Pavement Evaluation Using the Road Rater™ Deflection Dish

Final Report for MLR-89-2

May 1989

Highway Division
Iowa Department of Transportation

PAVEMENT EVALUATION USING THE ROAD RATER ™ DEFLECTION DISH

Final Report
for
Project MLR-89-2

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DISCLAIMER

ABSTRACT

In recent years the Iowa Department of Transportation has shifted emphasis from the construction of new roads to the maintenance and preservation of existing highways. A need has developed for evaluating pavements structurally to select the correct rehabilitation strategy and to properly design a pavement overlay if necessary. Road Rater non-destructive testing has fulfilled this need and has been used successfully to evaluate pavement and subgrade conditions and to design asphaltic concrete overlays and portland cement concrete overlays. The Iowa Road Rater Design Method has been simplified so that it may be easily understood and used by various individuals who are involved in pavement restoration and management.

Road Rater evaluation techniques have worked well to date and have been verified by pavement coring, soils sampling and testing. Void detection testing has also been performed, and results indicate that the Road Rater can be used to locate pavement voids and that Road Rater evaluation techniques are reasonably accurate. The success of Road Rater research and development has made dynamic deflection test data an important pavement management input.

INTRODUCTION

In recent years the Iowa Department of Transportation has shifted emphasis from the construction of new roads to the maintenance and preservation of the existing 10,000 mile Primary Highway System. This shift in emphasis has been due to funding shortages, completion of the Interstate Highway System, and the overall age of the existing highway system. A need has developed for evaluating pavements structurally to select the correct rehabilitation strategy and to properly design a pavement overlay if necessary.

The Iowa Department of Transportation purchased a Model 400 Road Rater from Foundation Mechanics, Inc., A Wyle Company of El Segundo, California, in November 1975. This dynamic device which measures amplitude of movement (hereafter called deflection) replaced the Benkelman Beam, which was last used in Iowa in 1977 (1). A method for designing asphaltic concrete (a.c.) overlays for flexible pavements, utilizing Road Rater deflection measurements, was developed in 1979 and became operational in May 1980. This flexible pavement - a.c. overlay design method has worked well. At this time, 4,560 miles of Iowa's Primary Highway System are portland cement concrete (p.c.c.). In addition, 3,700 miles of Iowa's a.c. pavements are composite (a.c. over p.c.c.) pavements rather than full depth flexible pavements. The flexible pavement - a.c. overlay design method, therefore, has been most useful on secondary highways.

A rigid and composite pavement - a.c. overlay design method was developed in November 1982. Charts were also developed in 1983 to estimate Westergaard's modulus of subgrade reaction (K) (2). Experience gained since 1983 has verified the validity of the rigid and composite pavement - a.c. overlay design method and subgrade reaction (K) charts (3). A Road Rater structural analysis is now performed on most rehabilitation and resurfacing project candidates.

Since the deflection based a.c. overlay design methods were empirically derived, the purpose of this report is to document research performed to date in Iowa. Development of the design methods, verification of the models, and application of the results are discussed. In addition, void detection testing has been performed in Iowa, and the results are also reviewed in this report.

EQUIPMENT

The Iowa DOT purchased a Model 400 Road Rater mounted in a Ford E250 van in 1975 from Foundation Mechanics, Inc., A. Wyle Company of El Segundo, California. The Road Rater is a dynamic deflection measuring device used to determine the structural adequacy of pavements. A large mass is hydraulically lowered to the pavement and oscillated through a servo value to produce a loading force (4). This force varies from 800 to 2,000 pounds on flexible pavements, and from 400 to 2,400 pounds on rigid and composite pavements. The resulting deflection is measured by four velocity sensors. One sensor is positioned directly under the ram, and the other three sensors are positioned at one foot, two feet and three feet respectively, from the ram (Figures 1, 2 and 3).

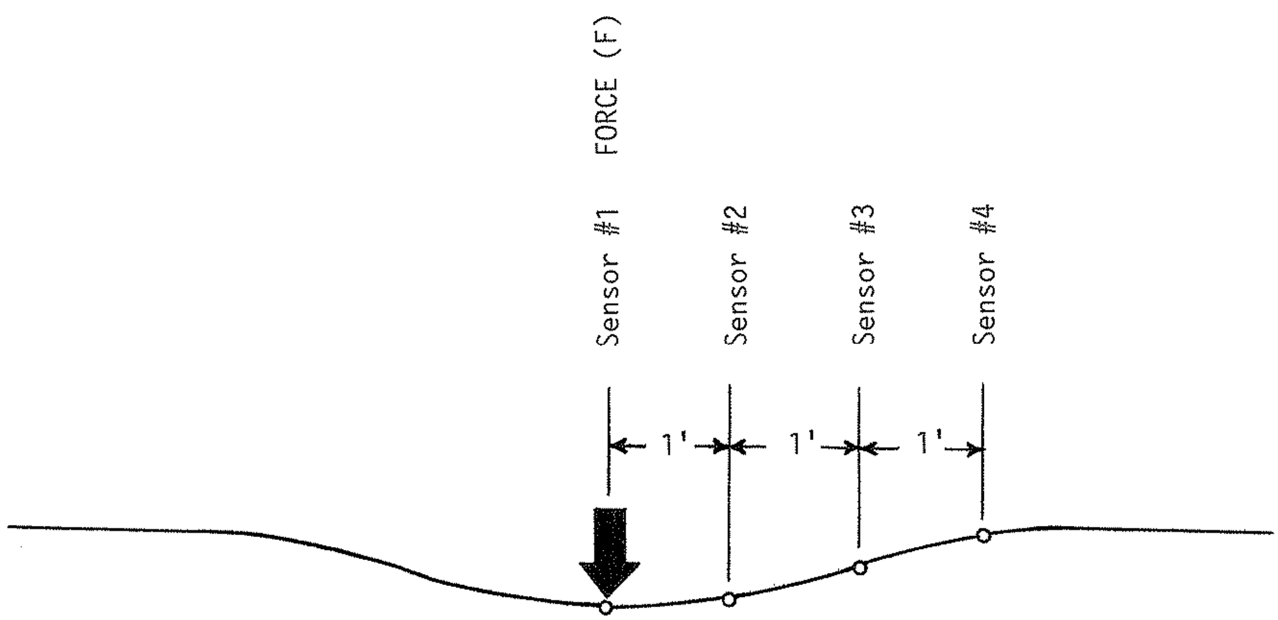


Figure 1
Road Rater Deflection Dish

Figure 2
Model 400 Road Rater

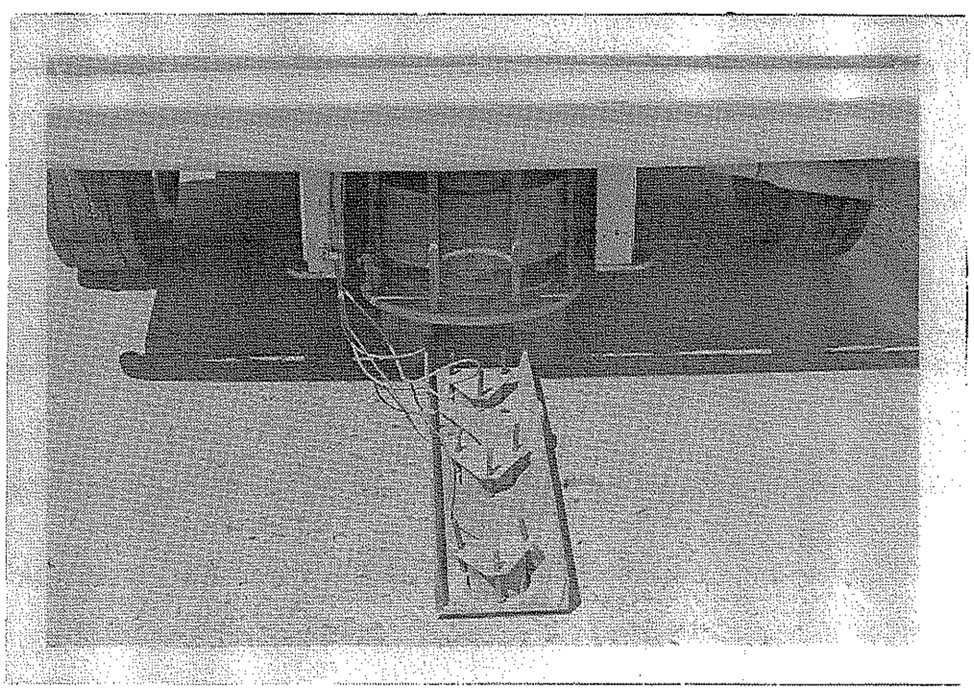


Figure 3
Mass and Sensors

The force applied to the pavement is also monitored by a velocity sensor (Figure 4). This velocity sensor is mounted on top of the hydraulic two-way ram and measures amplitude or peak-to-peak mass displacement. Force imparted to the pavement is expressed by the following equation:

$$F = 32.70f^2D$$

Where F is the peak-to-peak force in pounds, f is the frequency of the loading in Hertz, and D is the peak-to-peak displacement of the mass in inches. A force setting of 25 Hz and 0.058 inch mass displacement is used on flexible pavements and results in 1,185 pounds of peak-to-peak force.

$$F = 32.70(25)^2\ (0.058) = 1{,}185 \text{ pounds}$$

The force setting of 25 Hz and 0.058 inch mass displacement was recommended by the manufacturer for flexible pavements since that force setting correlated best to the Benkelman Beam (correlation coefficient =0.89). A similar study in Iowa yielded a correlation coefficient of 0.83 between the Road Rater and Benkelman Beam.

The manufacturer recommended a force setting of 30 Hz and 0.068 inch mass displacement on rigid and composite pavements which produces a peak-to-peak force of 2,000 pounds.

$$F = 32.70(30)^2\ (0.068) = 2{,}000 \text{ pounds}$$

This is the maximum functional force output of the Model 400 Road Rater. Hydraulic and electrical power are provided by an auxiliary motor mounted in the rear of the van (Figure 5).

The control console mounted in the van has four display meters to indicate deflections from the four velocity sensors placed on the pavement (Figure 6). Display Meter Number 4 is also used to calibrate mass displacement when the power switch is in the "monitor" position (5). A rotary "level" control is used to adjust the mass displacement to the desired output. Other switches are used to raise, lower and vibrate the mass. A six-position "range" switch has settings of 1, 2, 3, 5, 10 and 20, which are multipliers of the display meter readings. If Display Meter Number 1 reads 52 (0.52 of full scale) at range setting 3, the pavement deflection would be 1.56 mils (0.52 x 3 = 1.56 mils). The five-position "frequency" control has settings for 10, 20, 25, 30 and 40 Hertz. This feature allows the load frequency to be changed for different types of pavements. The frequency control is used in conjunction with the monitor position of the power switch and level control to change the peak-to-peak force from 1,185 pounds on flexible pavements to 2,000 pounds on rigid and composite pavements. The Road Rater was originally purchased because of the load-varying versatility.

A Model R-380 RVF Raytek infrared gun is used to measure pavement temperatures. This instrument enables pavement temperatures to be taken quickly for pavement inventory purposes (Figures 7 and

8). Calibration of the infrared gun is performed by moving an adjustment knob while aiming at a metal block of known temperature. The metal calibration block is painted flat black and has a circular temperature dial mounted directly to it (Figure 9).

The original 1975 Ford E250 van had 100,000 miles when it was replaced in the winter of 1984 and 1985 with a 1985 Ford E350 van. Conversion work of the new van was performed in the Iowa DOT Materials Laboratory. The automatic transmission of the original van was rebuilt once, the brakes were rebuilt several times, and the engine had a value job and new timing chain, but overall the van performed extremely well considering the abusive stop-go use. The Road Rater mechanism itself has also been very rugged and trouble-free. Most problems have been minor such as broken sensor wires at plug connections and frequent oil filter replacements for the hydraulic system.

The Iowa DOT paid $25,000 for its Model 400 Road Rater mounted in a van in 1975. Another Model 400 Road Rater was purchased in 1986 due to increased demand for deflection testing and cost $40,000 mounted in an Iowa DOT van. Two Road Rater crews operate simultaneously in the springtime annually. Safety vehicles with signs (or a flashing arrow board) are used to control traffic and protect the test vehicle (Figure 10).

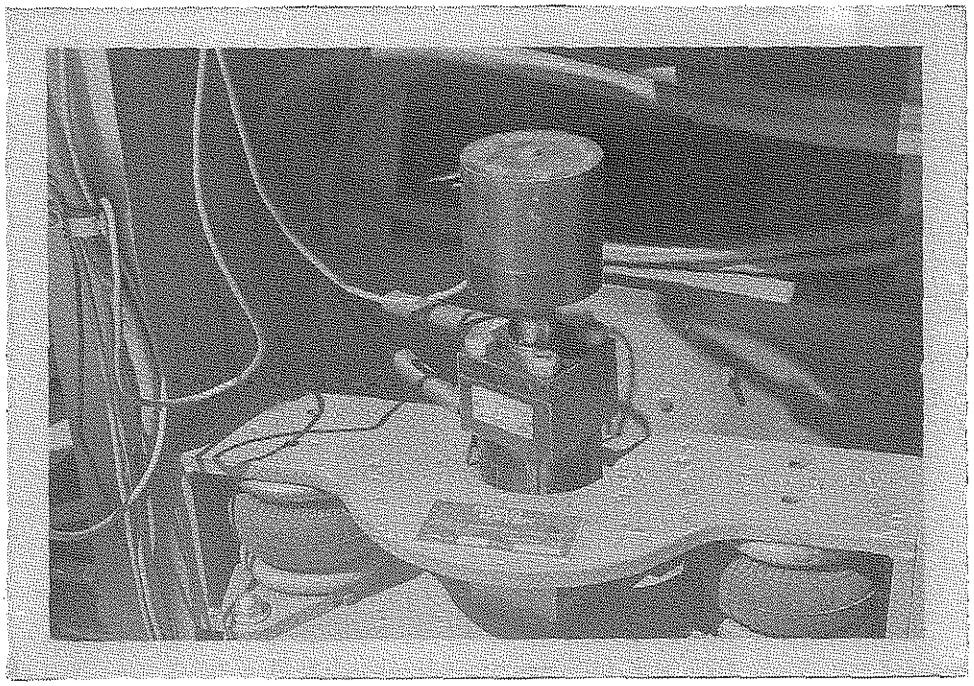


Figure 4
Velocity Sensor on Top of Ram

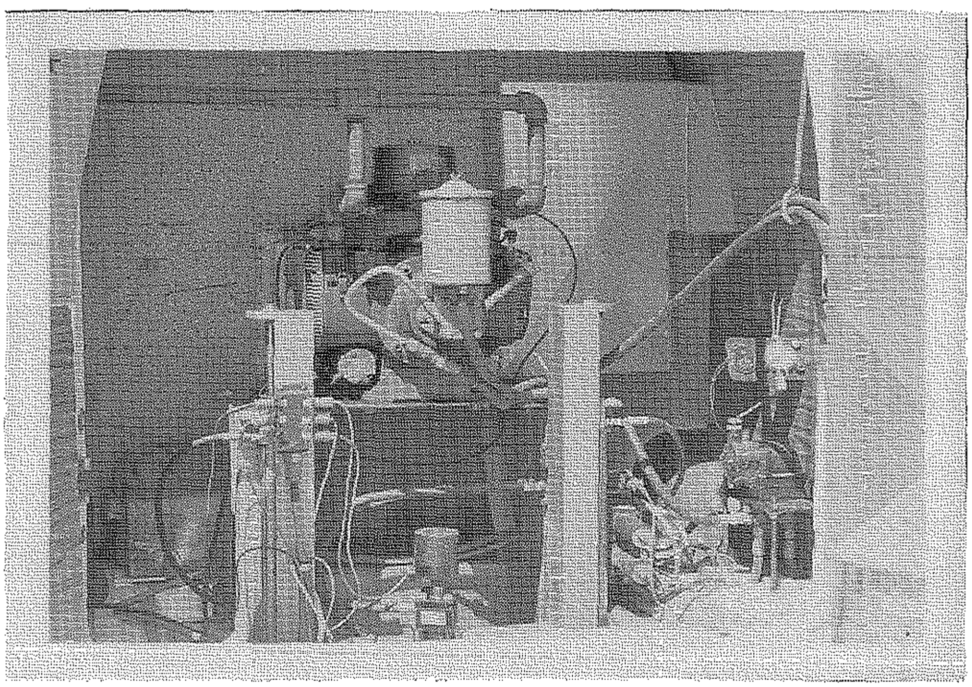


Figure 5
Auxiliary Motor

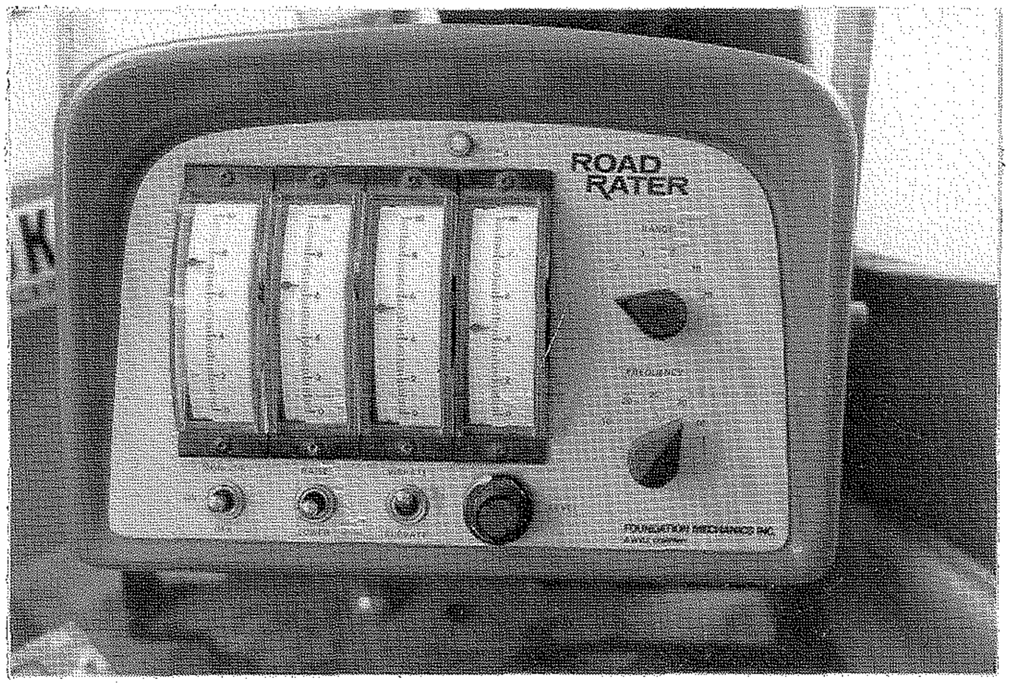


Figure 6
Control Console and Display Meters

Figure 7
Pavement Temperature Measurement

Figure 8
Raytek Infrared Temperature Gun

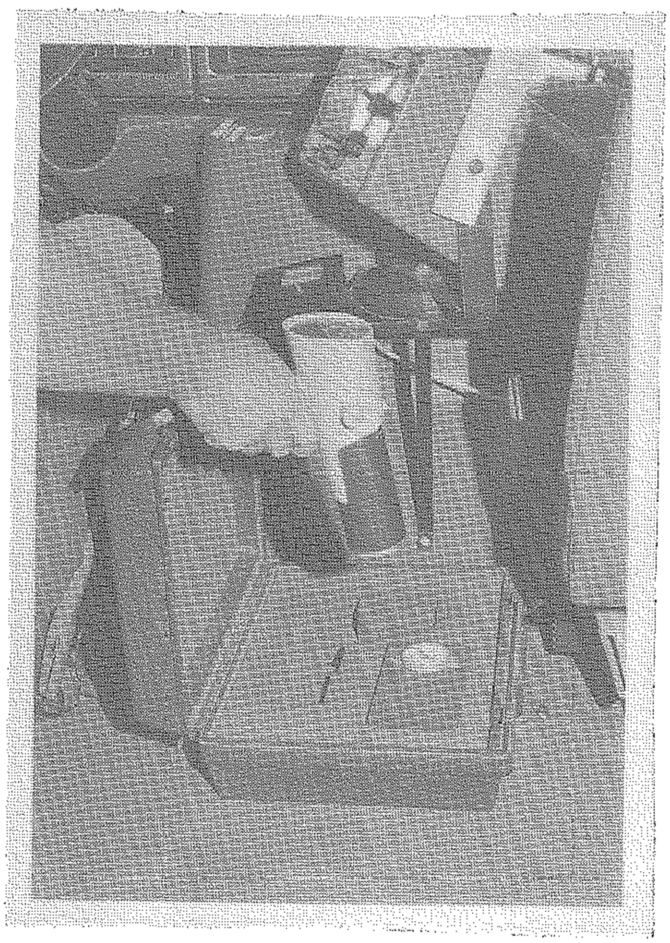


Figure 9
Infrared Temperature Gun Calibration

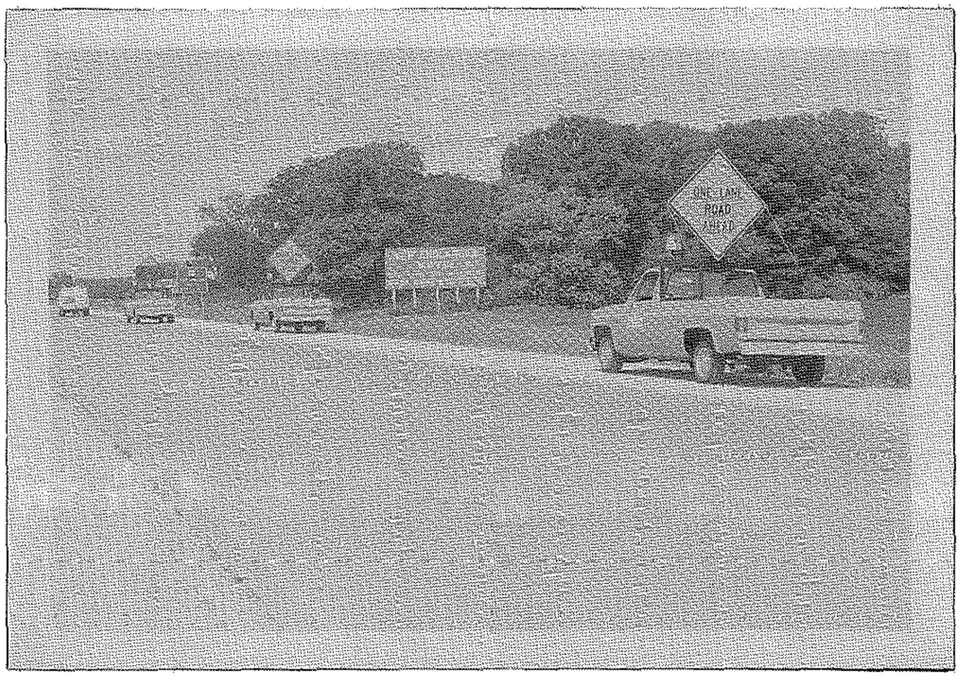


Figure 10
Road Rater Safety Vehicles

TEST PROCEDURE

The Road Rater test procedure (Test Method No. Iowa 1009-B) is included in Appendix A of this report. Annual testing is performed in the outside wheeltrack during the months of April and May when the roadways exhibit the greatest instability. Test data is recorded on coding sheets for processing by an IBM 3081 mainframe computer. All base relationships which convert pavement deflections and deflection basin shapes to Structural Ratings and Soil Support K Values, respectively, have been programmed into the computer.

Joints and mid-panel locations are tested on rigid and composite pavements. The ram is placed about one foot from the joint, and all sensors are positioned on the same pavement panel behind the joint. The condition of joints is evaluated by comparing the Structural Ratings and Soil Support K Values at joints with mid-panel values. In general, the mid-panel 80th Percentile Structural Rating is an adequate basis for design of asphaltic concrete overlays.

Thirty tests per control section are generally considered the minimum necessary to yield statistically valid information. For logistical reasons, only 10 joints are tested for each control section over 2 miles in length. Also due to logistical reasons, only 15 mid-panel locations and 6 joints are tested for control sections 2 miles or less in length.

Test data collected in this manner is used for inventory purposes in the pavement management system. It is also used to determine the nominal thickness of a.c. and p.c.c. overlay designs on individual projects. Detailed project design requires deflection readings every 100 to 200 feet and has never been done in Iowa due to the time required for the extensive evaluation.

Calibration procedures for the Model 400 Road Rater involve use of the monitor position of the power switch, the vibrate position of the function switch, the frequency control, and the level control to adjust the mass displacement to the desired setting. A daily repeatability check is also performed. Once a month, the monitor circuit (including the sensor and read-out equipment) and each of the ground deflection sensors and their read-out circuits are calibrated according to the manufacturer's recommended procedures.

Although an incorrect circuit board produced some bad test data in 1986, the Model 400 Road Rater test results are repeatable and machine calibration has not been a problem. The Road Rater is very forgiving from an operational standpoint to obtain good test data.

DEVELOPMENT OF FLEXIBLE PAVEMENT ASPHALTIC CONCRETE OVERLAY DESIGN PROCEDURE

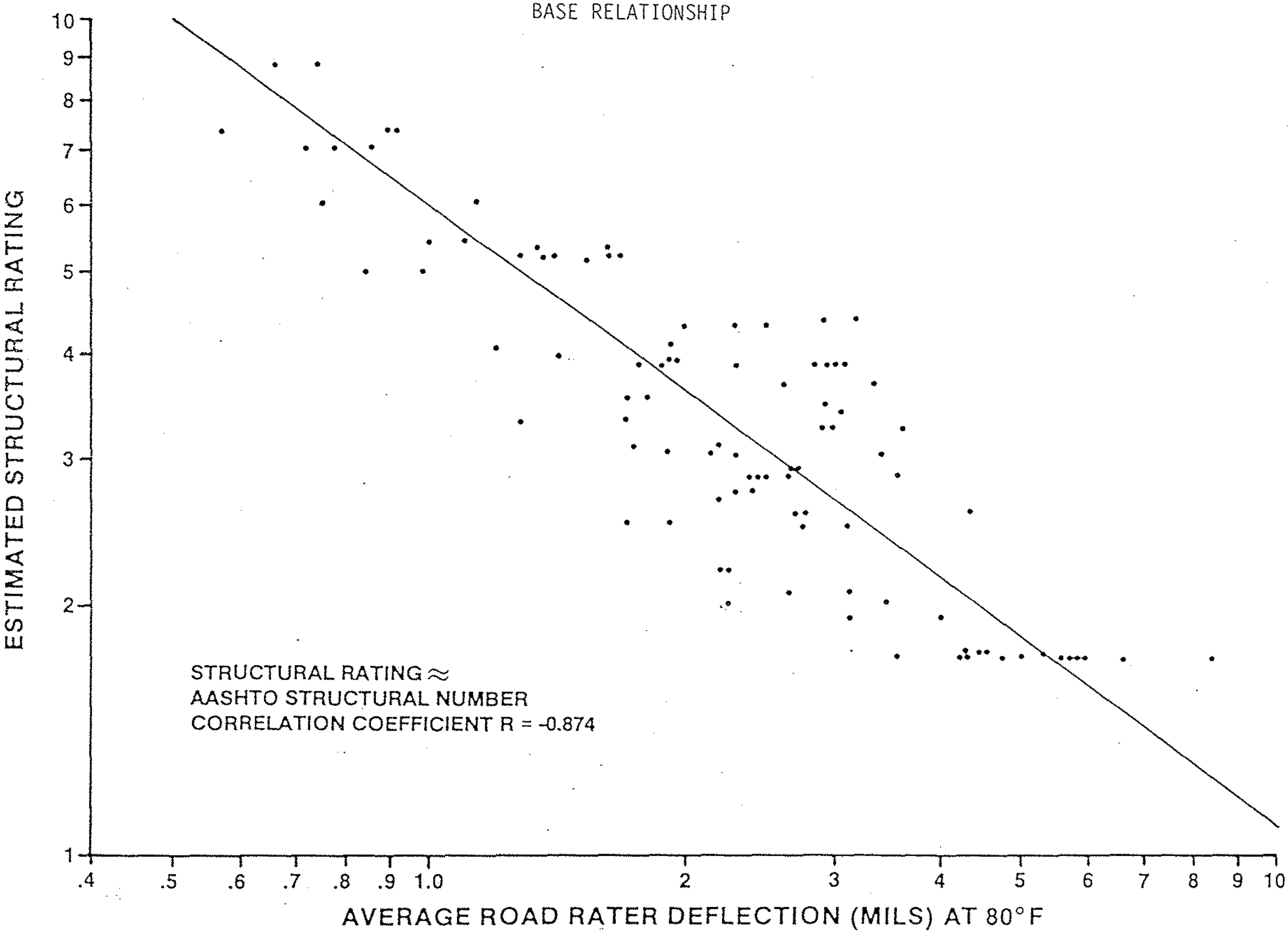
Development of the flexible pavement asphaltic concrete overlay design procedure is briefly described in Appendix B of this report. This paper was written in May 1980 and describes design procedures current at that time. It was agreed upon early in the research and development phase that the goal would be to tie Road Rater deflection data into existing Iowa DOT pavement design methods. These Iowa DOT flexible pavement design methods were patterned closely after AASHTO design procedures (6).

The base relationship for the flexible pavement a.c. overlay design procedure is shown in Figure 11. This relationship was developed by Bernhard H. Ortgies who held the position of Materials Bituminous Field Engineer at that time. Mr. Ortgies estimated the existing AASHTO Structural Number (SN) for a number of flexi-

Figure 11

FLEXIBLE PAVEMENT

BASE RELATIONSHIP



ble pavements ranging from inverted penetration surfaces on minor primary routes through full-depth a.c. Interstate highways. These estimated Structural Numbers were called Structural Ratings (SR's) to distinguish them from direct usage of AASHTO Flexible Design Guide Values. Mr. Ortgies used his best judgment to assign SR values that would either relate to or be identical to AASHTO SN's developed by Iowa DOT design procedures. The present condition of the pavement was considered when assigning SR values, and AASHTO values were depreciated as deemed appropriate to account for pavement deterioration, pavement performance, materials and traffic.

Estimated Structural Ratings were graphically related to average Sensor #1 deflection values in the flexible pavement base relationship. Average Sensor #1 deflection values were temperature corrected to 80°F using the principles developed by H. F. Southgate and R. C. Deen (1). A nomograph shown on page 54 was developed by Douglas M. Heins, Iowa DOT. This nomograph temperature corrects Sensor #1 deflection values to 80°F and converts them to Structural Ratings.

For design purposes, the 80th Percentile Structural Rating is used so that most or all weak areas are sufficiently strengthened by nominal a.c. overlay thickness design after normal surface preparation and patching procedures. The existing 80th Percentile Structural Rating is subtracted from the required Structural Number for the design life and the difference divided by an assigned coefficient to determine the nominal overlay thickness needed.

Assumed soil support values were used until 1983 when the flexible pavement - a.c. overlay design procedure was refined by incorporating soil support values determined from the Road Rater deflection basin. Development of soil support charts based on Road Rater deflection basins is discussed elsewhere in this report. Soil support values are expressed as Westergaard's modulus of subgrade reaction (K) on Road Rater computer printouts as shown on page 47.

The Surface Curvature Index (SCI) is the difference in mils between Sensor #1 and Sensor #2. The SCI divided by average Sensor #1 deflection (SCI/SENS 1) provides a ratio which was incorporated into the computer program in 1978 for future study because of research performed by M. C. Wang and T. D. Larson of Pennsylvania State University and A. C. Bhajandas and G. Cumberledge of Pennsylvania Department of Transportation (8). Although use and application of the SCI/SENS 1 Ratio was not thoroughly understood in 1978, it was used later in 1983 to develop subgrade reaction K charts.

The flexible pavement a.c. overlay design example in Appendix B illustrates that calculations are few and simple to perform when a Road Rater computer printout and Primary Pavement Determination traffic appendix are provided. This flexible pavement - a.c.

overlay design procedure based on Road Rater deflection data has worked very well in Iowa. This may be explained by the close proximity of Iowa to the AASHO Road Test conducted at Ottawa, Illinois, in the late 1950's. Many pavements designed in Iowa since that study have now reached terminal serviceability, and the performance curves and concepts of the AASHO Road Test have been verified as reasonably correct.

DEVELOPMENT OF RIGID AND COMPOSITE PAVEMENT-ASPHALTIC CONCRETE OVERLAY DESIGN PROCEDURE

Since about 83 percent of Iowa's Primary Highway System consists of either rigid or composite pavements, there was a great need to develop a rigid and composite pavement asphaltic concrete overlay design procedure. This was attempted prior to 1981 at the 25 Hertz and 58 percent mass displacement settings, but no pattern was found for the difference in deflection on sound concrete and the deflection on broken or unsound concrete. It was felt, therefore, that the Model 400 Road Rater had insufficient force to evaluate rigid and composite pavements. This thinking was prevalent until a FHWA short course entitled "Pavement Management Principles and Practices" by ARE, Inc. of Austin, Texas was conducted in Ames, Iowa from November 30 to December 2, 1981. The instructors were W. Ronald Hudson and John P. Zaniewski. Dr. Zaniewski indicated that the Dynaflect had been favorably compared with the U.S. Army Corps of Engineers' Waterways Experiment Station (WES) Vibrator in a study conducted by H. J. Treybig (9).

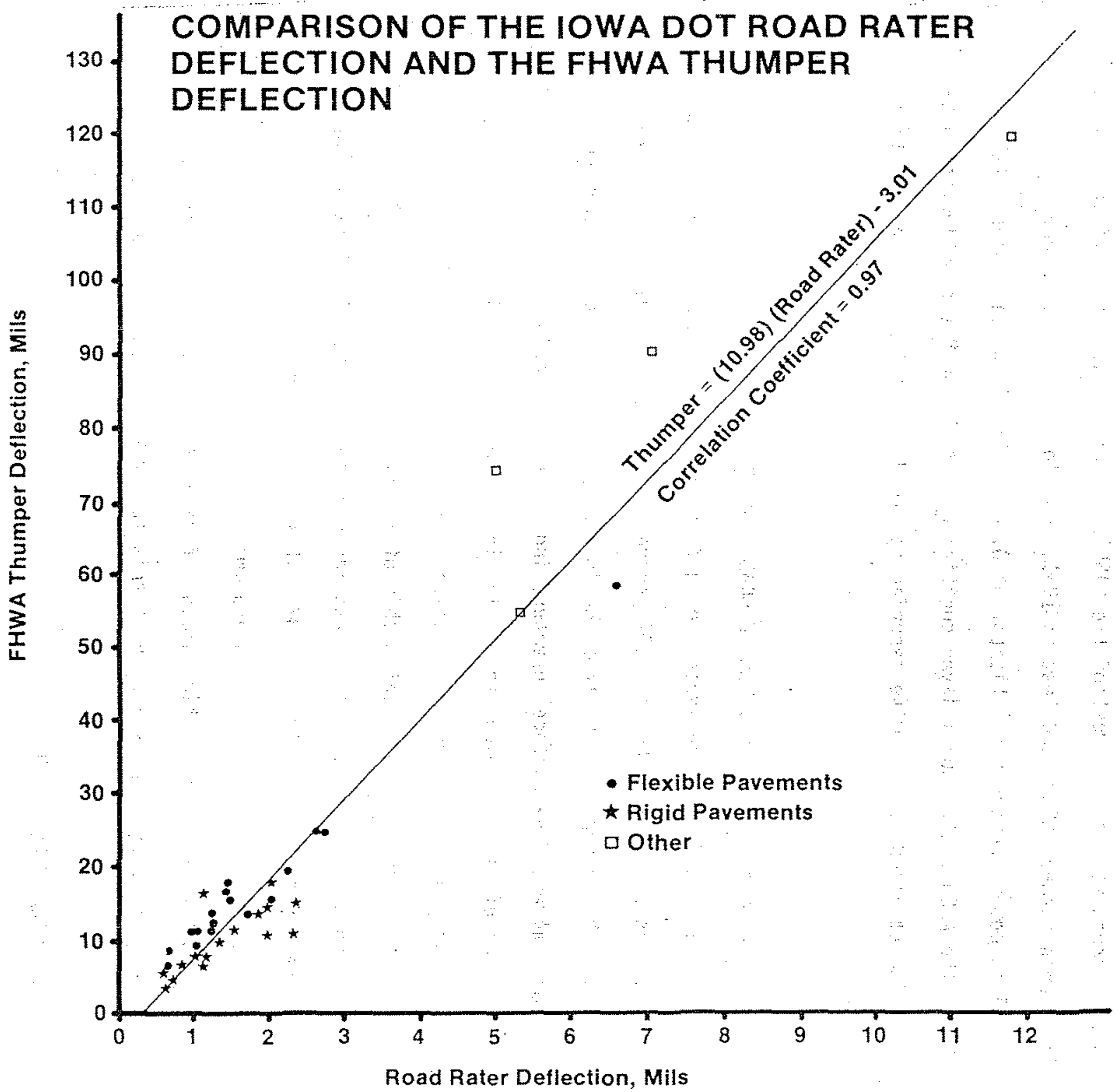
This paper revised our thinking that light load Nondestructive Testing (NDT) equipment could simulate heavy load NDT equipment.

Mr. J. W. Johnson, President of Foundation Mechanics Inc., was consulted to determine the best setting to use to evaluate rigid and composite pavements. Mr. Johnson recommended a setting of 30 Hertz and 68 percent mass displacement which produces a peak-to-peak force of 2,000 pounds. This is the maximum force output of the Model 400 Road Rater.

A work plan was developed in January 1982 to evaluate Road Rater application to rigid pavements and is shown in Appendix C of this report. The basic strategy was to search for correlations between Road Rater deflection readings and various rigid pavement performance variables. The Road Rater was correlated to the FHWA "Thumper" in April 1982 as itemized under Steps 6 and 7 of the work plan. Unfortunately, the 30 Hertz frequency was the only Road Rater frequency which would not function properly. Since the 30 Hertz frequency was inoperative, the 25 Hertz and 58 percent mass displacement setting was used to correlate the Road Rater to the FHWA "Thumper".

Road Rater deflections at the 1,185 pound peak-to-peak force correlated very well to 9,000 pound FHWA "Thumper" deflections (Figure 12). Data to perform this correlation was obtained from 39 different pavement sections ranging from 10" of p.c.c. pavement or 25" of a.c. pavement to a newly graveled unpaved road (10).

Figure 12



COMPARISON OF THE IOWA DOT ROAD RATER DEFLECTION AND THE FHWA THUMPER DEFLECTION
FHWA Thumper Deflection, Mils
Road Rater Deflection, Mils
Thumper = (10.98) (Road Rater) - 3.01
Correlation Coefficient = 0.97
• Flexible Pavements
★ Rigid Pavements
□ Other
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
1
2
3
4
5
6
7
8
9
10
11
12

The FHWA Thumper tested most of the 39 pavement sections at the 3,000, 6,000 and 9,000 pound force settings. A linear relationship existed among deflections at these force settings. That is, the 6,000 pound deflection was twice the 3,000 pound deflection, and the 9,000 pound deflection was three times the 3,000 pound deflection. This information provided the confidence that the Model 400 Road Rater had sufficient force to evaluate rigid and composite pavements.

An expert panel was proposed in Steps 3 and 4 of the work plan to estimate depreciated SN coefficients and nominal a.c. overlay thicknesses required on 23 test sections (each 1/2 mile in length), but the panel could not be assembled in 1982. Steps 1 and 2 of the work plan to determine structural composition and crack and patch survey of 23 test sections was accomplished, however, as was Step 5, Road Rater deflection testing at the 30 Hertz frequency when it was repaired in September 1982. An unusually wet summer and fall in 1982 permitted valid Road Rater test information to be obtained in October and November 1982.

The crack and patch survey in Step 2 of the work plan was performed according to Iowa Test Method No 1004-C included in Appendix D of this report. Cracking, C, is the linear feet of cracking 1/4" wide or sealed per 1,000 square feet of pavement. Patching, P, is the square feet of surface or full depth patches per 1,000 square feet of pavement. The crack and patch deduction on rigid pavements is 0.09 multiplied by the square root of the sum of C plus P. This crack and patch deduction is subtracted from the Longitudinal Profile Value (LPV) to determine the Present Serviceability Index (PSI). The LPV is determined by the Iowa Johannsen Kirk (IJK) Roadmeter which is correlated annually to the CHLOE Profilometer on 30 one-half mile test sections in late May or early June. In this manner, Iowa PSI values tie directly into the performance curves and concepts from the AASHO Road Test.

The Road Rater rigid pavement analysis procedure was developed in four weeks in November and December 1982 due to the urgent need to evaluate Interstate pavements. A spread sheet was used to analyze the test data and is included in Appendix E of this report. Information was placed on the spread sheet from left to right, and columns were added in attempts to obtain the best correlation between Road Rater deflection data and pavement performance variables. Plots are included on pages 76 through 86 in chronological order as they were developed. The coefficient of new portland cement concrete was assumed to be 0.50 Structural Numbers per inch of material. Also, it was assumed that badly cracked p.c.c. pavements would deflect more than uncracked p.c.c. pavements. It was known that Sensor #1 deflection and thickness of p.c.c. pavement should correlate well from the study done by E. D. Lukanen (11).

The correlation plot on page 82 indicated that Continuously Reinforced Concrete (CRC) pavements deflect in a similar manner as non-reinforced concrete pavements, but cracks were less than 1/4" wide and, therefore, CRC pavements did not follow this depreciated SN model. The correlation plot on page 83 excluded CRC pavements, but a few badly cracked pavements still would not follow the depreciated SN model based on the amount of cracking, C. The SCI/SENS 1 ratio compensated for this problem and was incorporated on the plot on page 84.

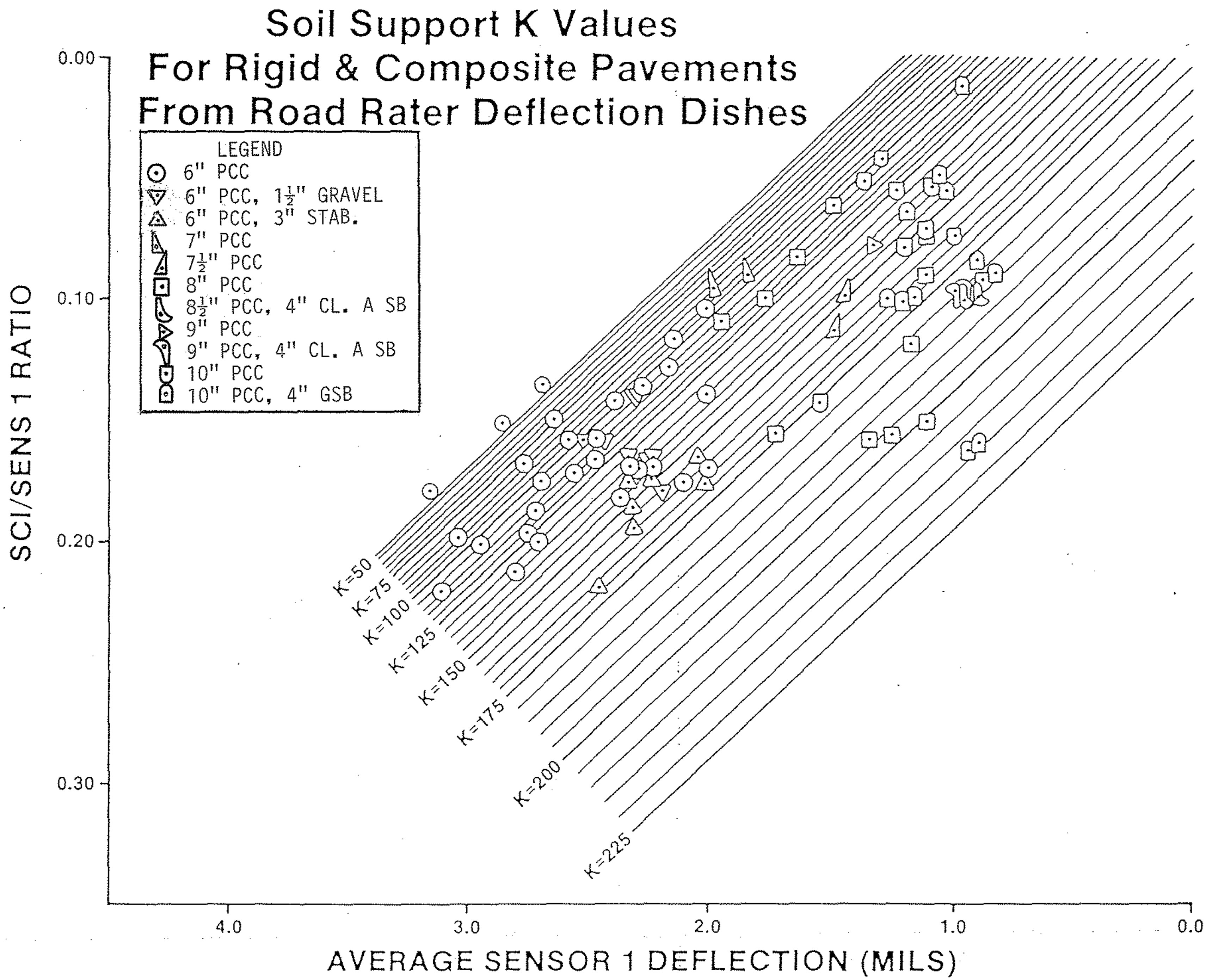
The base relationship to evaluate rigid pavements with the Road Rater is shown on page 85 of Appendix E and was verified with additional test data obtained in 1983. These additional data points are shown added to the base relationship on page 86. Some badly cracked pavements deflected less than expected, and this may be due to unusually good subgrade support, interlocking pavement pieces because of tighter cracks or joints, or collapsed pavement pieces into voids beneath the pavement. If pavements behaved in a totally predictable manner based on thickness and amount of cracking, there would be no need to perform Road Rater deflection testing. As it is, the Road Rater can be used to identify a "rubble" condition in the lower portion of a rigid or composite pavement. The Road Rater tends to read the inches of sound material from the top of the pavement to the first delamination plane. This was illustrated by pavement cores drilled on Iowa's 21 Long Term Monitoring (LTM) Sections for a FHWA Study (see Appendix F). The Road Rater can also be used to determine the subgrade support values for each individual pavement in the critical spring-thaw period annually. The rigid and composite pavement-asphaltic concrete overlay design procedure was reported on December 14, 1982, and used the nomograph on page 57 in a similar manner as was used in the flexible pavement - a.c. overlay design procedure. The mid-panel 80th percentile structural rating is sufficient in most cases to design an a.c. overlay which will adequately strengthen the joints. Comments were solicited on January 4, 1983, on the new deflection-based a.c. overlay design procedure, and a presentation was given on February 10, 1983. At the presentation, it was suggested that verification data be collected to develop confidence as was done with the flexible pavement-a.c. overlay design procedure. A Soil Support K Value Chart for rigid and composite pavements had also been developed at this time. The work plan to evaluate rigid and composite pavements was considered completed.

DEVELOPMENT AND VERIFICATION OF SOIL SUPPORT K VALUE CHARTS FOR RIGID, COMPOSITE AND FLEXIBLE PAVEMENTS

Soil Support K Value Charts were developed since it was recognized that the existing subgrade soil support could affect the overlay thickness required by several inches when using the AASHTO Design Chart for Flexible Pavements, p_t=2.5. It was also recognized that subgrade moisture could affect Road Rater deflection readings, but that this effect could be normalized by annual testing in April and May (only) when the pavements are in their weakest condition after the frost is out. Subgrades are generally saturated in April and May and can be identified by soil type or density through Road Rater deflection testing in this condition. At other times of the year, all subgrades are firm and deflect in a similar manner when tested with the Road Rater. It is extremely difficult or impossible to seasonally adjust Road Rater deflection data taken at other times of the year to a springtime condition unless detailed soils information is available. The only exception is a wet fall following an unusually wet and cool summer when Road Rater testing conditions may be very similar to springtime conditions. Since detailed soils information is not always available and since soil types can vary somewhat on the same pavement section, all Road Rater testing is conducted in April and May. This also restricts pavement temperatures to a lower range to prevent joint lockup on rigid and composite pavements, and to prevent large temperature corrections to deflections on flexible pavements.

The base relationship for Soil Support K Values for Rigid and Composite Pavements From Road Rater Deflection Dishes is shown in Figure 13. This relationship was developed using a similar approach as was used by R. W. Kinchen and W. H. Temple in Louisiana (12). The Louisiana DOT was one of the few states in early 1983 that had done much research and development work on rigid pavements using lightweight NDT equipment. Dynaflect was used in Louisiana DOT research, and Spreadability or Percent spread versus Dynaflect Sensor #1 Deflection was used to determine the subgrade strength (modulus of elasticity, Es). Spreadability conveyed as percent was the average of five Dynaflect sensor readings divided by the Sensor #1 deflection reading. The

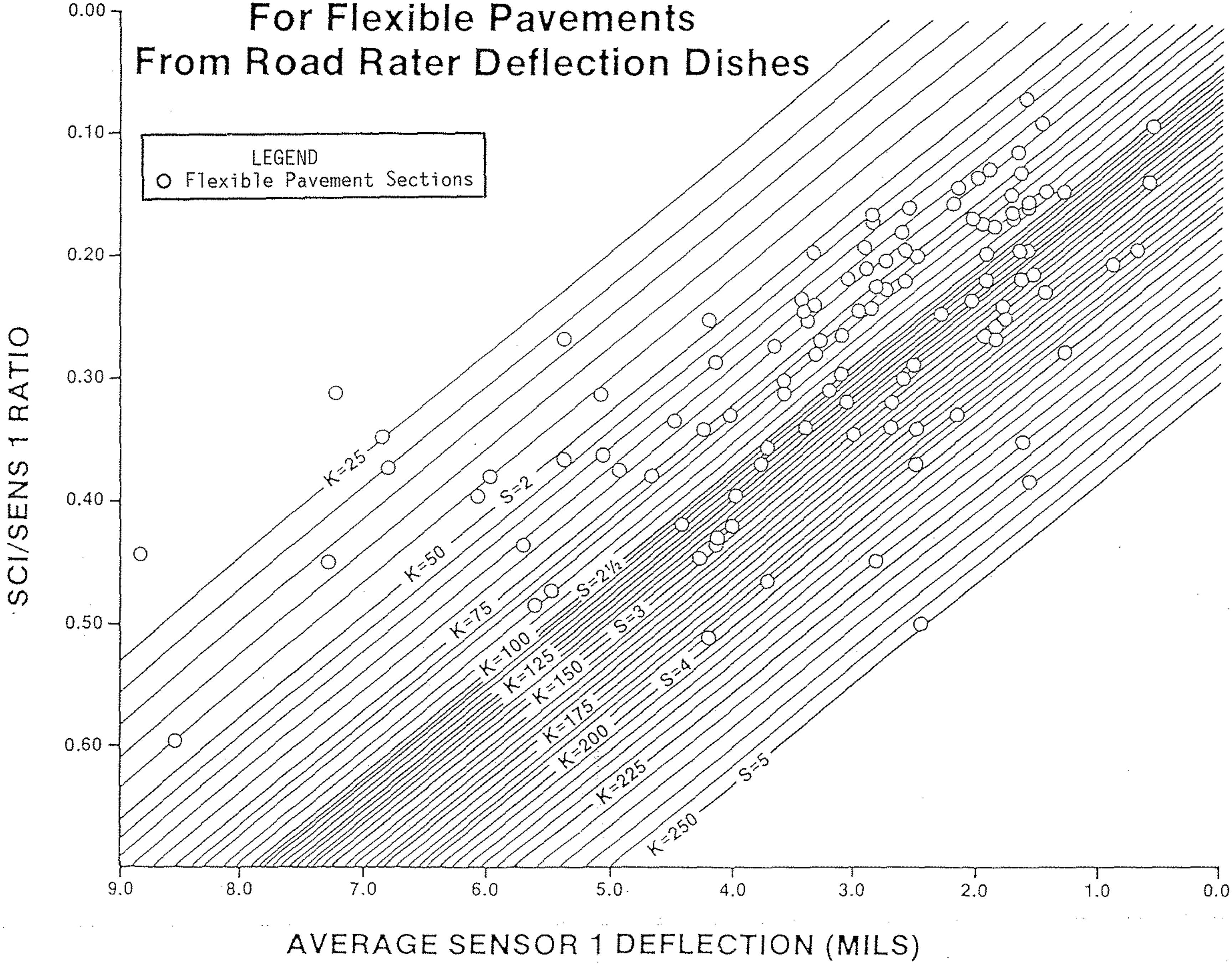
Figure 13



Soil Support K Values
For Rigid & Composite Pavements
From Road Rater Deflection Dishes
LEGEND
6" PCC
6" PCC, 1½" GRAVEL
6" PCC, 3" STAB.
7" PCC
7½" PCC
8" PCC
8½" PCC, 4" CL. A SB
9" PCC
9" PCC, 4" CL. A SB
10" PCC
10" PCC, 4" GSB
SCI/SENS 1 RATIO
0.00
0.10
0.20
0.30
K=50
K=75
K=100
K=125
K=150
K=175
K=200
K=225
4.0
3.0
2.0
1.0
0.0
AVERAGE SENSOR 1 DEFLECTION (MILS)

Figure 14

Soil Support K And S Values For Flexible Pavements From Road Rater Deflection Dishes



Louisiana DOT pavement evaluation chart was a modified version of a chart developed by N. K. Vaswani (13).

Soil subgrade factors, as used by the Iowa Department of Transportation rigid and flexible pavement design, were developed by correlating Plate Load Test information to standard Proctor Density and AASHTO Soil Group Index. These values have provided a basis for Iowa designs since the adaptation of the AASHO Road Test Guides during the late 1950's.

These historical subgrade values were applied for the development of the current Road Rater deflection basin derived "K" charts. Initial testing for this portion of the program was done on new roadways which contained known subgrade soils and subbase treatments. Deflection basins were developed for typical soil types and combinations of various soils and granular subbases. These first comparisons produced marginal results. It was apparent that a greater number of soil and subbase factors were needed. Load testing data for Illinois soils, published by Michael I. Darter (14), compared AASHTO soil types and their strengths at various states of saturation. This information was incorporated with Iowa "standard" subgrade design information. Using these new "expected" values, Road Rater K values were developed to provide answers for the various deflection basin problems.

In 1983 extensive pavement and subgrade testing was done for a selected study group of Iowa pavements (21 LTM Sections). Soil core samples were obtained at individual Road Rater test points. These samples were tested for in-place density, moisture content and AASHTO classification. Items investigated included moisture and in-place density effects for various soil types, values for glacial clay treatments commonly used in Iowa, common values for sand and gravel or crushed stone "special" treatments and effects of high saturation levels on silts and granular subbase. Sample comparisons of values are shown in Tables 1-5 of Appendix G.

The results obtained by this testing verified that individual materials and specific conditions yield reproducible, predictable Road Rater deflection basins. The necessary load testing to obtain companion "Westergaard" information was not performed; however, the assigned values provide a reasonable design range and the relationships for various materials are acceptable.

