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Assessment of Pavement Deflection for Rural Roads near Nagpur(Maharashtra)

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Abstract - In the present study, standard procedure has been followed to conduct the Benkelman Beam Deflections which represents the structural behaviour of the pavement. In order to implement corrections in the Benkelman Beam Deflection values, the data pertaining to pavement temperature, type of subgrade soil, plasticity index of soil, moisture content of subgrade soil and annual rainfall data has also been collected in the present study.Twelve rural roads stretches in the vicinity of Nagpur region of Maharashtra, India each of 2.5 km length and average width of 3 metre has been selected for collecting pavement structural data

Index Terms – Pavement structural, Benkelman Beam, Rural road .

1. INTRODUCTION

The structural evaluation of the selected twelve rural road sections of Nagpur region has been carried out. The structural parameters i.e. pavement deflection has been determined under the section of structural evaluation. The static load has been applied on the pavement surface and its rebound deflection has been measured using Benkelman Beam. The detailed procedure followed to determine pavement deflection has been presented in the below sections

Table 01: Selected Rural road Sections:

Road ID	**Road Name (Village Names)**	**Road ID**	**Road Name (Village names)**
NRR-1	Bokhara-Lonara	NRR-7	Sawarmendha -Brahmanwada
NRR-2	Lonara - Gumthala	NRR-8	Brahmanwada - Khandala
NRR-3	Gumthala - Gumthi	NRR-9	Khandala -Walni
NRR-4	Gumthala - bailwada	NRR-10	Sawarmendha - Champa
NRR-5	Gumthala-Chakkikhapa	NRR-11	Champa - Babulkheda
NRR-6	Gumthi - Sawarmendha	NRR-12	Babulkheda - Tandulwani

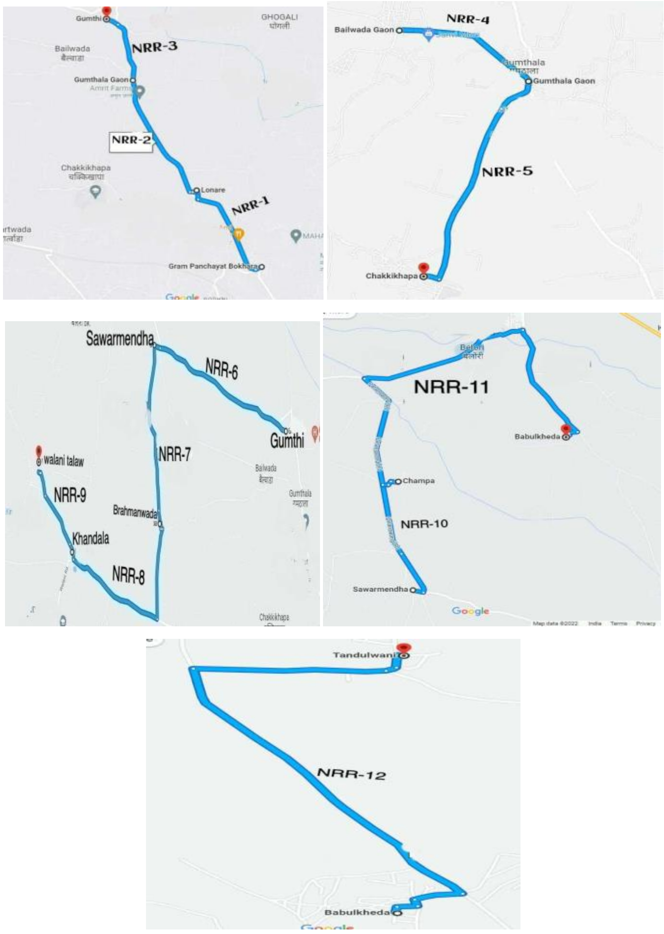

Fig.1 Selected rural road sections from nrr1 to nrr12 (Ref: Google Map)

2. RESEARCH METHODOLOGY

The In this research, 12 rural roads stretches in the vicinity of Nagpur, India, each measuring 2.5 km in length and averaging 3 metres in width were chosen for gathering pavement structural data. It also contains the usual method for performing Benkelman Beam Deflections, which reflect the pavement's structural behavior

