ASPHALTIC CONCRETE OVERLAYS OF RIGID AND FLEXIBLE PAVEMENTS

Interim Report No. 1

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Research Report No. 109

Research Project No. 69-3B
Louisiana HPR 1 (14)

Conducted By
LOUISIANA DEPARTMENT OF TRANSPORTATION
AND DEVELOPMENT, OFFICE OF HIGHWAYS
Research and Development Section
In Cooperation with
U. S. Department of Transportation
FEDERAL HIGHWAY ADMINISTRATION

SEPTEMBER 1977

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Asphalt Institute in their evaluation of the effects of asphalt mix variations on pavement deflections.

The authors are equally grateful for the diligent efforts of Messrs. Bruce J. Gueho, Wiley M. Depew, and Charles W. Johnson in the collection and reduction of data for this project.

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ABSTRACT

Determination of pavement overlay needs should logically encompass a quantitative analysis of the strengths and weaknesses within the pavement system. Personal experience and, to a lesser extent, destructive sampling and testing techniques have not always provided satisfactory means of selecting asphaltic concrete overlay thicknesses, from the standpoint of economics or objectivity. This study represents the development of an asphaltic concrete overlay design procedure which is less dependent on human judgement in evaluating pavement strengths.

The Dynaflect device and Mays Ride Meter were used to evaluate the structural and functional condition, respectively, of 53 test sections (27 asphalt, 15 composite, 11 P.C.C.) before overlay, and after overlay on a semiannual basis. Twenty-eight of the overlaid test sections have reached a point of structural failure after approximately six years of service. Tolerable deflection-traffic load relationships and the deflection attenuation properties of asphaltic concrete have been developed, representing the subgrade support conditions and properties of materials used in Louisiana. All deflection measurements of asphaltic concrete have been corrected for the effects of temperature. Deflection measurements taken before and after overlay were also adjusted to minimize the effect of seasonal subgrade moisture variation. This was accomplished using a graphical application of the two layered elastic theory.

Design guides for selecting the asphaltic concrete overlay thickness required to structurally rehabilitate flexible, composite, and rigid pavements have been developed. Overlay thickness requirements computed using the guides appear to be in close agreement with overlay requirements determined from the Louisiana-AASHO Flexible Pavement Design Guide.

INTRODUCTION

In the past the overlay design concept has been the simplest and fastest means of restoring the deteriorating surface courses of rigid and flexible pavements. The quality of design for many pavement overlays has suffered due to too great an emphasis on human judgement, however.

It is becoming increasingly important to establish a comprehensive overlay design procedure which emphasizes the two primary variables associated with pavement restoration--rideability and structural stability. This study considered these variables in developing design guides for asphaltic concrete overlays of flexible, composite, and rigid pavements. Tentative guides presented herein are based primarily on the structural needs of the pavements as determined by deflection analyses.

SCOPE

This study evaluated the effect of a given thickness of asphaltic concrete overlay in rehabilitating 53 test sections conforming to the experiment design. This factorial design specified various levels of traffic intensity and overlay thickness for both rigid and flexible pavements. Secondary variables considered were existing pavement structure components and quality of each, subgrade soil conditions, environment, and quality of the overlay mix.

This report presents analyses based on 11 semiannual evaluations of the test sections. Evaluation was comprised mainly of deflection and serviceability measurements and visual inspections.

Asphaltic concrete overlay thickness design guides have been developed for flexible, composite, and rigid pavements. Traffic load accumulations, deflection reduction properties of the overlays, and deflection measurements at failure provided the bases for analyses.

METHOD OF PROCEDURE

The four phases of this study are the project design, the pre-overlay and post-overlay data collection, and a data analysis. An explanation of each follows:

Phase I, Project Design:

An 18-cell factorial design based on the parameters of traffic intensity and thickness of overlay was established as indicated in Figure 1. A records search was conducted to determine the age, past and present traffic data, and the existing pavement structural section of each test project. The geographical locations of the test projects are indicated in Figure 2.

Phase II, Pre-Overlay Data Collection:

A 1,000-foot (305-m) test section was selected from each test project for evaluation. Present serviceability indices (P.S.I.) were determined with the Mays Ride Meter. Pavement deflections were measured with the Dynamic Deflection Determination System (Dynaflect). A description of the Mays Ride Meter and the Dynaflect device may be found in Appendix A. Deflection readings were obtained in alternate wheel paths at 100-foot (31-m) intervals in the outside lane of the test sections. During this time, air and surface temperatures were recorded. In-place moisture contents of the upper embankment layer were taken near the edge of the pavement to supplement the deflection data. Pertinent surface observations (cracking, patching, rutting, pavement crushing, etc.) were also noted. Traffic data was obtained from the Traffic and Planning Division to reflect pre-overlay traffic conditions.

Phase III, Post-Overlay Data Collection:

Coring provided the actual overlay thicknesses and made possible a condition evaluation of the surface, base, and subgrade materials. Tests conducted on the asphaltic concrete mixes included those for

FIGURE 1

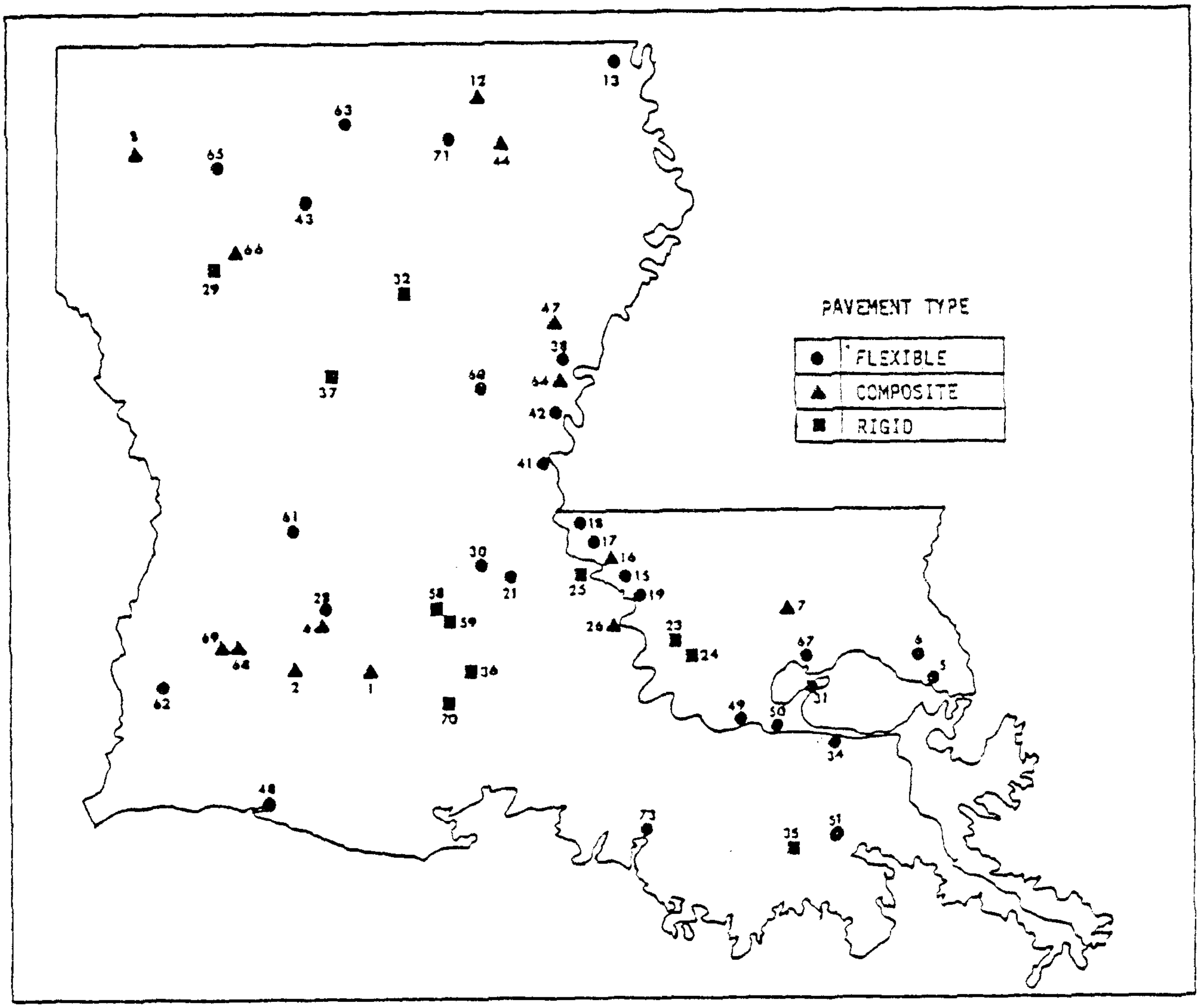
STUDY FACTORIAL DESIGN (TEST SECTION NUMBERS)

	RIGID PAVEMENT	FLEXIBLE PAVEMENT	RIGID PAVEMENT	FLEXIBLE PAVEMENT	RIGID PAVEMENT	FLEXIBLE PAVEMENT
ADT 4000+	58 59 64 *	15 67 73	7 * 12 * 23 24 26 *	5 31 71	16 * 36 70	6 17 51
ADT 1000-4000	66 * 68 * 69 *	19 38 62	1 * 2 * 25 28 * 29 32 37	18 48 61	4 * 8 * 35 44 * 47 *	13 60
ADT 0-1000		30 50 65		21 34 43 49		41 42 63
	THIN OVERLAYS 2 INCHES OR LESS		MEDIUM OVERLAYS 2 TO 4 INCHES		THICK OVERLAYS 4 INCHES OR GREATER	

*COMPOSITE PAVEMENT

FIGURE 2

LOCATION OF TEST PROJECTS



density, specific gravity, Marshall Stability, and cohesiometer. Deflections and P.S.I. determinations were made before overlay, after overlay, and semiannually thereafter. The Traffic and Planning Division provided traffic volume data for the time at which the overlay was constructed and subsequently on an annual basis. Pavement deterioration was noted to determine the point of structural failure of each overlaid test section. Fatigue cracking was the primary criterion used to define the failures.

Phase IV, Analysis:

Upon accumulation of sufficient data, a preliminary analysis was made to establish tolerable deflection levels and deflection attenuation relationships on rigid, flexible, and composite pavements. The overlay thickness design guides were then developed from these relationships.

DISCUSSION OF RESULTS

The results of the study are divided into three sections. The first section relates tolerable deflection levels for flexible and rigid pavements. These "critical" deflections represent the maximum pavement deflection allowable before failures occur in the form of fatigue cracks. The second section deals with deflection attenuation or the ability of a given thickness of asphaltic concrete overlay to reduce measured deflections to a tolerable level. The third section describes Louisiana's tentative design procedure for selecting the thickness of asphalt resurfacing needed in rehabilitating existing rigid, flexible, and composite pavements. Composite pavements are P.C.C. pavements which have been previously overlaid.

Tolerable Deflection

Tolerable deflections were measured on two types of pavement surfaces in this study. These include flexible or asphalt surfaces and rigid or jointed P.C.C. surfaces. These deflections were measured at a designated point of structural failure--the development of fatigue cracks.

Figure 3 and the first three columns of Table 1 relate the tolerable deflection-traffic load relationships determined for asphaltic concrete. The values represent end of life deflections for failed asphalt overlays. These overlay test sections represent 28 of the original 53 test pavements selected for evaluation. The sections include overlays of all three types of pavements: flexible, composite, and rigid.

Figure 4 and Table 2 relate the tolerable deflection--traffic load relationships determined for portland cement concrete pavement. Eleven of the original 53 test sections were jointed concrete pavement. Deflection tests represent the end of life condition on all test sections with the exception of section number 58, which was less than a year old prior to overlay.

FIGURE 3

TENTATIVE TOLERABLE DEFLECTION GUIDE FOR ASPHALTIC CONCRETE

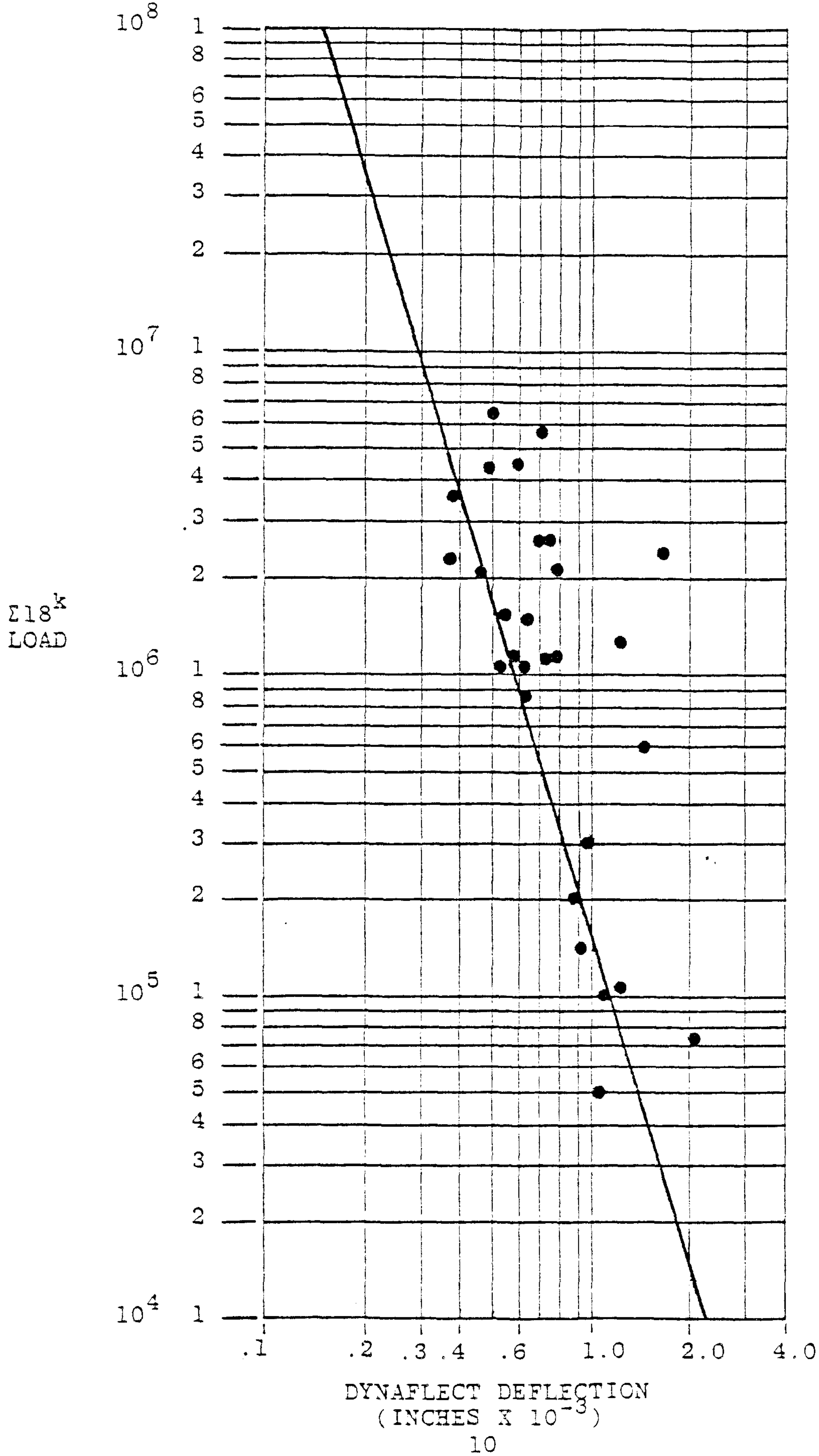


TABLE 1

ASPHALTIC CONCRETE TOLERABLE DEFLECTION DATA (END OF LIFE DEFLECTIONS FOR FAILED ASPHALT OVERLAYS)

Test Section Number	$\Sigma\ 18^k$ Load (x 10^3)	Deflection (In. x 10^{-3})	Percent Spread (% S)	Predicted Structural Numbers (SN)*	Deflection Determined Structural Numbers**	Residual SN
1	1.125	0.62	78	5.3	4.6	-0.7
2	0.872	0.63	81	5.0	4.6	-0.4
4	4.370	0.50	81	5.0	4.9	-0.1
7	2.361	0.39	84	6.0	5.9	-0.1
15	1.159	0.59	59	2.2	2.7	+0.5
17	1.121	0.53	60	2.3	2.8	+0.5
19	0.160	0.92	49	1.4	1.0	-0.4
21	0.106	1.34	59	1.4	1.4	0.0
23	6.400	0.50	81	4.4	4.9	+0.5
24	5.751	0.71	85	4.5	4.8	+0.3
25	1.356	1.27	73	3.0	2.8	-0.2
26	1.681	0.67	75	4.2	4.1	-0.1
28	3.635	0.39	78	5.2	5.4	+0.2
29	1.732	0.53	75	4.0	4.3	+0.3
34	0.075	2.12	74	1.9	2.1	+0.2
35	0.204	0.89	78	4.2	4.0	-0.2
36	2.723	0.70	78	4.6	4.3	-0.3
38	0.600	1.55	60	1.5	1.4	-0.1
48	0.295	0.98	63	2.1	2.3	+0.2
49	0.101	1.14	76	3.3	3.4	+0.1
51	2.662	0.71	83	4.5	4.7	+0.2
60	2.090	0.80	74	3.9	3.7	-0.2
62	0.051	1.02	62	1.9	1.9	0.0
64	4.441	0.62	82	4.9	4.8	-0.1
66	2.117	0.46	75	4.4	4.6	+0.2
67	2.436	1.83	72	2.0	2.1	+0.1
68	1.184	0.68	65	3.5	3.2	-0.3
69	1.184	0.70	66	3.5	3.2	-0.3

*Estimated from pavement cores.

