International Roughness Index (IRI)
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(IRI)

Uses & Comparison of IRI with other Jurisdictions
(Asphaltic Concrete Pavements)

Prepared by:
Moh Ashraf, P.Eng.
Infrastructure Systems Engineer

Reviewed by:
Roy Jurgens, P.Eng.
Director, Highway Asset Management

Program Management Branch
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Acknowledgements

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SUMMARY

- IRI is collected to monitor pavement roughness in most Canadian provinces and American states. Methods for collection and processing of the data vary between jurisdictions.

- IRI is not used as a performance measure in Canada except in Alberta. The U.S. Federal Highways Administration (FHWA) uses IRI as a performance measure for describing and monitoring pavement condition of its National Highway System. The state of Kansas uses IRI as a performance measure. The state of Washington describes the condition of their network in terms of percentages of miles in IRI rating categories.

- Almost all Canadian DOT’s convert IRI to a ride index and use it in their Pavement Management Systems.

- Alberta’s NHS is smoother than the NHS in four Canadian provinces (Saskatchewan, Manitoba, Quebec and New Brunswick) and about equivalent to one (B.C.) that reported IRI for their NHS. Alberta primary highways are smoother than the primary highways of Manitoba, New Brunswick, Quebec and Saskatchewan and approximately equivalent to highways of British Columbia and Ontario. Secondary highways are smoother than all six Canadian provinces and all nine states that reported IRI values for the secondary highways.

- Based on the IRI data collected in 1999 for the primary and secondary highways in Alberta, the average IRI for the new construction is 0.8 mm/m and the IRI just before rehabilitation was 2.3 mm/m.

- There are no IRI rating standards in Canada. Various U.S. states have varying rating standards for their state owned networks. The FHWA has IRI rating standards for Very Good, Good, Fair, Mediocre and Poor groupings for the Interstate and NHS networks.

RECOMMENDATIONS

It is recommended that:

- The IRI procedures for calibrations, data collection and frequency and interval of data collection and reporting be standardized across Canada, and alternately across the continent so that results are comparable between jurisdictions.

- Alberta Infrastructure establish IRI ratings similar to those used by the FHWA for its networks, and promote adoption of these standards across Canada.

- IRI threshold trigger values be established for planning and programming rehabilitation and maintenance programs. This is to be done for all highway service classes. An IRI of 2.6 mm/m should be used initially.

- Alberta Infrastructure review its method of setting and reporting IRI performance targets in the business plan. A method based on some percentile of the network to be maintained at or within an acceptable level should be considered as a supplement to the present network average IRI value.

- A comprehensive analysis of the impact of the three year construction and rehabilitation program on the future IRI condition of the networks be undertaken.
IRI – USAGE AND COMPARISON WITH OTHER JURISDICTIONS

Alberta Infrastructure adapted IRI as its performance measure for reporting pavement condition in 1998 after bench marking the primary highways network in 1996. The IRI is a simple and stable measure of road roughness. The reasons of simplicity and stability led Alberta to switch over to this measure from PQI, which is composed of 3 pavement condition parameters.

Since IRI is a relatively new measure of road roughness, Alberta Infrastructure is determined to make sure that IRI values for our networks provide true representation of the road smoothness by comparing ourselves with other jurisdictions.

Comparison Of IRI With Other Jurisdictions

A summary table comparing Alberta Infrastructure with other jurisdictions is shown in Table 1. In this table the averages are those based on quarter car model simulation recorded for both wheel paths and then averaged for further analysis and calculations.

As indicated by the table and the plot in Figure 1 Alberta highways are in the “Good” smoothness range using the FHWA and state standards listed in Table 2. A total of seven Canadian provinces collected and reported IRI.

Alberta’s NHS is smoother than the NHS in Saskatchewan, Manitoba, Quebec and New Brunswick and approximately equivalent to British Columbia. Only six provinces including Alberta reported the IRI averages for the NHS. Alberta’s primary highways are smoother than four provinces (Manitoba, New Brunswick Quebec and Saskatchewan) and are approximately the same as the other two provinces that reported IRI (British Columbia and Ontario). Alberta’s secondary highways are smoother than all other provinces.

When comparing with the US states Alberta did better than seven states out of 14 reporting IRI for the NHS. Alberta’s primary highways are smoother than five and about equivalent to two states out of 11 reporting. Alberta showed smoother results than all nine states reporting IRI for the secondary highways.

