Correlation of Present Serviceability Ratings with International Roughness Index

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The Indiana Department of Transportation (INDOT) is using a pavement management system to identify roads for periodic maintenance and reconstruction. The present serviceability index (PSI), pavement riding comfort index, is one of the major factors in selecting roads for rehabilitation. This study searched statistically realistic models for PSI and international roughness index (IRI) correlation. Ten randomly selected subjects rated 1-mi-long test sections at three roughness levels for both concrete and bituminous pavements. Two nearly identical cars were used, and each subject rated the 20 test sections as a driver and as a front seat passenger. Each rater assigned a PSI value between 0 and 5 (0 for worst, 5 for best) and also marked whether the ride on the section was acceptable. The IRI of each test section was measured by a van equipped with noncontact laser sensors. The statistical analyses indicated that the PSI rating observations were normally distributed, the variances were homogeneous, and the position of the rater in the car was not significant. Then the average PSI ratings and IRI values of the test sections were used for model searches. Simple linear and exponential models were obtained to fit the data with r^2-values ranging from 0.80 to 0.95. The acceptable service level IRI values were obtained by a logistic regression model using the average IRI and acceptance-rejection data of the test sections. Now INDOT can predict PSI values from collected IRI data. Using the IRI data and acceptable service level values, INDOT can identify roads for rehabilitation.

The Roadway Management Division of the Indiana Department of Transportation (INDOT) is utilizing a pavement management system for optimum rehabilitation of their highway system. The present serviceability index rating (PSI ratings or simply PSI) is one of the major factors in selecting the roads for rehabilitation and reconstruction. A realistic prediction of the PSI values may be obtained from the measured international roughness index (IRI) or the measured roughness number (RN or RIDE-SCORE).

Three research studies have been performed in Indiana to correlate PSI ratings with RN values. The first one was a Joint Highway Research Project study (*1*) by Mohan in 1978 in which a total of 94 test sections were selected on four pavement types—flexible, asphalt overlay, continuously reinforced concrete, and jointed reinforced concrete. A 20-member panel rated the test sections for PSI values, and RN values were measured by the PCA road meter. The PSI rating data were correlated with the RN with r^2-values ranging from 0.46 to 0.78.

The second research study, performed in 1982 by Trezos and Gulen (*2*), was undertaken to reestablish the PSI versus RN relationship developed by Mohan. This study was similar in design to the first one, but with several improvements. The PSI rating data versus RN models developed in the second study resulted in r^2-values ranging from 0.68 to 0.71.

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The third research study, performed in 1984 by Gulen et al. (*3*), examined the relationship between PSI ratings and RN as well as the effects of the pavement types, the rater's occupation, and the rater's vehicle type on the PSI ratings. Twelve raters (four highway engineers, four technical people, and four nontechnical people) rated 68 test sections for PSI on bituminous and concrete pavements. The PSI ratings were obtained by subjects who drove three car types (compact, mid-size, and full-size).

In the latest research study, performed outside Indiana, Al-Omari and Darter obtained data from Louisiana, Michigan, New Jersey, New Mexico, Indiana, and Ohio. Their results are reported in another paper in this Record. The relationships between IRI and PSI ratings were analyzed, and the following model was recommended:

$$PSI = 5 * e^{(-0.26 * IRI)} \quad (1)$$

where IRI is in millimeters per meter or

$$PSI = 5 * e^{(-0.0041 * IRI)} \quad (2)$$

where IRI is in inches per mile. The above prediction equations are not correct statistically; in fact, they are biased because they were forced to pass through PSI = 5 when IRI is zero.

For the current study only 10 randomly chosen raters were used to evaluate 20 randomly selected sections in Indiana to examine the relationships between PSI and IRI. There were 9 sections on bituminous and 11 sections on concrete pavement. The raters used two nearly identical cars (1992 Dodge Spirit) and made evaluations both as drivers and as right front seat passengers.

OBJECTIVE OF STUDY

The two main objectives of this study were as follows:

1. To establish statistically valid and realistic models between PSI ratings and IRI for both bituminous and concrete pavements using a minimum number of raters. For conversion of historical data, RIDE-SCORE was included in this study.
2. To define an unacceptable PSI rating value (critical PSI) for each pavement type or the types combined.