DEVELOPMENT OF TEMPERATURE CORRECTIONS FOR RIGID AND COMPOSITE PAVEMENTS

Temperature correction factors for Road Rater deflection data were more difficult to determine for rigid and composite pavements than for flexible pavements. This was due to discontinuities because of joints, joint lockup during high pavement temperatures, and slab curling due to temperature differentials on rigid pavements. Temperature corrections for composite pavements were originally thought to be functions of the a.c. overlay thickness, materials properties of the a.c. overlay, and the condition of the underlying p.c.c. pavement. A study of the effects of temperature on Iowa's rigid pavement study sections is shown in Figure 15. A full range of temperatures could not be obtained at one time and, therefore, the seasonal effects and influence of different subgrade conditions complicated attempts to develop a general temperature correction factor or equation which could be applied to all rigid pavements. Most of the rigid pavement temperature study sections in Figure 15 had very flat slopes indicating very little influence on the Structural Ratings from temperature. Some rigid pavements do have a tendency to deflect more at high pavement temperatures, however, and this is attributed to slab curling at mid-panel which is concave in shape and results in higher Road Rater deflections. Since no well-defined trends could be established from Figure 15, no temperature correction factors are applied to rigid pavements. This is a logical strategy since all Road Rater testing is conducted in April and May only when the average pavement temperature is about 70°F, and the range of temperatures is relatively small. Composite pavement temperature study sections are shown in Figure 16. The slopes of most composite pavement lines were similar and resulted in the following temperature correction equation:

$$\text{Temp.Corrected SR} = \text{Non-Temp. Corrected SR} + (70°\text{F} - \text{Pave.Temp.})(-0.0145\ \text{SR}/°\text{F})$$

where the pavement temperature is in degrees Fahrenheit. This temperature correction equation was developed in December 1983, and it was incorporated into the Road Rater computer program in 1984. Many of the data points in Figure 16 have been collected

FIGURE 15
ROAD RATER STRUCTURAL RATING
VERSUS
PAVEMENT TEMPERATURE
FOR RIGID PAVEMENTS

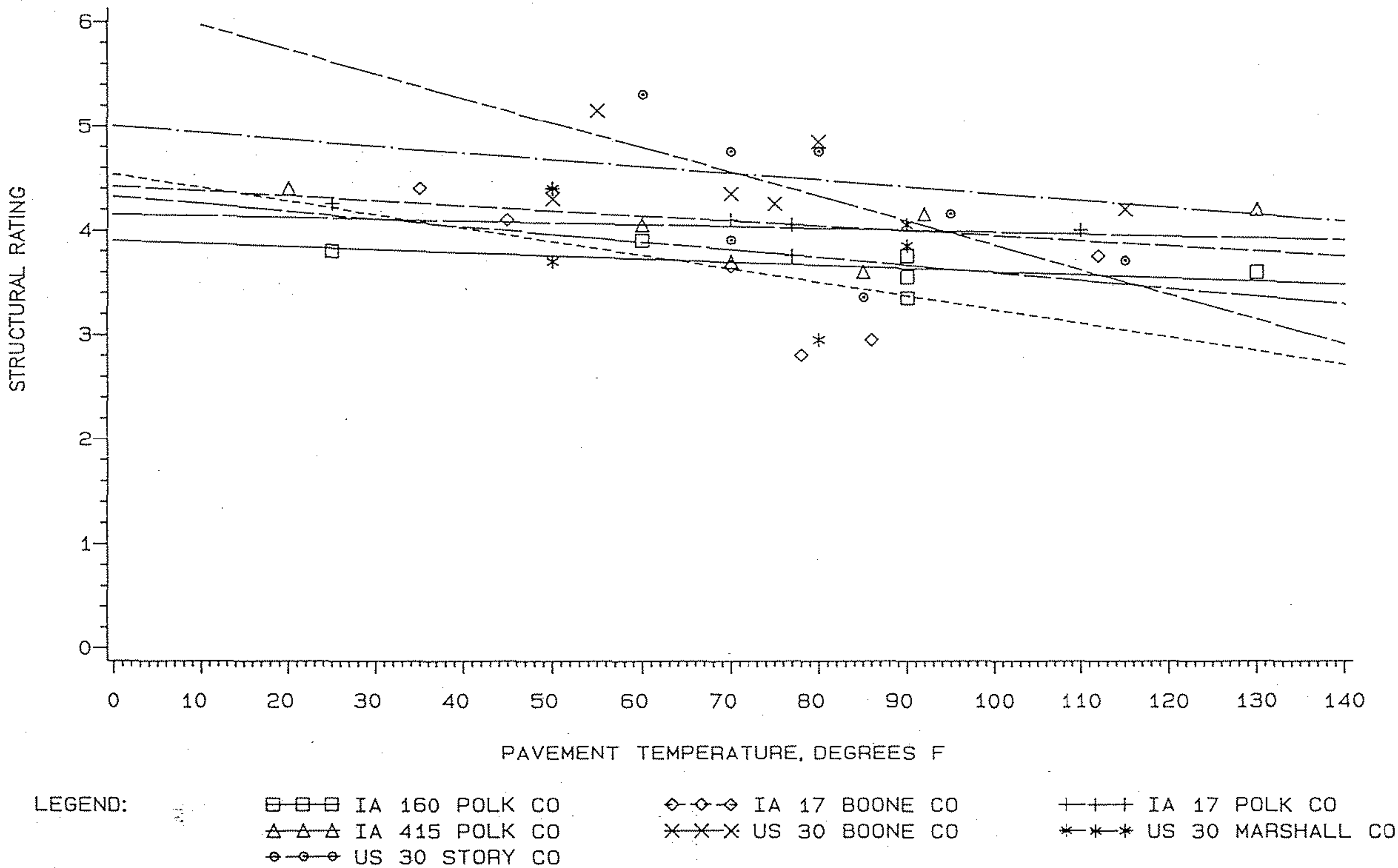
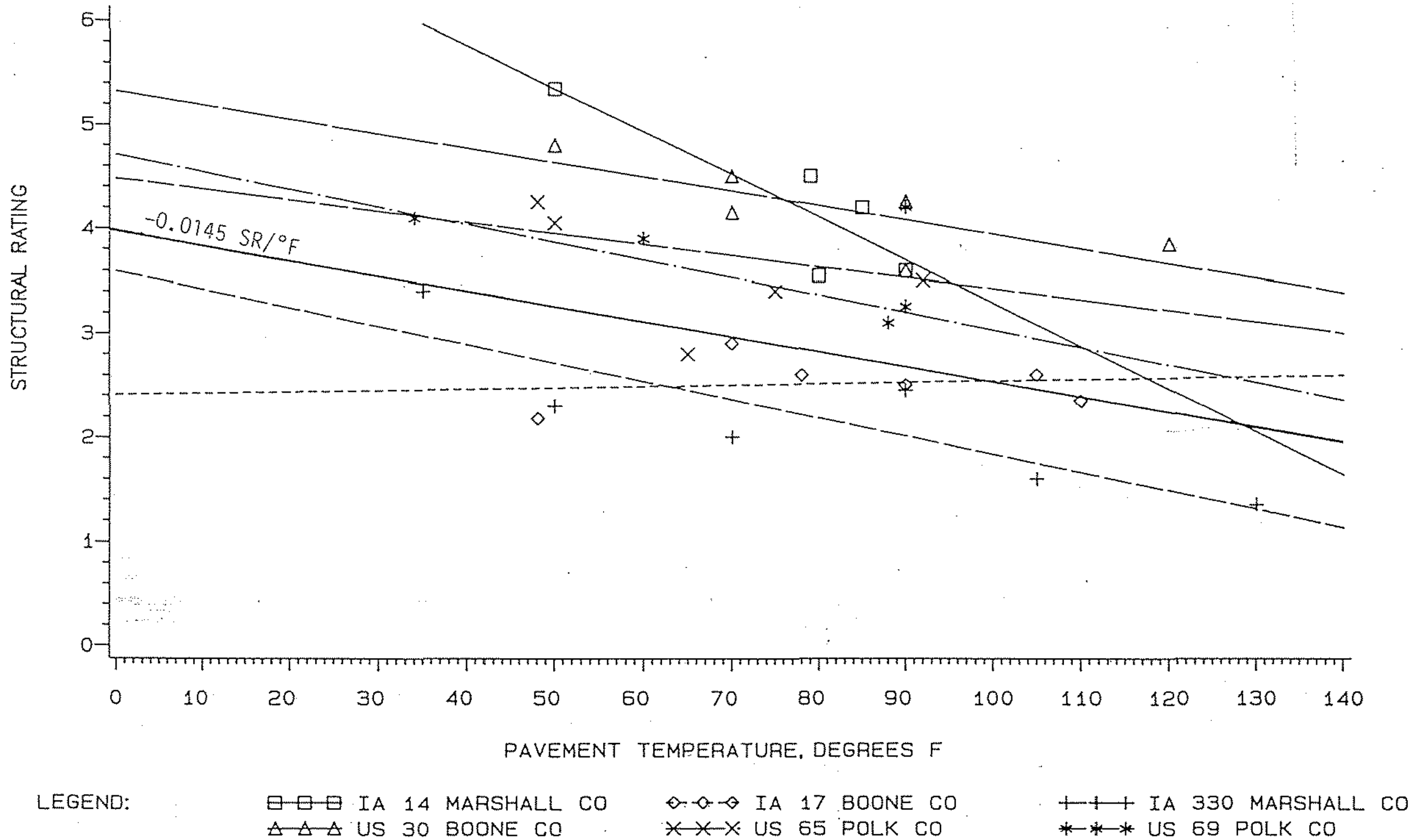


FIGURE 16
ROAD RATER STRUCTURAL RATING
VERSUS
PAVEMENT TEMPERATURE
FOR COMPOSITE PAVEMENTS



since December 1983, and they have generally supported this equation.

VERIFICATION OF FLEXIBLE, RIGID AND COMPOSITE PAVEMENT BASE RELATIONSHIPS

The flexible pavement - a.c. overlay design procedure has yielded reasonable results as described on page 50. In addition, Table 6 in Appendix G compares Road Rater a.c. overlay design estimates with District #5 recommendations on Iowa 22 and Iowa 70 in Johnson and Muscatine Counties. Road Rater a.c. overlay design estimates were reasonable and compared favorably with District #5 recommendations.

The rigid and composite pavement base relationship is verified by core samples drilled in October and November 1983 on 21 Long Term Monitoring Sections. These cores are shown in Appendix F of this report. Road Rater deflections are affected by subgrade condition, strength of materials, amount of cracking, delamination planes, temperature, etc., so Structural Ratings do not always agree with core condition and thicknesses. They do agree in general, however. For example, core #127 should have a structural number of 5.99 ((2¼" AC x 0.44)+(10" PC x 0.50) = 5.99). The Road Rater structural rating on October 17, 1983 was 5.60. Core #128 should have a structural number of 6.65 ((3 3/4" AC x 0.44)+(10" PC x 0.50) = 6.65). The Road Rater structural rating on October 17, 1983 was 6.65. The Road Rater was able to distinguish the difference in a.c. thickness between core #127 and core

#128. The Road Rater could also detect different thicknesses of sound concrete and rated cores correctly relative to each other.

One of the best cores was #285 which had a structural number of 10.95 ((7½" AC x 0.44)+(22½" ATB x 0.34) = 10.95). The Road Rater structural rating on November 3, 1983 was 10.00+. One of the worst cores was #303 which had a structural number of 5.84 ((2 3/4" AC x 0.44)+(9¼" x 0.50) = 5.84). The Road Rater structural rating on November 4, 1983 was 2.55 which accounted for the condition of D-cracked concrete missing from the core.

Tables 7 through 12 in Appendix G show Road Rater a.c. overlay designs for rigid and composite pavement study sections. Pavements ranged in condition from very poor to new. Overlay designs were reasonable although very thick overlays (or reconstruction) were required on most Interstate pavements.

VERIFICATION OF COEFFICIENT OF ASPHALTIC CONCRETE

The AASHTO design coefficient for asphaltic concrete for a Type A or Type B surface course was 0.44 structural numbers per inch of material. This coefficient for asphaltic concrete of 0.44 was verified on flexible pavements by a study of Road Rater deflections before and after placing asphaltic concrete overlays. The results of this study are shown in Table 13 of Appendix G. The average coefficient for asphaltic concrete was 0.52 structural numbers per inch of material which compares favorably with the AASHTO value of 0.44. Extra asphaltic concrete overlay thickness in wheeltracks to remove rutting may be responsible for study coefficients greater than 0.44.

The results of a similar study to verify the coefficient for asphaltic concrete of 0.44 on rigid pavements are shown in Table 14 of Appendix G. The average coefficient for asphaltic concrete on rigid pavements was 0.45 structural numbers per inch of material which also compares favorably with the AASHTO value of 0.44.

APPLICATION OF ROAD RATER VALUES FOR ASPHALTIC CONCRETE OVERLAY DESIGN

The Iowa Road Rater Design Method has been simplified so that it may be easily understood and used by the widely diverse groups of individuals who may be involved in pavement restoration and management. Basic "effective thickness" values were established by testing various new pavements. Standard AASHTO flexible coefficients were used to describe these design sections and applied as a scale for the Road Rater deflection information. Thus, all test information is displayed in effective new pavement units. These values may be easily converted for percent of deterioration or remaining life calculations.

The designer may determine a required thickness by any preferred design method. It is only required that the Road Rater subgrade values or their equivalent be applied to the overlay design. The existing effective thickness is subtracted from the required thickness or total required structure to arrive at a desired overlay thickness. This procedure has been cross checked with recommended AASHTO Interim Guidelines since the system was first introduced in Iowa on secondary pavements in 1979. Correlation has been excellent when the roadway conditions are "normal" or average. Investigations have been made by other test methods when Road Rater values have differed significantly from the required AASHTO values. In all cases to date, the additional testing has verified the information provided by the Road Rater. These verifications have ranged from cases of hidden deterioration to pavement sections which are significantly different from that indicated by existing records.

VOID DETECTION TESTING

Experimental void detection testing using the Road Rater was conducted in October 1984 on an I-80 subsealing project in Scott County. The purpose of this study was: 1) To determine if the Road Rater could locate voids under a pavement, and 2) to determine how well the contractor was filling voids.

Road Rater testing to locate voids must be done at cool temperatures when the joints are not locked up. Therefore, this type of Road Rater testing is normally done in the morning hours - especially in the summer months. Testing was conducted in the outside wheeltrack going against traffic at all joints and at midpanel cracks in the test section. This requires lane closure with cones to protect the testing crew and traveling public. The purpose of testing against traffic is: 1) To string the sensors out on the down-stream panel where voids are located so that Road

Rater K Value Soil Support Charts can be used, and 2) to place the weight of the Road Rater van on the up-stream panel to reduce the effects of any pre-loading which may close the voids prior to testing. The static load of the Road Rater in this configuration is 1,480 pounds.

The minimum Road Rater soil support K value possible from the data evaluation program is K=50. This was estimated to be the lowest K value possible on saturated clays in springtime friable conditions. Therefore, a sound 10" p.c.c. pavement over a void would be expected to have an unusually low Structural Rating and a soil support value of K=50.

The results of this study are illustrated by Table 15 in Appendix G. Road Rater testing was conducted on a section of I-80 at the joints on October 10, 1984, at 9:30 a.m. and a pavement temperature of 60°F before subsealing. The same joints were tested on October 11, 1984, at 10:35 a.m. and a pavement temperature of 60°F two hours after subsealing. For a sound 10" p.c.c. pavement, the joints before subsealing had unusually low Structural Ratings and soil support K values, but showed dramatic improvement two hours after subsealing. From this study it was concluded that: 1) The Road Rater can be used to locate voids beneath a p.c.c. pavement, and 2) the contractor was doing a good job of subsealing on this project. Further research using the Road Rater for void detection testing is being conducted.

ROAD RATER TESTING OF RETROFITTED LOAD TRANSFER DOWELS

Retrofitted load transfer dowels were installed in 1986 on the eastbound lanes of I-80 at milepost 290 in Scott County. This 10 inch thick mesh-dowel pavement has 76' 6" joint spacing and was built in 1960 on 4 inches of granular subbase. Diamond grinding and subsealing was performed on both lanes before dowels were installed. Dowels were inserted in the driving lane and in both lanes at some locations. Three or four bars were placed in each wheeltrack in slots at mid-depth (or above) to avoid mesh. Slots were partially filled with neat epoxy grout (no aggregate) which was displaced by dowels. Slots were topped off with epoxy and aggregate.

Table 16 in Appendix G illustrates Road Rater testing results on pavement sections with and without retrofitted dowels. Testing was performed on September 15, 1988 at 9:30 a.m. and at a pavement temperature of 70°F. The Road Rater ram was placed on the down-traffic side of cracks and joints where voids would be located, if any.

Structural rating numbers and soil support K values were substantially higher where dowels had been installed. The difference in Road Rater deflections is very pronounced at the boundary between doweled and undoweled pavement sections.

The Road Rater could distinguish where retrofitted dowels had been installed, and dowels appear to benefit the pavement through two years of service.

CONCLUSIONS

This report summarizes our experience to date with the Road Rater. Conclusions are as follows:

1. The Road Rater has been an effective tool to evaluate pavement and subgrade conditions for both flexible and rigid pavements.

2. An asphaltic concrete and portland cement concrete overlay design procedure based on Road Rater deflection data has been developed and is working well to date.

3. Void detection testing has been performed with encouraging results both in the Road Rater's ability to locate voids and in the verification of our analysis techniques.

4. Successful Road Rater research and development has made dynamic deflection data an important pavement management input.

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APPENDIX A

METHOD OF TEST FOR DETERMINING PAVEMENT DEFLECTION USING THE ROAD RATER

Test Method No. Iowa 1009-B
March 1985

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

Office of Materials

METHOD OF TEST FOR DETERMINING PAVEMENT DEFLECTION USING THE ROAD RATER

Scope

The Road Rater is an electronically controlled, hydraulically powered unit mounted in the back of a van type vehicle. The unit inputs a dynamic force into the pavement and measures the movement of the surface using velocity sensors. This velocity is integrated to show displacement which is referred to as pavement deflection. Pavement deflection is a measure of structural adequacy especially in the critical spring-thaw period occurring in April and May annually. The pavement deflection data can be used to predict the performance of the surface, the probable maintenance required, and the resurfacing needed to restore the surface to required structural capability.

Procedure

A. Apparatus

1. Road Rater (Figure 1)
2. Air Pressure Gauge
3. Temperature Equipment (Raytek Infrared Gun)
4. Safety Support Vehicles

B. Test Record Form

Original data is recorded on a data processing coding form (see example on page 5). The following data is recorded:

1. Sheet number is recorded in the upper right-hand corner sequentially from 01 to 99 per batch. Coding sheets with the same lab. number cannot be separated between batches. Therefore, it may be necessary to stop one batch at sheet number 97 or 98 and start another batch at 01. In addition, the northbound sheet must always precede the southbound sheet in sheet order, and the eastbound sheet must always precede the westbound sheet for each lab. number. If more than one coding sheet is needed to record all data in one direction for a specific lab. number, the second coding sheet must have an identical sheet number as the first coding sheet. Cross out the heading on the second coding sheet and print "continued". Also, on the right-hand side of the coding sheet (toward the middle), change the numbers in the vertical column to 13 through 24. This changes numbers on the first sheet precoded from 01 through 12.

2. County numeric designation in alphabetical order from 0 to 99 is entered.

3. Highway system is entered using the following codes:

   U - United States (US) Route
   S - Iowa (State) Route
   I - Interstate Route
   C - County Route
   M - Municipal (City) Route
   A - Airport

4. State or county route designation is entered. This field may include letters as well as numbers to accommodate county routes (M-27 for example).

5. Beginning and ending milepost on the primary system or mileage designation on the secondary system is entered. Mileposts are entered in ascending order for northbound and eastbound directions, and descending order for southbound and westbound directions.

6. Direction of the lane being tested is entered (N, S, E or W).

7. Pavement type is entered using the following codes:

   PC - Portland Cement Concrete
   AC - Asphaltic Concrete
   SC - Seal Coat
   COMP - Composite Pavements, Asphaltic Concrete Over Portland Cement Concrete

   Seal Coat (SC) is to be used for inverted penetration roads only. If an asphaltic concrete or composite pavement has been seal coated, it is to be coded as AC or COMP, respectively.

8. Date tested is entered by month, day and year in a six-digit code as follows: February 22, 1984-022284.

9. Time is entered based on a 24-hour clock when testing begins.

10. Lab. number is entered in sequential order as projects or control sections are tested. The first number represents the year tested. RA4-0001 is the first project tested in 1984 for example. A separate lab. number is used for joints on rigid and composite pavement sections.

11. Year built is the year of the most recent construction project. Do not consider a seal coat as the most recent construction project on an asphaltic concrete or composite pavement. For example, this pavement

Seal Coat	1984
3" AC	1969
9" PC	1949

is coded as a composite pavement built in 1969.

12. Observer is entered as the person operating the Road Rater and the person recording the test data.

13. Weather is entered as can best be described in five characters. CLEAR or CLOUD can be used to describe sunny or cloudy days, for instance.

14. Frequency in hertz is entered and must be either 25 or 30.

15. Beginning and ending pavement temperature for the direction tested is entered.

16. Test type is entered and must either be left blank, coded JT for joint, or coded SI for supplementary information. All non-primary, research and special testing (such as ramp testing or void detection testing) is coded as SI. The SI or JT codes remove Road Rater test data from the pavement management matrix listing.

17. History is entered by date tested, average structural rating and average soil support K value. History data is only recorded on one coding sheet (one direction) for each lab. number.

18. Location is entered by milepost, range (Road Rater console selection), Sensor 1 (per cent of meter), Sensor 2, Sensor 3, Sensor 4 and remarks (an identification of a complete remark shown at the bottom of the coding sheet).

19. Remarks are entered and include lane designation on multilane roadways, unusual conditions, etc. The first four positions in the Remarks Section of the coding sheet must match exactly to the remark identification at specific locations. SECL and SECH for superelevated curve low side and superelevated curve high side, respectively, are pre-coded and need not be explained in the Remarks Section of the coding sheet. One lab. number has provisions for eight different remarks (four remarks in each direction). This may be expanded by using the same procedure explained in B1. of this test method for additional deflection readings (over 36 per coding sheet). That is, the extra sheet has the same sheet number, and the numbers 1 through 4 on the right-hand side of the coding sheet are changed to 5 through 8.

C. Test Procedures

1. Determination of testing frequency

a. The minimum number of individual tests for inventory purposes shall be obtained according to the following schedule:

Test Section Length (Miles)	AC and SC Pavements (Tests)		PC and COMP Pavements (Tests)	
	Mid-Panel	Joints	Mid-Panel	Joints
2.0 or less	15	0	15	6
Over 2.0	30	0	30	10

1. Individual tests should be equally spaced and offset so the tests in one lane are between the tests in the adjacent lane.

2. The test interval shall not exceed 1.0 mile (0.50 miles between tests in adjacent lanes).

b. Testing frequency shall be as noted or as directed by the engineer for special test sections, research projects, or voids detection testing.

2. Preparation prior to testing

a. Turn on fan switch which ventilates the engine compartment. Also, open any engine compartment vent doors (if any).

b. Check engine oil level.

c. Start the engine and allow to run for a five minute warm-up period.

d. Check air pressure in the two upper air springs with a good tire air pressure gauge. Add air if required to bring the spring pressure to 50±5 psi.

e. Check air pressure in the six center air springs. This check must be made with the small valve that separates the two sets of air springs in the open position (clockwise to open). Add air as may be required to bring this pressure to 40±5 psi. Close the small valve (counter-clockwise) until finger-tight.

f. Install the channel that holds the sensors in the recess at the base of the foot. Lock the channel in place with set screws. Install Sensor No. 1, Sensor No. 2, Sensor No. 3 and Sensor No. 4 into the channel and secure electrical connections to designated recepticles.

g. On the console (Figure 2) within the vehicle place the power switch to "monitor". Hold the function switch to "elevate". Hold the movement switch in the "raise" position until the elevator cylinders are "full up" against the stops.

h. With the unit in the "full up" condition lift the upper lock rings on the elevator cylinders and remove the two sets of mechanical locking tubes.

i. With the power switch to "monitor" and the function switch held to "elevate", hold the movement switch to "lower" until the unit has been lowered sufficiently to elevate the van. Maintain these switch positions until no motion is evident (allow about 5 seconds).

j. With the function switch held to "elevate" and the movement switch held to "lower", read the system hydraulic pressure on the gauge. The pressure should be 600+25 psi.

k. Set the frequency control according to the following schedule:

Pavement Type	Frequency Setting (Hertz)
Interstate Pavements	30
Other Rigid (PC) & Composite Pavements	30
Other Flexible (AC & SC) Pavements	25

l. Place the function switch to vibrate and set Meter No. 4 to read 68 for the 30 Hertz frequency setting or 58 for the 25 Hertz frequency setting by adjusting with the "level" control.

m. Change the power switch to "on" and observe the reading on Meter No. 1.

n. Repeat steps g, i, l and m to check the repeatability of the setting each morning prior to testing operation.

o. Raise the unit to the "full up" position.

p. Stop the engine and check the level of hydraulic oil in the reservoir. Use clean "Aeroshell Fluid 4" to bring the level to between 1 and 2 inches from the top of the reservoir.

3. Testing Operation

a. Record computer coding sheet heading information as described in Section B (Test Record Form) of this test method.

b. Calibrate the Raytek Infrared Temperature Gun. Use the "indoor" setting and adjust the calibration knob to read exactly the temperature shown on the thermometer inset in the flat-black calibration standard.

c. Change the Raytek Gun setting to "outdoor", take a beginning pavement temperature, and record this reading on the computer coding sheet.

d. With the engine running, position the Road Rater foot over the outside wheel track at the predetermined longitudinal location. Test the driving lane (only) on 4-lane divided highways unless directed to do otherwise by the engineer. Test inside of a pavement widening crack if it occurs in the outside wheeltrack.

e. Place the vehicle in the "park position".

f. Lower the unit sufficiently to elevate the van, maintain the switch positions for about 5 seconds until no motion is evident.

g. With the power switch in "monitor" and the function switch in "vibrate" verify a 58 per cent or 68 per cent reading on Meter No. 1 for 25 Hertz and 30 Hertz, respectively.

h. Change the power switch to "on" and select a range that will yield a reading between 50 and 100 on Meter No. 1.

i. Record the milepost location, range, and readings for Sensor #1, Sesnor #2, Sensor #3 and Sensor #4. Note any changes in surface type.

j. Raise the unit and proceed to the next test location.

k. Take an ending pavement temperature reading after completing one direction of testing as described in steps b and c.

4. After testing operation

a. When traveling between testing locations assure that the elevator cylinders remain in the up position. If traveling more than 2 miles without testing, engage the mechanical locking tubes and "lower" the unit to secure them.

b. Upon completion of testing, remove the channel holding the sensors.

D. Precautions

1. Do not move the vehicle with the unit in the down position. A red light on the console indicates that the testing unit is too low to travel.

2. Before moving onto the traveled portion of the roadway, insure that all traveling safety is as required by the Traffic Engineering layout. Be sure that the required signs are in position and that all warning lights are functioning.

3. Read the Road Rater "Owners Manual Operations and Maintenance Guide" before operating the unit.

4. Coding sheet entries must be neat and legible. Make sure 6's and 0's or 4's and 9's do not look alike.

Figure 1
The Road Rater

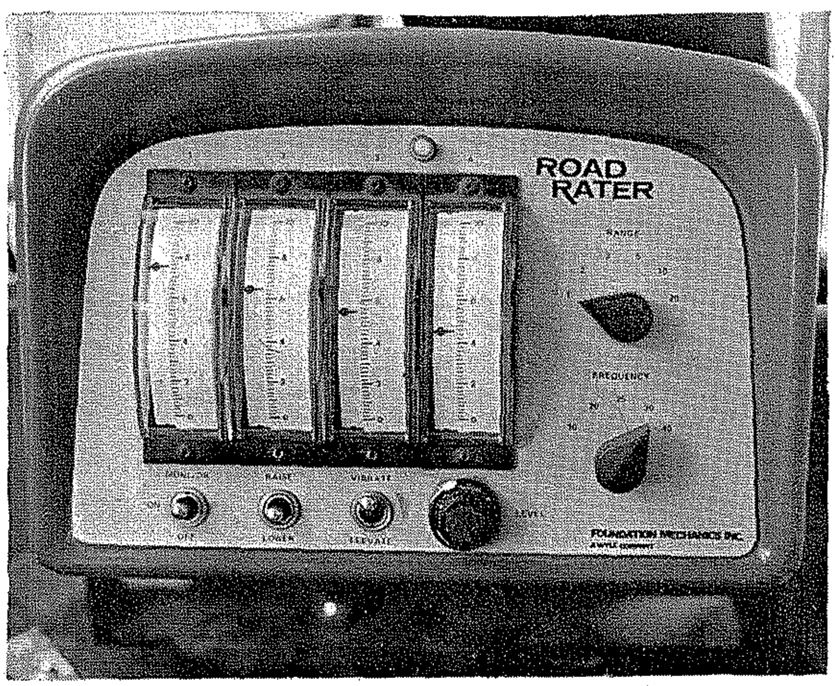


Figure 2
Road Rater Control Console

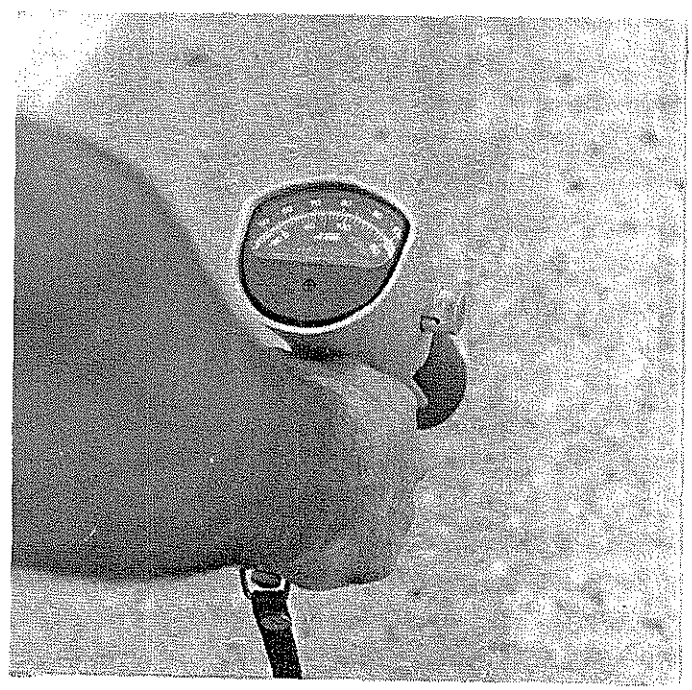


Figure 3
Raytek Infrared
Temperature Gun

Form 820040
2-84

Office of Materials
Road Rater Tests

Sheet No. 01

1 County 09 Highway Sys. U Route 218 Beginning MP 209.30 Ending MP 218.30 Direction N

Pavement Type COMP Date Tested 022284 Time 1045 Lab Number RA 4-0001 Year Built 83

Observer MCCAULEY FRETTE Weather CLEAR FREQ HZ (25, 30) 30 Beg. Temp. 50 End Temp. 50 Test Type (JT-Joint; SI-Supplemental Information)

History: Date SR K Date SR K Date SR K

Card	Location	Range	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Remarks	Location	Range	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Remarks	Location	Range	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Remarks	Line
2	210.000	02	.80	.48	.32	.26		216.000	02	.56	.46	.36	.30									01
2	210.500	02	.60	.46	.36	.28		217.000	02	.94	.46	.30	.24									02
2	211.000	02	.84	.54	.40	.32		218.000	02	.58	.34	.24	.18									03
2	211.500	02	.88	.48	.26	.22																04
2	212.000	02	.58	.46	.34	.30																05
2	212.500	02	.72	.54	.36	.30																06
2	213.000	02	.68	.52	.32	.26																07
2	213.500	01	.40	.30	.22	.20	SECH															08
2	214.000	02	.78	.50	.40	.30																09
2	214.500	01	.84	.50	.32	.26																10
2	215.000	01	.42	.32	.24	.22	SECH															11
2	215.500	03	.90	.42	.24	.18																12

Remarks

SECL - Superelevated Curve, Low Side. SECH - Superelevated Curve, High Side.

3 01
3 02
3 03
3 04

PROGRAM NUMBER- P2220050 OFFICE OF MATERIALS
COMPUTER RUN DATE- 11-29-84 ROAD RATER TESTS

COUNTY- BREMER	BEGINNING MP.... 209.30	LAB NO...... RA4-0001	WEATHER CLEAR	FREQ. HZ... 30
U.S. ROUTE...... 0218	ENDING MP....... 218.30	YEAR BUILT.. 1983	OBS.... MCCAULEY-FRETTE	DISP %..... 68
PAVEMENT TYPE... COMP	COMPUTED MILES.. 9.00	DATE TESTED. 02-22-84	TIME... 10:45	TEST TYPE..

ROAD RATER DEFLECTION (MILS)

	NORTHBOUND						SOUTHBOUND						
M-P	SENS 1	SENS 2	SENS 3	SENS 4	S.R.	SOIL K	SENS 1	SENS 2	SENS 3	SENS 4	S.R.	SOIL K	REMARKS
209.750							1.04	0.84	0.64	0.44	4.99	220.	
210.000	1.60	0.96	0.64	0.52	3.31	225+							
210.250							3.10	1.80	1.00	0.70	1.95	225+	
210.500	1.20	0.92	0.72	0.56	4.27	225+							
210.750							2.94	1.62	1.20	0.66	2.04	225+	
211.000	1.68	1.08	0.80	0.64	3.17	225+							
211.250							1.92	1.08	0.68	0.52	2.96	225+	
211.500	1.76	0.96	0.52	0.44	3.04	225+							
211.750							1.68	1.04	0.64	0.44	3.32	225+	
212.000	1.16	0.92	0.68	0.60	4.40	221.							
212.250							0.88	0.64	0.52	0.40	5.74	225+	
212.500	1.44	1.08	0.72	0.60	3.64	225+							
212.750							1.28	1.04	0.80	0.72	4.18	212.	
213.000	1.36	1.04	0.64	0.52	3.83	224.							
213.250							1.20	1.00	0.72	0.44	4.42	206.	
213.500	0.40	0.30	0.22	0.20	10.96	225+							SECH
213.750							1.20	0.88	0.60	0.48	4.42	225+	
214.000	1.56	1.00	0.80	0.60	3.39	225+							
214.250							0.96	0.58	0.40	0.32	5.34	225+	
214.500	0.84	0.50	0.32	0.26	5.83	225+							
214.750							1.40	0.96	0.60	0.44	3.88	225+	
215.000	0.42	0.32	0.24	0.22	10.51	225+							SECH
215.250							0.48	0.30	0.20	0.18	9.54	225+	SECH
215.500	2.70	1.26	0.72	0.54	2.05	225+							
215.750							1.84	1.16	0.80	0.60	3.07	225+	
216.000	1.12	0.92	0.72	0.60	4.54	214.							
216.500							1.40	0.60	0.40	0.24	3.88	225+	
217.000	1.88	0.92	0.60	0.48	2.87	225+							
217.500							1.98	1.02	0.60	0.42	2.88	225+	
218.000	1.16	0.68	0.48	0.36	4.40	225+							

* S U M M A R Y O F D A T A *

DIRECTION	SENS1 STD.DEV.	SENS1 MAX.	SENS1 MIN.	SENS1 AVE.	SENS1 80%	SENS2 AVE.	SENS3 AVE.	SENS4 AVE.	SCI	SCI/SENS1	AVE. SR	80% SR	AVE. SOIL K	BEG. TEMP	END TEMP
NORTH	0.58	2.70	0.40	1.35	1.84	0.86	0.59	0.48	0.49	0.366	4.68	2.48	225.	50.	50.
SOUTH	0.72	3.10	0.48	1.55	2.16	0.97	0.65	0.47	0.58	0.375	4.17	2.61	223.	60.	60.
COMB	0.65	3.10	0.40	1.45	2.00	0.91	0.62	0.47	0.54	0.371	4.43	2.54	224.		

* * * * * H I S T O R Y * * * * * REMARKS: SECL- SUPERELEVATED CURVE, LOW SIDE. SECH- SUPERELEVATED CURVE, HIGH SIDE

* DATE *
* TESTED AVE.SR AVE.SOIL K *
* *

APPENDIX B

ASPHALTIC CONCRETE OVERLAY DESIGN OF FLEXIBLE BASE PAVEMENTS BASED ON ROAD RATER DEFLECTION DATA

ASPHALTIC CONCRETE OVERLAY DESIGN OF FLEXIBLE BASE PAVEMENTS BASED ON ROAD RATER DEFLECTION DATA

By C. J. Potter
5/15/80

Background Information:

The Road Rater was purchased in the Spring of 1976 as a replacement for the old Benkelman Beam. The Benkelman Beam Versus Road Rater correlation coefficient was 0.83. The basic differences between the Road Rater and Benkelman Beam are as follows:

1. The Benkelman Beam uses a static 18,000 lb. load while the Road Rater uses a dynamic 800 to 2,000 lb. loading.

2. The Road Rater tests much faster and more economically than the Benkelman Beam.

3. The Road Rater better simulates a moving truck than the Benkelman Beam.

The Road Rater deflection ram was originally front-mounted but was rear-mounted during the winter of 1977-78. Since that time van handling has greatly improved, and front suspension parts are no longer overstressed.

Committee meetings including B. C. Brown, R. A. Shelquist, B. H. Ortgies, R. A. Britson, D. M. Heins and C. J. Potter have been held periodically since the Spring of 1978 to provide guideance for the Road Rater program. Temperature correction factors were developed in 1978, but seasonal correction attempts have been unsuccessful. All Road Rater testing is now performed in April and May every year when pavements are in their weakest condition. The Road Rater does not have sufficient ram weight to effectively evaluate rigid pavements, although it has been used occasionally to identify severely deteriorated rigid pavements beneath asphaltic concrete resurfacing.

In the Winter of 1978, Al Torkildson of Data Processing was extremely cooperative in developing a computer program to perform statistical analysis on Road Rater deflection data. We now have Road Rater computer printouts similar to Pavement Friction computer printouts, which have eliminated many man-hours of manual data reduction time.

In the Spring of 1979, the Road Rater was used to rank forty-four (44) airports having flexible base runways for the Aeronautics Division. The Aeronautics Division plans to use this information to help set priorities for State participation in airport projects and to check consultants' asphaltic concrete overlay designs.

In the Fall of 1979, the Road Rater was used to rank 124 miles of asphaltic concrete pavement for Lloyd Herbst, Sioux County Engineer. Road Rater results correlated fairly well to field conditions. The Road Rater identified the only full-depth A.C. section (4" SASB, 6" ATB, 2" Type B) as number one of nineteen sections. Other sections (4" SASB, 6" Bit. Tr. Agg. Base, 2 1/2" Type B) which had not been resurfaced were ranked 19, 18, 17, 16, 15, 13, 12 and 10 respectively. Nominal asphaltic concrete overlay thicknesses based on Road Rater information were determined for five (5) Sioux County sections totaling thirty-eight (38) miles. Two inches of resurfacing has been used in the past in Sioux County with good success. Road Rater designs were 2 3/4", 1 3/4", 2 1/2", 1 1/2" and 1" respectively.

Other 1979 Road Rater A.C. Overlay designs included Monona County FR-175-1(20) on Iowa 175 from the Missouri River to I-29 and from 4th Street in Onawa easterly to county road L-12; and Keokuk County FR-78-1(16) on Iowa 78 from Iowa 149 east to Iowa 1. Road Rater designs were 3" and 4" from Iowa 175 and Iowa 78 respectively, while Project Concept Statements called for 3" on both projects. 3" is adequate on Iowa 78 based on <u>average</u> Road Rater deflection, and the Road Rater printout was used to identify weak areas for possible subdrains or strengthening courses.

In Grundy County, the Road Rater was used in 1979 on S75 from Whitten north to Iowa 175 and on T55 from Iowa 175 north to Dike. Road Rater designs were a sealcoat on S75 and 2" on T55.

In 1980, Road Rater information was used for Tama County on Iowa 8 from Traer to Iowa 21. The Road Rater design was 3 1/4" while the proposed overlay thickness was 3".

An asphaltic concrete overlay design method for flexible base pavments is now fully operational and submitted herein to the Soils Design Section of the Office of Road Design for use and further development. So far, A.C. Overlay designs based on Road Rater deflections seem reasonable and support designs based on field review and engineering judgment. Road Rater information must be used in conjunction with a field review, however, to identify the type and amount of surface distress. In some instances, a thicker A.C. Overlay may be necessary to control reflective cracking than determined by Road Rater structural rating alone.

The 1980 Road Rater program includes an inventory of all primary flexible base pavements which have not previously been tested. We hope to complete this inventory in 1981 as well as update older Road Rater information.

<u>Definition of Terms</u>:

The Road Rater measures pavement deflection in mils under an 800 to 2000 lb. dynamic force at 25 cycles per second. Sensor 1 is located directly under the ram; Sensor 2 is located one foot away from the ram; Sensor 3 is located two feet away from the ram; and Sensor 4 is located three feet away from the ram. We presently only use and report Sensor 1 and Sensor 2 since most structural information can be determined from these sensors alone. All Road Rater testing is performed at OWT and results are recorded on coding sheets which are later sent to Data Processing. Road Rater tests are staggered in adjacent lanes and taken every 1/2 mile with a minimum of 30 tests per test section. More tests (50 minimum) are needed for special evaluation of a given roadway to isolate weak areas.

The Road Rater Structural Rating (SR) is a number which represents the present pavement level of performance based on Sensor 1 deflection. The SR can be thought of as the existing in situ Structural Number (SN) determined from AASHTO coefficients. For design purposes, the 80th percentile Sensor 1 deflection is corrected for temperature to 80° F and used to determine the SR.

The Surface Curvature Index (SCI) is the difference in mils between Sensor 1 and Sensor 2 deflection. Smaller SCI's indicate foundation or drainage problems while higher SCI's indicate surface weakness.

The SCI divided by average Sensor 1 deflection (SCI/SENS 1) provides a ratio which is an indication of pavement strength. Smaller SCI/SENS 1 ratios indicate stronger pavements.

Beginning and ending mileposts on Road Rater computer printouts will correspond with those in <u>Test Sections By Mileposts, Highway Division, Office of Materials, March 1979</u>. This book is updated every two years.

Pavement temperatures are noted in the Remarks column of Road Rater Computer printouts in $^{\circ}$F.

<u>A.C. Overlay Design Procedures:</u>

The asphaltic concrete overlay design method we are currently using enters Road Rater information directly into flexible pavement design procedures in the <u>Guide For Primary And Interstate Pavement Design, Office of Road Design, Soils Section, October, 1976</u>. Pavement determination traffic appendices from Advance Planning are used with nomographs in the <u>AASHTO Interim Guide for Design of Pavement Structures 1972</u> to determine the Structural Number (SN) required based on a 15 year asphaltic concrete overlay design life.

The present 80th Percentile Structural Rating (SR) determined by the Road Rater is subtracted from the required SN and the difference divided by the coefficient of Type "B" asphaltic concrete (0.44) to design the nominal A.C. Overlay thickness. The 80th percentile deflection is used to assign SR values so that most or all weak areas are removed by nominal thickness design and normal surface preparation and patching procedures.

Example:

A.C. Overlay Design for Iowa 229 from Garwin to U.S. 63

6" Rolled Stone Base	1957
3" A.C.	1957
Seal Coat	1974

$$
\begin{aligned}
6'' \times 0.10 &= 0.60 \\
3'' \times 0.35 &= 1.05 \\
1'' \times 0.20 &= \underline{0.20} \\
& 1.85 \quad \text{Calculated Existing SN}
\end{aligned}
$$

1980 Road Rater 80% SENS 1 Deflection = 4.09

Must Correct For Temperature Using Nomograph on Page 20, Road Rater, Dynamic Deflections for Determining Structural Rating of Flexible Pavements, Highway Division, February 1979, Iowa Highway Research Board Final Report HR-178.

Enter Surface Temperature on Left (40° F)

Enter 80% Road Rater SENS 1 Deflection on Right (4.09 Mils)

Read 80% SR = 1.77

For SN = 3, 8 + 11 = 19 (18K Single Axle Loads Per Day, 20 years)

$19 \times \frac{15}{20} = 14.25$ (18K Single Axle Loads Per Day, 15 Years)

$P_t = 2.5$, $S = 2.5$, $R = 2.0$

Enter AASHTO Nomograph

Read Required SN = 3.22

80% SR $= \frac{1.77}{1.45} \div 0.44 = \underline{\underline{3\ 1/4''}}$

PROGRAM NUMBER- P2220050
COMPUTER RUN DATE- 32/24/80

OFFICE OF MATERIALS
ROAD RATER TESTS

COUNTY- TAMA	BEGINNING MP....	0.49	LAB NO...... RR1-0009		WEATHER CLDY
PRIMARY ROUTE... 0229	ENDING MP.......	5.41	YEAR BUILT..	1974	OBS.... TWOHEY-PAGE
PAVEMEMT TYPE.. SC	COMPUTED MILES..	4.92	DATE TESTED. 04-14-80		TIME... 13:14

ROAD RATER DEFLECTION (MILS)

	EASTBOUND		WESTBOUND		
M-P	SENS 1	SENS 2	SENS 1	SENS 2	REMARKS
0.550			2.88	2.28	
0.700	3.00	1.90			
0.850			3.50	2.60	
1.000	2.40	1.56			
1.150			3.50	2.50	
1.300	3.00	2.10			
1.450			2.46	1.80	SECL
1.600	4.00	2.80			
1.750			4.00	2.00	
1.900	3.00	2.50			
2.050			3.30	2.30	SECH
2.200	4.20	3.00			
2.350			3.90	2.70	
2.500	4.00	2.50			
2.650			4.40	2.80	
2.800	2.22	1.38			
2.950			3.50	2.60	T040
3.100	2.58	1.92			
3.250			4.80	3.50	
3.400	2.40	1.98			T040
3.550			5.80	4.00	
3.700	4.40	3.20			
3.850			3.00	2.30	
4.000	4.00	2.60			
4.150			2.70	2.16	
4.300	3.00	2.00			
4.450			3.50	2.30	
4.600	3.00	2.20			
4.750			2.28	1.74	
4.900	2.58	1.98			

* * * * * * * * * * S U M M A R Y O F D A T A * * * * * * * * * * * * * *   * * * * * H I S T O R Y * * * * *

DIRECTION	SENS1 STD.DEV.	MAX.	MIN.	AVE.	80%	SENS2 AVE.	SCI	SCI/SENS1
EAST	0.74	4.40	2.22	3.19	3.80	2.24	0.94	0.296
WEST	0.93	5.80	2.28	3.57	4.35	2.51	1.06	0.298
COMB	0.84	~~4.40~~ 5.80	2.22	3.38	4.09	2.37	1.00	0.297

REMARKS: TNNN- SURFACE TEMPERATURE. SECL- SUPERELEVATED CURVE, LOW SIDE. SECH- SUPERELEVATED CURVE, HIGH SIDE

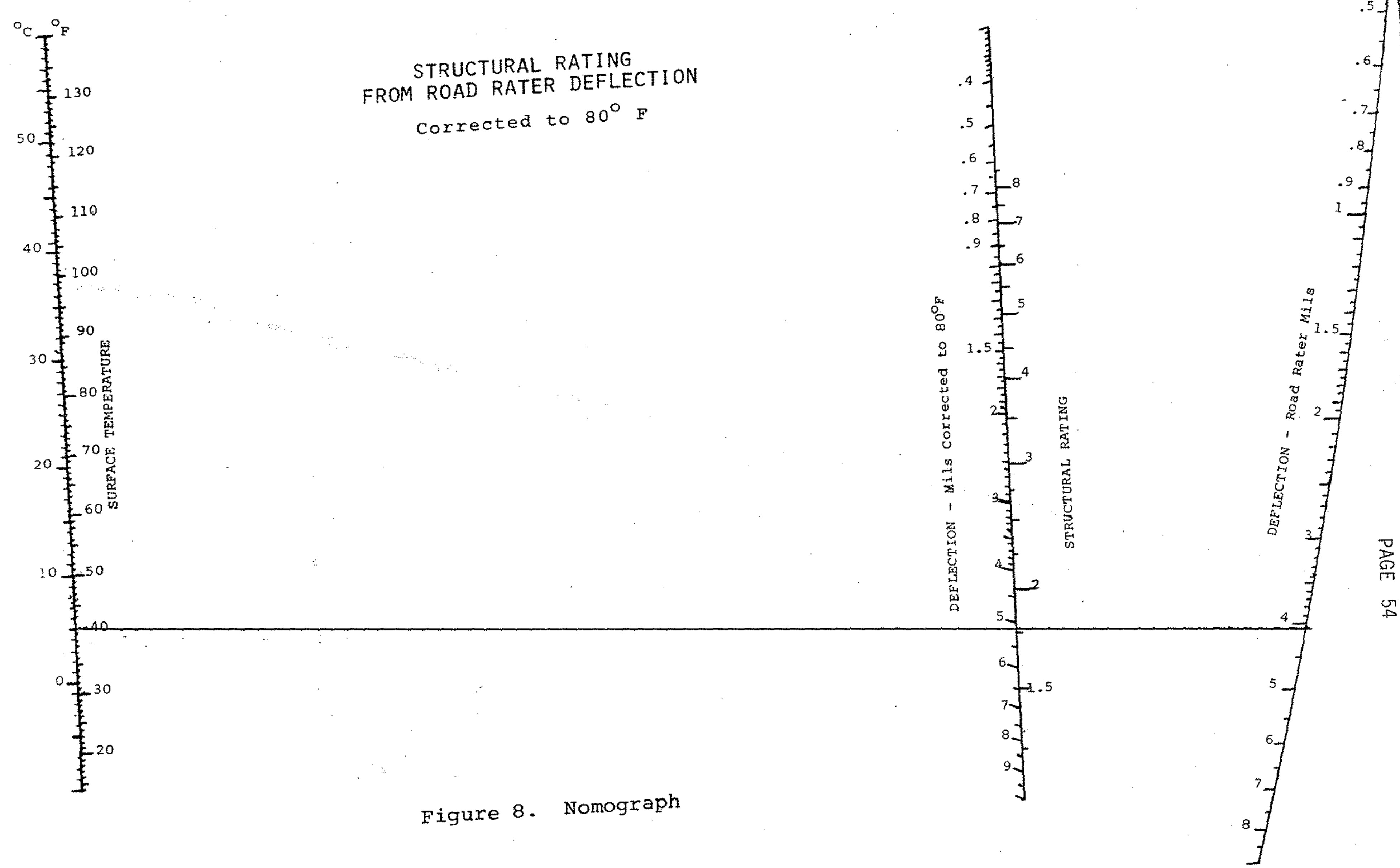
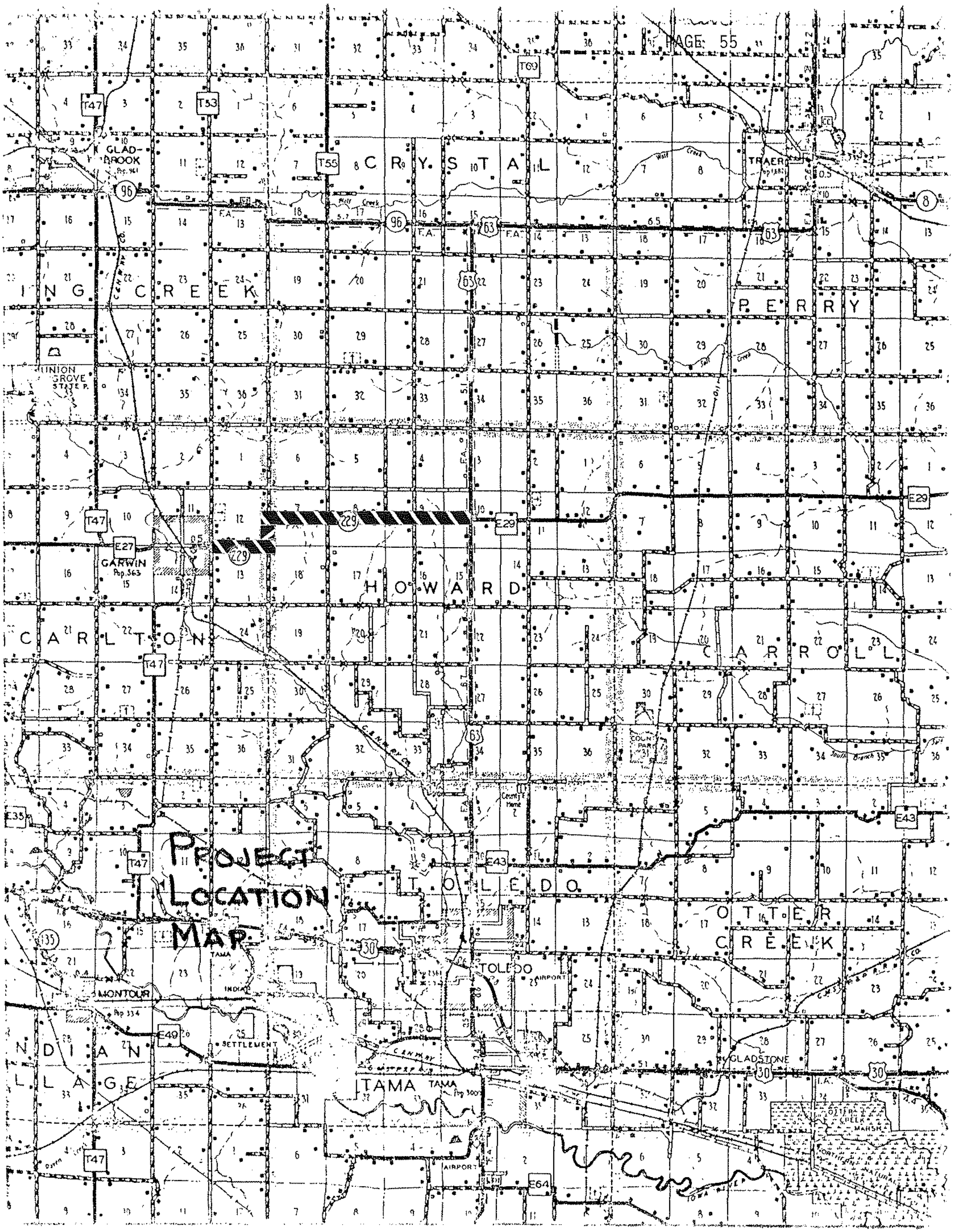


Figure 8. Nomograph


PAGE 55
PROJECT LOCATION MAP
CRYSTAL
PERRY
HOWARD
CARLTON
CARROLL
TOLEDO
OTTER CREEK
INDIAN VILLAGE
GLADBROOK
TRAER
GARWIN
UNION GROVE STATE P.
MONTOUR
TOLEDO
TAMA
GLADSTONE
AIRPORT
SETTLEMENT
COUNTY PARK
OTTER CREEK MARSH
T47
T53
T55
T69
E27
E29
E35
E43
E49
E64
96
63
229
30
135
8

TAMA COUNTY PRIMARY PAVEMENT DETERMINATION ESTIMATE # 4256

LOCATION OF PROJECT IS IA 229-ECL GARWIN TO US 63
PROJECT NONE
SOURCE OF TRAFFIC IS 4256
THE PROGRAM YEAR IS 1979
THE DESIGN YEAR IS 1999
THE TOTAL PROGRAM YEAR TRAFFIC IS 530
DESIGN YEAR TRUCK TRAFFIC IS 90
DESIGN YEAR P.C. & P.U. IS 540
TOTAL DESIGN YEAR TRAFFIC IS 630

SECTION DESCRIPTION	LENGTH	SU 2	SU 3	BUSES	RV	TK	TS 3	TS 4	TS 5+	DB	TOTAL
PL	4.92	43	7	1	1	5	5	4	24	0	90

TOTAL SECTION LENGTH = 4.92 MILES

		FLEXIBLE		RIGID	
NO. OF SINGLE AXLES BOTH DIRECTIONS		DAILY	20 YEAR	DAILY	20 YEAR
SINGLE AXLE WEIGHT GROUP	22,001 AND UP	0.03	219.00	0.03	219.00
SINGLE AXLE WEIGHT GROUP	20,001 - 22,000	0.03	219.00	0.03	219.00
SINGLE AXLE WEIGHT GROUP	18,001 - 20,000	0.31	2263.00	0.31	2263.00
SINGLE AXLE WEIGHT GROUP	16,001 - 18,000	1.14	8322.00	1.14	8322.00
SINGLE AXLE WEIGHT GROUP	12,001 - 16,000	5.04	36792.00	5.04	36792.00
SINGLE AXLE WEIGHT GROUP	8,001 - 12,000	20.88	152424.00	20.88	152424.00
SINGLE AXLE WEIGHT GROUP	7,001 - 8,000	5.16	37668.00	5.16	37668.00
SINGLE AXLE WEIGHT GROUP	3,001 - 7,000	28.37	207101.00	28.37	207101.00
SINGLE AXLE WEIGHT GROUP	0 - 3,000	14.43	105339.00	14.43	105339.00

18K EQUIVALENT SINGLE AXLE LOADS PER DAY, 20 YR

SN 3 =	8	D 7 =	7
SN 4 =	8	D 8 =	7
SN 5 =	7	D 9 =	7
SN 6 =	6	D 10 =	6

NO. OF TANDEM AXLES BOTH DIRECTIONS		DAILY	20 YEAR	DAILY	20 YEAR
TANDEM AXLE WEIGHT GROUP	46,001 AND UP	0.00	0.00	0.00	0.00
TANDEM AXLE WEIGHT GROUP	44,001 - 46,000	0.01	73.00	0.01	73.00
TANDEM AXLE WEIGHT GROUP	42,001 - 44,000	0.04	292.00	0.04	292.00
TANDEM AXLE WEIGHT GROUP	40,001 - 42,000	0.09	657.00	0.09	657.00
TANDEM AXLE WEIGHT GROUP	38,001 - 40,000	0.26	1898.00	0.26	1898.00
TANDEM AXLE WEIGHT GROUP	36,001 - 38,000	0.45	3285.00	0.45	3285.00
TANDEM AXLE WEIGHT GROUP	34,001 - 36,000	0.92	6716.00	0.92	6716.00
TANDEM AXLE WEIGHT GROUP	32,001 - 34,000	1.66	12118.00	1.66	12118.00
TANDEM AXLE WEIGHT GROUP	30,001 - 32,000	3.77	27521.00	3.77	27521.00
TANDEM AXLE WEIGHT GROUP	24,001 - 30,000	5.43	39639.00	5.43	39639.00

18K EQUIVALENT TANDEM AXLE LOADS PER DAY, 20 YR

SN 3 =	11	D 7 =	17
SN 4 =	11	D 8 =	17
SN 5 =	10	D 9 =	18
SN 6 =	10	D 10 =	18

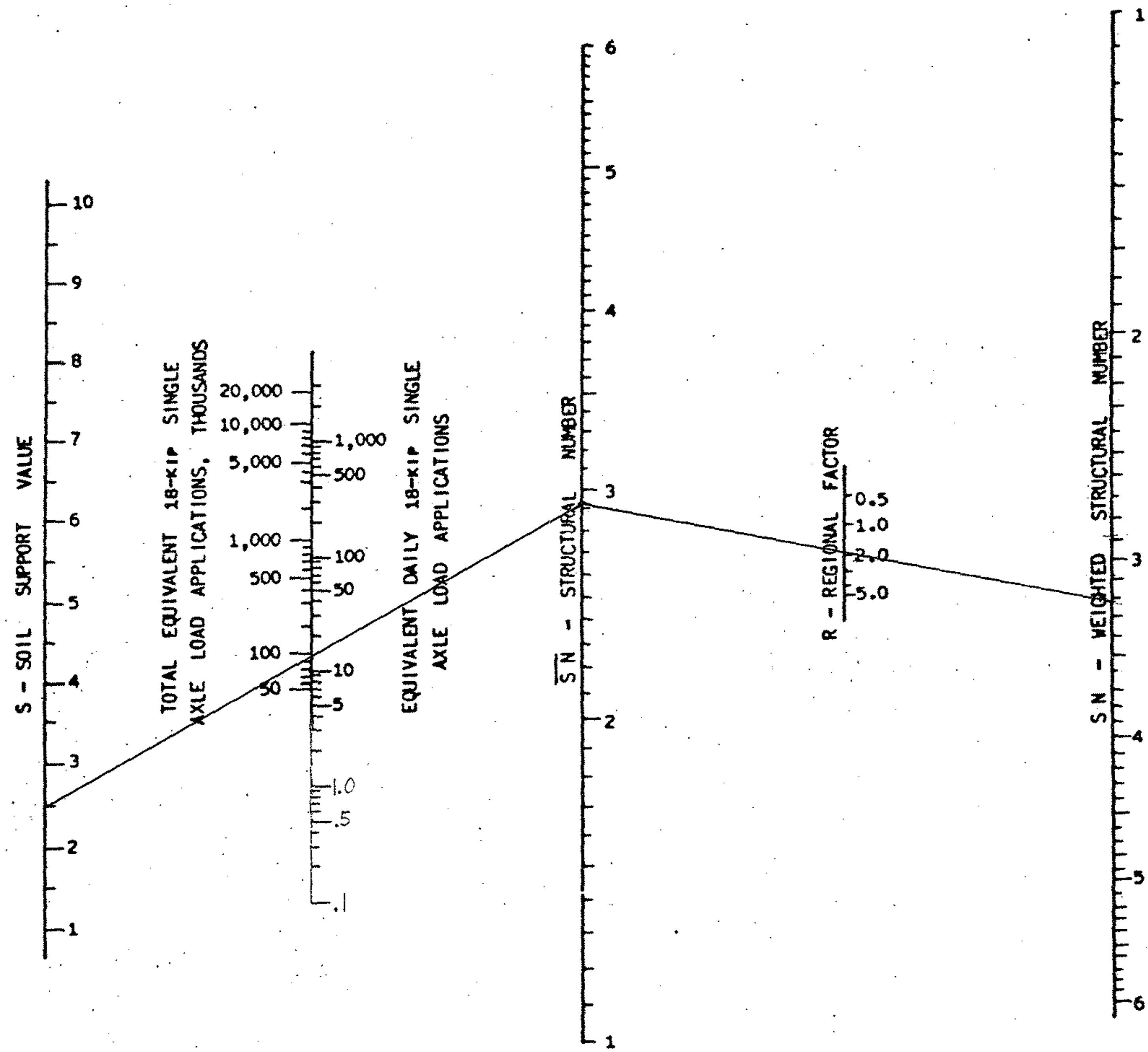


Figure II-1 Design Chart for Flexible Pavements, $p_t = 2.5$

TABLE I

Component	Coefficient New Road	Coefficient Old Road	Minimum Thickness Permitted
Surface Course			
Type A Asphalt Cement Concrete	0.44*	.35	3 (>300 tpd)
Type B Asphalt Cement Concrete	0.44*	.35	2 (<300 tpd)
Type B Asphalt Cement Concrete Class 2	0.40	.30	
Inverted Penetration	0.20	.20	
Base Course			
Type A Binder Placed as Base	0.40	.30	
Type B Asphalt Cement Concrete Base Class I	0.38	.30	2
Type B Asphalt Cement Concrete Base Class II	0.30	.25	2
Asphalt Treated Base Class I	0.34*	.25	4
Bituminous Treated Aggregate Base	0.23	.20	6
Asphalt Treated Base Class II	0.26	.20	4
Cold-Laid Bituminous Concrete Base	0.23	.15	6
Cement Treated Granular (Aggregate) Base	0.20*	.15	6
Soil-Cement Base	0.15	.10	6
Crushed (Graded) Stone Base ***	0.14*	.10	6
Macadam Stone Base	0.12	.10	6
Portland Cement Concrete Base (New)	0.50	.40	
Old Portland Cement Concrete	0.40**		
Subbase Course			
Soil-Cement Subbase	0.10	.10	6
Soil-Lime Subbase	0.10	.10	6
Granular Subbase	0.10*	.10	4
Soil-Aggregate Subbase	0.05*	.05	4

*Indicates coefficients taken from AASHTO Interim Guide for the Design of Flexible Pavement Structures.

