

**DEVELOPING METHODOLOGY FOR PRIORITY OF PAVEMENT
MAINTENANCE FOR URBAN ARTERIAL**Milaa Murshan¹, Monicaba Vala²*1 ME Student, Department of Civil Engineering, Marwari University, Rajkot 360003, Gujarat, India.**2 Assistant Professor, Department of Civil Engineering, Marwari University, Rajkot 360003, Gujarat, India.*

Abstract- Maintaining the roadway infrastructure takes great amount of money and time, big amount of money are invested in road maintenance to ensure the mobility of people and goods. Therefore, prioritization of maintenance works takes its importance for rating and ranking pavement conditions according to their relative importance thereby the costs will be minimized and the funds can be used in effective way. Since PMMS is a planning tool for evaluating pavement condition and deterioration caused by heavy traffic and weather effects, and contains a series of decision-making methods to determine how and when to maintain and/or rehabilitate the pavement and which pavement should maintain first, so that PMMS will be the most effective tool for enhancing prioritization process. This priority will determine the best list of selected sections for maintenance based on particular criteria like pavement condition, field survey results, traffic level, and pavement functions. Thus identify maintenance needs will result in control costs. Maintenance is essential to preserve and enhance economic and social benefits. The main aim of this research work is to provide priority index for maintenance of six sections of arterial roads in Rajkot city and developed methodology for priority of pavement maintenance activities calculated in Simple Ranking Technique (SRT). And defined and suggested methodology for PMMS in Rajkot city. Pavement Condition Index PCI was calculated in this study for rating and ranking the pavement.

Keywords: Prioritization, PCI, PMMS, Pavement Maintenance, Ranking and Rating of pavements.

1. Introduction

The road network of the city serves as the nervous network in our body to transport passengers, goods and services and to link various cities together. Therefore, keeping the roads in good condition is the responsibility of every transportation agencies. Driving on deteriorated roads will increase repair cost and fuel consumption. There are two main causes of pavement deterioration, the weather and heavy traffic loads and other sub causes like insufficient drainage and defects in the quality of materials used in pavement layers. Because our pavements wearing out we respond with maintenance and rehabilitation but costs of labor, equipment and materials needed to do that continue to increase while the budgets are not enough for all maintenance work, so we need a cost-effective approach to manage our vital infrastructure, which can be done by PMMS (which is the tool or method for providing information needed to make good decisions in cost effective manner and for monitoring how pavement segments age and deteriorate and to utilize our limited resources). It helps in these management by queries where network inventory is, how do we rate road data, what road condition is it, when should we fix the treatment rules and which roads do we fix first (prioritization). Thus, Managing the roads requires three procedures i) inventories of existing condition ii) Rating and evaluation of pavement conditions iii) using these evaluations to set maintenance prioritization.

1.1. Modules for Typical PMS:

The different modules that make up a typical PMS include database, three analysis methods and feedback.

- A database containing information needed to support the other PMS modules. A typical database contains an inventory of roadway features; Information on pavement condition; Construction, maintenance and rehabilitation history; Traffic Data and Cost data. And might also have data on design, materials, accidents by location and geometries. The database supports the other modules but it can also generate various reports. Among them Deficiency reports, performance history reports and maintenance, rehabilitation and reconstruction program reports.
- Three analysis methods will generate a variety of products helpful for decision making. three methods used to analysis pavement performance and cost data are i) pavement condition analysis; ii) priority assessment models; iii) network optimization models. i) The first method is Pavement Condition Analysis: This method uses numeric index to track pavement condition for instance 0 could mean the poorest pavement and 100 means the best. Managers use this analysis method to rank pavement areas by types of distress and condition at the function of traffic or road class, they can identify criteria for ordering repairs to each pavement segment and they can estimate funding needs for each kind of repair.
 - ii) The second analysis method is priority assessment model: This method determines repair strategies for individual projects first, it basis the strategy on lifecycle costs over a period of time such as 20 or 30 years

using this method can rank projects, categorize costs for treatments to make the funding needed to achieve network performance standards and advise single and multi-year programs.

iii) The third analysis method is the optimization model: This model starts with analysis of the entire network first trying to meet budget constraints.

- A feedback process: It uses continual field observations to improve the reliability of PMS analysis. Feedback is essential to the system. There are four common comparisons that managers use to both verify and improve the system reliability. They compare the actual cost of maintenance, rehabilitation and construction but those use in the system analysis after that they compare field observations of pavement and traffic conditions with the conditions predicted by the systems model and then they compare actual performance achieved with performance standards specified in the system analysis, finally They compare the actual treatment applied with the treatment recommended by the system.