SCOPE OF WORK

Design of Experiment

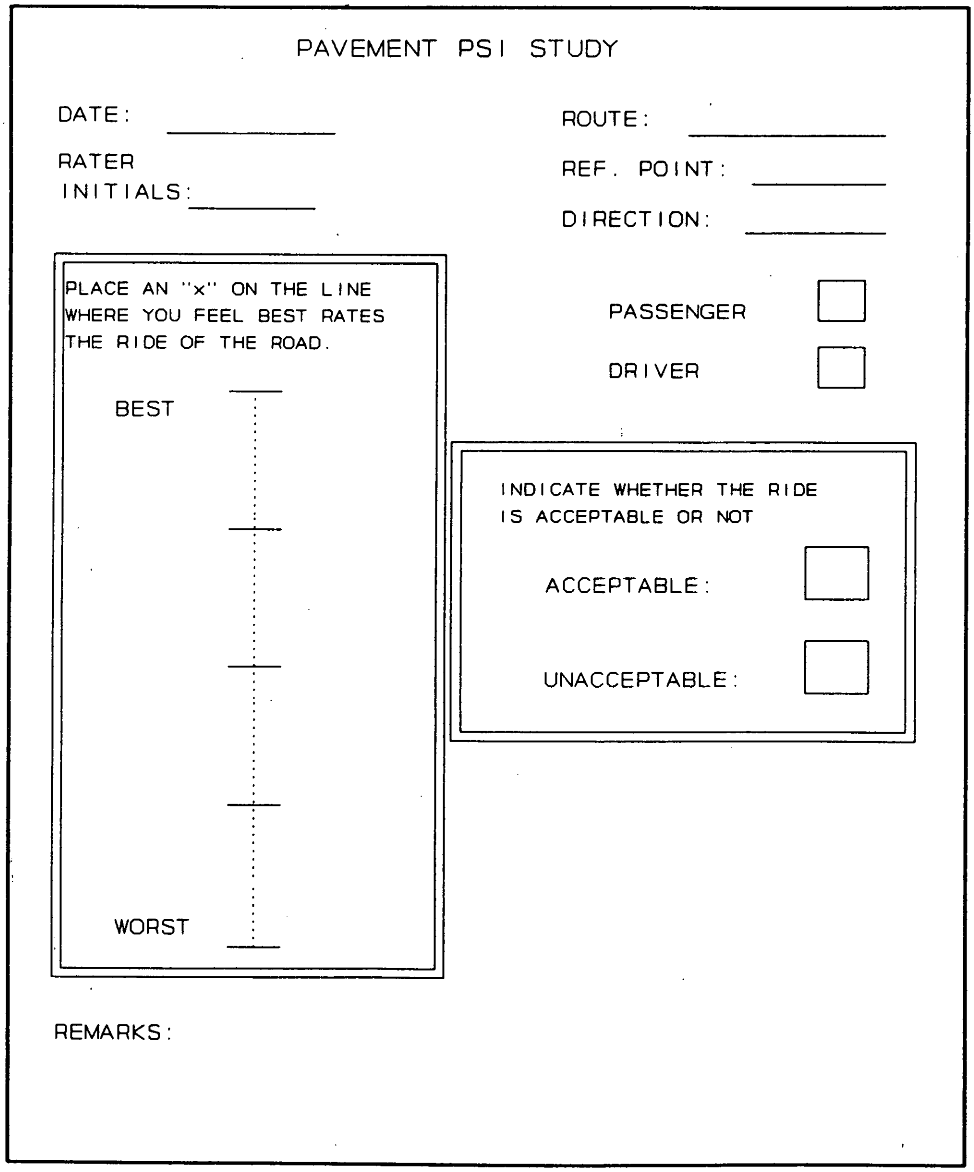
Ten subjects were selected to rate the test sections as a driver and passenger using one of the two nearly identical cars. Each person rated the sections once as a driver and once as a right front seat passenger. The design factors used in this study were

- Pavement type (fixed, two levels)
  —Bituminous pavement and
  —Concrete pavement.
- Roughness level (fixed, three levels)
  —Low (smooth roads),
  —Medium (medium smooth roads), and
  —High (rough roads).
- Test sections (random). A minimum of three 1-mi-long sections per roughness level for each pavement type was selected.
- Raters (random). Ten subjects were selected to rate the sections for PSI ratings.
- Location of raters in the car (fixed, two levels)
  —As a driver and
  —As a passenger (front seat).

Procedures for PSI Rating Data Collection

Selection of Raters

Ten subjects were randomly selected from INDOT. It was necessary to select raters within INDOT because of budget constraints and insurance liability.



PAVEMENT PSI STUDY

DATE: ____________ ROUTE: ____________

RATER INITIALS: ____________ REF. POINT: ____________

DIRECTION: ____________

PLACE AN "x" ON THE LINE WHERE YOU FEEL BEST RATES THE RIDE OF THE ROAD.

BEST

WORST

PASSENGER ☐

DRIVER ☐

INDICATE WHETHER THE RIDE IS ACCEPTABLE OR NOT

ACCEPTABLE: ☐

UNACCEPTABLE: ☐

REMARKS:

FIGURE 1 Data rating form.

TABLE 1 Expected Mean Squares for Full Model

	a F i	b R j	c R k	d F l	1 R n	EXPECTED MEAN SQUARES (EMS)
R_i	0	b	c	c	1	$\sigma^2+d\ \sigma^2_{SP}+bd\ \sigma^2_{RP}+cd\ \sigma^2_S+bcd\ \phi(R)$
$S_{(i)j}$	1	1	c	d	1	$\sigma^2+d\ \sigma^2_{SP}+cd\ \sigma^2_S$
P_k	a	b	1	d	1	$\sigma^2+d\ \sigma^2_{SP}+abd\ \sigma^2_P$
RP_{ik}	0	b	1	d	1	$\sigma^2+d\ \sigma^2_{SP}+bd\ \sigma^2_{RP}$
$SP_{(i)jk}$	1	1	1	2	1	$\sigma^2+d\ \sigma^2_{SP}$
L_l	a	b	c	0	1	$\sigma^2+\sigma^2_{SPL}+ab\ \sigma^2_{PL}+c\ \sigma^2_{SL}+abc\ \phi(L)$
RL_{il}	0	b	c	0	1	$\sigma^2+\sigma^2_{SPL}+b\ \sigma^2_{RPL}+c\ \sigma^2_{SL}+bc\ \phi(RL)$
$SL_{(i)jl}$	1	1	c	0	1	$\sigma^2+\sigma^2_{SPL}+c\ \sigma^2_{SL}$
PL_{kl}	a	b	1	0	1	$\sigma^2+\sigma^2_{SPL}+ab\ \sigma^2_{PL}$
$RPL_{(i)kl}$	0	3	1	0	1	$\sigma^2+\sigma^2_{SPL}+b\ \sigma^2_{RPL}$
$SPL_{(i)jl}$	1	1	1	0	1	$\sigma^2+\sigma^2_{SPL}$
$\epsilon_{(ijkl)1}$	1	1	1	1	1	σ^2 random error term

Selection of Vehicles

Two nearly identical mid-size vehicles (1992 Dodge Spirit), owned by INDOT, were selected.

Selection of Test Sites

Three 1-mi-long test sections in each of the three roughness levels were randomly selected for bituminous pavement. A total of eleven 1-mi-long test sections were randomly selected for concrete pavement: three high roughness sections, four medium roughness sections, and four low roughness sections.

