十、Design of Overlays for Flexible Pavements

参考資料：

1. Darter, M. I. " Techniques for Pavement Rehabilitation," Training Course, FHWA, 1987. (Block 5, Module 5C)
2. AASHTO, "AASHTO Guide for Design of Pavement Structures," Volume I, 1993. (Chapter 5)

◎Approaches

1. Engineering Judgement
2. Structural Deficiency:
   AASHTO structural number approach, Corps of Engineers
3. Deflection approach:
   Asphalt Institute (AI), California, Texas
4. Mechanistic Fatigue Damage Approach:
   (a) characteristic of pavements, E's
   (b) past damage
   (c) remaining life
   (d) required overlay thickness
   ➔ Not widely utilized

◎Types of Overlays over Rigid Pavements

AC, PCC (same as before)

◎Fundamentals of the AASHTO Overlay Design Procedure (Figure 2)

※Basic AASHTO Design Procedure:

Figure 1 Relationship of Serviceability, structural capacity, and traffic

$$SN_{OL} = SN_y - F_{RL}(SN_{xeff})$$

$$h_{OL} = SN_{OL} / a_{OL}$$

SN_{xeff} = effective structural capacity

F_{RL} = remaining life factor ≤ 1.0

◎AASHTO Flexible Overlay Design Over Flexible Pavements

Major Seven Steps:

1. Analysis unit delineation
2. Traffic analysis
3. Material and environmental study
4. Effective structural capacity analysis (SC_{xeff})
5. Future overlay structural capacity analysis (SC_y)
6. Remainling life factor deterimination (F_{RL})
7. Overlay design analysis

※Analysis Unit Delineation

1. determine boundaries along the project
2. accurate historic data available / unavailable

※Traffic Analysis (ESAL)

※Material and Environmental Study

1. existing pavement layer properties

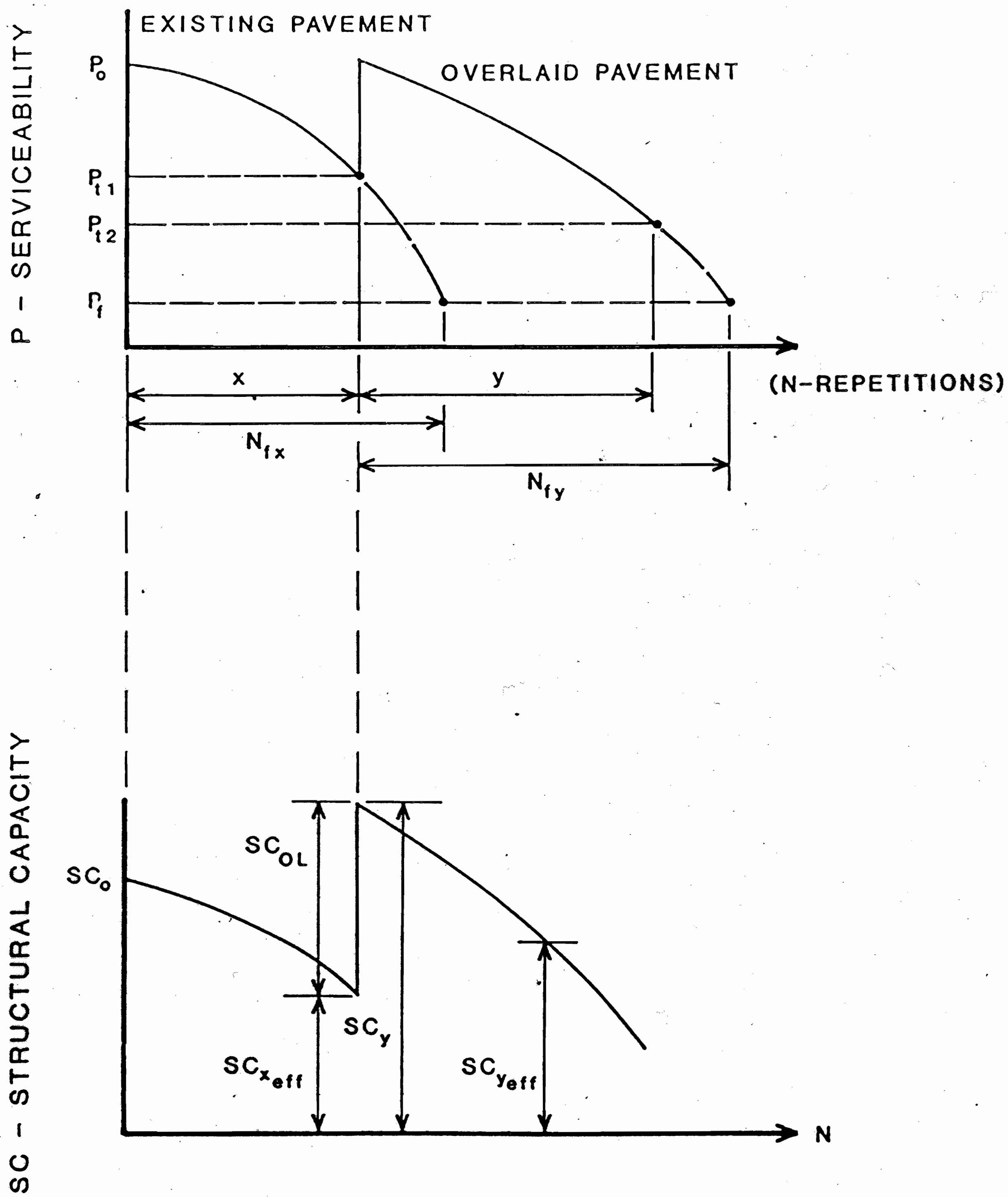


Figure 1. Influence of Traffic Loading on Pavement Serviceability and Structural Capacity (1).

