COMPARISON OF PROFILE INDEX AND INTERNATIONAL ROUGHNESS INDEX FOR PAVEMENT SMOOTHNESS INCENTIVE SPECIFICATIONS

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ABSTRACT
The Minnesota Department of Transportation (Mn/DOT) is currently evaluating a change from the Profile Index (PI) to the International Roughness Index (IRI) for smoothness specifications for portland cement concrete (PCC) pavements. This change has already occurred for bituminous pavements in Minnesota. The Mn/DOT Office of Materials, as well as paving contractors in Minnesota, is naturally concerned with the effects that this change will have on the quality of pavement surfaces and on the incentives paid for new pavement smoothness. The Office of Materials has funded an “implementation” project to compare the two smoothness statistics and to provide recommendations for implementing the new specification.

This paper contains several analyses and comparisons of the relative effects of pavement features in design and construction with regard to the results of pavement surface smoothness and incentive computations. It also contains an analysis of segment length for incentive/disincentive calculations on PCC pavement projects. The information presented in this paper can be useful to those considering changing pavement smoothness specifications from profile index to international roughness index.

INTRODUCTION
The Minnesota Department of Transportation (Mn/DOT) is currently evaluating a change from the Profile Index (PI) to the International Roughness Index (IRI) for smoothness specifications for portland cement concrete (PCC) pavements. This change has already occurred for bituminous pavements in Minnesota. The Mn/DOT Office of Materials, as well as paving contractors in Minnesota, is naturally concerned with the effects that this change will have on the quality of pavement surfaces and on the incentives paid for new pavement smoothness. The Office of Materials has funded an implementation project to compare the two smoothness statistics and to provide recommendations for implementing the new specification. More detailed analysis will be contained in the report for this project, which will be available from Mn/DOT in late 2007.

This paper contains analyses and comparisons between the Profile Index and the International Roughness Index, both of which are standard and widely-used measures for quantifying pavement surface roughness. The analyses include comparisons of the effects of:

- 15-foot (4.6 m) joint spacing, 25-foot (7.6 m) string line support spacing, and a combination of the two on IRI and PI
- 15-, 25-, and 50-foot (4.6-, 7.6-, and 15.2-m) sine waves on IRI and PI
- Varying wavelengths (with constant amplitude) on IRI and PI
- Transverse tining on IRI and PI
- Various wavelengths on incentives paid in Minnesota for smooth pavement surfaces
- Analysis segment length on incentives

Each of the analyses uses either real or simulated pavement profiles with various added “features” or wavelengths. While a direct comparison between PI and IRI is not possible, some of the reasons for the discrepancies between them have been identified in the literature and in the analyses conducted for this paper, and will be discussed here.

The analyses performed for this paper were accomplished with the use of the ProVAL 2.6 software, developed through funding from the Federal Highway Administration. The analyses conducted with ProVAL include Ride Statistics (International Roughness Index), Profilograph Simulation, and Power Spectral Density.

The power spectral density analysis (PSD) in the ProVAL software is a powerful tool used to analyze the component wavelengths within a signal. Originally developed for use in the electric power industry, the PSD analysis can identify dominant wavelengths in a pavement surface profile. Since this
method of analysis is used throughout this paper a short summary of how it is used in this paper is given in the next section.

POWER SPECTRAL DENSITY ANALYSIS

The power spectral density analysis was used to identify dominant wavelengths in pavement profiles. For example, when a 15-foot (4.6-m) joint spacing is used, the PSD analysis often finds dominant wavelength at 15 feet (4.6 m) per “cycle”. In this paper, for brevity, units of wavelength are reported in distances only, rather than distance per cycle. The dominant frequencies identified by the PSD analysis are features in the pavement profile that represent physical, repetitive components. Figures 1 and 2 demonstrate this analysis. Figure 1 is a profile of a pavement on a newly-constructed PCCP in Minnesota. This profile in Figure 1 was then analyzed using the PSD analysis in ProVAL. Figure 2 shows its component frequencies, or the “frequency content” of the profile. The range of wavelengths in Figure 2 is from about 1 to 200 feet (0.30 to 61 m). According to Karamihas (1), the range which most affects how a pavement feels to riders in a passenger car is approximately between 1.4 and 220 feet (0.43 and 67 m). The x-axis is a log scale of the wavelength, and the y-axis is a representation of the amplitude of the feature occurring at the particular frequency.

