IRC:81-1997

GUIDELINES
FOR
STRENGTHENING OF FLEXIBLE ROAD PAVEMENTS USING BENKELMAN BEAM DEFLECTION TECHNIQUE

(First Revision)

INDIAN ROADS CONGRESS

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GUIDELINES FOR STRENGTHENING OF FLEXIBLE ROAD PAVEMENTS USING BENKELMAN BEAM DEFLECTION TECHNIQUE

1. INTRODUCTION

A.C. Benkelman devised the simple deflection beam in 1953 for measurement of pavement surface deflection on the WASHO Test Road. It is widely used all over the World for evaluation of the requirements of strengthening of flexible pavements. Deflection beam has been in use in India for more than two decades by different organizations. To lay down a uniform procedure for the design of flexible overlays using the Benkelman Beam deflection technique, tentative guidelines were published by the Indian Roads Congress under the title "Tentative Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique" IRC:81-1981.

The tentative guidelines (IRC:81-1981) has been in use since then and based on their application in practice for design of overlays for flexible pavements, a lot of useful data have been collected and valuable experience gained. A research study entitled "Development of Methods such as Benkelman Beam Deflection Method for Evaluation of Structural Capacity of Existing Flexible Pavements and also for Estimation and Design of Overlays for Strengthening of any Weak Pavement" was also undertaken to collect data on pavement deflection values before and after overlaying and various other parameters like temperature, subgrade soil type and moisture and their influence on pavement deflection and service behaviour. Based on the findings of this study and the experience gained over the years with the use of deflection method and other studies carried out in the country, the Flexible Pavement Committee prepared revised draft guidelines which were discussed by the Highways Specifications and Standards Committee during the meeting held on 12th May, 1994. The HSS Committee referred this draft back to the newly constituted Flexible Pavement Committee for in depth study.

The above committee in its meeting held on 24th May, 1994 set up a subgroup with the following members for carrying out the revision of the present IRC:81- 1981.

Shri S.C. Sharma	...	Convenor
Prof. S.S. Jain	...	Member-Secretary

Members

Prof. A.K. Gupta	Prof. O.P. Bhatia
Prof. B.B. Pandey	Shri I.R. Arya
Prof. C.E.G. Justo	

The subgroup held six meetings and discussed at length various aspects of the guidelines in view of the changing loading conditions as well the findings of the Research Project R-6 of MOST. Dr. Sunil Bose and Shri Nirmal Jit Singh were also invited to attend the subgroup meetings.The draft prepared by the subgroup was approved by the Flexible Pavement Committee in its meeting held on 13th February, 1996 (personnel given below).

Prof. A.K. Gupta	..	Convenor
Prof. S.S. Jain	..	Member-Secretary

Members

Prof. C.G. Swaminathan	I.C. Goel
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	Dr. L.R. Kadiyali
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M.M. Jivani	Prof. P.D. Marathe

Prof. O.P. Bhatia

The guidelines were approved by the Highways Specifications and Standards Committee in its meeting held on 19th March, 1996 and by the Executive Committee in its meeting on 17th April, 1996. The guidelines were finally approved by the Council in its meeting held at Darjeeling on 24th May, 1996.

2. SCOPE

2.1. These guidelines are meant for evaluating the strengthening requirement of existing flexible road pavements using the Benkelman Beam Deflection Technique. The recommendations are based on the findings of MOST Research study (R-6) and work done at various academic and research institutions in the country as well as the field experience gained over the years in addition to the findings from abroad which are relevant to Indian conditions.

2.2. The guidelines may require revision from time to time in the light of future experience and developments in the field. Towards this end, it is suggested to all the organisations intending to use the guidelines to keep a detailed tabulated record of periodical deflection measurements (both before and after strengthening), type and thickness of overlay provided, performance, traffic, climatic conditions, etc.

3. BASIC PRINCIPLES OF DEFLECTION METHOD

3.1. Performance of flexible pavements is closely related to the elastic deflection of pavement under the wheel loads. The deformation or elastic deflection under a given load depends upon subgrade soil type, its moisture content and compaction, the thickness and quality of the pavement courses, drainage conditions, pavement surface temperature etc.

3.2. Pavement deflection is measured by the Benkelman Beam which consists of a slender beam 3.66 m long pivoted at a distance of 2.44 m from the tip (see Fig.1). By suitably placing the probe between the dual wheels of a loaded truck, it is possible to measure the rebound and residual deflections of the pavement structure. While the rebound deflection is the one related to pavement performance, the residual deflection may be due to non- recoverable deflection of the pavement or because of the influence of the deflection bowl on the front legs of the beam. Rebound deflection is used for overlay design. Para 4.3 discusses the method of deflection measurement and ***Annexure-1*** gives the measurement procedure.