NDT ➔ backcalculation techniques

2. existing subgrade properties (stress sensitivity)
3. design properties of overlay layers

※Effective Structural Capacity Analysis (SC_{xeff})

1. Estimate drainage coefficients (m_i) (Figure 3)
2. Use the modulus values determined in step 3 to determine existing layer coefficients (Figure 4 - Figure 8)
3. Calculate SN_{xeff}

$$SN_{xeff} = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

※Future overlay structural capacity analysis (SN_y)

Simply a new pavement design

※Remaining life factor determination (F_{RL})

1. Remaining life of existing pavement:
   NDT (Figure 9), Traffic Approach, Time Approach (Figure 10), Serviceability Approach (Figure 11), Visual Condition Survey Approach (Figure 12)
2. Remaining life of overlaid pavement (Figure 2)
3. Use R_{Lx} and R_{Ly} to determine F_{RL} (Figure 13)
   The procedure is very confusing and was removed in the new AASHTO Guide (1993).

※AC overlay thickness determination

$$h_{OL} = SN/a_{OL}$$

Figure 3. Recommended m_i Values for Modifying Structural Layer Coefficients of Untreated Base and Sub-Base Materials in Flexible Pavements.

Quality of Drainage	Percent of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
	Less Than 1%	1 - 5%	5 - 25%	Greater Than 25%
Excellent	1.40 - 1.35	1.35 - 1.30	1.30 - 1.20	1.20
Good	1.35 - 1.25	1.25 - 1.15	1.15 - 1.00	1.00
Fair	1.25 - 1.15	1.15 - 1.05	1.00 - 0.80	0.80
Poor	1.15 - 1.05	1.05 - 0.80	0.80 - 0.60	0.60
Very Poor	1.05 - 0.95	0.95 - 0.75	0.75 - 0.40	0.40

