Guide for Pavement Friction

2nd Edition • December 2022

AASHTO

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1. (top left) Typical asphalt pavement. Photo courtesy of Caltrans Pavement Program.
2. (top right) FHWA SCRIM truck outside parking bay in VTTI. Photo courtesy of Edgar de León Izeppi, Center for Sustainable and Resilient Infrastructure (CSRI), Virginia Tech.
3. (bottom right): Typical concrete pavement. Photo courtesy of Caltrans Pavement Program.
4. (bottom left): ASTM E274 Locked Wheel. Photo courtesy of Florida DOT.

ISBN: 978-1-56051-798-6 Pub Code: GPVF-2

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Acknowledgments

This second edition of the *Guide for Pavement Friction* was produced as part of the FHWA Continuous Pavement Friction Measurement and Pavement Friction Management for Safety project. Dr. Gerardo Flintsch, Director of the Center for Sustainable Transportation Infrastructure (CSTI) of the Virginia Tech Transportation Institute, was the principal investigator for this project. CSTI Research Scientists Edgar de León Izeppi and Samer Katicha, Research Associate Ross McCarthy, and Project Consultant Priscilla Tobias from ARORA and Associates supported this work. Several members from the project's Stakeholder Engagement Working Group, who are AASHTO members on different committees, also participated in the review. They are John Donohue (MO), Dulce Rufino Feldman (CA), Mike Vaughn (KY), Shawn Troy (NC), Stephen Read (VA), Mike Wells (VA), and William Lawrence (UT).

The original research was performed under NCHRP Project 1-43 by the Transportation Sector of Applied Research Associates (ARA), Inc. Dr. Jim W. Hall, Jr., was the principal investigator for the study.

Dr. Hall was supported in the research and in developing this guide by ARA research engineers Leslie Titus-Glover, Kelly Smith, and Lynn Evans, and by three project consultants—Dr. James Wambold (President of CDRM, Inc. and Professor Emeritus of Mechanical Engineering at Penn State University), Thomas Yager (Senior Research Engineer at the NASA Langley Research Center), and Zoltan Rado (Senior Research Associate at the Pennsylvania Transportation Institute).

The authors gratefully acknowledge all of the individuals with state departments of transportation (DOTs) who responded to the pavement friction survey conducted for this project. The authors also express their gratitude for the valuable input provided by knowledgeable representatives of DOTs, paving associations, academia, and manufacturers of friction measuring equipment, vehicle tires, and trucks.

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Abstract

This report contains guidelines and recommendations for managing and designing for friction on highway pavements. The contents of this report will be of interest to highway materials, construction, pavement management, safety, design, and research engineers, as well as others concerned with the friction and related surface characteristics of highway pavements.

Information is presented that emphasizes the importance of providing adequate levels of friction for the safety of highway users. The factors that influence friction and the concepts of how friction is determined (based on measurements of surface microtexture and macrotexture) are discussed. Methods for monitoring the friction of in-service pavements and determining appropriate actions in the case of friction deficiencies (friction management) are described. Also, aggregate tests and criteria that help attain adequate microtexture are presented, followed by a discussion of how paving mixtures and surface texturing techniques can be selected so as to impart the macrotexture required to achieve the design friction level.

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Chapter 1

Introduction

1.1 Background

Pavement–tire friction (or, simply, pavement friction) is one of many factors influencing highway safety performance; in particular, the probability of skid-related crashes. Highway agencies have recognized this fact since the 1920s with the primary focus on wet skid-related crashes (Moyer, 1959). Skid-related crashes are a result of many factors, such as road geometry, traffic characteristics (such as vehicle speed and driver action), pavement conditions, and weather conditions; and these factors must be considered together with friction data when evaluating the safety performance of a particular section of roadway.

The *Guidelines for Skid-Resistant Pavement Design*—published by the American Association of State Highway and Transportation Officials (AASHTO) in 1976 and superseded by this Guide—recommended pavement specifications that would yield the desired frictional properties upon completion of construction and that would maintain adequate long-term friction. This Guide discussed the importance of aggregate selection and mixture design for both asphalt- and concrete-surfaced pavements, and the role of microtexture and macrotexture in pavement surface friction.

The 2008 AASHTO *Guide for Pavement Friction* was prepared under NCHRP Project 1-43 and introduced additional information on friction management and provided information on nontraditional pavement surface texture related effects such as noise generation and pavement–tire splash and spray.

Roadway safety is a complex issue that involves consideration of human behavior, vehicle type, roadway design and operations, and the interaction of road users with the roadway. Significant advancements in the roadway safety state of practice have been made since the early 2000s. This has occurred through evolving research and technology, multidisciplinary approaches, and increased implementation of the evidence-based knowledge in programs to reduce traffic-related fatalities and serious injuries on all public roads.

The AASHTO *Highway Safety Manual* (HSM) (2014), first published in 2010, presents state-of-the-practice safety performance and predictive modeling analyses. These analyses can be used to quantify safety performance considering the friction available and comparing it to the friction demand to improve safety performance. Friction demand is the level of friction (micro- and macrotexture) needed to safely perform braking, steering, and acceleration maneuvers.