Instruction to PSI Raters

The raters were given a 1-hr orientation in which the road PSI rating responsibilities were described. Figure 1 shows the data

TABLE 2 Expected Mean Squares for Reduced Model

	a F i	b F j	c R k	d R l	n R n	EXPECTED MEAN SQUARES (EMS)
T_i	0	b	c	d	n	$\sigma^2+n\ \sigma^2_{SP}+bcn\ \sigma^2_{TP}+dn\ \sigma^2_S+bcdn\ \phi(T)$
$R_{(i)j}$	0	0	c	d	n	$\sigma^2+n\ \sigma^2_{SP}+cn\ \sigma^2_{RP}+dn\ \sigma^2_S+cdn\ \phi(R)$
$S_{(ij)k}$	1	1	1	d	n	$\sigma^2+n\ \sigma^2_{SP}+dn\ \sigma^2_S$
P_l	a	b	c	1	n	$\sigma^2+n\ \sigma^2_{SP}+abcn\ \sigma^2_P$
TP_{il}	0	b	c	1	n	$\sigma^2+n\ \sigma^2_{SP}+bcn\ \sigma^2_{TP}$
$RP_{(i)jl}$	0	0	c	1	n	$\sigma^2+n\ \sigma^2_{SP}+cn\ \sigma^2_{RP}$
$SP_{(ij)k}$	1	1	1	1	n	$\sigma^2+n\ \sigma^2_{SP}$
$\epsilon_{(ijkl)r}$	1	1	1	1	1	σ^2 random error term

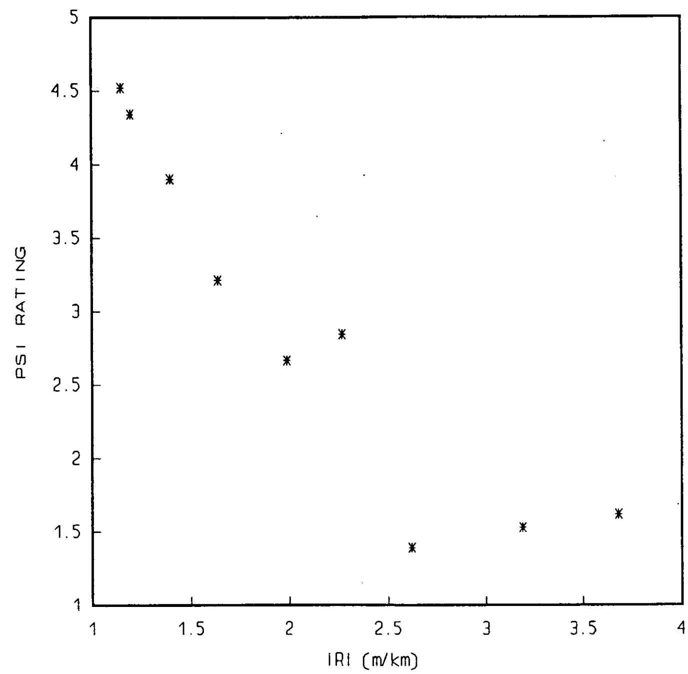


FIGURE 2 Average PSI versus average IRI (bituminous). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

rating form used in this experiment. The raters were instructed to evaluate the sections as a driver and as a front seat passenger on different days to minimize being influenced by their previous rating. They were to mark their PSI rating opinion value on the scale on the form and were asked to note whether the section was acceptable. A constant speed of 55 mph was specified to be maintained during the rating procedure.

IRI Data Collection

The IRI data for the selected test sections were collected by a noncontact, laser-based profilometer, designed in accordance with the World Bank recommendations, installed in a van and meeting FHWA Class II specifications for Highway Pavement Management System data collection. Three runs were made for each section at a near-constant speed to determine the IRI value. The standard deviation of the instrument can be as low as 0.25 in/mi for uniform road surfaces.

RIDE-SCORE Data Collection

The RIDE-SCORE data were collected by the Ultrasonic Ranging Road Meter-CS 8000 Model E installed in a second van (*4*). Three readings were obtained at constant speed.

DATA ANALYSIS

Analysis of PSI Versus IRI and RIDE-SCORE

The following steps were taken in the data analysis of the PSI ratings.

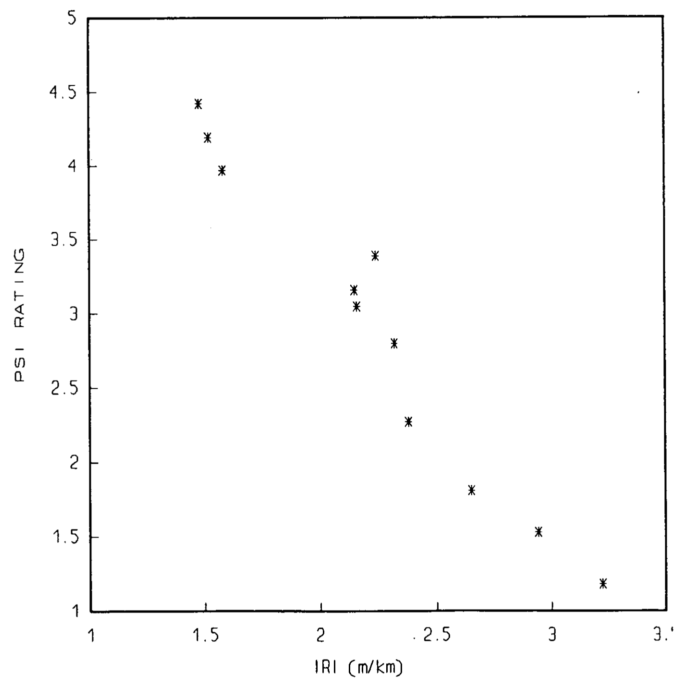


FIGURE 3 Average PSI versus average IRI (concrete). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

