Pavement Macrotecture and Its Effect on Bicycle Ride Quality

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Outline

- Project Background & Pavement Texture
- Macrotexture Measurement
- Bicycle Vibration Measurement
- Survey of Bicycle Ride Quality (Phase I)
- Remedial Treatment on SLO-1
- Additional Survey (Phase II)
- Remarks
Biking on Coastal Highway 1, California
2012, Chip Seal, 40 km ($2.1 million)
Help Us Fix Highway 1
Pavement Surface Texture Components and Wavelengths

- **Roughness (unevenness)**: Wavelength > 500mm
- **Megatexture**: 50mm < Wavelength < 500mm
- **Macrotecture**: 0.5mm < Wavelength < 50mm
- **Microtexture**: Wavelength < 0.5mm

- Short Stretch of Road
- Tire
- Tire/road Contact Patch
- Single Aggregate
Influence of Pavement Surface Texture on Motorized Vehicles
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Macrotexture Measurement Method

**Laser Texture Scanner (LTS)**
Spot measurement with need for traffic closure

**Mean Profile Depth (MPD)**
Unit: mm or in

**Inertial Profiler (IP)**
Continuous linear measurement without need for traffic closure
Example 3D Macrotexture Images and MPD from LTS

Microsurfacing, MPD = 1.1 mm

Coarser 9.5mm chip seal, MPD = 2.3 mm
Example MPD on SLO 1
Continuous Measurement with IP
MPD from LTS
for Different Roads and Sections
MPD Measured from IP for Different Phase I Sections

- SLO-1 Additional Rolling
- SLO-1
- Mono-395
- Mon-198
- SLO-227
- SLO-41

MPD (mm)

- Green: Both
- Red: Outside ETW
- Blue: Inside ETW

[Diagram showing MPD measurements for different sections]
Correlation of Macrotecture Measurements with IP and LTS

\[ y = 0.97x \]

\[ R^2 = 0.93 \]

![Graph showing correlation between MPD_IP and MPD_LTS with a linear trend line and R^2 value of 0.93.](image)
Survey Section #

1, 6 = 5/16 in PME Seal Coat
2, 5 = Modified Binder Seal Coat - Modified gradation
3, 4 = Modified Binder Seal Coat - Utilizing steel roller
7, 16 = Cinder Seal
8, 15 = Microsurfacing
9, 14 = 1/4 in PME Seal Coat - 2nd application of a double chip seal
10, 13 = Sand Seal
11, 12 = Slurry Seal
17, 18 = Old HMA Overlay on Mon-198
19, 20 = New Chip Seal on Mon-198 (Control)
21-23 = New Chip Seal on SLO-1 (Control)

LTS Measurement

Remedial treatment test sections Mon 198

Specification test sections Mon 198

Sand Seal

Chip Seal

SLO 1
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Bicycle Vibration Measurement

Accelerometers (solid red circles)
GPS unit (dotted blue circle)
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<th>Description</th>
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**Specification test sections Mon 198**

**Remedial treatment test sections Mon 198**
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Sections in Phase I Survey

Mon-198

SLO-1
Survey Briefing (Mon-198)
Bicyclist Survey

- Acceptability (0 = Unacceptable; 1 = Acceptable): average rate of all riders or percentage of riders rating pavements as “Acceptable”
- Ride Quality: 1 to 5, with 1 = Poor and 5 = Excellent

Other background information with potential explanatory power

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<th>No. of Riders</th>
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<td>16</td>
<td>24</td>
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Remedial Sand Seal on SLO-1

2013, Sand Seal, 40 km ($1.5 million)
Remedial Treatment on SLO-1

- Chip Seal Only
- After Sand Seal

SLO-1 Northbound

SLO-1 Southbound
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<td>3</td>
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<tr>
<td>Davis</td>
<td>4</td>
<td>6</td>
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<td>Santa Rosa</td>
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<td>26</td>
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<tr>
<td>Tahoe</td>
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<td>16</td>
</tr>
<tr>
<td>Chico Velo</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Alto Velo</td>
<td>4</td>
<td>16</td>
</tr>
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<td><strong>Total</strong></td>
<td><strong>42</strong></td>
<td><strong>107</strong></td>
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Remarks

• From preliminary results, 80% of riders rate pavements with 1.3 mm MPD as acceptable; 50% for 2.1 mm.
• Additional sand seal helped reduce the macrotexture (MPD) of the chip seal on SLO-1.
• Beside MPD (macrotexuture), IRI (roughness/unevenness) may also influence the bicyclist’s ride quality.
  • IRI is tuned for cars not bikes
  • Missing megatexture parameter
• Need to consider the balances & tradeoffs:
  • Ride quality (smoothness) and ride safety (skid resistance)
  • Vehicle users and bicycle users (different needs)
  • Performance and cost
Surface Treatment Macrotexture and Bicycle Ride Quality

Authors:
Hui Li, John T. Harvey, Calvin Thigpen, and Rongzong Wu

Part of Partnered Pavement Research Program (PPRC) Strategic Plan Element 4.47:
Impact of Chip Seal on Bicycle Ride Quality


Preliminary Results: Measurement of Macrotexture on Surface Treatments and Survey of Bicyclist Ride Quality on Mon-198 and SLO-1 Test Sections

Authors:
Hui Li, John Harvey, Rongzong Wu, Calvin Thigpen, Stefan Louw, Zhang Chen, Jeremy Lee, David Jones, and Amoh Razae

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Next Steps (2014-2016)

- Correlate MPD and treatment specifications
- Repeat measurements and surveys for urban treatments, different bicycle types, broader demographic of riders
- Long-term monitoring of texture and roughness change for different treatments
- Develop improved models to characterize the impact of texture and roughness and vibration on bicycle ride quality
- Develop guidelines for design of preservation treatments for bicycle routes on state highways and local streets
Questions?

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