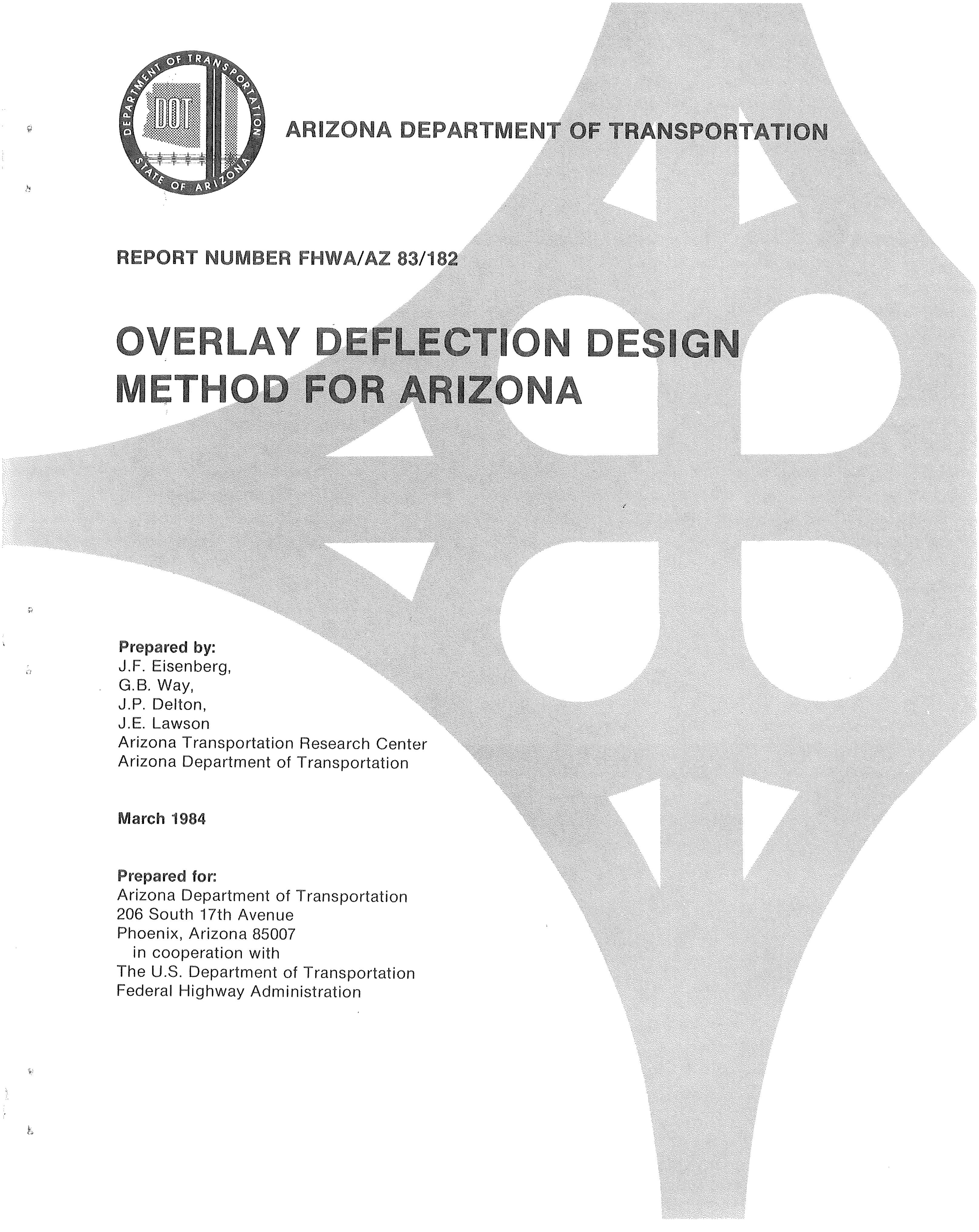

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OVERLAY DEFLECTION DESIGN METHOD FOR ARIZONA

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16. Abstract

A new Structural Overlay Design for Arizona (Soda) was developed. This design method is based upon Dynaflect deflection data being correlated to field performance. To derive the best fit equation, over thirty (30) variables and 170 observations were reviewed. The recommended equation contains five variables including traffic, spreadability index, roughness, region, and the number five geophone deflection. The correlation was acceptable and the final equation appears practical to use.

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METRIC CONVERSION FACTORS

1 mil = 0.0254 mm

1 inch = 2.54 cm

1 foot = 0.305 m

1 yd^2 = 0.836 m^2

1 mph = 0.447 m/sec

1 psi = 6.9 kN/m^2

1 ksi = 6.9 MN/m^2

1 kip = 4.45 kN

1,000 pounds = 1 kip

OVERLAY DEFLECTION DESIGN METHOD FOR ARIZONA

INTRODUCTION

The ability to accurately and objectively establish existing pavement rehabilitative requirements is essential. Since the number of major new construction projects is decreasing, it is evident that more money and reources will be expended on upgrading and restoring existing facilities. With the sharp increase in cost of materials and the steady depletion of natural resources, it is imperative that decisions on allocation of these natural resources and money be made in a logical and objective manner. Arizona, like other states, is faced with preserving its highway network. To do this, a myriad of overlay design strategies are employed. With regard to preservation two critical questions need to be addressed: which miles of highway need overlaying and how much overlay is needed? The Arizona pavement management system addresses which miles of highway need overlaying. The deflection overlay design method should address how much overlay is needed for structural integrity.

The purpose of this project was to analyze the past overlay deflection data developed as part of the Arizona Department of Transportation (DOT) pavement evaluation and research effort (1) (2) and from this analysis develop an overlay deflection design method for Arizona.

LITERATURE REVIEW

An enormous body of literature concerning deflection testing, analysis and design has been generated by researchers and practitioners over the years. Reference (3) through (10) refer to the large number of papers reviewed for this project. Particular attention was given to references 6 - 10 that appeared as part of a 1961 Association of Asphalt Paving Technologists preceedings entitled, "Symposium on Flexible Pavement Bahavior as Related to Deflection". The central concept behind highway design and construction is to build a structure which can accommodate the applied loads without undue deformation or distress for the expected life of the pavement. Figure 1 represents this concept wherein stresses generally diminish with increased structural thickness at increased depth.

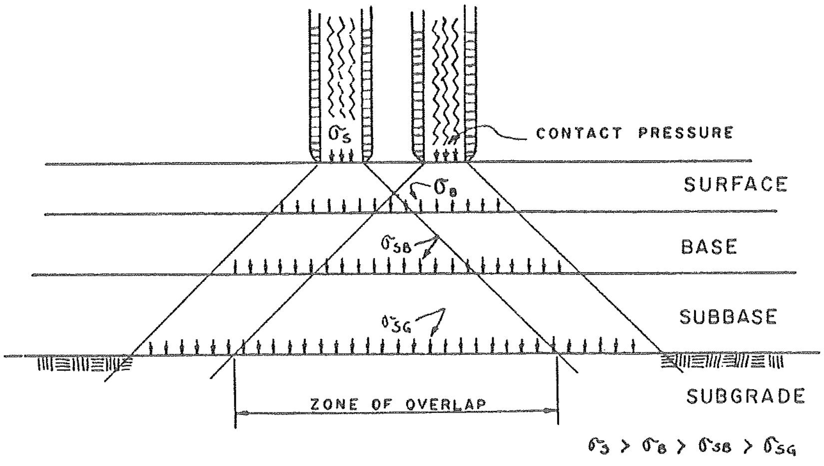


Fig. 1. Sketch Illustrating Simple Stress Distribution Through a Flexible Pavement.

A general solution for stress and deflection in a two layer system was developed by Burmister and later extended to three layers and then to N layers.

Deflection equations for flexible pavements take the following general form:

$$D = \frac{Pa}{E} \times F$$

where

D is deflection
P is contact pressure
a is radius of contact (circular)
E is modulus of elasticity of the subgrade
F is a dimensionless factor accounting for depth and the ratio of moduli of elastacity, pavement layers and subgrade (Ref. 28)

In general the deflection of each layer contributes to the measured surface deflection as shown in Figure 2.

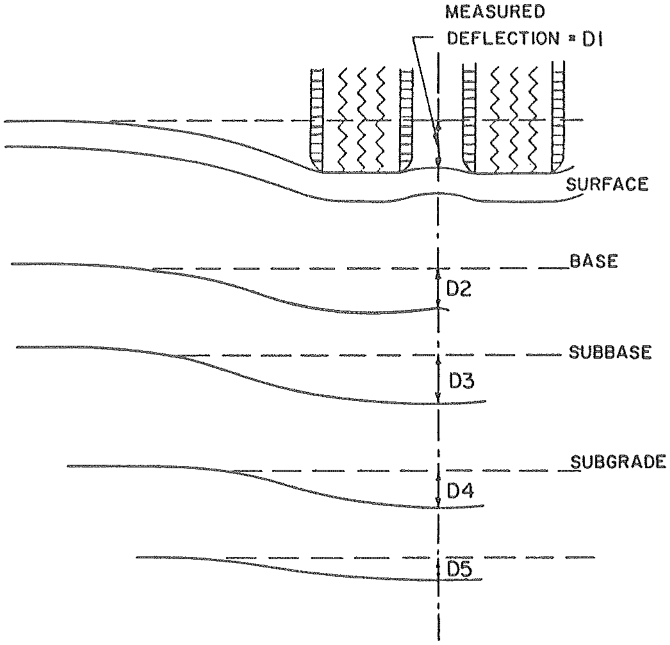


Fig. 2. Deflection Profiles.

Hence, $D1 = D2 + D3 + D4 + D5$

This simple concept of stress and deflections has lead to some very complicated mathematics and physics in order to analyze a set of static or dynamic deflections. This occurs because typically only the thickness of each layer and surface deflection are known.

Other important information such as layer modulus, state of stress and modulus/stress relationship are generally unknown.

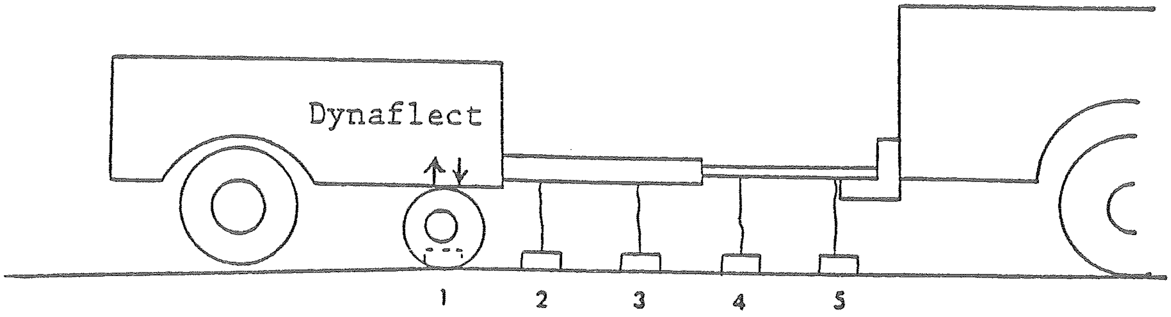
Over the years considerable work has been done to develop improved non-destructive testing devices (NDT) which determine the surface deflection. The emphasis of this work has been on portability and convenience to the user. Efforts have been made to simplify the mathematics of the deflection analysis in terms of layered properties and other pavement response. A host of NDT deflection devices have been developed. The Dynaflect, Road Rater, La Croix Deflectograph and Falling Weight Deflectometer are commonly used devices for highway design work. Heavier NDT deflection devices have been developed for the Federal Highway Administration, U.S. Army Corps of Engineers for airfields and a heavy load simulator for South Africa. Extensive literature has been written concerning the development and use of this equipment (Ref. 11 - 14).

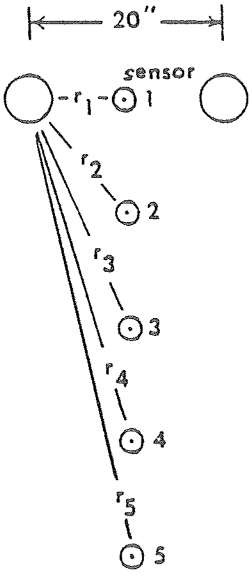
Arizona acquired a Dynaflect in 1972 and a Falling Weight Deflectometer in 1980. Although both pieces of equipment measure deflection they are quite different. The Dynaflect applies a 1,000 pound force peak to peak sinusoidal load at a frequency of 8 Hertz. The load is applied to two force wheels (Figure 3) 20 inches apart. Transducers called geophones are arrayed between the force wheels in such a manner that a deflection basin can be recorded. The Falling Weight Deflectometer (FWD), Figure 4, was developed to simulate the pulse load applied by an 18 kip axle load moving at approximately 55 mph. A weight is raised up a mast and dropped onto a spring loaded plate approximately 12 inches in diameter. This action develops a pulse wave that is detected by transducers located at the center of the plate as well as at various distances away from the plate. Considerable theoretical and practical verification (Ref. 15) were involved in developing this device, such that a physical and mathematical evaluation of the deflection basin is possible.

The role that deflections play in overlay design is varied. Ideally there would be a link between deflection and performance, however, it has been extremely difficult to verify this physical relationship due to the complexity of the problem. A number of empirical relationships have been developed and applied to overlay design problems. Arizona at present uses the empirical relationships developed by California (Ref. 16) which use the Dynaflect geophone centered between the force wheels (d1) deflection and the traffic level to estimate the amount of overlay thickness needed for a cracked asphaltic concrete (AC) pavement. The larger the deflection and/or traffic the greater the thickness of overlay needed. Rather than attempting to revise the California method to reflect Arizona's experience it was decided that the new Arizona Deflection Method should reflect the findings developed from actual field performance tests.

FIGURE 3

DYNAFLECT





r_1 = 10.0"

r_2 = 15.6"

r_3 = 26.0"

r_4 = 37.4"

r_5 = 49.0"

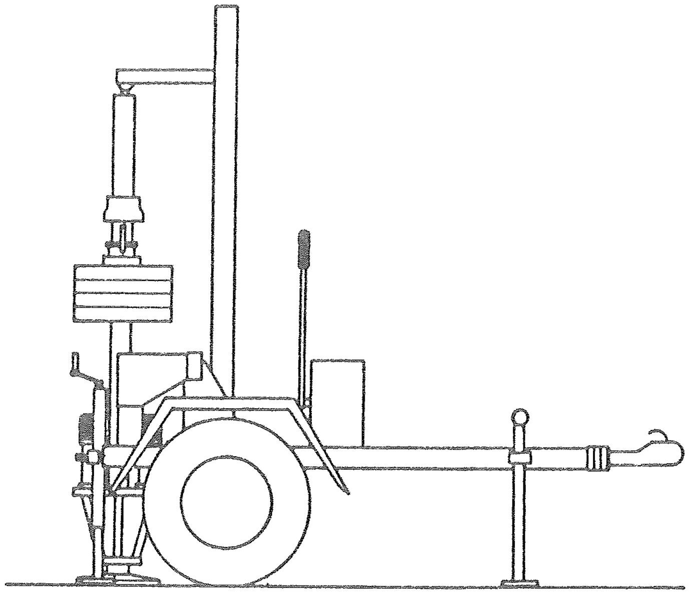
* 8 Hertz Oscillating Load

* 1000 pound peak to peak force

* Five geophones arrayed as shown between two force wheels

FIGURE 4

FALLING WEIGHT DEFLECTOMETER



The Falling Weight Deflectometer

* Variable pulse load by adjusting drop height of weight load can vary from 0 - 11,000 pounds force.

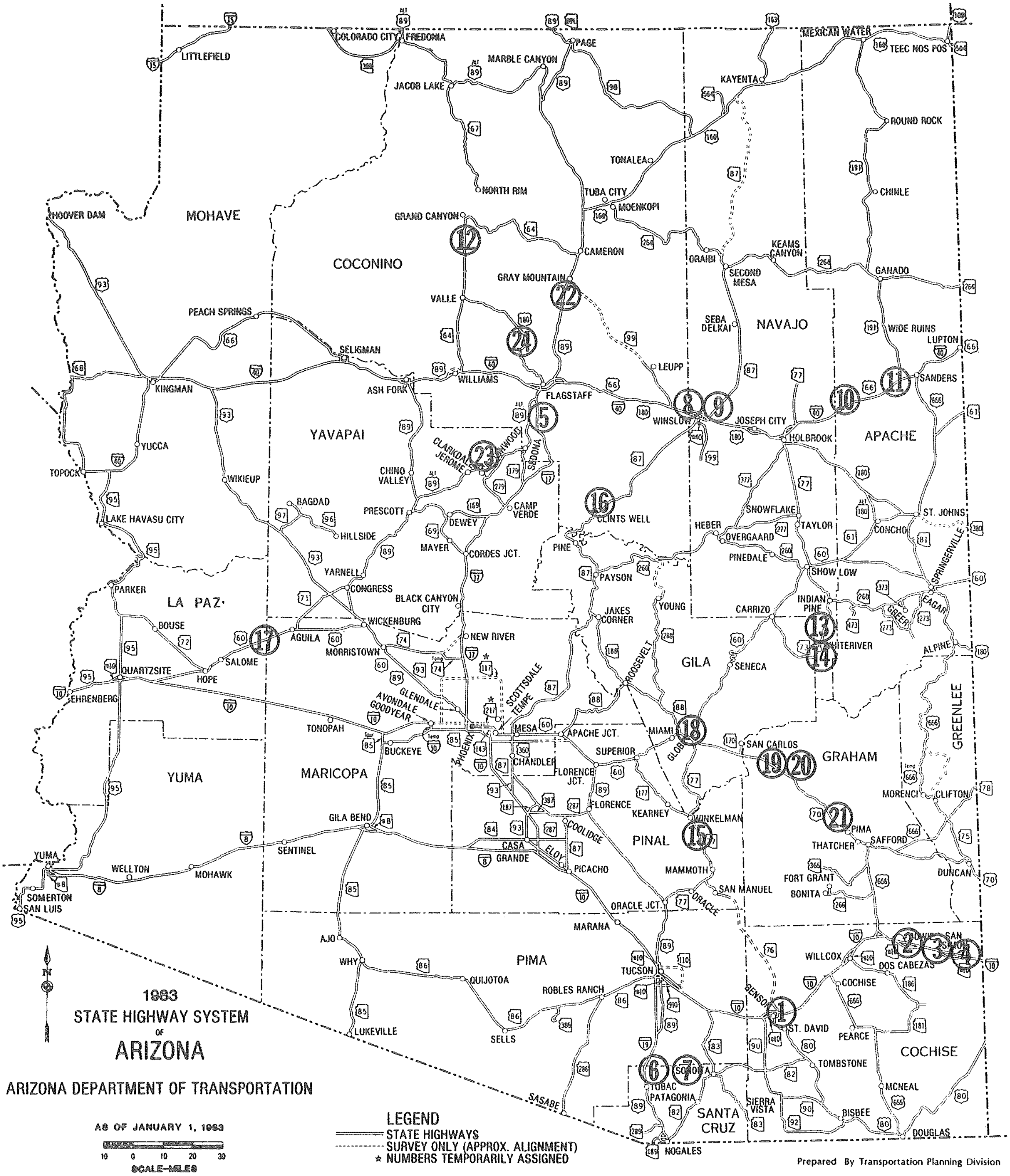
* Accelerometer at center of loaded plate. Additional accelerometers spaced out to a distance of about 7 plate radii.

* Plate approximately 12 inches in diameter

* Loaded plate simulates load from an 18 kip single axle load

FIGURE 5

OVERLAY SITES



SITE DESCRIPTION AND FIELD DATA

Nine interstate and thirteen non-interstate overlay projects were selected to develop the new overlay design method. Projects were selected because they represented standard overlays where before and after deflections as well as performance were known. Figure 5 shows the location of each project. Table 1 describes each site and assigns a number to each site. For all sites, except the three starred (*) sites (5,8,9), the last surfacing before overlay was the original construction. For sites 5, 8 and 9 an overlay was placed on the original surface and then subsequently overlaid again. There are eleven (11) interstate locations representing about 114 centerline miles. The average time between overlays is thirteen (13) years for the interstate and nineteen (19) years for the non-interstate. The relative amount of time between overlays is not necessarily an indicator of how well each highway performed. Table 2 is a general site description which gives elevation, regional factor, 1982 ADT, 1982 annual 18 kip single axle equivalent loads (SAEL), year built, material structural layers and thickness of each layer. Table 3 is a review of Dynaflect data gathered for each site.

The average first geophone (D1) deflection was less after the overlay for all 24 sites. The average project maximum Dynaflect deflection (D1) ranged from .73 mils to 3.73 mils before overlay and .57 mils to 2.06 mils after overlay.

