December 2023

Implementation Report
FHWA/MT-23-006/9757-705

More Info:

The research is documented in Report FHWA/MT-23-006/9757-705

Principal Investigator
Paul D. Krauss
pkrauss@wje.com
847.272.7400

MDT Technical Contact
Shane Pegram
spegram@mt.gov
406.444.6289

MDT Research Project Manager
Vaneza Callejas
vcallejas@mt.gov
406.444.6338

EVALUATION OF THIN POLYMER OVERLAYS FOR BRIDGE DECKS

https://www.mdt.mt.gov/research/projects/const/evaluation.aspx

Introduction and Purpose

Polymer overlays are composite materials consisting of organic polymer resins and aggregates. They are often applied to bridge decks to protect the deck from deicer (chloride) intrusion and subsequent corrosion-induced damage. A high-friction surface treatment (HFST) applied to a bridge deck often refers to a thin polymer overlay approximately ¼ inch thick that only differs from a conventional thin polymer overlay (TPO) by the use of special aggregate intended to increase and maintain high friction.

The Montana Department of Transportation (MDT) installed HFSTs on four bridge decks in 2014 and 2015 in order to improve their skid resistance. Initial skid numbers were approximately 80 after HFST installation but after only 3 or 4 years, two of the HFSTs had average skid numbers between 50 and 55 while the other two HFSTs had average skid numbers of 36 and 17. A skid number of 30 to 35 is typically considered to be the minimum acceptable skid number for highway structures. Because of the variable performance of the HFSTs and quick loss of skid resistance for two of the HFSTs, the suitability of HFSTs for Montana's diverse climates and traffic, which commonly uses snow chains in the winter, and the durability of HFSTs in Montana were questioned. Subsequently, the objective of this research was to assess the factors that influence the long-term performance of polymer-based HFST systems in Montana, specifically with respect to friction resistance and durability, and to provide guidance and recommendations to MDT regarding the use of HFSTs across Montana's varying geographic regions.

Implementation Summary

MDT has placed approximately 120 thin polymer overlays on decks as of the latter half of 2023. However, MDT has paused its use of thin polymer overlays in anticipation of the results of this study.

Based on this research, MDT concurs that the thin polymer overlays are generally of good quality and are performing reasonably well. The bridge and maintenance teams within MDT will need to discuss the results and decide if the performance documented by this study justifies the continued widespread use of thin polymer overlays across Montana, if thin polymer overlays should only be used under certain qualifying conditions, or if thin polymer overlays will no longer be used in Montana. This decision may depend on whether or not thin polymer overlays can provide equivalent or better long-term skid resistance compared to bare concrete decks. While this research study characterized the long-term skid resistance and chloride penetration resistance of thin polymer overlays in Montana, comparison to concrete deck controls was outside of the study's scope and further work needs to be done to answer this question.

MDT will determine how to implement the researchers' recommendations pertaining to the design, placement, and contract specifications for new thin polymer overlays. Further MDT has a need to consider and understand how best to maintain its existing thin polymer overlays. The maintenance team has previously conducted maintenance of existing thin polymer overlays by leveraging active contracts for new thin polymer overlays. If maintenance to address the skid resistance of existing thin polymer overlays is needed, the possibility of re-overlaying the driving lane or the wheel paths every 4 or 5 years may be investigated.

Implementation Recommendations

RECOMMENDATION 1:

The conclusions and recommendations of this study only apply to the polymer HFST or overlays investigated in this study. Other polymer formulations are likely to perform differently and should be evaluated separately. Trial installations and evaluation are recommended unless standard materials are being used and the contractor is well experienced.

MDT RESPONSE:

General agreement that trial evaluations are useful for new contracts.

RECOMMENDATION 2:

Use only cementitious repair materials for deck patching that are compatible with the polymer topping or other rapid setting materials shown to be compatible and having acceptable performance when used prior to placing polymer HFSTs. Avoid patch materials that are thermally incompatible or have high shrinkage. The polymer topping adhesion to any new patch material should be tested prior to use. Have contractors map locations and specifics of deck repairs prior to placing toppings and keep in project files.

MDT RESPONSE:

Current practice is to avoid polymer patch materials prior to HFSTs. Design staff to review project contract suggestions.