4. PROCEDURE FOR DEFLECTION SURVEY

4.1. General

The deflection survey essentially consists of two operations: (i) condition survey for collecting the basic information of the road structure and based on this, the demarcation of the road into sections of more or less equal performance; and (ii) actual deflection measurements.

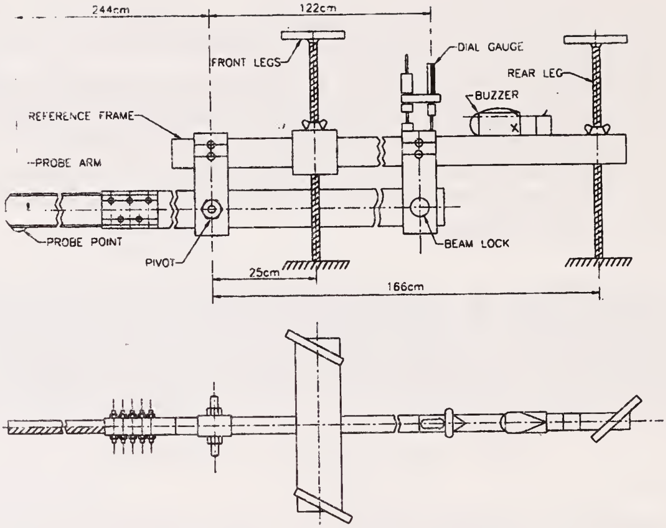

Fig. 1. Benkelman Beam

4.2. Pavement Condition Survey

4.2.1. This phase of operation, which shall precede the actual deflection measurement, consists primarily of visual observations supplemented by simple measurements for rut-depth using a 3 metre straight edge. Based on these, the road length shall be classified into sections of equal performance in accordance with the criteria given in Table 1.

Table 1 . Criteria for Classification of Pavement Sections

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 per cent shall be treated as failed.

4.2.2. As it is inexpedient to modify the overlay design at frequent intervals, it will be preferable if the length of each section is kept at a minimum of 1 km except in the case of localised failure or other situations requiring closer examination where minimum length of section may be suitably fixed.

4.2.3. The data collected during the condition survey shall be recorded as per the Proforma given in Table 2. In case the pavement shows severe distress or signs of premature failure further investigations would be necessary to ascertain the causes and design remedial measures.

4.3. **Deflection Measurements**

4.3.1. In each road section of uniform performance (see para 4.2) minimum of ten points should be marked at equal distance in each lane of traffic for making the deflection observations in the outer wheel path. The interval between the points should not be more than 50 m. On roads having more than one lane, the points marked on adjacent lanes should be staggered. In the transverse direction, the measurement points should be 60 cm from the pavement edge if the lane width is less than 3.5 m and 90 cm when the lane width is more than 3.5 m. For divided four lane highway, the measurement points should be 1.5 m from the pavement edge.

4.3.2. Variability of deflections in a given section should be considered for detecting spots where extra deflection measurements have to be made. For this purpose, highest and lowest values in a group of ten should be compared with mean value. If the highest or lowest values differ from the mean by more than one- third of mean then extra deflection measurements should be made at 25 m on either side of point where high or low values are observed.

4.3.3. For measuring pavement deflection the C.G.R.A. procedure (vide details given in ***Annexure-1***) which is based on testing under static load may be adopted. In this method, a standard truck having a rear axle weighing 8170 kg fitted with dual tyre inflated to a pressure of 5.60 kg/cm^2 is used for loading the pavement. During actual tests, the total load and the tyre pressure are maintained within a tolerance of +/- 1 per cent and +/- 5 per cent respectively.

4.3.4. Before starting the deflection measurements, the Benkelman Beam should be calibrated to ensure that the dial gauge and beam are working correctly. This can be done by using the simple procedure described below:

The beam is placed and levelled on a hard level ground. A number of metallic blocks of different thickness (measured accurately with a precision

Table 2

Table 2. Proforma for Recording Field Information Collected during the Pavement Condition Survey

Name of road :	Date of Survey :
	Traffic intensity : cv/day ...... Year.....
Section :	Annual Rainfall (mm) : high/low
No. of Traffic lanes :	Subgrade soil Type :

S.No.	Sub-Section from to	Height of emba.-nkment depth of cutting	Pavement-condition	Pavement details						Type of shoulder	Depth of water table m	Drainage condition	Remarks
				Surfacing		Base		Sub-base					
				Type	Thickness cm	Type	Thickness cm	Type	Thickness cm				
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Note : 1. **Classify as 'Good, Fair, or Poor' based on the criteria given in Table 1 (para 4.2)

2. ***Record any special or abnormal conditions such as flooding, submergence, failed section, previous failure history if any, etc.

micrometer) with perfectly plane faces are placed under the probe and the dial gauge reading recorded each time. If the beam is in order, the dial gauge on the beam should read one half the thickness of the metallic block on which the probe was placed. Otherwise, the dial gauge should be checked and replaced if necessary. If the dial gauge is functioning correctly, the beam pivot should be checked for free and smooth operation, secondly the striking plate beneath the dial gauge spindle should be checked to ensure that it is tightly secured and has not become grooved by the dial gauge stylus.

