

Existing Research found in light literature search:

Literature Search on Dynamic Friction Testing (DFT)

“An Approach to Maximize the Frictional Performance of Asphalt Mixtures by Integrating a Low Percentage of High-Friction-Resistance Aggregates”

Journal of Materials in Civil Engineering, 2026

<https://ascelibrary.org/doi/full/10.1061/JMCEE7.MTENG-22004>

The focus of this study was on proposing ways of economically improving the frictional properties of asphalt mixtures prepared with low-friction aggregates since, in many locations, the high-friction-resistant materials are becoming scarce. A systematic study was conducted to investigate several material-related, design-related, and construction-related parameters that may affect the frictional performance of asphalt mixtures to pinpoint the parameters that most significantly control the frictional performance. The following conclusions can be drawn from this study:

- While the frictional performance of aggregates significantly impacts the frictional performance of mixes, the change in binder grade does not.
- The binder content of the mix initially impacts its frictional performance. That impact significantly diminishes after the initial polishing cycles remove the binder film from aggregates.
- The aggregate gradation and the asphalt mixture with varying NMAAS did not significantly impact the mixture’s frictional performance. The combination of relatively higher surface area and proportion of the intermediate aggregates in the mix seems to control the mixture’s frictional performance. Preliminarily, aggregates passing a 4.75 mm sieve and retained on a 2.36 mm sieve principally control the mixture’s frictional performance.
- The air void percentage of the mixture does not seem to significantly affect its frictional performance because the change in air voids alters the internal structure more than the surface texture.

The practical implication of the findings in this study is that highway agencies and aggregate producers can significantly improve the long-term frictional performance of their mixes by focusing on using better-quality intermediate aggregates instead of valuable coarse aggregates. The aggregate surface area is a crucial parameter to consider when blending low- and high-friction-resistance aggregates. Further work is underway to verify and implement the findings of this study.

“Optimized Test Procedures for Measurement of Aggregates and Asphalt Mixtures Friction Performance for Routine Test Purposes”

Journal of Testing and Evaluation, 2026

<https://dl.astm.org/jte/article/54/2/597/29499/Optimized-Test-Procedures-for-Measurement-of>

This study aimed at optimizing AASHTO PP-103 and PP-104 specifications for measuring aggregate and asphalt mixture friction performance. To that end, an accelerated sample preparation process was developed and evaluated to ensure that it would not compromise the accuracy of measured friction values. A process for reducing the number of polishing cycles to accelerate the process was then proposed. A thorough evaluation of the parameters that can affect the results was also carried out. Finally, the overall repeatability of the optimized test procedures was thoroughly investigated. Based on the study results, the following conclusions can be drawn:

1. Aggregate specimens prepared with a mixture of LevelQuick RS and water yielded similar friction results to the process proposed in AASHTO PP-103 (using Wollastonite, polyester resin, and gelling agent) at a much lower cost and with a shorter curing period. This mixture was also used for accelerating the preparation of asphalt specimens.
2. Wet or dry polishing processes did not affect friction results for aggregate specimens since their void structure prevented water stagnation on the specimens. However, wet polishing resulted in higher friction values for asphalt specimens compared with dry polishing due to the formation of a thin water layer between the tire and the surface.
3. The polishing direction compared with the rotational direction of the DFT pads did not seem to significantly impact the measured friction values on both aggregate and asphalt specimens.
4. Repeated friction measurements with DFT on an aggregate specimen over 1 month yielded a standard deviation of ± 0.02 . This shows that the DFT device is highly repeatable since the standard deviation does not differ from the specified precision of ± 0.03 as per ASTM.
5. It is practical and feasible to predict the terminal friction values of aggregates and asphalt specimens by polishing them up to 25 k cycles. The friction values after 0 k, 5 k, and 25 k polishing cycles for aggregates and 1 k, 10 k, and 25 k polishing cycles for asphalt can be used to predict the terminal friction value via a curve fitting process. This process will reduce the testing period to approximately 7 h.

