Sound Absorption Characteristics of Typical Pavements: An Ontario Study

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Presentation Outline

- Introduction
- Objectives
- Sample Collection/Preparation
- Equipment and Testing
- Analysis and Results
- Conclusions and Recommendations
- Acknowledgements

Introduction

- Traffic noise is a growing problem
- Pavement and surface types are major contributors at speeds over 35 km/h
- Noise reduction mechanism by pavement:
  - Mechanical impedance: Depends on relative stiffness of tire and pavement
  - Acoustic impedance: Largely depends on surface type (porous or non-porous) and texture
- An absorptive surface reduces air compression and reflection of sound energy

Introduction (Cont'd.)

- For a given texture, increased absorption means reduced sound generation and propagation
- Porous or acoustically absorptive pavements can significantly reduce roadside or on-road noise
- Durability and maintenance are major issues for those pavements, especially for highways
- Durability and economy should be given primary consideration in all noise reduction options

Past Studies

- Superpave and SMA are quietest in Wisconsin/ Minnesota and U.K., respectively *(12, 15)*
  - Both are known for good durability
- SMA absorbed 12% while Superpave absorbed 6-7% of sound *(17)*
- SMA in Ontario absorbed 6% of sound *(18)*
- In Europe, double layer porous asphalt (PA) was quieter with sound absorption of 39% *(14)*
  - Noise increase within a short period and pavement durability are major issues

Past Studies (Cont'd.)

- Sound absorption increases with an increase in surface texture *(16):*
  - 6-10% for 10 mm SMA versus 6-12% for 15 mm SMA
- Contrast: Mix with smaller aggregates are more acoustic than that with large size aggregates *(4)*
- 80% and 92% sound absorption by 50.8 mm and 25.4 mm thick OGFC, respectively *(17)*
  - Seemed to be unreasonable as sound reflection or propagation is minor (20% and 8%, respectively)
  - Ontario study: OGFC absorbed 9-10% of sound *(18)*

Objectives

- Inconsistent results in different studies
- A comprehensive study at University of Waterloo
  - Tire-road noise, sound absorption and surface friction
- This paper focused on:
  - Quantifying sound absorption of conventional/ durable PCC and AC pavements
  - Determining effect of conventional PCC surface texturization and thickness on sound absorption
  - Examining effect of AC density, thickness, air voids and surface macrotexture on sound absorption

PCC Sample Preparation

- Standard 30 MPa ready mix concrete
- 152 mm diameter and 76 mm thick specimens
  - Surface texturization: screed, burlap, corn broom plastic turf, exposed aggregates and steel tine
  - 3.2 mm wide and 4 mm deep steel tining were spaced uniformly at 16 mm or randomly at 10-22 mm
  - Three replicate specimens for each type of texture
- Three 1.20 m x 1.20 m panels: 76 mm, 200 mm and 260 mm thick

Sample PCC Specimens

a) Screed Finish

b) Astroturf Dragged Surface

c) Burlap Dragged Surface

d) Broom Dragged Surface

Finished PCC Slabs

AC Pavement Samples

- 150 mm diameter cores from as-built (new) surfaces on Ontario highway projects:
  - Six regular 12.5 mm Superpave (SP12.5)
  - Six fine graded 12.5 mm Superpave (SP12.5Fine)
  - A 12.5 mm SMA (SMA12.5)
- Three replicate specimens from each project, except SMA (two cores)
  - Approximately equal height (41 mm to 49 mm)
- Additional SP12.5 cores: Thinner and thicker than other specimens

Equipment and Testing

Impedance tube for sound absorption testing of cylindrical samples (170 Hz to 1,350 Hz)

Typical AC specimens

a) SP12.5 b) SP12.5Fine c) SMA

Equipment and Testing (Cont'd.)