**This value is for reasonably sound existing concrete. Actual value used may be lower, depending on the amount of deterioration that has occurred.

***No current specification

APPENDIX C

WORK PLAN TO EVALUATE ROAD RATER EFFECTIVENESS ON RIGID PAVEMENTS

 1/7/82

C. Potter

WORK PLAN TO EVALUATE ROAD RATER EFFECTIVENESS ON RIGID PAVEMENTS

An Asphaltic Concrete Overlay design procedure based on Road Rater deflection values was developed by D. Heins and C. Potter in 1978 and 1979 and was presented to the Office of Road Design as operational in May 1980. This A.C. Overlay design procedure is working reasonably well without further development or refinement as recently related to me by Kermit Dirks of Soils Design. The present A.C. Overlay design procedure does have limitations, however, in that it is restricted to flexible pavements.

The objective of this work plan is to expand the present A.C. Overlay design procedure to include rigid or composite pavements. This entails testing a number of rigid pavements of various thicknesses and levels of deterioration with the Road Rater to search for correlations between Road Rater deflection readings and various rigid pavement composition and performance variables such as thickness, CHLOE slope variance, PSI, crack and patch deduction, depreciated SN values, estimated A.C. Overlay thickness by visual observation, etc.

An A.C. Overlay design procedure for rigid and composite pavements will be pursued if meaningful relationships between Road Rater deflection readings and rigid pavement performance variables can be found.

The Work Plan is as follows:

Heins 1. Determine the structural composition of 23 CHLOE Test sections from historical information.

Frette 2. Crack & Patch survey 23 CHLOE test sections.

Britson & Potter	3.	Estimate a depreciated SN coefficient for each of 23 CHLOE test sections.
Britson & Potter & Shelquist	4.	Estimate visually the nominal A.C. Overlay thickness required on 23 CHLOE test sections.
Potter	5.	Test 23 CHLOE test sections with the Road Rater in April 1982. Minimum of 30 tests per section approximately equally spaced. No effort made to hit or miss cracks, construction joints, patches, etc. (statistically randomly selected locations). Test at 68% mass displacement and 30 Hertz frequency.
Potter & Marks	6.	Test as many CHLOE test sections as possible with FHWA "Thumper" in April 1982.
Potter & Marks	7.	Correlate Iowa DOT Road Rater To FHWA "Thumper".
Potter & Marks & Dirks	8.	Evaluate Iowa DOT A.C. Overlay design procedure against FHWA A.C. Overlay design procedure and select the best procedure for use in Iowa.
Potter	9.	Periodically (every two or three months) test 23 CHLOE test sections with the Road Rater in 1982 and 1983 to check for temperature and seasonal variations on rigid pavements.
Potter	10.	Expand the Road Rater study of rigid pavements to include D-cracked pavements, CRC pavements, etc., <u>if</u> meaningful relationships exist between Road Rater deflection readings and performance variables on 23 CHLOE test sections.
Potter	11.	Develop an A.C. Overlay design procedure on rigid or composite pavements based on Road Rater deflection readings assuming this is possible (California says Dynaflect cannot evaluate rigid pavements; Louisiana & Texas says it can. There is much disagreement nationwide at present whether lightweight dynamic delfection measuring equipment such as Dynaflect and the Model 400 Road Rater can effectively evaluate rigid pavements.)

APPENDIX D

METHOD OF DETERMINATION OF PRESENT SERVICEABILITY INDEX

Test Method No. Iowa 1004-C
December 1981

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

Office of Materials

METHOD OF DETERMINATION OF PRESENT SERVICEABILITY INDEX

General Scope

The Present Serviceability Index (PSI) was developed by the AASHO Road Test as an objective means of evaluating the ability of a pavement to serve traffic. The Present Serviceability Index is primarily a function of longitudinal profile with some influence from cracking, patching and rut depth.

The AASHO rating scale ranges from 0 to 5 with adjective designations of:

Very Poor	0 - 1
Poor	1 - 2
Fair	2 - 3
Good	3 - 4
Very Good	4 - 5

The Bureau of Public Roads has a similar scale with the following designations which are more realistic in the evaluation of new pavements:

PSI	Rating
Above 4.5	Outstanding
4.5 - 4.1	Excellent
4.1 - 3.7	Good
3.7 - 3.3	Fair
Below 3.3	Poor

The test is conducted in two parts: (1) Determination of the Longitudinal Profile Value (LPV), (2) Determination of Deduction for Cracking, Patching and Rut Depth.

Part I. Determination of the Longitudinal Profile Value

Scope:

The Iowa DOT uses three methods for determination of the longitudinal profile value:

1. CHLOE Profilometer
2. BPR Type Road Roughometer
3. IJK Type Road Meter

Test Procedure:

1. The determination of longitudinal profile value by the CHLOE Profilometer is described in Test Method No. Iowa 1003-A.

2. The determination of road roughness by the BPR Type Roughometer is described in Test Method No. Iowa 1001-A. The inches per mile as described therein is then used in conjunction with the most current correlation of road roughness (inches/mile) vs. longitudinal profile value (LPV) determined by the CHLOE Profilometer to obtain a longitudinal profile value.

3. The determination of the road meter roughness value, which is the same as the Longitudinal Profile Value, by the IJK Type Road Meter, is described in Test Method No. Iowa 1002-B.

Part II. Determination of Deduction for Cracking, Patching and Rut Depth

Scope:

The purpose of this portion of the test is to determine the value of the Present Serviceability Index lost due to physical deterioration of the roadway.

The evaluation is conducted according to general procedure established by the AASHO Road Test and described in detail in the "Highway Research Board Special Report 61E."

Test Procedure -- Flexible Pavement:

The equation for Present Serviceability Index of flexible pavement is:

$$PSI = LPV - .01\ \sqrt{C+P} - 1.38\ \overline{RD}^2$$

where;

PSI = Present Serviceability Index

LPV = Longitudinal Profile Value

C+P = Measures of cracking and patching of the pavement

$\overline{RD}$ = A measure of rutting in the wheel paths

Cracking, C, is defined as the square feet per 1000 square feet of pavement surface exhibiting alligator or fatigue cracking. This type of cracking is defined as load related cracking which has progressed to the state where cracks have connected together to form a grid like pattern resembling chicken wire or the skin of an alligator. This type of distress can advance to the point where the individual pieces become loosened.

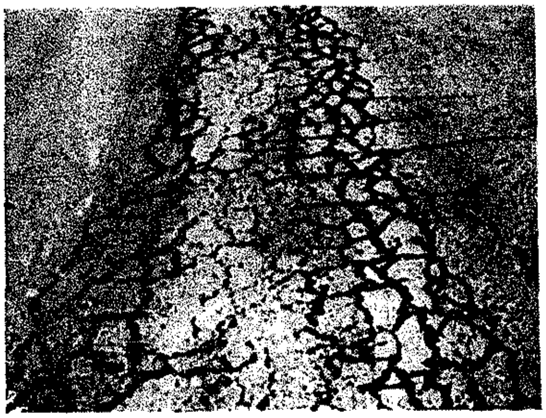


Figure 1.

Alligator cracking

Figure 2.

Longitudinal Cracks

Patching, P, is the repair of the pavement surface by skin (i.e. widening joint strip seal) or full depth patching. It is measured in square feet per 1000 square feet of pavement surface.

Rut depth, $\overline{RD}$, is defined as the mean depth of rutting, in inches, in the wheel paths under a 4-ft straightedge.

Cracking, L, is defined as the number of longitudinal (parallel to traffic flow) cracks which excede 100 feet in length and 1) are open to a width of 1/4" over half their length or 2) have been sealed. If these cracks are observed to occur less than 3 feet from one another, the condition described under C should be looked for and if present reported instead of reporting the distress as longitudinal cracking.

Cracking, T, is defined as the number of transverse (right angles to traffic direction) cracks that are open to a width of 1/4" over half their length or have been sealed. Random or diagonal cracks are ignored.

Faulting, F, is defined as the mean vertical displacement, in inches, measured with a 4-ft. straightedge.

Figure 3.

Transverse Cracks and Faulting

Test Procedure -- Rigid Pavement:

The equation for Present Serviceability Index of rigid pavement is:

$$PSI = LPV - .09 \sqrt{C+P}$$

where;

PSI = Present Serviceability Index

LPV = Longitudinal Profile Value

C+P = Measures of cracking and patching of the pavement

Cracking, C, is defined as the lineal feet of cracking per 1000 square feet of pavement surface. Only those cracks which are open to a width of 1/4" or more over half their length or which have been sealed are to be included.

Patching, P, is the repair of the pavement surface by skin or full depth patching. It is measured in square feet per 1000 square feet of pavement surface.

Rut depth, $\overline{RD}$, is defined as the mean depth of rutting, in inches, in the wheel paths under a 4-ft. straightedge.

Faulting, F, is defined as the mean vertical displacement, in inches, measured with a 4-ft. straightedge.

D-cracking, D, refers to a characteristic pattern than can develop in portland cement concrete. Initially, the occurrence of D-cracking <u>may</u> be preceded and accompanied by staining of the pavement surface near joints and cracks. However, <u>not all stained joints and cracks develop D-cracking</u>. D-cracked concrete will first exhibit fine parallel cracks adjacent to the transverse and longitudinal joints at the interior corners. The D-cracks will bend around the corner in a concave or hourglass pattern. As the D-cracking progresses, the entire length of the transverse, longitudinal and random cracks will be affected. The cracked pieces may become loose and dislodged under the action of traffic. The occurrence of D-cracking in the check sections will be rated on a point scale as described in the Test Procedure section.

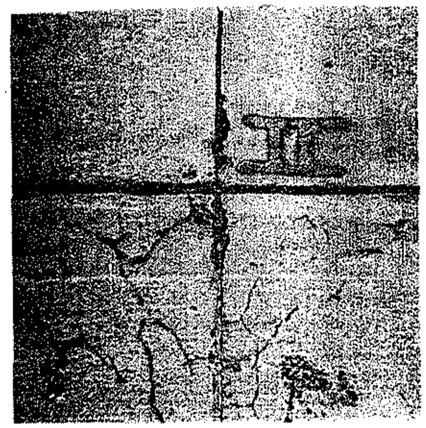


Figure 4.

D-cracking - Initial stages

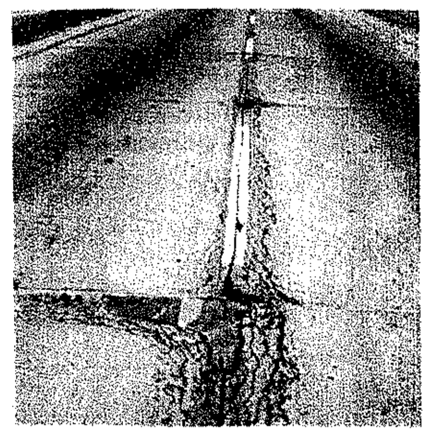


Figure 5.

D-cracking - All joints affected

<u>Procedure</u>

A. Apparatus

1. A passenger vehicle with an accurate odometer.

2. A four foot long rut/fault gauge.

3. Mechanical counters.

4. A 50-foot tape.

5. Safety equipment -- hard hats, safety vests, survey signs.

B. Test Record Forms

1. Crack and Patch Survey worksheet (A.C. or P.C.C.).

2. Crack and Patch Calculation and Summary Sheet.

3. Present Serviceability Index Summary (Form 915).

C. Test Procedure

The control sections are as described in the "Control Sections by Mileposts" booklet. For control sections of 0-5.00 miles in length, one representative 1/2 mile test section will be evaluated. For 5.01-10.00 miles, two 1/2 mile test sections are used. Three 1/2 mile sections are used for any control section greater than 10.0 miles.

After determining a location for the representative 1/2 mile test section or sections, the county, highway number, beginning and ending control section milepost, pavement width, beginning and ending milepost of the 1/2 mile test section being surveyed, date of survey and names of those doing the survey shall be recorded on the worksheet.

Flexible

The procedure for evaluation of flexible pavement is to drive on the shoulder, if possible, and estimate the area of each instance of alligator cracking and patching recording them individually on the worksheet.

The rut depth is measured in the outside and inside wheeltrack in both lanes at 0.05 mile intervals and recorded (10 sets of readings per test section).

While driving the first and last 0.05 mile portion of the test section the number of longitudinal and transverse cracks meeting the previously described criteria will be counted and recorded. Transverse cracks extending across only one lane will be counted as "half cracks" and recorded as such.

While driving the first and last 0.05 mile portions, the occurrence of faulted cracks will be looked for and the worst instance in each portion will be measured. These measurements will be taken one foot in from the pavement edges at the two cracks selected and the data recorded.

Rigid

The procedure for rigid pavement is to drive on the shoulder, if possible, and count all cracks meeting the previously described criteria. Cracks extending across only one lane are recorded as "half cracks" and summed to full cracks during the data summary phase. Longitudinal, diagonal and random cracks are accounted for by estimating how many times they would extend across the roadway and recording that number.

The area of each patch is estimated and recorded individually on the worksheet.

The rut depth is measured in the outside and inside wheeltracks of both lanes. One set of measurements will be taken at the beginning of the 1/2 mile test section and one set at the end.

Faulting is measured one foot in from each pavement edge at 0.05 mile intervals and recorded (10 sets of readings per check section).

The D-crack Occurrence Factor (DOF) in the test section will be evaluated and assigned a numerical rating based on the following description.

DOF Value

0 = No D-cracking noticeable

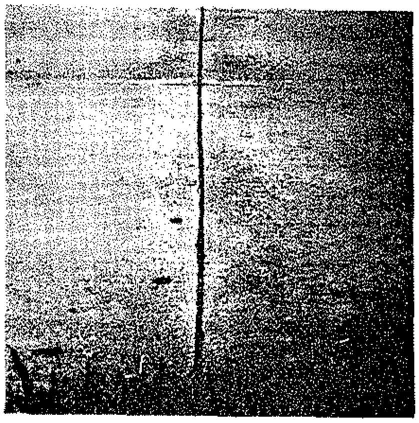
1 = D-cracking is evident at some joints especially the interior corners. Pavement is sound condition and no maintenance is required due to D-cracks.

2 = D-cracking is evident at most joints and has progressed across width of slab. Pavement is in sound condition and no maintenance is required due to D-cracking.

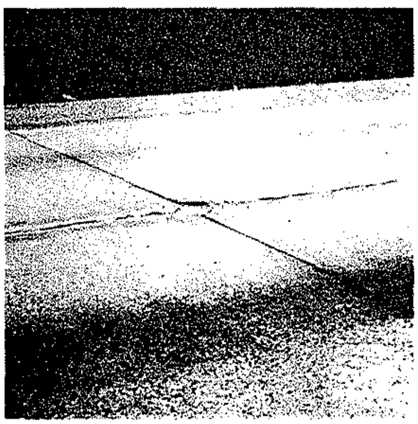
3 = D-cracking is evident at virtually all joints and random cracks. Minor raveling and spalling are occurring and traffic is causing some loosening of cracked pavement. Some minor maintenance of spalled areas is required.

4 = D-cracking very evident as in 3 above. Spalling and removal by traffic has progressed to point that regular maintenance patching is required. Effect on riding quality of pavement is now noticeable.

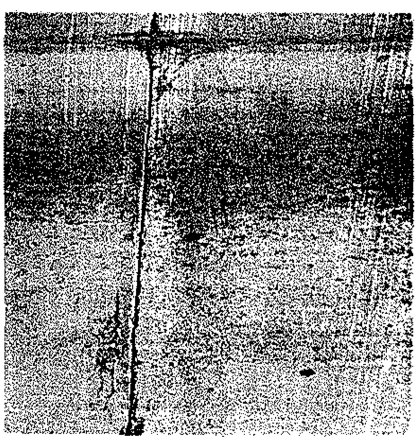
5 = D-cracking has continued to progress at sites identified in 3 above and requires regular maintenance patching. Full depth patches may be necessary. Ride quality has deteriorated to point where reduced driving speed is necessary for comfort and safety.



DOF = 0



DOF = 1



DOF = 2

DOF = 3

DOF = 4

DOF = 5

Figure 6. Examples of D-crack Occurrence Factors

D. Calculations

1. Flexible Pavement

a. The area of cracking is totaled and divided by the area of the test section in thousands of square feet to obtain C.

b. The area of patching is totaled and divided by the area of the test section in thousands of square feet to obtain P.

c. The rut depth measurements are totaled and averaged to obtain $\overline{RD}$.

D. The number of longitudinal cracks in the two areas surveyed are totaled, averaged, and reported as L.

e. The number of transverse cracks and 1/2 cracks (divided by 2) in the two areas surveyed are totaled, averaged, and reported as T.

f. The faulting measurements are totaled and averaged to obtain F.

g. Cracking (C), patching (P), and rut depth ($\overline{RD}$) as calculated above and LPV, as determined in Part I, are used in the following formula to determine the Present Serviceability Index (PSI):

$$PSI = LPV - 0.01\sqrt{C+P} - 1.38\ \overline{RD}^2$$

2. Rigid Pavement

a. The number of cracks and 1/2 cracks (divided by 2) are totaled and multiplied by the width of the roadway and divided by the area of the test section in thousands of square feet to obtain C.

b. The area of patching is totaled and divided by the area of the test section in thousands of square feet to obtain P.

c. The rut depth measurements are totaled and averaged to obtain $\overline{RD}$.

d. The faulting measurements are totaled and averaged to obtain F.

e. Cracking (C) and patching (P) as calculated above and LPV as determined in Part I are used in the following formula to determine the Present Serviceability Index (PSI):

$$PSI = LPV - .09\ \sqrt{C+P}$$

E. Reporting Results

1. Lab. Number.
2. Beginning Milepost.
3. Ending Milepost.
4. Road Number.
5. Length.
6. Surface Type.
7. Direction and Lane.
8. RMRV or LPV.
9. Deduction for cracking and patching.
10. Present Serviceability Index.

APPENDIX E

RIGID PAVEMENT ROAD RATER RESEARCH SPREAD SHEETS AND PLOTS

INTRODUCTION

Spread sheets on pages 70 through 75 were used to develop the best correlation between Road Rater deflection data and pavement performance variables. This was accomplished by adding columns from left to right as plots on pages 76 through 86 indicated improved correlation. These plots are in chronological order and resulted in the base relationship to evaluate rigid pavements shown on page 85. Additional test data obtained in 1983 supported this base relationship and is shown on page 86.

RIGID PAVEMENT ROAD RATER RESEARCH
October 1982
Charles Potter, P.E.

Test Section Number	CHLOE Slope Variance	Crack & Patch Deduction	Present Serviceability Index	Structural Composition	Age	80th Percentile Deflection	SCI/SENS 1 Ratio	SCI	80th Percentile Deflection at Joints	SCI/SENS 1 Ratio at Joints	SCI at Joints	Structural Number (SN) When New	Depreciated SN (1-(C&P/0.70)) (New SN)	Cracking (C) Linear Feet/1000 Sq. Ft.	Depreciated SN (1-(C/45)) (New SN)	Average Deflection	Average Deflection at Joints	Depreciated SN $\frac{(0.15/(SCI/SENS\ 1))+(1-(C/45))}{2}$ (NewSN)	Depreciated SN (1-((SCI/SENS 1)/0.90)) (New SN)	Depreciated SN (1-(C/60)) (New SN)	Depreciated SN $\frac{(1-((SCI/SENS1)/0.90))+(1-(C/60))}{2}$ (NewSN)	AC Overlay Required For 15 Year Design Life
1S	6.20	.35	4.15	6"PCC	12	3.50	.220	0.69	3.99	.285	0.98	3.00	1.50	15.15	1.99	3.11	3.44	2.02	2.27	2.24	2.26	2 1/4"
2N	5.83	.25	4.35	6"PCC	12	3.11	.200	0.54	3.74	.246	0.84	3.00	1.93	7.58	2.49	2.72	3.42	2.37	2.33	2.62	2.48	1 3/4"
6E	44.16	.56	1.94	8"PCC	14	2.59	.110	0.22	3.22	.195	0.48	4.00	0.80	35.61	0.83	1.96	2.46	3.14	3.51	1.63	2.57	4"
11N	10.74	0.	3.81	4"GSB 8"CRC	15	1.71	.098	0.15	1.55	.066	0.10	4.40	4.40	0.	4.40	1.52	1.46	--	--	--	--	7 1/4"
12N	10.96	.40	3.39	4"GSB 8"CRC	15	1.42	.105	0.14	1.62	.089	0.13	4.40	1.89	0.	4.40	1.32	1.44	--	--	--	--	7 1/4"
13S	10.63	.25	3.57	4"GSB 8"CRC	15	1.51	.131	0.18	1.58	.163	0.22	4.40	2.83	0.	4.40	1.35	1.35	--	--	--	--	6 1/2"
14S	9.09	0.	4.00	4"GSB 8"CRC	15	1.32	.104	0.13	1.40	.119	0.15	4.40	4.40	0.	4.40	1.21	1.27	--	--	--	--	6 1/2"
21E	13.54	.55	3.02	6"PCC	18	3.39	.213	0.60	3.50	.256	0.80	3.00	0.64	24.24	1.38	2.82	3.12	1.75	2.29	1.79	2.04	2"
22E	12.39	.41	3.25	6"PCC	18	3.43	.198	0.61	3.50	.295	0.94	3.00	1.24	14.02	2.07	3.06	3.17	2.17	2.34	2.30	2.32	2 1/4"
23W	12.83	.39	3.23	6"PCC	18	3.38	.201	0.60	3.97	.267	0.92	3.00	1.33	12.88	2.14	2.97	3.46	2.19	2.33	2.36	2.35	2"
24W	12.82	.35	3.27	6"PCC	18	3.28	.198	0.55	3.16	.267	0.80	3.00	1.50	14.77	2.02	2.75	2.98	2.15	2.34	2.26	2.30	2"
26W	12.31	.48	3.19	6"PCC	19	2.66	.182	0.43	3.07	.266	0.76	3.00	0.94	11.36	2.24	2.38	2.88	2.36	2.39	2.43	2.41	1/2"
27W	13.32	.37	3.22	6"PCC	19	2.73	.142	0.34	2.95	.223	0.58	3.00	1.41	11.74	2.22	2.40	2.62	2.69	2.53	2.41	2.47	1/2"
28E	11.33	.37	3.38	6"PCC	19	3.02	.159	0.41	3.36	.220	0.66	3.00	1.41	8.71	2.42	2.60	3.02	2.63	2.47	2.56	2.52	1"
29E	11.12	.34	3.43	6"PCC	19	3.12	.137	0.37	3.33	.215	0.66	3.00	1.54	6.44	2.57	2.70	3.05	2.93	2.54	2.68	2.61	1 1/4"
38W	19.83	.54	2.66	3"Stab. 6"PCC	25	2.79	.219	0.54	4.57	.289	0.97	3.30	0.75	18.94	1.91	2.47	3.36	2.09	2.50	2.26	2.38	1 1/4"
39E	29.38	.56	2.29	3"Stab. 6"PCC	25	2.57	.194	0.45	4.69	.307	1.07	3.30	0.66	24.62	1.49	2.32	3.50	2.02	2.59	1.95	2.27	1"
40W	26.82	.53	2.40	3"Stab. 6"PCC	28	2.54	.176	0.41	7.15	.514	2.52	3.30	0.80	22.73	1.63	2.36	4.90	2.22	2.65	2.05	2.35	3/4"

RIGID PAVEMENT ROAD RATER RESEARCH
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41E	27.02	.55	2.37	3"Stab. 6"PCC	28	2.49	.168	0.39	3.53	.357	1.06	3.30	0.71	21.21	1.74	2.31	2.96	2.29	2.68	1.94	2.31	3/4"
44W	5.82	.43	4.17	6"PCC	14	3.06	.168	0.47	3.31	.265	0.75	3.00	1.16	22.35	1.51	2.77	2.84	2.09	2.44	1.88	2.16	1 1/2"
45W	7.87	.47	3.70	6"PCC	14	2.54	.168	0.39	4.43	.298	1.05	3.00	0.99	27.27	1.18	2.33	3.54	1.93	2.44	1.64	2.04	3/4"
46E	6.21	.26	4.24	6"PCC	14	2.59	.136	0.31	4.00	.260	0.84	3.00	1.89	8.33	2.44	2.29	3.24	2.87	2.55	2.58	2.56	3/4"
47E	6.20	.36	4.14	6"PCC	14	2.70	.166	0.41	2.71	.170	0.42	3.00	1.46	16.29	1.91	2.48	2.47	2.31	2.45	2.19	2.32	1"
48E	7.85	.31	3.87	6"PCC	14	2.94	.172	0.38	3.82	.259	0.82	3.00	1.67	11.74	2.22	2.57	3.18	2.42	2.43	2.41	2.42	1 1/4"
49E	6.45	.20	4.24	6"PCC	14	2.64	.158	0.39	3.70	.215	0.64	3.00	2.14	4.92	2.67	2.48	2.98	2.76	2.47	2.75	2.61	3/4"
51W	7.78	.33	3.86	6"PCC	14	3.40	.150	0.46	5.19	.253	0.96	3.00	1.59	13.26	2.12	2.65	3.79	2.56	2.50	2.34	2.42	1 3/4"
52N	5.96	.16	4.40	6"PCC	18	3.14	.187	0.51	5.04	.268	1.02	3.00	2.31	3.03	2.80	2.73	3.80	2.60	2.38	2.85	2.62	1 3/4"
53N	5.52	.35	4.34	6"PCC	18	3.08	.152	0.44	3.67	.230	0.77	3.00	1.50	15.53	1.96	2.87	3.35	2.46	2.49	2.22	2.36	1 3/4"
54S	5.44	.49	4.22	6"PCC	18	3.51	.180	0.57	4.19	.274	1.02	3.00	0.90	29.54	1.03	3.17	3.72	1.77	2.40	1.53	1.97	2 1/4"
55S	5.65	.17	4.48	6"PCC	18	2.92	.175	0.47	3.46	.255	0.77	3.00	2.27	3.41	2.77	2.70	3.01	2.67	2.42	2.83	2.63	1 1/2"
56W	12.53	.24	3.41	1 1/2"Grav 6"PCC	26	2.85	.159	0.41	3.61	.173	0.47	3.15	2.07	7.20	2.65	2.54	2.71	2.81	2.59	2.77	2.68	1"
57W	12.43	.39	3.27	1 1/2"Grav 6"PCC	26	2.55	.139	0.32	3.53	.265	0.78	3.15	1.40	5.68	2.75	2.30	2.94	3.07	2.66	2.85	2.76	1/2"
58W	10.14	.18	3.69	1 1/2"Grav 6"PCC	26	2.65	.165	0.39	2.93	.195	0.52	3.15	2.34	4.16	2.86	2.34	2.64	2.86	2.57	2.93	2.75	3/4"
59W	13.22	.16	3.43	1 1/2"Grav 6"PCC	26	2.48	.164	0.37	2.95	.233	0.59	3.15	2.43	1.51	3.04	2.26	2.54	2.96	2.58	3.07	2.83	1/2"
60E	11.90	.31	3.39	1 1/2"Grav 6"PCC	26	2.43	.179	0.40	3.30	.220	0.63	3.15	1.76	8.33	2.57	2.21	2.87	2.60	2.52	2.71	2.62	1/4"

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Test Section Number	CHLOE Slope Variance	Crack & Patch Deduction	Present Serviceability Index	Structural Composition	Age	80th Percentile Deflection	SCI/SENS 1 Ratio	SCI	80th Percentile Deflection at Joints	SCI/SENS 1 Ratio at Joints	SCI at Joints	Structural Number (SN) When New	Depreciated SN (1-(C&P/0.70)) (New SN)	Cracking (C) Linear Feet/1000 Sq. Ft.	Depreciated SN (1-(C/45)) (New SN)	Average Deflection	Average Deflection at Joints	Depreciated SN (0.15/(SCI/SENS 1))+(1-(C/45)) / 2 (New SN)	Depreciated SN (1-((SCI/SENS 1)/0.90)) (New SN)	Depreciated SN (1-(C/60)) (New SN)	Depreciated SN (1-((SCI/SENS1)/0.90))+(1-(C/60)) / 2 (New SN)	AC Overlay Required For 15 Year Design Life
61E	11.84	.30	3.41	1 1/2"Grav 6"PCC	26	2.49	.166	0.38	2.70	.235	0.56	3.15	1.80	6.44	2.70	2.31	2.39	2.77	2.57	2.81	2.69	1/2"
62E	11.75	.35	3.36	1 1/2"Grav 6"PCC	26	2.51	.141	0.32	2.86	.254	0.67	3.15	1.58	2.65	2.96	2.30	2.65	3.15	2.66	3.01	2.84	1/2"
63E	12.50	.26	3.39	1 1/2"Grav 6"PCC	26	2.75	.159	0.33	2.41	.167	0.37	3.15	1.98	7.20	2.65	2.44	2.23	2.81	2.59	2.77	2.68	1"
64W	4.97	.10	4.78	6"PCC	5	2.25	.141	0.29	3.00	.189	0.48	3.00	2.57	1.14	2.92	2.03	2.52	3.00	2.53	2.94	2.74	0"
65W	5.88	.11	4.47	6"PCC	5	2.55	.128	0.28	3.39	.167	0.45	3.00	2.52	1.51	2.90	2.19	2.70	3.00	2.57	2.92	2.75	0"
66E	5.79	.12	4.49	6"PCC	5	2.70	.116	0.25	3.61	.230	0.64	3.00	2.49	1.89	2.87	2.17	2.79	3.00	2.61	2.91	2.76	1/4"
67E	5.18	.16	4.64	6"PCC	5	2.22	.104	0.21	2.52	.157	0.34	3.00	2.31	3.03	2.80	2.02	2.19	3.00	2.65	2.85	2.75	0"
68W	19.29	.39	2.84	3"Stab 6"PCC	27	2.25	.165	0.34	3.13	.235	0.64	3.30	1.46	7.20	2.77	2.05	2.70	2.89	2.70	2.90	2.80	1/4"
69W	22.74	.54	2.54	3"Stab 6"PCC	27	2.68	.185	0.43	3.46	.229	0.72	3.30	0.75	11.36	2.47	2.33	3.14	2.57	2.62	2.68	2.65	1"
70E	22.75	.53	2.55	3"Stab 6"PCC	27	2.61	.174	0.39	4.41	.293	0.91	3.30	0.80	10.98	2.49	2.25	3.12	2.67	2.66	2.70	2.68	1"
71E	22.28	.43	2.67	3"Stab 6"PCC	27	2.16	.174	0.35	4.41	.374	1.10	3.30	1.27	7.20	2.77	2.02	2.94	2.89	2.66	2.90	2.78	0"
72W	6.20	0.	4.50	6"PCC	3	2.25	.170	0.34	---	---	---	3.00	3.00	0.	3.00	2.02	---	2.82	2.43	3.00	2.72	0"
73W	7.65	.08	4.13	6"PCC	3	2.53	.169	0.38	7.17	.320	1.98	3.00	2.66	0.76	2.95	2.25	6.18	2.81	2.44	2.96	2.70	0"
74E	9.08	0.	4.00	6"PCC	3	2.39	.174	0.37	6.36	.324	1.88	3.00	3.00	0.	3.00	2.13	5.80	2.79	2.42	3.00	2.71	0"
75E	6.94	0.	4.34	6"PCC	3	2.44	.170	0.39	7.49	.283	1.88	3.00	3.00	0.	3.00	2.30	6.64	2.82	2.43	3.00	2.72	0"
76W	15.02	.06	3.41	4"GSB 10"PCC	18	1.09	.159	0.15	3.70	.620	1.48	5.40	4.94	0.45	5.35	0.91	2.38	5.22	4.45	5.36	4.91	3/4"

RIGID PAVEMENT ROAD RATER RESEARCH
October 1982
Charles Potter, P.E.

Route	County	Direction	From Milepost	To Milepost	Crack & Patch Deduction	Present Serviceability Index	Structural Composition	Age	80th Percentile Deflection	SCI/SENS 1 Ratio	SCI	80th Percentile Deflection at Joints	SCI/SENS 1 Ratio at Joints	SCI at Joints	Structural Number (SN) When New	Depreciated SN (1-(C&P/0.70))(New SN)	Cracking (C) Linear Feet/1000 Sq. Ft.	Depreciated SN (1-(C/45))(New SN)	Average Deflection	Average Deflection at Joints	Depreciated SN (0.15/(SCI/SENS1))+(1-(C/45))(NewSN) / 2	Depreciated SN (1-((SCI/SENS1)/0.90))(New SN)	Depreciated SN (1-(C/60)) (New SN)	Depreciated SN (1-((SCI/SENS1)/0.90))+(1-(C/60))(New SN) / 2	AC Overlay Required For 15 Year Design Life
I-80	Pott.	EB	6.61	11.52	0.00	3.50	4"GSB 8"CRCP	13	2.49	0.103	0.18	2.18	0.149	0.27	4.40	4.40	0.	4.40	1.73	1.82	--	--	--	--	10 1/2"
		WB	6.61	11.52	0.05	3.50	4"GSB 8"CRCP	13	1.88	0.020	0.03	1.95	0.042	0.08	4.40	4.09	0.38	4.36	1.59	1.80	--	--	--	--	9"
I-80	Pott.	EB	11.52	18.93	0.10	3.80	4"ATB 8"CRCP	13	1.53	0.102	0.13	1.50	-0.011	-0.02	5.36	4.59	1.14	5.22	1.30	1.42	--	--	--	--	7 1/2"
		WB	11.52	18.93	0.00	4.05	4"ATB 8"CRCP	13	1.48	-0.023	-0.03	1.48	0.0	0.0	5.36	5.36	0.	5.36	1.31	1.32	--	--	--	--	7 1/4"
I-80	Pott.	EB	18.93	27.00	0.10	3.45	4"ATB 8"CRCP	13	1.57	0.130	0.18	1.28	0.118	0.14	5.36	4.59	1.14	5.22	1.37	1.22	--	--	--	--	7 3/4"
		WB	18.93	27.00	0.05	3.50	4"ATB 8"CRCP	13	1.53	0.054	0.07	1.66	0.023	0.03	5.36	4.98	0.57	5.29	1.31	1.41	--	--	--	--	7 1/2"
I-80	Pott.	EB	27.00	33.80	0.45	3.05	4"GSB 8"CRCP	16	1.83	0.129	0.20	2.07	0.125	0.22	4.40	1.57	0.	4.40	1.57	1.73	--	--	--	--	8 3/4"
		WB	27.00	33.80	0.50	3.15	4"GSB 8"CRCP	16	2.00	0.145	0.24	1.75	0.115	0.18	4.40	1.26	0.	4.40	1.62	1.54	--	--	--	--	9 1/2"
I-680	Pott.	EB	13.05	29.21	0.10	3.85	4"GSB 8"CRCP	16	1.71	0.043	0.07	2.75	0.081	0.16	4.40	3.77	0.	4.40	1.53	1.98	--	--	--	--	4 3/4"
		WB	13.05	29.21	0.30	3.80	4"GSB 8"CRCP	16	2.13	0.075	0.13	2.70	0.075	0.17	4.40	2.51	3.17	4.09	1.76	2.25	--	--	--	--	6 1/4"
I-80	Dallas	EB	100.80	106.16	0.10	2.95	AC/PC Var.	16																	7"
		WB	100.80	106.16	0.45	3.20	4"GSB 10" Std. PCCP	16	1.29	0.054	0.06	3.00	0.215	0.51	5.40	1.93	4.17	4.90	1.13	2.36	5.40	5.08	5.02	5.05	6 1/4"
I-80	Dallas	EB	106.16	111.14	0.40	3.00	4"GSB 8" Bar Mats	16	1.92	0.127	0.19	2.63	0.222	0.50	4.40	1.89	0.19	4.38	1.47	2.23	--	--	--	--	9 1/4"
		WB	106.16	111.14	0.35	3.15	4"GSB 8" Bar Mats	16	2.11	0.101	0.18	1.79	0.047	0.08	4.40	2.20	0.	4.40	1.74	1.69	--	--	--	--	10"

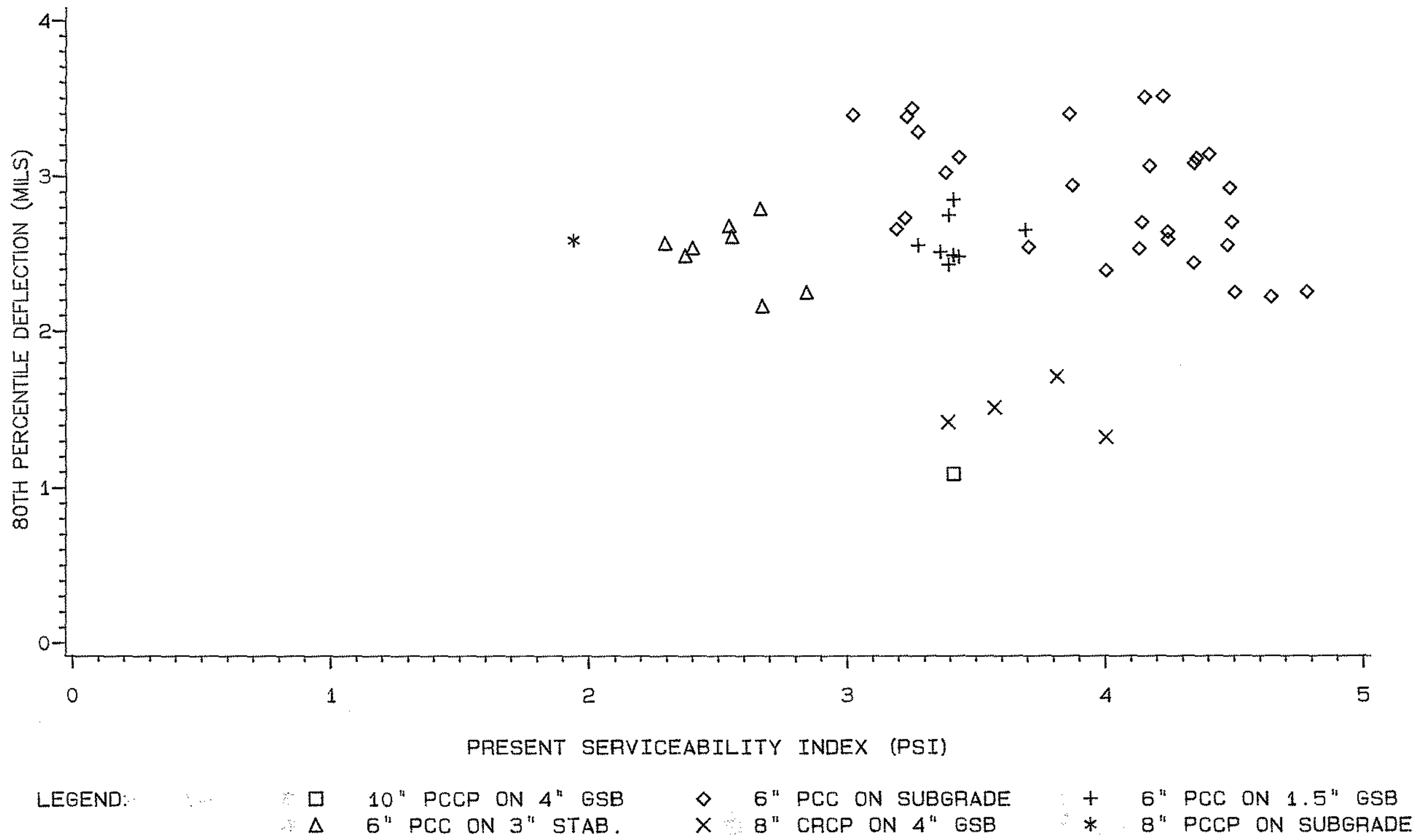
RIGID PAVEMENT ROAD RATER RESEARCH
October 1982
Charles Potter, P.E.

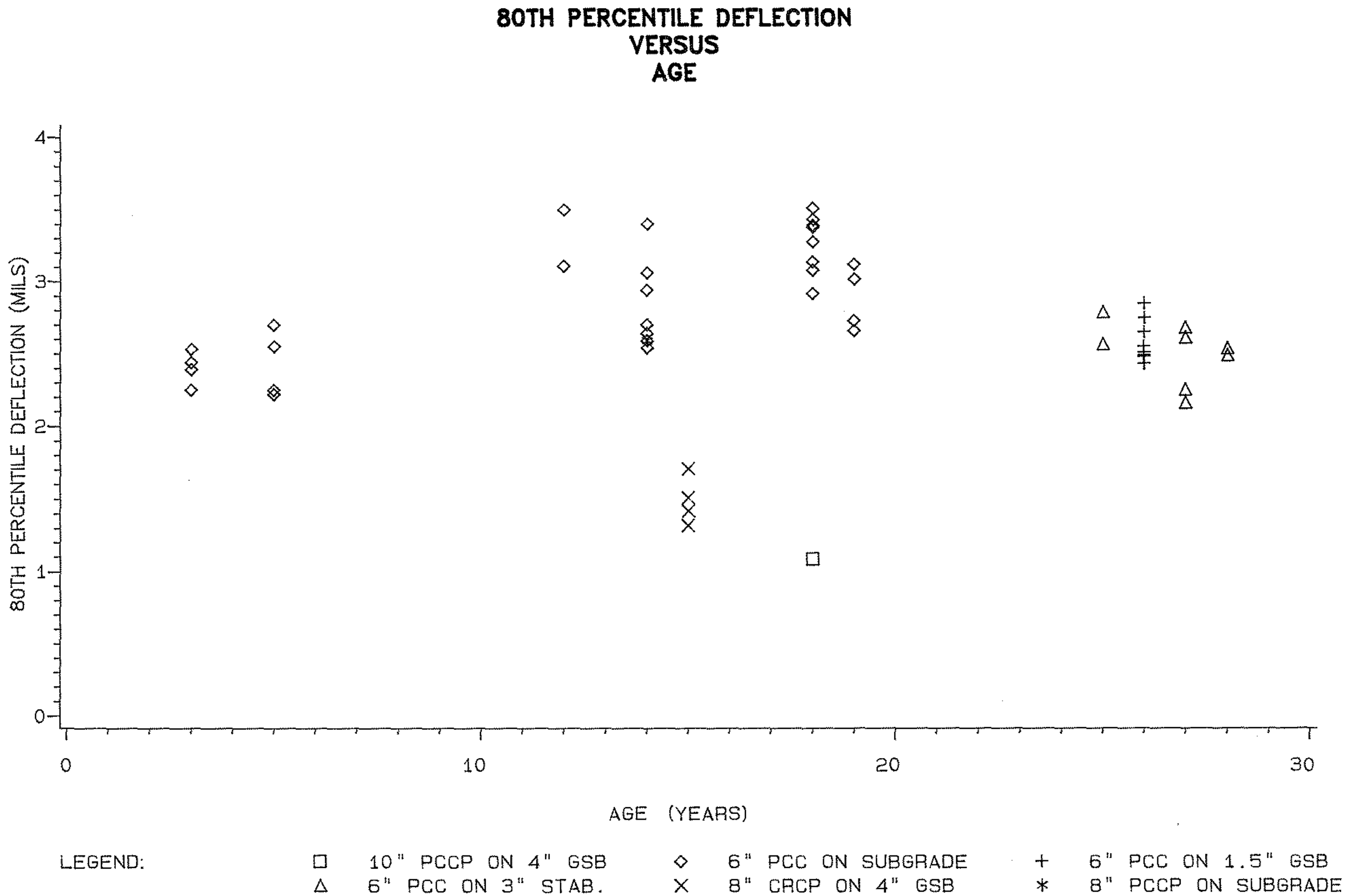
Route	County	Direction	From Milepost	To Milepost	Crack & Patch Deduction	Present Serviceability Index	Structural Composition	Age	80th Percentile Deflection	SCI/SENS 1 Ratio	SCI	80th Percentile Deflection at Joints	SCI/SENS 1 Ratio at Joints	SCI at Joints	Structural Number (SN) When New	Depreciated SN (1-(C&P/0.70))(New SN)	Cracking (C) Linear Feet/1000 Sq. Ft.	Depreciated SN (1-(C/45))(New SN)	Average Deflection	Average Deflection at Joints	Depreciated SN ((0.15/(SCI/SENS1))+(1-(C/45)))/2 (New SN)	Depreciated SN (1-((SCI/SENS1)/0.90))(New SN)	Depreciated SN (1-(C/60))(New SN)	Depreciated SN ((1-((SCI/SENS1)/0.90))+(1-(C/60)))/2 (NewSN)	AC Overlay Required For 15 Year Design Life
I-80	Dallas	EB	111.14	118.00	0.60	2.65	4"GSB 8" Bar Mats	16	2.32	0.100	0.19	2.62	0.168	0.37	4.40	0.63	0.95	4.31	1.93	2.21	--	--	--	--	10 1/2"
		WB	111.14	118.00	0.50	3.15	4"GSB 8" Bar Mats	16	2.38	0.115	0.22	2.09	0.103	0.19	4.40	1.26	0.	4.40	1.89	1.86	--	--	--	--	10 1/2"
I-80	Dallas	EB	118.00	122.40	0.30	3.00	4"GSB 8" Bar Mats	16	2.48	0.125	0.27	3.09	0.177	0.47	4.40	2.51	2.65	4.14	2.12	2.64	--	--	--	--	10 3/4"
		WB	118.00	122.40	0.50	3.20	4"GSB 8" Bar Mats	16	2.98	0.169	0.41	2.72	0.135	0.31	4.40	1.26	0.	4.40	2.45	2.29	--	--	--	--	11 1/2"
US 30	Story	EB	148.00	156.21	0.10	3.05	4"GSB 10" PCCP	18	1.24	0.055	0.06	1.41	0.216	0.26	5.40	4.63	0.95	5.29	1.04	1.22	5.40	5.07	5.31	5.19	2 3/4"
		WB	148.00	156.21	0.10	3.10	4"GSB 10" PCCP	18	1.17	0.012	0.01	1.42	0.207	0.25	5.40	4.63	0.76	5.31	0.98	1.22	5.40	5.33	5.33	5.33	2"
IA 17	Boone	NB	21.63	32.76	0.00	4.20	8" PCCP	2	1.59	0.157	0.21	4.33	0.296	1.00	4.00	4.00	0.	4.00	1.36	3.39	3.91	3.30	4.00	3.65	0"
		SB	21.63	32.76	0.00	4.20	8" PCCP	2	1.28	0.151	0.17	3.03	0.320	0.86	4.00	4.00	0.	4.00	1.11	2.67	3.99	3.33	4.00	3.67	0"
IA 17	Hamilton	NB	39.76	48.95	0.00	4.20	7 1/2" PCCP	4	1.65	0.098	0.14	2.88	0.252	0.57	3.75	3.75	0.	3.75	1.46	2.27	3.75	3.34	3.75	3.55	0"
		SB	39.76	48.95	0.00	4.20	7 1/2" PCCP	4	1.73	0.113	0.17	3.05	0.262	0.68	3.75	3.75	0.	3.75	1.50	2.58	3.75	3.28	3.75	3.52	0"
IA 17	Hamilton	NB	134.00	135.39	0.00	4.10	8" PCCP	3	1.38	0.118	0.14	1.84	0.121	0.17	4.00	4.00	0.	4.00	1.18	1.42	4.00	3.48	4.00	3.74	1 3/4"
		SB	134.00	135.39	0.00	4.10	8" PCCP	3	1.41	0.090	0.10	1.75	0.150	0.20	4.00	4.00	0.	4.00	1.11	1.36	4.00	3.60	4.00	3.80	1 3/4"
520	Hamilton	EB	135.58	140.09	0.00	4.30	4" Cl. ASB 8 1/2" PCCP	3	1.06	0.097	0.09	2.59	0.280	0.60	5.61	5.61	0.	5.61	0.91	2.14	5.61	5.00	5.61	5.31	2"
		WB	135.58	140.09	0.00	4.30	4" Cl. ASB 8 1/2" PCCP	3	1.09	0.099	0.10	2.37	0.258	0.50	5.61	5.61	0.	5.61	0.97	1.92	5.61	4.99	5.61	5.30	2 1/4"
520	Hamilton	EB	141.50	149.50	0.05	4.15	4" Cl. ASB 9" PCCP	7	1.08	0.096	0.09	2.28	0.260	0.38	5.86	5.44	0.25	5.83	0.97	1.45	5.86	5.23	5.84	5.54	2 1/4"
		WB	141.50	149.50	0.10	4.15	4" Cl. ASB 9" PCCP	7	1.13	0.094	0.09	1.90	0.239	0.38	5.86	5.02	1.20	5.70	0.99	1.57	5.86	5.25	5.74	5.50	2 1/2"

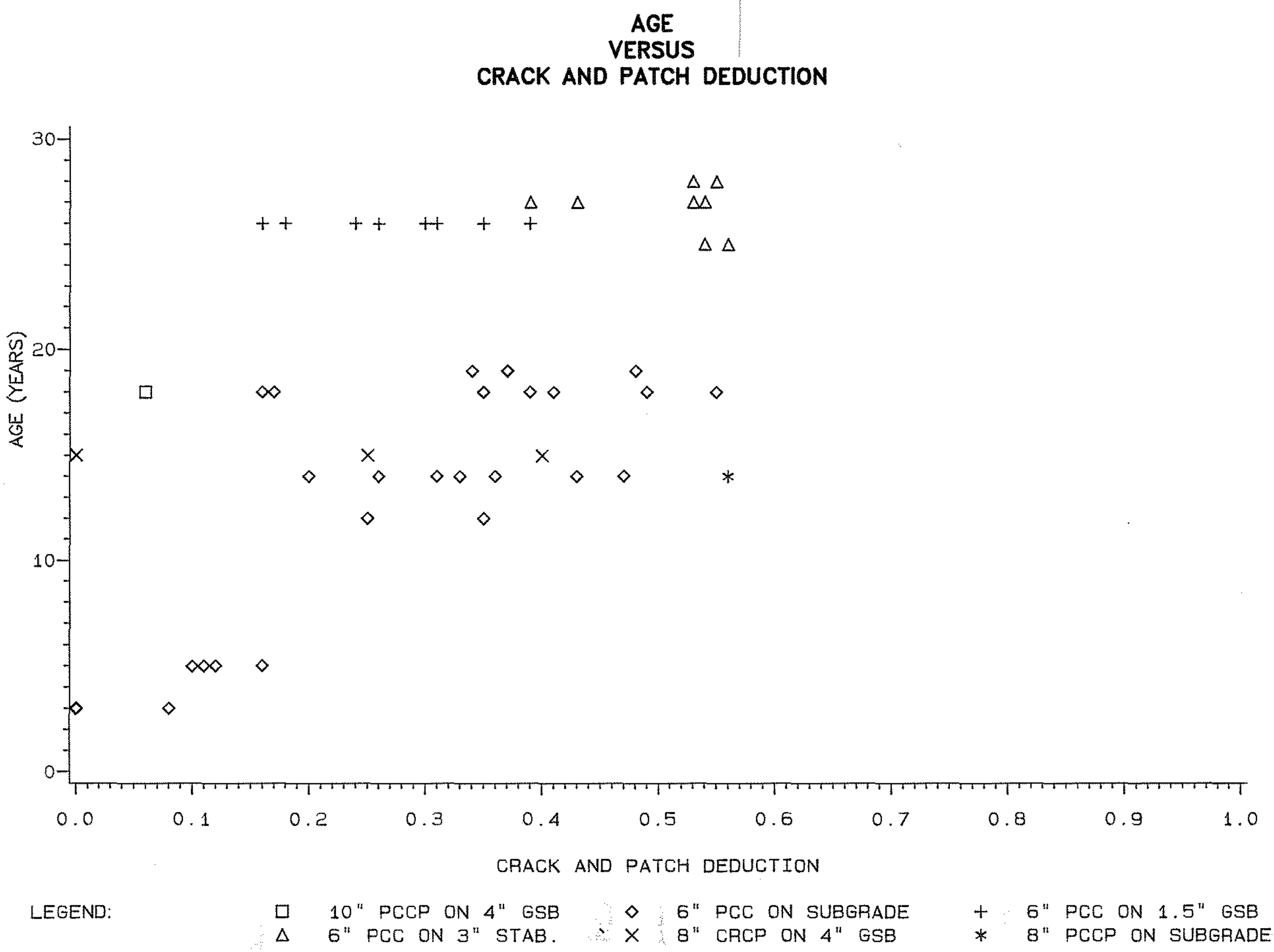
RIGID PAVEMENT ROAD RATER RESEARCH
October 1982
Charles Potter, P.E.

