International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 2, Issue 2, ISSN No. 2455-2143, Pages 70-75
Published Online December-January 2016 in IJEAST (http://www.ijeast.com)

DETERMINATION OF PAVEMENT CONDITION INDEX USING VIDEOTAPING AND IMAGE PROCESSING

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Abstract— **Pavement deterioration is resulted by both environmental and structural causes. It is required to maintain on time, with right materials, at right place with minimum cost. Hence pavement condition survey to be conducted time-to-time to assess its condition and maintain on time. This paper deals with the development of efficient and cost effective system for pavement condition survey. Video camera is fitted in a vehicle at proper height and orientation to capture the condition images. Images are analyzed using image processing technique to extract the distresses data. Scale was made to convert pixel value into linear measurement units. PCI is calculated based on severity level and density using PAVER system. Effect of road stretch length was also examined. Results show that adopted survey method is capable to efficiently gather the data instead of manual method. Shorter length consideration may be effective and economic rather than the longer one.**

Keywords— **Image processing, Portable Low cost survey vehicle, PCI**

I. INTRODUCTION

Road Transportation occupies a very important and dominant position in the overall transportation system of India. The growth in the road traffic in the post-independence era has been very unprecedented both, in terms of goods as well as passenger traffic. The vehicular traffic increased from 3 lakh to 430 lakh traffic during the period 1951-2001. But it is very unfortunate, that the corresponding growth in road network has not been in proportion with that of the huge growth in vehicular population, which has been increased from 4 lakh km to 33 lakh kilometer during the same period of that from 1951-2001. The traffic loadings are also been much heavier than that of its specified limit of 10.2 tones. Without any adequate and timely maintenance of roads, roads deteriorate excessively which leads to higher vehicle operating costs, increasing number of accidents as well as reduced reliability of transport services. Thus, there is a need of developing some scientific approach towards the determination of timely maintenance and rehabilitation requirements of the pavements. Efforts are also needed for the development of road management and planning tools to improve any of the existing highway networks. These tools are important for the assessment of the financial needs and the evaluation of the alternative maintenance strategies. In such situation the development as well as the practice of an efficient Pavement Management System (PMS) would provide some of the objective information and useful analysis to ensure consistent and important cost-effective decisions of the selected highway networks.

Manual visual inspection survey for pavement surface condition is very time consuming and requires the involvement of the manpower for the measurement of distresses. This survey is very difficult to carry out when large volume of traffic plying on the roads. There are also automated survey systems along with network vehicle but very costly so it is not feasible for all agency or road construction department to procure it. In this direction an attempt has been made to develop a low cost survey technique. This technique comprises of videotaping and image processing. The objective of this paper is to develop a technique for execution of pavement condition survey, data extraction and evaluation of pavement condition index.

II. LITERATURE SURVEY

SandraA. K. and Sarkar A.K. (2012) had developed a model between the IRI data and distress data, collected over 39.5 km of road stretches in Rajasthan. Out of several distress the contribution of ravelling and potholes are predominant on Indian roads. **Ouyang A. et. al. (2011)** had extracted the pavement cracks with the help of digital image processing having its advantage of collection of large amount of information and automatic detection.

Joubert D. et. al. (2011) has developed a sensor system which wasmounted on the vehicle for the detection. It was used for the analysis and extraction of the shape of potholes. This method was given a very good result especially for potholes and its 3-D view. **Salari E. et. al. (2012)**studied on pavement distress evaluation using 3D depth information from stereo vision. They had used two video cameras for the 3-D shape extraction of the potholes. The coding for the 3-D profile determination was done in MATLAB software.

III. METHODOLOGY

This methodology consists of two phases, first phase is capture of pavement surface condition and second phase is determination of Pavement Condition Index. First phase includes Image capture through videotaping, image freeze and format, still image, pavement distress detection and classification, distress class and distress severity. Second phase includes determination of pavement condition index and based on that rating the pavement condition using PAVER system.

