Design of Overlay for Flexible Pavement

Types of Overlays

- Asphalt overlay over asphalt pavements
- Asphalt overlays on CC pavements
- CC overlays on asphalt pavements
- CC overlays on CC pavements

Steps in Design of Overlays

- Measurement and estimation of the strength of the existing pavement
- Design life of overlaid pavement
- Estimation of the traffic to be carried by the overlaid pavement
- Determination of the thickness and the type of overlay

Effective Thickness Method

- Basic concept
  - Thickness of overlay is the difference between the thickness required for a new pavement and the effective thickness of the existing pavement
  - $h_{OL} = h_n - h_e$
  - Where,
  - h_{OL} = thickness of overlay
  - h_n = thickness of new pavement
  - h_e = *effective* thickness of existing pavement

Effective Thickness Method

- All thicknesses of new and existing materials must be converted into an equivalent thickness of AC

$$h_e = \sum_{i=1}^{n} h_i C_i$$

h_i = thickness of layer i

C_i = conversion factor for layer i

Asphalt Institute Conversion Factors

➢ Subgrade	0.0
➢ Granular sub-base, reasonably well graded, hard aggregates with some plastic fines and CBR not less than 20%. Use upper part of range if PI is less than 6; lower part of range if PI is more than 6	0.1 – 0.2
➢ Asphalt concrete surfaces and bases that exhibit Appreciable cracking and crack patterns	0.5 – 0.7
➢ Asphalt concrete surfaces and bases that exhibit Some fine cracking, have small intermittent cracking patterns and slight deformation in the wheel paths but remain stable	0.7 – 0.9
➢ Asphaltic concrete, including asphaltic concrete base, generally uncracked, and with little deformation in the wheelpaths	0.9 – 1.0

Example

- Thickness of existing pavement
  - 250 mm GSB
  - 250 mm WBM
  - 100 mm BM
  - 40 mm AC
- Thickness of new pavement
  - 300 mm GSB
  - 250 mm WMM
  - 100 mm DBM
  - 40 mm AC

Example

- Condition of old pavement layers
  - GSB and WBM layers are in good condition with PI of fines more than 6
    - Conversion factor = 0.1
  - BM layer shows aggregate degradation
    - Conversion factor = 0.5
  - AC layer shows appreciable cracking
    - Conversion factor = 0.6
- Effective thickness of the old pavement
  - $h_e = 0.1\times(250+250) + 0.5\times100 + 0.6\times40$
    $= 124$ mm