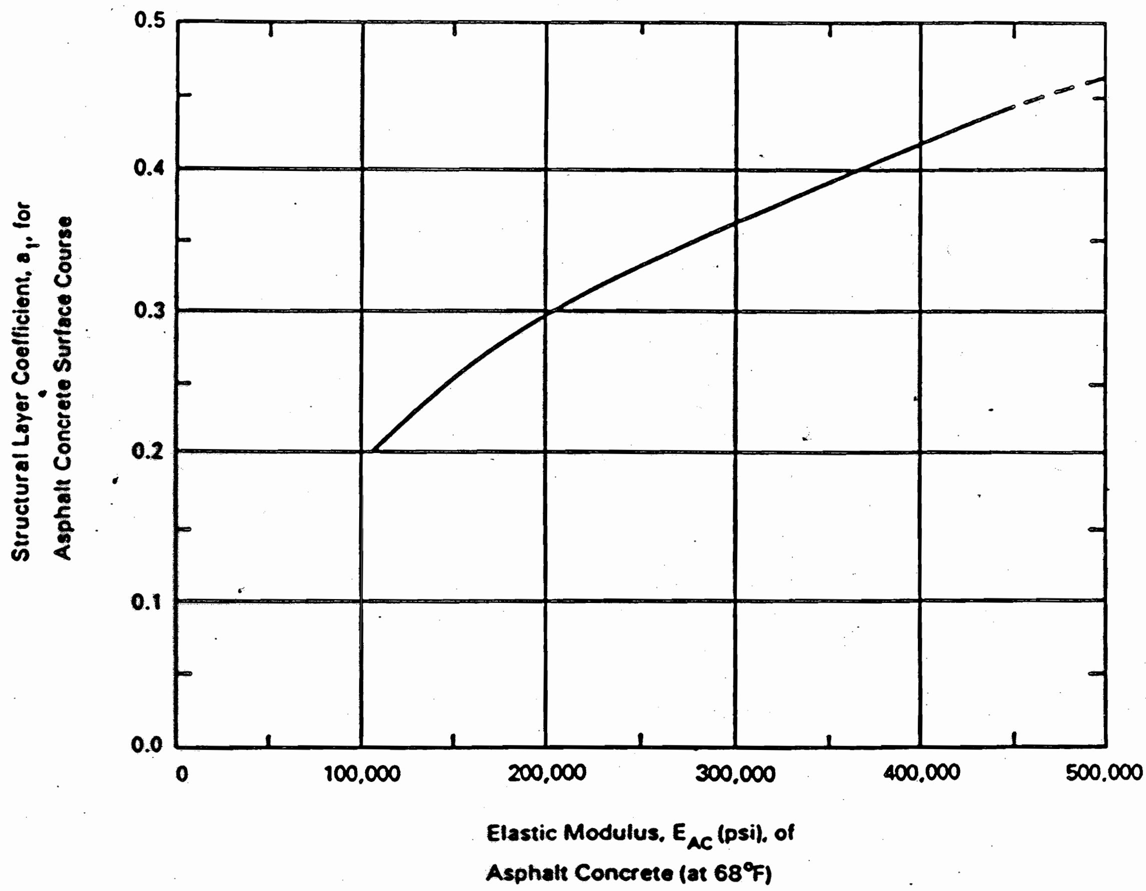
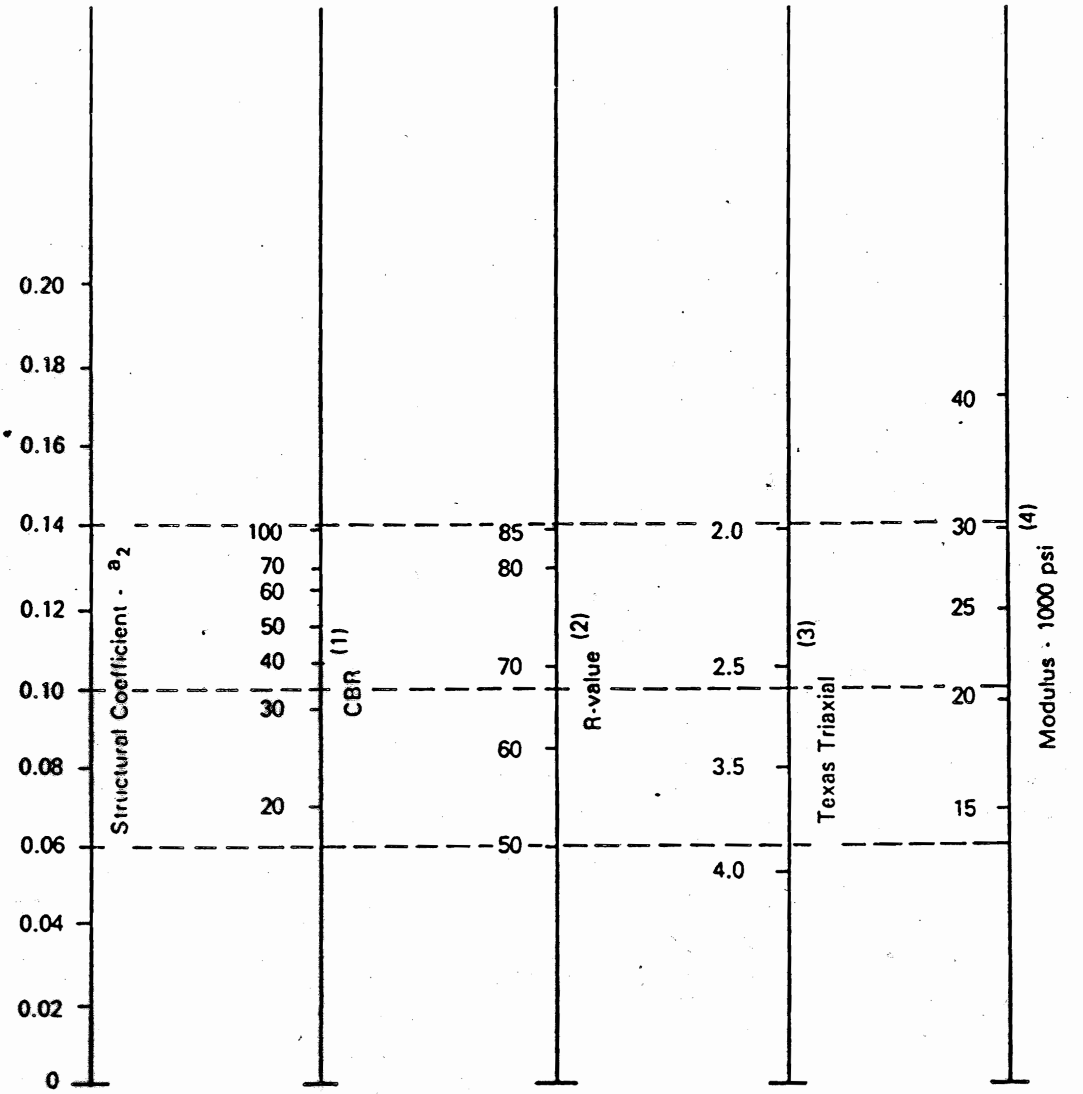


Figure 4. Resilient Modulus of Asphaltic Concrete Related to Structural Layer Coefficient.



(1) Scale derived by averaging correlations obtained from Illinois.
(2) Scale derived by averaging correlations obtained from California, New Mexico and Wyoming.
(3) Scale derived by averaging correlations obtained from Texas.
(4) Scale derived on NCHRP project

Figure 5. Variation in Granular Base Layer Coefficient (a_2) with Various Base Strength Parameters.