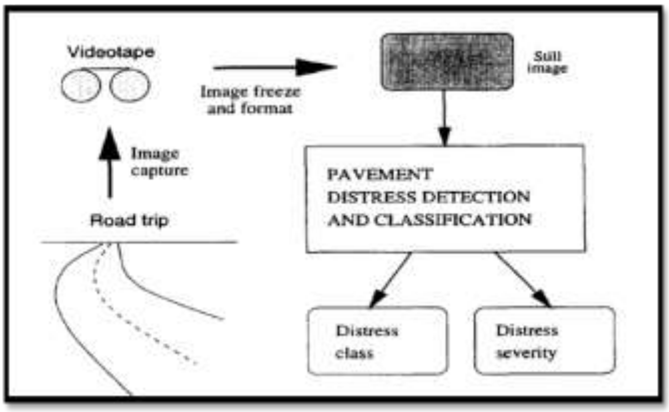

Figure-1: Flow chart of work

1)Video recording of pavement surface

Webcam camera was mounted in the back of an e-rickshaw at 1.2 meter height, held lens vertically in downward direction as shown in Figure-2. The vehicle was allowed to ply with a speed of 20 kilometres per hour. . The camera was kept in perpendicular direction to the surface of bituminous road so that the data captured do not distort and the actual image remains as it is on the road. Proper precaution was taken because when image will distorts it will not give actual measurement of distresses.

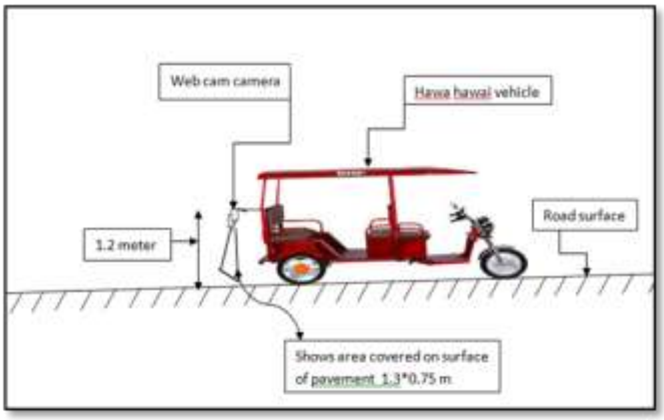

Figure-2: Setup used for survey

2)Extraction of data

Video recording was uploaded to the personal computer. Considering 100 meter length of the road section, still images were taken after identifying the distresses available in the that section. Measurement was taken through image processing method using MATLAB software as function discussed in the following subsections.

2.1) Rectangular and Square Measurements

Generally some distresses like alligator cracking, bleeding, block cracking, patching, utility cut patching, polished aggregate, weathering and ravelling are measured in terms of area. For this purpose rectangular or square shape may be considered for measurement of area wherever applicable. Both the shapes can be monitored using the same command ***imrect*** as shown in Figure-3 for example.

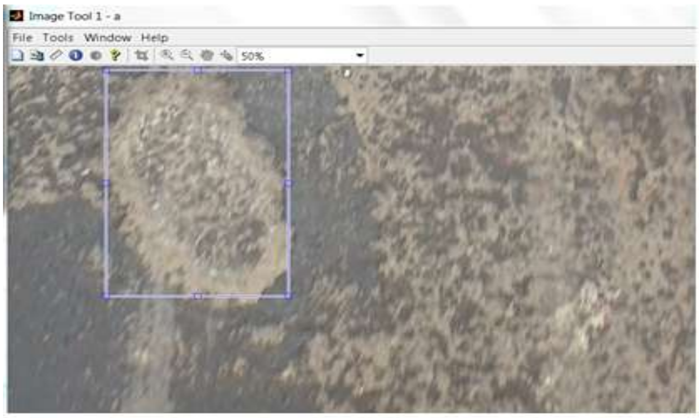

Figure-3: Measurement of high-severity ravelling

2.2) Circle and Ellipse Measurements

Distress like potholes measured in terms of numbers for computation of density but severity level of potholes depends on its diameter and depth. This work is limited to only capture top view rather than side view. Thus, only diameter has been measured. In this connection, circle or ellipse shape option may be taken wherever required. The diameter of the potholes can be measured as using the command ***imellipse.***

