High Friction Road Surface

Evaluation of High-Friction Surface Treatment Effectiveness Using Pre- and Post-Application Skid Tests

High-friction surface treatments (HFST) are thin layers of specialized aggregate bound to pavement with a durable resin, designed to significantly increase pavement skid resistance. The aggregates are typically calcined bauxite or other hard, polish-resistant materials with a high frictional value.

HFST is most often applied at crash-prone locations such as sharp curves, steep grades, ramps, and intersections, where vehicles are more likely to lose traction. By providing a much higher coefficient of friction than conventional asphalt or concrete surfaces, HFST reduces stopping distances, enhances vehicle control, and lowers the likelihood of roadway departure and wet-weather crashes.

High Friction Surface Treatment (HFST) can generally be identified through a combination of visual inspection, surface texture assessment, and contextual roadway clues. Visually, HFST exhibits a distinctly coarse, angular appearance due to the use of epoxy-bonded calcined bauxite aggregate. The surface typically resembles industrial anti-slip coating or coarse sandpaper and lacks the longitudinal striations associated with milled asphalt. Unlike chip seal, the aggregate is not loose; rather, it is uniformly embedded within a resin binder.

HFST is typically installed at horizontal curves, signalized intersections, steep downgrades, and ramp terminals where agencies seek to mitigate wet-weather or loss-of-control crashes. The treated section may appear darker or more uniform than adjacent pavement and may produce increased tire noise due to its enhanced macrotexture. Definitive confirmation, however, should be obtained through agency maintenance records, construction plans referencing HFST or calcined bauxite overlays, or site-specific friction testing. Reliance solely on assumed roadway characteristics without verification may lead to inaccurate friction inputs in accident investigations.

Extensive field studies and state DOT applications have shown crash reductions of 30–50% at treated sites, especially under wet conditions. The Federal Highway Administration (FHWA) advanced studies have shown crash reduction of 57 percent for total crashes and a crash reduction of 83 percent for crashes on wet curves. Although HFST installation costs are higher than traditional paving, the safety benefits and extended service life (often 5–10 years depending on traffic loading) make it a cost-effective countermeasure.

The effectiveness of a high-friction surface treatment (HFST) was evaluated through controlled vehicle-based skid testing conducted before and after application of the treatment. Pre-application testing was performed on the existing pavement surface, and post-application testing was conducted approximately nine months after HFST installation to assess both initial performance and durability under normal traffic exposure. All testing was performed at the same roadway location under comparable geometric and environmental conditions to isolate the effect of the surface treatment on available pavement friction.

Across all four photographs, the High Friction Surface Treatment (HFST) is identifiable by its distinctly uniform, coarse aggregate surface applied within targeted roadway segments. In the upper-left image, the red-pigmented curve surface represents HFST, easily distinguished from conventional asphalt by its consistent coloration and sandpaper-like macrotexture. In the upper-right image, the lighter tan surface through the horizontal curve indicates an epoxy-bonded aggregate overlay confined to the curve limits. In the lower-left image, the older red treatment is visible along the curve approach and shoulder area, contrasting sharply with adjacent newly treated pavement in contrast with the darker roadway asphalt. In the lower-right image, the darker, uniformly textured section along the curve approach reflects a similar friction-enhancing application. In each case, HFST is characterized by its thin bonded layer, defined application boundaries, and visibly coarse texture designed to increase wet-weather skid resistance.



Three test vehicles were used to reduce vehicle-specific bias and improve the robustness of the results. Each vehicle was instrumented with a VC4000 accelerometer mounted and calibrated in accordance with manufacturer specifications. Controlled braking maneuvers were conducted to measure longitudinal deceleration, which was subsequently used to calculate coefficients of friction for each test run. The use of multiple vehicles and independent data acquisition systems provided a cross-check of results and increased confidence in the measured friction values.

Testing included straight-line and curved braking maneuvers conducted under both dry and wet pavement conditions, where applicable. For each test condition, the vehicle was accelerated to a consistent target speed and subjected to firm braking sufficient to approach tire adhesion limits without inducing wheel lockup or electronic stability system intervention. Wet-condition testing was conducted by uniformly wetting the pavement surface prior to each braking run to simulate reduced-traction conditions. Each test scenario was repeated a minimum of three times per vehicle to evaluate repeatability and allow for statistical comparison.

Average Coefficient of Friction (μ)

Test Condition	Vehicle 1	Vehicle 2	Vehicle 3
Dry (Pre)	0.736 ± *0.014*	0.797 ± 0.015	0.782 ± 0.018
Dry (Post)	0.870 ± *0.020*	0.823 ± 0.015	0.839 ± 0.058
Wet (Pre)	0.723 ± *0.047*	0.707 ± 0.006	0.735 ± 0.017
Wet (Post)	0.883 ± *0.049*	0.883 ± 0.012	0.847 ± 0.050

Values are mean ± standard deviation (from 3 runs).

