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DEVELOPMENT OF MAINTENANCE MANAGEMENT SYSTEM BY FUNCTIONAL EVALUATION FOR RURAL ROADS IN HIMACHAL PRADESH

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ABSTRACT
In Himachal Pradesh, India, rural roads are crucial to the state's social and economic advancement. In Himachal Pradesh, rural roads have contributed around 79% of the total road length. The state transportation officials face a difficult task in maintaining this extensive system of rural roads. Furthermore, the money needed for their regular or periodic maintenance is scarce, thus appropriate maintenance techniques are needed to make the most use of the available resources. The current study focuses on creating a maintenance management strategy for Himachal Pradesh's rural road network. To assess pavement performance and adjust plans accordingly, periodic pavement evaluations are necessary. The functional evaluation addresses pavement distresses and riding comfort, or the pavement's roughness, while the structural evaluation addresses the pavement's structural characteristics, such as pavement deflection and modulus reactivity. The current study examines functional evaluation and looks at a variety of pavement distresses, the majority of which are seen on Himachal Pradesh's rural roadways. The current study has additionally examined mean texture depth and skid resistance in addition to pavement distresses. To carry out the investigation, six sample road sections in the Solan and Shimla districts have been chosen. Data on roughness and distress have been gathered for a total of 2.5 kilometers on the designated portions. Because the 2.5 km stretch accurately depicts the entire length of the road in terms of traffic volume and climatic elements, it has been chosen to conduct tests on each road. The study also intends to create a mathematical model that takes the greatest depth of the pothole and its mean diameter as input factors to predict the volume of the pothole. A very excellent correlation between the estimated and observed volumes of potholes has been identified, with a non-linear model predicting a good value of pothole volume with coefficient of determination, or R2 = 0.85.

Keywords:
Functional Evaluation, Distresses, Potholes, Regression

INTRODUCTION

With time, every highway asset deteriorates, most notably the established pavement structure. It is crucial that these man-made constructions, similar to flexible pavements, be routinely evaluated in order to determine their current state as well as the remaining life of the roads and the length of additional time that people can use them safely.

Therefore, it is necessary to have some equipment to evaluate the pavements' pre-existing conditions, collect some suitable data, and use the information collected with the intention of improving the pavements' condition and durability.

A. Factors Affecting Pavement's Performance

- **Traffic**: One of the primary factors influencing pavement performance is traffic. Pavement performance is influenced by axle load spectrum, wheel load repetitions, axle configurations, and classification traffic volume.
- **Moisture:** The primary factor behind any pavement degradation is moisture. It is the greatest threat to any pavement and can cause total disruption. Moisture reduces the interlocking of particles and causes displacement of particles, resulting in uneven settlement and other distresses.
- **Subgrade**: Since the subgrade layer, which is the lowest layer of pavement, ultimately bears all wheel

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load, the subgrade is the lifeblood of any pavement. The subgrade's ability to support weight is indicated by its California Bearing Ratio (CBR) value. Low subgrade bearing capacity led to distresses including rutting and reflection cracking, which have a direct impact on pavement performance.

- **Quality of Construction**: • The performance of pavements is significantly influenced by the quality of construction. Pavements with good durability are those that use high-quality aggregates and binder materials. The IRC code's requirements for pavement thickness should be properly followed, and quality checks should be carried out on a regular basis.

B. Functional Evaluation

The diagnosis or investigation of the pavement's external surface conditions is known as functional evaluation. To implement timely maintenance measures, pavements must be assessed. If appropriate maintenance is not performed, the different distresses that are present on a pavement will inevitably progress due to their uncertain character. Pavement function is evaluated using a non-destructive method. The two primary areas of functional evaluation are riding quality and pavement discomfort. Roughness and safety assessments are also included in the evaluation of riding quality.

C. Functional Evaluation: Parameters

Roughness: As seen in Fig. 1, pavement roughness is one measure of how comfortable road users are. It is described as the vertically oriented undulations in the pavement's smoothness profile relative to its planar surface. It's an unwanted departure that detracts from the quality of the ride. A variety of tools, like MERLIN and Bump Integrator, can be used to measure it. Measuring units include m/km, mm/km, and so forth.

