Research Brief

Wisconsin Highway Research Program
Project 0092-15-06
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Long-Term Degradation and Strength Characteristics of Wisconsin Virgin Base Aggregates under HMA Pavements

Research Objectives

- Investigate the long-term performance of base layer aggregates beneath hot mix asphalt (HMA) pavements
- Determine if base layer aggregates degradation and strength reduction occurs over time and identify causes
- Apply findings to calibration of WisDOT's AASHTOWare Pavement ME Design software

Research Benefits

- Provided three methods to improve accuracy of AASHTOWare Pavement ME Design software
- Improved WisDOT's methods for designing pavements and rehabilitating existing pavements to increase long-term performance

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Background

Aggregate base course layers serve an important role in hot mix asphalt (HMA) pavement stability and performance by providing structural support to the surface layer and by dissipating traffic loads and transferring them to the underlying pavement layers or subgrade. Poor base layer performance due to long-term degradation can cause serious pavement distress such as fatigue cracking, rutting, corrugation, depression and frost heave. The Wisconsin Department of Transportation (WisDOT) has hypothesized that base layer aggregate degradation may be caused by: individual aggregate chemical and physical breakdown; freeze-thaw action; and infiltration of subgrade materials.

WisDOT is deploying AASHTOWare Pavement ME Design software in which the base layer aggregate characteristics significantly influence the pavement thickness design and pavement performance. The purpose of this research was to investigate long-term performance of virgin aggregate bases in HMA pavements; investigate and document strength reductions over time; and evaluate the likely causes of both. This information will help local calibration of the AASHTOWare Pavement ME Design software.

Methodology

The research team investigated the performance of HMA pavements with aggregate base course layers at 27 sites constructed between six and 85 years ago across Wisconsin. Pavements were subjected to Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR) and Dynamic Cone Penetrometer testing, as well as visual distress surveys and surface coring.

Evaluating the structural capacity of HMA pavement using a Falling Weight Deflectometer

Samples were collected from the field sites and subjected to laboratory tests, including: standard compaction; particle size analysis; Atterberg limits; sodium sulfate soundness; Micro Deval; absorption; specific gravity; repeated load triaxial (to determine resilient modulus); and soaked California Bearing Ratio (CBR).

"This research will help WisDOT's engineers determine base layer moduli more easily through readily available parameters, such as base age and aggregate properties."
– Andrew Zimmer, WisDOT

Interested in finding out more?

Final report is available at: WisDOT Research website.

Results

Laboratory and field tests indicated significant variability in the properties and characteristics of base layer aggregate materials. Particle size distribution for the majority of the investigated base aggregates partially fell outside WisDOT base aggregate gradation specifications at the time of construction. This may be due to freeze-thaw cycles and repeated traffic loads degrading aggregate particles. Fines found in 15 of the aggregate samples were non-plastic. Visual inspections did not show widespread pumping and contamination of the base layers from subgrade soils.

Strength and modulus evaluations of the investigated base aggregates and pavement test sections revealed low CBR numbers, especially in gravel and crushed-gravel aggregate samples and those with large amounts of fines. Wisconsin virgin aggregates from both pits and quarries demonstrated acceptable resilient modulus values, but those of gravel and crushed-gravel aggregates were low.

FWD results showed significant variability in pavement surface deflections (D_0) and back-calculated base layer moduli (E_{Base}) within and between test sections. Average E_{base} was low, ranging from 16 to 139 ksi, with 14 of 20 sections measuring 45 ksi or less. E_{Base} variability was significant within the sections with lower pavement condition index and higher International Roughness Index values.

Recommendations for Implementation

The research team proposed three methods to account for the reduction of in-service base layer aggregate condition over time in its aggregate base layer modulus input for the software:

1. Use aggregate base layer age without field or laboratory tests to provide a rough estimate of its resilient modulus.
2. Use existing base layer aggregate gradation and density, determined through tests of pavement cores and base aggregate materials.
3. Use the Back-calculation Module of the software; this requires deriving base layer modulus estimates through FWD and GPR testing.

These improved prediction methods will help WisDOT design pavements with improved long-term performance by more accurately addressing aggregate contamination, degradation and disintegration. They can also help prioritize the timing and level of rehabilitation of existing pavements.

This brief summarizes Project 0092-15-06,
"Evaluation of the Long-Term Degradation and Strength Characteristics of In-situ Wisconsin Virgin Base Aggregates under HMA Pavements"
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