Tables 4 and 5 are a review of actual ride and cracking conditions for all sites from year 1972 to 1982. Table 6 is review of age, ride, cracking, rut depth and present serviceability index (PSI) before overlay. The following table is an average condition before overlay.

AVERAGE PAVEMENT CONDITION BEFORE OVERLAY

	Interstate 11 Sites	Non Interstate 13 Sites	All 24 Sites
Age, Years	13	19	16
Percent Cracking	11	21	16
Ride, MAYS RIDE-METER Inches/Mile	175	177	176
Rut Depth, Inches	0.17	0.21	0.19
PSI	2.93	2.85	2.89

DATA ANALYSIS AND INTERPRETATION

Data from the 24 sites was assembled into a regression matrix of 170 mile post location and 31 variables (Appendix A). The 31 variables represent either physical measurements or their concomitant calculated values. The 31 variables included in the regression analysis were:

1. Regional Factor (R).
2. Spreadability Index before the overlay (SIB). See equation 6.
3. Tensile strain at the bottom of the existing AC pavement before the overlay. See Appendix B.
4. Vertical strain on the subgrade before the overlay. See Appendix B.
5. Modulus of AC pavement before the overlay. See Appendix B
6. Modulus of the unbound base before the overlay. See Appendix B.
7. Modulus of the subgrade (Esg) before the overlay. The Esg was determined by fitting theoretical deflection basins to the measured Dynaflect deflection basins through the technique described in Appendix B. Linear bivariate regression models were fitted to these data; Esg was the dependent variable and the fifth Dynaflect sensor deflection (D5) was the independant variable. A reciprocal transformation of the dependent variable, Esg, resulted in the relationships:

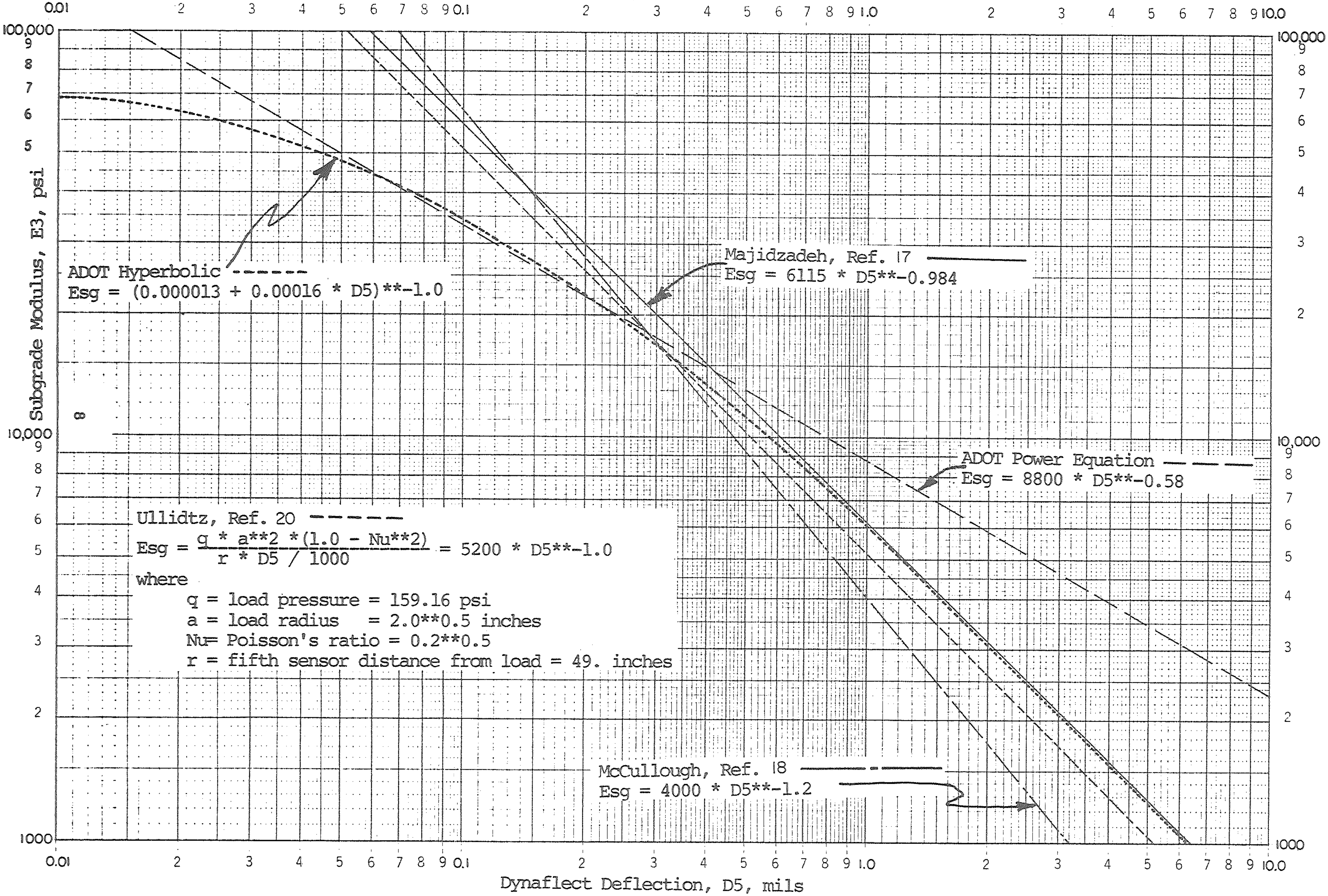


Figure 6 Fifth Sensor Deflection - Subgrade Modulus Relationship

$$(E_{sg}, psi)^{-1} = 0.000013 + 0.00016 \times (D5, mils) \qquad \text{EQ. 1}$$

Standard Error of Estimate = 0.00001

Coefficient of Determination = 0.82

This relationship is compared with the finding of others (Ref. 17, 18 and 20) in Figure 6.

8. Surface Curvature Index (SCI) before the overlay, Calculated by subtracting Dynaflect sensor two deflection (D2) from Dynaflect sensor one deflection (D1).
9. Dynaflect sensor one deflection (D1) before the overlay.
10. Dynaflect sensor five deflection (D5) before the overlay.
11. Existing AC pavement age at the time of the overlay.
12. Accumulated 18,000 pound single axle equivalent load coverages on the existing pavement before the overlay.
13. Slope of a linear least-squares regression with Mays roughness before the dependent variable and pavement age in years the independent variable i.e., change in roughness/year.
14. Intercept (Age = 0) of the regression equation described in # 13.
15. Thickness of the existing AC pavement before the overlay.
16. Thickness of the existing unbound base.
17. Roughness of the existing AC pavement just before the overlay. (Po). This value was found by using the Pavement Performance Information System (PMIS) data bank which included Mays Ride Meter roughness (MR) values for the years 1972 through 1982. Most of the 170 milepost locations included in the regression data set were "as-built" (year of the last major construction activity prior to the overlay) before 1972. An MR of 50 was assumed for the as-built pavements (Age = 1). Actual MR values for the years 1972-1982s were used as the dependent variable values and the respective ages in years from the as-built year were the independent variable observations. A bivariate linear least-squares regression model was fitted to these observations. For the regression equations with zero or negative slopes, the slope was set to zero. The intercept for these cases was the arithmetic mean of the MR. The Po values used in the multiple regression model were calculated by substituting the pavement age at the time of the overlay into the bivariate linear equation as the independent variable and solving for the dependent variable, Po.
18. AC overlay thickness (T).
19. Speadability Index after the overlay (SIA).
20. Tensile strain at the bottom of the existing AC pavement after the overlay. See Appendix B.
21. Vertical strain on the subgrade after the overlay. See Appendix B.
22. Effective modulus of the composite of the existing AC pavement and the AC overlay. See Appendix B.
23. Modulus of the unbound base after the overlay. See Appendix B.
24. Modulus of the subgrade after the overlay. See Appendix B.
25. SCI (see #8) after the overlay.
26. D1 after the overlay
27. D5 after the overlay
28. Equivalent thickness of the AC overlay (ET). From Kirk and Ullidtz (Ref. 19, 20 and 21) the equivalent thickness of the pavement structure above the subgrade was defined as:

$$ET,m = f(H1(E1 / Em)^{0.33} + H2(E2/Em)^{0.33} \ldots Hm\text{-}1(Em\text{-}1/Em)^{0.33}) \qquad \text{Eq. 2}$$

In this study,

$m = 4$
$E4$ = subgrade layer modulus and
$E3,H3$ = unbound base modulus and thickness
$E2,H2$ = existing AC pavement modulus and thickness
$E1,H1$ = AC overlay modulus and thickness
f = an adjustment factor, assumed to be unity

The equivalent thickness of the AC overlay is obtained by calculating ET,m with and without the overlay and subtracting; since E2,H2,E3,H3, and E4 are treated as constants before and after overlay, the equivalent AC overlay thickness (ET) equation reduces to:

$$ET = T\,(Eov/Esg)^{0.33} \qquad \text{Eq. 3}$$

Where

T = the AC overlay thickness, inches.
Eov = modulus of the AC overlay, ksi
Esg = modulus of the subgrade, ksi; determined from D5. See equation 1.

29. Slope of a linear least-squares regression with Mays roughness as the dependent variable and pavement age after the overlay as the independent variable (i.e., change in roughness/year).

30. Intercept (Age = 0) of the regression equation described in #29.

31. Expected 18000 pound single axle equivalent loads on the overlaid AC pavement during the design period in thousands (the common logarithm of this value is the dependent variable in the regression model, L). To determine this value a bivariate linear least-squares regression line was fitted to the MR values for each year subsequent to the AC overlay; i.e., the dependent variable was MR and the independent variable was the time or age in years since the overlay. The linear equation was then used to solve for the number of years until the expected MR would reach 260 inches. The number of years was constrained to be 30. The accumulated loads L in thousands during this time was calculated from:

$$L = AADL \times t \times (200 + t \times GF) \times 0.000005 \qquad \text{Eq. 4}$$

Where

$AADL$ = the average annual 18000 SAEL in the overlay year
t = the design period or the time until the MR reaches a value of 260 (Subject to a maximum of 30).
GF = the traffic loads growth factor, expressed as a percentage of the beginning AADL. The Arizona DOT GF is linear, i.e., the change in traffic volume and loads is the same for each year under consideration.

Within the multiple regression analysis, variables number 1 through 30 were regressed against number 31. The intent of this analysis was to determine whether deflection and/or deflection derived values were significantly related to the number of loads to failure. It was determined that of all the deflection variables, Spreadability Index was the most significantly correlated to the dependent variable. Further analysis was performed to derive a general Arizona overlay equation.

STRUCTURAL OVERLAY DESIGN FOR ARIZONA (SODA)

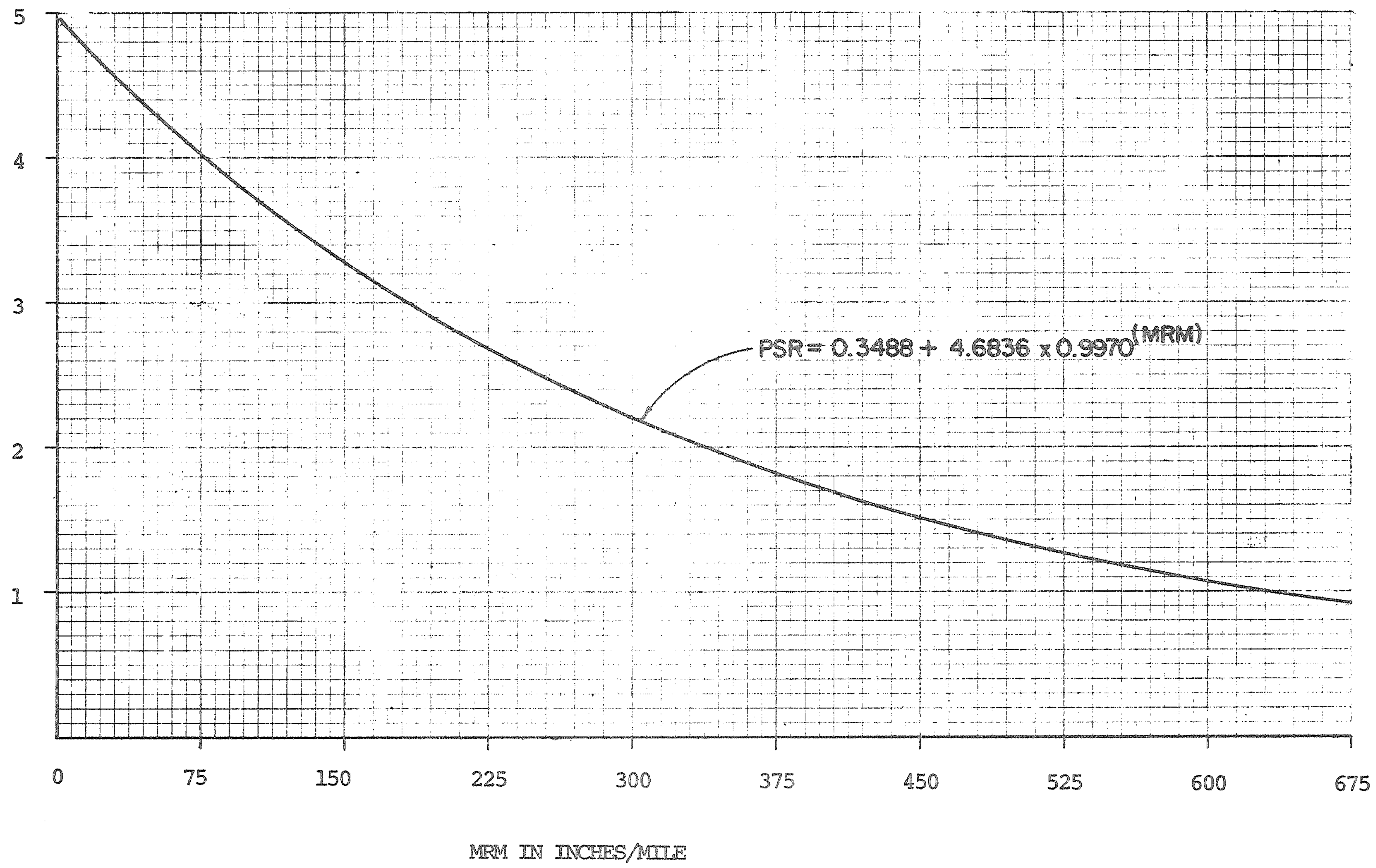
An AC overlay performance prediction model based on Dynaflect deflections and actural field data was derived by using multiple regression. The general form of the overlay equation is:

$$Pt = f\,(R,D,Po,L,T) \qquad \text{Eq. 5}$$

FIGURE 7

PRESENT SERVICEABILITY RATING

RELATED TO MAYS RIDE METER ROUGHNESS



$$PSR = 0.3488 + 4.6836 \times 0.9970^{(MRM)}$$

where

Pt = a pavement performance measurement characteristic over time t
R = an environmental factor
D = deflection measurements
Po = the level of the pavement performance characteristic for the existing pavement before the overlay is placed.
L = the expected traffic loading on the overlaid pavement during time t
T = the AC overlay thickness

For the ADOT overlay design based on Dynaflect deflections, these variables are defined as follows:

t is the actual or extrapolated time in years until the overlaid pavement reaches 260 inches of roughness measured by the Mays Ridemeter (MR). An MR of 260 is equivalent to a Present Serviceability Rating (PSR) of 2.5 which is considered the limiting PSR for all pavements on the State highway system. See Figure 7.

R is equivalent to the Regional Factor developed at the AASHTO Road Test. At the Arizona DOT R is a funtion of the climatological area, the average annual rainfall, and the elevation of the project pavement (refer to the Materials Design Manual (Ref. 23)).

D is the five Dynaflect deflection measurements in mils, expressed as the Spreadability Index (SI). (Ref. 24)

$$SI = \frac{D1 + D2 + D3 + D4 + D5}{5 \times D1} \times 100 \qquad \text{Eq. 6}$$

Po is the Mays Ridemeter inches of roughness on the existing pavement before the overlay is placed.

L is the 18000 pound SAEL's expected on the overlaid pavement during the design period, in thousands.

T is the thickness (inches) of the AC overlay that will provide the required time until the pavement is expected to reach 260 inches of roughness (PSR = 2.5).

The multiple regression analysis performed on the data from the 24 projects (170 milepost observations) produced the following functional relationships:

$$\log L = -0.104 \times R - 0.000578 \times Po + 0.0653 \times SIA \qquad \text{Eq. 7}$$

Where

$SIA = SIB + 0.899 \times ET$ and
$ET = T \times (Eov/Esg)^{0.333}$ and
$Esg = (0.013 + 0.16 \times D5)^{-1}$
D5 is fifth Dynaflect sensor deflection, mils.
Esg is the estimated modulus of the subgrade, ksi
log is the common logarithm with Base 10.
Eov is the estimated modulus of the AC overlay; for ADOT it is a constant 200 ksi
ET is the equivalent thickness of the AC overlay, inches.
SIB is the spreadability index of the existing pavement before the AC overlay.
SIA is the predicted spreadability index of the overlaid AC pavement.
By substitution, combining terms, and rearranging these equations we obtain:

$$T = \frac{\log L + 0.104 \times R + 0.000578 \times Po - 0.0653 \times SIB}{0.0587 \times (2.6 + 32.0 \times D5)^{0.333}} \qquad \text{Eq. 8}$$

SENSITIVITY ANALYSIS

The relative effect of the independent variables on overlay thickness, ordered by decreasing importance is:

1. L, the number of 18000 pound SAEL's (thousands)
2. SIB, the spreadability index before the overlay.
3. R, the Regional Factor
4. D5, Dynaflect sensor #5 deflection, mils.
5. Po, Mays Ridemeter roughness in inches.

An inspection of Table 7 and Table 8 reveals that variable L and variable SIB have practically an equal effect on overlay thickness and that these two variables have double or triple the effect of any of the other three variables.

D5 and Po have an almost equal effect on overlay thickness for typical ranges in value of these two variables.

DISCUSSION

The inclusion of the Spreadability Index (SIB) in the overlay equation is indicative of its importance and rationality as a parameter to represent the load-carrying capacity of a pavement. However, it does not sufficiently reflect fundamental materials properties and the inter-related pavement structure stresses and strains to justify its use as the sole indicator of pavement performance. For example, since spreadability is a function of the ratio of E1, E2, and E3 it is possible for a pavement structure with three week layers to have the same spreadability as a pavement structure with three proportionally strong layers. This shortcoming of the overlay design equation could likely be corrected by the inclusion of Dynaflect sensor 1 (D1) deflection as a separate variable in the overlay design equation. Unfortunately, for the data set used in this study, the D1 value was found to be statistically insignificant during the multiple regression analysis. Another candidate variable that could have made up for the inadequacies of the spreadability index, SCI, also proved to be statistically insignificant.

It is important to note that the sensor 5 deflection (D5) appears in the denominator of the overlay equation. This parameter is assumed to be significantly sensitive only to the modulus of the subgrade; this has been confirmed during the course of this study and other deflection related investigations at Arizona DOT. D5 is inversely related to the subgrade modulus; directly related to the effective thickness of the AC overlay; and therefore indirectly related to the overlay thickness requirement estimated by the full equation. The incorporation of D5 as a separate deflection variable in the overlay equation tends to ameliorate the limitations of the Spreadability index as an indicator of pavement structural performance. Future improvement to the overlay design procedure will quite likely focus on the inclusion of a parameter that is more sensitive to the individual stiffnesses of the pavement layers.

The modulus of the AC overlay (Eov) was treated as a constant (200 ksi) in this study (Ref. 25). Some laboratory testing in conjunction with in-situ deflection measurements should be undertaken to provide a reasonable estimate of the Eov.Empirical equations that use the results of relatively routine tests to estimate AC modulus are appealing from a practical and implementable approach. For example, from Reference 26:

$$\text{Log } E = -0.124262 + 1.25469 \times K - 0.0616215 \times V$$

Where

E = dynamic modulus, 10^5 psi (at 4 Hertz loading frequency)
K = log of Marshall stability (lb.) divided by 100 times Marshall flow (0. 01 inch)
V = percent air voids for the modulus speciment minus percent air voids for the Marshall test specimen.
log = common logarithm (base 10)

The principal advantage gained by making use of these test results to elimate modulus is the relative ease with which they can be incorporated into a specification plan. The importance of having some degree of construction control on the AC mix characteristics used during the overlay design procedures cannot be over-emphasized.