Fig.1: Roughness

Rut Depth: The longitudinal depression created by repetitive movement along a vehicle's wheel path is known as rutting. A straightedge can be used to measure it, as illustrated in Figure 2. It mostly happens as a result of the subgrade's and the flexible pavement layers that follow having a low load carrying capacity.

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Fig. 2: Rut Depth/Rutting

Skid Resistance: The force created when a tire and the pavement surface come into contact with one another to prevent wheels from rotating in the opposite direction of motion after applying brakes is known as skid resistance. When the surface is wet or dry, there are differences in the resistance to skid. The Skid Resistance Pendulum Tester Machine can be used to measure the skid resistance of a pavement surface.

Macro-Texture: The definition of surface texture in pavement refers to the surface's divergence from its genuine planar surface. The resistance to skids on a wet surface at high speeds is determined by the macro-texture. The primary reason for the insufficient depth of macro-texture is the abrasive effect of traffic, which causes the binder material to wear and break.

Pot Hole: Potholes, as depicted in Fig. 3, are the bowl-shaped depressions that regularly occur on pavement surfaces as a result of aggregate particles becoming dislodged. These are isolated incidents of distress that have a significant impact on how well drivers ride. Potholes should be repaired as soon as possible because they could become dangerous for vehicles as they become more severe with time.

Fig. 3: **Pothole Depression**

Patching: As seen in Fig. 4, patching is the term used to describe any assistance given or pavement repair work done to address any localized distress such as raveling, potholes, etc. But because patching itself also degrades a vehicle's ride quality, it falls into a distressing category.

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Fig. 4: Patching at RR-1

METHODOLOGY

A. Selection of Rural Road Stretches

Table 1 lists the six highways that have been chosen for the functional evaluation in the region of Shimla and the Solan district.For the purpose of conducting the numerous tests, each road's length has been set at 2.5 kilometers. The 2.5 km length was chosen with the understanding that, in terms of both traffic volume and climatic considerations, the chosen 2.5 km road stretch represents the entirety of the route. To calculate the measurements of different distresses, each chosen route has been split into portions measuring 50 meters each. Figures 5 and 6 display the maps of specific rural road segments.

Table 1: Selected Rural Roads

Road ID	Name of the road
RR-1	Domehar Wakna Road
RR-2	Kyari Bangla Road
RR-3	Industrial Road
RR-4	Salana Road
RR-5	Shoghi Lagroo Road
RR-6	Nain Basal Road

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Fig. 5: Selected Rural Roads

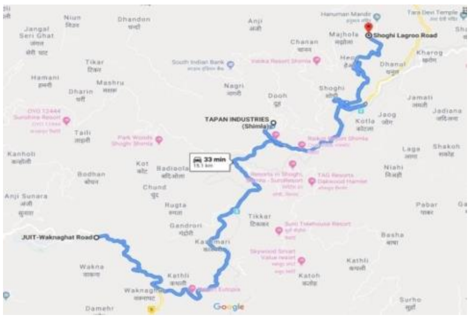

Fig. 6: Selected Rural Roads

B. Measurement of Pavement Distresses

In essence, pavement distresses are flaws in the pavement that are readily apparent to the unaided eye. There are many other kinds of distresses, including bleeding, raveling, cracking, patching, potholes, delamination, rutting, and so on, but in this study, only the forms of distresses that are frequently seen on the chosen rural road segments have been considered. Thus, in the current study, cracking, patching, potholes, and rutting have all been examined and assessed.

C. Measurement of Rutting

The longitudinal depression created along the wheel path by multiple vehicles moving over the same path repeatedly is known as rutting. The 3-meter straightedge, which shows the rut depth in Fig. 7, has been used in the current investigation to determine rutting. Nonetheless, the majority of the chosen road portions do not exhibit rutting.

