Noteworthy Practice for *South Dakota HFST for Winter Road Conditions*

South Dakota High Friction Surface Treatment (HFST) Projects

In South Dakota an average of 3,479 fatal and serious injury crashes occurred from 2013 through 2017; 59% of these crashes were lane departure crashes[1]. While investigating lane departure crashes in their state, the South Dakota Department of Transportation (SDDOT) found lane departure crashes were five times more likely to involve winter road conditions than wet road conditions. In addition, one-third of the lane departure crashes occurred on horizontal curves, even though horizontal curves account for less than 10% of the system[2].

Figure 1: Approach to Horizontal Curve along I-90. Source: SDDOT

To help vehicles maintain their lane during critical braking and cornering maneuvers, in 2014 SDDOT installed high friction surface treatments (HFSTs) at four horizontal curves with crash rates two to four times higher than the statewide average, with most incidents occurring during snow-packed or icy road conditions[3]. HFST is a thin layer of calcined bauxite aggregate bonded to the pavement with a polymer resin binder that has long-lasting skid resistance and makes the pavement more resistant to wear and polishing. Since this was the first time HFSTs were deployed in the state, a simple before-after analysis in lieu of more advanced statistical analysis methods was performed at these four locations showing a 78% reduction in run-off-road (ROR) crashes for 2015 when compared to the average number of crashes per year for the before period of 2009 through 2013. Similarly, they observed an 89% reduction for 2016 compared to the before period crashes (see Table 1). SDDOT further observed that HFSTs performed well during winter road conditions.

Table 1. Crash History at Four Horizontal Curves Treated with HFSTs[3]

Location	Before (2009–2013) ROR Total Crashes	Before (2009–2013) ROR Average Crashes/Year	After (Oct 2014–April 2015) ROR Crashes	After (2015) ROR Total Crashes	After (2015) % Crash Reduction	After (2016) ROR Crashes	After (2016) % Crash Reduction
I-229 NB	11	2.2	0	0	100%	1	55%
I-229 SB	18	3.6	1	1	83%	0	100%
14A Deadwood	13	2.6	1	1	62%	0	100%
14A Lead	5	0.6	0	0	100%	0	100%
Total:	47	9.0	2	2	78%*	1	89%*

* 2015 value calculated as (9.0 -2)/9.0 = 0.78 (or 78%); 2016 value calculated as (9.0-1)/9.0 = 0.89 (or 89%)

[1] South Dakota Department of Transportation. *2019 South Dakota Strategic Highway Safety Plan*, Pierre, SD, 2019.
[2] Roadway Safety Foundation and Federal Highway Administration. *2019 National Roadway Safety Awards Noteworthy Practices Guide (South Dakota: Application of High-Friction Surface Treatment (HFST) in Winter Road Conditions)*, https://safety.fhwa.dot.gov/roadwaysafetyawards/2019/20200116_Noteworthy%20Guide-508%20Compliant.pdf (accessed 2021).
[3] South Dakota Department of Transportation. *Accelerated Innovation Deployment (AID) Demonstration Project: High Friction Surface Treatment*, Final Report, Pierre (SD), 2015.

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Based on this experience, SDDOT expanded their use of HFSTs. In 2017, SDDOT installed HFSTs at 15 locations with a high frequency of winter-road-condition crashes (see Figures 1 and 2). After two winters, a simple before-after analysis of the crash data showed a 78% reduction in total crashes, and an economic analysis revealed a benefit-cost ratio of 12:1 from these projects. SDDOT estimates use of HFSTs in South Dakota will save $18M in societal crash costs. SDDOT is pleased with the results of the HFST installations in reducing crashes and plans to use this treatment at additional strategic locations throughout the state[2].

Identifying Treatment Locations

When assessing the appropriateness of a HFST[4], agencies should consider curve locations with:

- High target crash frequencies (e.g., wet-weather crashes and/or winter-road-condition crashes above the statewide average).
- Low pavement friction.
- Large speed differentials between tangents and points of curvature and geometric factors (e.g., curve radius).
- Failure of previously installed lower-cost treatments.
- Structurally sound pavements requiring minimal surface repair.

Figure 2: HFST along Horizontal Curve on Rural Multilane Roadway. Source: SDDOT

Effect of Snowplows on HFST Applications

SDDOT has not encountered any challenges with the durability of HFSTs involving snow removal equipment and has not experienced any notable removal of HSFTs during snow removal activities. The bauxite surface wears well under heavy snowplowing[5].