TABLE 3 Prediction Equations for PSI Values

NO	SURFACE	PREDICTION EQUATION	r^2	MSE
1	Bituminous	$\hat{PSI}=4.8 - 0.06\ RIDE$	0.86	0.232
2	Bituminous	$\hat{PSI}= 5.70\ e^{-0.02\ RIDE}$	0.94	0.165
3	Bituminous	$\hat{PSI}= 9.9 - 4.8\ Log_{10}(RIDE)$	0.92	0.131
4	Bituminous	$\hat{PSI}= 5.5 - 1.25\ IRI$	0.85	0.251
5	Bituminous	$\hat{PSI}= 7.21\ e^{-0.47\ IRI}$	0.84	0.143
6	Bituminous	$\hat{PSI}= 4.8 - 6.36\ Log_{10}(IRI)$	0.92	0.135
7	Bituminous	$\hat{PSI}= 8.3 - 3.78\sqrt{IRI}$	0.89	0.183
8	Concrete	$\hat{PSI}= 5.8 - 0.08\ RIDE$	0.88	0.155
9	Concrete	$\hat{PSI}= 8.75\ e^{-0.0302\ RIDE}$	0.90	0.149
10	Concrete	$\hat{PSI}= 13.7-6.9\ Log_{10}(RIDE)$	0.89	0.142
11	Concrete	$\hat{PSI}= 7.1 - 1.88\ IRI$	0.95	0.061
12	Concrete	$\hat{PSI}= 14.05\ e^{-0.74\ IRI}$	0.93	0.129
13	Concrete	$\hat{PSI}= 6.0 - 9.35\ Log_{10}(IRI)$	0.94	0.081
14	Concrete	$\hat{PSI}= 11.2 - 5.58\sqrt{IRI}$	0.95	0.066
15	Bit.& Conc.	$\hat{PSI}= 5.2 - 0.06\ RIDE$	0.83	0.229
16	Bit.& Conc.	$\hat{PSI}= 6.59\ e^{-.03\ RIDE}$	0.86	0.251
17	Bit.& Conc.	$\hat{PSI}=10.5-5.0\ Log_{10}(RIDE)$	0.80	0.255
18	Bit.& Conc.	$\hat{PSI}= 6.1 - 1.46\ IRI$	0.86	0.183
19	Bit.& Conc.	$\hat{PSI}= 9.00\ e^{-0.56\ IRI}$	0.84	0.161
20	Bit.& Conc.	$\hat{PSI}=5.2 - 7.16\ Log_{10}(IRI)$	0.87	0.162
21	Bit.& Conc.	$\hat{PSI}= 9.2 - 4.32\sqrt{IRI}$	0.88	0.163

Where:

r^2 : *Coefficient of Determination*

$$MSE = \frac{\sum_{i=1}^{N} (\hat{PSI} - PSI)^2}{N - u}$$; *Mean Square Error*

N : *Number of data points*

u : *Number of Parameters in the Prediction Equation*

$\hat{PSI}$: *Predicted Present Serviceability Index-Rating*

PSI : *Observed Present Serviceability Index-Rating*

IRI : *International Roughness Number in inches / mile.*

Note: IRI is in units of mm/m. (1 mm/m = 63.36 in/mi).

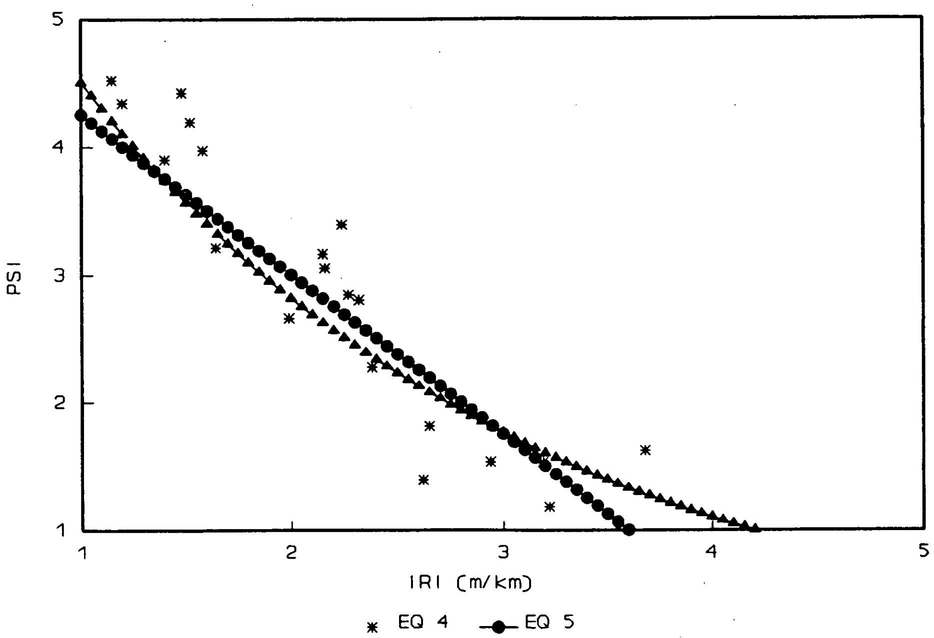


FIGURE 4 Prediction equations 4 and 5 for bituminous pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