Uses of IRI

Although IRI is not widely used directly in business plans as performance measure as yet, almost all states and most Canadian provinces collect it and convert to either RCI (ride scale 0-10), Ride Index (scale 0-100) or Present Serviceability Index (ride scale 0-5). Some most common conversion equations are:

\[ RCR = 8.52 - 7.49 \times \log_{10}(IRI) \]  
\[ \text{Ontario} \]

\[ PSI = 5.6972 - 2.104 \times \sqrt{IRI} \]  
\[ \text{Minnesota} \]

Quebec uses IRI for planning and programming their maintenance activities. The IRI is converted to a ride index with a scale of 0 to 100 using the following equation:

\[ \text{Ride Index} = 116.667 - 16.667(\text{IRI}) \]
The US State of Colorado converts IRI to a ride index using the following equation:

\[ \text{Ride Index} = 100 - \left[ \frac{(100-\text{Th})(\text{avg. IRI}-40)}{\text{X}} \right] \]

Where Th=50; X=104 for Interstate and 150 for all other highways

**Business Plan Reporting:** Among the seven Canadian provinces collecting IRI, Alberta Infrastructure is the only one using IRI directly in their business plan.

The US Federal Highway Administration uses IRI as a performance measure for describing the pavement condition of their National Highway System. An example for the 1999 business plan is “91.5 percent of miles on the NHS will have an IRI of less than or equal to 170 inches/mile (2.69 mm/m).

The state of Kansas uses IRI as a performance measure. This state has categorized the pavement condition at 3 performance levels and the targets being “85.5 percent of the network is to be maintained at level 1 with only less than 3 percent being in level 3”. The range of levels in IRI terms is shown in Table 2.

Some states such as the state of Washington describes their networks as percent of miles in each category of IRI rating of Very Good, Good, Fair, Poor and Very Poor. All service classes are included in the rating.

The decision of not switching over to IRI completely could be due to the fact that the existing Pavement Management Systems across North America have been developed based on conventional data collection tools and practices that excluded IRI. Pavement designers and engineers are familiar with the scales and their interpretations of RCI, RI and PSR. Making a switch over to IRI would need parallel usage of both IRI and ride indices for some time till enough familiarity and ease is achieved.

**Potential Inconsistencies with IRI**

IRI is a standard measure worldwide for road roughness. However, it still presents some inconsistency issues due to variability in equipment being used to collect it and due to data being analyzed using quarter car model and half car model. The potential inconsistencies are summarized in the Table 3.

A majority of the jurisdictions appear to have consistency in reporting their results. However, some jurisdictions are showing results in the good range, which would be rated as being poor in other jurisdictions. Data from Quebec, New Brunswick, Alaska and Pennsylvania are showing relatively rougher networks compared to other jurisdictions.

The concept of IRI being a standardized measure is not entirely true. It is a standardized measure if the same rules with respect to data collection and processing are applied.

