AN INVESTIGATION OF THE INTERSTATE 80 RUTTING IN ADAIR COUNTY

October 1983
Highway Division
Iowa Department of Transportation

AN INVESTIGATION
OF THE
INTERSTATE 80 RUTTING
IN
ADAIR COUNTY

BY

VERNON J. MARKS

515/239-1447

HIGHWAY DIVISION

IOWA DEPARTMENT OF TRANSPORTATION

AMES, IOWA

OCTOBER 1983

TABLE OF CONTENTS

SUMMARY....1

INTRODUCTION....2

HISTORY....2

REHABILITATION DESIGN....3

- Structural....3
- Asphalt Mixture....5

PROJECT CONSTRUCTION....5

- Mix Production....5
- Mix Placement Procedure....6
- Compaction Procedure....7
- Hydrated Lime....7

PHYSICAL INVENTORY....7

- Cross Sections....7
- Longitudinal Subdrains....8
- Structural Analysis....8
- Pavement Sections....8
- Core Drilling and Analysis....9

AMBIENT TEMPERATURES OF 1983....10

DISCUSSION OF FACTORS CONTRIBUTING TO THE RUTTING PROBLEM....10

- Asphalt Cement Content and Grade....10
- Mixture Density and Voids....11

FACTS....13

FINDINGS....14

CONCLUSIONS....14

RECOMMENDATIONS....15

ACKNOWLEDGEMENTS....15

APPENDIX

- Appendix A - Location and History
- Appendix B - Rehabilitation Design
- Appendix C - Construction Data
- Appendix D - Physical Inventory Data
- Appendix E - Climatological Data

SUMMARY

This investigation was initiated to determine the causes of a rutting problem that occurred on Interstate 80 in Adair County. I-80 from Iowa 25 to the Dallas County line was opened to traffic in November, 1960. The original pavement consisted of 4-1/2" of asphalt cement concrete over 12" of rolled stone base and 12" of granular subbase. A 5-1/2" overlay of asphalt cement concrete was placed in 1964. In 1970-1972, the roadway was resurfaced with 3" of asphalt cement concrete. In 1982, an asphalt cement concrete inlay, designed for a 10-year life, was placed in the eastbound lane.

The mix designs for all courses met or exceeded all current criteria being used to formulate job mixes. Field construction reports indicate that asphalt usage, densities, field voids and filler bitumen determinations were well within specification limits on a very consistent basis.

Field laboratory reports indicate that laboratory voids for the base courses were within the prescribed limits for the base course and below the prescribed limits for the surface course. Instructional memorandums do indicate that extreme caution should be exercised when the voids are at or near the lower limits and traffic is not minimal. There is also a provision that provides for field voids controlling when there is a conflict between laboratory voids and field voids. It appears that contract documents do not adequately address the directions that must be taken when this conflict arises since it can readily be shown that laboratory voids must be in the very low or dangerous range if field voids are to be kept below the maximum limit under the current density specifications.

A rut depth survey of January, 1983, identified little or no rutting on this section of roadway. Cross sections obtained in October, 1983, identified rutting which ranged from 0 to 0.9" with a general trend of the rutting to increase from a value of approximately 0.3" at MP 88 to a rut depth of 0.7" at MP 98. No areas of significant rutting were identified in the inside lane. Structural evaluation with the Road Rater indicated adequate structural capacity and also indicated that the longitudinal subdrains were functioning properly to provide adequate soil support values. Two pavement sections taken from the driving lane indicated very little distortion in the lower 7" base course. Essentially all of the distortion had occurred in the upper 2" base course and the 1-1/2" surface course.

Analysis of cores taken from this section of Interstate 80 indicated very little densification of either the surface or the upper or lower base courses. The asphalt cement content of both the Type B base courses and the Type A surface course were substantially higher than the intended asphalt cement content. The only explanation for this is that the salvaged material contained a greater percent of asphalt cement than initial extractions indicated. The penetration and viscosity of the blend of new asphalt cement and the asphalt cement recovered from the salvaged material were relatively close to that intended for this project.

The 1983 ambient temperatures were extremely high from June 20 through September 10.

The rutting is a result of a combination of adverse factors including, (1) high asphalt content, (2) the difference between laboratory and field voids, (3) lack of intermediate sized crushed particles, (4) high ambient temperatures. The high asphalt content in the 2" upper base course produced an asphalt concrete mix that did not exhibit satisfactory resistance to deformation from heavy loading. The majority of the rutting resulted from distortion of the 2" upper base lift.

Heater planing is recommended as an interim corrective action. Further recommendation is to design for a 20-year alternative by removing 2-1/2" of material from the driving lane by milling and replacing with 2-1/2" of asphalt concrete with improved stability. This would be followed by placing 1-1/2" of high quality resurfacing on the entire roadway. Other recommendations include improved density and stability requirements for asphalt concrete on high traffic roadways.

INTRODUCTION

The purpose of the investigation was to determine the causes for a rutting problem that has occurred on a 13-mile segment of I-80 in Adair County. The segment of concern lies between Iowa 25 and the Dallas County line (MP 85.74 to 99.43) (Appendix A-1). The investigation was conducted by Highway Division personnel from the offices of Materials, Construction, Maintenance, Road Design, and District Four.

HISTORY

The original pavement construction was begun in 1959 and completed in 1960 (Appendix A-2). The construction sequence was 12" granular subbase, 12" rolled stone base, and 4-1/2" of Type A asphalt cement concrete. Construction was suspended in 1959 due to cold temperatures while placing the rolled stone base and asphalt cement concrete. Construction resumed the spring of 1960 and was completed in September. Longitudinal subdrains (6" perforated metal pipe) were installed at various locations 28-1/2" below the top of pavement and 13' from the centerline of the road to provide an outlet for water which had penetrated into the rolled stone base. This subdrain installation was unique for Iowa's young interstate system. Unfortunately, they did not function due to too much relatively impermeable material surrounding the drain, which prevented water infiltration. This experience provided valuable information for improvement of future design criteria.

The first resurfacing of this stretch of I-80 occurred in 1964. The overlay consisted of 1-1/2" of a 3/4" mix with 5% AC and 4" of a 1-1/2" mix with 4-1/2% to 5% AC.

It was determined to resurface the roadway again in 1970. The project was staged due to the low clearance of several structures. Approximately 10 miles of pavement were resurfaced in 1970 with the balance being resurfaced in 1972 after the structures had been raised to accommodate the additional thickness of the overlay. The project consisted of a 1" overlay of a 3/8" mix with 6% AC surface course and a 2" overlay of a 3/4" mix with 5% AC binder course.

In 1980 a pavement repair contract was let which included this section of I-80. The driving lane of the eastbound roadway was heater scarified 13' wide to a depth of 1" from MP 93.85 to MP 99.43 and resurfaced with a 1" overlay of 7.25% AC hot sand mix. Longitudinal edge subdrains were installed in a 48" deep trench, measured from the top of proposed pavement and designed to penetrate the rolled stone base, at various locations along the oustide edge of the eastbound driving lane between MP 94 and MP 98.

The original traffic projections could not be found but a similar project of I-80 from the Cass County line east 6.1 miles had an estimated 1958 AADT of 5600 and 1975 AADT of 13,800. The typical estimated truck traffic volumes used for that time period was 10%. 1982 AADT was 12,000 with 35% trucks and projected 2002 AADT is 20,000 with 27% trucks.

REHABILITATION DESIGN

In 1982, a field review team composed of personnel from the offices of Road Design, Materials and Maintenance determined that this section of Interstate 80 between MP 85.75 and 99.43 was in critical condition and in need of rehabilitation. The deterioration of the driving lane was much more critical than the passing lane. The funding available to correct the situation was limited. The first alternative considered for rehabilitation of this section was to replace the center 24' of both eastbound lanes for the entire 13.6 miles. It was determined that the cost for this rehabilitation would be prohibitive. There were also traffic control and safety problems with this type of construction. Another alternative considered for this rehabilitation was to replace the center 24' of the eastbound lanes for approximately five miles and extensively patch the remaining eight miles. The life expectancy and economy of the patched sections were very questionable. In addition to the traffic control and safety problems mentioned for the previous alternate. There would be substantial future maintenance on the patched section of this roadway.

The alternative selected for rehabilitation of this section of Interstate 80 was to replace the 12' driving lane eastbound for 13.6 miles. An economic analysis of the three alternate rehabilitation systems showed the inlay alternate to be the most cost effective. The traffic could be maintained in the eastbound passing lane. It was determined that the deteriorated material should be milled out and replaced with an inlay. Both a portland cement concrete inlay, as used in the westbound lanes, and an asphalt concrete inlay were considered. The primary factor in the selection of the asphalt cement concrete inlay was that the existing pavement would be recyclable into the project.

Structural

The structural design is primarily dependent upon the traffic volume and recommended design life for the particular construction or rehabilitation in question. The Office of Road Design uses AASHTO design criteria to determine the pavement section required to carry a particular traffic volume for a particular design life. The Office of Road Design developed a 20-year design life inlay structure (Appendix B-1) and also a 7-year "stage" design life for an inlay. The final decision was a 10-year "stage" construction. An outline of the Office of Road Design considerations for those design lifes is as follows:

I. Recommended design for 20-year life or 12 million 18 kip equivalent axle load applications.

   A. Install continuous longitudinal subdrains at outer edge of driving lane.

   B. Mill existing driving lane surface to a depth of 9 inches and replace with 9" Type 'B' recycled ACC base.

   C. Resurface entire roadway width with 3" of Type 'A' ACC surface.

   Assumptions:

      1. The single 48" deep edge drain installation would control the moisture content of the 24" granular section for the full width of the pavement. It is significant to note that the 12" granular and 12" rolled stone base section had historically contained excess moisture and was basically considered unstable.

         For design purposes, a drained, granular soil support value of 5 was assigned; a similar 'K' value was assigned for the PCC alternate.

      2. A normal heavy traffic split was assumed for the passing lane. With the assumed subbase improvement, sufficient structure could be obtained by patching and surface improvement.

      3. The inlay concept attained the required driving lane structural improvement with minimal work required for shoulder and foreslope adjustment.

II. Recommended design for 7-year "stage" construction - asphaltic concrete alternate only.

   A. Full length longitudinal subdrains.

   B. Mill existing driving lane to a depth of 7" and replace with 7" Type 'B' recycled ACC base.

   C. Resurface entire roadway with 3" of Type 'A' ACC surface.

III. Final staff decision - 10-year "stage" construction.

   A. Full length longitudinal subdrains.

   B. Mill existing driving lane to a 9" depth and replace with 9" Type 'B' recycled ACC base.

   C. Place 1-1/2" recycled Type 'A' ACC surface course on entire roadway.

Asphalt Mixture

The use of the salvaged asphalt cement concrete material presented some problems in the mix designs. The Iowa DOT utilizes a .45 power gradation curve to yield an asphaltic concrete mixture with maximum density (Appendix B-2 and B-3). The amount of fine material, however, is limited to improve the stability and insure voids to contain the desired asphalt cement. Much of the problem with this mix design was related to obtaining a sand that was sufficiently open graded to provide the desirable voids for the asphalt cement to comply with minimum mix criteria. Two samples of salvaged material to be used in the Type B base were obtained. A blend of these two salvaged materials was used in developing a mix design for the Type B base. The asphalt content of those two samples was 4.45 and 5.56. For design purposes, an asphalt content of 5.0% was used for the salvaged material. The approved job mix criteria for the Type B base called for an asphalt content of 5.0% in a 50-50 mix. This required the addition of 2.6% of new asphalt cement. The lab voids were 3.2% with a filler bitumen ratio of 1.1.

The mix design for the Type A surface course was based on two samples of selected salvaged material having asphalt cement contents of 5.39 and 5.46. The approved mix design for the surface course was for an asphalt content of 4.5% using 45% salvaged material and 55% virgin aggregate in the mix. This required an addition of 2.2% of new asphalt cement based upon an asphalt content of 5.4% in the salvaged material. The laboratory voids for the surface mix were 4.5% with a filler bitumen ratio of 1.2.