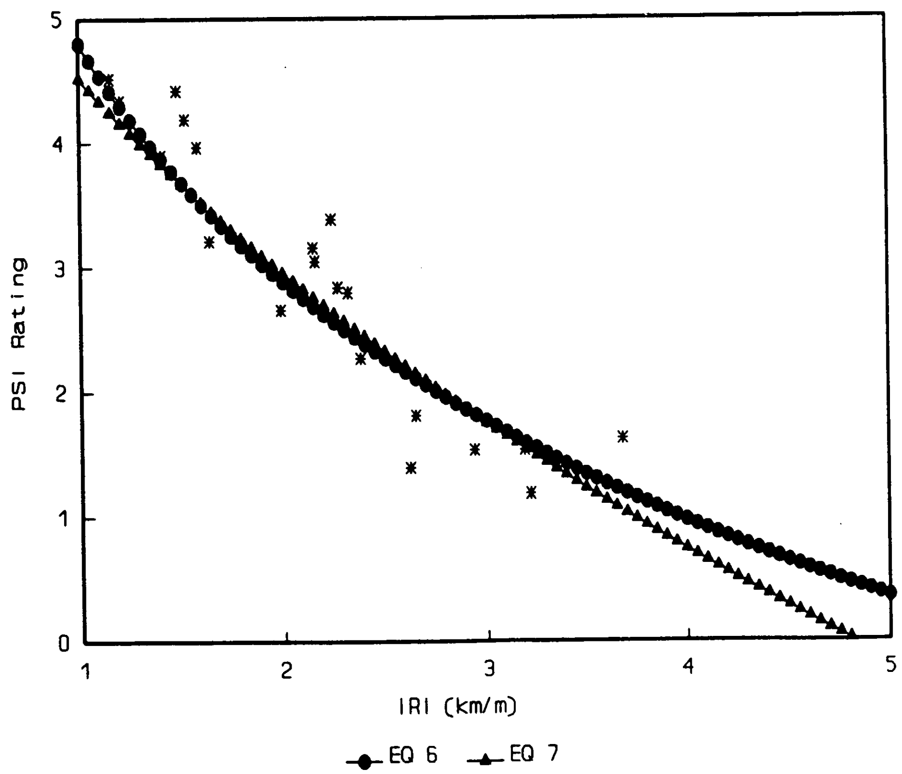


FIGURE 5 Prediction equations 6 and 7 for bituminous pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

Normality of PSI Rating and Homogeneity of Variances

The distribution of the PSI ratings for each test section was checked and found to be normal for both pavements types. The variances of the PSI ratings among the test sections were checked and found to be homogeneous for both pavement types.

Analysis of Variance

The main purpose of this step was to determine whether the position of the rater in the car was significant. Before the actual numerical procedure can be run, however, the expected mean squares (EMS) for the proposed model (Equation 3) must be derived (5–7).

The analysis of variance (ANOVA) model was as follows:

$$PSI_{ijkln} = \mu + R_i + S_{(i)j} + P_k + RP_{ik} + SP_{(i)jk} + L_l + RL_{il} + SL_{(i)jl} + PL_{kl} + RPL_{ikl} + SPL_{(i)jkl} + \epsilon_{(ijkl)1} \quad (3)$$

where

PSI = present serviceability index rating;
μ = overall mean;
R_i = roughness levels, fixed (i = 1,2,3);
$S_{(i)j}$ = test sections, random, within roughness levels;
P_k = raters, random (k = 1, . . . , 10);
L_l = rater's location in car, fixed (l = 1,2);
RL = interaction of roughness with rater's location;
RP = interaction of roughness with rater;
SP = interaction of section with rater;

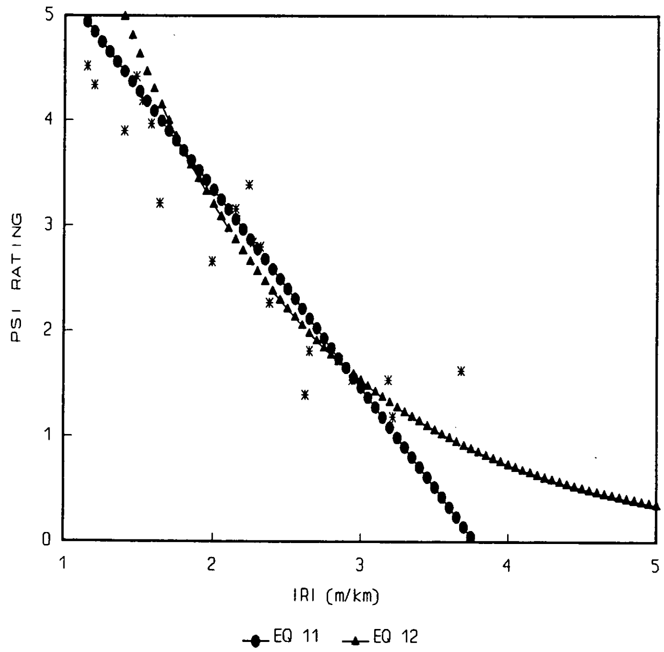


FIGURE 6 Prediction equations 11 and 12 and concrete pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

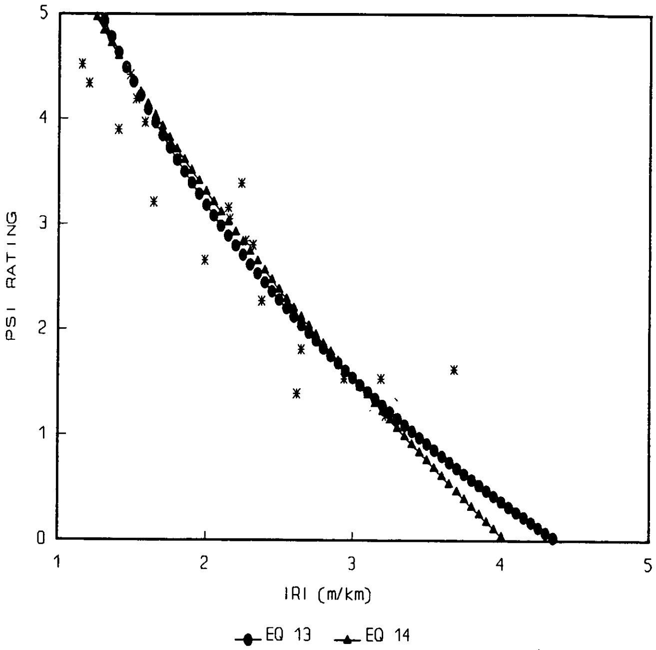


FIGURE 7 Prediction equations 13 and 14 for concrete pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

SL = interaction of section with rater's location;
PL = interaction of rater with rater's location;
RPL = interaction of roughness, rater, and location;
SPL = interaction of rater, section, and location; and
$\epsilon_{(ijkl)1}$ = experimental error assumed normal and independently distributed $NID(0, \sigma^2)$.