**IRI Before and After Construction**

An analysis of data collected during the 1999 survey season indicates that IRI of new construction ranged from 0.54 to 1.19 mm/m with average being 0.79 mm/m. The IRI of the road sections, just before putting an overlay, ranged from 1.89 to 2.91, with the average being 2.3 mm/m. Based on two years of data and its analysis and communications with other jurisdictions, an IRI of 2.5 to 2.6 mm/m could be used for identifying pavement sections requiring rehabilitation due to roughness. This measure will be evaluated regularly to verify its appropriateness. The values from Alberta and Ontario are listed in Table 4.
<table>
<thead>
<tr>
<th>DOT Name</th>
<th>Year</th>
<th>NHS</th>
<th>Freeway</th>
<th>Primary Highway</th>
<th>Secondary Highway</th>
<th>Primary &amp; Secondary</th>
<th>Local</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CANADA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alberta</td>
<td>1999</td>
<td>1.58</td>
<td>1.61</td>
<td>1.26</td>
<td>1.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>1999</td>
<td>1.53</td>
<td>1.60</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manitoba</td>
<td>1999</td>
<td>1.93</td>
<td>2.32</td>
<td>2.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Brunswick</td>
<td>1998</td>
<td>1.72</td>
<td>2.24</td>
<td>3.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>1999</td>
<td>1.29</td>
<td>1.60</td>
<td>1.93</td>
<td></td>
<td></td>
<td>2.27</td>
</tr>
<tr>
<td>Quebec</td>
<td>1999</td>
<td>2.25</td>
<td>2.69</td>
<td>2.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>1999</td>
<td>1.8</td>
<td>1.9</td>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>USA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montana</td>
<td>1999</td>
<td>1.33</td>
<td>1.47</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idaho</td>
<td>1999</td>
<td>1.39</td>
<td>1.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>1999</td>
<td>1.28</td>
<td>1.48</td>
<td>1.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oregon</td>
<td>1999</td>
<td>1.89</td>
<td>2.03 *</td>
<td></td>
<td>2.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minnesota</td>
<td>1999</td>
<td>1.41</td>
<td>1.61</td>
<td>1.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alaska</td>
<td>1999</td>
<td>1.86</td>
<td>2.28 *</td>
<td></td>
<td>2.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Dakota</td>
<td>1999</td>
<td>1.43</td>
<td>1.43</td>
<td>1.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utah</td>
<td>1999</td>
<td>1.29</td>
<td>1.49</td>
<td>1.89</td>
<td>1.76</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>1999</td>
<td>1.82</td>
<td>1.56</td>
<td></td>
<td>2.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nevada</td>
<td>1999</td>
<td>1.90</td>
<td>1.64</td>
<td></td>
<td>2.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kansas*</td>
<td>1999</td>
<td>1.27</td>
<td>1.26</td>
<td></td>
<td>1.38</td>
<td>2.76</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1999</td>
<td>1.75</td>
<td>1.39</td>
<td>2.07 *</td>
<td>3.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa*</td>
<td>1999</td>
<td>1.61</td>
<td>1.97 *</td>
<td></td>
<td></td>
<td></td>
<td>2.29</td>
</tr>
<tr>
<td>Wisconsin*</td>
<td>1998</td>
<td>1.87</td>
<td>2.0</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Includes Urban Highways
- Primary Highways include NHS
- NHS include Freeways or Interstates
Figure-1 International Roughness Index (IRI) Comparison with Other Jurisdictions

[Bar graphs showing average IRI for different jurisdictions, with Alberta highlighted as having a value of 1.58, 1.61, and 1.26 for Primary Highways, Secondary Highways, and NHS respectively.]

-6-
## TABLE 2

IRI RATING IN KEY U.S. STATES & FHWA

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>INTERSTATE</th>
<th>OTHER ROADS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good</td>
<td>Less than 0.95</td>
<td>Less than 0.95</td>
</tr>
<tr>
<td>Good</td>
<td>0.95 – 1.49</td>
<td>0.95 – 1.49</td>
</tr>
<tr>
<td>Fair</td>
<td>1.50 – 1.89</td>
<td>1.50 – 2.69</td>
</tr>
<tr>
<td>Mediocre</td>
<td>1.90 – 2.69</td>
<td>2.70 – 3.48</td>
</tr>
<tr>
<td>Poor</td>
<td>Greater than 2.69</td>
<td>Greater than 3.48</td>
</tr>
</tbody>
</table>

1999 Performance Target for NHS: “91.5% of kilometers on the NHS that meet pavement performance standards for acceptable ride quality (IRI is less than or equal to 170 in/mi (2.69 mm/m)).”

### NORTH DAKOTA

<table>
<thead>
<tr>
<th>IRI (mm/m)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>0 – 0.95</td>
</tr>
<tr>
<td>Good</td>
<td>0.96 – 1.50</td>
</tr>
<tr>
<td>Fair</td>
<td>1.51 – 2.09</td>
</tr>
<tr>
<td>Poor</td>
<td>Greater than 2.09</td>
</tr>
</tbody>
</table>

### WASHINGTON DOT

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>IRI (mm/m)</th>
<th>TYPICAL CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good</td>
<td>Less than 1.50</td>
<td>Smooth Pavement</td>
</tr>
<tr>
<td>Good</td>
<td>1.50 – 3.48</td>
<td>Modest roughness, upper value noticeable to motorists</td>
</tr>
<tr>
<td>Poor</td>
<td>3.48 – 5.01</td>
<td>Older pavements, roughness quite noticeable, uncomfortable to drivers</td>
</tr>
<tr>
<td>Very Poor</td>
<td>Greater than 5.01</td>
<td>Very rough pavement, uncomfortable to all motorists</td>
</tr>
</tbody>
</table>

### IRI: KANSAS DOT

<table>
<thead>
<tr>
<th>IRI (mm/m)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (Level 1)</td>
<td>Less than 1.66</td>
</tr>
<tr>
<td>Deteriorating (Level 2)</td>
<td>1.66 – 2.59</td>
</tr>
<tr>
<td>Deteriorated (Level 3)</td>
<td>Greater than 2.59</td>
</tr>
</tbody>
</table>

**Performance**

“85.5% of all roads shall be in Level 1 and less than 3% in level 3. Recently Kansas DOT has exceeded their performance goal and 90% of their network is at Level 1.”

