Section 1

Background

Texas has been and continues to be a leader in research, development, and implementation of skid resistant pavement surfacing. Research over the past 30 years has yielded an immense databank of information regarding skid, pavement friction and wet weather accident relationships. Two types of surface texture affect wet pavement friction: macrotexture and microtexture. Macrotexture in bituminous surfaces is largely provided by the size, quantity, and spacing of coarse aggregate and in concrete surfaces by treatments such as tining and carpet drag. Microtexture in bituminous surfaces is largely provided by the texture and shape of the coarse aggregate particles and in concrete surfaces by the fine aggregate.

Roadway characteristics like speed, traffic, number and weight of trucks, vertical and horizontal grades, number and location of driveways, and intersecting roadways have a significant impact on the frictional demand for a specific section of pavement. Climate also has a significant impact on the frictional demand of a specific section of pavement since dry pavement surfaces provide better skid resistance than wet pavement surfaces. Texas is divided into the following 4 climatic regions:

♦ Region I, wet with no freeze-thaw cycles
♦ Region II, wet with freeze-thaw cycles
♦ Region IV, dry with no freeze-thaw cycles
♦ Region V, dry with freeze-thaw cycles.

Figure 1 shows the location of each of the 4 climatic regions in Texas.

The frictional demand is different for pavement surfaces in these regions and must be taken into consideration when selecting a surfacing strategy. Several paving strategies and surface types are available to meet the frictional demands of the roadway. These strategies include the use of various levels of micro-texture, macro-texture and geometrics. The Pavement Design Guide can provide additional information about paving strategies and surface types.

The Texas Wet Weather Accident Reduction Program (WWARP) provides engineers a framework for identifying existing pavement friction, tools for specifying new pavement surfaces that will meet project-specific friction demand, and a means to track the effectiveness of the program. Wet weather accident analysis, aggregate selection, and skid testing are three interrelated phases of the program and are described in the following sections.

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Fig. 1. Location of the Four Climatic Regions in Texas
Federal Mandate

On June 27, 1967, the Federal Highway Administration (FHWA) issued Highway Safety Program Standard 12, which states in part that, “every State shall have a program of design, construction and maintenance to improve highway safety.” On July 19, 1973, the FHWA issued IM 21-2-73, which provided basic guidelines for a Skid Accident Reduction Program. On December 23, 1980, the FHWA published Technical Advisory (T) 5040.17, which provides that, “the State’s program shall provide that there are standards for pavement design and construction with specific provision for high skid resistant qualities.” The most recent FHWA document relating to skid safety is T 5040.36, dated June 17, 2005. T 5040.36 states, “Both microtexture and macrotexture are necessary to provide wet pavement friction at low and high speed conditions. The selection of the surface texture type to be provided at a specific location should be based upon existing conditions at that site. When selecting a texturing method or establishing a threshold value for a friction-related parameter, an agency should consider many factors including splash and spray, climate, traffic, speed, geometry, conflicting movements, materials and costs, and presence of noise sensitive receptors. Due to widely varying conditions at individual project locations, it is unlikely that one surface type or texturing method will always be the best choice for all projects within a State or jurisdiction.”

Department Responsibilities

TxDOT implemented WWARP in order to take advantage of the increased knowledge gained through our research efforts and to more effectively and efficiently address the various regional demands of Texas pavements.

As part of this implementation, the department will:

♦ establish and maintain programs to ensure that pavements with good skid resistant characteristics are used

♦ develop and implement methodologies for the detection and improvement of locations with a significant incident of wet weather accidents using accident record systems and countermeasures to address those locations

♦ implement methods for analysis of the skid resistant characteristics of selected roadway sections to:
  • ensure pavements that are being constructed provide adequate skid resistance
  • develop an overview of the skid resistant properties of the highway system
  • provide information for use in developing safety improvement projects and implementation of cost effective treatments at appropriate locations.

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The Construction Division, Materials and Pavements Section (CST-M&P) is responsible for developing, implementing, and maintaining WWARP. Other divisions charged with responsible support include Traffic Operations, Transportation Planning and Programming, and Maintenance. However, it is the district’s responsibility to ensure safe and adequate frictional properties for their pavements through sound engineering judgment and applying the concepts described in this guide. A singular mark of success for this program will be a reduction in the rate of wet weather accidents.

Effective Date of Implementation

Change to an aggregate classification system (from polish value and skid exception) became effective on all projects let on or after October 1, 1999. The requirement for collection of mandatory skid testing began May 1, 1999.
Section 2

Wet Weather Accident Analysis

The purpose of a wet weather accident analysis is to:

♦ identify locations with wet weather accidents, evaluate and determine the cause or causes of high accident incidents during wet weather; determine corrective measures and take appropriate actions in a timely and systematic manner,

♦ ensure that surfaces have adequate, durable friction properties; and

♦ ensure that available resources, including high quality aggregates and local materials, are properly used to enhance accident reduction in a cost-effective manner.

