Safe, Quiet and Durable Highways

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Rocky Mountain Asphalt Conference
February 21, 2008
Today’s Plan

- Basics of noise generation and amplification and surface texture

- How mix design can play a role in reducing tire-pavement noise
Where does the noise come from?

Noise generation and amplification at interface
Change the Interface

- Change geometry and contact area
  - Eliminate “hard” flat surfaces in horn, channels, etc.
  - Reduce contact area
  - Dissipate sound energy rather than reflecting it
Interface Features

- Porosity
- Texture
- Elasticity
- Aggregate Size
How does porosity help?

- Array of tortuous pores
- Dissipates energy through friction
- Reduce surface area and slip-stick or stick-snap
- Reduces horn effect
How does texture influence noise?

- Tire distorts as it grips protruding aggregates
- Negative texture – tire skims over surface
- Avoid surfaces like aggressive chip seals, exposed aggregate
Negative vs. Positive Texture
How does elasticity help?

- More “give” in the pavement may cause less vibration in tire
- Heavily modified binders may help
- Experimental elastic or poroelastic pavements
  - Have been attempted, but generally expensive and not very durable
How does size help?

- Less distortion of tire around smaller aggregate particles
  - Reduced tire vibration

- Air voids and porosity more widely distributed with smaller aggregates (at same air void content)
How do we incorporate these features in a mix?

- Smaller NMAS
- Fine graded mixes
- Porous mixes
- Modified binders
- Combinations of the above
Designing Quieter Mixtures

- Use a smaller NMAS conventional mix
  - Reduces vibrations in tire
  - Not as quiet as porous pavements, but familiar and durable
  - Finer aggregates lead to higher binder content – improved durability?
Fine Graded Superpave

Interest is growing due to:

- Evidence that fine graded mixes can be rut resistant
- Concerns about durability
- Reduced permeability
Fine-Graded Superpave

Percent Passing

Sieve Size (mm) Raised to 0.45 Power
Possible Benefits

- “Smooth” surface texture with small aggregate
- Reduced macrotexture
- Negative, not positive, texture
- Reduced permeability
- Increased durability (?)
- Lower noise
How to Design

- Modify aggregate gradation
- Increase fine aggregate (minus 2.36mm)
- Avoid hump at 0.6 to 0.3mm
- Watch dust content (minus 75µm)
- Watch VMA and Nini
Successful Design Requires

- “High quality” fine aggregate
- Sand that will help increase internal resistance to compaction to meet densification at Nini (crushed vs natural)
- “Clean” sand to avoid hump and keep dust within limits
Limitations

- Not as quiet as porous mixes
- Do not reduce splash and spray
- Require good aggregates for rut resistance and frictional properties
- More binder ($)

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Designing Quieter Mixes

- Use a porous mixture
  - Changes geometry of interface and reduces contact area
  - Negative texture
  - Need to maintain drainage path ("daylight")
Applications of Porous Pavements for Noise Control

- Typically high volume, high speed traffic
- Higher speeds cause higher noise
- Action of tires at high speeds helps to clean pores, avoid clogging
- Side benefits of porous surfaces
  - Reduced splash and spray
  - Increased macrotexture, friction
Special Considerations

- **Design to control draindown**
  - Add fibers or modifiers

- **Winter maintenance issues**
  - More rapid icing of surface
  - Earlier and more frequent deicing needed

- **Duration of benefits uncertain**
  - Clogging of voids
  - Two layer porous may help
Two-Layer Porous Pavements

Fine porous layer prevents clogging of lower, coarser porous layer
Two-Layer Porous Pavements

- Experimental use in Denmark, France and Italy
- In development stage in the Netherlands
- Growing interest in US
- Placed “warm on warm”
- Noise reduction of 8-9 dB vs. conventional hot mix
Another Consideration -- Drainage

- Porous Surface
- Daylight or Drain
- Impermeable Base
  (Top Sealed)
Porous Pavement Performance

- Noise reductions of
  - 5-10 dB over PCCP
  - 3 dB over conventional dense graded mixes
- Affected by design, construction and maintenance
- Service life varies, but long life can be attained
- Other benefits – ride, rut and cracking resistance, safety
Designing Quieter Mixtures

- Use a modified binder
  - More elasticity
  - Probably not a substantial improvement by itself (maybe 1 dB)
- Use a small NMAS porous mixture with a modified binder
  - All the benefits above
The Challenge

Low Noise Surfaces

Long-Term Durability

Low Spray/Good Visibility

Safety/Skid Resistance

Keep the Cost Low
Conclusions

- Asphalt is the quiet ride
- Conventional asphalt mixes can be quieter
- Porous pavements can reduce tire-pavement noise by as much as 10 dB
- Requires attention to detail in design, mix design, construction and maintenance
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