1.2. Level of PMS:

A typical PMS includes two major levels of the decision making process: i) Network Level; and ii) Project Level.

A network level decisions concern widespread program and policy issues covering an entire network of roads.

A project level decisions address engineering and technical aspects of pavement maintenance on a project-by-project basis.

Managers use one of four decision-making methods which are matrix method, decision tree, lifecycle cost analysis, and optimization methods.

- a. The matrix method: It matches a set of a specific pavement problems with a set of maintenance, rehabilitation and reconstruction treatments. Engineering judgment acquired through experience is used to decide which treatment to use.
- b. A decision tree method: It shows different combinations of pavement problems coupled with the appropriate treatment again using experienced engineer to select the appropriate treatment for each combination.
- c. Lifecycle Cost Analysis: By using this method, managers choose treatments based on which will cost the least over the life of the pavement.
- d. Optimization Method: It focuses on a specific goal such as an increase in pavement performance standards for this method the engineer decides based on an Objective-Function may be maximization of benefits or maximization of performance standards. This Objective-Function provides a clear measure of success they also consider decision variables and constraints such as the total available budgets.

1.3. Components of PMS:

PMMS consists of six different components:

- a. Setting the basic objectives;
- b. Defining the work activities and standards;
- c. Developing annual work programs;
- d. Organizing and allocating the resources;
- e. Authorizing and scheduling work
- f. Reporting and evaluating the performance.

1.4. Type of Maintenance Works:

Based on natural of task and severity of defects maintenance works can be classified into different types like Corrective, Preventive Resurface, Rehabilitation and Reconstruction.

Corrective Maintenance: It is the activities performed to detect, isolate, and correct the failure thereby the faulty devices, machines, or systems could be return to their normal operable state. Corrective Maintenance contrast with Preventive Maintenance. It is one that corrects the defects observed in the equipment or facilities, is the most basic maintenance and troubleshooting is or defects and correct or repair. Objectives of the corrective maintenance is to lengthen the life of the facility and for offering optimal performance. **Preventative Maintenance:** It is a tool for pavement preservation unlike routine maintenance that involves regularly scheduled activities. It is a strategy which is planned, it is not reactive maintenance intended to keep a pavement at a particular level of service rather preventive maintenance supplies quantifiable cost effective treatments to preserve an existing roadway retard future deterioration and improve the functional condition of the system and unlike rehabilitation which restores a pavement structure the goal of preventive maintenance is to extend the life of structurally sound pavements we all know that we don't wait until the wood is rotted before we paint our house and the same philosophy should be true with payments we should apply preventive maintenance treatment of all the payments still in good condition. **Resurface:** It is the method in which we remove the deteriorated surface and sub-surface layers of the pavements and put new layers. Resurfacing the road is long-term process aimed to reshape the pavement surface with asphalt overlay. There are different types of road resurfacing like i) Slurry Seal or Cape Seal ii) Single Surface Treatment iii) Double Surface Treatment iv) Gravel Resurfacing "Re-

graveling” v) occasional resurfacing, and vi) Structural and functional overlay. Rehabilitation: It is the action of restoring the normal and healthy life of a pavement that has been damaged to its initial condition. Rehabilitation may be structural or functional improvement of a pavement to extend its service life. If more than 25 per cent of the road’s length needs rebuilt the work is rehabilitation not maintenance. Reconstruction: It is the process of removing and replacing of all asphalt and concrete layers, and sometimes removing the base and sub-base layers and reconstruct them, in order to improve and enhance the subgrade and drainage. Reconstruction is rarely used because of its high cost. Some of pavement conditions which require reconstruction are obsolete geometrics, capacity improvement needs, and/or alignment changes. Required maintenance works for treatments can be

1.5. Pavement Maintenance Prioritization and Its Advantages:

Prioritization is a sequential method which enlists pavement maintenance programs and chooses which programs should be done first in order of their importance. Prioritization is a procedure helps in determining or selecting the preferred project or activity from a number of feasible alternatives. The prioritization process can be used by professional planners in selecting the best projects, or by the leadership to determine the best plans. There are several methods of prioritization, ranging from the simple to the more complex. Some processes are complicated and require mathematical abilities. Other techniques are simple to use and do not require mathematical analysis. Thus, pavement maintenance prioritization depends on decision making methods which vary from simple ranking to complex optimization. Prioritization of pavement maintenance depends on the importance of road sections, both present and future pavement conditions. The advantages of maintenance prioritization are as follows:

- Prioritization technique is appropriate to all decision-makers. It helps in making a decision which will vary in detail and difficulty.
- The main advantage or prioritization is to identify a set of suggested strategies applied to different road sections to reduce treatment costs and increase benefits.
- Prioritization process helps in determining and selecting which strategies for specific road sections best fit the problem objectives and constraints.
- It provides the ability to develop cost-effective, policy-oriented work plans.
- Prioritization process helps in putting flexible decision trees and helps in selecting proper treatment strategies for pavement sections in relation to its condition, weather, traffic levels, and agency policies.
- By help of prioritization, pavement preservation needs can be easily estimated and available budgets can be distributed accordingly.

2. Objectives and Scope of Research:

The main objectives of this research are to identify the different types of distresses and defects on flexible pavement and to determine the pavement condition index PCI of the pavement and to develop a Maintenance Priority Index of the flexible pavement and to recommend and define strategy for pavement management maintenance system based on PCI values and to prioritize pavement maintenance Activities implemented under Pavement Management System (PMS) study. This research work is limited to study three main roads in Rajkot district namely Raiya road, Nana Mava road and Dr. Yagnik road in six sections (upside and downside).

3. View of Literature:

Many researchers have been attempted to set priority list for road maintenance. J. Farhan, et al. (2009) used Analytical Hierarchy Process (AHP) for the prioritization of pavement maintenance activities based on multi-criteria decision-making process and pair-wise comparison. M. T.Obaidat et al. (2006) gave classifications and maintenance priorities of flexible pavement and using (PCI) for rating the condition of pavement surface and they prioritized the maintenance activities based on the Priority Index (PI). The classification process included distress type, distress severity level and options for repair. They developed these data in GIS software environment. Vishwanath .G et al. (2013) determined the length of the arterial path of the selected area, assessed the status of the selected segment based on the distress survey, evaluated the PCI values of the different sections, and to recommend PCI based pavement management strategy values. The authors concluded that PCI achieved an objective rational basis for deciding of maintenance and rehabilitation requirements for arterials roads. Shah. Y. U et al. (2013) showed different priority methods used in the pavement management system covers various methods from simple judgment to complex model. These methods are then classified as sorting methods, optimization methods, artificial intelligence techniques, and analytical hierarchical process methods. In this paper, the study area is identified first, and then a variety of field surveys are carried out to collect inventory data, crustal data and cost data. After the traffic count, the structural analysis of the Benkelman beam deflection method and the functional evaluation of the five-wheel collision integrator were carried out. From the evaluation, the MPI method is used to prioritize. The emergency index (UI) is carried out by multiple and degree. And then the weight analysis to the designated distress.

4. Data Collection and Data Analysis:

4.1. Data Collection:

Rajkot city is selected as a case study in this research and the road inventory data collected is shown in the following table:

Section Name	Road name	Road segment		Road length (km)	Pavement width (m)	Shoulder Width (m)	Median Width (m)	Type
		From	To					
A	Nana Mava	Nana Mava Circle	Laxminagar Underpass	1.2	7	2	0.7	Asphalt
B	Nana Mava	Laxminagar Underpasses	Nana Mava Circle	1.2	7	2.8	0.7	
C	Raiya Road	Raiya Circle	Kishanpara Circle	2.2	7.3	2.8	0.9	Asphalt
D	Raiya Road	Kishanpara circle	Raiya circle	2.2	7	2.6	0.9	
E	Dr. Yagnik Road	Race Course	Ramakrishna Ashram	1.2	5.6	None	0.4	Asphalt
D	Yagnik	Rama Krishan	Race Course	1.2	6.2	None	0.4	

Table (1): Road Inventory Data for selected Road in Rajkot City

Traffic Volume is conducted for 24 hours during consecutive four days from 05-10-2016 to 08-05-2016 every day six peak hour, three in Morning Peak hours from 9:00 Am to 12:00 Noon and another three hours in evening peak hours from 5:00 Pm to 8:00 Pm. The volume was noted by counting the number of vehicles passing through the road section at every 10 minutes intervals by manual counting as well as mechanical counters. From this study the traffic count was in the range of 9,500-25,500 Vehicle per day. The highest traffic volume is experienced in Raiya road section D it is equal to 90491 vehicles per 4 days.