![Figure 1 Sample pavement profile from a newly-constructed Minnesota highway.](image)

The frequency plot shown in Figure 2 indicates two dominant wavelengths – one at about 3.5 feet (1.1 m) and one at 25 feet (7.6 m). At a speed of 65 mph (105 km/h), the 3.5-foot (1.1-m) feature in the pavement would feel similar to 27 Hz and the 25-foot (7.6-m) feature would feel similar to 3.8 Hz. At the proper amplitude, the feature with the 3.5-foot (1.1-m) wavelength is likely to produce the “chatter” or “whine” heard on some concrete pavements. The feature at the 25-foot (7.6-m) wavelength is assumed to be the effect of the paver’s string line support placement. Figure 3 shows a similar plot, of a different profile, with wavelengths also between 1 and 200 feet (0.30 and 61 m), and dominant wavelengths at 15 and 25 feet (4.6 and 7.6 m). The 15-foot (4.6-m) wavelength corresponds most likely with the 15-foot (4.6-m) joint spacing, and the 25-foot (7.6-m) wavelength likely corresponds with the string line support spacing, similar to the pavement profile in Figure 2.

1 inch = 25.4 mm, 1 ft = 0.30 m
The effect of the IRI analysis and its wavelength response can be seen in the following figure, which shows the power spectral density of the profile in Figure 1, which is similar to the PSD shown in Figure 2, except that in Figure 4 the standard IRI filter has been applied prior to the PSD. In this figure, the dominant wavelength at 3.5 feet (1.1 m) has been eliminated due to the IRI “filter”, and the 25-foot (7.6 m) wavelength has been amplified. These are features of the IRI analysis that will be discussed later in this paper.

\[ 1\, \text{ft} = 0.30\, \text{m} \]
PROFILE ANALYSIS
The primary focus of this section is to identify differences in pavement profiles based on the wavelength content, or the dominant wavelengths present in many PCCP profiles in Minnesota. In order to avoid any inherent bias in the profiles used for this analysis, and to eliminate the potential confounding effects of other dominant wavelengths, generic profiles were generated using pseudo-random numbers based on a standard normal distribution. This was done using techniques reported in NCHRP Report 353 by Gillespie et al. (2) and Rasmussen et al. (3). These generic, randomly-generated profiles do not have any dominant wavelengths, and thus are well-suited for this type of analysis. The original approach to this analysis was to remove specific dominant wavelengths from actual pavement profiles. This proved difficult and ran the risk of removing other wavelengths besides those in question, and tended to smooth out the profile data too much, resulting in much lower roughness index values than were found in the original profiles. Thus, beginning with a randomly generated profile and adding a specific wavelength proved to be a much better method.

After generating several random profiles to provide a statistical basis for the analysis, several “features” were added to them to generate more realistic profiles with only a single dominant wavelength, in most cases. These features include two types of repeating patterns – catenaries, which simulate the sag in a paving string line, and sine waves, which are generic representations of repeating features similar to catenaries.

IRI vs. PI
The purpose of the generic, random pavement profiles is to evaluate the effects of a single wavelength with the assurance that other wavelengths are not present to confound the analysis. The first analysis that compares IRI and PI added specific wavelengths, one at a time, to a set of five randomly-generated profiles and then computed the average and standard deviation of the profile statistics determined by the ProVAL software. For the PI analyses, the zero-blanking band was used in order to capture all of the roughness in the summary statistic.

The features added to the random profiles included the following:

- 15-foot (4.6-m) joint spacing, representing slightly upward curled slabs (catenary curve)
- 15-foot (4.6-m) joint spacing, representing slightly downward curled slabs (catenary curve)
- 15-foot (4.6-m) wavelength sine wave
- 25-foot (7.6-m) string line spacing (catenary curve)

\[1 \text{ ft} = 0.30 \text{ m}\]
- 25-foot (7.6-m) wavelength sine wave
- 50-foot (15.2-m) string line spacing (catenary curve)
- 50-foot (15.2-m) wavelength sine wave
- 15-foot (4.6-m) upward curled slabs + 25-foot (7.6-m) string line spacing

