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MEASUREMENT OF RUTTING CRACKS ON FLEXIBLE PAVEMENT BY BENKELMAN BEAM

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ABSTRACT:

This paper explores the pivotal role of pavement deflection assessment in evaluating flexible pavement performance, with a particular importance on the enduring utilization of the Benkelman Beam Deflection (BBD) technique despite its associated costs and time demands. It introduces an innovative methodology employing Multivariate Regression Analysis to predict pavement deflection characteristics based on pavement layer thicknesses and sub-grade soil California Bearing Ratio, utilizing field data collected by various agencies to develop the model. Additionally, the paper highlights the significance of complete pavement condition surveys, about evaluations of riding quality, distress types, and sub-grade soil characteristics through soil sampling. The structural evaluation of flexible pavements, focusing on rebound and residual deflections measured by the Benkelman Beam, is discussed in the context of pavement performance and overlay design. The study's practical application is demonstrated through the evaluation of overlay thickness for State Highway 126 from Warananagar Junction to Nave paragon Junction. While traditional road bearing capacity measurements depend on the Benkelman beam, which provides maximum vertical deflection under a 50 KN wheel load, modern methods such as falling weight reflectometers offer full deflection basin measurements, even though at a higher cost. The paper introduces a cost- effective approach developed by the Department of Forest Opening Up, utilizing the Benkelman beam to measure the full deflection basin, thereby enhancing efficiency in assessing forest road bearing capacity. Furthermore, the paper discusses the challenges associated with defining pavement bearing capacity and highlights stiffness as an objectively measurable parameter correlated with deformation under given weight. Strengthening pavements through overlays is identified as a critical maintenance measure to ensure effective performance under dynamic and static loads over the design period, underscoring the importance of road maintenance in reflecting a nation's prosperity. Despite various alternative methods for designing overlays, the BBD technique stands out for its ease of use and convenience.

Introduction:

Transportation infrastructure, particularly roads, plays a pivotal role in a country's economic development. Pavements, being fundamental to this infrastructure, facilitate transportation and economic activities while enhancing living standards. However, all civil structures have a finite lifespan, necessitating maintenance and rehabilitation to extend their longevity. Maintenance activities, ranging from surface defect corrections to structural enhancements, are crucial for ensuring road performance and efficiency. Pavement evaluation is essential for both repairing existing roads and ensuring the quality of new ones. This thesis focuses on the structural evaluation of existing flexible pavements using the Benkelman beam method to determine pavement deflection. Subsequently, overlay thickness is calculated as per IS standards. Strengthening pavements through overlays aims to enhance performance under dynamic and static loads over a specified design period. Effective road management requires timely maintenance and rehabilitation to protect initial investments in transportation infrastructure.

Pavement rehabilitation activities, while less conspicuous than construction, are vital for preserving infrastructure and minimizing economic losses. Improved rehabilitation designs are essential to meet modern traffic needs and ensure longer-lasting, cost-effective pavement. Emphasizing maintenance and rehabilitation actions is critical for strengthening pavements, providing a smooth riding quality, reducing accidents, and ensuring safe and efficient traffic movement.

Objectives

1. To evaluate the surface condition of existing pavement.
2. To study the traffic volume for a selected stretch.
3. To measure the deflection of pavement by using Benkelman beam method.
4. To analyze the causes of pavement deterioration.

LITERATURE REVIEW

Evaluation and Strengthening of Reconstructed Roads Excavated for Utilities Using Benkelman Beam Deflection (BBD) Technique (A Case Study) By- Umersalam, Alsana Bashir, Dr. Mohammad Shafi Mir, Tanzeel

This study addresses the necessity of pavement evaluation and measures in urban areas of Kashmir, where frequent cutting and refilling for utilities disrupt road pavements. It includes field data collection, laboratory investigations, and overlay design based on rebound deflection, culminating in conclusions and recommendations for improving road design and performance.

Evaluation of Rigid Pavements by Deflection Approach By -Akshay Gadiya, Sagar Bhor, Parimal Parchure, Ankkit Bafna

This paper explores the utility of the Benkelman Beam Deflection (BBD) Test in evaluating load transfer efficiency (LTE) of dowel bars in newly constructed rigid pavements. By measuring deflections on loaded and unloaded slabs across dowel bars using BBD technique, the study aims to assess the overall performance and effectiveness of the pavement

NonLinear Multivariate Regression Analysis for the Prediction of Characteristic Deflection of Flexible Pavements By- Suneet Kaur, Dr.V.S.Ubbobeja, Dr. Alka Agrater

This paper discusses the significance of pavement deflection in assessing flexible pavement performance, highlighting the continued use of the Benkelman Beam Deflection (BBD) technique despite its drawbacks. It introduces a model based on Multivariate Regression Analysis to predict pavement deflection based on pavement layer thicknesses and sub-grade soil characteristics, utilizing field data from highway development and strengthening projects in Madhya Pradesh.

