

RELATIONSHIP BETWEEN TIME SINCE LAST MAINTENANCE AND PAVEMENT CONDITION FOR PROVINCIAL HIGHWAYS IN PAKISTAN

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1. INTRODUCTION

The pavements are complex structures and they behave in a complex way to various environmental variables and traffic loading conditions. The predictions of the future pavement conditions are a matter of great concern to road engineers. This knowledge of the future condition of the pavement is necessary for budget optimization. An effective maintenance plan should be developed based on the actual pavement condition, traffic volume, environmental effects, and desired performance standards. In many developing countries such as Pakistan, due to the absence of an effective maintenance plan, the roads to be selected for future maintenance plans are usually based on the time period since they were last rehabilitated or maintained. The three types of maintenance activities practicing in Pakistan are routine maintenance, periodic maintenance, and rehabilitation. The definitions are given in Table 1.

In this research, the relationship between the pavement condition and the age, or time period since the pavement was last rehabilitated or maintained, was examined in order to find the relationship of pavement condition with age. The reason to study the association of time period since the last maintenance with pavement condition was to check the concept of the current trend of budget distribution for maintenance activity based on the time period in Khyber Pakhtunkhwa province of Pakistan.

2. METHODOLOGY

2.1 Data

The data for analysis was collected from the Communication and Works Department, Peshawar. The sample size consisted of 105 sections of the provincial highway network.

2.2 Analysis

The variable "pav_cond" representing the pavement condition was the dependent variable and was divided into 03 categories i.e. bad, fair, and good, depending on the International Roughness Index (IRI) and vehicular speed. The definitions are mentioned in Table 2. The variable "time.sincelast_rehab" was an independent variable representing the pavement age which was measured from the date of last rehabilitation or maintenance activity. First, the Chi-square test with the cross-tabulation analysis was performed to find the association of the pavement condition with the age. For this purpose, the pavement sections were grouped, based on the distribution of pavement sections' age in the available data into three categories:

New - Pavement sections with age up to 3 years
Medium - Pavement sections with age from 4-6 years
Old - Pavement sections with age greater than 6 years

The percentage of pavement sections according to three groups is summarized in Figure 1. The new group consisted of more than 80% of sections while the old group consisted of about 5% of pavement sections.

In the next step, ordinal logistic regression (OLR) was performed to examine the suitability of age for predicting the pavement condition. Open-source statistical analysis software R was used to conduct cross-tabulation and ordinal logistic regression analyses [1].

Table 1 Description of road maintenance techniques

Maintenance	Description	Time period
Routine Maintenance	Low-cost work to minimize future deterioration due to weathering or by traffic load	After 03 years
Periodic Maintenance	Periodic restoration works of road.	After 06 years
Rehabilitation	Major work to restore the road to its original condition	After complete failure

Table 2 Description of pavement condition

Pavement Condition	IRI	Speed (kph)	Area Damaged (%)
Bad	7-10	25-40	10-25
Fair	4-6	40-60	5-10
Good	0-4	Over 60	-

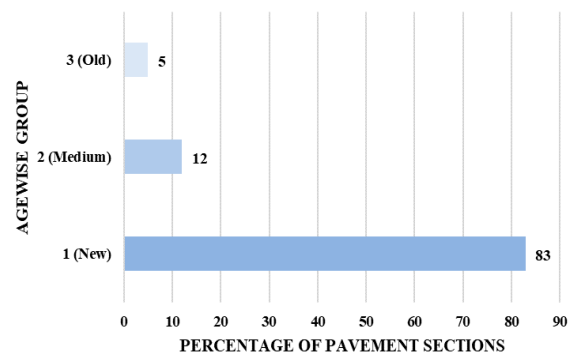


Figure 1 Pavement condition according to three groups

3. RESULTS & DISCUSSION

3.1. Cross-Tabulation Analysis

Figure 2 represents the results of the cross-tabulation analysis. It was found that more than 80% of roads are in fair to good condition in the new group. Whereas the

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medium group consisted of 25% of roads each in good and bad condition and 50% of roads in fair condition. Similarly, the old group consisted of 100% of roads in bad condition. There is no single road in good or in fair condition in the old group.

