A Comparative Study on Pavement Condition Rating Methods for Flexible Roads

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***Abstract*— the purpose of this study is to conduct a physical survey for distresses analysis of 50 lanes of urban flexible roads and to conduct a comparative study on pavement condition rating methods (PCRM) using IRC method, and Highway preservation system. 50 lanes of urban flexible pavements from all over Pune city are selected as a case study. The lanes are visually surveyed to detect the types, severity and extent of the distresses based on IRC and WDOT guidelines (Distress identification manuals). Firstly the lane wise data base is created. Secondly the severity and extent is determined based on IRC and WDOT (DIM). And thirdly the lane wise Pavement condition index (PCI) values are calculated by the methods of IRC, and HPS. To differentiate between both the methods the correlation analysis has been carried out.**

***Index Terms*— Correlation analysis, Distresses analysis, differentiate, Pavement condition rating, Pavement condition index, physical survey.**

I. INTRODUCTION

Distresses analysis for flexible roads are the systematic examination, evaluation and measure of its surface condition for detecting the distresses, their types, severity and extent. Distresses analysis are carried out to determine the pavement condition indices for roads in order to rate the current condition of its surfaces, provide maintenance and rehabilitation policies as well as for better pavement management practices, such as prioritization rating, budget allocation, database creation for future management practices and development.

The distresses are investigated by visual inspection and automatic instruments. In both cases the distresses are analyzed based on pavement distresses manuals, and the PCI values are calculated by different methods. In this study the PCI calculation is carried out by two different methods to determine the relationship between both the methods and to suggest the most suitable method.

II. OBJECTIVE OF STUDY

1. To analyze the distresses for 50 lanes of urban, flexible pavement located in the city of Pune based on the guide lines (Distresses identification manuals) of IRC and WSDOT.
2. To calculate the PCI values based on IRC, and Highway preservation system.
3. To differentiate between the aforementioned methods using correlation analysis.

III. PAVEMENT DISTRESSES ANALYSIS AND PAVEMENT CONDITION INDEX

A. Distresses Analysis

Under continuous traffic loading the fatigue failure of the HMA happens and that causes a number of cracks. The cracking begins at the bottom of the HMA due to its highest tensile stress and then appears on the surface as longitudinal cracks.

To use an appropriate maintenance and repairing strategy, the severity, extent and type of distress should be understood, and most preferably the causes of the deterioration should be understood. The common types of distresses are as under [1].

1. Rutting

In the wheel path the surface of the pavement depressed. The surface will uplift along the one and another side of the rut. The ruts can be better detected after a rain when the water is ponded in. and ponded ruts cause vehicle hydroplaning and the ruts keeps the vehicle toward rutted area.

2. Transversal (thermal) cracking

The forms of cracks that is created perpendicular to the pavement's centerline direction is called transversal cracking. It is called thermal cracking too. It allows moisture and causes roughness.

3. Potholes

A bowl-shaped distress form in the surface of pavement that could penetrate through the HMA layer to the base course. Potholes are having sharp edges and vertical sides. When the HMA is thin, the potholes are most likely to occur. The roads with 100mm HMA and more than that is less prone to potholes. Potholes create roughness and damage the vehicles passing through them with high speed. And moisture infiltration is likely to occur

4. Joint Reflection Cracking

These are cracks in pavements. The cracks typically occur on the underlying pavement joints. The joint reflection cracking are only limited to the underlying joints or any other types of underlying cracking. These types of cracking allows moisture and roughness.

5. Corrugation and shoving

This is kind of plastic movement. Corrugation and shoving are waves across the pavement surface. The waves are perpendicular to the centerline of the pavement. This kind of distresses occur where traffic starts and stops.

6. Patching

When some portion of the pavement is replaced by new material to repair the pavement is called patching. This is said to be a defect despite of its well performance.

7. Raveling

When the aggregate particles dislodged progressively on the HMA layer is known as raveling. The causes of skidding and vehicle hydroplaning are the loose of debris on the pavement, roughness and water collection in the raveled location.

