Assessment on Harmony of Pavement Condition Index Using ASTM, IRC and Regression Techniques

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***Abstract*—Pavement maintenance and rehabilitation of low volume roads to the designated level of serviceability is a daunting task. Pavement condition index (PCI) is a promising numerical indexing technique for the structural integrity and performance of in-service pavements. Assessment of PCI is depending on theresults obtained from the visual inspection survey from which type, intensity and severity of various distresses are diagnosed. Indexes estimated from various techniques are appearing to be similar and tempting to adopt different indexes for comparing the performance of in-service pavement sections. The basic objective of this study is to carry out a comparative study on PCI values estimated from American Standard for Testing Materials (ASTM) and Indian Road Congress (IRC) techniques. To determine the level of agreement between these estimated indexes, a database composed of PCI values of 20.35 km of in-service distressed low volume PMGSY roads in India was used. The comparison of rating scales depicts that only 32% of pavement sections were representing similar rating whereas, for the other sections shown significant differences among seemingly similar pavement condition indexes. In addition, Index values estimated from the developed linear regression model for low volume roads shows good agreement with in-situ measured data. The developed model index values were also compared with ASTM and IRC techniques which show substantial increase in the similarity of ratings varying from 50 % to 69 % of pavement sections. Thus the developed model is simpler and robust in indicating the realistic performance of the pavement condition for defining optimum maintenance strategy.**

***Index Terms*— visual inspection survey, pavement condition index, low volume roads, linear regression**

I. Introduction

Assessment of in-service pavement condition for periodic maintenance and rehabilitation has become significant prerequisite for efficient pavement management systems (PMS). The in-service pavement condition is being representing in various types of indexes, which are combination of several distress types [1]. Numerous researchers and various transportation agencies globally developed indexes that aggregates distresses to single platform of indexing such as Pavement Condition Distress Index($PCI_{Distress}$),present serviceability index (PSI), Pavement Condition Roughness Index ($PCI_{Roughness}$), International roughness index (IRI), Pavement Condition Structural Capacity Index ($PCI_{Structure}$), present serviceability rating (PSR)and Pavement Condition Skid Resistance Index (PCI_{Skid}) [2], [3]. Among various indexes, PCI is widely accepted index standardized by American standards for testing materials (ASTM) and Indian road congress (IRC) todefine performance based rehabilitation and maintenance techniques [4]. Numerous efforts were been made in predicting the Pavement condition index by using various soft computing techniques like Artificial Neural Networks (ANN), Genetic Programming, Analytical Hierarchical process (AHP), auto-regression and Fuzzy logic approaches [3]. Each and every technique has its own merits and demerits in terms of complexity in calculation, requirement of large data set, expert opinion based modeling, errors in scaling system etc [4].

However, in the current scenario, the significant prerequisite for comparing pavement infrastructure performance is based on PCI that influences greatly on defining the strategic maintenance and rehabilitation policies (Neumann and Markow 2004). Therefore, comparison of PCI values estimated from various approaches prompt to compare the performance based maintenance strategies. This triggers interest in comparative studies of PCI. But the comparison of PCI estimated using various approaches is highly questionable [5]. Few comparative studies on PCI were carried out globally such as [4] carried out a comparative study to ascertain the level of agreement on six Pavement condition indexes from five departments of transportation (DOTs) in United States. Whereas, in developing countries like India, Few researchers gave extensive efforts in developing various distress indexes for urban and rural networks [6], [7]. Few Pavement infrastructure agencies adopt both ASTM and IRC standard techniques and subsequently identified the differences. These differences are needed to be taken into account, supported with literature and empirical data and further this knowledge is to be disseminated to other stakeholders in this field. Thus there is need for the requirement of comparative study to

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address the possible reason for the differences in pavement condition indexes in the Indian scenario. This study made an attempt to fill the gap.

Thus this study is primarily focused to carryout a comparative study of pavement condition indexes (PCIs) estimated by two standard techniques suggested by ASTM and IRC. In addition, this study also developed a PCI prediction model based on the distress intensity of Alligator cracking, longitudinal or transverse cracking, Depression or settlement, Raveling, Potholes, and Patch work. The PCI predicted from the developed model is compared with ASTM estimated PCI and identified the agreement of difference. The PCIs were estimated based on the field database information collected by visual inspection survey on selected Low volume PMGSY road sections of length 20.35 km in the state of Chhattisgarh, India.

