



Guide for Pavement Friction: Background and Research

DETAILS

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Research Results Digest 321

GUIDE FOR PAVEMENT FRICTION: BACKGROUND AND RESEARCH

This digest summarizes the findings from NCHRP Project 1-43, "Guide for Pavement Friction." It was prepared by Amir N. Hanna, NCHRP Senior Program Officer, from the contractor's final report authored by J. W. Hall, K. L. Smith, and L. Titus-Glover of Applied Research Associates, Inc.; J. C. Wambold, CDRM, Inc.; T. J. Yager, NASA Langley Research Center; and Z. Rado, Pennsylvania Transportation Institute. J. W. Hall served as principal investigator.

INTRODUCTION

This digest summarizes the findings of the research conducted under NCHRP Project 1-43 to develop a guide that addresses frictional characteristics and performance of pavement surfaces and considers related tire-pavement noise and other relevant issues. The research was concerned with highway pavements constructed with asphalt and concrete surfaces and did not deal with roads with unpaved surfaces or non-highway pavements.

Pavement friction is an important consideration in pavement performance. Microtexture and macrotexture are extremely important pavement surface characteristics to the development of surface friction. The microtexture is the critical component for surface friction. However, macrotexture provides a means for removing water from the surface thereby enhancing the role of microtexture in obtaining better surface friction at high speeds. Surface treatments are often applied to enhance these characteristics and increase surface friction. However, increasing macrotexture may result in greater noise generation and propagation. Similarly, noise-reduction techniques some-

times adversely affect surface friction. Therefore, the relationship between friction and noise generation must be carefully considered when designing pavement surfaces.

The *Guidelines for Skid Resistant Pavement Design*, published by AASHTO in 1976, recognized the importance of providing skid-resistant pavements. Although much research has been conducted on pavement surface characteristics since development of this guide, the acquired information has not been integrated into a comprehensive, systematic approach for identifying friction needs and determining pavement friction strategy. In addition, because of the continued introduction of new materials and increasing demands from highway users, the need for developing a more comprehensive guide for pavement friction became apparent.

NCHRP Project 1-43 was conducted to develop a guide for pavement friction aimed at assisting highway engineers in (1) understanding the issues associated with pavement friction and its importance to highway safety and (2) instituting pavement friction management and design practices and processes that optimize friction safety while recognizing other related factors. The

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research accomplished this objective by conducting a comprehensive review of literature and current practices, developing a practical approach to friction management and design based on the principle that an appropriate level of pavement friction must be maintained across all pavement sections within a given highway network, and preparing a guide that presents guidelines and recommendations for managing and designing for friction on highway pavements.

PAVEMENT FRICTION AND SAFETY

Highway crashes are complex events that result from one or more contributing factors in three broad categories: driver-related, vehicle-related, and highway-condition related. Crash investigations have shown a link between crashes and pavement surface characteristics (e.g., friction and texture). Also, it is expected that the number of wet-weather crashes will increase as pavement friction decreases and that “splash” and “spray” will affect drivers’ visibility on wet highways and increase crash risk. Although highway agencies employ design, construction, and management practices that influence highway condition, these agencies cannot realistically employ means to control driver-related and vehicle-related factors.

PAVEMENT FRICTION AND SURFACE TEXTURE

Pavement friction is generated as the tire rolls or slides over the pavement surface and a force that resists the relative motion between a vehicle tire and a pavement surface is developed. Pavement friction plays a vital role in keeping vehicles on the road by enabling the drivers to control/maneuver the vehicle in a safe manner (in both the longitudinal and lateral directions). Pavement friction is defined by the friction coefficient; generally the higher the coefficient, the more control the driver has over the vehicle. In addition to surface texture, the vehicle speed; tire tread design and depth; tire inflation pressure; and the presence of water, snow and ice, and contaminants on the pavement surface also influence the friction coefficient. Several methods and devices are available for measuring pavement frictional characteristics.

