ISU – FHWA – ACPA Surface Characteristics

Program Update

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National Concrete Pavement Technology Center

Uniting agencies, industry, and researchers to advance concrete pavement technology

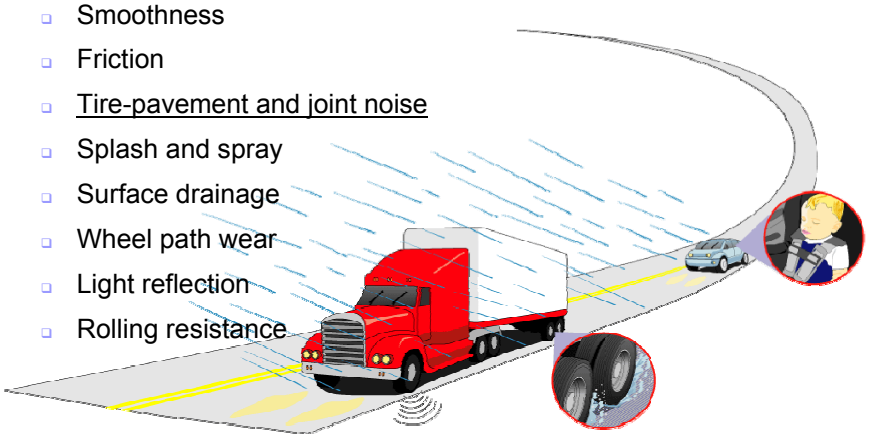
U.S. Department of Transportation
Federal Highway Administration

ACPA

Surface Characteristics

Any factors that effect:

- Smoothness
- Friction
- Tire-pavement and joint noise
- Splash and spray
- Surface drainage
- Wheel path wear
- Light reflection
- Rolling resistance



Our Motivation

Management Goals

- To implement the Quiet Pavements International Scan findings
- To leverage funds
- To leverage experiences
- To promote unified solutions

Our Motivation

Technical Goals

- To understand the relationship between noise and texturing/grinding
- To develop the noise-texture-time relationship
- To develop construction techniques that are repeatable and cost effective
- To evaluate non-texturing options
  - *Pervious concrete, exposed aggregate, etc.*

Our Motivation

Very little systematic information

Nearly all previous experiments have fallen short.

Why? Inadequate noise and texture measurements.

Project Team

Iowa State University

- Paul Wiegand, Dale Harrington, Tom Cackler, Jim Cable, Jim Grove

TDC Partners, Ltd.

- Ted Ferragut

The Transtec Group, Inc.

- Robert Rasmussen, Eric Mun
- Robert Light, George Chang, Bebe Resendez

Technical Experts

- Steve Karamihas, Bob Bernhard, Ulf Sandberg
- Bob Prisby, Gary Fick

Project Team

ACPA / IGGA

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FHWA

Mark Swanlund

Tom Harman

Texture Field Experiments

Key Study Points

1. Study all types of textures
2. Study noise vs. texture vs. friction vs...
3. Relative ranking, not elimination
4. Sophisticated modeling not viable at this time
5. Control construction variability without heavy capital expenditure

Texture Field Experiments

A performance-based noise specification:

- *The tire-pavement noise shall not exceed **X dBA** or contain tonal frequencies at **Y Hz** for **P1%** of the pavement when measured by **Z procedure** at **D days** after placement.*
- *Furthermore, the noise shall not exceed these values for **P2%** of the pavement after a **T year** period.*

Note

This isn't being promoted !!!
But, are we prepared to fill in the missing details?

Texture Field Experiments

An end-result texture specification:

- *Just describe the texture features we want...*
  - *But with what procedure?*
  - *But with what tolerances?*
  - *But what about wear rates over time?*
  - *But when should we measure?*

"¾-in. spacing and ⅛-in. deep"

IS THIS GOOD ENOUGH FOR FUTURE?