II. Methodology and Data Collection

Six in-service distressed low volume road sections covering an overall length of 20.35 km developed under Pradhan Mantri Gram SadakYojana (PMGSY) scheme were selected in this study from the state of Chhattisgarh, India. The details of selected road sections are shown in Table I. The detailed flow chart of study methodology is shown in Fig. 1

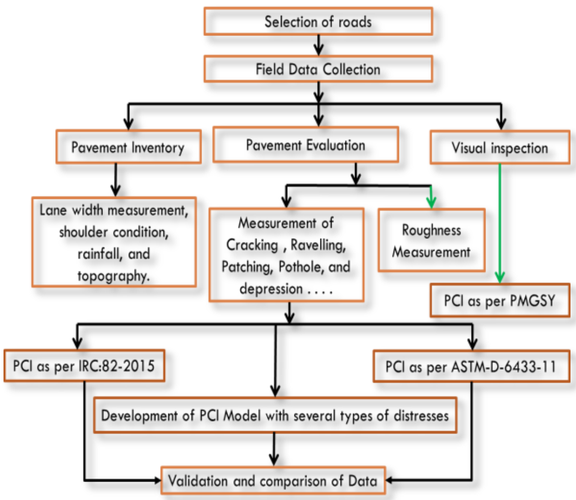


Figure 1. Flow chart of study methodology.

Detailed Visual condition survey (Stage-I evaluation) was carried out covering an overall length of 20.35 Km as shown in Table I. Each road section is divided into various subsections of length 50m each and the corresponding distresses were identified, measured and noted in the developed survey forms as per the guidelines suggested by ASTM, IRC and NRRDA [8-10]. Simultaneously video recording of selected pavement section at 20 KMPH speed and photographs of various distresses measurements were taken and sample photographs are shown in Fig. 2. The matrix selection of pavement section for visual inspection survey is defined according to the age of the pavement section as shown in Fig.3.

TABLE I. Details of Study Sections

PS*	Name of the Road Sections	Year of Completion	Total length of the road	Major Distress identified
1	Kanharpuri to Silli	2014	4.10 Km	Series of Longitudinal cracks, Initial stages of rutting
2	Sirssahi T04 to Sikaritola	2010	4.00 Km	Entire pavement stretch is raveled. Few sections were undergone with
3	T05 to Boirdih	2010	2.26 Km	First 1.5 Km stretch were undergone with medium to high severity potholes
4	R.D.C. Road to Farhadh	2010	1.60 Km	Entire stretch is distressed with high severity. Series of
5	Main road T05 to KhiloraMandir	2013	4.35 Km	Series of Longitudinal and edge cracks with low to medium severity on entire stretch. Rutting was
6	T01 to Pendrikurd	2008	4.04 Km	Few sections were diagnosed with series of longitudinal and edge cracking at

Plate 1: High severity Edge cracking | Plate 2: Longitudinal Cracking/Patching /rutting | Plate 3: High severity rutting

Plate 4: Medium severity Pothole | Plate 5: High severity Alligator cracking and rutting | Plate 6: High severity Longitudinal cracking

Figure 2. Captured photographs of pavement distresses identified on selected road sections

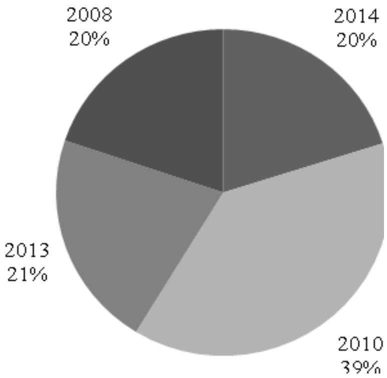


Figure 3. Percentage length of pavement sections selected according to age.

III. Data Analysis and Estimation of Pavement Condition Index

The measured distresses for each subsection of length 50m were recorded in the developed survey forms. The distress measurements recorded for each 50 m subsection is aggregated to 1 km interval were analyzed and percentage of each distress intensity is estimated. Further, the percentage of each distress intensity is aggregated for the entire study length of pavement section as shown in Fig. 4.