“Study of the surface texture evolution and friction degradation in asphalt pavements during wear process”

Wear, 2025

<https://www.sciencedirect.com/science/article/abs/pii/S0043164824004794>

Asphalt pavements constitute an important part of global transportation infrastructure, and their surface texture directly impact driving safety and comfort. Understanding the evolution of surface texture during wear and its effect on friction degradation is essential for pavement maintenance and safety assessment. This study conducted accelerated wear tests on three typical asphalt pavements (AC-13, SMA-13, and OGFC-13) using a self-

developed indoor plate accelerated load wear tester (PALWT). A 3D laser scanner and a dynamic friction tester were used for pavement surface modeling and friction measurement. Based on the ISO 25178-2 standard, areal field parameters and functional volume parameters were innovatively introduced into the pavement wear quantification system to reveal the wear mechanisms of material loss and transfer. Results showed that the macrotexture characteristics of the pavement shifted from rough to flat after wear, with peak features gradually disappearing and texture directionality transitioning from multi-directional to the traffic direction. Wear caused a decrease in material at the surface peaks and valley areas while accumulating material in the core area. The dynamic friction coefficient (DFT40, DFT60, and DFT80) of asphalt pavements initially increased (peaking at around 3000 wear cycles) before decreasing and eventually stabilizing. Open-graded and gap-graded pavements generally outperform dense-graded pavements in terms of friction retention. Peak material volume (V_{mp}) and valley void volume (V_{vv}) effectively reflected material redistribution during wear across peak, core to valley, showing a strong correlation with skid resistance. Mean peak curvature (S_{pc}) significantly improves skid resistance at low to medium speeds, while texture aspect ratio (S_{tr}) becomes critical under high-speed conditions by ensuring stable multidirectional tire-road interaction.

“Relating aggregate friction properties to asphalt pavement friction loss through laboratory testing, statistical analysis, and machine learning insights”

International Journal of Pavement Engineering, 2025

This study applied statistical and machine learning approaches to relate aggregate friction properties and shape characteristics to asphalt mixture friction loss, focusing on gap- and dense-graded (DG) mixtures. Aggregate morphology and friction properties were quantified through an aggregate imaging measurement system (AIMS), a dynamic friction tester (DFT), and a British pendulum tester (BPT) over varying Micro-Deval test (MDT) durations. Meanwhile, DFT and circular track metre (CTMeter) assessed the friction and texture properties of asphalt mixtures in conjunction with the three-wheel polishing device (TWPD), simulating traffic-induced polishing. Random Forest Analysis (RFA) emphasized the significance of aggregate terminal friction properties in pavement frictional performance. Loss of aggregate friction properties (%), measured by DFT at 20 km/hr (DFT20), was the most significant material property for evaluating pavement friction loss, accounting for approximately 20% of the total effect, followed by the terminal texture index. Two analytical models were proposed: the first correlated the friction properties of asphalt mixtures to the corresponding aggregate sources using DFT20 values. Meanwhile, the second model integrated mixture gradation and aggregate morphology, achieving an overall coefficient of determination (R^2) of 0.93. Finally, the study provides a preliminary approach for screening aggregate quality and mix design to achieve cost-effective, optimal frictional performance.

“Contributions of aggregate mineralogical and morphological parameters to aggregate frictional performance”

Construction and Building Materials, 2025

<https://www.sciencedirect.com/science/article/pii/S0950061825015612>

This study examined the contributions of aggregate mineralogical and morphological parameters on aggregate frictional performance. A powder X-ray diffraction instrument was used for mineralogical assessment, whereas an aggregate image measurement system was used to capture the morphological parameters of aggregates. The frictional performance of aggregates was evaluated using three-wheel polishing and dynamic friction tester devices. Based on this study, the following conclusions can be drawn:

The average hardness value (AHV) was prominently and texture was less prominently correlated with aggregate frictional performance, while the contrast of hardness (COH) and angularity exhibited a weaker correlation.

Four multiple linear regression models were developed to estimate the friction values of a given aggregate source based on its mineralogical and/or morphological parameters. The most pragmatic and practical model was the one that incorporated only mineralogical parameters (AHV and COH). That model exhibited similar accuracy and uncertainty as the model that used both mineralogical and morphological parameters.

