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PAVEMENT DISTRESS CONDITION EVALUATION USING ROLLING STRAIGHT EDGE

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ABSTRACT

Reasonable evaluation of the pavement distress condition is a very important part of the pavement management system. The objective of this research is to develop an effective method to evaluate asphalt and cement concrete pavements distress condition in Hyderabad. To assess the severity of asphalt pavement distresses, single evaluation index was proposed, namely the Pavement Condition Index (PCI). This practice covers the determination of roads and parking lots pavements condition through visual surveys using the Pavement Condition Index (PCI) method of quantifying pavement condition.

In the condition survey, detailed information related to type, severity and density of existing distresses was collected. Surface distresses of selected stretches of pavements located in Hyderabad are evaluated based on type, frequency and severity according to ASTM D6433-2007. The ASTM D6433 – Manual for Condition Rating for Flexible and Rigid Pavements gives a good description of the types of defects, how they should be evaluated and quantified in terms of PCI values. Note that there are different criteria for asphalt, concrete, and composite pavements and for gravel roads The collected data was then used to determine needed maintenance activities on a project level. This process was proven to be labour intensive and very time consuming.

To overcome this difficulty, a Rolling Straight Edge is fabricated. The RSE is a portable apparatus which is used for quickly assessing the surface condition of a road, or a particular pavement surface irregularity. The collected data on the above selected road pavement sections are used for determination of their respective SD values.

These indices (i.e. PCI and SD values) are correlated and these relationships can be used to determine road roughness values, Further, these indices can also be used to track the performance of pavement and the rate of the changes in deterioration over a period of time. This distress rate and the history of such data can be used to determine the appropriate maintenance needs on time and also for rehabilitation funding needs on a network basis.

Keywords: Pavement Distress, Pavement roughness, PCI, SD, Rolling straight edge.

I. GENERAL

The pavement fail to retain their serviceable condition till the end of their desire period due to uncertainty in several factors considered as a design parameters, which include traffic occurrence, axle loads, weather conditions , variable sub grade strength , drainage conditions along the road way, rainfall , and variability in constructions of different layers of pavement. The maintenance and repair of the pavement are inevitable for collecting failures and prolonging service life.

Rigid pavement include plane and reinforced Portland cement concrete (PCC) pavements. The commonly known causes of distress and failures in rigid pavement are temperature variation across the depth of the slab, moisture changes in supporting granular layers, traffic induced stress, poor quality of material and construction defects.

1.1 Need for the Study

However, pavements fail to retain their serviceable conditions till the end of their design period due to uncertainty in several factors considered as design parameters which include traffic occurrence, axle loads, weather conditions, variable sub-grade strength, drainage conditions along the road way, rainfall, variability in construction of different layers of pavement. Design life of a Flexible pavement can be considered as 20 years or even up to 30 years for special cases. Because of this, maintenance and repair of pavements are inevitable for correcting failures and prolonging service life.

Rigid pavement has the ability to bridge small imperfections in the sub-grade. Rigid pavements lasts much, much longer i.e., 30+ years compared to 5-10 years of flexible pavements. In the long run it is about half the cost to install and maintain but, the initial costs are high.

It consists of less Maintenance cost and Continuous Traffic and Flow with high efficiency in terms of functionality

- ❖ It is measured at different severity levels.
- ❖ Present pavement conditions can be assessed.
- ❖ Severity levels indicate right time at different degree of distress.
- ❖ Optimal time and suitable repair and rehabilitation strategies can be evolved by using this method.

1.2 Objectives of the Study

a) To identify the location of the study area for different types of pavements (Flexible Pavement and Rigid Pavements) by using Google maps.

b) To conduct manual distress surveys on the above selected road stretches.

c) To collect the road unevenness data by using 3m rolling straight edge.

d) Correlation of the findings obtained from distress surveys and the Rolling Straight Edge measurements.

e) To determine the PCI values of the above selected roads by using ASTM D 6433-07

f) To determine RMSVA and SD values of the above selected roads from the unevenness data collected.

g) To correlate and determine a relationships between the calculated values of PCI, RMSVA and SD.