PROJECT CONSTRUCTION

No significant construction problems were identified during the 9" asphaltic cement concrete inlay and the 1-1/2" asphaltic concrete resurfacing of the rehabilitation project. The project began with the milling of specified deteriorated sections of the passing lane on July 22, 1982. The first Type B base mix material was placed on July 27, 1982. The passing lane inlay was completed on August 4, 1982. Construction of the base in the driving lane was initiated on August 6, 1982. The first Type A surface was laid on September 2, 1982, and the Type A surface was completed on September 30, 1982.

Repair work in the driving lane included continuous placement of 48" deep longitudinal subdrains along the outside one foot of the 12' lane.

Mix Production

The recycled mixture was produced in a Standard Havens drum mix plant. Production in tons per hour changed throughout the project depending on the percent of moisture in the salvage and the virgin materials. Combined moisture on the original salvage material was approximately 6%. Moisture in the salvage material on the new millings ranged from 2.5% to 3.0%. Moisture in the virgin aggregate ranged from 2.9% up to 5.3% with an average of approximately 4.2%. Production ranged from approximately 205 tons per hour the first couple of days, until modification of the plant drum was made, thereby increasing the production to about 300 tons per hour.

Daily construction reports do not indicate any deficiencies in the base that would be suspect. Asphalt usage as determined by tank measurements are very close to the intended new AC. Densities and field voids were excellent and the filler bitumen ratios were all below the 1.3 maximum. The daily laboratory reports do show the asphalt extractions as being a little higher than design and/or intended. This is not uncommon, however, with the method being used since it involves a retention factor that is not 100% accurate. In reviewing the laboratory voids, it can be noted that they are consistently below the mix design voids of 3.2%, the range being 2.0 to 3.6% with 2.0 to 2.5% being the predominate range (Appendix C-1). A lab void content of 2.0 to 6.0 is the range specified by I.M. 511 for a Type B class 1 mix with a caution to consider traffic volume.

Daily construction reports also indicate that actual asphalt usage in the surface as determined by tank measurements are very close to the intended new AC. They also show that the intended new AC was increased three times during the project progress (Appendix C-2). Densities and field void determinations are all within specification limits except for one day. The laboratory extraction reports show asphalt contents about as expected when compared to the intended asphalt. The reports indicate asphalt increases of 0.3%, 0.1% and 0.2% during project progress. Voids as determined by the laboratory range from 2.1 to 3.5%. A range of 3.5 to 6% is specified in I.M. 511. The I.M. advises extreme caution when mixtures exhibit average values near the lower laboratory void limits and the ADT exceeds 500 VPD.

The gradations of the combined aggregate were very consistent and very close to that of the trial mix. Only once was the gradation outside of the limits. The plant was equipped with totalizers on the salvaged material, virgin aggregate and asphalt cement. The daily totals (Appendix C-3) indicate excellent delivery of the intended quantities of each material.

Mix Placement Procedure

The Type B class 1 base mixture was placed in two lifts with a Blaw Knox PF-500 paver. Equipment changes were minor and involved first moving the paver from spanning the trench to placing the paver in the trench.

The profile of the base was improved by changing from manual to full automatic controls and adding a 30' ski on August 2. The first lift of asphaltic concrete filled the 9" deep trench and was compacted to approximately 7" depth. Construction procedures per Standard Specification 2203 applied. The limiting factor was that the top lift be placed so that the compacted thickness be not greater than 2". The contractor was able to demonstrate that the thicker lift (exceeded 3") could be placed with satisfactory compaction and smoothness.

Special Provision #399 required that the final lift not be placed the same day as lower lifts. This requirement was adhered to. See laying sequence (Appendix C-4 and C-5).

Compaction Procedure

Initially rolling and compaction of the lower lift was accomplished with a single drum vibratory roller (Raygo 404-B). A finish roller was added after the first three to four days to take out undulations in the bottom lift. The upper 2" base lift was rolled with a three-roller train consisting of the single drum vibratory, a pneumatic roller and a static steel roller.

For the surface course, the contractor used either the single drum vibratory (Raygo 404-B) or dual drum vibratory (Dynapac CC-42A) for breakdown, an intermediate pneumatic roller and a static steel finish roller. A pneumatic roller was later pulled on the shoulder which required Class II compaction (approved roller pattern criteria). The remainder of the base and surface course required Class I compaction (94% density criteria). The density results are given in Appendix C-1.

Hydrated Lime

The plant inspector indicated it was very difficult to check the rate of addition of the hydrated lime. For this project, hydrated lime was added on the cold feed salvaged belt. To the total project, 1.06% of hydrated lime was added by weight. It was noted by the inspectors that the height of the material in the silo affected the feed of that material. A total of 950 tons were used for the approximate 89,000 tons of mix produced. There was some variation in the feed of this material. Daily checks on the rate were not made. The hydrated lime is a mineral filler and occupies voids thereby reducing voids available for asphalt cement. High delivery may contribute to mix instability.

PHYSICAL INVENTORY

A rut depth survey of this section of roadway on January 3, 1983, revealed little or no significant rutting. The rut depths at that time ranged from 0.12" to 0.17" (Appendix D-1).

Substantial rutting is now readily evident to a motorist while traveling this section of Interstate 80. A systematic inventory was necessary to determine the extent and variations of the problem.

Cross Sections

On October 4, 1983, cross sections of the driving lane of the eastbound roadway of Interstate 80 were taken at all milepost markers between MP 86 and MP 99 and at 1/4 of a mile increments between mileposts. These cross sections were taken utilizing a 14' straightedge. One end of the straightedge was placed at the centerline of the eastbound roadway, with the other end extending onto the outside shoulder. Measurements were taken at every low point and every high point across this outside lane. Rut depths of both the inside and outside wheelpaths were determined from plotted cross sections using these measurements. The rut depths varied from 0 to 0.9 inches (Appendix D-2, D-3 and D-4). Most of the roadway exhibits rutting in excess of 0.2". The general trend is for the rutting to increase from a value of approximately 0.3" at MP 88 to a rut depth of approximately 0.7" at MP 98. Milepost 96.0 and 97.75 were selected as being exceptionally bad areas for further investigation. A cross section of a severely rutted section is plotted in Appendix D-5.

Cross sections were also determined for the inside lane at every milepost and at 1/2 mile increments. No areas of significant rutting were identified in the inside lane.

Longitudinal Subdrains

A field review of all longitudinal drain outlets was conducted on October 5, 1983. The drain outlets appear to be functioning to allow moisture to escape from the rolled stone base section beneath the asphalt concrete. Nineteen outlets were identified as being wet. Thirty-one outlets were damp. Fourteen outlets were dry. Many outlets of the steel drains are partially plugged with stone and earth material. A maintenance cleaning operation would improve the effectiveness of these outlets.

Structural Analysis

A structural analysis survey has been conducted using the Road Rater, a dynamic deflection device. Testing was performed on March 1, 1983, and again on May 25, 1983. For data results see Appendix D-6. The Road Rater data for the asphalt concrete section in question yielded March 1983, structural numbers of 5.55 and 5.7. On May 25, 1983, a structural number of 6.75 was obtained. The structural number necessary to yield a 20-year design life is 5.49. The Road Rater indicated K values of 225 in March, 1983, and 235 on May 25, 1983, both yielding soil support values of 4.5. The soil support value required for a 20-year design life is 5.0.

Drainage appears to be effective. The nearly equal values obtained in March and late May indicate that winter conditions (frost) had no damaging effects on this material. The slightly lower "worst time" SSV values were more than offset by higher than required structural numbers.

An overall assessment indicates more structure was obtained than anticipated. By AASHTO methods, the March Road Rater information indicates that this pavement will carry approximately 10 million 18 kip equivalent axle loads. This translates into approximately 16 years of life at the predicted 1740 18K/day rate.

Pavement Sections

The wheel saw was used to obtain two transverse pavement sections. One was taken near MP 96.0 and the other near MP 97.75. Two cuts were made leaving a section approximately 12" wide. Within this 12"-wide section, a diamond saw cut was made near one wheel saw cut. These cuts were made on October 7, 1983, and the resulting pavement sections were transported to Ames on October 10, 1983. Using cross sections obtained at these locations prior to the use of the wheel saw, these sections were restored to proper alignment in the central laboratory. The lines denoting the various lifts are readily apparent in the diamond cut. Severe distortion is noted in the line at the bottom of the 1-1/2" surface course. Only minor distortion is noted in the line at the bottom of the 2" base course lift. The thickness of the surface lift is very uniform (Appendix D-7) indicating that the majority of the distortion is in the 2" upper base lift.

Core Drilling and Analysis

Cores were obtained from one location in each mile of the project. The longitudinal location was determined by throwing four die and subtracting four. The resulting number was the number of delineators (at 0.05 mile intervals) beyond the milepost marker where the cores would be taken. The lateral location was determined by throwing two die and subtracting one. The resulting number was the number of feet right of the centerline of the eastbound roadway where the cores were drilled. One full depth core was drilled at each location. Cores were drilled just ahead and just behind the full depth core through the 1-1/2" surface lift and the 2" base course for a total of 3-1/2". The two additional cores were necessary to yield sufficient material for laboratory analysis of the 1-1/2" surface course and the 2" lift of base course at each location. Mixture characteristics were determined from a laboratory evaluation of these drilled cores.

Special cores were drilled at MP 96 and MP 97.75 where severe rutting conditions were identified. Five cores were drilled at each of these two locations. One core was drilled in the inside wheelpath. The second core was drilled at the ridge immediately to the right of the inside wheel rut. The third core was drilled approximately at the quarter point. The fourth core was drilled in the rut of the outside wheelpath and the fifth core was drilled just to the right of the outside wheelpath rut. A pair of cores was obtained at each of these locations. One core was retained by the Iowa Department of Transportation while the other core was delivered to the Asphalt Paving Association of Iowa for evaluation by the Chicago Testing Laboratory. The cores were obtained on October 5, 1983.

An analysis of the sets of five cores taken at MP 96.0 and MP 97.75 (Appendix D-8) exhibits no significant relationship between the density or void content of the 7" lower base, 2" upper base or the surface course.

Evaluation of the sets of three cores taken from each mile of the project has yielded data on density, voids, asphalt content, filler bitumen ratio, asphalt penetration and asphalt viscosity (Appendix D-9). An analysis of the base lifts of the cores taken at one location in each mile of the project indicates densities ranging from 2.38 to 2.41 for the 2" upper base lift. The voids ranged from 2.1 to 5.0%. The asphalt content ranged from 4.87 to 6.18%, which is substantially greater than the intended asphalt cement content. The intended asphalt cement content was 5.0%. The only explanation for the additional asphalt above the intended is that there was a greater asphalt cement content in the salvaged material than initial extractions indicated. Previous history had shown that both the gradation and the percent of asphalt in salvaged asphalt cement concrete material had been very consistent. The penetrations of the recovered asphalt range from 70 to 91 with the viscosities ranging from 1,490 to 2,060.

The densities of the lower 7" base course ranged from 2.34 to 2.40 with void contents ranging from 2.2 to 7.0%. The asphalt content ranged from 4.60 to 5.75%. Penetrations on the recovered asphalt cement ranged from 72 to 90 with viscosities ranging from 1,450 to 2,060.

The densities of the surface course ranged from 2.27 through 2.40 with voids ranging from 3.7 to 10.3%. The intended asphalt for the surface course was 4.5% to begin the project. The asphalt content from the cores ranged from 4.40% through 5.54%. Penetrations of the extracted asphalt ranged from 28 through 63 and related very well to the void content. The higher the void content, the lower the penetration. The viscosities ranged from 2,380 through 9,130. The greater void content apparently allowed hardening or aging of the asphalt cement. Prior research substantiates that asphalt hardening occurs with higher void contents.