Example

- Equivalent thickness of new pavement in terms of AC

  $h_n = (300+250)\times0.2 + (100+40)\times1.0$

  $= 250$ mm

Thickness of Overlay $= h_n - h_e$

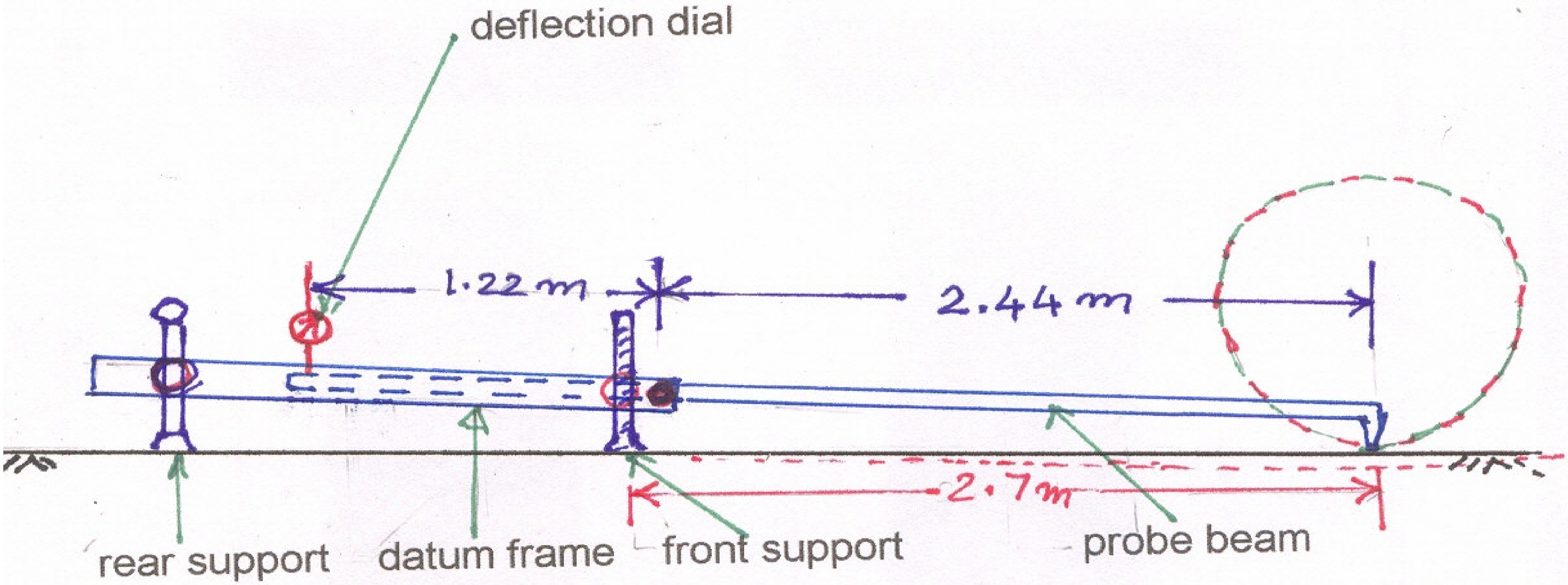
$= 250 - 124$

$= 126$ mm

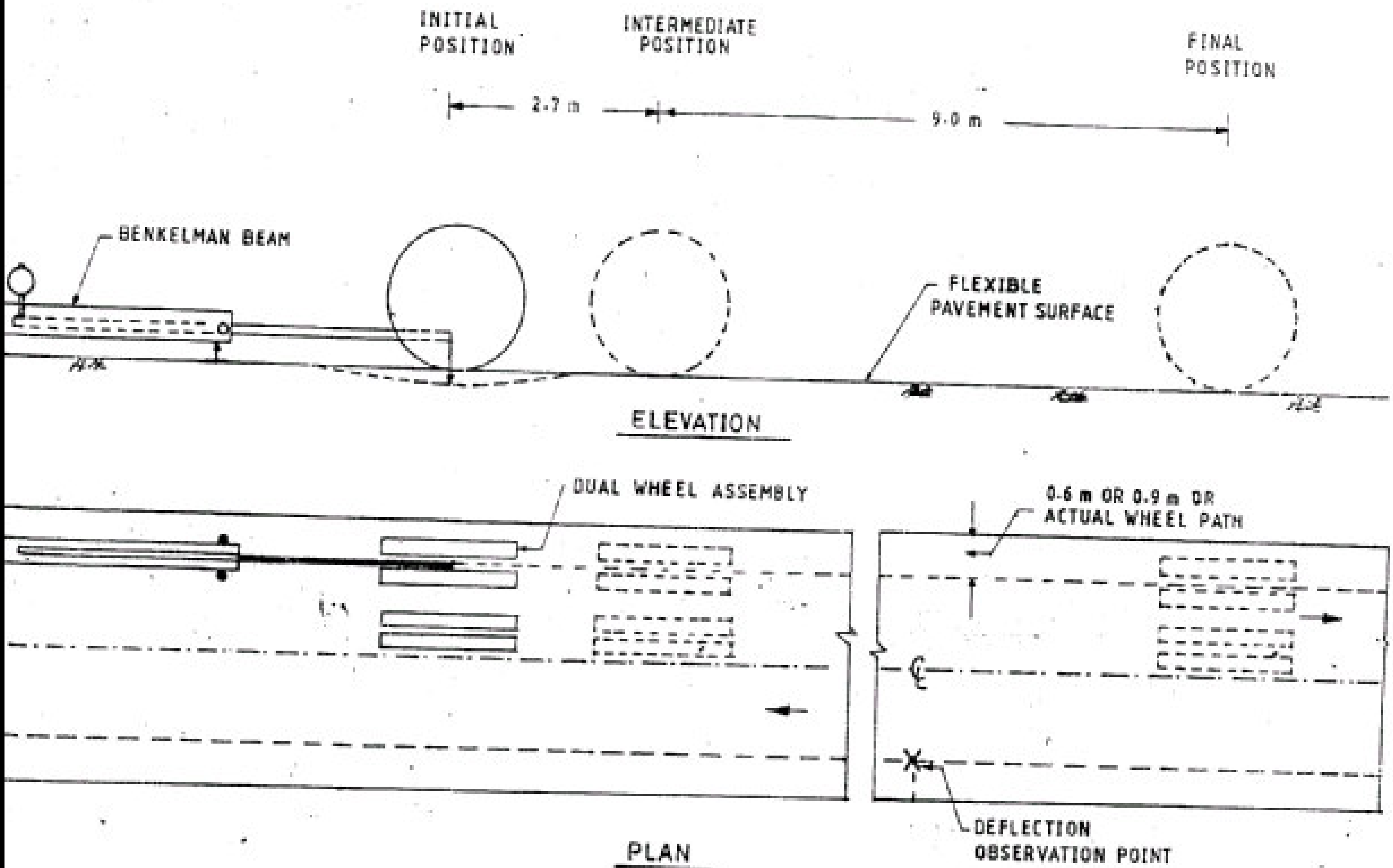
Provide 90 mm DBM + 40 mm AC as overlay

Deflection Approach

- The structural strength of pavement is assessed by measuring surface deflections under a standard axle load
- Larger pavement deflections imply weaker pavement and subgrade
- The overlay must be thick enough to reduce the deflection to a tolerable amount
- Rebound deflections are measured with the help of a Benkelman Beam



Benkelman Beam



.1- SCHEMATIC DIAGRAM OF REBOUND DEFLECTION MEASUREMENT USING BENKELMAN BEAM.

Specifications for Measurement

- Condition survey and deflection data are used to establish sections of uniform performance
- At least 10 deflection measurements should be made for each section per lane subject to a minimum of 20 measurements per km.
- If the highest or the lowest deflection values for the section differ from the mean by more than one-third of the mean, then extra deflection measurement should be made at 25 m on either side of point where high or low values are observed.

Pavement Condition Survey

- Visual inspection of the road stretch and grouping into sub-stretches
- Assessment of pavement cracking – type & percentage cracked area
- Rut depth measurements