**From Figure 6, page 18.

Average Absolute Residual = 0.24

Standard Deviation = 0.17

FIGURE 4

TENTATIVE TOLERABLE DEFLECTION GUIDE FOR PORTLAND CEMENT CONCRETE PAVEMENTS

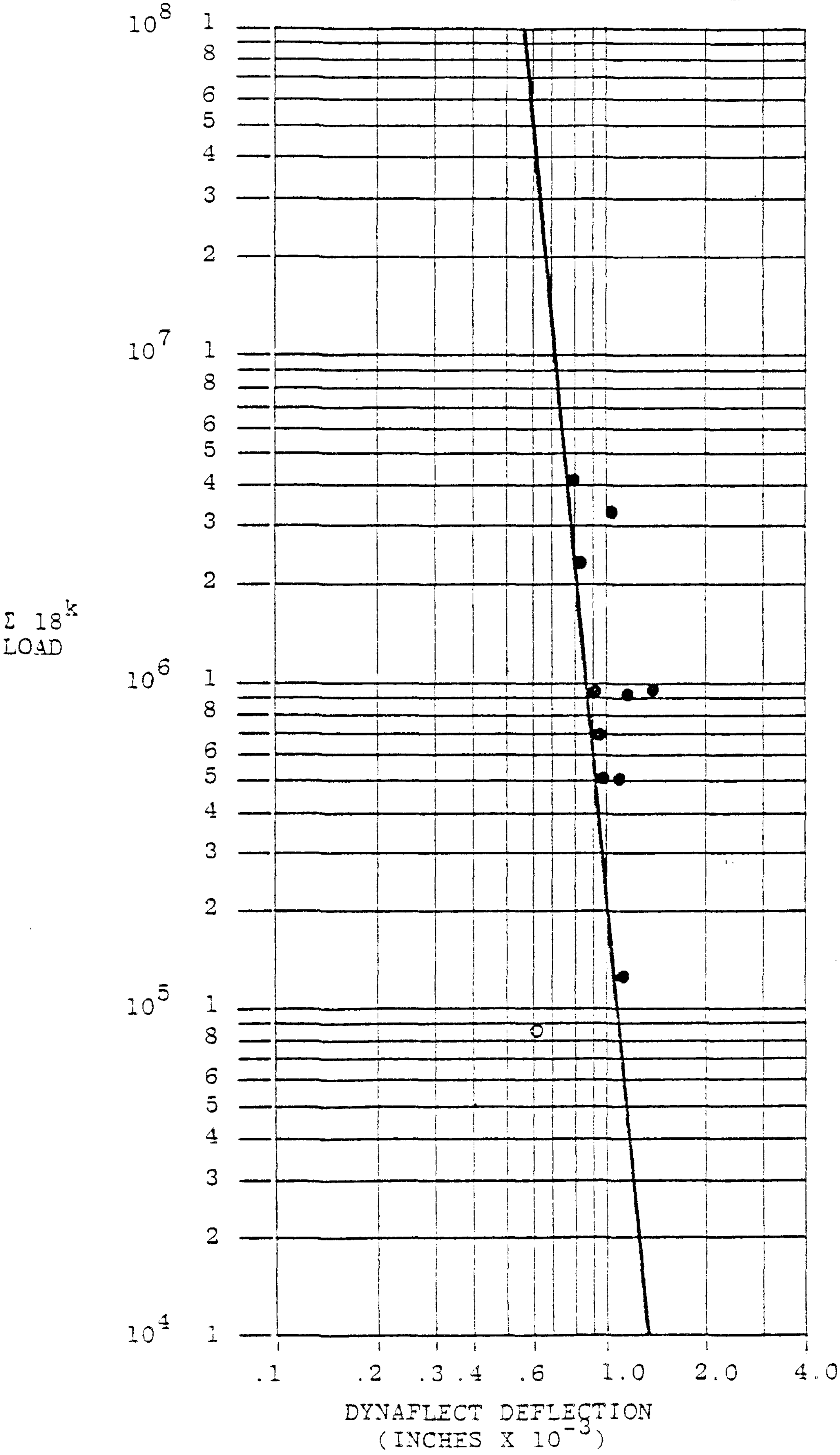


TABLE 2

PORTLAND CEMENT CONCRETE TOLERABLE DEFLECTION DATA
(END OF LIFE DEFLECTIONS ON P.C.C. SECTIONS BEFORE OVERLAY)

Section Number	$\Sigma\ 18^k$ Load ($\times 10^3$)	Deflection Mid Slab (In. $\times 10^{-3}$)	P.C.C. Pavement Thickness (Inches)
23	4.010	0.81	8/7/8
24	3.378	1.08	8/7/8
25	0.973	1.50	6
29	0.974	0.96	6
32	0.512	1.06	8
35	0.139	1.14	9/6/9
36	2.363	0.85	8/6/8
37	0.517	1.04	8
58*	0.088	0.62	8
59	0.696	0.91	7
70	0.924	1.22	6

*This P.C.C. pavement was less than one year old prior to overlay and, therefore, does not represent an end of life deflection.

Theoretically, the tolerable deflections represent the end of the design life of a pavement which has been subjected to an indicated number of applications of an equivalent, 18,000-pound (8.16-Mg) single-axle load. An estimate of the traffic loads which will traverse a pavement at some future date has, therefore, an associated tolerable deflection level as indicated in Figures 3 and 4. A comparison of this tolerable deflection with the existing pavement deflection defines the required deflection reduction necessary to prevent fatigue cracking during a selected design period. The relationship between required deflection reduction and thickness of asphalt overlay will be discussed in a later section of the report.

Failure Criteria

The primary failure criterion used to evaluate the P.C.C. pavements prior to overlay and the asphalt overlays of all test pavements was the development of fatigue cracking.

Fatigue cracks occurring in the asphalt blankets of overlaid test sections were further defined as Class II alligator cracking as described in AASHO Road Test Report 5, Pavement Research (9)*. The tolerable deflection relationship indicated in Figure 3 may require some degree of adjustment as additional test sections experience the transition from Class I to Class II fatigue cracking. Included as additional criteria were the development of rutting greater than one-half inch (1.3 cm) and a Present Serviceability Index (P.S.I.) of 2.5 or less. A description of the P.S.I. rating system may be found in Appendix A.

Overlaid test sections in which failure cracks have developed contain only slight to moderate rutting, 0.15 inch (0.38 cm) on the average. Asphaltic concrete pavements constructed in Louisiana are generally

*Underlined numbers in parentheses refer to numbered entries in the section of this report entitled "References."

much stiffer than those found in other states. This is primarily due to an AC-40 asphalt mix used in conjunction with smooth, river-deposited aggregate. Consequently, the asphalt overlays evaluated in this study have been observed to crack before developing severe rutting.

Overall, the P.S.I. values of the failed test sections remain in the "fair" to "good" categories. The roughness values are not expected to drop below 2.5 in many of the sections until alligator cracking has progressed to Class III and patching is required. This is, of course, provided that other types of asphalt failures, such as reflection cracking or waves caused by early base failures, do not develop first. A rapid decrease in pavement serviceability has been observed on flexible pavements once water entering through the surface cracks has further weakened the pavement supporting layers.

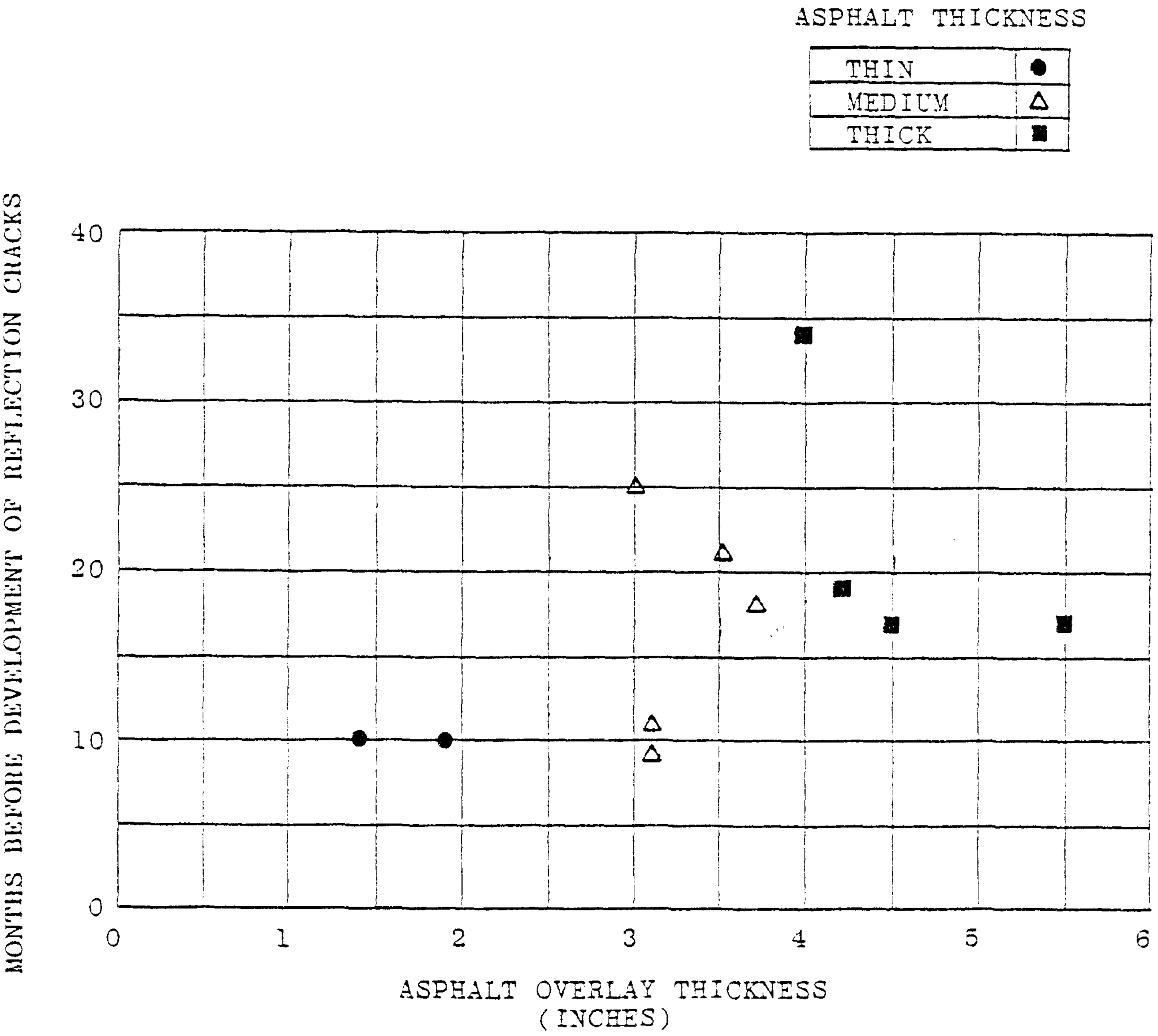
Reflection cracks associated with overlays of jointed concrete pavement were not considered fatigue cracks in this analysis. These cracks are thought to be caused more by thermally induced stresses and strains rather than by the accumulated traffic loads. Figure 5 illustrates the average time in months before reflection cracks were observed over joints in P.C.C. pavements surfaced with thin, medium, and thick asphalt blankets. The thicker blankets, 4 to 6 inches (10 to 15 cm), were observed to have delayed the reflection cracks for no longer than three years in any one section.

Effect of Variables

The primary variable influencing measured deflections was temperature. This was the only variable which could be isolated in this phase of the data analysis. A procedure for determining temperature-deflection correction factors, developed by H. F. Southgate (8), has produced excellent results in Louisiana and is considered a necessary part of all deflection analyses of flexible pavement. All deflections measured in this study have been adjusted to a standard temperature of 60° F. (16° C.). The deflection values adjusted in this manner

FIGURE 5

REFLECTION CRACKING AND OVERLAY THICKNESS



represent deflections which would have been measured had the average temperature of the asphalt blanket been 60° F. (16° C.) Uncorrected deflections measured at high pavement temperatures would have resulted in tolerable deflection levels much greater than those indicated in Figure 3.

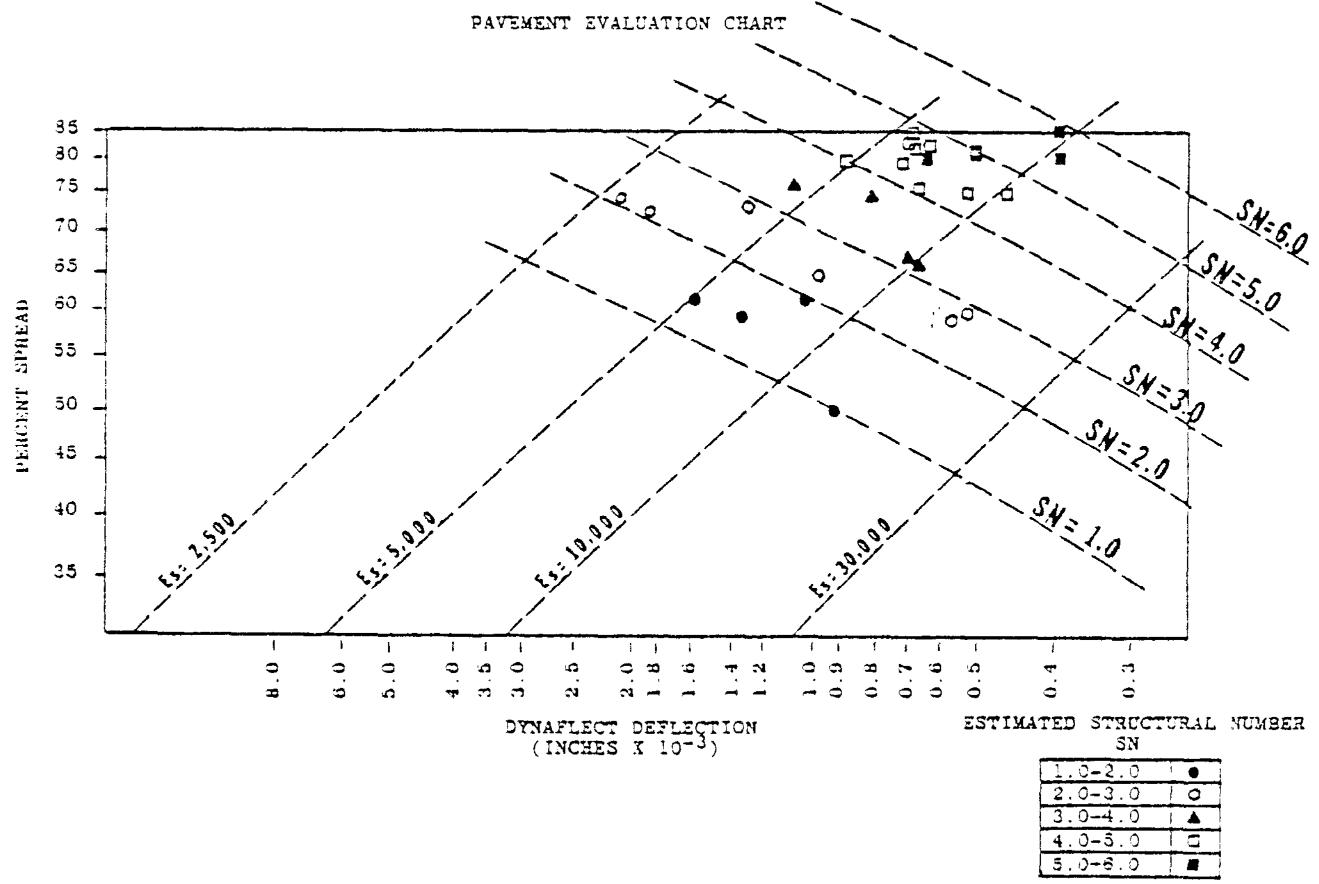
The effects of variations in asphalt mix properties and in theoretical subgrade support on measured deflections were analyzed with the assistance of the Asphalt Institute as reported in reference (4). Results of test data obtained from cores of 22 overlaid test sections were submitted to the Institute for analysis. These tests included density, theoretical specific gravity, Hveem cohesion at 140° F. (60° C.), as well as Marshall stability and flow values at 38° F. (3° C.), 90° F. (32° C.), and 140° F. (60° C.). The results of the analysis indicated that (1) for a given subgrade modulus, the variation in pavement surface deflection does not change drastically with a significant change in asphalt surface modulus, and that (2) for a given surface modulus, the variation in deflection is quite significant for a small change in subgrade modulus.