From the pavement sections it was apparent that the 2" upper base course did not exhibit satisfactory resistance to deformation from traffic and the majority of the rutting resulted from distortion of that lift. The core analysis indicates asphalt contents in the 2" upper base course in excess of the intended amount and confirms the asphalt content indicated by mix samples at time of construction.

AMBIENT TEMPERATURES OF 1983

The high temperatures experienced in the summer of 1983 were near record levels (Appendix E-1). July temperatures were 3° to 5° above normal and vied with 1974 and 1957 as Iowa's hottest July since 1955 and 1936. August temperatures were the highest since 1947 with an average of 6° above normal and vied with 1936 as Iowa's second hottest August. September was unseasonably warm the first ten days and latter six days of the month. Overall, the summer of 1983 was the interstate system's most severe summer with extremely high temperatures and temperature stresses from June 20 through September 10, 1983 (Appendices E-2 through E-6).

DISCUSSION OF FACTORS CONTRIBUTING TO THE RUTTING PROBLEM

Modifications of the specifications or mix design procedures for asphalt cement concrete have been few and relatively insignificant over the past few years. Most projects constructed using these specifications are performing adequately at the present time. This project was constructed completely within the present Iowa DOT specifications and, obviously, is not performing satisfactorily. It is, therefore, readily apparent that the present specifications do not adequately insure an asphalt cement concrete with the required resistance to deformation under heavy traffic loadings.

Asphalt Cement Content and Grade

A new AC5 asphalt cement was blended with the asphalt cement recovered from the salvaged material in an effort to obtain a desired grade of asphalt cement. The penetrations and viscosities of the extracted asphalt cement from the surface course cores indicate an asphalt cement slightly harder than the intended results, but well within an acceptable range. The penetration and viscosities of the Type B base courses indicate a slightly softer grade asphalt than intended from the blended asphalt cement, but again, within the range of acceptable values.

It appears that a major contributor to the poor resistance to deformation under load is the higher than intended asphalt cement content. The stability of the mix is severely reduced by this increased asphalt and also contributes to low void content which further reduces the stability of the mix. The higher than intended asphalt cement content was indicated by extraction from mix samples taken at time of construction. The asphalt content determined from tank measurements plus asphalt cement in the salvaged material was taken as the correct asphalt content at time of construction. The indicated high asphalt content should have been investigated at time of construction and was not. Modification of instructional memorandums is needed to ensure that the resultant asphalt cement content is relatively close to the intended asphalt content.

Mixture Density and Voids

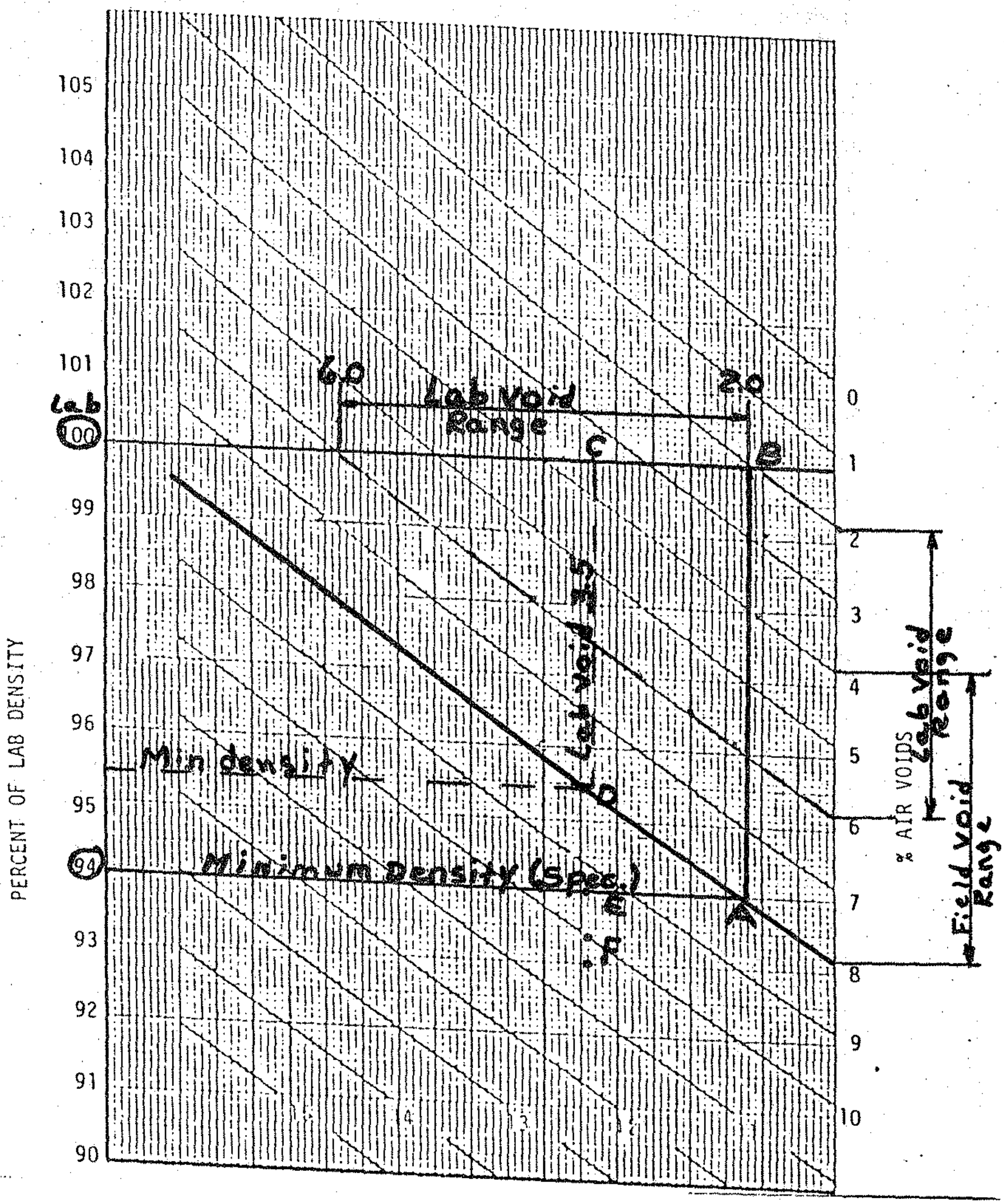
The relationship between laboratory voids, compacted voids and percent density is a critical relationship that must be further evaluated.

Ideally, the voids in an asphalt pavement should never be less than 3% after about three years of service. Perhaps a safer minimum for a high traffic facility is in the area of 4.5 to 6% based upon 100% of laboratory density. The maximum void content in a newly compacted pavement should be in the range of 4 to 8% and, to a degree, dependent upon traffic. A range of 6 to 8% would be a good range for a high traffic facility. This range between laboratory and pavement voids allows for only 1.5 to 2% decrease under traffic.

The only way this tight range can be acomplished is through higher density and more compactive effort. As an example, with a laboratory density of 2.34 and voids of 3.5, it would be necessary to compact to 95.5% of laboratory density to bring the compacted voids to a minimum of 8%. The graph on the following page illustrates that 94% of density, as a minimum, is too low, particularly where high traffic volumes are a factor.

In using the graph, first consider 94% of lab density as a minimum with 8% maximum field voids. From the intersection of these points (A), it can be seen that lab voids must be at about 2% (B). This is considered a minimum which will serve light traffic conditions but is inadequate for heavy traffic.

Assuming that 3.5 is an appropriate minimum laboratory void for a particular condition (C), it can be seen that about 95.5% density is the minimum density needed to assure compliance with 8% maximum pavement voids (D). Ninety-four percent density would result in voids of over 9% (E), while 93% density results in voids in excess of 10% (F).



Density/Air Voids

The Iowa DOT personnel recognized the critical relationship between densities and void content and made an effort to improve the condition in 1978. In 1978 a tentative specification raising the density requirement to 95% was proposed to the Iowa DOT Specification Committee. This recommendation was subsequently submitted to the Asphalt Paving Association of Iowa (APAI) for consideration. This recommendation was considered by the APAI on March 19, 1979. Based upon that consideration, the APAI official stand presented on August 13, 1979, was to oppose the increase in density requested by the Iowa DOT. The Iowa DOT was successful on August 14, 1979, in increasing the density requirements from 93% to 94%.

The higher than intended asphalt cement content of the 2" upper base resulted in detrimental effects in regard to density, laboratory voids and field voids. First, the additional asphalt immediately reduces the laboratory voids. The mix must have characteristics to retain sufficient voids after compaction. This may be achieved either by reduction of the asphalt cement content or increase of the crushed particles in the asphalt cement concrete mix. This recycled asphalt concrete mix had approximately 65% crushed particles. It has been recommended that for heavy traffic roadways, a specification requiring 80% crushed particles should be considered. Present Iowa DOT density specifications are too low to consistently achieve the desired laboratory and field void contents. It would be desirable to change the compaction density requirement to the range of 96%.

FACTS

1. I-80 has extremely high traffic (2000± trucks eastbound).

2. Summer 1983 temperatures were extremely high for an extended period with record highs since 1936.

3. From milepost 86 to 99, I-80 developed extensive wheel rutting in the eastbound driving lane during July, August and September, 1983.

4. Since original construction in 1959, this section has been the subject of numerous rehabilitation efforts.

5. The eastbound roadway was substantially rehabilitated in 1982 by removing 9" of mainline driving lane and replacing with 10-1/2" of recycled hot mix asphalt concrete.

6. Prior to the 1982 work, pavement distortion from structural deficiencies was evident.

7. The 1982 rehabilitation work was developed as a 10-year life design concept.

8. The 1982 project was constructed in total compliance with contract documents.

FINDINGS

1. Road Rater data verifies that the required design structural value was achieved and necessary subgrade support was obtained through the use of 1982 longitudinal drains.

2. Most of the distortion exists in the 1-1/2" surface course and the 2" upper base. There is very little distortion in the 7" lower base.

3. Surface distortion was first noted in mid July and has progressed to as much as 0.9" at some locations.

4. Review of the mix design and mix placed indicates the following:

    A. The 7" lower and 2" upper bases were over asphalted.

    B. More crushed particles were needed in the intermediate sizes (between #4 and #30 screens) to improve stability.

    C. The 2" upper base course did not exhibit satisfactory stability and the majority of the rutting resulted from distortion of that lift.

    D. The extracted asphalt content of the base from 1983 roadway cores confirmed the asphalt content in the 1982 mix samples and was consistently higher than intended, based on the added new asphalt documented in plant records plus that estimated in the salvaged asphalt.

    E. Asphalt contents in excess of the intended amount was the major contributor to the instability.

    F. Current specifications do not adequately address the critical relationship between laboratory and field voids and laboratory and field densities for high volume heavy traffic roads.

    G. During construction of the surface course the intended asphalt was increased on three occasions to bring the roadway voids into compliance with required limits.

CONCLUSIONS

1. The rutting is the result of a combination of adverse factors including:

    A. High asphalt content
    B. Difference between laboratory and field voids
    C. Lack of intermediate size crushed particles
    D. High ambient temperature

RECOMMENDATIONS

Interim corrective alternatives are recommended in the following order:

1. Heater planing
2. Rotomill planing
3. No interim treatment

Two 20-year design alternatives are recommended in the following order:

1. Remove a minimum of 2-1/2" from the driving lane by milling and replace with 2-1/2" of asphalt concrete with improved stability. Place a 1-1/2" high quality resurfacing on the entire roadway.

2. Remove a minimum of 4" from the driving lane by milling and replace with 4" of asphalt concrete with improved stability. Program a 1-1/2" resurfacing after six years.

The following specification changes should be pursued:

1. Increase density requirements to 95% for all asphalt pavements.

2. Require 97% density for all interstate work.

3. Specify Type "A" mixture for all interstate base courses.

4. Strengthen the language of Instructional Memorandum 511 to better correlate the relationship of both lab and field voids and densities.