Route	County	Direction	From Milepost	To Milepost	Crack & Patch Deduction	Present Serviceability Index	Structural Composition	Age	80th Percentile Deflection	SCI/SENS 1 Ratio	SCI	80th Percentile Deflection at Joints	SCI/SENS 1 Ratio at Joints	SCI at Joints	Structural Number (SN) When New	Depreciated SN (1-(C&P/0.70))(New SN)	Cracking (C) Linear Feet/1000 Sq. Ft.	Depreciated SN (1-(C/45))(New SN)	Average Deflection	Average Deflection at Joints	Depreciated SN ((0.15/(SCI/SENS1))+(1-(C/45)))/2 (New SN)	Depreciated SN (1-((SCI/SENS1)/0.90))(New SN)	Depreciated SN (1-(C/60))(New SN)	Depreciated SN ((1-((SCI/SENS1)/0.90))+(1-(C/60)))/2 (NewSN)	AC Overlay Required For 15 Year Design Life
520	Hamilton	EB	149.50	152.50	0.10	4.00	4"GSB 10" PCCP	14	1.01	0.083	0.08	1.72	0.163	0.25	5.40	4.63	1.14	5.26	0.91	1.52	5.40	4.90	5.30	5.10	1 1/4"
		WB	149.50	152.50	0.05	4.00	4"GSB 10" PCCP	14	1.20	0.049	0.05	1.33	0.093	0.11	5.40	5.01	0.57	5.33	1.07	1.21	5.40	5.11	5.35	5.23	3"
US 30	Marshall	EB	172.00	179.00	0.00	3.70	4" Grad. St. Base 8" CRCP	19	1.83	0.091	0.14	1.69	0.095	0.14	4.56	4.56	0.	4.56	1.55	1.52	--	--	--	--	4 1/2"
		WB	172.00	179.00	0.00	3.75	4" Grad. St. Base 8"CRCP	19	1.70	0.116	0.18	1.67	0.160	0.25	4.56	4.56	0.	4.56	1.56	1.55	--	--	--	--	4 1/2"
IA 160	Polk	EB	0.00	1.22	0.60	2.65	10"-8"-10" PCCP	35	2.93	0.156	0.27	--	--	--	4.30	0.61	29.73	1.46	1.75	--	2.80	3.55	2.17	2.86	2 1/2"
		WB	0.00	1.22	0.60	2.55	10"-8"-10" PCCP	35	1.48	0.156	0.20	--	--	--	4.30	0.61	29.73	1.46	1.26	--	2.80	3.55	2.17	2.86	2 1/2"
IA 415	Polk	NB	2.50	4.50	0.25	3.20	10" PCCP	21	2.31	0.144	0.23	--	--	--	5.00	3.21	8.05	4.11	1.58	--	4.65	4.20	4.33	4.27	3 3/4"
		SB	2.50	4.50	0.05	3.65	9" PCCP 1943 3" AC Resurf. 1960	39	1.07	0.140	0.13	--	--	--	5.82	--	--	--	0.90	--	--	--	--	--	0"
IA 17	Polk	NB	0.00	7.50	0.20	3.20	10" PCCP	23	1.96	0.052	0.07	--	--	--	5.00	3.57	2.84	4.68	1.37	--	5.00	4.71	4.76	4.74	1 3/4"
		SB	0.00	7.50	0.20	3.15	10" PCCP	23	1.72	0.054	0.07	--	--	--	5.00	3.57	2.84	4.68	1.25	--	5.00	4.70	4.76	4.73	1 3/4"
I-80 3" PCC Overlay	Pott.	EB	35.10	39.68	0.05	4.00	4"GSB 8"CRCP 3" PCC Overlay 1979	16	1.82	0.083	0.11	2.83	0.244	0.57	4.40 5.90	5.48	0.	5.90	1.37	2.34	--	--	--	--	8 3/4"

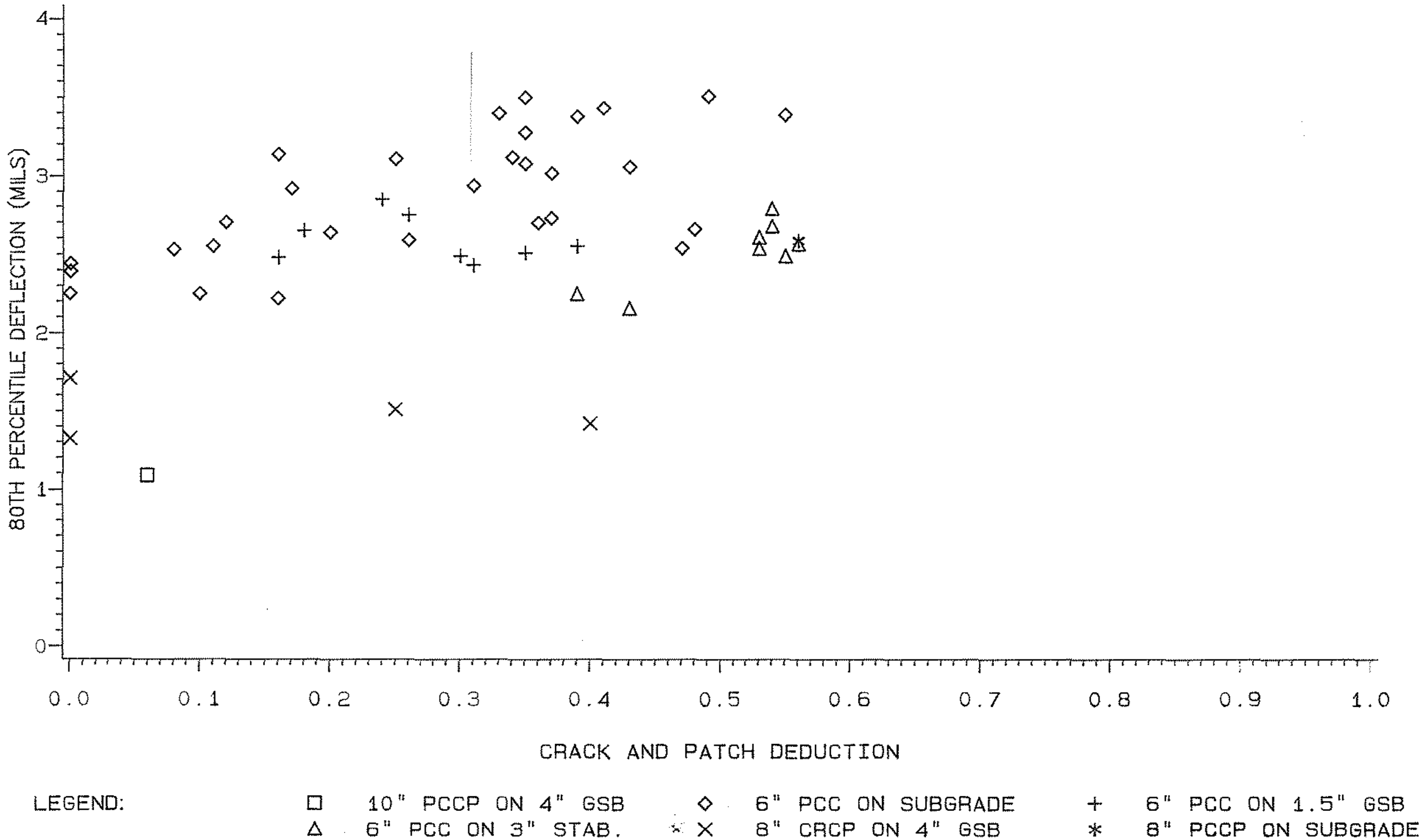
80TH PERCENTILE DEFLECTION VERSUS PRESENT SERVICEABILITY INDEX



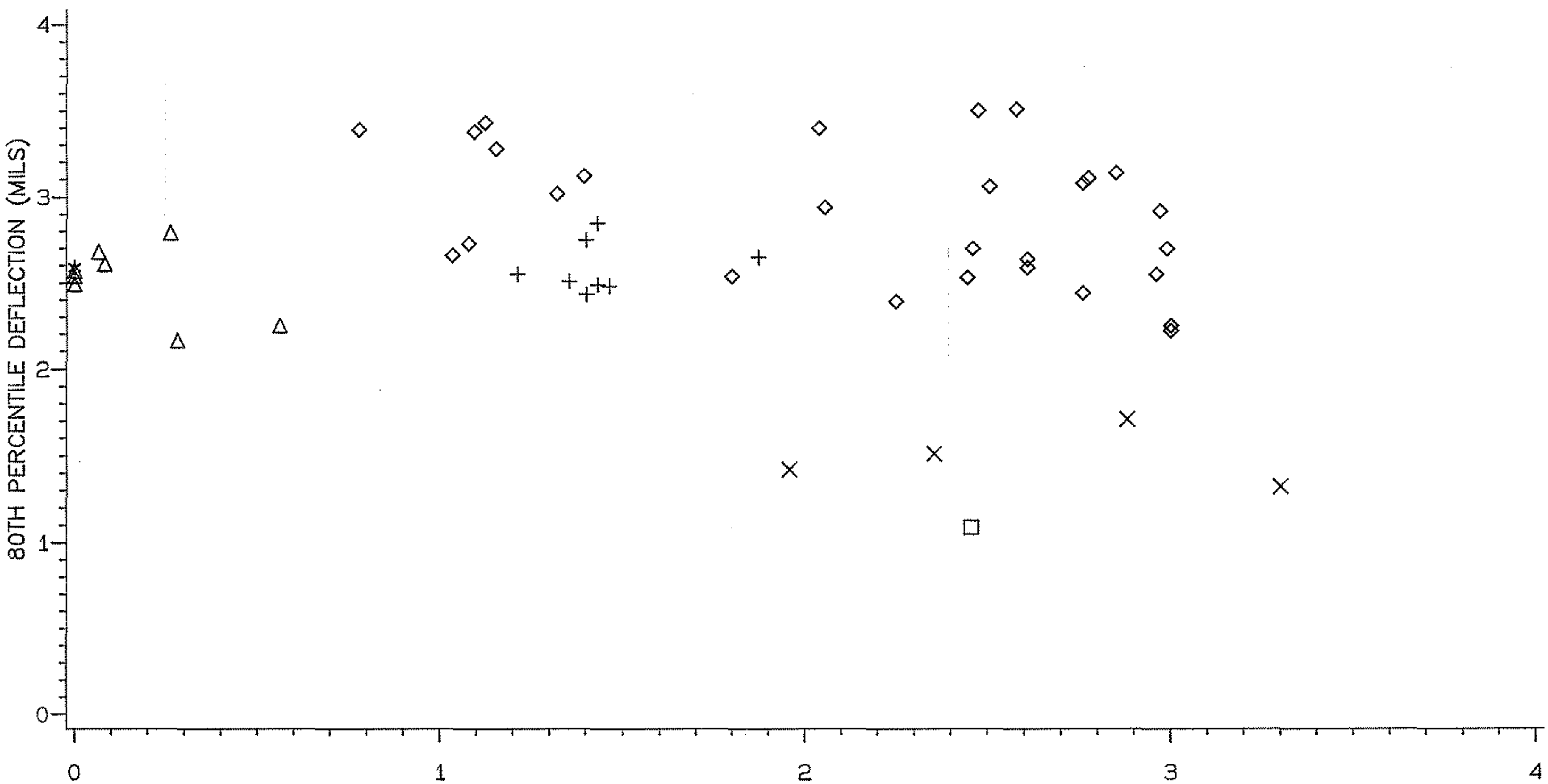

80TH PERCENTILE DEFLECTION
VERSUS
AGE
80TH PERCENTILE DEFLECTION (MILS)
AGE (YEARS)
LEGEND:
10" PCCP ON 4" GSB
6" PCC ON SUBGRADE
6" PCC ON 1.5" GSB
6" PCC ON 3" STAB.
8" CRCP ON 4" GSB
8" PCCP ON SUBGRADE


AGE
VERSUS
CRACK AND PATCH DEDUCTION
AGE (YEARS)
30
20
10
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
CRACK AND PATCH DEDUCTION
LEGEND:
□ 10" PCCP ON 4" GSB
◇ 6" PCC ON SUBGRADE
+ 6" PCC ON 1.5" GSB
△ 6" PCC ON 3" STAB.
× 8" CRCP ON 4" GSB
* 8" PCCP ON SUBGRADE

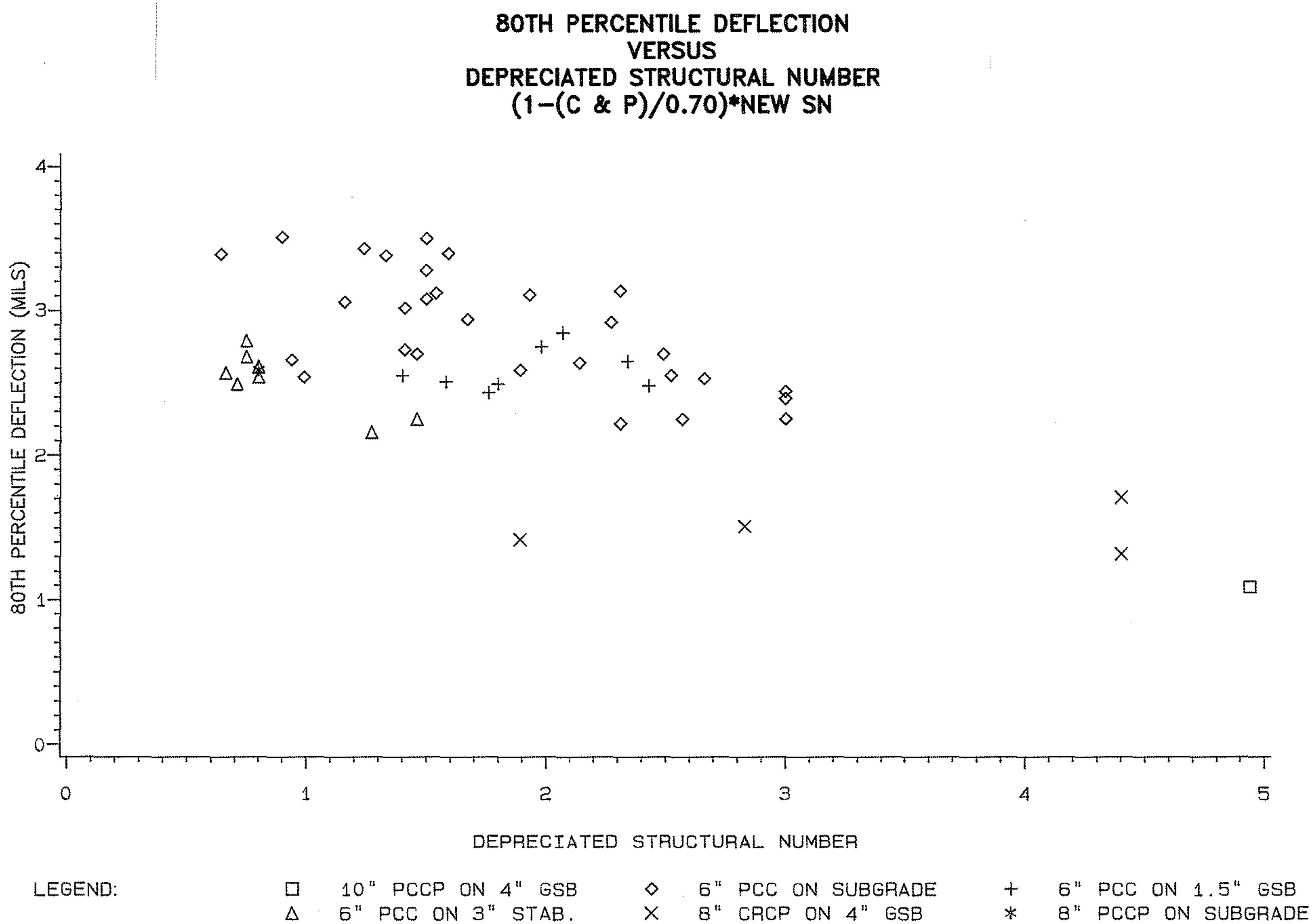
80TH PERCENTILE DEFLECTION VERSUS CRACK AND PATCH DEDUCTION

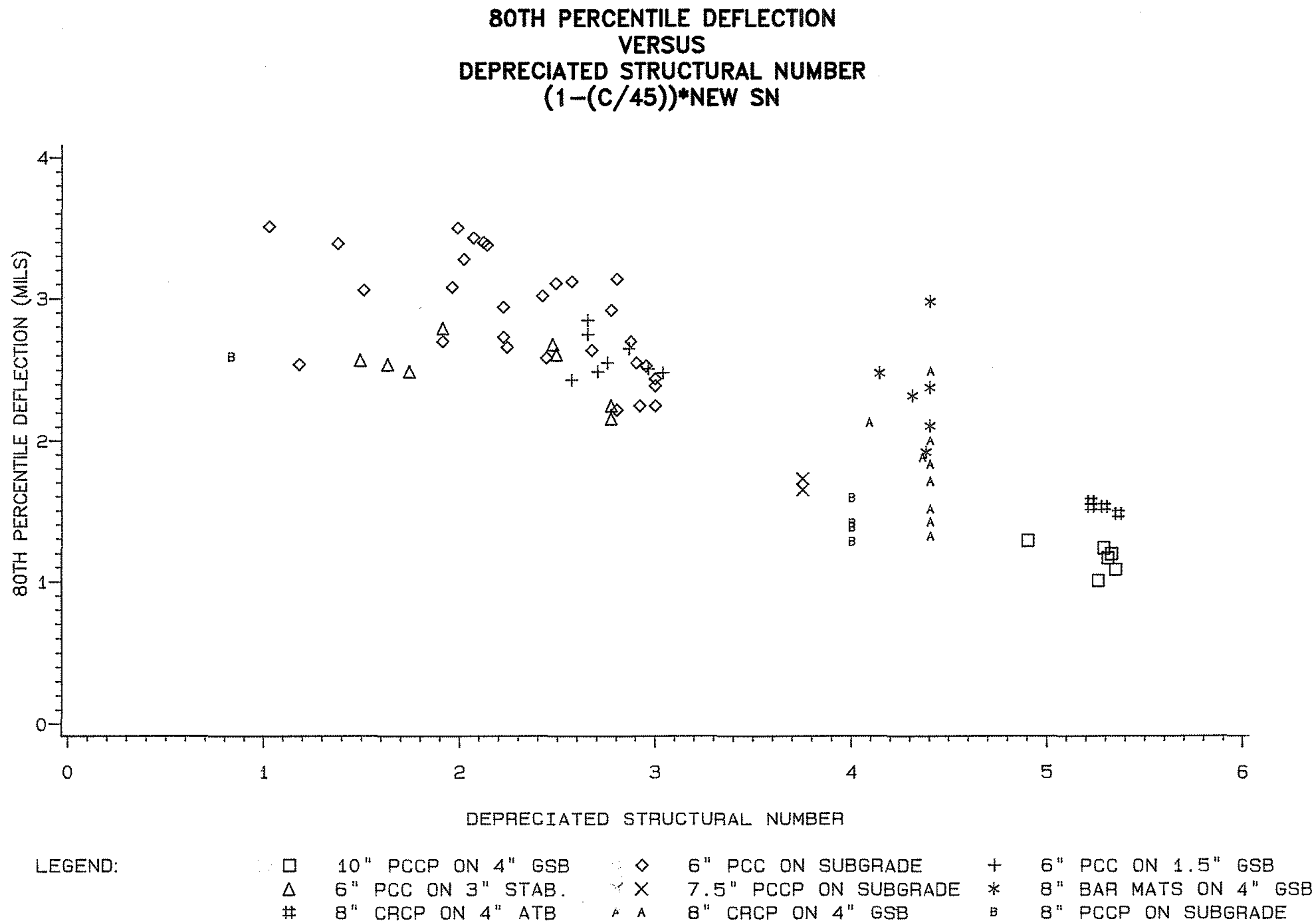


80TH PERCENTILE DEFLECTION
VERSUS
DEPRECIATED STRUCTURAL NUMBER
(1-(4.5-PSI)/2.00)*NEW SN

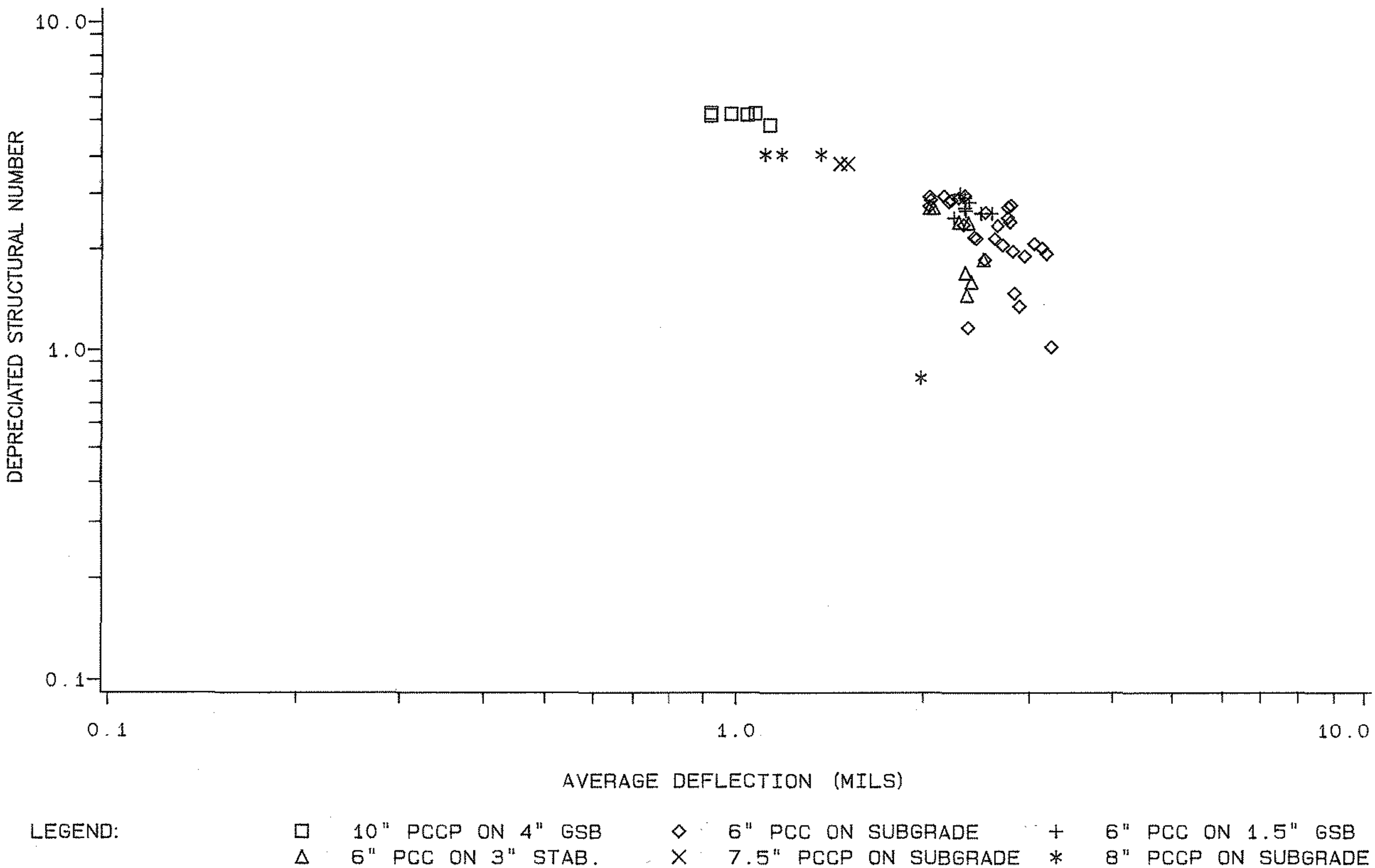


LEGEND: □ 10" PCCP ON 4" GSB ◇ 6" PCC ON SUBGRADE + 6" PCC ON 1.5" GSB
△ 6" PCC ON 3" STAB. × 8" CRCP ON 4" GSB * 8" PCCP ON SUBGRADE

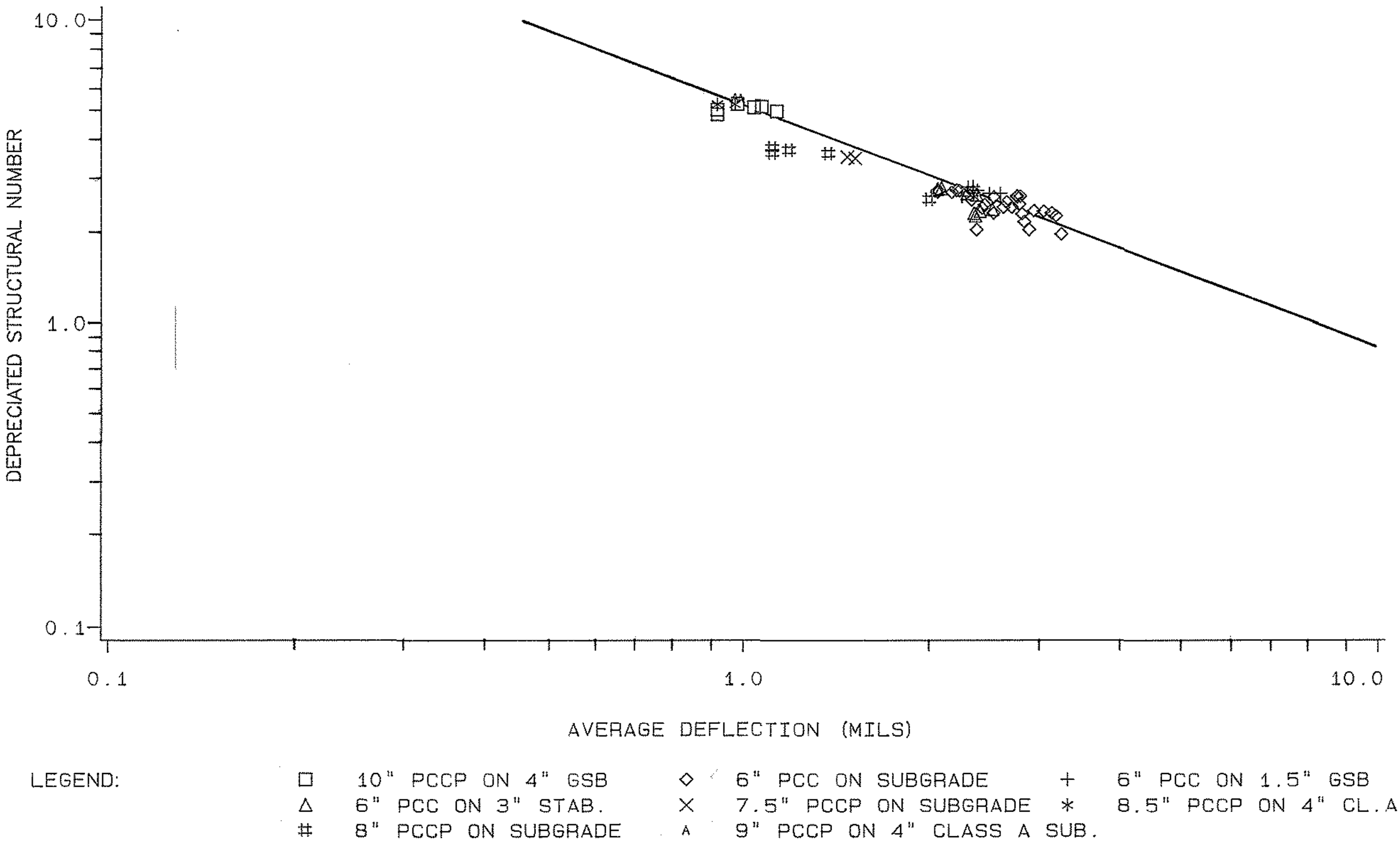

80TH PERCENTILE DEFLECTION
VERSUS
DEPRECIATED STRUCTURAL NUMBER
(1-(C & P)/0.70)*NEW SN
80TH PERCENTILE DEFLECTION (MILS)
0
1
2
3
4
0
1
2
3
4
5
DEPRECIATED STRUCTURAL NUMBER
LEGEND:
10" PCCP ON 4" GSB
6" PCC ON SUBGRADE
6" PCC ON 1.5" GSB
6" PCC ON 3" STAB.
8" CRCP ON 4" GSB
8" PCCP ON SUBGRADE


80TH PERCENTILE DEFLECTION
VERSUS
DEPRECIATED STRUCTURAL NUMBER
(1-(C/45))*NEW SN
80TH PERCENTILE DEFLECTION (MILS)
0
1
2
3
4
0
1
2
3
4
5
6
DEPRECIATED STRUCTURAL NUMBER
LEGEND:
10" PCCP ON 4" GSB
6" PCC ON SUBGRADE
6" PCC ON 1.5" GSB
6" PCC ON 3" STAB.
7.5" PCCP ON SUBGRADE
8" BAR MATS ON 4" GSB
8" CRCP ON 4" ATB
8" CRCP ON 4" GSB
8" PCCP ON SUBGRADE

AVERAGE DEFLECTION
VERSUS
DEPRECIATED STRUCTURAL NUMBER
(1-(C/45))*NEW SN



AVERAGE DEFLECTION
VERSUS
DEPRECIATED STRUCTURAL NUMBER
.5((1-((SCI/SENS1)/0.90))+(1-(C/60)))*NEW SN

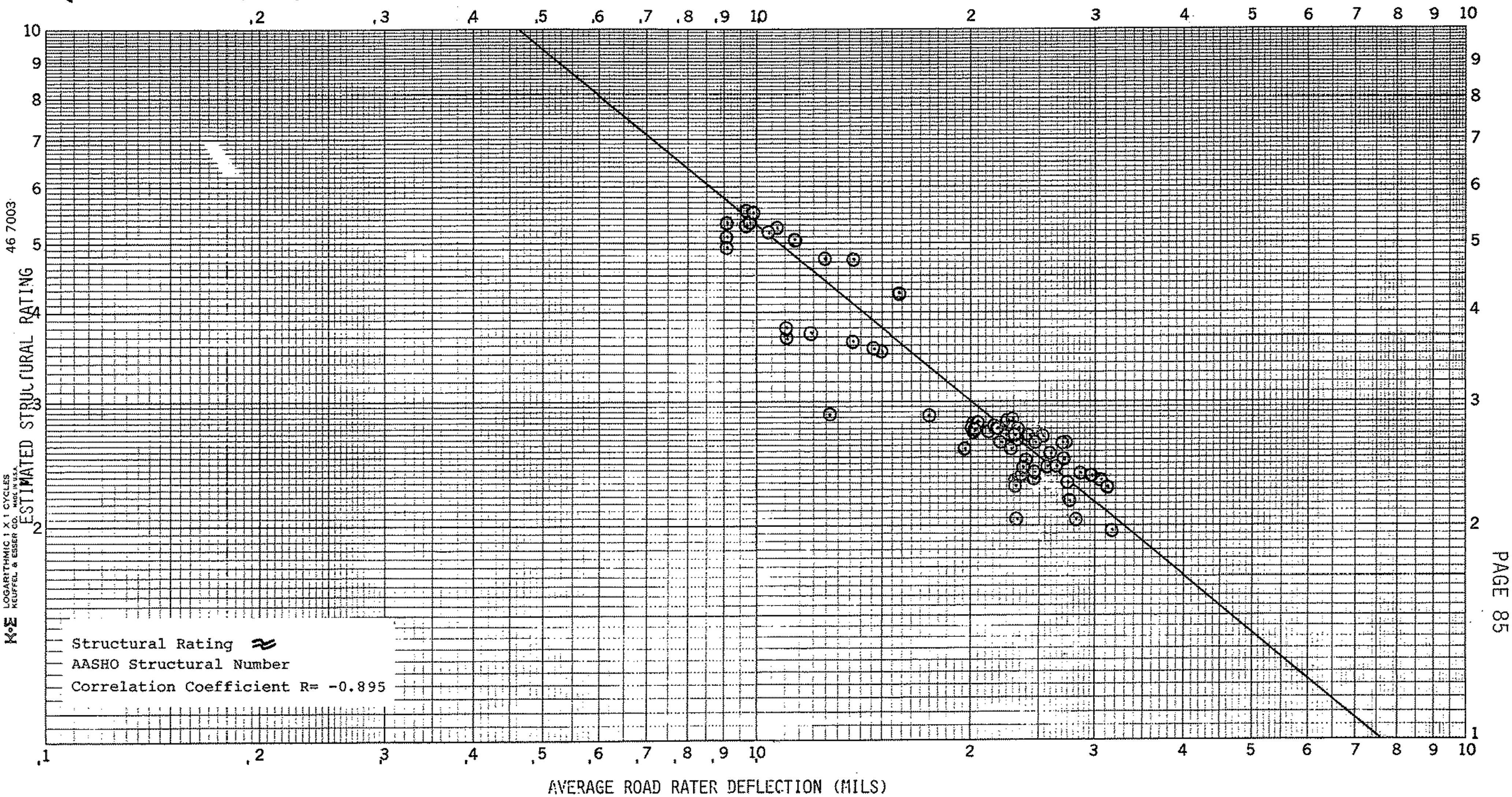


ESTIMATED STRUCTURAL RATING

$$\left(\frac{\left(1-\frac{\frac{SCI}{SENSI}}{0.90}\right)+\left(1-\frac{c}{60}\right)}{2}\right)\left(\text{NEW SN}\right)$$

AVERAGE ROAD RATER DEFLECTION VERSUS ESTIMATED STRUCTURAL RATING

NOVEMBER 22, 1982

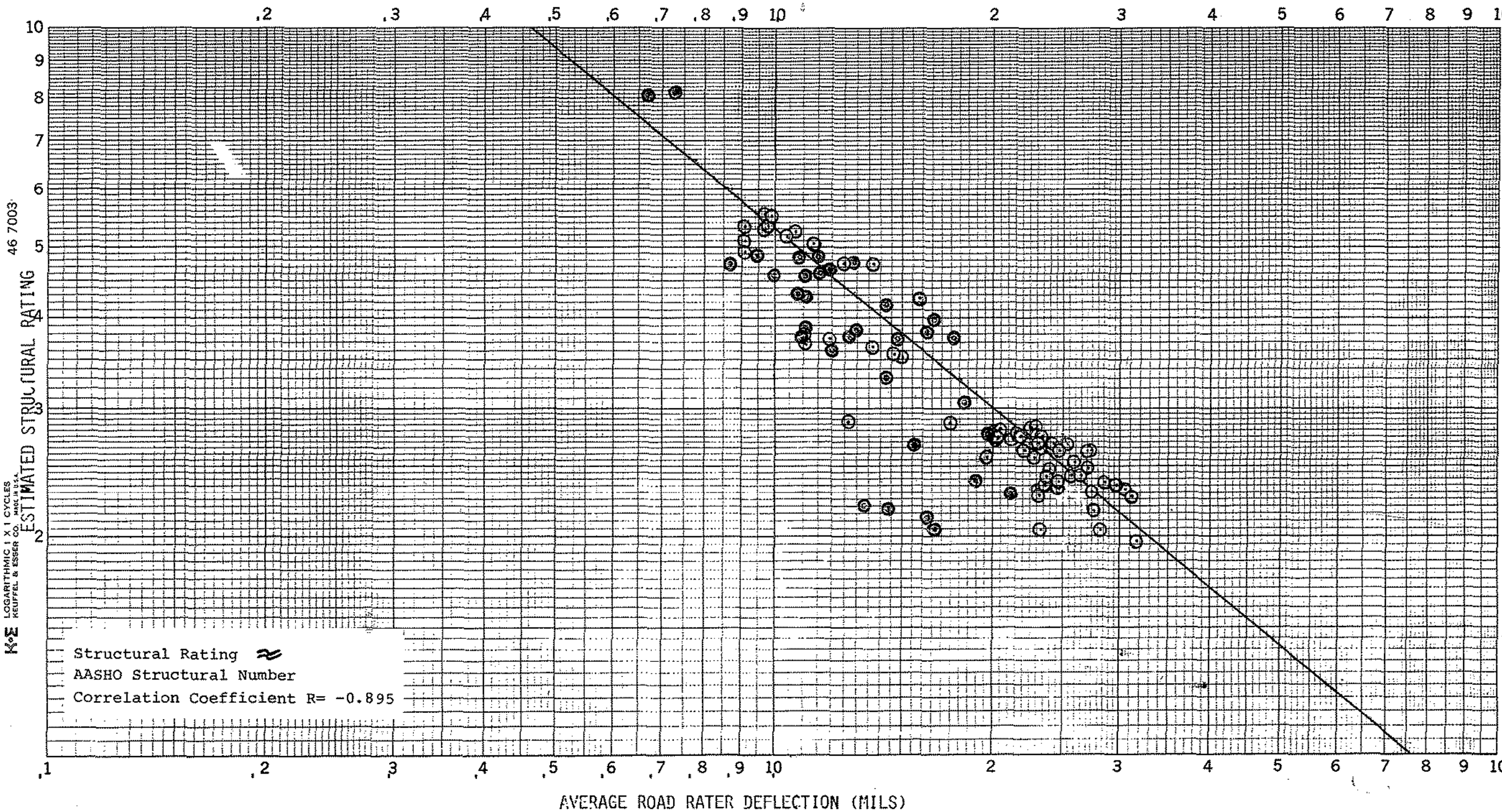


Estimated Structural Rating

$$\left(\frac{\left(1-\frac{\frac{SCI}{SENSI}}{0.90}\right)+\left(1-\frac{C}{60}\right)}{2}\right)\left(\text{NEW SN}\right)$$

AVERAGE ROAD RATER DEFLECTION VERSUS ESTIMATED STRUCTURAL RATING

November 22, 1982

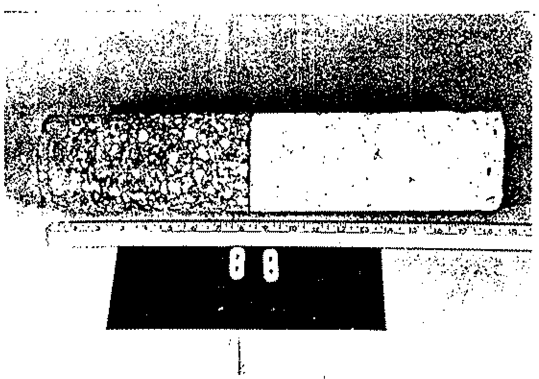


APPENDIX F

LONG TERM MONITORING CORE PICTURES

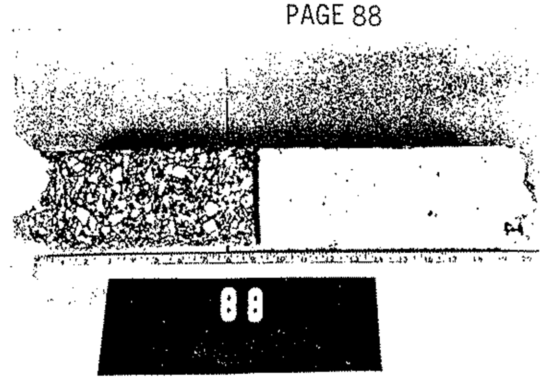
INTRODUCTION

Core samples shown on pages 88 through 130 were obtained in October and November 1983 on 21 Long Term Monitoring Sections. The Road Rater tested in the outside wheeltrack and then was moved to permit core drilling and soil sampling at the same location. Road Rater testing in the spring of 1983 was performed in the outside wheeltrack at approximately the same locations. Cores are shown measured from the top down with the top located at the left-hand side of the photos.



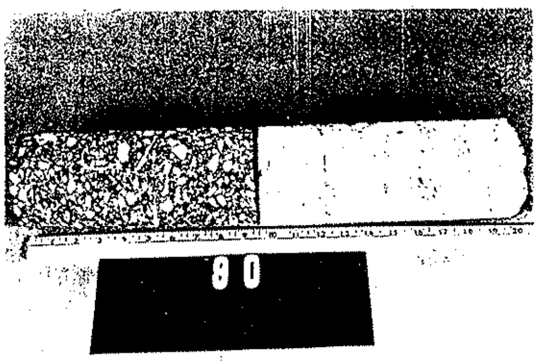
Core No.	Route	Milepost	Dir.	County
88	US 30	141.35	WB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	6.35	225
10-14-83	75°	6.10	225+



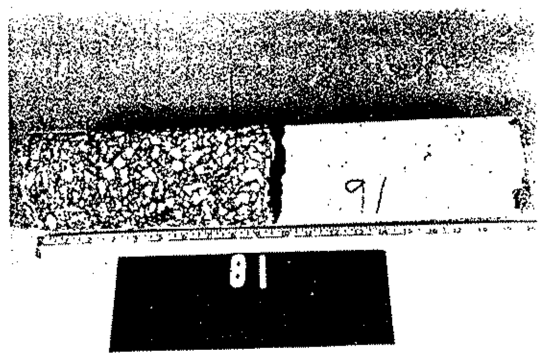
Core No.	Route	Milepost	Dir.	County
89	US 30	140.85	WB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	4.55	225+
10-14-83	75°	3.30	225+



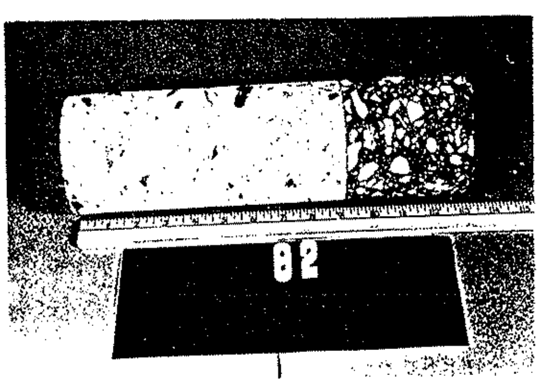
Core No.	Route	Milepost	Dir.	County
90	US 30	140.35	WB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	7.00	225+
10-14-83	75°	6.60	225+



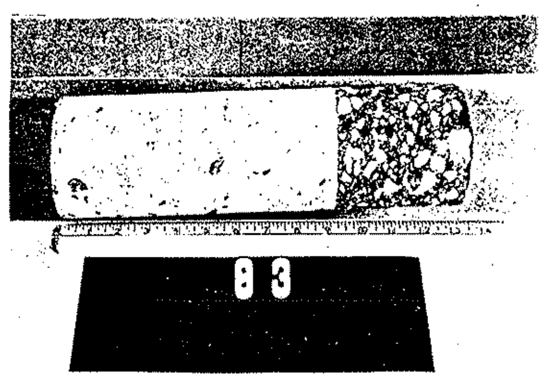
Core No.	Route	Milepost	Dir.	County
91	US 30	139.85	WB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	7.50	150
10-14-83	75°	6.10	225+



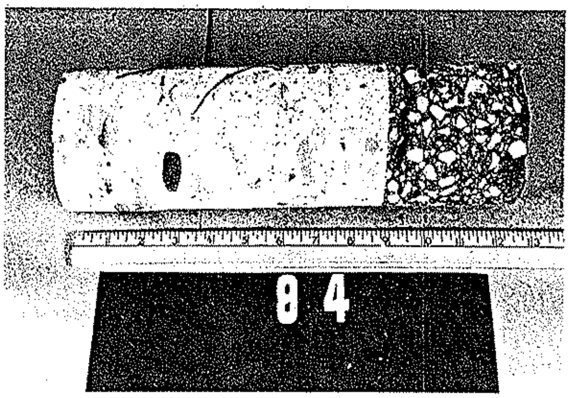
Core No.	Route	Milepost	Dir.	County
92	US 30	139.50	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	5.70	215
10-14-83	75°	5.70	225+



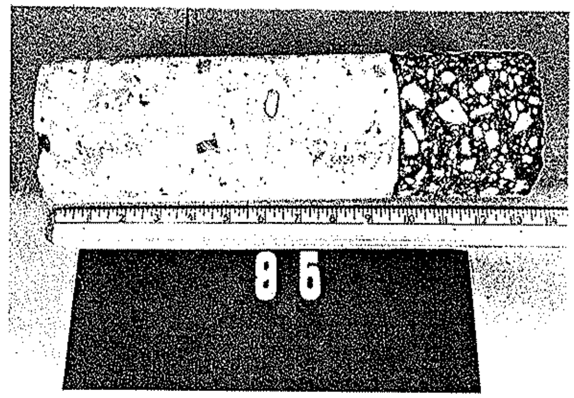
Core No.	Route	Milepost	Dir.	County
93	US 30	140.00	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	6.35	225
10-14-83	75°	5.45	225+



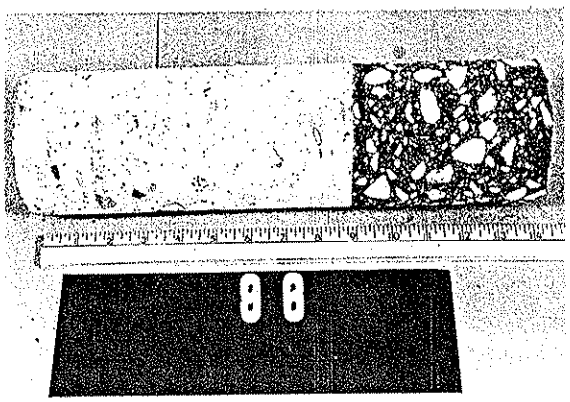
Core No.	Route	Milepost	Dir.	County
94	US 30	140.50	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	4.55	185
10-14-83	75°	5.80	225+



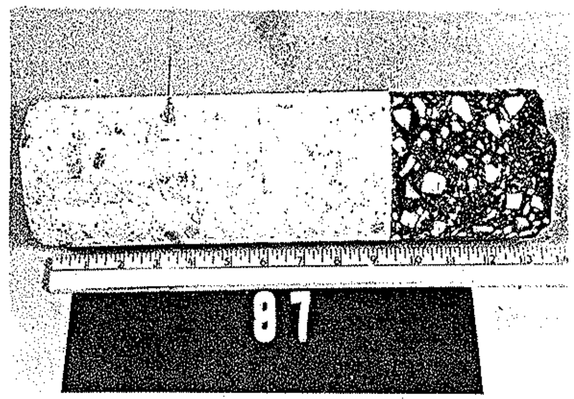
Core No.	Route	Milepost	Dir.	County
95	US 30	141.00	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	6.70	210
10-14-83	75°	5.80	225+



Core No.	Route	Milepost	Dir.	County
96	US 30	141.50	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	5.70	190
10-14-83	75°	5.80	220

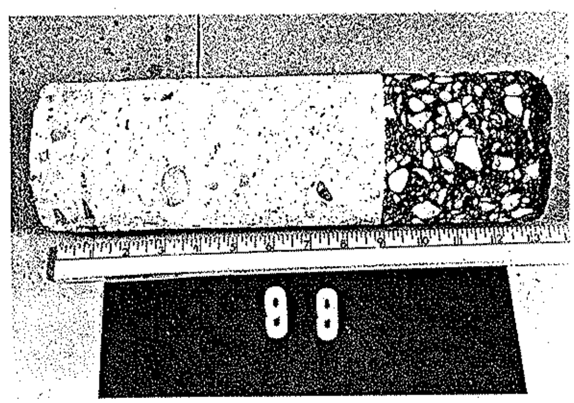


Core No.	Route	Milepost	Dir.	County
97	US 30	142.00	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	6.70	225+
10-14-83	75°	6.35	225+

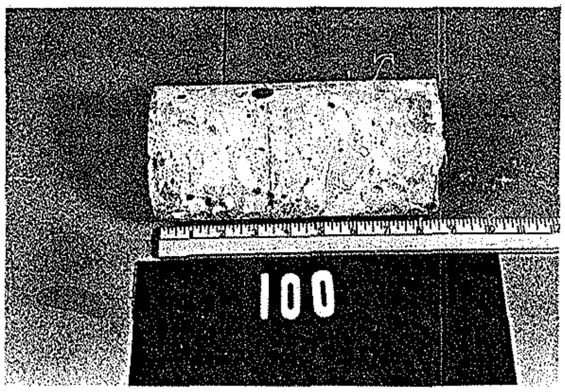
Core No.	Route	Milepost	Dir.	County
98	US 30	142.50	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	5.55	205
10-14-83	75°	5.55	225



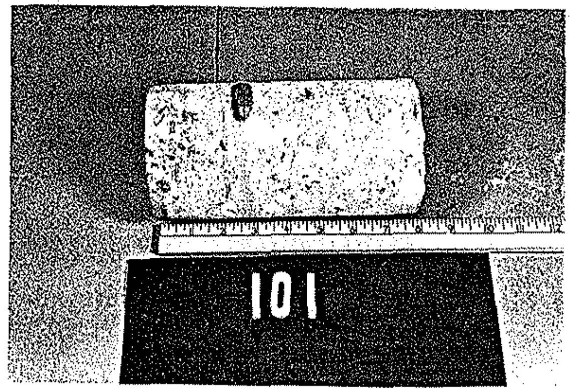
Core No.	Route	Milepost	Dir.	County
99	US 30	143.00	EB	Boone

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-19-83	55°	4.95	180
10-14-83	75°	5.90	225+



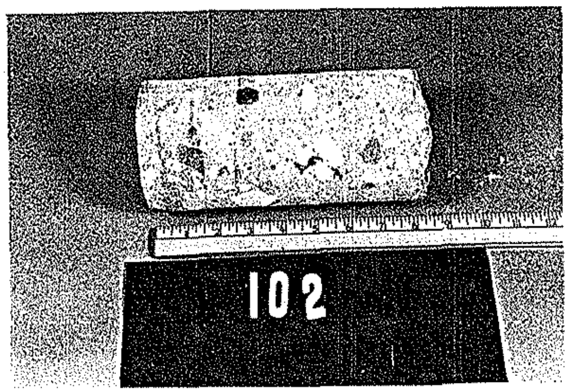
Core No.	Route	Milepost	Dir.	County
100	US 30	173.00	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	4.30	80
10-14-83	50°	3.60	225+



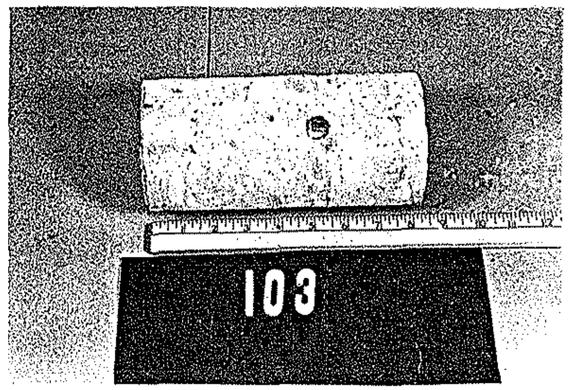
Core No.	Route	Milepost	Dir.	County
101	US 30	173.80	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	4.55	170
10-14-83	50°	3.85	225



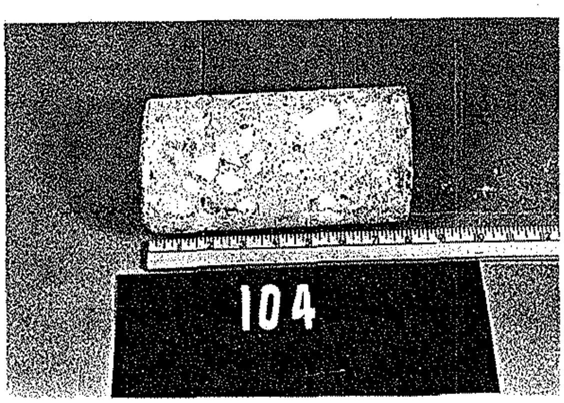
Core No.	Route	Milepost	Dir.	County
102	US 30	175.00	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.45	145
10-14-83	50°	2.75	160



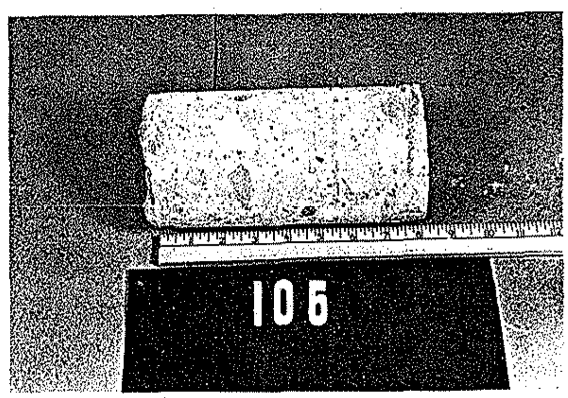
Core No.	Route	Milepost	Dir.	County
103	US 30	175.80	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.90	155
10-14-83	50°	3.90	220



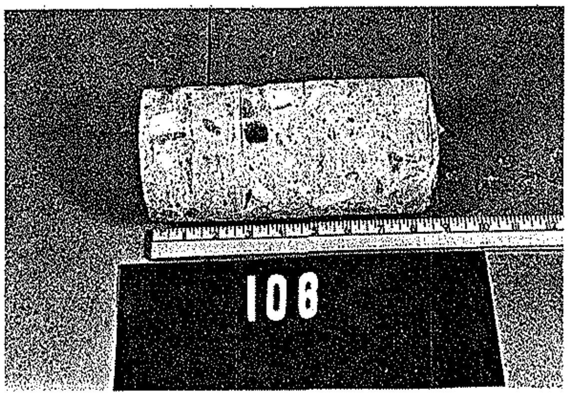
Core No.	Route	Milepost	Dir.	County
104	US 30	177.00	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.60	155
10-14-83	50°	3.70	195



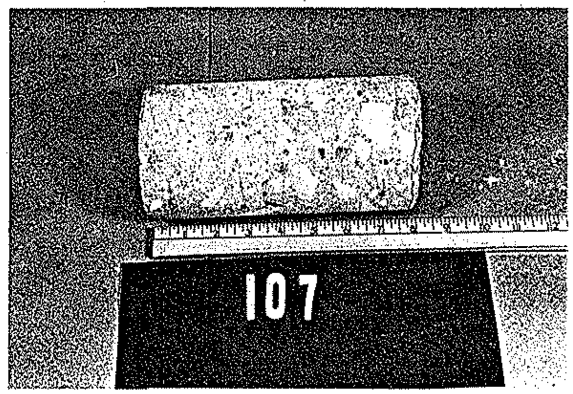
Core No.	Route	Milepost	Dir.	County
105	US 30	177.80	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	4.25	190
10-14-83	50°	3.10	225+



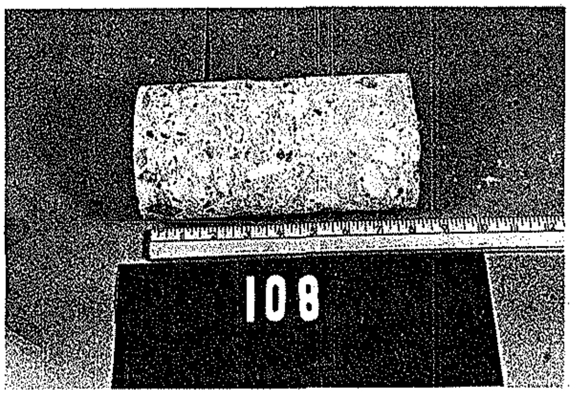
Core No.	Route	Milepost	Dir.	County
106	US 30	178.00	EB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	4.10	185
10-14-83	50°	3.45	215