Study Types

- Type 1. New Construction and Repeat Visits
  - Noise, texture, smoothness, friction, and concrete early
- Type 2. In Service with Repeat Visits
  - Measure noise, texture, smoothness, friction
- Type 3. In Service – One Time Only
  - Measure noise and texture

Type 1 Sites

- Construction
  - Nominally 10 texture configurations
  - Include tining, drag, and grinding
  - Spacing and depth variations
  - Minimum 500 ft. test sections
  - One longer (2500 ft.) site for variability
  - Iowa complete. Additional sites pending (MO, WI)
  - Develop “Better Practices of Texturing”

Type 2 Sites

- In Service, Evaluate Annually
  - Relatively new sites, or those with existing (early) data
  - Loud and quiet sites
  - Variety of configurations – width and depth variations
  - Noise, texture, friction, smoothness
  - Purpose: constructability, variability, time history

Type 3 Sites

- In Service, One Time Only
  - Any age
  - Loud and quiet sites
  - Variety of configurations – width and depth variations
  - Noise and texture, one time
  - Purpose: inventory and noise-texture relationships

Test Sites

Type 1 New (wear study)	IA, (MO, WI)
Type 2 Existing (wear study)	CO, ND, KS, IA, GA, WI
Type 3 Existing (catalog only)	CO, ND, MN, IA, AL**, GA, NC, VA, OH, IN, MI, Quebec, NY, MO, (TX, CA, AZ)

** NCAT

Test Sections

To Date: 213 Unique Textures Tested

- 71 Transverse Tining (incl. 6 skewed)
- 51 Longitudinal Tining (incl. 1 sinusoidal)
- 1 Cross-Tined (transverse and longitudinal)

- 20 Diamond Ground
- 8 Grooved (2 longitudinal, 6 transverse)

- 30 Drag (Burlap, Turf, Broom, Belt, Carpet)
- 1 Transverse Broom

- 3 Exposed Aggregate
- 3 Shot Peened
- 1 Milled

- 19 HMA
- 5 Surface Treatments

Over 547 unique test sections for a total of over 143,000 ft !

Measurements

- Mega-, macro-, and micro-texture
- Noise, smoothness, friction, and concrete tests
- Demonstration of innovative equipment
- Early, frequent, and detailed data collection:
  - First days of operation
  - 30-90 days later (or after following winter)
  - Annually until stable

Measurements

Noise

- On-Board Sound Intensity (OBSI)
- Wayside
- In-Vehicle

Smoothness

- Inertial Profiler

Macrotexture

- RoboTex (LMI line laser)
- Circular Texture Meter (CTM)
- Sand patch
- Digital imaging (lab)

Microtexture / Friction

- Locked wheel skid trailer (smooth tire)
- Dynamic Friction Tester (DFT)

Noise Protocols

On-Board Sound Intensity (OBSI)

- Differs from the CPX “noise trailer” –
  OSBI is a more sophisticated technique but requires more expertise
- Paired microphones in OBSI allow for directionalized measurement
- Shielding from external noise sources not required

Noise Protocols

Wayside

- Controlled pass-by (CPB) measures noise “roadside” using test vehicle under controlled conditions
- Same vehicle used for OBSI and CPB noise testing
- Time-averaged wayside on some sites, following FHWA and ISO SPB guidelines for testing

Noise Protocols

In-Vehicle Noise

- Standardized by SAE J1477 and ISO 5128
- Same vehicle used for OBSI and In-Vehicle noise testing

Microtexture / Friction Protocols

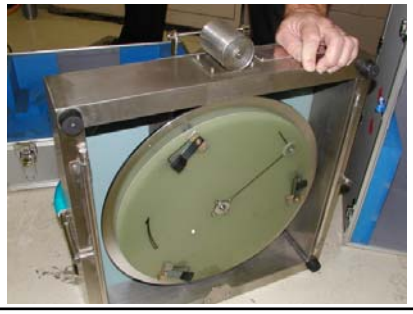
Locked Wheel Skid Trailer (with Smooth Tire)

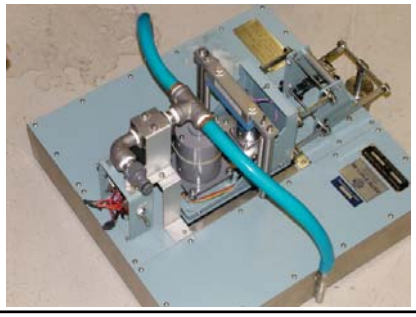
- Measures wet friction at one slip speed = velocity of test vehicle
- Smooth tire allows for differentiation of macrotexture effects on friction
- Allows for comparison to some current DOT practices
- Standardized in ASTM E 274 (ASTM E 524 for test tire)

Microtexture / Friction Protocols

Dynamic Friction Tester

- Measures friction as a function of speed
- Measures wet friction on small rubber pads which slow from 50 mph
- Coupled with macrotexture, allows prediction of International Friction Index (IFI) and correlated relationships to E 274 trailer
- Standardized in ASTM E 1911

