AN ANALYSIS OF A SPECIFIC CASE WITH FLEXIBLE PAVING'S PERFORMANCE

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ABSTRACT

The roadway infrastructure's major components are pavements, and in India, flexible pavements tend to degrade faster than anticipated by the designer. Hence, a pavement performance study is highly necessary to assess their performance. In this thesis, sample data will be used to examine the pavement performance, including the International Roughness Index (IRI), Structural Number (SN), equivalent single axle loads (ESAL), Pavement Condition Index (PCI), and Characteristic deflection from Benkelman Beam test.

The pavement performance study will be conducted in four sections, and the calculation of IRI requires the calibration and validation of merlin equations with respect to auto-level. Only then can the structural number be determined by considering layer coefficients and matching pavement layer thicknesses. The Benkelman Beam test will be used to calculate the rebound deflection of the pavement, and three people's traffic will be calculated to assess the pavement's load-carrying capacity.

Overall, this study will provide valuable insights into the performance of flexible pavements in India and could help improve the design and maintenance of such pavements in the future.

Key words: *Roadway infrastructure, pavements, flexible pavements, pavement performance study, International Roughness Index, Structural Number, equivalent single axle loads, Pavement Condition Index, Benkelman Beam test, sample data, merlin equations, calibration, validation, layer coefficients, pavement layer thicknesses, rebound deflection, load-carrying capacity, India.*

Introduction

Road infrastructure is one of the transport infrastructures that play a prominent role in improving any area accessibility and movement of population as it provides door to door service. The road network in India accounts world's second largest which is widely spread across 30 states of the country. The road network has increased to 4.82 million km (considering all type of roads) from 2 million km that was in 1990s. It is observed that annually billions of rupees are lost to economy due to constraints of road quality and its capacity. Developing countries like India is now facing a challenge of preserving and enhancing transportation system infrastructure, so there is a need of planning and maintenance strategies.

In India mostly there are two types of pavement (i) Flexible pavement and (ii) Rigid pavement. This study limits only to flexible pavements. As, the funding available for pavement periodic maintenance and its management system is limited, there is great need for optimum and efficient maintenance and management of road network. Normally, flexible pavements are designed for 15-20 years but because of increase in traffic intensity, repetition of load, durability of various pavement conditions, unpredictable environmental factors, improper construction practices, lack of good quality materials, high tyre pressure, drainage, increase in axle loads, etc., flexible or bituminous pavements are showing early signs of distresses. This reduces performance of pavements. Hence there is a need to study the performance of flexible pavements.

1. 2 Need for the Study

The roads of the country are showing early signs of distress after each monsoon. This is leading to heavy loss on maintenance and also resulting in poor riding quality, prone to accident, and speed reduction. The factors causing deterioration of roads are so complex to understand and they vary from one place to another. Hence, there is a need to study the different pavement performance indicators like roughness, traffic, deflection, etc. mechanism on a regular basis, and say for six months. In this study, readings are taken only two times at a section.

1. 3 Objectives of the Study

The main objectives of this study are the following:

a) To collect data on the performance of roads including the road inventory data.

b) To conduct traffic volume study and study axle load pattern.

c) To conduct functional and structural evaluation of the pavement sections in respect of sustainability of the concerned pavements.

d) Evaluation of structural number of pavements.

e) To establish relationships of pavement deterioration with traffic growth with due consideration of independent variables/parameters.

1.4 **Scope of the Study**

The scope of works covers the following:

a) Selection of pavement sections under different traffic, different pavement thickness and pavement crust conditions including up gradation ones.

b) Collection of road inventory data of selected pavement sections.

c) Collecting performance data in respect of identified parameters.

d) Analysis of collected data and development of models to predict the performance of road pavements to establish sustainability.

2 Empirical Observations: Data Collection

3.1 Field Data Collection and Laboratory Investigations

Data collection has ranged from visual observations to the use of 8.16 KN axle load truck to measure surface deflection, unevenness by merlin, field density by sand replacement method, distress studies, traffic flow with axle load surveys, and laboratory tests like compaction, CBR, Gradation, etc.