Because there was no replication, the three-way interaction, *SPL*, was used as an error term. The EMS table (Table 1) shows how various *F*-tests should be performed.

F-test for *L*:

$$F = \frac{EMS(L) + EMS(SPL)}{EMS(PL) + EMS(SL)} \quad (4)$$

The number of test sections for concrete pavement was not the same for each roughness level; therefore the statistical analysis system (SAS) at Purdue University was used for statistical computations (*8*). The statistical computations indicated that the position of the raters in the car was not significant (*F*-value was less than 1). Then, the following reduced ANOVA model (Equation 3) was written to check the effect of the surface type as well as the other terms.

$$PSI_{ijkln} = \mu + T_i + R_{(i)j} + S_{(ij)k} + P_l + TP_{il} + RP_{(i)jl} + SP_{(ij)kl} + \epsilon_{(ijkl)n} \quad (5)$$

where

μ = overall mean;
T_i = pavement type, fixed (i = 1,2);
$R_{(i)j}$ = roughness levels, fixed;
$S_{(ij)k}$ = sections, random, within roughness levels;

P_l = raters, random;
TP = interaction of pavement with rater;
RP = interaction of roughness with rater;
SP = interaction of section with rater; and
$\epsilon_{(ijkl)n}$ = experimental error, $NID(0, \sigma^2)$.

The corresponding EMS table (Table 2) was prepared to show various F-tests.

F-test for T, pavement type:

$$F = \frac{EMS(T) + EMS(SP)}{EMS(TP) + EMS(S)} \quad (6)$$

Statistical computations indicated that pavement type was not significant (F-value was less than 1).

PSI Rating Versus IRI and RIDE-SCORE

Because the distribution of PSI ratings for each test section was found to be normal and the variances among the test sections were homogeneous, the PSI ratings for each test section were averaged. Similarly, the IRI and RIDE-SCORE values for test sections were averaged. Various plots were prepared to see the nature of the PSI ratings and corresponding IRI and RIDE-SCORE (see Figures 2 and 3 for overall average PSI ratings).

Regression analyses were performed using the average data to relate PSI ratings to the IRI and RIDE SCORE. Regression models that best fit the data are listed in Table 3 for each pavement type and combination of both pavements. The regression equations and combined actual data are plotted in Figures 4 through 11.

Figures 4 and 5 show the Prediction Equations 4 through 7 for bituminous pavements. Figures 6 and 7 show the Prediction Equations 11 through 14 for concrete pavements. Figures 8 and 9 show the Prediction Equations 18 through 21 for both pavement types combined.

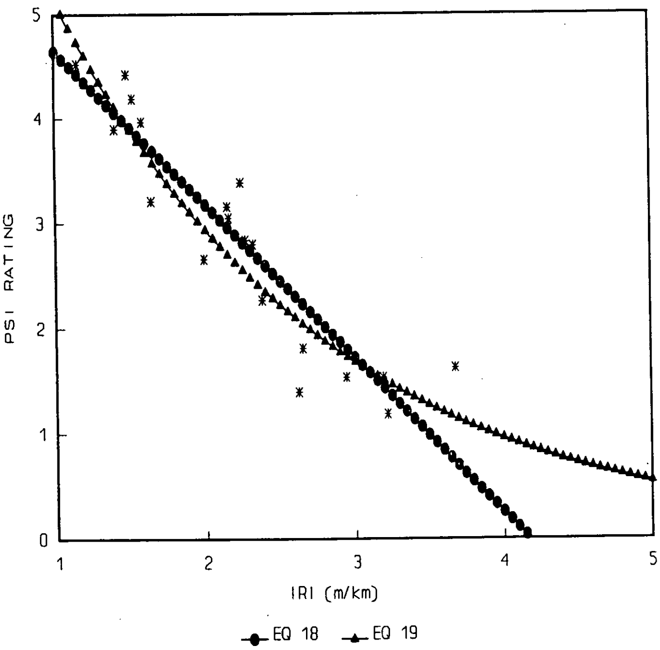


FIGURE 8 Prediction equations 18 and 19 for combined pavement (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

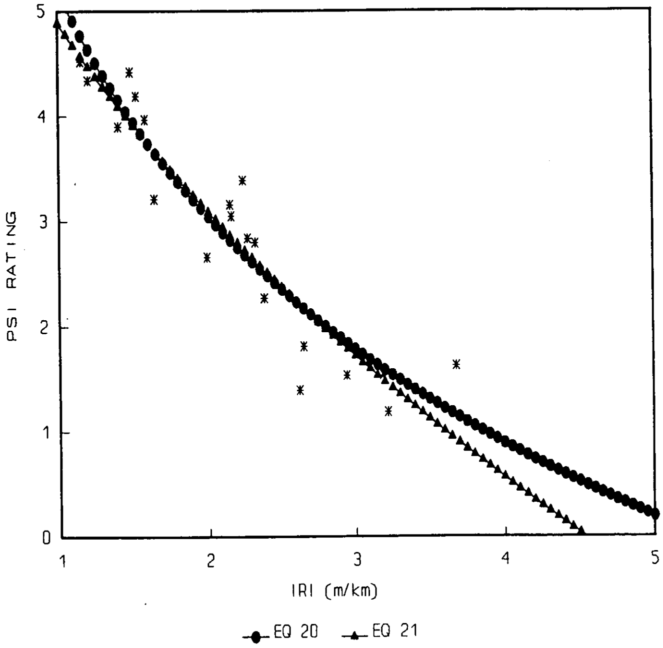


FIGURE 9 Prediction equations 20 and 21 for combined pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

The prediction equations in Figures 4 through 9 show that the predicted PSI rating values are very close when a PSI rating value is between 1.5 and 4.5, indicating that any of the prediction equations can be selected for practical purposes. Figure 10 shows linear prediction Equations 4, 11, and 18 for bituminous, concrete, and both pavement types combined, respectively. The predicted PSI rating values from these three equations are very close when a PSI rating is between 2.0 and 3.2. This indicates that any of these prediction equations can be used for rehabilitation analyses purposes because this range is of chief concern to the rehabilitation analysis.