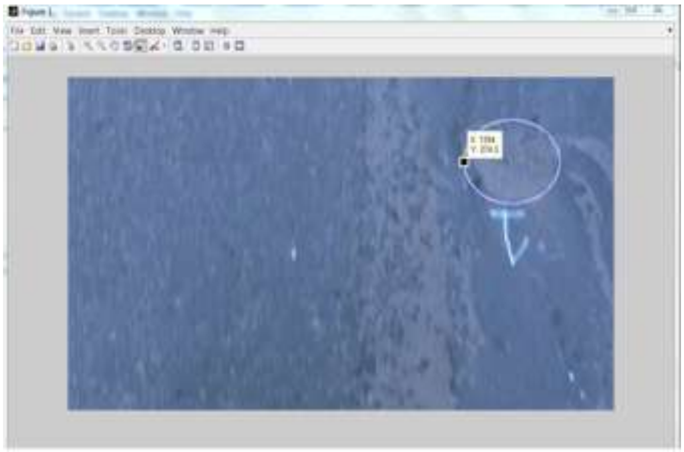

Figure-4: Shows Co-ordinate of potholes

2.3) Linear measurements

Linear measurement involves only one dimensional measurement and is generally used in different types of distresses such as edge cracking, longitudinal cracking and transverse cracking. For this ***imtool*** function can be used to determine the length of cracks.

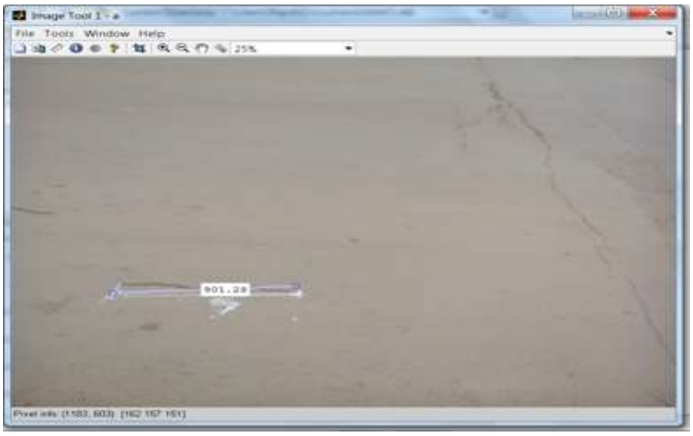

Figure-5: Measurement of Transverse Cracking

2.4) Scaling

Since the data extracted from image processing gives the dimensions (length, width, and diameter) in *pixels* unit but actual measurement are done in metric unit. It is required to establish a mathematical relationship between metric unit and pixels. For this purpose, a section of road selected to measure the distresses manually as well as videotaping method.

While taking sample data a formula is used to determine the no of sample units required is given as

$$SS = P(1-P) * (Z/E)^2 \text{.......eq(1)}$$

Where SS= sample size,
P= Sample proportion (worst case 50%),
Z= z Value(depends on confidence level),
E= Margin of error(it is the measurement of variation within the data),the smaller this value the more uniform is the data.

Figure-6 represents that there is linear relationship between pixels and metric units with coefficient of determination equal to 0.989.

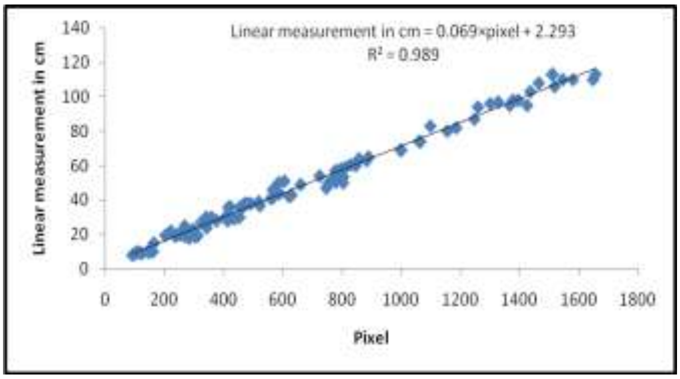

Figure-6: Relation between pixel and centimetre

IV .STUDY LOCATION

For implementation of designed methodology arterial roads are selected at Patna in Bihar, India where distresses are available as judged by preliminary survey. Study sections of road are indicated in the Figure-7.