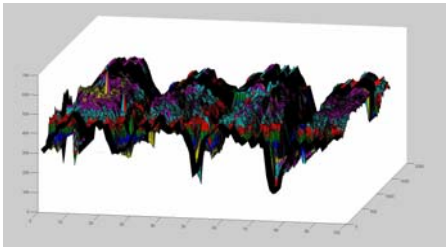


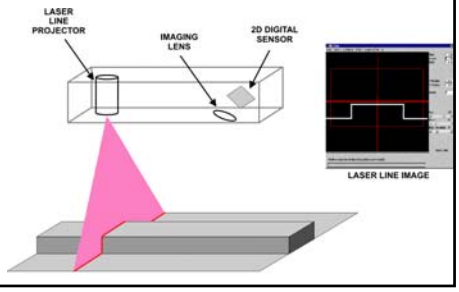


Macrotexture Protocols

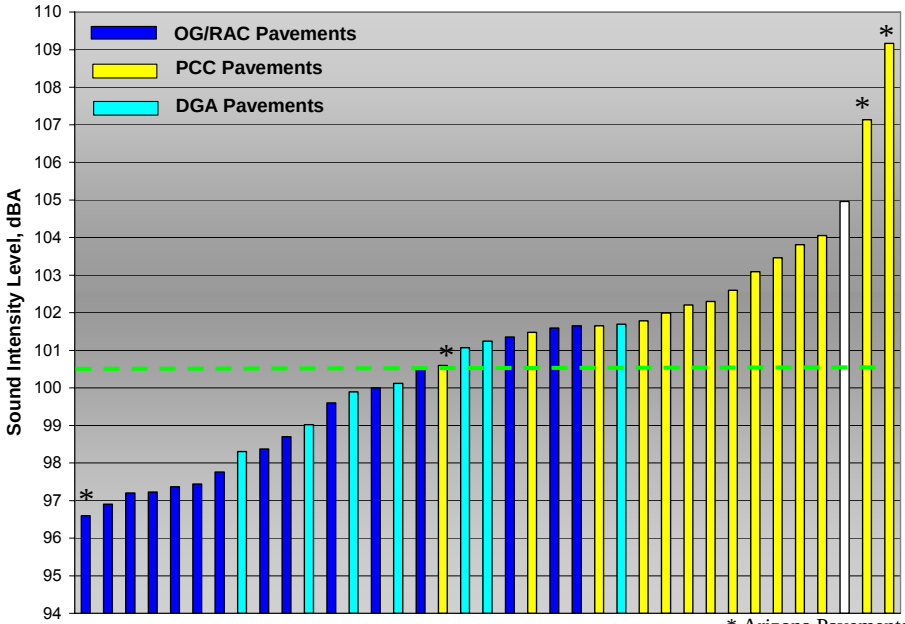
RoboTex Texture Device

- Robotic Texture (RoboTex) built around LMI-Selcom RoLine line laser
- 3-D texture profiling at 0.9 mm × 0.45 mm sample interval
- Height sensor resolution is 0.01 mm (accuracy ~ 0.05 mm)
- Same line laser unit currently being evaluated by profiler vendors to help solve “footprint” issues