A general confirmation of these findings was made possible through the application of a modified version of the pavement evaluation chart developed by N. K. Vaswani (10). The chart represents a graphical means of distinguishing between the performance or strength contribution of the subgrade and the pavement layers. Deflection analyses of pavement systems can be very misleading without the ability to make this distinction. A seasonal change in subgrade moisture can significantly increase pavement deflections, for example, but this increase may not necessarily indicate a strength loss in the upper pavement layers.

Vaswani defines an additional evaluation parameter termed spreadability which, unlike radius of curvature calculations, has the effect of quantifying the shape of the Dynaflect deflection basin from measurements at five locations along the basin. These five deflections are determined by readings from the five sensors of the Dynaflect device. Spreadability is the average of the five sensor deflection measurements expressed as a percentage of the first sensor deflection value. Spreadability or % Spread is thus defined so that pavements with higher % Spreads have a greater ability to distribute induced traffic loads. An estimate of the subgrade strength (modulus of elasticity, Es) and the relative strength of the total pavement section may be made by plotting % Spread and first sensor deflection values.

The pavement evaluation chart in Figure 6 has been modified to include Louisiana's Dynaflect-Benkelman beam correlation (Figure 21, Appendix B) and estimated structural numbers, SN, using the flexible pavement design coefficients indicated in Table 6, Appendix C.

FIGURE 6
PAVEMENT EVALUATION CHART



The SN values were estimated by visual inspection of cores taken to determine the thickness and condition of each pavement layer after overlay. The data points in Figure 6 are keyed to represent ranges in SN values.

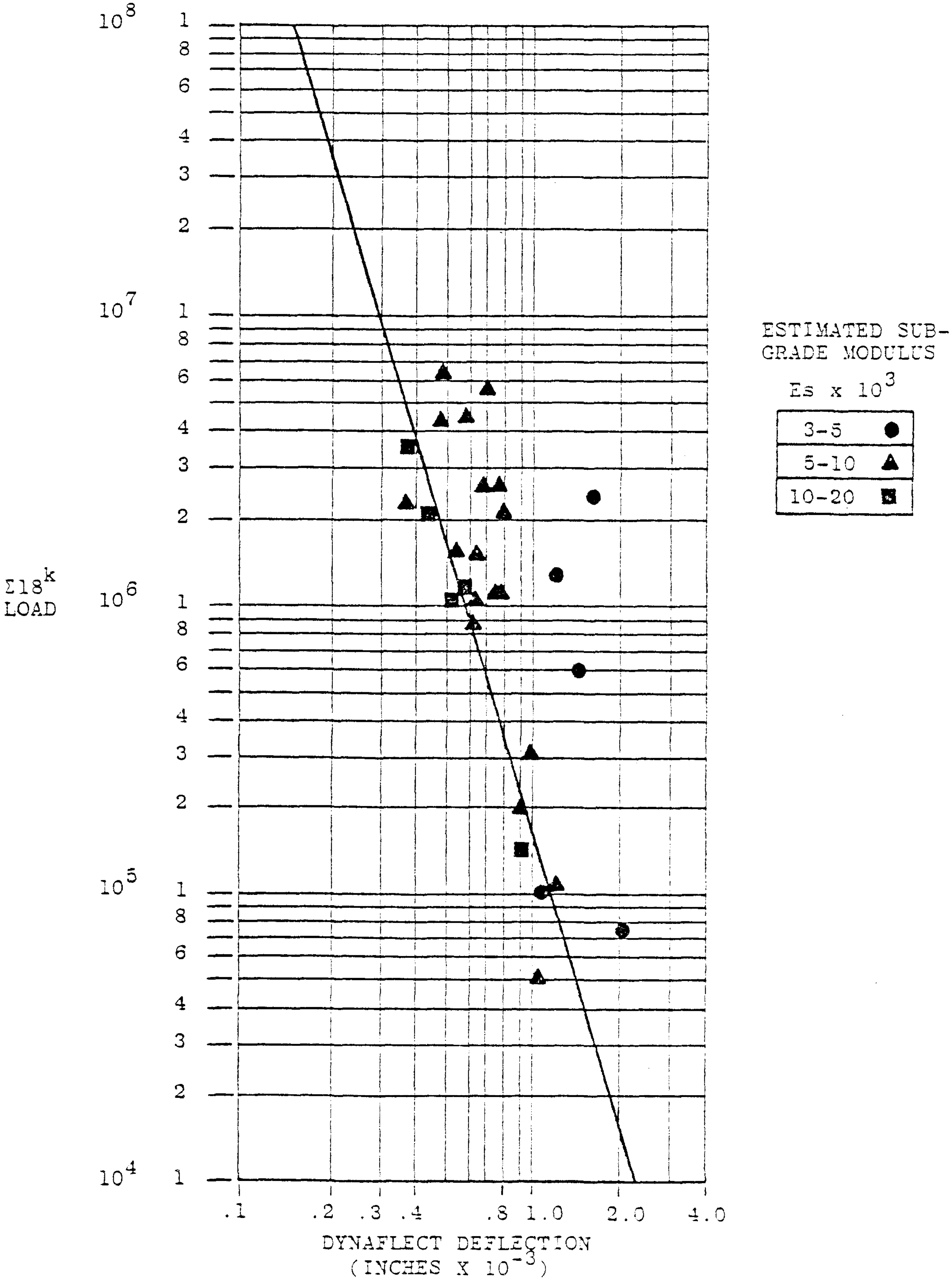
The structural numbers indicated in the chart represent the 28 failed asphalt overlays listed in Table 1. In this table a comparison of predicted and measured structural numbers is provided. The average absolute residual SN is 0.24 with a residual standard deviation of 0.17. Four of the test sections listed in Table 1 have measured SN values which vary from the predicted values by 0.5 or greater. It is believed that these larger residuals are due to incorrect estimates of the pavements structural condition (as determined from the cores). The authors have more confidence in the ability of the Dynaflect device to characterize the pavement strengths.

The pavement evaluation chart divides a pavement section into two strengths: relative subgrade strength (Es) and total pavement strength (SN). Tests on a given pavement at two points in time can provide a means of determining whether the subgrade layers, the pavement layers, or both have decreased in relative strength. From a maintenance standpoint, such information can be used to help in selecting the most appropriate rehabilitation techniques. Some degree of reconstruction may be required, in addition to an asphalt overlay, where base or subgrade failures are detected. Destructive sampling of each pavement layer followed by laboratory testing would be a considerably more expensive method of determining this information if adequate sampling were achieved.

Figure 7 represents the spread in the data used to develop the tolerable deflection guide (Figure 3) for asphaltic concrete. Here the data points are keyed to relative subgrade modulus values estimated from Figure 6. Test sections with weaker Es values, 3,000 to 5,000 P.S.I. (20.7 and 34.5 M Pa.), can be observed to yield higher deflection values than sections with better subgrade support

FIGURE 7

EFFECT OF SUBGRADE STRENGTH ON DEFLECTION

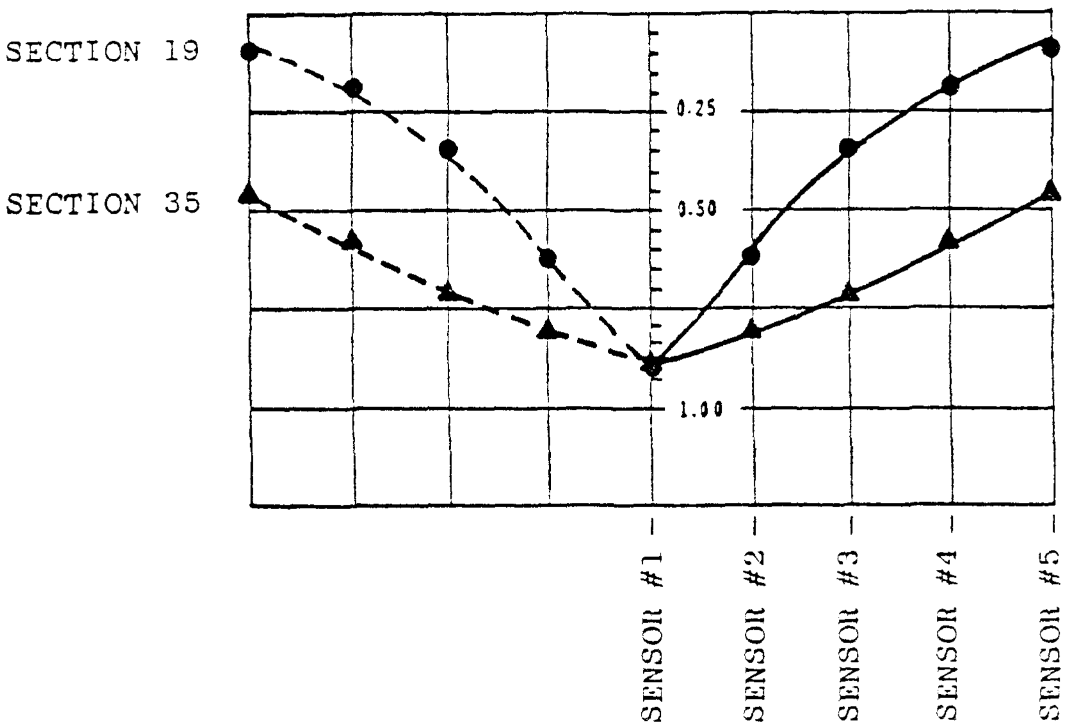


values. This would seem to support the conclusion that variations in subgrade moduli can significantly affect measured deflection levels of pavement systems.

If deflections are influenced by subgrade conditions to this extent, how then can overlay needs be predicted using only measured surface deflections? An answer to this question is provided through the following example: The deflection basins of two test sections are illustrated in Figure 8. The total strength of each of the sections is assumed to be approximately equal, as indicated by the equivalent sensor #1 values. Several structural differences may be observed, however. The Surface Curvature Index, S.C.I., (as defined in Appendix A) and measured structural number, SN, of test section 19 both indicate weak or thin upper pavement layers. Conversely, the S.C.I. and SN values of test section 35 indicate stronger or thicker upper pavement layers. What then is the equalizing factor which makes the two pavement systems approximately equal in strength? The answer may be found by examining the estimated subgrade moduli, Es, of the sections. The thicker pavement was constructed over a relatively weaker subgrade, whereas the thinner pavement was constructed over a relatively stronger subgrade. This comes as no surprise, since the AASHO Design Guides provide thicker pavement sections for decreasing subgrade support capabilities. These comparisons illustrate the ability of deflection tests to characterize the strength and hence the structural needs of pavements with different typical sections, subgrades, etc. An overlay design based on a measured maximum (first sensor) deflection would seem quite adequate then to predict the additional strength required for a pavement system, regardless of the location of its weakest or strongest layers.

FIGURE 8

DEFLECTION BASIN--PAVEMENT CHARACTERISTICS
(TEST SECTIONS 19 AND 35)



SECTION NO.	SN	S.C.I.	% SPREAD	Es
19	1.0	0.30	48	17,000
35	4.0	0.08	78	5,000

Comparison of Research Findings

Alligator type fatigue cracking of flexible pavement is the result of tension cracks which have been extended through the asphalt blanket by the continued application of traffic loads. These tension cracks are the result of tensile stresses which reflect a failure of the lower pavement layers to support the upper pavement layers. With this is mind it is understandable why Louisiana pavements, with relatively weak subgrades and with relatively stiff asphalt mixtures, would experience lower tolerable deflection levels than those measured at the AASHO Road Test, as illustrated in Figure 9.

Deflection Attenuation

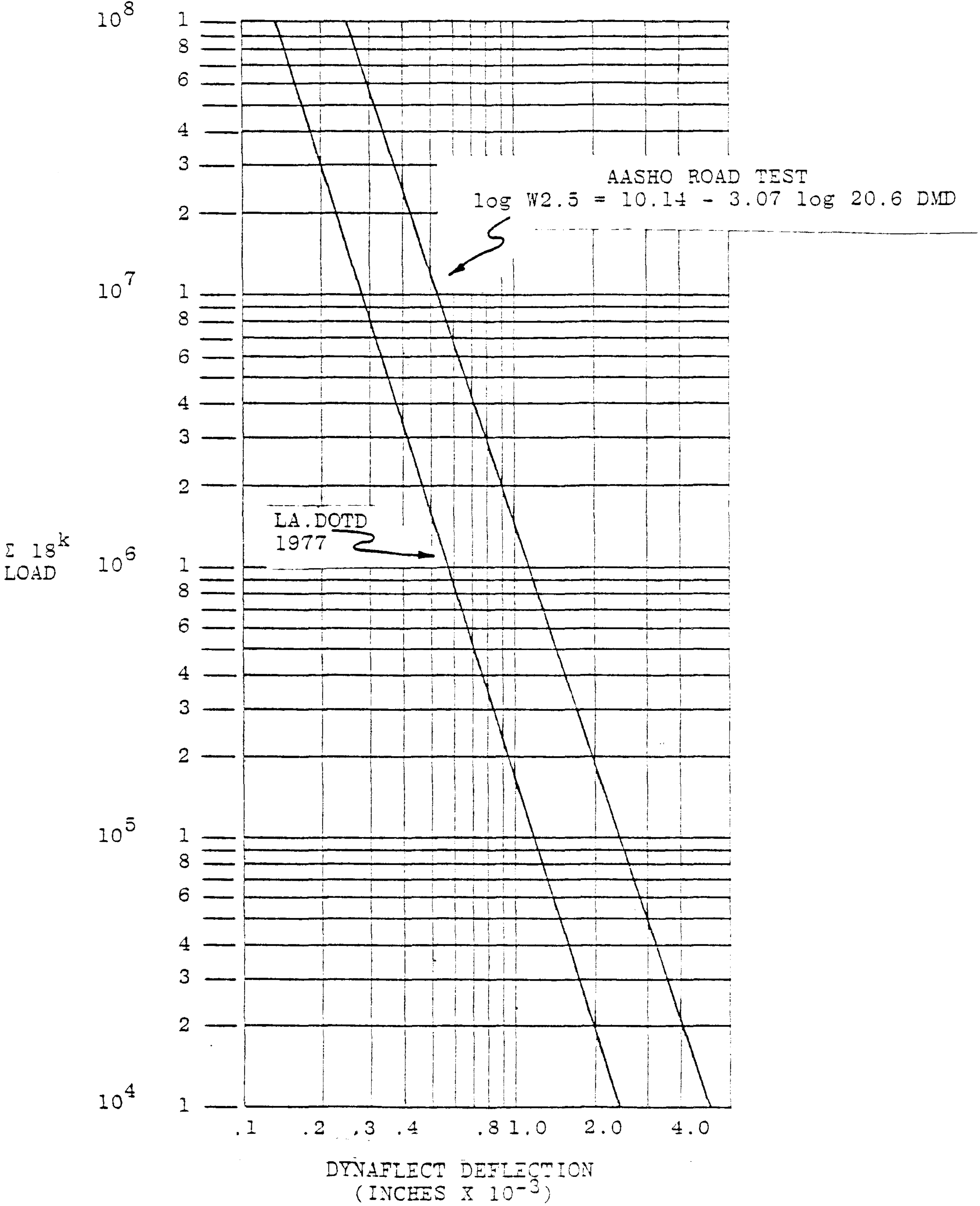
Other researchers have investigated the level of deflection reduction afforded by asphaltic concrete overlays primarily by using one of two methods: (1) by determining the ratio of the strength of asphaltic concrete to the strength of gravel and then developing the deflection attenuation relationship based on the reduction capabilities of gravel, or (2) by measuring pavement deflections before and after overlay and observing the actual percent reduction. The latter was chosen to be the method used in this study.

Effect of Variables

The three most influential factors in the analysis of deflections measured before and after overlay were (1) the effect of temperature, (2) the effect of seasonal subgrade moisture variation, and (3) the effect of the relative deflection levels of each test section before overlay. Deflection values have been adjusted to minimize the effects of changes in temperature and subgrade moisture as indicated in Table 3 and Figure 10 for the flexible test sections, Table 4 and Figure 11 for the composite test sections, and Table 5 and Figure 12 for the rigid test sections. A general reduction in scatter of data points can be observed for each of the three pavement types after adjusting for the effects of these variables.