Pavement surface texture is influenced by many factors, including aggregate type and size, mixture proportions, and texture orientation and details. Texture is defined by two levels of texture: microtexture

and macrotexture. Microtexture depends on surface properties of the aggregate particles contained in the paving material and is mainly responsible for pavement friction at low speeds. Macrotexture is influenced by the properties of the paving mixture and the method of finishing/texturing of the surface. Macrotexture helps (1) reduce the potential for separation of tire from pavement surface due to hydroplaning and (2) induce friction for vehicles traveling at high speeds. Currently, there are no direct means for measuring microtexture in the field. However because microtexture is related to low slip speed friction, it can be estimated using a surrogate device. Macrotexture is characterized by the mean texture depth and the mean profile depth; several types of equipment are available for measuring these indices.

PAVEMENT FRICTION MANAGEMENT

Pavement engineers have recognized the need for designing and maintaining roadway surfaces that enhance highway safety. Such a need is accomplished by implementing pavement friction management (PFM) programs that ensure availability of the surface friction and texture levels needed to minimize the risk of skid-related crashes. Federal mandates and directives addressing highway safety generally allow state highway agencies some flexibility in developing and implementing such programs.

A PFM framework is expected to include (1) a system for evaluating in-service pavement friction; (2) a system for correlating available friction with wet-weather crashes; and (3) guidance on the design, construction, and maintenance of pavement surfaces that will provide adequate friction throughout the pavement design life.

In the traditional pavement management system (PMS), pavement sections within a network are grouped together for evaluation based on the consistency of structural features, construction history, and traffic. The PFM defines pavement sections for evaluation based on similar principles but with consideration to the consistency in friction demand levels. Ideally, PFM programs should consider factors that influence friction demand levels, such as highway alignment, highway features/environment, traffic characteristics, and vehicle/driver characteristics. However, vehicle/driver characteristics are generally not included in such programs because of the difficulty in assessing their effects. Several highway

agencies in the United States and other countries have established friction demand categories with consideration to the other factors (highway alignment, highway features/environment, and traffic characteristics).

A comprehensive PFM program requires the consideration of pavement friction, pavement texture, and crash rates and should encompass the following key components:

- Network definition—Subdividing the highway network into pavement-section groups according to levels of friction need;
- Network-level data collection—Collecting the necessary information (test protocols, friction and texture data, crash data, etc.);
- Network-level data analysis—Analyzing collected data to establish investigatory and intervention friction levels and identify sections requiring detailed investigation or intervention;
- Detailed site evaluation—Evaluating and testing deficient sections to identify remedial actions; and
- Selection and prioritization for restoration—Identifying candidate sections for short-term and long-term corrective actions together with potential restoration treatments and schedule.

PAVEMENT FRICTION DESIGN

To build a pavement surface with adequate friction, consideration must be given to material and construction activities that influence the microtexture and macrotexture characteristics of the surface. Microtexture plays a role in the development of pavement-tire frictional forces and is primarily governed by the properties of the aggregates used in the surface, including hardness, mineralogy, shape, texture, angularity, abrasion resistance, polish resistance, and soundness. Macrotexture facilitates drainage and reduces the potential for hydroplaning; it is influenced by the paving mixtures and texturing methods. The process of friction design involves the following steps:

- Determining the design friction level required to provide adequate microtexture and macrotexture during the design period;
- Selecting aggregates with the physical, chemical, and mechanical properties that will provide both the initial and long-term friction requirements;

- Establishing the combinations of aggregate source, mixture type and proportions, texturing method, etc., that will provide the desired friction levels;
- Developing construction specifications to provide guidance on the requirements for aggregates, mixtures, handling, placement, compaction, curing, other factors that influence the surface; and
- Formulating and evaluating with consideration to monetary and nonmonetary factors, potential design strategies to identify the preferred pavement design option.