II. RESEARCH METHODOLOGY

The research methodology adopted for the present study is described below in Fig.1

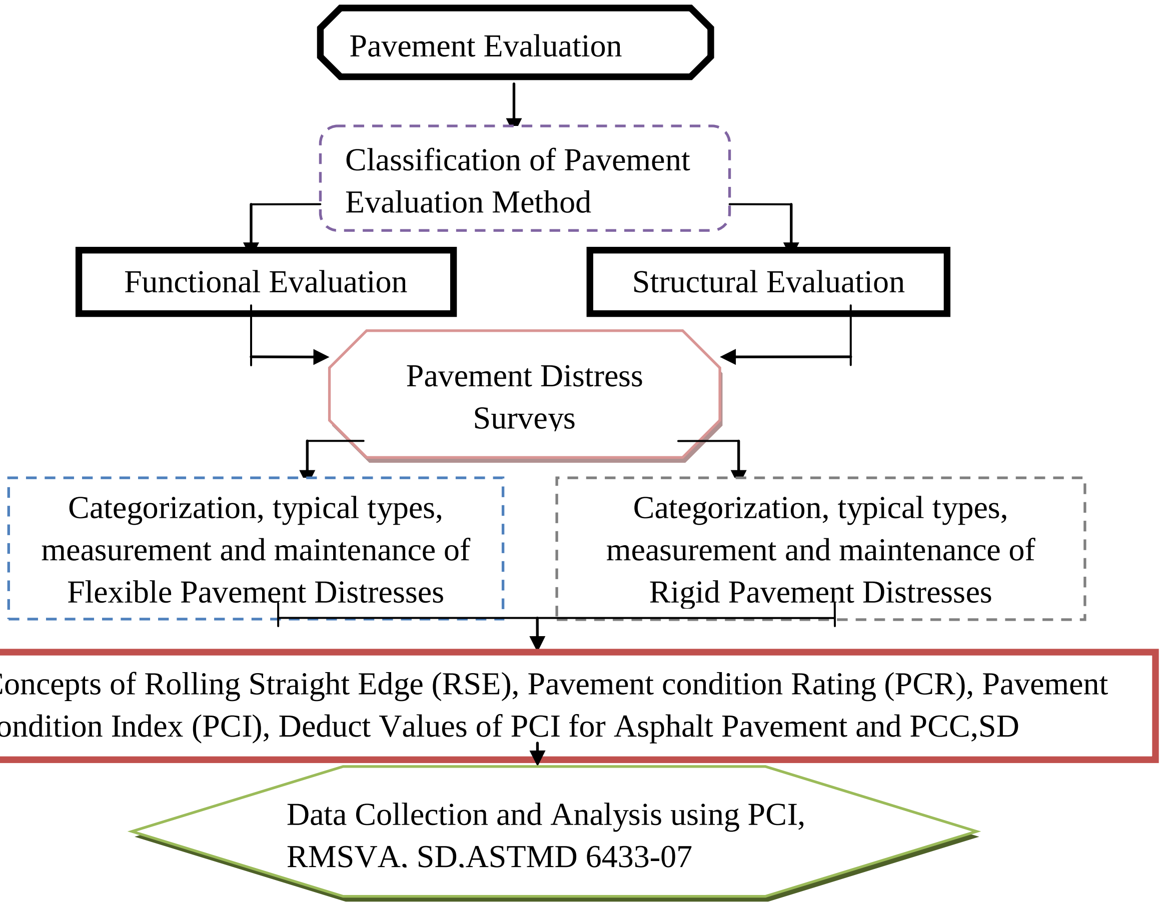

Fig 1 Proposed Structure of Research Methodology

III. OVERVIEW OF LITERATURE

The following are the details of literature pertaining to the present study.

Roger Smith et al. (1998) This paper describes the evaluation of several automated and manual methods of collecting pavement distress data used to calculate the Pavement Structural Condition used in Washington and the Pavement Condition Index used in Oregon. Selecting the best method of collecting data is always a process of trade-offs, and there is normally an increase in cost associated with an increase in accuracy, precision, and resolution.