Pavement Evaluation by Benkelman Beam of State Highway Section (Waghodiya Crossing to Limda) By- A.A.Patel

The nondestructive structural evaluation of pavements, utilizing methods like the Benkelman Beam, is crucial for managing the deteriorating condition of highways and other exposed structures. This study focuses on State Highway 158 from Waghodiya crossing to Limda, conducting detailed pavement condition surveys and structural evaluations to determine the appropriate overlay thickness needed for maintenance and strengthening measures.

Structural evaluation using Benkelman beam deflection technique and rehabilitation of flexible pavement for state highway 188 (Sarsa junction to vasad junction) By- G.Bhatt Mayank

To conduct a thorough performance analysis, data on the historical riding quality, pavement surface condition, distress types, and subgrade soil evaluation are essential. The structural evaluation of flexible pavements on State Highway 188 from Sarsa Junction to Vasad Junction includes measuring pavement deflection using the Benkelman Beam, particularly focusing on rebound deflection for overlay design, to determine the appropriate overlay thickness needed for maintenance and strengthening measures.

PAVEMENT DISTRESSES AND ROUGHNESS MODELING - A CASE STUDY by- Saranya

Ullas, Sreelatha T, B.G Sreedevi

Pavement deterioration is a multifaceted process influenced by structural fatigue, functional distresses, traffic, climate, materials, and time. This study identifies main distresses on selected road stretches and develops regression models using SPSS to approximate expected conditions, recognizing the complexity of the deterioration process and the importance of performance models in predicting pavement performance.

REPORT ON PAVEMENT DESIGN FOR THE SECTION OF ROAD FROM TRANSPORT ROAD TO DIAMOND POINT ROAD

The planned widening of the road section from Transport Road to Diamond Point involves a pavement design based on current carriageway conditions and soil investigations by the Centre for Transportation Engineering, JNTU. The evaluation of the existing road structure using the Benkelman Beam Deflection technique guides overlay recommendations as per IRC 81:1997, while the widening segment follows IRC 37:2001 standards, with each portion undergoing separate BBD surveys for customized overlay design.

ROAD RATHODE BESKELMAN BEAM PAVEMENT DEFLECTIONS By -Gary W.

Sharpe, Herbert F. Southgate

In Kentucky, pavement evaluation methods utilize both Road Rater deflection measurements and Benkelman beam tests, although each method operates differently. The Road Rater employs dynamic loading with vibrating impulses, while the Benkelman beam relies on a lever-arm principle, leading to differences in sensitivity between the two methods.

METHODOLOGY

The methodology of the project work is classified into two measure steps. the first one is the traffic data collection and the other one is the data analysis and design. the overall methodology involves:

1) The survey for the classification of pavement as good, fair or poor depending upon rut depth measurements.
2) Traffic survey.
3) Actual measurements of deflections using Benkelman beam.
4) The calculation and the application of correction factors for temperature variation.
5) Evaluation of pavement and conclusion.

CLASSIFICATION OF PAVEMENT

The preliminary phase of operation involves visual inspections and rudimentary measurements, such as rut-depth assessments using a 3 m straight edge, to classify road lengths into sections of uniform performance. These observations and measurements serve as the basis for categorizing the road into segments with consistent characteristics, following criteria outlined in a designated table

Classification	**Pavement condition**
Good	**No cracking, rutting less than 10 mm**
Fair	**No cracking or cracking confined to single crack in the wheel track with rutting between 10 mm and 20 mm**
Poor	**Extensive cracking and/or rutting greater than 20 mm. Sections with cracking exceeding 20 percent shall be treated as failed.**

From Warana to Amrutnagar, the road stretch is classified as 'fair'.
From Amrutnagar to New Pargaon, the road stretch is classified as 'poor'.

TRAFFIC SURVEY

- Design of overlay considers traffic in terms of million standard axle (MSA).
- If data on wheel load distribution or vehicle damage factors are available, cumulative standard axles can be calculated based on actual data. Otherwise, design traffic is calculated using procedures outlined in IRC: 37.

- Only commercial vehicles with a laden weight of 3 tonnes or more and their axle loading are considered for design purposes.
- Traffic from both directions is considered for two-lane roads, while for multilane divided highways, traffic is considered in the direction of heavier traffic.
- To estimate design traffic, factors such as existing traffic, potential changes in road network and land use, traffic growth, and design life are taken into account.
- Initial daily average traffic flow estimation is typically based on 7-day 24-hour classified traffic counts. In exceptional cases where this data is unavailable, a 3-day count can be used.

$$Ns = \frac{365 \text{ X A} \{ (1+\text{r})^{x} - 1 \}}{\text{r}} \text{X F}$$

Where,

Ns = The cumulative number of standard axles to be catered for in the design

A = Initial traffic, in the year of completion of construction, in terms of the number of commercial vehicles per day
r = Annual growth rate of commercial vehicles