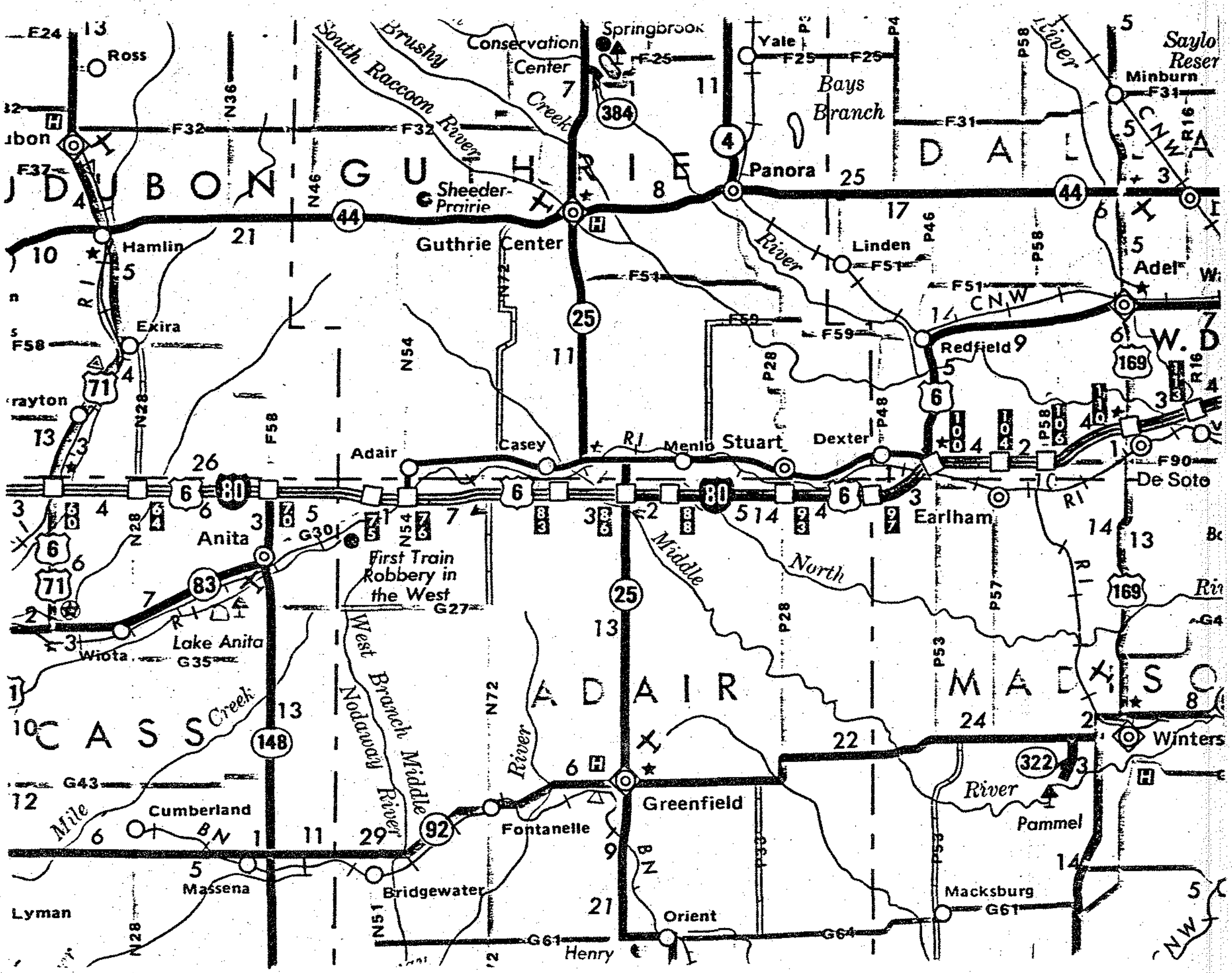
5. Review crushed particle requirements and limits for recycled mixes and all other mixes used under heavy traffic with consideration of increasing the minimum crushed particle requirement.

ACKNOWLEDGEMENTS

The evaluation task force included Charles Huisman, Robert Shelquist, Don Jordison, John Lane, Lowell Zearley, Vernon Marks, Rod Monroe, Steve Tritsch, Jack Percival, Ed O'Connor, Kermit Dirks and Dwight Rorholm. Appreciation is extended to many Iowa DOT personnel and especially to the evaluation task force for gathering and evaluating data and also for participating in the writing of this report. Appreciation is also extended to Janelle Feaker for providing excellent secretarial assistance.

Appendix A

LOCATION & HISTORY


Ross
Hamlin
Exira
Anita
Wiota
Lake Anita
CASS
Cumberland
Massena
Lyman
Adair
Casey
Menlo
Stuart
Dexter
Earlham
De Soto
Guthrie Center
Sheeder-Prairie
Conservation Center
Springbrook
Yale
Panora
Linden
Redfield
Adel
Minburn
Saylo Reser
Bays Branch
South Raccoon River
Brushy Creek
First Train Robbery in the West
West Branch Middle Nodaway River
ADAIR
Fontanelle
Greenfield
Bridgewater
Orient
Henry
MADISON
Winters
Pammel
Macksburg
Middle
North
River
GUTHRIE
DALLAS
AUDUBON

Construction Projects
for
I-80 FROM IA 25 TO DALLAS COUNTY LINE

Original Construction

I-80-2(11)89 1959
MP 85.80 - 92.73
12" Granular Subbase
12" Rolled Stone Base
4 1/2" Type A ACC 3/4" Mix
Coarse Agg-Menlo
Subdrains-various locations

I-80-2(12)96 1959
MR 92.73 - 100.80
12" Granular Subbase
12" Rolled Stone Base
4 1/2" Type A ACC 3/4" Mix
Coarse Agg-Early Chapel
Subdrains-various locations

Resurfacing

FI-80-2(23)89 1964
MP 85.80 - 92.73
1 1/2" Surface 3/4" Mix 5.0% AC
2" Binder 1 1/2" Mix 4.5% AC
2" Leveling 1 1/2" Mix 5.0% AC
Coarse Agg-Menlo & Early Chapel
Total Tonnage = 92,015

FI-80-2(24)96 1964
MP 92.73 - 100.80
1 1/2" Surface 3/4" Mix 5.0% AC
2" Binder 1 1/2" Mix 4.75% AC
2" Leveling 1 1/2" Mix 4.25% AC
Coarse Agg-Menlo & Early Chapel
Total Tonnage = 61,783

Resurfacing

INP-80-2(30)89--15-01 1970
MP 85.80 - 99.43 (9.995 mi.)
Various Locations
1" Surface 3/8" Mix 6.0% AC
2" Binder 3/4" Mix 5.0% AC
Coarse Agg-Schildberg, Adair Co.
Total Tonnage = 80,208

INP-80-2(43)89--15-01 1972
MP 85.80 - 99.43 (4.843 mi.)
Various Locations
1" Surface 3/8" Mix 6.0% AC
2" Binder 3/4" Mix 5.0% AC
Coarse Agg-Schildberg, Adair Co.
Total Tonnage = 44,101

Resurfacing

IR-80-2(88)86--12-01 1980
MP 93.85 - 99.43 EB Driving Lane
Heater-Scarify 1 inch, 13 ft. wide
1" Hot-sand Mix 7.25% AC
Fine Agg-Finley
Total Tonnage = 1729
Subdrains-various locations

Reconstruction

INP-80-2(42)102--15-25 1971
MP 99.43 - 100.8
10" PCC C-3 Mix
Coarse Agg-Booneville Pit

Rehabilitation

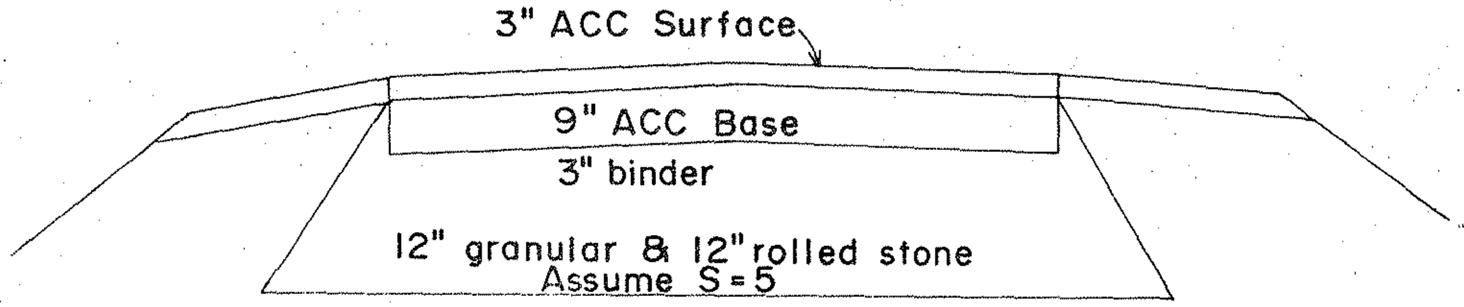
I-IR-80-2(82)86--14-01 1979
MP 93.85 - 99.43 Westbound
Remove 9" Existing AC Concrete
Inlay 10" PCC 24 ft. wide C-4WR Mix
Coarse Agg-Gilmore City
Subdrains-both sides

I-IR-80-2(89)86--14-01 1981
MP 85.75 - 93.85 WB Driving Lane
Remove 10" Existing AC Concrete
Inlay 10" PCC 12'-6" wide C-3WR Mix
Coarse Agg-East Des Moines Pit
Subdrains-outside lane

Appendix B

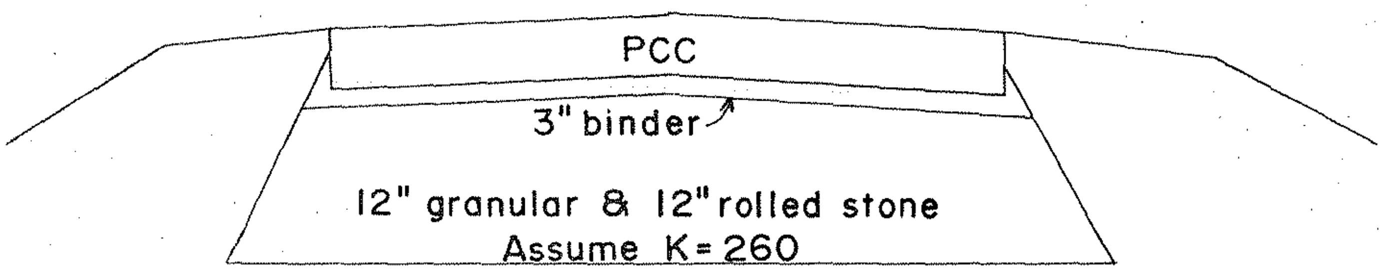
REHABILITATION DESIGN

PAVEMENT DETERMINATION



3" Surface	@	0.44	= 1.32
9" Base	@	0.38	= 3.42
3" Binder	@	0.25	= 0.75
			5.49

Above section good for 12 to 13 million repetitions ± 18 to 19 years



10" PCC good for 15 million repetitions ± } AASHTO
9½" PCC good for 11 million repetitions ± }