Mansour (2008) The Pavement Maintenance Management System (PMMS) of Riyadh city perform comprehensive pavement visual survey prior to each maintenance program. In the condition survey detailed information related to type, severity and density of existing distresses was collected.

Ouyang1 (2011) Pavement crack is the main form of early diseases of pavement. The use of digital photography to record pavement images and subsequent crack detection and classification has undergone continuous improvements over the past decade.

Khazanovich (2011) Delamination due to layer debonding or stripping between hot mix asphalt layers can cause distresses such as longitudinal cracking in the wheel path and tearing in the surface. Since these distresses cannot be detected by visual inspection of the pavement, Highway Agencies are interested in finding nondestructive methods for detecting delamination to maintain roadway networks.

Bandini et al. (2012) The New Mexico Department of Transportation (NMDOT) has a program to collect distress data through visual surveys and uses this information at the network level, together with roughness and rutting data, to calculate its pavement serviceability index.

Sebastiano (2013) Local Authority road networks commonly include roads with different functional characteristics and a variety of construction types, which require maintenance solutions tailored to their needs.

Khan and Riaz (2013) Better and efficient Transportation system is a key to success for a developing nation. But it is affected by large number of causes and one of them is the distresses develop on the pavement during its service and result in premature failure of the pavements. There are numerous distresses found in the road.

IV. FIELD STUDIES AND METHODOLOGY

Study Area for Flexible Pavement is selected as follows:

Location-1: Osmania University (Physical Education Department to temple)

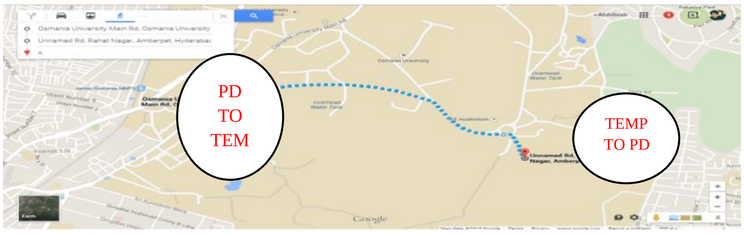

Figure 2 Route Map of Road-1 (*Source Google Maps)*

The study area represents for pavement distress conducted route map from Physical Education Department to temple as in Fig 2

4.1 Study Area for Rigid Pavements Karvan Road 1

The following are the study locations considered in this study:

Location 1 - Karwan Road, Attapur, Mehdipatnam (Road 1)

The study area represents for pavement distress conducted route map from temple to Karvan Bus Stop as in Fig 3.

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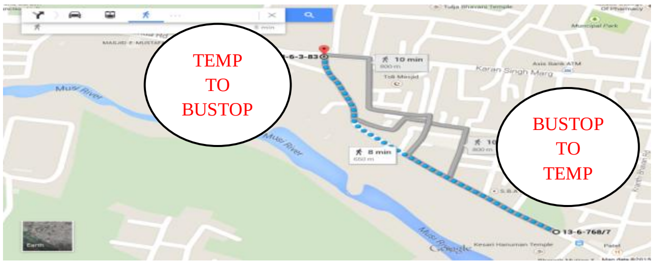

Figure 3 Map View of Karvan Road

Figure 3.1 Map View of Ramanthapur Road

Location 2– Ramanthapur

The study area represents for pavement distress conducted route map from Kaman to Colony as in Fig 3.1.

V. DISTRESS SURVEYS ON FLEXIBLE PAVEMENTS

The survey road is selected and length of 30m section is considered for inspection. The distress survey procedures and measurement practices adopted are different around the world, but are necessarily same and conceptual similar, with only minor variations. The asphalt concrete pavement which is selected is divided into 30m per section along the roadway. The section dimension being 30x [4.6 to 5.6 avg.], each section is keenly observed and the different types of distresses with their different severity levels at different points are noted on the data sheet to measure each distress type properly, the inspector must be familiar with each individual distress criteria.