The data include:

i. Inventory of study sections.

ii. Pavement shoulder condition.

iii. Pavement distress studies or surface deflection.

iv. Unevenness of pavement using MERLIN.

v. Characteristic deflection using Benkelman beam as per IRC 81, 1997.

vi. Traffic studies for 3 days.

vii. Pavement layer composition from in-situ trial pits and sample is obtained for further study of its properties.

viii. In-situ density of sub-base and base course by sand replacement method.

ix. Laboratory investigation on sub-grade, sub-base, base properties which mainly include CBR.

2. 1. 1 Inventory Details of Study Sections

i. Four sections were chosen from sites close to Raipur. Length of each section is chosen as 500m. Details of sections are not presented here for publication purposes.

Figure 2: Trial Pit and Sand Replacement Method in Progress

i. **Rainfall data**: Average rainfall data in these sections from previous year studies have rainfall less than 1300mm. This information will be helpful both for surface drainage characteristics and also for finding characteristic deflection.

ii. **Temperature**: Field temperature is calculated using glycerol and thermometer.

iii. Shoulder condition is checked whether it is good or not.

iv. Details of traffic data are not presented here for publication purposes.

3. 2 Roughness Survey

Roughness gives an idea about functional performance of pavement. Roughness is expressed in terms of convenient index that gives comfort to traffic user while accessing roads of any given profile while travelling. Both surface distresses and profile have influence on ride comfort. There are many indices to measure roughness like Bump Integrator value, MERLIN index, Unevenness Index, International Roughness Index. The standard index followed across world for determining roughness is IRI. This IRI can be calibrated for different instruments. (IRC, SP 16).

3. 2. 1 Roughness Measuring Instrument

There are different experimental setups to use roughness. They include Rod and level Survey, Dipstick Profiler, Profilo-graphs, Response type road roughness meters, MERLIN, fifth wheel Bump indicator (Indian practice), Profiling devices, etc. (Internet Source)

Here, in this study roughness is measured by both merlin and auto-level (rod and level survey).

3. 2. 2 The Merlin

It is an instrument that is developed to measure longitudinal road profile. The readings are taken graphically. With less estimation in error, merlin roughness index can be converted into IRI. It is widely used because of its simplicity, easy to work and handle. It is not suitable for calculating roughness at long stretches as it is slow and manually done.

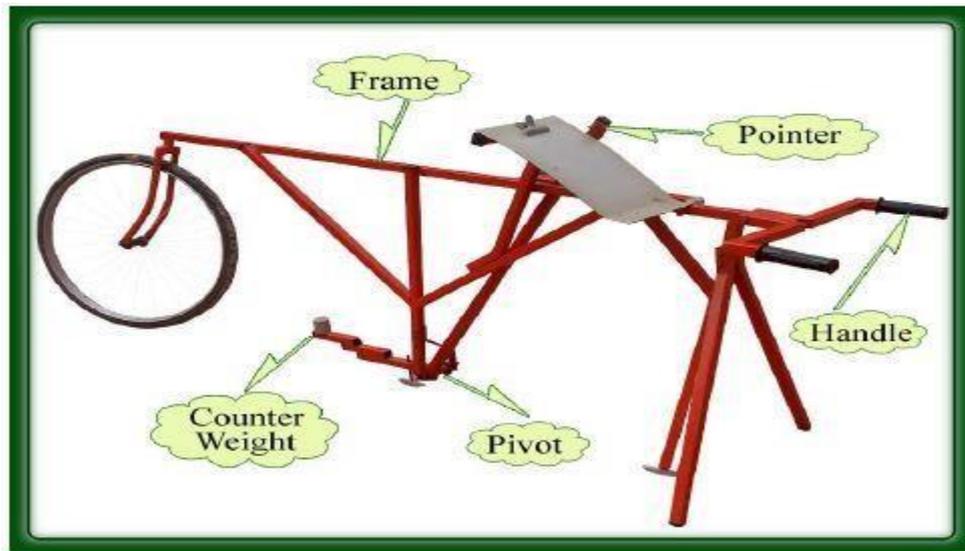The device is called MERLIN-Machine for Evaluating Roughness using Low-cost instrumentation. (TRL Report 229, 1996)

Figure 3: The MERLIN (Kumar et al. 2008)

Merlin consists of front and rear legs where it can rest on pavement surface along with probe at half the midway. The device is 1.8m separated. With reference to imaginary line between front and rear foot, the position of probe which can be above or below the line and this gives mid-chord deviation. The probe goes up or down relative to the imaginary line joining front and rear foot. The probe moves because of counter weight located at same side and at the end of probe there is a hinge where it connects with moving arm. A moving arm has a pointer thatis attached to chart. For each position, we have to mark a cross in chart provides where the arm points. The pointer movement depends on mid chord deviation exhibited by probe. (TRL Report 229, 1996)

