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Research Paper

Moderation Effect of Raveling on Bleeding failure of Flexible Pavements

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Abstract

This paper evaluates the moderation effect of raveling on bleeding failure of Flexible pavements with the support of moderation models. Failures in flexible pavements results due to its component layers which undergo distress due to innumerable causes. There are different types of failures in flexible pavements like alligator cracking, corrugations, shoving, pot holes, rutting, raveling and bleeding. Determination of the type and extent of failure and its reason is necessary to facilitate correction in mix design, construction and maintenance for the road projects. A moderator is a qualitative or quantitative variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable. Four road sections have been considered for data collection and model validation. Linear models have been developed to check the mediation and moderation effects of raveling on bleeding failure for both the roads and these models are validated on other two road sections. The study accentuates that there is no mediating effect of raveling on bleeding but it effects the bleeding moderately. These validated models can be surely used to find the bleeding failure, if ravelling parameters are known and hence, the survey time and cost can be minimized.

Keywords: Rutting, Ravelling, Bleeding, Moderator, Mediator and chi-square test

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1. Introduction

Transport in India is an important part of the nation's economy. Development of infrastructure within the country has progressed at a rapid phase [Shabana and Dr. Molugaram, 2019]. The last century has seen an intensive process of urbanization in rural as well as metro cities. This has led for a need of rapid construction of roads and transportation infrastructure. Pavements are essential features of the urban communication system and provide an efficient means of transportation. A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade [Tom, V. M. and Krishna Rao, K. V., 2007]. Flexible pavements are preferred over cement concrete roads because of couple of advantages like they can be strengthened and improved in stages with the growth of traffic. The flexible pavements are less expensive in regards to initial cost and maintenance. The pavement structure should offer surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. Contingently transmitting stresses due to wheel load are sufficiently reduced, consequentially load does not exceed bearing capacity of the sub grade [Milind V. Mohod and Dr. Kadam, K. N., 2016]. Road network in India has expanded from 0.4 million km in 1951 to about 3.32 million kilometers presently, a sevenfold increase, but traffic has increased 120 times. This change is imperating to the deterioration of surface of the pavements and need to rehabilitate them before further damage could occur [Jundhare et al., 2012]. For addressing pavement failures in India, conducting pavement evaluation surveys cost around ₹. 30,000 per Km and is time consuming. Hence the objective of this current study is to experimentally check the impact of linked flexible pavement failure parameters and to establish a model among them which serves the purpose of calculating unknown parameters so that, the survey time and road project cost can be minimized.

2. Flexible pavement failures

Failures in flexible pavements results due to its component layers which undergo distress due to innumerable causes. There are different types of failures in flexible pavements like alligator cracking, corrugations, shoving, pot holes, rutting, raveling and bleeding. Determination of the type and extent of failure and its reason is necessary to facilitate correction in mix design, construction and maintenance for the road projects. The depression formed in the surface is called the rutting as shown in Figure 1. The main cause of rutting is structural distressing and heavy wheel loads than permitted values. Rut is formed in the wheel path surface. Rut will make the other sides of the wheel to undergo uplift. The formed pavement uplift is also called as shearing. Ruts like depressions are evident after rain, where these depressions would be filled with water. Progressed state of rut and shearing is called Raveling. Raveling is the phenomenon of aggregate loss from a surface course [Joelle De Visscher and Ann Vanelstraete, 2017]. The dislodgement of aggregate particles will result in the disintegration of the asphalt progressively from the surface to downward direction. The direct cause of failure is the action of shear forces due to traffic. The disintegration of the hot mixed asphalt finally leads bleeding of the flexible pavement. The phenomenon of separation of asphalt binder from aggregate particles of the pavement surface is called as bleeding.

Figure 1. Rutting failure of flexible pavement

3. Moderation and Mediation effect

Relations between variables are often more complex than simple bivariate relations between a predictor and a criterion. Rather these relations may be modified by, or informed by, the addition of a third variable in the research design. Examples of third variables include suppressors, confounders, covariates, mediators, and moderators [MacKinnon et al., 2000]. Mediation analysis tests a hypothetical causal chain where one variable affects a second variable and, in turn, that variable affects a third variable. Mediators describe the how or why of a relationship between two other variables and are sometimes called intermediary variables since they often describe the process through which an effect occurs. This is also sometimes called an indirect effect. A moderator is a qualitative or quantitative variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable. A given variable may said to function as a mediator to the extent that it accounts for the relation between the predictor and the criterion. Mediators explain how external physical events take on internal psychological significance. Whereas moderator variables specify when certain effects will hold, mediators speak to how or why such effects occur. The general test for mediation is to examine the relation between the predictor and the criterion variables, the relation between the predictor and the mediator variables, and the relation between the mediator and criterion variables. In this present study, an attempt has been made to check mediation and moderation effect of Raveling on bleeding failure of flexible pavement. A relation is tried to establish as shown in Figure 2 and 3.

