RESEARCH ADMINISTRATION
Bureau of Field Services
Michigan Department of Transportation

Research Spotlight

Project Information

REPORT NAME: US-23 Aggregate Test Road: Long-Term Performance Evaluation

START DATE: January 2016

REPORT DATE: March 2017

RESEARCH REPORT NUMBER: SPR-1652

TOTAL COST: $48,890

COST SHARING: 20% MDOT, 80% FHWA through the SPR, Part II, Program

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Long-term study yields valuable insight into pavement performance

Keeping Michigan roads in good condition is an ongoing challenge, given the stresses of traffic and weather. A research project on US-23 monitored the long-term performance of five aggregates used in concrete pavement mixtures and evaluated numerous other variables. The study provided real-time data over 23 years in service that will enable MDOT to improve road performance and longevity on future projects.

Problem

Sections of US-23 test road: (left) Typical transverse mid-panel crack spalling in Section B (blast-furnace slag aggregate) in 2006. (right) A typical transverse joint found in Sections A through E in 2016. There was no sign of deterioration at the joints.

Planning, designing and building state roads is a complex and expensive undertaking. MDOT is committed to building safe, smooth and durable roads that withstand the rigors of tens of thousands of cars and heavy trucks each day plus the punishing effects of Michigan's extreme weather and temperature fluctuations. Identifying optimal materials and construction methods for durable pavements requires expertise as well as ongoing research.

The Michigan Aggregate Test Road project on US-23 in Monroe County is a long-term study of concrete pavement performance. Initiated in 1992, this project was set up to evaluate the performance of five coarse aggregate types used in concrete mixtures, particularly as they relate to the damage effects from nature's cyclic freezing and thawing. The current performance evaluation was based upon the evidence gathered over 23 years from specially constructed pavement test sections. Current average daily traffic along these sections is approximately 20,000 vehicles, 18 percent of which are commercial trucks.

(continued)

"The findings from this long-term research project emphasize the importance of a well-engineered pavement structure along with high-quality materials to achieve our objective of building long-life pavements."

John Staton, P.E.
Project Manager

Research

Five 1-mile-long test sections of US-23 were constructed. Each test section was separated by a 500-foot-long transition section. The entire test road was constructed on a 4-inch asphalt-treated permeable base (ATPB) layer on top of a 3-inch gravel separator layer. Half of each test section was built on the original natural soil subbase, which had poor drainage. The other half of each section was constructed on a well-draining permeable sand subbase. Each individual test section was constructed using a different coarse aggregate in the concrete mixture: Sections A and D contained differing freeze-thaw quality crushed limestone, Sections C and E contained differing freeze-thaw quality gravel, and Section B contained manufactured blast-furnace slag.

While the primary objective for this test road was to study the long-term performance of concrete aggregate types, researchers examined other factors affecting performance over time. They evaluated the performance of four concrete mixtures containing natural coarse aggregates of differing freeze-thaw quality, concrete containing natural coarse aggregates compared to that made with manufactured blast-furnace slag coarse aggregate, and also the influence of the subbase drainage characteristics versus concrete pavement performance over the five concrete holistic test sections. They also compared the performance of the entire test road built upon ATPB – not standard in 1992 – to typical roads built upon the standard unbound open-graded drainage course base layer, which still remains as today's standard.

Over the years, researchers conducted periodic detailed field inspections of each test section, with additional extensive nondestructive in situ testing in 2006 and 2009. In 2016, they extracted core samples from the pavement sections that were tested for air void parameters and permeability at the University of Michigan.

Results

After 23 years of service, the concrete at the joints for all five sections showed no sign of freeze-thaw distress despite containing coarse aggregate of varying frost susceptibility. Joint faulting was also kept within acceptable limits. Both findings are attributed to the use of the ATPB layer, which reduces load-related deflection and provides for enhanced drainage at the joints. However, one of the concrete sections (Section B) containing blast-furnace slag developed full-lane mid-slab cracking in more than 75 percent of pavement slabs within five years. After 19 years of service, severe spalling of these cracks required full-depth repairs in 29 percent of the slabs in the truck lane. It appears that the root cause is directly or indirectly related to the structural weakness of the coarse aggregate in the concrete mixture for Section B.

Value

This study provides extensive useful data for future road construction. After 23 years in service, it was shown that a firm and stable ATPB layer built upon a well-draining sand subbase along with a functioning and well-maintained drainage system will ensure that any water that enters the pavement structure will freely drain away from the road, reducing the likelihood for later freeze-thaw damage to the concrete pavement. This study also documented that the upfront emphasis on quality and structural integrity for each element of the pavement structure will, in due diligence, reap future rewards in terms of improved pavement performance and longevity.

Research Administration

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This final report is available online at

www.michigan.gov/documents/mdot/SPR1652_572249_7.pdf.

Research Spotlight produced by CTC & Associates LLC, August 2017.