



An Overview of Recent Taconite- Based Repair and Pavement Preservation Applications: *Innovative Pavement Repair and Patching Project; and Alaska Glenn Highway Sand Seal Project*

**Session 8: Pioneering Pavements and
Maintenance: The Future of Minnesota's Roads**

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University of Minnesota Duluth

November 3, 2016

27th Annual CTS
**TRANSPORTATION
RESEARCH
CONFERENCE**
Curiosity. Discovery. Innovation.

**Natural Resources
Research Institute**
UNIVERSITY OF MINNESOTA DULUTH
Driven to Discover

What we do: the NRRI mission



Deliver applied research solutions to balance economy, resources and environment for resilient communities

- ✓ Broad Engagement
- ✓ Collaboration, Consortia

- ✓ Science-Driven
- ✓ Future-Focused

By-Products Development Program

The program is focused on mineral resource based by-product recovery and utilization strategies, and value-added product and technology development

- find potential beneficial end-uses that make environmental and economic sense at...



- includes the development of associated intellectual property (IP) and patents

Innovative Pavement Repair and Patching Project

EVALUATE AND DEVELOP INNOVATIVE PAVEMENT REPAIR AND PATCHING: TACONITE-BASED REPAIR OPTIONS

Contract No. 99008, Work Order 51



The Problem: Potholes and other pavement failures

- **Potholes and other types of premature pavement failures are an ongoing repair challenge and expense for transportation maintenance departments at all levels.**



Taconite-based Repair Methods

- **NRRI has focused on two approaches to all-season pavement repair:**
 - 1. A taconite-based pothole and pavement repair compound***
 - 2. Microwave-based pothole and pavement repair***
- **Both represent value-added niche products and technologies that take advantage of the chemistry and mineralogy of taconite materials**

Taconite-based pothole and pavement repair compound



- **The NRRI developed and patented a rigid, taconite mineral-based, all season rapid setting repair compound that contains neither petroleum nor portland cement**
- **The compound takes advantage of the chemistry and mineralogy of taconite materials**

An exothermic reaction occurs between magnetite-bearing components and activator



**134°F within ~10 minutes,
indicating set: Oct 31, 2012**

Condition January 7, 2013

Condition on December 26, 2014



Field Test: Hwy 169 near Keewatin, MN with MnDOT November 4, 2010



Keewatin patch condition

May 16, 2011



Feb 12, 2013



May 30, 2014



Findings and Next Steps

- The project showed the compound can be an effective repair alternative, but that it would benefit further from formula simplification coupled with automated/mechanized deployment
- A new LRRB-supported project is underway:
“Optimized taconite-based pavement repair compound and deployment system”
Work Order 241

Activities to date

- **Modification of the NRRI's taconite-based repair compound, with an emphasis on developing and optimizing a finer-grained (“pumpable/extrudable”) formulation, and potentially imparting “flexural” properties**
- **Initial lab testing: 2016**



Activities to date

- Initial field testing: November 2, 2016



Mesaba Ave.
Duluth, MN

Pavement condition and initial repairs



Next Steps

- Use findings (pros and cons) from field tests to make formulation adjustments (late 2016-early 2017)
- Develop and field test/demonstrate a low-cost mechanized system that can efficiently mix and place the repair compound in larger quantities while minimizing or eliminating direct contact and hand-mixing by maintenance personnel (during 2017)

Examples

Machine Technologies

MP-25 Mixing Pump

Self-Leveling Underlayments Made Easy

Mix, pump and spray most pre-blended cementitious construction materials with a single, easy-to-use machine. Self leveling underlayments and toppings, concrete repair mortars, grouts and fireproofing are all suited applications.