- Observations on other types of pavement deterioration

Loading and other standards

- axle load of 8170 kg / load of 4085 kg on dual wheels
- tyre pressure, p = 5.6 kg / cm^2
- standard pavement temperature = 35^o C
- highest subgrade moisture content soon after monsoon

Some precautions during rebound deflection observations

- very low or zero values
- variation of individual values, not more than one third of mean value


NHA 83


N-H-4
303 Km
26-4-94

Placement of Probe

Other Measurements and Data

Measurement of pavement temperature (at one hour intervals)
Measurement of field moisture content of subgrade soil
Typical subgrade soil samples for lab. Tests (soil classification)
Other data to be collected

- annual rain fall
- traffic data : classified volume of vehicles of gross load over 3 t, growth rate, axle load data / VDF values

Analysis of Data

Leg correction, if any, at each point of deflection observation:

- If (Di ~ D_f) is less than 0.025 mm (2.5 div.), D = 0.02 (D_0 ~ D_f)
- If (Di ~ D_f) is more than 0.025 mm (2.5 div.), D = [0.02 (D_0 ~ D_f) + 0.0582(D_i – D_f)]

Mean deflection, D

Characteristic Deflection, D_c = (D + 2 σ) for important roads to cover

- 97.7 % deflection values, or D_c = (D + σ) for low traffic roads, to cover 84.1 % deflection values

Application of temperature correction factor @ 0.01 mm per °C variation from the standard temperature of 35° C or 0.01 (t~35)