Figure 11 shows the Prediction Equations 7, 14, and 21 in which the square root of IRI is used for bituminous, concrete, and both pavement types combined.

The predicted PSI rating values from these three equations are very close when the PSI rating is between 1.8 and 3.0, indicating that any of these equations can also be used for rehabilitation analysis purposes. For conservative rehabilitation analysis, Prediction Equations 19 and 21 are recommended. Table 3 also shows r^2 values, coefficients of determination, and MSE. Any equation listed in Table 3 can be used to predict PSI ratings from both the IRI and the RIDE-SCORE for bituminous and concrete pavements as well as the combination of both pavements.

Terminal-Critical IRI Values Determinations

The ten raters also identified whether the test sections were acceptable in terms of riding comfort. These two responses can be considered as two outcomes of a binary variable, Y. Denoting the outcomes by 1 for acceptance and 0 for rejection gives the Bernoulli random variable. Therefore the logistic regression model (function) Equation 7 was used to obtain the critical IRI values (*9*).

$$E(y) = \frac{e^{\beta_0 + \beta_1 * (IRI)}}{1 + e^{\beta_0 + \beta_1 * (IRI)}} \quad (7)$$

where $E(Y)$ is the expected value of Y, the mean response. An interesting property of the logistic function is that it can easily be made linear. $E(Y) = p$ since the mean response is a probability when the dependent variable is an indicator (binary) variable. Then, with the following transformation,

$$L = \text{Log}_e \left(\frac{p}{1 - p} \right) \quad (8)$$

from Equation 7,

$$L = \beta_0 + \beta_1 * (IRI) \quad (9)$$

The transformation in Equation 9 is called the logistic or logit transformation of the probability p. β_0 and β_1 are parameters to be determined.

The field data were rearranged to enable use of the logistic software of SAS. The maximum likelihood estimation was used to estimate the parameters β_0 and β_1 using the following SAS commands:

PROC CATMOD; BY PVMT LOC; WEIGHT COUNT; DIRECT IRI; MODEL Y = IRI/PREDICT;

The computed maximum likelihood parameter estimates for the logistic model are given in Table 4. The likelihood p-values indicated that the linear models fit well except for bituminous as passenger. The predicted logits

$$\hat{L} = \hat{\beta}_0 + \hat{\beta}_1 * IRI \quad (10)$$

were computed for IRI from 0.79 m/km (50 in./mi) to 4.7 m/km (300 in./mi). Then the predicted probability of acceptance, $\hat{p}$, was computed from

$$\hat{p} = \frac{e^{\hat{L}}}{1 + e^{\hat{L}}} \quad (11)$$

and the results were plotted as in Figure 12.

For practical purposes, INDOT uses $p = 0.85$ for multiple purposes. For this reason, the corresponding average critical values of IRI were computed as follows from Equations 8 and 9 using $p = 0.85$:

- Bituminous pavement—as driver: 2.15 m/km (136 in./mi); as passenger: 2.25 m/km (142 in./mi).
- Concrete pavement—as driver: 2.30 m/km (146 in./mi); as passenger: 2.45 m/km (155 in./mi).

As seen in Figure 12, when p is approximately 0.80, the four curves are practically merging, and, because the difference between driver and passenger is not significant as found before, logistic regression analysis was performed by combining driver and passenger data. The average critical values of IRI using $p = 0.85$ were found to be 2.19 m/km (139 in./mi) and 2.38 m/km (151 in./mi) for bituminous and concrete pavements, respectively.

Figure 12 shows that passengers are more tolerant (less critical) of roughness than drivers for both pavement types. Above an IRI

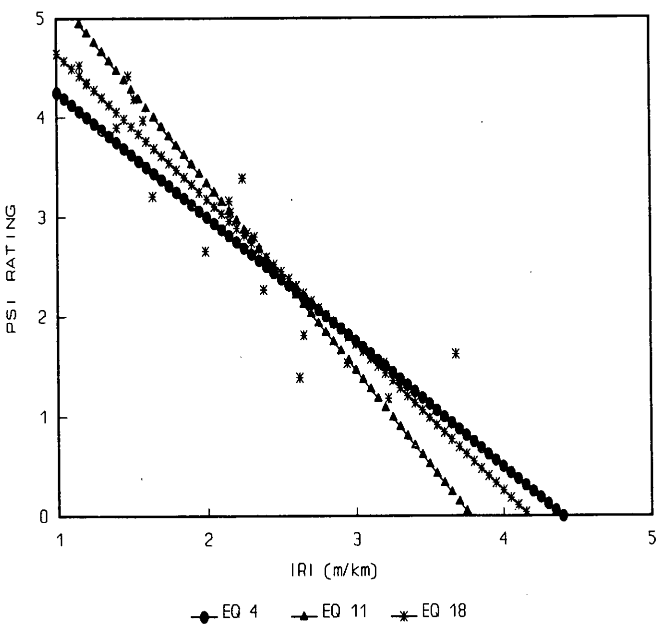


FIGURE 10 Linear prediction equations for combined pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