3. PAVEMENT BENKELMAN BEAM DEFLECTION TEST

In the present study, it was decided that 10 measurement points per kilometre will be taken for data collection. Hence, 25 points per road stretch were selected to determine the characteristic deflection as per the procedure laid down in IRC: 81-1997 "Guidelines for strengthening of flexible road pavements using Benkelman Beam Deflection Technique". A standard two axle truck having rear axle load of 8.16 tonnes and tyre pressure of 5.6 kg/cm2 was used for measurement of initial reading, intermediate reading and final reading at each selected point 60 cm away from the pavement edge. The temperature correction was not applied because the average day temperature in the selected stretch region is less than 20o C for more than four months in a year. All the deflection measurements have been made when the ambient temperature was greater than 20o as suggested by IRC: 81-1997. Subgrade soil samples were taken from the test pits evaluation for determining the subgrade moisture content. These soil samples were oven dried in the laboratory for finding out the moisture content needed for applying moisture correction factor in characteristic deflection calculations.

To measure the response of a flexible pavement in terms of surface rebound deflections under static standard axle truck wheel loading, A.C. Benkelman introduced the Benkelman Beam (BB) in 1953. The beam was especially made for the road tests conducted by the Western Association of State Highway Organization

(WASHO). The BB method played a major role in the evaluation of the overlay design using surface rebound deflections measured under standard axle loads similar to truck traffic loading. The Benkelman Beam is simple, inexpensive and reliable equipment uses to assess the structural adequacy of a flexible pavement.

Fig 2 Benkelman Beam Deflection study on selected stretches (NRR-2)

The BB test has been done as per the procedure laid in IRC: 81-1997. The details of the Benkelman Beam test as recommended by the IRC: 81-1997 are presented below.

The Benkelman Beam consists of a probe of slender beam 3.66 m in length. It is pivoted at a distance of 2.44 m from the probe point (Fig 3.2). The probe beam is mounted in position by a reference beam of length 2.66 m. The reference beam is equipped with front and rear legs for initial horizontal adjustment using a spirit level. A dial gauge is installed on the reference beam 1.22 m away from the pivot and its spindle is in contact with the other end of the probe beam.

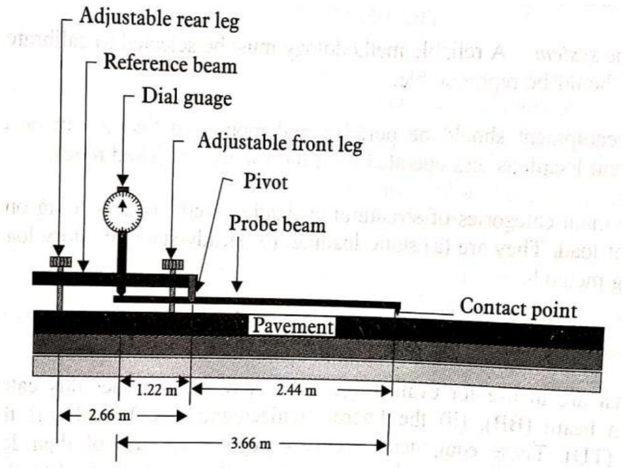

Fig 3.Salient features of a Benkelman Beam

3.1 Calibration of Benkelman Beam

Before using the Benkelman Beam, its dial gauge should be calibrated by placing its probe point on a metallic plate of known thickness (Fig 3.3). The reading on the dial gauge should be checked as one-half of the thickness of the metallic plate, since the distance between the pivot to the spindle of the dial gauge is one-half the distance between the pivot and the probe point. While calibrating, the reference beam should be horizontal and there should be no vibrations in the ground. Free movement of the probe beam should be ensured at the pivot.

