EXPANDING THE REALM OF POSSIBILITY

Findings from NCHRP Projects on Surface Texturing and Pavement Friction

Presentation to:

AASHTO Highway Subcommittee on Construction

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An Employee-Owned Company

Outline

- NCHRP 1-43 – Guide for Pavement Friction
  - Discuss content of the Guide
- NCHRP 10-67 – Texturing of Concrete Pavements
  - Status of testing program and preliminary findings

Guide for Pavement Friction

NCHRP 1-43

- NCHRP Project 1-43 objectives:
  - develop a "Guide for Pavement Friction" for consideration and adoption by AASHTO and subsequent use by State and local highway agencies
  - address frictional characteristics and performance of highway pavement surfaces (asphalt and concrete)
  - consider safety and other relevant issues, such as tire–pavement related noise and economics
- Guide provides:
  - information on aggregates and mixture types that result in long-lasting, high-quality friction surfaces
  - information on friction-testing methods, equipment, and indices
  - methods for establishing investigatory and intervention friction levels

Guide for Pavement Friction

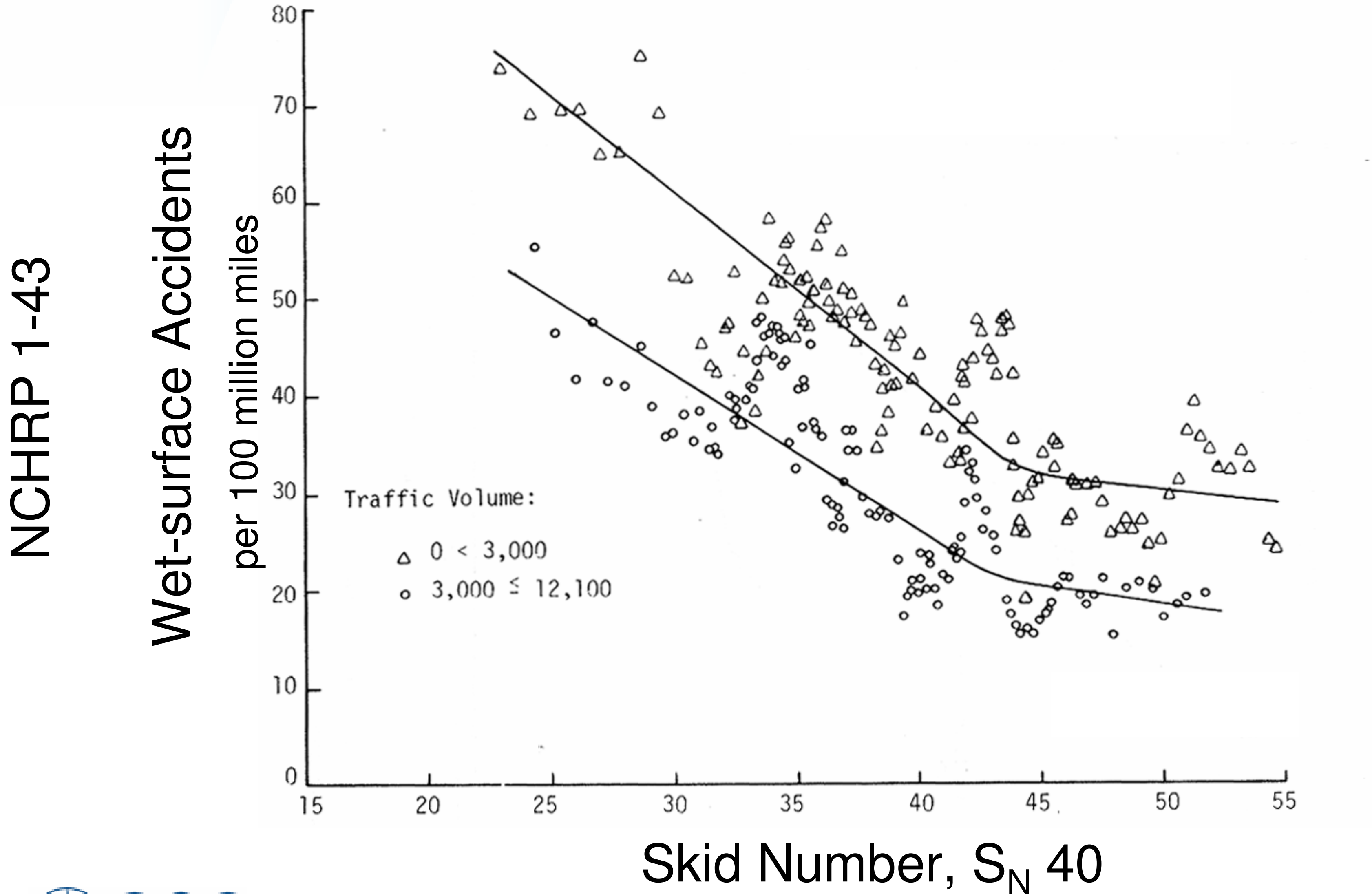
Chapters of the Guide include:

- Pavement Friction Overview
  - Importance Of Pavement Friction
  - Pavement Friction Principles
- Pavement Friction Management
  - Developing Pavement Friction Management Policies
  - Establishing the Pavement Friction Management Program
- Pavement Friction Design
  - Developing Friction Design Policies
  - Project-level Design Guidelines

Importance of Friction

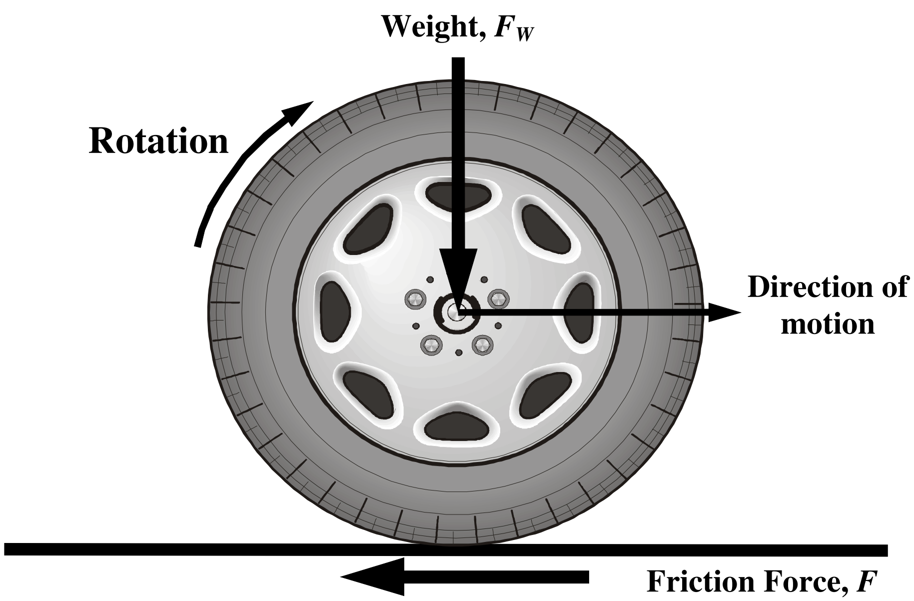
- Highway safety
  - Average of 6.4 million highway crashes occurred annually between 1990 and 2003
  - Crashes resulted in 3 million injuries, 42,000 fatalities, and countless pain and suffering
  - Cost of highway crashes is estimated at $230.6 billion annually
- Adequate friction on wet pavements can reduce accidents

Wet Weather Crashes versus Friction



Basics of Friction Testing

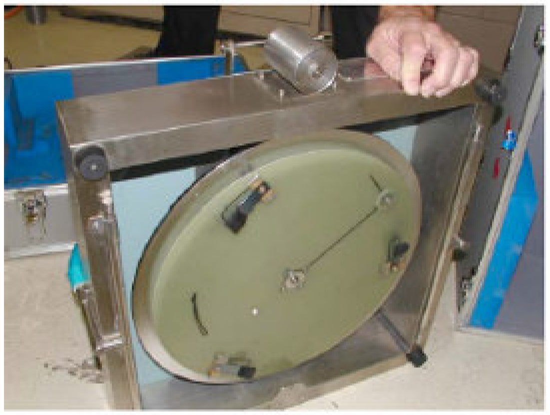
Friction - force that resists the relative motion between a tire and pavement surface