Figure 4: MERLIN Readings at Site

3. 2. 3 Method of Use

Initially, before starting the experiment all the front feet, rear feet and probe islevelled to same level. The level of probe is adjusted using turn screw. Place Merlin chart at plank available at top and mark the mid position of chart. Now the pointer of moving arm should point the midpoint of chart. As, the circumference of front wheel is 2.25 m so readings are taken at every multiple intervals of 2. 25 m. in total, 200 readings are to be taken so as to cover 450m. At each point, the position of pointer with a cross in a suitable section is carried out by administrator. For further system of estimations, the merlin's handle is rolled forward and heading towards and rehashed. To have a note on number of cross done till yet, there is a tally box provided at extreme left corner. The chart is removed after 200 observations. The distribution of marks or cross on chart gives roughness on road. Depending on movement of pints, the graph is scattered. We now consider 90% of the points in the chart that means eliminating 5% points on both top and bottom side.

3.Analysis of Data, Results And Discussions

3. 1 Merlin

By the use of MERLIN, an attempt was made to determine IRI at four sections (1A, 2A, 3A, 4A) which were stated above. It is calculated for both left and wheel paths.

The MERLIN Roughness Index is as follows:

Clearly, most of the values are having MERLIN Roughness Index (D) < 42. Merlin calibration equations are valid only for D >42.

In order to find correlation between D and IRI by auto-level, some sections are chosen at NIT Raipur. Some sections are found to have D>42 and some D<42.

Details of auto level and merlin data for IRI are not presented here for publication purposes.

4. 2 Benkelman Beam Results

By use of Benkelman-beam, characteristic deflection is obtained for all sections that are chosen.

For calculating characteristic deflection, plastic and liquid limit of soil is required. Plastic and liquid limit of soil sub-grade is as follows:

4. 3 Traffic Data Calculation

As present data of traffic is available (shown above), we can estimate number of equivalent standard axle loads the pavement has experienced till yet. Assumption is done on traffic growth rate. It is taken as 7. 5%. One of the readings how ESAL is estimated is given below. A per IRC 37, 2012 for the pavement which experiences commercial vehicles between (500-1500, vehicle damage factor is taken as 3.5 provided the section is plain.

4. 4 Structural Number

Layer coefficients of pavement courses are obtained by Soaked CBR values as per AASHTO that is discussed above. Surface and binder course are assumed to have layer coefficient of 0.39.

4. 5 Pavement Condition Index

For calculating pavement condition Index, we should first calculate the amount and type of severity present in each type of distress. PCI values are shown below. The severities like low, medium and high should be calculated on percentage of pavement section.

4.6 Pavement Performance Modelling

Factors considered in pavement performance modelling are structural number, traffic in ESAL (in msa), IRI and characteristic deflection obtained from Benkelman-beam test. Linear and non-linear regression analysis is done on observed values. Here, in our study the reliability of regression model is measured by its goodness of fit, which is represented in terms of coefficient of correlation (R^2 value).

SUMMARY AND CONCLUSIONS

Based on the study conducted on four sections of flexible pavements close to Raipur, it can be concluded that the pavement performance of these sections is satisfactory even after 3-5 years of construction. The study included the measurement of various parameters such as International Roughness Index, Benkelman beam deflection, and pavement distress study to assess the performance of the pavement.

The MERLIN equations were calibrated and validated for D>42 and D<42. The comparison of IRI values obtained by auto level and MERLIN showed that auto level had a small error, indicating the accuracy of the measurement method. The IRI values at all sections were low, which is a good sign of functional pavement performance.

Furthermore, modelling was conducted on pavement performance indicators such as IRI and characteristic deflection, and the coefficient of correlation (R2 value) was found to be within permissible limits. This suggests that the models are reliable in predicting pavement performance.

Overall, the study suggests that the flexible pavements in the selected sections near Raipur are performing well and meeting the functional requirements even after a few years of construction. The results of the study can be useful for the design and maintenance of flexible pavements in similar conditions.