The final overlay equation represents not only the best fit multiple regression solution, but also the end product of many hours of group discussion concerning overlay design experience and philosophy. The reliablility of the final equation can be no better than the data used to develop it. The 170 observations represents about a two percent sampling of ADOT's highway system. One of the problems in developing the equation was that the thickness of overlay was not uniformly distributed over a large range; rather there were clusters of thickness generally less than 3 inches. To account for this each of the 170 mileposts observation sets was weighted in the regression program (Ref. 27 and Ref. 28) by the reciprocal of the total number of times that a particular thickness occurred in the data set. Even though attempts were made to smooth the data, the final equation can give unreasonable overlay thicknesses, thus the range of thickness solutions has been constrained between zero and six inches.

Before the regression analysis began, it was necessary to identify the controlling failure mode. Both cracking and ride were considered, however, due to the small amount of cracking that had occurred after overlay (Table 6), cracking was eliminated. Certainly cracking is important, but this data set unfortunately did not provide sufficient history. In addition, Arizona's policy of using a special treatment (surface recycling or asphalt rubber) for highways with greater than 10 percent cracking could be a significant contributing factor to restrain cracking. After examining the Mays ridemeter roughness data it was decided that it would be the controlling failure mode. From previously conducted studies (Ref 2, 22) a value of 260 inches of roughness was selected as the pavement terminal roughness. This value corresponds to a 2.5 present serviceability rating, which is consistent with the AASHTO Road Test terminal serviceability index or TSI. Since the failure point was set at 260 inches/mile roughness, when in fact the average overlay was placed at 170 inches/mile, the solution tends to be on the conservative (thicker) side.

One of the concerns when using deflection data for design of overlays is the possibility that the test results are not a true representation of the worst case conditions and consequently the overlay will be inappropriately designed. Many schemes have been devised to adjust the observed values to a standard set of conditions. Most are based on temperature correction factors or adjustments for "critical" season.

Previous studies in Arizona have shown that the temperature correction factors are unreliable and their use has been discontinued. These earlier Arizona studies were concerned with the maximum deflection only. Since the SODA method uses the complete basin rather than only the maximum deflection a new study was made of the influence of temperature and/or season versus spreadability. Details are contained in Appendix D.

The results indicate that there is a seasonal effect that is related to asphaltic concrete thickness. Attempts to isolate this effect in terms of temperature were not successful. Based on the available information it is believed appropriate testing seasons can be established.

CONCLUSION

The purpose of this research was to use Arizona data to derive an Arizona overlay deflection method. Such a method has been developed and documented. The method is a combination of empirical and theoretical concepts and is built around the Dynaflect deflection device. In addition, it has been developed in such a way that other devices can be used. Arizona has a Falling Weight Deflectometer and its use will be integrated into the new overlay method. The new overlay method is intended to be used to identify the thicknesses of overlay needed to structurally accommodate the anticipated 18 Kip SAEL for the specified design period. It should not be used as the sole determinant of whether an overlay is needed. If no overlay thickness is indicated for structural reasons, an overlay may still be placed to correct other problems such as excessive cracking, roughness, rutting, bleeding and/or ravelling. The method does not address the structural requirements of a recycling design at this time.

RECOMMENDATIONS

*The results of this study should be considered for imediate implementation on State-funded overlay projects. A BASIC computer program has been written and is available for use (appendix C).

* Approval for use on Federal aid projects should be requested.

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TABLE 1

OVERALL SUMMARY OF SITES

			MILEPOST		YEAR	
SITE #	ROUTE #	DIRECTION	BEGIN	END	NEW SURFACE BEFORE OVERLAY	OVERLAID
1	I-10	WB	297	301	1967	3/1976
2	I-10	EB	368	376	1962	9/1975
3	I-10	EB	376	378	1966	9/1975
4	I-10	WB	368	376	1962	9/1975
5	I-17	NB	313	323	11/1966*	8/1977
6	I-19	NB	37	39	8/1953	6/1976
7	I-19	NB	39	40	11/1953	6/1976
8	I-40	EB	259	264	1972*	12/1980
9	I-40	EB	264	268	1972*	12/1980
10	I-40	EB	311	318	1960	8/1974
11	I-40	WB	313	318	1960	8/1974
12	SR-64		224	237	1956	6/1975
13	SR-73		351	358	1952	10/1975
14	SR-73		350	351	1967	1975
15	SR-77		120	135	1964	3/1977
16	SR-87		292	305	1964	6/1975
17	US-60		50	62	1968	6/1975
18	US-60		245	247	1966	6/1975
19	US-70		300	306	1959	6/1977
20	US-70		306	314	1959	6/1978
21	US-70		331	335	1952	6/1978
22	US-89		451	458	1937	8/1976
23	US-89A		356	370	1937	2/1977
24	US-180		223	235	1958	7/1976

* LAST NEW SURFACE WAS AN OVERLAY

TABLE 2
SITE GENERAL DESCRIPTION

SITE NUMBER AND NAME EXACT LOCATION AND PROJECT NUMBER	ROUTE	ELEV. FT. (METERS)	REG. FACTOR	1982 ADT	1982 18 kip SAEL	DATE BUILT	THICKNESS IN INCHES*									
							ACFC	SEAL COAT	AC	PCCP	BTB	BSB	CTB	AB	SM	SGS
1. Benson MP 296.7-301.3	I-40 WB	4200 (1280)	1.9	14,200	360,674	1965 1976	.5 .5		2.5 1.3					4	13	
2. Bowie - 1 MP 367.7-375.9	I-10 EB	3690 (1125)	1.7	8,580	216,027	1962 1975	.5		3.0 1.3					4	12	
3. Bowie - 2 MP 375.9-378.3	I-10 EB	3600 (1097)	1.7	8,580	216,027	1966 1975	.5 .5		3.5 1.3					6	21	
4. Bowie - 3 MP 367.7-378.3	I-10 WB	3645 (1111)	1.7	8,580	216,027	1962 1975	.5		3.0 1.3					4	12	
5. Munds Park MP 312.9-323.0	I-17 NB	6412 (1954)	3.9	7,200	92,907	1962 1966 1977	.5		5.5 1.5	RM		2		5	9	12
6. Tubac - 1 MP 37.1-39.0	I-19 NB	2925 (892)	2.0	7,200	71,390	1953 1976	.5		4.8			2		3	12	
7. Tubac - 2 MP 39.0 - 40.0	I-19 NB	2900 (884)	1.8	9,200	91,223	1953 1976	.5		6.5			2		2	4	
8. Winslow - 1 MP 259.0 - 264.4	I-40 EB	4885 (1489)	1.7	8,345	220,272	1958 1975 1980	.5 .5		3.5 1.3 6.0		3				6	
9. Winslow - 2 MP 264.4-268.2	I-40 EB	4885 (1489)	1.7	8,345	220,272	1962 1972 1974 1980	.5 .5	.3	4.0 1.5 6.0	RM				6	6	

HS - Heater Scarification
RM - Rubber Membrane

TABLE 2
SITE GENERAL DESCRIPTION

SITE NUMBER AND NAME EXACT LOCATION AND PROJECT NUMBER	ROUTE	ELEV. FT. (METERS)	REG. FACTOR	1982 ADT	1982 18 kip SAEL	DATE BUILT	THICKNESS IN INCHES*									
							ACFC	SEAL COAT	AC	PCCP	BTB	BSB	CTB	AB	SM	SGS
10. Holbrook - 1 MP 311.2 - 317.8	I-40 EB	5625 (1715)	1.8	8390	272,021	1960 1974	.5		4.0 2.8				6		9	
11. Holbrook - 2 MP 312.5 - 317.6	I-40 WB	5625 (1715)	1.8	8390	272,021	1960 1974	.5		3.0 3.3		5				4	
12. Grand Canyon MP 224.0 - 237.1	SR 64		2.6	2595	3,915	1956 1973 1975		.3 .3	3.0			2			6	
13. White River -1 MP 348.9 - 350.1 MP 351.1 - 357.7	SR 73	5220 (1591)	4.1	2030	9,959	1952 1975 1981	.5		2.0	HS		2			12	
14. Whiteriver - 2 MP 350.1 - 351.1	SR 73	5220 (1591)	4.1	2030	9,959	1967 1972 1975 1977	.5	.3 .3	2.0	HS		2.5			17	
15. Winkelman MP 120.4 - 134.7	SR 77	2100 (640)	2.0	2,350	16,685	1964 1977	.5		2.0 1.5	HS				4	9	
16. Clints Well MP 292.4 - 304.6	SR 87	7271 (2216)	3.8	509	8,838	1964 1975		.3	2.0			1.0			21	
17. Salome MP 49.7 - 62.4	US 60	1900 (579)	1.0	1845	73,394	1958 1968 1975	.5	.3	1.5 1.2	HS		2.0		3	9	

HS - Heater Scarification

TABLE 2
SITE GENERAL DESCRIPTION

SITE NUMBER AND NAME EXACT LOCATION AND PROJECT NUMBER	ROUTE	ELEV. FT. (METERS)	REG. FACTOR	1982 ADT	1982 18 kip SAEL	DATE BUILT	THICKNESS IN INCHES*									
							ACFC	SEAL COAT	AC	PCCP	BTB	BSB	CTB	AB	SM	SGS
18. Globe	US 60	3430				1966	.5		4.0					4	9	
MP 245.2 - 247.3		(1046)	1.7	17,150	135,443	1975	.7		1.5	HS						
19. San Carlos - 1	US 70	2690				1959						2.5			21	
MP 300.1 - 306.4		(820)	2.0	2,285	16,842	1977			1.5	RM						
20. San Carlos -2	US 70	2730				1959						2.5		3	9	
MP 306.4 - 314.2		(832)	1.8	2,285	16,842	1978			1.5							
						1979		.3								
21. Pima	US 70	3374				1951						2.0			9	
MP 330.9 - 335.6		(1029)	1.6	4,140	30,513	1978			3.0							
						1980		.3								
22. Gray Mtn.	US 89	4936				1937						1.0		2	4	
MP 450.5 - 458.0		(1505)	1.8	5,405	49,912	1976		.3	1.5	RM						
23. Cottonwood	US89A	4372				1937						1.5			5	
MP 356.1 - 370.2		(1333)	2.2	4,625	12,415	1970		.3								
						1977		.3	1.5	RM						
						1978		.3								
24. Flagstaff	US 180	7970				1958		.3				1.0		2	9	
MP 222.9 - 235.3		(2430)	3.9	2,525	3,893	1971		.3								
						1976		.3	3.0	RM						
						1976		.3								

HS - Heater Scarification
RM - Rubber Membrane

TABLE 3

AVERAGE DYNAFLECT DEFLECTION

B - Before Overlay
A - After Overlay

SITE	MONTHS	TYPE	# OF TESTS	GEOPHONE #1	#2	#3	#4	#5
1	-27	B	46	.70	.49	.28	.18	.12
1	-3	B	12	.92	.63	.38	.23	.16
1	Overlay		3/1976					
1	+23	A	13	.61	.44	.25	.18	.13
2	-30	B	90	1.22	.64	.29	.20	.15
2	Overlay		9/1975					
2	+3	A	24	.61	.46	.29	.21	.15
3	-30	B	29	1.89	.97	.48	.29	.23
3	Overlay		9/1975					
3	+3	A	8	.82	.63	.37	.25	.19
4	-30	B	88	1.20	.66	.33	.22	.17
4	Overlay		9/1975					
4	+3	A	24	.74	.54	.34	.24	.16
5	-27	B	30	.73	.55	.33	.21	.13
5	Overlay		8/1977					
5	+8	A	30	.63	.47	.25	.15	.09
6	-31	B	8	.89	.45	.21	.14	.09
6	Overlay		6/1976					
6	+20	A	6	.59	.42	.27	.21	.14
7	-31	B	3	1.00	.55	.27	.18	.14
7	Overlay		6/1976					
7	+20	A	3	.76	.55	.35	.23	.15
8	-79	B	79	1.89	1.39	.87	.62	.44
8	-70	B	79	1.95	1.44	.95	.72	.52
8	-67	B	78	1.72	1.27	.84	.59	.45
8	-49	B	17	1.52	1.11	.79	.50	.37
8	-20	B	17	1.53	1.07	.65	.45	.34
8	Overlay		12/1980					
8	+1	A	16	.64	.54	.44	.38	.32
8	+5	A	17	.88	.68	.53	.46	.35

TABLE 3

AVERAGE DYNAFLECT DEFLECTION

B - Before Overlay
A - After Overlay

				GEOPHONES				
SITE	MONTHS	TYPE	# OF TESTS	#1	#2	#3	#4	#5
9	-79	B	9	1.36	.83	.45	.31	.23
9	-70	B	9	1.95	1.28	.73	.50	.32
9	-67	B	9	1.38	.87	.50	.34	.26
9	-49	B	11	1.30	.89	.60	.32	.24
9	-20	B	11	1.20	.75	.47	.28	.22
9	Overlay		12/1980					
9	+1	A	11	.57	.45	.34	.28	.21
9	+5	A	11	.81	.64	.44	.31	.24
10	-15	B	58	1.32	1.01	.69	.45	.29
10	Overlay		8/1974					
10	+12	A	16	1.13	.90	.69	.48	.30
10	+45	A	16	.99	.75	.55	.38	.27
11	-11	B	45	1.64	.99	.54	.31	.21
11	Overlay		8/1974					
11	+12	A	13	1.62	1.03	.61	.35	.20
11	+45	A	13	1.38	.92	.50	.34	.23
12	+14	B	137	1.64	.72	.28	.16	.10
12	Overlay		6/1975					
12	+11	A	37	1.01	.63	.27	.15	.10
12	+47	A	37	.78	.42	.26	.13	.08
13	-5	B	20	2.30	1.18	.59	.34	.23
13	Overlay		10/1975					
13	+22	A	20	1.25	.70	.41	.21	.14
14	-5	B	4	2.15	1.03	.44	.22	.13
14	Overlay		10/1975					
14	+22	A	5	1.12	.63	.38	.19	.12
15	-36	B	42	1.11	.59	.29	.21	.14
15	-14	B	43	1.22	.57	.30	.18	.13
15	Overlay		3/1977					
15	+20	A	43	.66	.42	.20	.14	.10

TABLE 3

AVERAGE DYNAFLECT DEFLECTION

B - Before Overlay
A - After Overlay

			# OF	GEOPHONES				
SITE	MONTHS	TYPE	TESTS	#1	#2	#3	#4	#5
16	-12	B	116	.85	.49	.26	.16	.11
16	Overlay		6/1975					
16	+27	A	36	.73	.40	.19	.13	.08
16	+47	A	36	1.00	.55	.22	.14	.09
17	-14	B	34	.96	.53	.27	.18	.13
17	Overlay		6/1975					
17	+9	A	34	.78	.54	.32	.18	.13
17	+38	A	26	.76	.51	.29	.20	.15
18	-17	B	4	1.76	1.16	.56	.36	.23
18	Overlay		6/1975					
18	+8	A	4	1.40	.92	.64	.42	.30
18	+41	A	4	.94	.71	.48	.35	.24
19	-40	B	19	1.40	.85	.48	.34	.25
19	-16	B	19	2.02	1.27	.69	.47	.33
19	Overlay		6/1977					
19	+17	A	19	1.11	.79	.46	.37	.25
20	-52	B	22	1.17	.82	.56	.42	.33
20	-28	B	23	1.61	1.14	.71	.53	.40
20	Overlay		6/1978					
20	+5	A	19	1.08	.78	.54	.46	.35
21	-52	B	10	1.46	1.01	.66	.53	.39
21	-28	B	10	1.73	1.21	.79	.61	.45
21	Overlay		6/1978					
21	+5	A	10	1.20	.85	.52	.42	.32
22	-24	B	14	1.89	.99	.50	.31	.19
22	Overlay		8/1976					
22	+11	A	14	.63	.38	.23	.14	.09
22	+32	A	14	.87	.44	.24	.13	.08

TABLE 3

AVERAGE DYNAFLECT DEFLECTION

B - Before Overlay
A - After Overlay

SITE	MONTHS	TYPE	# OF TESTS	GEOPHONE #1	#2	#3	#4	#5
23	-9	B	42	1.65	.90	.43	.23	.14
23	Overlay		2/1977					
23	+19	A	42	.90	.54	.29	.16	.10
24	-23	B	36	3.73	1.50	.57	.27	.20
24	Overlay		7/1976					
24	+1	A	36	2.06	.90	.37	.16	.10
24	+25	A	36	1.31	.76	.34	.20	.09

TABLE 4

AVERAGE RIDE

SITE	72	73	74	75	76	77	78	79	80	81	82
1	47	46	46	61	43*	39	34	23	55	73	43
2	77	104	183	45*	47	47	51	52	72	89	67
3	64	92	173	41*	43	45	45	45	72	96	81
4	91	102	179	38*	43	42	51	47	65	73	64
5	44	59	66	63	74	54*	48	48	72	87	79
6	232	224	237	292	42*	46	52	50	58	81	78
7	191	164	213	230	44*	45	50	45	55	99	70
8	27	57	63	100	136	179	187	131	56*	86	90
9	19	48	77	104	114	160	158	101	59*	85	96
10	211	259	43*	46	59	123	100	121	132	145	129
11	186	215	42*	47	61	145	122	148	156	184	166
12	154	137	144	131*	116	124	150	137	140	154	153
13	219	192	222	189	69*	127	103	84	87	89	69
14	178	163	232	152	74*	125	84	76	82	77	110
15	115	116	115	98	104	80*	80	90	90	87	105
16	227	199	194	194	108*	132	158	135	146	180	158
17	60	88	86	108	48*	104	77	59	82	85	57
18		92									99
19	126	106	116	101	115	139	113*	106	101	95	112
20	158	132	132	127	131	167	99*	94	94	88	101
21	191	160	147	155	142	194	88*	71	73	67	73
22	157	161	163	208	93*	64	86	79	90	90	81
23		194	199	231	172	85*	115	102	127	110	107
24	387	318	362	424	85*	87	114	116	129	137	134

* YEAR OF OVERLAY

TABLE 5

AVERAGE CRACKING

SITE	72	73	74	75	76	77	78	79	80	81	82
1	3	1	1	1	0*	0	0	3	0	.3	.3
2		20	20	0*	0	0	0	.2	.4	.3	.4
3		1	1	0*	0	0	0	.5	.5	.5	0
4		21	21	0*	0	0	.2	.5	.6	.7	1.0
5	0	0	1	.8	.8	0*	0	0	.1	.2	0
6	2	2	2	2	0*	0	0	0	0	0	1.0
7	2	2	2	2	0*	0	0	0	0	1.0	1.0
8		0					1.4	0	0*	0	0
9		.3					.8	0	0*	0	2.5
10		10	0*	0	0	0	0	.2	5.5	.2	.1
11		45	0*	0	0	0	.2	1.2	7.0	1.4	11.8
12		49	49	0*	0	0	0	.7	.7	.5	.6
13		30	30	30	0*	0	0	.9	.9	1.7	.3
14	0	0		0	0*	0	0	0	0	0	0
15	1.5	1.5	1.1	1.0	1.2	0*	.1	.2	.9	.9	.9
16		2.2	2.2	2.2	0*	0	.3	.3	.2	1.6	2.8
17		39	39	39	0*	0	0	0	0	0	.1
18											1.5
19	8.3	7.0	6.7	5.3	9.7	9.7	0*	2.5	1.5	4.7	5.8
20	3.0	3.0	3.3	2.8	6.5	6.5	0*	.9	1.0	.8	1.0
21	6.0		0	6.0	17.5	24.0	0*	0	0	0	0
22		11	11	11	0*	0	0	0	0	0	0
23			3.6	10.4	5.9	0*	0	0	0	0	2.5
24		95	95	95	0*	0	0	0	.4	0	0

* YEAR OF OVERLAY

TABLE 6

AVERAGE PAVEMENT CONDITION BEFORE OVERLAY

SITE	AGE YEARS	PERCENT CRACKING	RIDE INCHES/MILE	RUT DEPTH INCHES	PSI
1	9	1	61	.25	3.94
2	13	25	185	.30	2.66
3	9	1	174	.20	2.84
4	13	21	179	.25	2.74
5	11	1	74	.10	3.83
6	23	2	292	.20	2.20
7	23	2	230	.25	2.47
8	8	1	131	.05	3.22
9	8	1	101	.05	3.51
10	14	12	269	.15	2.31
11	14	53	225	.10	2.51
12	19	49	131	.30	3.04
13	23	30	189	.20	2.70
14	8	0	152	.15	3.03
15	13	1	104	.15	3.46
16	11	2	194	.35	2.59
17	7	39	108	.15	3.36
18	9	8	117	.15	3.31
19	18	9	141	.15	3.09
20	19	5	170	.25	2.82
21	27	24	194	.10	2.71
22	39	11	208	.15	2.63
23	40	6	172	.25	2.81
24	18	95	424	.35	1.54

TABLE 7

SENSITIVITY ANALYSIS

		Regional Factor (R) = 1								
		SIB = 30			SIB = 43			SIB = 56		
		D5=0.1	D5=0.2	D5=0.3	D5=0.1	D5=0.2	D5=0.3	D5=0.1	D5=0.2	D5=0.3
L = 100	Po=100	1.93	1.66	1.50	0.0	0.0	0.0	0.0	0.0	0.0
	Po=200	2.47	2.14	1.93	0.0	0.0	0.0	0.0	0.0	0.0
	Po=300	3.02	2.61	2.36	0.0	0.0	0.0	0.0	0.0	0.0
L = 1000	Po=100	6.00	6.00	6.00	3.36	2.90	2.62	0.0	0.0	0.0
	Po=200	6.00	6.00	6.00	3.91	3.37	3.05	0.0	0.0	0.0
	Po=300	6.00	6.00	6.00	4.45	3.85	3.48	0.0	0.0	0.0
L = 3000	Po=100	6.00	6.00	6.00	6.00	6.00	6.00	0.0	0.0	0.0
	Po=200	6.00	6.00	6.00	6.00	6.00	6.00	0.38	0.33	0.30
	Po=300	6.00	6.00	6.00	6.00	6.00	6.00	0.93	0.80	0.72

L = 18000 pound single axle equivalent loads, thousands
Po = Mays Ridemeter roughness in inches
SIB = Spreadability index before the overlay
D5 = Dynaflect sensor #5 deflection, mils

Table 8

SENSITIVITY ANALYSIS

		Regional Factor (R) = 3								
		SIB = 30			SIB = 43			SIB = 56		
		D5=0.1	D5=0.2	D5=0.3	D5=0.1	D5=0.2	D5=0.3	D5=0.1	D5=0.2	D5=0.3
L = 100	Po=100	3.90	3.37	3.04	0.0	0.0	0.0	0.0	0.0	0.0
	Po=200	4.45	3.84	3.47	0.0	0.0	0.0	0.0	0.0	0.0
	Po=300	5.00	4.31	3.90	0.0	0.0	0.0	0.0	0.0	0.0
L = 1000	Po=100	6.00	6.00	6.00	5.33	4.61	4.16	0.0	0.0	0.0
	Po=200	6.00	6.00	6.00	5.88	5.08	4.59	0.0	0.0	0.0
	Po=300	6.00	6.00	6.00	6.00	5.55	5.02	0.0	0.0	0.0
L = 3000	Po=100	6.00	6.00	6.00	6.00	6.00	6.00	1.81	1.56	1.41
	Po=200	6.00	6.00	6.00	6.00	6.00	6.00	2.36	2.03	1.84
	Po=300	6.00	6.00	6.00	6.00	6.00	6.00	2.90	2.51	2.27

L = 18000 pound single axle equivalent loads, thousands
Po = Mays Ridemeter roughness in inches
SIB = Spreadability Index Before the overlay
D5 = Dynaflect sensor #5 deflection, mils

APPENDIX A
DATA FOR REGRESSION ANALYSIS

Data displayed in Appendix A falls into two groups. Pages 32 - 34 contain data before overlay. Pages 33 - 36 contain data after overlay.