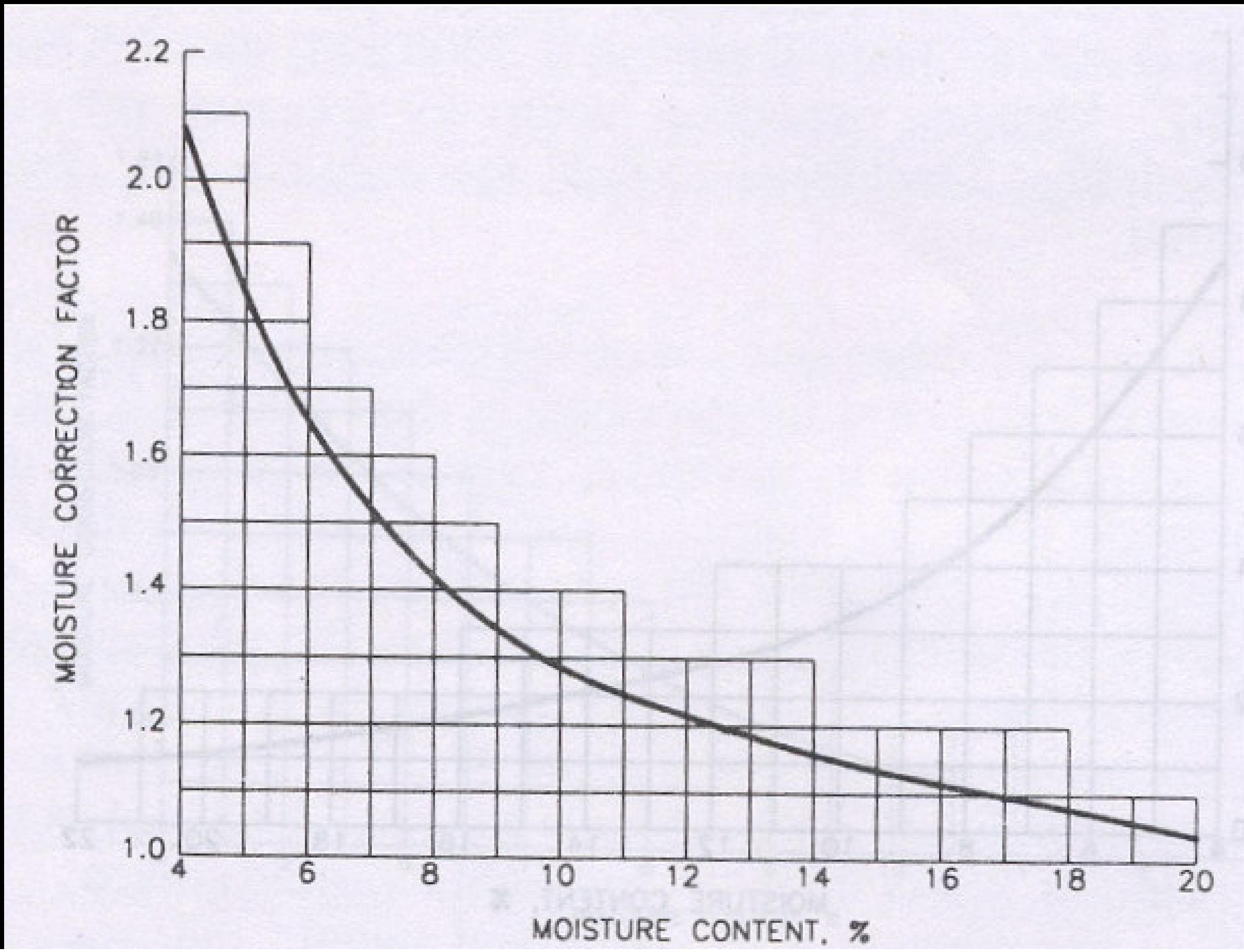
Corrections for Deflections

- Temperature Correction
  - Stiffness of the Bituminous layers get affected due to which deflections vary
  - Standard temperature is 35^{0}c
  - Correction for temperature variation on deflection values measured at pavement temperature other than 35 ^{o}C should be 0.01mm for each degree change from the standard temperature.