Since the aggregate mineralogical parameters are the principal factors contributing to aggregate frictional performance, highway agencies could potentially use a powder X-ray diffraction instrument to prescreen the aggregates before subjecting them to lengthy three-wheel polishing and dynamic friction tester devices. While this study provides valuable insights into the factors influencing aggregate frictional performance, future research could focus on optimizing aggregate frictional performance by adjusting the mineralogical and morphological parameters.

“Assessment of Laboratory Friction Testing Equipment and Validation of Pavement Friction Characteristics with Field and Accelerated Friction Testing”

Louisiana Transportation Research Center, 2025

<https://rosap.ntl.bts.gov/view/dot/82247>

This report reviews the research and advancements in using the Three-Wheel Polishing Device (TWPD) for aggregate polishing and the Dynamic Friction Tester (DFT) to measure the polishing resistance of coarse aggregates in asphalt wearing course mixes. The Louisiana Department of Transportation and Development (DOTD) currently employs the British Polishing Wheel (BPW) test procedure to determine the polished stone value (PSV) of aggregates and specifies PSV-based aggregate friction rating requirements in asphalt mixture design for wearing courses. However, due to significant

variations in aggregate production and shipments, it is common for the same type of aggregate, delivered at different times, to yield substantially different PSV results.

“Alternative Approaches for Rapid Evaluation of Frictional Resistance of Aggregates”

TRR 2678, 2024

<https://journals.sagepub.com/doi/pdf/10.1177/03611981241239961>

Skid resistance of pavements plays a crucial role in ensuring the safety of road users, particularly under wet weather conditions. The standardized method for evaluating the skid resistance of aggregates, AASHTO PP103, requires using a threewheel polishing device.

That test procedure requires significant time for specimen preparation, testing, and monitoring of aggregate stockpiles. This study aims to propose alternative test methods to reduce the time required for the evaluation of skid resistance of aggregates. Two approaches were examined as alternatives to the AASHTO PP103 method. The first approach involved using a micro-deval abrasion device to polish the aggregates before evaluating the skid resistance of the aggregates using a dynamic friction tester. In the second approach, a multiple linear regression equation was proposed that uses conventional mechanical performance test results as independent variables to predict skid resistance. Twenty-one aggregate samples were collected from various sources in Texas for this study. The study results indicate that both approaches can be used as surrogate methods for AASHTO PP103 for rapid screening of the skid resistance of aggregates, which could help manage aggregate quality control and assurance.

“Prediction of pavement friction coefficient based on dynamic friction test simulation”

Tribology International, 2024

<https://www.sciencedirect.com/science/article/abs/pii/S0301679X23007879>

In this study, a virtual dynamic friction test (DFT) framework was developed based on the finite element (FE) method to predict the coefficient of friction (COF) of pavement. Uniquely, this framework only necessitates the point cloud data of the target pavement, sourced via laser scanning, for input, and subsequently delivers COF-speed curves as output. A standout benefit is its foundation on the enhanced Persson’s friction theory for defining the interaction dynamics between the rubber slider and pavement. This contrasts with traditional FE-friction simulations, which rely on results from friction experiments. Consequently, preliminary friction tests are rendered redundant within our approach. During validation, the average predicted COF results for eight pavement samples, as determined by our framework, demonstrated no significant differences (with the number of parallel tests compared to averages from actual DFTs. Offering parametric control over vital factors like water film thickness and rubber’s slip velocity, the virtual DFT model provides an innovative avenue to study the combined effects of

water and velocity on pavement friction. Additionally, leveraging the virtual DFT methodology can slash the duration of field tests by over 50%.

“Experimental study on the high-speed frictional behavior between the tire and asphalt pavement”

Construction and Building Materials, 2023

<https://www.sciencedirect.com/science/article/pii/S0950061823004932>

Driving speed, pavement type, surface characteristics, intermediate media, and tire properties are the key factors influencing the frictional behavior between tire and pavement. Although there are many kinds of equipment for friction coefficient tests based on the rubber-pavement contact mechanism, there is still a lack of equipment that can simulate the skid resistance behavior of high-speed vehicles based on real tire in the laboratory. Therefore, High-speed Friction Testing (HSFT) equipment was developed based on real tire loading, which well solves the deficiency of the current test methods. Based on this test platform, multi-factor coupling skid resistance tests were carried out on the asphalt concrete (AC-10/13/16) and the Open-Graded Friction Coarse (OGFC-10/13/16) samples. Statistical comparison and nonlinear fitting analysis were conducted on the results under various loading conditions. The results show that driving speed, water film thickness, and tire load are all negatively correlated with skid resistance, and their influence extent can be ranked as water film thickness > tire load > driving speed. The established μ HSFT skid resistance model based on multi-factor coupling shows high reliability, which can be used as the basis for pavement construction and is an important reference for future unmanned driving technology.