Machine Technologies MP-25 Mixing Pump

- Up to 200 bags an hour production
- Mix and pump in one compact unit
- Single and three-phase configurations
- Easy operation and cleanup

SPECIFICATIONS

MP-25 Mixing Pump	Standard Output	High Output
Pump Motor	4KW (5.4HP)	5.5KW (7.5HP)
Water Pump	0.45HP	0.45HP
Pumping Output	110 bags (50 cuft/hr)	200 bags (100 cuft/hr)
Pumping Pressure	425 PSI	425 PSI
Pumping Distance	200'+	200'+
Pumping Height	60'+	60'+
Hopper Loading	42'	42'
Hopper Capacity	5 cuft.	5 cuft.
Weight	425 lbs.	505 lbs.
Dimensions	60" L x 52" H x 32" W	60" L x 52" H x 32" W
Power Requirement	220V, 30amp, 1 Phase	220V, 30amp, 3 Phase

A.P.E. Pothole Fill Machine - Model LP 310



The A.P.E. Pothole Fill Model LP 310 machine is exclusively designed to dispense DOT-POTHOLE FILLER® components as a slurry pothole fill for use on asphalt and concrete roads, parking lots, and similar surfaces. The machine automatically mixes and dispenses a proprietary combination of dry bulk aggregate, liquid, and activator in prescribed ratios to create the long-life pothole repair. The A.P.E. Model LP 310 is mounted on a 9,900 lb. GVWR tandem axle trailer designed to comply with DOT road-worthy requirements for the USA and Canada.

Microwave-based pothole and pavement repair



Microwave

Microwave Repair Methodology

Combine mobile microwave technology with compounds containing recycled/byproduct materials such as recycled asphalt pavement (RAP)/millings, microwave-absorbing taconite materials (Tac), and recycled asphalt shingles (RAS)



Objective

Repair potholes and damaged pavement in all seasons, especially winter.

Microwave (left); HeatWurx IR (right)



Results

- **HeatWurx**: About 1 hour for pavement to reach ~180°F at a depth of 2 inches; temperature at surface close to 400°F (starting pavement temperature ~35°F)
- **Microwave**: 5-7 minutes to heat pavement and patch material to >200°F to a depth of 2 to 3 inches; easy to shovel