Different types of distresses were observed based in visual survey these distresses are Potholes, Patching, Raveling, Longitudinal Cracking, Alligator Cracking and Rutting. The Patching, Raveling and Alligator Cracking were measured in square meter units (width and length). Whereas potholes were measured in numbers and rutting measured in average depth in meter and longitudinal Cracking measured in meter.

4.2. Data Analysis:

Based on measurements of pavement condition and distresses severity, the pavement condition index which is a numerical value between 0 and 100 used for rating and indicating general conditions of a pavement. ASTM has standardized PCI surveying processes and calculation methods for both road and airport pavements. PCI was calculated by the following procedure:

- a. Measure the distresses.
- b. Determine the total distress for each type of defect except rutting take the average rutting in one section.
- c. Calculate the density for each type of distress by using the following formula

$$\text{Density} = \frac{\text{Total of distress of same type in the selected section}}{\text{The Area of the selected Section}} * 100$$
- d. Determine the Severity for each type of distress whether it is low, medium or high. Note that there is no criteria for determining the severity for some types of distress, it depends on the visual inspections and on the engineer judgment.
- e. From Severity levels and density in percentage diagram determine the deduct value for each distress type figure (1).

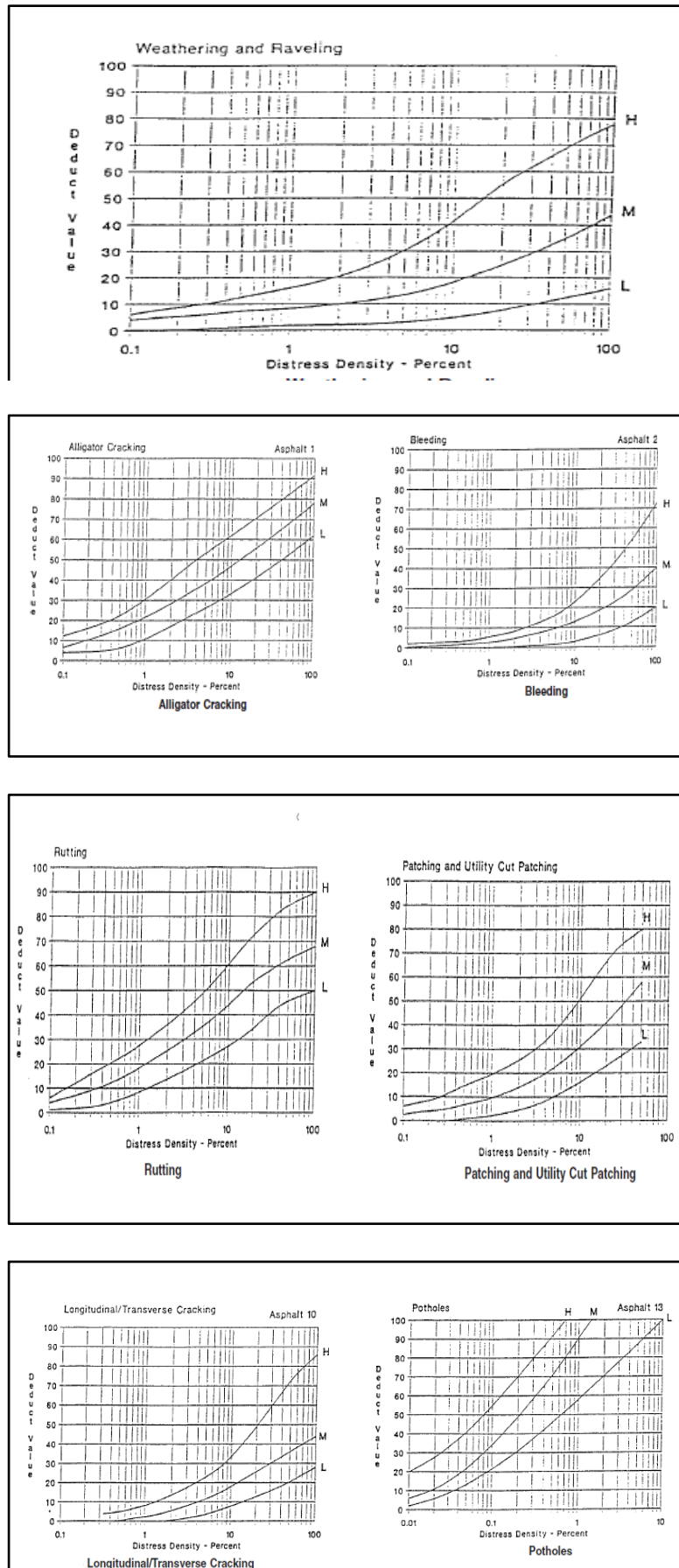


Figure (1): Deduct Value Calculation

- f. For Calculating the Corrected Deduct Value (CDV) first calculate the allowable number of deducts (m).