“Laboratory Evaluation of Aggregate Friction and Texture Properties”

TRR, 2021

<https://journals.sagepub.com/doi/full/10.1177/03611981211016465>

Aggregate shape, texture, and angularity are important physical properties for the development of high-quality adhesive systems with asphalt binder, and a good quality aggregate skeleton in asphalt and concrete mixtures. These properties are commonly measured using systems that employ images of aggregate samples taken with a digital camera. In practice, macro-texture measurements are commonly conducted nondestructively at highway speed using high-frequency lasers. There is a need to investigate the application of these optical sensors for measuring aggregate texture in the laboratory. Researchers used a laser-based scanning system to test aggregates from five sources before and after Micro-Deval abrasion. The aggregate specimens were embedded in a ring-shaped polyester material and tested with the aggregate ring texturing system (ARTS) along with the dynamic friction tester (DFT) to characterize micro-texture and frictional properties. Researchers analyzed the laboratory test data to evaluate the relationship between DFT friction at 60 km/h (DFT_{60}) and the micro mean profile depth obtained with the ARTS. This analysis showed that the igneous and gravel aggregates had

better micro-texture and frictional characteristics compared with the dolomite and limestone aggregates. The results from this implementation project showed the potential for using the ARTS to improve the Texas Department of Transportation's existing surface aggregate classification system. Further testing is needed to characterize aggregates from other sources and compile a more comprehensive and representative database with which to establish meaningful aggregate classification criteria that include surrogate statistics for expected field performance.

“Dynamic friction coefficient between tire and compacted asphalt mixtures using tire-pavement dynamic friction analyzer”

Construction and Building Materials, 2020

<https://www.sciencedirect.com/science/article/pii/S0950061820314975>

This study proposes a newly developed real-time testing system, namely, a tire-pavement dynamic friction analyzer (T DFA), to measure the dynamic friction coefficient between tire and pavement. Based on the self-developed T DFA, the friction coefficient between tire and pavement can be measured in real-time in the lab. A number of working conditions of tires were mimicked and tested. Subsequently, the effect of parameters such as tire load, tire pressure, actual tire-pavement contact area, tire speed, and slip ratio on pavement friction were investigated. It is found that there is a closely linear correlation between the actual tire-pavement contact area and the dynamic friction coefficient (DFC), and such correlation differs with the variation of pavement types. DFC usually has a negative linear relationship to tire speed. As slip ratio varies from 0% to 100%, the strongest correlation between DFC and Mean profile depth (MPD) can be found at the interval of 10%–15% slip ratio, which indicates that the pavement macrotexture also plays a role in the peak value of friction coefficient for the asphalt pavement. This testing method is very promising for the estimation of friction properties of pavement in the phase of lab mix design. It may also be used in the materials selection for pavement design.

“Prediction of tire–pavement friction based on asphalt mixture surface texture level and its distributions”

Road Materials and Pavement Design, 2020

<https://www.tandfonline.com/doi/abs/10.1080/14680629.2018.1560354>

Tire–pavement friction plays a key role in traffic safety. With the development of auto vehicle industry, most of the new vehicles are equipped with Anti Braking System (ABS). Therefore, a prediction model representing the braking process of vehicles equipped with ABS is deemed necessary. In this paper, the tire–pavement friction is measured by Dynamic Friction Tester (DFT) and Hand Friction Tester. The surface texture of asphalt pavement is acquired using a recently developed program named as 2-Dimensional Image Texture Analysis Method (2D-ITAM). Tire–pavement friction at optimum design slip speed corresponding to the maximum tire–pavement friction is calculated with a widely used model. Then a prediction model correlating the tire–pavement friction at optimum design slip speed with the macro-texture and micro-texture of pavement is established using

multivariate non-linear regression analysis. This prediction model is validated through laboratory test indicating its effectiveness of predicting the tire–pavement friction. The model is anticipated to be an improved tool which can be considered by practitioners in an optimized asphalt mixture design including the evaluation of skid resistance of pavement.

