**Needs Statement 574 –Mesabi HFST: Literature Search**

**Prepared for:** Beth Klemann

**Prepared by:** Jim Byerly, Electronic Resources Librarian

**Resources searched:** Library catalog, ASCE Database, RiP, TRID, Transport Database, Web

**Summary:** Results are compiled from the databases named above. Links are provided for full-text, if applicable, or to the full record citation. I completed my searches using the following terminology: high friction surface treatment, HFST, friction course, epoxy, asphalt binder, microsurfacing, mesabi friction, calcined bauxite. I have divided the results into the categories of most relevant and least relevant.

**Most Relevant Results**

**ASCE Database**

**Effectiveness and Cost-Effectiveness Evaluation of Pavement Treatments Using Life-Cycle Cost Analysis**

Linyi Yao; Qiao Dong, Ph.D.; Fujian Ni; Jiwang Jiang

*Abstract*

This paper evaluated the effectiveness and cost-effectiveness of pavement treatments based on the equivalent area method, which uses the area bounded by posttreatment performance curve, threshold, and unified standard service time, as the measure of effectiveness. Multiple linear regression analysis was applied to analyze the influence of factors including traffic level, milling, characteristics of a road section, surface thickness, and crack treatments. Life-cycle cost analysis was conducted to compare the cost-effectiveness of different treatment strategies over a 20-year analysis time frame. Three different asphalt mixtures with different gradations and three preventive treatments including ultrathin friction overlay, hot-in-place rehabilitation, and **microsurfacing** were investigated. The data of pavement surface condition index (PCI), riding quality index (RQI), and rutting depth index (RDI) collected in Zhejiang Province in China were adopted to evaluate the treatment performance. Analysis results showed that a lower traffic growth rate and a thicker asphalt layer are associated with a higher treatment effectiveness. Lighter traffic volume and a thicker asphalt layer contribute to higher cost-effectiveness. Milling and crack treatment appear to increase effectiveness but reduce cost-effectiveness. Road sections with a big curvature and long, steep slopes tend to have lower effectiveness. In addition, alternately using an asphalt overlays and preventive treatments showed a high cost-effectiveness and is recommended. **Microsurfacing** is cost-effective when applied relatively early in the pavement life.

[https://ascelibrary.org/doi/10.1061/JPEODX.0000106](https://ascelibrary.org/doi/10.1061/JPEODX.0000106)

**Transport Database**

**Result 2.**

**Title**

Does friction and colour equal safety? [road surface treatments].
Using high friction surface treatments to reduce traffic accidents.

A Study of the Effectiveness of Tyregrip High Friction Surface Treatment

Reddy, Vivek; Datta, Tapan; Savolainen, Peter; Pinapaka, Satya

Abstract. This article reports on a study of the effectiveness of high friction surface treatment (tradename Tyregrip) to reduce the potential for runoff-road crashes. The Florida Department of Transportation (FDOT) and the Federal Highway Administration (FHWA) installed the Tyregrip high friction surfacing systems along a 300-foot section of the on-ramp to northbound I-75 from eastbound Royal Palm Boulevard in the city of Weston (Broward County), Florida. The Tyregrip surfacing system consists of a highly-modified exothermic epoxy resin two-part binder usually top dressed with a calcined bauxite with a polished stone value (PSV) of 70%. This system has long-lasting durability and skid resistance properties on both wet and dry pavement conditions. The authors discuss measurements of crash frequency, vehicle speeds, shoulder encroachments, data on the friction factor, tests for variability, and tests for differences in the mean
speeds. Travel speeds were found to decrease after the application of the Tyregrip (an average of 3.72 mph under dry 
pavement conditions and 2.62 mph under wet pavement conditions). The proportion of vehicles encroaching onto the 
shoulder was found to decrease substantially under wet pavement conditions after the installation of the Typegrip 
treatment. The authors conclude that the use of Tyregrip may be a practical countermeasure for improving safety at 
locations that are prone to run-off-road crashes, particularly sharp curves and entry/exit ramps.