FIGURE 9

A COMPARISON OF LOUISIANA AND AASHO TOLERABLE DEFLECTIONS FOR ASPHALTIC CONCRETE



AASHO ROAD TEST
$\log W2.5 = 10.14 - 3.07 \log 20.6\ DMD$

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1977

TABLE 3

DEFLECTION ATTENUATION DATA - FLEXIBLE TEST SECTIONS
(BEFORE OVERLAY - AFTER OVERLAY - PERCENT REDUCTION IN DEFLECTION)

TEST SECTION NUMBER	PARENT PAVEMENT THICKNESS (INCHES)			OVERLAY THICKNESS	AS MEASURED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS WITH MOISTURE ADJUSTMENT		
	HMAC	BASE	SUBBASE	(INCHES)	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.
5	4.5/6.5	8" SAND SHELL	11" SELECT SOIL	4.0	1.74	1.40	20	2.52	0.77	69	2.52	1.40	44
6	6.0	12" S/C/G*	12" SELECT SOIL	4.3	1.22	0.69	43	1.38	0.38	72	1.38	0.65	52
13	8.0	16" SELECT SOIL	--	4.5	2.73	0.96	65	3.20	1.10	65	3.20	1.10	65
15	3.3	5" S/C/G	--	2.1	0.70	0.60	14	0.57	0.50	18	0.57	0.50	12
17	3.5	12" SELECT SOIL	--	3.8	0.85	0.53	38	0.64	0.40	38	0.64	0.41	36
18	3.8	6" S/C/G	--	2.5	1.75	0.95	46	1.42	0.80	44	1.42	0.90	36
19	1.0	6" SELECT SOIL	--	1.6	2.30	1.18	49	1.67	0.94	44	1.67	1.16	30
21	2.0	4" S/C/G	--	2.3	2.62	1.50	43	1.86	0.92	51	1.86	1.20	35
30	2.0	7" S/C/G		2.7	1.09	0.94	14	0.74	0.86	0	0.74	0.80	0
31	1.3	36" SAND SHELL	12" SOIL LIME	3.1	2.16	1.63	25	1.23	0.88	28	1.23	0.90	27
34	1.0	5" CLAM SHELL	--	3.1	3.29	2.08	37	2.43	1.73	29	2.43	1.60	33
38	1.8/1.2	5" S/C/G*	--	1.8	2.45	1.80	26	1.67	1.44	14	1.67	1.44	14
41	1.2	6" S/C/G	--	5.9	1.62	1.17	28	1.96	0.67	66	1.96	0.73	63
42	1.2	6" S/C/G	--	5.3	2.55	1.58	38	1.68	0.90	46	1.68	0.86	49
43	2.0	6" SELECT SOIL	--	3.1	0.85	0.56	34	0.80	0.37	54	0.80	0.48	40
48	3.0	6" SAND SHELL	--	3.5	1.53	1.09	29	1.30	0.62	52	1.30	0.90	31
49	3.5/2.0	2" S/C/G	--	3.5	1.36	1.54	0	2.11	0.85	60	2.11	1.50	29
50	5.8	3" SAND SHELL	4" S/C/G	2.0	1.64	2.08	0	1.64	1.16	29	1.64	1.50	9

*S/C/G - SAND-CLAY-GRAVEL

TABLE 3 (CONTINUED)

DEFLECTION ATTENUATION DATA - FLEXIBLE TEST SECTIONS
(BEFORE OVERLAY - AFTER OVERLAY - PERCENT REDUCTION IN DEFLECTION)

TEST SECTION NUMBER	PARENT PAVEMENT THICKNESS (INCHES)			OVERLAY THICKNESS	AS MEASURED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS WITH MOISTURE ADJUSTMENT		
	HMAC	BASE	SUBBASE	(INCHES)	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.
51**	3.0	20" S/C/G*	--	4.5	1.70	1.48	13	1.43	0.81	43	1.43	1.00	30
60**	1.0	6" SOIL CEMENT	--	6.7	1.50	0.62	59	0.99	0.61	38	0.99	0.50	50
61**	3.5	6" SOIL CEMENT	--	4.8	1.05	0.65	38	0.65	1.09	0	0.65	0.58	11
62	1.5	5" SOIL CEMENT	--	1.5	1.89	1.90	0	1.19	1.16	3	1.19	1.18	1
63**	2.8	8" S/C/G	--	5.8	0.67	0.82	0	0.47	0.48	0	0.47	0.45	4
55	1.3	7" S/C/G	--	1.8	1.11	1.28	0	0.70	1.15	0	0.70	0.87	0
67	0.8	10" SAND SHELL	--	1.0	3.99	1.99	50	2.03	1.69	17	2.03	1.77	12
71	1.0	8" S/C/G	--	3.9	1.51	0.92	39	1.18	0.54	54	1.18	0.75	36
73	2.0/4.0	12" SAND SHELL	12" SAND	1.5	1.91	1.25	35	1.01	1.09	0	1.01	0.90	11

*S/C/G - Sand-Clay-Gravel

**Greater than 14 months between before and after overlay deflections; these sections were not included in Figure 10.

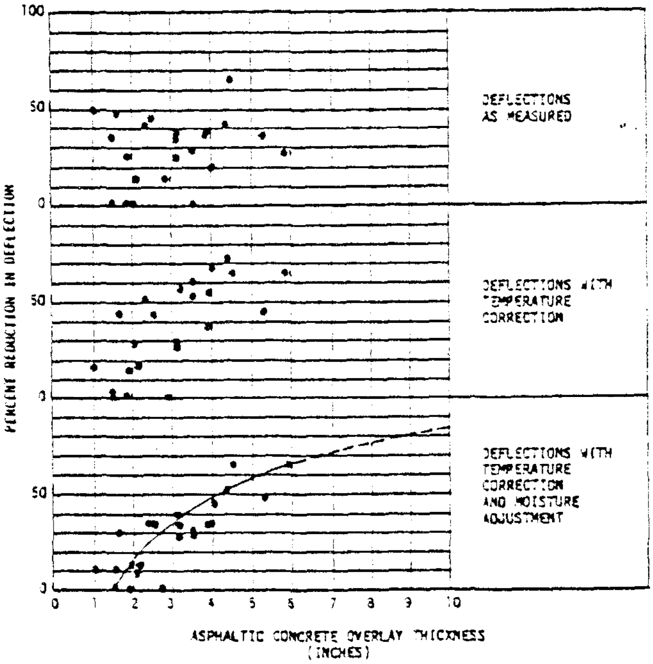


FIGURE 10

FLEXIBLE PAVEMENT DEFLECTION REDUCTION GUIDE

TABLE 4

DEFLECTION ATTENUATION DATA - COMPOSITE TEST SECTIONS
(BEFORE OVERLAY - AFTER OVERLAY - PERCENT REDUCTION IN DEFLECTION)

TEST SECTION NUMBER	PARENT PAVEMENT THICKNESS (INCHES)			OVERLAY THICKNESS	AS MEASURED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS WITH MOISTURE ADJUSTMENT		
	HMAC	PCC	BASE	(INCHES)	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.
1	3.5	7.5	--	3.8	0.74	0.84	0	0.82	0.42	49	0.82	0.58	37
2	2.5	7.0	--	3.6	0.81	0.80	1	0.90	0.65	28	0.90	0.75	17
4	3.0	7.0	--	3.5	0.66	0.50	24	0.67	0.45	33	0.67	0.50	25
7	3.0	6.5	10" SELECT SOIL	3.9	0.72	0.60	17	0.69	0.50	28	0.69	0.51	26
8	5.5	8.3	--	3.5	0.59	0.62	0	0.61	0.43	30	0.61	0.47	23
12	5.0	7.0	--	3.0	0.86	0.53	38	1.14	0.74	35	1.14	0.80	30
16	2.5	6.4	--	4.1	0.55	0.42	24	0.42	0.32	24	0.42	0.33	21
26	3.0	6.0	--	4.1	1.10	0.64	42	0.63	0.48	24	0.63	0.48	24
28	2.0	7.0	--	4.1	1.11	0.48	57	0.73	0.40	45	0.73	0.43	41
44	5.0	7.0	--	4.8	0.68	0.61	10	0.69	0.35	49	0.69	0.41	41
47	4.0	6.0	--	4.0	0.58	0.46	21	0.66	0.25	62	0.66	0.38	42
64	1.5	6.0	36" SELECT SOIL	1.5	0.86	0.86	0	0.47	0.66	0	0.47	0.60	0
66	3.3	7.0	--	2.3	0.60	0.56	7	0.35	0.36	0	0.35	0.32	9
68	4.3	9.0	5" SAND SHELL	1.6	1.04	1.35	0	0.68	1.05	0	0.63	1.05	0
69	4.3	9.0	5" SAND SHELL	2.0	1.23	1.30	0	0.80	1.05	0	0.80	0.78	3

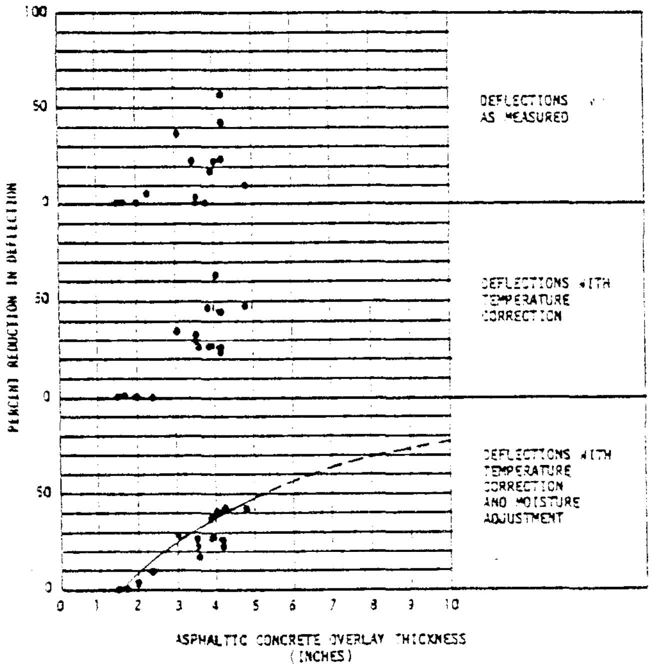


FIGURE 11

COMPOSITE PAVEMENT DEFLECTION REDUCTION GUIDE

TABLE 5

DEFLECTION ATTENUATION DATA - PCC TEST SECTIONS
(BEFORE OVERLAY - AFTER OVERLAY - PERCENT REDUCTION IN DEFLECTION)

TEST SECTION NUMBER	PARENT PAVEMENT THICKNESS (INCHES)		OVERLAY THICKNESS	AS MEASURED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS			TEMPERATURE CORRECTED DEFLECTIONS WITH MOISTURE ADJUSTMENT		
	PCC	BASE	(INCHES)	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.	BEFORE	AFTER	% RED.
23	8.0	--	3.0	0.81	0.70	14	0.81	0.35	57	0.81	0.65	20
24	8.0	--	3.2	1.08	0.66	39	1.08	0.34	69	1.08	0.77	29
25	6.0	--	3.1	1.50	1.36	9	1.50	0.72	52	1.50	1.16	23
29	6.0	8" SELECT SOIL	3.0	0.90	0.78	13	0.90	0.55	39	0.90	0.75	17
32	8.0	23" SELECT SOIL	4.5	1.06	0.78	26	1.06	0.53	50	1.06	0.80	25
35	7.0	--	3.5	1.14	0.88	23	1.14	0.83	27	1.14	0.85	25
36	7.0	--	4.4	0.85	0.82	4	0.85	0.70	18	0.85	0.58	32
37	8.0	14" SELECT SOIL	3.8	1.04	0.68	35	1.04	0.67	36	1.04	0.75	28
58	8.0	6.5" SOIL LIME	2.1	0.62	0.61	2	0.62	0.35	44	0.62	0.52	16
59	7.0	--	2.0	0.91	0.81	11	0.91	0.39	57	0.91	0.70	23
70	6.0	--	5.5	1.22	0.72	41	1.22	0.44	64	1.22	0.77	37

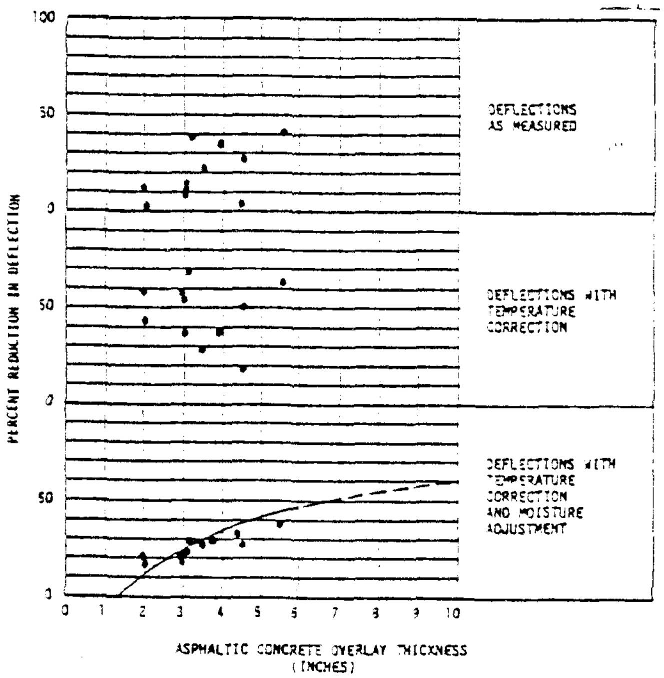


FIGURE 12

RIGID PAVEMENT DEFLECTION REDUCTION GUIDE

On one test section (Section #49, Table 3), for example, there was a 74° F. (23° C.) temperature differential in surface temperatures recorded during deflection measurements before and after overlay. The 3.5-inch (8.9-cm) asphalt resurfacing was calculated to have increased deflections by 13%! A 60% reduction in deflection was calculated after correcting the deflections to a standard (60° F. 16° C.) temperature (8).

The before-overlay deflections for Section #49 were measured in March, 1971, while the after-overlay deflections were obtained in August, 1971. A dramatic increase in subgrade support (Es) can be observed in Figure 13 after plotting the before and after overlay measurements on the pavement evaluation chart. The chart indicates an increase in SN from 1.8 to 3.2 upon addition of the 3.5-inch (8.9-cm) overlay, as would be expected. The effect of the dry season condition on the measured deflections exaggerates the percent deflection reduction actually attributable to the asphalt overlay, however. An adjusted deflection was computed by shifting point 2 along its SN = 3.2 line back to the subgrade support conditions which existed before overlay. This adjusted deflection represents the deflection which could have been measured after overlay had the subgrade moisture not decreased. A more reasonable deflection reduction of 29% was then calculated for the 3.5-inch (8.9-cm) overlay.

The degree of deflection adjustment required for Section #49 is a result of its geographical location within the state. This test section is located near the Mississippi River and therefore is subject to large seasonal changes in subgrade moisture. Other test sections were located in areas not as subject to seasonal subgrade moisture variation. The magnitude of adjustment required for these pavements was naturally not as large as for test sections located in the low-lying, swampy areas. Several test sections (such as Section #73, Figure 14) were tested under dryer subgrade conditions before overlay than after overlay. The after-overlay deflection levels on

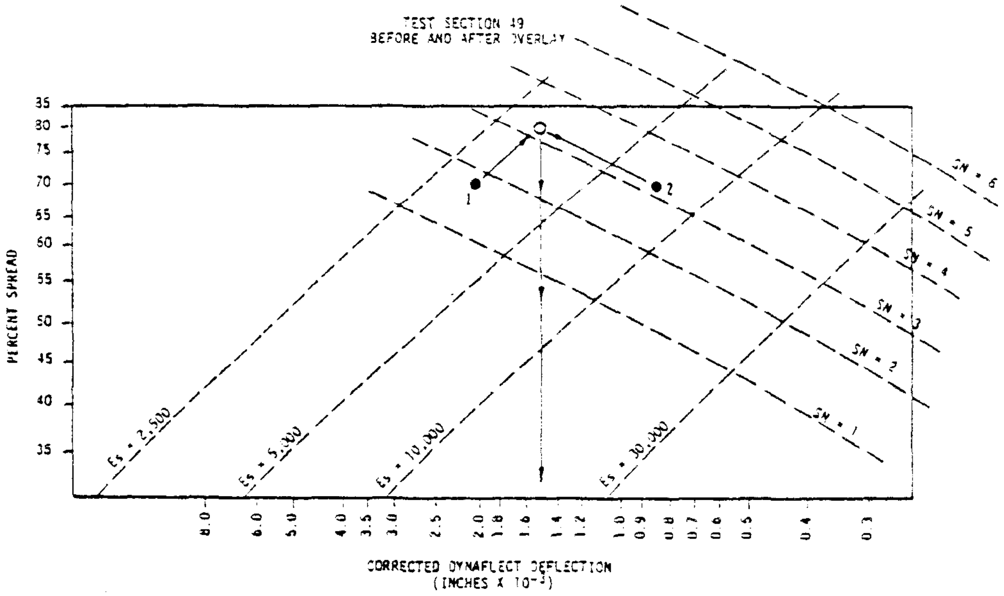


FIGURE 13

DEFLECTION ADJUSTMENT FOR SUBGRADE MOISTURE
EXAMPLE I

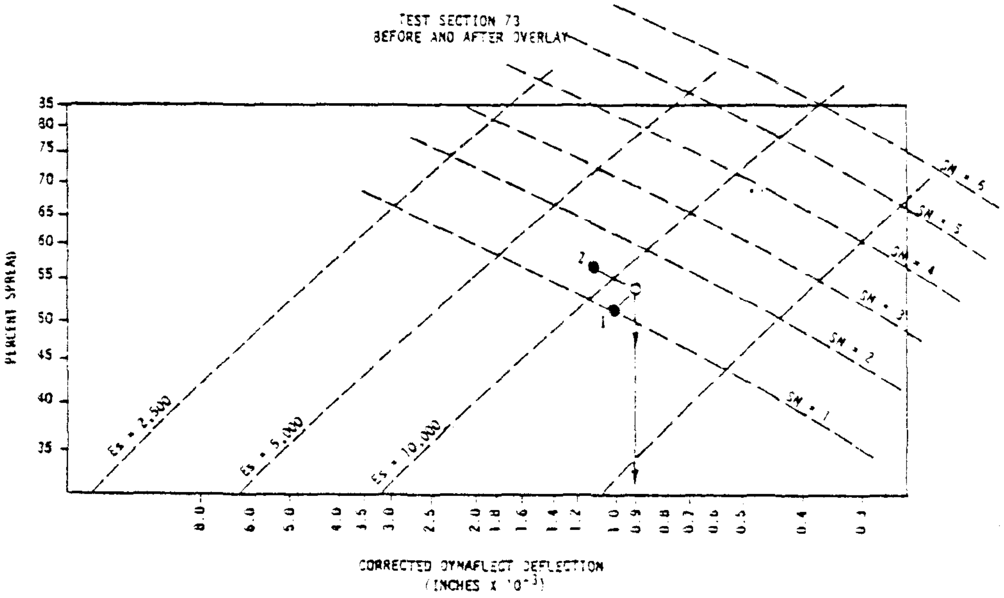


FIGURE 14

DEFLECTION ADJUSTMENT FOR SUBGRADE MOISTURE
EXAMPLE II

these test sections were decreased accordingly for a more proper moisture-related comparison with before-overlay deflections.

