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LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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Cold and snowy winters make potholes common in Minnesota, to the irritation of drivers and road crews alike.

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# Pothole Prevention and Repair Strategies: A Continuing Challenge

## What Was the Need?

Potholes irritate drivers and frustrate crews tasked with keeping roads safe and drivable. Pavements crack, water seeps in, and winter temperatures freeze and expand the water, leaving behind a pothole or larger crack during spring thaws. Current repair materials and methods for winter and spring repair remain either impractically expensive or effective only for short periods.

Warm-weather patches with hot-mix asphalt (HMA) work well. But in cold weather, HMA spreads unevenly and is difficult to compact properly because it hardens quickly. More fluid, cold-weather asphalt mixes designed for patching don't always compact properly or adhere well to pothole walls.

Durable, cost-effective repairs elude road crews, whether the options are sophisticated, new winter repair methods or standard warm-weather approaches. Crews look for effective repairs that will be durable enough to last through more than a year's worth of seasonal stresses.

*Research shows that pothole prevention requires repairing pavement cracks as they develop. Repairing potholes effectively is more difficult in winter than in summer. Durable winter repairs require expensive patching materials and expensive, on-site heating technologies. Taconite mixes and mixtures modified with graphite nanoplatelets show promise for long-lasting repair, even in winter.*

## What Was Our Goal?

MnDOT and the Local Road Research Board needed a scientific assessment of pothole repair materials and practices. The primary goal of this project was to identify critical factors in pothole formation and repair in order to identify solutions that would reduce the occurrence of potholes and increase the durability of repairs. Researchers were also tasked with investigating the potential of newer materials in repair mixes.

## What Did We Do?

Researchers began by reviewing national and international literature about pothole causes and repair activities. They also surveyed MnDOT maintenance superintendents and local engineers on current repair practices.

The research team then conducted numerical simulations of square, diamond and round pothole repair shapes to determine if some shapes were more conducive to reducing stress in repair materials. This stress analysis included the use of different common pothole filling mixes and their interface with existing pavement materials.

In the next stage of research, the team evaluated six asphalt mixes for relevant mechanical properties: four winter mixes, a polymer-modified hot mastic asphalt mix suitable for winter and summer use, and a summer mix in two forms modified with graphite nanoplatelets (GNP). Mixes were evaluated for compaction and bonding, tensile strength and water penetration.

Finally, researchers studied national and international pavement preservation and pothole prevention practices and the cost-effectiveness of pothole repair with a focus on Minnesota cost information.

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Pothole repair samples performed poorly in water penetration tests, which suggested that most mixes will perform poorly under seasonal freeze-thaw stresses.

## What Did We Learn?

Potholes begin with crack propagation. Failure to repair cracks early in their development leads to potholes. Sometimes even timely repairs only slow pothole development.

The most common pothole repair in Minnesota is throw-and-roll with HMA (using a truck's tires to compact shoveled-in asphalt). Newer, more durable repairs include taconite-based materials activated chemically or by heating potholes with a truck-mounted microwave unit before and after filling. While promising and, in the case of the microwave method, potentially effective in extreme cold, these approaches require further research before becoming widely used in winter and spring repairs.

Modeling showed that the lowest maximum stresses between pavements and pothole patching materials occurred when patches were made from the same material as the pavement. This study's exploration of pothole repair shapes found that circular repairs offer the best filling and compacting performance; repair materials cannot fill corners, even with significant compaction.

Laboratory analysis showed that cold mixes compact and bond poorly. To be more effective, these materials require significant curing not possible in the field unless heating is provided. The polymer-modified mastic patching material that was heated was stronger than the winter mixes even at very cold temperatures. Most mastics are used in warm weather, but this material may be effective for winter uses.

Water penetrated tested mixes easily. GNP modifiers improved compaction, tensile strength, fracture energy and fracture resistance in the summer mix. GNP additives were not used in winter mixes for this study and were not tested for water penetration.

Minnesota preservation practices can prevent or delay potholes with proactive budgeting and maintenance, and proper matching of treatments to specific repair situations. Data necessary for cost-benefit analysis in Minnesota was not available, and limited conclusions could be drawn about cost-effectiveness of the pothole repair options.

## What's Next?

The only prevention for potholes is a solid pavement structure and timely preservation activities. The most cost-effective repairs are made in warm weather. Effective winter patching requires materials that are more expensive than typical repair materials along with expensive, on-site heating technologies.

This research is part of a larger effort by MnDOT to improve pothole repair approaches and develop pothole repair guidance for crews throughout the state, including the recently released Comprehensive Field Evaluation of Asphalt Patching Methods and Development of Simple Decision Trees and a Best Practices Manual. GNP-modified mixes warrant further study, especially in winter mixes. If MnDOT can encourage cost tracking, analysis of the cost-effectiveness of various pothole repair methods, including the mastic tested in this research, may become possible.

*This Technical Summary pertains to the LRRB-produced Report 2018-14, "Pothole Prevention and Innovative Repair," published April 2018. The full report can be accessed at* mndot.gov/research/reports/2018/201814.pdf.

***"We had been squaring off potholes, making sure patches were all at right angles. But in this study, we found that square patches increase stresses at the boundaries. The ideal is a circular patch."***

**—Todd Howard,**
Assistant County Engineer, Dakota County

***"To make winter repairs last longer, you need to provide an external source of heat to cure winter patching materials."***

**—Mihai Marasteanu,**
Professor, University of Minnesota Department of Civil, Environmental and Geo-Engineering

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