Steps

Deploy



Heat



Fill hole



Compact



Result



October 30, 2012



November 6, 2012



February 6, 2013



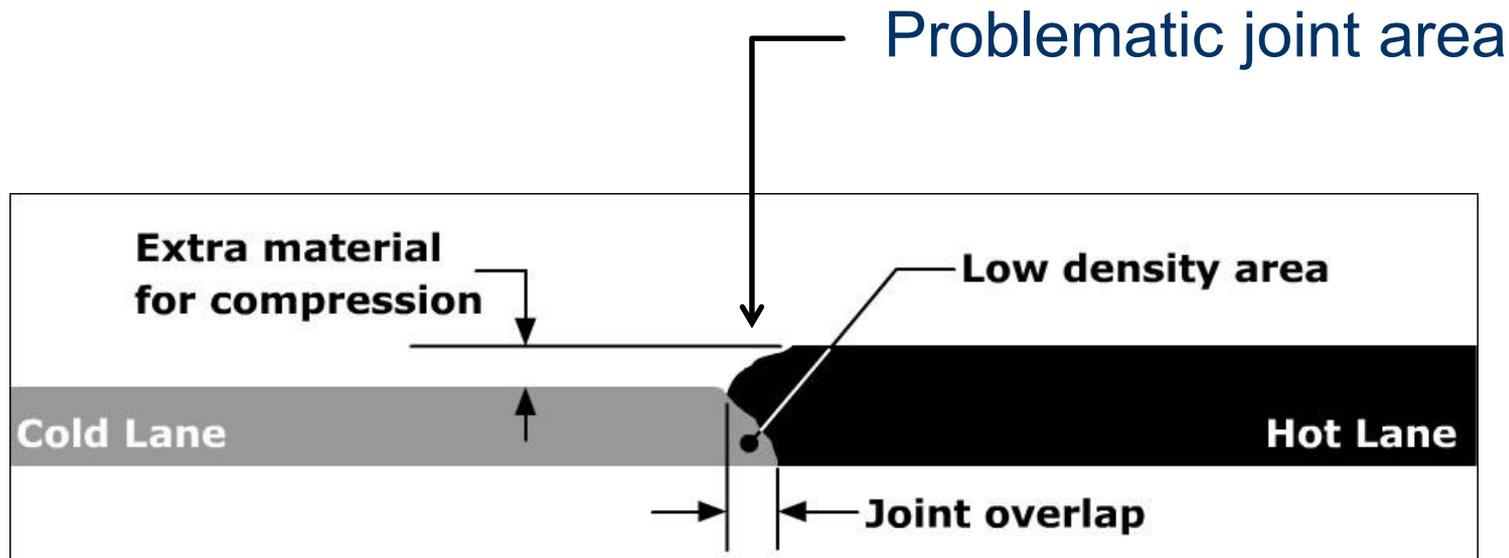
May 17, 2013

Findings

- **Because the microwave equipment heats the existing pavement to the point that the pavement itself becomes part of the repair, an excellent bond is achieved.**