$$m = 1 + \left(\frac{9}{98}\right) * (100 - MaxDV)$$

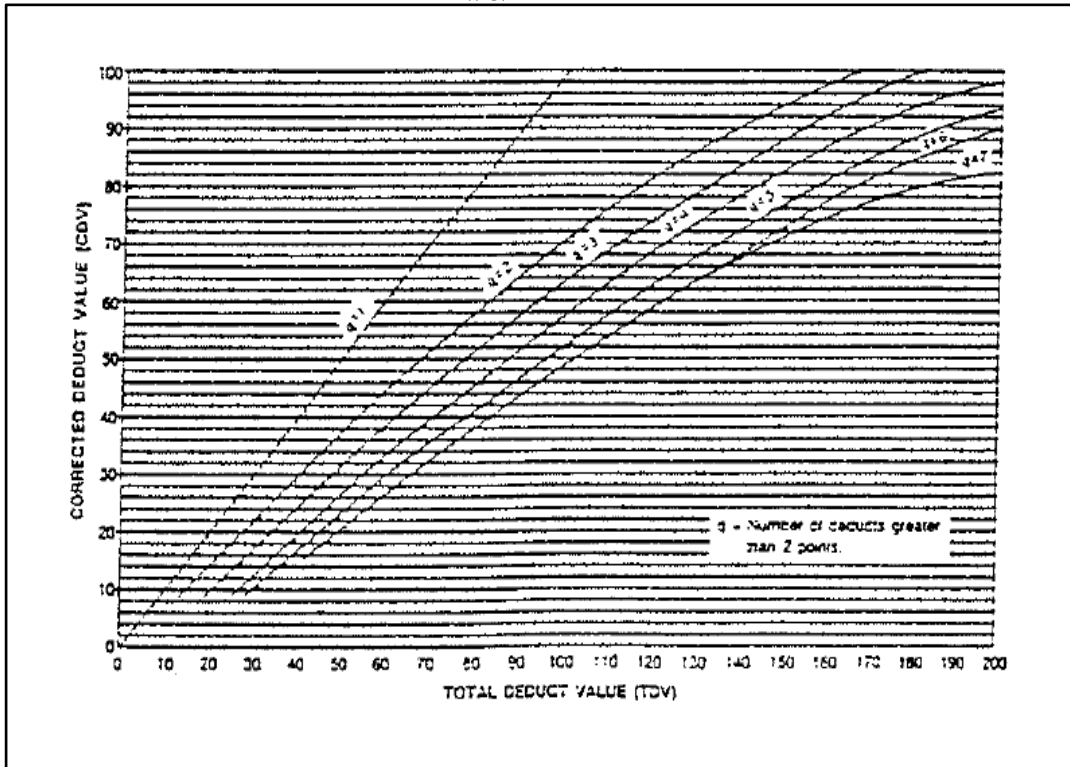


Figure (2): Calculation of Corrected Deduct Value

- g. After finding the value of (m) calculate the total deduct value by adding all individual deducts and the determine (q) as a number of deduct finally find the CDV from the Correction curve shown in figure (2).
 h. Take the maximum value of CDV and calculate PCI from the following Formula:

$$PCI = 100 - Max\ CDV$$

- i. From the Pavement Condition Index Chart give the appropriate Rating. Figure (3)

Standard PCI™ Rating Scale	Suggested Colors
100 Good	Dark Green
85 Satisfactory	Light Green
70 Fair	Yellow
55 Poor	Light Red
40 Very Poor	Medium Red
25 Serious	Dark Red
10 Failed	Dark Grey
0	