◎AASHTO Rigid Overlays Over Flexible Pavements

1. Determine composite modulus of subgrade reaction (k_c)
2. Treat as a new rigid pavement design

◎Example Problems

※Major Steps

Step 1 – Collect basic information and design criteria

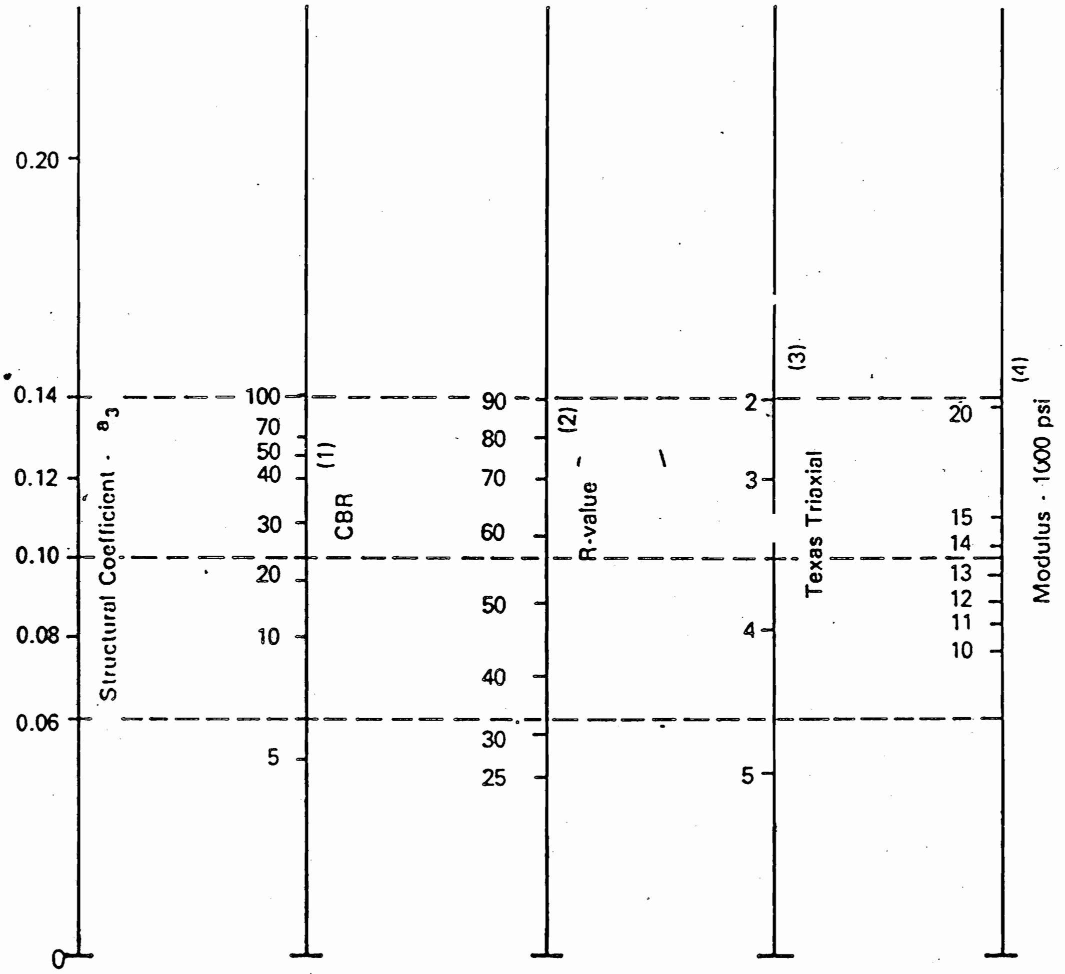
Step 2 – Determine the required structural capacity to support the future traffic

Step 3 – Determine the effective SC of the existing pavement

Step 4 – Determine the remaining life factor

Step 5 – Computation of final overlay design thickness

※Design of flexible overlays over flexible pavements (Figure 20 ~ Figure 22)



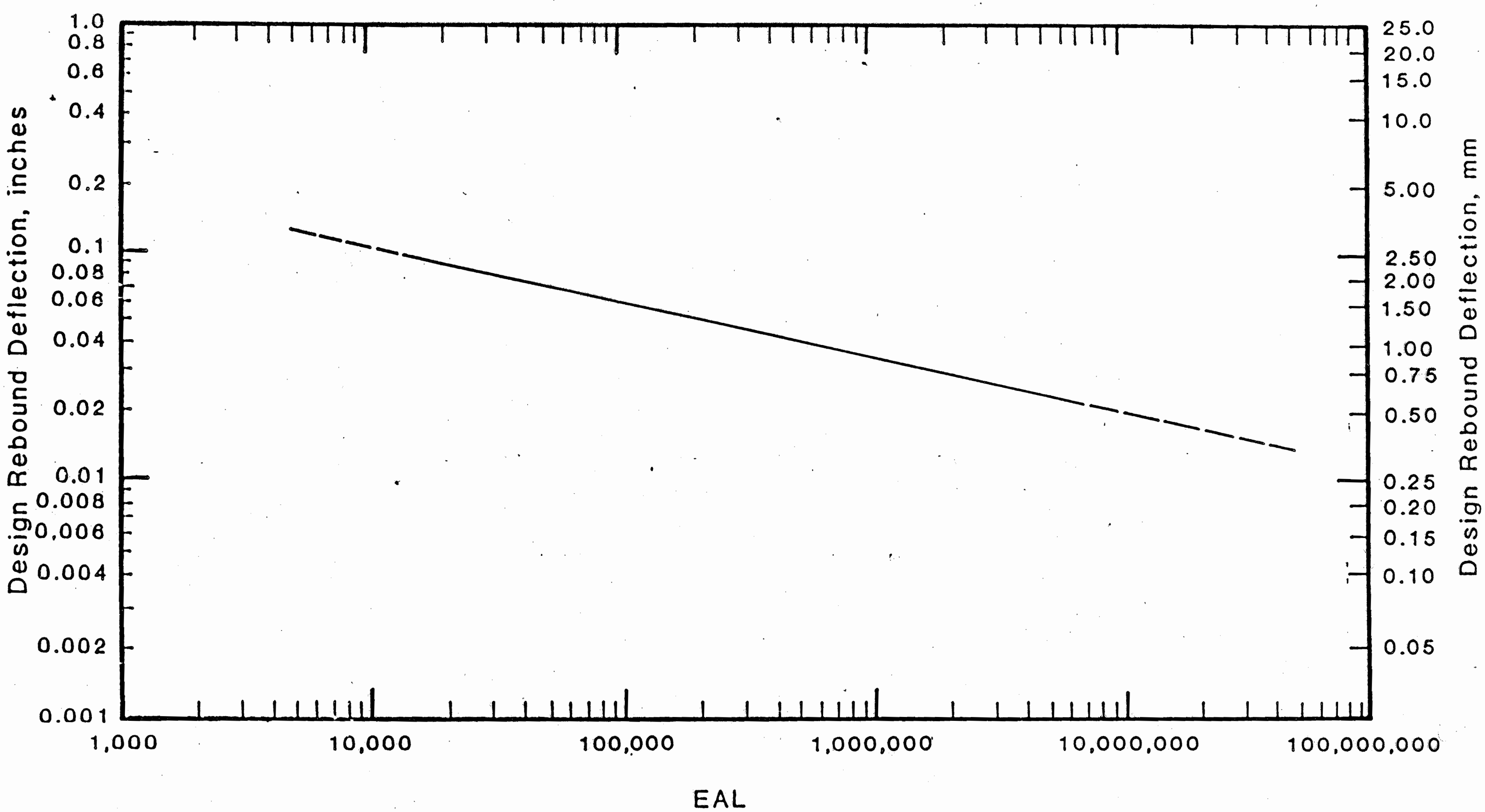
(1) Scale derived from correlations from Illinois.