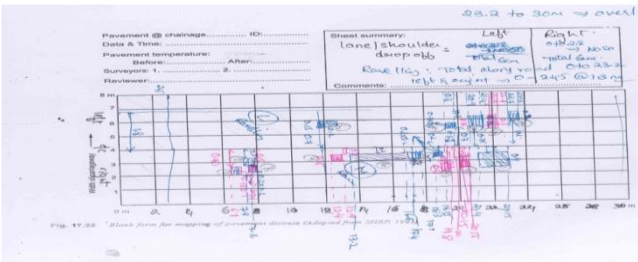

Figure 4 Filled in Form for Mapping of Pavement Distress

The sheet represents different values entered for pavement distress on flexible pavements as in Fig 4

5.1 Distress Surveys for Rigid Pavements

The survey road is selected and lengths of 18m sections are considered for inspection. The distress survey procedures and measurement practices adopted are different around the world, but are necessarily the same and conceptual similar, with only minor variations. The Portland cement concrete pavement which is selected is divided into 6slabs/section along the road way. The slab dimension being 6x4.5, each slab is keenly observed and the different types of distresses with their different severity levels at different points are noted on the data sheet to measure each distress type properly, the inspector must be familiar with the individual distress criteria.

RIGID PAVEMENT FIGURE

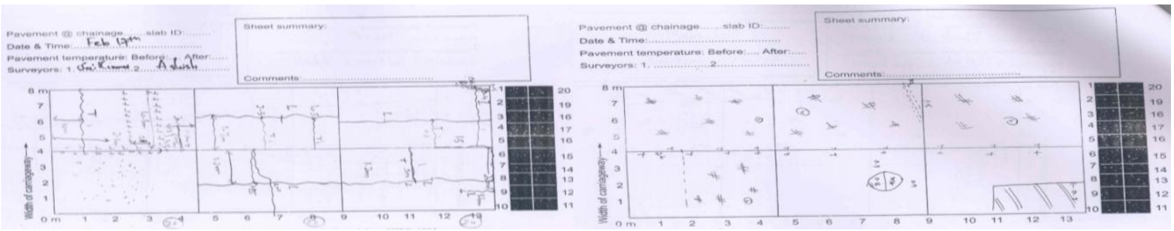

Figure 5 Filled in Form for Mapping of Pavement Distress

The sheet represents different values entered for pavement distress on rigid pavements as in Fig 5

VI. FABRICATION WORK FOR INSTRUMENT

For making of fabrication work of RSE instrument has collected data by reference of pavement evaluation and Maintenance Management System on basis of standard values are used.

6.1 Rolling Straight Edge

The Rolling Straight Edge (RSE) consists of a straightedge that rolls on two wheels under two ends, with another rolling wheel fixed midway. The RSE is moved manually by a person walking at slow speed and halted every 1.5m along a wheel path for measuring surface deviations (dhi).

6.2 Product Description

Easy-to-use, one-person operation Lightweight aluminum frame construction. Vertical-sweep visual indicator. Optional simultaneous sound indicator. Available in 10, 12, and 16ft lengths The Hi-Low Detector (Rolling Straight Edge) is used for measuring pavement plainness. Rolled by one person along a highway, airport runway, or bridge surface, the unit detects, registers, and dye marks high and low areas that need to be ground or re-rolled. The Travelling Beam Device is used for detecting surface irregularities in both concrete and asphalt pavements.

The apparatus consists essentially of a 3 meter length beam with rigid wheels at the extremities and a wheel at the middle, which can detect any vertical deviation of the surface from a straight-line between the two wheels at the ends of the machine.

Measuring capacity of the device is ±25 mm with 5mm increments. It comprises manual dye marker which can mark irregular surfaces of the road.

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Figure 6 Fabrication Works for All the Parts

Figure 7 Rolling Straight Edge (RSE) Measurement in Progress

VII. DATA COLLECTION AND ANALYSIS

This chapter deals with the classified of comparison between Rolling Straight Edge (RSE) and Root mean square error vertical acceleration(RMSVA) are conducted for this work data extracted from the analysis.