Development of Alternative High Friction Surfaces for Oklahoma
Heitzman, Michael; Vrtis, Michael

Abstract. Oklahoma Department of Transportation (OK DOT) wanted to identify maximum surface friction performance 
of asphalt surface mixtures using regionally available aggregates as alternatives to a standard high friction surface 
treatment using resin binder and imported calcined bauxite aggregate. The laboratory study was divided into two 
phases. Phase I compared aggregate/mixture combinations that were expected to have the best potential to provide 
high pavement surface friction characteristics. Phase II studied the types of tack coats to determine the best tack 
application for the selected friction surface. The OK DOT staff identified regionally available sources with good friction 
performance characteristics, including mine chat, rhyolite, sandstone, and granite. The mixture type selected for the 
study was open graded friction course (OGFC). A testing and conditioning protocol developed at National Center for 
Asphalt Technology (NCAT) was used for measuring the friction performance of pavement surfaces. Based on the Phase I 
friction results, the sandstone OGFC section was selected for further study on the NCAT Pavement Test Track. Variables 
in the Phase II tasks were one type of tack coat and two application rates. Preparing laboratory slabs involved 
compacting the underlying slab, conditioning the surface of the slab, applying the tack coat, and placing the OGFC layer 
on top. Cores were taken from the slabs for bond strength shear testing. Cores from the slabs with the higher tack coat 
application rate had higher interface bond strength.
Laboratory Evaluation of Aggregates for High-Friction Surface Treatment
Zahir, Humaira; Hossain, Mustaque; Miller, Rick

Abstract. Road surfaces may prematurely lose pavement friction due to polished aggregates on sharp horizontal curves, steep grades, or near intersections resulting in vehicle skidding. The problem gets exacerbated during wet weather. The Federal Highway Administration (FHWA) estimates that about 70% of wet pavement crashes can be prevented or minimized by improving pavement friction. High Friction Surface Treatment (HFST), a specially-designed thin surface application of hard aggregates and thermosetting resins like epoxy, has been proven to be an effective method to increase road surface friction. Calcined bauxite has been predominantly used in the United States as the hard aggregate in combination with an epoxy binder for HFST. However, this treatment is expensive since the calcined bauxite is imported. The objective of this study is to evaluate the performance of a local aggregate in HFST. Slab specimens of hot-mix asphalt (HMA) were compacted in the laboratory and treated with HFST systems incorporating both calcined bauxite and a local, hard aggregate. The treated HMA specimens were then tested with a Dynamic Friction Tester (DFT) and a Circular Texture Meter (CTM) to determine the frictional coefficient and the mean profile depth (MPD), respectively. Also, Hamburg Wheel Tracking Device Testing was conducted on these HFST systems to evaluate wearing resistance under repetitive wheel load. The results show that the local aggregate can be a suitable substitute for the calcined bauxite in HFST.

Record Type: Publication
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Supplemental Notes: This paper was sponsored by TRB committee AFP70 Standing Committee on Aggregates. Alternate title: Laboratory Evaluation of Aggregates for High Friction Surface Treatment.
Monograph Title: TRB 96th Annual Meeting Compendium of Papers
Corporate Authors: Transportation Research Board 500 Fifth Street, NW Washington, DC 20001 United States Pagination: 11p
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Friction Management on Kansas Department of Transportation Highways
Zahir, Humaira; Islam, Shuvo; Hossain, Mustaque