F = Vehicle damage factor (number of standard axles per commercial vehicle)

P.C.U. Conversion & Number of commercial vehicles per day & Cumulative number of standard axles in terms of MSA

Type of vehicle		**Truck**	**Four- wheeler/three-wheeler**	**Bus**	**Total**	**Ns (msa)**
Day-1	**Up**	**204X3 = 612**	**1712X1 = 1712**	**44X3 = 132**	**2456**	**57.07**
	Down	**155X3 = 465**	**1552X1 = 1552**	**45X3 = 135**	**2152**	**50.00**
Day-2	**Up**	**220X3 = 660**	**1750X1 = 1750**	**46X3 = 138**	**2548**	**59.21**
	Down	**165X3 = 495**	**1573X1 = 1573**	**48X3 = 144**	**2212**	**51.33**
Day-3	**Up**	**242X3 = 726**	**1802X1 = 1802**	**50X3 = 150**	**2778**	**64.55**
	Down	**173X3 = 519**	**1582X1 = 1582**	**54X3 = 162**	**2263**	**52.58**
Day-4	**Up**	**223X3 = 669**	**1762X1 = 1762**	**46X3 = 138**	**2569**	**59.69**
	Down	**158X3 = 474**	**1560X1 = 1560**	**52X3 = 136**	**2190**	**50.88**
Day-5	**Up**	**245X3 = 735**	**1784X1 = 1784**	**55X3 = 165**	**2684**	**62.37**
	Down	**182X3 = 546**	**1593X1 = 1593**	**59X3 = 167**	**2316**	**53.82**
Day-6	**Up**	**263X3 = 789**	**1815X1 = 1813**	**58X3 = 174**	**2778**	**64.55**
	Down	**188X3 = 564**	**1601X1 = 1601**	**49X3 = 147**	**2312**	**53.72**
Day-7	**Up**	**255X3 = 765**	**1826X1 = 1826**	**52X3 = 156**	**2747**	**63.83**
	Down	**179X3 = 537**	**1619X1 = 1619**	**45X3 = 135**	**2291**	**53.24**

Traffic Survey

Actual Deflection

XT= 2[Dfinal – Dinitial + 2.91[2 X Diff between Dfinal and Dintermidiate]

Chainage	Side	Dial gauge reading			Actua l deflec tion	Rebo und deflec tion	Pave ment tempe rature	Temp eratu re corre ction value	Mean deflec tion	Standa rd deviati on	Charact eristics deflectio n
		Di	Dinter	Df							
0	Left	0.36	0.61	0.01	-4.192	-8.38	31^0 C	0.01	-0.256	0.31	0.37
	Right	2.29	2.32	2.38	0.52	1.04					
50	Left	0.13	0.15	0.23	0.66	1.32					
	Right	2.03	2.03	2.03	0	0					
100	Left	0.85	0.86	1.2	2.67	5.34					
	Right	1.65	1.59	1.52	-0.66	-1.32					
150	Left	0.13	0.25	0.67	3.52	7.04					
	Right	1.23	1.29	1.37	0.74	1.48					
200	Left	1.25	2.66	0	-12	-24					
	Right	0.96	1.08	1.03	-0.73	-1.46					
250	Left	0.45	0.49	0.52	0.81	1.62					
	Right	0.54	0.96	0.9	0.37	0.74					
300	Left	0.26	0.31	0.48	1.42	2.84					
	Right	1.31	1.31	1.1	-1.64	-3.28					
350	Left	0.4	1.07	1.54	5.01	10.02					
	Right	1.48	2.45	2.48	2.17	4.34					
400	Left	0.01	0.25	0.32	1.02	2.04					
	Right	0.36	0.37	0.53	1.27	2.54					
450	Left	0.35	0.35	0.01	-2.65	-5.3					
	Right	2.35	2.36	2.41	0.41	0.82					
500	Left	0.02	0.03	0.01	-0.13	-0.26	31^0 C	0.01	2.286	2.286	6.86
	Right	0.11	0.11	0.02	-0.7	-1.4					

Insert Instrument Between Dual Wheels of Truck

Actual Reading On Dial Gauge

Conclusion:

Based on the evaluation conducted according to IRC guidelines, the following conclusions were drawn:

1) Pavement Condition: Rutting exceeding 20 mm indicates poor surface condition.
2) Traffic Volume: High cumulative number of standard axles suggests heavy traffic.
3) Overlay Thickness Requirement: Pavement deflection survey indicates a need for a minimum overlay thickness of 300 mm to strengthen the existing pavement.
4) Drainage Issues: Lack of proper drainage system results in water accumulation on the road surface, exacerbated by water from surrounding areas.

The evaluated sites exhibit poor pavement condition, heavy traffic volume, a need for substantial pavement overlay, and drainage deficiencies contributing to waterlogging issues during rainy periods. Addressing these concerns will be crucial for improving the overall quality and functionality of the roads.

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