(2) Scale derived from correlations obtained from The Asphalt Institute, California, New Mexico and Wyoming.

(3) Scale derived from correlations obtained from Texas.

(4) Scale derived on NCHRP project *(3)*.

Figure 8. Variation in Granular Subbase Layer Coefficient (a_3) with Various Subbase Strength Parameters.



Design Rebound Deflection Chart

Figure 14. Influence of Deflections on Number of 18-kip ESAL Applications to Failure (3).

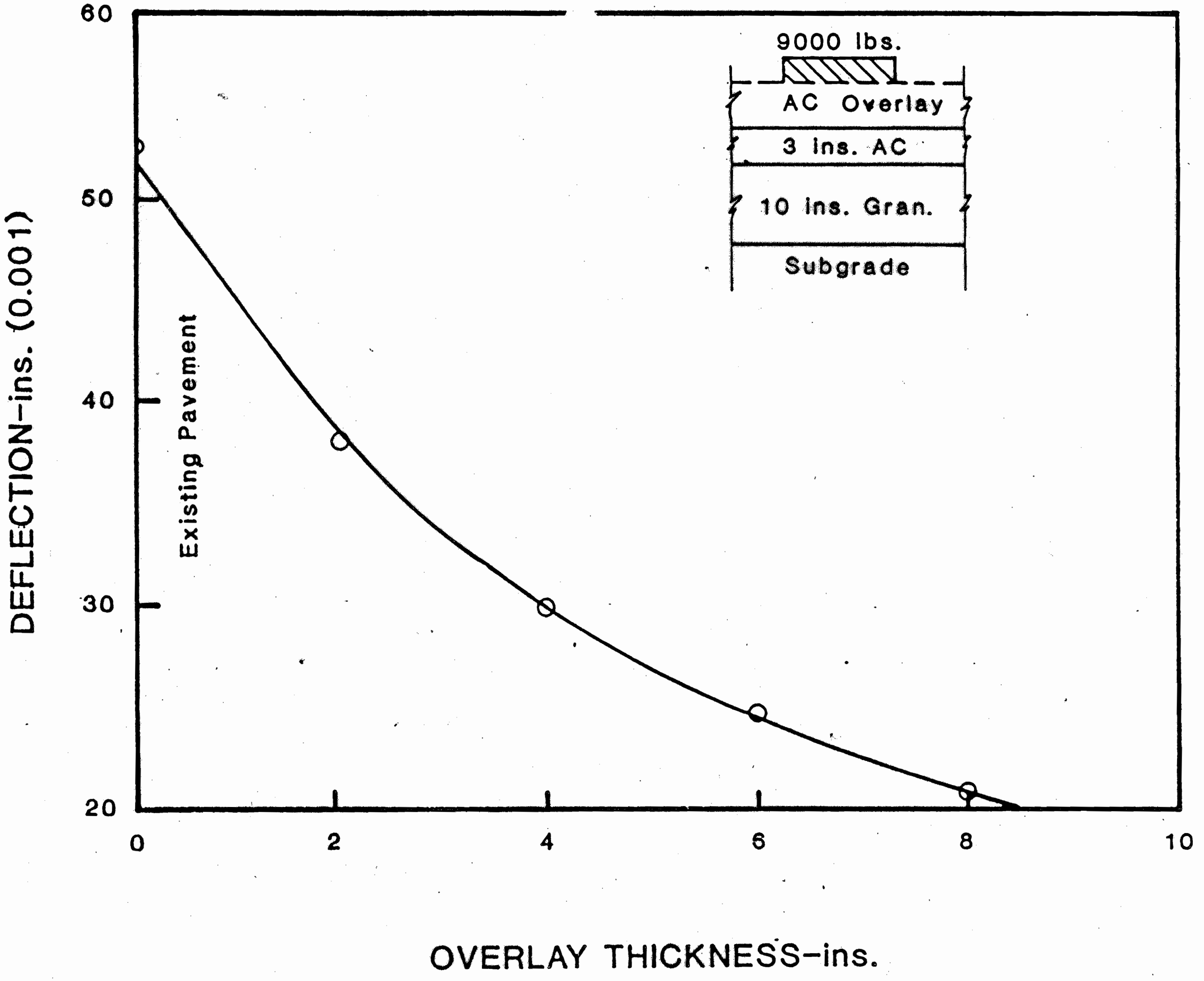


Figure 15. Effect of Overlay Thicknesses on Maximum Deflection Using Elastic Layer Theory.