Percent Improvement

Dry Condition (Pre vs Post):

Vehicle 1: **+18.2%**
Vehicle 2: **+3.3%**
Vehicle 3: **+7.3%**

Wet Condition (Pre vs Post):

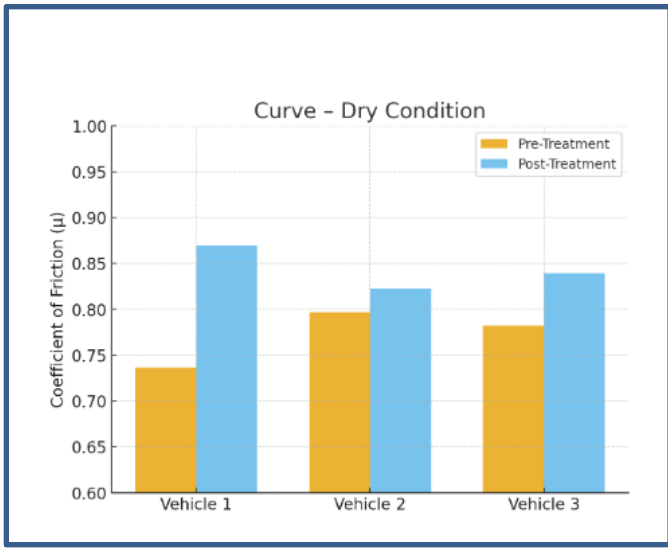
Vehicle 1: **+22.1%**
Vehicle 2: **+24.9%**
Vehicle 3: **+15.2%**

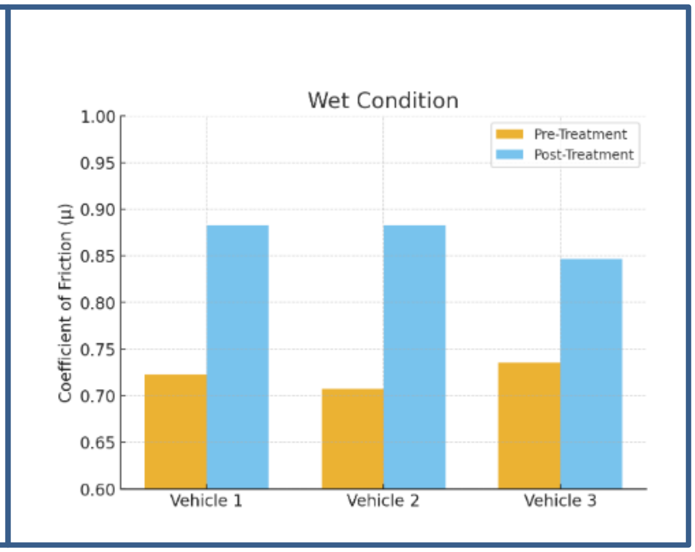
Variations in the magnitude of percent improvement among the test vehicles are attributed to differences in baseline friction levels, tire characteristics, and vehicle braking system response, which influence how each vehicle interacts with the treated surface.

This study evaluated the effectiveness of a high-friction surface treatment (HFST) through controlled pre- and post-application skid testing using multiple vehicles and repeat braking trials. The results demonstrate that the HFST produced a measurable and sustained increase in pavement friction, particularly under wet roadway conditions, where available friction is most critical for vehicle control and crash avoidance.

Key Findings

- The HFST resulted in a consistent and substantial improvement in wet-surface friction across all test vehicles, with increases ranging from approximately 15% to 25%.
- Improvements under dry conditions were more variable. Vehicle 1 exhibited a notable increase in friction (+18%), while Vehicles 2 and 3 showed more modest gains (+3% to 7%).
- Standard deviations were generally small, indicating good repeatability of the braking measurements. Greater variability was observed for Vehicle 3 in the post-treatment dry condition.
- Overall, the results demonstrate that the HFST provided the greatest safety benefit under wet conditions, where available pavement friction is most critical for braking performance and crash avoidance.





Across all three test vehicles, wet-condition coefficients of friction increased by approximately 15% to 25% following HFST installation. These gains were consistent among vehicles and were observed nine months after application, indicating that the treatment maintained its frictional performance under normal traffic exposure. The magnitude of improvement under wet conditions is especially significant, as wet pavement friction is commonly associated with increased stopping distances, loss of lateral control, and elevated crash risk.

Dry-condition results showed more variability. Vehicle 1 exhibited a substantial increase in dry friction (+18%), while Vehicles 2 and 3 showed more modest improvements (+3% to 7%). This variability is consistent with expectations, as untreated dry asphalt surfaces already provide relatively high friction, reducing the proportional benefit achievable through surface treatment. Nonetheless, even modest increases in dry friction can contribute to improved safety margins, particularly in curves where lateral friction demand is elevated.

