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Study On Performance Of Flexible Highway Pavements

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Abstract
The evaluation of pavement riding quality entails a comprehensive examination of the functional behaviour of a stretch of road surface. Information on the history of riding quality of the pavement stretch is required for a functional behaviour or performance study. Pavement surface condition is assessed at a certain moment during a condition survey. A Bump Integrator, which defines the total surface condition of the pavement in physical terms, can measure the riding quality of a pavement. The pavement maintenance engineer must examine the functional condition of a pavement surface on a regular basis. Unevenness is normally measured with response type measuring equipment, which is relatively fast and inexpensive. The towed fifth wheel Bump Integrator is one such instrument.
The slope variance or cumulative humps and depressions (mm/km) are commonly used to describe the unevenness recorded by these instruments. The Benkelman Beam is used to assess the deflection of flexible pavement in structural evaluations. The rebound and residual deflections of the pavement structure may be measured. The residual deflection may be attributed to non-recoverable pavement deflection or the action of the deflection bowl on the front legs of the beam, whereas the rebound deflection is linked to pavement performance. Overlay design employs rebound deflection. The objective of the present study is to carry out the various studies to evaluate the performance (in service behavior) of flexible National Highways and State Highway near Bhopal. A detailed pavement condition survey is done on 2 National Highways and 1 State Highway and the road condition is evaluated both functionally and structurally.
Keywords: Functional evaluation, Structural evaluation, pavement performance, road roughness.

1. Introduction

Bituminous pavements all over the world are showing early symptoms of degradation due to increased traffic intensity, high tyre pressure, growing axle loads, and other factors. Paved roads in tropical and subtropical nations deteriorate differently from those in more temperate locations of the world. This is sometimes owing to a lack of suitable pavement materials and building procedures, and occasionally it is due to extreme climatic conditions.
The capacity of a road to handle the demands of traffic and the environment during its design life is known as pavement performance. Deterioration is defined as a decrease in the pavement's performance over time. Many variables contribute to the deterioration of flexible pavements, including traffic, climate, material, building quality, and time. The procedure becomes extremely complicated as a result of the various factors. Performance models may be used to anticipate the state of the road at any given time.
After each monsoon, the country's roads, particularly those in the south, exhibit symptoms of distress, resulting in significant losses in road maintenance as well as poor riding quality, accidents, and a drop in speed. The elements that contribute to road degradation are numerous and vary from location to location. As a result, before deciding on a specific road rehabilitation method, a detailed investigation of the degradation process in various climatic zones and soil conditions is required. The current study was performed in response to the necessity for a complete analysis covering all types of roads in the state with variable traffic and soil conditions.. It is hoped that this study would help to provide the data gap for sustainable road development in the State.
The study's overall goal is to assess the dependability, surface condition, structural failure, and safety of in-service roads in terms of pavement layer strength and subgrade soil parameters, as well as build correlations and models for

prediction. Examine the study stretches for structural and functional issues. In Andhra Pradesh, investigate the condition of pavements under various soil conditions. Develop a relationship between pavement strength, subgrade soil parameters, and pavement condition.. Study the periodic performance of the study roads. Review the models available for predicting the pavement condition. Develop models to predict the performance of flexible pavements and compare the same with models developed using other techniques. Compare the different overlay strategies and select the most feasible option. Develop models to predict the Riding Comfort and Skid Resistance of the pavement to support timely intervention.

Materials and methods

Pavement Evaluation

One of the most important functions of a pavement engineer is the evaluation of inservice pavements. It is necessary for them to know the condition of pavement surface with reference to the riding quality and to fix suitable failure criteria to establish maintenance and priority programs. The evaluation of riding quality of pavement involves a study of the functional behavior of a stretch of road pavement in its entire reach. For a functional behaviour or performance analysis, information is needed on the history of riding quality of the pavement stretch. Until a measure of pavement serviceability was developed after the AASHO road test, little attention was paid to the evaluation of pavement performance and the pavement was either considered satisfactory or unsatisfactory. The idea of relative performance was not adequately developed. There are two general types of pavement condition indices: one type of index (type 1) represents raw data for only one pavement condition parameter (e.g. distress, roughness, deflection, skid resistance, etc.). The other type of index represents a combination of more than one pavement condition parameter. The method consists of combining all or some of the rating so as to constitute a global (or serviceability) index representing the pavement condition. The AASHO Road Test, 1958-61, and researchers associated with it, made an enormous contribution to the technology base of pavement management using pavement evaluation.