In general the pavement evaluation chart has been observed to indicate slight increases in subgrade support as additional layers were added to a pavement system. This is thought to be due to the confining effect of the added layers. Also on many pavements, a gradual decrease in subgrade support has been observed as the roadbed weakens under traffic. It has been assumed for the purposes of this analysis that these two factors cancel each other, since the average time between before- and after-overlay deflections was approximately eight months. This assumption enabled the investigators to attribute changes in subgrade modulus before and after overlay to variations in moisture and adjust deflections accordingly by the pavement evaluation chart.

The effect of relative deflection levels measured before overlay (whether high or low) on the percent reduction in deflection after overlay was another factor which influenced the data. Pavements which exhibited relatively low deflections before overlay did not attain as great a degree of deflection reduction for the same thickness of resurfacing as that provided to pavements with higher initial deflections. There was insufficient data at any given thickness of overlay to permit development of a linear relationship, however. The effect of initial deflections on deflection reduction has resulted in the development of separate reduction guides for flexible, composite, and rigid pavement test sections. This seems reasonable since deflection levels measured on the flexible sections were generally higher.

Another observation which may be made of the deflection reduction guides is the inability of the very thin overlays, 1 to 1.5 inch (2.5 to 3.8 cm), to reduce pavement deflections.

Comparison of Research Findings

Deflection reduction curves for the three pavement types are superimposed in Figure 15. The 2:1 asphalt-to-gravel-ratio curve used in the development of overlay design guides by other states is also indicated. This theoretical curve, with its origin translated to the right by 1 1/2 inches of asphaltic concrete, would agree with the relationship developed for the composite pavements. The flexible pavement relationship reflects less pavement support and hence higher before-overlay deflections than the composite pavements, which have the benefit of 6 to 8 inches (15 to 20 cm) of concrete. It is probable that this added support would be more representative of support conditions found in more stable areas of the country and used in development of the 2:1 asphalt-to-gravel strength relationship.

Overlay Thickness Design Procedure

An effective overlay thickness design procedure must include estimates of future traffic loads. Accuracy is essential, since an underestimation will probably result in premature pavement failures. The task of accurately forecasting traffic loads is complicated by many factors, such as unexpected increases in traffic intensity, changes in percent of heavy vehicles in the traffic stream, limited sample sizes, and the inaccuracies introduced by projecting traffic data. These variations, along with the variables associated with field testing of pavements, will from time to time introduce some degree of error into the selection of overlay thickness using any design method. Accordingly, the design charts illustrated in Figures 16, 17, and 18 have been entitled design guides. The guides are to be used as an aid in selecting overlay thicknesses and not as a rigid standard.

The design guides were developed by application of Figures 3, 4, and 15. Figures 3 and 4 provided the means to predict the tolerable deflection level (associated with end of life or incipient fatigue failures) for a given projected traffic load accumulation. Comparison of tolerable deflection with measured deflection yielded percentage reduction required. Figure 15 then provided the means to

FIGURE 15

A COMPARISON OF DEFLECTION REDUCTION RELATIONSHIPS WITH THE 2:1 THEORY

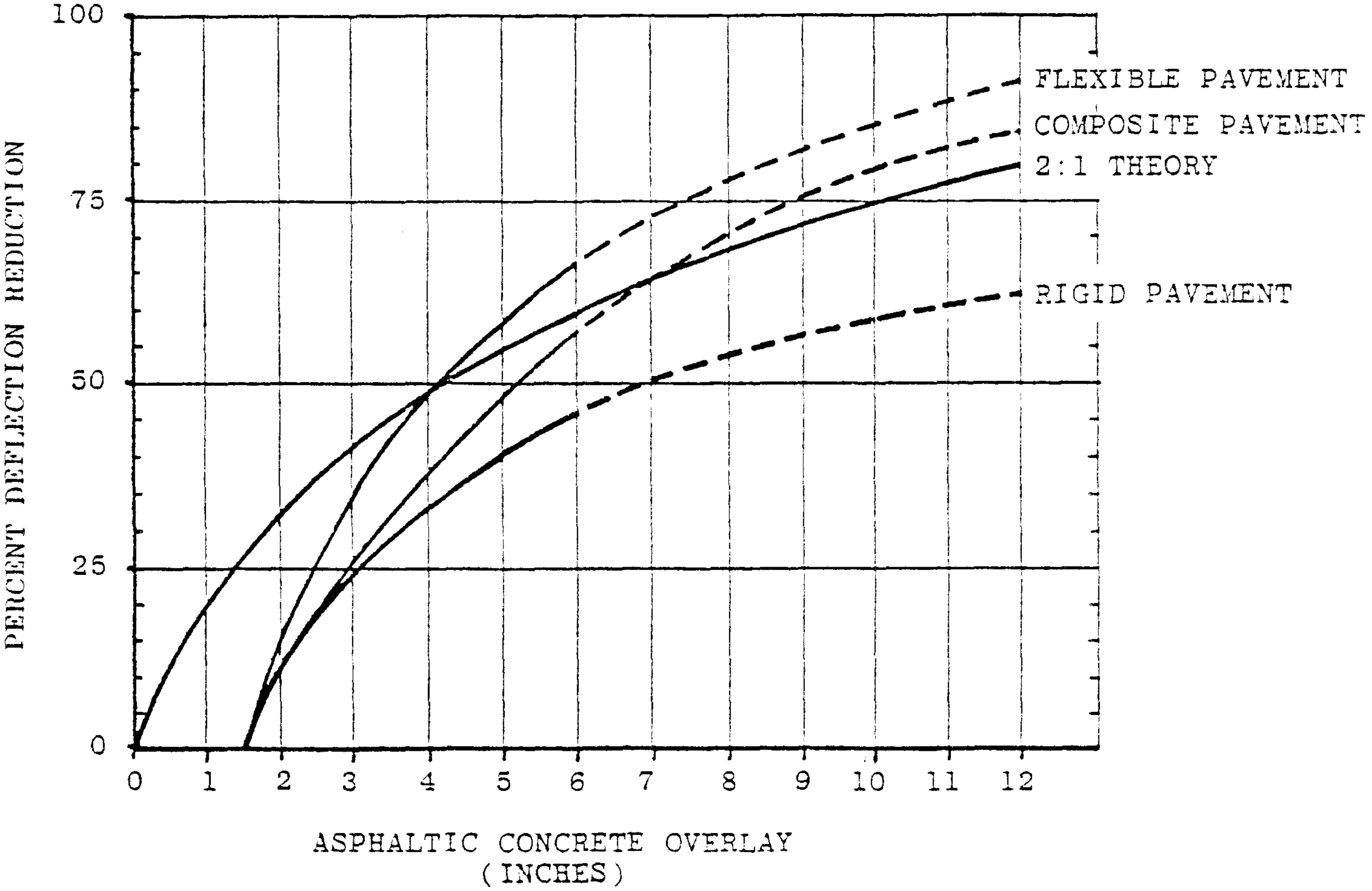


FIGURE 16

DESIGN GUIDE FOR ASPHALT OVERLAY
OF FLEXIBLE PAVEMENT

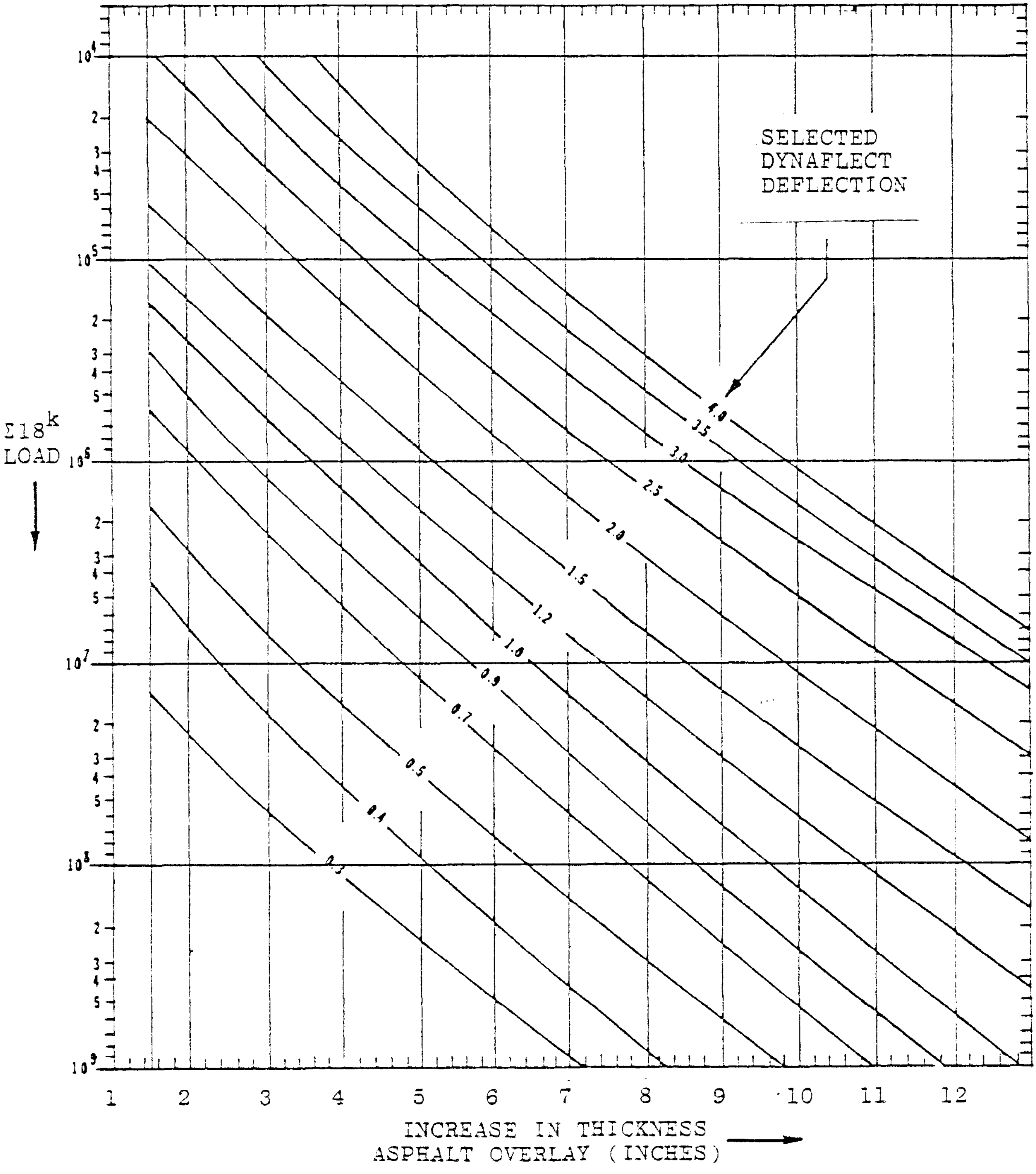
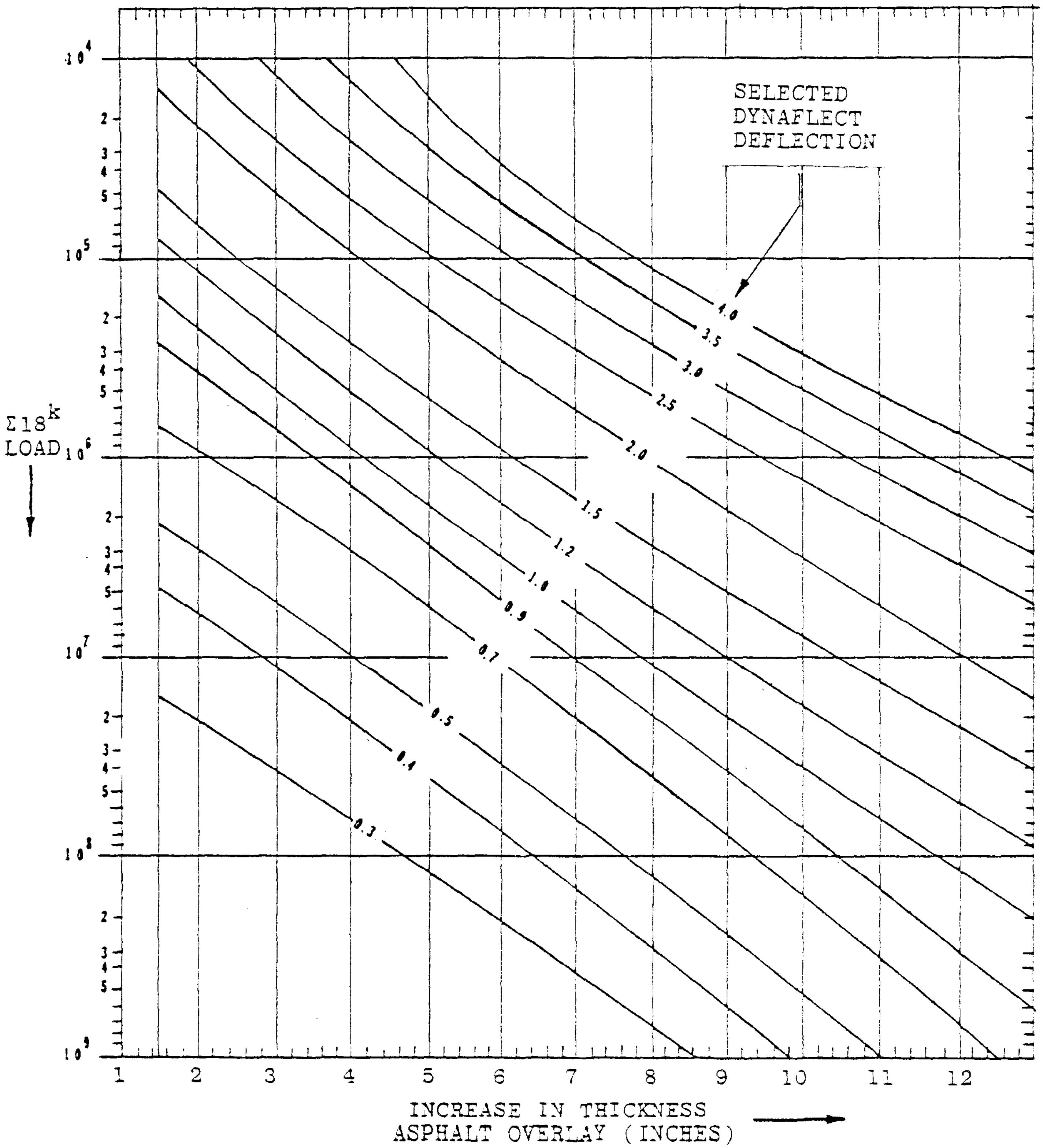


