DEVELOPMENT OF PAVEMENT MANAGEMENT STRATEGIES FOR ARTERIAL ROADS

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Abstract

An arterial road is a high-capacity urban road which delivers the traffic from collector roads to freeways, and between city centres at the maximum and possible level of service. Therefore it is very important to maintain these roads as they are subjected to heavy traffic and on monsoon or poor drainage conditions which may damage the pavements at a faster rate further requiring timely maintenance and costly rehabilitation. Assessing the condition of the pavement periodically is important so that maintenance work can be taken up accordingly in order to slow down the deterioration rate. A tool which can access the deterioration of pavement is a Pavement Condition Index (PCI) which is a distress study carried out on pavement. PCI is a numerical rating of the pavement condition that ranges from 0 -100 with 0 being worst possible condition 100 being the best possible condition. Therefore, this paper aims at bringing out the methodology used in carrying out the survey on the pavement and for rating of the pavement (PCI) with the case studies of four arterial roads of Rajarajeshwari Zone, Bangalore city and the PCIs of rating of these pavements at the time of studies was found to be from very poor to excellent. Pavement management strategies have been proposed based on the condition rating.

Keywords: *Flexible Pavements, ASTM, PCI, Pavement Maintenance, Arterial roads*

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1. INTRODUCTION

Road maintenance is one of the important components of the entire road system. The maintenance operations involve the assessment of road condition, diagnosis of the problem and adopting the most appropriate maintenance steps. Even if the highway is well designed and constructed, they require maintenance, the extent of which will depend on several factors including the pavement type. In order to carry out design of pavement rehabilitation, the existing pavement condition must be evaluated. Such an evaluation usually involves the assessment of the existing pavement surface distress, roughness, rutting.

During the past four decades, Bangalore has seen many developments in the form of increased land use of urban and rural areas, rapid growth of population and increasing number of motorised and non-motorised vehicles, with steep rise in industrial, commercial, and residential activities improved transport system namely, Bangalore Metro which is under progress. Therefore it is very important to maintain these roads as they are subjected to heavy traffic (truck load) and on monsoon or poor drainage conditions which may damage the pavements.

1.1 Need for the Study

For the improvement of urban road condition, there is a need to develop a set of procedures that will provide a systematic evaluation of highway needs, based on appropriate engineering decision and expert knowledge and at the same time to determine which road stretches need maintenance and which are the sections for which the maintenance operation can be deferred.

1.2 Objectives of Present Paper

The objectives of the present paper is to,

1. Identify the arterial road length in the selected zone,
2. To assess the condition of selected stretches based on distress survey,
3. To evaluate the PCI value of different sections of road,
4. To recommend the pavement management strategies based on PCI values

2. REVIEW OF LITERATURE

2.1 General

In the stream of roadway technology, pavement distress and failure is considered as a complex as several factors are

responsible for the pavement deterioration and failure. The type and extent of maintenance requirement for a road also depends on the serviceability standard laid down, the maintenance needs, funds available and many other factors. The current engineering practice for selection of maintenance and rehabilitation alternatives is based on subjective judgment and engineering experience.

2.2 Pavement Condition Index (PCI)

Initially PCI was developed by the United States Army Corps of Engineers and is based on a visual survey of the pavement [1]. PCI is a numerical rating of the pavement condition that ranges from 0 -100 with 0 being worst possible condition 100 being the best possible condition [2]. It is a statistical measure and requires manual survey of the pavement. PCI surveying processes and calculation methods have been standardized by ASTM for both roads and airport pavements.

The PCI provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement, which also indicates the structural integrity and surface operational condition (localized roughness and safety). The PCI cannot measure structural capacity nor does it provide direct measurement of skid resistance or roughness. It provides an objective and rational basis for determining maintenance and repair needs and priorities. Continuous monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. The PCI provides feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures.

The PCI values obtained from visual inspection i.e. distress survey by recording the severity and extent of the various distress namely cracking, rutting and potholes occurred to pavement can be utilized well in prioritizing the maintenance strategies [3]. This method provides cost effective maintenance and rehabilitation measures for planners and decision makers for maintenance of pavement in road network.

The PCI provides an objective rational basis for determining the maintenance and rehabilitation needs of highway pavements and for prioritisation of the pavement sections for maintenance on priority. This methodology considers the common type of distresses in highway pavements and suggests the maintenance treatment considering the overall health of the pavement section [4]. PCI is meant to provide an objective, rational basis for determining maintenance and rehabilitation needs and priorities and a warning system for early identification or projection of major repair requirements or both.

The PCI can be used as a tool for assessing the condition of the pavement for periodic maintenance work which could be taken up accordingly in order to slow down the deterioration rate of rural roads constructed under PMGSY scheme in India [5].

The cost effective maintenance and management strategies can be developed by assessing the severity and extent of measured pavement distress values, further which can be used as input to Pavement Maintenance & Management System (PMMS). In developing the maintenance and management strategies PCI plays a major role including type of pavement and other road related information [6].

