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Benkelman Beam Deflection for Flexible Road Pavement

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Abstract:- The objective of overlay thickness design is to strengthen the existing flexible pavement with a suitable flexible pavement overlay so as to withstand the traffic loads during the desired design life. In the present case study, we are designing the overlay for existing flexible pavement. The study highlights the need of pavement evaluation and pavement evaluation measures for the road pavement in maddur. This report includes the collection of required fielddata like, traffic data, pavement surface condition and rebound deflection by using Benkelman beam deflection technique(BBD), laboratory investigation and finally the design of the overlay thickness of the pavement required for strengthen the road stretches.

Keywords:- *Road Pavement, Deflection, Cracks, Bituminous Macadam, Surface Coat, Liquid Limit, Plastic Limit and Moisture Content.*

I. INTRODUCTION

➢ *Definition of Road Pavement*

Road pavement refers to the topmost layer of a road that provides a smooth and durable surface for vehicles. It distributes the weight of traffic, prevents damage to underlying layers, and ensures sufficient traction. It consists ofmultiple layers including subgrade, sub base, base course, binder course and surface course. Materials like crushed stone,asphalt or concrete are used for construction. Proper maintenance and periodic resurfacing are necessary for longevity and performance.

➢ *Types of Pavements*

There are two types of pavements they are:

- *Flexible pavement*

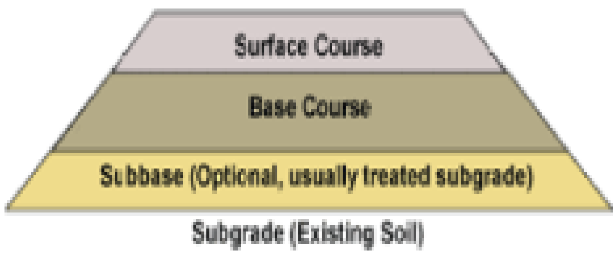

Fig 1 Flexible Road Pavement Cross Section

- *Rigid Pavement.*

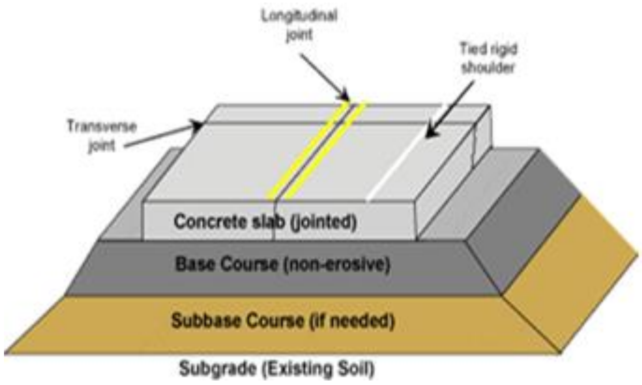

Fig 2 Ring Road Pavement Cross Section

II. BBD TECHNIQUE

Structural Evaluation of Flexible Pavements by Benkelman Beam Deflection(BBD) Method.

Benkelman beam is less expensive deflection measuring equipment and the method’s study issimple and easy to carry out. The Indian Roads Congress (IRC) has issued by the guidelines for conducting

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'Benkelman Beam Deflection' (BBD) studies for structural evaluation offlexible pavements and the design of overlay thickness for strengthening the same. Therefore, this method of pavement evaluation and overlay design is generally followed in this country. The magnitude of 'rebound deflection' of a flexible pavement when a standard wheel load of a truck is moved forward is measuredusing Benkelman beam.

➢ *Equipment*

In order to conduct BBD studies on a flexible pavement the following equipment and accessories are required:

- ✓ Standard Benkelman beam with dial gauge
- ✓ Loaded truck as specified
- ✓ *Accessories and tools for collection of subgrade soil sample, measurement of pavement temperature, etc.*

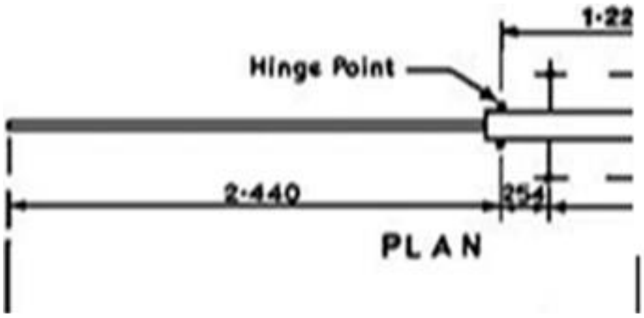

Fig 3 Diagram Showing Critical Dimension of Benkelman

➢ *Preliminary Studies*

Prior to running the deflection studies. It is essential to carry out preliminary studies consisting of the following operations:

- ✓ Pavement condition survey.
- ✓ Demarcation of the road into sub-stretches basedon pavement surface condition andgrouping the sub stretches into three groups.
- ✓ Marking of deflection observation points along the selected wheel paths.