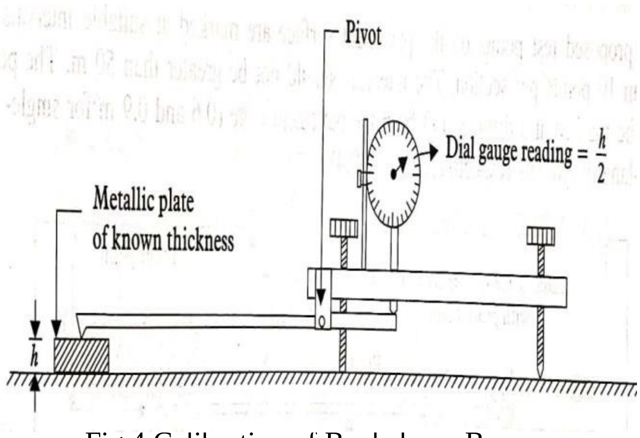

Fig 4 Calibration of Benkelman Beam

3.2 Method of Measurement of Rebound Surface Deflections

The Canadian Good Roads Association (CGRA) procedure has been adopted for measurement of pavement surface deflection. Initially, the BB probe point is inserted between the dual tyres of a standing truck's rear axle (Fig 3.4). The standard values of truck rear axle weight and the inflated tyre pressure has been taken as 8170 kg and 5.6 kg/cm2 respectively. During the test, the rear axle load and the tyres pressure should not change beyond a tolerance limit of ± 1 and ± 5% respectively (IRC: 81-1997).

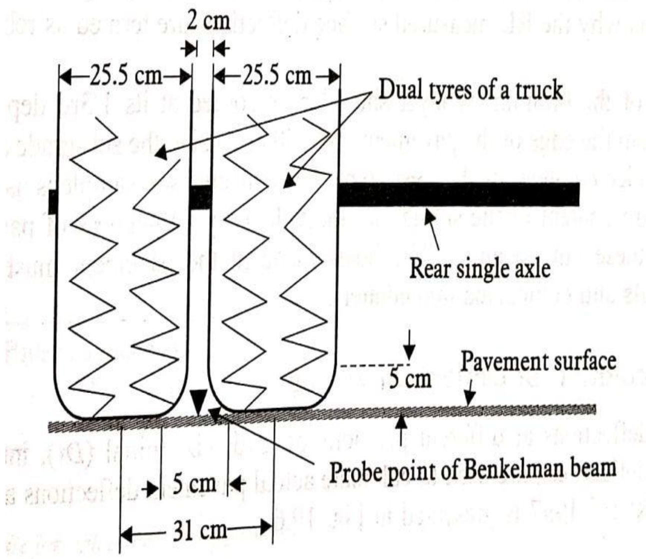

Fig 5 Initial Position of the Benkelman Beam probe point in between the dual wheels of a track

The proposed test points on the pavement surface are marked at suitable intervals not less than 10 points per section. The intervals should not be less than 50 m. The points should be marked at a distance (Y) from the pavement edge (0.6 and 0.9 m for single and double lane respectively) (Fig 6).

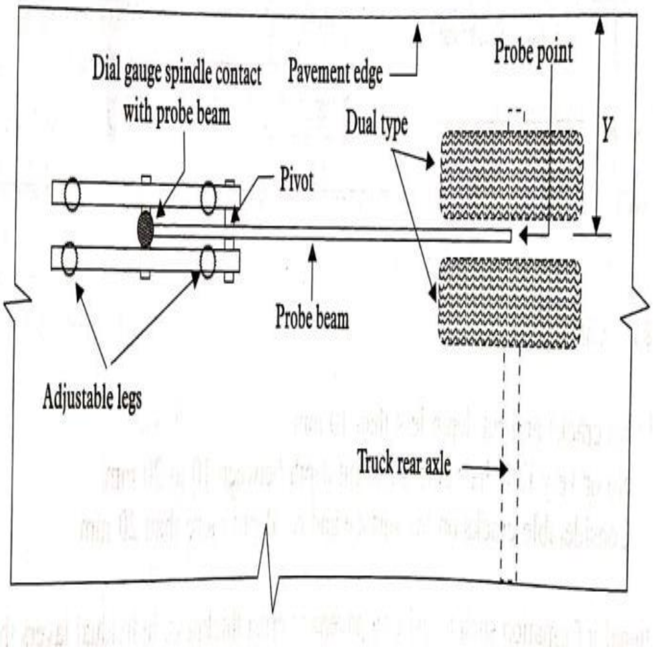

Fig 6 .Plan view of Benkelman Beam Testing

Horizontality of the reference beam should be checked and the dial gauge's initial reading (Do) recorded when the probe is deflected under the given standard loading conditions (Fig

3.6 (a)). Second reading or intermediate reading (Di) is recorded when the truck is driven at a creep speed (≤ 2 km/h) and stopped 2.7 m from the initial position (Fig 3.6 (b)). Finally, the truck is allowed to move further by 9 m and the third reading or final reading (Df) is recorded (Fig 7(c)). The above readings should be recorded when the rate of deformation of pavement is less than or equal to 0.025 mm per minute.