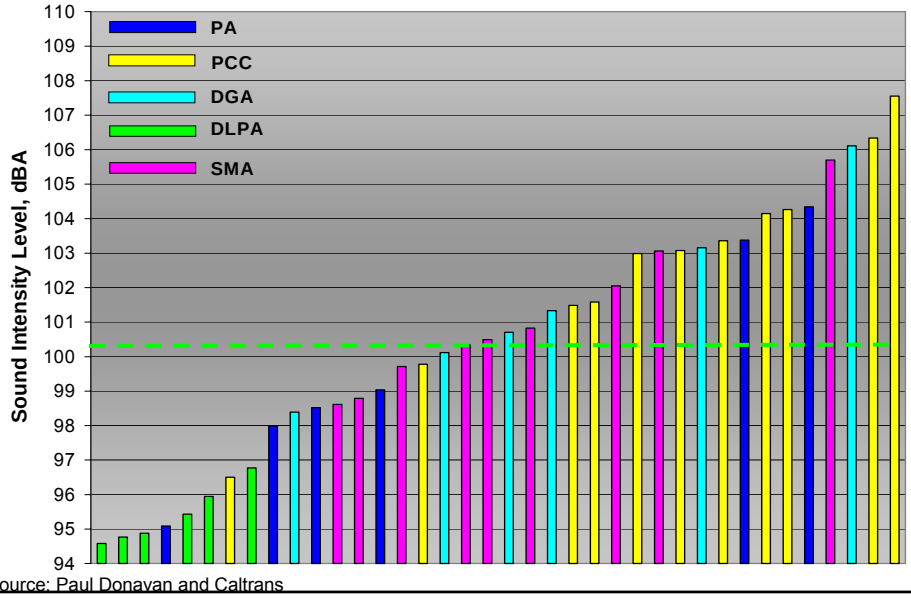
Caltrans State-Wide Data Base



Source: Paul Donavan and Caltrans

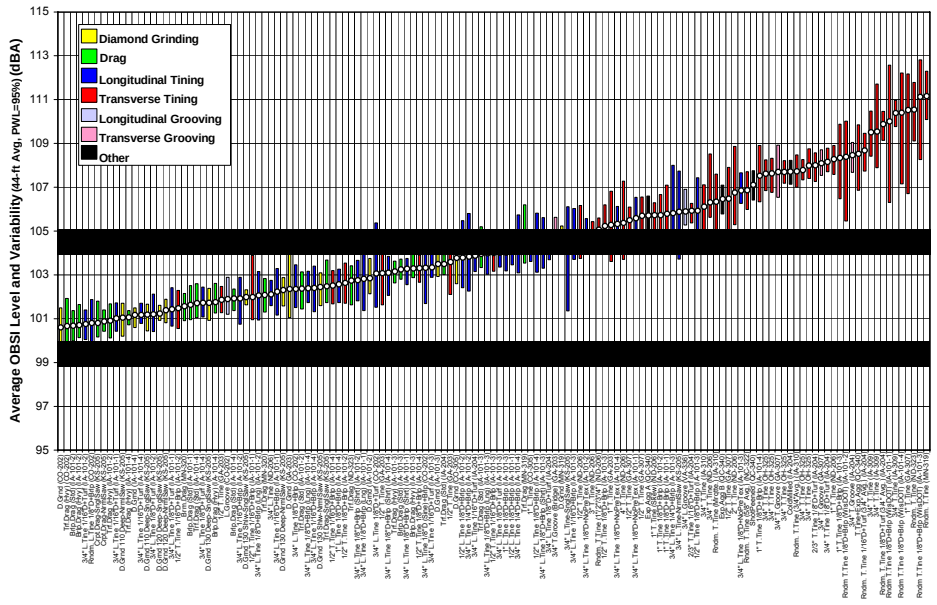
* Arizona Pavements

European Pavements at 97 km/h

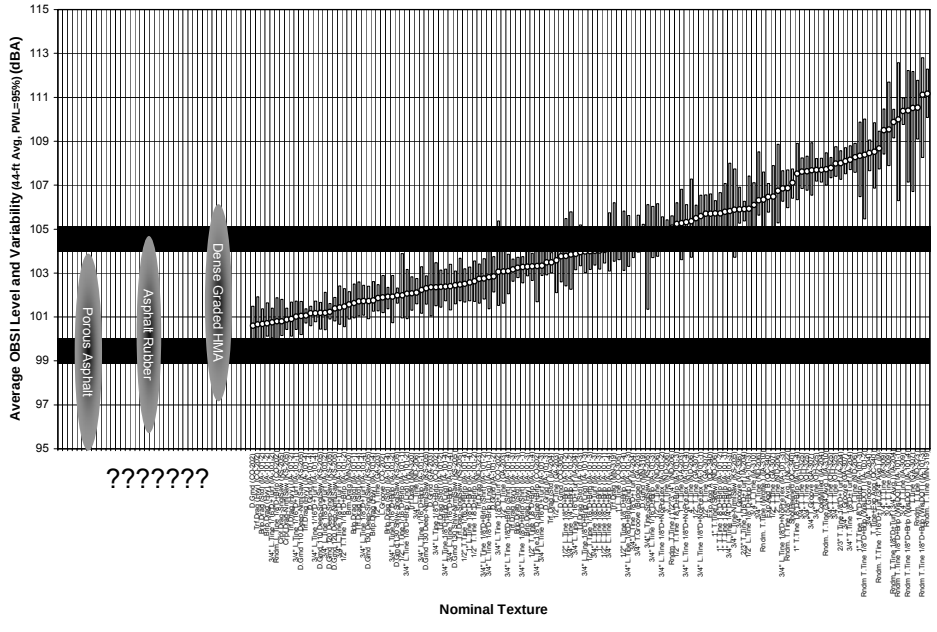


Source: Paul Donavan and Caltrans

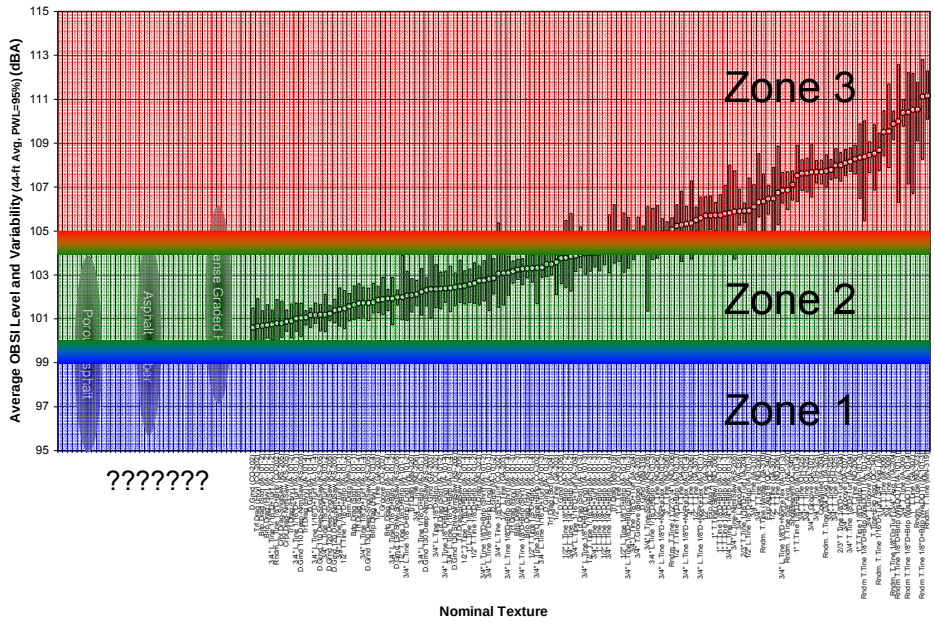
Noise Zones



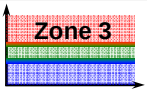
Noise Zones



Noise Zones



Noise Zones



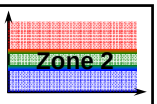
Zone 3 – "No Zone"

~ 104/105 to 115 dBA (OBSI)

- This Zone is typical of the perception of concrete pavements
- New Pavements: Nothing ever in this zone
- Existing Pavements: "Worst-first" remediation
  - Examine both dBA and frequencies for "the worst"
  - Examine deteriorated joints (esp. faulting, spalling)
  - Promote restoration of smoothness, friction, and noise

Maybe 80-90% of travelers and abutters are impacted by this Zone?

Noise Zones

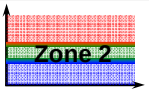


Zone 2 – "Quality Zone"

~ 99/100 to 104/105 dBA (OBSI)

- All nominal textures, new and in-service
  - Drag, Grinding, Longitudinal, and even Transverse!
- Key Issues
  - Understand and control variability
  - Produce negative and consistent texture
  - Control joints – thin joints

Noise Zones



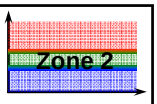
Zone 2 – "Quality Zone"

~ 99/100 to 104/105 dBA (OBSI)

- Quieter Solutions <102 dBA OBSI
  - 50% - Burlap Drag and Astroturf
  - 50% - Diamond Grinding
  - 20% - Longitudinal texture (highly variable though)
  - 5% - Transverse texture (1/2" spacing, shallow = 30%)

These are today's chances of hitting this goal.

Noise Zones



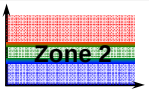
Zone 2 – "Quality Zone"

~ 99/100 to 104/105 dBA (OBSI)

- Quieter Solutions <102 dBA OBSI
  - Examine drag/turf data along with friction
  - Examine German burlap practice
  - Experiment with two-lift construction
    - Thin top course with high quality mix
    - Should improve and hold friction and noise
    - May prove economical

KEY: High Quality Mixes!!

