PAVEMENT FUNCTIONAL SURFACE CHARACTERISTICS

Midwestern Pavement Preservation Partnership

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By Roger M. Larson, APTech

Phone/Fax 703-455-7681

rlarson@pavementsolutions.com

Pavement Functional Surface Characteristics (PFSC)

OVERVIEW / TEXTURE

1. Why PFSC are Important
2. Description of Functional Performance
3. Key Functional Performance Factors
4. Measurement and Evaluation Tools
5. Summary

Most design and construction specifications address only ride.

Pavement Preservation Contribution to Safety

As Professional Engineers we need to do what we can to improve safety. A tremendous opportunity exists.

By monitoring and improving texture and friction, we can contribute to reducing deaths, serious injuries, and traffic delays!

WHY IS TEXTURE IMPORTANT?

- Friction (Safety)
  - 43,000 Die On U.S. Roads Annually
  - 2 Million Personal Injury Crashes
  - 3 Million Personal Injuries
  - 6 Million Crashes Annually
  - Impact On Traffic Delays

  Annual cost $230.6 Billion
- Noise (Environment)
  - Problem In Urban Areas

WHY IS TEXTURE IMPORTANT?

- Worldwide safety problem – Over one million deaths and 50 million injuries annually
- In the U. S., the 43,000 deaths and 3 million injuries annually are unacceptable

Some highway crashes can be prevented or deaths and serious injuries minimized! My estimate = 10 to 20%

Tire Pavement Noise and Safety Performance Report – May 1996

- FHWA-SA-96-068 documented results of PCC Surface Texture Technical Working Group

Appendices document International and U. S. research studies regarding the effect of pavement texture on noise and safety for both PCC and AC pavements

U.S. vs. International Accident Rates

Fatalities per 100 thousand population

1975	U.S. 20.7	OECD median 18.5
2000	U.S. 15.2	OECD median 11.0

Fatalities per 10,000 registered vehicles

1975	U.S. 3.2	OECD median 5.9
2000	U.S. 1.9	OECD median 1.9

Fatalities per 100 million vehicle km

1975	U.S. 2.1	OECD median 3.6
2000	U.S. 0.9	OECD median 1.3

FHWA FY 2004 Safety Focus Areas

- Reduce roadway departure crashes
- Reduce number of collisions at intersections
- Improve pedestrian safety
- Encourage states to adopt
  - Strategic and performance based goals
  - Implement data improvement programs
  - Identify priority improvement projects
- By 2008 reduce fatality rate to 1.0 per 100 million VMT compared to 1.53 in 2000

Three Pillars of Safety Design

- Driver Behavior
- Vehicle Design
- Infrastructure

This presentation will focus on the infrastructure:

- **Geometric design (Reduce texture/friction demand) – large amount of data available!**
- **Pavement surface characteristics (increase texture/friction provided)- largely ignored!!**

Emphasize Infrastructure

- Most current safety effort is on the vehicle and driver issues
- Most infrastructure effort is on geometric design issues
- **Minimal effort on evaluating the effect of improving pavement surface characteristics on reduction of fatalities, serious injuries, and traffic incident delays**

Geometric Design - Critical Crash Locations

- 50 percent of crashes are on two lane roads
- 25 percent of crashes are on horizontal curves
- more than 50 percent of combined fatal and injury crashes occur at intersections

86 percent crashes occur on dry pavement (day or night) – need to address both total and wet weather crashes

Role of Infrastructure

- Geometric design considerations (reduce friction demand)

- **Pavement surface characteristics (increase texture/friction provided – reduce stopping distances)**

Vehicle tire/pavement interaction is the major concern. This is where the rubber (tire) meets the road!

Role of Infrastructure

Concerns

- No specific goal relating increasing network texture/friction on reduction of deaths, injuries, and traffic delays
- No performance indicator(s) to quantify effect of increasing texture/friction on reducing annual deaths, injuries, and traffic delays
- Safety is high priority user concern that is not being directly addressed – greater concern as population ages–slower reactions

Safety Management System (SMS) Status

- NCHRP Synthesis 158, Wet Pavement Safety Programs (1990)
- Mandated SMS in 1991 made optional in 1995
- May 10, 1996 FHWA Revised SMS Guidelines
- NCHRP Synthesis 291, Evaluation of Pavement Friction Characteristics (Dec 2000)
- NCHRP Synthesis 321: Roadway Safety Tools for Local Agencies (2003)
- NCHRP Synthesis 322 on Safety Management Systems (2003)
- NCHRP 17-34 Highway Safety Manual proposed
- NCHRP Report 501: Integrated Safety Management Process (2003)