FIGURE 17

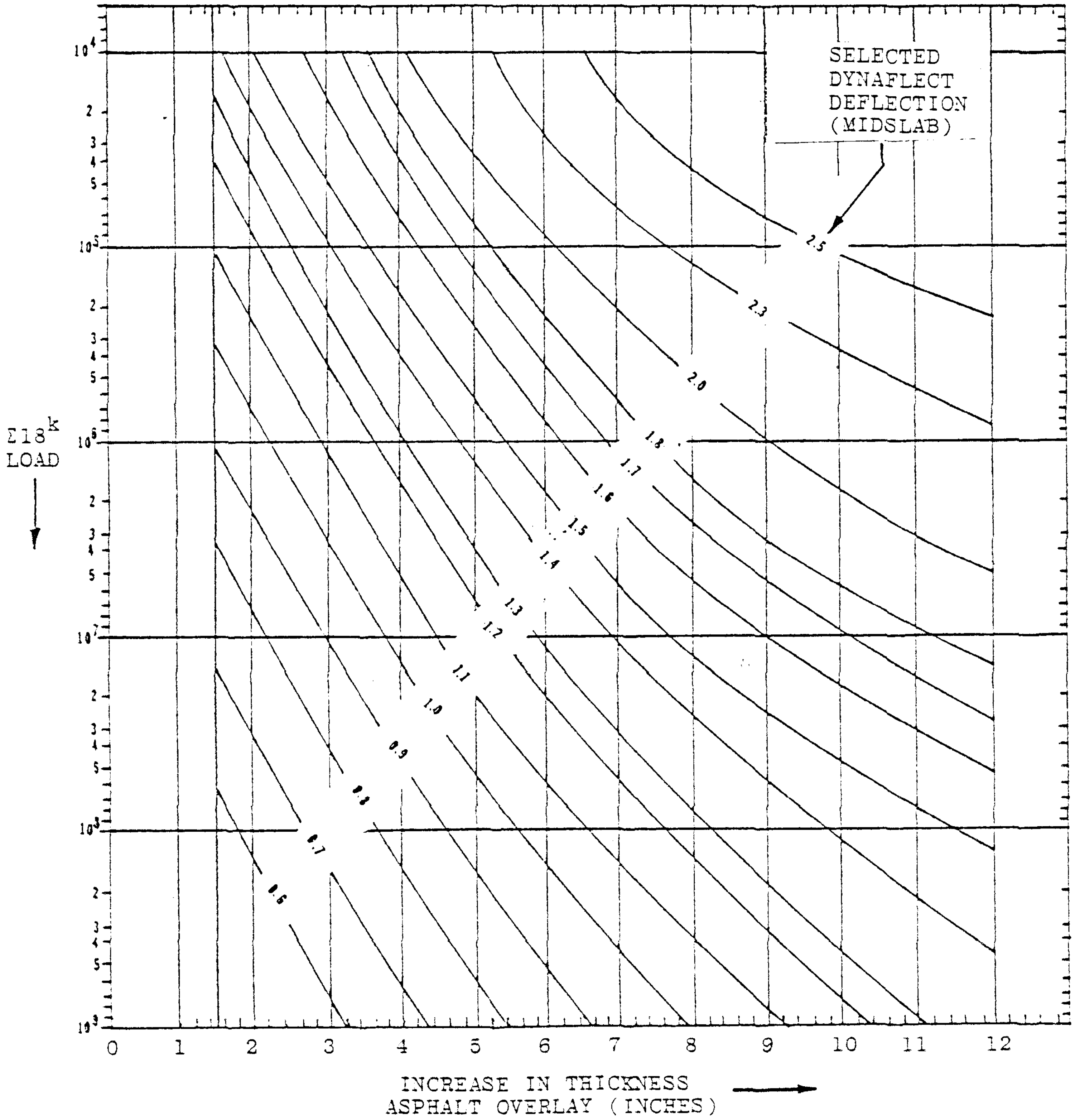
DESIGN GUIDE FOR ASPHALT OVERLAY
OF COMPOSITE PAVEMENT



LA. DOTD-1977
(TENTATIVE)

FIGURE 18

DESIGN GUIDE FOR ASPHALT OVERLAY
OF RIGID PAVEMENT



specify the thickness of overlay required to effect the reduction in deflection. Iteration of this process using a range of traffic loads and measured deflection levels yielded Figures 16, 17, and 18.

Three significant advantages of this method are (1) the elimination of reliance on human judgement in an estimation of pavement strength, (2) elimination of the expenses and inaccuracies associated with destructive testing of pavement components, and (3) the ability to increase sample sizes or points of evaluation within a given project.

Deflection Sampling Pattern

The objective of a deflection sampling pattern in this analysis is to characterize the weakest area or areas of the project to be evaluated. The asphalt overlay thickness design is then based on the weakest areas in the pavement structure, since pavement performance is usually associated with these areas.

It is felt that effective sampling can be achieved if the following testing guidelines are used as a <u>minimum</u> sampling shceme:

(Flexible Pavements)

1) Projects which are two miles (3.1 km) or less in length should be tested at 0.05 mile (81 m) intervals in the wheelpath exhibiting the most distress. This usually occurs in the outside wheelpath.
2) Projects which are greater than two miles (3.2 km) in length should be divided into test sections. Each test section should be 0.2 miles (0.3 km) in length. One test section should be chosen from each mile (1.6 km) of roadway and should encompass the most heavily distressed portion of that mile (1.6 km). A minimum of 10 random deflection measurements should be made in each test section.

In addition, testing should include both lanes of a two-lane highway and both outside lanes of a four-lane highway.

(Rigid Pavements)

The same general minimum sampling plan should be used to evaluate P.C.C. pavements. Deflection measurements of jointed pavements are usually taken at midslab and across transverse contraction joints. However, measurements used to select asphaltic concrete overlay thicknesses are selected from the midslab readings only. Deflection readings near transverse pavement joints are usually higher than the overall measured deflections due to the joint discontinuity. These values can provide important information about pavement support in the joint areas, as well as an estimate of the load transfer capabilities of the joint system.

Selected Deflection Levels

(Flexible Pavements)

The selection of an appropriate deflection level for characterizing flexible pavements should give emphasis to the most heavily distressed areas. It is of course these areas which detract from a safe and smooth ride. Pavement rehabilitation design would then also give emphasis to the weakest area(s) within a pavement project.

Emphasis of pavement performance deficiencies must be tempered with consideration of available economic resources to develop viable rehabilitation designs. The highway engineer can select the highest deflection in a test section and confidently design a lasting overlay--if funds permit construction thereof. In many cases it would be more practical to select a design deflection level near the 95th percentile. This means that five percent of the measurements were greater than the selected level. The implication is that five percent of the project may need maintenance before the end of the design life.

The authors' experiences indicate that the 95th percentile deflection level can be adequately approximated using the following equation:

$$Ds = \frac{D_1 + D_2}{2}, \text{ where}$$

Ds = selected deflection
D_1 = highest deflection
D_2 = second highest deflection

(Rigid Pavements)

The selected deflection level for tests on P.C.C. pavements should also be the average of the two highest deflections. Unusually high, isolated midslab readings on the order of 2.00+ milli-inches may indicate voids caused by base or subbase erosion. For reasons of economy, asphalt overlay thicknesses should not be selected on the basis of isolated conditions such as these. Instead, additional corrective measures should be employed prior to overlay, such as soil-cement slurry injection or reconstruction where it is warranted.

Overlay Thickness Selection

The overlay design guides of Figures 16, 17, and 18 are used by entering the charts with the total traffic load, $\Sigma 18^k$ (8.16 Mg) load, projected to the end of the design period. The thickness of asphalt overlay is then determined by locating the intersection of the estimated traffic load and the selected pavement deflection. The indicated thickness of asphalt resurfacing will theoretically prevent the pavement from exceeding a tolerable deflection level. This is the deflection level which will be reached by the end of the design period when the pavement has been subjected to the estimated number of load repetitions.

Overlay thickness selection using the methods described in this report appears to be very compatible with overlay requirements determined from the Louisiana-AASHO Flexible Pavement Design Guide. The three examples which follow illustrate this point. A summary of the overlay design method may be found in Appendix D.

(Example I) Flexible Pavement

Route: Interstate, I-55, Hammond to Ponchatoula
Typical Section: 5" A.C., 17" sand and shell, 8" lime-treated soil
Condition: Fatigue cracking and patching
Maximum Measured Deflection: 2.22 milli-inches
Selected Deflection: 2.21 mill-inches
Surface Temperature: 88° F.
Design Period: 20 years
Projected Load: $5.8 \times 10^6\ \Sigma 18^k$

Step 1) The average pavement temperature is calculated to be 80° F. (These calculations involve Southgate's temperature correction procedure, reference 8.) The selected deflection is corrected to an equivalent deflection:

$$2.21 \times 0.78 = 1.72 \text{ milli-inches}$$

Step 2) The design guide for flexible pavement (Figure 16) is entered at a traffic load of 5.8×10^6.

Step 3) Approximately 8.4 inches of asphalt would be necessary to accommodate the indicated total traffic load during the 20-year design period.

Calculations using the Louisiana-AASHO Flexible Design Guide indicate that between 8 and 9 inches would be required to sustain the pavement for 20 more years. It was not feasible to place this thickness of resurfacing, however, due to overpass clearance restrictions in the area. The actual recommendation made was for reconstruction of the entire pavement section. This was considered feasible since the project was only 1 1/2 miles in length.

(Example II) Composite Pavement

Route: Interstate, I-10, Texas Line to Weigh Station
Typical Section: 3.5" A.C., 7" P.C.C., 12" shell
Condition: Reflection cracks and fatigue cracks throughout
Maximum Measured Deflection: 1.44 milli-inches
Selected Deflection: 1.41 milli-inches
Surface Temperature: 127° F.
Design Period: 10 years
Projected Load: $2.1 \times 10^6\ \Sigma 18^k$ loads

Step 1) The average pavement temperature is calculated to be 109° F. (These calculations involve Southgate's temperature correction procedure, reference 8.) The selected deflection is corrected to an equivalent deflection at 60° F.:

$$1.41 \times 0.62 = 0.87 \text{ milli-inches}$$

Step 2) The design guide for composite pavement (Figure 17) is entered at a traffic load of 2.1×10^6.

Step 3) Approximately 4.4 inches of asphalt is indicated where the load and deflection lines intersect.

Calculations with the Louisiana-AASHO Flexible Design Guide indicate that four inches of asphalt would be necessary to sustain the life of this pavement for ten years.

(Example III) Rigid Pavement

Route: Interstate, I-10, Lake Charles (Westlake)
Typical Section: 8" P.C.C., 12" sand and shell
Condition: Fatigue cracking and patching
Maximum Measured Deflection: 1.17 milli-inches
Selected Deflection: 1.10 milli-inches
Design Period: 10 years
Projected Load: $9.0 \times 10^6\ \Sigma 18^k$ loads

Step 1) The selected midslab deflection value is 1.10 milli-inches.

Step 2) Entering the design guide for overlays of rigid pavement (Figure 18) with a traffic load of 9.0×10^6, the required asphalt resurfacing is 4.5 inches.

Calculations using the Louisiana-AASHO Flexible Pavement Design Guide also indicate that approximately 5 inches of resurfacing will be required for an extended 10-year life at the indicated traffic load.

SUMMARY AND CONCLUSIONS

1. Design guides have been developed for selecting the asphaltic concrete overlay thicknesses required to structurally rehabilitate flexible, composite, and rigid pavements in Louisiana.

2. The guides represent a rapid, rational approach to overlay thickness design. Advantages relative to existing methods include: (1) the elimination of reliance on human judgement in estimating the strengths and weaknesses of pavement systems, (2) the elimination of destructive sampling methods and costly laboratory testing, and (3) the ability to significantly increase sample sizes or points of evaluation within a pavement system.

3. Overlay thickness requirements computed using the guides appear to be in close agreement with overlay requirements determined using the Louisiana-AASHO Flexible Pavement Design Guide.

4. Tolerable deflection levels have been established for both asphalt and P.C.C. pavements. The tolerable deflections measured in Louisiana are generally lower than those developed at the AASHO Road Test and by other states. A combination of stiff asphalt mixes and relatively low soil support properties has been observed to cause the early fatigue cracking.

5. Separate overlay-deflection reduction relationships have been developed for flexible, composite, and rigid pavements primarily due to the lower deflection values measured on the composite and rigid pavements. In general asphalt overlays of 1.5 inch (5.1 cm) or less provided no deflection reduction.

6. The thicker asphalt overlays, 4 to 6 inches (10 to 15 cm), placed over jointed P.C.C. pavements delayed reflection cracking for no longer than three years in any one test section.

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APPENDIX A

DESCRIPTION OF FUNCTIONAL AND STRUCTURAL PAVEMENT EVALUATION TECHNIQUES

FUNCTIONAL EVALUATION OF PAVEMENTS

The Mays Ride Meter (M.R.M.) operates from inside a standard size car and records road roughness as reflected by movement of the vehicle's axle with respect to its chassis. A transmitter attached to the differential collects this movement information and feeds it to a portable recorder located on the front seat. Quantitative and qualitative roughness measurements are presented on a strip chart produced by the recorder. The base speed for the M.R.M. is 50 miles per hour, and correlation curves for each M.R.M. convert test data obtained at other speeds to that at the base speed.

M.R.M. measurements are reported in terms of a Present Serviceability Index (P.S.I.). This P.S.I. has been defined as a "numerical index (ranging from 0.0 to 5.0) of the ability of a pavement in its present condition to serve traffic." Perfectly smooth pavement would have a P.S.I. of 5.0. Pavement so rough as to be impassable would have a P.S.I. of 0.0.

More specifically, a numerical-adjective description of P.S.I. is as follows:

4.1 - 5.0	Very Good
3.1 - 4.0	Good
2.1 - 3.0	Fair
1.1 - 2.0	Poor
0.0 - 1.0	Very Poor

STRUCTURAL EVALUATION OF PAVEMENTS

The Dynamic Deflection Determination System (Dynaflect) is a trailer-mounted device which induces a dynamic load on the pavement and measures the resulting slab deflections by use of geophones (usually five) spaced under the trailer at approximately one-foot (39.5-cm) intervals from the application of the load. The pavement is subjected to a 1000-pound (454-kg) dynamic load at a frequency of eight cycles per second, which is produced by the counter-rotation of two unbalanced flywheels. The generated cyclic force is transmitted vertically to the pavement through two steel wheels spaced 20 inches (50.8 cm) center-to-center. Any horizontal reactions will cancel each other due to the opposing rotations. The dynamic force varies in sine wave fashion from 500 pounds (227 kg) upward to 500 pounds (227 kg) downward during each rotation. The entire force transmitted to the pavement, however, consists of the weight of the trailer (about 1600 pounds, 726 kg) and the dynamic force which alternately adds to and subtracts from the static weight. Thus, the dynamic force during each rotation of the flywheels at the proper speed varies from 1100 to 2100 pounds (499 to 953 kg). The deflection measurements induced by this system are expressed in terms of milli-inches of deflection (thousandths of an inch).

Figure 19 is a photograph of the Department's Dynaflect device. Figure 20 is a representation of the deflection basin which the Dynaflect generates. The Dynaflect actually measures the extent of only one half of the deflection bowl, with the other half assumed to be a mirror image of the measured portion. In Figure 20 the measurement W_1 is the maximum depth of the deflection bowl and occurs near the force wheels. The terms W_2, W_3, W_4, and W_5 are the deflections related by geophones 2 through 5, respectively.

The maximum (first sensor) deflection W_1 provides an indication of the relative strength of the total road section. The Surface Curvature Index, S.C.I. (W_1-W_2), provides an indication of the relative strength of the upper (pavement) layers of the road section. The Base Curvature Index, B.C.I. (W_4-W_5), and the fifth sensor value W_5 provide a measure of the relative strength of the foundation. For all four parameters, W_1, S.C.I., B.C.I., and W_5, lower values indicate greater strength.