Noise Zones

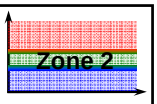


Zone 2 – "Quality Zone"

~ 99/100 to 104/105 dBA (OBSI)

- Quieter Solutions <102 dBA OBSI
  - Examine grinding data along with friction
  - Determine differences with blade/spacing issue
  - Link smoothness – noise – friction relationships

Noise Zones

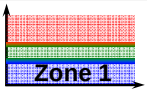


Zone 2 – "Quality Zone"

~ 99/100 to 104/105 dBA (OBSI)

- Quieter Solutions <102 dBA OBSI
  - Examine tining data along with friction
  - Much more analysis on width – depth – spacing
  - Much more analysis on construction variability
  - Develop life curves as a function of mix durability

Noise Zones

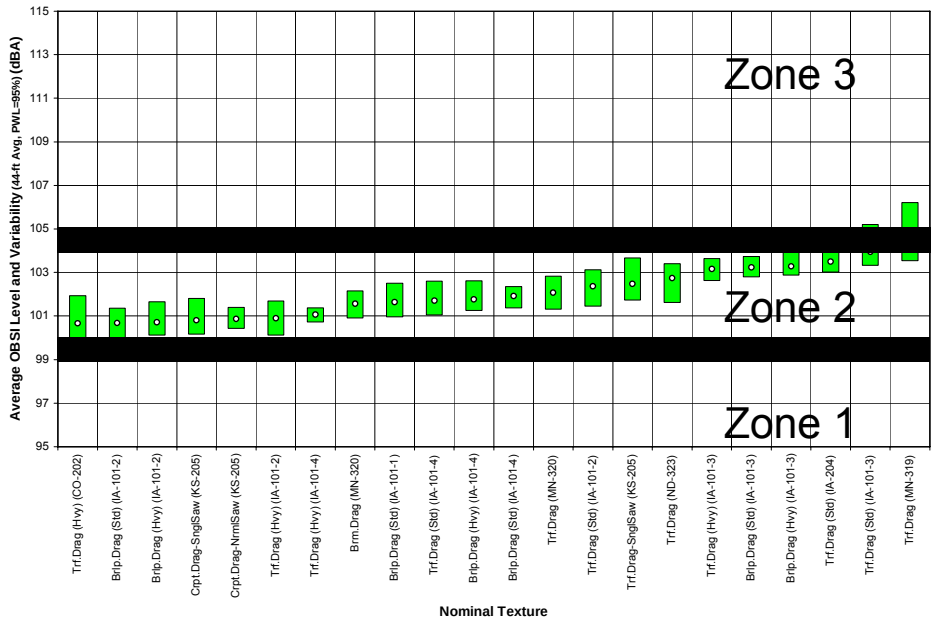


Zone 1 – "Innovation Zone"

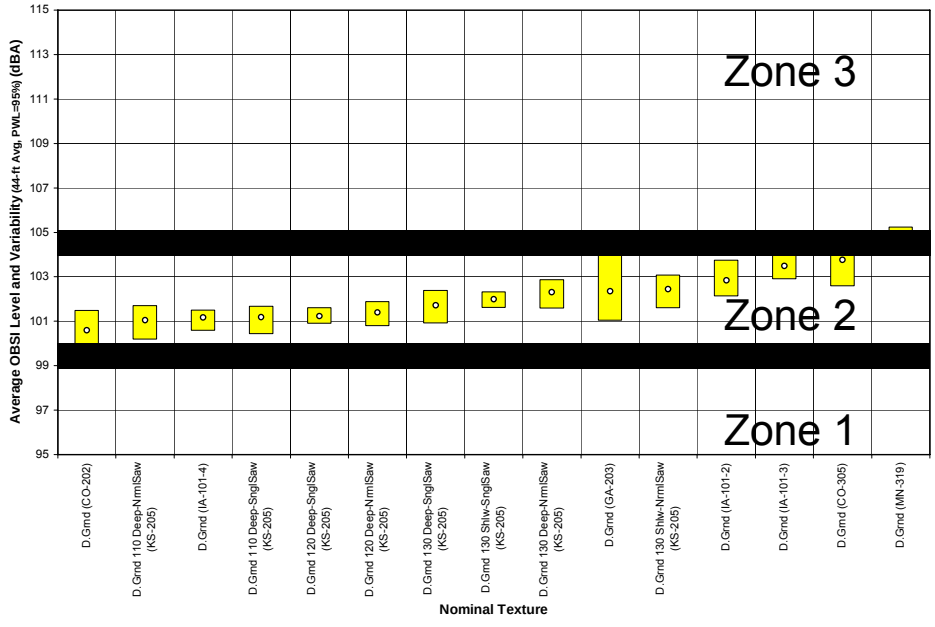
~ 95 to 99/100 dBA (OBSI)

- Beyond capability of dense concrete
- No current solutions
- Innovative Possibilities
  - Porous, inclusions, polymers, etc, etc
  - Negative texture, porosity, damping effect
  - Low Volume – pervious pavements
  - High Volume – thin overlay w/polymers and fibers