Abstract. The Federal Highway Administration (FHWA) estimates that about 70% of wet pavement crashes can be prevented or minimized by improving pavement friction. High Friction Surface Treatment (HFST), a specially-designed thin surface application of hard aggregates and thermosetting resins like epoxy, has been proven to be an effective method to increase road surface friction. Calcined bauxite has been predominantly used in the United States as the hard aggregate in combination with an epoxy binder for HFST. However, this treatment is expensive since the calcined bauxite is imported. The objectives of this study are to evaluate the performance of a local aggregate in HFST and to evaluate the 3-dimensional laser profiler for measuring pavement texture. Slab specimens of hot-mix asphalt (HMA) were compacted in the laboratory and treated with HFST systems incorporating both calcined bauxite and a local, hard flint aggregate from Picher, Oklahoma. The treated HMA specimens were then tested with a Dynamic Friction Tester (DFT) and a Circular Track Meter (CTM) to determine the frictional coefficient and texture depth, respectively. Also,
Hamburg Wheel Tracking Device tests were conducted on these HFST systems to evaluate wearing resistance under repetitive wheel load. Field measurements of texture depths on HFST were also done. Statistical analysis was performed to compare the performance of high friction surfaces prepared with different aggregate epoxy combinations. The results show that flint aggregate can be a suitable substitute for the calcined bauxite in HFST. Field measurements also showed marked improvements in texture depth with HFST. Texture depth and skid number determined by the ASTM skid trailer vary with pavement surface types and treatments. Mean Texture Depth (MTD) of high friction surface treatment is generally greater than 1 mm. A good correlation between skid number and MTD was found for the MTD range of 0.5 to 1.5 mm.

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Friction Surface Treatment Selection: Aggregate Properties, Surface Characteristics, Alternative Treatments, and Safety Effects
Li, Shuo; Xiong, Rui; Yu, Demei; Zhao, Guangyuan; Cong, Peiliang; Jiang, Yi

Abstract. This study aimed to evaluate the long term performance of the selected surface friction treatments, including high friction surface treatment (HFST) using calcined bauxite and steel slag, and conventional friction surfacing, in particular pavement preservation treatments such as chip seal, microsurfacing, ultrathin bonded wearing course (UBWC), and diamond grinding. This study also attempted to determine the correlation between vehicle crash and pavement surface friction, which makes it possible to quantitatively establish the so-called crash modification factors (CMFs) that are extremely useful in selecting a cost-effective solution to reduce wet pavement vehicle crashes. In-depth reviews were conducted to identify the aspects of the properties for aggregates used in HFST, including aggregate abrasion value (AAV), Los Angeles abrasion (LAA), Micro-Deval abrasion, and polished stone value (PSV). Extensive laboratory testing was conducted to examine the LAA, Micro-Deval abrasion, and PSV, and to provide first-hand data on the calcined bauxite and steel slag that may be used for HFST and friction surfacing in Indiana. Laboratory accelerating polishing was carried out to evaluate the effect of aggregate gradation and identify the HFST systems with satisfactory friction performance with respect to surface macro-texture and friction. Test strips were installed in the pavement on a real-world road to further evaluate the friction performances of the promising HFST systems under the true traffic polishing and assess the potential effect of winter and snow plow. Pull-off testing was also conducted to examine the bonding between the proposed HFST systems and the substrate surface. Field friction test data was utilized to evaluate the long-term friction performances of pavement preservation treatments, including chip seal, microsurfacing, UBWC, and diamond grinding. Statewide vehicle crash data between 2010 and 2014 was examined to determine the crash statistics associated with pavement friction. The crash data was also matched to the annual pavement inventory friction
data to quantify the probabilistic association between vehicle crash and pavement friction with respect to interstate, US, and state highways, respectively. Specification requirements were established for the properties of calcined bauxite and steel slag for HFST and friction surfacing with respect to LAA, Micro-Deval abrasion, PSV, Al2O3 content, and fine aggregate angularity (FAA). Specification requirements were also developed for HFST aggregate gradation and surface friction performance. Regression models were developed for predicting the friction numbers of chip seal, microsurfacing, UBWC, and diamond grinding over their service lives. Regression models were also provided to quantify the effectiveness of friction surfacing for interstate, US, and state highways, respectively.