Road Safety Audits and Reviews

- FHWA 1995 Report of International Scan of Road Safety Audits
- NHI Course 380069, Road Safety Audits and Reviews updated 12/02
- 2002 Australian Report on Benefits of Road Safety Audits
- Jan. 2003 ERF CD-ROM addresses Road Safety Audits also

Geometric Design Guidelines

Goal is to reduce friction demand

- **Highway Design and Traffic Safety Engineering Handbook, McGraw Hill, 1999, 600 pages**
- **NCHRP Report 440, Accident Mitigation Guide for Congested Rural Two-Lane Highways, 2000, 78 pages**
- **NCHRP Synthesis 299, Recent Geometric Design Research for Improved Safety and Operations, 2001, 140 pages**
- **AASHTO Guidelines (next slide)**

Large number of publications are available – Computer programs being developed to provide user friendly guidance

AASHTO Guidelines

- **Highway Safety Design and Operations Guide, AASHTO Yellow Book, 1997**
- **AASHTO Strategic Highway Safety Plan: A Comprehensive Plan to Substantially Reduce Vehicle-Related Fatalities and Injuries on the Nation's Highways, 1998 (NCHRP 17-18)**
- **"The Green Book" – A Policy on Geometric Design of Highways and Streets, 4th Edition, 2001**
- **Roadside Design Guide, 3rd Edition, 2002**
- **NCHRP 1-43, Proposed Update of 1976 Guide for Skid Resistant Pavement underway**
- **NCHRP 10-69, PCC Surface Texturing**

Geometric Design Computer Programs

Assist designers in checking safety related criteria:

- FHWA Integrated Highway Safety Design Model (IHSDM), 5 modules released Jan. 2003
- SPR 2(183) Demo CD ROM available
- FHWA Safety Analyst under development

AASHTO TSIMS (NCHRP 17-18) effort and Development of Highway Safety Manual (NCHRP 17-34) underway

NCHRP 1-43 – Guide for Pavement Friction

- Comprehensive manual for AASHTO adoption
- Design, materials, monitoring, legal issues
- Expected completion 2006
- Should help uniformity of State requirements

NCHRP 10-69 – Texturing of Concrete Pavements

- Looking at alternatives to tining
- Focusing on durability, safety, and noise
- Initiated by States with texture-durability issues
- Scope expanded by NCHRP panel
- Includes overlay options
- Expected completion in 2005 or 2006

FOUR MAIN CAUSES OF POOR SKID RESISTANCE

- Rutting
- Polishing
- Bleeding
- Dirty pavement

Rutting is the only factor currently monitored (with 3 or 5 laser systems)

Can now technically address Polishing, Bleeding, Raveling/Segregation

Studies on AC Texture/Friction

- Noyce – U of WI
- Doug Hanson – Auburn (NCAT)
- Rebbecca McDaniel – Midwest Superpave Center
- FHWA- Use of PMS to Monitor Superpave Performance
- AZ DOT – Quiet Pavements and Preventive Maintenance Studies
- Texas – Wet Weather Accident Reduction Program (WWARP) – macrotexture, pavement type, and aggregate type used to predict + or – 6 FN50B

Equipment Developments

- Routine collection of macro texture now possible - ASTM Standard Practice E-1845
  - **Some states collecting but data not used**
  - **With three laser system compare polishing, bleeding, and raveling/segregation in and between wheelpaths**
- Transverse scanning laser –
  - **promising new development for rut depth (960 measurements over 14 ft width)**
  - **could be lowered and a separate pass made to evaluate texture in and between wheelpaths (polishing, bleeding, and raveling/segregation)**

Consideration of Tire/Pavement Friction/Texture Effects …5/14/99

- Referenced available workshop and conference proceedings since 1958
- Summarized existing guidelines
- Summarized research and implementation activities
- Recommended Actions

Attachment 1 summarized studies showing "Effect of Friction/Texture on Crash Rates"

Attachment 1 – Effect of Friction/Texture on Crash Rates

- Issue #1 – Minimum level of friction/texture
  - **Best Practice, United Kingdom since late 80's (Investigatory Level based on site category) – *Updated 15 yrs SURF 2004***
  - **Fatality rate has dropped from 15 to 6 per 100 thousand population**
- Issue #2 – Is there evidence that increasing friction/texture reduces wet or total crash rate?
  - **Four case studies documented that increasing friction/ texture reduced crash rates**

Proceedings, Pavement Evaluation 2002, Roanoke, VA

- Latest data gathering equipment demonstrated
- Results of FL, MD, and VA friction studies presented
- MD results demonstrated adverse effects of polishing aggregates on crash rates

Recommendations - Texture

- Greater International Cooperation Needed
- Need to clearly identify effect of increasing network texture/friction on reduction of deaths, injuries, and traffic delays
- Provide training on safety analysis at both the network and project levels (Emphasize route or area-wide safety analysis-proactive rather than spot safety analysis-reactive)

1. Why PFSC Important

SUMMARY

- 43,000 deaths and 3 million injuries annually - $230 Billion annual cost
- Poor surface conditions contribute to 13,000 fatalities (30%) annually

Greater attention to improving pavement condition and safety (texture/skid resistance) could reduce crashes an estimated 10-20 percent!