8. Bleeding

This distress is a shiny, glass-like reflected film of bituminous binder on the surface of pavement. It can become extremely sticky in some cases.

B. Pavement Condition Index

Pavement condition index is analyzing and evaluating of the pavement condition for each segment in length. PCI can be determined by manual visualization and that has to be conducted periodically and the numerical rating starting from 1 to 100 is awarded to each road section. The typical rating is: 90 to 100 for excellent; 80 to 89 for very good; 70 to 79 for good; 60 to 69 for fair; and lower than 60 for poor. There are so many standards developed by different organizations such as the method of U.S Army corps of engineering, the Highway preservation system useful in Canada, the Indian Road Congress (IRC) method. Each method is based on different criteria. The main use of PCI is to determine the fund required to maintenance and rehabilitation and to determine the priority of the segment to be repaired first [1].

IV. RESEARCH METHODOLOGY

Research methodology is based on three stages:

A. Pre data collection
B. Data collection
C. Post data collection

A. Pre data collection:

In this particular part of data collection the objectives and problem statement have been placed. And the literature survey has been carried out. For this research, urban flexible roads in the city of Pune have been selected as a case study.

B. Data collection:

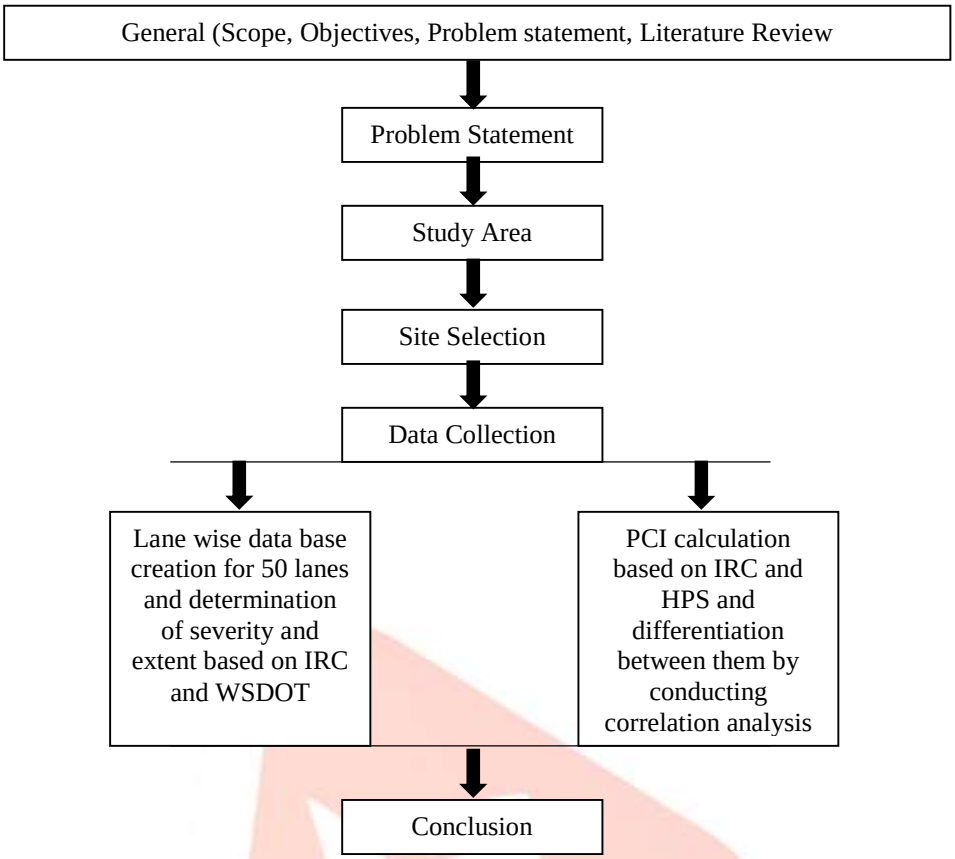
In this particular part, periodical site visits were carried out for the purpose of identification of the forms of distresses, the measurement of distresses and severity and extent determination of the distresses.