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Least Relevant Results

ASCE Database

An Evaluation of the Effectiveness of Geo-Textile-Binder-Aggregate System for Surface Treatment of Distressed Asphalt Pavement
Yanping Sheng ; Shuanfa Chen ; and Linbing Wang
Abstract
The surface treatment method presented in the paper, a mineral aggregate layer paved on geo-textile coated with asphalt layers on both sides, can improve the performance of existing asphalt pavement surface such as slip resistance, waterproof, and wear resistance. The sample fabrication method is determined by structural characteristic of the treatment method. Eight structures with different asphalt and geo-textile combinations are selected for testing, and the optimal dosage of asphalt and mineral aggregate are determined. The optimal structural combination is obtained on the basis of testing the shear capability of the eight structures. The shear capability of the optimal structural combination is tested under different vertical pressures and temperatures by the shear capability test machine for asphalt road surface structure layers, which is developed by the research team. Test results show that the combination of KLMY90# base asphalt and short fiber geo-textile with density of 300g/m2 is the optimal structure. The friction coefficient of the optimal structure is 0.5989. The results also show that shear capability under high temperature is better than which under low temperature. Finally, the construction procedure is also described. The test road shows that this surface treatment method is economical and effective.
https://ascelibrary.org/doi/10.1061/41064%28358%29365
Library Catalog

**Mesabi-select concrete pavement five year performance Report**

- **Creator:** Rohne, Ryan J.
- **Contributor:** Minnesota. Department of Transportation. Research Services Section.; Minnesota. Department of Transportation. Office of Materials and Road Research.
- **Description:** Cell 54 was constructed in the fall of 2004 on the MnROAD low-volume loop. It is made up of eight inches of concrete underlain by Class 5 aggregate base and approximately three inches of compacted in-situ fill. Mn/DOT constructed this cell to study the properties of Mesabi-Select as coarse aggregate in concrete. This mineral aggregate that contains less iron than the ore, was obtained from overburdens in the iron ore ledges in northern Minnesota. There is no record of a previous cell constructed to study the suitability of Mesabi-Select in concrete. Cell 54 is in very good condition after five years. There are very few cracks of low severity. The types of distress found were spalling of transverse joints, longitudinal cracking, and transverse cracking. Very little joint faulting has occurred. In-situ concrete surface permeability measurements indicate that the concrete is good quality. Friction and ride quality measurements indicate that Cell 54 is in very good condition. Falling weight deflectometer (FWD) deflections at the surface and top of the base were of similar magnitude as in other doweled jointed plain concrete pavement (JPCP) test cells of similar design.

Availability and location:
- MnDOT Library Main Collection - MNDOT TE278 .I98 2010

Transport Database

Result 8.

**Title**  
Surface retexturing, rejuvenation boost N.C. interstate performance.

**Source**  
Pavement Preservation Journal. 2014. 7(1) pp 37-39 (Figs., Photos.)

**URL**  

**Abstract**  
Faced with a lack of funding, Division 3 of the North Carolina Department of Transportation decided to use a process - surface retexturing coupled with asphalt binder rejuvenation using a maltene-binder rejuvenator -that was less extreme than the initial idea to mill and replace the open graded friction course. New specifications were developed, and the process met the requirements to improve surface friction for safety, as well as macro texture for improved transverse water low and a reduction in hydroplaning, as well as correction of in-place asphalt binder rheology for lifecycle extension and durability. Details of the project are presented here.

**Publication Year**  
2014

Result 18.

**Title**  

**Source**  
Project Title: Performance of Permeable Friction Courses (PFC) Pavements Over Time. Report Date: October 2009; Published: February 2010.
Over the past several years, the Texas Department of Transportation (TxDOT) adopted the use of porous or permeable friction course (PFC) mixtures as a thin asphalt pavement surface layer to provide safety and environmental benefits. This type of mixture is defined in TxDOT Specification Item 342 as a surface course of a compacted permeable mixture of aggregate, asphalt binder, and additives mixed hot in a mixing plant. Recent research addressed important design, construction, and maintenance issues associated with PFC, which has been increasingly employed by TxDOT. In order to complete the evaluation of this relatively new hot mix asphalt concrete mixture type as a possible solution for improving pavement safety and reduction of pavement noise, performance will be tracked over time in this research project to assess benefits, cost, and changes in benefits. The main objective of this research project is to develop a database of PFC performance in terms of functionality (noise reduction effectiveness and permeability), durability (resistance to raveling and possibly rutting and cracking), and safety (skid resistance and accident history), in order to produce guidelines for design, construction, and maintenance of PFC mixtures. This report includes a comprehensive and focused review of research conducted since 2004 related to the mix design, performance (i.e., functionality, durability, and safety), construction, and maintenance of surface courses using PFC.