4.3.5. Deflections measured by the Benkelman Beam are influenced by the pavement temperature. For design purposes, therefore, all deflection values should be related to a common temperature. Measurements made when the pavement temperature is different than standard temperature would need to be corrected. The standard temperature and the procedure for correction are discussed in para 4.4.

4.3.6. Pavement deflections are also affected by seasonal variations in climate. For the purpose of applying these guidelines, it is intended that the pavement deflections should pertain to the period when the subgrade is at its weakest condition. In India, this period occurs during the recession of monsoon. It is, therefore, desirable to conduct deflection measurements during this period. Where the same is not feasible, a correction factor should be applied, vide para 4.5.

4.3.7. The deflection measurements, pavement temperature, subgrade soil & deflection, and other information collected during the deflection study should be recorded in the proforma given in Table 3.

4.4. Correction for Temperature Variations

4.4.1. The stiffness of bituminous layers changes with temperature of the binder and consequently the surface deflections of a given pavement will vary depending on the temperature of the constituent bituminous layers. For purposes of design, therefore, it is necessary that the measured deflections be corrected to a common standard temperature. For areas in the country having a tropical climate, the standard temperature is recommended to be 35°C (also see para 4.4.4.). Correction for temperature is not applicable in the case of roads with thin bituminous surfacin (such as premix carpet or surface dressing over a non-bituminous base) since these are usually unaffected by changes in temperatures. But temperature correction will be required for pavements having a substantial thickness of bituminous construction (i.e. minimum 40 m). Correction need not however, be applied in the latter case if the road is subject to severe cracking or the bituminous layer is substantially stripped.

4.4.2. Available information shows that the deflection-pavement temperature relationship is linear above a temperature of 30°C. For convenience in the application of the temperature correction, it is recommended that the deflection measurements should be taken when the pavement temperature is within the range of 30°C - 35°C, preferably when the temperature is uniform and is near the standard temperature of 35°C. Accordingly, as far as possible deflection measurements should be made during morning and evening hours on summer months.

Table 3. Proforma for Recording Pavement Deflection Data

Name of Road :	Date and time of observation	:
	Climatic conditions (hot/humid/cold)	:
Section :	Air temperature, °C	:
	Annual rainfall, mm.	:
No. of traffic lanes :	Whether temperature correction is to be applied	: Yes/no
	Whether correction for seasonal variation is to be applied	: Yes/No

S.No.	Location of test point and identification of lane	Pavement temperature, °C	Type of Soil & PI	Moisture content %	Dial gauge reading Initial	Intermediate	Final	Rebound Deflection (mm)
1	2	3	4	5	6	7	8	9

Note: The values of pavement surface temperature will be measured at every hour during the deflection study

4.4.3. Correction for temperature variation on deflection values measured at pavement temperature other than 35°C should be 0.01 mm for each degree centigrade change from the standard temperature of 35°C. The correction will be positive for pavement temperature lower than 35°C and negative for pavement temperature higher than 35°C. For example, if the deflection is measured at a pavement temperature of 37°C, the correction factor will be 0.02 mm (=2 x .01) which should be subtracted from the measured deflection to obtain the corrected value corresponding to standard pavement temperature of 35°C.

4.4.4. In colder areas, and areas of altitude greater than 1000m where the average day temperature is less than 20°C for more than 4 months in a year, the standard temperature of 35°C will not apply. In the absence of adequate data about deflection- performance relationship, it is recommended that the deflection measurements in such areas be made when the ambient temperature is greater than 20°C and that no correction for temperature need be applied.

4.4.5. In cases where temperature correction is to be applied, the pavement temperature should be measured during the deflection survey. The measurement should be made at a depth of 40 mm using a suitable short-stem mercury or a digital contact thermometer. For this purpose, a hole of about 45 mm deep and about 10 mm diameter should be drilled in the pavement and filled with glycerol and temperature can then be recorded after about 5 minutes.

4.5. Correction for Seasonal Variation

4.5.1. Since the pavement deflection is dependent upon change in the climatic season of the year, it is always desirable to take deflection measurements during the season when the pavement is in its weakest condition. Since, in India, this period occurs soon after monsoon, deflection measurements should be confined to this period as far as possible. When deflections are measured during the dry months, they will require a correction factor which is defined as the ratio of the maximum deflection immediately after monsoon to that of the minimum deflection in the dry months.