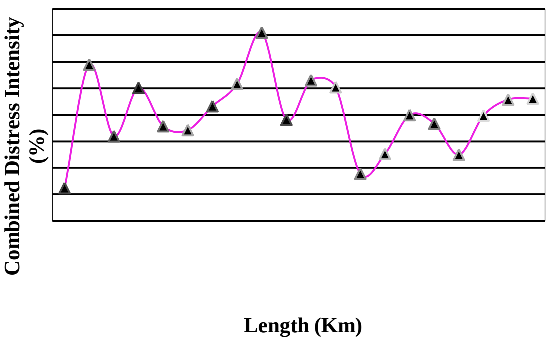


Figure 4. Combined distress intensity for each kilometre length of study section.

IV. Estimation of PCI

Based on the calculated combined distress intensity for each subsectionof length 200m, pavement condition index was estimated as per the guidelines suggested by [8], [10].

A. *PCI by ASTM D6433-11*

The calculation procedure suggested in ASTM standard was initially according to [11]. This PCI calculation procedure involves various types of distresses with distinct severity levels are aggregated to single PCI value. The severity level of each distress is designated in three categories (i.e., low, medium, and high) based on the unit length and area. The final PCI is defined in the rating scale varying from 0 to 100. The final estimated PCI values for each subsection of length 50m of study sections is shown in Fig. 6.

The calculation procedure summarized in following steps:

1. Determination of pavement distresses and their severity, which can be low, medium, or high.
2. Determination of deduct values from the deduct value curves for each distress. Fig. 5 shows typical deduct value curve for Longitudinal cracking.
3. Calculation of maximum number of deduct values from the maximum allowable deduct number, by using (1):

$$m_i = 1 + (9/98)\ (100 - HDV) \qquad (1)$$

   where, m_i = maximum allowable number of deduct values and HDV = greatest individual deduct value.

4. Determination of q, the number of deduct values greater than 2.
5. Determination of the total deduct value (TDV), which is the summation of all deduct values.
6. Determination of the corrected deduct value (CDV) based on the correction curves using q and the TDV
7. Reductions of the smallest deduct value greater than 2 to exactly 2.
8. Repetition of steps 4 through 7 until q is equal to 1.
9. Determination of the maximum CDV (CDV_{max}) and computation of the PCI using (2):

$$PCI = 100 - CDV_{max} \qquad (2)$$

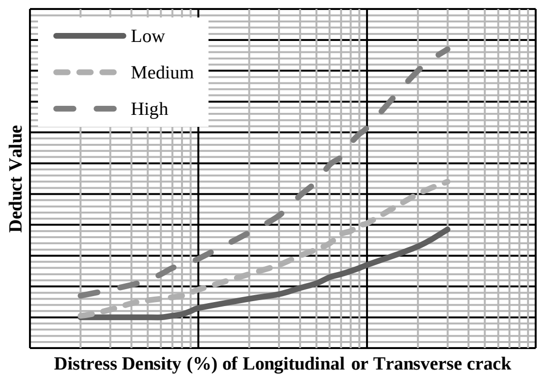
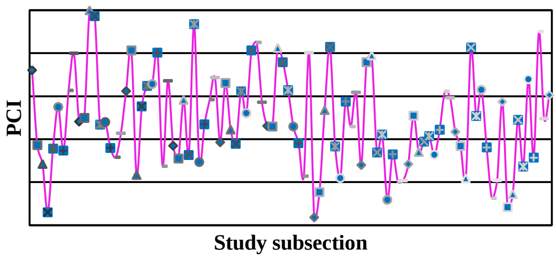


Figure 5. Typical deduct value curves for Longitudinal or Transverse crack.



*SS – Study subsection (length 200m)

Figure 6. PCI for each subsection as per ASTM

B. PCI as Per IRC: 82-2015

IRC developed codal provisions for periodic and routine maintenance of bituminous surfaces of highways initially in 1982. This codal provision is primarily focused on the identification and estimation of distress intensity only. Further IRC has revised the codal provision in 2015 recommending and suggesting the calculation of PCI for all categories of roads. Default weights have been assigned and distress intensity estimated the final PCI value and condition is determined. Table II shows typical calculation of PCI to the scale of 0 to 3 for major district roads (MDR), other district roads (ODR) and Village roads (VR). The final estimated PCI values for each subsection of length 200m of study sections is shown in Fig. 7.