- **The microwave approach merits further development and consideration, as the field performance of repairs suggests it has long-term potential for more widespread use, not only for pothole repair but for other asphalt pavement heating applications. For example...**

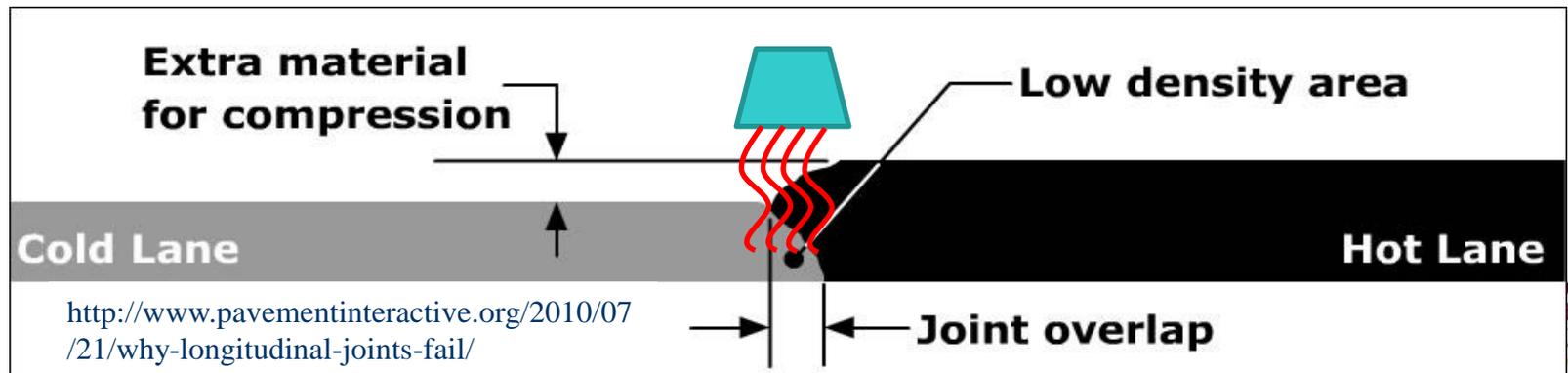
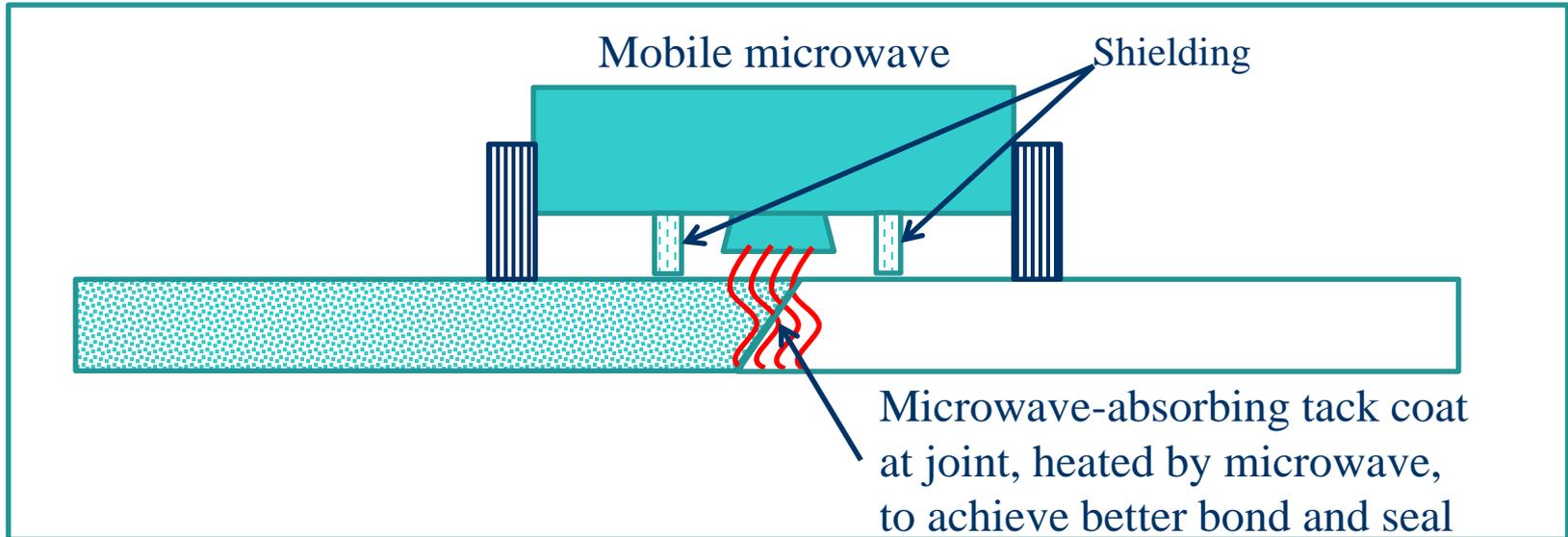
A solution for longitudinal joint failure?