Root mean square error vertical acceleration (RMSVA) : the measured evaluation data obtained from the rolling straightedge can be used to determine a rolling index , the root mean square vertical acceleration . It is the RMS value of the change in slope by base distance, which can be defined as below

$$slope_i = \frac{[dh_{i+1} - dh_i]}{b} ; slope_{i+1} = \frac{[dh_{i+2} - dh_{i+1}]}{b} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}(1)$$

$$\Delta slope_i = \frac{slope_{i+1} - slope_i}{b} = \frac{[dh_{i+2} + dh_i - 2 \times dh_{i+1}]}{b^2} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_}(2)$$

The RMSVA value was used in the 1980. Determination of these indices of roughness is now obsolete as the IRI is widely determined by the method by which the riding quality related to surface characteristics pavement is better defined

$$RMSV_b = \frac{1}{n-2} \sqrt{(\sum_{i=1}^{n-1} (\Delta slope_i)^2} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}(3)$$

Mid Chord Deviation: The measured elevation data obtained from the rolling straightedge can be used to determine roughness index as mid chord deviation, which is also applicable to MERLIN measurements

$$MCD_{i@b} = [dh_{i+1} - 0.5 \times (dh_{i+2} + dh_i)] \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}(4)$$

Standard deviation: The measured data can be used to determine roughness in the form of standard deviation obtained at a section length of 100m and 150m respectively ,as used by japan Road Association.

Standard Deviation SD (in mm) = $\sqrt{\frac{n\sum_{i=1}^{n} h_i^2 - (\sum_{i=1}^{n} h_i)^2}{n(n-1)}}$ _____________(5)

VIII. FINAL CALCULATED VALUES OF RSE, PCI AND SD FOR FLEXIBLE PAVEMENT

The summary of the test results obtained by conducting Rolling Straight Edge (RSE) and PCI surveys are as follows:

Table 8.1 Comparisons for RMSE, PCI Vs SD for Flexible Pavement

Name	RSE	PCI	SD
Number	104	99	104
Mean	0.17387	63.4242	0.0341
Standard Deviation	0.17526	21.8119	0.05966
Maximum	0.72219	96	0.0608
Minimum	0.01798	14	0.00115

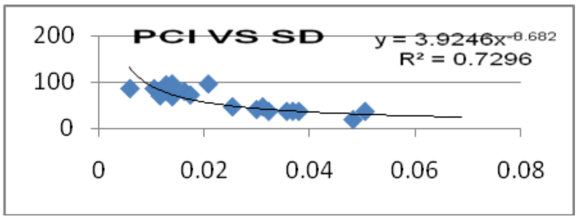

Figure 8 Comparison PCI Vs SD for Flexible Pavement

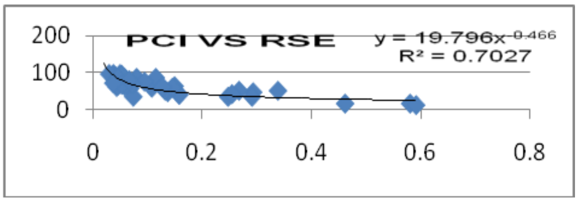

Figure 8.1 Comparison for PCI Vs RSE for Flexible Pavement

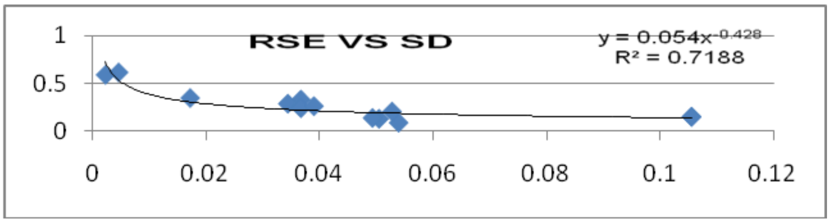

Figure 8.2 Comparisons for RSE Vs SD for Flexible Pavement (Low)

IX. FINAL CALCULATED VALUES OF RSE, PCI AND SD FOR RIGID PAVEMENT

Table 9.1 Comparison for RMSE, PCI Vs SD for Rigid Pavement

Name	RSE	PCI	SD
Number	109	74	109
Mean	0.17506	63.1351	0.03934
Standard Deviation	0.07159	15.266	0.01835
Maximum	0.55851	93	0.08833
Minimum	0.06442	25	0.0029