TABLE II. PAVEMENT DISTRESS BASED RATING FOR MDR(S) AND RURAL ROADS (ODR AND VR)

Defects	Range of Distress			Weights
Cracking (%)	>20	10-20	<10	1.00
Raveling (%)	>20	10-20	<10	0.75
Pothole (%)	>1	0.5 to 1	<0.5	0.50
Patching (%)	>20	5-20	<5	0.75
Settlement and depression (%)	>5	2 to 5	<2	0.75
Rating	1	1.1 - 2	2.1 - 3	
Condition	Poor	Fair	Good	

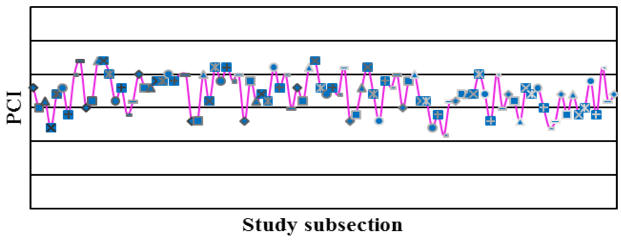


Figure 7.PCI for each subsection as per IRC.

V. DEVELOPMENT AND VALIDATION OF EMPIRICAL MODEL

Total deduct values and PCI values were calculated for each subsection of length 50m generating a data set of 400 cumulative deduct values and PCI values. A data set of 283 was selected for model development and 100 data set were selected for mode validation. The detailed descriptive statistics of data set used for model development is shown in Table III.

Multi-variate linear regression model was developed to predict cumulative deduct values by using percentageof distress intensity of Alligator cracking, longitudinal or transverse cracking, raveling, potholes, patch work and depression or settlement estimated for each subsection of length 50 m from selected study sections as shown in (3). The regression results and the corresponding coefficients of explanatory variables is shown in Table IV.Further the predicted cumulative deduct values is used to calculate PCI by using split function. The range of PCI was defined as (0,100), so for measuring PCI split function was recommended as shown in (4).

TABLE III. DESCRIPTIVE STATISTICS OF DATA SET

Statistical Criterion	Alligator cracking (%), x_1	Longitudinal or transverse cracking (%), x_2	Raveling (%), x_3	Potholes (%), x_4	Patch work (%), x_5	Depression/ Settlement (%), x_6	CDV, Y	ASTM PCI
Mean	1.43	4.30	8.12	0.30	14.74	14.51	58.05	41.95
Standard Deviation	3.51	6.07	9.09	0.48	15.95	14.82	20.59	20.59
Minimum	0	0	0	0	0	0	3.69	5.0276
Maximum	20.94	35.81	42.41	2.74	67.58	55.5	94.9724	96.31

Note: CDV= Cumulative deduct value.

TABLE IV. REGRESSION COEFFICIENTS AND STATISTICS

Regression Coefficients		Regression Statistics	
Alligator Cracking (%)	2.306	Multiple R	0.95
Lon/Trans Cracking	1.366	R Square	0.91
Reveling	1.322	Observations	283
Potholes	30.678		
Patchwork	0.624		
Depression/ Settlement	0.896		

$$CDV = (a \times X_1) + (b \times X_2) + (c \times X_3) + (d \times X_4) + (e \times X_5) + (f \times X_6) \quad (3)$$

Where, X_1 is % of Alligator cracking, X_2 is % of longitudinal and transverse cracking, X_3 is % of Raveling, X_4 is % of Potholes, X_5 is % of Patch work, X_6 is % of Depression and settlement.

$$\begin{aligned} PCI &= 100 - CDV \quad \text{if } CDV < 100 \\ PCI &= 0 \quad CDV > 100 \end{aligned} \quad (4)$$

A data set of distress intensities and PCI values of 25% is used for validation and verification of developed model. Fig. 8 shows statistical performance of developed models by comparing measured and predicted PCI values shows fair agreement of model.