$$\mu = \frac{F}{F_W}$$

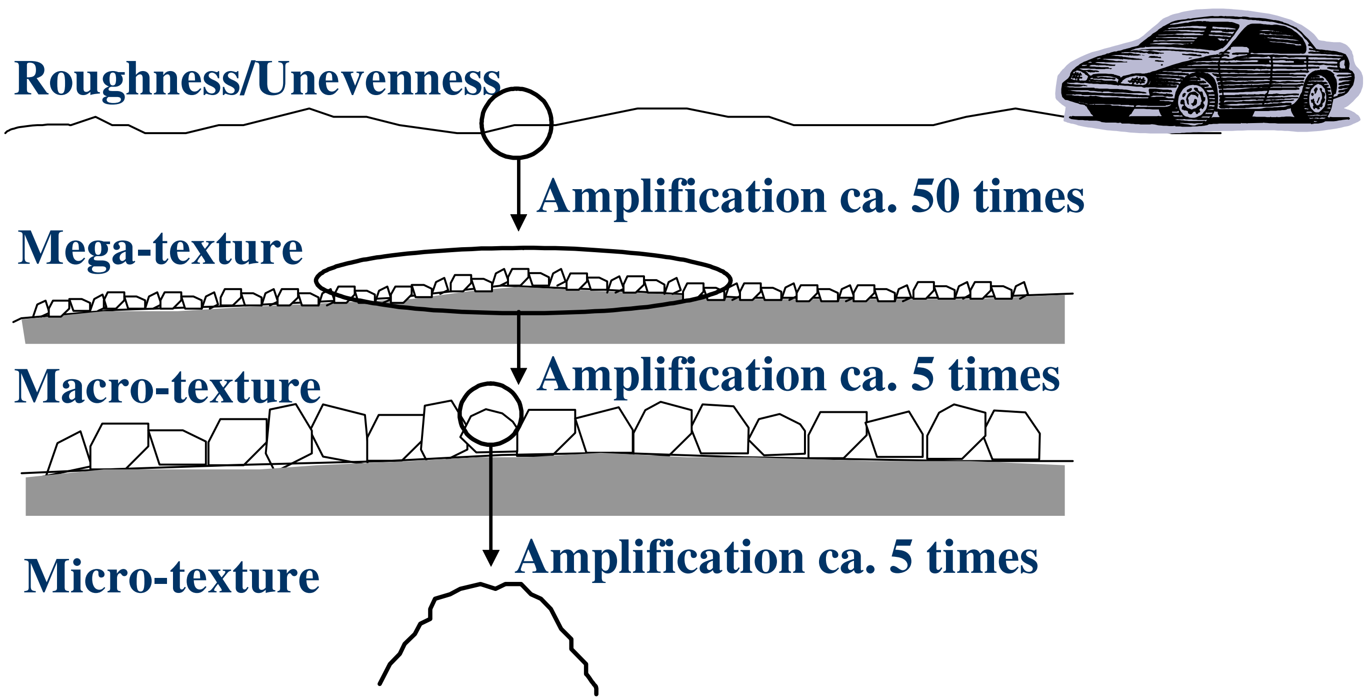
Measurement of Friction

- Micro-texture
  - ASTM E 1911 (DF Tester)
  - ASTM E 274 and ASTM E 501 (ribbed tire)
- Macro-texture
  - ASTM E 274 "Skid Resistance of Paved Surfaces Using Full-Scale Tire" and ASTM E 524 (smooth tire)
  - ASTM E 2157 (CT Meter)
  - ASTM E 965 (Sand Patch)
  - Others



Levels of Surface Texture

NCHRP 1-43



Reference Length

Short stretch of road

Tire

Road–Tire Contact Area

Single Chipping

International Friction Index (IFI)

- Developed by PIARC
- Based on ASTM E 1960

$$F(S) = F(60) \times e^{\left(\frac{60-S}{S_P}\right)}$$

$$S_P = 89.7 * MPD + 14.2$$

$F(S)$ = adjusted value of friction for a slip speed of S
$F(60)$ = measured friction value at slip speed of 60 km/hr
S_P = speed number, km/hr
S = measurement speed, km/hr
MPD = mean profile depth (macro-texture), mm

- Sp from CT Meter or high-speed profiler (each gives MPD) or from relationships between MPD, MTD (Sand Patch), and OFT (Outflow Meter).
- F(S) is friction value from a variety of testing equipment/methods at slip speed S.