Fig. 7: Rutting

D. Measurement of Volume of Potholes

As illustrated in Fig. 8, the volume of potholes has been measured by substituting the pothole basin for the known volume of sand. In order to eliminate this labor-intensive and time-consuming way of determining the pothole, a mathematical model has also been developed to calculate the volume of the pothole. In addition to measuring the pothole's volume, the mean diameter and maximum depth have also been noted for each pothole volume. In the current investigation, a correlation has been shown between the pothole's volume and its maximum depth and mean diameter.

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Fig. 8: Volume Determination by Replacing Sand withBowl of Pothole

E. Measurement of Patching

Patching, which is frequently employed to conceal pavement degradation, has been measured with an easy-to-use measuring tape. Since patching is typically done in square or rectangular shapes, calculating the patched area is made easier. Fig. 9 displays the patching sample on RR-6.

Fig. 9: Sample Patching on RR-6

F. Measurement of Cracking

On the chosen rural road segments, several forms of cracking have been seen, including longitudinal, transverse, alligator, fatigue, edge, and reflection cracking.It is easy to determine the area of the cracked portion of the roads because the area was measured using a basic measuring tape, which turned the area into an approximate rectangle or square. For each specific road, the total cracked area has been calculated by adding together all the various forms of cracking.

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Figs. 10–12 display the various forms of cracking that have been discovered on the chosen country roads.

Fig. 10: Sample of Longitudinal cracking

Fig. 11: Sample Transverse cracking

Fig. 12: Sample Alligator cracking

G. Rating of Pavement Sections

On the chosen rural route segments, the distress data has been gathered. The chosen rural roads are where the distress parameters—cracking, potholes, and patching—have been most prevalent. As indicated in Table 2, each pavement segment has been assessed using the IRC: 82-2015 rating system. Table 3 also provides the weighting assigned to each distress metric, indicating the relative importance of each distress in terms of pavement performance or maintenance techniques based on its severity. By dividing the overall area of distress by the total area of the pavement section, the distress data gathered on each road stretch has been translated into a percentage. The final rating of each selected rural road is represented by the average of all the ratings for that specific road.

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Table 2: Pavement Performance Rating based on Distress

Distress (%)	Range of Distresses		
Cracking	> 20	10 to 20	< 10
Potholes	> 1	0.5 to 1	< 0.5
Patching	> 20	5 to 20	< 5
Rating	1	1.1 to 2	2.1 to 3
Condition	**Poor**	**Fair**	**Good**

Table 3: Weightage of Distresses

Distress	**Weightage corresponding to Maintenance**
Cracking	1
Pothole	0.5
Patching	0.75

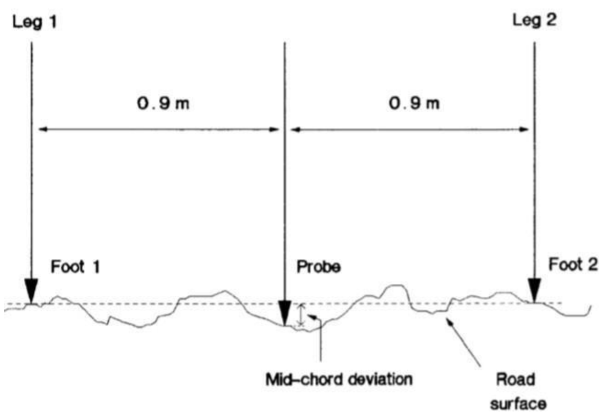

Fig. 13: Working Principle of MERLIN

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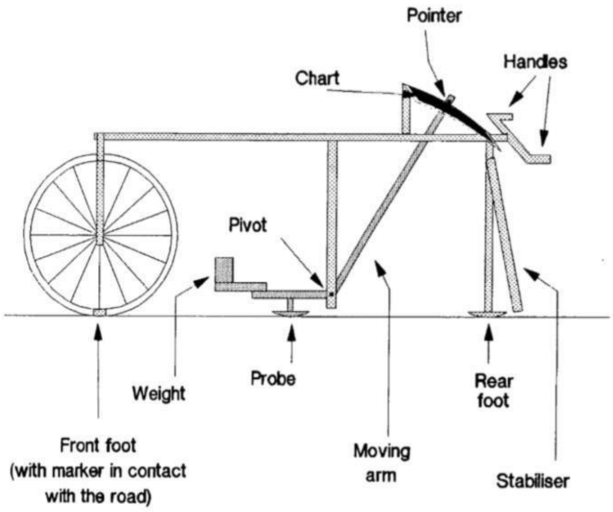

Fig. 14: **Component parts of MERLIN**

The pavement can be categorized using the IRI values as suggested by IRC: 82-2015 and shown in Table 4.