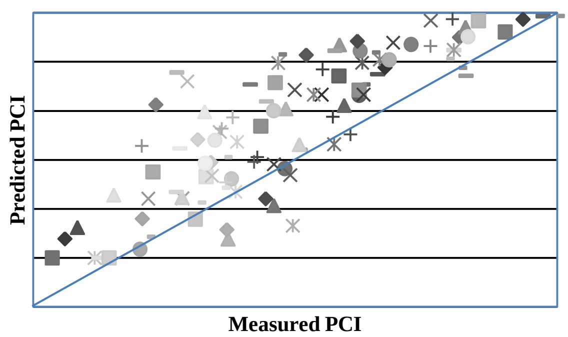


Figure 8.Measured PCI versus the predicted PCI.

VI. Comparison of ASTM, IRC and Regression Model PCI Values

Comparison of PCI values was done in two distinct phases, (1) Comparison between ASTM and IRC estimated PCI values and (2) Comparison between ASTM and Regression model PCI values.

Based on the estimated PCI values using ASTM and IRC standards, the range of rating scale for PCI is 0 to 100 with 7 condition classes for ASTM whereas for IRC standard 0 to 3 with 3 condition classes respectively. Therefore, instead of comparing the PCI values, condition of particular PCI value is compared for each subsection. However inorder to maintain the consistency ASTM classes were clustered into 3 condition classes.

The ASTM condition classes failed, Serious, and very poor is clustered into Poor. Whereas, classes poor and fair is clustered into fair and classes Satisfactory and Good is clustered into Good respectively as shown in Table V. Thus the final comparison of PCI condition classes among ASTM with IRC techniques is designated in terms of percentage similarity. The percentage similarity of condition classes is only 32% among ASTM and IRC standards. The detailed comparison is shown in Table VI.

Similarly, comparison of ASTM values with regression modeled PCI values was carried out as shown in Fig 8. Comparison of condition classes were also carried out among ASTM and regression models in three distinct ways. (1) ASTM 7 condition classes with regression model 7 condition classes results in 32% similarity. (2) ASTM 5 condition classes with regression model 5 condition classes results in 50% similarity. (3) ASTM 3 condition classes with regression model 3 condition classes results in 69% similarity. The detailed comparative analysis is shown in Table VI.

TABLE V. Grouping of ASTM Classes