CONCLUSIONS AND SUGGESTED RESEARCH

The study examined the current state of the practice regarding pavement friction and highlighted the following findings:

- Laboratory testing—Several tests are available to assess aggregate's potential to provide adequate frictional characteristics.
- Field Testing—Several tests are available for measuring pavement friction and texture.
- Surface mixtures and texturing methods—Size and gradation of the aggregates used in asphalt concrete mixtures and the type of texturing applied to concrete pavement surfaces generally control macrotexture of the pavement surface.
- Friction management systems—There is no nationwide use of friction management systems in the United States; only a few state departments of transportation (DOT) have introduced comprehensive friction management programs,
- Friction design policy—Friction design policies vary widely among state DOTs and generally relate to aggregate quality and wet-weather safety.
- Friction investigatory and intervention levels—Such levels are generally not defined for the different categories of highways.

The information obtained in this project provided a basis for developing guidelines and recommendations for managing and designing for friction on highway pavements. This information was incorporated into a guide document prepared specifically for consideration and adoption by AASHTO.

Although a large amount of information on pavement friction, texture, and related topics is available and considered in this project, further research will help address some of the issues relevant to the design, testing, and management for friction that were not dealt with in this project. For example, research is needed to (1) enhance or develop improved laboratory and field test methods and explore the potential for developing a universal friction/texture measuring index, (2) monitor texture depth and its impact on noise and help better assess the long-term performance of pavement texture, and (3) develop further guidance on friction design and management practices to help reduce the potential for risk of tort litigation.

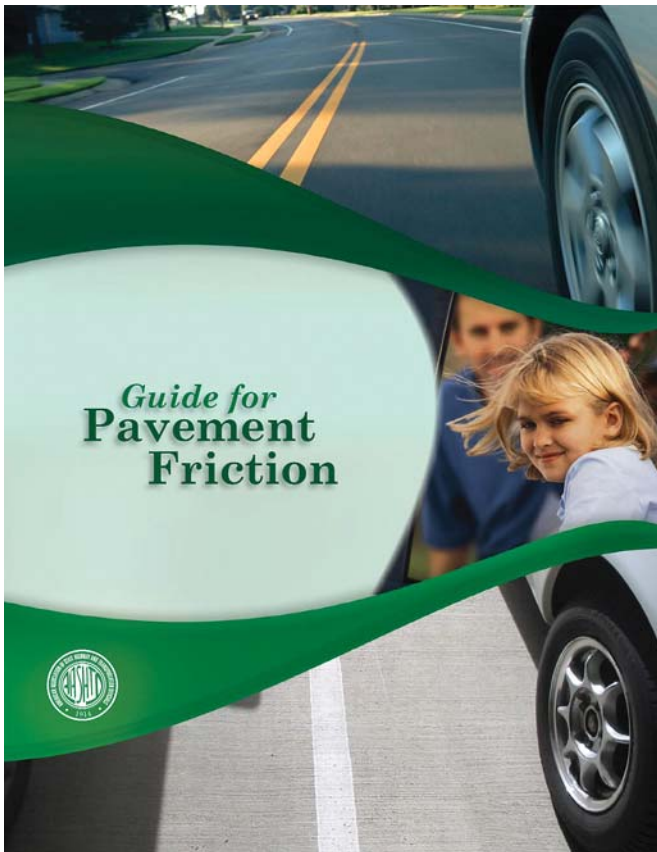
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FINAL PRODUCTS

The contract agency’s final report titled “Guide for Pavement Friction: Final Report,” gives a detailed account of the project, findings, and conclusions including further information on the current practices regarding pavement friction. The report, which was distributed to NCHRP sponsors (i.e., state DOTs), is available online at www.trb.org as NCHRP Web-Only Document 108.

Accompanying the final report was a guide document that was provided to AASHTO for consideration and adoption. Following review and revision, this document was published by AASHTO as the *Guide for Pavement Friction* (Item Code: GPVF-1); it is available from AASHTO, 444 N. Capitol Street, NW, Washington, DC 20001.



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