PUTTING RESEARCH TO WORK **BRIEF**

Feasibility Analysis of Base Compaction Specification

Appropriate design and construction of the aggregate base layer has significant influence on structural stability and performance of pavements. Controlling the construction quality of the granular base layer is important to achieve long-lasting pavements with good ride quality and minimized distress. The Wisconsin Department of Transportation (WisDOT) construction specifications have been transitioning from "method" specifications to "performance" specifications. However, WisDOT's base aggregates specifications have not yet made that transition. A base aggregate specification that is based on performance criteria for compaction will improve pavement structural designs and reduce construction costs and delays arising from base failures during construction. The quality of the constructed aggregate base layers is evaluated by either density-based methods or modulus-based methods to ensure that the product will lead to long-lasting and better-performing pavements.

What is the Problem?

Density-based quality control and quality assurance (QC/QA) of constructed aggregate base layers are commonly used by state highway agencies in the U.S. and Canada. However, these spot-based methods do not provide continuous characterization of the aggregate base in terms of density and uniformity. Some of these measurements are labor intensive and time consuming (e.g., in-place density using sand cone method and moisture content determination by the oven dry method). Development of performance-based QC/QA specifications requires evaluation of base layer compaction using rapid and reliable techniques. Continuous characterization to identify uniformity and consistency of aggregate base layers is crucial. On the other hand, mechanistic-empirical pavement design requires layer modulus as input for pavement design and for evaluating pavement performance. Therefore, establishing methodologies that characterize the required modulus based on both field and laboratory test methods is important. An essential feature of a modulus-based construction specification framework is to evaluate long-term performance of a constructed base layer. The premise behind this approach is that field control of moisture and modulus is necessary and sufficient to ensure long-term pavement performance.

Research Objective

The objective is to establish the technical engineering and cost analysis that will allow WisDOT to objectively evaluate the feasibility of switching specification philosophies for base aggregate materials. The research results will also provide technical recommendations for a modulus-based aggregate specification. The specification will utilize performance criteria in terms of a minimum and uniform stiffness measurement parameter consistent with Mechanistic-Empirical Pavement Design Guide (MEPDG) input parameters.

Methodology

Eleven existing hot mix asphalt (HMA) pavement projects were subjected to nondestructive testing using the falling weight deflectometer (FWD). Visual pavement distress surveys were also carried out for these projects. Additionally, 10 aggregate base course projects under construction were subjected to field testing and evaluation using the light weight deflectometer (LWD), dynamic cone penetrometer (DCP), sand cone test for in-place density, and GeoGauge. Laboratory tests of compaction, particle size analysis, and resilient modulus were conducted on materials obtained from aggregate base course projects at the pavement research laboratory at the University of Wisconsin – Milwaukee. Performance analysis of the pavement from the field deflection data was performed using DARWin-ME software.

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(a) Resilient Modulus Test Device for Simulation of Cyclic Traffic Load

(b) Light Weight Deflectometer (LWD) Test

(c) a distressed pavement in Wisconsin

Results

- The existing flexible pavements that showed early distresses exhibited high levels of spatial variability and non-uniformity in aggregate base course layers as demonstrated by FWD testing and back-calculated base layer modulus values and distributions. Similar research showed that non-uniformity of base layers caused more distresses and cracks in portland cement concrete pavements when compared with more uniform bases that are "softer."
- The existing flexible pavements that performed well exhibited low levels of spatial variability and good uniformity in aggregate base course layers as shown by the FWD test results and the back-calculated base layer modulus values and distributions.
- High spatial variability in field density and moisture content exists in base course layers under construction as demonstrated by the relative compaction test results. Spatial variability and non-uniformity were also demonstrated by the results of the LWD and GeoGauge results where the layer moduli vary within a large range of values.
- Mechanistic-empirical sensitivity analyses on the effect of the base course layer modulus on pavement performance demonstrated that pavement with lower base layer modulus will exhibit earlier fatigue bottom-up cracking and develop more rutting.
- The survey indicated that 42% of the highway agencies are looking for new methodologies such as modulus-based specifications to replace or complement their current density-based specifications.

Recommendation

The researchers recommend density-based and modulus-based methods to evaluate performance of base layer, with more consideration for the modulus-based methods. The use of portable devices such as LWD, GeoGauge, and DCP, which will provide spatial quantification for base layer moduli and estimate for base layer strength variation with depth, is recommended. The researchers also recommend considering implementation of methods for characterizing uniformity of aggregate base layers such as continuous compaction control and intelligent compaction techniques. Research projects could be conducted to establish acceptance criteria and levels, bias, accuracy, etc. for modulus-based selected devices and how these measured values are correlated to field measurements.

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