Deteriorating longitudinal joints between adjacent driving lanes and paved shoulders are a major long-term maintenance for DOTs, and a safety problem for the driving and motorcycling public.



<http://www.pavementinteractive.org/2010/07/21/why-longitudinal-joints-fail/>

Applications



Media attention

THE CONVERSATION

Academic rigor, journalistic flair

Arts + Culture Economy + Business Education Environment + Energy Health + Medicine Politics + Society **Science + Technology** Election 2016

Microwave repairs might annihilate zombie potholes once and for all

March 9, 2016 6:13am EST



The vehicle-based microwave system, making the streets safe again. Zankov et al., 2016, CC BY-ND

<https://theconversation.com/microwave-repairs-might-annihilate-zombie-potholes-once-and-for-all-39160>

March 9, 2016 6:13am EST

The Economist

JUNE 11TH-17TH 2016

Britain leans towards Brexit

South Korea: no place for working women

Waging war on potholes

Speech therapy for central bankers

Goodbye to the Greatest

Fixing potholes

The hole story

Researchers are inventing new ways to prevent a motoring curse

POTHoles are a scourge of rich and poor countries alike. The American Automobile Association recently calculated that 16m drivers in the United States suffered pothole damage to their vehicles in the past five years. That damage ranged from punctures, via bent wheels, to broken suspensions. The bill to fix it was about \$3 billion a year. In India, meanwhile, the cost of potholes is often paid in a harsher currency than dollars. There, more than 3,000

people a year are killed in accidents involving them. Yet cash-strapped governments often ignore the problem, letting roads deteriorate. In Britain, for example, some £12 billion (\$17 billion) would be needed to make all roads pothole-free. Ways of repairing potholes more cheaply and enduringly would thus be welcome. And several groups of researchers are working on it.

The most common cause of potholes is water penetrating cracks in a road's surface ▶▶



Instant duck pond

The Economist June 11th 2016

▶ and weakening its foundation. This is a particular problem with asphalt surfaces. These are made from an aggregate of materials bound together by sticky bitumen. The constant pounding of traffic disintegrates the road surface above the weakened area. In cold climates the destruction is aggravated by water in the cracks freezing and thawing. The shattered asphalt then peels away, leaving a pothole.