This activity may be conducted as safety improvement projects and should make effective use of the Crash Record Information System (CRIS) which is currently under development. Items to be reviewed from the crash records are total crashes, wet surface condition crashes, and the ratio of wet surface/dry surface condition crashes.

Identification of Wet Weather Accident Sites

Upon implementation of CRIS, accident records will be searched annually by the Traffic Operations Division to identify sites which are over represented with wet surface condition accidents. A listing of traffic accident information will be provided to the Construction Division (CST), Materials and Pavements Section (M&P) for distribution to the districts on an annual basis.

The district will consult at least annually with local law enforcement personnel, maintenance supervisors, and other field personnel to identify problem locations.

Office Review

For evaluation purposes the district may desire to have informal meetings to analyze the accident data with the various staff sections.

The District Pavement, Maintenance and the Traffic Engineers should review listings of wet surface condition accidents and skid test information together. Additional or supplemental traffic accident information may be required to fully analyze the collisions. Additional accident information is available through CRIS. If additional assistance is required, district personnel may contact the Traffic Operations Division for help in obtaining additional traffic accident information.

District pavement and maintenance personnel are familiar with the history of the pavement surface. The district maintenance personnel and the District Transportation Planning and Development personnel will be aware of proposed modifications and projects that have been scheduled. Information on the history of the location and the schedule of proposed improvements to the location is essential to designing cost effective countermeasures.
There are four basic steps that may be taken by the district in their evaluation of the data.

1. The selected locations can be compared to the previous three years maintenance program to track changes to the pavement over the reporting period.

2. The Pavement Engineer may consult the schematics or other sources to determine the geometric layout of the area. It is at this point that the engineer might consult a more detailed list of the location’s accidents to determine the most probable causes.

3. A site visit should be made to the location to visually assess the condition of the pavement surface, the roadway drainage and the traffic characteristics that might contribute to a high demand for friction.

4. Using the detailed accident data, the historical records of pavement modification, skid data and the site information, the District Pavement Engineer, the District Traffic Engineer and/or the District Maintenance Engineer may determine if the site warrants modification.

Field Review

The selected locations should be inspected and evaluated. An analysis or review group composed of various disciplines, such as materials, design, construction, maintenance, traffic and safety, may be an effective way of accomplishing a comprehensive field review.

The review group should analyze accidents at each location and use all areas of expertise to propose corrective actions. Corrective actions may include drainage improvements, surface preparations (remove mud, restore cross slope), signage (Mud on Roadway, Slow Down in Wet Weather, etc.) and/or programming for future surfacing improvements (Safety Program, Rehabilitation Program, Preventive Maintenance, etc.).

Visual inspections for elements that could result in wet weather accidents should be considered. Some of these areas are:

♦ rutting or wheel path channelization
♦ build up on shoulder edges that cause ponding on the road surface
♦ bleeding of pavements
♦ drainage issues that result in water on the pavement
♦ geometrics (grade & curvature)

The visual inspection should determine the need for additional information such as skid testing, texture measurement, etc.

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Report

Once the field review has been completed, the District Pavement Engineer will be responsible for drafting a report documenting the site location, evaluation of the site and action taken or recommended. Reports will be kept on file at the district office and a copy will be submitted to the Geotechnical, Soils and Aggregates Branch of CST-M&P.

Division Oversight

CST will be the office of primary responsibility for oversight of this program. Other divisions charged with responsible support include Traffic Operations, Design, Maintenance and Transportation Planning and Programming.
Section 3

Aggregate Selection

The aggregates selected for use in pavement surfacing should provide adequate microtexture, such that when combined with adequate pavement macrotexture, the frictional demands of the roadway will be met. The aggregate selection program described herein is for coarse aggregate used on the final surface of travel lanes consisting of hot mix asphalt concrete or surface treatments and will not apply to concrete pavements. Microtexture for concrete pavements is provided through the fine aggregate matrix and the quality is controlled primarily through the acid insoluble residue test.

The first step in aggregate selection is to determine the overall frictional demand of the roadway surface. The designer should consider the factors and guidelines provided below and, using engineering judgment, determine the overall frictional demand (low, moderate, or high) of the roadway surface. Some of the major factors which influence the overall frictional demand include:

♦ precipitation (wet days per year, inches per year)
♦ traffic volume (ADT, vehicles per lane, etc.)
♦ posted speed
♦ geometrics (both number and severity of horizontal and vertical curves, super elevation, etc.)
♦ frequency of vehicle stops (driveways, crossroads, etc.)
♦ amount of cross traffic
♦ amount of truck traffic (percent, number ESALs)
♦ surface texture (rough, smooth, etc.)
♦ drainage characteristics (cross slope, ponding, rutting, etc.)
♦ visibility restrictions (sight distance)
♦ accident history
♦ skid performance
♦ material availability.