Flexible Pavement Riding Quality Concepts

Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle delay costs, fuel consumption and maintenance costs. The World Bank found road roughness to be a primary factor in the analyses and trade-offs involving road quality vs. user cost (UMTRI, 1998). Roughness is also referred to as "smoothness" although both terms refer to the same pavement qualities.

Need for Evaluation of Riding Quality

One of the most important functions of a pavement engineer is the evaluation of inservice pavements. It is necessary for them to know the condition of pavement surface with reference to the riding quality and to fix suitable failure criteria to establish maintenance and priority programs. The evaluation of riding quality of pavement involves a study of the functional behaviour of a stretch of road pavement in its entirety. For a functional behaviour or performance analysis, information is needed on the history of riding quality of the pavement stretch. Until a measure of pavement serviceability was developed after the AASHO road test, little attention was paid to the evaluation of pavement performance and the pavement was either considered satisfactory or unsatisfactory. The idea of relative performance was not adequately developed. In condition survey, pavement surface condition is measured at a given time. The assessment of riding quality is considered to be the most important component of pavement surface condition. This type of survey is not concerned with evaluating the structural strength of pavement and generally no attempt is made to determine the reason for the evenness or any other type of pavement condition. The major objectives of undulations/unevenness measurements of road pavements are as follows:

1. To determine whether the pavement surface is acceptable even from the point of view of riding quality for motor vehicles
2. To measure the unevenness of various stretches of the road system periodically and to maintain the record to decide priority for improvement of road surface conditions or riding quality from the point of view of the road users.
3. To decide the type of pavement surface treatment to improve the riding quality to the desired level.

The responsibility of the highway Engineer is to provide road profile as free as possible from necessary undulations. However, as Millard and Lister have pointed out, unless a cash value is put on riding comfort this leads to an open ended financial commitment. Clearly the cost involved specifically in obtaining a satisfactory surface profile must be limited to a few percent of the cost of laying the pavement.

Unevenness/ Roughness of Flexible Pavements

The riding quality of a pavement can be measured by a Bump Integrator which qualifies in to physical terms, the overall surface condition of the pavement. It is thus a very useful tool in the hands of a maintenance engineer.It is

necessary for the pavement maintenance engineer to evaluate functional condition of a pavement surface from time to time. The functional requirements of a pavement surface from user's point of view are to provide safe, comfortable and fast movement of the vehicles at reasonably low vehicle operation cost. Unevenness is normally measured with response type measuring equipment, which is relatively fast and inexpensive. The towed fifth wheel Bump Integrator is one such instrument. The unevenness measured by these devices is generally expressed in terms of cumulative humps and depressions (mm/km) or slope variance. The work carried out as a part of the Road User Cost Study has revealed that, for every 100 mm/km increase in roughness, the speeds reduces by 1.5 to 2.5 km/hr.
Predicting the trends of unevenness progression over the life cycle of a road pavement is undoubtedly the most critical of the various pavement performance predictions. Since, the vehicle operation cost components for a road on a given alignment depends to a large degree on unevenness, which has been proved in the Kenya study on the cost of operation of vehicles, the optimum timing of maintenance interventions and economic benefits accruing from them depend greatly on the prediction of unevenness progression. The study of pavement unevenness is important from the following aspects.