Corrections for Deflections

- Correction for Seasonal Variation
  - Deflection depends upon the change in the climate
  - Worst climate (after monsoon)-considered for design
  - Depends on subgrade soil and moisture content
  - Correction for seasonal variation depends on type of soil subgrade (sandy/gravelly or Clayey with PI<15 or Clayey with PI>15), field moisture content, average annual rain fall (<1300 mm or >1300 mm)

Seasonal Correction Factor (clayey subgrade, PI>15, rainfall>1300)



Computation of Design Traffic

- The design traffic is considered in terms of the cumulative number of standard axles ,

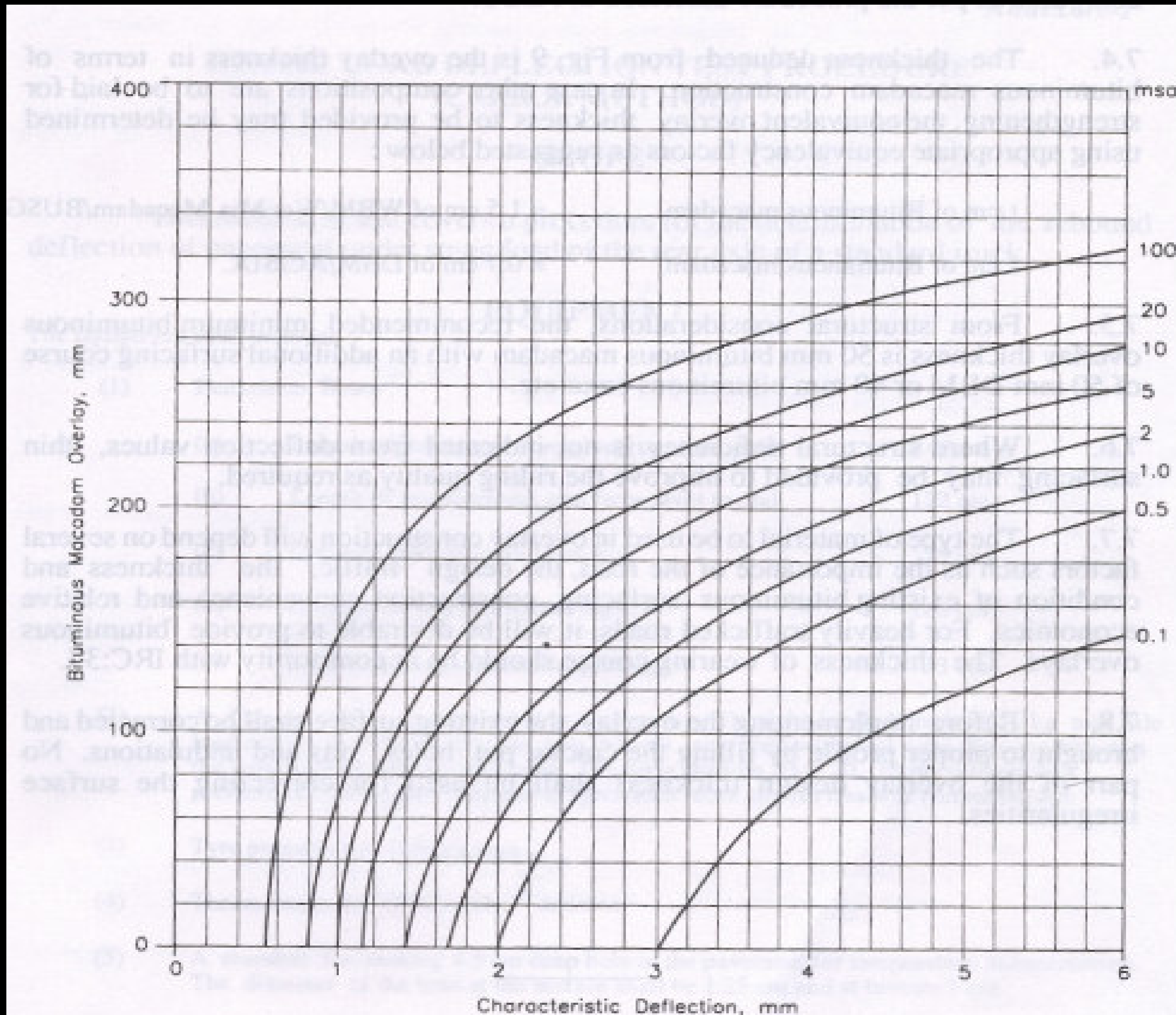
$$N_s = \boxed{\frac{365 * A[(1+r)^X - 1]}{r} * F}$$

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 on design lane**
r	=	**Annual growth rate of commercial vehicles**
X	=	**Design life in years**
F	=	**Vehicle Damage Factor**

Design of Overlay (IRC)

- Design curves relating characteristic pavement deflection to the cumulative number of standard axles are to be used.
- The Deflection of the pavement after the corrections i.e., Characteristic Deflection is to be used for the design purposes.
- The design traffic in terms of cumulative standard number of axles is to be used.