4.5.2. Correction for seasonal variation shall depend on type of subgrade soil, its field moisture content (at the time of deflection survey) and average annual rainfall in the area. For this purpose, subgrade soils have been divided into three broad categories, namely sandy/gravelly, clayey with low plasticity (PI $\leq$ 15) and clayey with high plasticity (PI > 15). Similarly, rainfall has been divided into two categories, namely low rainfall (annual rainfall $\leq$ 1300 mm) and high rainfall (annual rainfall >1300 mm). Moisture correction factors (or seasonal correction factors) shall be obtained from Figs. 2 to 7 for given field moisture content, type of subgrade soil and annual rainfall.

4.5.3. The soil sample for determination of subgrade type and its field moisture content shall be scooped from below the pavement as shown in Fig. 8. For this purpose a test pit at the shoulder (adjacent to pavement edge) shall be dug to a depth upto 15 cm below the subgrade level in every kilometer depending on the uniformity of subgrade soil, topography of the area and road profile. A soil sample of weight not less than 100 gm should be collected using an auger from the subgrade underneath the deflection observation points i.e. 0.6 m and 0.9 m from the pavement edge for single and two lane pavements respectively at a depth of 50 mm to 100 mm below the subgrade level as shown in Fig.8. The subgrade soil shall be tested as per IS-2720 - for type of subgrade soil, plasticity index and field moisture content. The test pit shall be made good immediately after taking soil sample and study of pavement composition.

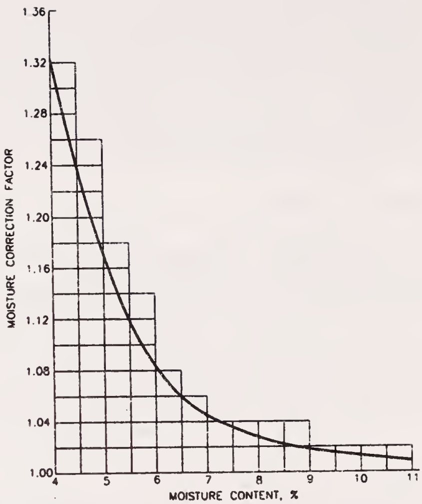

Fig. 2. Moisture correction factor for Sandy/Gravelly soil subgrade for low rainfall areas (Annual rainfall ≤ 1300 mm)

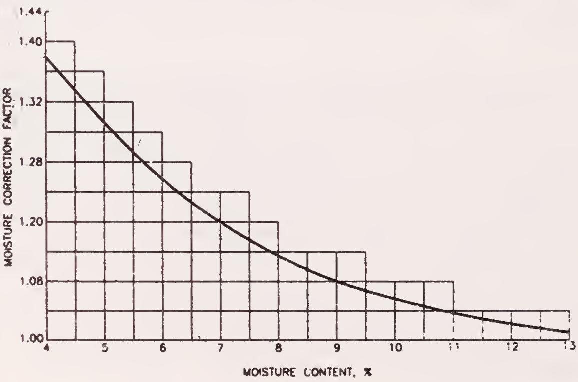

Fig. 3. Moisture correction factor for Sandy/Gravelly subgrade for high rainfall areas (Annual rainfall > 1300 mm)

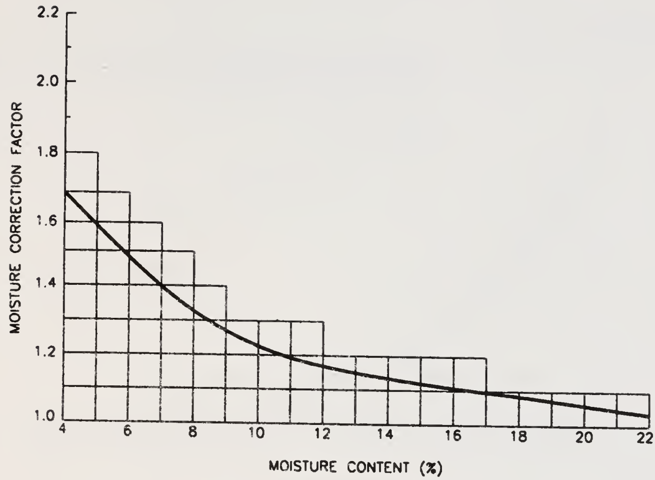

Fig. 4. Moisture correction factor for clayey subgrade with low plasticity (PI < 15) for low rainfall areas (Annual rainfall ≤ 1300 mm)