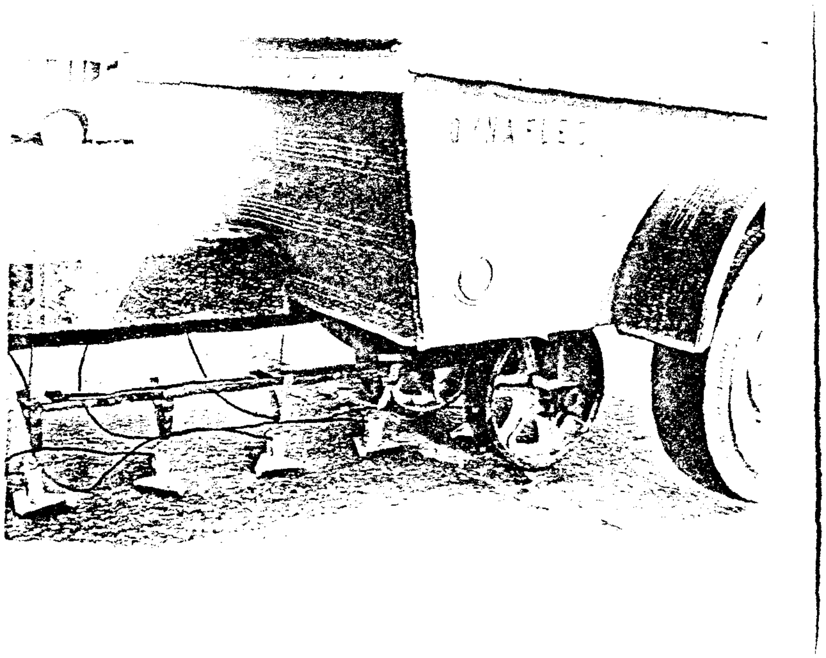


FIGURE 19

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT, OFFICE OF HIGHWAYS' DYNAMIC DEFLECTION DETERMINATION SYSTEM (DYNAFLECT)

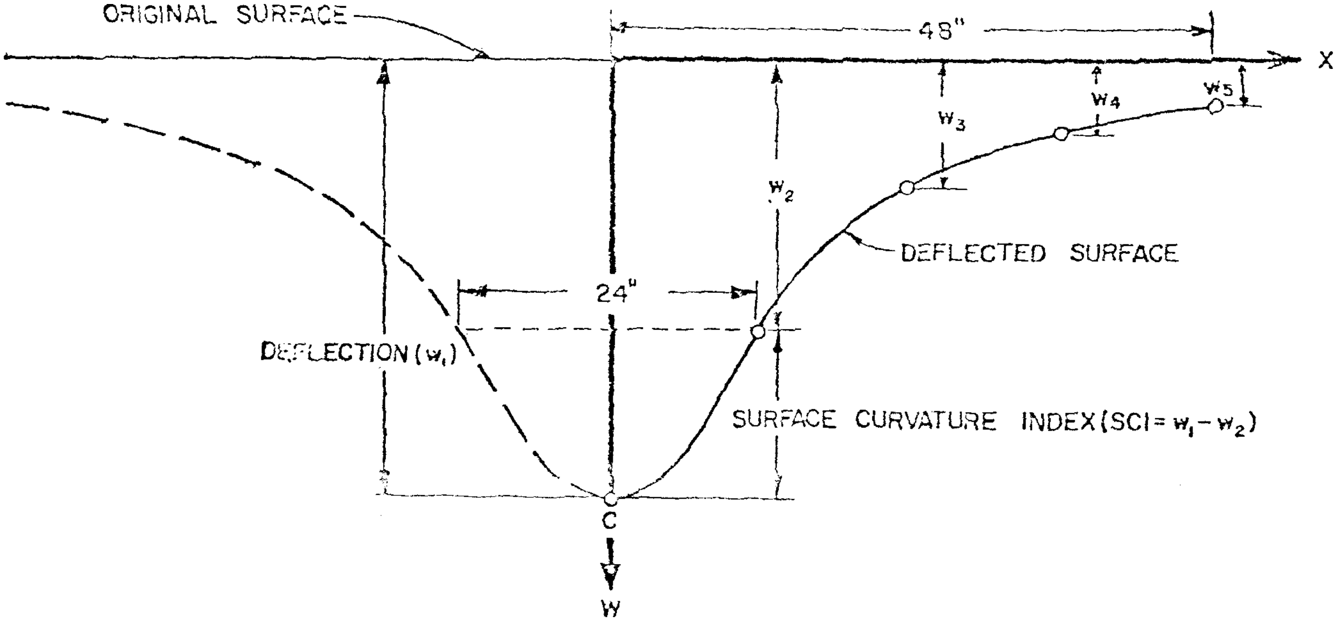


FIGURE 20

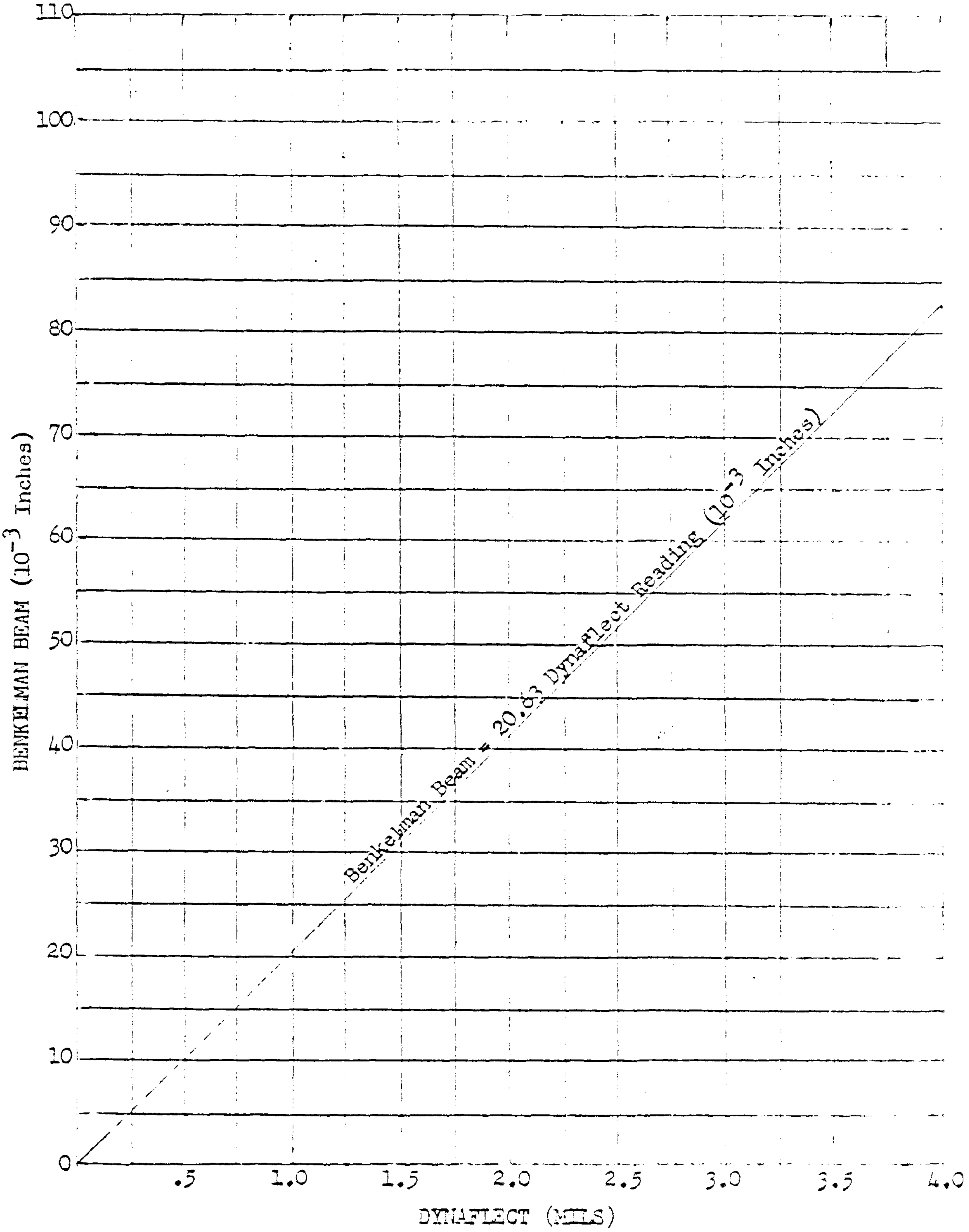
TYPICAL DYNAFLECT DEFLECTION BOWL

APPENDIX B

PLOT OF DYNAFLECT-BENKELMAN BEAM RELATIONSHIP

FIGURE 21

PLOT OF DYNAFLECT-BENKELMAN BEAM RELATIONSHIP
(LOUISIANA DEPARTMENT OF TRANSPORTATION
AND DEVELOPMENT)



APPENDIX C

PAVEMENT COEFFICIENTS FOR FLEXIBLE SECTION DESIGN

TABLE 6

PAVEMENT COEFFICIENTS FOR FLEXIBLE SECTION DESIGN (LOUISIANA, 1975)

	STRENGTH	COEFFICIENT
I. SURFACE COURSE		
Asphaltic Concrete		
Types 1, 2, and 4 base course and wearing course	1000+*	0.40
Type 3 wearing course	1800+	0.44
Type 3 base course	1500+	0.43
II. BASE COURSE		
Untreated		
Iron ore - Grade B	3.7-**	0.06
Sand clay gravel - Grade A	3.3-	0.08
Sand clay gravel - Grade B	3.5-	0.07
Sand and shell	2.2-	0.10
Shell	2.2-	0.10
Cement Stabilized		
Soil cement	300 psi+	0.15
Iron ore - Grade B	300 psi+	0.15
Sand clay gravel - Grade B	500 psi+	0.18
Sand and shell	650 psi+	0.23
Shell	650 psi+	0.23
Lime Stabilized		
Sand shell	2.0-**	0.12
Sand clay gravel - Grade B	2.0-	0.12
Asphalt Stabilized		
Hot mix base course - Type 5A	1200+*	0.34
Hot mix base course - Type 5B	800+	0.30

*Marshall Test.

**Texas Triaxial Test

TABLE 6 (CONTINUED)

PAVEMENT COEFFICIENTS FOR FLEXIBLE SECTION DESIGN (LOUISIANA, 1975)

	STRENGTH	COEFFICIENT
III. SUBBASE COURSE		
Lime treated sand clay gravel - Grade B	2.0-**	0.14
Sand and shell	2.0-	0.14
Shell	2.0-	0.14
Sand clay gravel - Grade B	3.5-	0.11
Lime treated soil	3.5-	0.11
Suitable material	A-6 (PI=15-)	0.04
Old gravel or shell roadbed	8-inch thickness	0.11
Sand	R-value=55+	0.11
IV. COEFFICIENTS FOR BITUMINOUS CONCRETE OVERLAY BASE COURSE		
Bituminous concrete pavement		
New		0.40
Old		0.24
Portland cement concrete pavement		
New		0.50
Old, fair condition		0.40
Old, failed		0.20
Old, pumping		0.10
Old, pumping (to be undersealed)		0.35

**Texas Triaxial Test

APPENDIX D

SUMMARY OF OVERLAY THICKNESS DESIGN PROCEDURE

Method of Test For

DETERMINING THE THICKNESS OF HOT MIXED ASPHALTIC CONCRETE FOR STRUCTURAL OVERLAYS OF ASPHALTIC CONCRETE, P.C.C., AND COMPOSITE PAVEMENTS

Scope

1. This method of test is intended to provide the thickness of hot mixed asphalt concrete required to structurally rehabilitate asphalt and portland cement concrete pavements, and composite pavements.

Apparatus

2. (a) Dynaflect Deflection Determination System
   (b) Surface and air thermometers

Calibration

3. The Dynaflect should be calibrated daily following the standard calibration procedure set forth for this test equipment.

Preparation

4. The average daily 18-kip equivalent single axle load (A.D.L.) for the beginning and end of the selected design period (10 years, 20 years, etc.) must be obtained to provide an estimate of future traffic loads.

5. The project to be tested should be researched to determine pertinent project information such as project length and typical section, making note of any variation in section design within the project. The project must be divided into two or more projects if variations in section design are noted.

Sampling

6. The following is set forth as a minimum testing scheme:

(a) Projects which are two miles (3.1 km) or less in length should be tested at 0.05 mile (81 m) intervals in the wheelpath exhibiting the most distress.

(b) Projects which are greater than two miles (3.2 km) in length should be divided into test sections. Each test section should be 0.2 miles (0.3 km) in length. One test section should be selected from each mile (1.6 km) of roadway and should encompass the most heavily distressed portion of that mile (1.6 km). A minimum of ten random deflection measurements should be made in each test section.

(c) Testing should include both lanes of a two lane highway and both outside lanes of a four lane highway.

Testing

7. (a) Deflection tests should be conducted following the standard test procedures used for the Dynaflect device.

(b) Deflection tests on jointed P.C.C. pavements should be conducted at midslab in the outside wheelpath.

(c) Visual observations of pavement condition should accompany all deflection measurements.

(d) Air temperature, surface temperature, and the time of day must be recorded at least once during each hour of testing on asphalt surfaces.

Data Analysis

8. (a) The A.D.L. for the median year of the design period is calculated by averaging the A.D.L. values for the beginning and end of the design period.

(b) The estimated 18-kip equivalent single axle load which will traverse the asphaltic concrete overlay is then calculated using the following formula:

$$\Sigma 18^{k} \text{ Load} = \text{Median Year A.D.L.} \times \text{No. Years in Design Period} \times 365$$

9. Deflection test values on asphaltic concrete surfaces must be corrected for the effect of temperature. The standard correction procedure used with the Dynaflect device requires the following data as input: (1) measured deflection, (2) surface temperature at time of test, (3) time of day, (4) average ambient temperature for the five days previous to the day of testing, and (5) the total thickness of asphalt tested. The temperature correction procedure is used to determine the average pavement temperature at time of testing and the adjustment factor for the measured deflections.

10. (a) The selected deflection level for asphaltic concrete pavements should be determined using the following formula:

$$Ds = \frac{D_1 + D_2}{2}$$

where Ds = selected deflection

D_1 = highest deflection

D_2 = second highest deflection

(b) The selected deflection level for tests on P.C.C. pavements should also be the average of the highest two deflections. Unusually high isolated midslab readings (on the order of 2.00 milli-inches) may indicate a void under the P.C.C. pavement or an isolated area which will require partial reconstruction prior to overlay.

Overlay Thickness Selection

11. (a) The overlay design guides of Figures 1, 2, and 3 are used by entering the charts with the total projected traffic load, $\Sigma 18^K$ Load (Sec. 8 (b)). The thickness of asphalt overlay is then determined by locating the intersection of the projected traffic load and the selected deflection level (Sec. 10 (a) (b)).

Reports

12. Report project identification information, design period and total projected traffic load for the period, selected deflection levels, and thickness of asphalt concrete overlay for each test section.

Examples

13. (a) (Example I) - Composite Pavement

Route: Interstate, I-10, Texas Line to Weigh Station

Typical Section: 3.5" A.C., 7" P.C.C., 12" shell

Condition: Reflection cracks and fatigue cracks throughout

Maximum Measured Deflection: 1.44 milli-inches

Selected Deflection: 1.41 milli-inches

Surface Temperature: 127° F @ 12:00 noon

Design Period: 10 years

Projected Load: 2.1×10^6 $\Sigma 18^k$ loads

Step 1) The mean pavement temperature is calculated by entering Figure 4 with the pavement surface temperature + the 5-day mean air temperature history. The temperature at any depth in the A.C. blanket can be determined by reading across from the desired depth of A.C. The mean pavement temperature is the temperature at middepth of the A.C. blanket.

Pavement Surface Temperature + 5-day Mean Air Temperature =
127° F + 75° F = 202° F

From Figure 4 202° F @ 3.5"/2 = 1.8" indicates
109° F Mean Pavement Temperature

Step 2) The deflection adjustment factor may now be obtained by entering Figure 5 with the mean pavement temperature.

From Figure 5 a deflection adjustment factor of 0.62 is obtained. The selected deflection = 1.41 milli-inches. Equivalent deflection = 1.41 (0.62) = 0.87 milli-inches.

Step 3) The design guide for composite pavement (Figure 2) is entered at a traffic load of 2.1×10^6.

Step 4) Approximately 4.4 inches of asphalt concrete overlay is indicated where the load and deflection lines intersect.

(b) (Example II)

Route: Interstate, I-10, Lake Charles (Westlake)

Typical Section: 8" P.C.C., 12" sand and shell

Condition: Fatigue cracking and patching

Maximum Measured Deflection: 1.17 milli-inches

Selected Deflection: 1.10 milli-inches

Design Period: 10 years

Projected Load: 9.0×10^{6} $\Sigma 18^{k}$ loads

Step 1) The selected maximum midslab deflection value is 1.10 milli-inches.

Step 2) Entering the design guide for overlays of rigid pavement (Figure 3) with a traffic load of 9.0×10^{6}, the required asphalt resurfacing is 4.5.