DEFINITIONS FOR PAGES 32 THROUGH 34.

R - AASHTO Regional Factor
AADL - Average number of 18 kip single axle equivalent loads (SAEL) per day for the as-built year.
GF - Traffic load growth factor in percent.
TSAEL - Cumulative 18 kip SAEL in thousands from the as-built year to year of overlay.
YEAR AS - as-built year (year highway constructed).
YEAR OV - Year highway overlaid.
THICK BASE - Unbound crushed stone base in inches.
THICK AC - Asphaltic concrete surface thickness.
MAYS ROUGHNESS BY YEAR - Mays meter roughness in inches/mile.
DYNAFLECT DEFLECTIONS - All five geophone deflections in mils.
SPREAD - Spreadability Index.

Page 33 - 35

All definitions the same as pages 30 - 32 except for the following:

AADL - average number of 18 kip SAEL per day for the year 1982.
TSAEL - Cumulative 18 kip SAEL in thousands for a ten year design period starting at the year of overlay.
THICK ACT - Actual constructed overlay thickness
THICK DES - Design thickness from SODA.
MAYS DES - Mays roughness used for design.

Appendix A

Before Overlay

```
                                YEAR  THICK                  MAYS ROUGHNESS BY YEAR           DYNAFLECT DEFLECTIONS
ROUTE MILE   R AADL  GF   TSAEL AS OV BASE  AC  72  73  74  75  76  77  78  79  80  81  82   D1   D2   D3   D4   D5 SPREAD
**************************************************************************************************************************
I 10 W 297 1.9  624 1.9  3044.7 65 77   13 3.0  44  49  52  55  47  36  32  20  52  58  38 0.88 0.60 0.39 0.24 0.18   52.0
I 10 W 298 1.9  753 1.4  3575.2 65 77   13 3.0  48  42  36  59  45  34  26  18  39  71  36 0.83 0.67 0.49 0.33 0.25   61.9
I 10 W 299 1.9  753 1.4  3575.2 65 77   13 3.0  60  50  59  76  47  37  37  26  56  82  51 0.88 0.58 0.33 0.20 0.14   48.4
I 10 W 300 1.9  562 2.0  2756.9 65 77   22 3.0  37  43  36  53  55  47  40  28  72  80  48 0.96 0.65 0.36 0.21 0.13   48.1
I 10 E 368 1.7  343 2.1  1849.7 62 75   19 3.0  80  45 147  40  58  52  53  54  83 109  63 1.23 0.62 0.27 0.18 0.14   39.7
I 10 E 369 1.7  343 2.1  1849.7 62 75   19 3.0 111 136 166  49  62  47  59  66  61  87  65 1.57 0.68 0.29 0.19 0.15   36.7
I 10 E 370 1.7  343 2.1  1849.7 62 75   16 3.0  87 141 190  51  58  46  49  43  62  58  63 1.59 0.73 0.29 0.18 0.13   36.7
I 10 E 371 1.7  343 2.1  1849.7 62 75   16 3.0  85 129 215  46  49  43  47  49  76  69  64 1.17 0.66 0.28 0.19 0.14   41.7
I 10 E 372 1.7  343 2.1  1849.7 62 75   16 3.0  63 114 192  37  52  44  43  47  64  89  68 1.01 0.58 0.26 0.17 0.12   42.4
I 10 E 373 1.7  343 2.1  1849.7 62 75   16 3.0  63  87 181  46  52  49  57  57  69 108  79 0.74 0.47 0.24 0.17 0.12   47.0
I 10 E 374 1.7  343 2.1  1849.7 62 75   16 3.0  69  91 200  53  59  53  61  62  84 102  81 0.82 0.50 0.27 0.20 0.16   47.6
I 10 E 375 1.7  343 2.1  1849.7 62 75   16 3.0  88 108 190  47  50  46  49  51  77  72  61 1.12 0.66 0.35 0.24 0.20   45.9
I 10 E 376 1.7  393 2.1  1413.0 66 75   27 4.0  68  84 182  40  51  46  47  50  66  90  78 1.79 0.93 0.46 0.27 0.20   40.8
I 10 E 377 1.7  393 2.1  1413.0 66 75   27 4.0  60 101 165  43  46  45  44  41  78 103  87 1.81 0.90 0.43 0.27 0.22   40.1
I 10 W 368 1.7  343 2.1  1849.7 62 75   19 3.0  61  82 145  32  46  39  53  45  58  60  77 1.08 0.57 0.28 0.20 0.15   42.2
I 10 W 369 1.7  343 2.1  1849.7 62 75   19 3.0 125 146 204  28  46  39  59  42  59  56  64 1.29 0.70 0.34 0.20 0.16   41.7
I 10 W 370 1.7  343 2.1  1849.7 62 75   16 3.0 192 101 219  39  52  39  49  44  70  80  56 1.73 0.82 0.40 0.24 0.18   39.0
I 10 W 371 1.7  343 2.1  1849.7 62 75   16 3.0 153 170 201  41  47  46  47  44  69  86  51 1.42 0.75 0.39 0.25 0.17   42.0
I 10 W 372 1.7  343 2.1  1849.7 62 75   16 3.0  77 105 169  41  46  43  43  42  72  70  55 1.16 0.62 0.28 0.17 0.13   40.7
I 10 W 373 1.7  343 2.1  1849.7 62 75   16 3.0  56  69 158  42  46  50  57  54  74  67  77 0.73 0.48 0.25 0.18 0.14   48.8
I 10 W 374 1.7  343 2.1  1849.7 62 75   16 3.0  54  85 190  44  62  53  61  63  69  79  87 1.08 0.66 0.32 0.22 0.17   45.4
I 10 W 375 1.7  343 2.1  1849.7 62 75   16 3.0  47  68 168  36  46  37  49  34  49  51  54 1.02 0.62 0.36 0.25 0.20   48.0
I 17 N 313 3.9  152 2.6   697.5 66 77   27 8.3  60  72  81  74  80  60  64  72  87 115  87 1.01 0.82 0.52 0.23 0.14   53.9
I 17 N 314 3.9  152 2.6   697.5 66 77   24 8.0  42  49  51  56  62  42  51  53  74 105  91 1.12 0.91 0.63 0.37 0.21   57.9
I 17 N 315 3.9  152 2.6   697.5 66 77   24 8.0  34  39  61  61  88  46  44  45  65  62  64 1.21 0.92 0.62 0.37 0.22   55.2
I 17 N 316 3.9  152 2.6   697.5 66 77   26 8.0  26  39  57  55  75  52  36  33  79  90  77 0.53 0.40 0.24 0.18 0.11   55.1
I 17 N 317 3.9  141 2.8   653.3 66 77   26 8.0  35  52  63  70  71  52  49  37  71 104  94 0.65 0.52 0.35 0.29 0.23   62.8
I 17 N 318 3.9  141 2.8   653.3 66 77   26 8.0  40  62  51  52  69  48  37  43  63  76  65 0.80 0.68 0.42 0.28 0.24   60.5
I 17 N 319 3.9  135 2.9   628.5 66 77   26 8.0  50  80  93  65  94  63  51  51  67  72  79 0.81 0.53 0.25 0.15 0.09   45.2
I 17 N 320 3.9  135 2.9   628.5 66 77   26 8.0  49  56  65  67  97  47  48  38  80  66  76 0.62 0.42 0.22 0.12 0.08   47.1
I 17 N 321 3.9  135 2.9   628.5 66 77   26 8.0  43  63  59  63  92  68  39  40  60  84  78 0.75 0.57 0.26 0.13 0.06   47.2
I 17 N 322 3.7  141 2.8   653.3 66 77   26 8.0  56  73  81  93 107  66  57  70  74  97  90 0.99 0.67 0.36 0.26 0.19   49.9
I 19 N  37 1.8   98 2.8  1087.6 53 76   12 2.0 219 185 207 283  51  46  55  53  56  80  83 0.89 0.44 0.24 0.18 0.08   41.1
I 19 N  38 1.8   98 2.8  1087.6 53 76   15 2.0 232 224 237 292  45  47  50  47  60  83  75 0.79 0.40 0.16 0.11 0.08   39.0
I 19 N  39 1.8   98 2.8  1087.6 53 76   15 2.0 191 164 213 230  50  45  50  45  55  99  71 1.17 0.62 0.31 0.21 0.16   42.2
I 40 E 259 1.7  428 2.9  1394.7 72 80    9 8.6  20  38  52  79 124 191 191 235  93 105 114 0.63 0.52 0.24 0.18 0.12   53.7
I 40 E 260 1.7  428 2.9  1394.7 72 80    9 8.6  40  64  72 104 163 183 169  98  50  81  83 2.03 1.42 0.80 0.63 0.43   52.3
I 40 E 261 1.7  428 2.9  1394.7 72 80    9 8.1  23  68  66 115 131 137 159 103  44  70  91 1.05 0.71 0.57 0.37 0.28   56.8
I 40 E 262 1.7  428 2.9  1394.7 72 80    9 8.6  29  56  62 103 146 156 193 103  55  96  93 2.04 1.40 0.77 0.61 0.44   51.6
I 40 E 263 1.7  428 2.9  1394.7 72 80    9 8.6  23  61  64 101 207 228 224 118  37  77  75 1.87 1.20 0.72 0.54 0.44   51.0
I 40 E 264 1.7  428 2.9  1394.7 72 80   15 8.6  15  35  41  82 105 133 133 126  61  63  65 0.95 0.53 0.28 0.14 0.06   41.3
I 40 E 265 1.7  428 2.9  1204.5 72 79   12 6.3  14  34  41  79  90 122 154  98  43  56  78 0.98 0.61 0.37 0.19 0.17   47.3
I 40 E 266 1.7  428 2.9  1204.5 72 79   12 6.3  21  58 112 135 179 209 168  82  72  58 103 0.84 0.50 0.24 0.18 0.13   45.0
I 40 E 267 1.7  428 2.9  1204.5 72 79   12 6.3  26  65 113 119 142 174 178  99  61 163 143 1.33 0.72 0.45 0.24 0.19   44.1
I 40 E 312 1.8  389 2.2  2293.9 60 74    4 4.0 197 250  38  36  58 124  89 104 114 138 112 0.99 0.80 0.62 0.42 0.29   63.0
I 40 E 313 1.8  373 2.3  2212.9 60 74    9 4.0 275 322  49  50  78 135 124 149 181 191 186 1.19 0.90 0.64 0.42 0.28   57.6
I 40 E 314 1.8  373 2.3  2212.9 60 74    6 4.0 187 266  38  47  64 123  98 122 132 112 116 1.19 0.91 0.59 0.36 0.22   55.0
I 40 E 315 1.8  373 2.3  2212.9 60 74   12 4.0 198 241  46  52  71 123 114 145 158 171 158 1.17 0.88 0.57 0.33 0.20   53.8
I 40 E 316 1.8  373 2.3  2212.9 60 74    4 4.0 198 266  55  52  73 118  89 114 117 139 144 1.37 1.02 0.68 0.45 0.30   55.8
I 40 E 317 1.8  373 2.3  2212.9 60 74    6 4.0 175 214  35  39  58 114  85  89  93 118  98 1.37 1.02 0.68 0.45 0.30   55.8
I 40 W 313 1.8  373 2.3  2212.9 60 74    4 8.0 216 268  47  56  78 145 117 152 157 217 228 1.50 0.95 0.53 0.33 0.22   47.1
I 40 W 314 1.8  373 2.3  2212.9 60 74    4 8.0 150 189  38  45  70 134 106 124 130 162 149 1.30 0.76 0.38 0.21 0.14   42.9
I 40 W 315 1.8  373 2.3  2212.9 60 74    7 8.0 190 230  47  48  72 155 143 150 146 190 167 1.57 0.93 0.52 0.28 0.19   44.5
I 40 W 316 1.8  373 2.3  2212.9 60 74    4 8.0 213 211  41  60  67 173 155 211 183 214 199 1.41 0.84 0.48 0.27 0.20   45.4
S 64 E 225 2.6    6 3.7    56.2 56 75    6 2.3 148 129 142 134 128 123 138 138 145 144 165 1.40 0.59 0.22 0.12 0.08   34.4
S 64 E 226 2.6    6 3.7    56.2 56 75    6 2.3 163 148 154 125 113 113 136 125 127 149 150 3.23 1.40 0.60 0.36 0.21   35.9
S 64 E 227 2.6    6 3.7    56.2 56 75    6 2.3 176 151 161 113 115 106 128 120 115 139 137 2.46 1.14 0.40 0.20 0.10   35.0
```

