IRI Smoothness Criteria for Asphalt Concrete Pavements in Louisiana

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ABSTRACT

This paper presents the results of research conducted to develop smoothness criteria based on the International Roughness Index (IRI) for asphalt pavements in Louisiana. Measurements of longitudinal profiles using the high-speed profiler were conducted along 73 miles of pavement in 23 different projects. The profile index with 0.2-inch blanking bandwidth and IRI were determined from the collected data. Statistical analysis was conducted to establish relationship between IRI and profile index with 0.2-inch blanking bandwidth. The proposed mathematical models were used to develop smoothness criteria based on IRI for asphalt pavements in Louisiana.

INTRODUCTION

Currently, evaluation of pavement smoothness in Louisiana for construction acceptance and pay adjustment is conducted using the profile index with 0.2 in. blanking bandwidth (PI_2). There is a concern among state highway agencies regarding the use of PI_2 for evaluation of pavement smoothness and ride quality. Evaluation of pavement smoothness using the PI_2 results in filtering portion of the pavement roughness, and therefore, shows smoother roads than reality.

The international roughness index (*IRI*) was introduced to quantify the roadway smoothness from the longitudinal road profile. After measurement of longitudinal road profile, the *IRI* is determined using a mathematical model by accumulating the output of quarter-car model and dividing by the profile length. The *IRI* is expressed in mm/km or inch/mile. The *IRI* is a rational indicator that reflects the smoothness of pavements and ride quality.

There is an ongoing effort by Louisiana Department of Transportation and Development (LA DOTD) to switch the pavement smoothness criteria from PI_2 to *IRI*. It is believed that this step will lead to reliable evaluation of pavement smoothness in Louisiana and produce smoother roads. This paper presents the results of research conducted to develop *IRI*-based smoothness criteria for evaluation of asphalt concrete pavements in Louisiana.

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BACKGROUND

The use of the *IRI* is becoming increasingly popular among the state highway departments. Virginia and Pennsylvania have developed new specification for roadway smoothness based on *IRI*. Virginia Department of Transportation (VDOT) developed special provision regarding the smoothness of asphalt pavement surfaces based on the international roughness index and is administered with a laser-equipped South Dakota-style inertial road profiler. The pay factors and the corresponding required smoothness values of pavement surfaces are presented in Table 1.

Table 1 – Virginia DOT pay adjustment criteria based on final IRI (McGhee 2000)

IRI After Completion (mm/km)	Pay Adjustment (% Pavement unit price)
Under 710.0	104
710.1 – 790.0	103
790.1 – 870.0	102
870.1 – 950.0	101
950.1 – 1100.0	100
1100.1 – 1260.0	98
1260.1 – 1420.0	95
1420.1 – 1580.0	90
Over 1580.1	Subject to corrective action
Under 870.0	104
870.1 – 950.0	103
950.1 – 1025.0	102
1025.1 – 1100.0	101
1100.1 – 1260.0	100
1260.1 – 1420.0	98
1420.1 – 1580.0	95
1580.1 – 1740.0	90
Over 1740.1	Subject to corrective action

IRI units may be converted to in/mile by multiplying by 0.06336

The current LA DOTD specifications for pay adjustment are based on the profile index with 0.2 inch blanking bandwidth. Table 2 presents the pay adjustment criteria using the PI_2 according to the standard specification of LA DOTD.

METHODOLOGY

Twenty-three sections on asphalt concrete pavement were identified for this research. These sections are located on major highways in Louisiana and represent a wide range of pavement smoothness. Profile data were collected on these sections using the Louisiana Transportation

Research Center (LTRC) high-speed road profiler. The profiler uses three laser height sensors to measure the distance between the road and a vehicle reference point. The IRI and profile index with 0.2-inch blanking bandwidth were determined from the measured longitudinal profile.

Table 2 – LA DOTD pay adjustment criteria based on PI_2

Payment Adjustment (%) Current Specifications Based on PI_2	100	95	80	50 or Remove
Multi-lift new construction and overlays more than two lifts	# 3.0	3.1 – 4.0	4.1 – 6.0	> 6.0
Single-lift construction over cold planed surfaces and two lift overlays	# 5	5.1 – 6	6.1 – 10	> 10
Single-lift overlays over existing surfaces	#8	8.1 – 10	10.1 – 15	> 15

ANALYSIS OF COLLECTED DATA

The profile data collected using the high-speed profiler were processed to obtain the profile index with 0.2 inch blanking bandwidth and the international roughness index. Figure 1 depicts the calculated *IRI* versus PI_2 for the investigated pavement sections. Examination of Figure 1 shows that there is high variability in the data; however, a correlation between *IRI* and PI_2 might be possible to obtain. Statistical analyses were conducted to evaluate the correlation between *IRI* and PI_2 and to assess the possibility of getting reliable prediction of *IRI* using PI_2. The analyses consisted of regression analysis and analysis of variance.