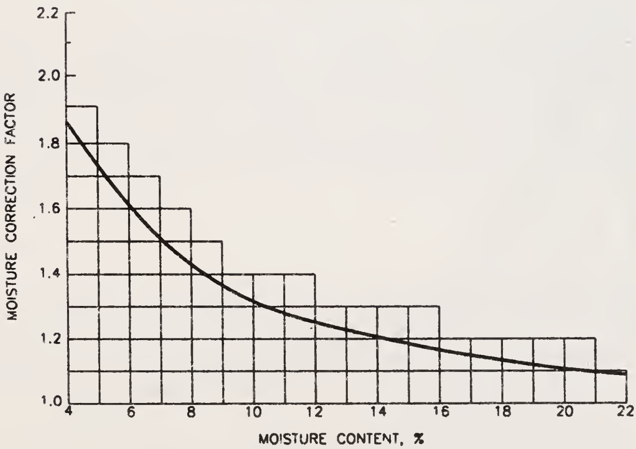

Fig. 5. Moisture correction factor for clayey subgrade with low plasticity (PI < 15) for high rainfall areas (Annual rainfall > 1300 mm)

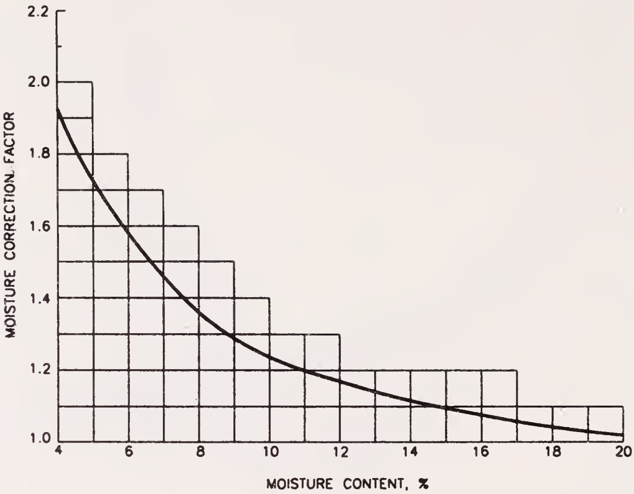

Fig. 6. Moisture correction factor for clayey subgrade with high plasticity (PI > 15) for low rainfall areas (Annual rainfall ≤ 1300 mm)

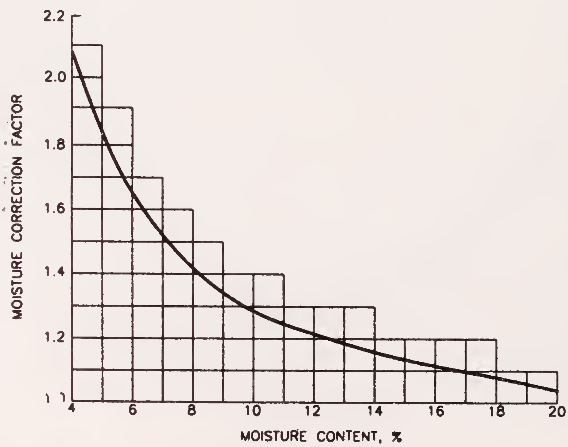

Fig. 7. Moisture cor: ection factor for clayey subgrade with high plasticity (PI > 15) for high rainfall areas (Annual rainfall > 1300 mm)

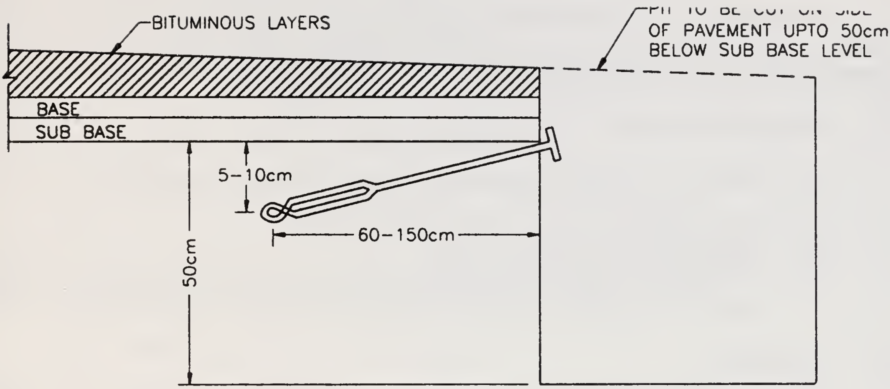

Fig. 8. Determination of field moisture content using auger

4.5.4. The annual rainfall data has to be obtained for that particular area. The deflection values corrected for temperature shall be multiplied by the appropriate values of seasonal correction factors to obtain corrected values of deflection.

5. TRAFFIC

Traffic in terms of million standard axle shall be considered for the design of overlay. If sufficient data are available at the stretch with respect to the wheel load distribution of commercial vehicles or the vehicle damage factor and their transverse placement, the cumulative standard axles may be worked out based on actual data, otherwise design traffic may be calculated as per the procedure given in IRC:37 and para 5.4 below.