Before Overlay

ROUTE	MILE	R	AADL	GF	TSAEL	YEAR		THICK		MAYS ROUGHNESS BY YEAR											DYNAFLECT DEFLECTIONS					
						AS	OV	BASE	AC	72	73	74	75	76	77	78	79	80	81	82	D1	D2	D3	D4	D5	SPREAD
S 64 E	228	2.6	6	3.7	56.2	56	75	6	2.3	144	128	141	116	120	112	144	120	137	130	145	1.70	0.60	0.13	0.05	0.02	29.4
S 64 E	229	2.6	6	3.7	56.2	56	75	6	2.3	161	142	165	128	131	124	152	142	153	166	164	2.31	0.74	0.23	0.13	0.08	30.2
S 64 E	230	2.6	6	3.7	56.2	56	75	6	2.3	142	131	151	135	134	129	152	147	141	165	163	1.45	0.56	0.17	0.12	0.07	32.7
S 64 E	231	2.6	6	3.7	56.2	56	75	6	2.3	122	105	120	130	138	123	161	139	126	140	170	1.24	0.55	0.18	0.08	0.05	33.9
S 64 E	232	2.6	6	3.7	56.2	56	75	6	2.3	194	164	172	136	133	122	156	135	129	165	166	1.21	0.63	0.21	0.11	0.06	36.7
S 64 E	233	2.6	6	3.7	56.2	56	75	6	2.3	144	128	140	144	142	134	157	145	151	167	164	1.15	0.53	0.21	0.12	0.08	36.3
S 64 E	234	2.6	6	3.7	56.2	56	75	6	2.3	124	119	110	131	140	133	154	137	136	142	143	0.71	0.30	0.12	0.06	0.04	34.6
S 64 E	235	2.6	6	3.7	56.2	56	75	6	2.3	192	176	151	147	146	141	166	149	174	177	166	0.80	0.40	0.22	0.13	0.08	40.7
S 64 E	236	2.6	9	4.9	91.5	56	75	6	2.3	141	126	117	129	129	124	155	147	143	164	137	1.44	0.71	0.38	0.24	0.16	40.7
S 73 N	349	3.7	15	1.5	155.1	52	76	12	4.3	147	133	129	130	72	114	102	77	92	82	115	1.62	0.85	0.45	0.25	0.15	41.0
S 73 N	350	4.1	15	1.5	155.1	52	76	17	5.1	178	163	232	152	84	125	84	76	82	77	111	0.90	0.38	0.15	0.05	0.02	33.3
S 73 N	351	4.1	15	1.5	155.1	52	76	12	4.3	285	262	256	218	67	106	83	63	63	64	44	1.57	0.68	0.25	0.13	0.06	34.3
S 73 N	352	4.1	15	1.5	155.1	52	76	12	4.0	257	219	269	269	73	124	99	89	88	96	78	2.14	0.94	0.42	0.25	0.19	36.8
S 73 N	353	4.1	15	1.5	155.1	52	76	12	4.0	221	189	223	228	81	143	133	116	118	118	109	2.49	1.23	0.56	0.30	0.20	38.4
S 73 N	354	4.1	15	1.5	155.1	52	76	12	4.0	214	192	227	116	67	126	92	75	76	81	65	2.31	1.16	0.57	0.32	0.20	39.5
S 73 N	355	4.1	15	1.5	155.1	52	76	12	4.0	251	203	246	212	87	127	113	91	94	101	60	2.13	1.19	0.63	0.34	0.23	42.4
S 73 N	356	4.1	15	1.5	155.1	52	76	12	4.0	198	174	190	188	90	150	114	85	81	91	58	2.54	1.38	0.64	0.36	0.23	40.6
S 73 N	357	4.1	15	1.5	155.1	52	76	12	4.0	200	205	266	215	85	140	102	86	101	95	77	2.54	1.38	0.64	0.36	0.23	40.6
S 77 N	121	2.0	30	2.1	148.0	65	77	13	2.3	113	105	102	96	110	77	74	80	91	79	82	0.97	0.52	0.31	0.22	0.17	45.2
S 77 N	122	2.0	30	2.1	148.0	65	77	16	2.3	112	109	108	98	106	67	67	83	74	79	90	1.01	0.53	0.30	0.19	0.15	43.2
S 77 N	123	2.0	30	2.1	148.0	65	77	16	2.3	121	114	112	100	104	89	102	115	119	109	130	1.19	0.61	0.40	0.26	0.21	44.9
S 77 N	124	2.0	30	2.1	148.0	65	77	16	2.3	114	134	119	123	116	61	57	67	66	71	85	1.15	0.50	0.23	0.12	0.08	36.2
S 77 N	125	2.0	30	2.1	148.0	65	77	13	2.3	141	172	177	159	139	80	80	92	91	86	107	1.39	0.65	0.28	0.14	0.10	36.8
S 77 N	126	2.0	30	2.1	148.0	65	77	13	2.3	118	110	124	87	145	97	98	106	108	102	119	0.58	0.30	0.19	0.12	0.09	44.1
S 77 N	127	2.0	29	2.1	156.4	64	77	13	2.3	119	124	117	94	122	97	93	99	104	95	102	1.21	0.58	0.28	0.16	0.12	38.8
S 77 N	128	2.0	29	2.1	156.4	64	77	13	2.3	113	88	89	75	103	72	77	81	76	82	96	0.73	0.32	0.21	0.14	0.10	41.1
S 77 N	129	2.0	29	2.1	156.4	64	77	13	2.3	107	92	90	69	94	70	68	78	77	70	84	1.04	0.47	0.23	0.14	0.11	38.3
S 77 N	130	2.0	29	2.1	156.4	64	77	13	2.3	120	119	119	92	121	86	86	103	102	93	117	1.19	0.49	0.24	0.15	0.11	36.6
S 77 N	131	2.0	30	2.1	148.0	65	77	13	2.7	104	119	112	92	127	79	77	87	88	87	111	1.99	0.89	0.44	0.23	0.14	37.1
S 77 N	132	2.0	30	2.1	148.0	65	77	10	2.7	107	113	117	96	125	83	84	89	91	89	94	1.58	0.66	0.32	0.19	0.15	36.7
S 77 N	133	2.0	30	2.1	148.0	65	77	10	2.7	106	106	104	91	110	84	78	87	81	90	115	1.66	0.72	0.37	0.22	0.16	37.7
S 77 N	134	2.1	30	2.1	148.0	65	77	10	2.3	118	105	103	87	103	94	98	112	107	134	146	0.71	0.33	0.17	0.10	0.07	38.9
S 87 N	292	3.8	20	1.8	22.5	72	75	21	2.0	166	145	146	100	111	118	130	117	121	152	141	0.84	0.50	0.24	0.11	0.06	41.7
S 87 N	293	3.8	16	1.8	70.6	64	75	21	2.0	237	215	223	105	120	126	149	126	136	158	133	0.72	0.38	0.22	0.11	0.08	41.9
S 87 N	294	3.8	16	1.8	70.6	64	75	21	2.0	274	227	194	100	118	117	141	120	112	166	152	0.78	0.40	0.18	0.08	0.05	38.2
S 87 N	295	3.8	16	1.8	70.6	64	75	21	2.0	265	233	219	105	145	154	187	169	192	231	209	0.92	0.55	0.32	0.19	0.12	45.7
S 87 N	296	3.8	16	1.8	70.6	64	75	21	2.0	237	207	225	105	119	125	153	133	141	195	159	0.67	0.37	0.22	0.12	0.09	43.9
S 87 N	297	3.8	16	1.8	70.6	64	75	21	2.0	209	171	190	105	168	181	196	181	221	245	238	0.67	0.36	0.20	0.12	0.08	42.7
S 87 N	298	3.8	16	1.8	70.6	64	75	21	2.0	199	194	190	100	124	134	160	139	148	180	162	0.81	0.46	0.25	0.16	0.11	44.2
S 87 N	299	3.8	16	1.8	70.6	64	75	21	2.0	208	174	167	100	122	132	163	134	133	151	152	0.80	0.45	0.24	0.16	0.10	43.7
S 87 N	300	3.8	16	1.8	70.6	64	75	21	2.0	243	212	224	98	104	119	151	121	139	163	142	0.83	0.50	0.27	0.19	0.14	46.5
S 87 N	301	3.8	16	1.8	70.6	64	75	21	2.0	215	181	165	105	112	122	145	120	137	167	136	0.80	0.52	0.29	0.19	0.13	48.2
S 87 N	302	3.8	16	1.8	70.6	64	75	21	2.0	200	189	162	88	94	111	137	107	116	156	120	0.76	0.39	0.20	0.11	0.07	40.3
S 87 N	303	3.8	16	1.8	70.6	64	75	21	2.0	213	185	174	115	115	135	156	134	133	169	157	0.71	0.41	0.23	0.14	0.09	44.5
S 87 N	304	3.3	16	1.8	70.6	64	75	21	2.0	253	212	186	150	121	155	187	165	201	199	181	0.71	0.41	0.23	0.14	0.09	44.5
U 60 E	51	1.0	133	2.4	425.6	68	76	9	3.5	32	53	69	77	49	101	79	54	75	72	62	0.92	0.54	0.25	0.18	0.13	43.9
U 60 E	52	1.0	133	2.4	425.6	68	76	9	3.5	60	72	84	104	49	105	65	45	63	74	47	1.19	0.56	0.18	0.08	0.05	34.6
U 60 E	53	1.0	133	2.4	425.6	68	76	12	3.5	67	87	87	116	35	100	70	41	77	83	35	0.89	0.55	0.23	0.12	0.07	41.8
U 60 E	54	1.0	133	2.4	425.6	68	76	12	3.8	70	89	75	129	49	100	69	60	72	63	43	0.57	0.31	0.16	0.10	0.07	42.5
U 60 E	55	1.0	133	2.4	425.6	68	76	9	3.8	66	110	77	143	60	115	78	66	75	70	64	0.74	0.35	0.19	0.14	0.10	41.1
U 60 E	56	1.0	133	2.4	425.6	68	76	9	3.8	66	105	92	118	69	110	88	76	79	84	73	0.87	0.48	0.23	0.17	0.12	43.0
U 60 E	57	1.0	113	2.9	368.2	68	76	12	3.8	56	77	81	117	52	95	72	55	80	80	52	0.96	0.60	0.34	0.22	0.15	47.3
U 60 E	58	1.0	113	2.9	368.2	68	76	9	3.8	54	90	87	86	52	87	71	52	89	91	51	0.92	0.56	0.29	0.20	0.14	45.9
U 60 E	59	1.0	113	2.9	368.2	68	76	9	3.8	59	85	86	86	43	100	65	47	92	97	57	0.80	0.46	0.25	0.18	0.12	45.2
U 60 E	60	1.0	113	2.9	368.2	68	76	9	3.8	70	98	99	95	62	111	89	70	93	106	72	0.77	0.50	0.26	0.18	0.12	47.5
U 60 E	61	1.0	113	2.9	368.2	68	76	12	3.8	71	107	112	119	75	120	98	86	102	117	92	0.57	0.31	0.20	0.14	0.12	47.0
U 60 E	62	1.0	113	2.9	368.2	68	76	9	3.8	69	103	96	62	60	95	74	93	60	102	60	0.57	0.32	0.20	0.14	0.12	47.4

Appendix A

Before Overlay

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                                YEAR   THICK           MAYS ROUGHNESS BY YEAR             DYNAFLECT DEFLECTIONS
ROUTE MILE   R AADL  GF   TSAEL AS OV BASE  AC  72  73  74  75  76  77  78  79  80  81  82   D1   D2   D3   D4   D5 SPREAD
*************************************************************************************************************************
U 70 E 301 2.0  19 2.4   161.8 59 78   21 2.8 134 106 125 101 144 148 119 128 120 114 128 2.14 1.19 0.58 0.37 0.24   42.2
U 70 E 302 2.0  19 2.4   161.8 59 78   21 2.8 140 111 119 103 133 167 111 103  95  94 101 1.74 0.99 0.46 0.27 0.18   41.8
U 70 E 303 2.0  23 3.7   215.6 59 78   21 2.8 113  96 106  88 118 110  92  75  64  67  86 1.90 1.14 0.70 0.53 0.40   49.2
U 70 E 304 2.0  23 3.7   215.6 59 78   21 2.8 136 121 132 117 139 134 119 114  97 100 130 2.74 1.89 1.06 0.77 0.55   51.2
U 70 E 305 2.0  23 3.7   215.6 59 78   21 2.8 120 100 106  95 113 124 102  91 104  85  96 2.33 1.57 0.86 0.58 0.40   49.3
U 70 E 306 1.8  23 3.7   215.6 59 78   21 2.8 157 128 130 131 145 154 135 127 141 115 141 1.67 1.06 0.55 0.39 0.29   47.4
U 70 E 307 1.8  23 3.7   215.6 59 78   12 2.5 143 124 127 117 141 160 104  95  97  94  99 1.86 1.33 0.77 0.52 0.36   52.0
U 70 E 308 1.8  23 3.7   215.6 59 78   12 2.5 138 121 128 116 157 179  96  82  91  86 114 1.62 1.05 0.58 0.43 0.31   49.3
U 70 E 309 1.8  23 3.7   215.6 59 78   15 2.5 149 135 154 147 171 192 100  95  98  88 105 1.67 1.23 0.83 0.67 0.53   59.0
U 70 E 310 1.8  23 3.7   215.6 59 78   15 2.5 153 124 150 129 151 149  99 100 100  89  94 1.16 0.92 0.67 0.54 0.42   64.0
U 70 E 311 1.8  23 3.7   215.6 59 78   15 2.5 176 146 141 130 145 179  94  94  94  87 104 1.85 1.37 0.83 0.62 0.48   55.7
U 70 E 312 1.8  23 3.7   215.6 59 78   15 2.5 174 143 140 128 147 168  87  78  67  75  79 1.33 0.98 0.67 0.53 0.43   59.2
U 70 E 313 1.8  23 3.7   215.6 59 78   12 2.5 167 136  78 118 129 160  84  75  70  70  81 1.55 0.98 0.58 0.44 0.33   50.1
U 70 E 314 1.8  27 3.0   240.6 59 78   12 2.5 153 130 130 108 192 184 133  75  57  73  82 1.55 0.98 0.58 0.44 0.33   50.1
U 70 E 331 1.5  28 4.2   410.8 52 78    9 3.5 245 211 207 211 216 216  85  79  97  80  88 2.55 1.65 0.90 0.64 0.43   48.4
U 70 E 332 1.5  42 3.4   603.9 51 78    9 3.5 145 132 106 102 112 149  90  68  71  63  69 2.26 1.53 0.86 0.62 0.43   50.4
U 70 E 333 1.5  41 3.0   567.7 51 78    9 3.5 174 144 139 144 173 204  94  62  69  66  72 1.33 0.91 0.73 0.62 0.48   61.2
U 89 N 443 2.5  69 3.8  1710.0 37 76   12 2.0 188 167 186  65  78  58  80  75  96 110  78 1.95 1.02 0.53 0.29 0.19   40.8
U 89 N 444 2.5  69 3.8  1710.0 37 76   12 2.0 183 194 143  62  79  55  86  66  75  74  58 2.19 1.13 0.58 0.41 0.28   41.9
U 89 N 445 2.5  69 3.8  1710.0 37 76   12 2.0 147 136 130 156 165 168 145 153  96  92  75 0.97 0.60 0.32 0.21 0.14   46.2
U 89 N 446 2.5  69 3.8  1710.0 37 76   12 2.0 139 127 109 200 199 178 187 188 148 130 123 1.39 0.74 0.44 0.31 0.21   44.5
U 89 N 447 2.5  69 3.8  1710.0 37 76   12 2.0 186 225 154  85  89  81  96  88 123  70  71 1.49 0.89 0.57 0.34 0.23   47.2
U 89 N 448 2.5  69 3.8  1710.0 37 76   12 2.0 164 184 177  75  92  78 102  87 100  69  68 1.62 0.92 0.55 0.35 0.25   45.6
U 89 N 449 2.5  69 3.8  1710.0 37 76   12 2.0 157 182 212 132 132 135 135 121 116  92  93 2.19 1.15 0.60 0.33 0.19   40.7
U 89 N 450 1.8  69 3.8  1710.0 37 76   12 2.0 134 153 124 107  95  62  79  82  75  66  77 2.18 1.15 0.60 0.33 0.19   40.8
U 89 N 452 1.8  69 3.8  1710.0 37 76   12 2.0 125 132 136 162 108  55  75  68  89  59  72 1.57 0.97 0.58 0.37 0.23   47.4
U 89 N 453 1.8  69 3.8  1710.0 37 76   12 2.0 147 158 189 231 130  68  91  91  81  84  93 1.18 0.64 0.29 0.20 0.14   41.5
U 89 N 454 1.8  69 3.8  1710.0 37 76   12 2.0 164 164 174 214 133  71  91  86  76  89  96 1.63 1.00 0.51 0.29 0.20   44.5
U 89 N 455 1.8  69 3.8  1710.0 37 76   12 2.0 154 155 175 225 129  59  81  72 101  99  71 1.18 0.61 0.30 0.18 0.10   40.2
U 89 N 456 1.8  69 3.8  1710.0 37 76   12 2.0 155 160 161 230  61  65  79  72 101 109  78 1.92 0.91 0.34 0.15 0.06   35.2
U 89AN 357 2.5  17 2.7   369.4 38 77    8 2.8 140 166 169 204 164  75 112  97 140 103 118 1.43 0.81 0.45 0.22 0.12   42.4
U 89AN 358 2.5  17 2.7   369.4 38 77    8 2.8 180 221 198 245 209  90 123 110 122  90 102 1.40 0.85 0.50 0.30 0.21   46.6
U 89AN 359 2.5  17 2.7   369.4 38 77    8 2.8 170 192 195 216 197  79 111  99 119  96  87 1.18 0.68 0.34 0.22 0.14   43.4
U 89AN 360 2.5  17 2.7   369.4 38 77    8 2.8 150 176 196 201 176  89 104  97 116 109  95 1.05 0.64 0.36 0.24 0.16   46.7
U 89AN 361 2.5  17 2.7   369.4 38 77    8 2.8 150 171 195 199 186  85 112 102 123 118 102 1.19 0.58 0.30 0.19 0.12   40.0
U 89AN 362 2.5  17 2.7   382.2 37 77    8 2.8 160 186 186 179 188  78 111 104 119 115 114 1.66 0.81 0.30 0.14 0.09   36.1
U 89AN 363 2.5  17 2.7   382.2 37 77    8 2.8 190 219 208 252 215  88 121 100 127 105 108 2.26 1.34 0.57 0.23 0.13   40.1
U 89AN 364 2.5  14 3.0   327.0 37 77    8 2.8 190 211 222 238 209  69 109  85 121  92 101 1.84 0.90 0.43 0.24 0.15   38.7
U 89AN 365 2.5  14 3.0   327.0 37 77    8 2.8 160 177 199 210 181  76 108  82 109  86  89 2.10 1.20 0.60 0.31 0.18   41.8
U 89AN 366 2.5  14 3.0   327.0 37 77    8 2.8 150 193 176 212 192  91 120 100 126 115 118 0.77 0.34 0.16 0.09 0.05   36.6
U 89AN 367 2.5  14 3.0   327.0 37 77    8 2.8 150 173 187 321 180  81 110  87 114  93  93 1.04 0.50 0.18 0.08 0.03   35.2
U 89AN 368 2.5  14 3.0   327.0 37 77    8 2.8 210 247 236 267 211 101 120 107 130 131 120 1.65 0.82 0.30 0.12 0.06   35.8
U 89AN 369 2.5  14 3.0   327.0 37 77    8 2.8 220 241 270 315 266  99 120 126 137 144 118 1.03 0.60 0.26 0.14 0.08   41.0
U 89AN 370 2.7  14 3.0   327.0 37 77    8 2.8 225 242 281 287 272 175 130 133 139 148 135 1.03 0.60 0.26 0.13 0.08   40.8
U180 E 224 3.9   8 1.0    57.3 58 76   11 1.6 418 338 431 478 107  99 119 124 122 154 153 2.95 1.39 0.52 0.28 0.23   36.4
U180 E 225 3.9   8 1.0    57.3 58 76   11 1.6 418 348 461 515 108  96 146 151 147 178 174 3.23 1.40 0.32 0.07 0.05   31.4
U180 E 226 3.9   8 1.0    57.3 58 76   11 1.6 407 344 365 463 115  89 130 169 183 166 167 3.85 1.71 0.57 0.24 0.16   33.9
U180 E 227 3.9   8 1.0    57.3 58 76   11 1.6 416 348 436 480 106 102 121 122 131 136 134 3.37 1.29 0.34 0.16 0.10   31.2
U180 E 228 3.9   8 1.0    57.3 58 76   11 1.6 424 334 387 479  93  83 109 103 112 117 122 4.04 1.71 0.49 0.11 0.05   31.7
U180 E 229 3.9   8 1.0    57.3 58 76   11 1.6 340 277 319 381  80  76  94  99 128 127 131 2.63 0.97 0.42 0.18 0.08   32.5
U180 E 230 3.9   8 1.0    57.3 58 76   11 1.6 319 258 275 337  84  82 108 109 120 145 146 3.31 1.50 0.41 0.24 0.21   34.3
U180 E 231 3.9   8 1.0    57.3 58 76   11 1.6 360 299 327 388  96  88 125 103 131 124 138 4.78 1.20 0.40 0.14 0.13   27.8
U180 E 232 3.9   8 1.0    57.3 58 76   11 1.6 372 301 346 337  77  87 112 107 125 134 122 4.27 1.86 0.90 0.46 0.29   36.4
U180 E 233 3.9   8 1.0    57.3 58 76   14 1.6 384 314 326 410  86  78 102  98 121 118 113 4.04 1.91 1.23 0.76 0.60   42.3
U180 E 234 3.9   8 1.0    57.3 58 76   14 1.6 407 329 329 398  76  64  90  79  98 103  91 3.10 1.17 0.39 0.13 0.11   31.6
U180 E 235 4.0   8 1.0    53.9 59 76    9 2.8 138 112 120 131  95  99 120 115 128 124 111 2.47 0.79 0.26 0.07 0.04   29.4
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After Overlay

