Concrete Pavements and Smoothness

Louisiana Transportation Engineering Conference
2007
Pavements and life will always have bumps.

Learning to manage the bumps brings higher quality.

Chris Abadie
“smooth” Internet images
Internet Images
ASTM Definition of Roughness

“The deviations of a pavement surface from a true planar surface with characteristic dimensions that affect vehicle dynamics......”
The LTPP GPS-3 experiment showed that adjustments in design features, materials properties, and construction procedures provide smoother-built pavements with longer service life.

--“Achieving a High Level of Smoothness in Concrete Pavements Without Sacrificing Long-Term Performance”, FHWA-HRT-05-069.
## Results of Smoothness Modeling Sensitivity Analysis (NCHRP 1-31, Smoothness Specifications for Pavements)

<table>
<thead>
<tr>
<th>Reduction in roughness</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama PCC</td>
<td>11</td>
<td>28</td>
<td>55</td>
</tr>
<tr>
<td>Arizona PCC</td>
<td>7</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>Illinois CRC</td>
<td>5</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Minnesota PCC</td>
<td>6</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Illinois AC/PCC</td>
<td>4</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Alabama AC</td>
<td>8</td>
<td>20</td>
<td>39</td>
</tr>
<tr>
<td>Arizona AC</td>
<td>3</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Minnesota AC</td>
<td>5</td>
<td>11</td>
<td>23</td>
</tr>
</tbody>
</table>
Articles

PCC Pavement Smoothness:

- “Characteristics and Best Practices for Construction”, FHWA-IF-02-025,
- “Constructing Smooth Concrete Pavements”, ACPA Technical Bulletin TB-006.0-C, guidelines
ACPA Covers Concrete Pavement Smoothness

Does pavement smoothness affect anything other than driver comfort?

The answer:

A resounding YES!

Staff
June 17, 2005
Construction Bulletin
ACPA's plan is to promote a uniform ride quality measurement:

- Based on the International Roughness Index
- Uses equipment and procedures that are repeatable and reproducible
- Uses equipment readily available to contractors for quality control
- Is not improperly influenced by surface type or texture
- Represents the actual experience of the traveling public

June 17, 2005
Construction Bulletin
Analysis of differences in the longitudinal profile and roughness indices that are attributable to the different profiling equipment that have been used in the LTPP program.

Conclusion: Good agreement of IRI values among the different inertial profilers that have been used in the LTPP program.
NHI Training

- 131100 Pavement Smoothness: “Use of Inertial Profiler Measurements for Construction Quality Control”
How to construct smooth pavements

- Constructing smooth pavements requires attention to detail. Uniformity in concrete production and delivery, support conditions (both under the pavement and in the trackline), placement and consolidation, and surface texturing are the primary construction processes influencing smoothness. However, perhaps the most important details are high-quality stringlines (one line on each side, adequately tensioned with closely spaced pins) and an accurately set up paver (including sensor system).
Pavement Smoothness
National Customer Survey

- Pavement Condition (smoothness) 36%
- Safety 22%
- Traffic Flow 16%
- Visual Appeal 11%
- Bridge Condition 6%
- Maintenance Response Time 6%
- Travel Amenities 3%
Louisiana Pavement Facts

- Louisiana has 1000 miles of concrete pavement
- 118 miles have been constructed in 70 contracts over the last 5 years at a cost of $473 million
- Most projects are 2 miles long or less
NHI Model (1993 AASHTO Pave.)

PSR = Constant x e (-0.0041*IRI)
Purposes for Smoothness Measurements

- Maintain construction quality
- Locating abnormal changes in the highway
  - subsurface problems, drainage, construction deficiencies
- Allocation of road maintenance resources
- Pavement serviceability performance and design
Smoothness Measurements

History
Methods

- Rolling Straightedge
- Ride Number (AASHO Road Test)
- BPR Roughometers
- Mays Ride Meter
- California Type Profiler (PI), La Specs since early eighties
- Inertial type Profilometers (RN, PI, IRI)
Setting up Calibration Site w/ Walking Profiler
ICC laser profiler measures pavement profile (IRI), rutting, and PCC joint faulting at normal highway speeds.
US 190; CRCP, LA 1 to Hwy 415, Iberville Parish
I-10 Baton Rouge

Pavement Performance

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2002</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
US 171 Florien to Hornbeck (2 adjacent projects)
2005 IRI = 92 inches per mile
Deficiencies with Current PI System (Manual)