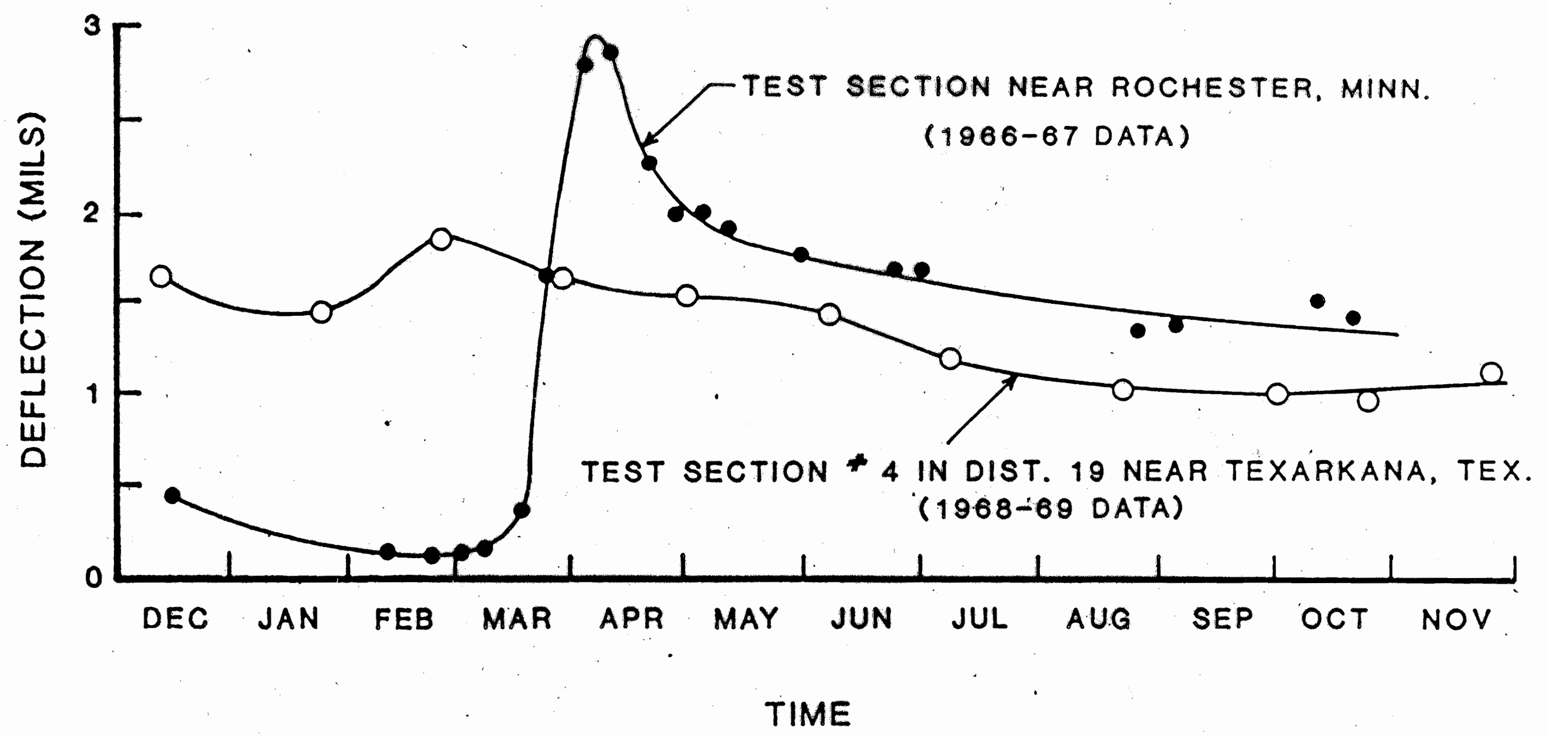


Figure 16. Illustration of the Effect of Geographical Location on Seasonal Deflections (3).