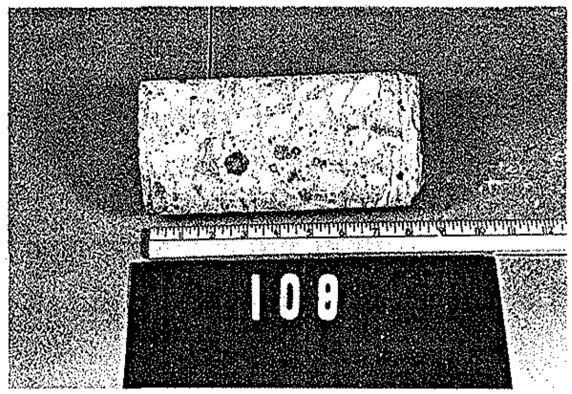
Core No.	Route	Milepost	Dir.	County
107	US 30	177.20	WB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.70	50
10-14-83	50°	2.35	195



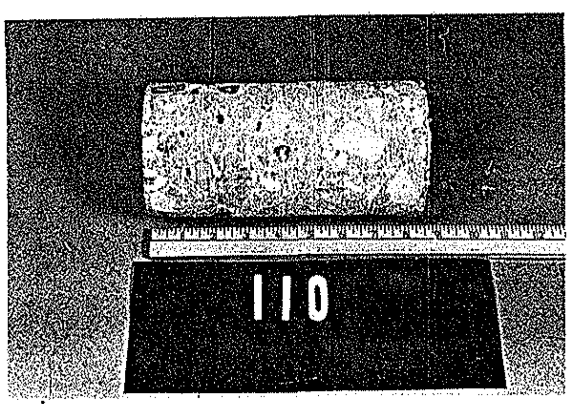
Core No.	Route	Milepost	Dir.	County
108	US 30	176.00	WB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.35	135
10-14-83	50°	3.30	205



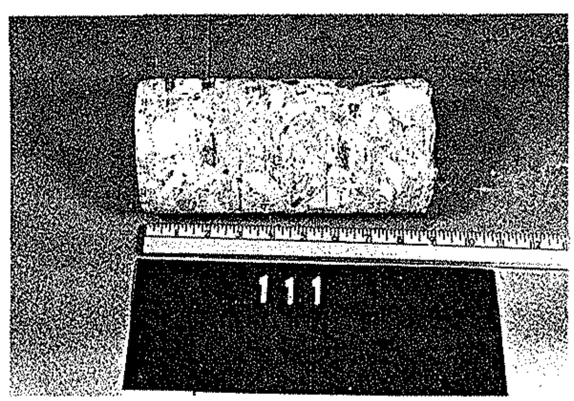
Core No.	Route	Milepost	Dir.	County
109	US 30	174.80	WB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	2.95	140
10-14-83	50°	3.10	165



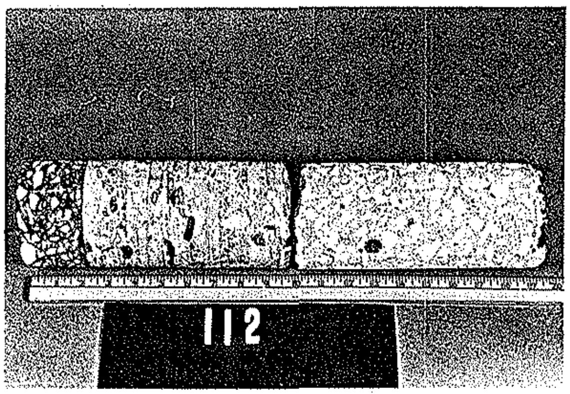
Core No.	Route	Milepost	Dir.	County
110	US 30	174.00	WB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.70	165
10-14-83	50°	2.40	200



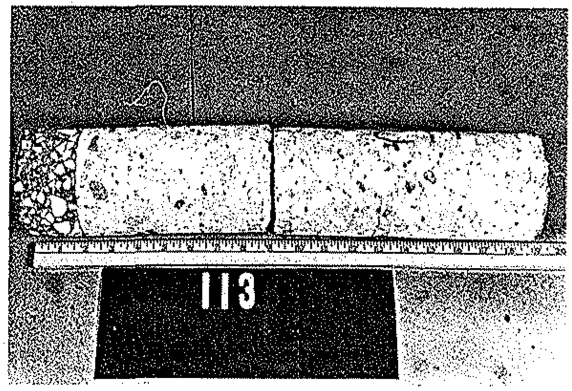
Core No.	Route	Milepost	Dir.	County
111	US 30	173.60	WB	Marshall

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-16-83	65°	3.45	165
10-14-83	50°	3.60	225+



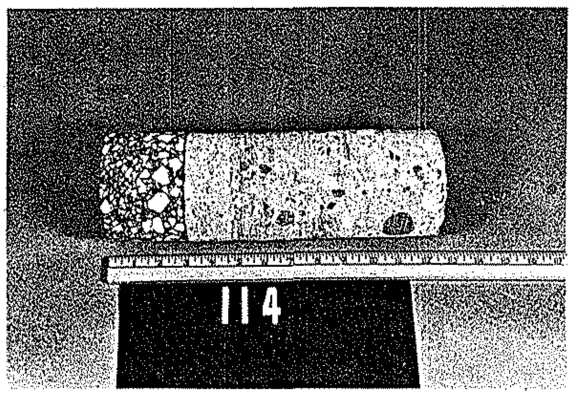
Core No.	Route	Milepost	Dir.	County
112	US 30	124.15	WB	Boone

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
6-15-83	70^o	5.00	215
10-14-83	50^o	4.10	185



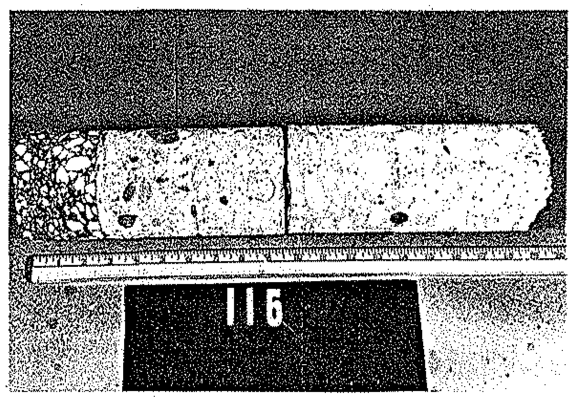
Core No.	Route	Milepost	Dir.	County
113	US 30	123.75	WB	Boone

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
6-15-83	70^o	2.85	80
10-14-83	50^o	4.85	215



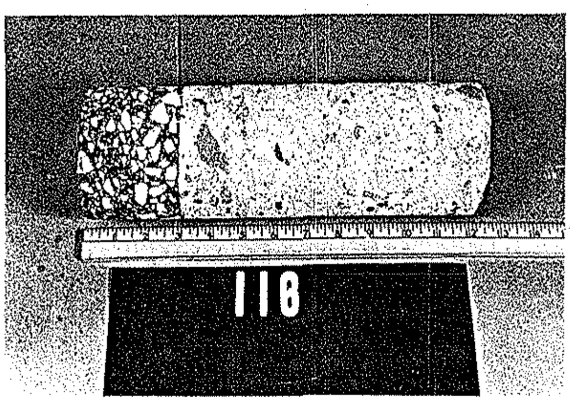
Core No.	Route	Milepost	Dir.	County
114	US 30	123.25	WB	Boone

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
6-15-83	70^o	5.00	200
10-14-83	50^o	6.00	225+



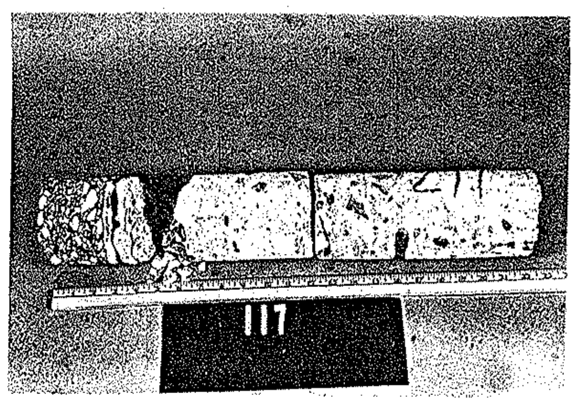
Core No.	Route	Milepost	Dir.	County
115	US 30	123.00	EB	Boone

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
6-15-83	70^o	5.00	215
10-14-83	50^o	6.20	225+



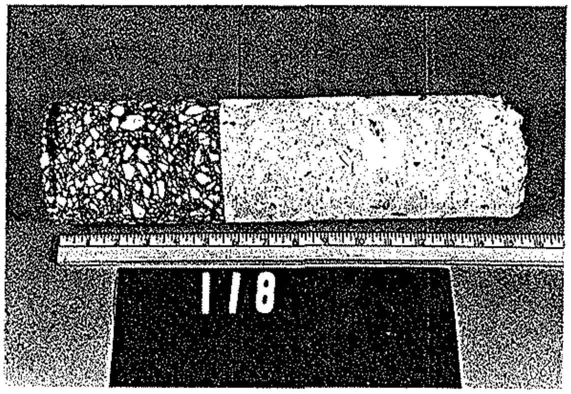
Core No.	Route	Milepost	Dir.	County
116	US 30	123.50	EB	Boone

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
6-15-83	70^o	6.30	225
10-14-83	50^o	6.50	225+



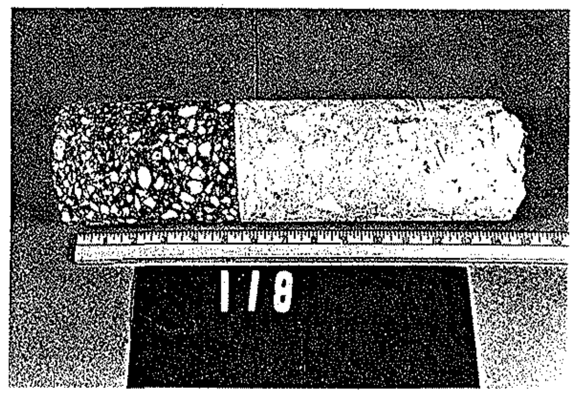
Core No.	Route	Milepost	Dir.	County
117	US 30	123.80	EB	Boone

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
6-15-83	70^o	4.85	180
10-14-83	50^o	3.35	225+



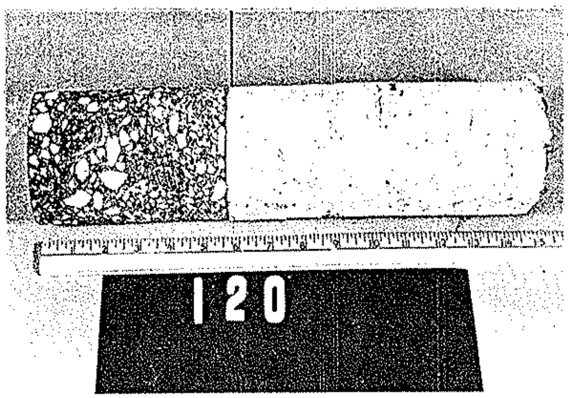
Core No.	Route	Milepost	Dir.	County
118	US 20	136.50	WB	Hamilton

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-7-83	95°	3.60	225+
10-14-83	60°	5.55	225+



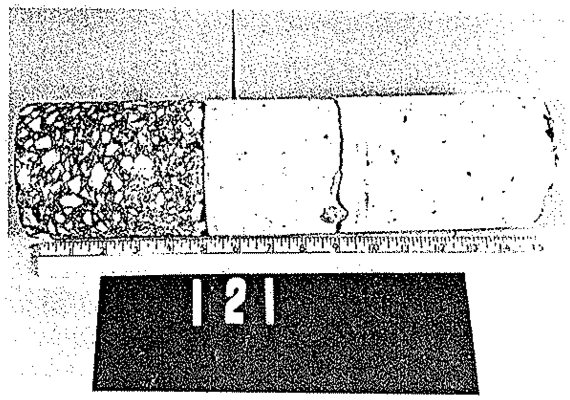
Core No.	Route	Milepost	Dir.	County
119	US 20	135.50	WB	Hamilton

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-7-83	95°	3.80	215
10-14-83	60°	4.95	215



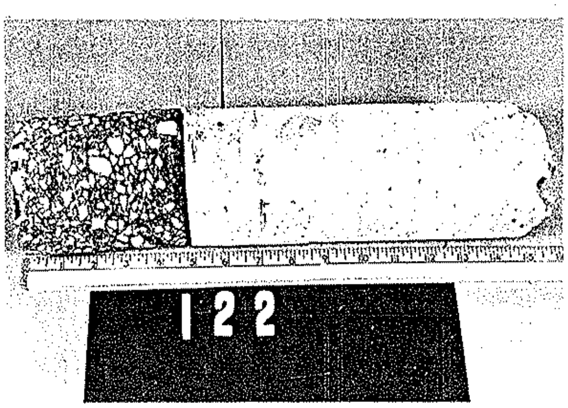
Core No.	Route	Milepost	Dir.	County
120	US 20	134.50	WB	Hamilton

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-7-83	95°	3.50	225+
10-14-83	60°	5.45	225+



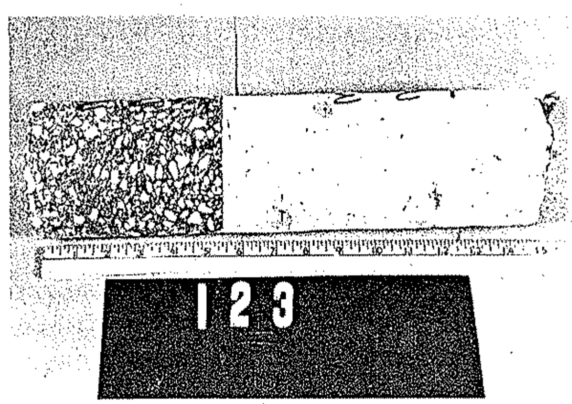
Core No.	Route	Milepost	Dir.	County
121	US 20	135.00	EB	Hamilton

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-7-83	95°	3.90	220
10-14-83	60°	4.85	215



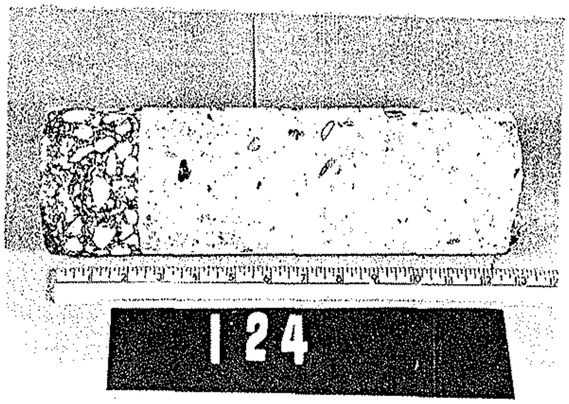
Core No.	Route	Milepost	Dir.	County
122	US 20	136.00	EB	Hamilton

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-7-83	95°	3.60	225+
10-14-83	60°	6.00	225+



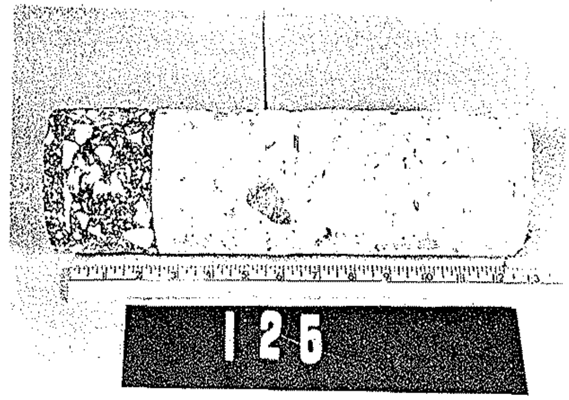
Core No.	Route	Milepost	Dir.	County
123	US 20	137.00	EB	Hamilton

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-7-83	95°	4.25	210
10-14-83	60°	5.80	225+



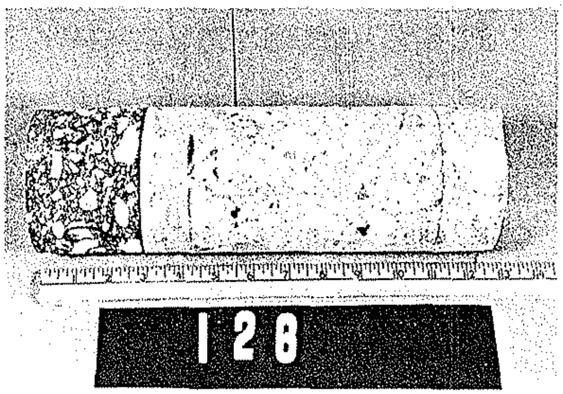
Core No.	Route	Milepost	Dir.	County
124	I-35	51.50	SB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	75°	5.70	125
10-17-83	60°	5.80	225+



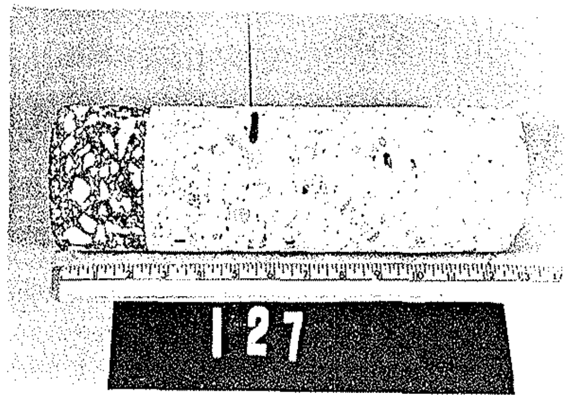
Core No.	Route	Milepost	Dir.	County
125	I-35	50.50	SB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	75°	4.55	100
10-17-83	60°	4.95	225+



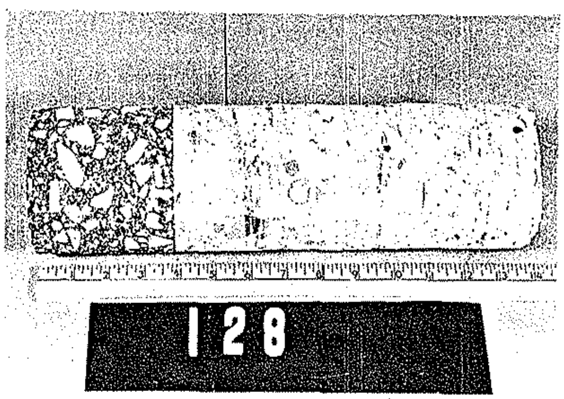
Core No.	Route	Milepost	Dir.	County
126	I-35	49.50	SB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	75°	6.30	135
10-17-83	60°	8.50	225+



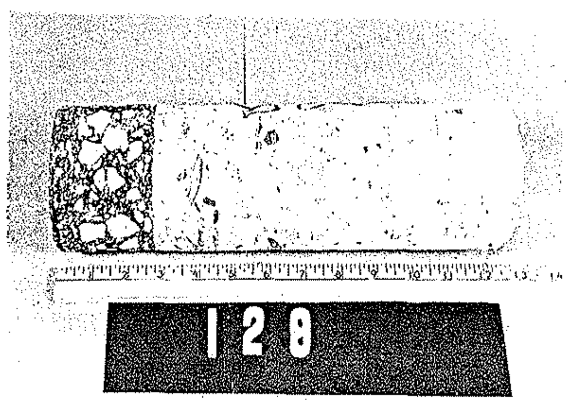
Core No.	Route	Milepost	Dir.	County
127	I-35	48.50	SB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	75°	4.95	155
10-17-83	60°	5.60	225+



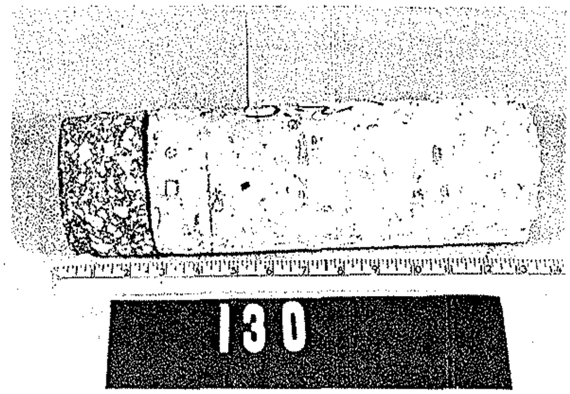
Core No.	Route	Milepost	Dir.	County
128	I-35	47.50	SB	Warren

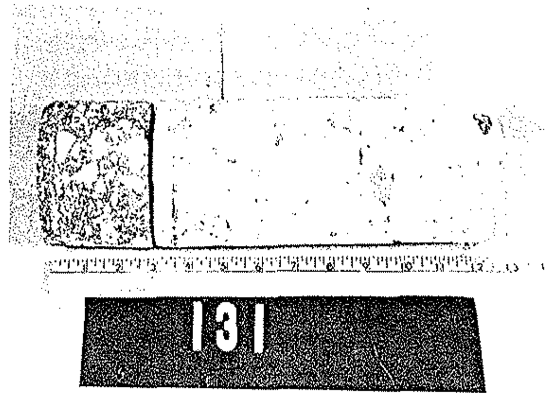
Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	75°	7.90	160
10-17-83	60°	6.60	225+



Core No.	Route	Milepost	Dir.	County
129	I-35	49.00	NB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	90°	5.10	125
10-17-83	75°	6.20	225+



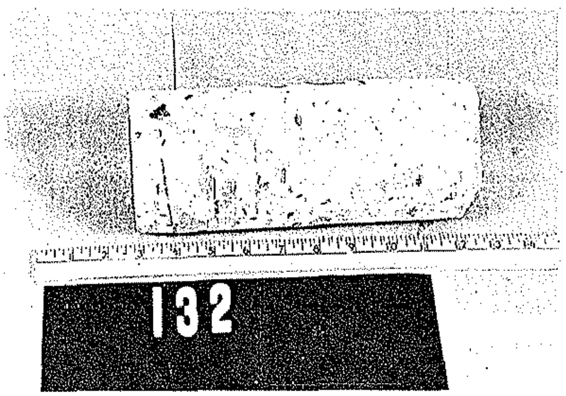


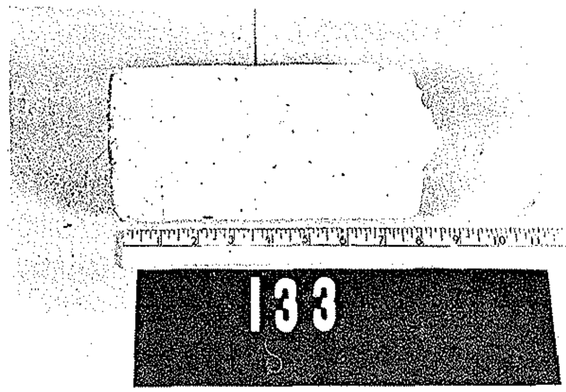
Core No.	Route	Milepost	Dir.	County
130	I-35	50.00	NB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	90°	6.35	135
10-17-83	75°	5.60	225

Core No.	Route	Milepost	Dir.	County
131	I-35	51.00	NB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	90°	6.35	135
10-17-83	75°	6.60	225+



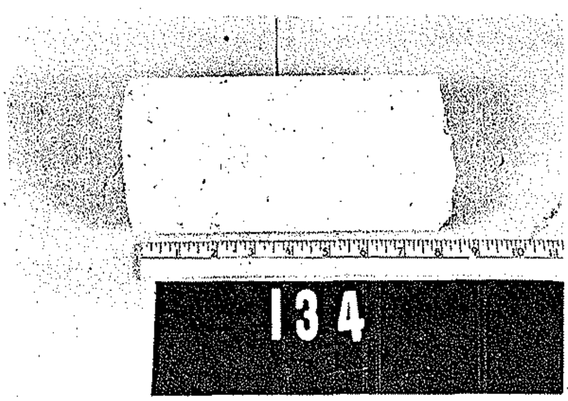


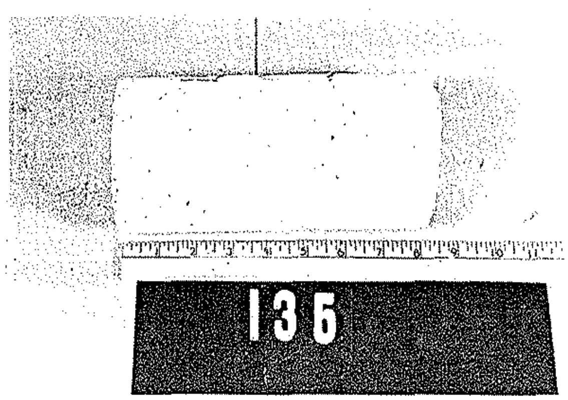
Core No.	Route	Milepost	Dir.	County
132	I-35	51.50	NB	Warren

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-16-83	Not Tested	Not Tested	Not Tested
10-17-83	75°	4.40	215

Core No.	Route	Milepost	Dir.	County
133	US 71	28.90	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	4.55	205
10-18-83	50°	3.20	185



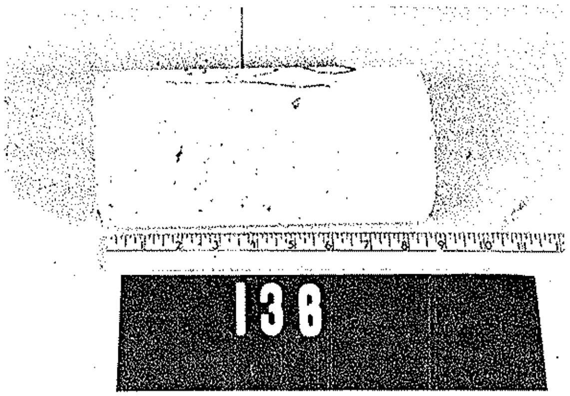


Core No.	Route	Milepost	Dir.	County
134	US 71	27.90	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	4.00	180
10-18-83	50°	4.00	225+

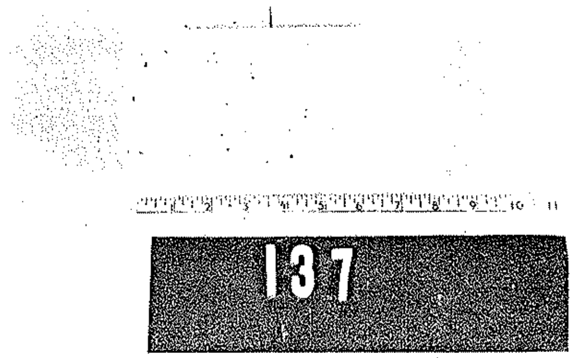
Core No.	Route	Milepost	Dir.	County
135	US 71	26.80	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	4.45	200
10-18-83	50°	3.70	195



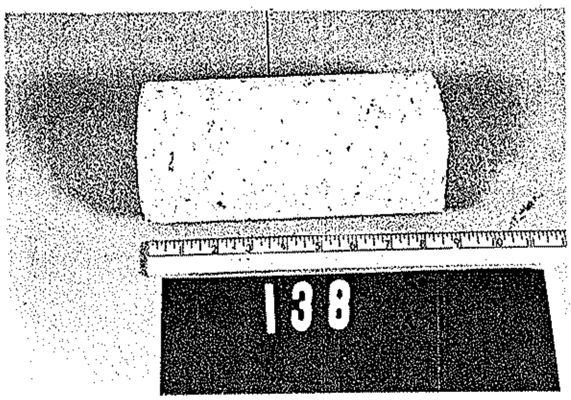
Core No.	Route	Milepost	Dir.	County
136	US 71	25.60	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	4.55	205
10-18-83	50°	4.25	220



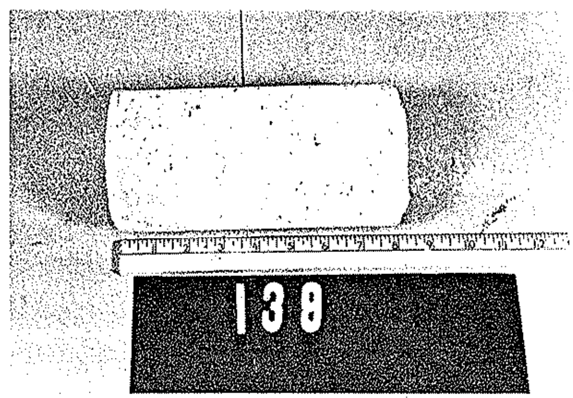
Core No.	Route	Milepost	Dir.	County
137	US 71	25.00	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	3.80	185
10-18-83	50°	3.30	195



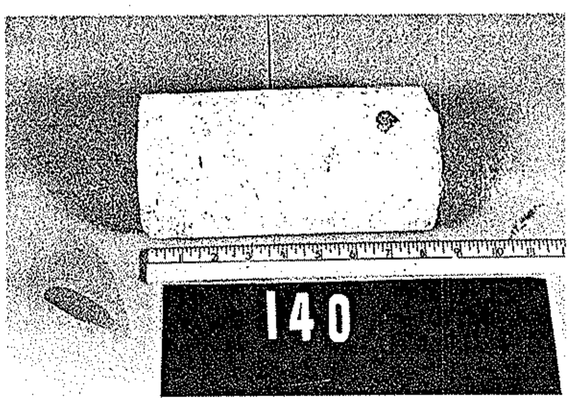
Core No.	Route	Milepost	Dir.	County
138	US 71	25.20	NB	Montomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	2.80	130
10-18-83	50°	3.60	200



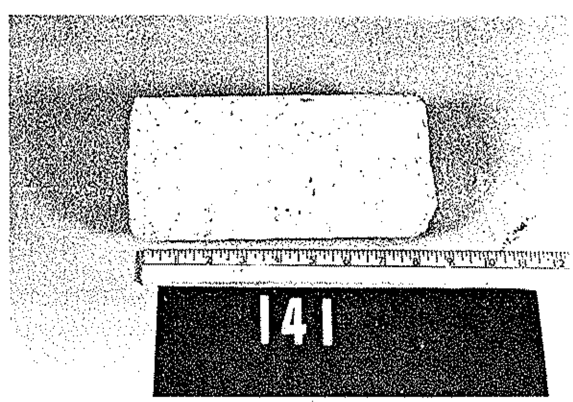
Core No.	Route	Milepost	Dir.	County
139	US 71	26.45	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	2.60	65
10-18-83	50°	3.05	185



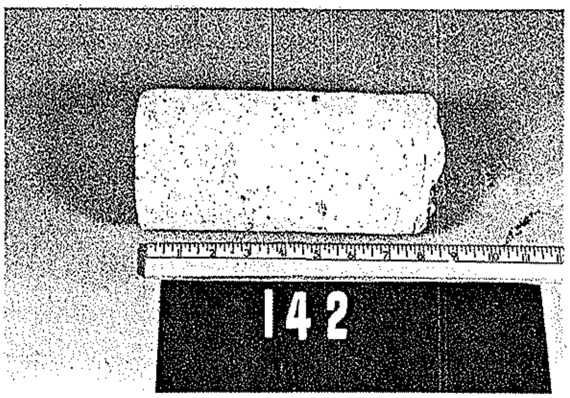
Core No.	Route	Milepost	Dir.	County
140	US 71	27.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	3.80	200
10-18-83	50°	3.70	215



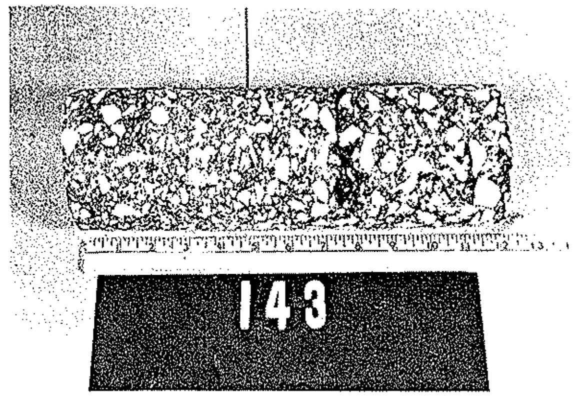
Core No.	Route	Milepost	Dir.	County
141	US 71	28.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	3.85	200
10-18-83	50°	4.10	200



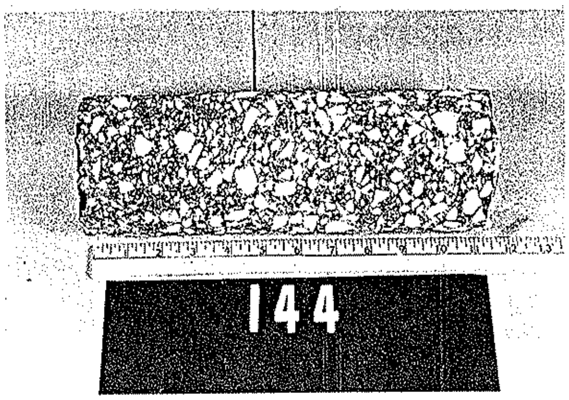
Core No.	Route	Milepost	Dir.	County
142	US 71	29.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	4.00	180
10-18-83	50°	4.00	210



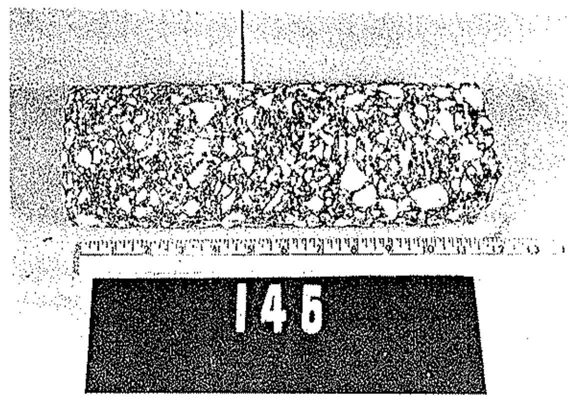
Core No.	Route	Milepost	Dir.	County
143	US 71	30.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	4.40	95
10-18-83	65°	5.10	90



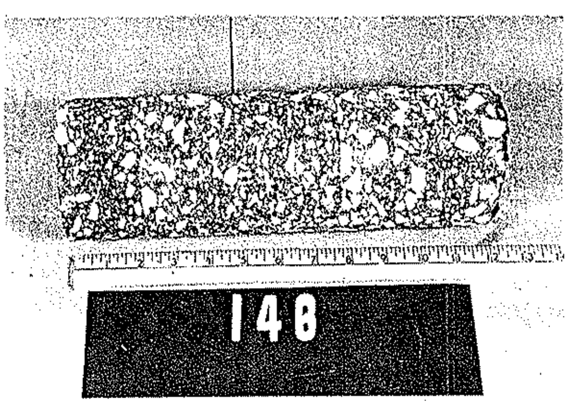
Core No.	Route	Milepost	Dir.	County
144	US 71	31.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	5.05	110
10-18-83	65°	5.50	215



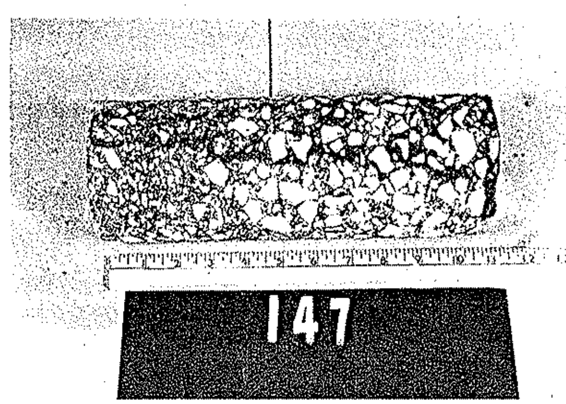
Core No.	Route	Milepost	Dir.	County
145	US 71	32.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	4.75	130
10-18-83	65°	4.95	185



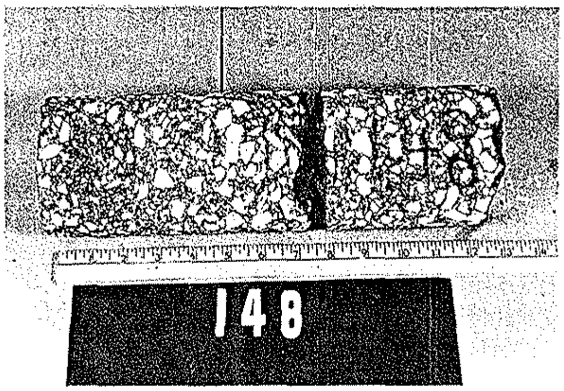
Core No.	Route	Milepost	Dir.	County
146	US 71	33.10	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	5.05	110
10-18-83	65°	7.50	230



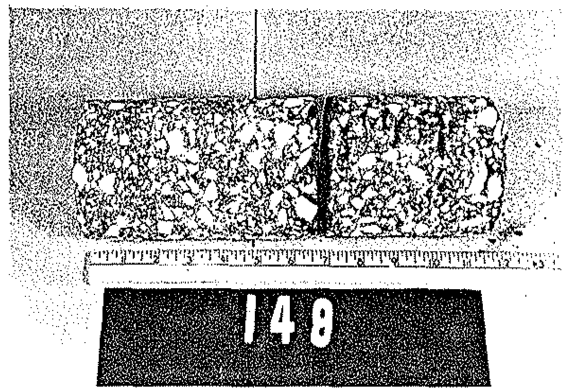
Core No.	Route	Milepost	Dir.	County
147	US 71	34.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	4.75	150
10-18-83	65°	5.50	205



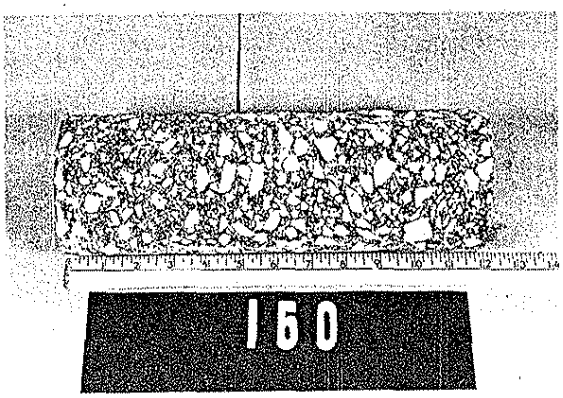
Core No.	Route	Milepost	Dir.	County
148	US 71	35.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	5.05	110
10-18-83	65°	5.50	165



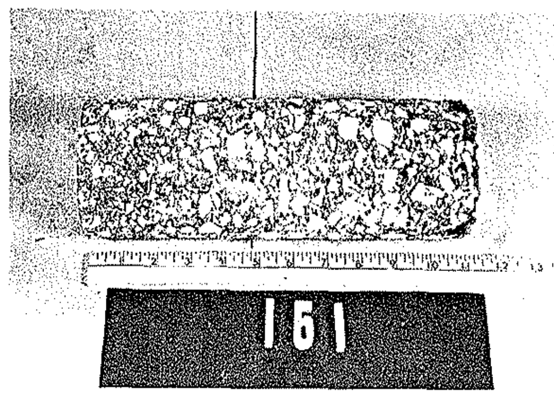
Core No.	Route	Milepost	Dir.	County
149	US 71	37.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	4.50	60
10-18-83	65°	4.60	215



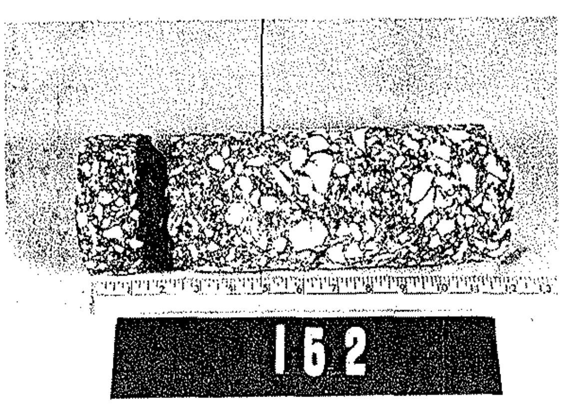
Core No.	Route	Milepost	Dir.	County
150	US 71	38.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	3.90	125
10-18-83	65°	5.35	95



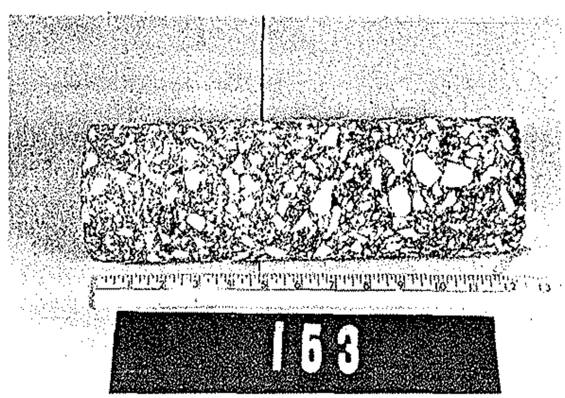
Core No.	Route	Milepost	Dir.	County
151	US 71	39.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	4.75	170
10-19-83	50°	4.70	210



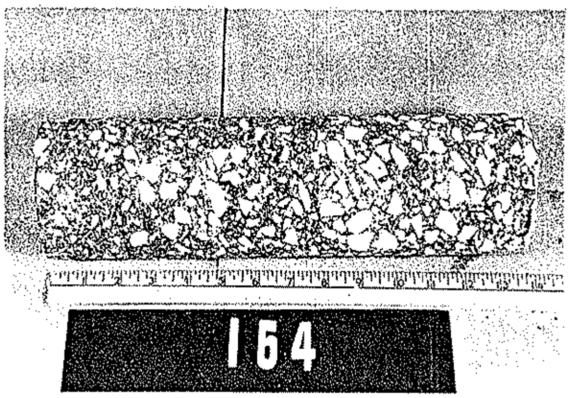
Core No.	Route	Milepost	Dir.	County
152	US 71	40.00	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	3.45	85
10-19-83	50°	4.55	220



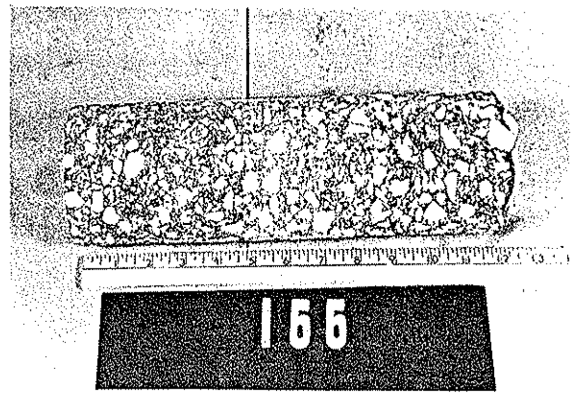
Core No.	Route	Milepost	Dir.	County
153	US 71	40.50	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	4.75	110
10-19-83	50°	3.80	195



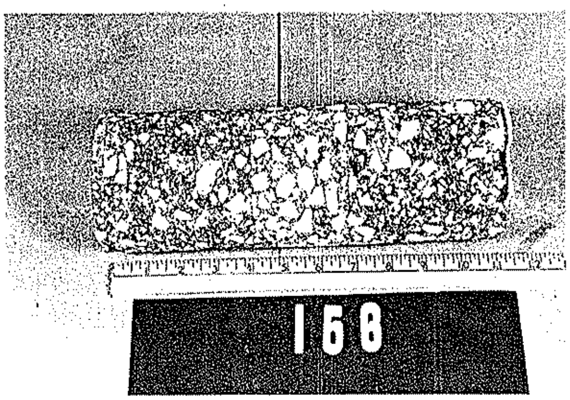
Core No.	Route	Milepost	Dir.	County
154	US 71	41.10	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	5.10	140
10-19-83	50°	6.90	235



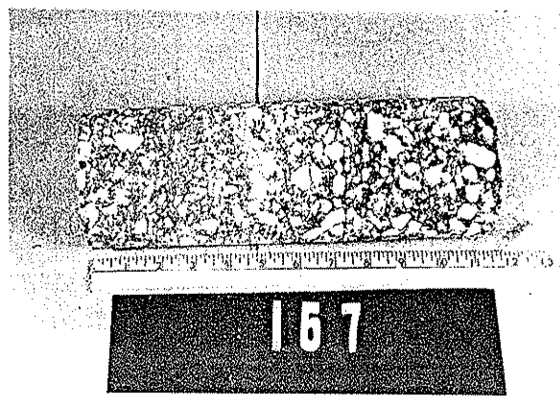
Core No.	Route	Milepost	Dir.	County
155	US 71	41.50	NB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	100°	5.90	125
10-19-83	50°	5.30	230



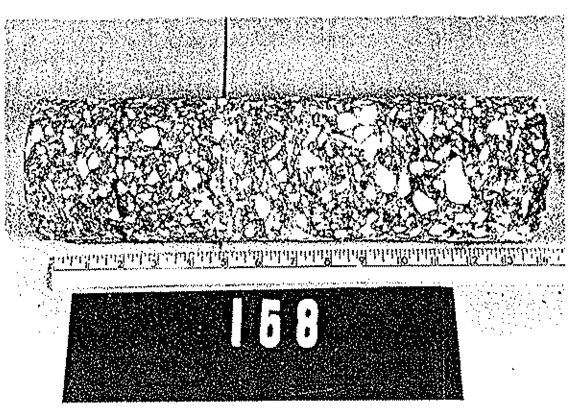
Core No.	Route	Milepost	Dir.	County
156	US 71	40.30	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	4.95	95
10-19-83	50°	4.70	210



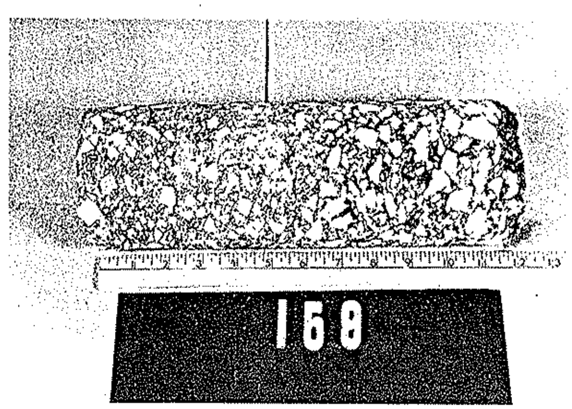
Core No.	Route	Milepost	Dir.	County
157	US 71	39.80	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	3.30	110
10-19-83	50°	5.30	100



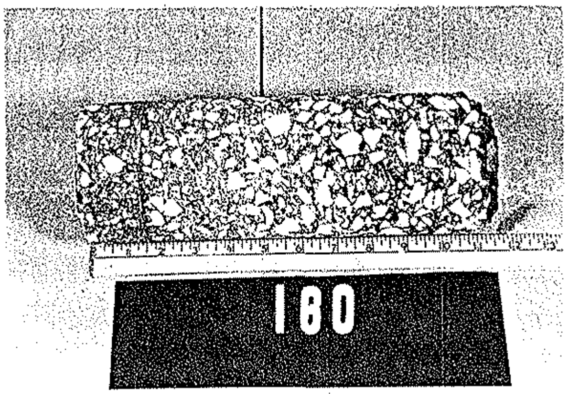
Core No.	Route	Milepost	Dir.	County
158	US 71	39.20	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	Not Tested	Not Tested	Not Tested
10-19-83	50°	6.00	245



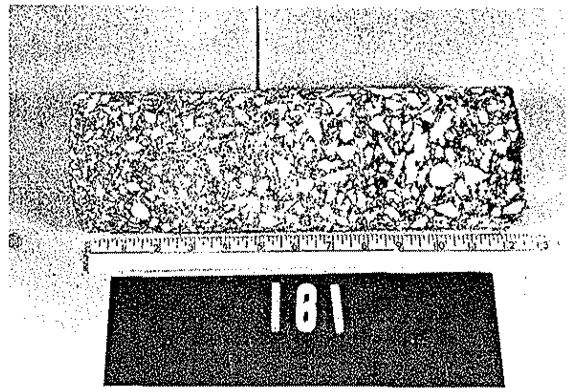
Core No.	Route	Milepost	Dir.	County
159	US 71	38.80	SB	Montgomery

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-26-83	90°	3.55	105
10-19-83	50°	4.40	230



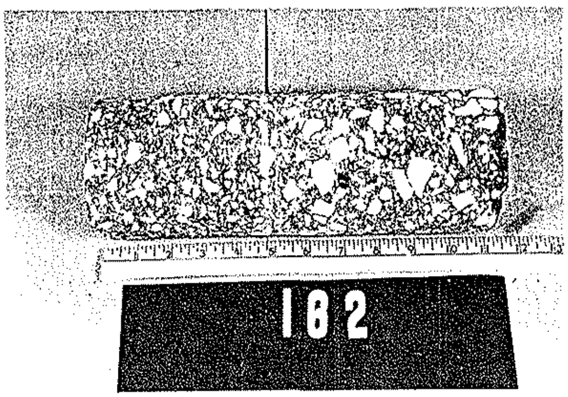
Core No.	Route	Milepost	Dir.	County
160	US 71	37.50	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	5.20	155
10-19-83	50^{o}	3.60	200



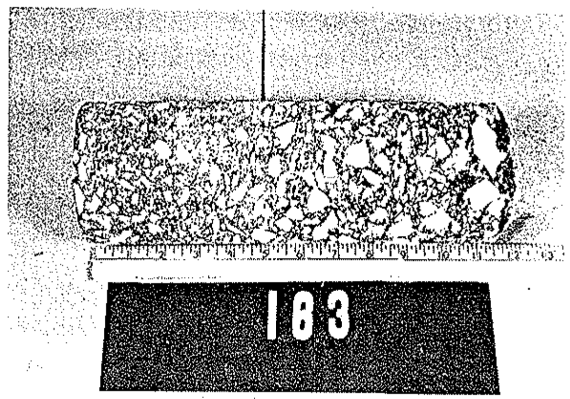
Core No.	Route	Milepost	Dir.	County
161	US 71	36.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	4.30	80
10-19-83	50^{o}	4.80	215



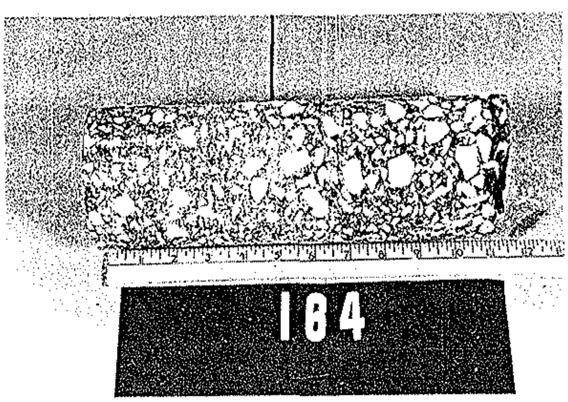
Core No.	Route	Milepost	Dir.	County
162	US 71	35.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	3.30	95
10-19-83	50^{o}	3.80	205



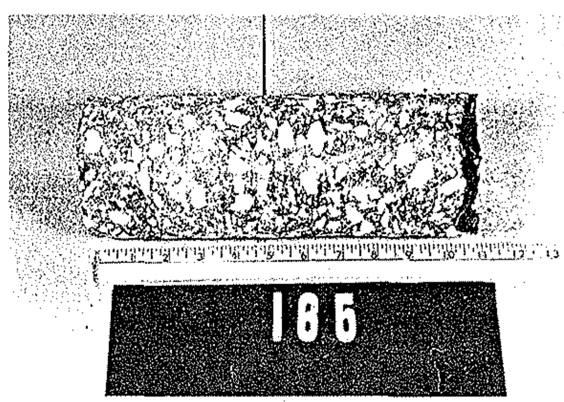
Core No.	Route	Milepost	Dir.	County
163	US 71	34.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	4.60	155
10-19-83	50^{o}	4.80	215



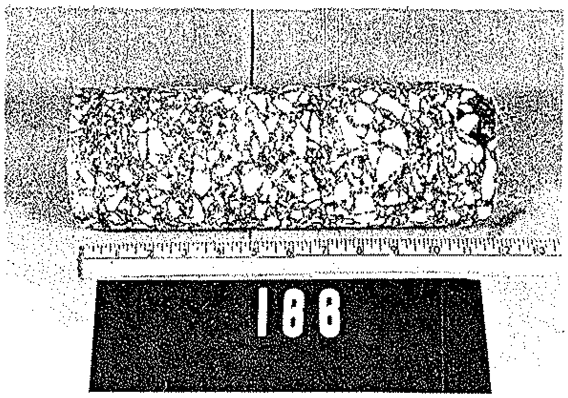
Core No.	Route	Milepost	Dir.	County
164	US 71	33.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	5.40	150
10-19-83	50^{o}	5.60	250



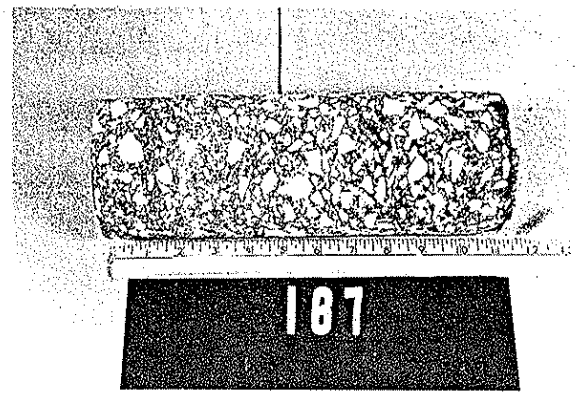
Core No.	Route	Milepost	Dir.	County
165	US 71	32.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	6.90	200
10-19-83	50^{o}	6.40	230



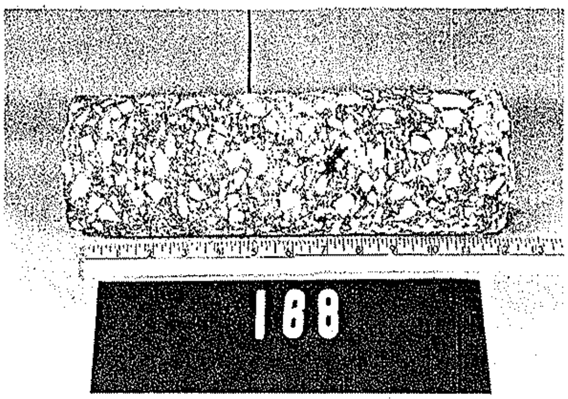
Core No.	Route	Milepost	Dir.	County
166	US 71	31.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	6.25	160
10-19-83	50^{o}	6.00	235



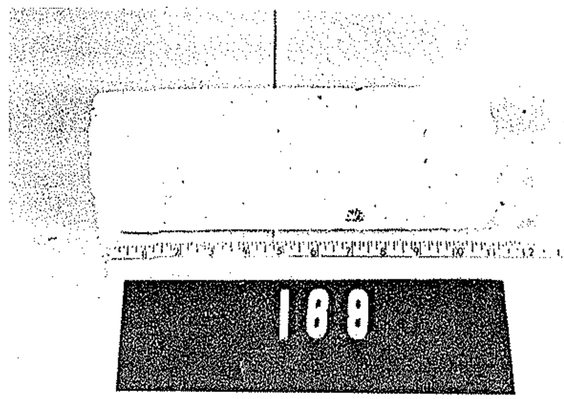
Core No.	Route	Milepost	Dir.	County
167	US 71	30.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	4.05	125
10-19-83	50^{o}	4.25	165



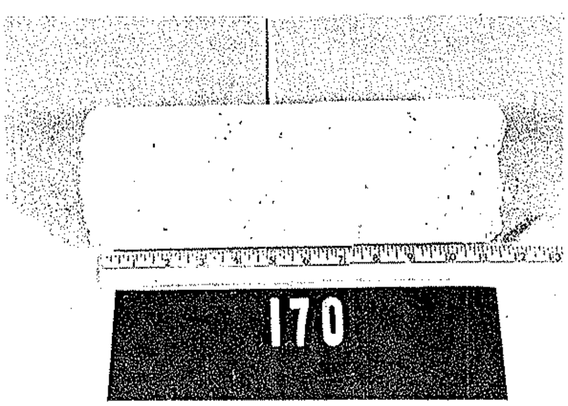
Core No.	Route	Milepost	Dir.	County
168	US 71	29.80	SB	Montgomery

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
5-26-83	90^{o}	4.60	135
10-19-83	50^{o}	5.20	230



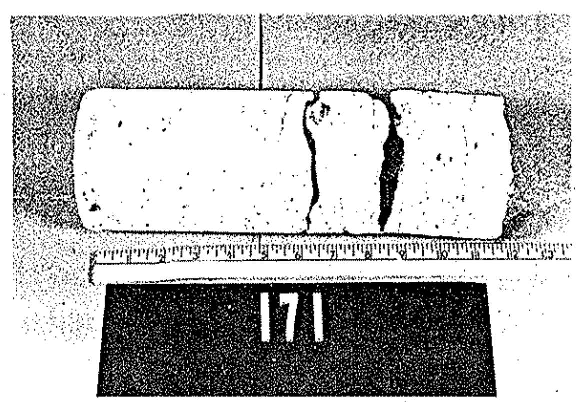
Core No.	Route	Milepost	Dir.	County
169	I-80	35.40	EB	Pottawattamie

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
3-2-83	60^{o}	4.40	185
10-20-83	45^{o}	3.85	215