Decay time of a 60 dB sound

20 Hz to 10 kHz

Calculate sound absorption using Sabine formula

Portable Reverberation Chamber for sound absorption testing of large panels

PCC Sound Absorption

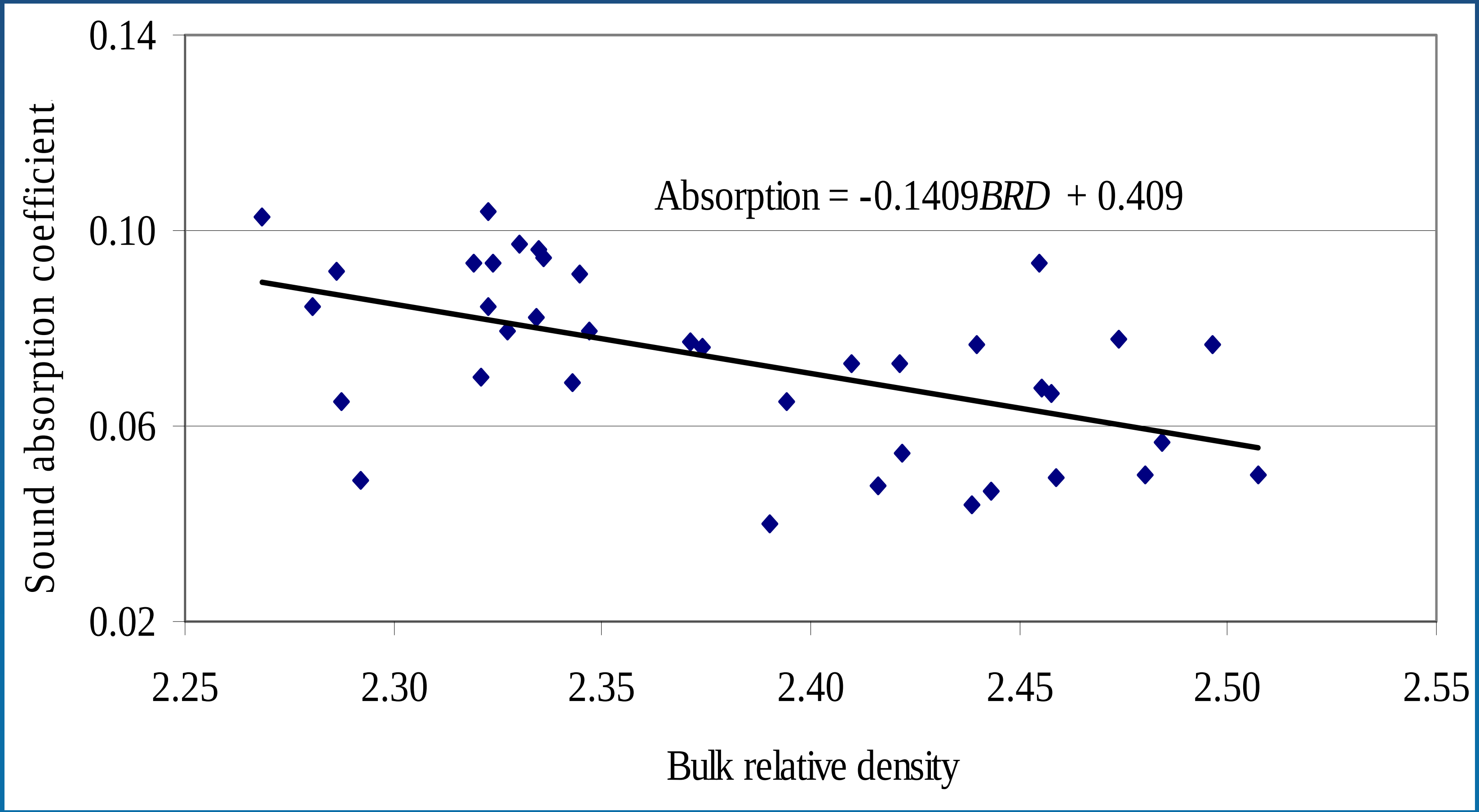
- PCC slabs: 76 mm to 260 mm thick
  - Peak sound absorption of 3-4%
  - No remarkable effect of varying thickness
- Textured PCC surfaces
  - 5-6% absorption, slightly higher than slab
  - Effect of variation in consolidation (vibrator for slab versus rod for cylinder)
  - No significant effect of variation in texture type or texture depth
  - Absorption depends mainly on interconnected voids

