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Pavement Surface Distress Evaluation Using PCI

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Abstract: ***The aim of this paper is to evaluate the condition of the road performance for maintenance that occur due to surface distresses of various sections along the study area using Pavement Condition Index (PCI) concept. The study area along the Vidya Path and Vigyan Path in Chandigarh consisting of flexible pavement is selected to develop a Pavement Condition Index so as to assess the maintenance and rehabilitation needs. The PCI method was used as it is a distress based rating which evaluates the comprehensive visual condition of a road by categorizing different distresses and their severity. The mathematical expression for pavement condition index (PCI) provides an index reflecting the surface distresses which are the manifestations of pavement failure. The model for computing PCI is based upon the summation of deducts points for each type of observable distress. The paper involves extensive use of Google Earth Pro Software for drawing elements of Sections on Map and transferring the coordinates of sections to the field using GPS instrument. Surface distress and severity level data is acquired on the PCI inventory by visual field inspection on different sections. The weighted PCI of the different Sample Units along both the sections is calculated and subsequently results can be used for resurfacing/maintenance work on priority basis.***

Keywords: PCI, Section, Sample Unit, Maintenance, Distress, Chainage, Severity

I. INTRODUCTION

Road network plays an indispensable role in the achievement of government's overall social, economic, security, and developmental goals. Much capital has been expended in developing extensive road networks worldwide. To preserve the investment spent on this huge network of pavement, extensive maintenance and repair activities are necessary, with the intention of using funds optimally. With a large network of highways in place, a highway engineer's concern is shifted from construction to maintenance. To evaluate the maintenance requirements of pavement, distress based ratings, for example, PCI (Pavement Condition Index) is used to evaluate the comprehensive condition of a road by categorizing a pavement's surface distresses by type, frequency, and extent. Pavement condition is a generic phrase to describe the ability of a pavement to sustain a certain level of serviceability under given traffic loadings. PCI is a numerical rating of the surface condition of a pavement with 100 representing the best possible condition and 0 representing the worst possible condition of the road surface. The failure of a pavement may be defined as when PCI reaches a threshold (certain specified) value. PCI provides a tool on pavement performance for improvement of current pavement design and maintenance procedures. It is a statistical measure and requires manual survey of the pavement. PCI surveying processes and calculation methods have been standardized and for roads codal provisions of ASTM D6433-2011 has been used.

II. RESEARCH METHOD

The methodology involves the development of PCI Inventory as per ASTM D6433-2011 for data acquisition of distress survey. The study area of Chandigarh consisting of two sections namely Vidya Path having stretch of 7.2 km and Vigyan Path having stetch of 4.4 km were selected. Google Earth Pro Software was used for drawing elements of Sections on Map. Coordinates of sample units for different chainage were imported from the maps of both the sections and located on the site using GPS instrument. Distress and severity data is then acquired from the study area by visual inspection. Data collected is then analysed by assigning distress values and subsequently applying correction using Deduct Value Curves for Asphalt as per ASTM D6433-2011. Weighted PCI values of both the sections were then calculated.

A. Study Area

The study area chosen for carrying out the distress survey is located in the city of Chandigarh, India. Vidya Path having stretch of 7.2 km denoted as Section 1 and Vigyan Path having stretch of 4.4 km denoted as Section 2 were selected for carrying out the distress survey. The distress survey was carried out in the month of November, 2017 at both sections. Aerial View of Vidya Path selected has been shown in Fig.1 along with the marked location of the selected four Sample Units in Section 1.

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Fig. 1 Google Earth Aerial View of Section 1 (Vidya Path) using Google Earth Pro Software

B. Dividing Road Sections into different Sample Units

Both the road sections were divided into sample units after fixing the length of sample unit to a constant value of 200 m. The sample units were selected at random and spacing interval of fixed distance were calculated between the sample units. Table I enlists the basic details of both the sections where distress survey was carried out.

Table I: Basic Details of Roads selected for Distress Survey

Road	Section Name	Section Length (km)	Sample Unit Length (m)	Number of Sample Units (N)	Number of Sample Units to be inspected (n)	Spacing interval between two sample units (i=N/n)
Vidya Path	1	7.2	200	36	4*	9 (1800 m)
Vigyan Path	2	4.4	200	22	4*	5.5 (1100 m)

*As per ASTM D6433-2011 for sample units between 16 to 40

C. Marking Sample Units using Google Earth Pro

The sample units used for determining the PCI values in the sections are marked on the map using Google Earth Pro software. First of all road stretch of various sections were drawn on the map using Path Trace method. The length of various sections thus obtained were noted along with the requisite number of sample units to be surveyed. The stretch was thus divided into 'n' number of sample units. In both the sections, the number of sample units to be inspected comes out to be four in number. After choosing any random sample number the chainage of the first sample unit to be surveyed is to be drawn on the map using Path Trace method from the start point of the section. The area is then selected and marked on the map using different points. The coordinates at the start and end point of the sample unit are noted down for reference that is to be used on the site for carrying out the distress survey. Table II below shows the start and end points of sample units of both the sections.