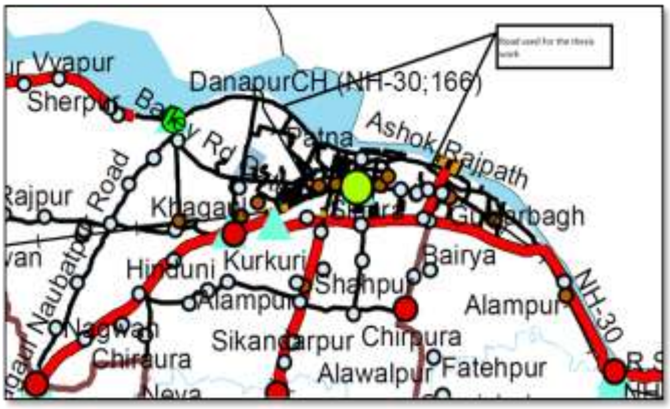

Figure-7: Study locations at Patna, Bihar (source RCD, Govt. of Bihar)

Study was carried out on Ashok Rajpath road where two sections were selected namely Gandhi Maidan to NIT more and Kurji more to Digha. The road sections are bituminous topped as detailed given in Table-1.

Table1: Surveyed stretch of roads

Index	Road Name	Surveyed stretch	Surveyed length
Stretch-1	Ashok rajpath	Gandhi maidan to NIT more	1.9km
Stretch-2	Kurji - Digha	Bashghat to Kurji more	5.2km
		Total length	7.1km

V .PAVEMENT CONDITION INDEX (PCI)

Pavement condition index is a numerical indicator rating of the pavement condition ranging from 0 to 100 with value 0 being the worst possible condition and value of PCI 100 being the best possible condition. It gives the present condition of the pavement. Generally if the pavement is very old and condition is very poor then the pavement condition index is near to 0 but if the pavement is newly made then its condition has not deteriorated easily thus its pavement condition index is very close to 100. The pavement condition index is equal to 100 subtracted by corrected deduct value. The pavement condition rating varies from ***failed*** condition to ***excellent*** condition of the pavement.

$$\mathbf{PCI = 100 - CDV} \text{.......eq(2)}$$

$$\mathbf{CDV = f(N, TDV)} \text{........eq(3)}$$

Where PCI is pavement condition index, CDV is corrected deduct value depends on TDV and N which can be determined from figure given in the code.TDV is total deduct value which is determined from the deduct values of individual distresses based on individual distresses severity levels which can be determined from standard figures given in the code used. N is number of distress parameters considered. The Pavement Condition Index rating is used for rating of pavement which depends on distress type, distress severity and distress quantity.

VI . RESULTS AND DISCUSSIONS

Scaling was done to establish the relationship between pixel of the image and linear measurement unit. For that ten kilometer of road was surveyed manually as well as adopted video graphic method and data were extracted that shows linear relationship as represented by equation-4.

$$\boldsymbol{Measurement(cm) = 0.069x\ \ pixel + 2.293, R^2 = 0.989} \text{......eq(4)}$$

There was an error of 6.5% was found between the two methods, which is negligible. The value of Pavement Condition Index was 50 for pavement from Gandhi Maidan to NIT more and Rating was fair. Where as PCI of pavement from Kurji more to Digha was 85 and its Rating was Very Good. On both roads weathering and raveling are present in maximum numbers of sections, for first road present in 19/19 sections that means it is present in 100% and for the second road present in38/52 sections that means it is present in 73%. Thus most of the deterioration is caused by weathering and raveling.

Effect of length for density calculation on pavement condition index has been exercised. Figure 8 to 11 shows the effect of length 100m, 500m, 1000m and overall length respectively on PCI for stretch-1.