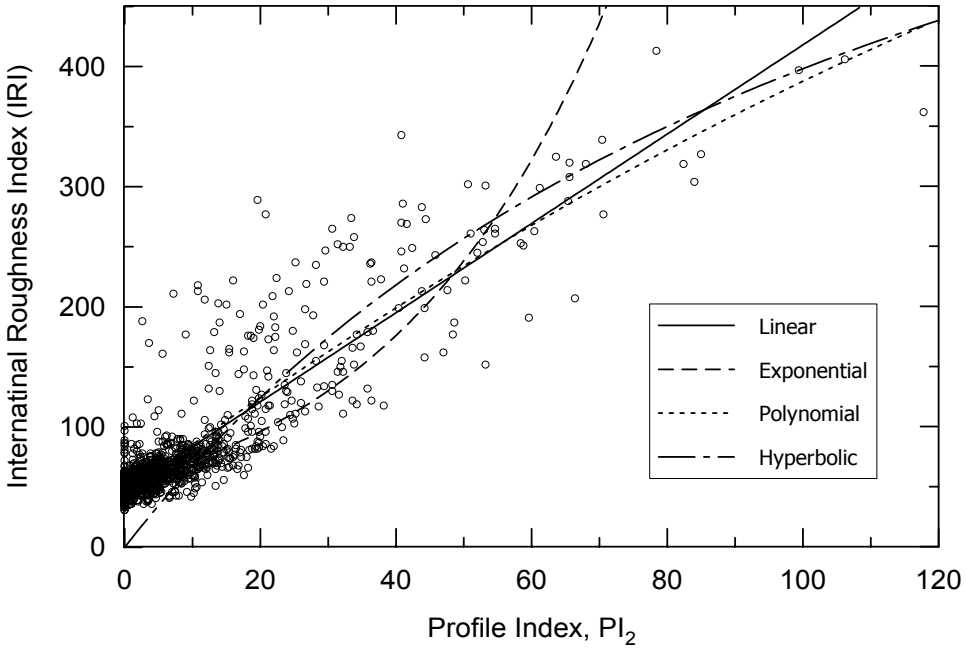

Figure 1: IRI versus PI_2 of the investigated pavement sections.

Regression Analysis

Regression analysis was conducted in which four different functions were attempted to establish relationship between *IRI* and PI_2. These functions are linear, exponential, hyperbolic, and polynomial. Results of the regression analysis are presented in Figure 1. The linear function with intercept (Figure 1) is given by the following equation:

$$IRI = 46.77 + 3.71PI_2 \quad (1)$$

the coefficient of determination (R^2) for Equation 1 is 0.79 and the standard error of estimation is 25.3. The following exponential, hyperbolic, and polynomial functions were also obtained using regression analysis:

$$IRI = \begin{cases} 52.73e^{0.0302PI_2} \\ \dfrac{7.25PI_2}{1+0.0082PI_2} \\ 44.8 + 4.15PI_2 + 0.0072PI_2^2 \end{cases} \quad (2)$$

R^2 for these relationships are 0.70, 0.78, and 0.79, respectively. The standard error of estimation for the hyperbolic function is 44.75. Results of the regression analysis showed that *IRI* could not be estimated from PI_2 with an acceptable margin of uncertainty. The proposed relationships in Equations 1 and 2 were used to predict *IRI* corresponding to the PI_2 values used in LA DOTD specification. The results are presented in Table 3.

Table – 3: International roughness index predicted from profile index with 0.2 inch blanking bandwidth using different functions.