AC Sound Absorption

- SP12.5 mixes: 4.8-7.9% sound absorption (average 6.3%)
- SMA 12.5 mix: 7.5% sound absorption
- SP12.5Fine mixes: 6.8-9.2% sound absorption (average 8.5%)
- Absorption of SP12.5Fine mixes: 2.2% higher than SP12.5 mixes
- Frequencies at peak sound absorption: 400 Hz to 1,100 Hz

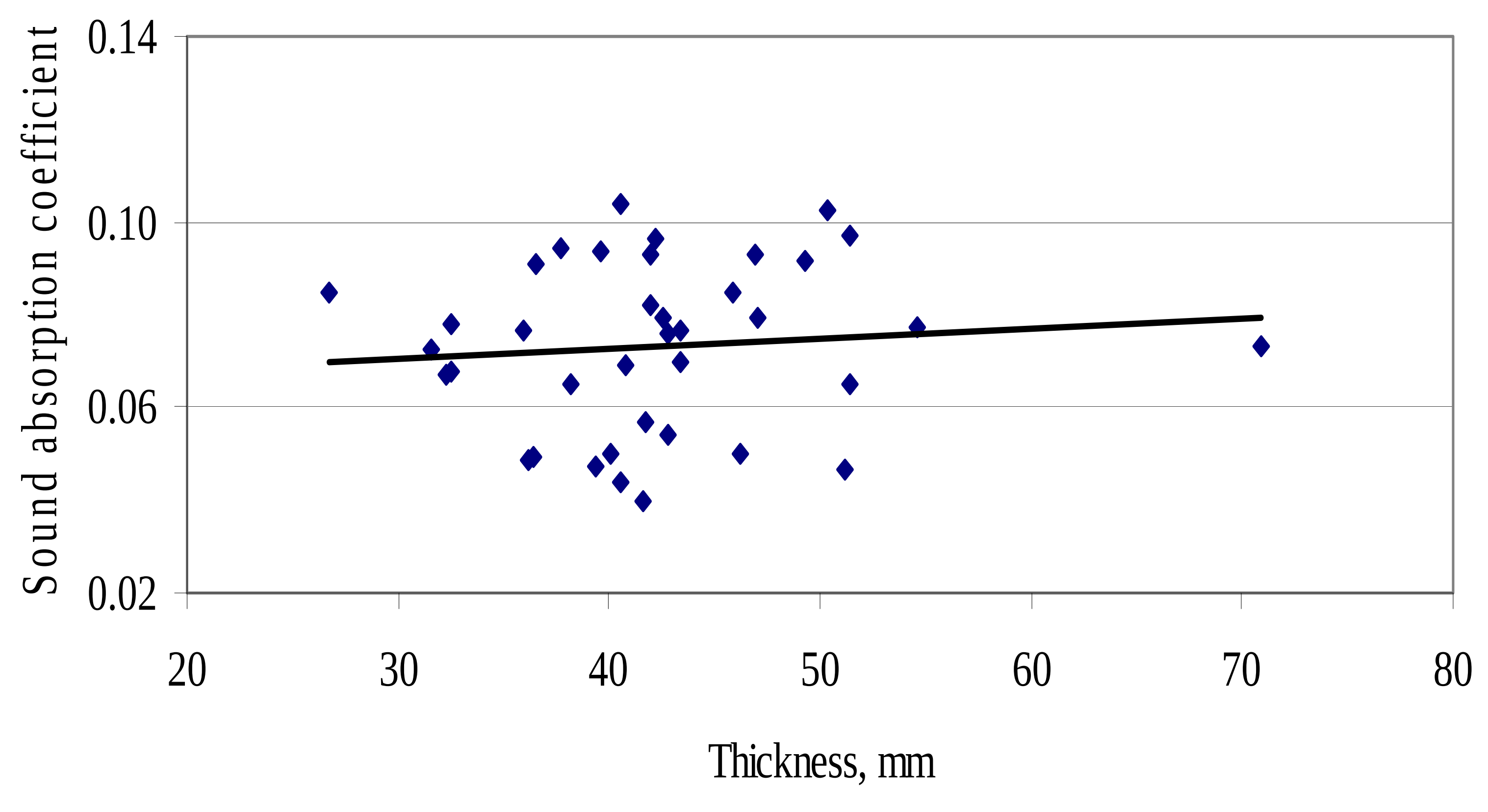
Effect of AC Density

- Sound absorption decreases with increase in density: Finer mixes, higher sound absorption