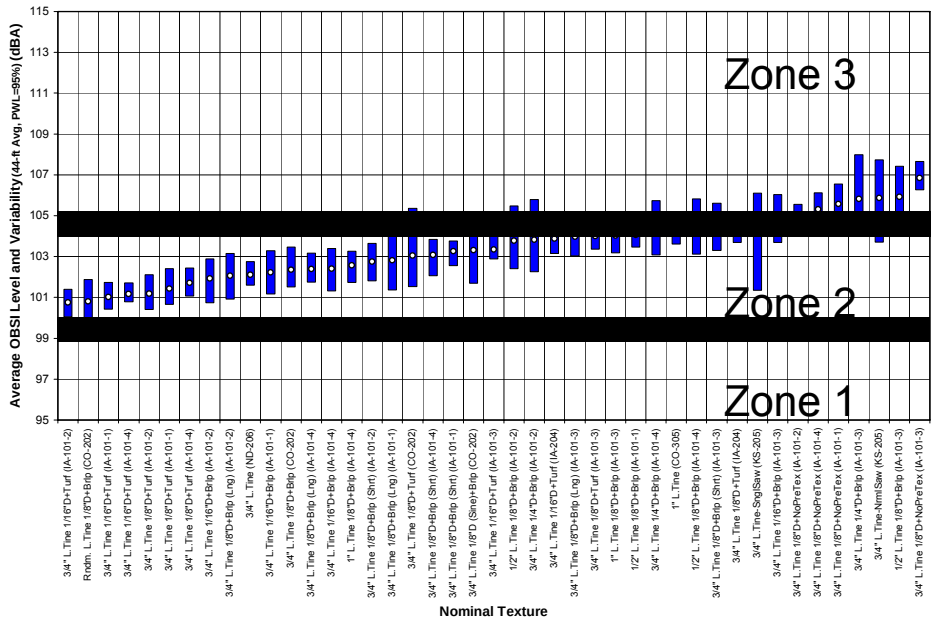
Preliminary Catalog Results – Drag



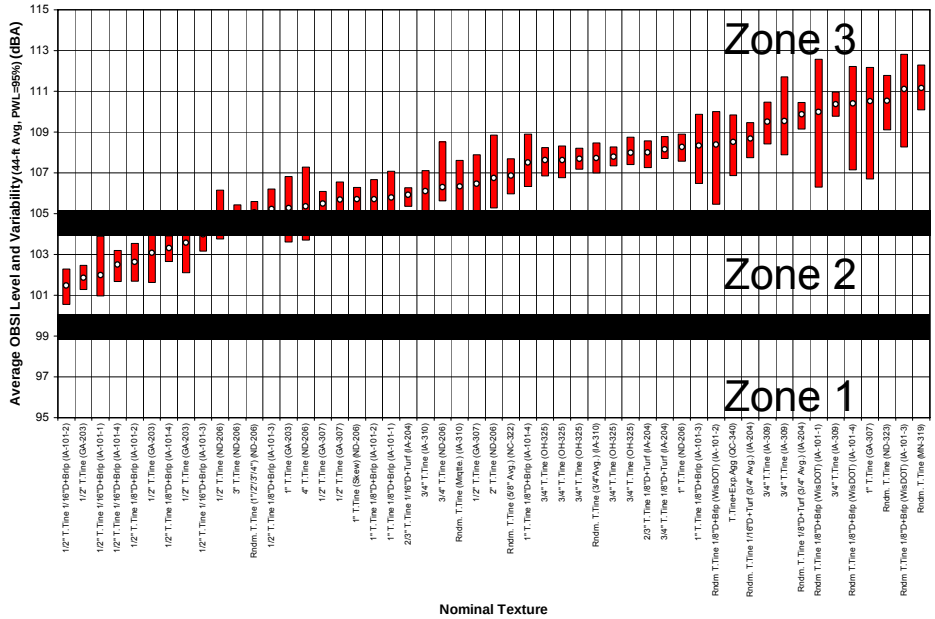
Preliminary Catalog Results – Grinding



Preliminary Catalog Results – Long. Tine

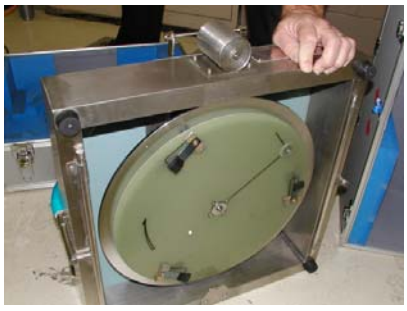


Preliminary Catalog Results – Trans. Tine



What about Friction?

