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Prioritisation of Pavement Maintenance based on Pavement Condition Index

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Abstract

The main objective of this study is to determine the Pavement Condition Index (PCI) through field data collection and analysis to prioritize the maintenance of pavements. Distress data such as cracks, patches, potholes, ruts etc. was collected along the identified sections of pavements selected based on severity of distress. Corrected deduct values were obtained by assigning weightages to different types of distress and PCI obtained. It was found from the analysis of data that a thin overlay was required as a rehabilitation measure for one of the study stretches. The road authorities of this location also came out with the same remedy thorough their own study, there by establishing one of the findings of this study. Suitable remedial measures for rehabilitating the pavement to different study locations were suggested.

Keywords: Acceptability Levels, Deduct Values, Distress, Inventory, Pavement, PCI

1. Introduction

Quality and efficiency of the pavements affects the quality of the life. Deterioration and failure of pavements are mainly due to aging, misusing. Thus maintenance and preservation of the pavements has a great national interest. PCI has emerged with different stages of composure and adopted all over the world for prioritising the pavements for maintenance and rehabilitation works. PCI is based on visual survey of various types of distress in a pavement. This method is very simple, easy and an inexpensive one for finding the present condition of pavements and for identifying the maintenance and rehabilitation needs. PCI is an evaluation process which is determined according to the procedures contained in ASTM D 5340 and is adopted worldwide for measuring the condition of the pavements by considering the functional parameters with the significance of structural performance. Occasional maintenance on the same pavements will exhibit variations in performance levels with time and it can also be used for prediction of present condition of pavements. In the present study distress data is collected on selected sections of pavement and PCI is evaluated after ascertaining the severity and intensity of distress, by assigning weightages and finding the corrected deduct values etc. From the estimated PCI values of study sections it is proposed to rank the pavements for prioritizing the maintenance program. There are several indices available for finding the pavement condition.

2. Methodology

The scope of work was divided into the following steps:

- Study area characteristics and identification of study sections.
- Visual inspection on selected locations.
- Collection of Data.
- Identification of distress and its severity level.
- Assigning acceptability levels and weightages.
- Determination of PCI.
- Determination of priorities for maintenance.

2.1 Study Area Characteristics

Thanjavur, a small sized city located at about **10°46'56.99"N 79°7'52.51"E** and at a distance of 350 km from Chennai (Tamil Nadu, India) in the southern part is

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chosen for present study. The city is well connected by rail and road network system with other towns and cities. The city is nearer to Karikaral port and Ariyalur **11°8'14"N 79°4'40"E** (industrial area) and Kumbakonam **10.97°N 79.42°E** (tourist centre) which in turn has large volume of traffic.

2.2 Identification of Study Sections

Two stretches have been identified for the present study, one is from Thanjavur – Ayyampetai with a stretch length of 7 km and the other is from Sathamagalam – Keelapur with a stretch of 4 km. The identified study locations are badly affected pavements sections in those regions.

2.3 Visual Inspection

It is the preliminary investigation and it can be done along the deteriorated areas of the pavement. From the visual inspection it can be found that the pavements mainly had Cracks, Patches and Potholes and Ruts.

2.4 Data Collection

The adopted methodology was based on the PCI and it involves a set of indices like pavement distress, rider comfort, and pavement condition rating. The data concerning to distress viz., cracks, patches, potholes, ruts along with their severity levels and extent are collected. A total of 11km are selected for present study nearby Thanjavur.

2.4.1 Area of Cracking

It is usually represented as the percentage of the total cracked area for one kilometre and the severity levels are given as **Low (L), Medium (M) and High (H).**

% density = area of cracked portion in pavement/total sample area.

2.4.2 Area of Patching

It is usually represented as the percentage of the total area of the patches for one kilometre and the severity levels are assigned as **Low (L), Medium (M) and High (H).**

% density = area of patched portion in pavement/total sample area.

2.4.3 Pavement Condition Rating

A scale was rated with 0 – 10 and that point refers the visual condition of the pavement. Ratings were given based on visual inspection, which should be carried all the way of the pavement. Inspection can be done for surface characteristics (cracks, potholes, rut and patches).

2.4.4 Traffic Volume Studies

For the selected sections the traffic count was found to be in the range of 3000 – 4000 vehicles/day.

2.4.5 Rider Comfort and Ride Quality

A survey had done for finding the ride quality, for this a set of users like students, walkers, job holders, lorry drivers, workers etc., are asked to rate the riding quality of pavement on a scale of 0 -10 and they are represented in Table 1.

Table 1. Ride quality rating

Rating	Ride quality	Description
0 – 2	Very poor	constant bumps or depressions.
2 – 4	Poor	frequent bumps or depressions.
4 – 6	Fair	intermittent bumps or depressions.
6 – 8	Good	few bumps or depressions.
8 – 10	Excellent	very smooth.

