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The Relation between Structural Distresses in the Flexible Pavements

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***Abstract:** The pavement management system deals with maintenance, repair, and rehabilitation of pavements. Pavement Condition evaluation is one of the critical steps in the pavement management system. It required distresses identification and measurement on the pavement surface. Structural distresses are an essential component in the pavement condition evaluation. To take decisions precisely, it is necessary to develop the relationship between various distresses. In this study, the relationship between structural distresses in flexible pavements has been analyzed. The primary structural distresses as longitudinal cracking, transverse cracking, Fatigue cracking, Block cracking, and deflection has been considered for the study. The correlation between all the distresses has been analysis. For correlation analysis, the Pearson Correlation Coefficient is used. The values of the Pearson correlation coefficient indicate that there is a strong positive relationship betweenthe distresses. Furthermore, to develop a prediction model, the regression analysis has been done. The values of the coefficient of regression indicate that the relationship is linear and positive between the structural distresses.*

***Keywords:** Pavement, Structural Distresses, Correlation, Regression*

I. INTRODUCTION

Structural and functional characterization of existing pavement is done through the field survey and testing of pavement. This process of is known a pavement evaluation [1]. Pavement structural distresses such as Longitudinal cracking (LC), Transverse cracking (TC), Fatigue cracking (FC), Block cracking (BC), and deflection Def) are essential for evaluating pavement surface conditions. The distresses can significantly reduce performance and shorten the service lives of flexible pavements. Ouma et al. used wavelet morphology to analyzed relation between various cracks which includes longitudinal, transverse, diagonal tec. [2]. Generating prediction models for distresses in the pavement explains the reasons for distresses appearance and considered the heart of the pavement maintenance management system [3].

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There are three types of prediction models; empirical, mechanistic-empirical, and probabilistic models. The last two types require a large number of pavement segments, which can be grouped in homogenous categories. So, they may be not suitable for urban roads in small cities. Empirical models are developed by regression analysis and more ideal for small networks. Many studies and agencies use the regression analysis for developing prediction models, which can be used in evaluating various maintenance techniques and generating future maintenance plans.

Structural capacity of the existing pavements is check through deflection assessment. Overstressed pavements surfaces are due to maximum deflection [4]. N M Barudin et al. proved that there is no correlation between structural and functional properties in flexible pavements. For the study they considered international roughness index, rut depth etc. as functional properties and elastic modulus, California ration as structural properties. [5]. C. Makendran et al.were developed prediction model for Indian country low volume road by using multiple linear regression analysis different types of distresses such as cracks , roughness etc. are analyzed through the developed model [6].

From a literature study, it is observed that modeling the relationship between distress parameters is useful for the efficient pavement management system. These relationships are also beneficial for road deterioration studies and in the design and analysis of flexible pavements [7]. The main objective of this study is to analyze the relation between all the structural distresses. Correlation analysis and regression analysis has been done to determine the relationship between the above mentioned distresses.

II. METHODOLOGY

The data collection for the study was done by measuring distress on the road segments of the Pimpri Chinchwad area of Pune city. Five roads of flexible pavement are considered. Two-kilometer section of each road is found for the study. Total of five structural Distresses are considered, and eleven functional distresses are considered for the study. Five Structural distresses are Fatigue cracking, longitudinalcracking,transverse cracking, block cracking, and deflection.

Longitudinal and transverse cracks are measured in linear mode by measuring length. Fatigue and block cracks are measured by considering the area enclosed by the cracks. Characteristic deflection is measured by using a Benkelman beam of deflection measurement.

In this work, to determine the relationship between all the distresses, correlation analysis has been done. Pearson coefficient of correlation is calculated for the measured distresses.
The attempt has been made to developed relationships between the distresses by using regression analysis.

1. Correlation

In this study, correlation analysis has been done to determine the functional variation between different distresses. Structural and functional distresses are considered separately. Pearson coefficient of correlation is determined by using SPSS software. The value of the coefficient always lies between +1 and -1. Value more significant than 0 indicates a positive association i.e., as the value of one variable increases, so does the value of the other variable. A value less than 0 indicates a negative association i.e., as the value of one variable increases, the value of the other variable decreases. The correlation analysis is carried out between longitudinal cracking and transverse cracking, fatigue cracking, block cracking, and deflection respectively for structural distresses

2. Linear Regression

Prediction of an outcome variable by considering one or more input variable is done by regression analysis. Simple linear regression is the basic form of regression analysis. It is used to predict a continuous outcome variable from continuous input variable. Values of R^2 below 0.2 are considered weak, between 0.2 and 0.4, moderate, and above 0.4, strong. In this work, regression analysis has been done by considering longitudinal cracking as an independent variable. Graphical representation of the regression model for Road 1 is shown in the following figure1 (A) to figure 1(D)