PI_2	Predicted IRI			
	Linear $R^2 = 0.79$	Exponential $R^2 = 0.70$	Hyperbolic $R^2 = 0.78$	Polynomial $R^2 = 0.79$
3	57.9	57.7	21.2	57.2
4	61.6	59.5	28.1	61.3
5	65.3	61.3	34.8	65.4
6	69.1	63.2	41.5	69.4
8	76.5	67.1	54.4	77.5
10	83.9	71.3	67.0	85.6

15	102.5	82.9	96.8	105.4

Analysis of Variance

The results of the regression analysis on the data did not yield good results. This is due to the high variability of the relationship between *IRI* and PI_2 especially at high PI_2 values. Therefore, analysis of variance was conducted on the collected data with PI_2 less or equal to 20. The reason is that for PI_2 of more than 20 the data showed the highest variability; in addition, at this level of PI_2 the pavement surface is rough and might not be safe and functional.

The *IRI* values corresponding to PI_2 range from 0 to 0.5 were grouped together. Then, the number of points, mean, standard deviation, and coefficient of variation for *IRI* were calculated. Calculations were also conducted for PI_2 range from 0.5 to 1.0 up to the maximum value of PI_2. The results are shown in Figure 2. Inspection of Figure 2 shows that there is a well-defined relationship between *IRI* and PI_2 up to PI_2=20. For PI_2>20, the data show high degree of variability. Therefore, the analysis will consider the well-defined portion of the data with PI_2 less or equal to 20. This is acceptable since the objective of the research was to establish criteria of pavement smoothness for acceptance and pay of pavement construction and maintenance. Therefore, the analysis will focus on low values of *IRI* and PI_2, which indicate smooth pavements.

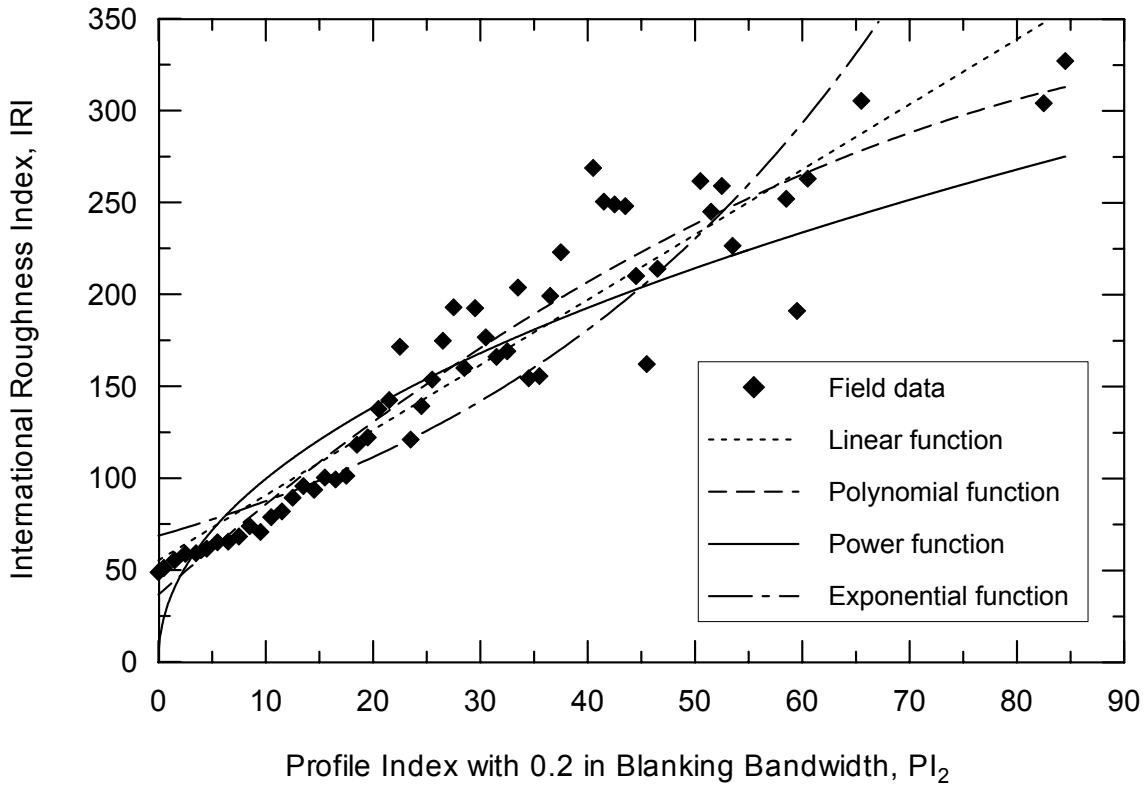

Figure 2: Mean IRI versus mean PI_2.