RECOMMENDATION 3:

Address issues with incomplete consolidation and entrapped air voids within the HFSTs by requiring that the contractor demonstrate that the resin content is appropriate in a trial demonstration, or through evaluation of the in-place overlay. Back rolling the first layer or an optimization study may be valuable.

MDT RESPONSE:

This will require testing (pilot program) and coordination with material manufacturer and contractor.

RECOMMENDATION 4:

Improve detailing at the bridge approach joint. Control and match elevations across the joint. Extend the thin HFST some distance, e.g., approximately 10 feet, beyond the bridge ends if the approaches are portland cement concrete to minimize vertical offsets and reduce snow plow damage and edge wear of the overlay on the bridge deck. Consider grinding existing deck along the approach joints to increase thickness of polymer topping along this edge.

MDT RESPONSE:

Some contracts already require grinding the deck edge to increase polymer overlay thickness. Extending overlay over approach slabs is a good idea on a project-by-project basis.

RECOMMENDATION 5:

Continue to monitor skid resistance of the HFSTs. Data pertaining to driving lanes and passing lanes should be kept in separate datasets instead of averaged. Additionally, the data should be categorized by aggregate source (type) in order to develop appropriate expectations for the performance of the various aggregate types and HFST systems and their appropriateness across different exposures.

MDT RESPONSE:

Agree that it's a good idea to continue monitoring since end of life is still uncertain.

RECOMMENDATION 6:

Armorstone (basalt) appears to maintain skid resistance longer than naturally occurring calcined bauxite aggregate; however, differences in deck exposures of the study bridges may affect performance. A Mohs hardness of at least 7 is preferred and some states prohibit the use of flint rock in HFSTs due to their tendency to polish and have poor long-term skid performance.

MDT RESPONSE:

To be considered. Will depend on aggregate availability and cost.

RECOMMENDATION 7:

HFSTs in this study lost surface friction before wearing through. Ideal HFSTs would maintain surface friction throughout their life. Surface friction and wear rely on the aggregate properties as well as the polymer resin modulus and toughness. New resin formulations that do not polish and maintain skid resistance as they wear is a focus for future research.

MDT RESPONSE:

Other formulations of HFSTs should be evaluated prior to use.

RECOMMENDATION 8:

Evaluate and test if an additional layer of HFST may be applied on top of the existing overlay. Consider reapplication of HFST to driving lanes after five years to restore skid resistance and extend deck protection.

MDT RESPONSE:

This is a good idea that should be investigated further.

RECOMMENDATION 9:

Favor new bridge decks and decks without signs of corrosion initiation as candidates for thin polymer overlays or HFSTs. However, bridge decks in need of local full- or partial-depth patches do not need to be precluded from consideration. Corrosion testing, half-cell potential surveys, and determination of chloride contents in the deck can aid in optimizing deck selection. Avoid use on decks with widespread damage due to reinforcing corrosion (decks near the end of their service life).

MDT RESPONSE:

Agree that design should include HFSTs on decks in good condition and avoid decks near end of service life.

RECOMMENDATION 10:

Transverse deck cracks tend to reflect with time. Primer was noted to penetrate deck cracks and may help reduce reflective cracking.

MDT RESPONSE:

Good idea to require primer on decks with cracking.

RECOMMENDATION 11:

While current practice appears adequate, achieving good bond is critical to polymer overlay performance. Implement quality assurance/quality control testing to ensure adequate surface preparation and to monitor polymer batching, mixing, placement, and curing. Depending on the deck surface condition, micromilling may be advantageous to remove surface contamination and chloride-contaminated concrete. Specify a) concrete surface profile (CSP) of at least 5, b) Maximum concrete deck moisture of 5% per moisture meter (see NYSDOT), c) minimum direct tensile bond strength (ASTM C1583) of 250 psi, and d) specify primer to fill and seal cracks when available.

MDT RESPONSE:

To consider for modifications to specifications.

RECOMMENDATION 12:

Consider a 5-year warranty clause as specified by other states.

MDT RESPONSE:

To consider for modifications to specifications.

DISCLAIMER STATEMENT

ALTERNATIVE FORMAT STATEMENT

Alternative accessible formats of this document will be provided on request. Persons who need an alternative format should contact the Office of Civil Rights, Department of Transportation, 2701 Prospect Avenue, PO Box 201001, Helena, MT 59620. Telephone 406-444-5416 or Montana Relay Service at 711.

This public document was published
in electronic format at no cost for printing and distribution.