Table II: Chainage of Sample Units of Both Sections

Chainage (m)	Sample Unit 1		Sample Unit 2		Sample Unit 3		Sample Unit 4	
	Start	End	Start	End	Start	End	Start	End
Section 1	600	800	2600	2800	4600	4800	5600	6800
Section 2	200	400	1500	1700	2800	3000	4100	4300

D. Locating Sample Units Using GPS Instrument

The coordinates of the chainage of these sample units were observed form Google Earth Pro Software and then transferred to the ground using GPS Instrument. Table 3 below shows the coordinates of start and end points of sample units in Section 1.

Table III: Coordinates of End Points of Sample Units in Section 1

Sample Unit	Starting Coordinate		Ending Coordinate	
1	30°45'48.33"N	76°47'19.53"E	30°45'43.07"N	76°47'23.93"E
2	30°45'14.25"N	76°47'47.96"E	30°45'9.21"N	76°47'52.25"E
3	30°44'40.60"N	76°48'16.22"E	30°44'35.32"N	76°48'20.61"E
4	30°44'6.84"N	76°48'44.64"E	30°44'2.10"N	76°48'49.70"E

E. Visual Inspection

Inspection of each sample unit chosen individually is performed by walking over the sample unit length and carrying out visual distress survey to identify type, severity and quantity of distresses. Recording of the data as per ASTM D6433-2011 is done on the Condition Survey Data Sheet. An illustration of the data collected in Sample Unit 2 of Section 1 (Vidya Path) has been shown under:

ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

SKETCH:

BRANCH: Vidya Path | SECTION 1 | SAMPLE UNIT: II
SURVEYED BY: Parveen | DATE: | SAMPLE AREA: 2743

1. Alligator Cracking	6. Depression	11. Patching & Utility Cut	16. Shoving
2. Bleeding	7. Edge Cracking*	12. Polished Aggregate	17. Slippage Cracking
3. Block Cracking	8. Joint Reflection Cracking*	13. Potholes#	18. Swell
4. Bumps and Sags*	9. Lane/Shoulder Drop Off*	14. Railroad Crossing	19. Weathering/Raveling
5. Corrugation	10. Long and Trans Cracking*	15. Rutting	

DISTRESS SEVERITY	QUANTITY										TOTAL	DENSITY %	DEDUCT VALUE
1L	4.32	7.92	4.86	2.88	5.94	2.16	23.4	8.1			59.58	2.17	17
1M	2.97	3.6	12.15	7.56	7.02	4.14					37.44	1.36	24
1H	0.94										0.94	0.03	0
2L	0.54	0.36									0.9	0.03	0
10L	3.9	1.8	2.7	4.5							12.9	0.47	0
10M	9	5.4	1.2	2.1	2.7						20.4	0.74	1
11L	1.98	48.96									50.94	1.86	4
												Σ	46
Note: All measurements are in square meters except * (meters) and # (numbers)												PCI	54

Figure 2: Sample Data Sheet for Section 1 Sample Unit 2 for Distress Survey as per ASTM D6433-2011

F. Calculation Of PCI

The weightages are assigned to all types of distress considering the severity levels and its extent. The deduct value graph for different type of distresses along with severity levels are used to find deduct values for different distresses. Subsequently corrected deduct values are obtained from the respective curves in ASTM D6433-2011 to find out the PCI values. The pavement condition index (PCI) is calculated using equation (1) as under:

$$PCI = 100 - CDV \quad (1)$$

Where: CDV = Corrected Deduct Value

Instead of using sample unit area calculation by multiplying road width with sample unit length, Google Earth Pro Software was used to determine the area of the sample units. The weighted PCI value of the section based on different sample units involved is calculated using equation 2 as under:

$$PCI_S = \overline{PCI}_r = \frac{\sum_{i=1}^{n}(PCI_{ri} \cdot A_{ri})}{\sum_{i=1}^{n} A_{ri}} \quad (2)$$

Where: $\overline{PCI}_r$ = Area Weighted PCI of randomly surveyed sample units,
PCI_{ri} = PCI of random sample unit i,
A_{ri} = area of random sample unit i,
n = number of random sample units surveyed.