ROUTE			MILE	R	AADL	GF	TSAEL	OV	THICK		MAYS	MAYS ROUGHNESS BY YEAR											DYNAFLECT DEFLECTIONS					
								YR	ACT	DES	DES	72	73	74	75	76	77	78	79	80	81	82	D1	D2	D3	D4	D5	SPREAD
I	10	W	297	1.9	922	1.9	3685.0	77	1.8	3.3	53	44	49	52	55	47	36	32	20	52	58	38	0.65	0.47	0.27	0.22	0.16	54.5
I	10	W	298	1.9	988	1.4	3858.6	77	1.8	0.0	49	48	42	36	59	45	34	26	18	39	71	36	0.62	0.45	0.26	0.21	0.17	55.2
I	10	W	299	1.9	988	1.4	3858.6	77	1.8	5.8	60	60	50	59	76	47	37	37	26	56	82	51	0.73	0.46	0.22	0.19	0.12	47.1
I	10	W	300	1.9	852	2.0	3420.8	77	1.8	5.6	50	37	43	36	53	55	47	40	28	72	80	48	0.47	0.32	0.20	0.15	0.09	52.3
I	10	E	368	1.7	592	2.1	2387.7	75	1.8	6.0	96	80	45	147	40	58	52	53	54	83	109	63	0.67	0.44	0.22	0.17	0.10	47.8
I	10	E	369	1.7	592	2.1	2387.7	75	1.8	6.0	147	111	136	166	49	62	47	59	66	61	87	65	0.76	0.50	0.26	0.21	0.14	49.2
I	10	E	370	1.7	592	2.1	2387.7	75	1.8	6.0	151	87	141	190	51	58	46	49	43	62	58	63	0.65	0.43	0.24	0.15	0.09	48.0
I	10	E	371	1.7	592	2.1	2387.7	75	1.8	6.0	156	85	129	215	46	49	43	47	49	76	69	64	0.47	0.29	0.22	0.13	0.09	51.1
I	10	E	372	1.7	592	2.1	2387.7	75	1.8	6.0	134	63	114	192	37	52	44	43	47	64	89	68	0.66	0.51	0.30	0.19	0.12	53.9
I	10	E	373	1.7	592	2.1	2387.7	75	1.8	5.1	120	63	87	181	46	52	49	57	57	69	108	79	0.77	0.50	0.28	0.18	0.11	47.8
I	10	E	374	1.7	592	2.1	2387.7	75	1.8	4.5	131	69	91	200	53	59	53	61	62	84	102	81	0.60	0.40	0.26	0.19	0.13	52.7
I	10	E	375	1.7	592	2.1	2387.7	75	1.8	5.2	139	88	108	190	47	50	46	49	51	77	72	61	0.78	0.58	0.34	0.24	0.19	54.6
I	10	E	376	1.7	592	2.1	2387.7	75	1.8	6.0	127	68	84	182	40	51	46	47	50	66	90	78	0.88	0.55	0.27	0.20	0.15	46.6
I	10	E	377	1.7	592	2.1	2387.7	75	1.8	6.0	123	60	101	165	43	46	45	44	41	78	103	87	0.79	0.52	0.27	0.24	0.17	50.4
I	10	W	368	1.7	592	2.1	2387.7	75	1.8	6.0	103	61	82	145	32	46	39	53	45	58	60	77	0.69	0.40	0.26	0.15	0.10	46.4
I	10	W	369	1.7	592	2.1	2387.7	75	1.8	6.0	170	125	146	204	28	46	39	59	42	59	56	64	0.68	0.45	0.24	0.17	0.11	48.5
I	10	W	370	1.7	592	2.1	2387.7	75	1.8	6.0	182	192	101	219	39	52	39	49	44	70	80	56	0.48	0.32	0.25	0.16	0.10	54.6
I	10	W	371	1.7	592	2.1	2387.7	75	1.8	6.0	187	153	170	201	41	47	46	47	44	69	86	51	1.00	0.63	0.30	0.24	0.16	46.6
I	10	W	372	1.7	592	2.1	2387.7	75	1.8	6.0	126	77	105	169	41	46	43	43	42	72	70	55	0.95	0.61	0.29	0.23	0.15	46.9
I	10	W	373	1.7	592	2.1	2387.7	75	1.8	3.8	103	56	69	158	42	46	50	57	54	74	67	77	0.78	0.56	0.34	0.23	0.14	52.6
I	10	W	374	1.7	592	2.1	2387.7	75	1.8	5.6	120	54	85	190	44	62	53	61	63	69	79	87	0.86	0.62	0.33	0.26	0.17	52.1
I	10	W	375	1.7	592	2.1	2387.7	75	1.8	3.9	105	47	68	168	36	46	37	49	34	49	51	54	0.59	0.45	0.27	0.24	0.16	58.0
I	17	N	313	3.9	261	2.6	1076.5	77	2.3	0.0	80	60	72	81	74	80	60	64	72	87	115	87	0.85	0.66	0.39	0.21	0.11	52.2
I	17	N	314	3.9	261	2.6	1076.5	77	2.3	0.0	59	42	49	51	56	62	42	51	53	74	105	91	0.97	0.79	0.43	0.21	0.09	51.3
I	17	N	315	3.9	261	2.6	1076.5	77	2.3	0.0	70	34	39	61	61	88	46	44	45	65	62	64	0.77	0.61	0.35	0.19	0.10	52.5
I	17	N	316	3.9	261	2.6	1076.5	77	2.3	0.0	63	26	39	57	55	75	52	36	33	79	90	77	0.40	0.29	0.21	0.12	0.07	54.5
I	17	N	317	3.9	255	2.8	1061.1	77	2.3	0.0	69	35	52	63	70	71	52	49	37	71	104	94	0.38	0.28	0.17	0.13	0.09	55.3
I	17	N	318	3.9	255	2.8	1061.1	77	2.3	0.0	62	40	62	51	52	69	48	37	43	63	76	65	0.58	0.43	0.21	0.17	0.11	51.7
I	17	N	319	3.9	251	2.9	1049.0	77	2.3	5.1	85	50	80	93	65	94	63	51	51	67	72	79	0.70	0.43	0.23	0.12	0.07	44.3
I	17	N	320	3.9	251	2.9	1049.0	77	2.3	3.9	78	49	56	65	67	97	47	48	38	80	66	76	0.40	0.27	0.13	0.07	0.04	45.5
I	17	N	321	3.9	251	2.9	1049.0	77	2.3	4.0	75	43	63	59	63	92	68	39	40	60	84	78	0.37	0.21	0.11	0.06	0.04	42.7
I	17	N	322	3.7	255	2.8	1061.1	77	2.3	1.7	94	56	73	81	93	107	66	57	70	74	97	90	0.69	0.45	0.23	0.16	0.12	47.8
I	19	N	37	1.8	196	2.8	815.6	76	8.0	5.4	237	219	185	207	283	51	46	55	53	56	80	83	0.54	0.34	0.27	0.16	0.10	52.2
I	19	N	38	1.8	196	2.8	815.6	76	5.3	6.0	262	232	224	237	292	45	47	50	47	60	83	75	0.71	0.52	0.33	0.24	0.18	55.8
I	19	N	39	1.8	196	2.8	815.6	76	5.3	4.0	211	191	164	213	230	50	45	50	45	55	99	71	0.63	0.45	0.25	0.23	0.14	54.0
I	40	E	259	1.7	603	2.9	2520.1	80	6.8	1.9	228	20	38	52	79	124	191	191	235	93	105	114	0.52	0.36	0.20	0.19	0.13	53.8
I	40	E	260	1.7	603	2.9	2520.1	80	6.8	1.7	169	40	64	72	104	163	183	169	98	50	81	83	0.96	0.73	0.69	0.53	0.39	68.7
I	40	E	261	1.7	603	2.9	2520.1	80	6.8	0.0	155	23	68	66	115	131	137	159	103	44	70	91	0.79	0.63	0.52	0.41	0.32	67.6
I	40	E	262	1.7	603	2.9	2520.1	80	6.8	2.1	171	29	56	62	103	146	156	193	103	55	96	93	1.20	0.92	0.65	0.63	0.49	64.8
I	40	E	263	1.7	603	2.9	2520.1	80	6.8	2.5	217	23	61	64	101	207	228	224	118	37	77	75	0.90	0.71	0.61	0.56	0.46	72.0
I	40	E	264	1.7	603	2.9	2520.1	80	6.8	6.0	150	15	35	41	82	105	133	133	126	61	63	65	0.72	0.55	0.28	0.21	0.10	51.7
I	40	E	265	1.7	603	2.9	2520.1	79	6.5	4.9	145	14	34	41	79	90	122	154	98	43	56	78	0.71	0.56	0.35	0.23	0.18	57.2
I	40	E	266	1.7	603	2.9	2520.1	79	6.5	6.0	215	21	58	112	135	179	209	168	82	72	58	103	0.75	0.54	0.29	0.24	0.16	52.8
I	40	E	267	1.7	603	2.9	2520.1	79	6.5	6.0	194	26	65	113	119	142	174	178	99	61	163	143	0.93	0.68	0.54	0.35	0.24	58.9
I	40	E	312	1.8	754	2.2	3054.8	74	2.8	0.0	231	197	250	38	36	58	124	89	104	114	138	112	0.64	0.60	0.54	0.40	0.29	77.2
I	40	E	313	1.8	745	2.3	3032.0	74	2.8	0.6	309	275	322	49	50	78	135	124	149	181	191	186	1.04	0.70	0.55	0.34	0.24	55.2
I	40	E	314	1.8	745	2.3	3032.0	74	2.8	1.7	235	187	266	38	47	64	123	98	122	132	112	116	1.10	0.81	0.46	0.31	0.19	52.2
I	40	E	315	1.8	745	2.3	3032.0	74	2.8	2.3	227	198	241	46	52	71	123	114	145	158	171	158	0.81	0.67	0.47	0.27	0.21	60.0
I	40	E	316	1.8	745	2.3	3032.0	74	2.8	1.2	240	198	266	55	52	73	118	89	114	117	139	144	0.87	0.61	0.42	0.26	0.15	53.1
I	40	E	317	1.8	745	2.3	3032.0	74	2.8	1.1	201	175	214	35	39	58	114	85	89	93	118	98	0.87	0.61	0.42	0.26	0.15	53.1
I	40	W	313	1.8	745	2.3	3032.0	74	3.3	5.9	251	216	268	47	56	78	145	117	152	157	217	228	1.04	0.73	0.40	0.31	0.21	51.7
I	40	W	314	1.8	745	2.3	3032.0	74	3.3	6.0	175	150	189	38	45	70	134	106	124	130	162	149	1.10	0.63	0.32	0.14	0.12	42.0
I	40	W	315	1.8	745	2.3	3032.0	74	3.3	6.0	217	190	230	47	48	72	155	143	150	146	190	167	1.42	0.87	0.52	0.28	0.17	45.9
I	40	W	316	1.8	745	2.3	3032.0	74	3.3	6.0	218	213	211	41	60	67	173	155	211	183	214	199	0.86	0.53	0.26	0.19	0.13	45.8
S	64	E	225	2.6	11	3.7	47.6	75	3.3	0.0	145	148	129	142	134	128	123	138	138	145	144	165	0.65	0.32	0.17	0.09	0.06	39.7
S	64	E	226	2.6	11	3.7	47.6	75	3.0	0.0	161	163	148	154	125	113	113	136	125	127	149	150	1.02	0.60	0.42	0.20	0.14	46.7
S	64	E	227	2.6	11	3.7	47.6	75	3.0	0.0	169	176	151	161	113	115	106	128	120	115	139	137	0.62	0.31	0.18	0.06	0.04	39.0

After Overlay

						OV	THICK		MAYS	MAYS ROUGHNESS BY YEAR											DYNAFLECT DEFLECTIONS					
ROUTE	MILE	R	AADL	GF	TSAEL	YR	ACT	DES	DES	72	73	74	75	76	77	78	79	80	81	82	D1	D2	D3	D4	D5	SPREAD
S 64 E	228	2.6	11	3.7	47.6	75	3.0	1.3	143	144	128	141	116	120	112	144	120	137	130	145	0.73	0.34	0.20	0.06	0.04	37.5
S 64 E	229	2.6	11	3.7	47.6	75	3.0	0.7	162	161	142	165	128	131	124	152	142	153	166	164	0.71	0.31	0.14	0.06	0.04	35.5
S 64 E	230	2.6	11	3.7	47.6	75	3.0	0.0	147	142	131	151	135	134	129	152	147	141	165	163	0.68	0.34	0.22	0.09	0.05	40.6
S 64 E	231	2.6	11	3.7	47.6	75	3.0	0.0	120	122	105	120	130	138	123	161	139	126	140	170	0.63	0.28	0.17	0.07	0.05	38.1
S 64 E	232	2.6	11	3.7	47.6	75	3.0	0.0	183	194	164	172	136	133	122	156	135	129	165	166	0.87	0.45	0.27	0.11	0.07	40.7
S 64 E	233	2.6	11	3.7	47.6	75	3.0	0.0	142	144	128	140	144	142	134	157	145	151	167	164	0.79	0.41	0.24	0.13	0.09	42.0
S 64 E	234	2.6	11	3.7	47.6	75	3.0	0.0	121	124	119	110	131	140	133	154	137	136	142	143	0.36	0.18	0.13	0.06	0.05	43.3
S 64 E	235	2.6	11	3.7	47.6	75	3.0	0.0	179	192	176	151	147	146	141	166	149	174	177	166	0.43	0.21	0.15	0.08	0.05	42.8
S 64 E	236	2.6	17	4.9	77.3	75	3.0	0.0	131	141	126	117	129	129	124	155	147	143	164	137	0.69	0.44	0.29	0.17	0.12	49.6
S 73 N	349	3.7	27	1.5	105.9	76	2.0	0.0	140	147	133	129	130	72	114	102	77	92	82	115	1.14	0.58	0.33	0.18	0.13	41.4
S 73 N	350	4.1	27	1.5	105.9	76	2.0	4.4	190	178	163	232	152	84	125	84	76	82	77	111	0.75	0.32	0.13	0.05	0.02	33.9
S 73 N	351	4.1	27	1.5	105.9	76	2.0	3.8	267	285	262	256	218	67	106	83	63	63	64	44	0.78	0.44	0.18	0.10	0.06	40.0
S 73 N	352	4.1	27	1.5	105.9	76	2.0	1.7	268	257	219	269	269	73	124	99	89	88	96	78	1.19	0.57	0.32	0.18	0.11	39.8
S 73 N	353	4.1	27	1.5	105.9	76	2.0	0.6	227	221	189	223	228	81	143	133	116	118	118	109	1.22	0.68	0.44	0.22	0.15	44.4
S 73 N	354	4.1	27	1.5	105.9	76	2.0	0.0	194	214	192	227	116	67	126	92	75	76	81	65	1.73	0.95	0.56	0.25	0.15	42.1
S 73 N	355	4.1	27	1.5	105.9	76	2.0	0.0	240	251	203	246	212	87	127	113	91	94	101	60	0.93	0.63	0.43	0.21	0.17	51.0
S 73 N	356	4.1	27	1.5	105.9	76	2.0	0.0	196	198	174	190	188	90	150	114	85	81	91	58	1.47	0.78	0.49	0.22	0.13	42.0
S 73 N	357	4.1	27	1.5	105.9	76	2.0	0.0	233	200	205	266	215	85	140	102	86	101	95	77	1.47	0.78	0.49	0.22	0.13	42.0
S 77 N	121	2.0	46	2.1	185.5	77	2.0	0.0	114	113	105	102	96	110	77	74	80	91	79	82	0.96	0.60	0.25	0.17	0.13	44.0
S 77 N	122	2.0	46	2.1	185.5	77	2.0	0.0	115	112	109	108	98	106	67	67	83	74	79	90	0.60	0.39	0.18	0.13	0.08	46.0
S 77 N	123	2.0	46	2.1	185.5	77	2.0	0.0	119	121	114	112	100	104	89	102	115	119	109	130	0.69	0.52	0.24	0.19	0.16	52.2
S 77 N	124	2.0	46	2.1	185.5	77	2.0	1.9	134	114	134	119	123	116	61	57	67	66	71	85	0.73	0.47	0.17	0.09	0.06	41.6
S 77 N	125	2.0	46	2.1	185.5	77	2.0	1.6	175	141	172	177	159	139	80	80	92	91	86	107	0.77	0.46	0.16	0.10	0.07	40.5
S 77 N	126	2.0	46	2.1	185.5	77	2.0	0.0	129	118	110	124	87	145	97	98	106	108	102	119	0.32	0.23	0.13	0.08	0.06	51.2
S 77 N	127	2.0	46	2.1	185.5	77	2.0	0.1	124	119	124	117	94	122	97	93	99	104	95	102	0.57	0.33	0.18	0.12	0.09	45.3
S 77 N	128	2.0	46	2.1	185.5	77	2.0	0.0	99	113	88	89	75	103	72	77	81	76	82	96	0.99	0.56	0.32	0.19	0.10	43.6
S 77 N	129	2.0	46	2.1	185.5	77	2.0	0.3	95	107	92	90	69	94	70	68	78	77	70	84	0.83	0.58	0.25	0.18	0.12	47.2
S 77 N	130	2.0	46	2.1	185.5	77	2.0	1.4	123	120	119	119	92	121	86	86	103	102	93	117	0.39	0.24	0.15	0.10	0.08	49.2
S 77 N	131	2.0	46	2.1	185.5	77	2.0	1.1	123	104	119	112	92	127	79	77	87	88	87	111	0.61	0.39	0.22	0.13	0.09	47.2
S 77 N	132	2.0	46	2.1	185.5	77	2.0	1.3	124	107	113	117	96	125	83	84	89	91	69	94	0.62	0.28	0.18	0.13	0.11	42.6
S 77 N	133	2.0	46	2.1	185.5	77	2.0	0.7	112	106	106	104	91	110	84	78	87	81	90	115	0.59	0.42	0.21	0.16	0.12	50.8
S 77 N	134	2.1	46	2.1	185.5	77	2.0	0.1	110	118	105	103	87	103	94	98	112	107	134	146	0.42	0.21	0.09	0.05	0.04	38.6
S 87 N	292	3.8	24	1.8	95.5	75	2.0	0.0	153	166	145	146	100	111	118	130	117	121	152	141	1.04	0.70	0.21	0.13	0.06	41.2
S 87 N	293	3.8	24	1.8	95.5	75	2.3	0.0	242	237	215	223	105	120	126	149	126	136	158	133	1.11	0.64	0.21	0.15	0.07	39.3
S 87 N	294	3.8	24	1.8	95.5	75	2.3	0.2	246	274	227	194	100	118	117	141	120	112	166	152	1.01	0.47	0.17	0.07	0.04	34.9
S 87 N	295	3.8	24	1.8	95.5	75	2.3	0.0	256	265	233	219	105	145	154	187	169	192	231	209	1.03	0.63	0.25	0.18	0.11	42.7
S 87 N	296	3.8	24	1.8	95.5	75	2.3	0.0	240	237	207	225	105	119	125	153	133	141	195	159	0.88	0.48	0.17	0.11	0.07	38.9
S 87 N	297	3.8	24	1.8	95.5	75	2.3	0.0	203	209	171	190	105	168	181	196	181	221	245	238	0.79	0.47	0.21	0.14	0.09	43.0
S 87 N	298	3.8	24	1.8	95.5	75	2.3	0.0	208	199	194	190	100	124	134	160	139	148	180	162	1.04	0.57	0.21	0.15	0.11	40.0
S 87 N	299	3.8	24	1.8	95.5	75	2.3	0.0	194	208	174	167	100	122	132	163	134	133	151	152	0.82	0.51	0.20	0.12	0.07	42.0
S 87 N	300	3.8	24	1.8	95.5	75	2.3	0.0	243	243	212	224	98	104	119	151	121	139	163	142	1.02	0.63	0.25	0.19	0.11	43.1
S 87 N	301	3.8	24	1.8	95.5	75	2.3	0.0	198	215	181	165	105	112	122	145	120	137	167	136	0.79	0.47	0.21	0.14	0.09	43.0
S 87 N	302	3.8	24	1.8	95.5	75	2.3	0.0	195	200	189	162	88	94	111	137	107	116	156	120	0.87	0.51	0.21	0.13	0.08	41.4
S 87 N	303	3.8	24	1.8	95.5	75	2.3	0.0	203	213	185	174	115	115	135	156	134	133	169	157	1.00	0.57	0.21	0.15	0.08	40.2
S 87 N	304	3.3	24	1.8	95.5	75	2.3	0.0	230	253	212	186	150	121	155	187	165	201	199	181	1.01	0.58	0.21	0.15	0.08	40.2
U 60 E	51	1.0	201	2.4	821.7	76	1.7	1.7	71	32	53	69	77	49	101	79	54	75	72	62	0.24	0.19	0.13	0.10	0.08	61.7
U 60 E	52	1.0	201	2.4	821.7	76	1.7	6.0	92	60	72	84	104	49	105	65	45	63	74	47	0.35	0.21	0.10	0.05	0.04	42.9
U 60 E	53	1.0	201	2.4	821.7	76	1.7	3.5	103	67	87	87	116	35	100	70	41	77	83	35	0.61	0.37	0.18	0.11	0.07	43.9
U 60 E	54	1.0	201	2.4	821.7	76	1.7	3.1	105	70	89	75	129	49	100	69	60	72	63	43	0.62	0.35	0.16	0.09	0.06	41.3
U 60 E	55	1.0	201	2.4	821.7	76	1.7	3.8	117	66	110	77	143	60	115	78	66	75	70	64	0.63	0.36	0.16	0.12	0.09	43.2
U 60 E	56	1.0	201	2.4	821.7	76	1.7	2.5	110	66	105	92	118	69	110	88	76	79	84	73	0.54	0.36	0.20	0.15	0.11	50.4
U 60 E	57	1.0	191	2.9	798.2	76	1.7	0.0	97	56	77	81	117	52	95	72	55	80	80	52	0.60	0.49	0.28	0.20	0.16	57.7
U 60 E	58	1.0	191	2.9	798.2	76	1.7	0.6	89	54	90	87	86	52	87	71	52	89	91	51	0.69	0.48	0.26	0.18	0.14	50.7
U 60 E	59	1.0	191	2.9	798.2	76	1.7	0.9	88	59	85	86	86	43	100	65	47	92	97	57	0.73	0.51	0.27	0.19	0.14	50.4
U 60 E	60	1.0	191	2.9	798.2	76	1.7	0.0	101	70	98	99	95	62	111	89	70	93	106	72	0.50	0.36	0.22	0.17	0.12	54.8
U 60 E	61	1.0	191	2.9	798.2	76	1.7	0.0	119	71	107	112	119	75	120	98	86	102	117	92	0.59	0.36	0.25	0.15	0.12	49.8
U 60 E	62	1.0	191	2.9	798.2	76	1.7	0.0	87	69	103	96	62	60	95	74	93	60	102	60	0.59	0.36	0.25	0.15	0.12	49.8

