Research Brief

Wisconsin Highway Research Program
Project 0092-20-05
March 2023

Quality Testing of Wisconsin Aggregates

Research Objectives

- Investigate the feasibility of implementing coarse aggregates (CA) soundness testing based on AASHTO T 103 or WisDOT Modified AASHTO T 103 procedures
- Understand the accuracy of the existing soundness procedures
- Recommend CA acceptance thresholds for Wisconsin aggregates used in base course, HMA pavement and PCC pavement regarding freeze-thaw durability

Research Benefits

- Improved specifications for coarse aggregate quality
- More accurate determination of the soundness of coarse aggregates
- Quality of coarse aggregates directly impacts long-term durability of Wisconsin pavements

Principal Investigator

Hani H. Titi, PhD, PE, M.ASCE
University of Wisconsin-Milwaukee
hanititi@uwm.edu

Project Manager

Erik Lyngdal, PE
Wisconsin DOT
erik.lyngdal@dot.wi.gov

Background

Various types of aggregates are used annually in Wisconsin for road- and bridge-related construction projects. Aggregates are important parts of base course and pavement surface layers in hot mix asphalt (HMA) and Portland Cement Concrete (PCC) pavements. As such, the long-term durability of pavements can be directly impacted by the quality of aggregates used. An internal audit of WisDOT specifications concluded that the frequency of testing for quality is less relative to surrounding states, which is due in part to higher-quality aggregate available to contractors in Wisconsin.

Despite this availability, localized pavement performance issues have raised concerns about the effectiveness of the current quality testing program and led to the need to improve specifications for aggregate quality. The main objective of this research project was to investigate the feasibility of implementing coarse aggregates (CA) soundness testing based on AASHTO T 103 or WisDOT Modified AASHTO T 103 test procedures. To accomplish this goal, a better understanding of the current soundness testing procedures is needed with respect to Wisconsin CA performance and use.

Before statewide implementation of AASHTO T 103, new limitations need to be selected for each aggregate application: base course, HMA pavement and PCC pavement.

Methodology

Coarse aggregate samples were collected for laboratory testing and evaluation from 34 sources (quarries and pits) consisting of different rock formations and various classifications. The laboratory testing included measurements of specific gravity, absorption, and vacuum absorption, sodium sulfate soundness (SSS), and freeze-thaw (F-T) tests. Additionally, the influence of the following on the test results was investigated: test type, F-T test equipment, test laboratory, test repeatability, number of wetting/drying cycles, number of F-T cycles, absorption, aggregate source, aggregate size fraction, and aggregate classification.

To investigate the influence of the CA quality on F-T durability of PCC in pavements, PCC test cylinders were made and exposed to rapid F-T tests as well as evaluations of the static and dynamic moduli up to 300 F-T cycles. PCC testing included ASTM C666, ASTM C215, ASTM C597, ASTM C39 and ASTM C856.

Additionally, field investigation including coring, pavement distress survey, and pavement condition evaluation using the WisDOT pavement management database were conducted to quantify the

"Results of this research validated WisDOT's belief in AASHTO T 103 as the best test procedure to indicate freeze-thaw durability. WisDOT will be expanding use of T 103 through the aggregate source approval program" – Erik Lyngdal, WisDOT

Interested in finding out more?

Final report is available at:
WisDOT Research website

effect of CA on PCC pavement durability and performance. Professional petrographic analysis was performed on the PCC cylinders and pavement surface cores.

Photos of PCC cylinders during F-T cycles showing the effect that CA quality had on the cylinders. Photos show CA fracture, PCC surface scaling and CA initiated cracking in the PCC cylinder surface, respectively.

Results

Test results showed there is no typical SSS vs F-T relationship. CA absorption is an influencing factor of F-T durability, but mixed results were also observed when considering carbonates (calcareous vs dolomitic limestone). Results also showed that different CA classifications exhibited different F-T results due to the variability in the CA size fractions.

PCC F-T performance evaluation showed that PCC exposed to F-T at younger age will exhibit larger deterioration and loss of elastic modulus. Field investigation showed that low and medium severity durability cracking, PCC pavement surface pitting/popouts exist on the investigated PCC pavements in Wisconsin, but not to a great extent. A comprehensive analysis of the test data and other subsets indicated that approximately 7% of CA tested in Wisconsin failed the 12% total mass loss threshold in the SSS currently specified by WisDOT for CA used in PCC acceptance and the18% threshold for dense graded base layers.

Recommendations for implementation

The research team recommends the following:

- Implement the WisDOT Modified AASHTO T 103 for CA durability evaluation.
- Require more frequent F-T testing for CA from rock formations with calcareous and dolomitic limestone.
- When the rock formation changes in a quarry, WisDOT should be notified, and samples should be evaluated.
- Different specifications for coarse aggregate acceptance can be implemented based on the source type, aggregate classification, and use in high-value projects

This brief summarizes Project 0092-20-05,
"Quality Testing of Wisconsin Aggregates"
Wisconsin Highway Research Program