C. Post Data Collection

According to the collected data from 50 individual lanes (urban flexible roads) Pune city. The severity and extent is determined based on the guidelines of IRC and WSDOT distresses identification manuals. The lane wise PCI values have been determined by HPS and IRC methods. In this particular phase the correlation analysis has been carried out to determine the relationship between both methods.

The Research methodology is further elaborated in figure (1),

Figure (1) Research methodology



V. DATA COLLECTION

The data is collected from 50 different lanes, urban roads in Pune city. The data is collected manually by conducting actual measurement of the distresses using measurement tape and other measurement devices. The length, width, depth and other relevant parameters were recorded and tabulated. The photos and videos of the samples were taken and recorded. Each lane has been visualized for 100m length with an average width of 3.5m.

Figure (2) Alligator Cracking

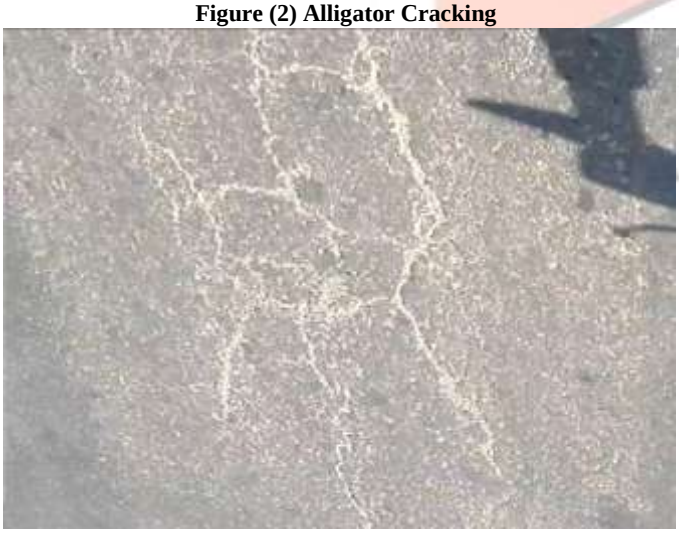


Figure (3) Patching

VI. DATA ANALYSIS

1. The actual data base is created for 50 lanes is shown in (appendix A). In this data base the severity and extent is calculated based on the guideline of WSDOT distresses identification manual [2].
2. Based on the actual data base, the most common types of distresses are observed:
   a. patching
   b. raveling

c. potholes
d. alligator cracking
e. bleeding
f. longitudinal cracking
g. transverse cracking
h. edge breakage
i. shoving
j. rock loose
k. delamination
l. segregation
m. joint cracking and
n. checking

3. The PCI calculation based on IRC [4] has been carried out and it is shown in part 1, (appendix B). Since this method rates the pavements on 1-3 rating scale. This rating scales needs to be converted to 0-100 rating scale by the methodology that is shown in table (1) and Figure (2).

Table (1)

CONVERSION OF (1-3) RATING SCALE INTO (0-100) RATING SCALE											
POOR				FAIR				GOOD			
1	0.067	0.067	55	1	0.133	0.133	70	1	0.2	0.2	85
2	0.067	0.133	56	2	0.133	0.267	71	2	0.2	0.4	86
3	0.067	0.2	57	3	0.133	0.4	72	3	0.2	0.6	87
4	0.067	0.267	58	4	0.133	0.533	73	4	0.2	0.8	88
5	0.067	0.333	59	5	0.133	0.667	74	5	0.2	1	89
6	0.067	0.4	60	6	0.133	0.8	75	6	0.2	1.2	90
7	0.067	0.467	61	7	0.133	0.933	76	7	0.2	1.4	91
8	0.067	0.533	62	8	0.133	1.067	77	8	0.2	1.6	92
9	0.067	0.6	63	9	0.133	1.2	78	9	0.2	1.8	93
10	0.067	0.667	64	10	0.133	1.333	79	10	0.2	2	94
11	0.067	0.733	65	11	0.133	1.467	80	11	0.2	2.2	95
12	0.067	0.8	66	12	0.133	1.6	81	12	0.2	2.4	96
13	0.067	0.867	67	13	0.133	1.733	82	13	0.2	2.6	97
14	0.067	0.933	68	14	0.133	1.867	83	14	0.2	2.8	98
15	0.067	1	69	15	0.133	2	84	15	0.2	3	99