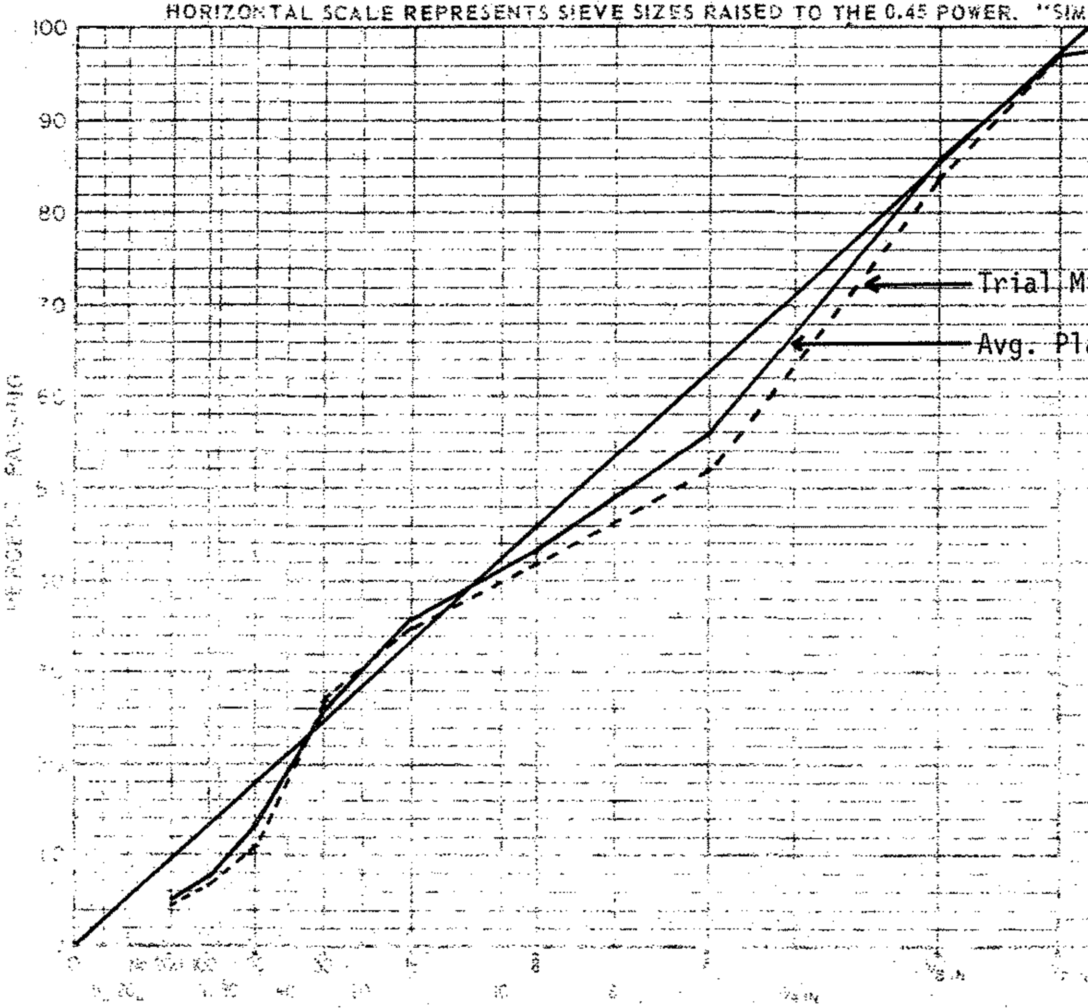
PROJECT NUMBER IR-80-2(91)36--12-01

Form 925
6-71

IOWA STATE HIGHWAY COMMISSION

GRADATION CHART

HORIZONTAL SCALE REPRESENTS SIEVE SIZES RAISED TO THE 0.45 POWER. "SIMPLIFIED PRACTICE" SIZES INDICATED BY



SIEVE ANALYSIS % PASSING

Trial Mix	Avg. Plant	Specification
100	100	
97	97	
84	86	
52	56	
42	43	
35	36	
27	26	
11	13	
6.7	7.9	
5.2	5.4	

Co. PROJECT NO.

TYPE, SOURCE, PRODUCER OF AGG.

TYPE CONST., LOCATION ON PROJECT

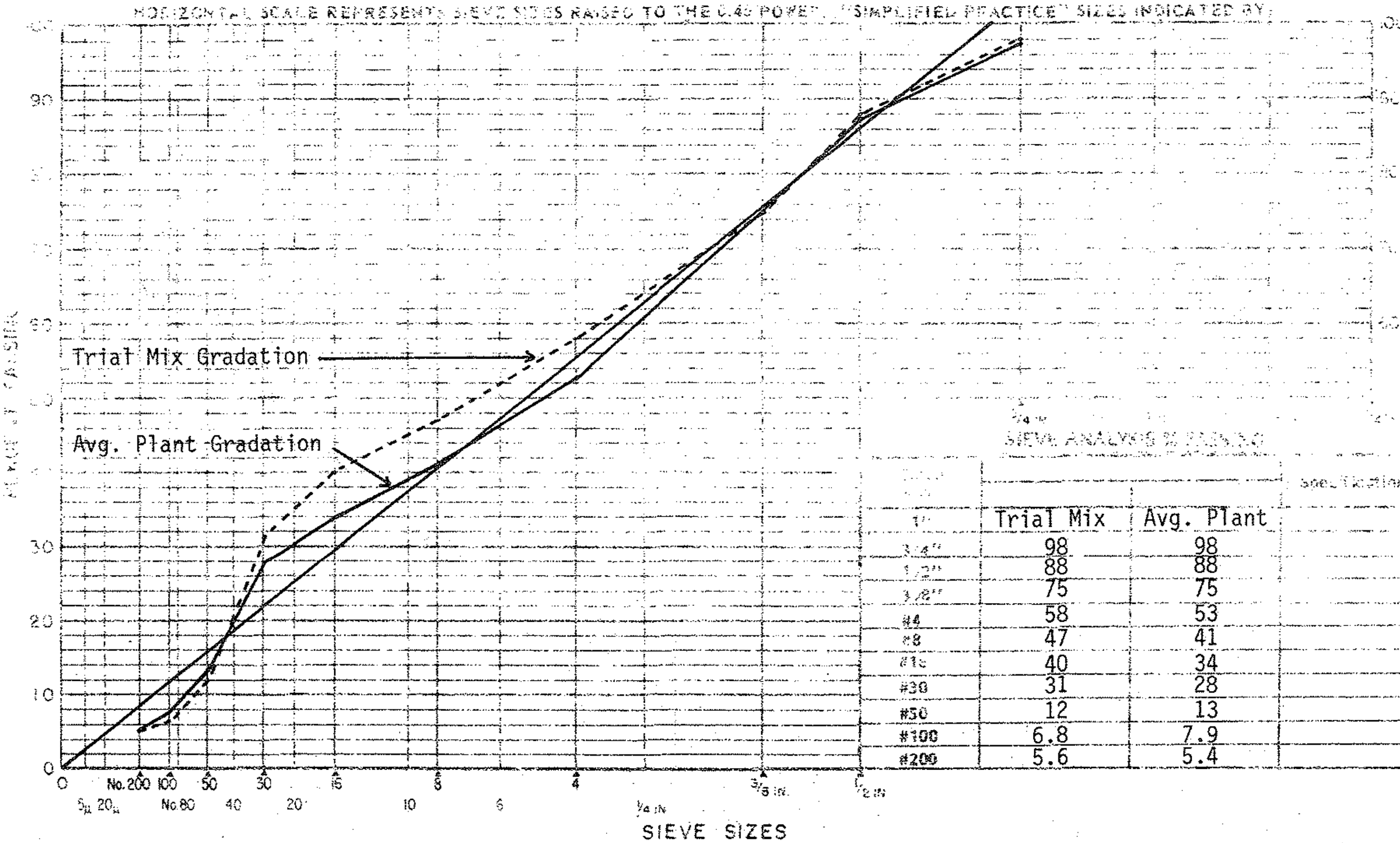
Type A Surface Adair

SAMPLED FROM | SAMPLED BY | DATE | QUANT. REPRESENTED | SIEVED BY | DATE | SIEVE METHOD | REMARKS

Form 925

IOWA STATE HIGHWAY COMMISSION

GRADATION CHART



SIEVE ANALYSIS % PASSING

	Trial Mix	Avg. Plant	Specification
1"			
3/4"	98	98	
1/2"	88	88	
3/8"	75	75	
#4	58	53	
#8	47	41	
#16	40	34	
#30	31	28	
#50	12	13	
#100	6.8	7.9	
#200	5.6	5.4	

Co.	PROJECT NO.	TYPE CONST; LOCATION ON PROJECT
TYPE, SOURCE, PRODUCER OF AGG.		Type B Class 1 Base Adair 2" Layer

SAMPLED FROM	SAMPLED BY	DATE	QUANT. REPRESENTED	SIEVED BY	DATE	SIEVE METHOD	REMARKS

Appendix C

CONSTRUCTION DATA

CONSTRUCTION DENSITY AND VOID SUMMARY

Daily Report No.	Date	Mixture (Type B, Base Type A, Surface)	High	Low	Avg.	QI	Avg. Field Voids	Lab Voids	Remarks*
1	7/27/82	Type B, base	98.3	97.5	97.9	4.88	5.3	3.3	
2	7/28/82	"	98.7	95.4	97.4	1.03	6.2	3.3	
3	7/29/82	"	95.8	92.5	94.6	0.17	9.3	4.0	NC Top 2"
4	7/30/82	"	100.4	97.1	98.3	1.30	5.3	3.7	
5	7/31/82	"	96.3	94.2	95.3	0.62	8.1	3.6	
6	8/2/82	"	97.1	94.6	95.7	0.68	8.5	4.4	
7	8/3/82	"	96.7	96.2	96.5	5.0	7.5	4.0	
8	8/4/82		No Density Cores - Small Quantity						
9	8/6/82	"	96.2	94.6	95.4	0.88	7.7	---	
10	8/7/82	"	98.3	95.8	96.9	1.16	6.1	3.2	
11	8/9/82	"	99.2	96.2	97.5	1.17	5.5	3.1	
12	8/11/82	"	99.2	93.7	96.2	0.40	6.7	2.2	
13	8/12/82	"	98.3	95.8	97.6	1.44	5.0	2.6	
14	8/13/82	"	99.6	95.8	97.8	1.00	7.1	2.3	
15	8/14/82	"	97.9	96.3	97.2	2.00	5.0	---	
16	8/16/82	"	97.9	94.2	96.7	0.73	5.3	2.6	
17	8/17/82	"	99.6	95.4	97.3	0.80	4.8	2.2	
18	8/18/82	"	97.1	92.5	96.0	0.43	5.9	1.9	
19	8/19/82	"	97.1	94.6	95.5	0.60	6.8	2.4	
20	8/20/82	"	98.3	94.6	96.4	0.63	5.8	2.2	
21	8/21/82	"	97.9	94.2	96.3	0.61	6.5	2.9	
22	8/23/82		No Density Cores - Small Quantity						
23	8/24/82	"	98.8	93.8	96.2	0.44	6.0	---	
24	8/25/82	"	98.3	95.0	96.2	0.66	6.2	2.4	
25	8/26/82	Type B, base	98.8	96.3	97.3	1.31	5.0	2.4	
26	8/27/82	"	97.9	95.4	96.3	0.94	6.2	2.6	
27	8/28/82	"	99.2	97.5	98.5	2.66	5.2	3.6	
28	8/31/82	"	97.1	95.4	96.2	1.29	6.4	2.7	
29	9/1/82	"	98.3	95.8	97.3	1.30	4.9	2.2	
30	9/2/82	"	99.6	95.0	98.1	0.89	4.2	---	
31	9/9/82	Type A, surface	No Density Cores - Small Quantity					1.8	
32	9/10/82	"	98.3	94.5	96.1	0.55	9.0	5.4	
33	9/11/82	"	96.7	95.4	95.8	1.40	7.9	3.9	
34	9/14/82	"	98.7	93.3	96.1	0.40	7.0	3.2	
35	9/15/82	"	97.1	92.4	95.4	0.306	7.9	3.5	NC
36	9/16/82	"	98.3	96.2	97.5	1.66	6.2	3.6	
37	9/18/82	"	98.3	93.3	95.5	0.296	7.7	3.3	NC
38	9/19/82	"	97.5	95.4	96.5	1.17	7.1	3.6	
39	9/20/82	"	96.7	92.9	95.4	0.37	7.1	2.7	
40	9/21/82	"	96.7	95.0	95.7	0.98	6.8	2.5	
41	9/22/82	"	96.7	94.2	95.6	1.6	7.0	2.7	
42	9/23/82	"	96.2	94.2	95.4	0.70	6.9	2.4	
43	9/24/82	"	95.8	93.8	94.9	0.46	7.4	2.4	
44	9/25/82	"	96.7	95.0	95.7	0.98	5.4	1.1	
45	9/26/82	"	97.5	94.6	96.3	0.78	5.7	2.1	
46	9/27/82	"	No Density Cores - Small Quantity						
47	9/28/82	"	95.8	94.6	95.0	0.83	7.8	3.0	
48	9/29/82	"	97.9	93.8	96.2	0.55	6.1	2.5	
49	9/30/82	"	98.3	95.0	96.5	0.77	5.8	2.4	