FIGURE 1

DESIGN GUIDE FOR ASPHALT OVERLAY OF FLEXIBLE PAVEMENT

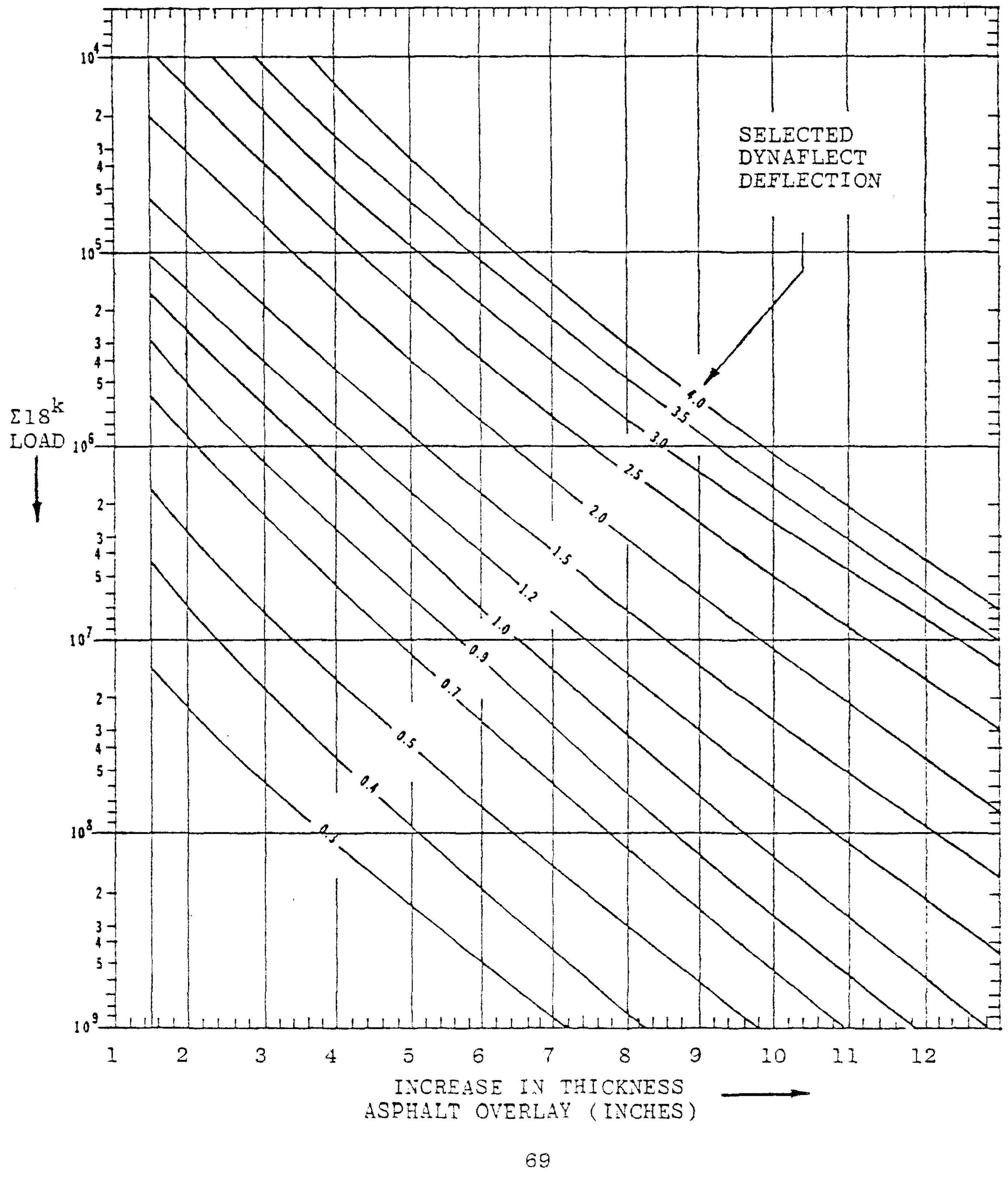
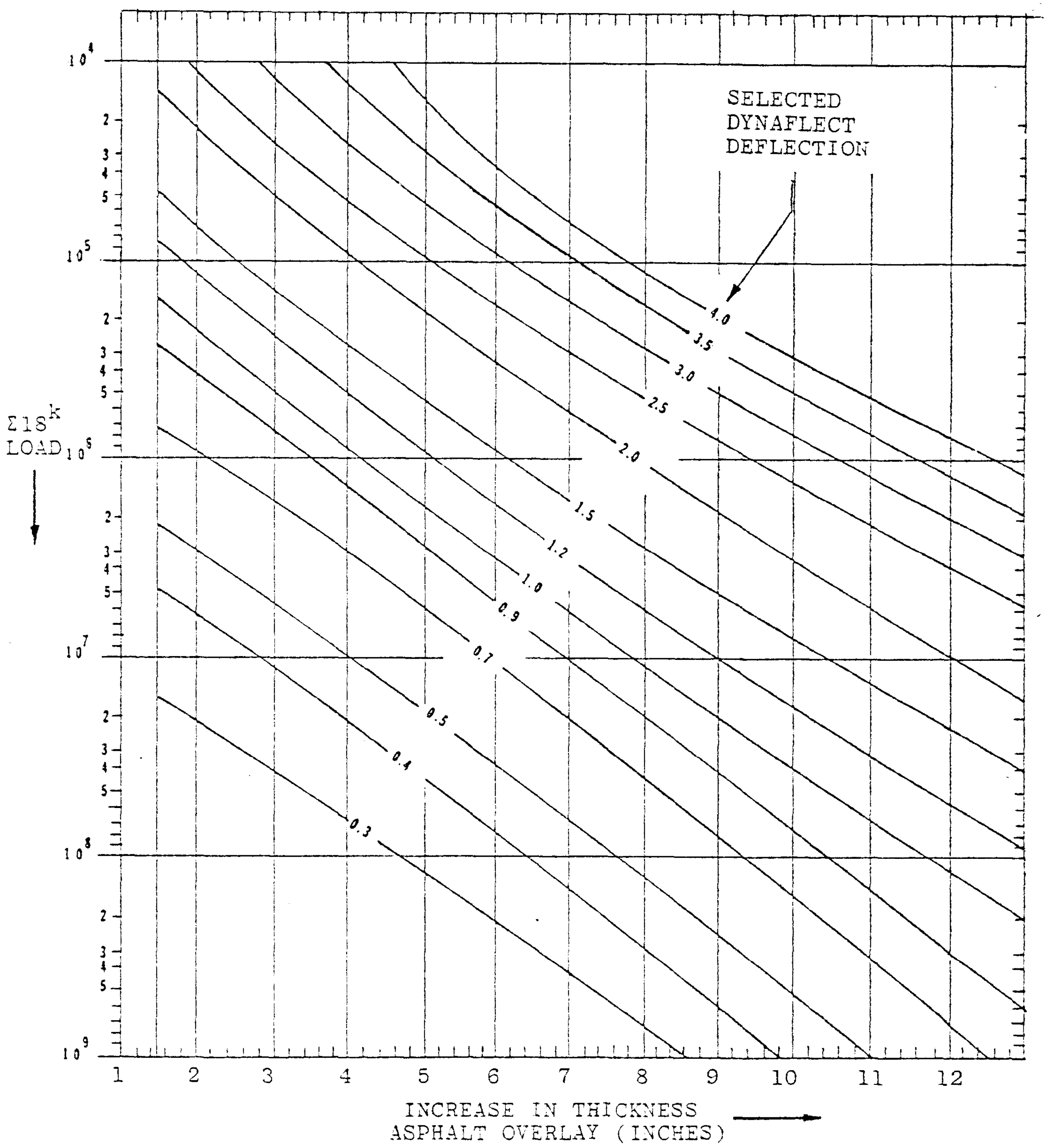


FIGURE 2

DESIGN GUIDE FOR ASPHALT OVERLAY
OF COMPOSITE PAVEMENT



LA. DOTD-1977
(TENTATIVE)

FIGURE 3

DESIGN GUIDE FOR ASPHALT OVERLAY
OF RIGID PAVEMENT

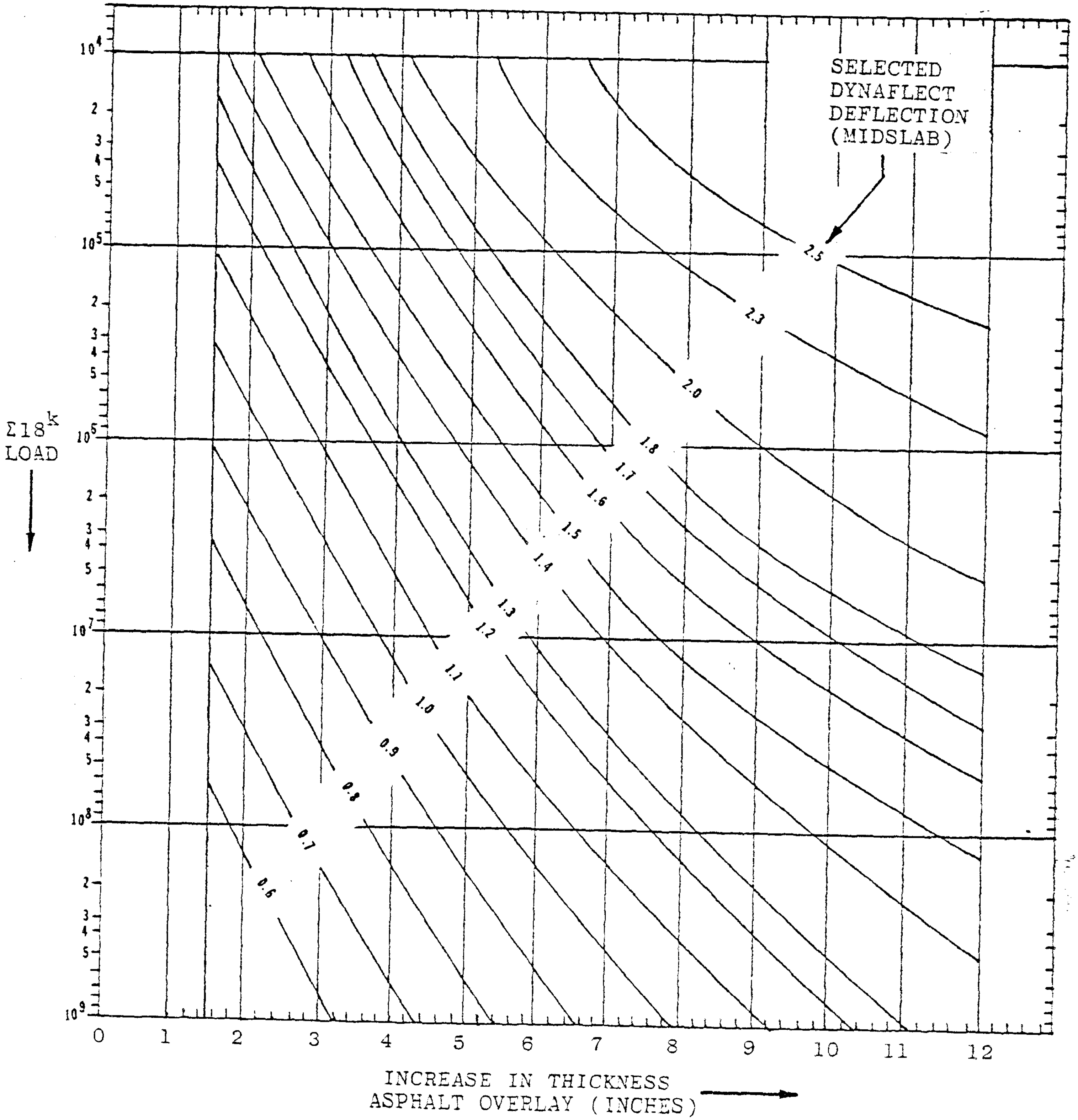
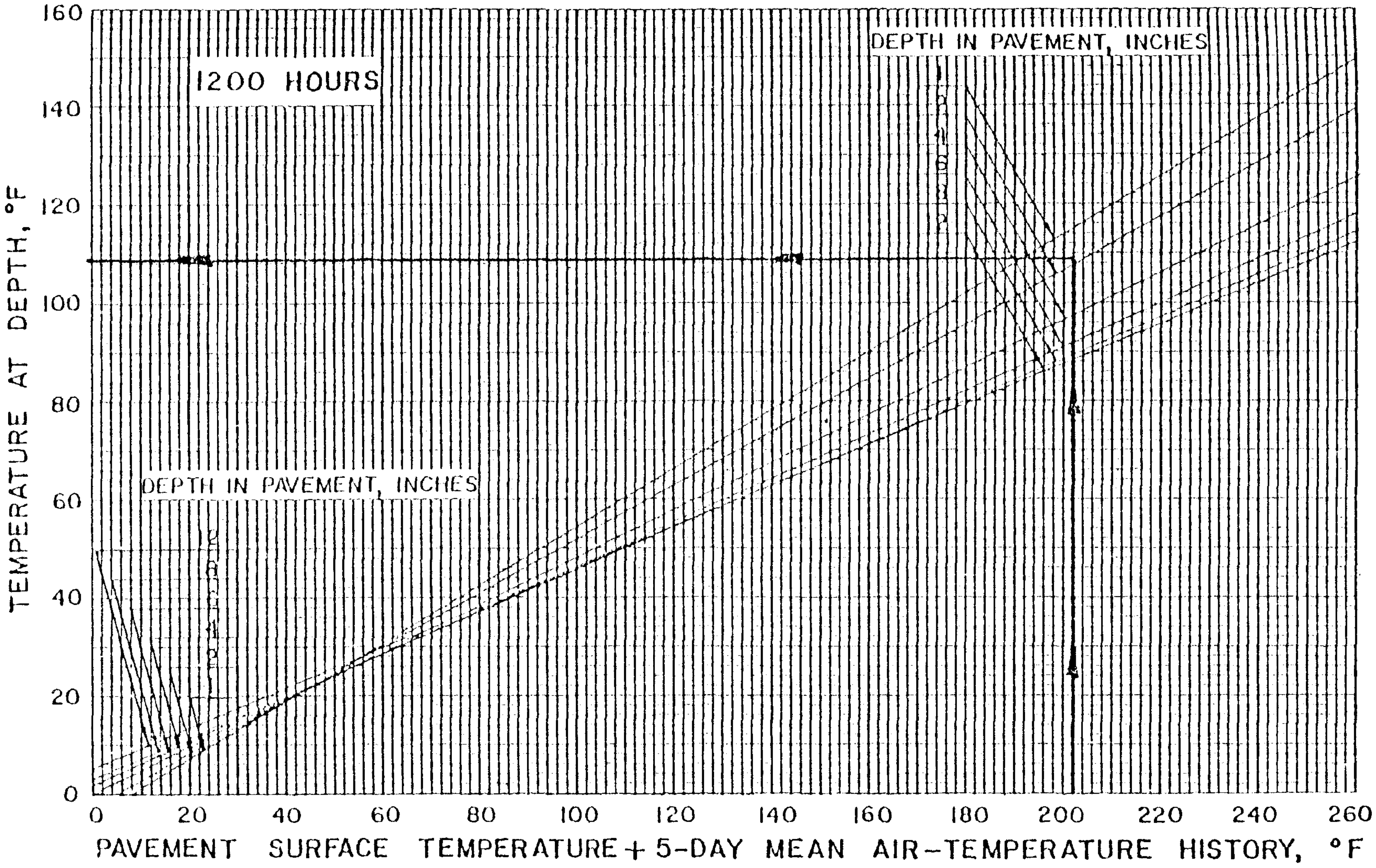
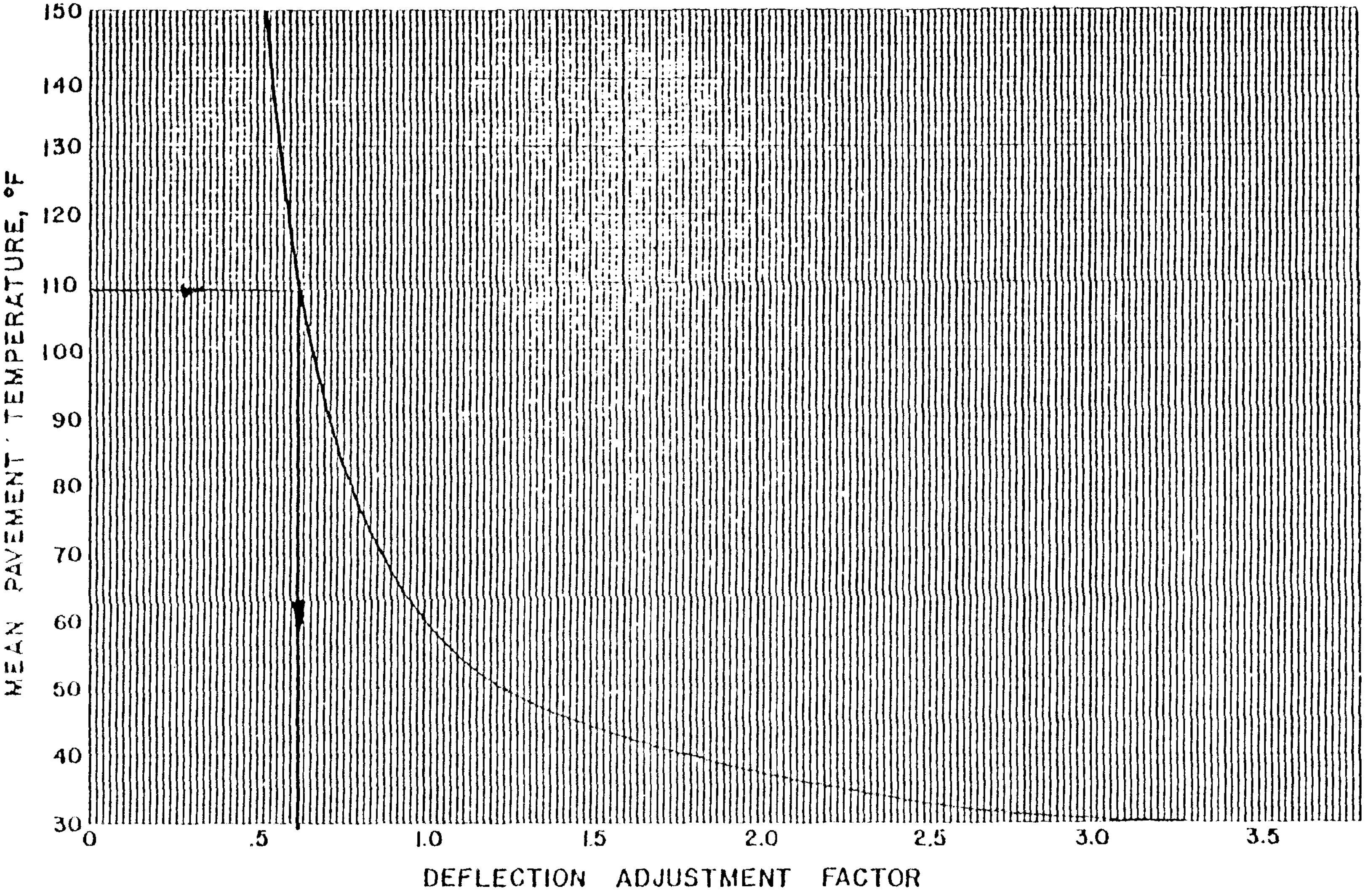


FIGURE 4



Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

FIGURE 5



Mean Pavement Temperature vs. Deflection Adjustment Factor