Kansas DOT is developing IRI performance model. We may get some information on their models in about a 2 – 3 month period.
TABLE 3

IRI – POTENTIAL INCONSISTENCIES

A. Data Collection and Storage

1. Shots taken at less than 1 inch, 1 inch, 4 inches, 6 inches.
2. Filters applied for data reduction (moving average filter); IRI greater than 350 in/mi (5.5 mm/m) is filtered out.
3. Data stored at 50-metre interval, 100-metre interval, one kilometre interval.

B. Reporting of IRI

1. Reporting based on Right Wheel Path – Interstate Highways in USA.
2. Reporting based on average of both wheel paths – States and Canadian Provinces.
3. ¼ car model
4. ½ car model

C. Equipment Used

1. Laser based
2. Ultrasonic based
3. Profilographs
4. K.J. Law
5. South Dakota Profilometer
6. Sensors: Layout and mixup of Laser and Ultrasonic

D. Various Rating

<table>
<thead>
<tr>
<th>Category</th>
<th>Utah</th>
<th>Kansas</th>
<th>North Dakota</th>
<th>Washington State</th>
<th>FHWA</th>
<th>Michigan</th>
<th>Montana</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. Good</td>
<td>&lt; 0.71</td>
<td>0 – 0.95</td>
<td>≤ 1.50</td>
<td>&lt; 0.95</td>
<td>&lt; 0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.71 – 1.11</td>
<td>0.96 – 1.50</td>
<td>&gt; 1.50 – ≤ 3.5</td>
<td>0.95 – 1.49</td>
<td>0.79 – 1.39</td>
<td>&lt; 1.18</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>1.12 – 1.58</td>
<td>1.66 – 2.59</td>
<td>1.51 – 2.09</td>
<td>1.50 – 2.69</td>
<td>1.40 – 2.04</td>
<td>1.20 – 3.54</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>1.59 – 2.13</td>
<td>&gt; 2.59</td>
<td>&gt; 2.09</td>
<td>&gt; 3.50 – ≤ 5.0</td>
<td>2.70 – 3.48</td>
<td>&gt; 2.04</td>
<td>&gt; 3.56</td>
</tr>
<tr>
<td>V. Poor</td>
<td>&gt; 2.13</td>
<td></td>
<td></td>
<td>≥ 5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: See plot in Figure-2

<table>
<thead>
<tr>
<th>Category</th>
<th>Germany</th>
<th>Finland</th>
<th>Hungary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Motorways</td>
</tr>
<tr>
<td>Threshold IRI</td>
<td>1.5</td>
<td>Excellent</td>
<td>&lt; 1.3</td>
</tr>
<tr>
<td>Alert IRI</td>
<td>3.5</td>
<td>Good</td>
<td>1.4 – 2.6</td>
</tr>
<tr>
<td>Target IRI</td>
<td>4.5</td>
<td>Fair</td>
<td>2.7 – 4.0</td>
</tr>
<tr>
<td>Poor</td>
<td>4.2 – 5.5</td>
<td>Unsatisfactory</td>
<td>1.81 – 2.20</td>
</tr>
<tr>
<td>Very Poor</td>
<td>&lt; 5.5</td>
<td>Poor</td>
<td>&gt; 2.21</td>
</tr>
</tbody>
</table>
### TABLE 4

**IRI: PRIOR TO AND AFTER NEW CONSTRUCTION**

<table>
<thead>
<tr>
<th></th>
<th>ALBERTA</th>
<th>ONTARIO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td><em>IRI – New Construction (mm/m)</em></td>
<td>0.56 – 0.97</td>
<td>0.77</td>
</tr>
<tr>
<td><em>IRI – Prior New Construction (mm/m)</em></td>
<td>1.85 – 2.91</td>
<td>2.23</td>
</tr>
</tbody>
</table>