Condition Class No.	ASTM condition class (A)	Condition Class (B)	Condition Class (C)
1	Good	Good	Good
2	Satisfactory	Fair	
3	Fair		Fair
4	Poor	Poor	
5	Very Poor	Serious	Poor
6	Serious		
7	Fail	Fail	

TABLE VI. Comparative Analysis of PCI

ASTM PCI	Grouping of condition classes			IRC PCI	Rating	% of Similarity (ASTM (A) vs IRC)	Regression Model	Rating	% of Similarity (ASTM (A) vs RM)	Rating	% of Similarity (ASTM (B) vs RM)	Rating	% of Similarity (ASTM (C) vs RM)
	A	B	C			32%		A	32%	B	50%	C	69%
6.0	Failed	Failed	Poor	1.2	Fair	0	7.78	Failed	1	Failed	1	Poor	1
3.6	Failed	Failed	Poor	1.3	Fair	0	0.00	Failed	1	Failed	1	Poor	1
8.4	Failed	Failed	Poor	1.4	Fair	0	12.44	Serious	0	Serious	0	Poor	1
55.0	Fair	Fair	Fair	1.8	Fair	1	66.62	Fair	1	Fair	1	Fair	1
62.8	Fair	Fair	Fair	2.0	Fair	1	79.62	Satisfactory	0	Fair	1	Good	0
62.4	Fair	Fair	Fair	2.0	Fair	1	84.51	Satisfactory	0	Fair	1	Good	0
55.2	Fair	Fair	Fair	1.9	Fair	1	76.97	Satisfactory	0	Fair	1	Good	0
64.8	Fair	Fair	Fair	1.9	Fair	1	83.83	Satisfactory	0	Fair	1	Good	0
65.7	Fair	Fair	Fair	2.0	Fair	1	74.96	Satisfactory	0	Fair	1	Good	0
67.1	Fair	Fair	Fair	2.0	Fair	1	77.74	Satisfactory	0	Fair	1	Good	0
58.3	Fair	Fair	Fair	2.0	Fair	1	74.23	Satisfactory	0	Fair	1	Good	0
58.4	Fair	Fair	Fair	1.9	Fair	1	87.02	Good	0	Good	0	Good	0
68.7	Fair	Fair	Fair	2.0	Fair	1	87.85	Good	0	Good	0	Good	0
66.1	Fair	Fair	Fair	1.9	Fair	1	80.91	Satisfactory	0	Fair	1	Good	0
62.2	Fair	Fair	Fair	1.6	Fair	1	66.32	Fair	1	Fair	1	Fair	1
57.2	Fair	Fair	Fair	1.5	Fair	1	57.59	Fair	1	Fair	1	Fair	1
62.9	Fair	Fair	Fair	1.8	Fair	1	70.80	Satisfactory	0	Fair	1	Good	0
57.6	Fair	Fair	Fair	1.9	Fair	1	84.55	Satisfactory	0	Fair	1	Good	0
61.9	Fair	Fair	Fair	2.0	Fair	1	88.46	Good	0	Good	0	Good	0
62.2	Fair	Fair	Fair	2.0	Fair	1	68.51	Fair	1	Fair	1	Fair	1
59.3	Fair	Fair	Fair	1.5	Fair	1	62.27	Fair	1	Fair	1	Fair	1
63.0	Fair	Fair	Fair	1.8	Fair	1	66.62	Fair	1	Fair	1	Fair	1
57.4	Fair	Fair	Fair	1.7	Fair	1	46.34	Poor	0	Poor	0	Poor	0