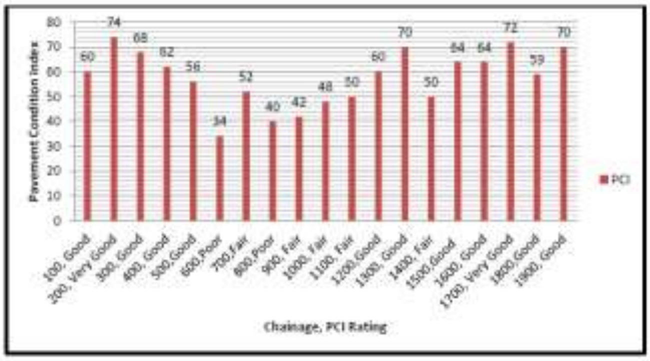

Figure 8: PCI for every 100m length of stretch-1

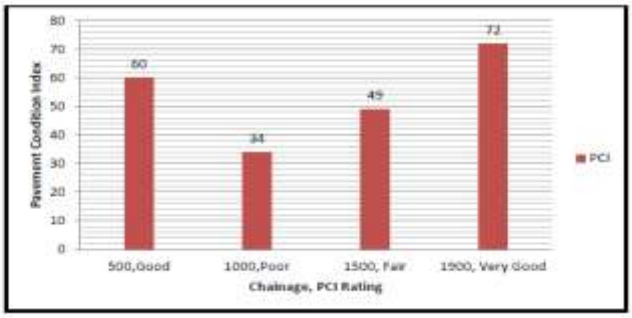

Figure 9: PCI for every 500m length of stretch-1

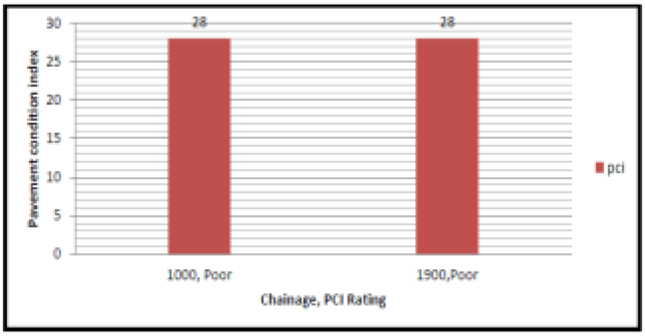

Figure 10: PCI for every 1000m length of stretch-1

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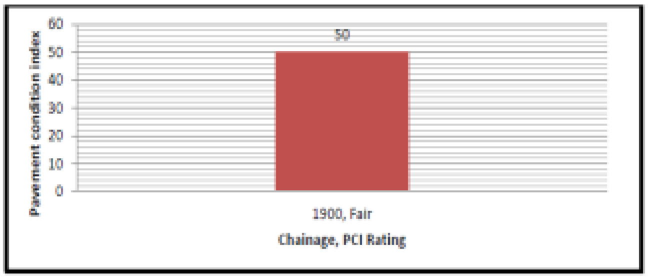

Figure 11: PCI for overall length 1900m section of stretch-1

For stretch-1 when hundred meters length had been considered, it was observed that ten sections are in good condition, two sections are in poor condition and two are in very good condition, and five are in fair condition. When five hundred meters length had been considered, it was observed that two sections are in poor condition whereas one section is in very good and another in good condition. When thousand meters length had been considered, it was found that both the sections are in poor conditions.

Figure 12 to 15 shows the effect of length 100m, 500m, 1000m and overall length respectively on PCI for stretch-2.