To make matters worse, any repairs that do happen are usually a lash-up. To save money, the material used for the patch is frequently “worked cold”. This means it is not heated with specialist equipment to make the bitumen in it soft enough to flow into the shape required and meld properly with the edges of the pothole. Instead the stuff is simply shovelled off the back of a lorry and pounded down. That can work as a temporary fix until the road can be resurfaced properly, but often as not this job gets delayed almost indefinitely, which results in more cracks appearing around the fill and yet more potholes.

What is needed is a material that can be used as readily as a cold patch, but which works as well as a hot one. Larry Zanko and his colleagues at the University of Minnesota Duluth, think they know what it is. They are mixing asphalt with ground iron ore that contains magnetite—an iron oxide which, as its name suggests, is magnetic. A phenomenon called ferromagnetic resonance means that when magnetite is zapped with microwaves of an appropriate frequency it gets hot.

Alaska Glenn Highway Sand Seal Project



ALASKA
Department of Transportation
And Public Facilities

SAND SEAL REPORT Glenn Highway Pavement Repairs, Boniface Interchange to Knik River Bridge

Project No. 51896

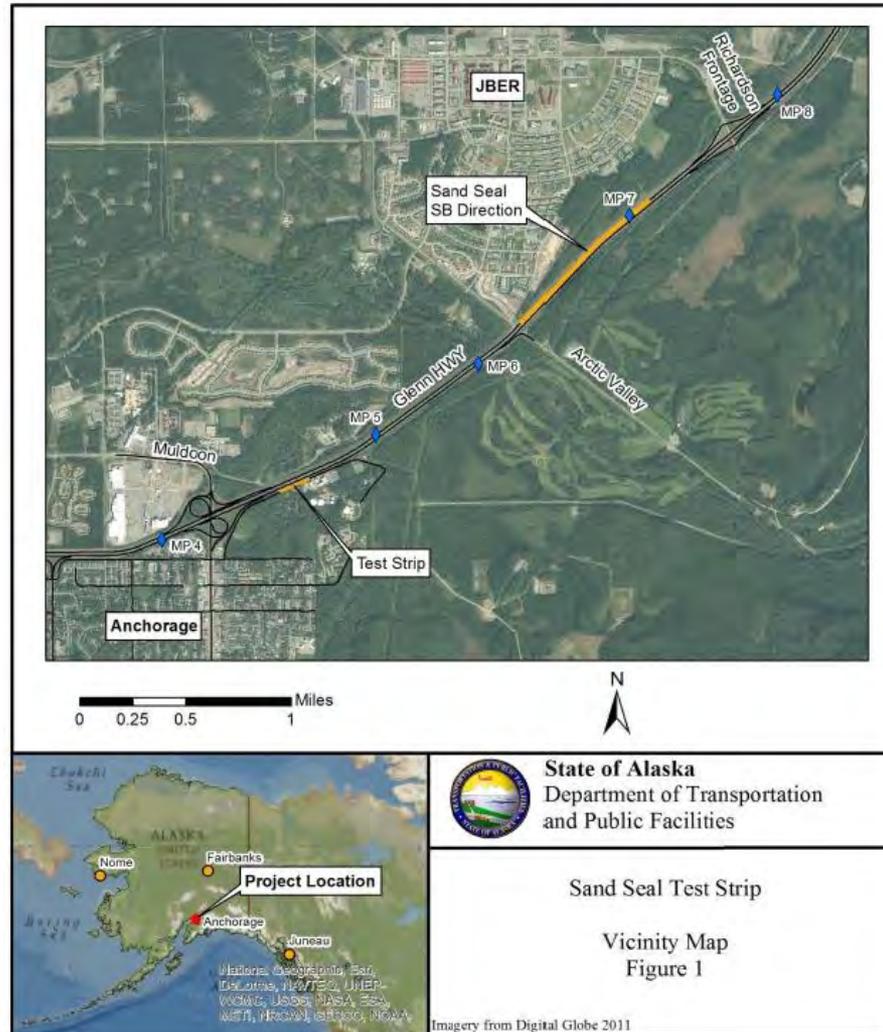
September 2014

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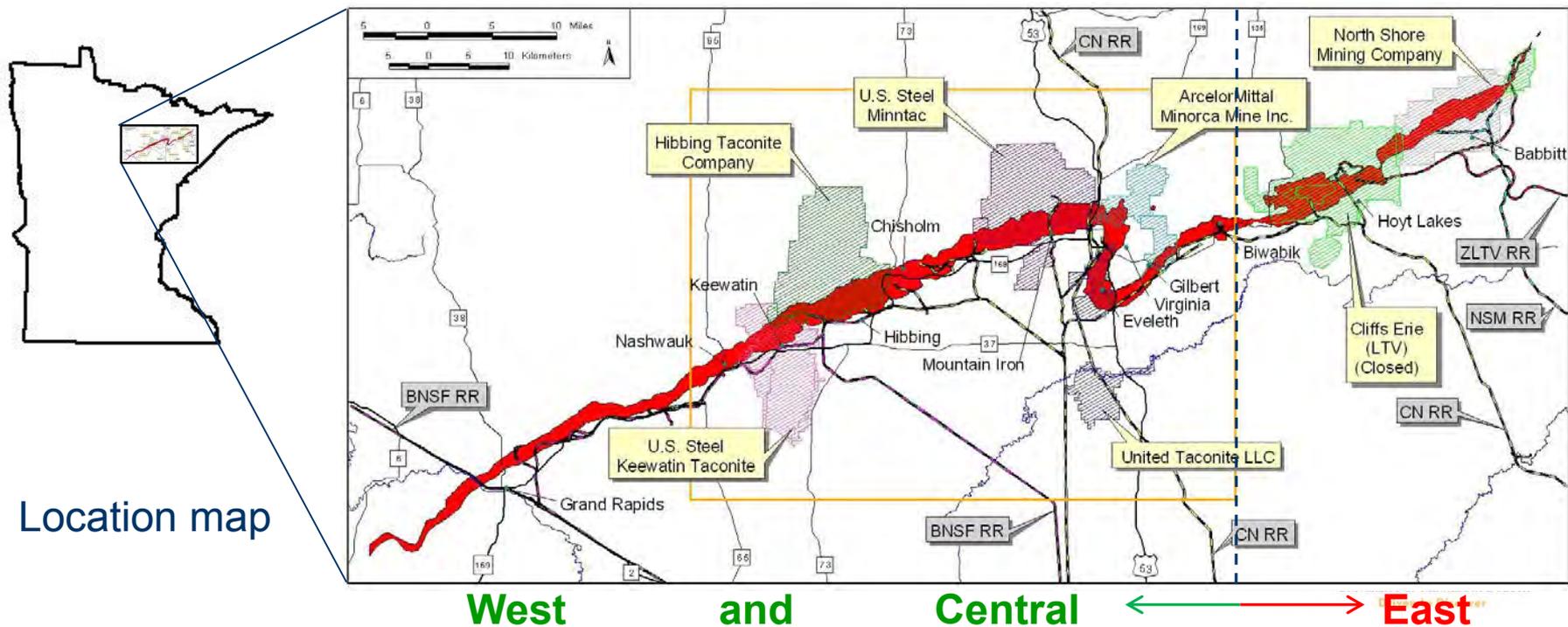
 **State of Alaska**
Department of Transportation
and Public Facilities