Development of Standard Specifications and Methods for Application

In 2014, when SDDOT first installed HFSTs at the four locations determined to have an over-representation of lane departure crashes during winter road conditions, two curves had concrete pavement and two curves had asphalt pavement. This allowed SDDOT to develop specifications for both types of pavements. The methods used to apply the HFSTs were very similar to how SDDOT applies an epoxy deck seal on a bridge deck. The only element that sets these types of applications apart is the type of aggregate used[3].

Recently, SDDOT transitioned from a semi-automated application method (see Figure 3) to a fully-automated application method (see Figure 4). A fully-automated HFST application typically involves a customized truck that mechanically mixes each component of the binder (in accordance with the current ambient or surface temperature) and applies a consistent layer of the binder to the pavement surface followed by the placement of aggregate on the epoxy through a drop spreader.

Figure 3: Semi-Automated HFST Application Method. Source: SDDOT

[4] Wilson, B.T., K.C.P. Wang, J.Q. Li, and G. Wang. *Recommendations Report for High Friction Surface Treatments: Candidate Sites, Materials, and Construction*, Report No. FHWA-SA-20-036, Federal Highway Administration, Washington, DC, 2020.
[5] Federal Highway Administration. *High Friction Surface Treatments – Frequently Asked Questions. Report No. FHWA-CAI-14-019, Washington, DC., 2014*.

One of the primary benefits of a fully-automated process is the time lapse between epoxy and aggregate applications is minimized which reduces the chance of hardening of the epoxy prior to placement of the aggregate. Other benefits include[6]:

- Even application of binder and aggregate.
- Reduced installation time, for example the range of application rates between manual and fully automated are as follows:
  - Manual 200 to 1000 square yards (SY)/hr.
  - Semi-automated 1800 SY/hr.
  - Fully-automated 2800 SY/hr.
- Reduced exposure of workers to live traffic.
- Reduced material component waste.

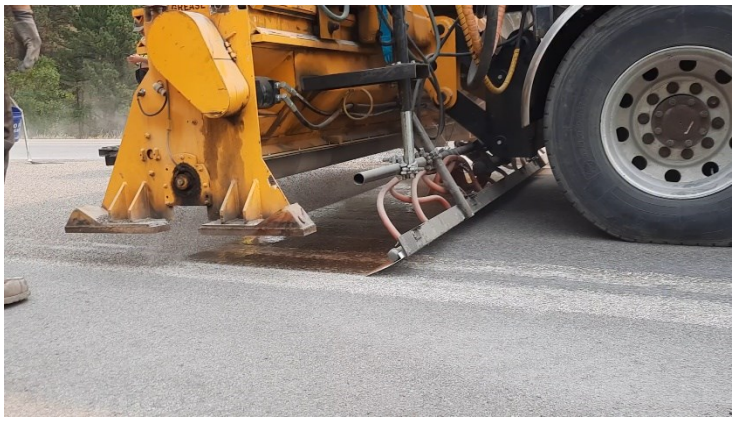

Figure 4: Fully-Automated HFST Application Method. Source: SDDOT

Lessons Learned

Based on their experience with HFSTs, SDDOT shared several lessons learned:

- HFST is a proven safety countermeasure suitable for all weather applications at strategic locations. Other State DOTs, even States that experience severe winter conditions, should not be reluctant to install a HFST as a safety countermeasure to reduce lane departure crashes at strategic locations, especially locations involving winter road condition.
- SDDOT has not experienced durability issues associated with HFSTs due to snow removal. HFSTs wear well under heavy snow plowing.
- SDDOT now applies HFSTs through a fully-automated process due to premature failures experienced on projects that used a semi-automated application method.

For Additional Information

For additional information about HFSTs and their effectiveness in reducing lane departure crashes, contact Joseph Cheung, FHWA Office of Safety, at **joseph.cheung@dot.gov**.

For additional information about SDDOT's applications and use of HFST, contact Dustin Witt, South Dakota Department of Transportation, at **Dustin.Witt@state.sd.us**.

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[6] Atkinson, J., J. Clark, and S. Ercisli. *High Friction Surace Treatment Curve Selection and Installation Guide.* Report No. FHWA-SA-16-034, Federal Highway Administration, Washington, DC, 2016.