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The following table shows how the factors listed above are categorized to determine the overall frictional demand of the roadway.

### Selection Guidelines for Bituminous Surface Aggregate Classification (SAC)

<table>
<thead>
<tr>
<th>Demand for Friction</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Designer’s Rating (L, M, or H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain Fall (in./yr.)</td>
<td>≤20</td>
<td>&gt;20 ≤40</td>
<td>&gt;40</td>
<td></td>
</tr>
<tr>
<td>Traffic (ADT)</td>
<td>≤5000</td>
<td>&gt;5,000 ≤15,000</td>
<td>&gt;15,000</td>
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<tr>
<td>Posted Speed (mph)</td>
<td>≤35</td>
<td>&gt;35 ≤60</td>
<td>&gt;60</td>
<td></td>
</tr>
<tr>
<td>Trucks (%)</td>
<td>≤8</td>
<td>&gt;8 ≤15</td>
<td>&gt;15</td>
<td></td>
</tr>
<tr>
<td>Vertical Grade (%)</td>
<td>≤2</td>
<td>&gt;2 ≤5</td>
<td>&gt;5</td>
<td></td>
</tr>
<tr>
<td>Horizontal Curve</td>
<td>≤3°</td>
<td>&gt;3° ≤7°</td>
<td>&gt;7°</td>
<td></td>
</tr>
<tr>
<td>Driveways (per mi.)</td>
<td>≤5</td>
<td>&gt;5 ≤10</td>
<td>&gt;10</td>
<td></td>
</tr>
<tr>
<td>Intersecting Rdwys (ADT)</td>
<td>≤500</td>
<td>&gt;500 ≤750</td>
<td>&gt;750</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Available Friction</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
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<tbody>
<tr>
<td>Cross Slope (in./ft.)</td>
<td>≤1/4</td>
<td>1/4 - 3/8</td>
<td>3/8 – 1/2</td>
<td></td>
</tr>
<tr>
<td>Surface Design Life (yrs.)</td>
<td>&gt; 7</td>
<td>&gt;3 ≤ 7</td>
<td>≤ 3</td>
<td></td>
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</tbody>
</table>

**Macro Texture of proposed surface**
- Fine (Examples: Microsurfacing, Type “F” HMAC)
- Medium (Examples: HMAC Type “C” & “D,” CMHB, SuperPave, SMA)
- Coarse (Examples: Seal Coat, PFC, OGFC)

Several parameters (i.e. cross slope, surface design life, macrotexture of proposed surface) can be changed by the designer and they can greatly influence the overall friction available and the needed microtexture of the aggregate used in the pavement. For example, a pavement with a relatively high cross slope (1/2 - 3/8 in. per ft.) should drain well. Available friction should be high for that parameter and microtexture needed by the aggregate will be low. Conversely, a pavement surface that is designed to last 10 yrs. will probably have low friction available by the end of the design life, which places a high microtexture demand on the aggregate.

After determining the friction demand and friction available for the roadway, the next step is to select an appropriate surface aggregate classification. The designer must balance the demand for friction with the available friction in order to determine the most appropriate surface aggregate classification required for the specific roadway section. The designer should use engineering judgment to select a surface aggregate classification that will provide adequate microtexture, such that when combined with adequate pavement macrotexture, the frictional demands of the roadway will be met.

### Recommended Surface Aggregate Classification

<table>
<thead>
<tr>
<th>MicroTexture</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation</td>
<td>SAC C</td>
<td>SAC B</td>
<td>SAC A</td>
</tr>
</tbody>
</table>

*continued...*
A listing of surface aggregate classifications by source is contained in the Bituminous Rated Source Quality Catalog (RSQC) maintained by CST. These classifications are based on a combination of friction and durability properties of the aggregate. As an example, a surface aggregate classification of “A” is assigned to an aggregate that has high frictional and durability properties. The criteria for aggregate classification are set by CST. The classification criteria are available upon request from the Geotechnical, Soils & Aggregates Branch of CST-M&P.

The last step is to document the process used to determine the overall frictional requirements for the project and specify the minimum surface aggregate classification to be used for the project. The final documentation should be reviewed by the District Pavement Engineer and a copy submitted to CST-M&P.
Section 4

Skid Testing

Skid testing will be performed on an annual basis. The skid data will be reviewed annually by the Pavements Section of the Design Division and the Construction Division (CST) to determine if the WWARP is working effectively and if the surface aggregate classifications are indicative of field performance.

Each district will collect skid data at 0.5 mile increments during the months of May through August of each year. Sections to be skid tested will be determined by the Materials and Pavements Section (M&P) of CST.

Skid data will be stored in PMIS and reports will be available for district review, evaluation and programming of projects as needed. CST-M&P will oversee the skid testing program, provide the districts with adequate skid testing equipment, assign vehicles to the various districts and provide training for skid operators in each district. However, the various districts will be responsible for collection of data, data input and data analysis.