Table 1 indicate the methodology of converting 1-3 point rating scale in to 0-100 point rating scale. Individual converting factors have been identified for category Poor, Fair, Good. The 1-3 PRS converting factors are compared with 0-100 PRS converting factors that are taken from figure 2.

Figure (2)
(0-100) rating scale

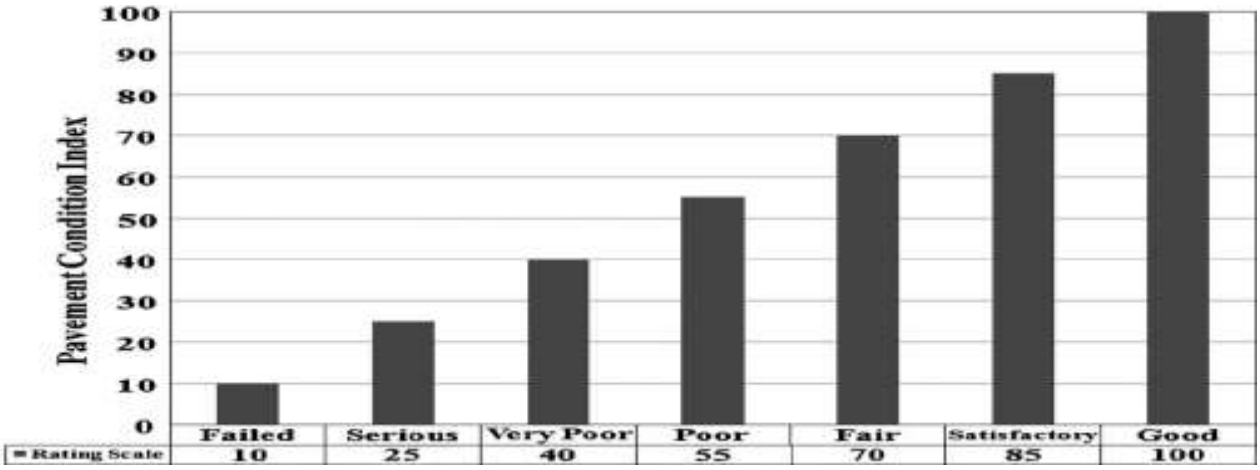


Figure 2 represent 0-100 point rating scale. Based on this figure the 1-3 PRS has been converted to 0-100 PRS.

And the summary of converted rating scale from 1-3 to 0-100 is shown in part 2, appendix (B)

4. The PCI calculation based on highway preservation method [3] has been carried out and shown in part 1, (appendix C). The summary of part 1 is shown in part 2, (appendix C).
5. Based on the aforementioned steps, the following table (2) conclude the PCI calculation based on both the methods.

