JOINT TRANSPORTATION RESEARCH PROGRAM

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Intelligent Compaction of Asphalt Pavement Implementation

Introduction

Asphalt pavement performance is affected by the quality of pavement structure, material, and construction. Hot mix asphalt (HMA) should be constructed with appropriate in-place density and impermeability to moisture, which affects the long-term performance.

Material-related measurements for the pay factors include binder content, air voids at N_{des} , and voids in mineral aggregate (VMA) at N_{des} . In addition, in-place density ($\% G_{mm}$) and smoothness are construction-related measurements. The in-place density is considered an indicator to evaluate the pavement performance and to identify the asphalt pavement construction quality.

There are three types of in-place density tests: (1) the core density test, (2) the nuclear density gauge test, and (3) the non-nuclear density gauge test. The density ($\% G_{mm}$) from a randomly selected core is a percent ratio of the bulk specific gravity (G_{mb}) to the maximum specific gravity (G_{mm}). The nuclear density gauge test and non-nuclear density gauge tests are the non-destructive tests. The Indiana Department of Transportation (INDOT) has adopted the core density test to collect the in-place densities for HMA quality assurance (QA); however, it has several inherent problems with the coring process, representativeness, and cost effectiveness.

Intelligent compaction (IC) technology offers several advantages over conventional methods of compaction. The Federal Highway Administration (FHWA) added IC to their Every Day Counts initiatives for accelerating its implementation. IC rollers can provide uniform compaction over pavements since operators can receive feedback about the condition of the materials being compacted and the number of passes over the asphalt mat in real time. The IC rollers are equipped with an integrated on-board documentation system, a Global Positioning System (GPS), an infrared temperature sensor, and an accelerometer. Therefore, the IC features can be more beneficial for nighttime operation, which is becoming more common for high traffic volume roads.

In this synthesis study we conducted a survey and interviews to gather information on (1) the usage of IC technology

by other state DOTs, (2) the benefits of applying IC technology, and (3) the application of IC to the asphalt pavement construction QC/QA. We also analyzed the data from IC technology demonstration performed on US 52 in West Lafayette, Indiana, in 2009, in conjunction with the FHWA IC research project, to validate the possibility of substituting the in-place density with the intelligent compaction measurement values (ICMV).

Findings

The main purpose of this research is to investigate the application of IC technology in QC/QA. A questionnaire survey was sent to AASHTO members to determine the current use of IC technology. A total of 26 AASHTO members participated in the survey. Only 2 states, Alaska and Vermont, have adopted IC technology for QC, while the other 24 respondents have not used it for either QC or QA. The reasons given for not using IC technology were (1) satisfaction with existing QC/QA procedures, (2) difficulty with adjustment due to the lack of specifications in determining stiffness in HMA, and (3) availability of IC equipment from contractors. In addition, 13 of the respondents stated that they do not have a plan for using IC technology in the future.

We conducted phone interviews to obtain practical information on the IC application in detail. We selected three states that have adopted IC technology and two states that have not adopted the technology. In addition, we interviewed three states and three IC vendors who had conducted IC demonstration projects between 2012 and 2014. The phone interview results revealed that nighttime paving and uniform compaction were the most important benefits of IC technology. Also, five out of six states indicated that IC technology is cost effective. Although using IC rollers can add cost, it does not significantly affect the total cost for the construction project since the IC compaction is a small portion of the total construction cost. With respect to the possibility of IC technology as a QA tool, the DOTs (Utah, Florida, and Maine) and vendors (HAMM, SAKAI, and Caterpillar) who participated in IC demonstration projects expressed some concerns about the relationship between in-place density and ICMV.

The objectives of analyzing the data obtained from the IC demonstration on US 52 were to explore the possibility of substituting the in-place density with the ICMV by determining the relationship between them. There are two in-place density tests: the non-destructive density test and the core density test. During the US 52 IC demonstration, the core density data were randomly selected while other test data (i.e., compaction control value (CCV), non-nuclear density gauge (NNG), temperature, and pass count) were collected at designated locations. Consequently, the core density data had to be excluded from the data analysis for establishing the relationship between core density and ICMV. In terms of the correlation between NNG and ICMV, the multiple regression model (predicted variable: non-nuclear density) indicated an R^2 value of 0.67 with statistically significant P-values for the independent variables (i.e., pass count, temperature, and CCV). Additionally, the pass count was identified to be an important variable affecting the multiple regression model based on the Analysis of Variance (ANOVA) test. This research also performed the optimal pass count and the compaction coverage analysis for the data available from IC demonstration on US 52.

Implementation

Based on the analysis of the results of the survey, phone interviews, and analysis of the data from IC demonstration on US 52, this research team determined that IC technology can be applied for QC but not for QA, as discussed below. With regard to the application of IC in QA, there is no solid evidence for the relationship between core density and ICMV to date to support the possibility of substituting in-place density with IC technology.

In terms of QC, IC technology can improve the compaction coverage and the uniform compaction achieved. The measurement of ICMV can improve the uniformity of compaction by determining a target optimal pass count. Also, as mapping is controlled by IC rollers, the compaction coverage can be identified. Several states are currently using IC technology for QC of pavement compaction and indicated satisfaction with IC technology in phone interviews. IC equipment costs more than normal compaction equipment. However, real-time

compaction measurement and uniform compaction would help contractors reduce pay adjustment issues. Also, the IC compaction is a small portion of the total construction and does not significantly affect the total cost for the construction project.

The relationship between non-destructive density, one of requirements of QC, and ICMV varied across the demonstration projects. The results of the demonstration data from other states indicated low correlations (less than 0.2 of R^2). Also, the result of the analysis of data obtained from IC demonstration on US 52 indicated 0.38 of R^2 . Therefore, more pilot studies should be conducted to improve the confidence of the relationship between non-destructive density and ICMV.

For IC application for QA, it is unlikely that ICMV could improve the effectiveness of QA. Based on the literature review, several IC demonstration projects have been conducted to identify the correlation between core density and ICMV data. However, their results do not indicate a strong correlation between core density and ICMV data.

Phone interviews conducted in the present research revealed that Utah, Florida, and Maine DOTs and IC roller vendors HAMM, SAKAI, and Caterpillar were apprehensive of the relationship between in-place density and ICMV. Also, as indicated earlier, the core density data available for this research were not reliable and thus could not be used for establishing the correlation between ICMV and the core density. As a result, this research is inconclusive about the relevance of ICMV in satisfying the requirements for QA.

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