*Remarks - NC = Non Compliance

Aggregate and Asphalt Content Changes

Aggregate Changes

Mix Type & Class	Lab No.	Date	Comments
Type B Class 1	ABD2-111	7-27-82 to 8-4-82	Allowed 45% crush in new aggregate Sources - 3/4" LST Chip - Menlo Sand - Van Meter Fine Sand - Smith Pit All material placed in passing lane 45/55 mix
Type B Class 1	ABD2-12B	8-6-82 to 9-2-82	Started - 45/55 first three days of base in driving lane - utilized similar job mix from another project. On 8-11 switched to 50/50 per ABD2-12B, but changed sand source to Army Post Road Pit from Van Meter Pit. Fine Sand - Smith Pit
Type A Surface	ABD2-146	9-7-82 to 9-30-82	45/55 1/2" LST Chip Gilmore City Sand - Army Post Road Sand - Smith Pit

Changes in Asphalt Content

Date	Percent	Location and Comment
7-27-82 to 8-4-82	2.4%	All passing lane inlay
8-6-82 to 9-1-82	2.7%	Changed job mix. Held same target throughout base construction in driving lane
9-9-82	2.3%	Surface course started
9-10-82	2.5%	Materials raised AC content to reduce field voids
9-18-82	2.6%	Materials raised AC 0.1% to reduce field voids
9-20-82	2.8%	Materials raised AC 0.2% to reduce field voids. Held until completion 9-29-82

PLANT READOUTS

Adair Co. IR-80-2(91)86

Date	(Tons) Recycle	(Tons) Virgin	(Gal.) A.C.	Target	(Percentage) Recycle	(Percentage) Virgin
7-27-82	401.3	487.7	4992	Base 45/55 mix	44.64	55.36
7-28-82	1167.3	1401.5	14779		45.44	54.56
7-29-82	316.1	383.2	3951		45.20	54.80
7-30-82	721.5	852.5	8911		45.84	54.16
7-31-82	530.7	720.8	7236		42.41	57.59
8-02-82	1253.9	1605.1	16563		43.86	56.14
8-03-82	786.1	929.1	10061		45.83	54.17
8-04-82	99.4	119.8	1337		45.25	54.65
8-06-82	1082.8	1304.3	15383	Base 45/55	45.36	54.64
8-07-82	1166.9	1386.5	16581		45.70	54.30
8-09-82	758.3	910.3	10848		45.45	54.55
8-11-82	1367.7	1427.3	18223	Base 50/50	48.93	51.07
8-12-82	1191.6	1249.2	15851		48.82	51.18
8-13-82	1287.8	1284.2	16784		50.07	49.93
8-14-82	1095.9	1086.6	14204		50.21	49.79
8-16-82	1078.6	1063.1	14003		50.36	49.64
8-17-82	1153.3	1127.5	14765		50.57	49.43
8-18-82	1253.0	1262.2	16466		49.82	50.18
8-19-82	1099.8	1121.4	14638		49.51	50.49
8-20-82	1102.2	1099.2	14337		50.07	49.93
8-21-82	994.0	1027.4	13323		49.17	50.83
8-23-82	1100.5	1202.9	15322		47.78	52.22
8-24-82	34.4	33.6	442		50.59	49.41
8-25-82	1549.3	1534.3	20182		50.24	49.76

Date	(Tons) Recycle	(Tons) Virgin	(Gal.) A.C.	Target	(Percentage) Recycle	(Percentage) Virgin
8-26	778.9	780.5	10153		49.95	50.05
8-27	1291.6	1252.5	16673		50.77	49.23
8-28	1203.8	1185.5	15660		50.38	49.62
8-31	583.9	600.8	7667		49.28	50.72
9-01	1508.0	1587.9	20318		49.36	50.64
9-02	1024.0	1056.3	13345		49.22	50.78
9-07	73.8	81.2	853		47.60	52.40
9-10	601.2	773.0	7292	Surface 45/45	43.75	56.25
9-11	648.4	799.7	8353		44.78	55.22
9-14	432.1	490.6	5411		46.83	53.17
9-15	944.9	1156.8	12307		44.96	55.04
9-16	714.1	925.8	8700		43.55	56.45
9-18	757.1	934.4	10258		44.76	55.24
9-19	878.5	1064.2	11817		45.22	54.78
9-20	982.7	1208.7	14259		44.84	55.16
9-21	717.3	881.8	10416		44.86	55.14
9-22	1123.1	1346.1	16375		45.50	54.50
9-23	931.8	1104.7	13573		45.75	54.25
9-24	749.5	935.1	11398		44.49	55.51
9-25	891.6	1154.4	13843		43.58	56.42
9-26	884.2	1094.2	13360		44.69	55.31
9-27	35.8	50.8	523		41.34	58.66
9-28	956.3	1164.2	14374		45.10	54.90
9-29	448.7	547.3	6710		45.05	54.95
9-30	1117.6	1374.6	16285		44.84	55.16

Comment: Plant recording equipment provided daily totals on salvage and virgin aggregates and asphalt cement. The above data was recorded in the plant inspector's diary.

Driving Lane
Base Course

Adair County
IR-80-2(91)86

2"	738+28 → 784+88 8-7-82	784+88 → 819+18 8-9-82	819+18 → 901+45 8-12-82	
7"	738+28 → 786+05 8-6-82	786+05 → 821+11 8-7-82	821+11 → 844+09 8-9-82	844+09 → 903+16 9-11-82

2"	901+45 → 920+67 8-13-82	920+67 → 967+11 8-14-82	967+11 → 1039+70 8-17-82	
7"	903+16 → 921+86 8-12-82	921+86 → 968+03 8-13-82	968+03 → 996+90 8-14-82	996+90 → 1041+06 8-16-82

2"	1039+70 → 1058+93 8-18-82	1058+93 → 1149+30 8-20-82	1149+30 → 1205+75 8-23-82 →	
7"	1041+06 → 1059+91 8-17-82	1059+91 → 1104+46 8-18-82	1104+46 → 1149+50 8-19-82	1149+50 → 1164+15 8-20-82

2"		1205+75 → 1237+29 8-25-82	1237+29 → 1287+91 8-26-82	1287+97 → 1352+73 8-28-82	
7"	1164+15 → 1207+07 8-21-82	1207+07 → 1236+99 8-23-82	1236+99 → 1238+04 8-24-82	1238+04 → 1288+82 8-25-82	1288+82 → 1303+97 8-26-82

2"	→ 1352+73	1352+73 → 1461+94 9-2-82		
7"	1303+97 → 1354+50 8-27-82	1354+50 → 1380+30 8-28-82	1380+30 → 1402+87 8-31-82	1402+87 → 1461+94 9-1-82

SURFACE COURSE PLACEMENT

DATE	LOCATION STATION	to	STATION	LANE
9- 9-82	738+28		746+02	Left
9-10-82	746+-2		822+61	Left
9-11-82	738+28		788+67	Right
9-14-82	788+67		823+32	Right
9-15-82	823+32		902+20	Right
9-16-82	822+61		887+23	Left
9-18-82	887+23		974+60	Left
9-19-82	902+20		992+10	Right
9-20-82	974+60		1086+52	Left
9-21-82	992+10		1069+02	Right
9-22-82	1086+52		1224+15	Left
9-23-82	1069+02		1153+67	Right
9-24-82	1153+67		1225+34	Right
9-25-82	1224+15		1344+19	Left
9-26-82	1225+34		1348+55	Left
9-27-82	1344+19		1310+07	Right
9-28-82	1348+55		1461+94	Left
9-29-82	1310+07		1351+57	Right
9-30-82	1351+57		1461+94	Right

Appendix D

PHYSICAL INVENTORY DATA

RUT DEPTH SURVEY
of the
I-80 EASTBOUND DRIVING LANE

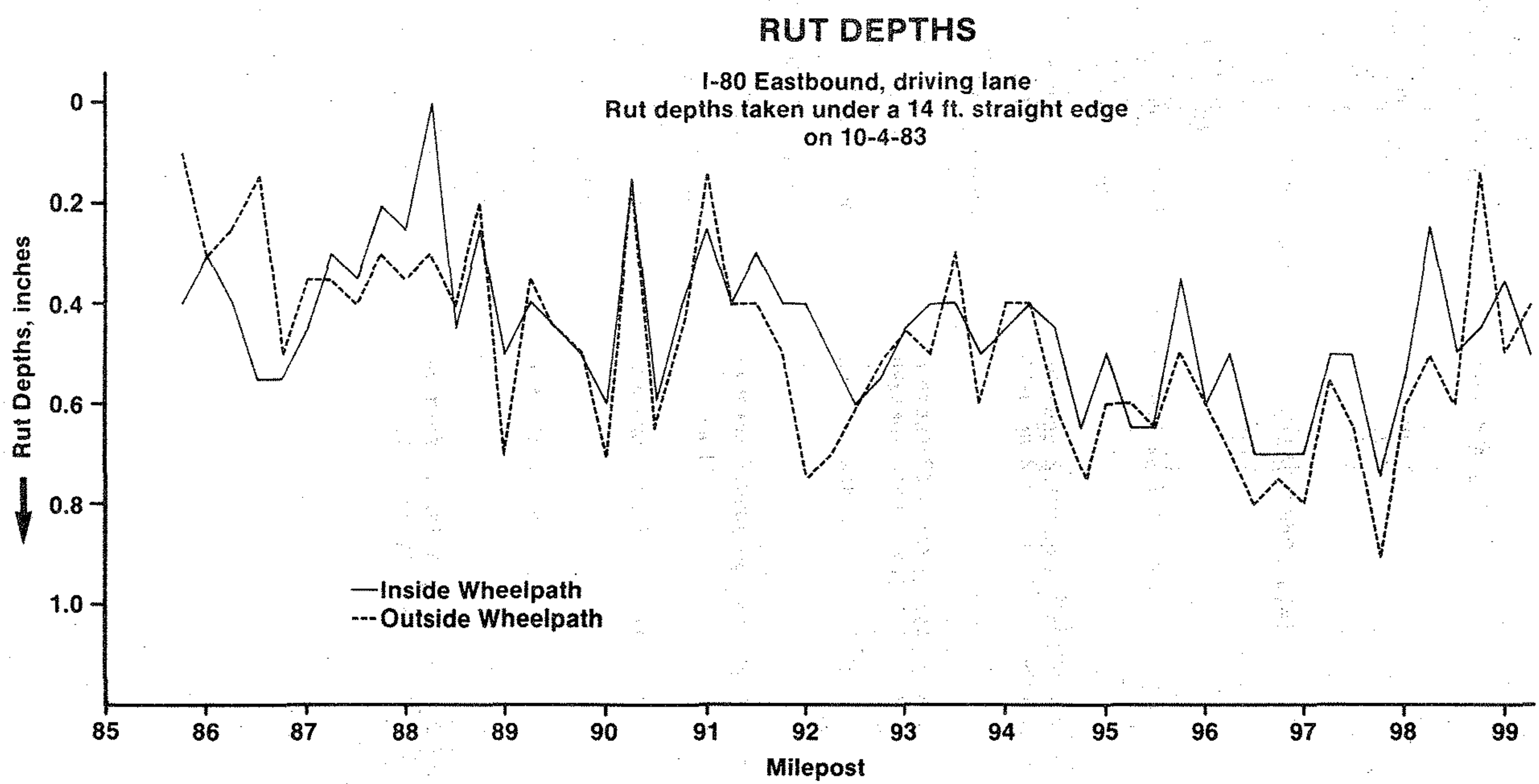
January 3, 1983

Milepost	Rut Depth Inches Outside Wheelpath	Rut Depth Inches Inside Wheelpath
85.75	.11	.10
86.00	.09	.09
87.00	.11	.12
87.50	.11	.10
88.00	.07	.10
88.50	.11	.10
89.00	.09	.05
89.50	.09	.09
90.00	.08	.10
90.50	.11	.17
91.00	.11	.07
91.50	.08	.05
92.00	.09	.10
92.50	.11	.10
93.00	.05	.09
93.50	.03	.07
94.00	.05	.09
94.50	.11	.11
95.00	.09	.11
95.50	.05	.10
96.00	.08	.08
96.50	.10	.11
97.00	.05	.07
97.50	.10	.10
98.00	.09	.09
98.50	.09	.10
99.00	.07	.09
99.45	.05	.09