Sand Seal Test Strip
Vicinity Map
Figure 1

Imagery from Digital Globe 2011

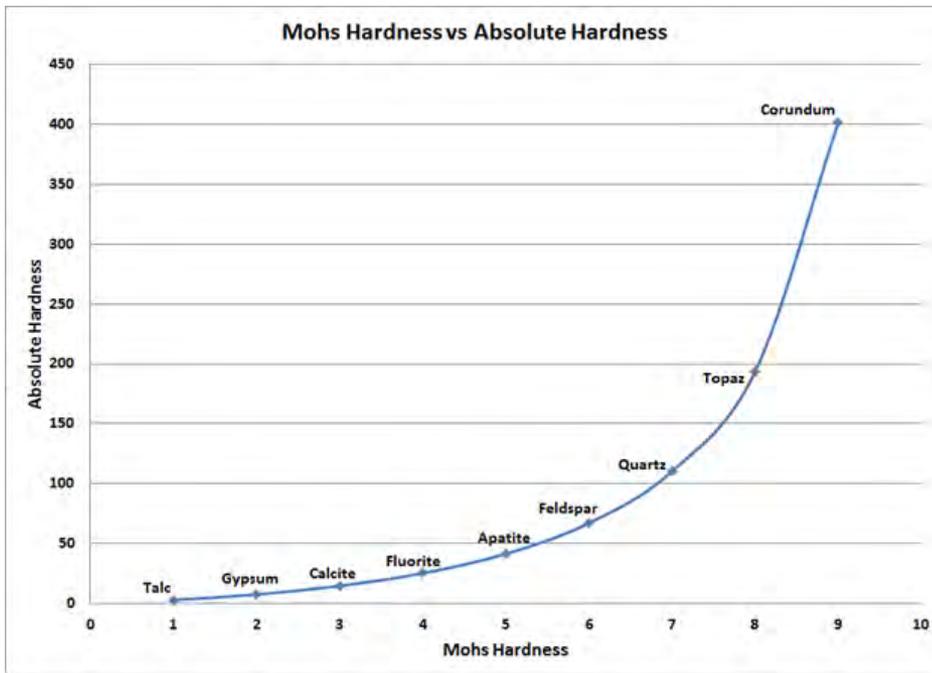
Source of friction aggregate

Minnesota's taconite mining industry generates tens of millions of tons of byproduct materials every year that could be used as aggregate. Friction aggregate represents a higher-value niche application.