1. To judge the quality of construction
2. To assess the need for renewal of pavement surfacing • To create a healthy competition in road construction industry to provide better riding comfort
3. To create good public relations as the road users will judge the quality of construction mainly from the riding qualities of a pavement
4. To work out the economic losses in terms of increased road user costs due to poor road surface condition and to convince the legislators about economic justification of maintenance and rehabilitation measures and better types of highway surfacing

In view of the above discussions it is very essential to measure qualitatively the surface unevenness in the following two cases:

[1]. Soon after the construction of each of the new pavement layers, as one of the essential quality control checks before approving the work.
[2]. At suitable intervals to evaluate the surface condition of existing pavement as a routine maintenance management step before the maximum permissible terminal values of undulations are reached.

Experimental process

Selection of Road Stretches

Urban roads

Based on a preliminary assessment with respect to the road conditions and traffic, 44 roads from five corporations, which represent urban conditions, were selected for the study. These road stretches were further divided into 68 homogeneous sections.

Study roads for periodic pavement performance evaluation

The road stretches for conducting the periodic evaluation were identified to represent variation in pavement composition, traffic composition, climatic conditions, terrain and soil characteristics. Eight roads with twelve homogeneous sections were selected as study stretches based on the above factors.

Field Data Collection and Laboratory Investigations

Data collection ranged from simple 'windshield surveys' to the use of testing vehicles that measure deflection, unevenness, skid resistance and cracking on the surface and axle load surveys. The data include:

1. Inventory of the study sections
2. Pavement drainage characteristics
3. Pavement surface condition (cracks, raveling, potholes, rutting, edge break etc.).
4. Unevenness using Bump Integrator (IRC SP 16, 2004).
5. Skid Resistance using portable skid-resistance Pendulum (BS 812-1967).
6. Rebound deflection using Benkelman Beam (IRC 81, 1997).
7. Traffic studies including axle load surveys using Portable Weigh Bridge (TRL Overseas Road Note 40).
8. Pavement composition from trial pits and core cutter method.
9. Texture depth using sand patch method (BS 598 part 105, 1990).
10. Field Density of the sub grade soil using sand replacement method (IS 2720 Part 28, 1974).
11. Laboratory investigation of the sub grade soil properties including CBR.

Data Compilation and Analysis

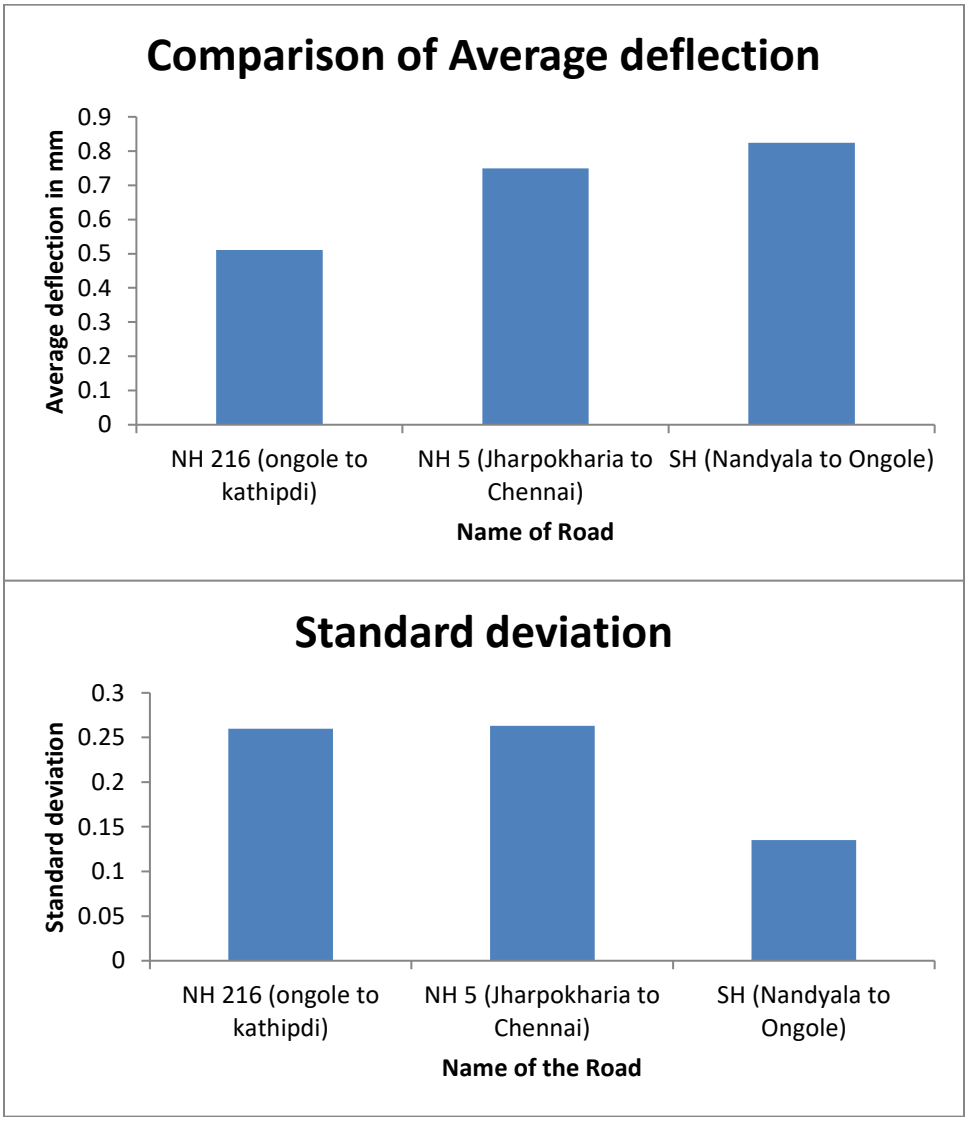
The collected data were compiled to suit to the requirements of the study and analyzed to determine the performance parameters like percentage of distress, rebound deflection in mm, roughness values in cm/km, IRI values and

