Executive Summary and Research Readiness Level Assessment

Development of High-Performance Rapid Patching Materials for Pavement Repair

Research Objectives

The goal of this study was to develop cost effective and durable high-performance rapid patching materials for full depth concrete pavement repair.

To achieve this goal, two specific objectives of this study were to:

1) Develop cost-effective patching materials that provide sufficient early strength (a minimum 3,000psi compressive strength in 4-8 hours) for proper traffic opening; and

2) Ensure long-term performance by diminishing durability issues (such as ASR) in the current PR mixes.

Research Benefits

The new repair mixture has appropriate workability and constructability for the easy placing in the field, as well as adequate early-age strength, long-term durability, and volume stability that meet NDOR specifications.

The success of the research resulted in cost savings and durable patching materials for concrete pavement repair.

Principal Investigators

Jiong Hu (P.I.) and Yong-Rak Kim (Co P.I.)
University of Nebraska

Lead TAC Member

Wally Heyen, PCC Engineer

Background

Concrete pavements exhibiting severe distresses which require patching are commonly observed in the concrete pavement in Nebraska. Due to the requirements of opening pavement to traffic after placing the rapid patching materials, it is essential for that concrete to achieve high early strength. To ensure this, a high cement content and chloride-based accelerators are currently used in the Nebraska Department of Transportation (NDOT) Portland cement-based rapid-patching materials. Besides its associated high cost, high cement content tends to result in a less stable mix with high shrinkage, high heat of hydration, and high cracking potential. In addition, using chloride-based accelerators has adverse effects on concrete durability. Also, the effect of the low ambient temperature has a considerable impact on the strength gain and needs to be assessed to estimate the traffic opening. Therefore, this project studied the performance of rapid patching materials for three different aspects: reducing cement content through optimizing aggregate gradation, replacing conventional calcium chloride with a non-chloride accelerator, and partial replacement of type I/II or type III cement with type IP cement. Fresh, early-age, mechanical, durability performance and constructability were evaluated on each of the developed mixture design. The performance of developed mixes at low ambient temperature (50 and 60°F) was also evaluated.

Conclusion

Overall, it appears that, with the optimized aggregate gradation, mixes with reducing cement content by up to 100lb/yd3 together have good constructability and can meet the general requirements, which were confirmed from the evaluation of key parameters, including early-age compressive strength, modulus of rupture, bond strength, surface resistivity, drying shrinkage, and alkali-silica reaction (ASR) resistivity. The nonchloride-based accelerator showed promising behavior as an alternative accelerator. The developed mixes exhibit satisfy early-age and 28-day compressive strength, modulus of rupture, and bond strength. The free shrinkage can be reduced by up to 30% with the lower cement content. The tendency of ASR deterioration can be reduced significantly by replacing 50% Type III cement with Type IP cement. Finally, as expected, when experiencing a low ambient temperature, strength growth can be delayed and employing PR3 mixes will be a more viable option to reduce the traffic closure durations.

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Interested in finding out more?
Final report is available at:
NDOT Research Website

NDOT Recommendations Based Off of Research Project

The Department will follow up during this year construction season. Additional mechanical and durability testing will be performed by Materials & Research in a construction setting vs a lab setting. To ensure the following

- Ensure a minimum 3,000 psi compressive strength in 4-8 hours for proper traffic opening.
- Ensure long-term performance by diminishing durability issues, such as ASR.

- *As provided by Wally Heyen, Lead TAC Member*

Technology Transfer

Transportation Research Board (TRB) papers

- S. Gholami, J. Hu, Y. Kim, and M. Mamirov, Performance of Portland Cement Based Rapid Patching Materials with Different Cement and Accelerators Types, and Cement Contents, Journal of Transportation Research Record, 2019, Vol. 2673 (11), pp. 172-184. https://journals.sagepub.com/doi/abs/10.1177/0361198119852330?journalCode=trra

Conference Presentations

- S. Gholami, J. Hu, and Y. Kim, "Invited Talk: Development of High-Performance Rapid Patching Materials for Pavement Repair", Nebraska Concrete Pavement Association Annual Workshop, Lincoln, NE, January 21, 2020.
- M. Mamirov, S. Gholami, J. Hu, Y. Kim, "Sustainable Pavement Concrete and Pavement Patching Materials through Aggregate Gradation Optimization and Reduced Cement Content", International Airfield and Highway Pavements Conference, Chicago, Illinois, July 21-24, 2019.
- S. Gholami, J. Hu and Y. Kim, Performance of Portland Cement Based Rapid Patching Materials with Different Cement and Accelerators Types, and Cement Contents, Transportation Research Board Meeting, Washington DC, January 13–17, 2019.

Research Readiness Level (RRL) Assessment

RRL 4

Level 4: Implementation

Research/Technology refined and adopted by the Department. Benefits of the implementation will be evaluated for a time frame of 5 years.

This brief summarizes Project SPR-P1 (18) – M071
"Development of High-Performance Rapid Patching Materials for Pavement Repair"
Nebraska Department of Transportation Research Program