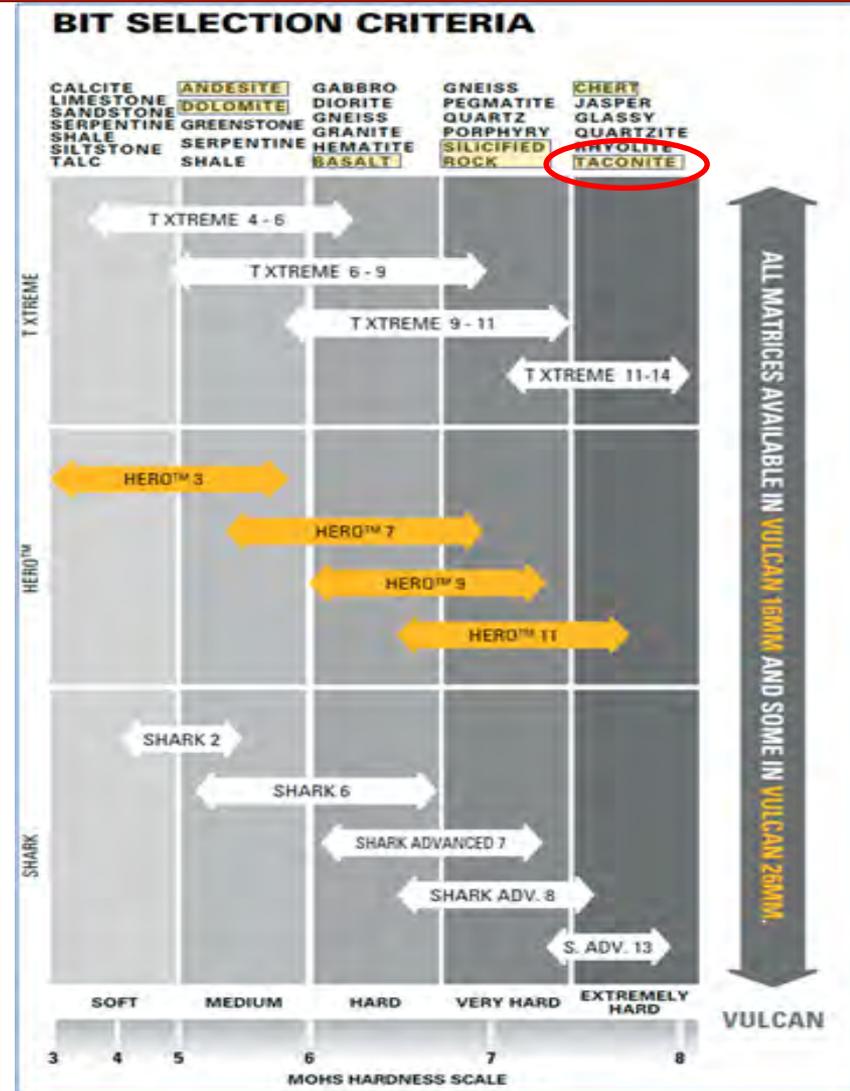


Positive attributes for friction applications

- One of the hardest natural aggregates
- Good angularity



source: <http://www.cidraprecisionservices.com/mohs-scale.html>



source: www.fordia.com/content/documents/Pdf/Arg/Techbook_low.pdf

Alaska sand seal project: Summer 2014

Lab Testing

Cores were obtained from the project area to be tested prior to the sand seal application. Sand seals with two different “hard aggregates” were applied to the surface of the cores and then Prall tested to evaluate the effectiveness of the preservation treatment. The two “hard aggregates” evaluated were Taconite and Calcined Bauxite.

Prall testing of the sand seals with the two different hard aggregates showed similar wear resistant results. Taconite sand was specified since it is available from Minnesota as an industrial byproduct, whereas Calcined Bauxite sand has to be imported to the US.



Glenn Hwy Pavement Repairs, Boniface Interchange to Knik River Bridge
Project No. 51896

[4]

September 2014

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Interesting Logistics

Final delivery to Anchorage was by container vessel

From Minnesota...



Two ~ 3000 lb (1400kg) super sacks were delivered

...to Alaska

Mesabi Sand Seal Aggregate



Pre-installation



Post-installation

<u>Sieve</u>	<u>Total % Passing</u>
#4	100
#8	100
#10	100
#16	85
#30	18
#40	4
#50	1
#200	0.2

Installation

Mesabi sand seal was applied on the in-bound, right lane of the Glenn Highway for a total distance of 4600 feet (1400m) (between pavement striping).

Application rate 0.6 to 0.8 pounds per square yard (0.33 to 0.43 kg per square meter)



DFT testing



Project completed: 7-30-2014



Findings

- **Good performance has been reported by Alaska DOT, and potential future uses of Mesabi friction aggregate are being considered for an upcoming (2017 or 2018) project in Homer, Alaska.**
- **The investigator recommends that “head-to-head” or “side-by-side” comparative testing with calcined bauxite under a variety of highway and climatic conditions be conducted**

Project support / collaboration

- **Minnesota Department of Transportation (MnDOT) / Minnesota Local Road Research Board (LRRB)**
- **Center for Transportation Studies – University of Minnesota (CTS-UM)**
- **Alaska Department of Transportation**

Supplemental

- **U.S. Department of Commerce, Economic Development Administration (EDA)**
- **University of Minnesota, Duluth – Natural Resources Research Institute (UMD-NRRI)**
- **Yawkey Minerals Management**

Acknowledgements

- **David M. Hopstock, PhD**
 - Microwave technology consultant, David M. Hopstock and Associates, LLC; Roseville, MN
- **John VanderHorn**
 - Yawkey Minerals Management
- **Vern Hegg**
 - Microwave Industry Consultants LLC, Monticello, MN
- and
- **David W. Hendrickson, NRRI-Coleraine**
- **Richard R. Kiesel, NRRI-Coleraine, and Coleraine Minerals Research Laboratory staff**
- **Sara P. Post and Julie A. Oreskovich, NRRI**
- **Will DeRocher**
 - Swenson College of Science & Engineering, UMD

Thank you

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