It is observed from Fig. 3.6 that initially the pavement surface is deflected under the loading. As the truck moves away, the pavement surface gradually regains its original level. This is the reason why the BB measured surface deflections are termed as rebound or elastic deflections.

Temperature of the bituminous layer should be recorded at its 1/3rd depth. A small pit should be cut from the edge of the pavement up to 50 cm inside the subgrade and a sample of the subgrade collected under the BB test point. The collected soil sample is used to determine the field moisture content of the subgrade. Individual layer thickness of pavements has been obtained from these cut openings. The holes made in the pavement must be filled with suitable materials and compacted immediately.

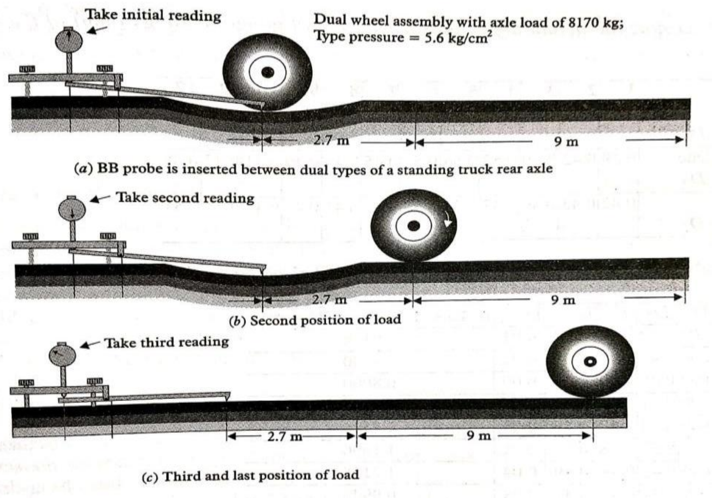

Fig 7. Measurement of pavement surface rebound deflection using Benkelman Beam

The recorded deflections at different positions of load, viz. initial reading (Do), intermediate reading (Di) and final reading (Df), have been used to calculate actual pavement deflections and the standard procedure of IRC: 81-1997 has been presented in Fig 7.

As the pavement surface deflections will be influenced by variations in the temperature of the bituminous layer, hence, all the measured deflections should be corrected to a standard temperature. The temperature correction has been applied as per the recommendation given in IRC: 81-1997. In the present study, the temperature correction has not been applied due to the following reason-

•The thickness of the bituminous layer on all the selected rural road sections is less than 40 mm.

The measured deflections are sensitive to the magnitude of strength of the subgrade. During post-monsoon season, the subgrade becomes soft or weak due to accumulation of moisture in the subgrade soil. Hence, if the deflections are measured during dry months, they should be corrected using seasonal correction factors given in six charts from IRC: 81-1997, using simple input parameters like subgrade soil type, plasticity index and annual rainfall of the region. All the BBD data calculations of the selected 12 rural road have been done by creating an excel programming for each individual stretch.A sample is shown in table 2.

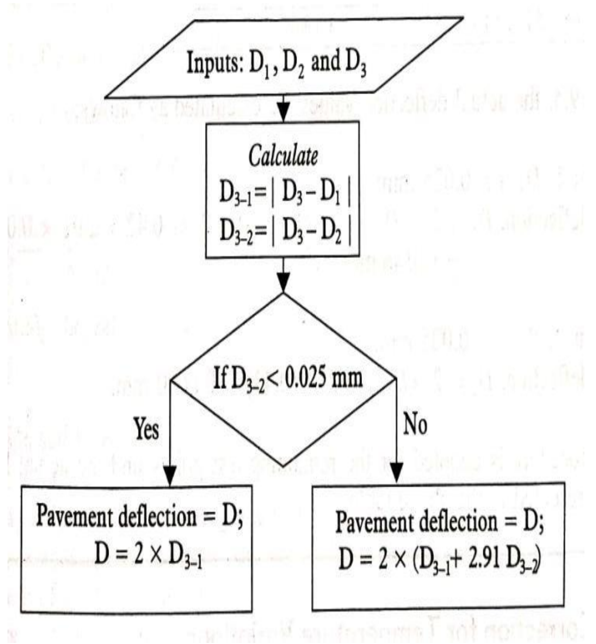

Fig 8.Procedure for calculating the pavement deflection from the Benkelman Deflection Data