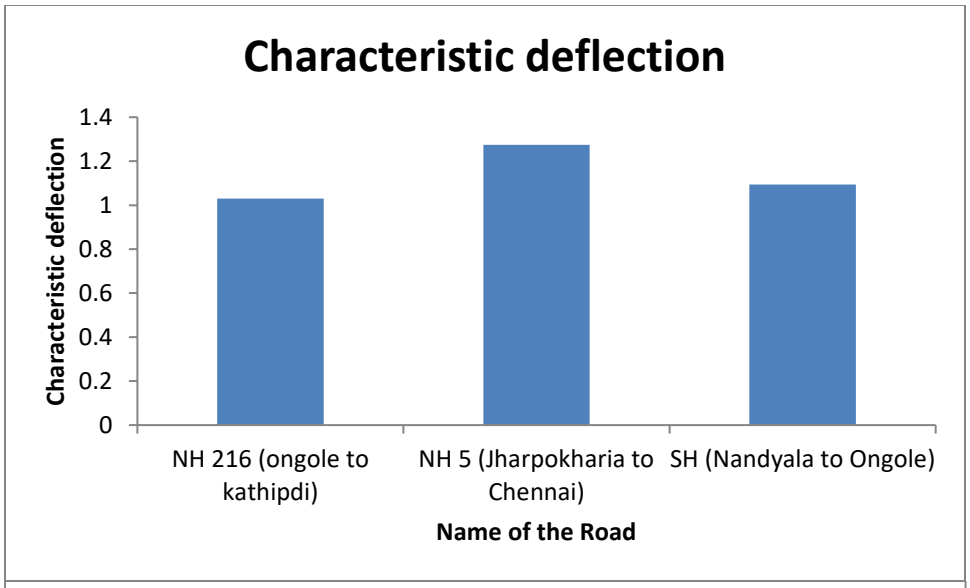
Vehicle Damage Factor (VDF). For analysis in HDM-4 software, the data was prepared under four categories namely pavement condition data, vehicle fleet data, Maintenance and Rehabilitation Works data and cost data.