Contd….



Overlay Thickness Design Curves (IRC)

Cont….

- The thickness obtained from the curves is in terms of Bituminous Macadam construction.

- If other compositions are to be laid then
  - 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/SDBC

Type of Material for Overlay

- The type of material for overlay depends on factors such as
  - Importance of the road
  - Design Traffic
  - Thickness and condition of the existing pavement
  - Construction convenience
  - Economics
- Before implementing the overlay, the existing surface is to be corrected and brought to proper profile by filling pot holes, ruts and undulations
- No part of the overlay thickness shall not be used for the correction of surface irregularities.

Example

- Deflection values:

  1.40,1.32,1.25,1.35,1.48,1.60,1.65,1.55,1.45,1.40,1.36,1.46,1.5,1.52,1.45 mm

- Pavement Temparature = 30^{o}C
- Subgrade moisture content = 8%, clayey soil, PI>15
- Average annual rain fall = 1500 mm
- Two lane single carriageway
- ADT of Trucks = 1000
- Annual growth rate = 5%
- VDF = 4.5

Example

- Mean deflection = 1.45 mm
- Standard Deviation = 0.107 mm
- Characteristic deflection = 1.45 + 2(0.107)

  = 1.664 mm

Correction for temperature = 0.01(35-30)

= 0.05 mm

Characteristic deflection after temp. correction = 1.664 + 0.05 = 1.714 mm

Seasonal correction factor = 1.4

Corrected characteristic deflection = 1.4 (1.714)

= 2.3996 mm

Example

- Design traffic = 1000 * 365*12.57*4.5*0.75
  = 15.5 msa
- Thickness of overlay in terms of BM from the chart = 190 mm
- Thickness in terms of DBM/AC = 190*0.7
  = 133 mm
- Provide 40 mm AC and 95 mm DBM

AI Deflection Method

- The overlaid pavement is considered as a two layer system with AC overlay as layer 1 and the existing pavement as layer 2.
- By considering the existing pavement as a homogeneous half space, and using the characteristic deflection the modulus value of layer 2 is found out from
- $E_2 = (1.5\ p\ a) / D_c$ *(A)*
- *Where,*
- *p = contact pressure (483 kPa)*
- *a = radius of contact, (163) mm*
- D_c = Characteristic deflection in mm

Expected Deflection after Overlay

$$D_d = \frac{1.5pa}{E_2}\left(\left\{1-\left[1+0.8\left(\frac{h_1}{a}\right)^2\right]^{-0.5}\right\}\frac{E_2}{E_1}\right.$$

$$\left. + \left\{1+\left[0.8\frac{h_1}{a}\left(\frac{E_1}{E_2}\right)^{1/3}\right]^2\right\}\right) \qquad \text{(B)}$$

h_1 = thickness of overlay

E_1 = modulus of overlay assumed as 3.5 GPa

Allowable Deflection

- It is assumed that there is a unique relationship between design deflection in mm and the allowable ESAL as shown by the following equation
  - $D_a = 26.322\ (ESAL)^{-0.2438}$ (C)

Overlay Thickness Design

- Determine the modulus value (E_2) of layer 2 using characteristic deflection in Eq. (A)
- Determine the allowable deflection using Eq. (C)
- Using Eq. (B) and taking D_d as D_a find the thickness of overlay h_1

Remaining Life

- Determine the characteristic deflection (D_c)
- Obtain remaining life (ESAL) from Eq. (C) by assuming D_c as D_a.
- Find the Growth Factor knowing the current year $(ESAL)_0$
- Growth factor = $(ESAL)_r$ / $(ESAL)_0$
- Estimate the traffic growth rate and find the design period corresponding to the growth factor