One improvement to this analysis could be the shape of the curled slabs. In the current analysis, the curled slab shape is modeled as a catenary, as are the string lines. A catenary curve is formed when a cable or string is supported by its ends only, and sags in the middle. The amount of sag is controlled by the tension in the cable. It is appropriate to model sagging string lines in this way, but there is likely a better way of modeling the shape of curled slabs. Byrum (4) suggested modeling the shape of curled slabs with a constant curvature. The exact shape is not significant, as can be seen in Table 1, the IRI and PI values (zero-blanking band) computed using both catenaries and sine waves of the same wavelength are very similar. Table 1 shows the average and standard deviation of the five random profiles and the additional features. The coefficients of variation are very small for IRI and PI0.0 (up to 3.6% and 7.8%, respectively).

### TABLE 1 Average and Standard Deviation of Random Profiles and Added Features

<table>
<thead>
<tr>
<th></th>
<th>IRI</th>
<th>PI0.0</th>
<th>IRI</th>
<th>PI0.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random</td>
<td>63.1</td>
<td>29.9</td>
<td>2.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Random+15-ft upward catenary</td>
<td>128.9</td>
<td>52.3</td>
<td>1.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Random+15-ft downward catenary</td>
<td>130.2</td>
<td>50.4</td>
<td>1.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Random+15-ft sine wave</td>
<td>135.8</td>
<td>50.3</td>
<td>1.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Random+25-ft upward catenary</td>
<td>76.7</td>
<td>43.6</td>
<td>1.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Random+25-ft sine wave</td>
<td>77.2</td>
<td>48.0</td>
<td>0.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Random+50-ft upward catenary</td>
<td>68.9</td>
<td>29.2</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Random+50-ft sine wave</td>
<td>68.6</td>
<td>28.9</td>
<td>2.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Random+15-ft and 25-ft upward catenaries</td>
<td>137.3</td>
<td>57.3</td>
<td>1.8</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Regardless of the random profile generated, as long as it was generated with the same input parameters to the random profile generator, the variability of the ride statistics were very small for both the IRI and PI. It is important to note that multiple random profiles, generated with the same input parameters, produce profiles with very similar ride statistics (2, 3).

The important information to observe in Table 1 is the change in the ride statistic when certain features are added to the random profile. The 15-foot (4.6-m) wavelength content added to the random profiles caused large increases in IRI when compared to the random profile (more than double), and the PI0.0 statistic increased only about 70%. Table 2 shows the percent change in the ride statistics over the unmodified random profile. In this table, it can be seen that the 15-foot (4.6-m) wavelength has the largest impact on IRI and that the combination of the 15- and 25-foot (4.6- and 7.6-m) wavelengths has the largest impact on PI.

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4 1 in/mi = 0.0158 m/km, 1 ft = 0.30 m
Table 2  Percent Change in Ride Statistics Over Unmodified Random Profile

<table>
<thead>
<tr>
<th></th>
<th>% Increase over Random</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRI</td>
</tr>
<tr>
<td>Random+15-ft upward</td>
<td>104%</td>
</tr>
<tr>
<td>Random+15-ft downward</td>
<td>106%</td>
</tr>
<tr>
<td>Random+15-ft sine</td>
<td>115%</td>
</tr>
<tr>
<td>wave</td>
<td></td>
</tr>
<tr>
<td>Random+25-ft upward</td>
<td>21%</td>
</tr>
<tr>
<td>Random+25-ft sine</td>
<td>22%</td>
</tr>
<tr>
<td>wave</td>
<td></td>
</tr>
<tr>
<td>Random+50-ft upward</td>
<td>9%</td>
</tr>
<tr>
<td>Random+50-ft sine</td>
<td>9%</td>
</tr>
<tr>
<td>wave</td>
<td></td>
</tr>
<tr>
<td>Random+15-ft and 25-ft upward</td>
<td>118%</td>
</tr>
</tbody>
</table>

Effect of Added Wavelengths on IRI and PI

A second analysis was conducted to determine the effects of specific, individual wavelengths on ride statistics. Based on the very small variation in ride statistics between the five random profiles, this second analysis was only conducted using one of the random profiles. Figure 5 shows this sensitivity of IRI and PI_{0.0} to individually added wavelengths. Figure 6 shows the same information, but shows the wavelength range only from 0 to 1 ft (0 to 0.30 m). The analysis conducted added a sine wave of the specified wavelength to one of the random profiles used in the previous analysis.