➢ *Pavement Condition Survey*

The pavement condition survey is carried by before shutting the actual deflection measurements. Member of the study team walk along the road stretch. nothing the Visual observations on the pavement condition. The points to be noted are: (a) type and extent of cracking (b) rut depth (c) type and extent of surface undulations and (d) pot-holes and other types of pavement distress.

Additional data to be collected during the condition survey are: (i) condition of the shoulders(ii) whether the road is in cut or fill and the average height of fill/depth of cutting (iii) changesin soil profile (iv) topography (v) climatic condition(vi) rainfall details and (vii) any other relevant features alongthe road.

Test pits are dug at approximately 250 to 500 m intervals depending on the uniformity in performance of pavement structure in to determine the pavement details such as, Thickness andsettlement of the pavement layers and the type of subgrade soil below, in addition subgrade soil samples are collected determine to Meet properties and the field moisture content of the soil at the nearest laboratory.

➢ *Field Data Collection During BBDStudies*

Before starting the deflection measurements, the Benkelman beam is calibrated to ensure that the dial gauge and the beam are working correctly. This is completed by placing the Benkelmanbeam on a level firm surface. A num of metallic blocks of precisely measured thickness are placed under the probe and the deflection dialgauge readings are writen down; ifthese two setsof values are not exactly the same, the hinge, fixing of the dial gauge, Points of contact of dialgauge with the beam etc. are checked and the defect if any, is rectified.

➢ *Deflecions Observations During the Field Studies*

The truck is driven slowly parallel to the edge and stopped such that the left dual wheel tires of the rear axle is centrally placed over the first deflection measurement point; this could be verified through the clear gap in b/w the tires.

The probe lower end of the beam is inserted between the gap of the dual wheel and is placed exactly over the deflection observation point.

When the dial gauge reading is stationary or when the change of pavement deflection is less than 0.025 mm per minute, the initial dial gauge reading, Do is noted. Both the readings of the large and small needles of the dial gauge may be noted; for initial reading it is convenientto set the large needle of the dial gauge to zero.The truck is moved forward slowly through a distance of2.7 m from the deflection observation point and is stopped. The intermediate dial gauge reading, D5 is noted when the rate of recovery of rebound deflection of the pavement is less than 0.025 mm per minute.The truck is then driven forward through a further distance of 9.0 m and the final dial gaugereading.

➢ *Measurement of Pavement Temperature*

The temperature of thick bituminous pavement layer is recorded at intervals of one hour duringthe study. A 10 mm diameter hole is drilled up to the deep of 45 mm on the thick bituminous pavementand is filled with glycerol. The temperature of the glycerol is measured after five minutes using a digital thermometer at 40 mm depth and is recorded as the pavement temperature. It is obvious that pavement temperature is to be measured only if the total thickness of bituminous layers is preferably more than 75 m. If thin bituminous surface course is hiding over granular base courseor if the total thickness of bituminous pavement layers is 40mm or lesser pavement deflection will not be affected by the temperature; therefore, it's not necessary to follow the above procedure of

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determining pavement temperature.

Fig 4 Measurement of Pavement Temperature

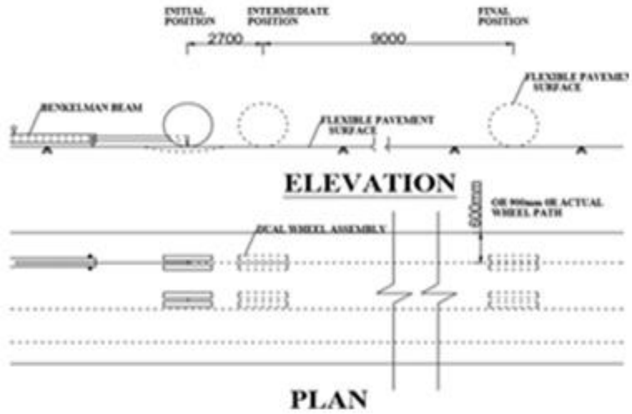

Fig 5 Method of Conducting Benkelman Beam Deflection Study at A Location

➢ *Calculation of Rebound Deflection Values*

Determination of rebound deflection value of the pavement or the selected observation point:

At each deflection observation point, the initial, intermediate and final deflection dial gauge readings Do, Di and Df are noted down as the standard wheel load of the truck moves forward. But the actual rebound deflection value of the pavement surface, D as indicated by the probe of the deflection beam is double the value indicated by the dial gauge readings Do and Df. Thisis because the distance between the hinge ofthe Benkelman beam and the probe of the deflection beam is twice the distance between the hinge and the dial gauge. Therefore, the actualrebound deflection value D is obtained by multiplying by two, difference b/w the initial and final dial gauge readings noted from the dial gauge readings.

$$\text{i.e., } D = 2\,(Do \sim Df)$$

Statistical analysis of deflection data: The rebound deflection values determined on different observation pointsof the selected sub- stretch of the road generally vary from point to point due to various causes. Therefore, the rebound deflection values determined at the selected set of spots in each sub-stretch are subjected to statistical analysis.

Mean deflection value:Let 'n' be the no. of deflection observation value in the sub-stretch. After applying leg correction if any, the rebound deflection value, Dx at each point is noted down. The mean deflection value Dm of 'n' deflection values may be directly be obtained by entering the deflection data in a scientific calculator or by using below equation.

$$Dm = \{EDx/n\}\ \text{mm}$$

➢ *Standard Deviation of Deflection Values:*

The value of standard deviation, 5 corresponding to 'n' deflection values is obtained directly by entering the data in a scientific calculator in the statistical mode or by using the relation is given in below equation.

$$S = \text{sqrt}\,(\text{sigma}\,(Dm-Dx)^{2}/(n-1))$$

➢ *Design of Flexible Pavement Overlayusing BBD Data*

The objective of overlay thickness design is to strengthen the existing flexible pavement with a suitable flexible pavement overlay so as to withstand the traffic loads duringthe desired design life. The overlay thickness required depends on two major factors, namely (i) stability of the existing flexible road pavement and (ii) Traffic loads is predicted in terms of cumulative standard axle load repetition (CSA) throughout the expected design life of theoverlay.

➢ *Stability of Existing Flexible Pavement:*

Standard axles during design life:

$$C\ S\ A = (365\ \{NFD[1+r]^{\,n-1}\}\ l)/r$$

➢ *Overlay's Thickness Design*

Overlay's thickness design of curves are developed based on extensive studies carried out in India; these have been presented in the guideline for strength of flexible road pavements published by the Indian Roads Congress.

III. RESULT

➢ *From IRC: 81:1997, for a characteristic deflection of 1.71mm and for 5 msa, the overlay thickness for the pavement is 107 mm of Bituminous Macadam. Therefore provide 50 mm BM and 25 mm of SDBC.*

(i.e. DBM or SDBC = 0.7 BM).

IV. CONCLUSION

- It is advisable to implement the necessary maintenance measures at an early stage when the distresses have just started showing up. It is seen that proper pavement measures at an early onset of distresses, can obviate major maintenance expenditure in future. This is because, in general, the rate ofdeterioration increases with time.

- Out of all the deflection measuring methods the BBD technique is the most simple and reliable method.
- This method is used to measure the rebound deflection of the pavement under static load.
- The correction of temperature is needed when bituminous layer is appreciably thick and temperature is standardized to350C.
- In colder areas where the average day temperature is < 200C for more than 4 months in a year, the standard temperature of 350C will not apply. It is been recommended that the deflection measurements in such areas be made when the ambient temperature is >200C and that no correction for temperature need be applied. Thus in case Kashmir valley no correction for temperature variation is needed..
- If the overlay for reinforcing National Highway/Expressway is carried out for 10 to 100 msa, the overlay thickness in mm in terms of Bituminous Macadam varies from 120 mm to 250 mm as per IRC: 811997 for typical deflection varies from 2.0 mm to 3.15 mm as obtained in this study. 70% of the design overlay thickness is to be considered, if the BM is replaced by DAC/SDAC/DBM/AC/SDC as per IRC:81-1997 guide lines.
- It may be noted that the strengthening of any given pavement structure for the applied wheel load varying from 0.1 to 100 msa become necessary when the characteristic deflection is found more than 3.0mm to 0.5 mm respectively.

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