1. Why Important? (Continued)

- In 1996, 21 of 48 States (44%) had no friction or texture requirements for HMA pavements–only 5 or 6 States had both
- Only 20 States (40%) are working on safety management systems (2003)
- During 1992-2001, average of 1300 work related civilian roadway fatalities each year (CDC) - #1 cause (22%)

2. Description of Functional Performance

- Ride Comfort – 1957 AASHO
- 1996 & 2000 Highway User Survey Results

In 2000, increased dissatisfaction with pavement condition (10%) and safety (3%)

1996 Highway Users Survey

Priorities for improvement:

1. Safety
2. Pavement condition
3. Traffic flow

2000 Highway Users Survey

Priorities for improvement:

1. Traffic flow
2. Safety
3. Pavement condition

2000 Highway Users Survey

- Pavement condition
  - Durable surfaces
  - Smooth ride
  - Quiet ride
  - Surface appearance
- Safety
  - Pavement markings
  - Friction in wet weather
  - Clear accidents more quickly

3. Key Functional Performance Factors

- Surface Durability (Condition)
- Ride comfort
- Pavement texture
  - Friction (safety)
  - Noise (environment)
- Aesthetics (appearance)

Surface Durability (2000)

- 67 percent – more durable surfaces
- 66 percent – repairs during non-rush hours
- 52 percent – reduced repair time

Safety – Major Issue

Past efforts mostly reactive not proactive!

- No goal to increase texture/friction at network level (Reduce splash/spray)
- No monitoring of texture/friction to verify improvements are being made
- No monitoring on effect of increasing friction/texture on crash reductions

Safety (Continued)

- Need research to verify cost-effectiveness of improving pavement condition and increasing texture/friction
- Address impact on:
  - Reducing roadway departures
  - Reducing intersections crashes
  - Reducing crashes on ramps
  - Reducing work zone fatalities
  - Reducing traffic delays

4. Measurement and Evaluation Tools

- Structural versus functional deficiencies
  - Rolling wheel deflectometer (FHWA)
  - Ground penetrating radar (AASHTO TIG)
- Durability (pavement condition)
  - Automated distress surveys (NCHRP Synthesis 334-2004)
- Ride comfort
  - Laser technology

4. Measurement and Evaluation Tools (Continued)

- Texture/Friction requirements (1996)
  - 21 of 48 States had no HMA requirements
  - Only 5 or 6 States addressed both
  - Minimum not desirable levels addressed
- Only 20 States developing SMS (2003)
- No States addressed pavement noise levels in specifications

No verification that customer expectations are met!

4. Measurement and Evaluation Tools (Continued)

- Need to promote "Best Practices"
  - FAA guidelines for skid resistant surfaces
    - Desirable friction and texture levels for new surfaces
    - Maintenance planning (Investigatory or warning) levels
    - Minimum acceptable levels
  - Others – U. K. (HAPAS) & NZ, South Africa PPGS, NY, TX

4. Measurement and Evaluation Tools (Continued)

- United Kingdom and New Zealand have very effective programs that address safety issues. U. K. just updated 15 year old procedure.
- U. K. Highway Authorities Product Approval Scheme (HAPAS) noted in July 2003 International Materials Scan
- South African Product Proposal Guarantee System also appears effective

AZ, NY, TX are developing procedures in U. S.

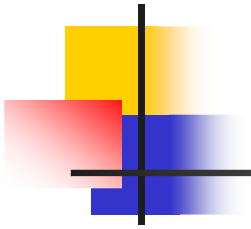
5. Summary

- Need better integration of management systems
  - Pavement management
  - Maintenance management
  - Safety management
- Need research to quantify benefits of improved pavement condition and increased texture/friction on safety at route and network levels

5. Summary (Continued)

- Need improved specifications to address functional performance (friction&noise)
- Need standardized evaluation techniques to verify customer expectations are met or exceeded

Need to demonstrate cost-effectiveness of improved pavement condition and increased texture/friction on route/network – Be Proactive



Questions?