ASTM PCI	Grouping of condition classes			IRC PCI	Rating	% of Similarity (ASTM (A) vs IRC)	Regression Model	Rating	% of Similarity (ASTM (A) vs RM)	Rating	% of Similarity (ASTM (B) vs RM)	Rating	% of Similarity (ASTM (C) vs RM)
	A	B	C			32%		A	32%	B	50%	C	69%
68.0	Fair	Fair	Fair	1.9	Fair	1	80.83	Satisfactory	0	Fair	1	Good	0
60.5	Fair	Fair	Fair	1.7	Fair	1	50.38	Poor	0	Poor	0	Poor	0
100.0	Good	Good	Good	2.2	Good	1	98.77	Good	1	Good	1	Good	1
97.3	Good	Good	Good	2.2	Good	1	98.67	Good	1	Good	1	Good	1
93.5	Good	Good	Good	2.1	Good	1	97.38	Good	1	Good	1	Good	1
90.1	Good	Good	Good	2.1	Good	1	92.24	Good	1	Good	1	Good	1
48.2	Poor	Poor	Poor	1.5	Fair	0	60.89	Fair	0	Fair	0	Fair	0
49.9	Poor	Poor	Poor	1.6	Fair	0	68.56	Fair	0	Fair	0	Fair	0
46.8	Poor	Poor	Poor	2.0	Fair	0	79.57	Satisfactory	0	Fair	0	Good	0
48.0	Poor	Poor	Poor	1.6	Fair	0	36.44	Very Poor	0	Serious	0	Poor	1
42.7	Poor	Poor	Poor	1.6	Fair	0	41.09	Poor	1	Poor	1	Poor	1
47.0	Poor	Poor	Poor	2.1	Good	0	83.03	Satisfactory	0	Fair	0	Good	0
44.5	Poor	Poor	Poor	1.6	Fair	0	63.83	Fair	0	Fair	0	Fair	0
52.1	Poor	Poor	Poor	2.1	Good	0	82.81	Satisfactory	0	Fair	0	Good	0
46.2	Poor	Poor	Poor	1.8	Fair	0	71.52	Satisfactory	0	Fair	0	Good	0
45.9	Poor	Poor	Poor	1.6	Fair	0	21.38	Serious	0	Serious	0	Poor	1
45.9	Poor	Poor	Poor	1.7	Fair	0	38.20	Very Poor	0	Serious	0	Poor	1
53.5	Poor	Poor	Poor	1.8	Fair	0	66.65	Fair	0	Fair	0	Fair	0
45.9	Poor	Poor	Poor	1.8	Fair	0	60.06	Fair	0	Fair	0	Fair	0
42.2	Poor	Poor	Poor	1.6	Fair	0	39.22	Very Poor	0	Serious	0	Poor	1
51.0	Poor	Poor	Poor	1.7	Fair	0	44.10	Poor	1	Poor	1	Poor	1
41.4	Poor	Poor	Poor	2.0	Fair	0	70.79	Satisfactory	0	Fair	0	Good	0
44.4	Poor	Poor	Poor	1.3	Fair	0	24.14	Serious	0	Serious	0	Poor	1
43.4	Poor	Poor	Poor	1.7	Fair	0	53.76	Poor	1	Poor	1	Poor	1
50.8	Poor	Poor	Poor	1.7	Fair	0	46.27	Poor	1	Poor	1	Poor	1
49.0	Poor	Poor	Poor	1.4	Fair	0	33.76	Very Poor	0	Serious	0	Poor	1
49.5	Poor	Poor	Poor	1.6	Fair	0	13.13	Serious	0	Serious	0	Poor	1
72.1	Satisfactory	Fair	Good	1.8	Fair	0	87.15	Good	0	Good	0	Good	1
80.0	Satisfactory	Fair	Good	2.2	Good	1	97.49	Good	0	Good	0	Good	1
81.4	Satisfactory	Fair	Good	1.8	Fair	0	77.56	Satisfactory	1	Fair	1	Good	1
80.3	Satisfactory	Fair	Good	1.9	Fair	0	84.83	Satisfactory	1	Fair	1	Good	1
81.3	Satisfactory	Fair	Good	1.8	Fair	0	90.00	Good	0	Good	0	Good	1
85.0	Satisfactory	Fair	Good	2.0	Good	1	96.76	Good	0	Good	0	Good	1
82.5	Satisfactory	Fair	Good	2.1	Good	1	94.19	Good	0	Good	0	Good	1
75.9	Satisfactory	Fair	Good	2.2	Good	1	96.85	Good	0	Good	0	Good	1
80.3	Satisfactory	Fair	Good	2.1	Good	1	84.90	Satisfactory	1	Fair	1	Good	1
83.0	Satisfactory	Fair	Good	2.1	Good	1	90.26	Good	0	Good	0	Good	1
75.8	Satisfactory	Fair	Good	1.9	Fair	0	86.41	Good	0	Good	0	Good	1
79.0	Satisfactory	Fair	Good	2.0	Fair	0	81.20	Satisfactory	1	Fair	1	Good	1
82.6	Satisfactory	Fair	Good	1.8	Fair	0	74.36	Satisfactory	1	Fair	1	Good	1
23.4	Serious	Serious	Poor	1.8	Fair	0	62.52	Fair	0	Fair	0	Fair	0
22.8	Serious	Serious	Poor	1.7	Fair	0	35.05	Very Poor	0	Serious	1	Poor	1
15.4	Serious	Serious	Poor	1.4	Fair	0	25.68	Very Poor	0	Serious	1	Poor	1