Agency Policies and Practices

- Friction Management
  - Adequate monitoring of friction and/or crashes
  - Proper and timely response to potentially unsafe roadway surfaces
- Friction Design
  - Ensure adequate levels of micro-texture and macro-texture
  - Ensure texture durability throughout pavement life

Friction Management

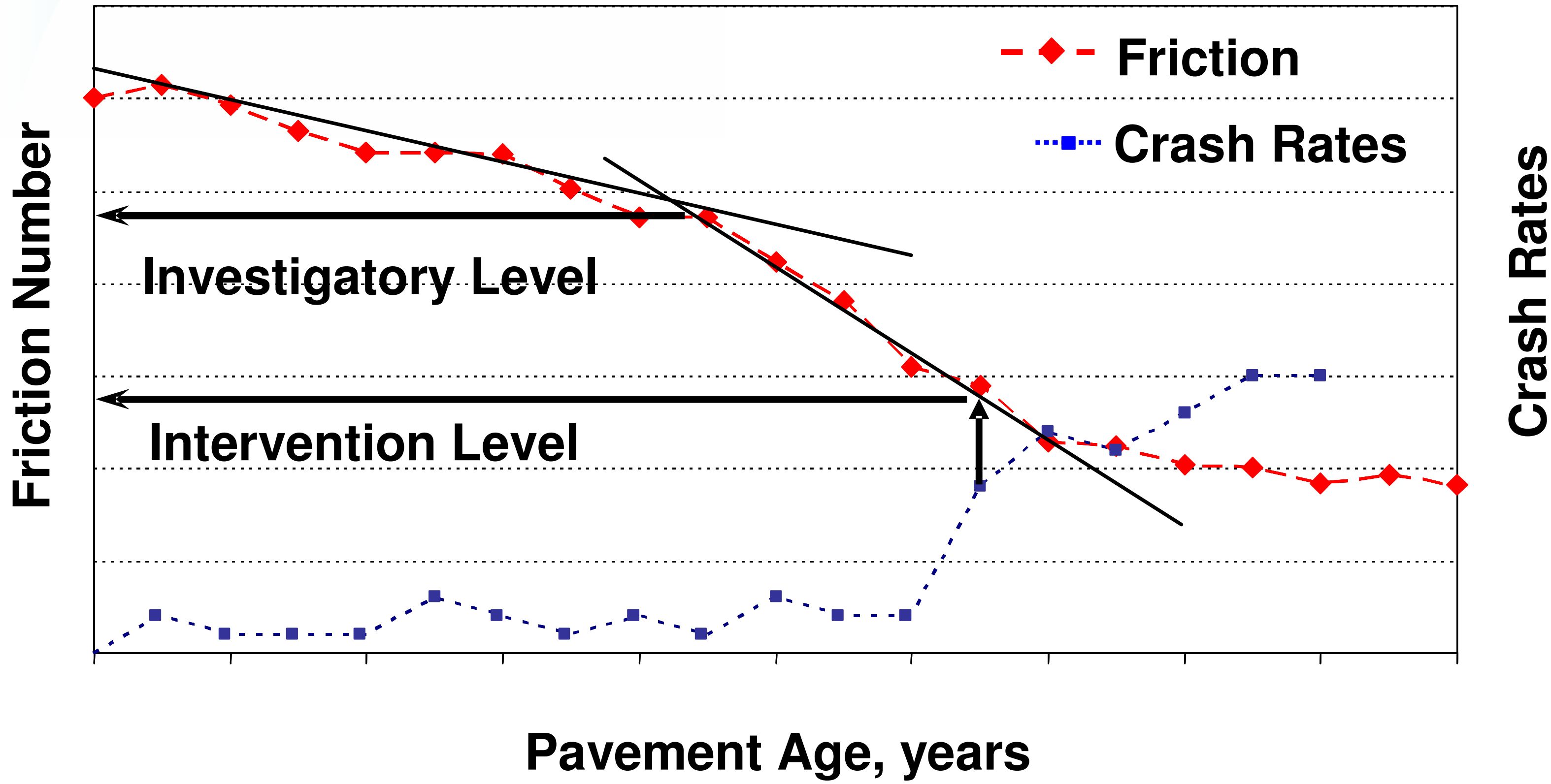
- PFM Program
  - A systematic approach to measuring and monitoring friction quality and wet crash rates, identifying surfaces and situations in need of remediation, and planning and budgeting for treatments and reconstruction
- Key Components
  - Network definition
  - Network-level data collection
  - Network-level data analysis
  - Detailed site investigation
  - Selection and prioritization of short and long term restoration treatments