Figure 5 shows that for wavelengths between about 5 and 8 feet (1.5 and 2.4 m) and from about 17 to 40 feet (5.2 and 12.2 m), the PI analysis indicates a greater sensitivity to roughness than IRI, and that between 8 and 17 (2.4 and 5.2 m) feet, the reverse is true. For wavelengths larger than 40 feet (12.2 m), both ride statistics tend not to show much increase with the addition of wavelength content in the profile. This means that the 15-foot (4.6-m) wavelength, which is likely related to joint spacing, would affect the IRI more than the PI ride statistic, and that the 25-foot (7.6-m) wavelength, often related to paver string line spacing, would affect the PI more than the IRI. Thus, a change in pavement smoothness specifications from PI to IRI would likely favor the contractor (provide larger bonus) in terms of string.

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\(1 \text{ ft} = 0.30 \text{ m}\)
line sag, and would favor the highway agency (provide smaller bonus) in terms of the 15-foot (4.6-m) joint spacing.

Figure 6 shows that the effect of tining and other macrotexture features in the pavement do not have as much of an effect on the IRI calculations, as they do for PI. This does not mean that texture does not affect the driver and passengers in a vehicle, as well as noise produced by the tire-pavement interaction, but simply that it does not significantly impact the IRI calculations.

The effect shown in Figures 5 and 6 is indicative of the “gain” shown in Figure 7, which is an indication of how much the ride statistic accentuates or attenuates specific wavelengths in pavement profiles. These plots are taken from Kulakowski and Wambold (5) for PI gain, and Sayers and Karamihas (6) for IRI gain.

![Figure 6 Sensitivity of IRI and PI to added wavelengths, highlighting 0 to 1 ft wavelengths.](image)

![Figure 7 Pavement profile wavelength response.](image)

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6 1 ft = 0.30 m
Effect of Tining

Mn/DOT construction specifications require a transverse metal-tine texture or an astro-turf or broom drag. However, current Mn/DOT special provisions allow for a turf drag or broom finish without tining. When tining is applied, a tining comb, according to Mn/DOT 2005 Standard Specification 2301.3L (7), must have a “randomized spacing of 16-26 mm (approximately 5/8 – 1 inch).” The “required tine width is 2-3 mm (approximately 1/12 – 1/8 inch) and the required tine depth is 3-8 mm (approximately 1/8 – 5/16 inch)”.

Using these parameters and the same random profile that was used in the analysis shown in Figures 5 and 6, a random pavement profile with a reverse profile of the randomly-spaced teeth in a tining comb was made. Since the tine spacing and width are very small, the reverse tining comb profile was resampled to a 0.1-ft (0.03-m) spacing, so that it would match the sampling interval used in the actual and generated profiles in the project. The resampling allowed the reverse tine profile to be added to the random profile at a 0.1-ft (0.03-m) spacing. Due to the resampling, much of the tining comb profile was lost.

The combined profile was then analyzed with ProVAL. Again, the random profile used was the same as that used in the previous analysis, shown in Figures 5 and 6. The spacing of the tines is purposefully random, but ranging between 0.052 and 0.083 ft (0.016 and 0.025 m). The ride values calculated by ProVAL are 64.3 in/mi (1.016 m/km) IRI, and 36.7 in/mi (0.580 m/km) PI0.0. This corresponds to a negligible increase in IRI (0.3%), and a 25% increase in PI0.0. The insignificant effect on IRI is to be expected, given the lack of change in the response curve in Figure 6 in the tining range.

While this specific example is based on randomly-generated pavement profiles and tining combs, the general effect seen would not be expected to change significantly when using real pavement profiles. Factors that might change the ride values include standard tining on a very smooth pavement surface (the relative effect of the tining would be larger than in this example) and a tined surface where the tine depth is greater than allowed in the standard specifications. If the tining is twice the allowable depth, the IRI in this example increases to 65.8 in/mi (1.040 m/km), and the PI0.0 increases to 40.5 in/mi (0.640 m/km).