After Overlay

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                                 OV  THICK   MAYS                      MAYS ROUGHNESS BY YEAR                  DYNAFLECT DEFLECTIONS
ROUTE MILE  R  AADL  GF   TSAEL  YR ACT DES  DES   72   73   74   75   76   77   78   79   80   81   82   D1   D2   D3   D4   D5 SPREAD
*************************************************************************************************************************************
U 70 E 301 2.0   37 2.4   151.3 78 1.8 0.0  138  134  106  125  101  144  148  119  128  120  114  128 1.10 0.64 0.37 0.25 0.16 45.8
U 70 E 302 2.0   37 2.4   151.3 78 1.8 0.0  142  140  111  119  103  133  167  111  103   95   94  101 1.18 0.83 0.42 0.29 0.15 48.6
U 70 E 303 2.0   46 3.7   199.0 78 1.8 0.0  113  113   96  106   88  118  110   92   75   64   67   86 0.98 0.77 0.46 0.40 0.30 59.4
U 70 E 304 2.0   46 3.7   199.0 78 1.8 0.0  141  136  121  132  117  139  134  119  114   97  100  130 1.31 1.01 0.60 0.44 0.34 56.5
U 70 E 305 2.0   46 3.7   199.0 78 1.8 0.0  119  120  100  106   95  113  124  102   91  104   85   96 1.34 0.91 0.56 0.47 0.28 53.1
U 70 E 306 1.8   46 3.7   199.0 78 2.1 0.0  154  157  128  130  131  145  154  135  127  141  115  141 0.86 0.64 0.23 0.22 0.22 50.5
U 70 E 307 1.8   46 3.7   199.0 78 1.8 0.0  149  143  124  127  117  141  160  104   95   97   94   99 1.17 0.68 0.53 0.44 0.27 52.8
U 70 E 308 1.8   46 3.7   199.0 78 1.8 0.0  155  138  121  128  116  157  179   96   82   91   86  114 1.14 0.72 0.48 0.34 0.25 51.4
U 70 E 309 1.8   46 3.7   199.0 78 1.8 0.0  176  149  135  154  147  171  192  100   95   98   88  105 1.02 0.72 0.61 0.54 0.42 64.9
U 70 E 310 1.8   46 3.7   199.0 78 1.8 0.0  155  153  124  150  129  151  149   99  100  100   89   94 0.79 0.65 0.46 0.39 0.31 65.8
U 70 E 311 1.8   46 3.7   199.0 78 1.8 0.0  167  176  146  141  130  145  179   94   94   94   87  104 1.31 0.99 0.63 0.57 0.43 60.0
U 70 E 312 1.8   46 3.7   199.0 78 1.8 0.0  164  174  143  140  128  147  168   87   78   67   75   79 1.09 0.77 0.57 0.45 0.36 59.4
U 70 E 313 1.8   46 3.7   199.0 78 1.8 0.0  142  167  136   78  118  129  160   84   75   70   70   81 0.86 0.60 0.38 0.31 0.25 55.8
U 70 E 314 1.8   54 3.0   226.7 78 1.5 0.0  167  153  130  130  108  192  184  133   75   57   73   82 0.86 0.60 0.38 0.31 0.25 55.8
U 70 E 331 1.5   55 4.2   242.9 78 3.3 0.0  234  245  211  207  211  216  216   85   79   97   80   88 1.19 0.84 0.48 0.41 0.29 53.9
U 70 E 332 1.5   84 3.4   358.7 78 3.3 0.0  131  145  132  106  102  112  149   90   68   71   63   69 0.97 0.66 0.51 0.39 0.27 57.7
U 70 E 333 1.5   81 3.0   340.0 78 3.3 0.0  176  174  144  139  144  173  204   94   62   69   66   72 1.32 0.89 0.57 0.50 0.38 55.5
U 89 N 443 2.5  137 3.8   595.1 76 3.8 3.8  154  188  167  186   65   78   58   80   75   96  110   78 0.92 0.66 0.40 0.23 0.13 50.9
U 89 N 444 2.5  137 3.8   595.1 76 3.8 2.9  148  183  194  143   62   79   55   86   66   75   74   58 0.78 0.57 0.37 0.23 0.16 54.1
U 89 N 445 2.5  137 3.8   595.1 76 3.8 0.9  147  147  136  130  156  165  168  145  153   96   92   75 0.66 0.40 0.24 0.15 0.10 47.0
U 89 N 446 2.5  137 3.8   595.1 76 3.8 1.8  148  139  127  109  200  199  178  187  188  148  130  123 0.65 0.40 0.24 0.15 0.10 47.4
U 89 N 447 2.5  137 3.8   595.1 76 3.8 0.4  166  186  225  154   85   89   81   96   88  123   70   71 0.63 0.40 0.25 0.17 0.11 49.5
U 89 N 448 2.5  137 3.8   595.1 76 3.8 1.2  153  164  184  177   75   92   78  102   87  100   69   68 0.56 0.40 0.28 0.20 0.13 56.1
U 89 N 449 2.5  137 3.8   595.1 76 3.8 4.0  176  157  182  212  132  132  135  135  121  116   92   93 0.78 0.52 0.32 0.18 0.10 48.7
U 89 N 450 1.8  137 3.8   595.1 76 3.8 3.1  133  134  153  124  107   95   62   79   82   75   66   77 0.78 0.52 0.32 0.18 0.10 48.7
U 89 N 452 1.8  137 3.8   595.1 76 2.3 0.0  142  125  132  136  162  108   55   75   68   89   59   72 0.56 0.33 0.25 0.14 0.10 49.3
U 89 N 453 1.8  137 3.8   595.1 76 2.3 3.2  188  147  158  189  231  130   68   91   91   81   84   93 0.58 0.28 0.15 0.09 0.07 40.3
U 89 N 454 1.8  137 3.8   595.1 76 2.3 1.3  185  164  164  174  214  133   71   91   86   76   89   96 0.87 0.49 0.28 0.16 0.10 43.7
U 89 N 455 1.8  137 3.8   595.1 76 2.3 4.2  184  154  155  175  225  129   59   81   72  101   99   71 0.89 0.40 0.19 0.08 0.05 36.2
U 89 N 456 1.8  137 3.8   595.1 76 2.3 6.0  183  155  160  161  230   61   65   79   72  101  109   78 0.81 0.37 0.19 0.11 0.07 38.3
U 89AN 357 2.5   34 2.7   140.9 77 2.1 0.0  175  140  166  169  204  164   75  112   97  140  103  118 1.02 0.64 0.48 0.25 0.17 50.2
U 89AN 358 2.5   34 2.7   140.9 77 2.1 0.0  220  180  221  198  245  209   90  123  110  122   90  102 0.67 0.48 0.31 0.20 0.15 54.0
U 89AN 359 2.5   34 2.7   140.9 77 2.1 0.0  202  170  192  195  216  197   79  111   99  119   96   87 1.34 0.45 0.24 0.15 0.10 34.0
U 89AN 360 2.5   34 2.7   140.9 77 2.1 0.0  187  150  176  196  201  176   89  104   97  116  109   95 0.42 0.29 0.22 0.14 0.09 55.2
U 89AN 361 2.5   34 2.7   140.9 77 2.1 0.0  189  150  171  195  199  186   85  112  102  123  118  102 0.50 0.36 0.20 0.14 0.08 51.2
U 89AN 362 2.5   34 2.7   140.9 77 2.1 1.5  187  160  186  186  179  188   78  111  104  119  115  114 0.57 0.42 0.16 0.12 0.06 46.7
U 89AN 363 2.5   34 2.7   140.9 77 2.1 0.0  226  190  219  208  252  215   88  121  100  127  105  108 1.24 0.64 0.34 0.19 0.08 40.2
U 89AN 364 2.5   27 3.0   113.3 77 2.1 0.0  223  190  211  222  238  209   69  109   85  121   92  101 0.64 0.52 0.24 0.15 0.08 50.9
U 89AN 365 2.5   27 3.0   113.3 77 2.1 0.0  193  160  177  199  210  181   76  108   82  109   86   89 1.13 0.61 0.38 0.21 0.14 43.7
U 89AN 366 2.5   27 3.0   113.3 77 2.1 0.4  193  150  193  176  212  192   91  120  100  126  115  118 0.68 0.39 0.19 0.11 0.06 42.1
U 89AN 367 2.5   27 3.0   113.3 77 2.1 1.5  211  150  173  187  321  180   81  110   87  114   93   93 0.50 0.27 0.09 0.04 0.02 36.8
U 89AN 368 2.5   27 3.0   113.3 77 2.1 1.2  244  210  247  236  267  211  101  120  107  130  131  120 0.74 0.50 0.19 0.10 0.06 43.0
U 89AN 369 2.5   27 3.0   113.3 77 1.8 0.0  274  220  241  270  315  266   99  120  126  137  144  118 0.82 0.48 0.24 0.12 0.05 41.7
U 89AN 370 2.7   27 3.0   113.3 77 2.1 0.0  273  225  242  281  287  272  175  130  133  139  148  135 0.82 0.48 0.24 0.12 0.05 41.7
U180 E 224 3.9   11 1.0    42.2 76 3.6 0.0  452  418  338  431  478  107   99  119  124  122  154  153 1.53 0.87 0.39 0.21 0.07 40.1
U180 E 225 3.9   11 1.0    42.2 76 3.6 2.7  475  418  348  461  515  108   96  146  151  147  178  174 1.40 0.72 0.24 0.09 0.02 35.3
U180 E 226 3.9   11 1.0    42.2 76 3.6 0.5  428  407  344  365  463  115   89  130  169  183  166  167 1.54 0.88 0.38 0.19 0.07 39.7
U180 E 227 3.9   11 1.0    42.2 76 3.6 2.4  457  416  348  436  480  106  102  121  122  131  136  134 1.33 0.76 0.31 0.16 0.06 39.4
U180 E 228 3.9   11 1.0    42.2 76 3.6 2.3  440  424  334  387  479   93   83  109  103  112  117  122 1.31 0.87 0.38 0.18 0.04 42.4
U180 E 229 3.9   11 1.0    42.2 76 3.6 1.1  356  340  277  319  381   80   76   94   99  128  127  131 0.79 0.55 0.25 0.14 0.06 45.3
U180 E 230 3.9   11 1.0    42.2 76 3.6 0.0  320  319  258  275  337   84   82  108  109  120  145  146 1.21 0.71 0.34 0.23 0.12 43.1
U180 E 231 3.9   11 1.0    42.2 76 3.6 3.9  371  360  299  327  388   96   88  125  103  131  124  138 0.80 0.43 0.15 0.08 0.03 37.2
U180 E 232 3.9   11 1.0    42.2 76 3.6 0.0  364  372  301  346  337   77   87  112  107  125  134  122 2.06 1.15 0.58 0.39 0.20 42.5
U180 E 233 3.9   11 1.0    42.2 76 3.6 0.0  387  384  314  326  410   86   78  102   98  121  118  113 1.64 1.07 0.59 0.45 0.26 48.9
U180 E 234 3.9   11 1.0    42.2 76 3.6 1.8  393  407  329  329  398   76   64   90   79   98  103   91 1.08 0.60 0.32 0.25 0.14 44.3
U180 E 235 4.0   11 1.0    42.2 76 3.6 2.1  132  138  112  120  131   95   99  120  115  128  124  111 1.01 0.55 0.22 0.10 0.04 38.0
```

APPENDIX B
ESTIMATION OF FUNDAMENTAL PAVEMENT MATERIALS PROPERTIES FROM DYNAFLECT DEFLECTIONS

The ADOT and other have invested considerable resources toward the determination of the fundamental properties of pavement materials (Refs. 1 through 15). The preponderance of the effort at ADOT was a continuation of studies begun at the Florida DOT using deflections obtained from the Falling Weight Deflectometer (FWD) (Reference 9). Although the results of these early experimentations were encouraging, the emphasis of the work at ADOT was shifted to other pavement management and design areas because:

1. The matching of theoretical deflection basins to measured deflection basins required excessive computer resources.
2. ADOT has never implemented pavement design procedures that involved the use of layered theory. Laboratory testing of pavement materials to determine fundamental stiffness (modulus) characteristics has been verly limited. The present ADOT specification would not provide a reasonable degree of certainty that as-constructed pavements would have the stiffness (modulus) developed in the laboratory during the AC mix design process.
3. The Dynaflect deflection test data was more difficult to evaluate and analyze. Some of the problems associated with using the Dynaflect for the determination of pavement layer stiffness are:
    a. The load is dynamic.
    b. The effective load magnitude is low.
    c. The load is fixed; stress sensitivity of materials cannot be determined.
    d. The deflection at the center of the load is not measureable; for some pavements, the law of superposition does not (apparently) hold, leading to unreasonable pavement layer stiffnesses.

The problem of matching a theoretical deflection basin to the measured Dynaflect deflecton basin was investigated as a part of this project. The basin-matching procedures that were available were somewhat inefficient requiring excessive computer execution time. An attempt was made to simplify the solution to the determination of surface deflections as a function of elastic modulus. The most commonly used computer programs available at ADOT to solve the layered pavement system problems were:

1. ELSYM5 (Ref. 19)
2. CHEVRON N-LAYER (Ref. 17, 18)
3. Various finite-element programs

A search of the literture for simplified alternate solutions disclosed an interesting approach by Jenffroy and Bachelez (Ref 16). The simplifying aspects of their solution included:

1. Limited to three layers.
2. The interface between the surface layer (AC layer) and the second layer (base) was assumed to be free of shear stresses (no friction).

    The integral equation for the vertical deflection of the pavement surface at a distance r from the load axis is:

$$w(r) = \frac{1.5 \times q \times a}{E2} \int_{0}^{+\text{infinity}} \frac{J1(X) \times J0(X \times r/a)}{X \times (T(X) + B^{3} \times X^{3})} \, dx$$

Where

a = load radius; for the Dynaflect = $2.0^{0.5}$
q = vertical load pressure; for the Dynaflect = 159 psi
w(r) = surface deflection at radius r
J1 = Bessel function of the first kind, order 1
J0 = Bessel function of the first kind, order 0
B = $H\ 1/2 \times ((E1/(6 \times E2))^{0.333})$

$$T(X) = \frac{1-2 \times N \times (1+2 \times (A \times X) \times EXP(-2 \times A \times X) + N^2 \times EXP(-4 \times A \times X)}{1+4 \times N \times A \times X \times EXP(-2 \times A \times X) - N^2\ EXP(-4 \times A \times X)}$$

N = (E2 - E3) / (E2 + E3)
A = H2/a
EXP = Napierian (natural) antilogarithm
Poisson's Ratio = 0.5
E1 = modulus of elasticity of the AC surface layer
E2 = modulus of elasticity of the unbound base layer
E3 = modulus of elasticity of the subgrade
H1 = thickness of the AC surface layer
H2 = thickness of the unbound base layer

It was necessary to evaluate the improper integral by numerical mehtods. The limit of the integral as x approaches zero is E1/(2 x E2); the upper limit of the integral as x approaches positive infinity is zero. Fortunately the value of the integral approximates its zero limit at a conveniently low value; for all practical purposes at x = 10. The IBM Scientific Subroutine, QSF was used to perform the integration calculations using Simpson's Rule. The efficienty of the integration calculation could be improved by developing a routine that is specially designed and programmed to solve this particular integral. The efficiency of the solution method for the Bessel Functions could also be improved.

A comparison of the deflections calculated by this simplified method with deflections calculated by the CHEVRON program did not exhibit significant differences at the radii of the normal Dynaflect geophone configuration (10.0, 15.6, 26.0, 37.4, 49.0 inches). There were significant differences in the calculated deflections at r = 0. The CHEVRON program consistently produced a larger deflection than the simplified method. While this presented no difficulty while working on Dynaflect deflection basin-mathcing problems, many other deflection basin configurations (e.g., FWD) include a measured deflection at r = 0. Other authors (Ref 6) have suggested that the ELSYM5 and CHEVRON programs calculate unrealistic deflections near the load. In the referenced paper, ELSYM5 deflections were compared with the BISAR deflections; ELSYM5 predicted significantly higher deflections in the vicinity of the applied load. Comparison of ELSYM5 and CHEVRON N-LAYER deflections during this project showed excellent agreement between the outputs of these two programs. Further inquiry into comparison of the simplified equation with CHEVRON-type layer theory programs may be undertaken; unfortunately, the BISAR program is not presently available at ADOT.

A more productive area to improve the efficienty of matching theoretical and measured deflection basins proved to be in improving the logic used to iteratively adjust the layer moduli to efficiently converge or match deflection basins. The current steps are:

1. Estimate an initial subgrade (E3) modulus from:

$$E3(psi) = \frac{q \times a^2 \times (1-Nu^2)}{w(r)}$$

Where

q = vertical load pressure; for Dynaflect = 159.16 psi
a = load radius; for Dnyaflect = $2^{0.5}$ = 1.414 inches
Nu = Poisson's ratio; assumed to be $0.2^{0.5}$ = 0.447
r = distance from the load; for the fifth Dynaflect sensors r = 49.0 inches
w(r) = Dynaflect deflection (inch) at r = 49.0 inches

Based on the findings of this project, the initial subgrade modulus should now be estimated from:

$E3(ksi) = (0.013+0.16 \times w(r))^{-1}$

2. Estimate the initial base (E2) modulus from:

   $E2(psi) = E3 \times F2$

Where

$F2 = 0.2 \times (25.4 \times H2)^{0.45}$

H2 = base thickness, inches:

F2 GE 2
F2 LE 4

GE, greater than or equal to
LE, less than or equal to

3. Estimate the initial AC surfacing (E1) modulus:

   E1 = 200000 psi
   DIFMIN = 100000
   N = 0

4. N = N + 1

   Calcullate five Dynaflect deflections at radii 10.0, 15.6, 26.0, 37.4, 49.0 inches.

5. Calculate the effective thickness of the AC surfacing and the unbound base as a function of the estimated subgrade modulus, E3.

   $HE1 = 0.9 \times H1 \times E1^{0.333} \div E3$

   $HE2 = 0.9 \times H2 \times E2^{0.333} \div E3$

   HE1 = effective thickness of the AC surface layer, inches
   HE2 = effective thickness of the unbound base layer,
   HE = HE1 + HE 2

6. Calculate the AC surfacing modulus adjustment factor, F1

   $F1 = (MDEF(1) + CDEF(1)) \times 0.5 \times MDEF(1)$

   Calculate the unbound base modulus adjustment factor, F2

   $F2 = (SMDEF + SCDEF) \times 0.5 \times SMDEF$

   Calculate the subgrade modulus adjustment factor, F3

   $F3 = (SGMDEF + SGCDEF) \times 0.5 \times SGMDEF$

Where

MDEF (1,2,3,4,5) = measured Dynaflect sensor deflection, 1 through 5
CDEF (1,2,3,4,5) = calculated Dynaflect sensor deflections, 1 through 5
SGMDEF = the sum of the measured deflections of those Dynaflect sensors located at distances from the load greater than HE (MDEF(5) is used if HE is greater than 49.0)
SGCDEF = the sum of the calculated deflections of those Dynaflect sensors used to calculate SGMDEF.
SGMDEF = the sum of the measured deflections of those Dynaflect sensors located at distances from the load less than or equal to HE.
SCDEF = sum of the calculated deflections at the same sensors used to calculate SMDEF.

7. E1, E2, E3 Adjustment Logic

```
A.  If ABS (F3-1.00) LT 0.02, E3 is not adjusted but E1 = F1 x E1: then go to Step D
B.  If ABS (F3-1.00) GT 0.02, and if F2 LT 1.0 and F1 LT 1.0, go to Step C

    If F2 GT 1.0 and F1 GT 1.0 go to Step C
    Otherwide, E1 = F1 x E1
    then go to Step C.
C.  If F3 GT 1.0 and F2 GT 1.0 go to Step E
    If F3 LT 1.0 and F2 LT 1.0 go to Step E
    Otherwise E2 = F2 x E2
    then go to Step D
D.  E2 = F2 x E2
    go to Step E
E.  If E1 GT 1500000, E1 = 1500000
     If E2 GT 500000, E2 = 500000
      If E3 GT 60000, E3 = 60000
       If E2 LT 15000, E2 = 15000
        If E3 LT 3000, E3 = 3000
         If E1 LT E2, E 1 = E2
F.     DIFI = ABS (F1 - 1.0)
       DIF2 = ABS (F2 - 1.0)
    DiDIF 3 = ABS (F3 - 1.0)
    TOTDIF = DIFI + DIF2 + DIF3
    If TOTDIF GT DIFMIN go to G
    E1SAVE = E1
    E2SAVE = E2
    E3SAVE = E3
    DIFMIN = TOTDIF
    go to G
G.  If (DIF1 LT 0.03 and
      DIF2 LT 0. 01 and
      DIF3 LT 0. 01) go to H
    If N GT 30 go to H
    Otherwise go to #4
H.  E1 = E1SAVE
    E2 = E2SAVE
    E3 = E3SAVE
```

END OF DEFLECTION BASIN FITTING ROUTINE

8. The modulus values of E1, E2, E3 and the thicknesses H1 and H2 are then input into the CHEVRON N-LAYER program. The other parameters used for input were: a 91.27 psi load uniformly distributed on a circular plate with a radius of 5.91 inches. Poisson's ratio of 0.35, 0.40, and 0.045 for the surfacing, base and subgrade layers, respectively. The load parameters are similar to that imposed by the FWD and also one-half of a legally-loaded heavy truck axle. The radial (tensile) strain at the interface of the existing AC pavement with the underlying base and the vertical strain at the top of the subgrade were the values used in the multiple regression analysis performed in this study.

   This matching of the theoretical deflection basin with the measured Dynaflect deflection basin generally produced subgrade (E3) modulus values which were greater than expected; the AC surfacing (E1) modulus values which were lower than anticipated. No attempt was made to apply any adjustment factors to either of these values as a part of this study.

APPENDIX B
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Appendix C

