which obtained results matched with physical expectations. The correlation observed between recorded values of extrusion force values and other established indices confirms the potential of employing this method for workability evaluation.