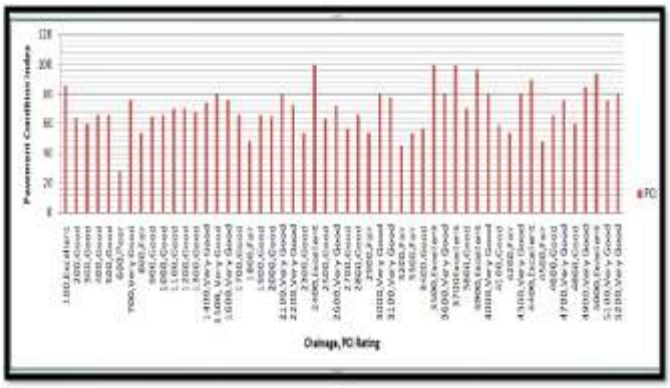

Figure 12**:** PCI for every 100m length of stretch-2

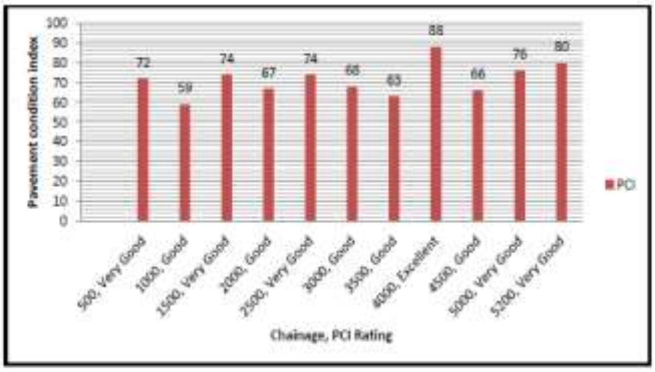

Figure 13**:** PCI for every 500m length of stretch-2

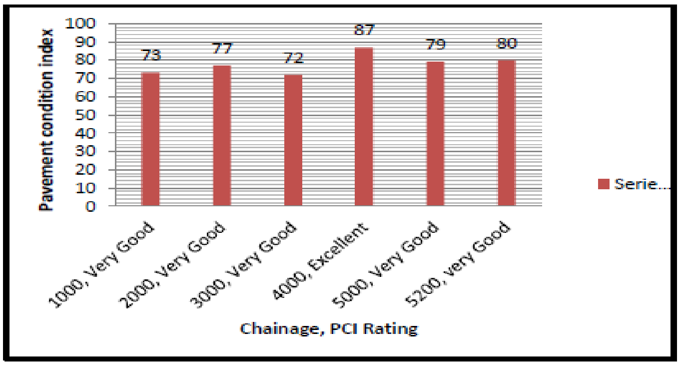

Figure 14**:** PCI for every 1000m length of stretch-2

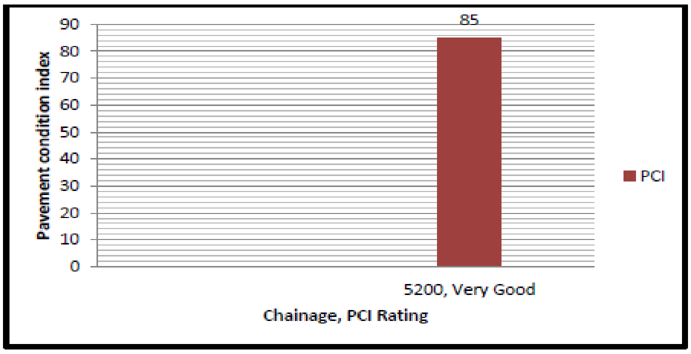

Figure 15**:** PCI for overall length of stretch-2

For stretch-2 when hundred meters length had been considered, it was observed that twenty sections are in good condition, fifteen sections are in very good condition, eight sections are in excellent, other eight sections are in fair condition and one is in poor condition. When five hundred meters length had been considered, it was observed that five sections are in good condition whereas other five sections are in very good and another one in excellent condition. When thousand meters length had been considered, it was found that five sections are in very good conditions and on in excellent condition.

VII .CONCLUSION

Manual pavement condition survey is time consuming and unsafe whereas automated network vehicle is very costly. An intermediate solution has been provided herewith by using videotaping from a running vehicle. Captured image can be measured in the office using image processing to extract the distress data.

Scale is prepared to convert the pixels units into linear measurement units, Scale showed linear relationship between them with negligible error.

PCI of flexible pavements are determined by using PAVER system through incorporating density and severity level of the distresses.

Shorter length consideration may be effective and economic than the longer one. Maintenance point of view it may be feasible but for rehabilitation may not be feasible.

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