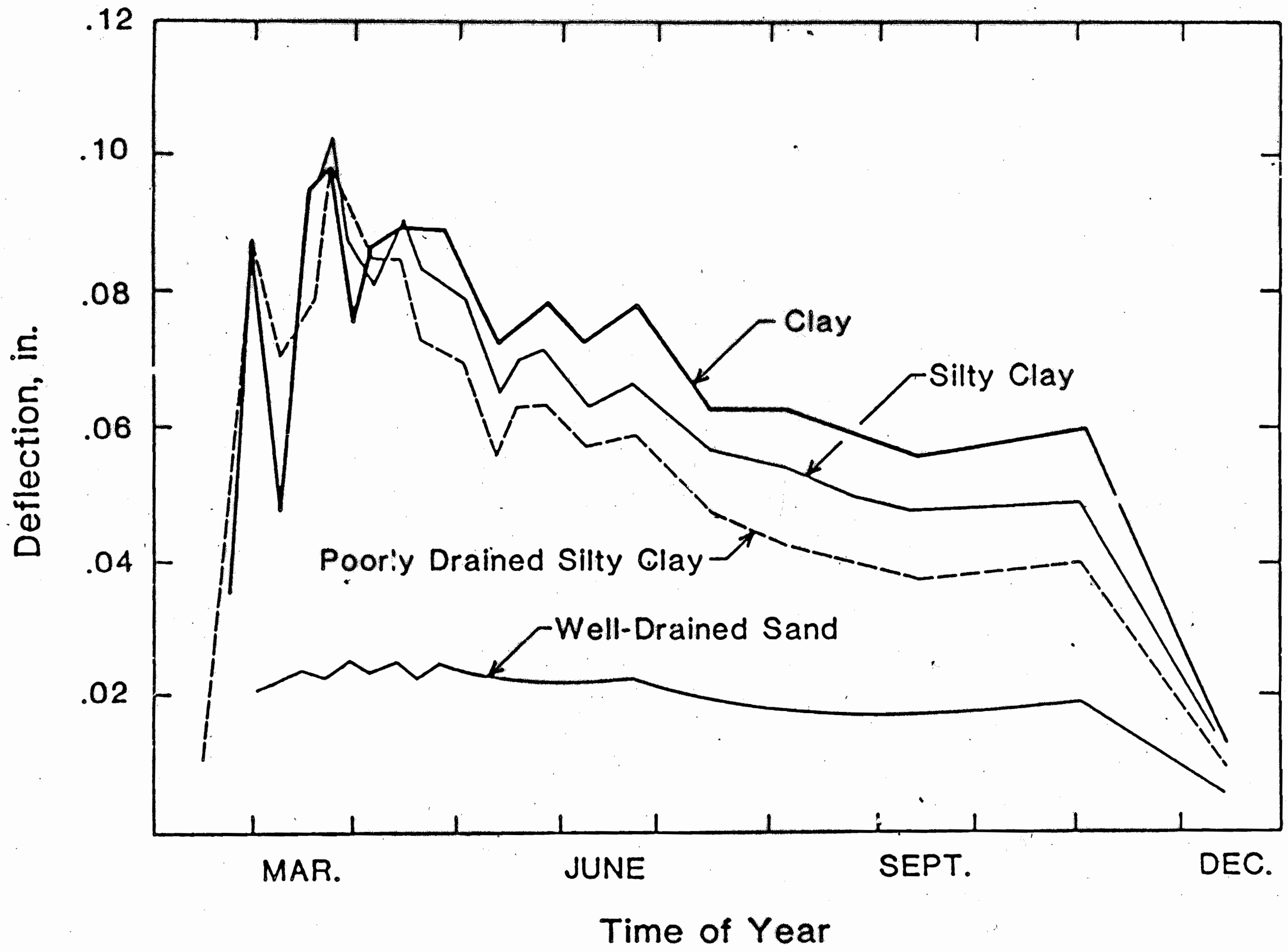


Figure 17. Influence of Subgrade Type on Seasonal Pavement Deflection Variations.