- Labor Intensive, Slow, Safety?
- Blanking Band Filtering out Roughness
- PI does not represent the “ride” of the Roadway
AMES “LISA” Lightweight Inertial Profiler

Lightweight profilers measure pavement profile (IRI), Profile index, (PI), rutting, and PCC joint faulting at 10-15 mph.
Surface Tolerance Requirements

- Inertial profilers approved by Materials Engineer
- Annual certification and site calibration
- Measurement of both wheel paths
- Average every 0.05 mile intervals
Requirements (Cont)

- diamond grind to meet specs
- Contractor Profile may be used for acceptance
<table>
<thead>
<tr>
<th>% of Unit Price</th>
<th>103%</th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>50% or Remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat. A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interstate and multi-lifts</td>
<td>&lt;55</td>
<td>&lt;65</td>
<td>65-75</td>
<td>NA</td>
<td>&gt;75</td>
</tr>
<tr>
<td>Cat. B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Lift Overlay</td>
<td>&lt;55</td>
<td>&lt;75</td>
<td>75-89</td>
<td>NA</td>
<td>&gt;89</td>
</tr>
<tr>
<td>Cat. C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-Lift Overlay</td>
<td>&lt;55</td>
<td>&lt;85</td>
<td>85-95</td>
<td>95-110</td>
<td>&gt;110</td>
</tr>
<tr>
<td>Incentive Pay,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;45; Final Completion, Average of All Travel Lanes (with no lot less than 100% pay); +5% of the value of the wearing course (plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Development of IRI Specifications for PCCP

LTRC Pavement Group
Methodology

- Collection of Profile Data on Selected PCCP jobs using LTRC ICC’s High Speed Profiler
- Developing PI and IRI data from the selected Sites
- Using Linear Regression to Establish IRI values based on the Existing PI specifications (similar to what was done for flexible pavements)
IRI & PI (each 0.05 mi. seg)

\[ y = 2.5104x + 64.124 \]
<table>
<thead>
<tr>
<th>Category/I</th>
<th>PCC Pavements</th>
<th>100</th>
<th>98</th>
<th>95</th>
<th>80</th>
<th>50% or remove and replace</th>
<th>Correct or Remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 45 mph</td>
<td>P</td>
<td>6.0</td>
<td>6.1-7.0</td>
<td>7.1-8.0</td>
<td>--------</td>
<td>--------</td>
<td>&gt; 8.0</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>75</td>
<td>76-90</td>
<td>90-100</td>
<td>--------</td>
<td>--------</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Cat. II, Urban Areas ≤ 45 mph</td>
<td>P</td>
<td>12</td>
<td>12.1-13.0</td>
<td>13.1-14.0</td>
<td>--------</td>
<td>--------</td>
<td>&gt;14.0</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>90</td>
<td>91-100</td>
<td>100-110</td>
<td>--------</td>
<td>--------</td>
<td>&gt;110</td>
</tr>
<tr>
<td>Cat. III non-continuous operations ≤ 45mph</td>
<td>P</td>
<td>20</td>
<td>20.1-22.0</td>
<td>22.1-24.0</td>
<td>24.1-26.0</td>
<td>--------</td>
<td>&gt;26</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>100</td>
<td>101-110</td>
<td>110-120</td>
<td>120-129</td>
<td>--------</td>
<td>&gt;129</td>
</tr>
</tbody>
</table>

Incentive recommended = 1% for 65 IRI
NHI Model (1993 AASHTO Pave.)

$$PSR = \text{Constant} \times e^{-0.0041 \times IRI}$$
Existing Smoothness Specifications

- Profile Index
- 0.2” Blanking Band
IRI = 97 in./mile
PI = 0.0 in./mile

Old Spec (PI) vs. New Spec (IRI)
How Bumps change IRI
IRI Calibration Requirements

- Five runs over each of two test locations
- Report mean and standard deviation
- The mean shall be within 5% of DOTD reference value for each test location.
- The standard deviation must be less than 3% of the mean IRI value in inches per mile
- DOTD to affix tag to certified unit with necessary computer settings
The Bottom Line is a Straight Line

- Smooth = long life and low maintenance
- All customers will say they prefer to ride on smooth pavement.
- Every phase of construction is a new opportunity to achieve a smoother road