Figure 3 depicts the mean *IRI* + standard deviation versus PI_2. Different functions were used to develop models between *IRI* and PI_2. These functions are linear, polynomial, and exponential. These correlations have high coefficient of determination and therefore considered herein to predict the *IRI* from PI_2. The results of the analysis shown in Figure 3 were used to propose smoothness specifications for asphalt pavements in Louisiana based on IRI. The proposed specifications are summarized together with the current specifications in Table 4.

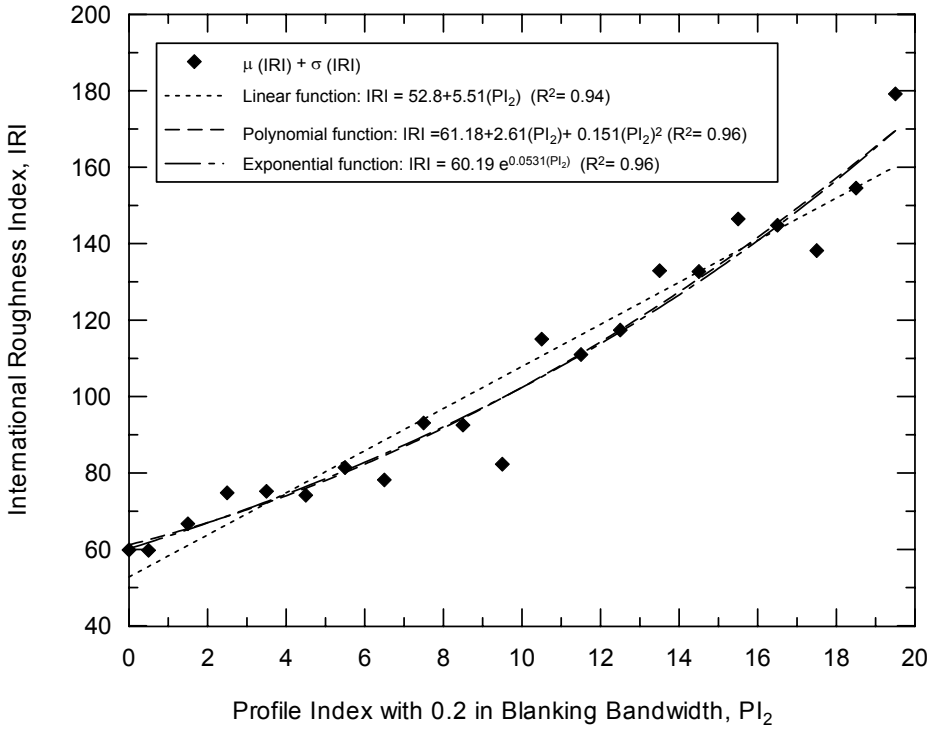

Figure 3: Mean IRI + standard deviation versus mean PI_2.

CONCLUSIONS

Evaluation of pavement smoothness in Louisiana for construction acceptance and pay adjustment is conducted using the profile index with 0.2 in. blanking bandwidth (PI_2). Evaluation of pavement smoothness using the PI_2 results in filtering portion of the pavement roughness, and therefore, shows smoother roads than reality. This paper presented the results of research conducted to help LA DOTD develop a pavement smoothness criteria based on *IRI*. Statistical analysis was conducted and used to develop mathematical correlations between IRI and profile index. These correlations were used to develop smoothness criteria based on IRI for asphalt pavements in Louisiana.

Table – 4: Louisiana proposed surface tolerance specifications based on international roughness index

	Payment Adjustment (%)	100	95	90	80	50 or Remove
Multi-lift new construction and overlays more than two lifts	Current Specifications Based on PI_2	# 3.0	3.1-4.0	NA	4.1-6.0	> 6.0
	Corresponding *IRI* Specifications	< 65	NA	NA	NA	> 65
Single-lift construction over cold planed surfaces and two lift overlays	Current Specifications Based on PI_2	# 5	5.1-6	NA	6.1-10	> 10
	Corresponding *IRI* Specifications	< 70	NA	71-89	NA	> 89
Single-lift overlays over existing surfaces	Current Specifications Based on PI_2	#8	8.1-10	NA	10.1-15	> 15
	Corresponding *IRI* Specifications	< 85	NA	86-110	NA	> 110

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