Preservation and Quality of Life, Framework and Examples

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Overview

• Preliminary framework for quality of life and pavement
• Some examples
  – Tire/pavement noise
  – Heat island
  – Bicycle ride quality
What affects quality of life?

• Already considered in PMS, LCCA:
  – Safety
  – Ability to access essential services
    • Health care
    • Nutrition
    • Education
    • Social access
    • Recreation
  – Cost and comfort of access in motor vehicles
What affects quality of life?

• Not generally considered in current systems:
  – Noise
  – Active transportation
    • Ride quality
    • Safety
  – Thermal comfort

• What else?
- $1.3+ million per mile
- Maintenance problems (graffiti) $100k/yr
- Can not be used everywhere
- Limit future highway expansion
- Not necessarily effective
- Block views
Figure 1.1: Timeline of completed data collection periods for asphalt and concrete pavement noise studies.
Instrumented car measures OBSI, IRI and macro-texture
1/3 Octave Band Analysis

Sound Intensity Levels, dB(A)

- less than a year old RAC-O (QP-41)
- 1-4 years old RAC-O (06-N467)
- older than 4 years OGAC (QP-23)
- less than a year RAC-G (QP-26)
- 1-4 years old RAC-G (ES-13)
- older than 4 years DGAC (QP-11)

Tire vibration at low freq
Air-pumping at high freq
Asphalt test sections:
Experiment Design

• Factorial experiment: 54 QP sections
  – Four mix types: dense-graded (DGAC) as control, open-graded (OGAC), rubberized open-graded (RAC-O), rubberized gap-graded (RAC-G)
  – Three age categories: < 1 year; 1-4 years; 4-8 years
  – Two traffic levels (low is < 32,000 ADT)
  – Two rainfall regions (low is < 24 inches/year)
  – Partial factorial for F-mixes, 19 mm open-graded

• Not controlled:
  – Maximum aggregate size (9, 12.5, 19 mm)
  – Polymer vs conventional binders in OGAC
OBSI for each age category over 6 years
Overall distribution of OBSI up to 15 years old

2 dBA

OGAC
RHMA-G
RHMA-O

HMA

Less noise
Performance model estimates of time to noise failure (same noise as DGAC)

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<th>OGAC</th>
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Performance model estimates of time to IRI failure (2.68 m/km = 160 inches/mile)

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New quieter small stone open-graded asphalt

- Based on field and lab studies
  - Smaller maximum aggregate size, less positive texture
  - Permeability of open-graded mixes
35 mph on test track

Figure 4.12: 1/3 octave band noise content for the four mixes.
Figure 9.1: Examples of residual specimens after Cantabro testing of the different OGFC mixes. (Note that each original specimen had a diameter of 4 inches [100 mm].)
Comparison with current Caltrans open-graded mix

• New smaller stone mixes are
  – More durable (Cantabro)
  – Quieter (35 mph OBSI)
  – Similar or slightly less friction
  – Similar or slightly less permeability
Predicting OGAC noise in the Lab

- Goal:
  - Include prediction of initial noise performance in the laboratory as part of mix design
Lab air permeability

MPD
Asphalt Summary

• Use of rubberized open graded recommended
  – Based on long-term noise, smoothness and permeability performance of current mixes

• Method of estimating field noise in the lab developed

• New quieter mixes developed based on findings
  – Need field validation
Concrete test sections:
Figure 5.7: Probability distributions of OBSI noise levels for concrete pavement textures as reported by the National Concrete Pavement Technology Center in 2010 (10).
UCPRC Results 2013

Graph showing the percentage distribution of overall sound intensity (dBA) for different ground types:
- Diamond ground (N=50)
- Diamond grooved (N=36)
- Longitudinal tined (N=38)
Grind and groove
OBSI - In and Out of Truck Lanes

Pre CDG

CDG

GnG

OBSI, dBA

PreCDG, Truck Lane
PreCDG, Traffic Lane
CDG, Truck Lane
CDG, Traffic Lane
GnG, Truck Lane
GnG, Traffic Lane
Types of heat island

• Urban heat island
  – CARB, Caltrans sponsored study
  – Response to legislation
  – Report and software publish late 2016

• Results of changing HMA/slurries to reflective surfaces
  – Small change in temperature, long time to implement
  – Net effect of change dominated by materials production, generally not beneficial
Types of heat island

• Local heat island
  – Effect on human thermal comfort
  – Balance reflectivity, evapo-transpiration, shade
  – UCPRC, USC and other research
Thermal Impact of Reflection

Lighter is hotter: legend range of 30 to 65 °C

Wall, 52 °C
Asphalt (B1), 60 °C
Wall, 55 °C
Concrete (C1), 45 °C
Heat Budget on Human Body

- Respiration heat $C_{res}$ and $E_{res}$
- Sweat evaporative heat $E_{sw}$
- Convention heat $C$
- Net radiation $R$
- Diffuse reflected radiation $D$
- Emitted radiation $E$
- $T_s$, $\alpha$, $\varepsilon$

Li et al. 2014
Heat Island

Chicago, IL
Preservation and Bicycle Riders

• Develop guidelines for design of preservation treatments suitable for bicycle routes on state highways and local streets in California

• Pavement texture measurements

• Bicycle vibration measurements

• Surveys of bicycle ride quality
  – 6 bicycle clubs
  – General public in Davis, Richmond, Chico, Sacramento, Reno

• Correlations between pavement texture, bicycle vibration and ride quality
Example 3D Macrotexture Images of MPD

Microsurfacing, MPD = 1.1 mm

Coarser 9.5mm chip seal, MPD = 2.3 mm
Conclusions from Bicycle Studies

- 80% of riders rate pavements with Mean Profile Depth values 1.8 mm or less as acceptable, limit chip stone size
- Most slurries on city streets produce high acceptability
- Distresses, particularly cracking, reduces ride quality
- Chip seal spec recommendations in Caltrans report
- Can be included in PMS
- Consider “Complete Pavement”
How to consider these preservation criteria?

- Collect the data
- Policy
- Consider in PMS prioritization and treatment identification
- Include in standard project design criteria
- First need to have knowledge and data
FHWA Towards Sustainable Pavements Reference Document

- State of the knowledge
- Search on “FHWA pavement sustainability”
- Also at web site
  - Tech briefs
  - Literature database
Acknowledgements

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• These results do not constitute a standard or specification

• The opinions expressed in this presentation are those of the authors only

• This work is a collaboration with colleagues at UCPRC (Davis and Berkeley), LBNL, USC, Oregon State U and Caltrans
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