For many years, highway engineers have identified locations with elevated wet crashes as being the primary locations that could benefit from friction enhancement treatments. However, during the decade of the 2010s, with more in-depth investigation of how roadway attributes contribute to the frequency and severity of crashes and application of innovative countermeasures, the U.S. saw a significant increase in the use of high-friction surface treatments (HFSTs). In a study conducted in Kentucky, the data demonstrated that at all the locations treated with HFST (ramps and curves), there were significant reductions in both wet and dry crashes (von Quintus and Mergenmeier, 2015). Highway engineers developed crash modification factors (CMFs), which represent the change in crashes expected after the implementation of a particular countermeasure, based on Kentucky's experience using HFST on curves (CMF = 0.125) and ramps (CMF = 0.079). These CMFs (CMF IDs 10330 and 10344) have high star quality ratings and are located in the CMF Clearinghouse (University of North Carolina Highway Safety Research Center, 2021), which provides a searchable database of CMFs along with guidance and resources on using CMFs in road safety practice.

Several other reports have also shown that the risk for both wet and dry crashes increases as pavement friction decreases (Wu et al., 2014; Pratt et al., 2014). In addition, data obtained with continuous friction measurements by the FHWA Pavement Friction Management (PFM) Support Project show that both wet and dry crashes increase when pavement friction decreases (de León Izeppi et al., 2019a). Therefore, consideration of the relationship between friction and all crashes (i.e., wet and dry combined) is both justified by research and consistent with proactive, systemic approaches to improving safety performance across the roadway network based on measurable risk and performance characteristics rather than nominal, reactive approaches such as hot-spot wet pavement crash clusters.

Initiatives such as the Safe System approach have further shifted efforts from past traditional practices to eliminate traffic-related fatalities and serious injuries on all public roads. The Safe System approach recognizes that humans make mistakes, and it is a shared responsibility to ensure that these mistakes and resulting crashes do not lead to fatalities or serious injuries. Furthermore, it emphasizes a proactive approach and builds redundancy in the design and operations of all parts of the roadway system.

The combined efforts of pavement and safety professionals align with the Safe System approach. There are even greater demands on highway engineers to design, construct, and maintain longer-lasting, cost-effective pavements while improving safety performance. There is also increasing focus on the needs of the highway user (safe and comfortable roads). The continued introduction of new materials, technologies, and safety performance analyses offers an opportunity to further integrate PFM and safety performance. The *Guide for Pavement Friction* should help highway engineers accomplish such a task.

1.2 Purpose and Scope of Guide

The *Guide for Pavement Friction* provides highway pavement and safety practitioners with guidance in designing, constructing, maintaining, and managing pavement surfaces to help transportation agencies achieve safety performance goals. This version of the Guide, while published by the AASHTO Committee on Materials and Pavements, includes review and input by members of the AASHTO Committee on Safety.

This Guide contains recommendations and tools for upper-level administrators and policymakers, as well as frontline pavement and safety designers, managers, and practitioners. These recommendations are intended to supplement, but not replace, an agency's normal pavement structural or mix design practices and safety analyses. This Guide covers the following topics:

- characteristics of pavement materials and surfaces that contribute to friction (microtexture and macrotexture);
- friction-testing methods, equipment, and indices;
- analysis methods for establishing friction demand based on investigatory friction levels for the following applications: (1) design of new pavement surfaces, (2) increased potential for skid-related crashes, and (3) the need for adequate cost-effective friction restoration;
- consideration of pavement friction and safety performance; and
- guidance for aggregates, mixtures, and surface types that result in long-lasting, high-quality friction surfaces, with proper consideration of noise, economics, and other friction-related issues (e.g., splash and spray, hydroplaning, tire wear).

This Guide addresses both asphalt (i.e., flexible and semi-rigid) and concrete (i.e., rigid) pavements associated with both original construction (i.e., new construction and reconstruction) and maintenance and rehabilitation (M&R) treatments. It does not address winter maintenance issues (i.e., snow and ice removal or treatment), unpaved surfaces, or nonroadway pavements.

1.3 Guide Organization and Use

This Guide is divided into four chapters covering the importance of pavement friction, the basic concepts of friction, how friction is measured and managed, and how to design for friction. Following this introductory chapter, Chapter 2 discusses the importance of providing adequate levels of friction for improved roadway safety performance, and it provides an overview of pavement friction (what it is and what influences it) and describes the equipment and methods used to measure and report friction and texture.

Chapter 3 discusses friction from the management standpoint, covering both policy development and the application of procedures for monitoring and restoring friction, based on the principle of friction supply versus friction demand, and integrating pavement friction into safety performance analyses. Chapter 4 guides the user through the surface friction design process. It discusses the development of design policies that help promote long-term, network-wide friction improvements, and provides project-level how-to guidance for designing pavements with proper friction. Lastly, a glossary of terms is included in Appendix A to facilitate understanding of the terminology and nomenclature contained in this Guide, a list of standards relevant to pavement friction is provided in Appendix B, and an index of these standards is provided in Appendix C.