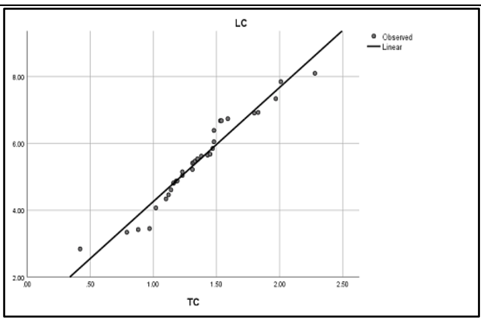

Figure1(A) Regression model LC V/S TC – Road 1

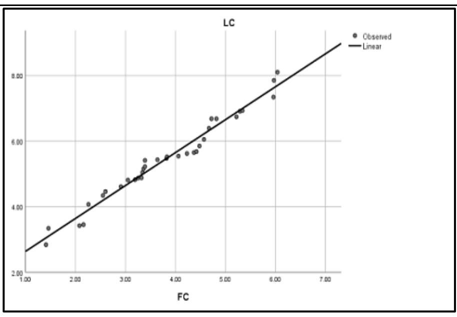

Figure1(B) Regression model LC V/S FC– Road 1

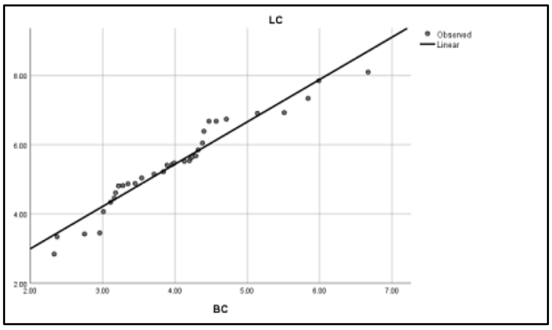

Figure1(C)Regression model LC V/S BC– Road 1

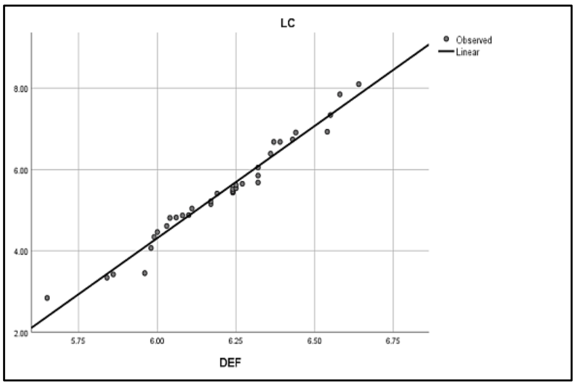

Figure1(D) Regression model LC V/S Def– Road 1

From the graph, it is observed that there is a linear relation between LC and all the distresses. The relationship is also positive as LC increases with the values of distresses increases. Hence this relation can be used to predict the LC value by putting respective distresses.
The detail result of Pearson coefficient of correlation and regression analysis is discussed in result and discussion part.

III. RESULT AND DISCUSSION

. The values of Coefficients are given in table I

Table- I: Pearson coefficient of correlation

Distresses	Road 1	Road 2	Road 3	Road 4	Road 5
	LC				
TC	0.972	0.909	0.985	0.951	0.961
FC	0.985	0.965	0.9	0.945	0.964
BC	0.961	0.978	0.783	0.949	0.969
DEF	0.984	0.866	0.888	0.959	0.971

Table I indicates that for structural distresses values of the coefficient is greater than 0 and nearer to 1. It indicates that there is a positive, strong relationship between all the distresses with each other.
Result of regression analysis is shown in Table II

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Table- II: Regression analysis

	Road 1		Road 2		Road 3		Road 4		Road 5	
Dependent Variable→	LC									
Independent Variable	***R***	***R²***	***R***	***R²***	***R***	***R²***	***R***	***R²***	***R***	***R2***
TC	0.972	0.945	0.909	0.826	0.985	0.969	0.982	0.962	0.978	0.986
FC	0.985	0.97	0.965	0.931	0.9	0.809	0.928	0.905	0.952	0.982
BC	0.969	0.938	0.978	0.956	0.783	0.613	0.857	0.921	0.936	0.968
DEF	0.984	0.968	0.866	0.75	0.888	0.789	0.823	0.908	0.857	0.913

Table II indicates that the value of R^2 is above 0.4, and it is on the higher side. Hence the regression analysis can be used effectively for distress prediction in this case.

IV. CONCLUSIONS

The major structural distresses as longitudinal cracking,transverse cracking, fatigue cracking, block cracking, and deflection. have been considered for the study. The Pearson coefficient of correlation has been determined between all the distresses. The values of the coefficient are greater than 0 and nearer to 1. It indicates that there is a positive, strong relationship between all the distresses with each other. The regression analysis is also done, which shows that the relation between distresses is linear and positive. The observed results show that the regression analysis can be used effectively for the prediction of distresses.

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