Again, a negligible effect in IRI, but more significant in PI.

Incentives and Disincentives – IRI vs. PI0.2

Since the response of the IRI and PI ride statistics is different, depending on the presence of 15- and 25-foot (4.6- and 7.6-m) wavelengths, it is understandable that the bonus or penalty assigned to a segment of highway would also be different. This is perhaps at the root of the differences which paving contractors see as important. Contractors want to understand – before bidding a project – how they will be paid, and how incentives and disincentives will be assigned. If there is something the contractor can do to improve his bonus or limit his penalty, he is likely to do it.

Table 3 shows a summary of several actual pavement profiles selected for further analysis, their associated average roughness indices, and the average assigned incentives / disincentives, based on the Mn/DOT specifications and 0.1-mile (0.161-km) segments. These profiles were grouped according to their dominant wavelength content. Also in this table is the change in incentive payment compared to the “no dominant wavelength” category of profiles analyzed. It should be considered, however, that these profiles are measured from actual pavements, and that the specific effect of dominant wavelengths on the ride statistics is not as consistent and predictable as for the randomly-generated profiles. Since the objective of the project that funded this research is to convert an existing PI specification with a 0.2-inch (5-mm) blanking band to IRI, the PI ride statistic reported in this section of this paper is using the 0.2-inch (5-mm) blanking band.
Table 3  Summary of Wavelength Contribution to Roughness

<table>
<thead>
<tr>
<th>Dominant Wavelength, ft</th>
<th>IRI, in/mi</th>
<th>PI0.2, in/mi</th>
<th>IRI Incentive, $/0.1-mile segment</th>
<th>PI0.2 Incentive, $/0.1-mile segment</th>
<th>Average Change in Incentive Over &quot;None&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>60.07</td>
<td>1.31</td>
<td>$523.91 $542.87</td>
<td>-- $542.87</td>
<td>-- $542.87</td>
</tr>
<tr>
<td>15</td>
<td>69.51</td>
<td>1.45</td>
<td>$153.07 $517.41</td>
<td>-70.8% $476.94</td>
<td>4.7% $542.87</td>
</tr>
<tr>
<td>25</td>
<td>47.92</td>
<td>0.39</td>
<td>$842.25 $711.89</td>
<td>0.6% $130.36</td>
<td>31.1% $542.87</td>
</tr>
<tr>
<td>50</td>
<td>58.48</td>
<td>1.29</td>
<td>$538.10 $561.99</td>
<td>2.7% $539.79</td>
<td>3.5% $542.87</td>
</tr>
<tr>
<td>Multiple</td>
<td>68.35</td>
<td>1.66</td>
<td>$252.33 $566.85</td>
<td>51.8% $542.87</td>
<td>4.4% $542.87</td>
</tr>
</tbody>
</table>

Figure 8 shows the value of the average incentive paid for each segment within the various wavelength categories. When no particular dominant wavelength is present in the profile, both IRI and PI pay about the same incentive (for the particular profiles used in this analysis). The figure also shows that when only a 50-foot (15.2-m) wavelength is dominant in the data, both IRI and PI produce approximately the same incentive.

![Figure 8](attachment:image.jpg)  

Figure 8  Average incentive by dominant wavelength.

When comparing IRI and PI for profiles with a dominant 15-foot (4.6-m) wavelength, The IRI analysis produces a much lower incentive value than the same profile analyzed in terms of PI. Conversely, with a 25-foot (7.6-m) wavelength, the IRI incentive is greater than the PI incentive, although not as great a difference as with the 15-foot (4.6-m) wavelength. These two differences are

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7 1 ft = 0.30 m, 1 in/mi = 0.0158 m/km, 1 mi = 1.61 km
understandable when considering the differences in the frequency response of each roughness index, previously discussed.

There are several reasons why the IRI and PI analyses do not produce results consistent with each other. One major reason is the differences in how they each respond to the various frequencies present within individual profiles, as has been shown in this paper. These differences cannot be easily reconciled, if at all, and so it is not possible nor is it necessarily desirable to develop an IRI incentive algorithm that will always produce an incentive consistent with that computed by a PI algorithm. To do so would require analysis of the wavelengths present in the profiles and extensive adjustment of the profiles themselves to “overcorrect” for the particular wavelengths that are attenuated or accentuated by the IRI or PI analysis. It is neither feasible, nor recommended to try to conduct such analyses or corrections. Comparisons in this section, then, are made between the existing PI incentive and the proposed IRI incentive.

