SPECIAL PROVISIONS FOR INTELLIGENT COMPACTION OF STABILIZED SUBGRADES

OVERVIEW: Improper compaction during construction is one of the leading causes for the early deterioration of asphalt pavements. Current quality control techniques used during construction are time-consuming and typically test less than 1% of the constructed pavement. Intelligent Compaction (IC) of soil and asphalt mixes is an innovative approach that has been utilized to achieve uniform, adequate compaction of pavement layers during construction, with real-time knowledge of the level of compaction achieved. The Federal Highway Administration (FHWA) has drafted Generic IC specifications for soils and asphalt pavements to facilitate the early adoption of this technology. These generic specifications are expected to serve as guidance to individual state Departments of Transportation (DOTs) in the development of specifications relevant to the respective states.

CURRENT RESEARCH: In this study, the researchers from the University of Oklahoma (OU) worked with the Oklahoma Department of Transportation (ODOT) to develop and validate “Special Provisions” for the use of IC rollers during compaction of stabilized subgrades. The Intelligent Compaction Analyzer (ICA) was developed in previous projects based on the hypothesis that the vibratory roller and underlying layer form a coupled system. Vibration features are extracted from the field data and used to predict the level of compaction using a trained neural network. Different components of the ICA integrated vibratory roller used during the compaction of a stabilized subgrade are shown in Figure 1.

In the ICA system, an accelerometer is mounted on the frame of the roller to record the vibrations of the roller during compaction. These vibrations are processed in real-time using signal processing techniques to determine the harmonics. These harmonics are then used to estimate the density or modulus of the material being compacted using a trained neural network. Global positioning system (GPS) receivers are used to record the spatial location of the roller at each instant. These readings provide as-built maps showing process information such as number of roller passes, roller path, and density or modulus to the operator, in real-time.

This project produced specifications (“Special Provisions”) for the intelligent compaction of stabilized subgrades that address IC rollers, GPS and data recording, Quality Control Plan, IC calibration and verification procedures, establishment of target IC-MV, and statistical acceptance testing and verification of IC-MV values reported at test locations. The specifications also address the verification of adequate site preparation prior to the construction.

The specifications were validated, reviewed, and modified through two different field projects. The research team in collaboration with ODOT identified two suitable field projects on Highway 9 and US-77 in Norman, Oklahoma. Virgin soil samples were collected from the job sites and brought to the OU Broce laboratory for testing. The stabilizers used in the Highway 9 project were cement kiln dust (CKD) and lime. The properties of the virgin soil and stabilized soil samples were studied in the laboratory. Required tests as indicated in the draft IC specifications were conducted for characterizing the modified soil mixture prior to the compaction. The subgrade soil was stabilized by mixing 12% CKD and 2.75% Lime to a depth of 200 mm (8 inches) in the field. The optimum moisture content (OMC) and maximum dry density (MDD) of the stabilized soil were found to be 13.1% and 17.6 kN/m³, respectively.
To validate the IC specifications, comparisons were made between the resilient modulus obtained from the regression models based on laboratory test data and ICA calibrated resilient modulus (Figure 2). It was not possible to conduct resilient modulus tests for every single variation in moisture content and dry density. Therefore, a separate regression model was developed for the resilient modulus as described in the developed specifications. The regression model was helpful in predicting the equivalent resilient moduli at different points in the field as a function of moisture content and dry density (within a specified margin of error). As shown in Figure 3, a good correlation was observed between the laboratory-measured resilient modulus and the IC-calibrated modulus. The R-squared value was higher than 0.65.

Figure 2: Comparison of NDG and ICA Field Results

Figure 3: Correlation between ICA and Lab Results

These results indicate the effectiveness of the developed specifications in compaction of soil subgrade pavement layers.

IMPACT: Intelligent Compaction is expected to result in the construction of higher quality and longer lasting pavements. This project led to development of specifications that are expected to help facilitate implementation of this technology.

About the Researchers
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