The relatively small standard deviations observed in most test conditions indicate that the braking measurements were repeatable and that the observed changes in friction are attributable to the surface treatment rather than random variability. The increased variability observed for Vehicle 3 in the post-treatment dry condition likely reflects vehicle-specific factors such as braking system response or tire characteristics, rather than a degradation of the HFST itself.

From an engineering perspective, the measured increases in coefficient of friction translate directly to reduced stopping distances and increased lateral force capacity. For example, a 20% increase in available friction corresponds to a comparable reduction in required braking distance or an increased margin against loss of control in curved alignments. These improvements are particularly relevant in locations with known wet-weather crash histories, where friction demand frequently exceeds available pavement friction.

Overall, the results of this evaluation confirm that high-friction surface treatment is an effective countermeasure for improving roadway skid resistance, with the greatest benefit realized under wet conditions. The sustained frictional improvements observed in this study support the use of HFST as a durable and practical safety treatment at locations prone to low-friction-related crashes, such as curves, ramps, and approaches to intersections. When assessed using objective vehicle-based testing methods, HFST demonstrates quantifiable performance benefits that align with observed crash reduction trends reported in broader field studies.

From an accident reconstruction perspective, the results of this study have direct implications for the selection of roadway friction values used in analytical calculations. In the absence of site-specific testing, reconstructionists commonly assume a nominal pavement coefficient of friction on the order of 0.70 to 0.75 for dry asphalt or concrete surfaces, with lower values typically assumed for wet conditions. These default values are widely used in braking, stopping distance, and loss-of-control analyses and are generally appropriate for conventional pavement surfaces of unknown condition.

The results of the present testing demonstrate that high-friction surface treatments can produce coefficients of friction that exceed these commonly assumed values, particularly under wet roadway conditions. Post-treatment wet coefficients of friction approaching or exceeding 0.85 were measured across multiple vehicles, representing increases of approximately 15% to 25% relative to pre-treatment conditions. As a result, the use of standard assumed friction values in the analysis of crashes occurring on HFST-treated roadways may underestimate available friction and overestimate braking distances.

When reconstructing crashes on roadways known to have high-friction surface treatments, reconstructionists should not rely solely on generic friction assumptions. Instead, site-specific testing, agency documentation, or conservative adjustments to assumed coefficients of friction should be considered. Failure to account for the increased frictional capacity of HFST surfaces may lead to inaccurate conclusions regarding vehicle speed, driver response, and crash causation. The findings of this study support the need for case-specific friction evaluation in HFST locations and reinforce the importance of incorporating measured or documented surface properties into forensic analyses whenever possible.

While high-friction surface treatments provide increased skid resistance under both dry and wet conditions, care should be exercised when extrapolating friction values between these conditions for analytical purposes. The results of this study demonstrate that the relative benefit of HFST is substantially greater under wet conditions than under dry conditions, where untreated pavement already exhibits relatively high friction. As a result, dry-condition friction values should not be assumed to increase proportionally to wet-condition improvements, nor should wet-condition friction be inferred solely from dry pavement testing.

In accident reconstruction analyses, it is common to estimate wet-surface friction as a percentage reduction from dry-surface values when site-specific data are unavailable. However, HFST-treated surfaces do not necessarily follow this conventional relationship. The specialized aggregates and resin binders used in HFST are specifically designed to resist polishing and maintain macrotexture in the presence of water, resulting in a frictional response that differs from conventional asphalt or concrete. Consequently, applying traditional wet-to-dry reduction factors to HFST surfaces may lead to inaccurate friction estimates.

Accordingly, when evaluating crashes occurring on HFST-treated roadways, reconstructionists should avoid direct wet–dry extrapolation and instead rely on condition-specific testing or documented performance data for the surface treatment. Where testing is not feasible, conservative assumptions should be clearly stated and supported by available literature. Recognizing the distinct frictional behavior of HFST under varying environmental conditions is essential to ensuring accurate and scientifically defensible reconstruction conclusions.

Martin Moreda is a certified and accredited accident reconstructionist (ACTAR 2562) and a 24-year veteran of the Secaucus Police Department, where he currently serves as Deputy Chief of Police. He is the principal and owner of Moreda Consulting, LLC, and has more than 20 years of experience in accident investigation and reconstruction. Mr. Moreda was a co-founder of the Hudson County Fatal Accident Investigation Unit and is recognized as a qualified subject matter expert in his field. He currently serves as Vice President of the New Jersey Association of Accident Reconstructionists (NJAAR) and holds the position of Chairman of the Seminar and Conference Committee.