Table (2)
PCI Calculation based on IRC and HPS methods

Sections	IRC Method				HP Method	
	1-3 Scale		0-100 Scale		0-100 Scale	
1	Poor	0.9125	Fair	68	Satisfactory	84.2
2	Fair	1.225	Satisfactory	78	Satisfactory	81
3	Fair	1.125	Satisfactory	78	Fair	80
4	Fair	1.5375	Satisfactory	80	Satisfactory	83.2
5	Fair	1.2375	Satisfactory	78	Good	91.5
6	Fair	1.4375	Satisfactory	79	Satisfactory	90
7	Poor	0.875	Fair	67	Satisfactory	83
8	Poor	0.875	Fair	67	Satisfactory	84
9	Fair	1.2	Satisfactory	78	Fair	77.1
10	Fair	1.65	Satisfactory	81	Satisfactory	84.5
11	Poor	0.925	Fair	68	Fair	73
12	Fair	1.1625	Satisfactory	78	Fair	71
13	Poor	1.06875	Satisfactory	77	Satisfactory	86
14	Fair	1.2375	Satisfactory	78	Fair	78
15	Fair	1.875	Satisfactory	83	Good	97
16	Poor	0.75	Fair	65	Good	95
17	Fair	1.225	Satisfactory	78	Fair	79.75
18	Fair	1.3125	Satisfactory	79	Satisfactory	86.6
19	Poor	0.875	Fair	67	Satisfactory	80.5
20	Poor	0.875	Fair	67	Satisfactory	80.5
21	Poor	1.095	Satisfactory	77	Satisfactory	83.6
22	Fair	1.575	Satisfactory	81	Satisfactory	85.1
23	Poor	1.05	Satisfactory	77	Satisfactory	82
24	Fair	1.125	Satisfactory	78	Satisfactory	87
25	Poor	1.05	Satisfactory	77	Satisfactory	84
26	Poor	1.05	Satisfactory	77	Satisfactory	84
27	Fair	1.12	Fair	70	Poor	57.75
28	Fair	1.12	Fair	70	Poor	57.75
29	Fair	1.3	Satisfactory	79	Satisfactory	88.1
30	Fair	1.3	Satisfactory	79	Satisfactory	88.1
31	Fair	1.225	Satisfactory	78	Satisfactory	85.5
32	Fair	1.225	Satisfactory	78	Satisfactory	85.5
33	Fair	1.325	Satisfactory	79	Satisfactory	88.5
34	Fair	1.325	Satisfactory	79	Satisfactory	88.5
35	Fair	1.2	Satisfactory	78	Good	94.5
36	Fair	1.2	Satisfactory	78	Good	94.5

37	Fair	1.2	Satisfactory	78	Good	94.5
38	Fair	1.2	Satisfactory	78	Good	94.5
39	Fair	1.45	Satisfactory	80	Good	92
40	Fair	1.45	Satisfactory	80	Good	92
41	Poor	1.05	Satisfactory	77	Good	95
42	Poor	1.05	Satisfactory	77	Good	95
43	Poor	0.8125	Fair	66	Satisfactory	88.5
44	Poor	0.8125	Fair	66	Satisfactory	88.5
45	Poor	1.075	Fair	69	Satisfactory	89
46	Poor	1.075	Fair	69	Satisfactory	89
47	Poor	0.855	Fair	66	Fair	76
48	Poor	0.855	Fair	66	Fair	76
49	Poor	0.966667	Fair	68	Good	90.5
50	Poor	0.966667	Fair	68	Good	90.5

Table 2 indicate the PCI calculation summary of 50 lanes that is carried out by IRC method and HPS. The first column shows the number of section, the 2nd, 3rd, 4th, 5th, columns shows the condition of the road, the rating calculated based on 1-3 PRS and 0-100 PRS with IRC method. And the 6th and 7th columns shows the condition and rating based on HPS.

6. To find out the relationship between both the methodologies, the correlation analysis has been carried out [5], it is shown in appendix D.

FINDINGS AND CONCLUSION

1. PCI calculated by IRC method based on 1-3 rating scale shows that the roads are mostly in Poor condition. It means the condition of roads are bad. Because 22 lanes out of 50 gives the Poor result which is almost 44%.
2. PCI calculated by IRC method based on the converted 0-100 rating scale shows that the roads are having satisfactory condition. It gives us an inference that roads are in quite good condition than that of 1-3 point rating scale.
3. PCI calculated by highway preservation method based on 0-100 point rating scale shows that the condition of the roads are better than that calculated by IRC method.

Since this is a controversial issue in PCI calculation, to carry out further differentiation between both the methods the correlation analysis has been done and the result of correlation coefficient is 0.274 indicating weak correlation. Which in detail it is shown in appendix D.

As concluding remarks, the overall concept of this study is that there is a huge difference in the result of pavement condition rating (PCR) conducted by IRC and HPS. To determine the causes of the differentiation, further analysis of distresses are recommended.

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