

## Fundamentals of Tire/Pavement Interaction Noise on Highways

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March 25, 2003

## 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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## What creates tire/pavement noise?

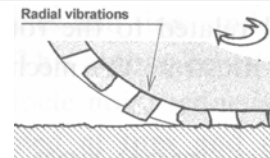
- Energy generation!
- Amplification!



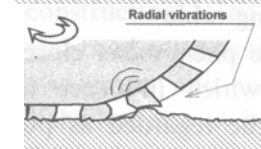
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## Energy Generation

Tread  
 Compression



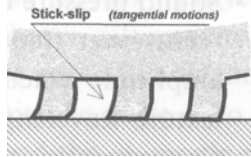
Tread vibration



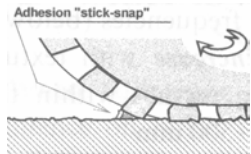
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## Tread Oscillation

Slip/stick



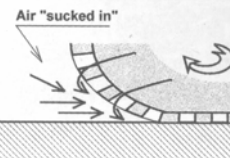
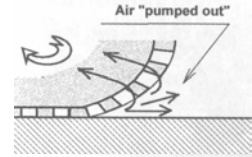
Tread Adhesion



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## Energy Generation

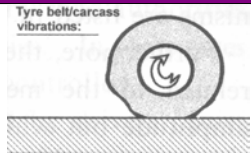
Air pumping



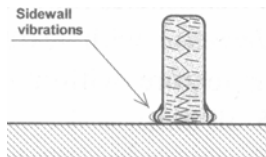
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## Amplification

Carcass vibration



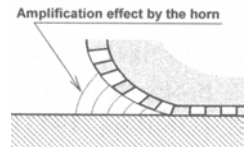
Sidewall vibration



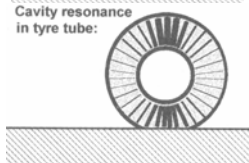
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## Amplification

Horn effect

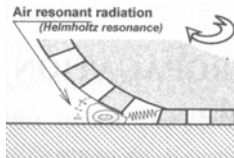


Cavity resonance



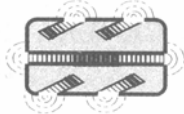
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Helmholtz resonance



Organ pipe modes

Pipe resonances in channels  
formed in the tyre foot-print:



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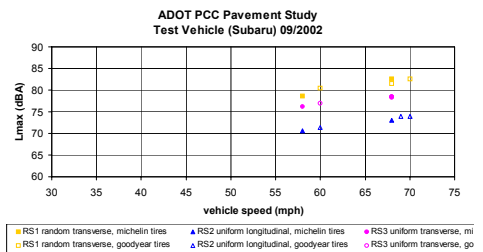
- ◆ Arizona DOT
- ◆ CALTRANS
- ◆ National Center for Asphalt Technology (NCAT) Studies

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- ◆ 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

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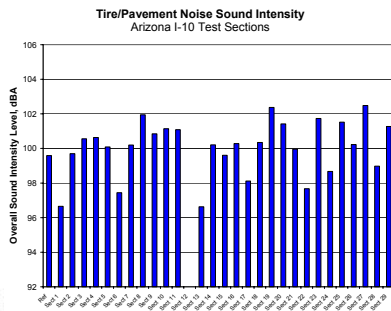


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## AZ Overall Results



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## 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



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## 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.



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## NCAT Studies

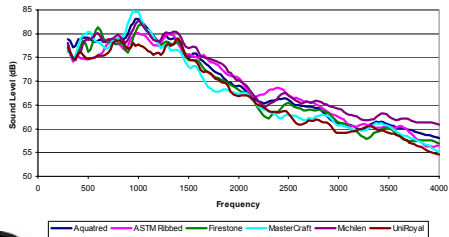


- ◆ NCAT Trailer
- ◆ Testing in
  - Michigan
  - Alabama
  - NCAT Test Track
  - More to come



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Comparison of Tires (Sound Pressure)



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- ◆ 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"



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

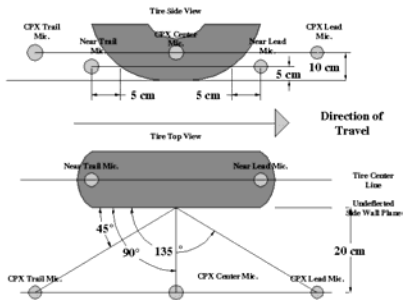


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## TPTA Mic Locations



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## “Smooth” Concrete



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## “Textured” Concrete



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## “Porous” Concrete

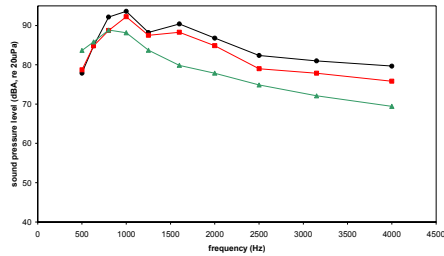


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30 mph

Standard tire

- = smooth pavement
- = textured pavement
- ▲- = porous pavement



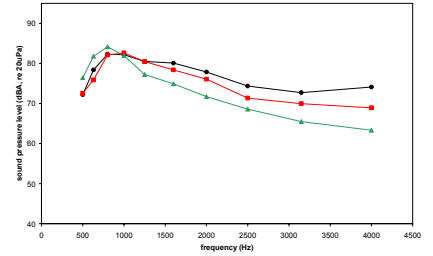
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30 mph

Standard tire

- = smooth pavement
- = textured pavement
- ▲- = porous pavement



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- ◆ 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

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