The p-value obtained from the Chi-square test was found to be less than 0.05 revealing that the pavement condition has an association with age. Whereas from the cross-tabulation analysis, it was found that the process of degradation of pavement was already been started at about three years as more than 30% of roads were in fair to bad condition. The percentage of good condition roads was further reduced from 64% in the new group to just 25% in the medium group, whereas the percentage of roads in fair and bad condition increased in the medium group, indicating that the pavement condition is deteriorating with time. Similarly, no good to fair condition roads was found in the old group showing that the pavement condition gets completely deteriorated after 06 years, which may result in huge rehabilitation costs.



Figure 2 Results of cross-tabulation analysis of pavement condition with age

3.2. Ordinal logistic regression

In the next step, OLR was carried out to examine the response of pavement condition with the age. `time.sincelast_rehab` was taken as an independent variable for predicting pavement condition. The numeral values of the independent variable were taken for analysis. The t value and p-value obtained from the OLR analysis between the variables `time.sincelast_rehab` and `pav_cond` were found to be -3.82 and 0.0001 respectively. The results of the ordinal logistic regression model showed that age (`time.sincelast_rehab`) is highly related to pavement condition. The negative sign indicated that with the passage of time, the pavement condition gets deteriorated. The odd ratio value was found to be 0.2 which indicates that there is a negative association between pavement condition and age.

In the next step, an ordinal logistic model was applied to make predictions about the pavement condition by varying the time period since the road was last rehabilitated. Figure 3 indicates the probability of the pavement condition with the age (`time.sincelast_rehab`). The curve of pavement with the bad condition is increasing with time and it is minimum at about 1 year but reached the maximum level of 100% when it reaches to 6 years. Correspondingly, the curve for good condition roads is

declining with age showing that the probability of roads in good condition is decreasing with time. It was found out that the pavement condition deteriorated with time. This association of pavement condition with time may represent the accumulated effects of load and non-load-related distresses [2].

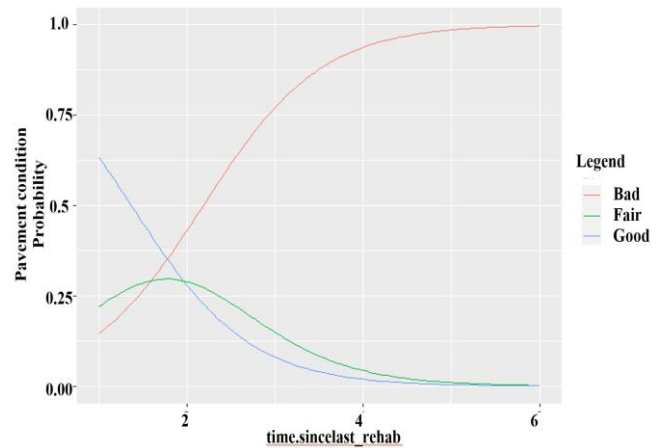


Figure 3 Graph showing the probability of pavement condition with the time period

4. CONCLUSION & RECOMMENDATIONS

In this paper, it was shown that the pavement condition has a strong association with age. It was concluded that the pavement deterioration begins immediately, even before it reaches 3 years of age, and gets worsened at 6 years of age. In the initial stage, the rate of deterioration is gradual. In the middle stage, the rate of deterioration increases and if they are not maintained under the routine maintenance plan or periodic maintenance plan, the pavement gets completely deteriorated in six years which may result in huge restoration costs.

It is recommended that the pavement condition must be assessed after construction/ rehabilitation and maintenance activity should be provided accordingly in order to protect it from full deterioration. However, it is also suggested to determine the other factors along with age that results in deterioration of pavement condition, in order to develop an effective maintenance plan.

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