Friction Management

- Two threshold levels defined by agency:
  - ***Investigatory*** – calls for detailed site investigation to determine need for remedial action; actions are:
    - Erect warning signs
    - More frequent testing
    - Further analysis of friction and crash data
    - Short-term restoration treatment
  - ***Intervention*** – Remedial action required; actions are:
    - Immediate restoration treatment
    - Erect warning signs
    - Program treatment in maintenance or construction work plan

Defining Levels

NCHRP 1-43



- Plot friction deterioration curve (for a specific friction demand category)
- Plot corresponding crash rates curve
- Set intervention level at significant increase in crash rates

Network-Level Friction Design

- Aggregate testing
  - Recommended tests that help characterize aggregate frictional (micro-texture) properties
  - Basic test criteria for discerning friction quality of aggregates
- Asphalt mix types and concrete texturing methods
  - Typical macro-texture depths
- Friction design categories
  - Matching aggregate sources and mix type/texturing techniques

Friction Design

- Project level design guidelines
  - Step 1 – Determine design friction level
  - Step 2 – Select aggregates (micro-texture)
  - Step 3 – Establish surface mix types and/or texturing techniques (macro-texture)
    - Use IFI equation to identify combination(s) of aggregate and mix type/texturing technique that satisfy design friction level
  - Step 4 – Develop construction specifications
  - Step 5 – Formulate design strategies

NCHRP 10-67 - Texturing of Concrete Pavements

- The objective of this research is to:
  - recommend methods for texturing concrete pavements for specific applications and ranges of climatic, site, and traffic conditions
  - identify methods (including tining and other means of texturing fresh and hardened concrete) that enhance surface characteristics, including texture, friction, and noise

Texturing of Concrete Pavements

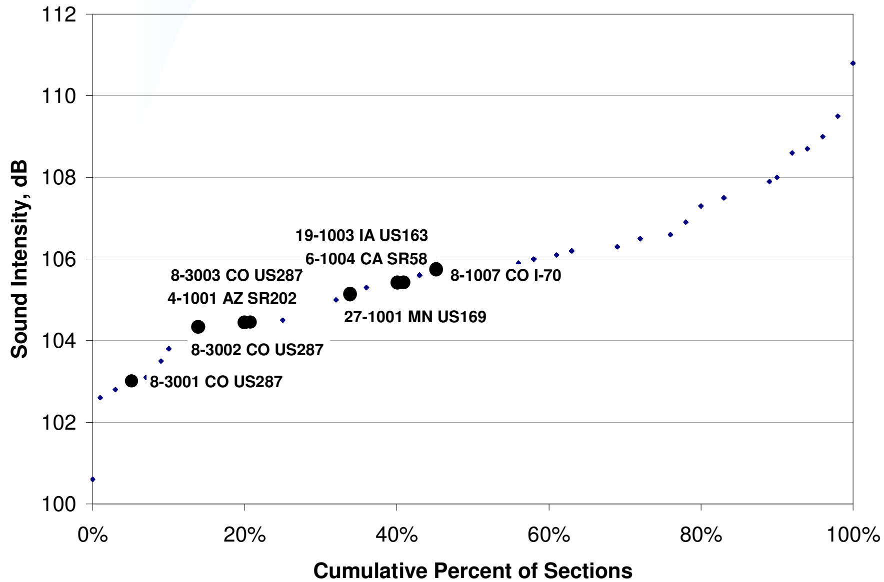
- Tests conducted on highway sections in 11 states
  - Arizona
  - California
  - Colorado
  - Illinois
  - Iowa
  - Kansas
  - Minnesota
  - North Carolina
  - North Dakota
  - Texas
  - Wisconsin