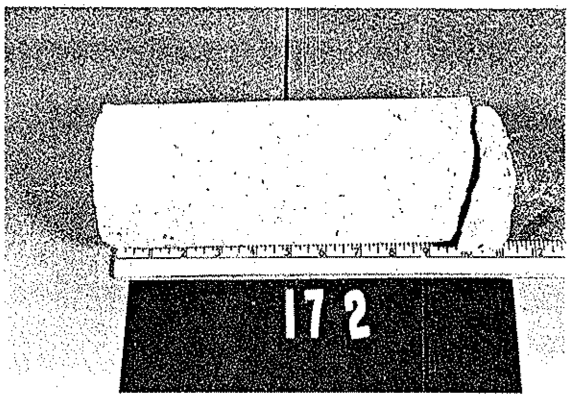
Core No.	Route	Milepost	Dir.	County
170	I-80	36.00	EB	Pottawattamie

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
3-2-83	60^{o}	5.50	215
10-20-83	45^{o}	4.55	225+



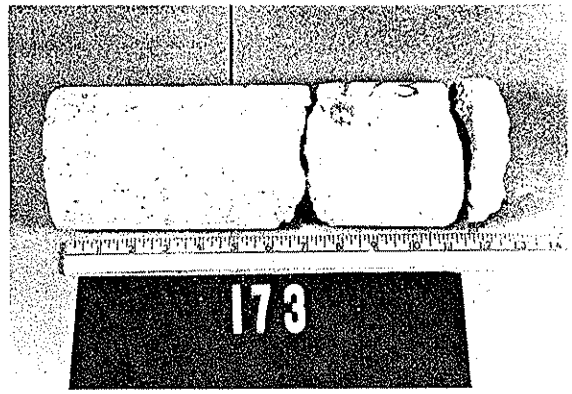
Core No.	Route	Milepost	Dir.	County
171	I-80	36.60	EB	Pottawattamie

Date Tested	Pave. Temp ^{O}F	Struct. Rating	Soil Support K Value
3-2-83	60^{o}	3.80	185
10-20-83	45^{o}	3.05	200



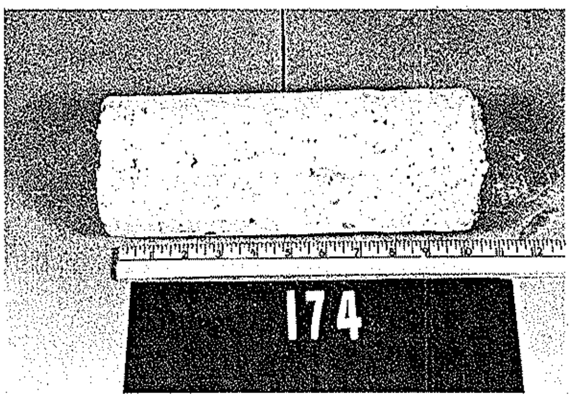
Core No.	Route	Milepost	Dir.	County
172	I-80	37.20	EB	Pottawattamie

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
3-2-83	60^o	3.80	185
10-20-83	45^o	3.50	200



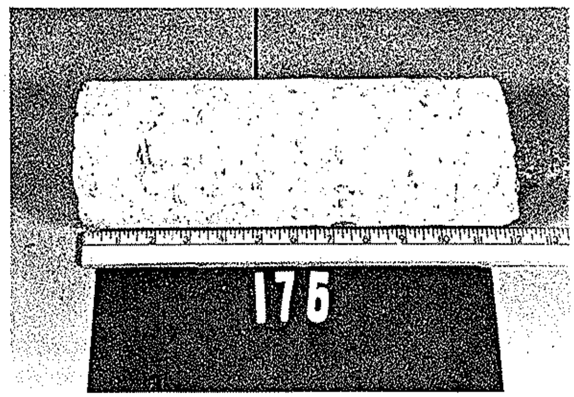
Core No.	Route	Milepost	Dir.	County
173	I-80	37.50	EB	Pottawattamie

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
3-2-83	60^o	4.40	130
10-20-83	45^o	3.10	220



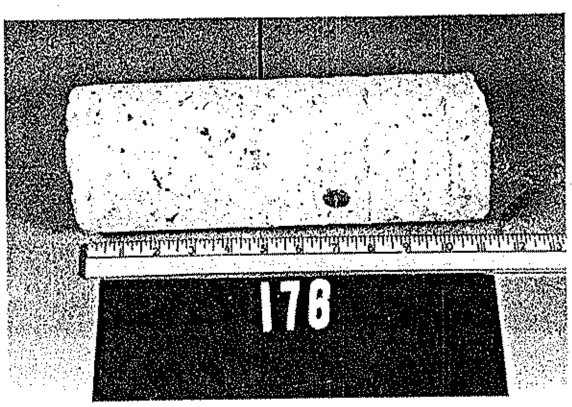
Core No.	Route	Milepost	Dir.	County
174	I-80	37.80	EB	Pottawattamie

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
3-2-83	60^o	4.00	180
10-20-83	45^o	3.60	190



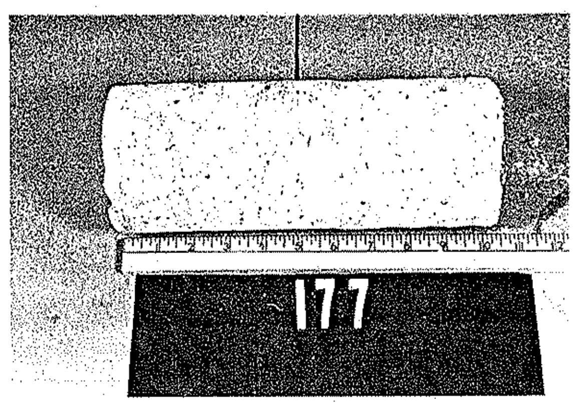
Core No.	Route	Milepost	Dir.	County
175	I-80	38.00	EB	Pottawattamie

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
3-2-83	60^o	4.70	195
10-20-83	45^o	4.55	205



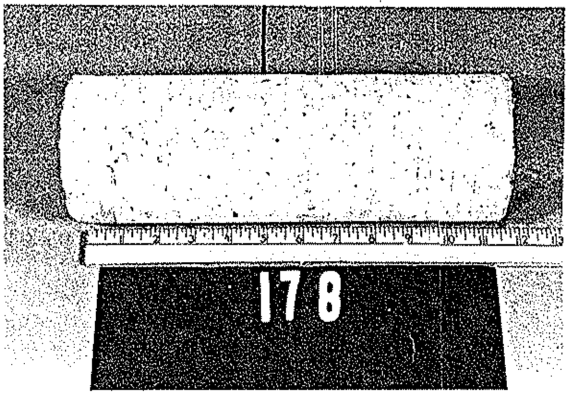
Core No.	Route	Milepost	Dir.	County
176	I-80	38.20	EB	Pottawattamie

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
3-2-83	60^o	3.85	150
10-20-83	45^o	3.70	215



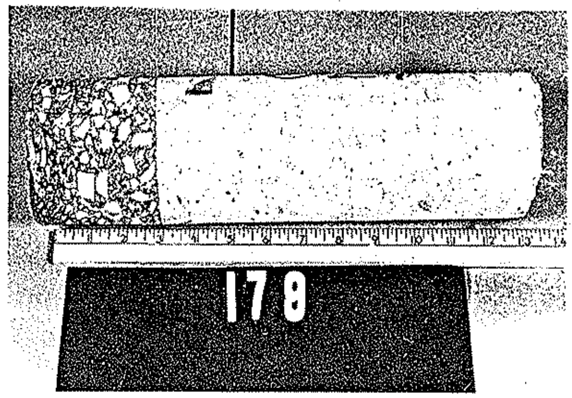
Core No.	Route	Milepost	Dir.	County
177	I-80	38.60	EB	Pottawattamie

Date Tested	Pave. Temp ^oF	Struct. Rating	Soil Support K Value
3-2-83	60^o	5.10	160
10-20-83	45^o	5.30	225



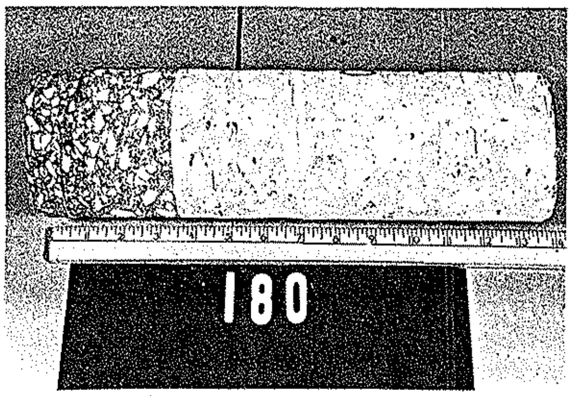
Core No.	Route	Milepost	Dir.	County
178	I-80	39.00	EB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
3-2-83	60°	5.00	180
10-20-83	45°	5.10	205



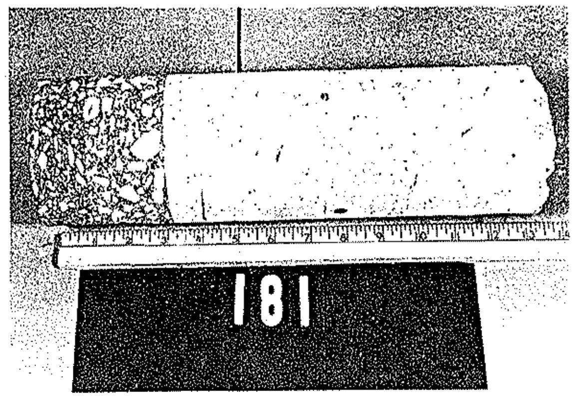
Core No.	Route	Milepost	Dir.	County
179	I-29	67.20	NB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	6.05	220
10-20-83	55°	7.65	225+



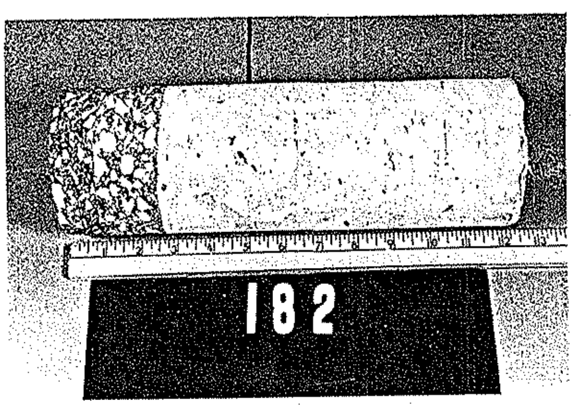
Core No.	Route	Milepost	Dir.	County
180	I-29	68.40	NB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	5.70	200
10-20-83	55°	6.35	225+



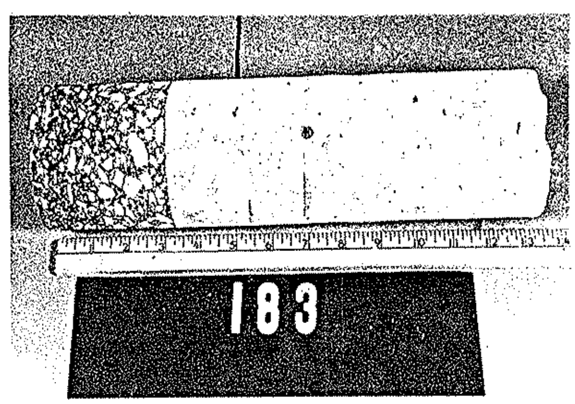
Core No.	Route	Milepost	Dir.	County
181	I-29	69.60	NB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	5.50	220
10-20-83	55°	6.10	225+



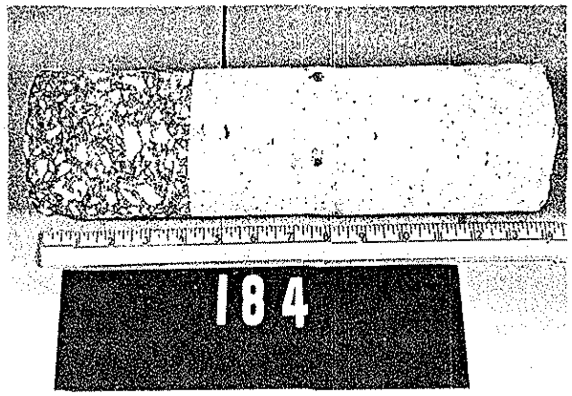
Core No.	Route	Milepost	Dir.	County
182	I-29	72.10	SB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	4.00	180
10-21-83	50°	5.80	225+



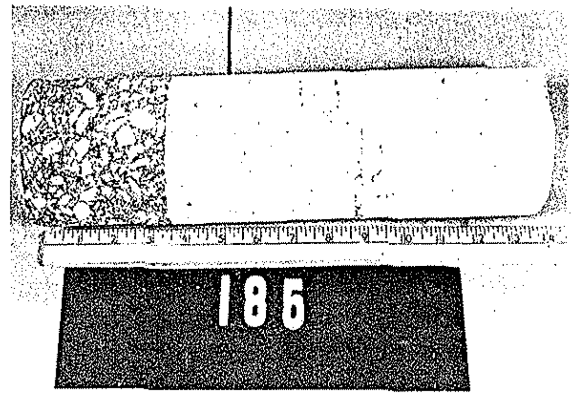
Core No.	Route	Milepost	Dir.	County
183	I-29	71.30	SB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	4.30	195
10-21-83	50°	4.20	225+



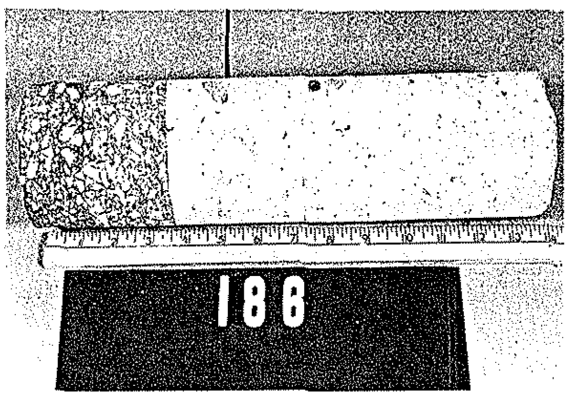
Core No.	Route	Milepost	Dir.	County
184	I-29	70.20	SB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	5.75	215
10-21-83	50°	4.40	225



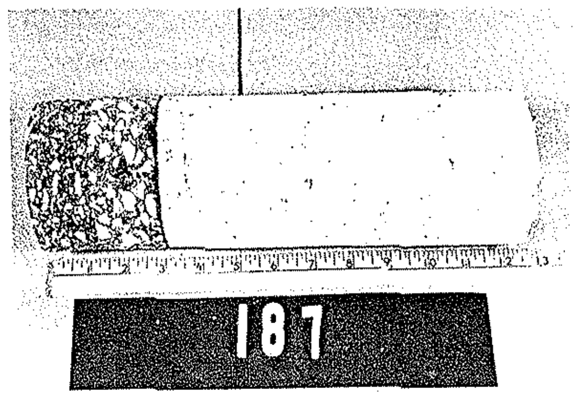
Core No.	Route	Milepost	Dir.	County
185	I-29	69.00	SB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	6.75	210
10-21-83	50°	6.65	225+



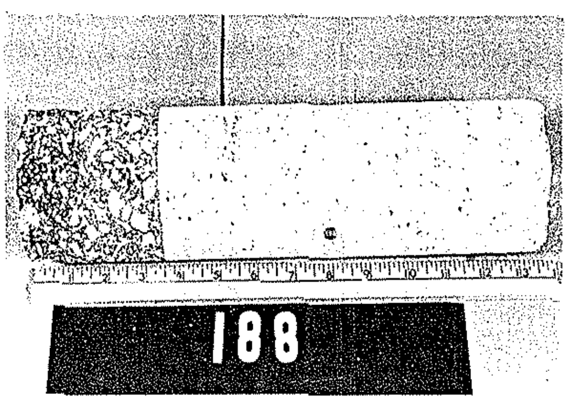
Core No.	Route	Milepost	Dir.	County
186	I-29	67.80	SB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	5.50	200
10-21-83	50°	4.70	225+



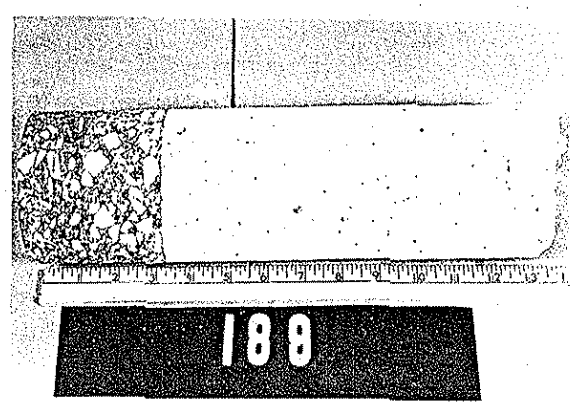
Core No.	Route	Milepost	Dir.	County
187	I-29	67.00	SB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	6.35	205
10-21-83	50°	4.85	225+



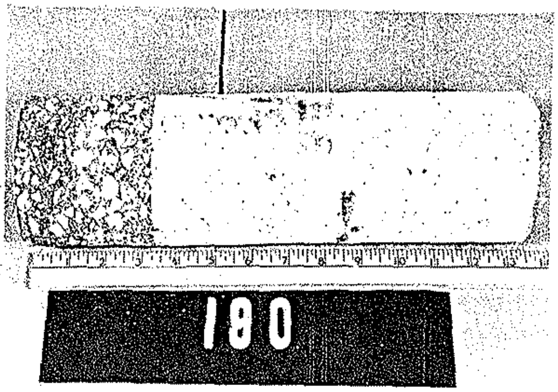
Core No.	Route	Milepost	Dir.	County
188	I-29	70.40	NB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	5.00	180
10-21-83	50°	4.85	225



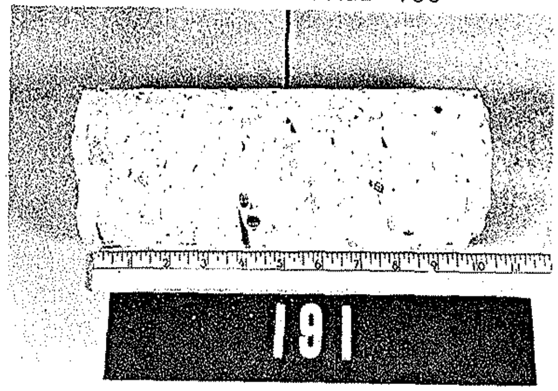
Core No.	Route	Milepost	Dir.	County
189	I-29	71.20	NB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	4.70	175
10-21-83	50°	5.45	225+



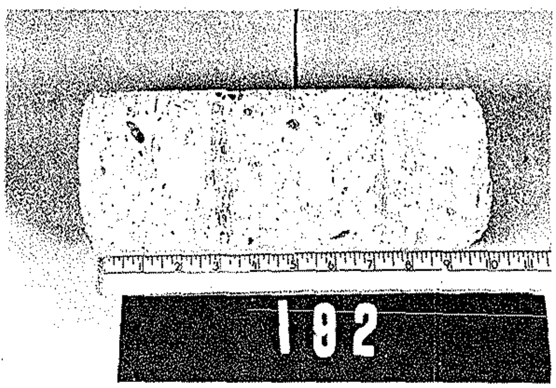
Core No.	Route	Milepost	Dir.	County
190	I-29	71.70	NB	Pottawattamie

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-2-83	75°	5.00	200
10-21-83	50°	4.40	215



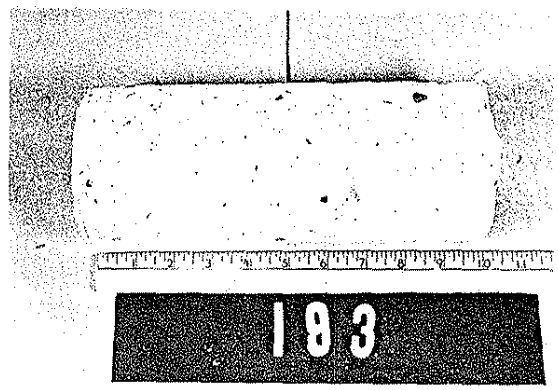
Core No.	Route	Milepost	Dir.	County
191	I-29	127.00	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.10	145
10-24-83	50°	4.85	225+



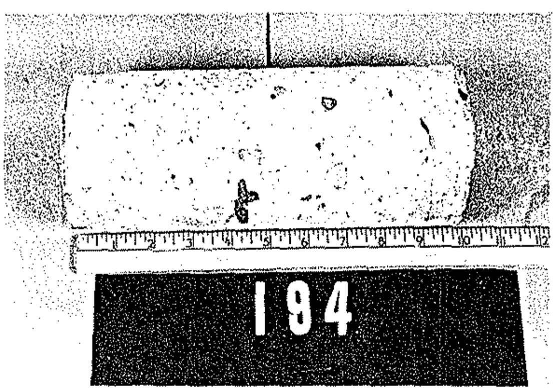
Core No.	Route	Milepost	Dir.	County
192	I-29	128.00	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.30	150
10-24-83	50°	4.70	225+



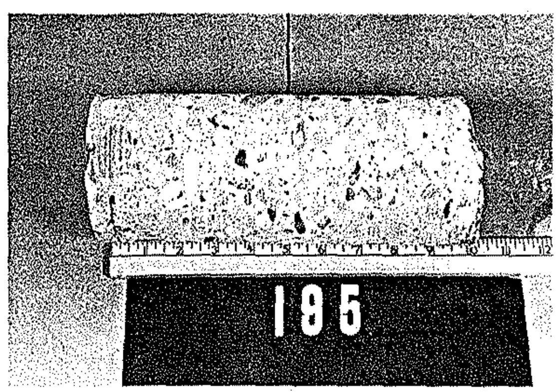
Core No.	Route	Milepost	Dir.	County
193	I-29	129.00	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	5.10	225+
10-24-83	50°	5.40	225+



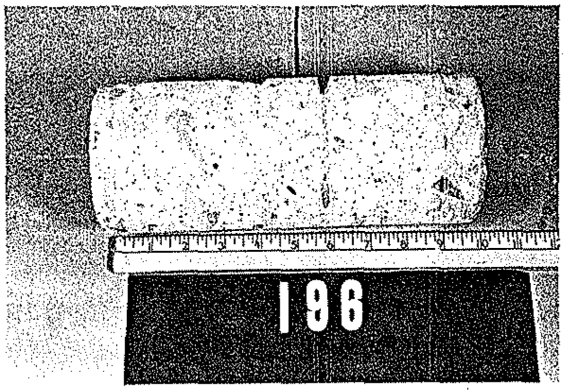
Core No.	Route	Milepost	Dir.	County
194	I-29	130.00	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.00	140
10-24-83	50°	4.25	225+



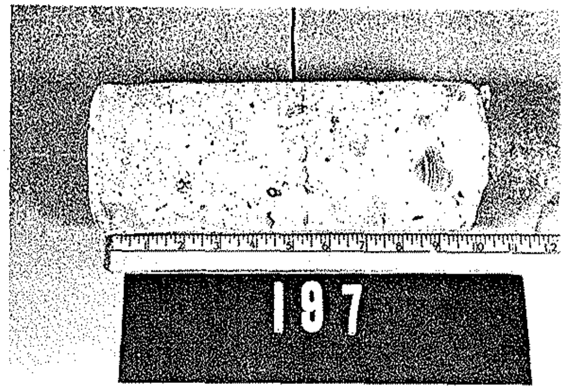
Core No.	Route	Milepost	Dir.	County
195	I-29	131.00	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.95	155
10-24-83	50°	5.10	205



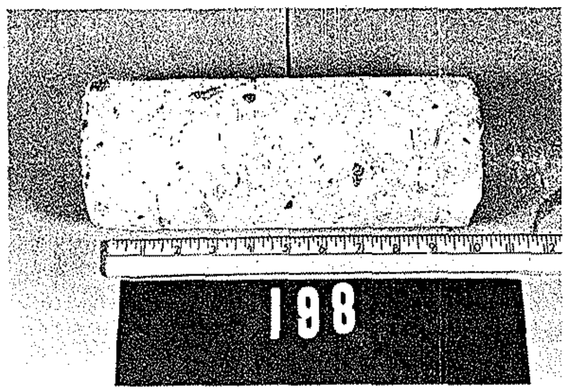
Core No.	Route	Milepost	Dir.	County
196	I-29	132.00	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.55	185
10-25-83	40°	3.85	225



Core No.	Route	Milepost	Dir.	County
197	I-29	132.80	NB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.90	180
10-25-83	40°	3.70	215

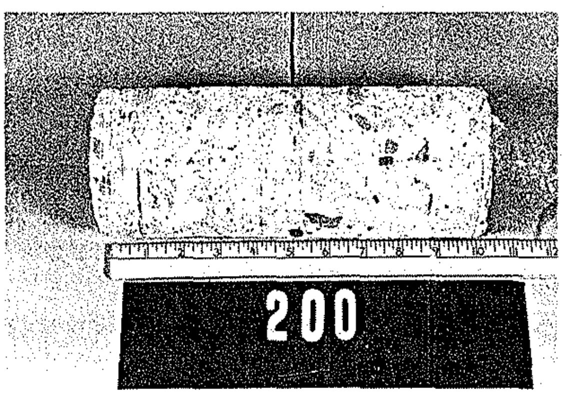


Core No.	Route	Milepost	Dir.	County
198	I-29	133.30	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.95	180
10-25-83	40°	4.40	215

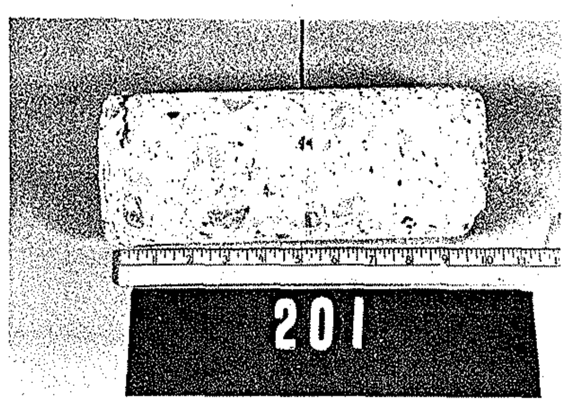
Core No.	Route	Milepost	Dir.	County
199	I-29	132.90	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.90	180
10-25-83	40°	4.40	215



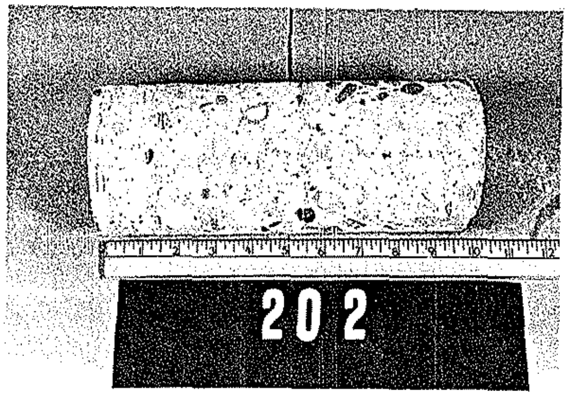
Core No.	Route	Milepost	Dir.	County
200	I-29	132.25	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	5.50	205
10-25-83	40°	3.90	220



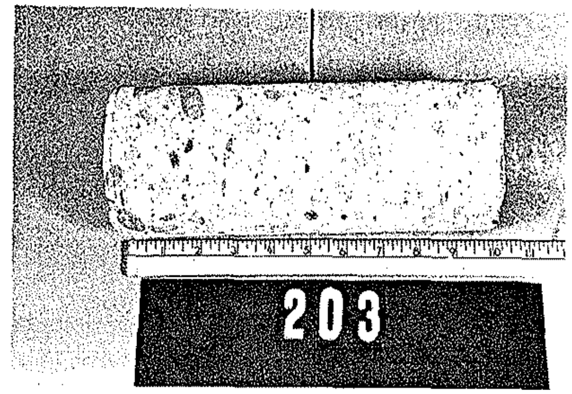
Core No.	Route	Milepost	Dir.	County
201	I-29	131.25	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	5.10	205
10-25-83	40°	4.85	225



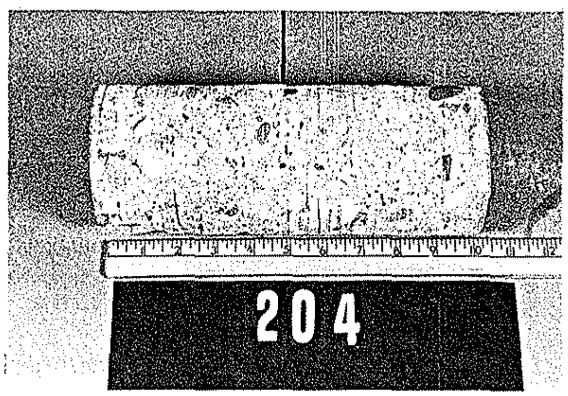
Core No.	Route	Milepost	Dir.	County
202	I-29	130.25	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.70	180
10-25-83	40°	4.70	225+



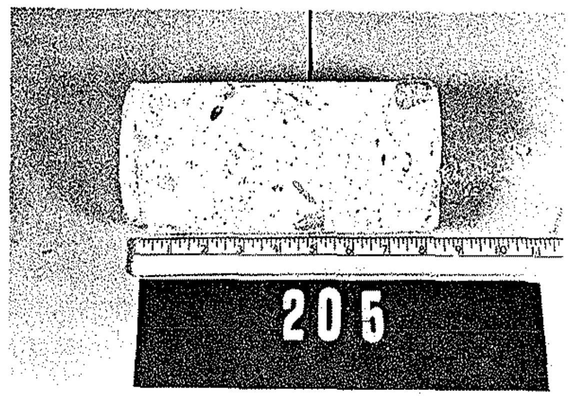
Core No.	Route	Milepost	Dir.	County
203	I-29	129.25	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.20	175
10-25-83	40°	4.55	225+



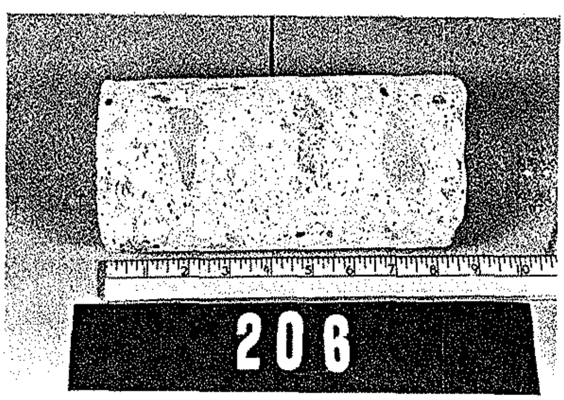
Core No.	Route	Milepost	Dir.	County
204	I-29	128.25	SB	Woodbury

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
6-29-83	75°	4.70	190
10-25-83	40°	5.40	215



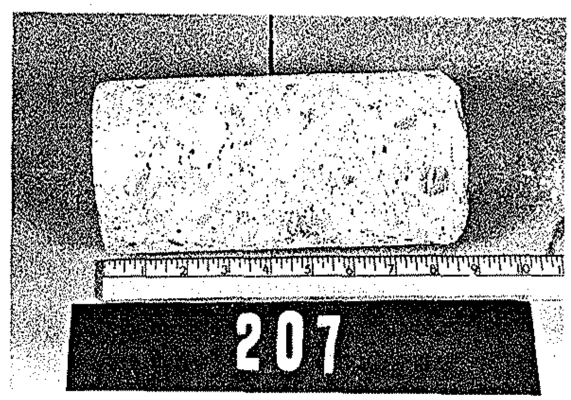
Core No.	Route	Milepost	Dir.	County
205	IA 3	70.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.40	195
10-25-83	60°	3.45	225



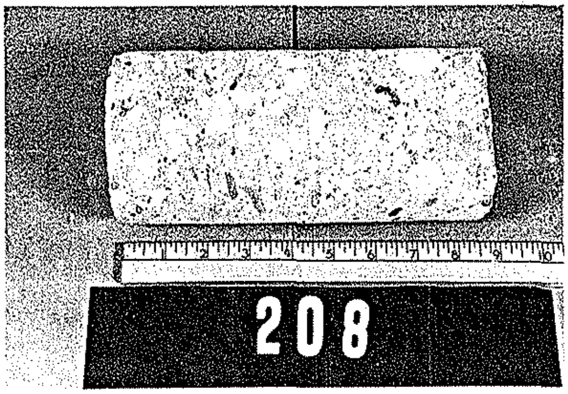
Core No.	Route	Milepost	Dir.	County
206	IA 3	72.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.10	170
10-25-83	60°	3.50	220



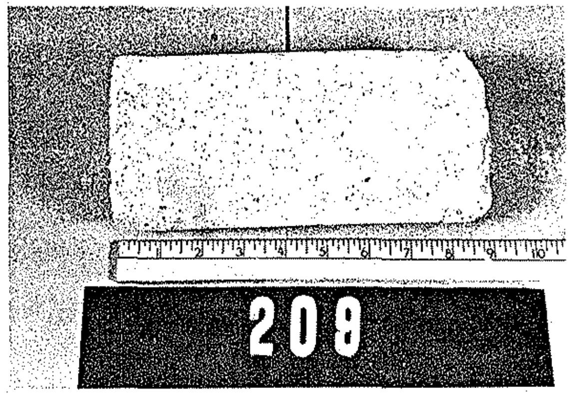
Core No.	Route	Milepost	Dir.	County
207	IA 3	73.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.50	170
10-25-83	60°	3.45	225



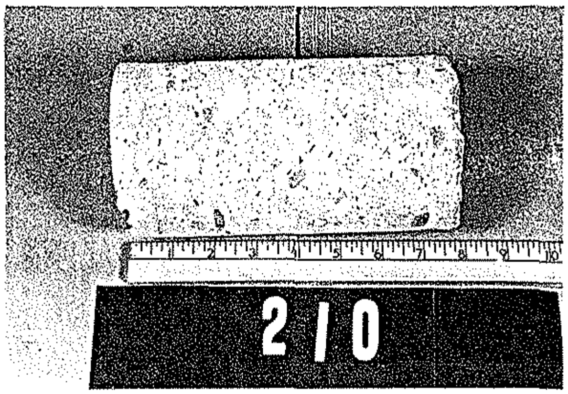
Core No.	Route	Milepost	Dir.	County
208	IA 3	74.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	2.30	80
10-25-83	60°	3.75	210



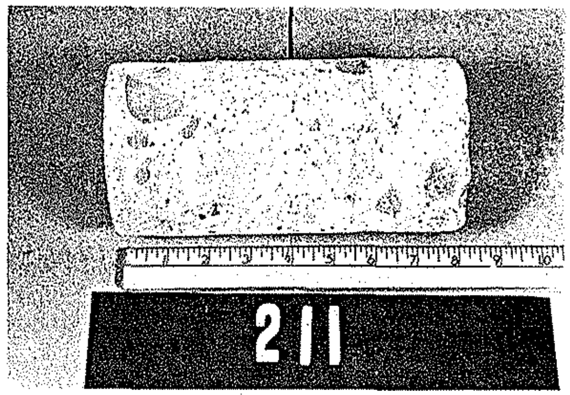
Core No.	Route	Milepost	Dir.	County
209	IA 3	75.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	2.60	190
10-25-83	60°	3.40	210



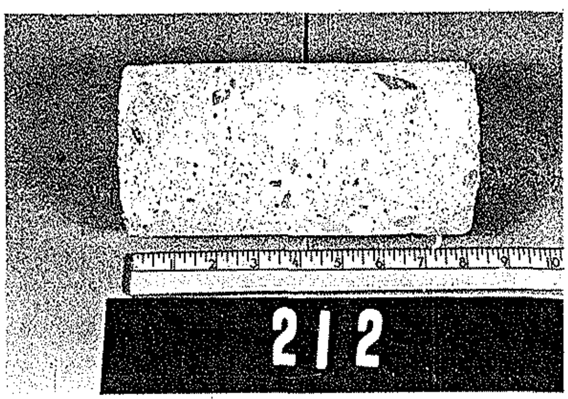
Core No.	Route	Milepost	Dir.	County
210	IA 3	77.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	2.90	180
10-25-83	60°	2.80	185



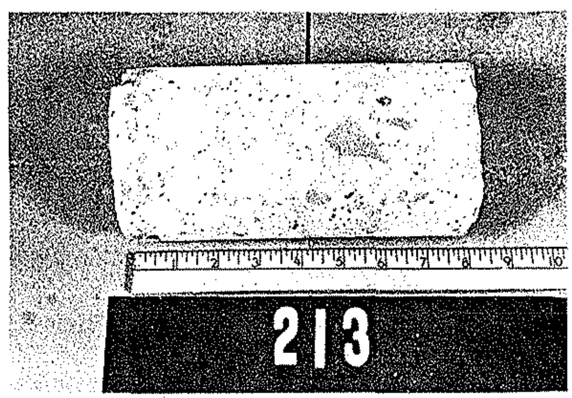
Core No.	Route	Milepost	Dir.	County
211	IA 3	78.50	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.60	200
10-25-83	60°	3.45	215



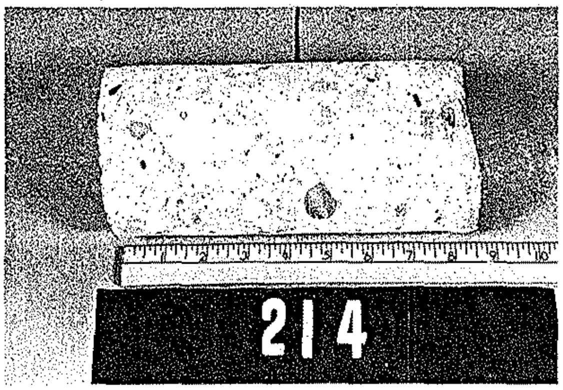
Core No.	Route	Milepost	Dir.	County
212	IA 3	79.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.60	200
10-25-83	60°	3.25	225



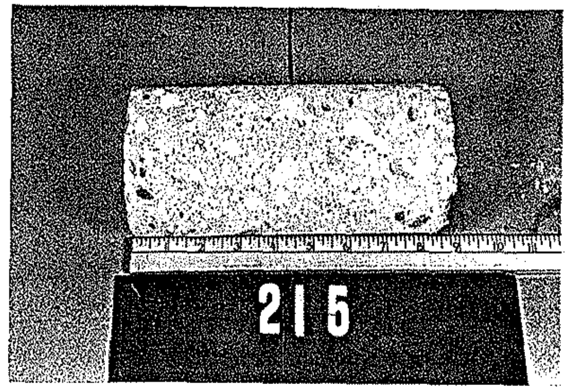
Core No.	Route	Milepost	Dir.	County
213	IA 3	79.50	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.40	190
10-25-83	60°	3.45	205



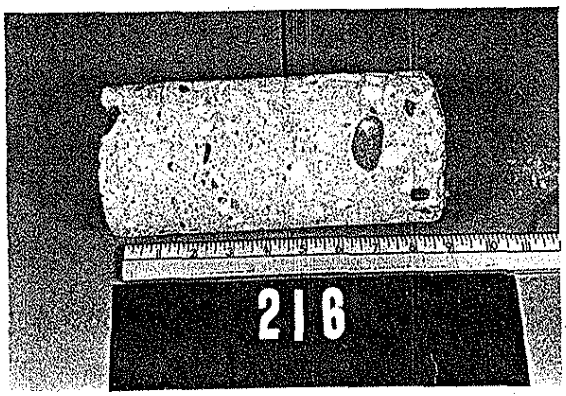
Core No.	Route	Milepost	Dir.	County
214	IA 3	80.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.60	215
10-25-83	60°	3.75	225+



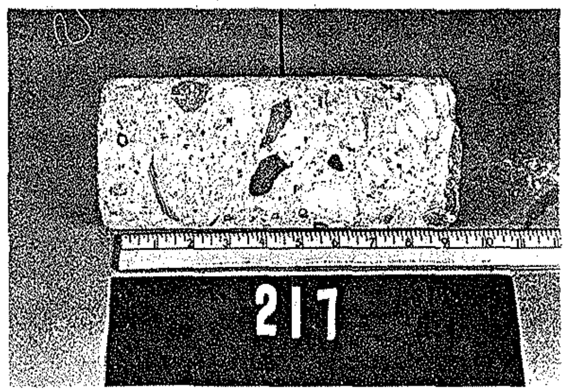
Core No.	Route	Milepost	Dir.	County
215	IA 3	80.50	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	2.90	125
10-25-83	60°	2.80	200



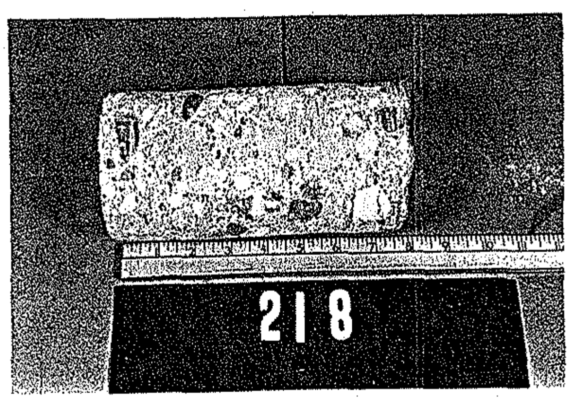
Core No.	Route	Milepost	Dir.	County
216	IA 3	81.00	EB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.60	200
10-25-83	60°	3.60	225



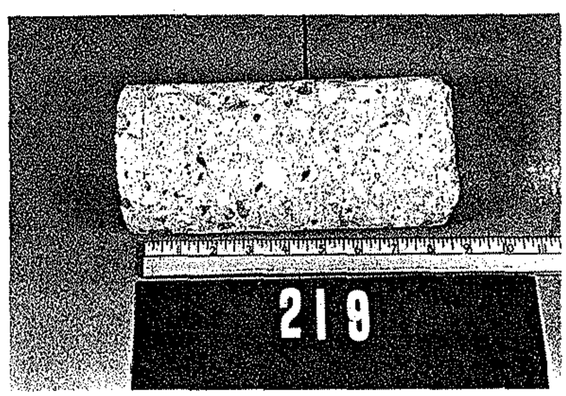
Core No.	Route	Milepost	Dir.	County
217	IA 3	81.30	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	4.25	210
10-25-83	60°	4.30	225



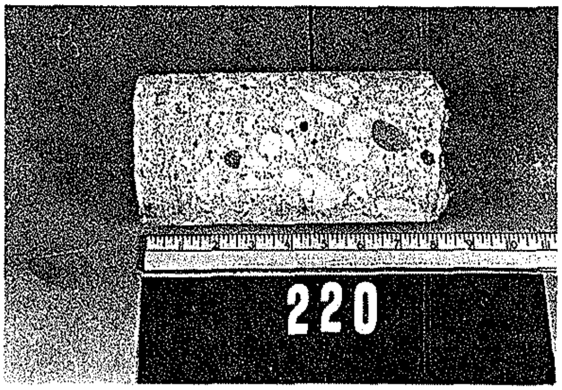
Core No.	Route	Milepost	Dir.	County
218	IA 3	80.80	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	2.90	125
10-25-83	60°	2.90	220



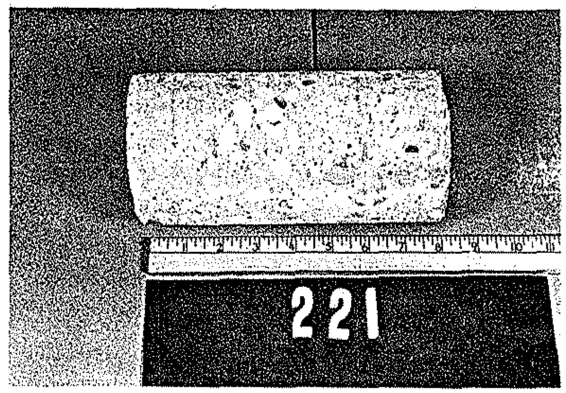
Core No.	Route	Milepost	Dir.	County
219	IA 3	80.30	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.50	185
10-25-83	60°	3.60	225



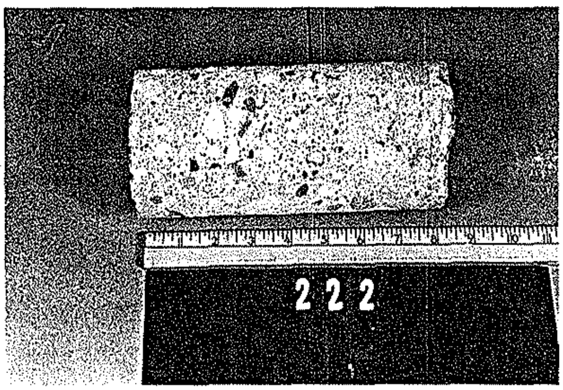
Core No.	Route	Milepost	Dir.	County
220	IA 3	79.80	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.70	220
10-26-83	30°	3.60	225



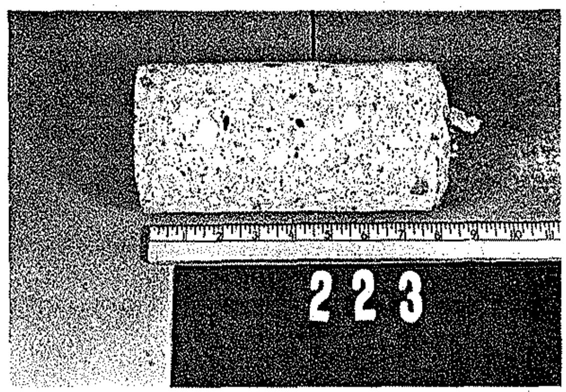
Core No.	Route	Milepost	Dir.	County
221	IA 3	79.30	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.10	185
10-26-83	30°	3.10	210



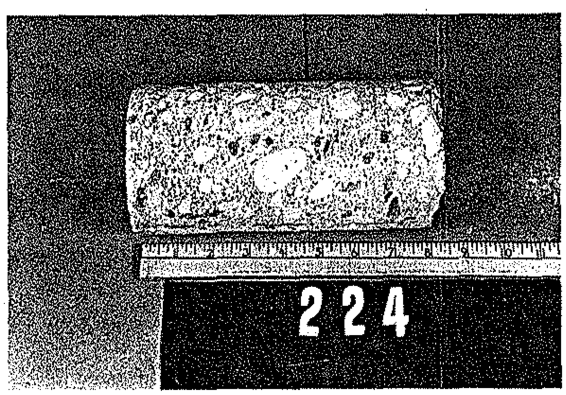
Core No.	Route	Milepost	Dir.	County
222	IA 3	78.30	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.85	210
10-26-83	30°	2.95	210



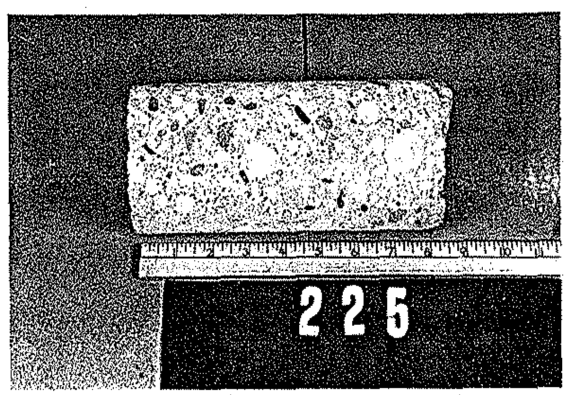
Core No.	Route	Milepost	Dir.	County
223	IA 3	77.50	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.60	190
10-26-83	30°	3.10	160



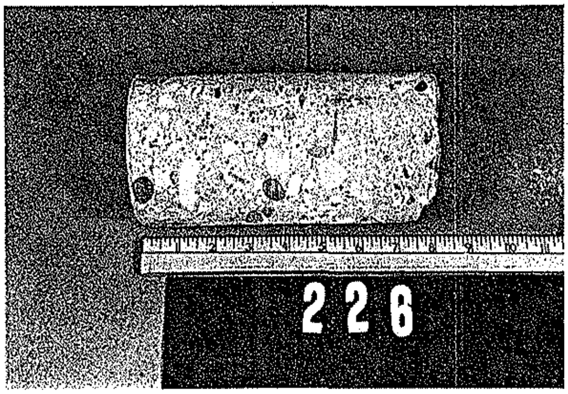
Core No.	Route	Milepost	Dir.	County
224	IA 3	76.50	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.70	220
10-26-83	30°	3.70	225



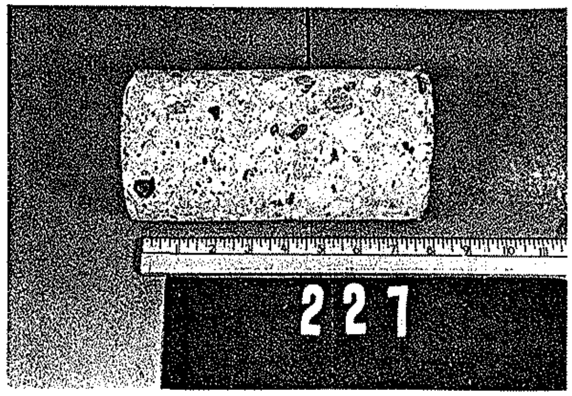
Core No.	Route	Milepost	Dir.	County
225	IA 3	75.50	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.30	200
10-26-83	30°	3.70	215



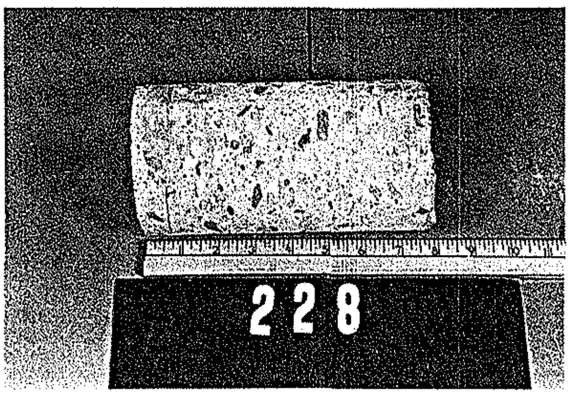
Core No.	Route	Milepost	Dir.	County
226	IA 3	74.50	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	3.40	190
10-26-83	30°	3.25	205



Core No.	Route	Milepost	Dir.	County
227	IA 3	72.50	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	100°	2.90	205
10-26-83	30°	2.70	190

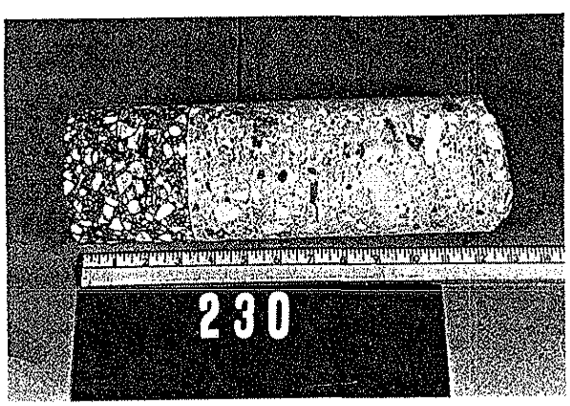


Core No.	Route	Milepost	Dir.	County
228	IA 3	71.00	WB	Buena Vista

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	Not Tested	Not Tested	Not Tested
10-26-83	30°	4.00	225

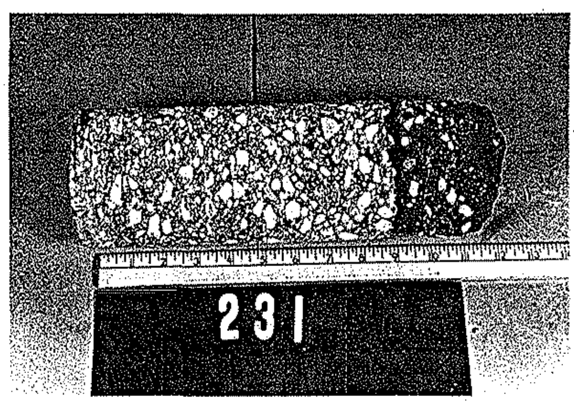
Core No.	Route	Milepost	Dir.	County
229	IA 4	127.00	NB	Emmet

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-20-83	125°	3.45	145
10-26-83	70°	4.10	200



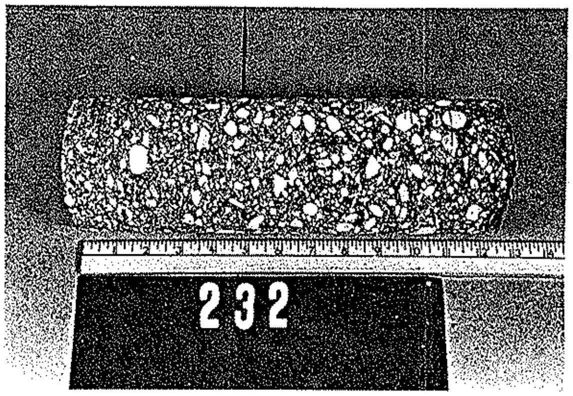
Core No.	Route	Milepost	Dir.	County
230	IA 4	128.00	NB	Emmet

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-20-83	125°	4.00	180
10-26-83	70°	4.30	155



Core No.	Route	Milepost	Dir.	County
231	IA 4	129.00	NB	Emmet

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-20-83	125°	2.15	165
10-26-83	70°	2.95	165

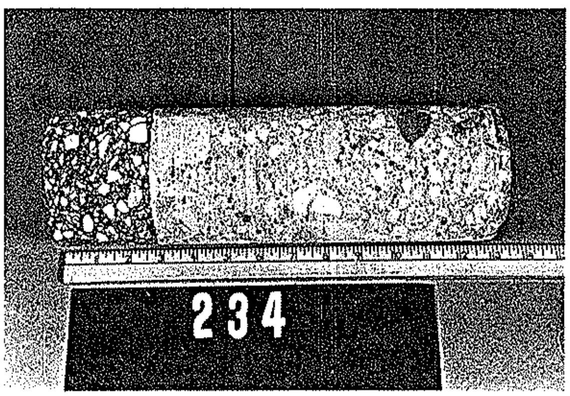


Core No.	Route	Milepost	Dir.	County
232	IA 4	129.25	SB	Emmet

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-20-83	125°	3.60	225+
10-26-83	70°	3.85	225

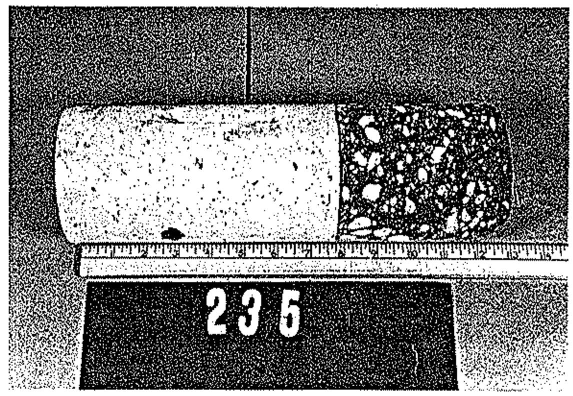
Core No.	Route	Milepost	Dir.	County
233	IA 4	128.50	SB	Emmet

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-20-83	125°	2.40	115
10-26-83	70°	3.30	180



Core No.	Route	Milepost	Dir.	County
234	IA 4	127.50	SB	Emmet

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-20-83	125°	2.60	130
10-26-83	70°	3.45	180

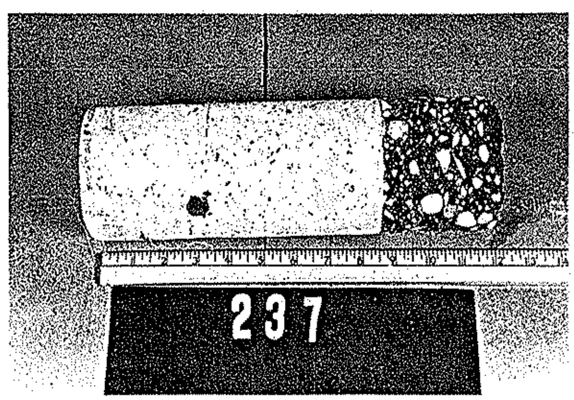


Core No.	Route	Milepost	Dir.	County
235	I-35	205.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	3.80	200
10-28-83	45°	4.30	225+

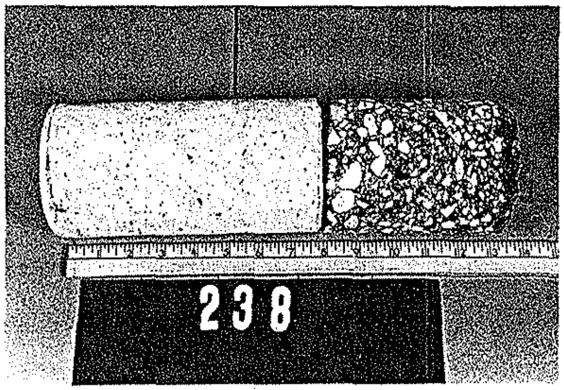
Core No.	Route	Milepost	Dir.	County
236	I-35	206.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	4.25	220
10-28-83	45°	4.40	225+