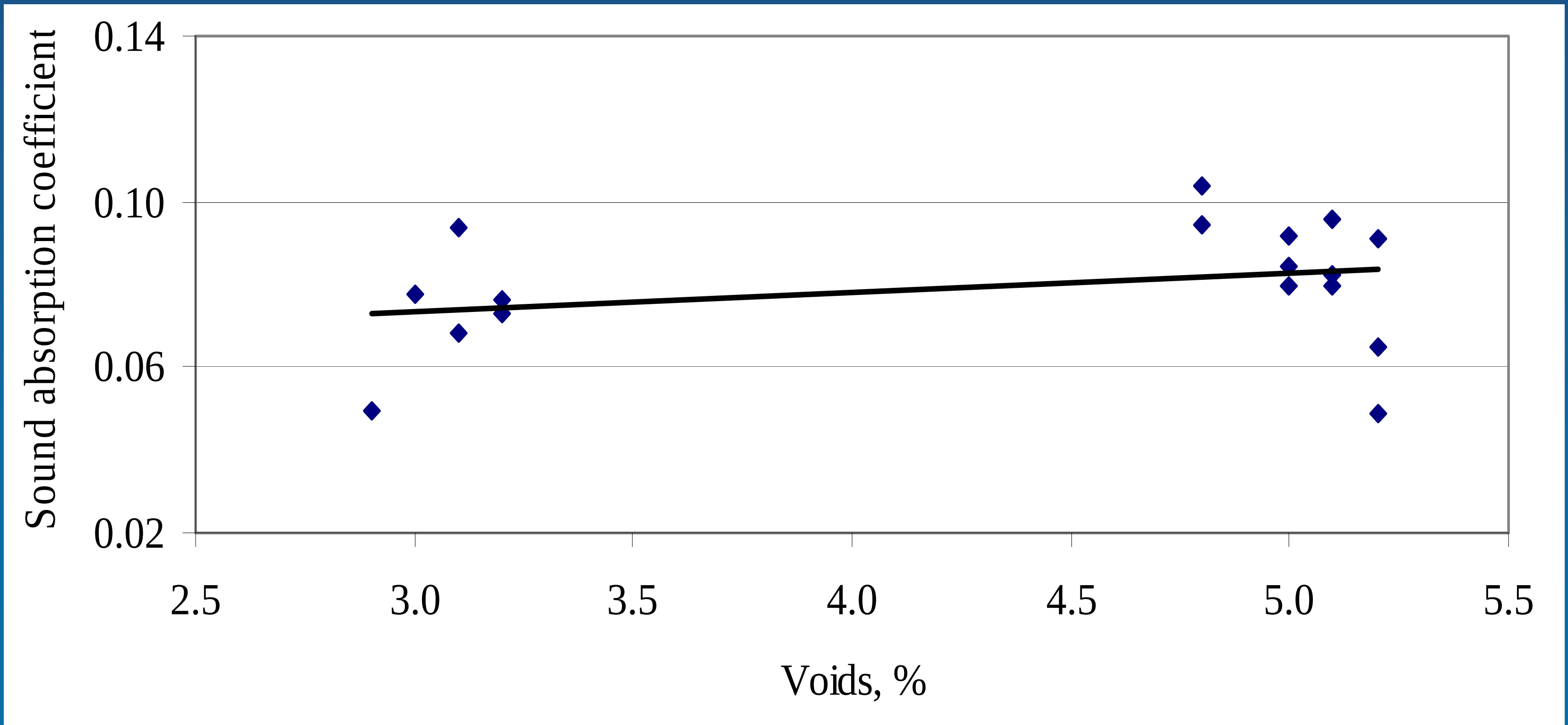
Effect of AC Layer Thickness

- Minor effect of dense AC layer thickness
- Increased thickness may not be justified cost