5.1 Future Scope

     i.   A good number of experiments can be conducted to calculate IRI by both auto level and MERLIN and can be compared.

     ii.   Pavement Condition should be monitored every six months so as to understand factors effecting pavement performance.

     iii.   Crack initiation and propagation models can be developed after having pavement distress data which is taken every six months.

     iv.   A number of sections with different material properties should be considered for predicting Pavement performance.

REFERENCES:

1. AASHTO (1993), 'AASHTO Guide for design of pavement structures', American Association of State Highway & Transportation Officials, Washington, D C.

2. Aggarwal S, Jain S S and Parida M (2002), 'A critical Appraisal of pavement management system', Journal of the Indian Roads Congress, Volume 63-2, 327 –403.

3. Cundill, M.A. (1996). "The Merlin Road Roughness Machine: User Guide", Research Report 229, Transport Research Laboratory (TRL), Berkshire, United Kingdom.

4. E. Spangler and W. Kelly, "GMR Road Profilometer - A Method for Measuring Road Profile." Highway Research Record 121, Highway Research Board, 1966.

5. Bose S, Sridhar R, Kamaraj C, Sharma G and Kumar G (2005), 'Investigation of moisture damage to bituminous pavement and effect on field performance – case studies', Journal of Indian Road Congress, 66 (3), Paper No. 517, 438 – 449.

6. Gedafa D S (2007), 'Performance prediction and maintenance of flexible pavement', Proc.Mid-continent transportation research symposium, Ames, Iowa

7. Gedafa D S, Hossain M and Miller R (2010), 'Estimation of remaining service life offlexible pavements from surface deflections', Journal of Transportation Engineering,@ASCE, 342 - 352.

8. Gupta A, Kumar P and Rastogi R (2011), 'Pavement deterioration and maintenance model for low volume roads', International Journal of Pavement Research and Technology, Volume 4, 195-202.

9. ASTM D 6433 (2007) 'Standard Practice for Roads and Parking Lots Pavement ConditionIndex'.

10. IRC 81 (1997), 'Guidelines for strengthening of Flexible pavements using Benkelman Beam Deflection Technique', Indian Roads Congress.

11. IS 2720 part 16 (1987), 'Indian Standard methods of test for soil', Laboratory determination of California Bearing Ratio.

12. IS 2720 part 8 (1987), 'Indian Standard methods of test for soil', Determination of water content-dry density relation using heavy compaction.

13. IRC 37 (2011), 'Guidelines for the design of Flexible pavements', Indian Roads Congress'.

14. MORT&H (2004), 'Guidelines for maintenance management of primary, secondary andurban roads', Indian Roads Congress.

15. B.C.Punmia (2012), 'Principles of Surveying'.

16. Nagakumar and Veeraragavan A (2000), 'Effect of climatic and traffic factors on flexible pavement response, an overview,' Journal of Indian Roads Congress, 112-141.

17. Long Term Pavement Management, Informational Management Systems Database, Federal Highway Administration

18. Salt G and Stevens D (2004), 'Pavement Performance Prediction- Determination and Calibration of Structural Capacity (SNP)', Report.

19. Turki I, Obedat S and Homoud A S (1996), Development of Models of Pavement Characteristics on Pavement Condition', Journal of Indian Roads Congress, Volume57-1, 201-219.140. Udayakumar L,

Robert.

20. Al-Omari and M.I. Darter. Effects of Pavement Deterioration Types on IRI and Rehabilitation. In Transportation Research Record 1505, TRB, National Research Council, Washington, D.C., 1995, pp. 5'7-65.

21. Chakraborty P and Das A (2003), Principles of Transportation Engineering, Prentice Hall, India.

22. Colin A, Franco P E (2007), 'Pavement Preservation utilizing crumb rubber asphalt', Journal of the Indian Roads Congress, Volume 68-2, 163- 174.

23. Collopl A C and Cebon D (1995), 'Parametric study of factors affecting flexible pavement performance, 'Journal of Transportation Engineering', 121, 485 – 494.

24. Crovette J A (2005), 'Development of Rational Overlay Design procedures for flexible pavements', Wisconsin Highway Research Programme, SDR #0092-00-05, Report.

25. Bose S, Sridhar R, Kamaraj C, Sharma G and Kumar G (2005), 'Investigation of moisture damage to bituminous pavement and effect on field performance – case studies', Journal of Indian Road Congress, 66 (3), Paper No. 517, 438 – 449.