As discussed in the previous section, the major difference between the incentive calculations with the PI and IRI analyses is the 15- and 25-foot (4.6- and 7.6-m) wavelengths. Although the differences are not solely caused by these two wavelengths (other wavelengths where the two respond differently would also cause differences) these are some of few primary wavelengths found in the 375 profiles analyzed for this project.

EFFECT OF SEGMENT LENGTH
The Mn/DOT specified segment length for analyzing pavement surface profiles for smoothness incentives is 0.1 mile (0.161 km). Many, but not all, states with smoothness incentive specifications use this value. The segment lengths specified by other states vary between 0.01 and 1.0 mile (0.0161 to 1.61 km). In order to evaluate the effect of segment length on IRI and the corresponding incentive / disincentive, three actual profiles were selected and analyzed using the ProVAL software with five different segment lengths – 0.01, 0.1, 0.25, 0.5, and 1.0 miles (0.0161, 0.161, 0.402, 0.805, and 1.61 km) per segment. The 0.01-mile (0.0161-km) segment length is the shortest of the states analyzed, and is specified by the Virginia DOT (8).

Figure 9 shows the average and standard deviation of IRI for the three profiles. The average IRI for any segment length does not change significantly, although the standard deviation decreases as segment length increases. The largest improvement in standard deviation occurs between the 0.01- and 0.1-mile (0.0161- and 0.161-km) segment lengths.

Figure 10 shows the total incentive that would be paid by the current Mn/DOT 2006 IRI Pilot Specification for PCC pavements, normalized to dollars per mile of project length. Again, the largest change is between the 0.01- and 0.1-mile (0.0161- and 0.161-km) segment lengths. As segment length increases beyond 0.1-mile (0.161-km), there are only small increases in incentive payment.

Besides being a standard length specified by most states, the 0.1-mile (0.161-km) segment length produces average IRI values, per individual segment, almost identical to those produced by other segment lengths. The standard deviation in the IRI values indicates much lower variability than in 0.01-mile (0.0161-km) segment length, and only slightly higher than with the longer segment lengths. The incentive calculated from IRI values with segment lengths less than 0.1-mile (0.161-km) seems to take advantage of the large variability in the values to reduce the overall incentive for the project.

An argument could be made to specify 1.0-mile (0.161-km) segments, with almost identical average IRI values as the 0.1-mile (0.161-km) segment, lower variability in IRI between segments, and only slightly higher total incentive values. Although this would not reduce the amount of profile measurement that must be conducted in the field, it would decrease the number of segments over an entire project. There are other reasons for and against the length of the segments, which are beyond the scope of this paper.
Figure 9  IRI average and standard deviation with varying segment length\(^8\).

Figure 10  Total incentive payment with varying segment length\(^8\).

\(^8\) 1 in/mi = 0.0158 m/km, 1 mi = 1.61 km
SUMMARY AND CONCLUSIONS
This paper presented analyses on theoretical, random pavement profiles as well as on actual profiles measured on newly-constructed Minnesota highways constructed with portland cement concrete. The relative effect of various component wavelengths on the PI and IRI analyses was discussed, and the resulting effect on the incentive and disincentive calculations was presented.

In general, features in the pavement (either in the design or construction) at about 15 feet (4.6 m) per cycle affect the IRI calculation more than PI, and the opposite is true for pavement features at about 25 feet (7.6 m) per cycle.

Incentives and disincentives specified by Mn/DOT in the existing PI_{0.2} specification will be affected by a change to a new IRI specification, but the relative effects will be based on the features designed and/or constructed in the new PCC pavement.

In the analysis to identify the optimum, or appropriate segment length for the incentive computation, any segment length between 0.1 and 1.0 mile (0.161 and 1.61 km) would not affect the IRI or the incentive/disincentive calculation significantly. There may be other reasons that an individual state might desire a particular segment length.

This paper focused only on the effect of wavelength and segment length on the PI and IRI incentive computations, but did not focus on the other aspects of smoothness specifications.

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REFERENCES