Pavement Smoothness and IRI Ride Specifications

North Central Asphalt User Producer Group (NCGUPG) Annual Meeting

February 19 -20, 2014
DISCOVER
ENGINEERING • LET'S MAKE A DIFFERENCE

FEBRUARY 16-22, 2014
Pavement Surface Characteristics
Key Areas for SC program

- Friction / Texture
- Rolling Resistance
- Noise
- Splash and Spray
- Smoothness / Ride Quality
Outcome – focus on ride quality

Smoothness (IRI), Possible National Performance Measure

Highlight team efforts in establishing national/AASHTO standards in pavement smoothness – need these for pavement condition performance measures.
Benefits of Smooth Pavements

- Satisfied road users
- Decrease in fuel consumption and vehicle maintenance costs
- Pavements that are built smoother remain smoother over time and provide a longer service life
- Dynamic loadings are lower on smooth pavements
Information on Ride Specs

www.smoothpavements.com
Profilograph
Representative Vehicle

- How many people drive a vehicle with a 25 foot wheelbase?
Who said this?

- No claim is made that the roughness or riding quality of a pavement is directly or completely reflected by the profile index.

- It should again be emphasized that strictly speaking, the devices reported herein do not furnish a direct index to “riding qualities”.

  - California Highways and Public Works, Vol. 39 March-April Nos. 3-4, “Profilograph-2” pg 54

- Francis N. Hveem, 1960 (inventor of the California Profilograph)
Percent Within Limits: PWL Ride Data

- Efficiently captures mean and standard deviation in one quality measure

\[ \bar{X} \] - mean
\[ s \] - standard deviation
Use of blanking bands of 0.1” and 0.2” cuts off the lower end of our normal distribution.
Advantages of IRI

• Reproducible, portable and stable with time

• General pavement condition indicator

• Describes roughness that causes vehicle vibrations
IRI is highly correlated to:

- Vertical passenger acceleration (Ride Quality)
- Tire Contact (vehicle control and safety)
- Output from Response Type Roughness Measuring Systems
Properties of IRI Analysis

- IRI computed using quarter car model
Computation of IRI

- Need longitudinal profile containing information relevant to ride

- Computation of IRI performed by a computer program as specified in ASTM Standard E1926

- Parameters of quarter car (e.g., spring stiffness, etc.) referred to as “Golden Car” parameters
Response of IRI to Wavelengths

- Peak at ~ 8 ft Axle Hop
- Peak at ~ 50 ft Body Bounce

IRI impacted by wavelengths from 4 to 100 ft

Gain

Wavelength, ft/cycle
Inertial Profiler Changes
Potential Reference Devices
Overview TPF 5(063)

- FHWA is lead agency with 22 participating State Highway Agencies (SHA’s)
  - FHWA Office of Pavement Technology (HIPT)
  - $1.8 Million 12 Year Study
  - FHWA Long Term Pavement Performance (LTPP)
  - FHWA Federal Lands
Participating State Agencies (22)

- Ohio
- Louisiana
- Kentucky
- California
- Colorado
- Florida
- Georgia
- Kansas
- Mississippi
- New Jersey
- Nevada
- New York
- North Dakota
- South Dakota
- Illinois
- North Carolina
- Maryland
- Oklahoma
- Connecticut
- Texas
- Wisconsin
- Pennsylvania
TPF 5(063) Priorities

1. Build Reference Profile Device
2. Critical Requirements - complete
3. Bumpfinder Software - complete
4. Certification/Validation Sites
5. Evaluating Upper Limits of Single Accelerometer – Phase I complete
6. Emerging Technology that Enhances Profile Measurement
7. Support RPUG
Progress on TPF 5(063) Priorities

1. Build a Reference Profile Device (ongoing):
   Two parts –
   i. Benchmark Testing – UMTRI
   ii. Reference Devices – New round of evaluations
      May 2013

2. Critical Requirements (completed): UMTRI;
   final report on pooled fund study website –
   “Critical Profile Accuracy Requirements”

- ProVAL 3.3 released in December 2011
  - Includes Automated Faulting Module (AFM)
- ProVAL 3.4 released Dec. 2012
- Multiple workshops – 10 annually
  - Scheduling has started for FY13
4. Certification/Validation Site
   i. Study under discussion with FHWA

5. Evaluating Upper Limits of Single Accelerometer
   i. Phase I: Starodub, Inc. – complete
   ii. Phase II: On hold for publication

6. Emerging Technology that Enhances Profile Measurement
   i. Urban IRI measurement – FHWA Federal Lands Study
   ii. Urban and low speed profile indices – NCHRP 10-93
FHWA Toolki

- Smoothness
  - ProVAL software (www.roadprofile.com) & workshops (10 per year)
  - ASTM E2560-07: Standard Specification for Data Format for Pavement Profile
  - NHI 131100 “Pavement Smoothness”
  - AASHTO Ride Quality Standards Implementation Contract – Assist SHAs
    - M328 Equipment Specification
    - R54 Accepting Ride Quality using an inertial profiler
    - R56 Certification of Inertial Profilers
    - R57 Operation of Inertial Profilers
Inertial Profilers – Getting Better
ProVAL 3.4 software & workshops
Frequently Asked Questions

• Who does the testing, and if not the owner then how do you certify machine and operator?
  – Best Practice: SHA for QA & contractor for QC
    • NH uses average of three runs. TN uses average of five runs
    – SHA certify profilograph and inertial profiler equipment & operators: set up a course & conduct annual equipment certification. FHWA assistance available.
    – SHA conduct QA tests on contractor data

• When is the testing done (daily, once paving complete, or after open to traffic)?
  – QC as soon as possible to monitor
  – QA once paving complete

• If not tested generally the day after paving do you know how much difference there is by the time the pavement is opened to traffic?
  – Unsure of studies related to this
Frequently Asked Questions

- What equipment/laser setup are you using for concrete?
  - AASHTO standards recognize limits of single point lasers. Recommend using line laser that averages across its range.