Source: From PCI distress manual from Metropolitan Transportation Commission

2.5 Identification of Distress and its Severity Levels

Damage and deterioration of pavements will occur as a result of traffic, pavement and climatic and environmental factors. These factors cause surface distress, consolidation or shear developing in sub grade, sub base or surface. The deterioration of a pavement is also apparent by various external signs and indicators called distress. Generally the pavements are fall into either cracking, Distortion or Disintegration. The functional failure causes distress in pavement surface resulting in cracks, depressions, rut formations and poor riding quality.

2.5.1 Cracks

Cracks in pavements are caused due to

- Surface deflection over foundation.
- Shrinking of surface.
- Contraction and expansion of surface.
- Poor construction practices and materials.

Classification of the severity levels for cracks, distortions and disintegration are represented in Table 2, 3 and 4.

Table 2. Description of severity levels for distress

Severity Level	Criteria
L	Independent cracks, spalls or weathering.
M	Advanced cracking, spalls or weathering.
H	Blocks are in multiple pieces or disintegrated.

2.5.2 Distortion

Distortion in pavements are caused due to

- Settlement of base.
- Insufficient compaction.
- Poor bonding between layers.
- Swelling.

Table 3. Description of severity levels for distress

Severity Level	Criteria
L	5 – 15 mm
M	15 – 30 mm
H	>30 mm

2.5.3 Disintegration

Disintegration in pavements are caused due to

- Improper compaction.
- Improper mixing.
- Adhesion losses.

Table 4. Description of severity levels for distress

Severity Level	Criteria
L	Patch is in good condition and the ride quality is unaffected.
M	Patch is fair condition and the ride quality is starting to deteriorate.
H	patch is In poor condition and the ride quality is affected.

Source: PCI distress manual from Metropolitan Transportation Commission

2.6 Pavement Condition Index

PCI is an evaluation process which is determined according to the procedures contained in ASTM D 5340 and it is adopted worldwide for measuring the condition of the pavements by considering the functional parameters with the significance of structural performance. Occasional maintenance on the same pavements will exhibit variations in performance levels with time and it can also be used for prediction of present condition of pavements.

Pavement condition Index is a measure for finding the functional failure in pavement and that is shown in Figure1.

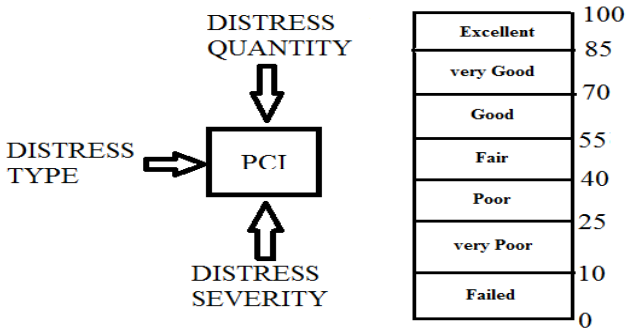

Figure 1. PCI chart.

2.7 Analysis and Results

In this study, the distresses which are conceived to reflect the pavement Condition are cracked area (%), patched area (%). In order to the find pavement condition based on these distresses, it is necessary to assign weightages to the different types of distresses, according to their severity levels. The weightages should be assigned/allotted to all types of distress considering the severity levels and its extent. Based on that weightages, acceptability levels are calculated.

2.7.1 Determination of Acceptability Levels

Cracked area $= e^{(0.0137 - 0.024CRA)}$

Patched area $= e^{(0.155 - 0.0398\ PA)}$

Rut depth $= 1.03952 - 0.0351RD$

Potholes $= e^{(0.073 - 0.077PT)}$

Where

CRA = crack area in %

PA = patch area in %

RD = rut depth in mm

PT = area of potholes in %

The following are the acceptability levels for studied sections and the acceptability levels for Thanjavur – Ayyampetai and Sathamangalam – Keelapur was shown in Table 5 and 6.

Table 5. Thanjavur – Ayyampetai region results

Distress type	1	2	3	4	5	6	7
Patch	0.74	0.68	0.75	0.75	0.74	0.73	0.76
Cracks	0.56	0.75	0.73	0.76	0.70	0.75	0.71
Potholes	0.97	1.00	1.00	1.00	0.95	0.97	0.94
Ruts	0.80	0.70	0.60	0.50	0.60	0.70	0.50

Table 6. Sathamagalam to Keelapur region results

Distress type	1	2	3	4
Patch	0.70	0.72	0.69	0.67
Cracks	0.69	0.70	0.75	0.70
Potholes	1.00	0.59	1.00	0.60
Ruts	0.5	0.16	0	0

Acceptability levels always should be in the range of 0 – 1

2.7.2 Deduct Value Determination

Deduct values are those which states the present condition of the pavements i.e., the quantity of the distress a pavement has encountered. Deduct values are calculated for every kilometre for all types of distress. Deduct values can be calculated by multiplying the percentage of distress and weight of severity level of distress Weightage

Deduct value = Weight of severity level of distress* percentage of distress

Total Deduct Values (TDV) are also to be calculated for each section and the summing of all the deduct values will gives the TDV and the assigned weightages for the Thanjavur – Ayyampetai and Sathamangalam – Keelapur was given in Table 7.