5.1. General

For purposes of the design, only the number of commercial vehicles of laden weight of 3 tonnes or more and their axle loading will be considered. The traffic is considered in both directions in the case of two lane road and in the direction of heavier traffic in the case of multi lane divided highways.

To obtain a realistic estimate of design traffic due consideration should be given to the existing traffic, possible changes in road network and land use of the area served, the probable growth of traffic and design life.

Estimate of the initial daily average traffic flow for any road should normally be based on 7-day 24-hours classified traffic counts. However, in exceptional cases where this information is not available 3-day count could be used.

5.2. **Traffic growth rate**

An estimate of likely growth rate can be obtained as follows:

a) By studying the past trend in traffic growth.
b) Elasticity of transport demand.
c) If adequate data is not available, it is recommended that an average value of 7.5 per cent may be adopted for roads in rural routes.

5.3. **Design life**

It is recommended that the design life for strengthening of major roads should be atleast 10 years. Less important roads may, however, be designed for a shorter design period but not less than 5 years in any case.

5.4. **Computation of design traffic**

5.4.1. The design traffic is considered in terms of the cumulative number of standard axles to be carried during the design life of the road. Its computation involves estimates of the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, the design life in years and the vehicle damage factor (number of standard axle per commercial vehicle) to convert commercial vehicles to standard axles.

The following equation may be used to make the required calculation

$$N_s = \frac{365 \times A\,[(1+r)^x - 1]}{r} \times F \qquad ..\ (1)$$

where,

N_s = 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 duly modified to account for lane distribution as explained in paragraph 5.4.2.
r = Annual growth rate of commercial vehicles
x = Design life in years
F = Vehicle damage factor (number of standard axles per commercial vehicle) refer to paragraph 5.4.3.

5.4.2. Distribution of commercial traffic over the carriageway

A realistic assessment of distribution of commercial traffic by direction and by lane is necessary as it directly affects the total equivalent standard axle load applications used in the design. It is recommended that for the time being the following distribution may be assumed for design until more reliable data on placement of commercial vehicles on the carriageway lanes are available. However, if in a particular situation a better estimate of the distribution of traffic between the carriageway lanes is available from traffic surveys, the same should be adopted and the design is based on the traffic in the most heavily trafficked lane. The design will normally be applied over the whole carriageway width.

(i) Single-lane roads (3.75 m width)

Traffic tends to be more channelised on single lane roads than on two lane roads and to allow for this concentration of wheel load repetitions, the design should be based on the total number of commercial vehicles per day in both directions multiplied by two.

(ii) Two-lane single carriageway roads

The design should be based on 75 per cent of the total number of commercial vehicles in both directions.

(iii) Four-lane single carriageway roads

The design should be based on 40 per cent of the total number of commercial vehicles in both directions.

(iv) Dual carriageway roads

The design of dual two lane carriageway roads should be based on 75 per cent of the number of commercial vehicles in each direction. The distribution factor shall be reduced by 20 per cent for each additional lane.

Ex: For dual three-lane carriageway distribution factor - 60 per cent

The traffic in each direction may be assumed to be half the sum in both directions when the latter only is known. Where significant difference between the two streams can occur, the condition in the more heavily trafficked lane should be considered for design. However, if on a particular situation a better estimate of the distribution of traffic between the carriageway lanes is available from traffic surveys, the same should be adopted and the design is based on the traffic in the most heavily traffic lane. The design will normally be applied over the whole carriageway width.

5.4.3. Vehicle damage factor

The vehicle damage factor (VDF) is a multiplier for converting the number of commercial vehicles of different axle loads to the number of standard axle-load repetitions. The vehicle damage factor is arrived at from axle-load surveys on typical road sections so as to cover various influencing factors such as traffic mix, type of transportation, type of commodities carried, time of the year, terrain, road condition and degree of enforcement. The AASHO axle load equivalence factors may be used for converting the axle load spectrum to an equivalent number of standard axles. For designing a strengthening layer on an existing road pavement, the vehicle damage factor should be arrived at carefully by using the relevant available data or carrying out specific axle load surveys depending upon importance of the project. Some surveys have been carried out in the country on National Highways, State Highways and MDR's which reveal excessive overloadng of commercial vehicles. The designer should take the exact value of VDF after conducting the axle load survey particularly in the case of major projects. Where sufficient information on axle load is not available, the tentative indicative values of vehicle damage factor as given in Table 4 may be used.