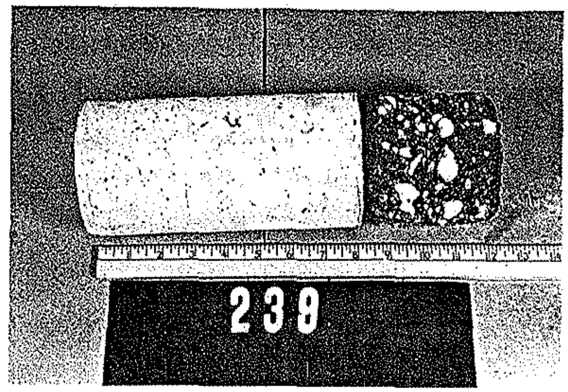
Core No.	Route	Milepost	Dir.	County
237	I-35	207.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	3.60	50
10-28-83	45°	4.55	225+



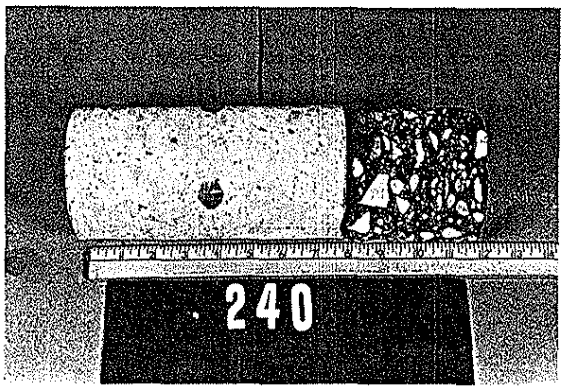
Core No.	Route	Milepost	Dir.	County
238	I-35	208.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	4.70	210
10-28-83	45°	3.60	175



Core No.	Route	Milepost	Dir.	County
239	I-35	209.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	4.70	210
10-28-83	45°	4.00	225



Core No.	Route	Milepost	Dir.	County
240	I-35	210.00	NB	Worth

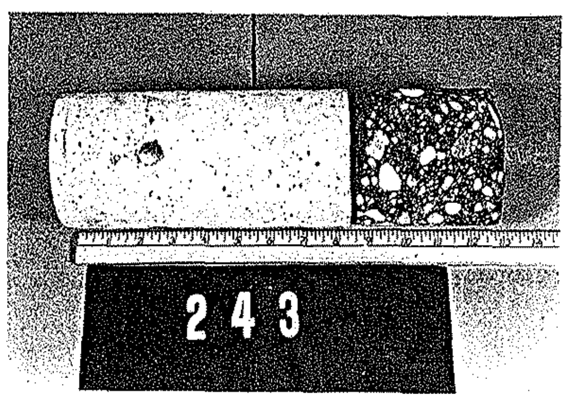
Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	5.30	225+
10-28-83	45°	4.85	225+

Core No.	Route	Milepost	Dir.	County
241	I-35	211.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	6.00	225+
10-28-83	45°	4.55	220

Core No.	Route	Milepost	Dir.	County
242	I-35	212.00	NB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	4.60	205
10-28-83	45°	4.40	135

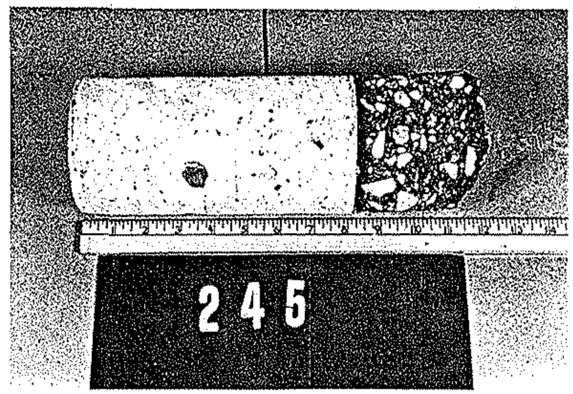


Core No.	Route	Milepost	Dir.	County
243	I-35	211.80	SB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	4.40	210
10-28-83	55°	5.15	225+

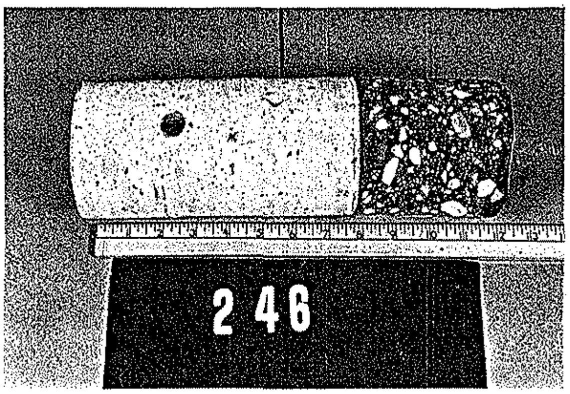
Core No.	Route	Milepost	Dir.	County
244	I-35	210.30	SB	Worth

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
7-21-83	120^{o}	4.60	205
10-28-83	55^{o}	4.85	225+



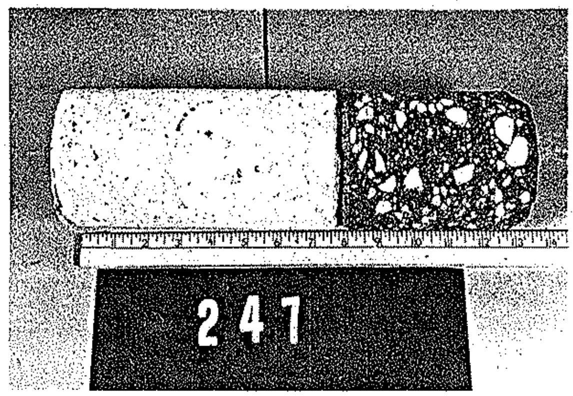
Core No.	Route	Milepost	Dir.	County
245	I-35	209.30	SB	Worth

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
7-21-83	120^{o}	5.10	160
10-28-83	55^{o}	4.85	225+



Core No.	Route	Milepost	Dir.	County
246	I-35	208.80	SB	Worth

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
7-21-83	120^{o}	5.10	160
10-28-83	55^{o}	4.10	225

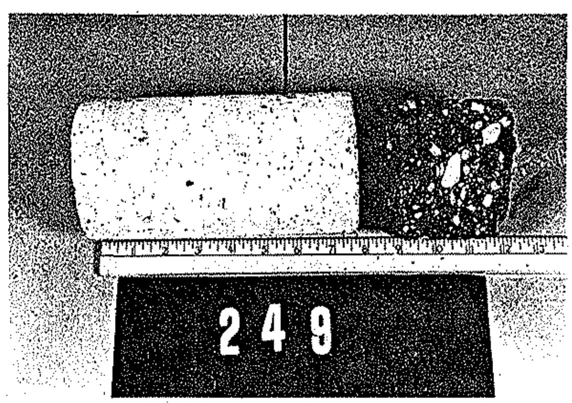


Core No.	Route	Milepost	Dir.	County
247	I-35	207.80	SB	Worth

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
7-21-83	120^{o}	5.75	225+
10-28-83	55^{o}	5.30	225

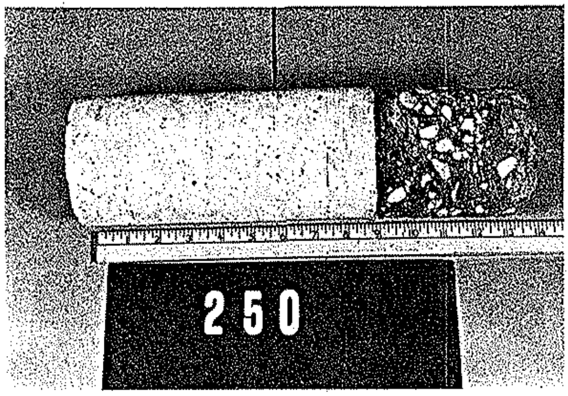
Core No.	Route	Milepost	Dir.	County
248	I-35	206.80	SB	Worth

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
7-21-83	120^{o}	4.60	220
10-28-83	55^{o}	4.85	215



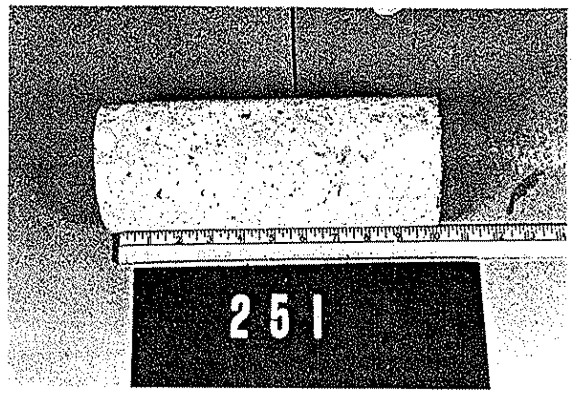
Core No.	Route	Milepost	Dir.	County
249	I-35	205.80	SB	Worth

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
7-21-83	120^{o}	4.15	200
10-28-83	55^{o}	4.70	225+



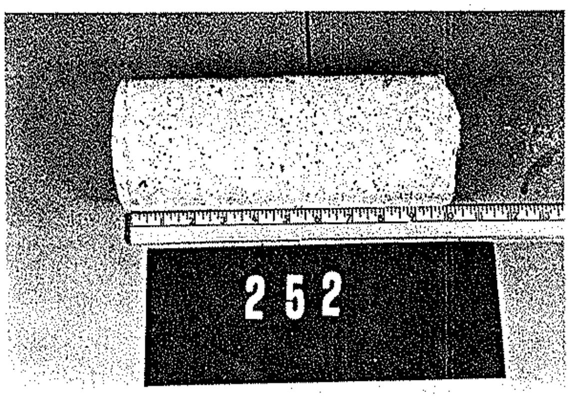
Core No.	Route	Milepost	Dir.	County
250	I-35	204.80	SB	Worth

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
7-21-83	120°	3.30	125
10-28-83	55°	4.95	225+



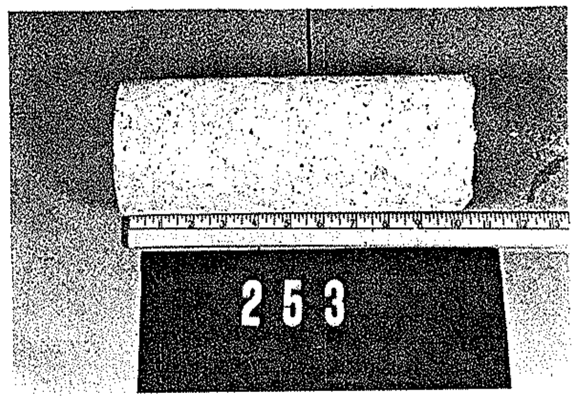
Core No.	Route	Milepost	Dir.	County
251	US 18	207.50	EB	Floyd

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-21-83	65°	3.80	185
10-31-83	50°	4.30	125



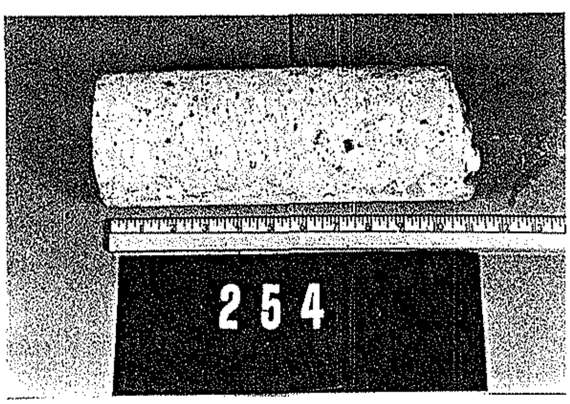
Core No.	Route	Milepost	Dir.	County
252	US 18	208.50	EB	Floyd

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-21-83	65°	5.55	140
10-31-83	50°	4.85	225+



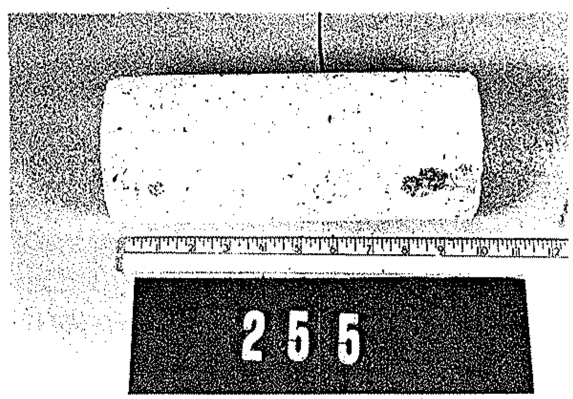
Core No.	Route	Milepost	Dir.	County
253	US 18	209.50	EB	Floyd

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-21-83	65°	5.50	215
10-31-83	50°	4.95	225+



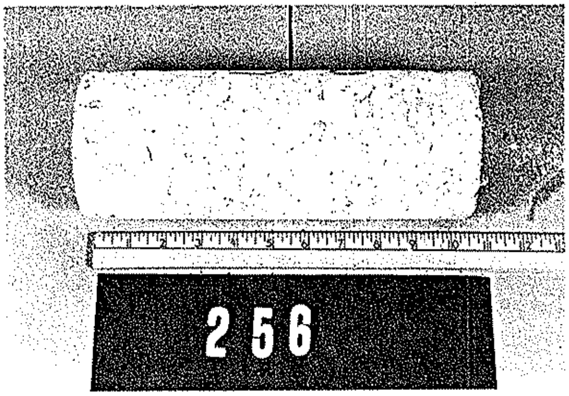
Core No.	Route	Milepost	Dir.	County
254	US 18	209.65	WB	Floyd

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-21-83	65°	5.55	200
10-31-83	50°	5.10	225+



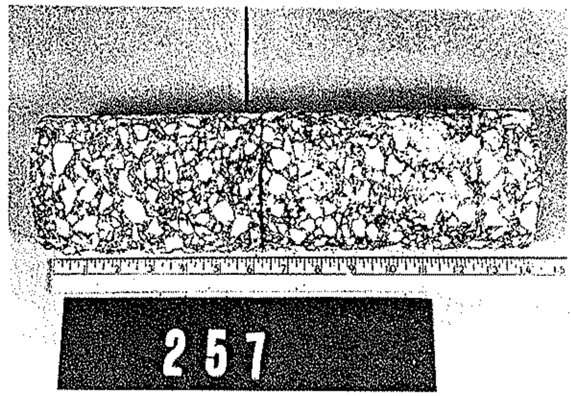
Core No.	Route	Milepost	Dir.	County
255	US 18	209.00	WB	Floyd

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-21-83	65°	4.95	155
10-31-83	50°	4.55	225+



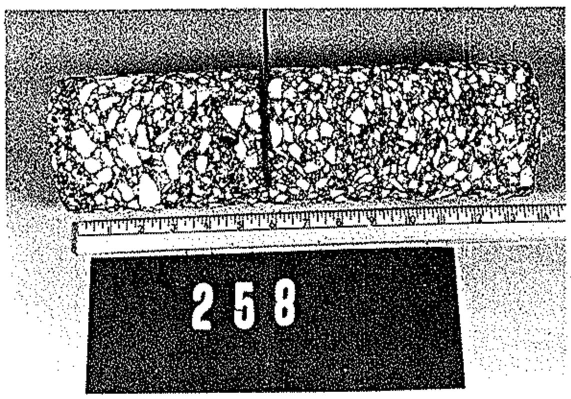
Core No.	Route	Milepost	Dir.	County
256	US 18	208.00	WB	Floyd

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-21-83	65°	6.10	155
10-31-83	50°	6.20	225+



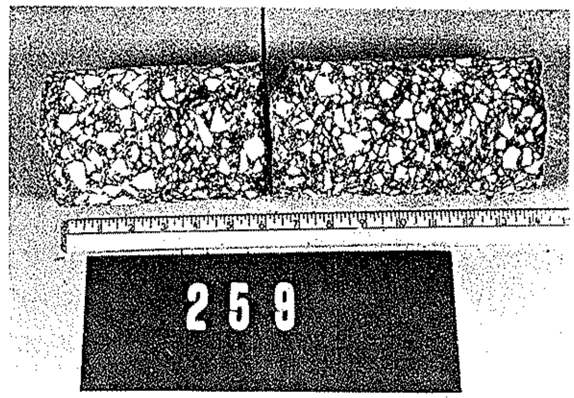
Core No.	Route	Milepost	Dir.	County
257	IA 21	95.25	SB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	4.60	100
11-1-83	50°	5.00	235



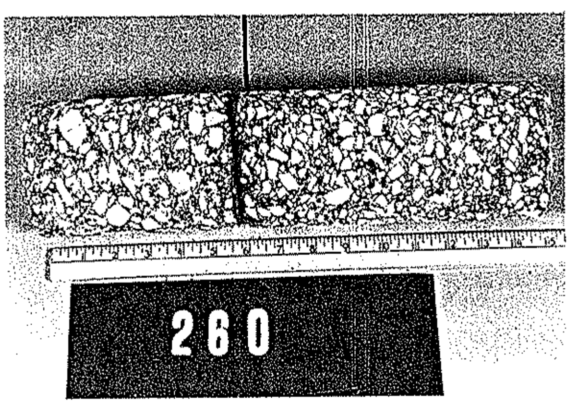
Core No.	Route	Milepost	Dir.	County
258	IA 21	94.25	SB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	2.95	60
11-1-83	50°	5.00	225



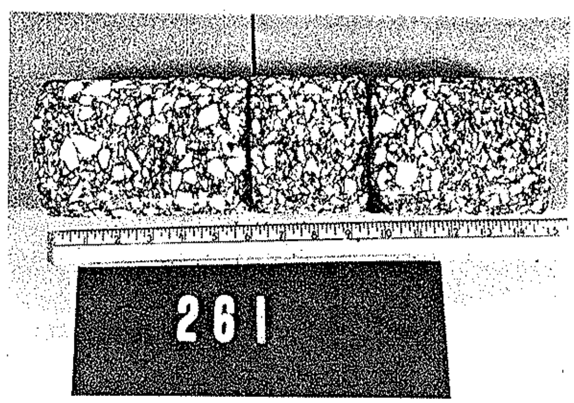
Core No.	Route	Milepost	Dir.	County
259	IA 21	93.25	SB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	2.55	145
11-1-83	50°	3.95	235



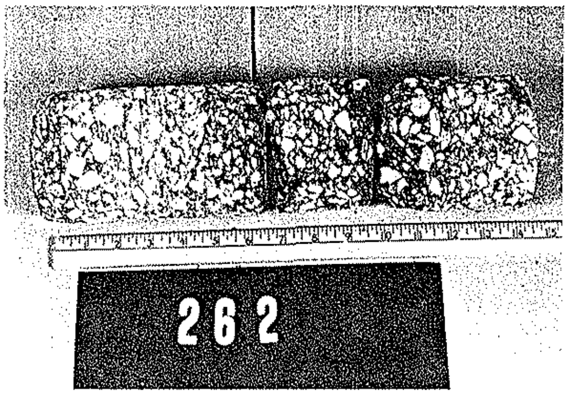
Core No.	Route	Milepost	Dir.	County
260	IA 21	92.25	SB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	65°	4.70	120
11-1-83	50°	5.60	250



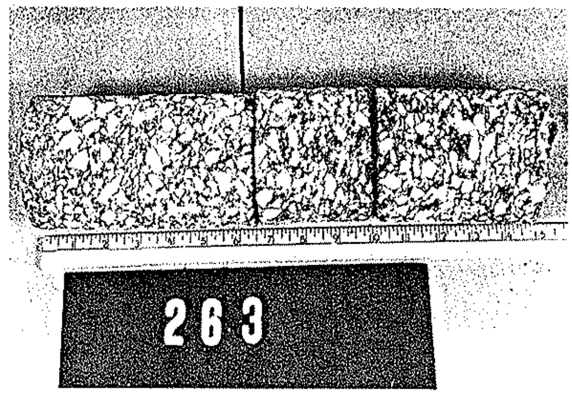
Core No.	Route	Milepost	Dir.	County
261	IA 21	91.25	SB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	65°	3.60	95
11-1-83	50°	4.70	225



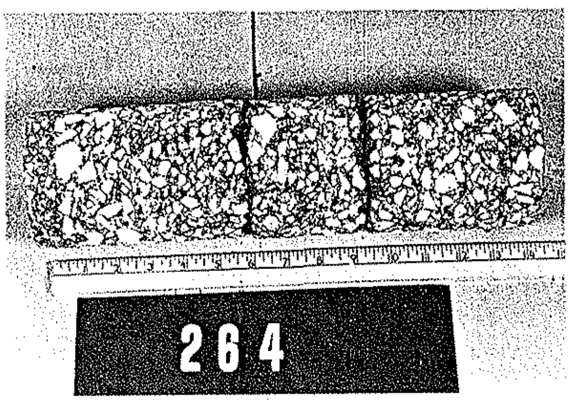
Core No.	Route	Milepost	Dir.	County
262	IA 21	90.25	SB	Black Hawk

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
4-11-83	65°	3.90	80
11-1-83	50°	4.70	225



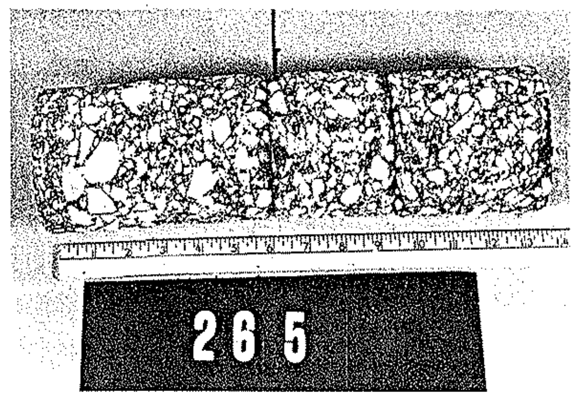
Core No.	Route	Milepost	Dir.	County
263	IA 21	89.25	SB	Black Hawk

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
4-11-83	65°	4.55	75
11-1-83	50°	4.45	225



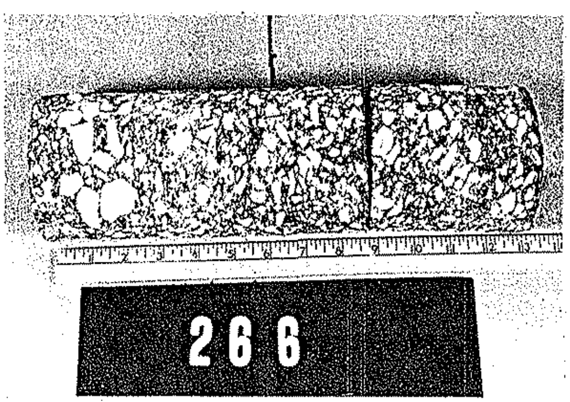
Core No.	Route	Milepost	Dir.	County
264	IA 21	88.25	SB	Black Hawk

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
4-11-83	65°	4.55	155
11-1-83	50°	5.50	240



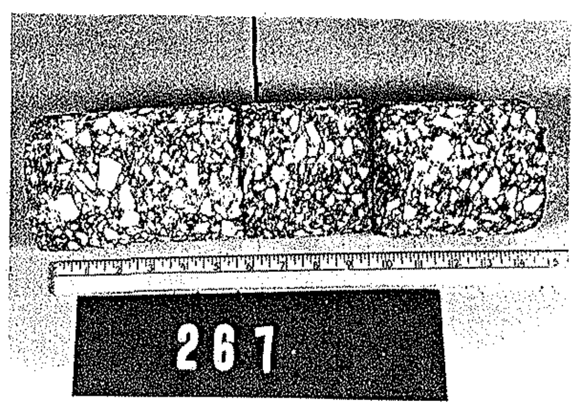
Core No.	Route	Milepost	Dir.	County
265	IA 21	87.25	SB	Black Hawk

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
4-11-83	65°	3.75	85
11-1-83	50°	4.20	215



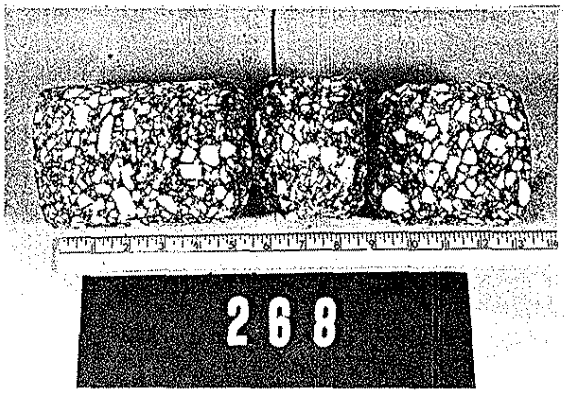
Core No.	Route	Milepost	Dir.	County
266	IA 21	88.50	NB	Black Hawk

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
4-11-83	55°	3.40	70
11-1-83	60°	5.70	185



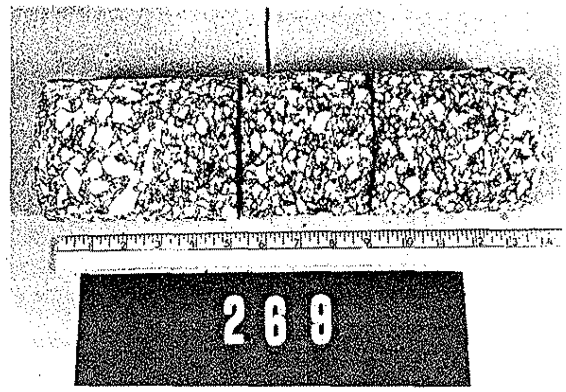
Core No.	Route	Milepost	Dir.	County
267	IA 21	89.00	NB	Black Hawk

Date Tested	Pave. Temp ^{o}F	Struct. Rating	Soil Support K Value
4-11-83	55°	4.30	75
11-1-83	60°	5.50	250



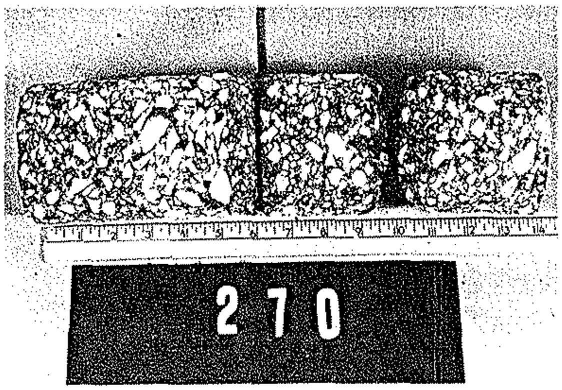
Core No.	Route	Milepost	Dir.	County
268	IA 21	90.00	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	4.20	100
11-1-83	60°	6.30	180



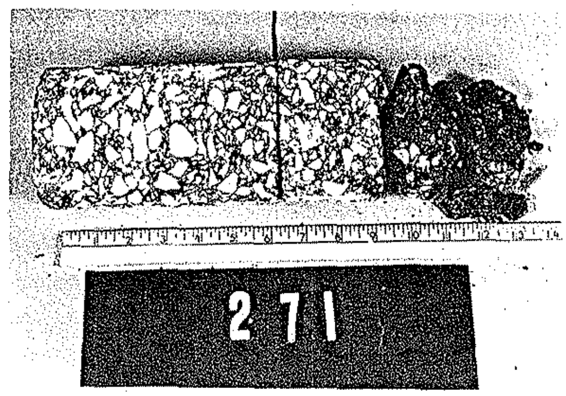
Core No.	Route	Milepost	Dir.	County
269	IA 21	91.00	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	5.00	95
11-1-83	60°	5.80	245



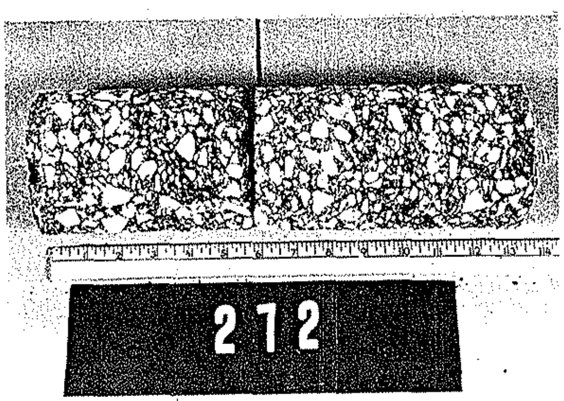
Core No.	Route	Milepost	Dir.	County
270	IA 21	92.00	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	3.35	75
11-1-83	60°	4.00	225



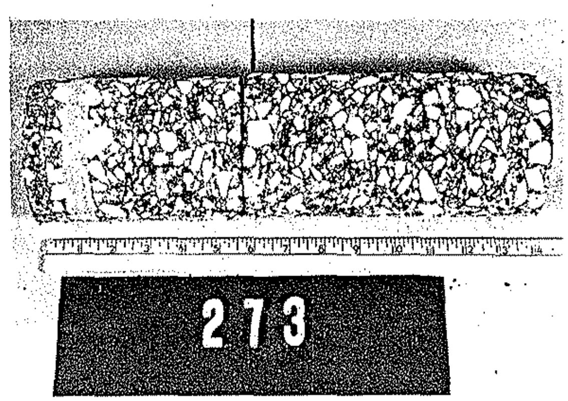
Core No.	Route	Milepost	Dir.	County
271	IA 21	93.00	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	3.70	80
11-1-83	60°	4.50	230



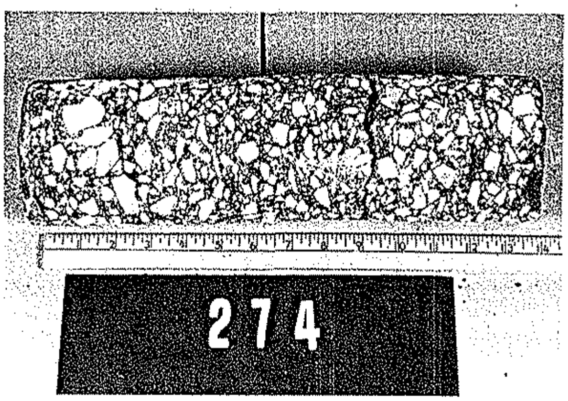
Core No.	Route	Milepost	Dir.	County
272	IA 21	94.00	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	2.85	90
11-1-83	60°	4.70	200



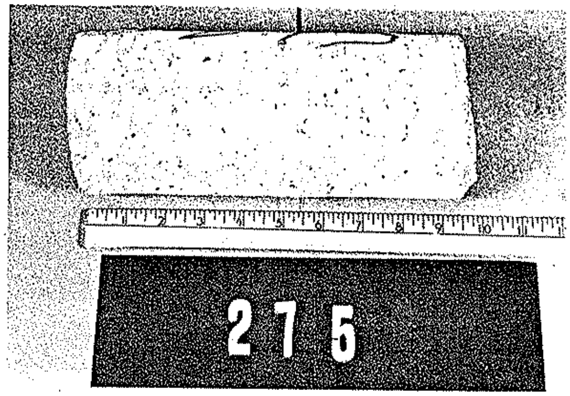
Core No.	Route	Milepost	Dir.	County
273	IA 21	94.50	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	2.65	90
11-1-83	60°	4.10	205



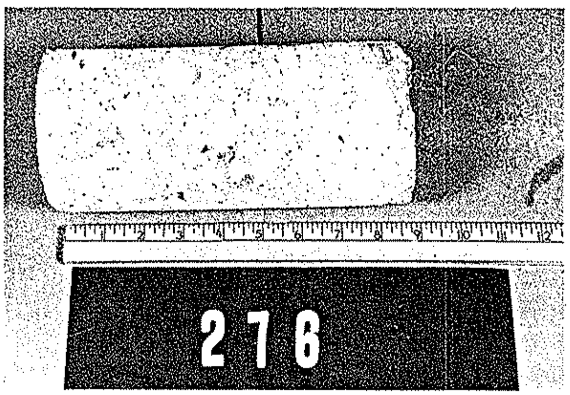
Core No.	Route	Milepost	Dir.	County
274	IA 21	95.00	NB	Black Hawk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-11-83	55°	5.00	95
11-1-83	60°	5.60	240



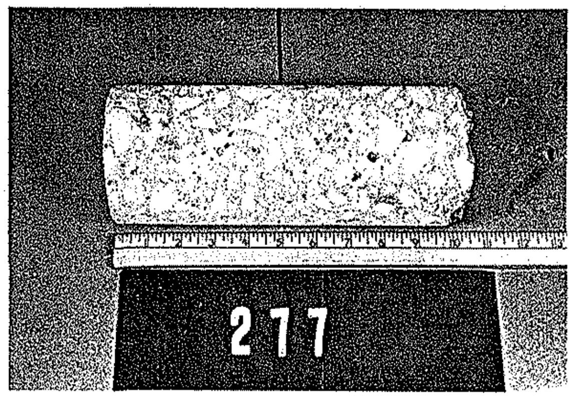
Core No.	Route	Milepost	Dir.	County
275	IA 51	0.50	NB	Allamakee

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-26-83	50°	3.60	50
11-2-83	55°	4.55	225+



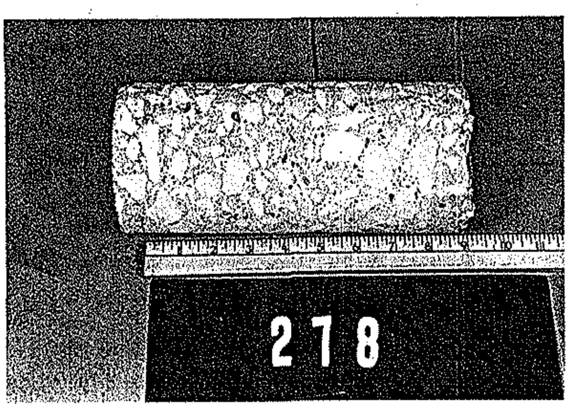
Core No.	Route	Milepost	Dir.	County
276	IA 51	1.70	NB	Allamakee

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-26-83	50°	4.40	90
11-2-83	55°	3.75	225+



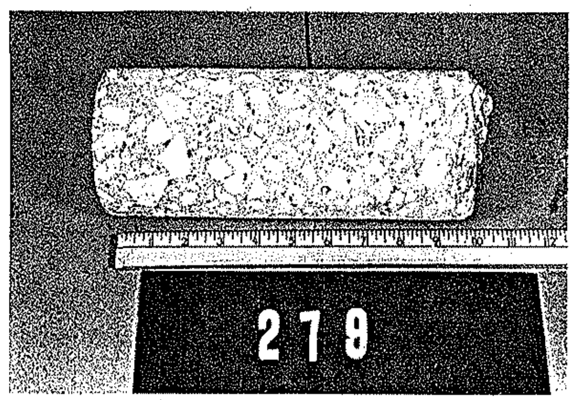
Core No.	Route	Milepost	Dir.	County
277	IA 51	2.70	NB	Allamakee

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-26-83	50°	4.40	165
11-2-83	55°	4.85	225



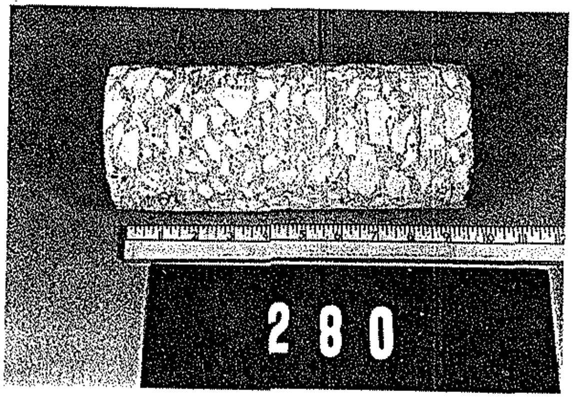
Core No.	Route	Milepost	Dir.	County
278	IA 51	3.05	SB	Allamakee

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-26-83	50°	4.90	115
11-2-83	55°	4.95	225+



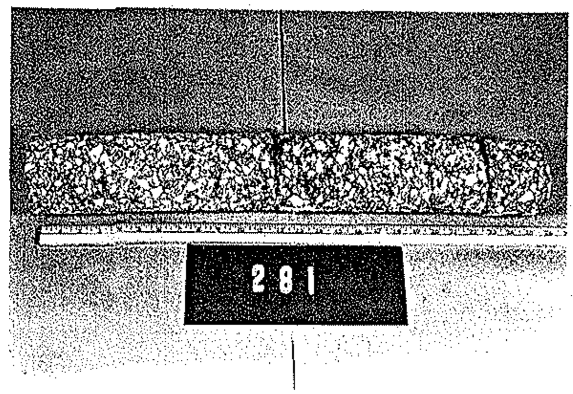
Core No.	Route	Milepost	Dir.	County
279	IA 51	2.00	SB	Allamakee

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-26-83	50°	3.60	155
11-2-83	55°	4.10	225



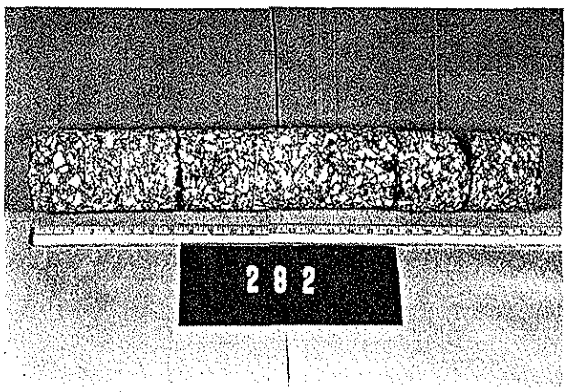
Core No.	Route	Milepost	Dir.	County
280	IA 51	1.00	SB	Allamakee

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
4-26-83	50°	4.20	125
11-2-83	55°	4.55	225+



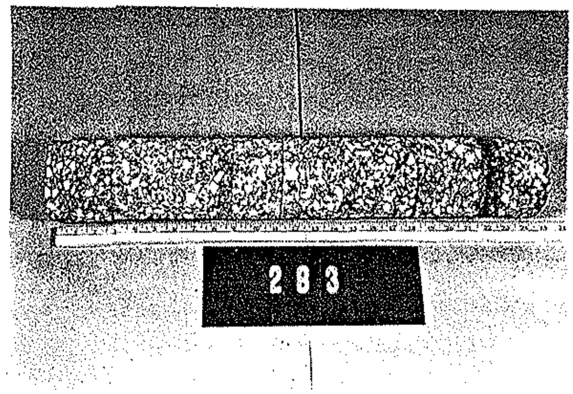
Core No.	Route	Milepost	Dir.	County
281	I-80	258.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	180
11-3-83	45°	8.25	225+



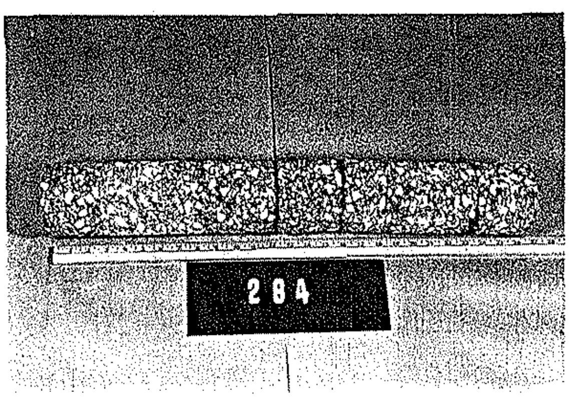
Core No.	Route	Milepost	Dir.	County
282	I-80	259.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	140
11-3-83	45°	6.50	225+



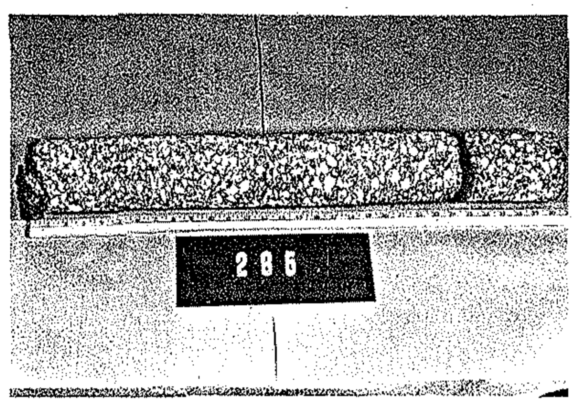
Core No.	Route	Milepost	Dir.	County
283	I-80	260.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	120
11-3-83	45°	7.80	225+



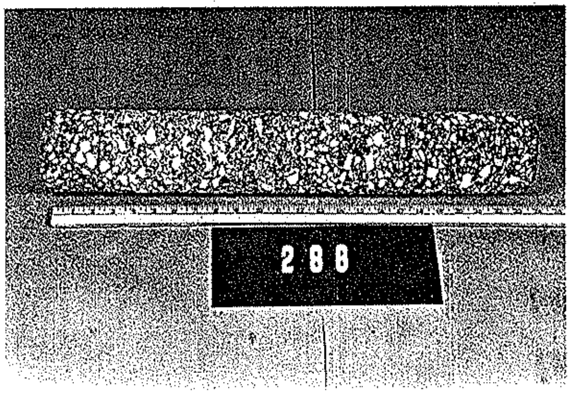
Core No.	Route	Milepost	Dir.	County
284	I-80	261.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00	165
11-3-83	45°	7.10	225+



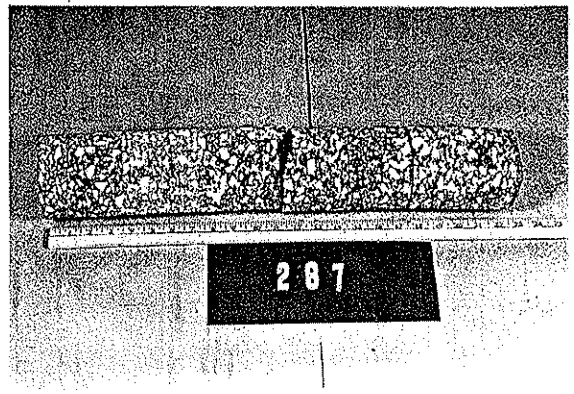
Core No.	Route	Milepost	Dir.	County
285	I-80	262.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	180
11-3-83	45°	10.00+	205



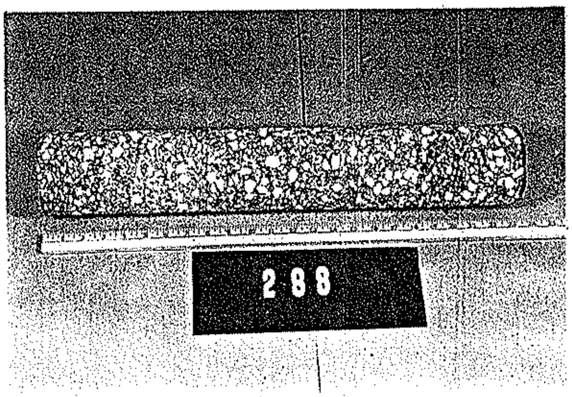
Core No.	Route	Milepost	Dir.	County
286	I-80	263.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	210
11-3-83	45°	8.25	225+



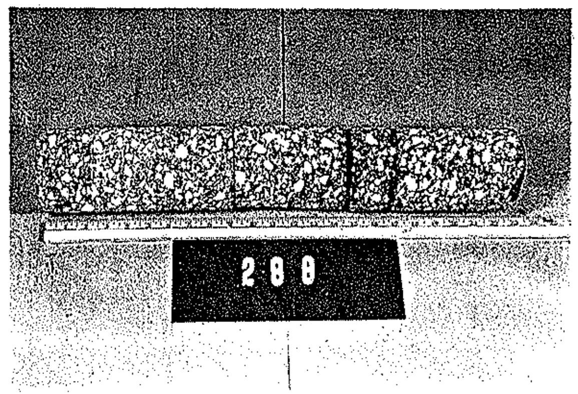
Core No.	Route	Milepost	Dir.	County
287	I-80	264.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	85
11-3-83	45°	5.45	225+



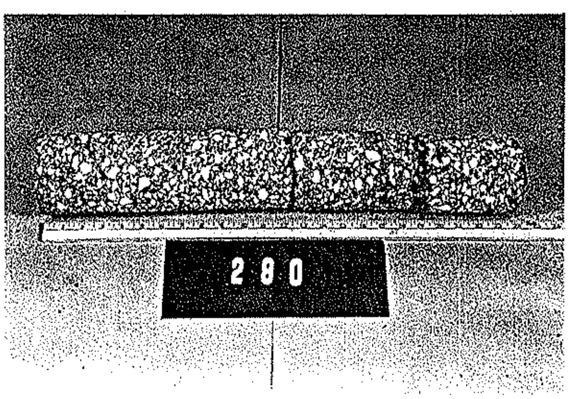
Core No.	Route	Milepost	Dir.	County
288	I-80	265.00	EB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	220
11-3-83	45°	5.65	225+



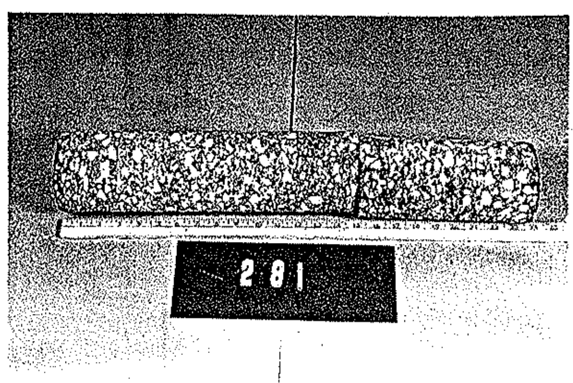
Core No.	Route	Milepost	Dir.	County
289	I-80	265.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	7.40	65
11-3-83	45°	6.00	225+



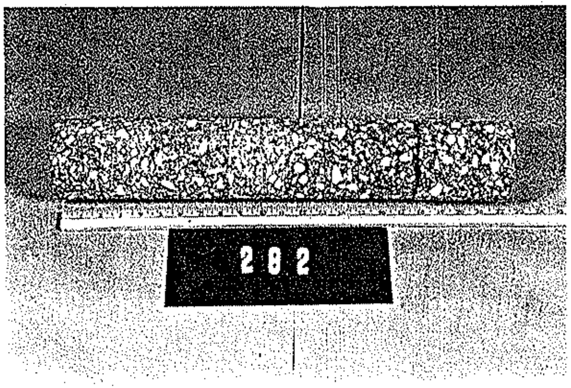
Core No.	Route	Milepost	Dir.	County
290	I-80	264.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	215
11-3-83	45°	10.00+	225+



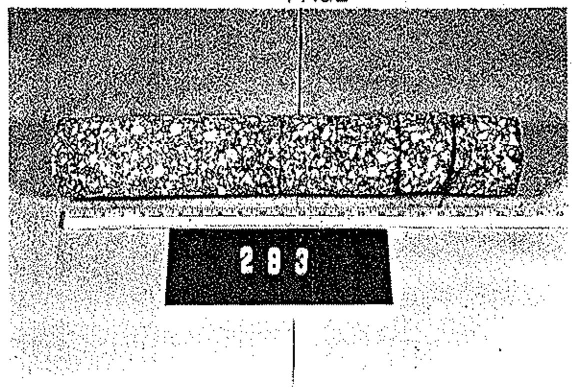
Core No.	Route	Milepost	Dir.	County
291	I-80	263.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	95
11-3-83	45°	9.35	225+



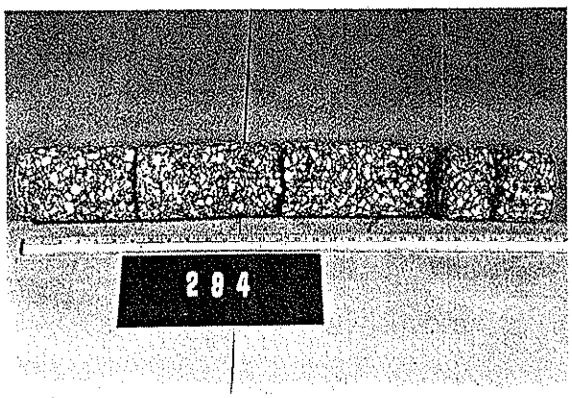
Core No.	Route	Milepost	Dir.	County
292	I-80	262.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	90
11-3-83	45°	7.45	225+



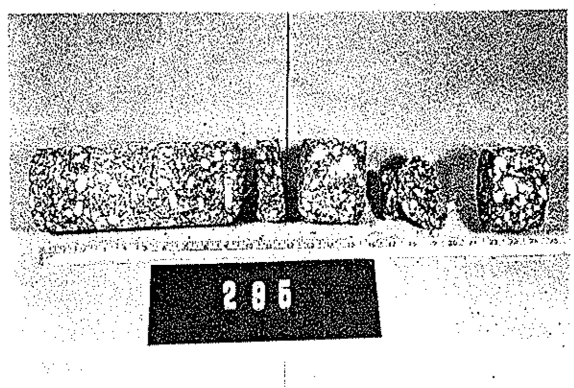
Core No.	Route	Milepost	Dir.	County
293	I-80	261.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	7.40	160
11-3-83	45°	5.40	170



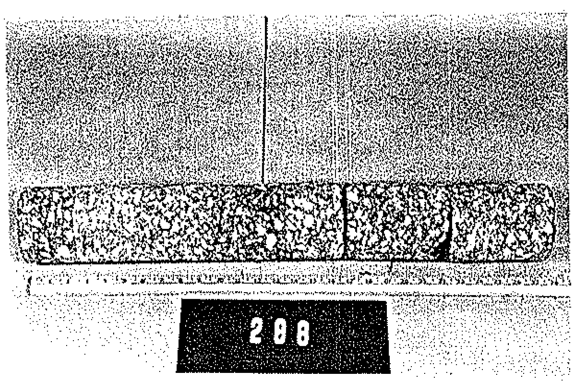
Core No.	Route	Milepost	Dir.	County
294	I-80	260.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	230
11-3-83	45°	8.75	225+



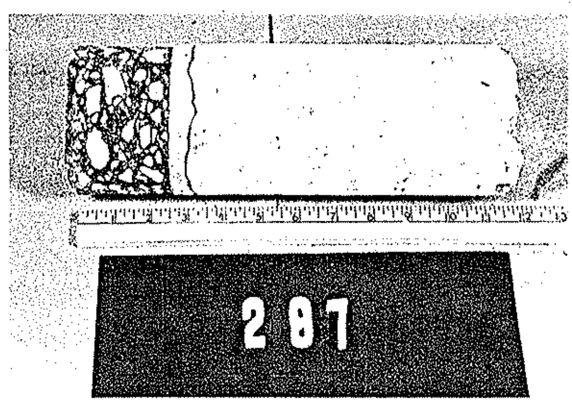
Core No.	Route	Milepost	Dir.	County
295	I-80	259.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	8.00+	90
11-3-83	45°	5.40	225+



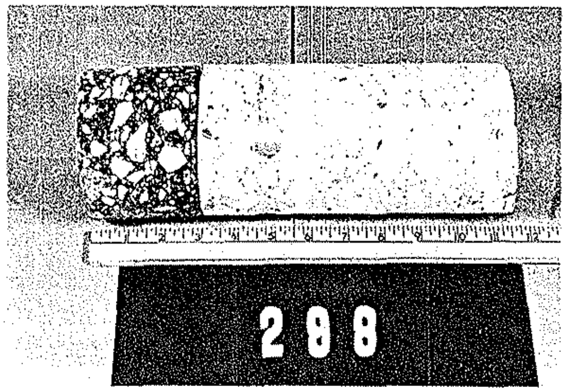
Core No.	Route	Milepost	Dir.	County
296	I-80	258.25	WB	Cedar

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-9-83	85°	7.60	90
11-3-83	45°	5.40	225+



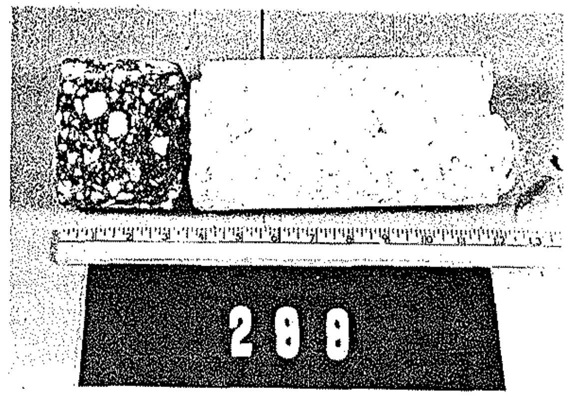
Core No.	Route	Milepost	Dir.	County
297	US 218	65.50	SB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	3.70	50
11-4-83	35°	3.60	225



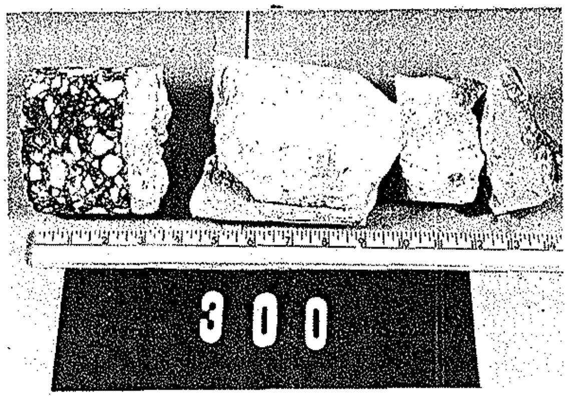
Core No.	Route	Milepost	Dir.	County
298	US 218	64.50	SB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	4.00	65
11-4-83	35°	3.75	225



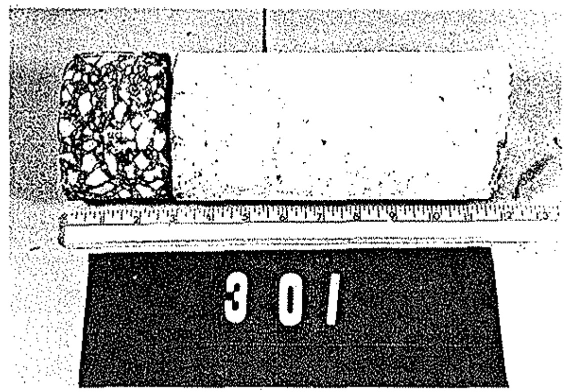
Core No.	Route	Milepost	Dir.	County
299	US 218	63.50	SB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	5.10	185
11-4-83	35°	3.70	225+



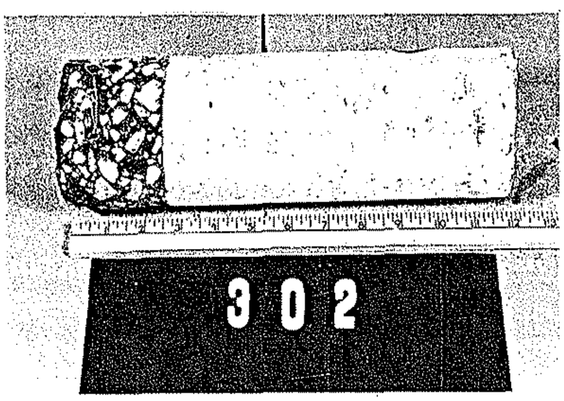
Core No.	Route	Milepost	Dir.	County
300	US 218	62.50	SB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	4.00	105
11-4-83	35°	3.60	225



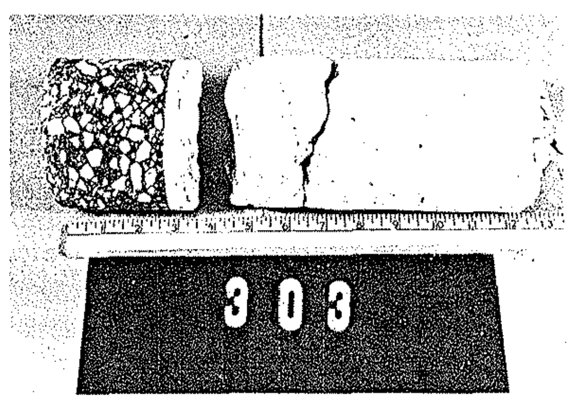
Core No.	Route	Milepost	Dir.	County
301	US 218	61.50	SB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	2.40	50
11-4-83	35°	2.00	225+



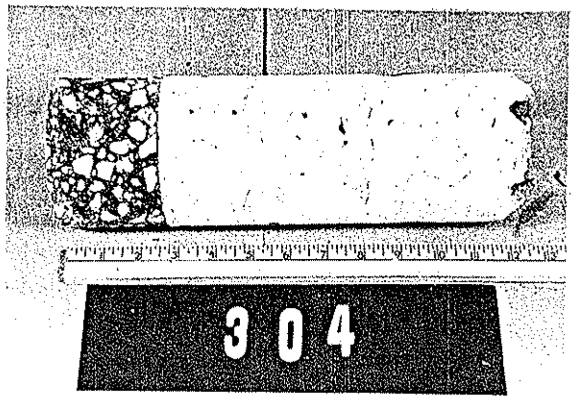
Core No.	Route	Milepost	Dir.	County
302	US 218	62.00	NB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	1.20	185
11-4-83	35°	2.10	225+