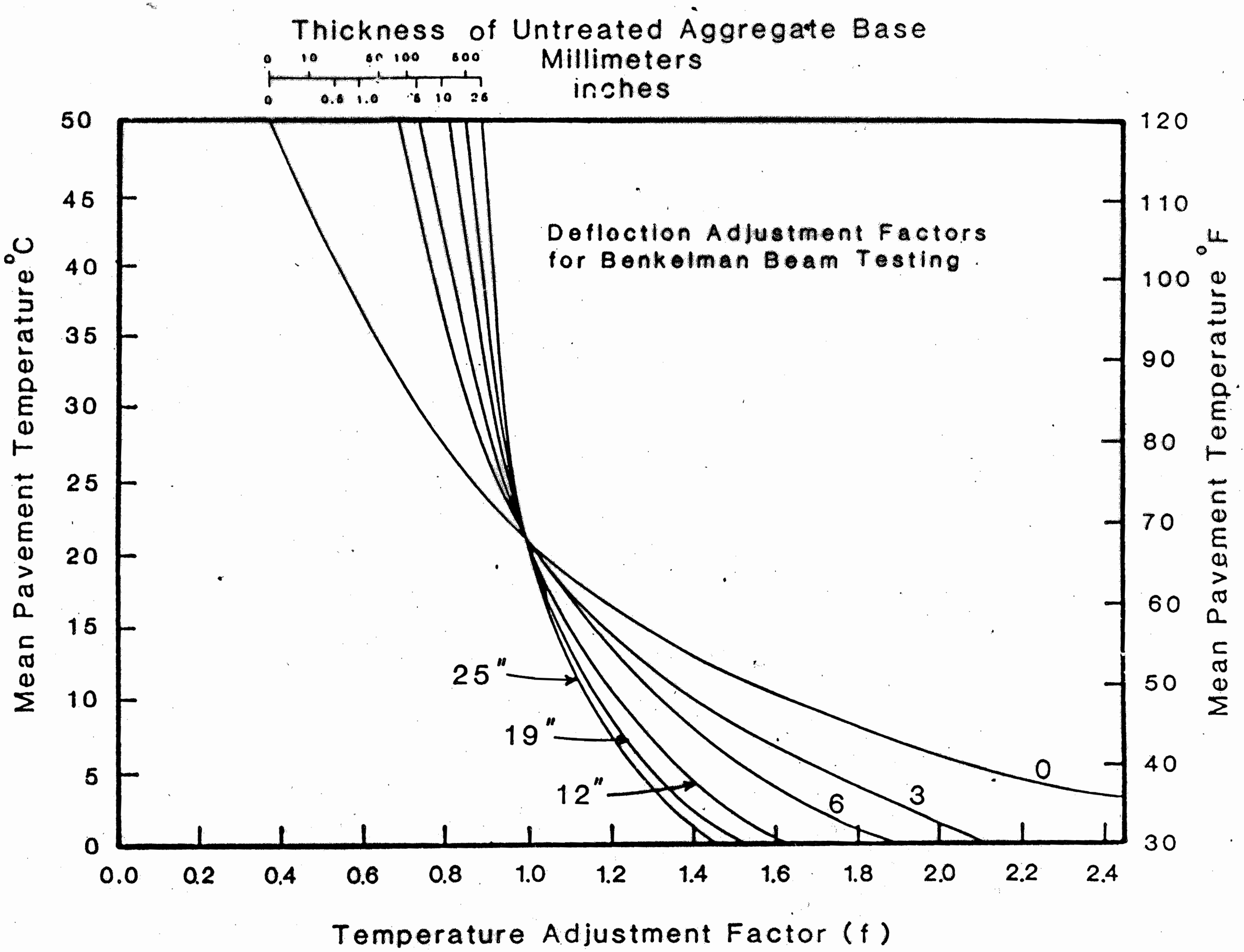


Figure 18. Temperature Adjustment Factors for Benkelman Beam Deflections (3).

AI Overlay

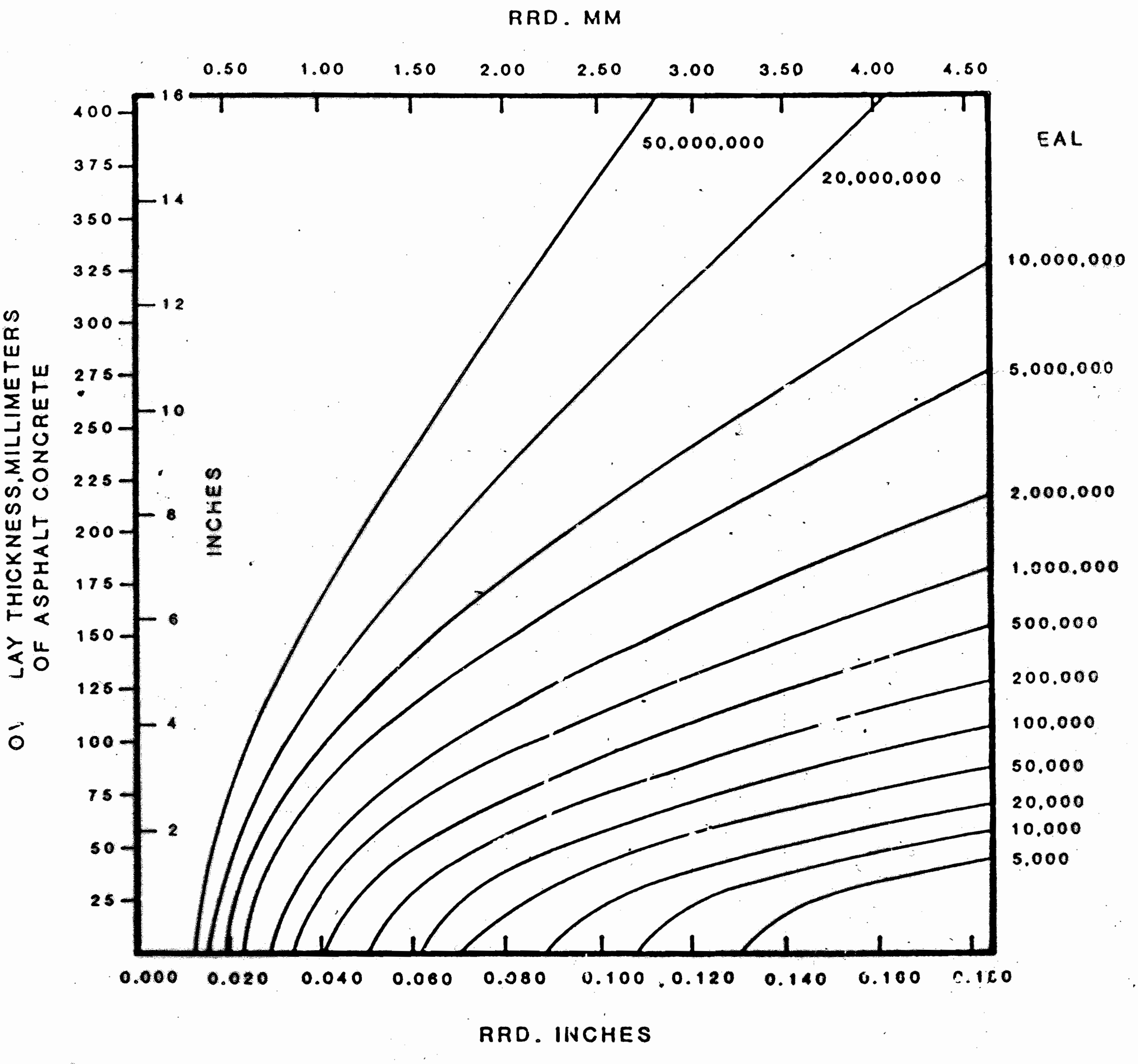


Figure 19. Overlay Thickness Design Chart (3).

RRD = (X + 2S) · c.f