```
 10 REM AC OVERLAY DESIGN USING DYNAFLECT DEFLECTIONS, FEB 1983, EISENBERG
 20 DIM A$79,M$(20),M(20),S(20),W(20,5),O(20)
 30 LET W$ = 'Y'
 40 PRINT
 50 PRINT USING 60,DAT
 60 :AC OVERLAY DESIGN USING DYNAFLECT DEFLECTIONS   ############
 70 PRINT
 80 PRINT 'TYPE A LINE OF RELEVANT INFORMATION, SUCH AS PROJECT NUMBER, PROJECT
NAME, ETC'
 90 PRINT 'USE ANY CHARACTERS EXCEPT COMMAS, SEMICOLONS, SLASHES, SINGLE OR DOUB
LE QUOTES'
 100 INPUT A$
 110 PRINT
 120 PRINT 'THE PROJECT REGIONAL FACTOR IS ='; 
 130 INPUT R
 140 IF R < 5 GOTO 170
 150 PRINT 'THE REGIONAL FACTOR IS TOO LARGE, TRY AGAIN'
 160 GOTO 120
 170 PRINT
 180 PRINT 'INPUT THE TRAFFIC GROWTH FACTOR (PERCENT) OR THE TOTAL 18000 POUND S
INGLE-AXLE'
 190 PRINT 'EQUIVALENT LOADS (18 KIP SAEL) EXPECTED DURING THE DESIGN PERIOD'
 200 REM G = GROWTH FACTOR
 210 INPUT G
 220 L1 = G
 230 REM IF G <= 20, INPUT MUST BE GROWTH FACTOR, ELSE TOTAL 18 KIP SAEL
 240 PRINT
 250 PRINT 'INPUT THE YEAR THE OVERLAY CONSTRUCTION WILL BE COMPLETED - 19XX';
 260 INPUT Y1
 270 IF Y1 > 60 & Y1 < 90 GOTO 300
 280 PRINT 'ERROR - OVERLAY YEAR IS NOT REASONABLE, TRY AGAIN'
 290 GOTO 250
 300 PRINT
 310 REM TRAFFIC IS ASSUMED TO BE FOR 1982 - CHANGE EACH YEAR OR INPUT???
 320 Y2 = 82
 330 IF G > 20 GOTO 380
 340 PRINT USING 350,Y2
 350 :INPUT THE 18 KIP SAEL FOR THE YEAR 19## =
 360 INPUT T
 370 PRINT
 380 PRINT 'THE OVERLAY DESIGN PERIOD =';
 390 INPUT Y3
 400 IF Y3 > 5 & Y3 < 31 GOTO 430
 410 PRINT 'THE DESIGN PERIOD IS NOT REASONABLE, TRY AGAIN'
 420 GOTO 380
```

```
 430 IF G > 20 GOTO 540
 440 D1 = Y1 - Y2
 450 D2 = 0.01 * G * T
 460 REM D1 IS THE TRAFFIC ADJUSTMENT YEARS
 470 REM D2 IS THE CHANGE IN 18 KIP SAEL PER YEAR
 480 REM T IS THE 18 KIP SAEL ADJUSTED FOR THE DIFFERENCE BETWEEN THE TRAFFIC
 490 REM DATA YEAR AND THE YEAR THE OVERLAY WILL BE CONSTRUCTED
 500 T = D1 * D2 + T
 510 L1 = T * Y3 * (200. + Y3 * G) * 0.005
 520 L1 = INT(L1 + 0.5)
 530 GOTO 570
 540 IF G > 10000 GOTO 570
 550 PRINT 'ERROR - THE 18 KIP SAEL IS NOT REASONABLE - TRY AGAIN'
 560 GOTO 170
 570 L2 = LGT(L1 * 0.001)
 580 PRINT
 590 I = 0
 600 I = I + 1
 610 PRINT 'INPUT THE LOCATION(S) THE DEFLECTIONS REPRESENT, SUCH AS MILEPOSTS O
R'
 620 PRINT 'STATIONS, IN ANY FORMAT (MAXIMUM OF 18 CHARACTERS)'
 630 INPUT M$(I)
 640 PRINT 'INPUT THE INCHES OF MAYS RIDEMETER ROUGHNESS';
 650 INPUT M(I)
 660 IF M(I) > 10 & M(I) < 1000 GOTO 690
 670 PRINT 'THE MAYS RIDEMETER ROUGHNESS IS NOT REASONABLE, TRY AGAIN'
 680 GOTO 640
 690 PRINT 'INPUT THE DYNAFLECT SENSOR DEFLECTIONS (MILS) 1 THRU 5, SEPARATED BY
 COMMAS';
 700 INPUT W(I,1),W(I,2),W(I,3),W(I,4),W(I,5)
 710 S(I) = (W(I,1)+W(I,2)+W(I,3)+W(I,4)+W(I,5)) * 20. / W(I,1)
 720 REM S(I) IS THE SPREADABILITY INDEX ACCORDING TO VASWANI
 730 O(I) = (L2 + 0.104 * R + 0.000578 * M(I) - 0.0653 * S(I)) / (0.0587 * (2.6
+ 32. * W(I,5))**0.333333)
 740 REM OVERLAY THICKNESS IS CONSTRAINED BY THE LIMITS OF 0 TO 6 INCHES
 750 IF O(I) < 0. THEN O(I) = 0.
 760 IF O(I) > 6. THEN O(I) = 6.
 770 PRINT
 780 PRINT USING 790,O(I)
 790 :OVERLAY THICKNESS = #.## INCHES
 800 PRINT
 810 PRINT 'DO YOU WISH TO CALCULATE ANOTHER OVERLAY THICKNESS FOR THIS PROJECT
(Y OR N)'
 820 INPUT Y$
 830 IF Y$ = W$ GOTO 600
 840 PRINT 'FOR A SUMMARY REPORT, PRESS THE CLEAR KEY, PRESS Y, THEN PRESS ENTER
```

```
 850 INPUT Y$
 860 IF Y$ <> W$ GOTO 1010
 870 PRINT USING 880,A$
 880 :##########################################################################
#####
 890 PRINT USING 900,R,Y1,Y3
 900 :REGIONAL FACTOR = #.#   OVERLAY YEAR = 19##   DESIGN PERIOD = ## YEARS
 910 PRINT USING 920,L1
 920 :TOTAL 18 KIP SAEL =#########
 930 PRINT
 940 PRINT TAB(25) 'DYNAFLECT DEFLECTIONS - MILS' TAB(63) 'OVERLAY'
 950 PRINT '  LOCATION        ROUGH   #1    #2    #3    #4    #5   SPREAD  THICK

 960 PRINT
 970 :################## ###  #.### #.### #.### #.### #.###  ###.#    #.##
 980 FOR N = 1 TO I
 990 PRINT USING 970,M$(N),M(N),W(N,1),W(N,2),W(N,3),W(N,4),W(N,5),S(N),O(N)
 1000 NEXT N
 1010 PRINT
 1020 PRINT 'DO YOU WISH TO CALCULATE OVERLAY THICKNESSES FOR A NEW PROJECT (Y O
R N)'
 1030 INPUT Y$
 1040 IF Y$ = W$ GOTO 40
 1050 END
 END OF DATA
```

```
Y
 EXAMPLE PROBLEM FOR REPORT
 REGIONAL FACTOR = 3.0   OVERLAY YEAR = 1983   DESIGN PERIOD = 10 YEARS
 TOTAL 18 KIP SAEL =   1000000

                         DYNAFLECT DEFLECTIONS - MILS          OVERLAY
   LOCATION        ROUGH   #1    #2    #3    #4    #5   SPREAD  THICK

 MP 1 - MP 3        200  3.520 2.170 1.060  .650  .490   44.8    3.24
 MP 4 - MP 5        100  1.510 1.140  .630  .390  .280   52.3    0.00
 MP 6 - MP 8        300  2.280 1.690  .930  .520  .360   50.7    1.23

 DO YOU WISH TO CALCULATE OVERLAY THICKNESSES FOR A NEW PROJECT (Y OR N)
 ?
N
 DATE: 83-076; TIME: 10:46:41.2; CPU TIME: 0000.2 SEC
```

APPENDIX D

A "satellite" study was done to investigate the effect of temperature and season. Temperature and/or seasonal effects are of concern to the users of non-destructive test (NDT) data because they could result in "incorrect" answers.

To study this effect, 20 sites that had monthly dynaflect and temperature measurements were analyzed.The analysis consisted of calculating the spreadability for each test date and plotting the spreadability versus month. Most projects had about two years of monthly data providing "double" coverage of the month axis. These spreadability versus month plots were then reviewed and categorized into three categories; 1-Low seasonal effect, 2-Medium seasonal effect, and 3-High seasonal effect. A project with low effect had a virtually unchanged spreadability from month to month whereas a high effect had obvious high and low spreadability points.

In looking through the individual spreadability versus month plots is was apparent that there were substantial differences in seasonal effect. A plot of "Seasonal" category (1,2,or3) versus asphaltic concrete thickness suggests that thicker AC has a more pronounced seasonal effect. (See Figure D1). This might suggest a temperature effect since the warmer months generally had lower spreadability for the thicker AC pavements. Attempts to compare temperature versus spreadability as well as cracking versus spreadability were not successful.

Some of the more interesting individual plots include Figure D2. This section of highway had monthly tests both before and after being overlaid. Prior to overlay, the seasonal effect was low whereas after overlay the effect was moderately high. It is also interesting to note that while the overlay was providing an apparent increase in strength during months 1 thru 5 and 8 thru 12, the strength, as measured by spreadability, was practically unchanged during months 5 thru 8.

Figure D3 is interesting because of the small but consistent effect caused by the ½ "finishing" course that was placed. Figure D4 is typical of a thin AC and low seasonal effect.

These preliminary findings would suggest that AC pavements under 5" can be tested at almost any time of year in Arizona with the results being usable, representative spreadability values. For pavements with AC over 5" thick, tests for worst case values should be during months 4 thru 10.

FIGURE D1

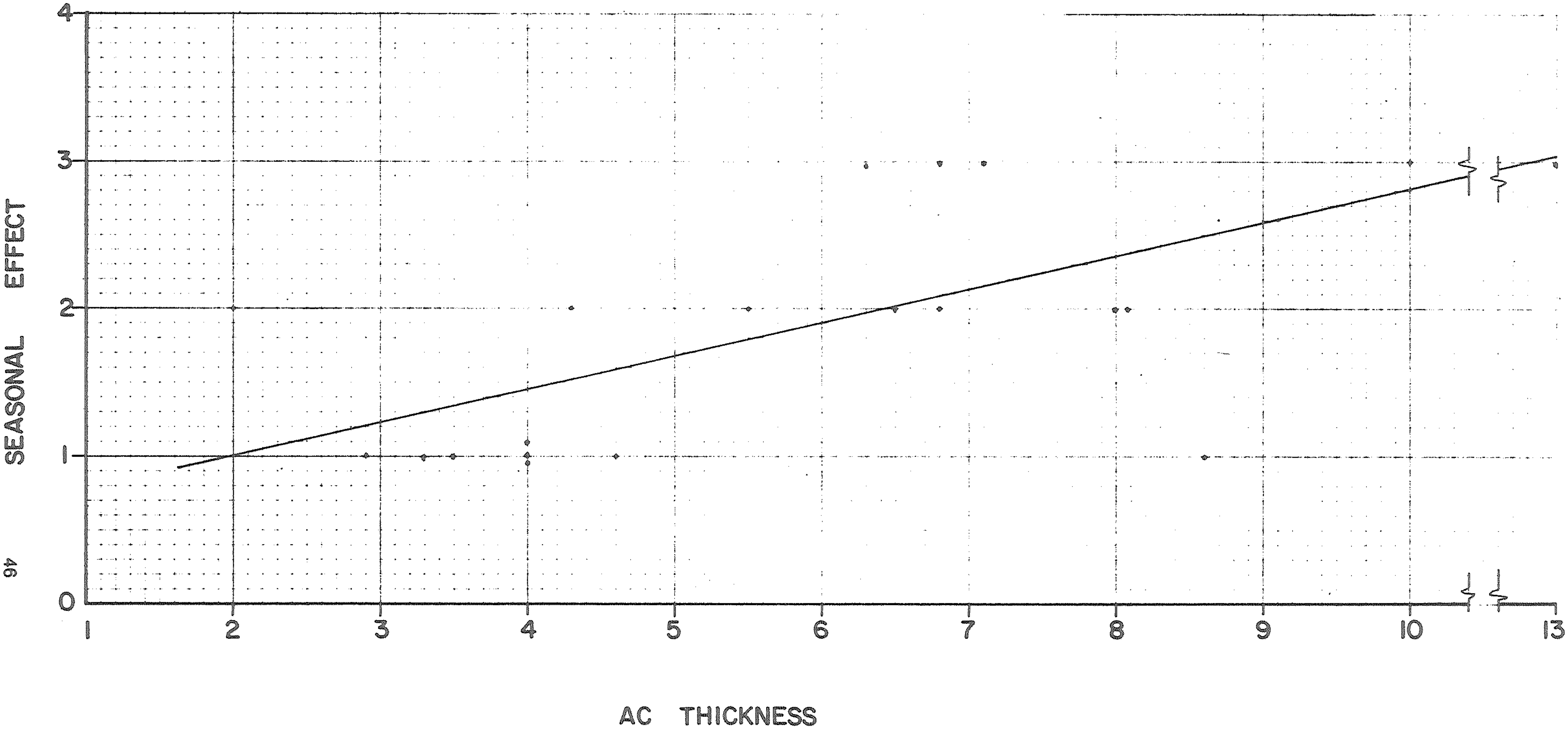

FIGURE D2

SYBIL RD. NO. 2 I10 W.B. M.P. 311

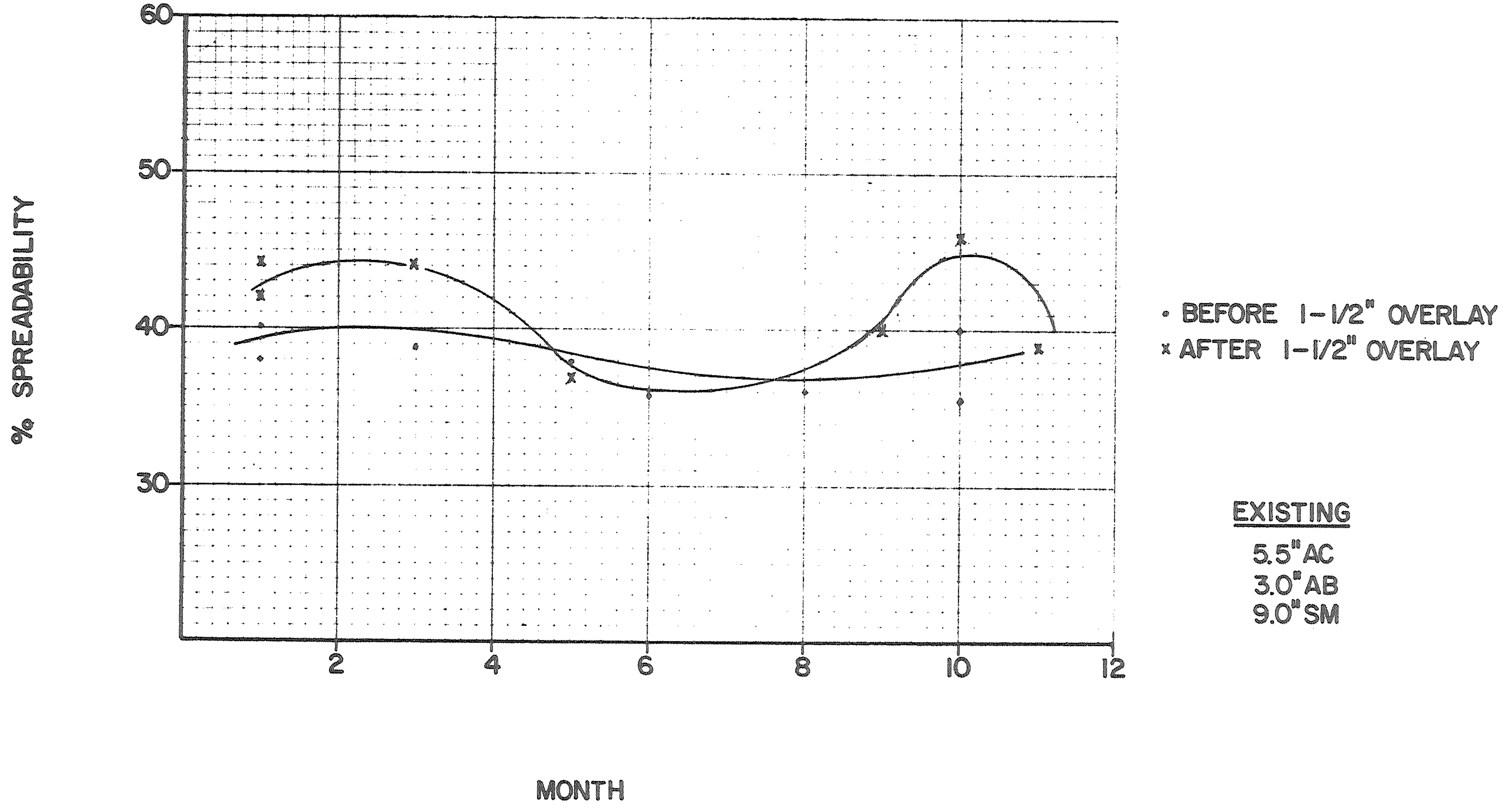

FIGURE D3

GILA BEND, #6 I 8 E.B. M.P. 113

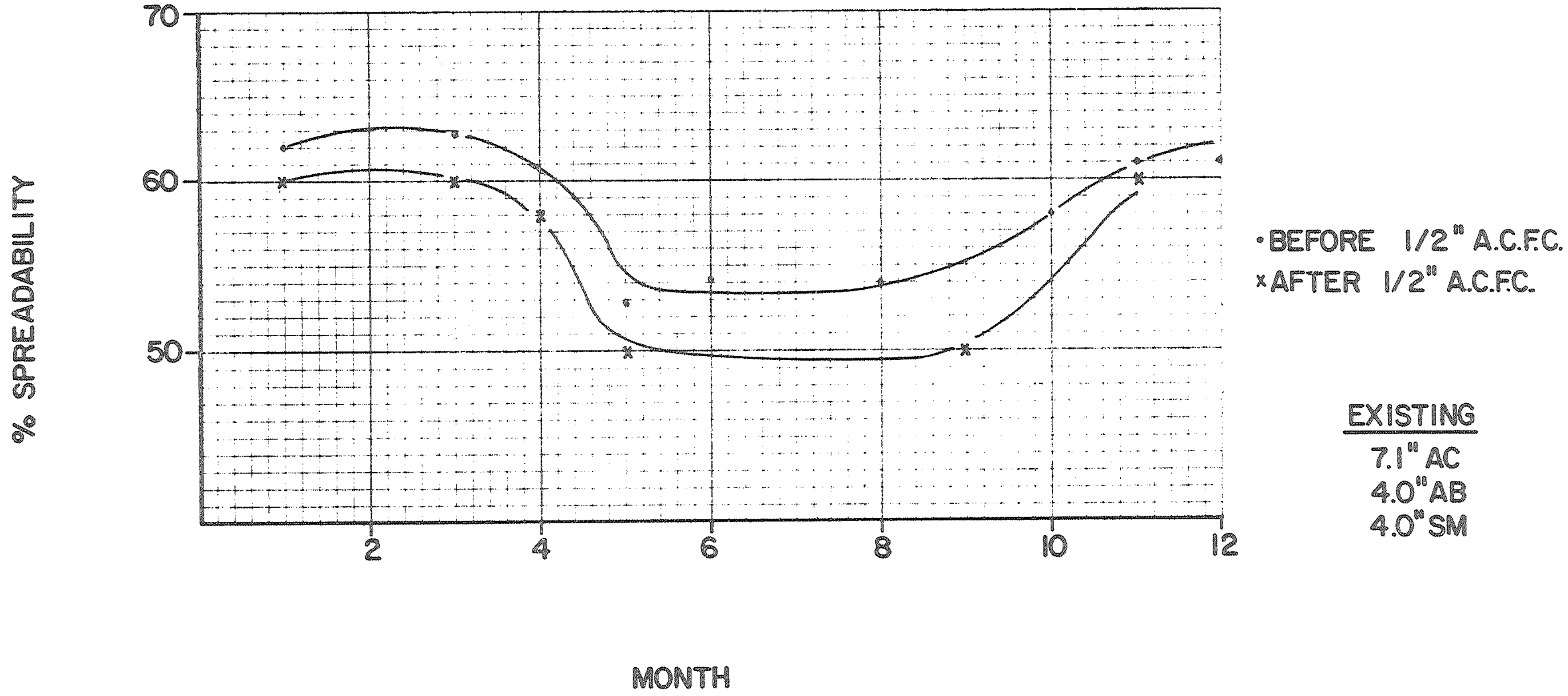

FIGURE D4

CUTTER, # 3 U.S. 70 M.P. 259