**Fundamentals of Tire/Pavement Interaction Noise on Highways**

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**Presentation**

- Short summary of the suspected causes of tire/pavement interaction noise (ref Sandberg 2002)
  - Energy generation
  - Amplification mechanisms
- Ongoing studies by Arizona DOT, CALTRANS, and NCAT
- Preliminary results on the Purdue University Tire Pavement Test Apparatus (TPTA)

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**Energy Generation**

- Tread Compression
  - Radial vibrations
- Tread vibration

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**What creates tire/pavement noise?**

- Energy generation!
- Amplification!
Tread Oscillation

- Slip/stick
- Tread Adhesion

Energy Generation

- Air pumping

Amplification

- Carcass vibration
- Sidewall vibration

Amplification

- Horn effect
- Cavity resonance
Amplification

- Helmholtz resonance
- Organ pipe modes

Current Field Testing

- Arizona DOT
- CALTRANS
- National Center for Asphalt Technology (NCAT) Studies

Arizona DOT

- Using Close Proximity Method (CPX) for sound pressure level and intensity measurement on 200+ test sites in AZ
  - Comparison of pavement type
  - Comparison with age
  - Speed
  - Vehicle type
- To be redone this spring

PCC Tining Study

![Graph showing vehicle speed vs. tire noise level]
**AZ Overall Results**

Tire/Pavement Noise Sound Intensity
Arizona I-10 Test Sections

**CALTRANS Studies**

- OGAC near Sacramento
  - no change in 5 years
  - 5-6 dB quieter than DGAC
- CPX testing throughout the state – 10 dB differences between quietest and loudest
- 5 test sections on Route 138 east of Lancaster, CA – 3 dB improvement for OGAC and RAC over DGAC for new installation

**Pilot Projects**

FHWA is considering proposals from Arizona and California for pilot projects where quiet highways are used to address noise issues. This option is open to others that can meet the requirements of the program.

**NCAT Studies**

- NCAT Trailer
- Testing in
  - Michigan
  - Alabama
  - NCAT Test Track
  - More to come
NCAT Test Track Results

Comparison of Tires (Sound Pressure)

- 0 50 100 150 200 250 300 350 400
- 0 2000 4000
- 0 50 60 70 80
- Frequency
- Sound Level (dB)

Aquatred, ASTM Ribbed, Firestone, MasterCraft, Michelin, UniRoyal

March 25, 2003

TPTA - Specs

- Two rolling tires
- Realistic pavement on the exterior of the drum
- Motor rated for 60 hp for braking capability
- Speeds up to 30 mph
- Loading capacity up to 1000 lbs
- Drum diameter of 12 feet
- Pavement depths of either 8” or 16”

March 25, 2003

TPTA - Status

- Tire/Pavement Test Apparatus (TPTA) was delivered in July, 2001.
- Recent studies of
  - PCC tining and texturing
  - Tire sidewall and treadband designs

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TPTA – 30 mph

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TPTA Mic Locations

“Smooth” Concrete

“Textured” Concrete

“Porous” Concrete
Conclusions

- Existing solutions 1-4 dB better than traditional pavement of same type:
  - Longitudinal tining on PCC
  - Open-graded or porous asphalt
- 5-10 dB should be possible when we resolve the challenges of
  - Understanding noise generation
  - Controlling pavement construction
  - Maintaining safety (friction)
  - Maintaining durability