

A Review on Performance Evaluation of Flexible Pavement

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Abstract – Evaluation of existing flexible pavement condition is a requirement to choose improvement technique that has to be implemented to improve its quality. Non-destructive testing methods are desirable to evaluate existing flexible pavement. The performance evaluation of flexible pavements are functional evaluation and structural evaluation. Structural properties of pavement is deflection. Structural evaluation of pavement is carried out by Benkelman Beam Deflection technique. Functional properties of pavement are roughness, rutting, crack, patch, potholes and raveling. This paper present a review on structural and functional evaluation of flexible pavement and relationship between the roughness and other surface distress.

Keywords – Benkelman Beam, Deflection, Functional Evaluation, Flexible pavement, Structural evaluation

I. INTRODUCTION

Road transport is the primary mode of transport in India, because of advantages like door to door service easy availability and flexibility to rural habitations. It is necessary to provide a good road network for the development of any country. India has the second largest road network system in the world. Road network in India has expanded from 0.4 million km in 1951 to about 5.47 million kilometers presently, a sevenfold increase, but traffic has increased 120 times. Rapid urban and industrialization growth has increased traffic and excessive usage of the roads. The performance evaluation of any flexible pavement are analyzed through structural evaluation and functional evaluation. Nondestructive testing methods can evaluate structural or functional condition. The performance evaluation of pavement can cover many aspects including assessment of traffic safety on road, evaluation of road surface condition, structural adequacy of pavement and rideability of pavement surface. Thus, the following characteristics are generally used to performance evaluation of pavement.

- Skid resistance
- Surface distress of pavement
- Rideability of pavement surface
- Pavement deflection

A. Structural Evaluation of Pavement

Deflection is the structural properties of pavement. Pavement deflection evaluation is an important study, because shape and magnitude of deflection is a function of structural condition, temperature, moisture condition and traffic type and volume affecting pavement structure. Benkelman Beam is used to evaluate the structural properties of pavement as per IRC: 81 – 1997. Benkelman Beam is shown in Figure 1. This method has been most widely used in India.



Figure 1. Benkelman Beam

B. Functional Evaluation of Pavement

Pavement condition survey and Roughness survey is carried out to evaluate functional properties of pavement. Pavement roughness is defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle. Roughness is an important pavement characteristic because it not only affects ride quality but also affects fuel consumption, vehicle delay costs and maintenance costs. The 5th wheel Bump Integrator is used to evaluate roughness of flexible pavement. 5th wheel Bump Integrator is shown in figure 2. Bump Integrator value is obtained in mm/km. This obtained value is converted in IRI (International Roughness Index) using following equation:

$$UI = 630 \times IRI^{1.12}$$

Where, UI is unevenness index in mm/km



Figure 2. 5th wheel Bump Integrator

In pavement condition survey, pavement surface condition is measured and different types of the distresses are observed like crack, potholes, patch, raveling and rutting.

II. LITERATURE REVIEW

Dhaval V. Lad et al. (2015)^[1] have conducted visual observation like rutting, potholes, cracks and patch work. They carried out Benkelman Beam test, traffic survey and collecting soil sample at waghodiya crossing to limda. They were calculate the overlay thickness of pavement. They were identified the Benkelman Beam deflection and visual observation correlates each other as per IRC: 81-1997.

G. Bhatt Mayank et al. (2013)^[2] have conducted visual observation for potholes, raveling, stripping and cracks. They were conducted Benkelman Beam test and structural inadequacy were found at selected section of SH – 188 sarsa to vasad junction. They were found overlay thickness in terms of bituminous macadam for selected stretches and it ranges from 110 to 210 mm. They identified Benkelman Beam deflection and visual observation correlates each other. Table – 1 shows the result of overlay thickness provided per km.

Table 1. Overlay thickness provided per km

Chainage (km)	Characteristic Deflection	Bituminous Macadam (mm)
0-1	2.27	200
1-2	0.72	120
2-3	2.66	210
3-4	1.43	160
4-5	0.92	140
5-6	2.62	210
6-7	2.45	200
7-8	1.21	110
8-9	1.30	130

Nabeel Yousuf et al. (2015)^[3] have analyzed strengthening of flexible pavement by Benkelman Beam Deflection technique. The recommended minimum bituminous overlay thickness from structural consideration was 50 mm

bituminous macadam with an additional surfacing course of 40 mm bituminous concrete or 50 mm DBM. The researcher said out of all deflection method the Benkelman Beam Deflection was most simple and reliable method.

D. R. Jundhare et al. (2012)^[4] have evaluated of ultrathin white topping by Benkelman Beam Deflection (BBD) test as per IRC: 81-1997 guidelines. The deflection values obtained after two year in this study was 0.461 mm, 0.415 mm and 0.265 mm at the edge, corner and interior respectively. Researchers compared results of BBD test from this study with the deflection values obtained by three dimensional FE model (Jundhare D. R. et al., 2012) and LTE values obtained by Cable, J. K. et al. (2006) as well as KENSLAB computer program, these values shown good agreement. Therefore they concluded that BBD test can be a useful, reliable and alternative tool to FWD for the study the performance evaluation of UTW overlay.