Table 7. Weightages to distress

Distress/Severity Level	Low	Medium	High
Cracking	0.4	0.7	1.0
Patching	0.3	0.6	1.0
Potholes	0.4	0.7	1.0
Ruts	0.3	07	1.0

2.7.3 Determination of PCI

The (PCI) is a numerical representation of existing pavement condition which is related to the pavement surface condition and its integrity. The PCI is a function of type, severity, extent and density of distress. It is impossible to find the PCI in any case if any of the distresses are neglected. PCI is meant to provide a basis for determining maintenance and rehabilitation needs and priorities for pavement. The pavement condition index (PCI) is given as

PCI = 100 - CDV

Where

CDV = corrected deduct value

Generally the PCI ranges from 0 to 100, in which a score of 100 represents a pavement in good state which is having more rider comfort ability and a score of 0 represents a pavement in worst/poor state. PCI values for all the selected pavement sections have been determined. The following table shows the PCI values of distinct pavement sections along with TDV and CDV for all study sections and the calculated TDV ,CDV and PCI for Thanjavur – Ayyampetai and Sathamangalam – Keelapur areas were given in Table 8 and 9.

Table 8. Estimated PCI values for Thanjavur – Ayyampetai section

Pavement section number	TDV	CDV	PCI
1	74	76	24
2	52	54	46
3	50	52	48
4	47	46	54
5	55	53	47
6	50	56	44
7	53	57	43

Table 9. Estimated PCI values for Sathamagalam – Keelapur section

Pavement section number	TDV	CDV	PCI
1	58	58	42
2	56	55	45
3	56	55	45
4	60	60	40

As per the calculated PCIs , corresponding condition was assessed and ranking and suggestions were given based on PCI values and they were shown in Table 10.

Table 10. Maintenance and rehabilitation strategies based on PCI

PCI value	Condition of pavement	Priority of ranking	Suggested Treatment
0 – 25	Worst	PR1 (Reconstruction)	Reconstruction
25 – 40	Poor	PR2 (Rehabilitation)	Thick over layer
40- 60	Fair	PR3 (Rehabilitation)	Mix seal surface/ Thin Over layer
60 – 85	Good	PR4 (Preventive Maintenance)	Seal Coat/ thin Pre Mixed Carpet
85 – 100	Excellent	PR5 (Corrective Maintenance)	No Maintenance

PCI values are categorised into 5 classes and they are ranked from PR1 to PR5 (high priority to low priority) as shown below

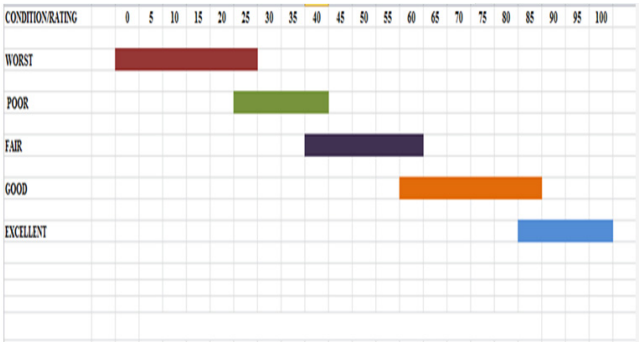

Figure 2. Representation of PCI ranges.

3. Discussions and Conclusions

From the studies it can be concluded that the pavements from Thanjavur – Ayyampetai and sathamagalam - keelapur having the PCI values which are in the range of **45 – 60** in which **25 %** of cracks, **20 %** of the patches, **15 %** of potholes were found on both sections. Extent and amount of cracking and patching values plays a vital relation with pavement condition rating values. From the acceptability levels we can state that the level of pavements for accepting was just found to be fair. PCI provides a subjective way for finding the maintenance needs of pavements and for prioritising the pavement sections based on priority. Pavements with high PCI do not require any maintenance activity on priority and the pavements with lower PCI requires maintenance on priority. It was found that all the selected pavement sections exhibits the all the distresses with the medium and high severity levels and the ruts depth was found to more severe in sathamagalam – keelapur region. Recently a thin overlay was laid in the region of Thanjavur – Ayyampetai**,** which was matching to the present result.

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