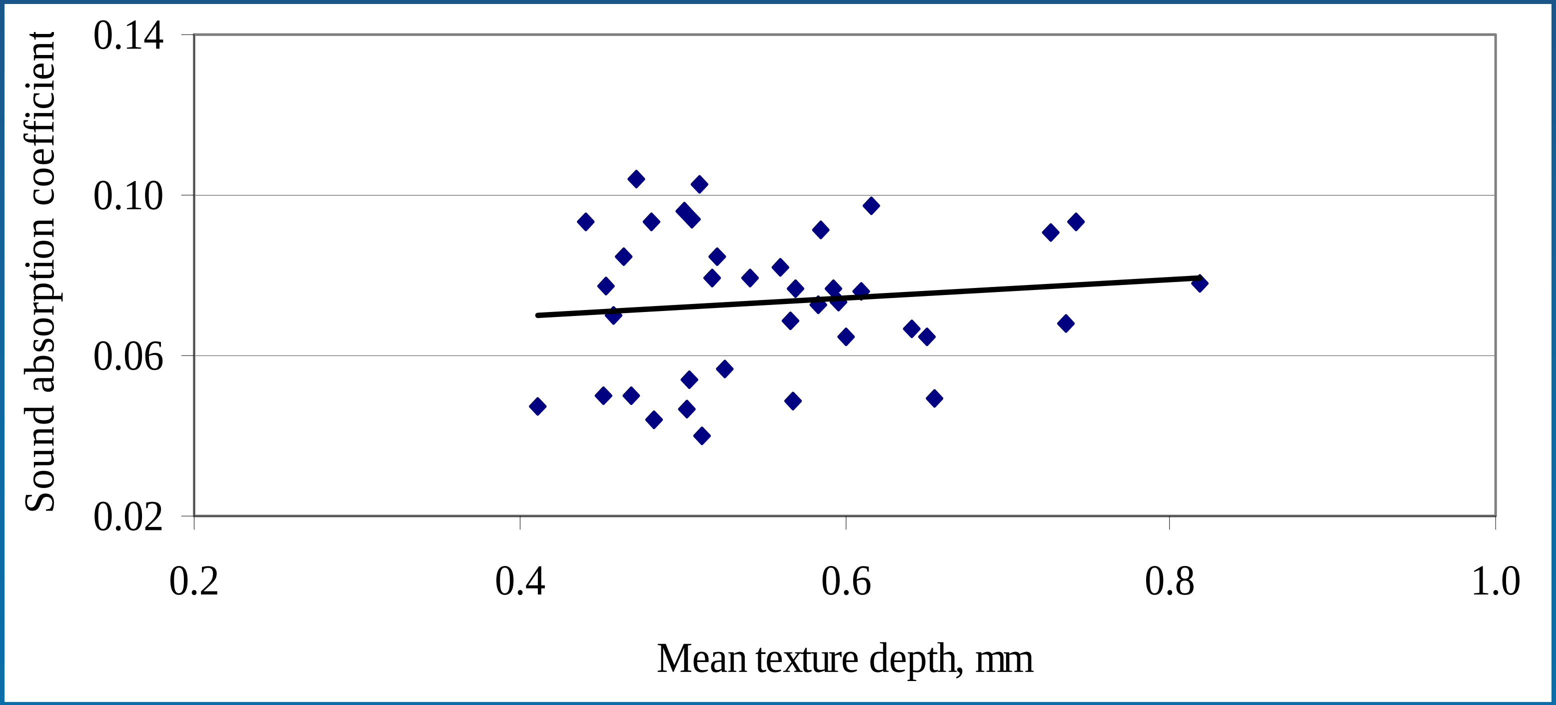
Effect of AC Voids

- Slight increase in sound absorption with increase in dense AC air voids content
- Statistically insignificant for conventional AC



Effect of AC Texture Depth

- Very weak correlation
- Shape, level or orientation of surface texture has no significant effect



Conclusions/Recommendations

- SP12.5, SMA12.5 and SP12.5Fine mixes absorbed 6.3%, 7.5% and 8.5% of sound, respectively
- Textured PCC surfaces absorbed 5% to 6% of sound
- Effect of dense PCC and AC layer thickness is insignificant
- Need further study to examine the effect of surface textures and air voids content

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