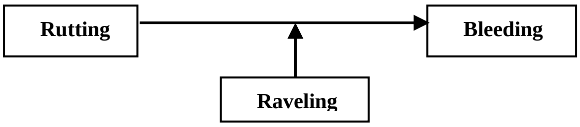

Figure 2. Moderation effect of Raveling on bleeding

Figure 3. Mediation effect of Raveling on bleeding

If rutting (X), raveling (Z) and bleeding (Y) are considered as three variables of interest, the mediation effect can be tested in three steps:

1. Test if X predicts Y,
$Y = B_1 + cX$

2. Test if X predicts Z,
$Y = B_2 + aZ$

3. Test if X still predicts Y when Z is in the model,
$Y = B_3 + c'X + bZ$

Moderation indicates that the X-Y relation differs by the level of Z. In multiple regression, X, Z and an interaction term between X and Z as predictors of Y will be included. If the regression coefficient of this interaction term is significant, it suggests that

Z modifies the X-Y relation. This relation can be illustrated by the equation (1).

$$Y = b_0 + aX + bZ + cXZ \quad \ldots\ldots\ldots\ldots\ (1)$$

a indicates the effect of X when Z is zero
b indicates the effect of Z when X is zero
c indicates how much the effect of X changes as Z changes one unit
The same has been tested for the mediation and moderation effects of raveling on bleeding failure of flexible pavement.

4. Road Data collection

Total 4 road sections have been selected for data collection, analysis and modeling of parameters. In these, two road sections are for the data collection and the remaining two for modeling. All the four road sections pavement is in failure condition. The road pavement inventory data has been collected from Arcot – Tindivanam section of SH-5 in the state of Tamilnadu, India from Km. 43.500 to Km. 86.000 (Road section 1). The pavement is of 2 lane with paved shoulders configuration. The rutting data in terms of meters, raveling in m^2 and bleeding in m^2 has been collected for modeling of parameters. The collected data is presented in Figure 4. It is found that the road was in deteriorated condition and needs rehabilitation or reconstruction.

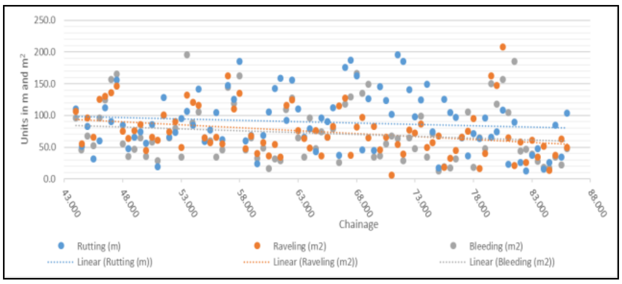

Figure 4. Road inventory data of road section 1

The second road stretch selected for inventory data collection is Shahpura – Alwar – Ramgarh - Nuh Road (NH-248A) from Km. 86.800 to Km. 127.700 (Length - 49.90 Km) in the state of Rajasthan, India (Road section 2). The pavement is of 2 lane with paved shoulders configuration. Few blocks of this road are in fair condition with good riding quality and remaining portion is in deteriorated condition. The collected data is presented in Figure 5.

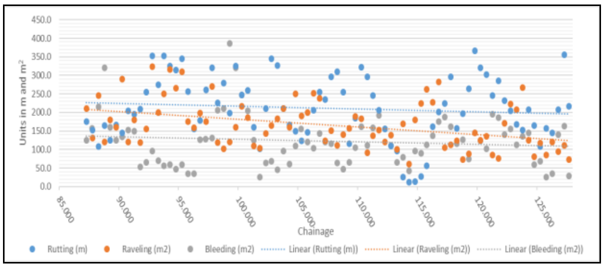

Figure 5. Road inventory data of road section 2

5. Model Generation

Linear models have been developed as per Figure 2, to check the mediation and moderation effects of raveling on bleeding failure for both the roads. The moderation effect for both the roads is presented in equation (2 and 3).
Moderation effect model:

$$Y_{Road\ 1} = 23.32 + 0.0043\ X + 0.29\ Z + 0.0034\ XZ \quad \ldots\ldots\ldots\ldots\ (2)$$

$$Y_{Road\ 2} = 0.652\ X + 0.69\ Z - 0.0032\ XZ - 14.13 \quad \ldots\ldots\ldots\ldots\ (3)$$

The regression coefficients observed to be in the range of 0.79 for road 1 and 0.74 for road 2 indicates a good fit of the model. The regression coefficients for different relationships for two road sections are presented in Table 1. These models with high regression coefficients support all conditions of moderation effect of raveling on bleeding failure of flexible pavement.

Table 1. Moderation effect testing

Road Details	Variable details	Linear model	Regression coefficient
Road section 1	X – Y	Y = 0.38 X + 37.70	0.74
	Y – Z	Y = 0.76 Z + 15.52	0.63
	X – Z	Z = 0.16 X + 59.11	0.69
Road section 2	X – Y	Y = 0.072 X + 107.12	0.83
	Y – Z	Y = 128.41 – 0.036 Z	0.72
	X – Z	Z = 0.073 X + 150.54	0.59

The mediation effect of raveling on bleeding has been tested by linear models as shown in Table 2. From the analysis, it is found that there is no mediating effect of raveling on bleeding but it effects the bleeding moderately.