3. FIELD STUDIES & DATA COLLECTION

3.1 General

The methodology adopted in this study provides a simple approach in the development of PCI for the selected arterial road stretches in Bangalore city for taking up cost effective maintenance measures/treatments. The maintenance treatment recommendations are based on PCI which involve the collection and preparation of road inventory data and report, visual distress survey of the selected stretches based on pavement performance related parameters.

3.2 Surface Distress Measurements

The existing pavement condition initially was assessed by visual inspection of the selected road stretches, and then the sections were made based on the distress type and severity. Then pavement surface distress measurement was carried out involving the identification of both type and severity of the pavement distresses present in the study area of the road sections. This procedure was performed with the use of Unified Facilities Criteria (UFC)-2004, ASTM D 6433-07, Paver asphalt distress manual-1997, Distress Identification Manual FHWA USDOT-2003, Oregon DOT Manual-2010 and SHRP-P-338 which contains definitions and information concerning pavement distresses.

3.3 Study Stretches

The following four arterial roads in Rajarajeshwari Zone, Bangalore city with total length of 36.5 km were selected and the same with brief inventory detail is listed in Table 1. All the roads selected are within the Bruhat Bangalore Mahanagara Palike (BBMP) limits.

Table 1 Selected Road Stretches

Location Code	Road Name	Length in km	Pavement Type	Divided Carriageway	Width in mtr	No. of Sections made
1	Magadi Road	9.5	Flexible	Yes	15	5
2	Uttarahalli Road	17	Flexible	No	10	9
3	Subramanyapura - Vasantapura Main Road	3.7	Flexible	No	10	2
4	Muddinapalya Road	6.3	Flexible	No	10	4

3.4 Methodology of Data Collection

Bangalore is India's fifth-most populous urban agglomeration, growing metropolitan city with population more than 8.426 million. The local authority (BBMP) has divided Bangalore into 8 zones namely, Bommonahalli Zone, Bangalore East Zone, Bangalore South Zone, Byatarayanapura, Mahadevapura, Bangalore West Zone, Dasarahalli and Raja Rajeshwari Nagar Zone. For the present study RR zone (details shown in Table 2) is chosen as this zone covers major roads that connects many educational institutions, hospitals, malls, toll roads, religious places, ring roads, developing areas and it also consist a major connectivity to another growing city Mysore. The roads in this zone considerably subjected to heavy axle loads, on monsoon rain and many developments work namely Bangalore Metro (Namma Metro) due to which the roads constructed are failed to serve their intended function, hence a study in this view is required.

Table 2 Road network detail of Rajarajeshwari Zone

Category of the road	Length in km
Arterial	94
Sub Arterial	118
Collector street	---
Local Street	---
Total Length	212

There are many feasible approaches to defining performance and assessing the condition of road facilities. A pavement condition needs to be characterized in quantifiable terms so that the potential performance can be associated to a defined condition. In this study (walk through) pavement survey was conducted and in this regard the procedure adopted was based on visual assessment of the type, quantity and severity of pavement distresses and results in the PCI. UFC – 2004 [1] was referred for calculation of PCI, the detail calculation procedure is explained in further section. It was aimed towards the evaluation and analyzing the existing roadway conditions so that a realistic definition of the individual problems and structural requirements of the roadway can be made.

4. ANALYSIS & RESULTS

4.1 Determination of Deduct Values and Pavement Condition Index

A Deduct Value (DV) is defined as the value that represents the amount of distress that a pavement has undergone or is subjected to. Each section was inspected and distress data, severity levels such as Low (L), Medium (M) and High (H) were recorded in the distress survey data sheet. The density of each individual distress was calculated using the Eqns. 1, 2, 3.

$$\text{Density} = \frac{\text{Distress amount in square meters}}{\text{Sample area in square meters}} \times 100\% \quad (1)$$

$$\text{Density} = \frac{\text{Distress amount in linear meter}}{\text{Sample area in square meters}} \times 100\% \quad (2)$$

$$\text{Density} = \frac{\text{Number of potholes}}{\text{Sample area in square meters}} \times 100\% \quad (3)$$

Then the DVs were determined from the DV curves, then for each distress type and severity Total Deduct Value (TDV) was computed by summing up all the individual DVs then the Corrected Deduct Value (CDV) was determined from CDV curve shown in Fig. 1. Then the PCI was computed using the Eqn. 4. All the PCIs and rating for the respective section with TDV and CDV are presented in Table 3.