Table 4 . Indicative VDF Values

Initial traffic intensity in terms of number of commercial vehicles per day (Traffic range)	Terrain	
	Rolling/Plain	Hilly
0-150	1.5	0.5
150-1500	3.5	1.5
more than 1500	4.5	2.5

6. ANALYSIS OF DATA FOR OVERLAY DESIGN

6.1. Characteristic Deflection

6.1.1. Overlay design for a given section is based not on individual deflection values but on a statistical analysis of all the measurements in the section corrected for temperature and seasonal variations. This involves calculation of mean deflection, standard deviation and characteristic deflection. The characteristic deflection for design purposes shall be taken as given in equations (4) and (5). The formulae to be used in the calculation are as follows:

Mean Deflection, $$\bar{x} = \frac{\Sigma x}{n} \qquad ..(2)$$

Standard Deviation, $$\sigma = \frac{\sqrt{\Sigma(x-\bar{x})^2}}{n-1} \qquad ..(3)$$

Characteristic Deflection,

(i) $Dc = \bar{x} + 2\sigma$ ..(4)
for major arterial roads (like NH & SH)

(ii) $Dc = \bar{x} + \sigma$ ..(5)
for all other roads

where
x = Individual deflection, mm
$\bar{x}$ = Mean deflection, mm
n = Number of deflection measurements
σ = Standard deviation, mm
Dc = Characteristic deflection, mm

These shall be recorded in the Proforma suggested in Table 5.

7. DESIGN OF OVERLAY

7.1. The design curves relating characteristic pavement deflection to the cumulative number of standard axles to be carried over the design life is given in Fig. 9.

7.2. The characteristic deflection (Dc) value to be used for design purposes will be the same as given in equations (4) and (5). This will be determined as per the procedure given in Para 6.1.

Table 5. Analysis of Test Data

Name of road :
Section :
No. of traffic lanes :

Date and time of observation :
Climatic conditions :
Ambient temperature, °C :
Pavement temperature, °C :

Location of test point	Measured deflection (from column 9 of Table 3)	Correction for temperature mm	Correction for season	Corrected deflection mm	Mean deflection $\bar{x}$ (mm)	Standard deviation σ (mm)	Characteristics deflection, mm as per equation (4) & (5) (mm)	Design traffic in million standard axles msa	Remarks
1	2	3	4	5	6	7	8	9	10

* Cumulative standard axles over design life.

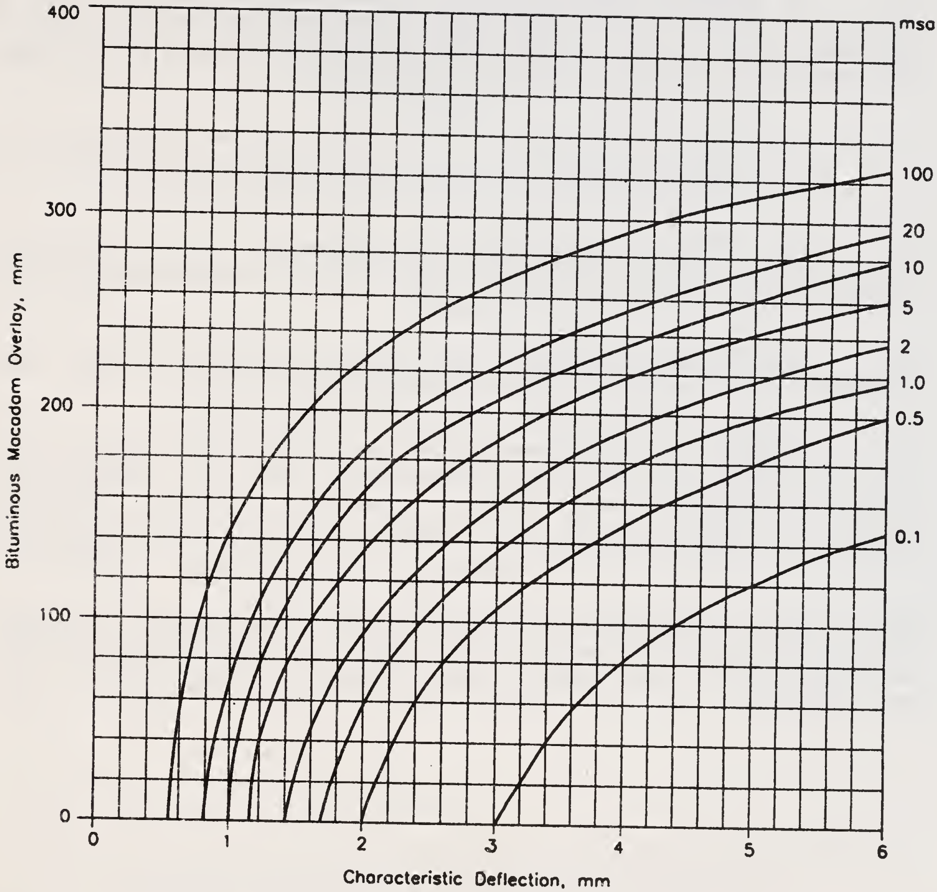

Fig. 9. Overlay Thickness Design Curves

7.3. The design traffic in terms of cumulative standard number of axles will be computed as per the procedure described in Para 5.

