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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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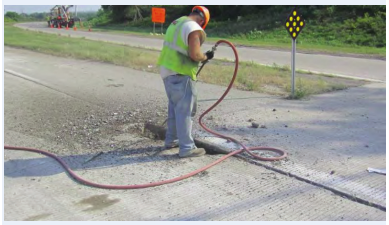
PROJECT COST:
$74,000



After removing damaged concrete, workers air blast excess material before applying a partial-depth repair patch.

Optimizing Materials and Methods for Partial-Depth Pavement Repair

By improving the quality of the patching materials and methods used for partial-depth repair, MnDOT can maximize the service lives of these repairs, saving on costs and minimizing traffic disruptions during construction.

What Was the Need?

As concrete pavements age, they can develop spalling and other forms of deterioration around the joints that separate the concrete slabs. To remedy this problem, MnDOT sometimes uses a process called partial-depth repair, in which damaged concrete is removed and replaced with a patching material.

MnDOT uses a variety of concrete mixtures for these patches—some that are developed in-house and some prepackaged mixtures that are supplied by vendors. To determine whether commercial mixtures are suitable for use in Minnesota, MnDOT tests the mixtures' compressive strength and other properties. Additional tests that MnDOT does not currently require might be helpful in evaluating the durability of patch materials in the state's harsh winter climate. Research was needed to establish the best tests for patching material acceptance criteria in Minnesota.

What Was Our Goal?

The objective of this project was to develop improved guidelines for evaluating prebagged commercial patching mixtures for partial-depth repair by establishing testing procedures that assess their material properties. Researchers also set out to evaluate the effectiveness of chemical admixtures for improving the performance of patching mixtures developed by MnDOT and to recommend effective partial-depth repair construction practices.

What Did We Do?

Researchers began by conducting a literature review on partial-depth patching materials and construction practices. Then they conducted three phases of laboratory testing to determine patching material properties that are most critical to predicting their performance.

In the first phase of testing, researchers conducted selected ASTM C928 tests on 13 materials, including both commercial mixtures and MnDOT mixtures with added chemicals. These tests are the most commonly available acceptance specifications for partial-depth patching materials and include compressive strength gain, flexural strength at four hours, setting time, freeze-thaw durability, shrinkage and bond strength.

Researchers then conducted six additional ASTM C928 tests related to cold climate conditions on the four materials that performed best in initial testing. The additional tests included coefficient of thermal expansion, abrasion resistance, modulus of elasticity, length change in sulfate, scaling resistance to deicing chemicals and the slant shear bond test.

For three materials, researchers conducted two tests to determine how well patches bond to the underlying concrete and whether using a cement and water grout mixture as a bonding agent is superior to using water alone. In the pull-out test, equipment is used to try to forcefully remove the patch from a concrete beam test specimen. In the pop-out bond test, a patched specimen is flexed to evaluate whether the patch will pop out.

continued

"We want to make sure that we have the most durable patching materials possible to help MnDOT save on road maintenance costs."

—Ronald Mulvaney,
Structural Concrete Engineer, MnDOT

"When a vendor approaches MnDOT with a new patching mixture, it is important to know what battery of tests should be conducted to determine whether it can be accepted for use. This project developed those procedures."

—Eshan Dave,
Assistant Professor, University of Minnesota Center for Transportation Studies

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Researchers tested the bond strength of half-slab concrete specimens by loading them at their midpoint to see if the resulting flexure caused a partial-depth repair patch to pop out.

What Did We Learn?

Using these test results, researchers developed a laboratory testing-based acceptance procedure for partial-depth materials that MnDOT can use to repair rigid pavements. They also made recommendations for using chemical admixtures in MnDOT patching materials, favoring MnDOT 3U18M; MnDOT District 3 Mix 2, which is 3U18-based; Futura-45, nonextended version; and Rapid Set Concrete Mix. Finally, they developed a best practices manual of proper construction techniques for partial-depth repair.

Laboratory results showed that the workability of patching mixtures is critical to their performance. Workability can be compromised in mixtures that attempt to maximize the rate of strength gain so that patching takes less time and roads can be opened to traffic sooner. Further, freeze-thaw testing showed that air entrainment is essential to performance, especially in Minnesota's colder climate.

Researchers did not observe much difference in mixtures when it came to bonding, with no specimens de-bonding during pop-out testing. Further, water performed just as well as cement grout for bonding; mixtures usually contain enough bonding material that grout offers no added benefit.

For construction techniques, researchers determined that based on pop-out bond and other tests, MnDOT's current methods for partial-depth patch repair are optimal. They recommended that patches be prepared using milling and feathering rather than saw cutting since saw cutting requires more time and patching material to fill repair areas.

What's Next?

Based on the results of this study, MnDOT is revising its qualification process for partial-depth patching. It will also be reviewing the report's construction recommendations to consider whether to update MnDOT's manual for partial-depth repairs. Implementing these changes will help MnDOT improve the longevity of patches, saving significantly on repair costs. MnDOT is also considering a recommendation by researchers for a more extensive field study that evaluates the performance of materials that meet the acceptance criteria developed in this study.

This Technical Summary pertains to Report 2014-41, "Evaluation of Concrete and Mortars for Partial Depth Repairs," published November 2014. The full report can be accessed at http://www.lrrb.org/PDF/201441.pdf.