$$PCI = 100 - CDV \quad (4)$$

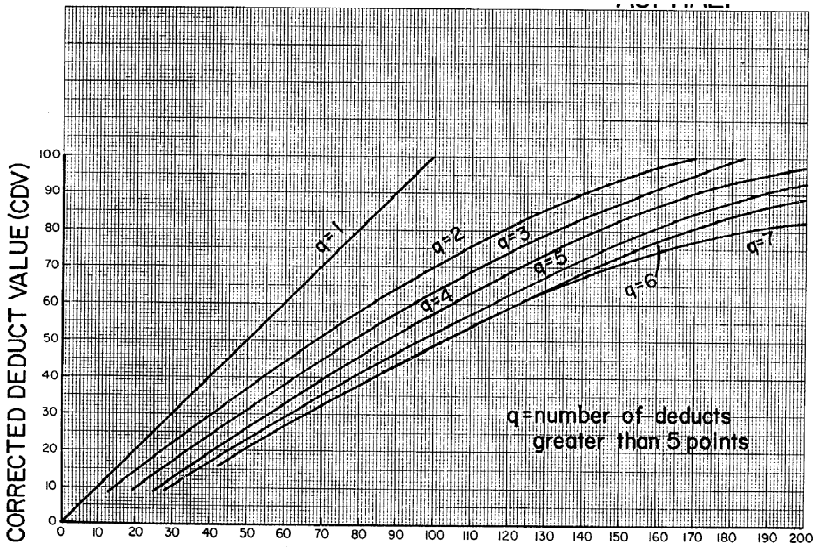

Fig1. Corrected deduct value curves for asphalt-surfaced pavements

Table 3 Computation of Pavement Condition Index

Location code	Beginning Post	End Post	Length of the Section in km	Width of the Section in m	TDV	CDV	PCI	RATING
1	Magadi Road Toll Booth	Mahadeshwara Nagar	2.7	8	63	40	60	Good
	Mahadeshwara Nagar	Magadi Road Toll Booth	2.7	8	38	28	72	Very Good
	Mahadeshwara nagar	Sumanahalli Bridge	2.7	7.5	86	55	45	Fair
	Sumanahalli Bridge	Mahadeshwara Nagar	2.7	7.5	107	62	38	Poor
	Sumanahalli Bridge	Kamakshipalya	2.4	7.5	140	73	27	Poor
	Kamakshipalya	Sumanahalli Bridge	2.4	7.5	143	80	20	Very Poor
	Kamakshipalya	Veeresh Theatre	1.2	7.5	100	58	42	Fair
	Veeresh Theatre	Kamakshipalya	1.2	7.5	136	70	30	Poor
	Veeresh Theatre	Chord Road (Petrol Bunk)	0.5	7.5	101	57	43	Fair
	Chord Road (Petrol Bunk)	Veeresh Theatre	0.5	7.5	85	54	46	Fair
2	SJBIT College of Engineering.	Kengeri sat. Bus Stop @ Mysore Road	2.2	10	100	63	37	Poor
	JSS College of Engineering	SJBIT College of Engineering.	1.2	10	56	35	65	Good
	Pattalamma Temple	JSS college of Engineering	2.7	10	101	57	43	Fair
	Uttaralli Main Cross	Pattalamma Temple	2	10	97	56	44	Fair
	Chikkalasandra Cross	Uttarahalli Circle	2.8	7.5	10.5	11	89	Excellent
	Kadrenahalli	Chikkalasandra Cross	2	7.5	52	38	62	Good
	ORR Near Dayanand Sagar College	Banashankari BMTC	1.4	12	66	43	57	Good

	Banashankari BMTC	Banerghatta ORR Circle Jayadeva Hospital	3	7.5	42	31	69	Good
	Banerghatta ORR Circle Jayadeva Hospital	Banashankari BMTC	3	7.5	86	55	45	Fair
3	Subramanyapura Bus Stop	Yadaualm School Junction	0.9	10	143	70	30	Poor
	Yadaualm School Junction	Konanakuntee @ Kanakpura Road	2.8	10	112	63	37	Poor
4	Vidhaynikethan School	Muddinapalaya	2.2	12.5	49	36	64	Good
	Muddinapalaya	Kempagawada Circle	0.7	8	22	16	84	Very Good
	Kempagawada Circle	Dwarakwas Road	2.1	7.5	120	63	37	Poor
	Dwarakwas Road	Magadi Road Toll Booth	1.3	9	108	75	25	Very Poor

Determination of appropriate maintenance measures

PCI Range	Rating	Maintenance Measures
86-100	Excellent	No maintenance required
71-85	Very Good	Little or no maintenance
56-70	Good	Routine maintenance, crack sealing and minor patching
41-55	Fairs	Preservative treatments (seal coating or thin non-structural overlay 2” or more)
26-40	Poor	Needs patching and repair prior to major overlay Milling and removal of deterioration extends the life of overlay.
11-25	Very Poor	Needs reconstruction with extensive base repair.
0-10	Failed	Total Reconstruction

DISCUSSION & CONCLUSIONS

1. PCI provides an objective rational basis for determining the maintenance and rehabilitation needs of urban roads.
2. The suggested methodology considered the common type of distresses in urban roads and suggests maintenance treatments considering the overall health of the pavement.
3. The urban sections that possess higher value of pavement condition index do not require maintenance and pavement section that are assigned lower value of pavement condition index require maintenance on priority.
4. PCI serves as a warning system for early identification or projection of major repairs required.
5. Potholes, weathering and raveling, alligator cracking, polished aggregate and rutting were the major distress identified on urban stretches. In some parts of the selected section of roads there were no pavement or wearing course was absent which require immediate attention.
6. Due to cutting of pavements across and along the roads for providing service lines or for repairing existing service lines and subsequent improper resurfacing has resulted in deterioration of pavements.
7. PCI is a function of the type of distress, density of distress and severity of distress hence management strategies have been recommended based on PCI values as per PASCER manual

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