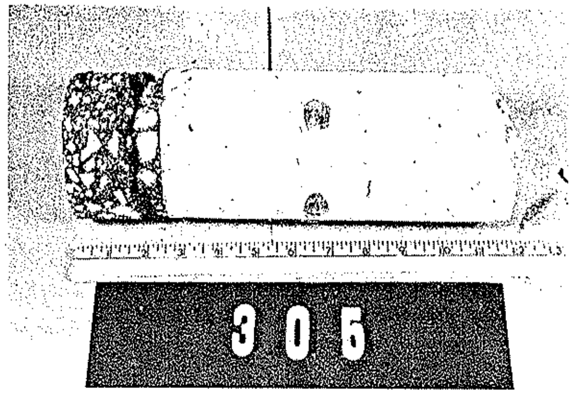
Core No.	Route	Milepost	Dir.	County
303	US 218	63.00	NB	Washington

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-5-83	65°	3.35	50
11-4-83	35°	2.65	225+



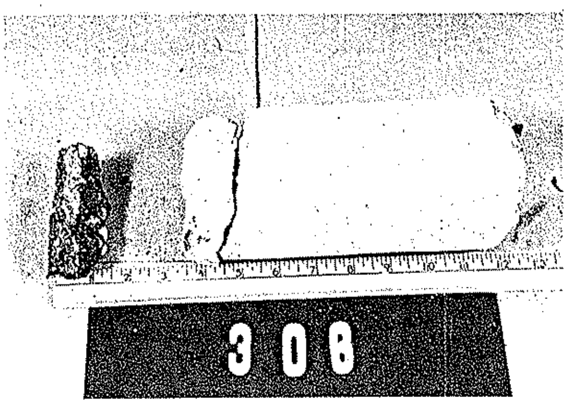
Core No.	Route	Milepost	Dir.	County
304	US 218	64.00	NB	Washington

Date Tested	Pave. Temp $^{\circ}F$	Struct. Rating	Soil Support K Value
5-5-83	65°	3.50	50
11-4-83	35°	2.60	190



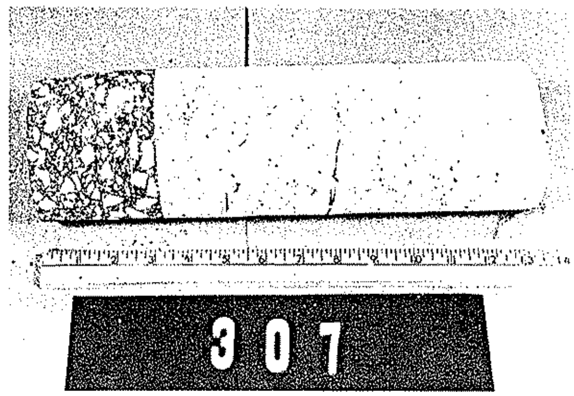
Core No.	Route	Milepost	Dir.	County
305	US 218	65.00	NB	Washington

Date Tested	Pave. Temp $^{\circ}F$	Struct. Rating	Soil Support K Value
5-5-83	65°	4.25	155
11-4-83	35°	2.55	170



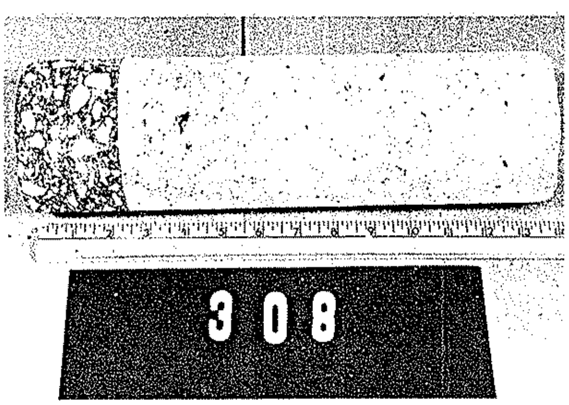
Core No.	Route	Milepost	Dir.	County
306	US 218	66.00	NB	Washington

Date Tested	Pave. Temp $^{\circ}F$	Struct. Rating	Soil Support K Value
5-5-83	65°	4.30	125
11-4-83	35°	2.90	220



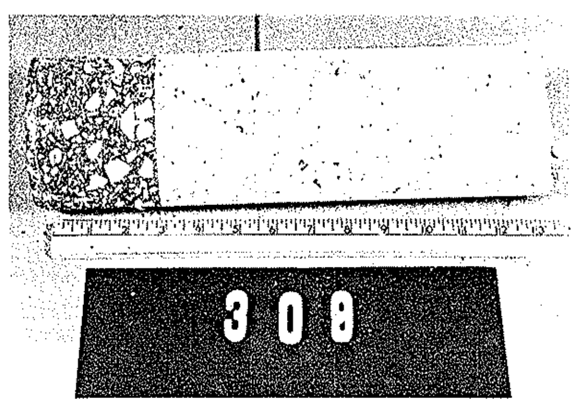
Core No.	Route	Milepost	Dir.	County
307	US 34	167.25	WB	Monroe

Date Tested	Pave. Temp $^{\circ}F$	Struct. Rating	Soil Support K Value
5-12-83	80°	5.55	200
11-7-83	65°	5.70	225+



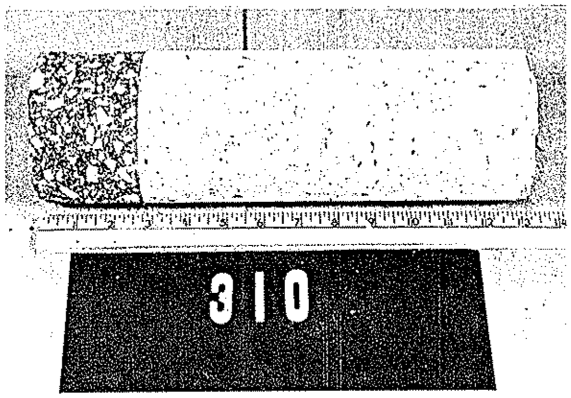
Core No.	Route	Milepost	Dir.	County
308	US 34	166.50	WB	Monroe

Date Tested	Pave. Temp $^{\circ}F$	Struct. Rating	Soil Support K Value
5-12-83	80°	6.35	190
11-7-83	65°	6.75	225+



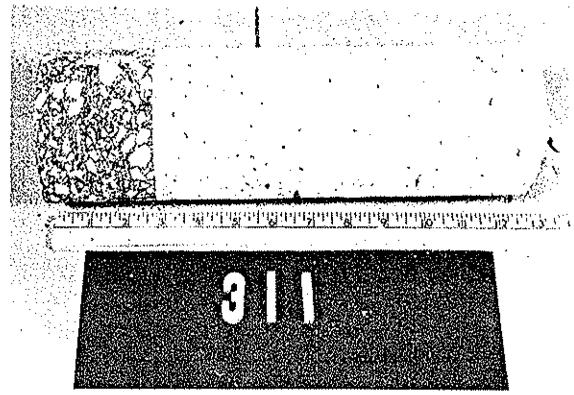
Core No.	Route	Milepost	Dir.	County
309	US 34	165.50	WB	Monroe

Date Tested	Pave. Temp $^{\circ}F$	Struct. Rating	Soil Support K Value
5-12-83	80°	6.50	205
11-7-83	65°	6.60	225+



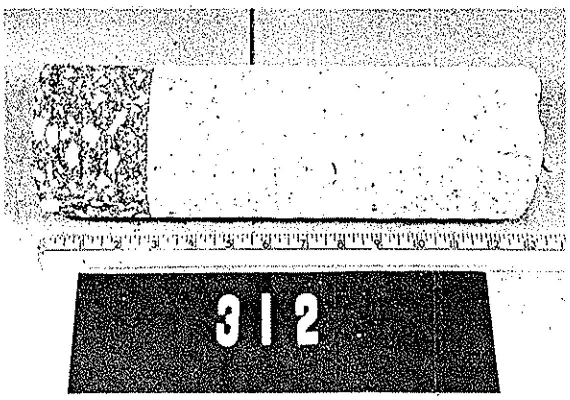
Core No.	Route	Milepost	Dir.	County
310	US 34	164.25	WB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	6.10	155
11-7-83	65°	6.50	225+



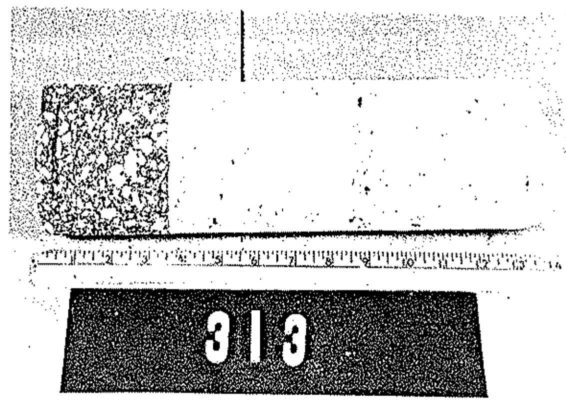
Core No.	Route	Milepost	Dir.	County
311	US 34	163.25	WB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	4.55	100
11-7-83	65°	5.40	225+



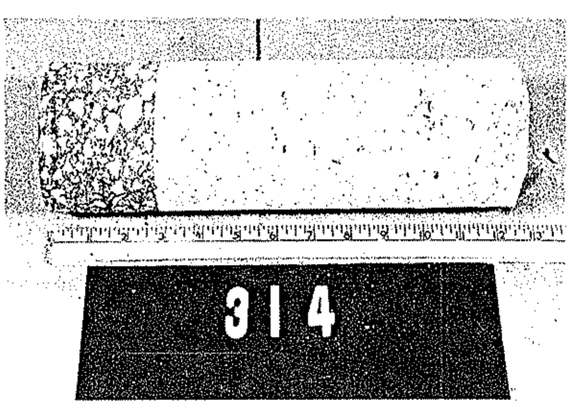
Core No.	Route	Milepost	Dir.	County
312	US 34	162.25	WB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	4.55	100
11-7-83	65°	5.55	225+



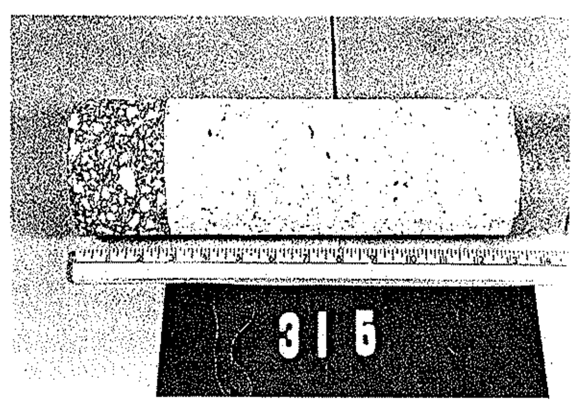
Core No.	Route	Milepost	Dir.	County
313	US 34	161.25	WB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	5.10	130
11-7-83	65°	6.00	225+



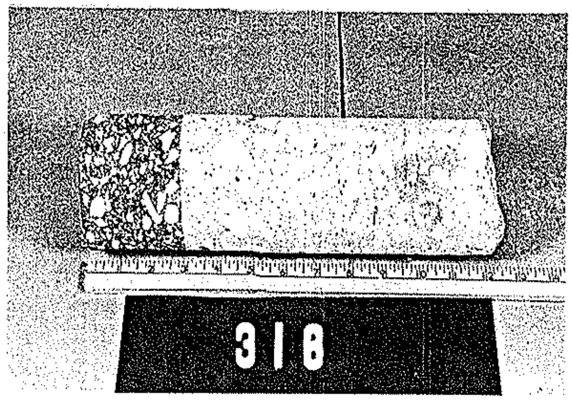
Core No.	Route	Milepost	Dir.	County
314	US 34	160.25	WB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	5.75	190
11-7-83	65°	6.50	225+



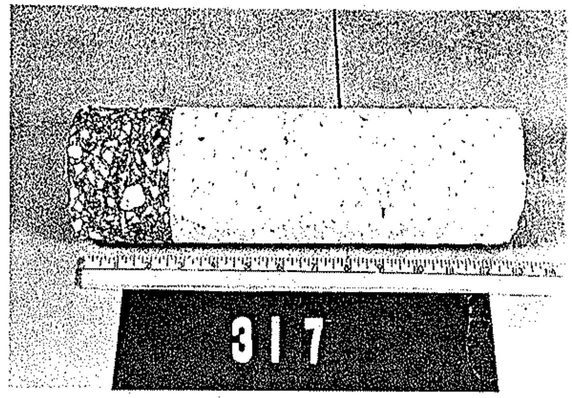
Core No.	Route	Milepost	Dir.	County
315	US 34	159.25	WB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	6.00	195
11-7-83	65°	5.40	225+



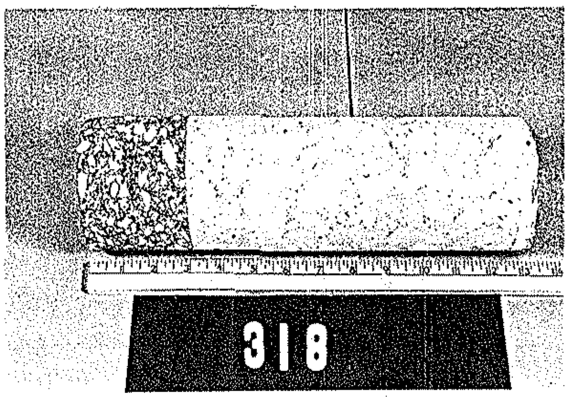
Core No.	Route	Milepost	Dir.	County
316	US 34	159.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	4.30	80
11-7-83	65°	4.70	225



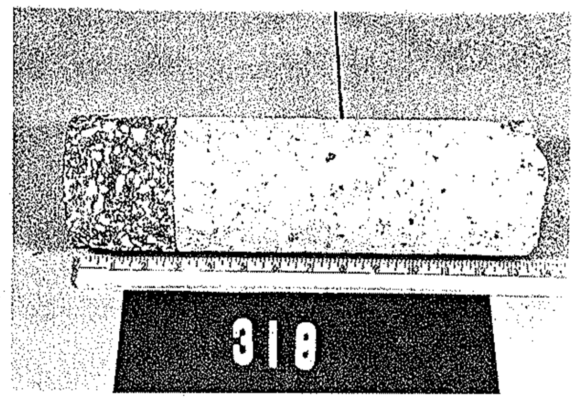
Core No.	Route	Milepost	Dir.	County
317	US 34	160.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	5.45	195
11-7-83	65°	6.00	225+



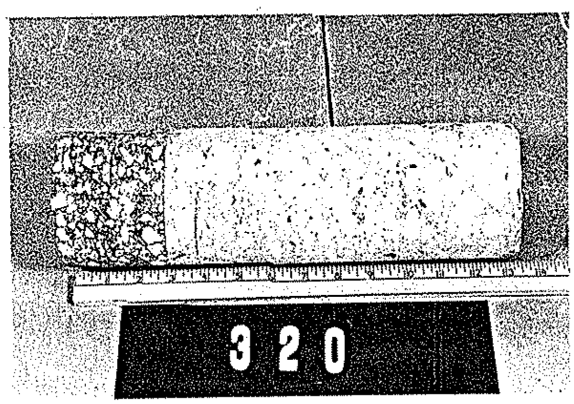
Core No.	Route	Milepost	Dir.	County
318	US 34	161.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	6.90	170
11-7-83	65°	6.50	225+



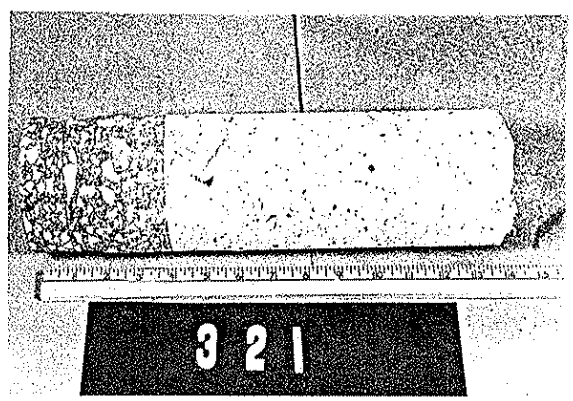
Core No.	Route	Milepost	Dir.	County
319	US 34	162.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	5.70	225+
11-7-83	65°	6.35	225+



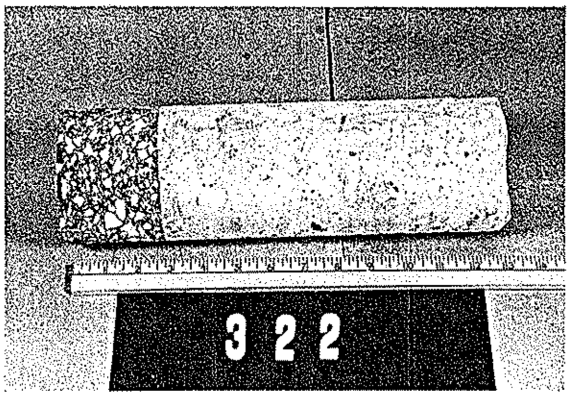
Core No.	Route	Milepost	Dir.	County
320	US 34	163.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	4.10	150
11-7-83	65°	5.55	225+



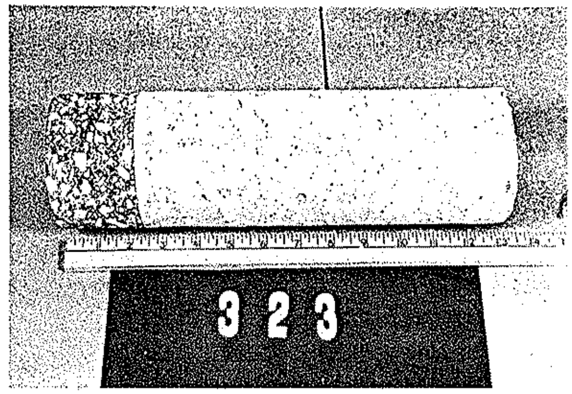
Core No.	Route	Milepost	Dir.	County
321	US 34	164.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	6.75	145
11-8-83	50°	6.50	225+



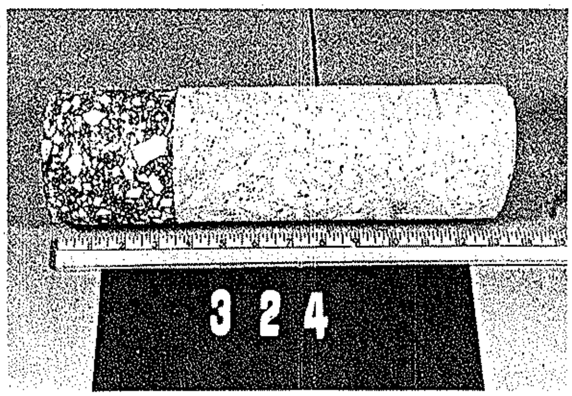
Core No.	Route	Milepost	Dir.	County
322	US 34	164.50	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	4.30	125
11-8-83	50°	7.60	225+



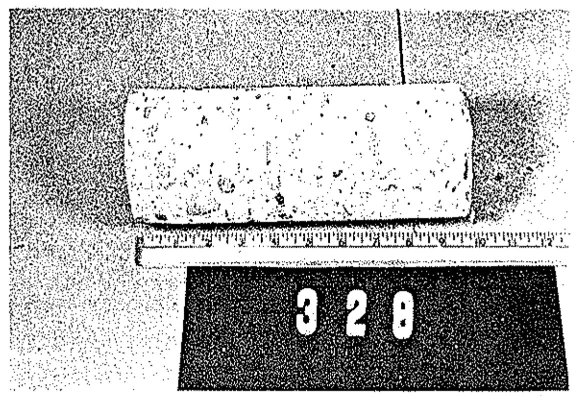
Core No.	Route	Milepost	Dir.	County
323	US 34	166.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	5.95	155
11-8-83	50°	6.50	225+



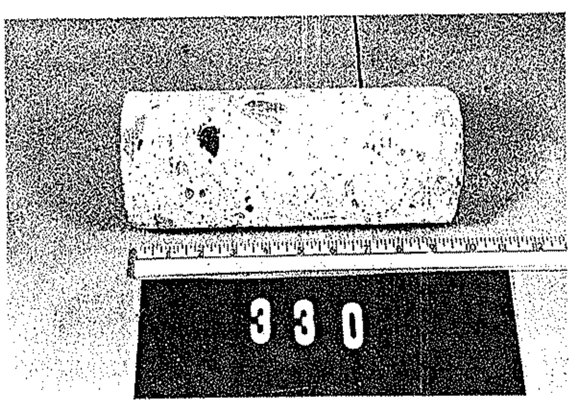
Core No.	Route	Milepost	Dir.	County
324	US 34	167.00	EB	Monroe

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-12-83	80°	4.70	190
11-8-83	50°	7.10	225+



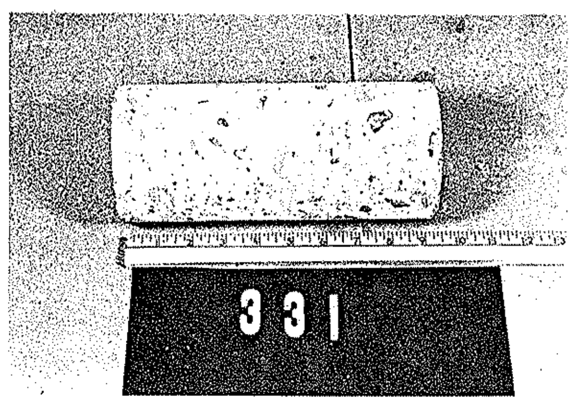
Core No.	Route	Milepost	Dir.	County
329	I-80	148.70	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.85	150
11-8-83	65°	4.85	225+



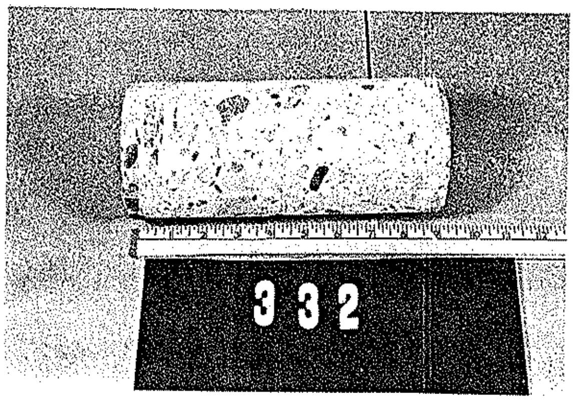
Core No.	Route	Milepost	Dir.	County
330	I-80	147.70	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	5.10	160
11-8-83	65°	5.00	225+



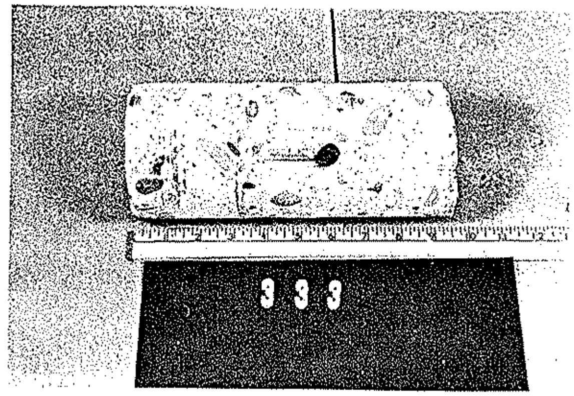
Core No.	Route	Milepost	Dir.	County
331	I-80	146.70	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	3.35	105
11-8-83	65°	4.00	210



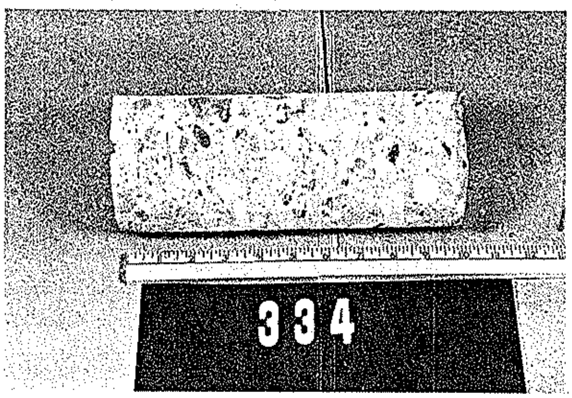
Core No.	Route	Milepost	Dir.	County
332	I-80	145.70	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	3.60	105
11-8-83	65°	3.75	210



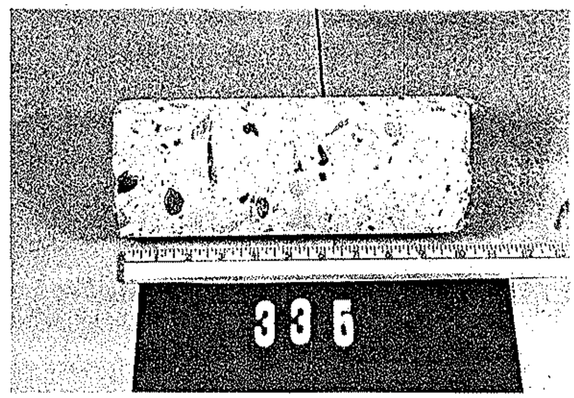
Core No.	Route	Milepost	Dir.	County
333	I-80	144.70	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.40	160
11-8-83	65°	4.20	225+



Core No.	Route	Milepost	Dir.	County
334	I-80	144.20	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	5.10	125
11-8-83	65°	5.80	225+

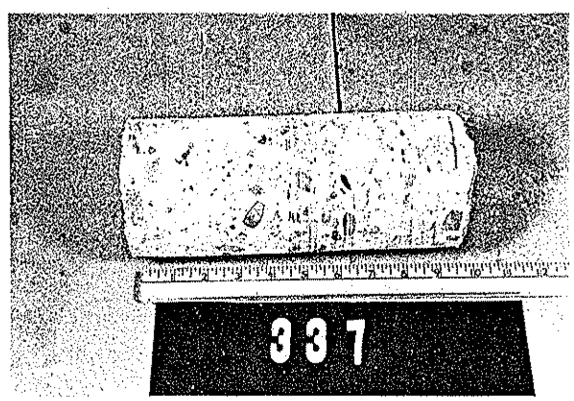


Core No.	Route	Milepost	Dir.	County
335	I-80	142.90	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.40	90
11-10-83	20°	4.55	220

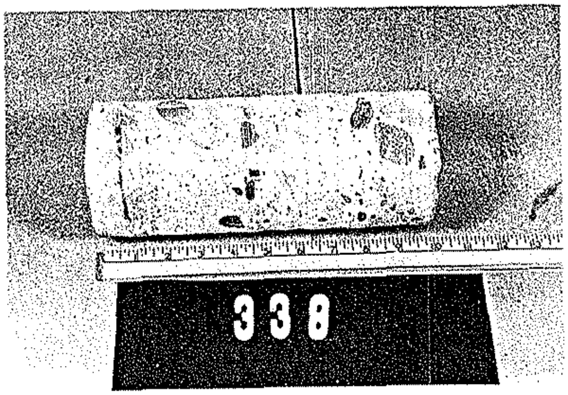
Core No.	Route	Milepost	Dir.	County
336	I-80	142.00	WB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.00	65
11-10-83	20°	4.85	225+



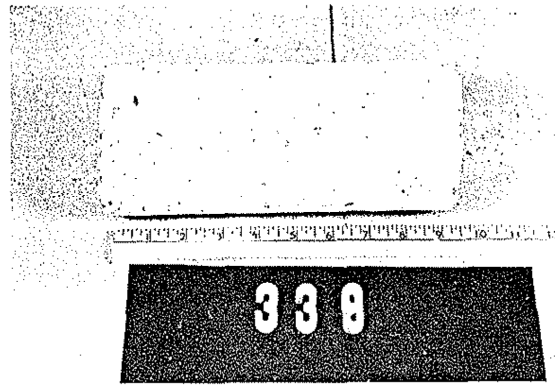
Core No.	Route	Milepost	Dir.	County
337	I-80	143.00	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.20	85
11-10-83	20°	4.40	215



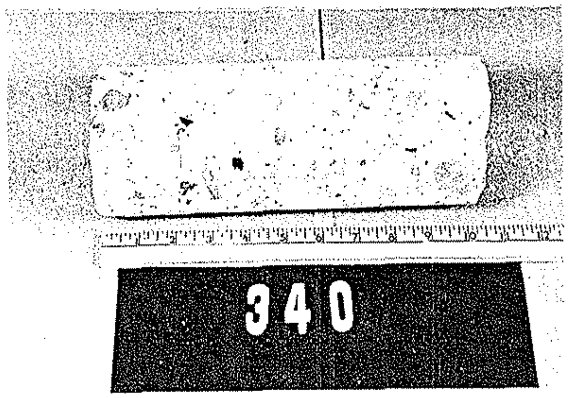
Core No.	Route	Milepost	Dir.	County
338	I-80	143.50	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	6.35	135
11-10-83	20°	5.40	225+



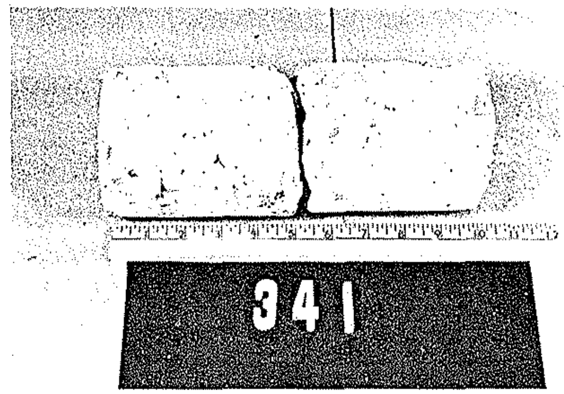
Core No.	Route	Milepost	Dir.	County
339	I-80	144.50	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.85	115
11-10-83	20°	4.00	225



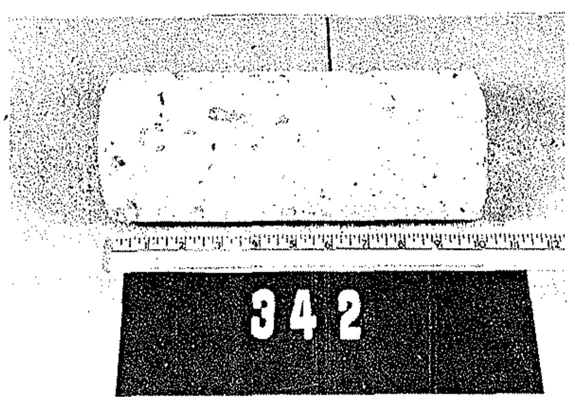
Core No.	Route	Milepost	Dir.	County
340	I-80	145.50	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	5.10	160
11-10-83	20°	4.85	225+



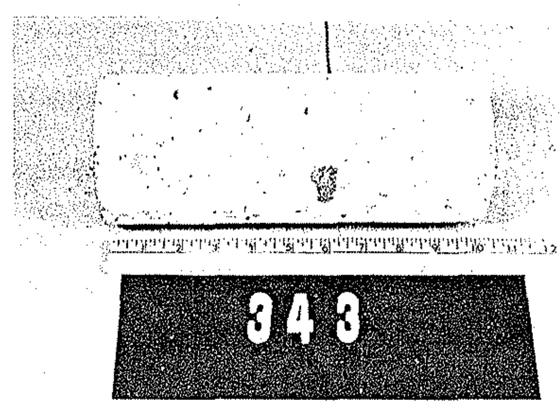
Core No.	Route	Milepost	Dir.	County
341	I-80	146.50	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.40	90
11-10-83	20°	5.10	225+



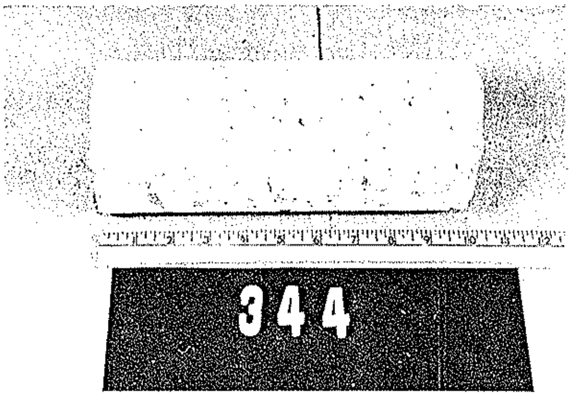
Core No.	Route	Milepost	Dir.	County
342	I-80	147.50	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	6.35	205
11-10-83	20°	4.00	225+



Core No.	Route	Milepost	Dir.	County
343	I-80	148.00	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.55	95
11-10-83	20°	3.35	225



Core No.	Route	Milepost	Dir.	County
344	I-80	148.30	EB	Polk

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value
5-11-83	55°	4.55	140
11-10-83	20°	4.70	175

Core No.	Route	Milepost	Dir.	County

Date Tested	Pave. Temp °F	Struct. Rating	Soil Support K Value

APPENDIX G

Table 1
Moisture - Density - Silt Content Relationships

Pavement Type	Core #	Field Density (pcf)	K Value (psi/in)	Silt Content (%)	Moisture Content (%)	Layer	Description
PC	133	111	205	35	16.2	B	Gr Br Glacial Clay
PC	134	109	180	48	16.5	B	Dk Br Silty Clay Loam
PC	134	111	200	42	17.4	B	Gr Br Glacial Clay
PC	136	108	205	37	18.3	B	Gr Br Glacial Clay
PC	138	100	130	61	21.6	B	Br Gr Silty Clay
PC	139	95	65	48	25.2	B	Gr Br Silty Glacial Clay
PC	140	108	200	40	17.8	B	Gr Br Glacial Clay
PC	141	118	200	41	12.7	B	Dk Br Sandy Silty Clay
PC	142	104	180	41	19.6	B	Br Gr Glacial Clay

Table 2
Glacial Clay Subgrade Treatment

Pavement Type	Core #	Field Density (pcf)	K Value (psi/in)	Silt Content (%)	Moisture Content (%)	Layer	Description
PC	211	118	200	36	14.0	B	Gr Br Clay Loam
PC	212	124	200			B	Br Gr Clay Loam
PC	213	118	190	42	12.2	B	Gr Br Glacial Clay
PC	214	120	215	36	12.3	B	Gr Br to Br Gr Glacial Clay
PC	215	115	125		11.8	B	Br Sand Clay Loam w/Sand Seams
PC	216	123	200	44	13.5	B	Br Sandy Clay Loam
PC	217	112	210		14.9	B	Dk Br Silty Clay Loam w/Gravel
PC	218	123	125	57	11.3	B	Br Sandy Loam
PC	219	115	185	36	10.6	B	Gr Br Sandy Clay Loam
PC	220	119	220	36	12.1	B	Br Gr Glacial Clay
PC	221	119	185	39	12.2	B	Gr Br Silty Glacial Clay
PC	222	112	210	35	15.7	B	Gr Br Glacial Clay
PC	223	115	190	35	13.5	B	Dr Br Clay Loam
PC	225	105	220	41	19.7	B	Br Gr Clay Loam
PC	225	105	200	43	17.7	B	Dk Br Clay w/Gravel + Sand Seams
PC	226	118	190	49	12.5	B	Gr Br Glacial Clay

Table 3
Silty Sand and Gravel Subgrade Treatment

Pavement Type	Core #	K Value (psi/in)	Silt Content (%)	Layer	Description
PC	169	185	10	B	Sand + Gravel
PC	170	215	10	B	Sand + Gravel
PC	171	185	8	B	Sand + Gravel
PC	172	185	9	B	Sand + Gravel
PC	173	130	10	B	Sand + Gravel
PC	174	180	9	B	Sand + Gravel
PC	175	195	17	B	Sand + Gravel
PC	176	150	20	B	Sand + Gravel
PC	177	160	19	B	Sand + Gravel
PC	178	180	14	B	Sand + Gravel
PC	191	145	14	B	Sand + Gravel
PC	192	150	19	B	Sand + Gravel
PC	193	225+	15	B	Sand + Gravel
PC	194	140	21	B	Sand + Gravel
PC	195	155	21	B	Sand + Gravel
PC	196	185	26	B	Sand + Gravel
PC	197	180	25	B	Sand + Gravel
PC	198	180	23	B	Sand + Gravel
PC	199	180	28	B	Sand + Gravel
PC	200	205	28	B	Sand + Gravel
PC	201	205	26	B	Sand + Gravel
PC	202	180		B	Sand + Gravel
PC	203	175	3	B	Sand + Gravel
PC	204	190	21	B	Sand + Gravel

Table 4
Saturated Silty Clays and Various Granular Treatments

Pavement Type	Core #	Field Density (pcf)	K Value (psi/in)	Silt Content (%)	Moisture Content (%)	Layer	Description
PC	253		215	2		B	Br Sand w/Occ Gravel
PC	254		200	2		B	Br Sand w/Occ Gravel
PC	255	113	155	33	13.8	B	Gr Br Clay Loam
PC	256		155	8		B	Br Sand w/Gravel
PC	275	102	50	73	19.9	B	Br Gr Silty Clay
PC	276	104	90	73	20.0	B	Br Gr Silty Clay
PC	277		165	9		B	Gravel (Limestone)
PC	278	106	115	63	19.0	B	Br Gr Silty Clay
PC	279		155	12		B	Gravel (Limestone)
PC	280	98	125	73	22.5	B	Br Gr Silty Clay

Table 5
High Silt Content in Granular Subbase

Pavement Type	Core #	K Value (psi/in)	Silt Content (%)	Layer	Description	Thickness (inches)	Layer C Density - Moisture (pcf) (%)
PC	329	150	10	B	Sand and Gravel	6"	111 lb. @ 15.9
PC	330	160	8	B	Sand and Gravel	4.5"	118 lb. @ 15.3
PC	331	105	16	B	Sand and Gravel	5"	111 lb. @ 16.7
PC	332	105	11	B	Sand and Gravel	6"	118 lb. @ 15.3
PC	333	160	8	B	Sand and Gravel	6"	111 lb. @ 15.8
PC	334	125	11	B	Sand and Gravel	5"	
PC	335	90	13	B	Sand and Gravel	4"	110 lb. @ 17.5
PC	336	65	14	B	Sand and Gravel	6"	102 lb. @ 19.8
PC	337	85	12	B	Sand and Gravel	5"	108 lb. @ 17.6
PC	338	135	12	B	Sand and Gravel	5"	111 lb. @ 16.9

Table 6
IA 22 & IA 70 Road Rater A.C.
Overlay Designs

Map Section Number	Route	From	To	Road Rater Structural Rating 1977	1978	1979	1980	1982	Road Rater A.C. Overlay Estimate Based On 15 Year Design Life	District #5 Recommendation
1	IA. 22	US 218	IA.405	1.65/1.45	*			1.50/1.10	7"	Reconstruction 1986
2	IA. 22	IA.405	Nichols	3.25/2.90	4.20/3.70	4.00/3.60		4.20/3.60	2"	Minor Resurfacing In Future
3	IA. 22	Nichols	E.Jct. IA. 70	3.20/2.70	3.25/2.75			3.50/3.00	3½"	Resurfacing 1984
5	IA. 22	IA.70	Muscatine	2.90/2.45	2.38/2.18			2.37/1.90	7"	3" - 4" Resurfacing 1984
7	IA. 70	Columbus Junction	Conesville				2.95/2.52	3.00/2.45	3"	Resurfacing In Future
6	IA. 70	Cones-ville	Nichols				2.20/1.85	2.38/2.05	4"	Resurfacing In Future
4	IA. 70	IA.22	West Liberty				2.80/2.45	3.10/2.60	5½"	3" - 4" Resurfacing 1984

NOTES:

* Too Low For Meaningful Structural Rating

1.50/1.10 The First Number Is The Structural Rating Based On Average Deflection. The Second Number Is The Structural Rating Based On 80th Percentile Deflection For Design Purposes.

Table 7
Requested Rigid Pavement Road Rater Testing

ROUTE	COUNTY	FROM	TO	STRUCTURAL COMPOSITION	As Const. NEW SN	AVE. SR	AVE. SR AT JOINTS	80th % SR	A.C. OVERLAY THICKNESS REQUIRED 10 YEAR DESIGN LIFE	15 Year DESIGN LIFE	20 YEAR DESIGN LIFE
				REQUESTED RIGID PAVEMENT ROAD RATER TESTING							
I-80	Pott.	MP 6.61 Council Bluffs	MP 11.52 Sec. 11, R-43W,T-75N	1969 4" GSB 8" CRCP	4.40	EB 3.40 WB 3.60	3.25 3.28	2.50 3.15	10" 8 1/4"	10 1/2" 9"	10 3/4" 9"
I-80	Pott.	MP 11.52 Sec. 11, R-43W,T-75N	MP 18.93 Underwood	1969 4" ATB 8" CRCP	5.36	EB 4.28 WB 4.28	3.98 4.24	3.73 3.83	6 3/4" 6 3/4"	7 1/2" 7 1/4"	7 3/4" 7 1/2"
I-80	Pott	MP 18.93 Underwood	MP 27.00 I-680	1969 4" ATB 8" CRCP	5.36	EB 4.10 WB 4.28	4.50 4.00	3.67 3.73	7" 6 3/4"	7 3/4" 7 1/2"	7 3/4" 7 3/4"
I-80	Pott	MP 27.00 I-680	MP 33.80 Shelby	1966 4" GSB 8" CRCP	4.40	EB 3.66 WB 3.59	3.40 3.72	3.24 3.00	8" 8 3/4"	8 3/4" 9 1/2"	9" 9 3/4"
I-680	Pott.	MP 13.05 I-29	MP 29.21 I-80	1966 4" GSB 8" CRCP	4.40	EB 3.73 WB 3.34	3.03 2.74	3.40 2.85	3 3/4" 5"	4 3/4" 6 1/4"	5 1/4" 6 3/4"
I-80	Dallas	MP 100.80 Redfield Inter-change	MP 106.16 P 58	1966 4" GSB 10" Std. PCCP Westbound. Eastbound Consists of AC And PC Sections of Various Composition. Eastbound PC Sections (Only) Were Tested And Averaged.	PC Various 5.40	EB 4.60 WB 4.80	2.02 2.63	4.00 4.30	6 3/4" 6"	7" 6 1/4"	7 1/4" 6 1/2"
I-80	Dallas	MP 106.16 P58	MP 111.14 US 169	1966 4" GSB 8" Bar Mats	4.40	EB 3.87 WB 3.36	2.75 3.45	3.10 2.87	9" 9 1/2"	9 1/4" 10"	9 1/2" 10"
I-80	Dallas	MP 111.14 US 169	MP 118.00 R22	1966 4" GSB 8" Bar Mats	4.40	EB 3.08 WB 3.14	2.78 3.20	2.65 2.60	10" 10 1/4"	10 1/2" 10 1/2"	10 1/2" 10 3/4"
I-80	Dallas	MP 118.00 R 22	MP 122.40 Polk Co. Line	1966 4" GSB 8" Bar Mats	4.40	EB 2.86 WB 2.55	2.40 2.70	2.52 2.17	10 1/2" 11 1/4"	10 3/4" 11 1/2"	11" 11 3/4"

Table 8
Requested Flexible Pavement Road Rater Testing

ROUTE	COUNTY	FROM	TO	STRUCTURAL COMPOSITION	As Const. NEW SN	AVE. SR	AVE. SR AT JOINTS	80th % SR	A.C. OVERLAY THICKNESS REQUIRED 10 YEAR DESIGN LIFE	15 Year DESIGN LIFE	20 YEAR DESIGN LIFE
				REQUESTED FLEXIBLE PAVEMENT ROAD RATER TESTING							
I-80	Pottawattamie	MP 27.00 I-680	MP 33.80 Shelby	1966 8" ATB Inside Shoulders	2.72	EB 2.25 WB 2.30 Tested At 25Hz & 58% @ 50°F	- -	1.95 2.05	- -	- -	- -
I-80	Jasper	MP 173.38 T22	MP 183.66 1 Mile E. of IA 146 (Grinnell)	1962 6" SAS 14" ATB 3" AC 1968 2 1/4" AC	7.37	EB 8.50 WB 8.60 Tested At 25 Hz & 58% @ 70°F	- -	6.95 7.40	0" 0"	0" 0"	1/4" 0"
						EB 5.62 WB 6.00 Tested At 30Hz & 68% @ 70°F (PCC Setting)	- -	4.55 4.95	5 3/4" 4 3/4	5 3/4" 4 3/4"	6" 5"

Table 9
Requested Composite (AC/PC) Pavement Road Rater Testing

ROUTE	COUNTY	FROM	TO	STRUCTURAL COMPOSITION	As Const. NEW SN	AVE. SR	AVE. SR AT JOINTS	80th % SR	A.C. OVERLAY THICKNESS REQUIRED 10 YEAR DESIGN LIFE	15 Year DESIGN LIFE	20 YEAR DESIGN LIFE
				REQUESTED COMPOSITE (AC/PC) PAVEMENT ROAD RATER TESTING							
US 30	Linn	MP 258.44 IA 13	MP 268.57 Cedar Co. Line	1953 9 1/2" PCCP 1965 3" AC	6.07	EB 5.40 WB 5.83 30 Hz & 68% @ 47°F	3.73 3.18	4.55 4.45	1 3/4"	2 1/2"	3 1/4"
US 30	Cedar	MP 268.57 Cedar Co. Line	MP 284.08 Clarence	1927 7" PCCP 1951 3" AC 1960 2" AC	5.70	EB 3.80 WB 4.55 30 Hz & 68% @ 49°F	2.85 1.88	3.00 3.88	4 1/4"	5"	5 3/4"
US 30	Tama	MP 204.42 Tama	MP 209.78 Old IA 212	1951 9" PCCP 1964 3" AC	5.82	EB 4.32 WB 4.32 30 Hz & 68% @ 34°F	2.80 3.58	3.06 3.25	4 3/4"	5 1/2"	6 1/2"
				1931 7" PCCP 1956 6" PCCP 1964 3" AC	7.82	EB 4.67 WB 3.15 30 Hz & 68% @ 34°F	3.03 3.88	3.72 2.18	6 1/4"	7"	7 3/4"

Table 10
Rigid Pavement Road Rater Study Sections

ROUTE	COUNTY	FROM	TO	STRUCTURAL COMPOSITION	As Const. NEW SN	AVE. SR	AVE. SR AT JOINTS	80th % SR	A.C. OVERLAY THICKNESS REQUIRED 10 YEAR DESIGN LIFE	15 Year DESIGN LIFE	20 YEAR DESIGN LIFE
				RIGID PAVEMENT ROAD RATER STUDY SECTIONS							
US 30	Boone	MP 131.00 Just West Of Des Moines River	MP 131.50	1964 4" GSB 10" PCCP	5.40	WB 5.70	2.60	4.95	0"	3/4"	1 1/4"
US 30	Story	MP 148.00 US 69	MP 156.21 Nevada	1964 4" GSB 10" PCCP	5.40	EB 5.13 WB 5.38	4.50 4.50	4.43 4.67	2" 1 1/2"	2 3/4" 2"	3 1/4" 2 3/4"
US 30	Marshall	MP 172.00 State Center	MP 179.00 S 70	1963 4" Grad.St. Base 8" CRCP	4.56	EB 3.70 WB 3.70	3.75 3.70	3.23 3.42	3 1/2"	4 1/2"	5"
IA 17	Boone	MP 21.63 1 Mile N. of US 30	MP 32.76 Hamilton Co. Line	1980 8" PCCP	4.00	NB 4.13 SB 4.90	1.95 2.37	3.62 4.30	0"	0"	0"
IA 17	Hamilton	MP 39.76 1 Mile N. Of Stanhope	MP 48.95 520	1978 7 1/2" PCCP	3.75	NB 3.88 SB 3.80	2.72 2.43	3.51 3.38	0"	0"	0"
IA 17	Hamilton	MP 134.00 W.End Of 520	MP 135.39 Old US 20	1979 8" PCCP	4.00	NB 4.60 SB 4.90	4.00 4.10	4.04 4.00	1 1/4"	1 3/4"	2 1/4"
520	Hamilton	MP 135.58 W. End Of 520	MP 140.09 IA. 17	1979 4" Cl. A SB 8 1/2" PCCP	5.61	EB 5.70 WB 5.43	2.85 3.10	5.05 4.95	1" 1 1/4"	2" 2 1/4"	2 1/4" 2 1/2"
520	Hamilton	MP 141.50 2 Miles E. Of I A 17	MP 149.50 US 69	1975 4" Cl. A SB 9" PCCP	5.86	EB 5.43 WB 5.34	3.90 3.67	4.95 4.78	1 1/4" 1 1/2"	2 1/4" 2 1/2"	2 1/2" 3"
520	Hamilton	MP 149.50 US 69	MP 152.50 I-35	1968 4" GSB 10" PCCP	5.40	EB 5.70 WB 5.00	3.77 4.50	5.30 4.55	1/2" 2 1/4"	1 1/4" 3"	1 3/4" 3 1/2"

Table 11
Rigid Pavement Road Rater Study Sections

ROUTE	COUNTY	FROM	TO	STRUCTURAL COMPOSITION	As Const. NEW SN	AVE. SR	AVE. SR AT JOINTS	80th % SR	A.C. OVERLAY THICKNESS REQUIRED 10 YEAR DESIGN LIFE	15 Year DESIGN LIFE	20 YEAR DESIGN LIFE
				RIGID PAVEMENT	ROAD RATER	STUDY SECTIONS	(CONT'D)				
I-80	Pott.	MP 35.10 Shelby	MP 39.68 US 59	1966 4" GSB 8" CRCP 1979 3" PCC Overlay EB	5.90	EB 4.10	2.65	3.25	8"	8 3/4"	9"
IA 160	Polk	MP 0.00 IA 415	MP 1.22 US 69	1947 10" -8" -10" PCCP	4.30	EB 3.35 WB 4.40	- -	2.20 3.83	Requested 12/7/82	Pavement Determinations	
IA 415	Polk	MP 2.50 2 Miles S. of IA 160	MP 4.50 IA 160	1961 10" PCCP	5.00	NB 3.64	-	2.66	"	"	"
IA 17	Polk	MP 0.00 IA 141	MP 7.50 Boone Co. Line	1959 10" PCCP	5.00	NB 4.10 SB 4.40	- -	3.05 3.40	"	"	"
I-35	Story	MP 111.60 US 30	MP 116.77 E 29	1967 4" GSB 8" CRCP	4.40	NB 4.00 SB 4.30	3.90 4.25	3.67 3.97	6 1/4" 5 1/2"	7 1/4" 6 1/2"	7 1/2" 6 3/4"

Table 12
Composite (AC/PC) Pavement Road Rater Study Sections

ROUTE	COUNTY	FROM	TO	STRUCTURAL COMPOSITION	As Const. NEW SN	AVE. SR	AVE. SR AT JOINTS	80th % SR	A.C. OVERLAY THICKNESS REQUIRED		
									10 YEAR DESIGN LIFE	15 Year DESIGN LIFE	20 YEAR DESIGN LIFE
COMPOSITE (AC/PC) PAVEMENT ROAD RATER STUDY SECTIONS											
US 69	Polk	MP 97.00 1 Mile N. Of Ankeny	MP 105.00 IA 210	1923 8" PCCP 1948 3" AC 1956 1 1/2" AC 1967 3/4" AC	6.31	NB 4.18 SB 4.05 30 Hz & 68% @ 38°F	- -	3.45 3.28	3/4"	1 1/2"	2"
US 65	Polk	MP 84.30 I-80	MP 87.18 Bondurant	1934 10" PCCP 1951 3" AC 1980 3" AC	7.64	SB 4.25 30 HZ & 68% @ 48°F	3.00	3.75	2 1/2"	2 3/4"	3 3/4"
IA 330	Marshall	MP 20.21 US 30	MP 23.42 Marshall- town	1924 8" PCCP Or 1937 7 1/2" PCCP And 1952 3" AC	5.32	NB 3.45 SB 3.33 30 Hz & 68% @ 48°F	3.10 3.75	2.75 2.73	2 1/2"	3"	3 1/2"
IA 415	Polk	MP 2.50 2 Miles S. of IA 160	MP 4.50 IA 160	1943 9" PCCP 1960 3" AC	5.82	SB 5.78 30 Hz & 68% @ 20°F	-	5.00	Requested Pavement Determination 12/7/82		

Table 13

Flexible Pavement Coefficient of Asphaltic Concrete

From Road Rater Deflection Testing

County	Route	From Milepost	To Milepost	Nominal AC Overlay Thickness	Year Resurf.	Road Rater Before Resurf. Ave.SR	Road Rater Before Resurf. Year	Road Rater After Resurf. Ave.SR	Road Rater After Resurf. Year	Coefficient of Asphaltic Concrete
Boone	IA 210	1.90	6.87	3"	1979	2.70	1978	4.62	1980	0.64
Hamilton	IA 175	159.04	164.53	4 1/2"	1977	2.20	1977	3.90	1978	0.38
Story	IA 210	15.15	20.19	3"	1978	3.30	1978	4.33	1979	0.34
Kossuth	IA 91	0.47	3.71	3"	1978	1.80	1978	3.66	1979	0.62
Jasper	IA 117	6.49	17.43	3"	1978	3.88	1977	5.09	1979	0.40
Marshall	IA 233	0.63	5.30	3"	1977	2.34	1977	3.43	1978	0.36
Keokuk	IA 78	0.00	13.31	3"	1980	3.16	1980	5.92	1984	0.92
									Average	0.52

Table 14

Rigid Pavement Coefficient of Asphaltic Concrete

From Road Rater Deflection Testing

County	Route	From Milepost	To Milepost	Pavement Type	Nominal AC Overlay Thickness	Year Resurf.	Road Rater Before Ave. SR	Road Rater Before Resurf. Year	Road Rater After Resurf. Ave. SR	Road Rater After Resurf. Year	Coefficient of Asphaltic Concrete
Mills Montgomery & Adams	US 34	21.88	63.73	PC	3"	1983	3.95	1983	5.12	1984	0.39
Pottawattamie	I-680	13.05	29.21	PC	1 1/2"	1983	3.64	1982	4.25	1984	0.40
Dallas	I-80 WB	99.21	100.80	PC	6"	1988	4.92	1987	8.02	1989	0.52
Polk	I-35 NB	92.77	101.78	PC	4"	1988	5.56	1987	6.92	1989	0.34
Story	I-35 NB	105.80	111.60	PC	4 1/2"	1987	5.18	1987	8.41	1988	0.72
Polk	I-80	127.17	132.00	PC	2"	1988	4.53	1988	5.14	1989	0.31
										Average	0.45

Table 15

Road Rater Void Detection Testing

I-80 EB SCOTT COUNTY

Station	Before Subsealing SR	Before Subsealing Soil K	2 Hours After Subsealing SR	2 Hours After Subsealing Soil K
529+00	1.73	50	2.22	122
529+25	1.77	50	3.46	207
529+50	1.57	50	2.75	198
529+75	1.33	50	2.30	179
529+00	1.77	50	3.33	173
530+25	1.57	50	2.75	183
530+50	1.51	50	3.21	192
530+75	1.73	50	3.68	197
531+00	1.46	50	3.46	197
531+25	1.37	50	2.48	161
531+50	1.44	50	2.48	161
531+75	1.70	50	2.22	144
532+00	1.25	50	3.21	192
532+50	2.15	137	2.88	219
533+00	1.73	50	3.53	188
534+00	1.46	50	3.10	194

TABLE 16
ROAD RATER TESTING OF RETROFITTED
LOAD TRANSFER DOWELS

MILEPOST	STRUCT. RATING	SOIL SUPPORT K VALUE	LOCATION	REMARKS
290.154	4.90	169	MIDP	LOAD TRANSFER DOWELS INSTALLED
290.156	4.56	206	CRCK	
290.160	3.80	173	JT	
290.164	4.02	185	CRCK	
290.165	4.56	155	MIDP	
290.167	4.02	185	CRCK	
290.170	2.67	143	JT	
290.172	5.34	133	MIDP	
290.175	2.50	106	JT	
290.181	3.60	199	CRCK	
290.182	5.34	133	MIDP	
290.184	3.13	163	CRCK	
290.187	1.33	50	CRCK	NO LOAD TRANSFER DOWELS INSTALLED
290.190	2.04	50	JT	
290.194	1.51	50	CRCK	
290.196	4.56	50	MIDP	
290.198	1.51	50	CRCK	
290.202	2.34	115	CRCK	
290.205	3.27	176	JT	
290.209	1.85	50	CRCK	
290.211	6.12	130	MIDP	
290.212	1.70	50	CRCK	
290.215	1.27	50	CRCK	
290.217	1.57	50	CRCK	