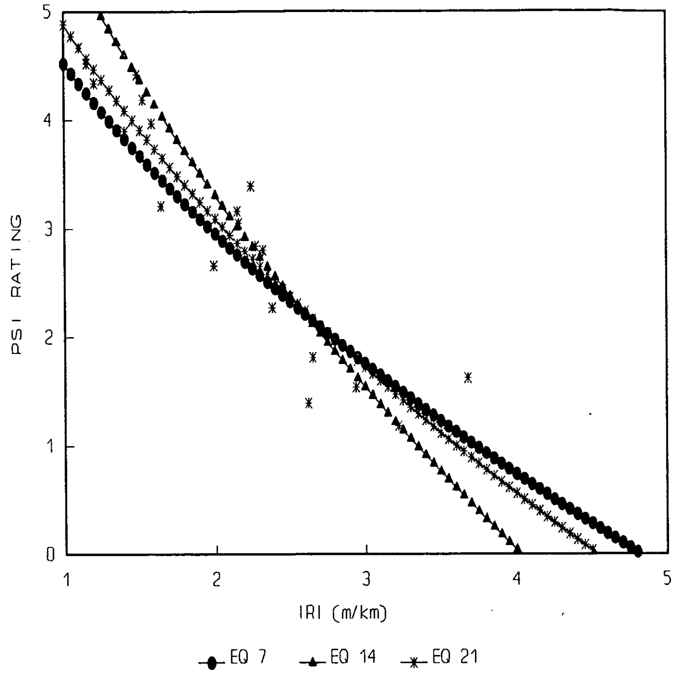


FIGURE 11 Square-root prediction equations for combined pavements (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

TABLE 4 Maximum Likelihood Parameter Estimates

	PAVEMENT TYPE			
	Bituminous		Concrete	
	Driver	Passenger	Driver	Passenger
β_0	6.7942	6.5189	16.1588	16.8853
β_1 *IRI*	-2.3536	-2.1310	-6.2510	-6.1864
Likelihood Ratio p-value	0.11	0.04	0.80	0.81

Note: IRI is in units of mm/m. (1 mm/m = 63.36 in/mi).

of approximately 150, Figure 12 shows that both passenger and drivers are more tolerant (less critical) of bituminous surfaces than of concrete surfaces for the same IRI.

Confidence intervals at 95 percent for average probability of acceptance, p, were computed for particular IRI values and are shown in Table 5. As seen in this table, prediction intervals cover $p = 0.85$ when IRI is 2.27 m/km (144 in./mi) for bituminous and 2.32 m/km (147 in./mi) for concrete pavements. For this reason, a single overall value of 2.3 m/km (146 in./mi) could be used as a critical value for IRI for practical use in pavement management decisions in Indiana.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were made on the basis of this study:

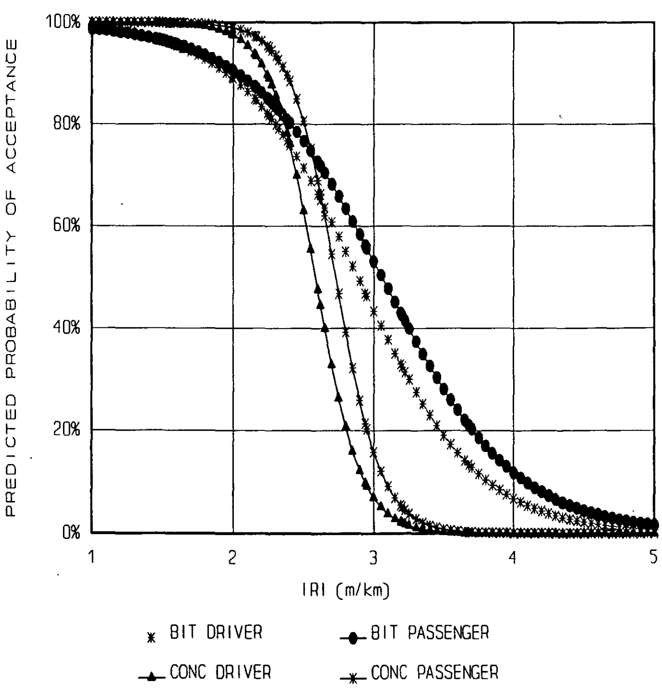


FIGURE 12 Predicted probability of acceptance versus IRI (see Table 3). [IRI in m/km (1 m/km = 1/63.36 in./mi).]

1. Ten or fewer randomly chosen raters may be sufficient to obtain PSI rating data for future studies.
2. The location of rater in the car (as a driver or as a front seat passenger) was found to be nonsignificant.
3. Prediction equations shown in Table 3 are all statistically sound. Selection of equations depends on the user's need. For practical purpose, INDOT may use any of the equations for combined pavement types.
4. Predicted critical IRI values shown in Table 5 are practical. However, a mean value of 2.3 m/km (145 in./mi) for IRI for all pavement types in Indiana is recommended for pavement management purposes.
5. The choice of prediction equations for PSI ratings depends on users. However, Prediction Equation 19 in Table 3 (Equations 12 and 13 in text) is recommended to predict PSI ratings from the IRI values for conservative rehabilitation. However, Linear Prediction Equation 18 in the table also can be used to predict PSI rating values from the IRI values.

$$PSI = 9.0e^{(-0.557 \cdot IRI)} \quad (12)$$

TABLE 5 Confidence Intervals at 95 Percent for Average Probabilities of Acceptance

IRI	BITUMINOUS		BITUMINOUS
	DRIVER	PASSENGER	Combined
1.99	0.81 - 0.98	0.83 - 0.99	0.84 - 0.96
2.27	0.70 - 0.92	0.74 - 0.95	**0.75 - 0.90**
2.53	0.50 - 0.80	0.59 - 0.85	0.59 - 0.79
IRI	CONCRETE		CONCRETE
	DRIVER	PASSENGER	Combined
2.32	0.74 - 0.94	0.85 - 1.00	**0.82 - 0.95**
2.38	0.66 - 0.90	0.81 - 0.99	0.76 - 0.92
2.65	0.20 - 0.60	0.44 - 0.80	0.37 - 0.64

Note: IRI is in units of mm/m. (1mm/m = 1/63.36 in/mi).

where IRI is in millimeters per meter or

$$P\hat{S}I = 9.0e^{(-0.008784 \cdot IRI)} \quad (13)$$

where IRI is in inches per mile.

6. It is highly recommended that this type of study be performed regularly with additional factors, such as vehicle type, to determine whether or not they are significant.

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