“Directional Skid Resistance Characteristics of Road Pavement: Implications for Friction Measurements by British Pendulum Tester and Dynamic Friction Tester”

TRR, 2019

<https://journals.sagepub.com/doi/pdf/10.1177/0361198119851453>

The British pendulum tester (BPT) and the dynamic friction tester (DFT) are commonly used to evaluate the polishing effect of traffic on pavement skid resistance. The present study was conducted to answer two questions: (i) whether the directional moving traffic action results in significant directional differences in skid resistance of the pavement, and (ii) if so, whether BPT and DFT are effective tools for evaluating the skid resistance performance of polished pavements with significant directional skid resistance characteristics. Five in-service pavement sections with different degrees of polishing were examined in this study. The following findings were obtained from the study: (a) There were statistically significant differences between the longitudinal and transverse skid resistance of the polished pavements tested; (b) there were no statistically significant differences between the longitudinal and transverse skid resistance of the newly paved unpolished pavement tested; (c) BPT was able to differentiate the directional skid resistance differences of the polished pavements tested; and (d) DFT was unable to differentiate the directional skid resistance differences of the polished pavements tested. DFT produces one skid resistance value for a circular path at each test point. The test results found that DFT overestimated the traffic-direction skid resistance of in-service pavements. The overestimation errors ranged from 0.001 to 0.023 DFT units, and the corresponding percent errors were from 0.4% to 11.1%. This finding suggests that the over-estimation effect of skid resistance directionality of polished pavements on DFT measurements should be recognized in pavement skid resistance evaluation and pavement safety studies.

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“Laboratory and field evaluation of asphalt pavement surface friction resistance”

Frontiers of Structural and Civil Engineering,

<https://link.springer.com/article/10.1007/s11709-017-0463-1>

Pavement surface friction is a significant factor for driving safety and plays a critical role in reducing wet-pavement crashes. However, the current asphalt mixture design procedure does not directly consider friction as a requirement. The objective of this study was to develop a surface friction prediction model that can be used during a wearing course mixture design. To achieve the objective, an experimental study was conducted on the frictional characteristics of typical wearing course mixtures in Louisiana. Twelve wearing course mixtures including dense-graded and open-graded mixes with different combinations of aggregate sources were evaluated in laboratory using an accelerated polishing and testing procedure considering both micro-and macro texture properties. In addition, the surface frictional properties of asphalt mixtures were measured on twenty-two selected asphalt pavement sections using different in situ devices including Dynamic Friction Tester (DFT), Circular Texture Meter (CTM), and Lock-Wheel Skid Trailer (LWST). The results have led to develop a procedure for predicting pavement end-of-life skid resistance based on the aggregate blend polish stone value, gradation parameters, and traffic, which is suited in checking whether the selected aggregates in a wearing course mix design would meet field friction requirements under a certain design traffic polishing.

Evaluating the Relationship of Asphalt Pavement Skid Resistance to Slip Speed Using Dynamic Friction Tester Measurements

ICCTP, 2010

[https://ascelibrary.org/doi/abs/10.1061/41127\(382\)397](https://ascelibrary.org/doi/abs/10.1061/41127(382)397)

Pavement skid resistance, which depends on slip speed, is an important factor impacting traffic safety. To deeply understand the relationship of asphalt pavement skid resistance to slip speed, field tests are conducted using Dynamic Friction Tester (DFT) at 33 test sites of 11 sections with various highway grades and surface types. Friction coefficients corresponding to various slip speeds (0 km/h through 80km/h by 0.1 km/h) are obtained for each test site. Evaluations show that the Penn State Model is not suitable for characterizing the curve of slip speed-friction coefficient measured by DFT. Then, a new model with 3 parameters is developed. Regression analysis of the 33 DFT measurements shows that the new model can accurately describe the relationship of asphalt pavement skid resistance to slip speed measured by DFT. It has the potential to improve skid resistance evaluation of asphalt pavement.