Dr. Umesh Sharma (2014)^[5] has evaluated one deteriorated road of Chandigarh city by Benkelman Beam Deflection technique. Based on pavement condition, it was recommended to provide overlay thickness on existing road. It has concluded that there was heavy traffic on the selected study area more than the capacity of this road. The recommended total overlay thickness was 110 mm with 70 mm bituminous macadam and 40 mm bituminous concrete in layers.

Umersalam et al. (2015)^[6] have collected required filled data like existing pavement structure, soil subgrade data, pavement surface condition, traffic data and rebound deflection by using Benkelman Beam Deflection (BBD) technique. They were evaluated total existing pavement thickness for site 1 and site 2 and compared them with new overall pavement thickness and it was evident that site 1 fall short by 360 mm and site 2 fall short by 320 mm. The required overlay thickness for site 1 and site 2 was 95 mm and 60 mm respectively to strengthening them.

Rokade S. et al. (2010)^[7] have conducted benkelman beam study on five stretches and structural adequacy were found. They were found roughness index value by bump integrator. They were found overlay thickness in terms of bituminous macadam for all stretches as shown in table 2.

Table 2. The Results of Benkelman Beam Study

Sr. No.	Name of the Road	Overlay thickness in terms of BM (mm)
1	NH 3	134.55
2	NH 12	167.53
3	NH 69	134.55
4	NH 86	164.85
5	SH 23	144.16

Saranya Ullas et al. (2013)^[8] were identified the different parameters affected pavement performance. It includes vehicle damage factor and modified structural number. They were developed performance prediction model using SPSS package. They were identified the observed values nearer to SPSS predicted values. By using T-test, reliability of roughness model was checked.

J. Rajendra Prasad et al. (2013)^[9] have developed a relationship between surface distress and roughness of PMGSY roads. They were selected eight PMGSY roads in Rajasthan. They were collected roughness data using Bump Integrator and calibrated by MERLIN (Machine for Evaluating Roughness using Low Cost Instrumentation). They developed regression equation between visual surface distress and IRI value based on the collected data of selected stretches.

Amarendra Kumar Sandra et al. (2012)^[10] developed relationship between pavement distress and roughness value of 39.5 km length of road such as Major District Road, State Highways and National Highways in India. The distresses such as cracking, patching, raveling, rutting and potholes were observed and roughness data was collected using fifth wheel BI (Bump Integrator).

Kyungwon Park et al. (2007)^[11] have established the relationship between roughness of asphalt pavement and surface distress. They were calibrate power regression model between IRI and PCI for different pavement stretches in the North Atlantic region. The resulted in 41% variation in Pavement Condition Index remains unaccounted by International Roughness Index.

Shabana Thabassum (2014)^[12] has developed correlation between Unevenness Index and Deflection values for flexible pavement. The existing pavement was evaluated by non-destructive testing. It was found that observed UI values

and model value have 90% similar. Therefore, anyone parameter known of deflection or unevenness, other parameter calculated using this model.

Manish Pal et al. (2014) ^[13] have conducted survey of Bump Integrator at a different speed. They developed generalized equation for standard speed of Bump Integrator using SPSS software. So they can convert BI values standard speed from different speed. They observed that roughness values decreases with increased in operating speed of Bump Integrator.

Lin et al. (2003) ^[14] have developed correlation analysis between pavement distresses and international roughness index by neural network. In this study, the coefficient between pavement distresses and IRI reaches 0.944. It shows that International Roughness Index may totally reflect on pavement distress conditions. Thus, IRI was used as a pavement performance index.

Muhammad Mubarak (2013) ^[15] has developed pavement roughness and pavement condition model for Saudi highways. The pavement condition rating was calculated based on rutting, raveling, cracking and International Roughness Index. They find the R^2 value 83.9% and 95% for Pavement Condition Rating and International Roughness Index by regression model.

O. S. Abiola et al. (2014) ^[16] have predicted visual survey scores in terms of pavement condition score from roughness value. They were collected data on traffic characteristics, International Roughness Index (IRI) and pavement roughness types for four consecutive years. In this result, IRI was a good substitute for visual score. About 78.8% observed data was recognized by the relationship between two indices.

III. CONCLUSION

This paper presented literature review on performance evaluation of flexible pavement. Most papers in this context are focused on structural evaluation of pavement by Benkelman Beam Deflection technique, evaluate pavement roughness and distress by Bump Integrator and visual observation at particular sections of the roads. Visual observation considers crack, patch, potholes, rutting and raveling. Roughness and visual distresses correlates each other. Regression model were developed between roughness and visual distress by using SPSS software.

IV. REFERENCES

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