Table 2. Mediation effect testing

Road Details	Variable details	Linear model	Regression coefficient
Road section 1	X – Y	Y = 0.20 X + 42.33	0.064
	Y – Z	Y = 0.074 Z + 64.12	0.079
	Y - X – Z	Z = 0.71 X + 0.15 Z – 3.31	0.60
	Y - Z	Y = 0.72 Z + 9.33	0.17
Road section 2	X – Y	Y = 0.13 X + 136.97	0.036
	Y – Z	Y = 128.41 – 0.036 Z	0.038
	Y - X – Z	Z = 102.61 – 0.078 X + 0.15 Z	0.041
	Y - Z	Y = 128.41 – 0.036 Z	0.12

6. Model Validation

The road sections considered for model validation are Mallasandra Karadi road (NH-206) from Km. 12.300 to Km. 50.100 with 2 lane earthen shoulder configuration in the state of Karnataka (Road section 3) and Firozpur Muktsar road (SH-78) from Km. 42.100 to Km. 88.200 with 2 lane earthen shoulder configuration in the state of Punjab (Road section 4). The developed models based on moderation effect were validated for these two road sections. The measured bleeding values from the road inventory survey are compared with the calculated values from the models as presented in Figure 6 and 7.

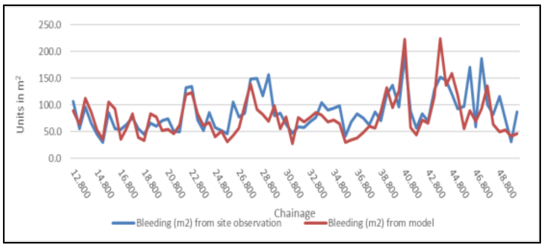

Figure 6. Model validation for road section 3

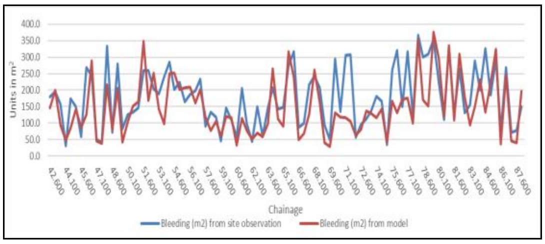

Figure 7. Model validation for road section 4

It is found that there is 10 to 17% overall variation between measured and calculated values of bleeding failure for the two road sections as shown in Figures 8 and 9.

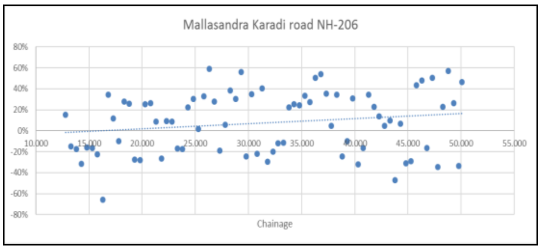

Figure 8. % data variation for Mallasandra Karadi road (NH-206)

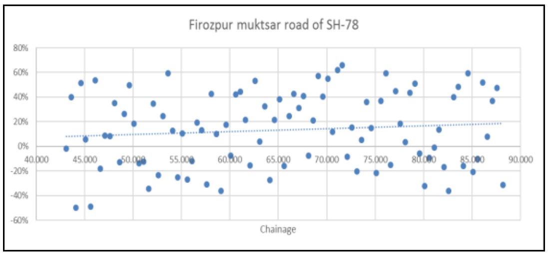

Figure 9. % data variation for Firozpur muktsar road (SH-78)

7. Conclusions

The chi-square test of independence is a nonparametric test, applied to test the hypothesis between two or more variables how likely the measured distribution of data fits with the distribution calculated from the model, i.e., to advise goodness-of-fit. It determines whether there is a significant connotation between two variables from the same group. It can be performed on (measured and calculated) both the bleeding failure data sets for two roads to check the association and goodness of fit. It is found that the value of $p < 0.05$, signifies both the data sets are associated. Present study concludes raveling failure is producing moderation effect on bleeding failure of flexible pavements.

8. References

-Joelle De Visscher and Ann Vanelstraete, “Ravelling by traffic: Performance testing and field validation”, Science Direct, International Journal of Pavement Research and Technology 10 (2017) 54–61.

-Jundhare, D. R., Dr. Khare, K. C., and Dr. Jain, R. K. (2012) “Development Correlation between Benkelman Beam Deflection and Falling Weight Deflectometer for Conventional White topping Overly”, J. Basic. Appl. Sci. Res., 2(9)8725-8731.

-MacKinnon DP, Krull JL, Lockwood CM., “Equivalence of the mediation, confounding, and suppression effect”. Prevention Science 2000; 1:173-181. 10. 1023 / A: 1026595011371.

-Milind V. Mohod and Dr. Kadam. K. N. “A Comparative Study on Rigid and Flexible Pavement: A Review”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. VII (May-Jun. 2016), PP 84-88.

-Shabana Thabassum and Dr. Kumar, M. “Age Factor in Truck Driver Behavioral Modeling – Indian Conditions” Indian Highways, December 2019.

-Tom V. Mathew and K V Krishna Rao, “Introduction to Transportation Engineering”, NPTEL May 3, 2007.