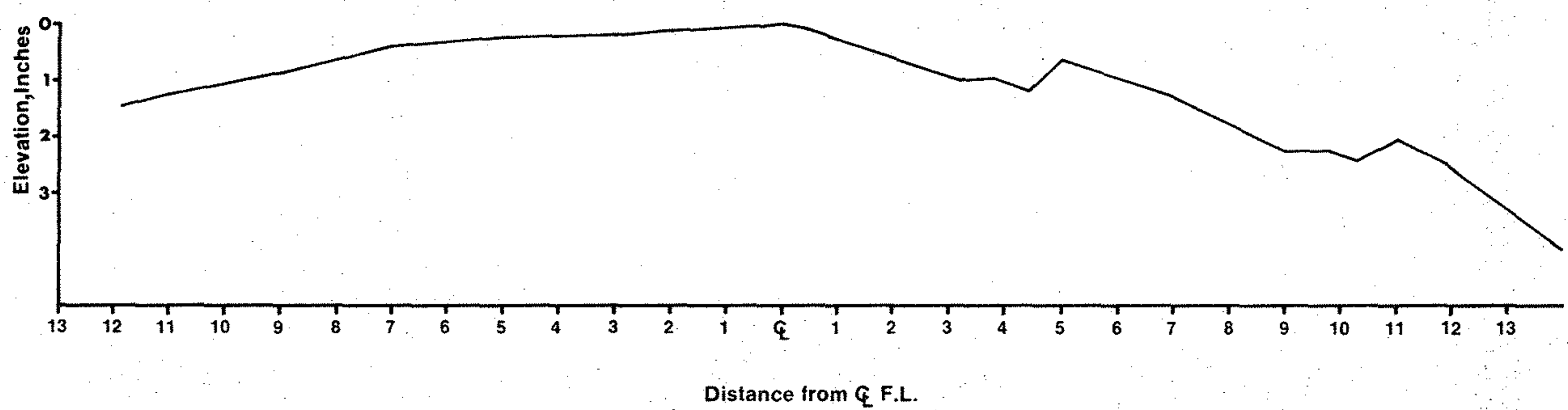
SUMMARY OF RUT DEPTHS
IN THE
EASTBOUND DRIVING LANE OF I-80

Milepost	Inside Wheelpath	Outside Wheelpath
85.75	0.04	0.10
86.00	0.30	0.30
86.25	0.40	0.25
86.50	0.55	0.15
86.75	0.55	0.50
87.00	0.45	0.35
87.25	0.30	0.35
87.50	0.35	0.40
87.75	0.20	0.30
88.00	0.25	0.35
88.25	0.00	0.30
88.50	0.45	0.40
88.75	0.25	0.20
89.00	0.50	0.70
89.25	0.40	0.35
89.50	0.45	0.45
89.75	0.50	0.50
90.00	0.60	0.70
90.25	0.15	0.15
90.50	0.60	0.65
90.75	0.40	0.45
91.00	0.25	0.15
91.25	0.40	0.40
91.50	0.30	0.40
91.75	0.40	0.50
92.00	0.40	0.75
92.25	0.50	0.70
92.50	0.60	0.60
92.75	0.55	0.50
93.00	0.45	0.45
93.25	0.40	0.50
93.50	0.40	0.30
93.75	0.50	0.60
94.00	0.45	0.40
94.25	0.40	0.40
94.50	0.45	0.60
94.75	0.65	0.75
95.00	0.50	0.60
95.25	0.65	0.60
95.50	0.65	0.65
95.75	0.35	0.50

Milepost	Inside Wheelpath	Outside Wheelpath
96.00	0.60	0.60
96.25	0.50	0.70
96.50	0.70	0.80
96.75	0.70	0.75
97.00	0.70	0.80
97.25	0.50	0.55
97.50	0.50	0.65
97.75	0.75	0.90
98.00	0.55	0.60
98.25	0.25	0.50
98.50	0.50	0.60
98.75	0.45	0.15
99.00	0.35	0.50
99.25	0.50	0.40


RUT DEPTHS
I-80 Eastbound, driving lane
Rut depths taken under a 14 ft. straight edge
on 10-4-83
Rut Depths, inches
0
0.2
0.4
0.6
0.8
1.0
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
Milepost
—Inside Wheelpath
---Outside Wheelpath

CROSS SECTION OF I-80 E.B. AT M.P. 94.75



I-80 FROM IA 25 TO DALLAS COUNTY LINE

1983 Road Rater Data

Following tests performed at 30 HZ and 68% setting on 3/1/83.

Eastbound - Driving Lane

MP 86.27 - 93.80	Average Structural Rating = 5.55	ACC
MP 93.80 - 99.43	Average Structural Rating = 5.70	ACC

Westbound - Driving Lane

MP 86.27 - 93.80	Average Structural Rating = 6.85	PCC
MP 93.80 - 99.43	Average Structural RAting = 7.35	PCC

Following tests performed at 30 HZ and 68% setting on 5/25/83.

Eastbound - Driving Lane

MP 86.27 - 99.43	Average Structural Rating = 6.75	ACC

Eastbound - Passing Lane

MP 86.27 - 99.43	Average Structural Rating = 5.50	ACC

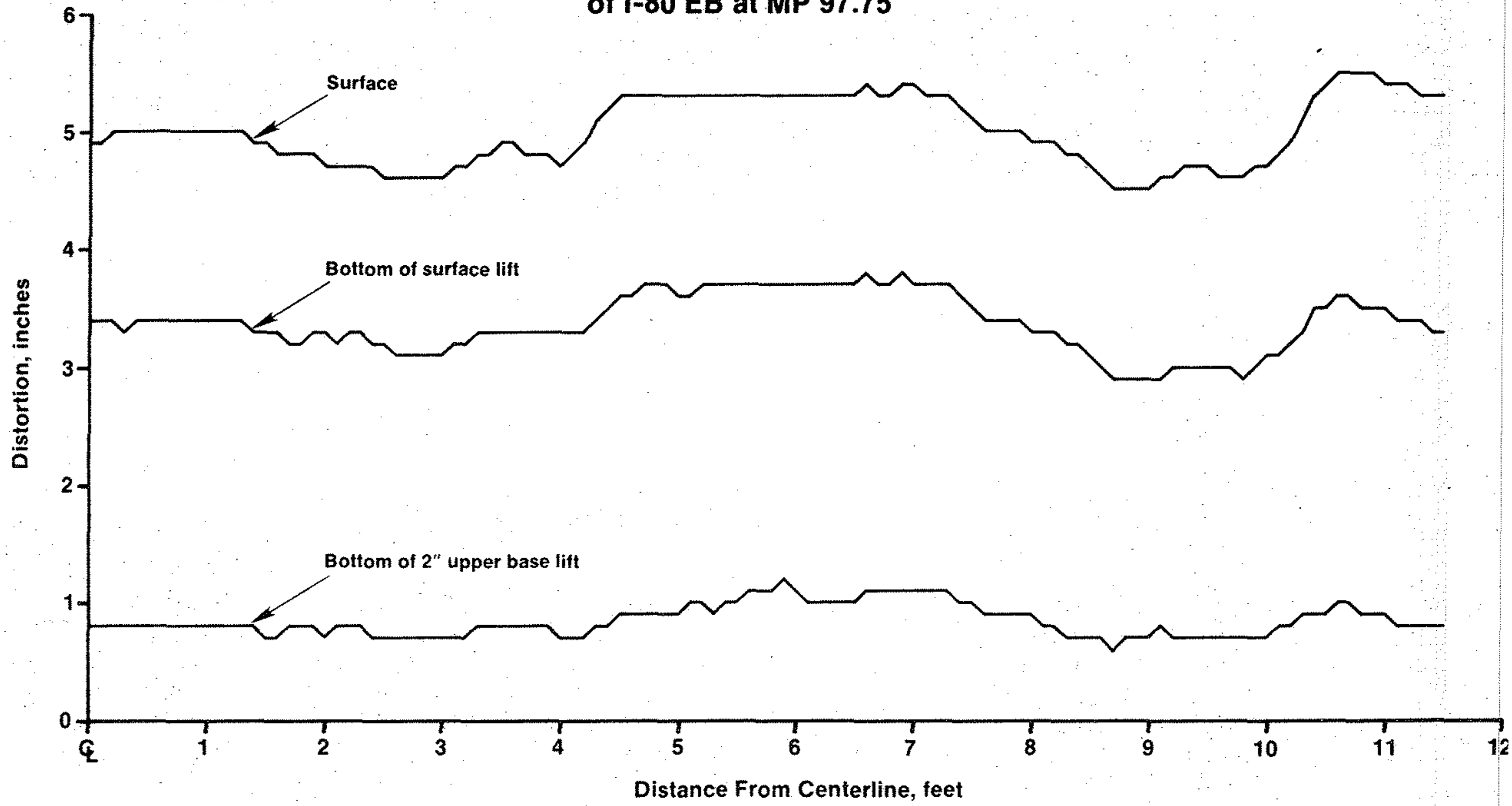
Westbound - Driving Lane

MP 86.27 - 99.43	Average Structural Rating = 6.70	PCC

Westbound - Passing Lane

MP 86.27 - 93.80	Average Structural Rating = 5.40	ACC
MP 93.80 - 99.43	Average Structural Rating = 7.10	PCC

A CROSS SECTION PLOT OF THE SURFACE AND LIFT INTERFACES OF THE TOP TWO LIFTS of I-80 EB at MP 97.75



DENSITY AND VOIDS

in

SEVERELY RUTTED AREAS

	Milepost 96.0					Milepost 97.75				
Core Number	5	7	9	11	13	15	17	19	21	23
Lateral Location	3.2R	4.0R	5.7R	9.2R	9.8R	3.8R	4.6R	6.5R	9.7R	10.5R
Surface	Rut	Ridge	1/4 Pt.	Rut	Ridge	Rut	Ridge	1/4 Pt.	Rut	Ridge
Specific Gravity	2.38	2.38	2.37	2.38	2.38	2.35	2.35	2.36	2.36	2.36
Voids	5.0	4.6	5.1	5.2	5.1	5.2	5.4	5.5	4.3	4.7
2" Upper Base										
Specific Gravity	2.38	2.39	2.39	2.39	2.40	2.40	2.40	2.41	2.41	2.40
Voids	3.8	2.9	3.5	3.0	2.3	2.8	2.9	1.9	1.6	2.3
7" Lower Base										
Specific Gravity	2.36	2.36	2.37	2.38	2.36	2.37	2.37	2.39	2.39	2.37
Voids	5.4	4.7	3.9	3.8	4.4	4.6	4.5	3.1	2.6	3.8

