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PAVEMENT DESIGN USING BENKELMAN BEAM METHOD

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ABSTRACT: *Effective pavement design is one of the most important aspects of project design. The pavement is the portion of the highway which is most obvious to the motorist. The condition and adequacy of the highway is often judged by the smoothness or roughness of the pavement. Deficient pavement conditions can result in increased user costs and travel delays, braking and fuel consumption, vehicle maintenance repairs and probability of increased crashes.*

The better the strength/stiffness quality of the materials the better would be the long-term performance of the pavement. Hence, the design of pavement should be focused on the efficient, most economical and effective use of existing materials to optimize their performance. The distressed pavements are left unmanaged and there is a need to rehabilitate the roads by using the environmental sustainable techniques so as to develop it for future generations. The rehabilitation techniques can be developed by studying the types of distresses, material conditions and environment conditions.

Keywords: pavement, braking, highway.

I. INTRODUCTION

One of the asphalt assessment strategy utilized nowadays much of the time is the Benkelman shaft diversion method for estimation of bounce back redirection of the pavement. Using the bounce back avoidance values acquired from the Benkelman avoidance estimation procedure and doing important adjustments of for the seasonal and temperature variations, an overlay thickness for the asphalt can be resolved and overlay is to be laid. Such that the heap can support stacks securely for the outline period .In request to safeguard from asphalt failure, the up keep is required for the asphalt routinely.

The transports street is an adaptable pavement (Bituminous Concrete) with WBM base course and GSB sub-base and dark cotton soil sub-level and open drainage frame work and poor asphalt condition i.e. with number of disappointments with width more than 20cm. Hence asphalt assessment is necessary. Thus asphalt assessment is to be done and overlay is to be laid

II. MOTIVATION

The objective of the project deals with the identification of the deflections in the pavement at the regular intervals and design the overlay as per the site requirements, we find out the deflections using the Benkelman's beam deflection and analyze. The methodology involved in the achievement of this objective is

- The first step involves the identification of the pavement with maximum deflection.
- After selection of the pavement, the next step involves the identification of the deflection locations and its condition. The bituminous samples are collected at three (3) regular intervals of the road.
- The properties of the bituminous samples are evaluated. The samples collected are tested for the properties like
- The mix design is prepared and Marshall Stability test is conducted to determine the density, flow, stability, Air voids, VMA, VFB.

III. DESIGN

FIELD AND LABORATORY INVESTIGATION

1 Dynamic Cone Penetration Test
2 In-situ Moisture content

Field Moisture

	1+000	2+000	3+500
Moisture	18%	12%	6%

3 In-situ Density by Core Cutter method

Table 3.2: Core Cutter

	1+000	2+000	3+500
Water Content	18%	12%	6%
Dry Density	1.58	1.75	1.74

Laboratory Investigations

Laboratory Tests on Sub grade Soil, the sub grade must be able to support loads transmitted from the pavement structure. This load bearing capacity is often affected by degree of compaction, moisture content, and soil type. A sub grade that can support a high amount of loading without excessive deformation is considered good. Sub grade materials are typically characterized by their resistance to deformation under load, in other words, their stiffness or their bearing capacity, in other words, their strength. In general, the more resistant to deformation a sub grade is, the more loads it can support before reaching a critical deformation value.

So to evaluate the properties of the existing subgrade the laboratory tests conducted are as follows

- Grain Size Analysis
- Atterberg Limits
- Free Swell Index
- Compaction and Optimum Moisture Content
- California Bearing Ratio Test

BITUMINOUS MIX DESIGN:

1 Specific Gravity Test

Specific Gravity of Various Binders

Binder Type	VG-30
Sp. Gravity	1.03

2 Penetration Test

Penetration values of Various Binders used in the Study

Binder Type	VG-30
Penetration	61

3 Softening Point Test

Table 4.5: Softening Point values of various Binders

Binder Type	VG-30	CRMB-60
Softening Point	53	64

Aggregate

1 Aggregate Impact Test: Aggregate impact value =13%

2 Specific Gravity and Water Absorption

Specific gravity and Water absorption results of aggregates

Location	Size (mm)	Specific Gravity	Water Absorption (%)
Local Material	25	2.60	0.33
	20	2.64	0.41
	10	2.61	0.63
	Dust	2.47	1.7

Bitumen Adhesion Test: The aggregate Coating Value = 98%

Shape Tests

Test Results of Elongation and Flakiness of Aggregates

Location	Size (mm)	Flakiness (%)	Elongation (%)	Combined Flakiness & Elongation Indices (%)
Local Materials	25	12.1	17.8	29.8
	20	9.4	34.3	43.7
	10	71.7	60	131.7

RAP usage in the mix

Reclaimed asphalt pavement (RAP) is the term given to removed and/or processed materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for construction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high- quality, well-graded aggregates coated by asphalt cement.