- What are the IRI numbers associated with acceptance/incentives? And are they the same for asphalt?
  - Set by individual SHAs. MS uses same for both ACC & PCC. MN uses combined spec with different thresholds.
  - [http://www.dot.state.mn.us/materials/smoothnessdocs/2399_2-6-13.pdf](http://www.dot.state.mn.us/materials/smoothnessdocs/2399_2-6-13.pdf)

- What bump threshold number do you use for concrete and is it the same as asphalt?
  - Set by each SHA, typically 0.3 inch for either pavement type.

- What do you base your Incentive payments on (set amount per tenth mile or % of a bid price)?
  - Set by each SHA, many use set amount per tenth mile.
Table 2399-4
Smoothness Pay Adjustments and Corrective Work for Bituminous Pavements

<table>
<thead>
<tr>
<th>Equation</th>
<th>Smoothness in/mi [m/km]</th>
<th>Pay Adjustment $/0.1 mi [0.16 km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMA-A</td>
<td>&lt; 30.0 [0.47]</td>
<td>400.00</td>
</tr>
<tr>
<td></td>
<td>30.0 – 75.0 [0.47 – 1.18]</td>
<td>$850.00 – 15.000 \times \text{Smoothness} \ [850.00 – 957.450 \times \text{Smoothness}]</td>
</tr>
<tr>
<td></td>
<td>&gt; 75.0 [1.18]</td>
<td>Corrective Work to ≤ 56.7 in/mi [0.89 m/km]</td>
</tr>
<tr>
<td>HMA-B</td>
<td>&lt; 33.0 [0.52]</td>
<td>270.00</td>
</tr>
<tr>
<td></td>
<td>33.0 – 85.0 [0.52 – 1.34]</td>
<td>$600.00 – 10.000 \times \text{Smoothness} \ [600.00 – 638.950 \times \text{Smoothness}]</td>
</tr>
<tr>
<td></td>
<td>&gt; 85.0 [1.34]</td>
<td>Corrective Work to ≤ 60.0 in/mi [0.94 m/km]</td>
</tr>
<tr>
<td>HMA-C</td>
<td>&lt; 36.0 [0.57]</td>
<td>180.00</td>
</tr>
<tr>
<td></td>
<td>36.0 – 95.0 [0.57 – 1.50]</td>
<td>$414.00 – 6.500 \times \text{Smoothness} \ [414.00 – 410.500 \times \text{Smoothness}]</td>
</tr>
<tr>
<td></td>
<td>&gt; 95.0 [1.50]</td>
<td>Corrective Work to ≤ 63.7 in/mi [1.01 m/km]</td>
</tr>
</tbody>
</table>
Frequently Asked Questions

• Do you use localized roughness in the IRI specification, if so what are the parameters for PCCP?
  – Set by SHA and varies: MnDOT uses a continuously reported IRI at 125 in/mi for both pavement types

• What smoothness checks do you use for mid-speed urban areas (40 to 50 mph) and how do you accomplish it?
  – Most agencies use ride indices (IRI or PI) for roadways with speeds > 45 mph

• If you have an IRI spec, do you still use a PI spec (California Profilograph) in any locations?
  – Generally not, but some use straightedge for localized roughness
Frequently Asked Questions

• Use ProVAL or the value the equipment software provides?
  – Most agencies are specifying ProVAL

• Are there any additional deducts, besides grinding, to meet a minimum IRI?
  – Some agencies will remove and replace at high values

• If ground, can the section be re-profiled to attain a smoothness bonus?
  – Again varies by agency, some allow others do not

• Does your state use a combined specification for both concrete and asphalt, if so do you use the same equations/IRI specs for both pavement types?
  – Set by each SHA & varies, MnDOT uses 30 in/mi for new ACC and 50 in/mi for PCC
Frequently Asked Questions

- Does your state require equipment and/or operator certification? Yearly, every x years?
  - If using contractor data, equipment every year and operator certification can vary from 3 to 5 years. MnDOT uses online training for operators.
    - [http://www.dot.state.mn.us/onlinelearning/mrr/pavementsmoothness/](http://www.dot.state.mn.us/onlinelearning/mrr/pavementsmoothness/)

- Do you require ProVAL?
  - Most agencies do when using IRI and can be used for PrI when collected with inertial profiler but ProVAL cannot be used for data collected by profilograph.

- Do you see an influence on type of pavement texture?
  - Coarse textures i.e. chip seals, tining, OPFC, challenge single point lasers. Line lasers provide viable alternative.

- Some states set their specs so tight they end up having the entire pavement ground – how do they handle that? How do you minimize grinding on the finished project?
  - Specs can be changed, but most tighten specs after contractors learn how to build smooth roads.
  - Good construction practices that include daily evaluations of finished product.
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