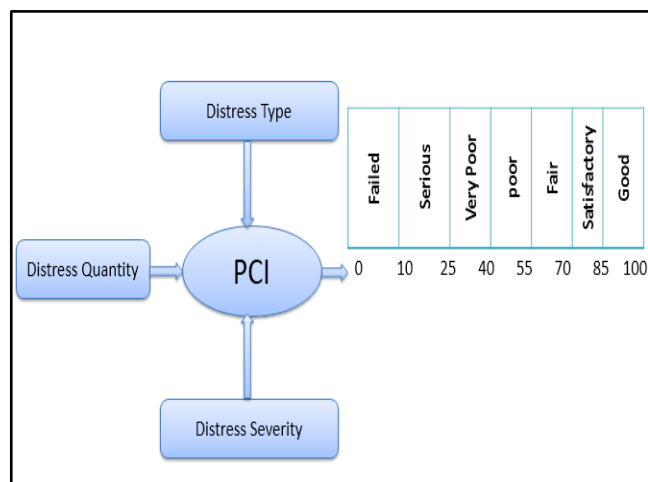


Figure (3): Values of PCI based on ASTDM

- j. The mean PCI for whole section is calculated by computing the average of all parts inspected in that section.

And based on traffic volume, the Average Daily Traffic was calculated as shown in table (2):

Total Traffic Volume in Certain Days						
Road Name	Nana Mava Road		Raiya Road		Dr. Yagnik Road	
No. Of Days	Section A	Section B	Section C	Section D	Section E	Section F
First Day 5/10/2016	17490	13086	14320	22182	10151	11544
Second Day 6/10/2016	15662	12203	13696	21457	9618	11327
Third Day 7/10/2016	16392	12079	14153	25447	9904	10949
Fourth Day 8/10/2016	15201	11929	13547	21405	10061	13113
Total	64745	49297	55716	90491	39734	46933
ADT	16186.25	12324.25	13929	22622.75	9933.5	11733.25

Table (2): Average Daily traffic (ADT) for Selected Sections

The priority index was calculated based on the following formula:

$$\text{Priority Index: } PI = DL / (TF * DF)$$

Where;

DL: Defect Length

TF: Traffic Factor

DF: Defect Factor

Defect Length DL: is the summation of defects for one type of distress in the whole road section.

Traffic Factor (TF): is the constant value assigned on the basis of the traffic level predominant on the road sections.

Defect Factor (DF): is a numerical value which is allocated to each road depends on the type of defect and the required treatment

5. Results and Findings:

The results were abstracted in Table (3)

Road Name	Section Name	PCI	PCR	PI	Suggested treatment
Nana Mava	A	79	Satisfactory	1.68	Routine Maintenance
	B	69	Fair	2.78	Preventive Maintenance
Raiya	C	71	Fair	3.18	Preventive Maintenance
	D	49	Poor	7.54	Thin Overlay
Dr. Yagnik	E	60	Fair	5.66	Preventive Maintenance
	F	55	Fair	2.92	Rehabilitation

Table (3): PCI, PCR, PI and suggested treatments

From above table we find that the highest priority for maintenance should be given to the section D in Raiya road as its condition is poor after that to the section E in Dr. Yagnik road and then to section F in Dr. Yagnik road and then to section B in Nana Mava road and finally to the section A in Nana Mava road as its PCI is the best and PI is the lowest. We conclude that if PCI is high the pavement is in better condition and if the PI is low it means the pavement in good condition and severity is less and urgent maintenance work required if PI is high the pavement needs maintenance as soon as possible. Note that in section F although its PCI is 55 (Fair) and it is less than the PCI value in section F but its PI value is more (5.66) that means in section E severity of distress more than section F. thus, Prioritization depends not only on the number of distresses but also on the severity of the distress and its density and on traffic volume because where traffic is high, the road deteriorates more.

6. Conclusion

This study has developed Priority Index for maintenance of six sections A,B,C,D,E and F of arterial roads in Rajkot city (Nana Mava Road, Raiya Road and Dr. Yagnik Road) based on several factors such us severity of distresses and their

density, pavement conditions, traffic volume. This study priority index was calculated in Simple Ranking Technique (SRT) method on these six sections and found that the section D is need maintenance before the others as its PCI value is 49 (Poor) and its PI is very high 7.54. Pavement Condition Index PCI was calculated in this study for rating and ranking the pavement. Spatial and attribute information of road network such as street name, number of lanes, pavement width, rating and type of pavement, type and number of distresses were used to evaluate pavement surface are included in this project. Based on the field observations the major distresses in the selected roads were potholes, patching, raveling and these distresses were more severe than other types of defect like Rutting, Longitudinal Cracking, Bleeding and Alligator Cracking. These distresses are measured in Meter, Square Meter and Number. Meter unit for longitudinal Cracking, Square Meter unit for Alligator cracking, Patching, Raveling and Bleeding, the potholes are measure in Number and Rutting are measured in the meter unit for average depth of ruts.

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