ASTM PCI	Grouping of condition classes			IRC PCI	Rating	% of Similarity (ASTM (A) vs IRC)	Regression Model	Rating	% of Similarity (ASTM (A) vs RM)	Rating	% of Similarity (ASTM (B) vs RM)	Rating	% of Similarity (ASTM (C) vs RM)
	A	B	C			32%		A	32%	B	50%	C	69%
22.0	Serious	Serious	Poor	1.3	Fair	0	24.12	Serious	1	Serious	1	Poor	1
11.7	Serious	Serious	Poor	1.2	Fair	0	0.00	Failed	0	Failed	0	Poor	1
20.4	Serious	Serious	Poor	1.1	Fair	0	3.56	Failed	0	Failed	0	Poor	1
20.7	Serious	Serious	Poor	1.6	Fair	0	45.70	Poor	0	Poor	0	Poor	1
21.9	Serious	Serious	Poor	1.3	Fair	0	8.59	Failed	0	Failed	0	Poor	1
12.5	Serious	Serious	Poor	1.2	Fair	0	0.00	Failed	0	Failed	0	Poor	1
20.8	Serious	Serious	Poor	1.3	Fair	0	15.96	Serious	1	Serious	1	Poor	1
14.5	Serious	Serious	Poor	1.7	Fair	0	0.00	Failed	0	Failed	0	Poor	1
37.2	Very Poor	Serious	Poor	1.5	Fair	0	7.71	Failed	0	Failed	0	Poor	1
28.5	Very Poor	Serious	Poor	1.6	Fair	0	24.26	Serious	0	Serious	1	Poor	1
35.6	Very Poor	Serious	Poor	1.7	Fair	0	51.38	Poor	0	Poor	0	Poor	1
34.7	Very Poor	Serious	Poor	1.4	Fair	0	48.01	Poor	0	Poor	0	Poor	1
36.0	Very Poor	Serious	Poor	1.8	Fair	0	52.70	Poor	0	Poor	0	Poor	1
31.6	Very Poor	Serious	Poor	1.4	Fair	0	22.57	Serious	0	Serious	1	Poor	1
27.4	Very Poor	Serious	Poor	2.0	Good	0	75.67	Satisfactory	0	Fair	0	Good	0
36.9	Very Poor	Serious	Poor	1.3	Fair	0	11.50	Serious	0	Serious	1	Poor	1
30.9	Very Poor	Serious	Poor	1.3	Fair	0	15.78	Serious	0	Serious	1	Poor	1
32.7	Very Poor	Serious	Poor	1.6	Fair	0	59.67	Fair	0	Fair	0	Fair	0
29.4	Very Poor	Serious	Poor	1.9	Fair	0	72.03	Satisfactory	0	Fair	0	Good	0
38.6	Very Poor	Serious	Poor	1.3	Fair	0	26.95	Very Poor	1	Serious	1	Poor	1
37.8	Very Poor	Serious	Poor	1.7	Fair	0	32.27	Very Poor	1	Serious	1	Poor	1
38.1	Very Poor	Serious	Poor	1.8	Fair	0	57.37	Fair	0	Fair	0	Fair	0
36.6	Very Poor	Serious	Poor	1.7	Fair	0	41.13	Poor	0	Poor	0	Poor	1
28.0	Very Poor	Serious	Poor	1.5	Fair	0	44.63	Poor	0	Poor	0	Poor	1
33.9	Very Poor	Serious	Poor	1.6	Fair	0	39.01	Very Poor	1	Serious	1	Poor	1
33.0	Very Poor	Serious	Poor	1.4	Fair	0	33.21	Very Poor	1	Serious	1	Poor	1
28.4	Very Poor	Serious	Poor	1.6	Fair	0	24.64	Serious	0	Serious	1	Poor	1
34.1	Very Poor	Serious	Poor	1.7	Fair	0	33.51	Very Poor	1	Serious	1	Poor	1
38.9	Very Poor	Serious	Poor	1.7	Fair	0	47.36	Poor	0	Poor	0	Poor	1
32.8	Very Poor	Serious	Poor	1.7	Fair	0	38.64	Very Poor	1	Serious	1	Poor	1
36.8	Very Poor	Serious	Poor	1.6	Fair	0	30.84	Very Poor	1	Serious	1	Poor	1
36.2	Very Poor	Serious	Poor	1.5	Fair	0	28.62	Very Poor	1	Serious	1	Poor	1
27.3	Very Poor	Serious	Poor	1.5	Fair	0	26.93	Very Poor	1	Serious	1	Poor	1
31.4	Very Poor	Serious	Poor	1.4	Fair	0	48.32	Poor	0	Poor	0	Poor	1

Note: 0= Not similar; 1= Similar

VII. Conclusions

In this study a comprehensive comparative analysis was carried out among the Pavement condition indexes estimated from ASTM, IRC and Regression modeling approaches based on the measured data base. Significant disagreement was identified by estimating the percentage similarity of overall distress condition for each section of length 200m among ASTM and IRC approaches. These differences can be attributed to classification of distress types, weights assigned, and mathematical forms.

Multi-variate linear regression model was also developed to predict the PCI values from distress intensity of various distresses like Alligator cracking, Longitudinal or Transverse cracking, Raveling, Potholes, Patchwork, and Depression or settlement. The statistical performance of the model with good correlation value and further validation of the models assured the fair applicability of the model.

The sensitivity of clustering of overall distress condition and classification of distress types among ASTM and regression model was identified in terms of percentage of similarity of overall distress condition. Thus this comparative study can be extended among various other soft computing approaches in the Indian context to suggest more robust technique for defining the optimum maintenance strategies.

Conflict of Interest

The authors declare no conflict of interest.

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