7.4. The thickness deduced from Fig. 9 is the overlay thickness in terms of bituminous macadam construction. In case other compositions are to be laid for strengthening, the equivalent overlay thickness to be provided may be determined using appropriate equivalency factors as suggested below :

1 cm of Bituminous macadam	= 1.5 cm of WBM/Wet Mix Macadam/BUSG
1 cm of Bituminous macadam	= 0.7 cm of DBM/AC/SDC

7.5. From structural considerations, the recommended minimum bituminous overlay thickness is 50 mm bituminous macadam with an additional surfacing course of 50 mm DBM or 40 mm bituminous concrete.

7.6. Where structural deficiency is not indicated from deflection values, thin surfacing may be provided to improve the riding quality as required.

7.7. The type of material to be used in overlay construction will depend on several factors such as the importance of the road, the design traffic, the thickness and condition of existing bituminous surfacing, construction convenience and relative economics. For heavily trafficked roads, it will be desirable to provide bituminous overlays. The thickness of wearing course should be in conformity with IRC:37.

7.8. Before implementing the overlay, the existing surface shall be corrected and brought to proper profile by filling the cracks, pot holes, ruts and undulations. No part of the overlay design thickness shall be used for correcting the surface irregularities.

Annexure-1

STATIC LOAD DEFLECTION TEST PROCEDURE (C.G.R.A. METHOD)

SCOPE

This method of test covers a procedure for the determination of the rebound deflection of pavement under static load of the rear axle of a standard truck.

EQUIPMENT

The equipment shall include:

(1) Benkelman Beam

(a)	Length of probe arm from pivot to probe point	244 cm
(b)	Length of measurement arm from pivot to dial	122 cm
(c)	Distance from pivot to front legs	25 cm
(d)	Distance from pivot to rear legs	166 cm
(e)	Lateral spacing of front support legs	33 cm

(2) A 5 tonne truck is recommended as the reaction. The vehicle shall have 8170 kg rear axle load equally distributed over the two wheels, equipped with dual tyres. Spacing between the tyre walls should be 30-40 mm. The tyres shall be 10 x 20, 12 ply inflated to a pressure of 5.60 kg/cm^2. The use of tyres with tubes and rib treads is recommended.

(3) Tyre pressure measuring gauge

(4) Thermometer (0-100°C) with 1° division

(5) A mandral for making 4.5 cm deep hole in the pavement for temperature measurement. The diameter of the hole at the surface shall be 1.25 cm and at bottom 1 cm.

Procedure

(1) The point on the pavement to be tested is selected and marked. For highways, the point should be located 60 cm from the pavement edge if the lane width is less than 3.5 m and 90 cm from the pavement edge for wider lanes. For divided four lane highway, the measurement points should be 1.5 m from the pavement edge.

(2) The dual wheels of the truck are centered above the selected point.

(3) The probe of the Benkelman beam is inserted between the duals and placed on the selected point.

(4) The locking pin is removed from the beam and the legs are adjusted so that the plunger of the beam is in contact with the stem of the dial gauge. The beam pivot arms are checked for free movement.

(5) The dial gauge is set at approximately 1 cm. The initial reading is recorded when the rate of deformation of the pavement is equal or less than 0.025 mm per minute.

(6) The truck is slowly driven a distance of 270 cm and stopped.

(7) An intermediate reading is recorded when the rate of recovery of the pavement is equal to or less than 0.025 mm per minute.

(8) The truck is driven forward a further 9 m.

(9) The final reading is recorded when the rate of recovery of pavement is equal to or less than 0.025 mm per minute.

(10) Pavement temperature (see para 4.4.) is recorded atleast once every hour inserting thermometer in the standard hole and filling up the hole with glycerol.

(11) The tyre pressure is checked at two or three hour intervals during the day and adjusted to the standard, if necessary.

CALCULATIONS

(1) Subtract the final dial reading from the initial dial reading. Also subtract the intermediate reading from the initial reading.

(2) If the differential readings obtained compare within 0.025 mm the actual pavement deflection is twice the final differential reading.

(3) If the differential readings obtained do not compare to 0.025 mm, twice the final differential dial reading represents apparent pavement deflection.

(4) Apparent deflections are corrected by means of the following formula :

$$X_T = X_A + 2.91\ Y$$

in which X_T = True pavement deflection

X_A = Apparent pavement deflection

Y = Vertical movement of the front legs i.e. twice the difference between the final and intermediate dial readings.

(5) The rebound deflection (%) (i.e. col. 9 of Table 3) shall be the twicc of the X_T value.