Taconite-Based Mixture Shows Further Promise for Repairing Potholes

What Was the Need?
Minnesota road crews battle pothole damage from freeze-thaw cycles in winter and spring on well-used roadways with quick, short-term repairs in spring. Methods like placing cold-mix asphalt in the hole and tamping the material with a shovel before moving on to the next pothole can allow the repair of numerous potholes in an hour. Quick and inexpensive, these approaches keep cars on the road with little interruption.

But in cold or wet weather, these repairs may fail within a week. Longer-term solutions typically are made in warm weather, when hot-mix asphalt is available and will bond better with the cavities it fills and when extensively pot-holed roads can be milled and covered with new asphalt. Mastic repairs, which require hours of cooling time and typically entail two lifts, also offer repairs that outlast a season.

A fast, durable repair that can be conducted in cool or wet weather remains an elusive and prized technology. Researchers at the University of Minnesota Duluth’s Natural Resources Research Institute (NRRI) have been developing a rapid patch using readily available, iron-like byproducts of northern Minnesota taconite mining that serves the steel industry. A 2016 project developed approaches that use taconite mixtures and microwave machinery to repair potholes in roughly 15 minutes while offering service for six to 12 months.

What Was Our Goal?
The Local Road Research Board is interested in developing improved taconite repair methods that would simplify mixing procedures, avoid the need for expensive and large specialized equipment, and speed up patching activity. These improved methods would repair a pothole in fewer than 15 minutes and provide a patch that would last more than one season or year.

What Did We Do?
Researchers examined taconite patch mixtures they had developed to identify improvements to make mixtures simpler in terms of necessary components and mixing activity. They identified local- and state-owned repair locations for field testing and examined inexpensive mixing equipment that would be easy to use in the field.

Potholes were repaired at locations in Duluth and in the state highway system nearby. In Duluth researchers repaired three concrete locations in June and September 2018. One of the June 2018 repairs failed by December 2018, most likely due to an incorrect formulation, but the remaining repairs performed well, especially the September 2018 repair. In summer of 2019, the research team tested mixtures and methods in the NRRI parking lot. In August 2019, crews patched MnDOT concrete locations on U.S. Highway 53 and at U.S. Highway 2 and Interstate 35 (I-35). In October 2019, crews patched potholes on I-35 near Spirit Mountain, as well as areas of an asphalt taxiway previously repaired with mastic at the Duluth International Airport. Researchers revisited all repair sites from 2018 and 2019 to inspect repair performance periodically.
Road crew and a researcher completed a taconite repair on U.S. Highway 2 and I-35 outside Duluth in August 2019.

**What Did We Learn?**

Taconite repairs set well in asphalt and concrete, and performed well for a year or more of observation. This method seems to be more durable than throw-and-go and cold-mix options for pothole repair, offering local agencies an asphalt-free and cement-free option using plentiful local materials and costing less than mastic or hot-mix asphalt repairs.

Previous taconite patching mixtures required mixing two packaged dry ingredients by hand with a liquid activator in a 5-gallon bucket. Researchers developed a two-ingredient mixture: an acidic activator somewhat like diluted phosphoric acid added to a dry material of 90% taconite tailings and concentrate that neutralizes the acidity of the mixture.

Teams first deployed the procedure using a continuous mixer in a hopper-and-auger configuration that ultimately worked poorly due to some mixture setting hard over the auger. Investigators then turned to a 15-gallon barrel—known as a “Mega Hippo”—with mixing tools and a liner that allowed crews to mix on-site. The material hardens quickly, requiring application within 30 minutes.

The mixture sets less quickly in cold temperatures than warm, but sets better in deep repairs than in shallow, where the mixture fights the thermal mass of the pavement in cold seasons. Fieldwork identified operating temperatures that allowed application of the material in potholes in cool to cold (subfreezing) fall conditions, with repairs to sites that were drivable in 30 minutes.

**What’s Next?**

The process requires further refinement of mixing methods and application to increase material quantities workable by local crews and speed up repair activity. Researchers aim for repairs that can accept traffic in 10 to 15 minutes or less under moderate to warm temperature conditions, but also recognize the need to accommodate repair situations where the material can remain workable for an hour or more.

Longer-term evaluation of repaired sites will help assess the cost–benefit of the method as researchers continue to develop the approach and evaluate performance over the span of years. The research team identified a cement mixer that includes a liner and could accommodate six times the material the Mega Hippo carries, a possibility that will require more investigation.