Table 4: Relationship between IRI and condition of thepavement

Range of IRI (m/km)	Categorization of Pavement
< 2.5	Excellent
2.5 - 4	Very good
4 - 6	Good
6- 8.5	Fair
8.5- 13.5	Frequent undulations
13.5- 16.5	Rougher surface
16.5-22.5	Very rough surface and unsatisfactory ride

H. Measurement of skid resistance

The amount of resistance that a pavement applies to wheels or limits their rotation following brake application is known as skid resistance. When a pendulum arm is allowed to fall freely under the force of gravity along with a reading pointer, the rubber slider at the bottom of the pendulum touches the pavement surface and provides a reading known as the skid resistance number. This is how the skid resistance tester is used to measure skid resistance, as seen in Fig. 15. The frictional characteristics of any pavement can be easily ascertained using this method. Before starting the test, the skid resistance tester's legs are adjusted to level it.

The test has been conducted at an interval of 100 m on each selected rural road stretches in Himachal Pradesh. The standard minimum resistance value suggested by TRL has been shown in Table 5.

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Fig. 15: Sample Data Collection using Skid Resistance

Table 5: Minimum Skid Resistance Value suggested by TRL

Category	**Type of Road Section**	**Minimum Value (Wet-Surfaces)**
A	Rotaries/Roundabout	65
B	NH/SH	55
C	All other surfaces	45

I. Measurement of macro-texture

Macro-Texture of Pavement Surface directly affects the skid resistance value due to exposure of aggregates due to rubbing action of wheels on the top surface of pavements. The mean texture depth (MTD) has been obtained on each selected rural road stretch using Sand Patch Apparatus Method as shown in Fig. 16 following standard codal provision given in ASTM E965.

The fine sand of Grade 2 with natural silica sand has been used in the present study to conduct sand patch method which has been spread in a circular sophisticated manner using 64 mm round rubber disc having 16 mm rubber thickness. The pavement surface having aggregates exposuregets filled due to gradual load applied using circular rubber disc up to its peak level. The mean diameter is measured after taking four sample of diameter reading in each direction. The mean texture depth (MTD) value in mm can be determined using the following relation-

MTD (Mean Texture Depth in mm) =Volume of sand used /
Area of circular patch

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Fig. 16: Sample of Sand Patch Method

RESULTS

Table 6 displays the MERLIN test findings that were utilized to calculate the International Roughness Index. For every chosen road stretch, six D value readings were obtained. The final IRI for each road stretch was then determined by averaging the D-values, and the IRI values were also used to suggest the state of the road. According to IRC 82:2015, the six chosen rural road segments have been graded using a distress-based rating methodology. Based on all of the related findings and weighted rating values, each rural road that was chosen has been given a final rating.

CONCLUSION

The following conclusions can be ascertained from the present study-

1. The six rural road segments that were chosen and located near Himachal Pradesh were determined to be in fair condition based on a system of weights and ratings that corresponded to the type and degree of hardship.
2. 2. Every road's International Roughness Index has been determined to be at a satisfactory level. Good surface profiles for RR-1 and RR-4 have been discovered, with IRI values of 5.62 and 3.95 mm/km, respectively. As indicated in Table 6, the remaining chosen rural road segments, however, had IRI values more than 6 mm/km.
3. 3. When compared to the macro texture depth discovered by the sand patch equipment and the skid resistance value determined by the skid resistance tester, it has been discovered that the former is safer.Also, the rut depth has not been found very significant on the selected rural road stretches. Hence, rutting has no impact on the pavement performance and not been taken in rating of pavements.
4. The non-linear regression model provided in Eq. 1 has a coefficient of determination, or R2 = 0.85, which indicates that the estimated and observed volumes of potholes have a strong association. Numerous highway.

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