Texturing of Concrete Pavements

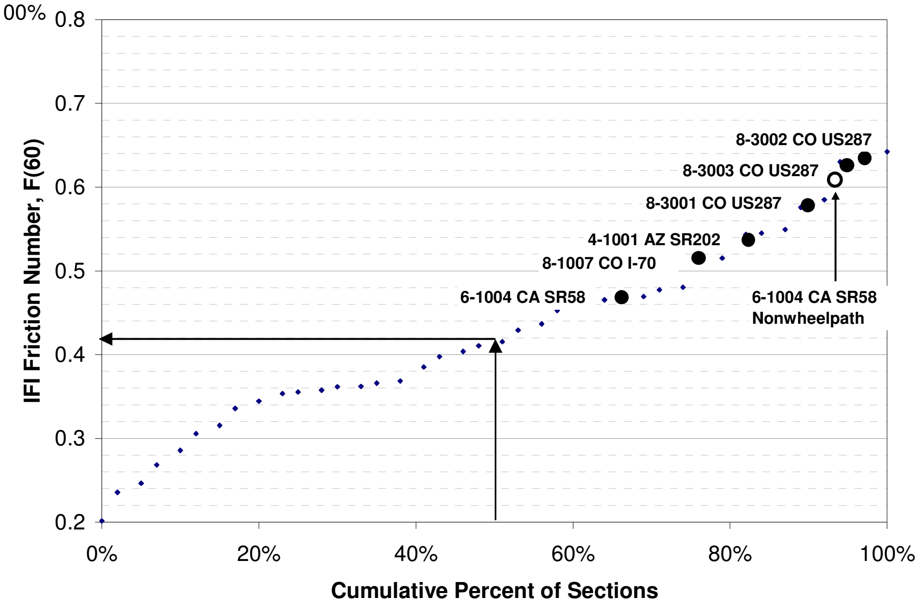
- Texture tests
  - CT Meter
  - High-speed profiler
- Friction tests
  - DF Tester
  - State locked-wheel skid tester
- Noise tests
  - Close proximity (Sound Intensity)
  - Interior
  - Far-field

Texturing of Concrete Pavements

NCHRP 10-67



- Data ranked to show lowest noise and highest friction



Recommended Textures for Test Sections

NCHRP 10-67

Texture No.	Pre-texture	Macro-texture				
		Texture	Direction	Spacing (mm)	Depth (mm)	Other
1	Heavy Turf Drag ($MTD \geq 1$ mm)	None				
2	None	Tining	Longitudinal	19	3.2	-
3	None	Diamond Grinding	Longitudinal	2.8	-	Without jacks
4	None	Diamond Grinding	Longitudinal	2.8	-	With jacks
5	Turf Drag	Tining	Longitudinal Meander	19	3.2	Sinusoidal Wave[a]
6	Turf Drag	Tining	Longitudinal	19	3.2	-
7	Burlap Drag	Grooving	Longitudinal	19	6.4	-
8	Turf Drag	Grooving	Longitudinal	19	6.4	-
9[b]	Burlap Drag	Tining	Transverse[c]	Random	3.2	-
10[b]	Participating Agency Standard					

a Sinusoidal wavelength of 406 ± 50 mm and amplitude of 203 ± 50 mm.

b Control sections.

c Skewed or unskewed, depending on joint orientation.

Construction of Test Sections

- Seeking states to participate in constructing and monitoring texturing test sections
- Construction to be done this year
- Texture, friction, and noise testing by ARA
- Traffic control (as needed) and ASTM E 274 testing by participating SHA