Table 2 :Sample Table of Benkelman Beam Characteristic Deflection Calculations for NRR-2

NRR2- Lonara-Gumthala Road					**Since, D_i-D_f<0.025mm**	**Mean**	**S.D.**	**For Rural Road**	Annual Rainfall=1065 mm, Type of soil=CLAYEY
D_o	D_i	D_f	D_i-D_f	D_o-D_f	$D = 2*(D_o-D_f)$	$\bar{D}$	σ	$D_c = \bar{D} + 1.5\,\sigma$	Moisture Correction Factor for 4%
0	0.178	0.181	0.003	0.181	0.362	0.360	0.08	0.48	**1.86**
0	0.242	0.251	0.009	0.251	0.502				PI =13.7
0	0.277	0.279	0.002	0.279	0.558				**Final D_c**
0	0.153	0.163	0.01	0.163	0.326				**0.91 mm**

0	0.189	0.191	0.002	0.191	0.382				Note: No temperature correction is required.
0	0.221	0.223	0.002	0.223	0.446				
0	0.118	0.119	0.001	0.119	0.238				
0	0.221	0.224	0.003	0.224	0.448				
0	0.118	0.121	0.003	0.121	0.242				
0	0.185	0.189	0.004	0.189	0.378				
0	0.133	0.135	0.002	0.135	0.27				
0	0.232	0.233	0.001	0.233	0.466				
0	0.211	0.215	0.004	0.215	0.43				
0	0.176	0.178	0.002	0.178	0.356				
0	0.155	0.159	0.004	0.159	0.318				
0	0.123	0.125	0.002	0.125	0.25				
0	0.171	0.173	0.002	0.173	0.346				
0	0.188	0.19	0.002	0.19	0.38				
0	0.134	0.137	0.003	0.137	0.274				
0	0.165	0.169	0.004	0.169	0.338				
0	0.113	0.116	0.03	0.116	0.232				
0	0.175	0.176	0.001	0.176	0.352				
0	0.212	0.216	0.004	0.216	0.432				
0	0.161	0.163	0.002	0.163	0.326				
0	0.178	0.18	0.002	0.18	0.36				

4.RESULTS AND DISCUSSION

The According to the Benkelman beam conduction, NRR5 has the most distinctive deflection value of 1.8 mm and NRR4 has the least characteristic deflection value of 0.65 mm for all twelve chosen rural road lengths. As a result, out of the twelve chosen sections related to poor structural strength, NRR5 must be maintained first.

Future study may include some more structural parameters and more stretches may be selected of longer length in kilometers

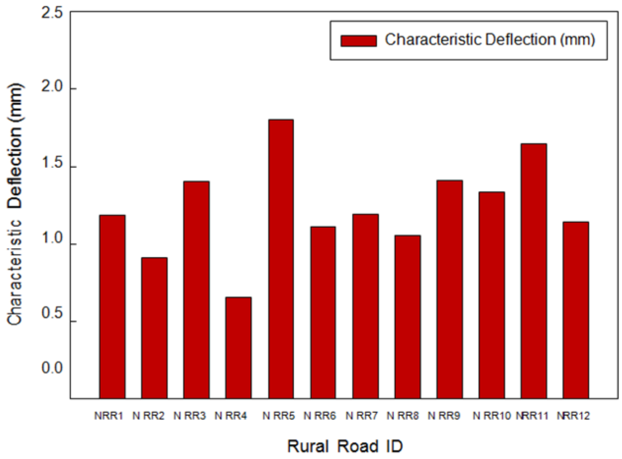

Fig 9. Characteristic Deflection of all selected stretches

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