DFT / CTM vs. the Skid Trailer

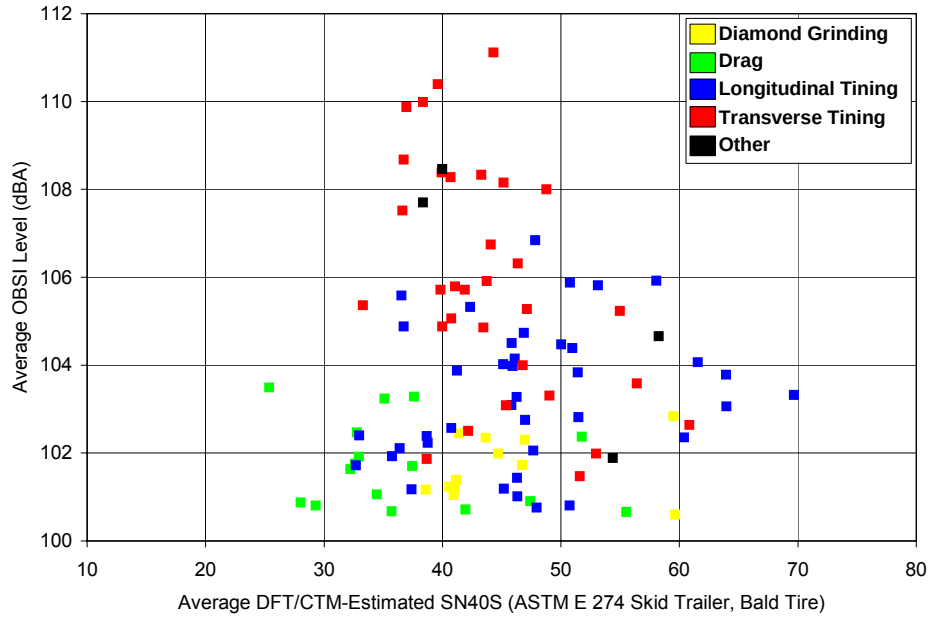


Friction (Microtexture)

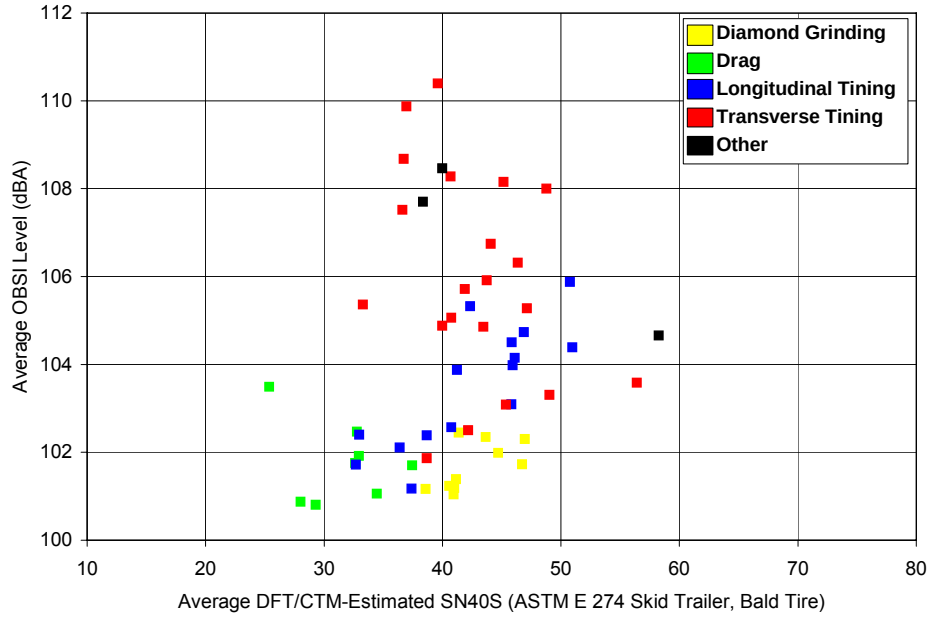
MPD (Macrotexture)

Skid Number (SN40S)

Noise vs. Friction — All Test Results



Noise vs. Friction — Trafficked Pavements



Part 3 – Next Phase

- Data Analysis !!
- Construction Specifications
- Construction Practices
- Build “Conventional” Test Sections
- Build Innovative Test Sections

Thank You