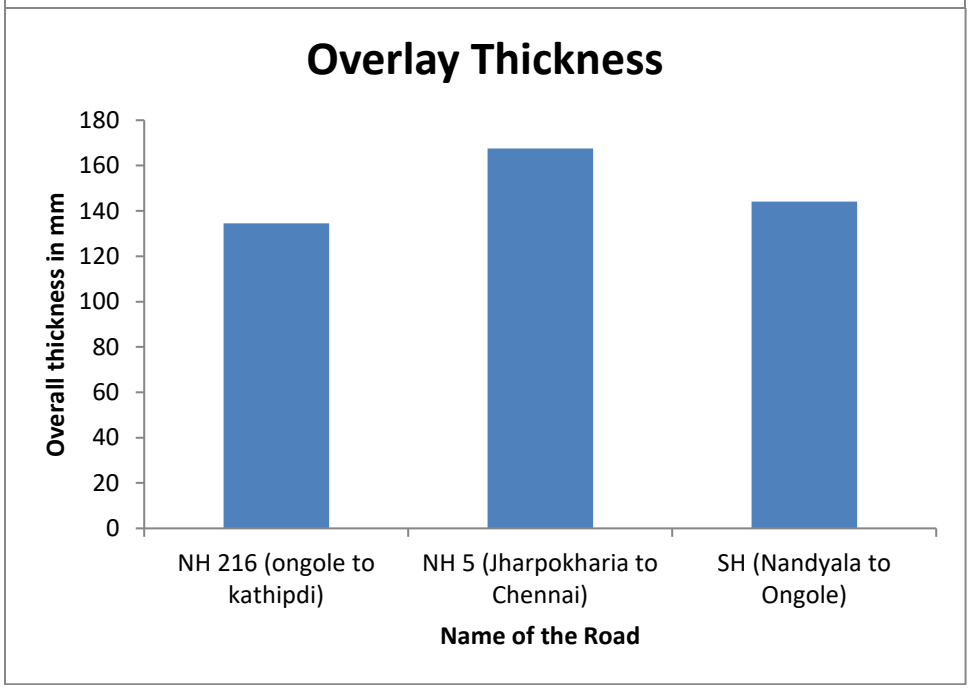
Development of Pavement Performance Models and Relationships

The influencing parameters were identified from the literature. Non-linear regression models using SPSS were developed. Calibration of HDM-4 deterioration models to suit to Indian conditions was done. Fuzzy rule based models were also developed for deflection and compared with other models. The effect of sub grade soil type on the rebound deflection and Modified Structural Number relationship has been checked using appropriate plots. Performance models were developed for cracking, pothole, raveling, roughness and for safety considerations.

Experimental results







Conclusions

1. The Traffic volume study (7 days count) indicate that in case of NH 216, NH 5, and SH the traffic is of very high intensity and also heavy axle load vehicles (rear axle load more than 10.2 t) ply on the roads.
2. The heavy axle loads on the road are leading to its premature failure and distresses like rutting, cracking, localized depressions etc.
3. The drainage system both longitudinal and transverse are inefficient and is not working properly especially for NH 216 and NH 5 leading to failures pertaining to improper drainage system, namely Pot holes, Stripping etc
4. The Benkelman beam study was conducted on all the stretches and structural inadequacy was found in the sections of all the stretches i.e. NH-216, NH5, and SH.
5. There is a need to go for measures such as an overlay on all the five stretches. The overlay thicknesses in terms of BM were found for all the stretches.
6. The Roughness Index Values (RI) were found by Bump Integrator for all the five stretches for each 100 m section and the pavement surface condition was rated as Very Poor, Poor, Average and Good.

7. The present study is based on Pavement Condition Index (PCI) and involves a set of performance variables, such as Pavement Distresses and Pavement Condition Rating.
8. The results of sub grade analysis shows that in stretches where high PI value was observed there is a need for a drainage or blanket layer to enhance the drainage characteristics of the layered system.
9. The methodology and analytical tools presented in this study are based on the extensive field data base from in-service heavily trafficked highway pavements, hence can be adopted as reliable techniques to study the various applications of flexible pavement deterioration models in the maintenance management system for highway pavements in India.
10. The Pavement Performance Study will help in arriving at the most appropriate maintenance and rehabilitation activity or remedial measures, suitable for a particular section of the road.

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