The utilization of RAP is done in the DBM and WMM layers i.e in the granular layers. High RAP content mixes may pose special problems in terms of workability and compactibility. So the % of RAP to be used is limited to 15% in the DBM mix and to 35% in the WMM mix. Considering these % of RAP, the Marshall Mix design is prepared.

Marshall Mix Design Procedure

1. The coarse aggregates used for granular construction are normally of the sizes mm. The fractions from 4.75mm to 150 micron are termed as fine aggregates. The size 4.75mm is a common size appearing in both the fractions.
2. Grading pattern of aggregates–coarse, fine or combined–is determined by sieving a sample successively through all the sieves mounted one over the other in order of size, with the larger sieve on the top. The material retained on each sieve after shaking, represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above.
3. Sieve analysis gives the gradation and the fineness modulus which is an empirical factor obtained by adding the cumulative percentages of aggregates retained on each of the dividing standard sieves and dividing by 100. The larger the figure, the coarser will be the material.
4. Bring the sample to an air dry condition either by drying at room temperature or in oven at a temperature of 100^{o}C to 110^{o}C. Take the weight of the sample.
5. Clean all the sieves and sieve the sample successively on the appropriate sieve starting with the largest as shown in Fig 4.1.
6. Shake each sieve separately over a clean tray.
7. On completion of sieving, note down the weight of them at trial retained on each sieve.

MARSHALL TEST PROPERTIES					
Bitumen %	**3.5**	**4**	**4.5**	**5**	**5.5**
Density	2.33	2.35	2.371	2.383	2.372
Max Specific Gravity	2.508	2.481	2.472	2.454	2.436
Va	6.5	5.7	4.1	2.9	2.62
VMA	12.41	12.14	11.83	11.84	12.71
VFB	45.42	57.17	65.34	75.59	79.39
Stability (Correction)	880	962	1075	1006	933
Flow in mm	3	3.3	3.7	4	4.2

PAVEMENT DESIGN:

Design of Flexible Pavements

As discussed earlier the design of flexible pavements is done by using the guidelines of IRC 37: 2012

IRC 37:2012

Indian roads congress has specified the design procedures for flexible pavements based on CBR values. The Pavement designs given in the previous edition IRC:37-1984 were applicable to design traffic up to only 30 million standard axles (msa). The earlier code is empirical in nature which has limitations regarding applicability and extrapolation. These guidelines follow analytical designs and developed new set of designs up to 150 msa.

These guidelines will apply to design of flexible pavements for Expressway, National Highways, State Highways, Major District Roads, and other categories of roads. Flexible pavements are considered to include the pavements which have bituminous surfacing and granular base and sub-base courses conforming to IRC/ MOST standards. These guidelines apply to new pavements.

In M-E pavement design approach, the pavement is idealized as a layered structure (generally assumed as elastic for simplicity in analysis) consisting of three to four horizontal layers made up of bituminous surfacing, base, sub-base and the subgrade. Each layer is characterized by its elastic modulus, Poisson's ratio and the thickness. Fatigue, rutting and low temperature cracking are generally considered as the important modes of failure of a bituminous pavement structure.

Indian Roads Congress Method is based on an empirical method where the thickness value of a pavement used was read from the CBR value of the sub-grade. From the design chart the total pavement thickness could be read for a given CBR value and cumulative standard axle load.

In our design the pavement is divided into four layers i.e Bituminous course, WMM layer, DBM layer and Sub grade. So we need to analyse the properties of all these layers.

Benkelman Beam Method:

This Method deals with the experimental investigation by using the Benkelman beam method, using this method we evaluate the max deflection that is occurring on the pavement at the regular intervals and hence we will design the overlay of the pavement. This test procedure covers the determination of the rebound deflection of a pavement under a standard wheel load and tyre pressure, with or without temperature measurements.