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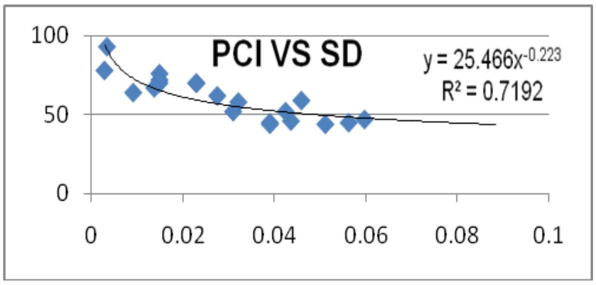

Figure 9 Comparison PCI Vs SD for Rigid Pavement-1

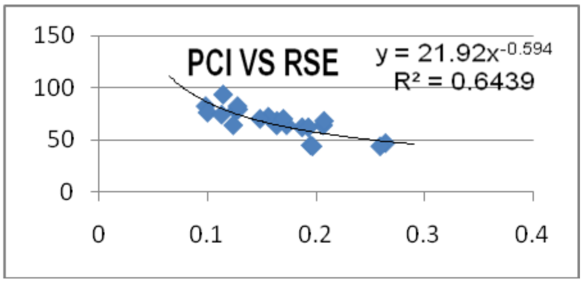

Figure 9.1 Comparisons for PCI Vs RSE for Rigid Pavement-2

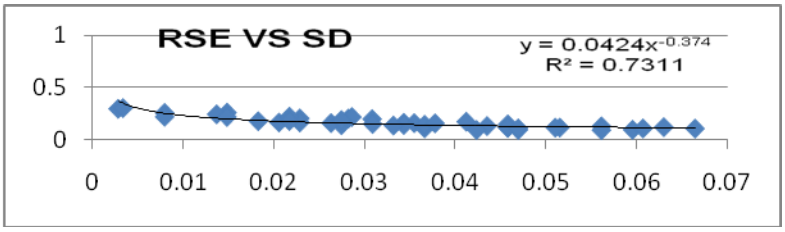

Figure 9.2 Comparisons for RSE Vs SD for Rigid Pavement (Low)

X. RESULTS FOR RIGID AND FLEXIBLE PAVEMENT

The statistical analysis is also done for the selected two roads and the average of the PCI values and standard deviation values and covariance value related to the two different roads are calculated as follows:

The following Correlations are developed:

The graph plotted for X axis as SD, RMSE and Y axis PCI and RMSE values and the following equations are developed. The R^2 values obtained are in the range of 0.70 to 0.73, which is acceptable range. So equations are valid.

For Flexible

1. PCI = y = 3.924 x $SD^{0.55}$, R^2=0.729
2. PCI = y = 19.79 x $RMSE^{0.48}$, R^2=0.702
3. RMSE = y = 0.054 x $SD^{-0.42}$, R^2=0.718

The graph plotted for X axis as SD, RMSE and Y axis PCI and RMSE values and the following equations are developed. The R^2 values obtained are in the range of 0.60 to 0.74, which is acceptable range. So equations are valid.

For Rigid

1. PCI = y = 25.46 x $SD^{0.22}$, R^2=0.719
2. PCI = y = 21.92 x $RMSE^{0.59}$, R^2=0.643
3. RMSE = y = 0.042 x $SD^{0.57}$, R^2=0.731

IX. CONCLUSIONS

The following are the conclusions drawn from the present study:

- The PCI value for Karwan road is 50, therefore according to PCI rating Index, and form the graph 5.2 the Karwan road condition is "POOR."
- The Maintenance Options: 1.surace treatment 2. seal, premix carpet.
- The PCI value for Ramanthapur road is 72; therefore according to PCI rating Index, and form the graph 5.2 the Ramanthapur road condition is "SATISFACTORY."
- The Maintenance Options: 1.surace treatment 2.Fog sealing , chip seal
- The PCI value for Osmania University road is 55; therefore according to PCI rating Index, and form the graph 5.2 the Osmania University road condition is "FAIR."
- The Maintenance Options: 1.surace treatment 2. Slurry seal, premix carpet.

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