III. ANALYSIS AND RESULTS

The weighted PCI values of both the sections were computed based on the areas of different sample units as per equation (2) and are tabulated as:

Table IV: Weighted PCI Value of Section 1

Sample #	Sample Unit Area (m^2)	Segment PCI (0-100)
1	2756	96
2	2743	69
3	2656	98
4	3058	100
Total Weighted Average PCI for Section 1		**91**

Table V: Weighted PCI Value of Section 2

Sample #	Sample Unit Area (m^2)	Segment PCI (0-100)
1	1938	62
2	2373	83
3	1967	96
4	1985	88
Total Weighted Average PCI for Section 2		**82**

IV. CONCLUSIONS

PCI Rating is pragmatic tool that can be used for maintenance requirements of road sections based on the capital to be spend. Maintenance is to be performed on the criteria of a threshold (certain specified) PCI value and those section whose PCI value is lower can be selected on priority basis than with the higher PCI value. The PCI rating of Section 1 (Vidya Path) was found out to be 91 whereas, the PCI rating of Section 2 (Vigyan Path) was found out to be 82. Based on the above result, Section 2 must be given priority over Section 1 for improvement of current pavement design or if maintenance/resurfacing work needs to be done.

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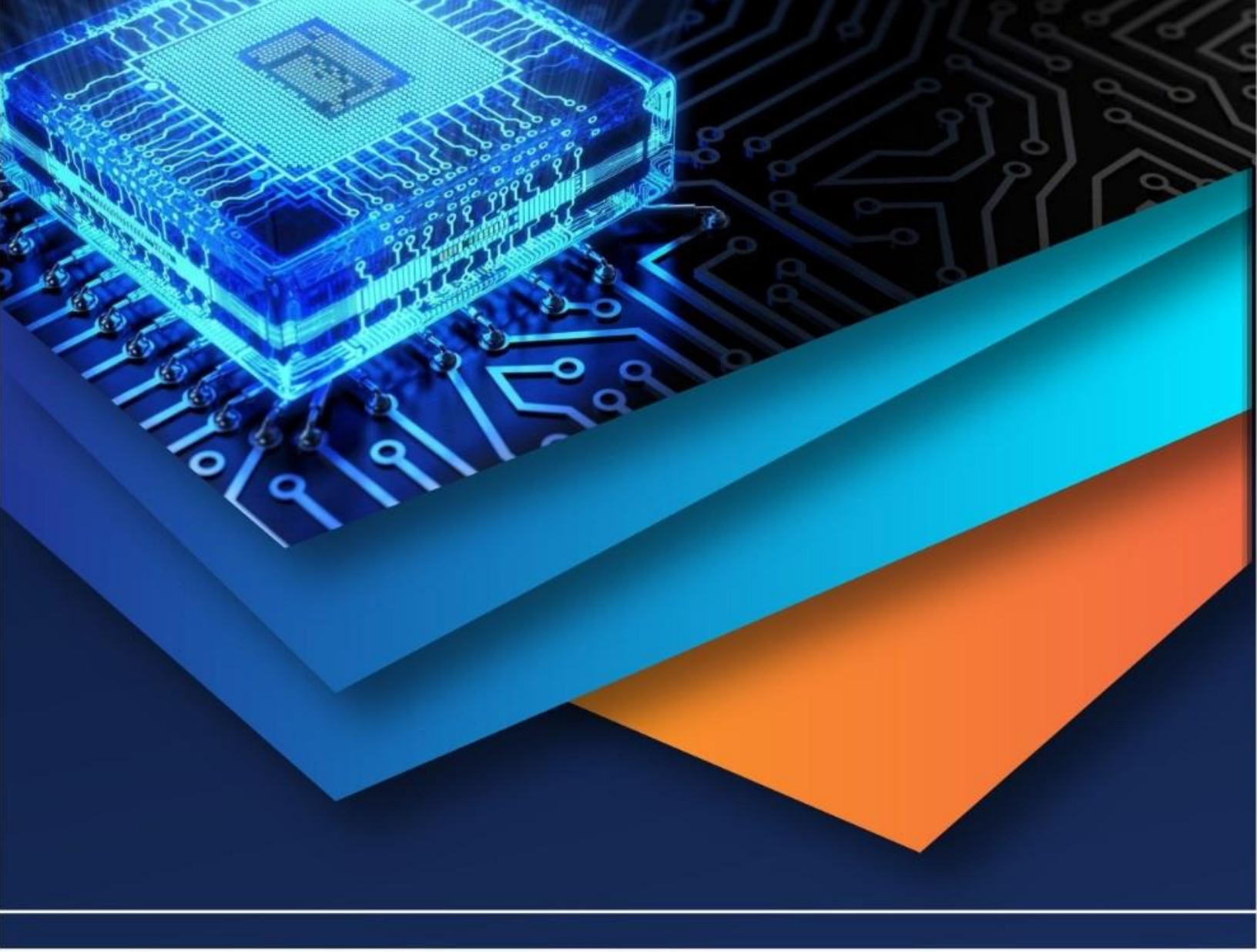

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