Equipments

The basic components or equipments required are as follows

1. A Benkelman beam to the ministry of works and development pattern having the dimensions shown in the figure. The beam must be fitted with a satisfactory locking device designed to secure the beam when moving to a new site and a suitable vibrator mounted at the pivot point.
   In sunny whether the beam may pass from shade into sunshine as the vehicle moves away .Therefore a shield similar to that described in Road Research Unit New letter No49 should be used.

2. A Truck or Tractor with an axial load of 8.2 +-0.15 Tones equally distributed on the two duel tyre wheels operating at the inflation pressure necessary to give tyre contact area of 0.048+-0.0002m^2. The tyre shall be 10.00 x 20,12 ply with tubes and rib treads.
3. A tyre pressure gauge graduated in 20Kpa divisions or smaller.
4. A thermometer with a range of 0-6^0 in 1^0C divisions.
5. A mandrel suitable for making a 1000mm deep hole in the pavement for inserting the thermometer. The diameter of the hole should be 13mm.
6. A can containing either glycerol or oil for filling the thermometer hole.

IV. RESULT

Procedure: Measurement of Deflection

1. The test pit shall be preselected and marked for the highway pavements, test points shall be located at the distances from the edge of the lane given in the below table.

Lane width(Meters)	Distance from the Edge(Meters)

28 or less	0.5
3.0	0.6
3.2	0.7
3.4	0.8
3.6 or more	0.9

2. The tyre pressure should be checked before the first test and then at intervals not exceeding three hours.
3. The truck shall be initially in a positioned with the test wheel between 100 and 150mm to the rare of the test spot, i.e, position A
4. The probe of the beam shall be inserted between the duel tyre of the test wheel with the toe located on the test spot.
5. The locking device shall b rleased and the rare of the beam adjusted so that the plunger is in contact with the dial guage.
6. The dial guage shall be set to read between 9 and 11mm (The actual reading need not be recorded) and the vibrator set in operation.
7. The truck shall be moved forward at creep speed so that the test wheel passes over the test spot and continues advancing to position 8 which is 2.7 +- 0.1 meters beyond to the test spot.
8. The start reading, S, is the maximum dial guage reading occurring during this movement of the truck from position A to position B, and will normally occur as the wheel passes over the test spot. This reading shall be recorded.
9. The Intermediate reading, I, is that figure indicated by the dial guage at rhe movement of the truck stops with the test wheel in position B, and reading shall be recorded.
10. The truck shall be moved forward until the test wheel is in position V which is not less than meters from position B.
11. The Final reading, F, is that figure indicated by the dial guage when the truck has stopped in the position C. This figure shall be recorded.

The rebound deflection of the pavement shall be calculated in the following manner:

(a) Two pavement rebound indicators shall be established by subtracting the intermediate and final readings from the start reading, i,e: (S - I) and (S - F)

(b) If the indicators so obtained agree within 0.03mm the true rebound deflection at temperature T shall be calculated as: X T = 2(S - F)

(c) If the indicators (S - I) and (S - F) differ by more than 0.03mm*** the initial shape of the bowl has been such as to influence the front support legs of the instrument and the calculations shall be adjusted as follows: X (T) = 2(S - F) + 5.82 (I - F)

(d) The pavement rebound deflection at a standard temperature of 20□ Cshall be calculated from the above figure by applying the formula :X 20 = X T +(20 – t)/110

Where X 20= temperature corrected rebound deflection in millimetres and t= temperature in degrees Celsius 40mm below the surface of the pavement.

S.No	Change and Identification of Lane	Dial Gauge Readings Initial(D_o), Intermediate(D_i), Final(D_F)		
1	0	0.010	0.006	0.003
2	2.7	0.007	0.007	0.007
3	9	0.005	0.005	0.006
4	2.7	0.005	0.005	0.006
5	9	0.015	0.016	0.017
6	2.7	0.016	0.016	0.017
7	9	0.024	0.024	0.025
8	2.7	0.026	0.027	0.028
9	9	0.028	0.028	0.029

10	2.7	0.015	-0.066	-0.148
11	9	0.026	-0.070	-0.167

1. Mean deflection=0.010255mm

2. Standard deviation =0.1432mm

3. Characteristic deflection.= 0.24191

V. CONCLUSION

From the Benkelman beam deflection technique conducted on the required stretch, the observations obtained are calculated and a design thickness of the overlay required is obtained. Hence overlay thickness of 12cm is to be laid on the existing pavement in order to sustain the increasing axle load for future 10 years. Bituminous concrete is to be laid on the existing flexible pavement.

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