ANALYSIS OF I-80 CORES

Core No.	1,2,3	24,25,26	27,28,29	30,31,32	33,34,35	36,37,38	39,40,41	42,43,44	45,46,47	48,49,50	5,7,9,11,13	51,52,53	54,55,56	15,17,19,21,23	57,58,59	60,61,62
Milepost	86.35	87.35	88.60	89.45	90.20	91.55	92.60	93.35	94.60	95.50	96.00	96.50	97.55	97.75	98.85	99.30
Surface Density	2.38	2.39	2.35	2.40	2.35	2.27	2.34	2.37	2.37	2.37	2.38	2.38	2.34	2.36	2.36	2.36
Voids	6.8	4.7	7.4	3.7	7.5	10.3	5.0	4.2	5.8	6.6	5.0	4.1	5.9	5.0	5.6	6.7
AC Content	N/A	5.16	4.40	5.18	4.89	4.61	5.28	5.13	4.89	4.99	5.04	5.31	5.29	5.30	5.17	5.54
FBR	N/A	1.51/1.32	1.55/1.31	1.43/1.24	1.64/1.43	1.60/1.39	1.53/1.34	1.50/1.31	1.60/1.39	N/A	1.44/1.25	1.37/1.19	1.55/1.36	1.41/1.23	1.57/1.38	1.39/1.21
Penetration	34	60	39	63	34	28	42	57	55	42	49	54	34	45	44	37
Viscosity	6730	2750	6240	2380	6660	9130	4840	3120	2950	4760	3540	2920	6230	3880	4670	5350
2" UPPER BASE																
Density	2.38	2.39	2.39	2.41	2.40	2.38	2.40	2.40	2.41	2.40	2.39	2.41	2.38	2.41	2.40	2.38
Voids	4.1	3.2	5.0	2.3	3.1	3.7	2.5	2.2	2.1	3.9	3.9	2.4	3.7	2.30	2.2	3.9
AC Content	N/A	5.33	4.87	5.60	5.31	5.55	5.39	6.18	5.70	5.22	5.70	5.56	5.69	5.75	5.91	5.43
FBR	N/A	1.50/1.31	1.38/1.17	1.48/1.30	1.49/1.30	1.37/1.17	1.39/1.21	1.05/0.89	1.21/1.04	N/A	1.07/0.89	1.26/1.08	1.23/1.05	1.08/0.90	1.27/1.10	1.27/1.09
Penetration	70	81	74	78	73	75	75	81	91	82	83	80	76	83	78	74
Viscosity	2060	1640	1910	1740	1980	1770	1900	1610	1490	1550	1590	1650	1760	1520	1630	1840
7" LOWER BASE																
Density	2.37	2.42	2.34	2.39	2.38	2.41	2.35	2.38	2.37	2.40	2.37	2.36	2.38	2.38	2.36	2.38
Voids	5.3	3.1	7.0	3.0	4.4	2.2	6.1	3.8	6.0	2.2	4.4	5.3	3.6	3.7	4.3	3.4
AC Content	5.34	5.10	5.06	5.46	5.28	5.51	4.60	4.68	5.38	5.61	5.70	5.08	5.47	5.75	5.55	5.53
FBR	N/A	1.22/1.02	1.32/1.13	1.43/1.25	1.48/1.29	1.43/1.25	1.32/1.10	1.60/1.39	N/A	N/A	1.07/1.89	1.20/1.80	1.22/1.04	1.08/0.90	1.29/1.11	1.28/1.10
Penetration	76	82	72	73	75	82	81	78	74	90	83	82	75	83	77	77
Viscosity	1840	1600	2060	1830	1870	1690	1780	1840	1770	1450	1590	1690	1850	1520	1710	1700

N/A - Not Available

Appendix E

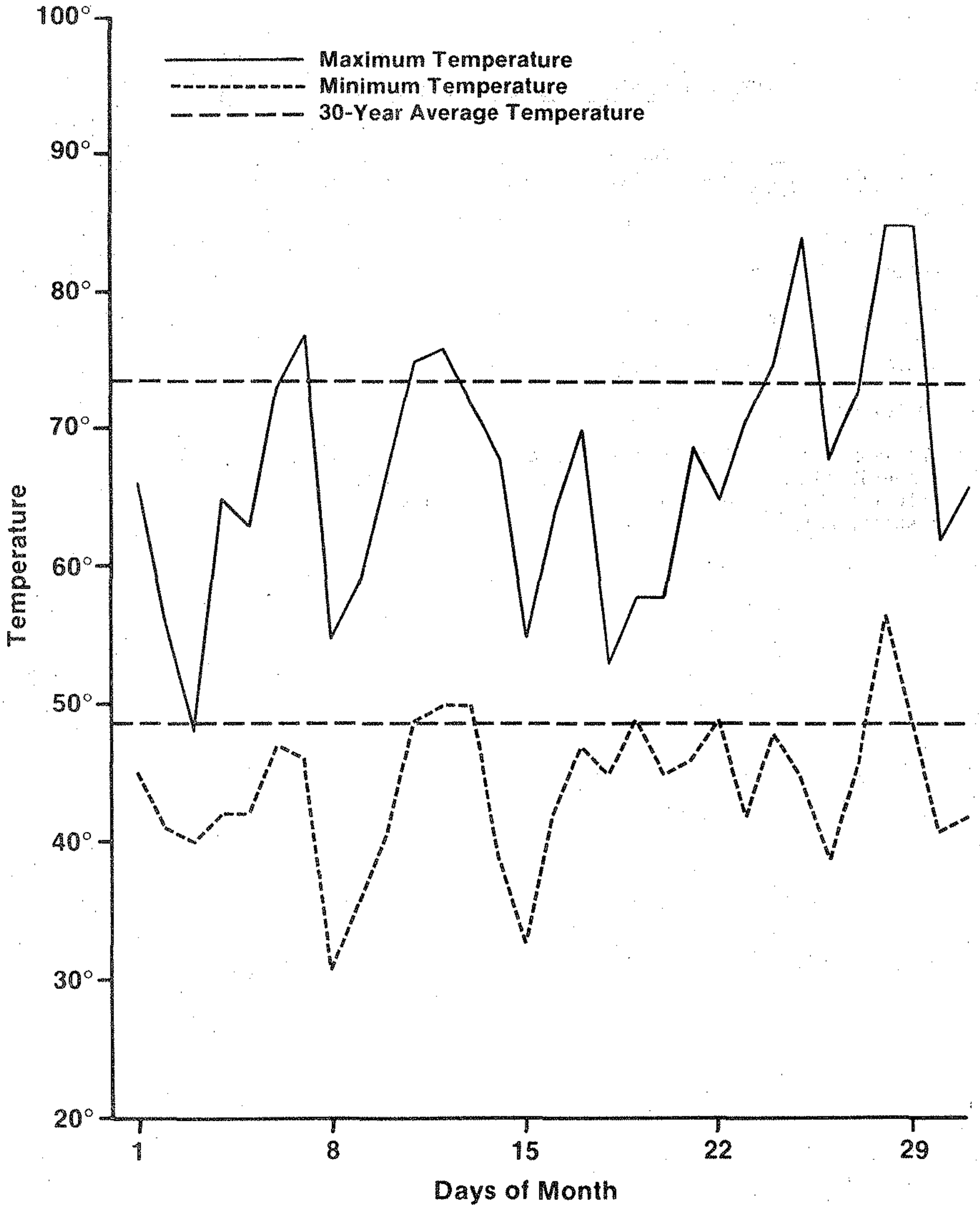
CLIMATOLOGICAL DATA

1983 Climatological Data - Guthrie Center Station

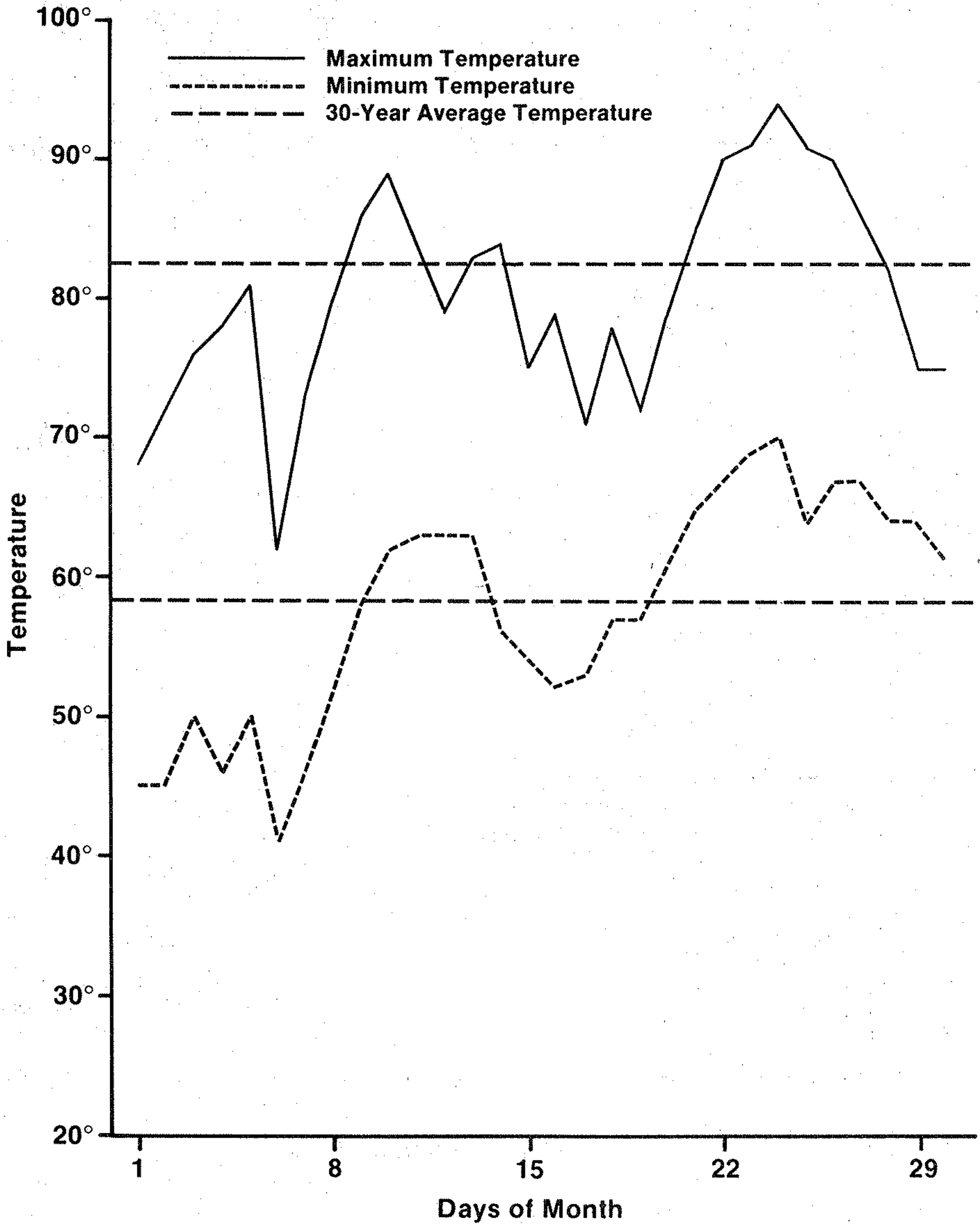
Month	Average Maximum	Average Minimum	30-YR Average Maximum	30-YR Average Minimum	Precip.	30-YR Average Precip.
May	67.1°	44.0°	73.6°	48.8°	5.30"	4.05"
June	80.3	57.7	82.6	58.3	5.68	4.49
July	89.8	63.9	87.0	62.8	1.82	3.90
August	92.3	65.9	84.9	60.5	2.79	4.38
September	76.5	50.4	76.3	51.2	2.49	3.66

The graphs on the following five pages show the maximum and minimum daily temperatures for the months of May, June, July, August, and September 1983. Note that the 30 year average maximum and minimum temperatures for the respective months are also plotted.

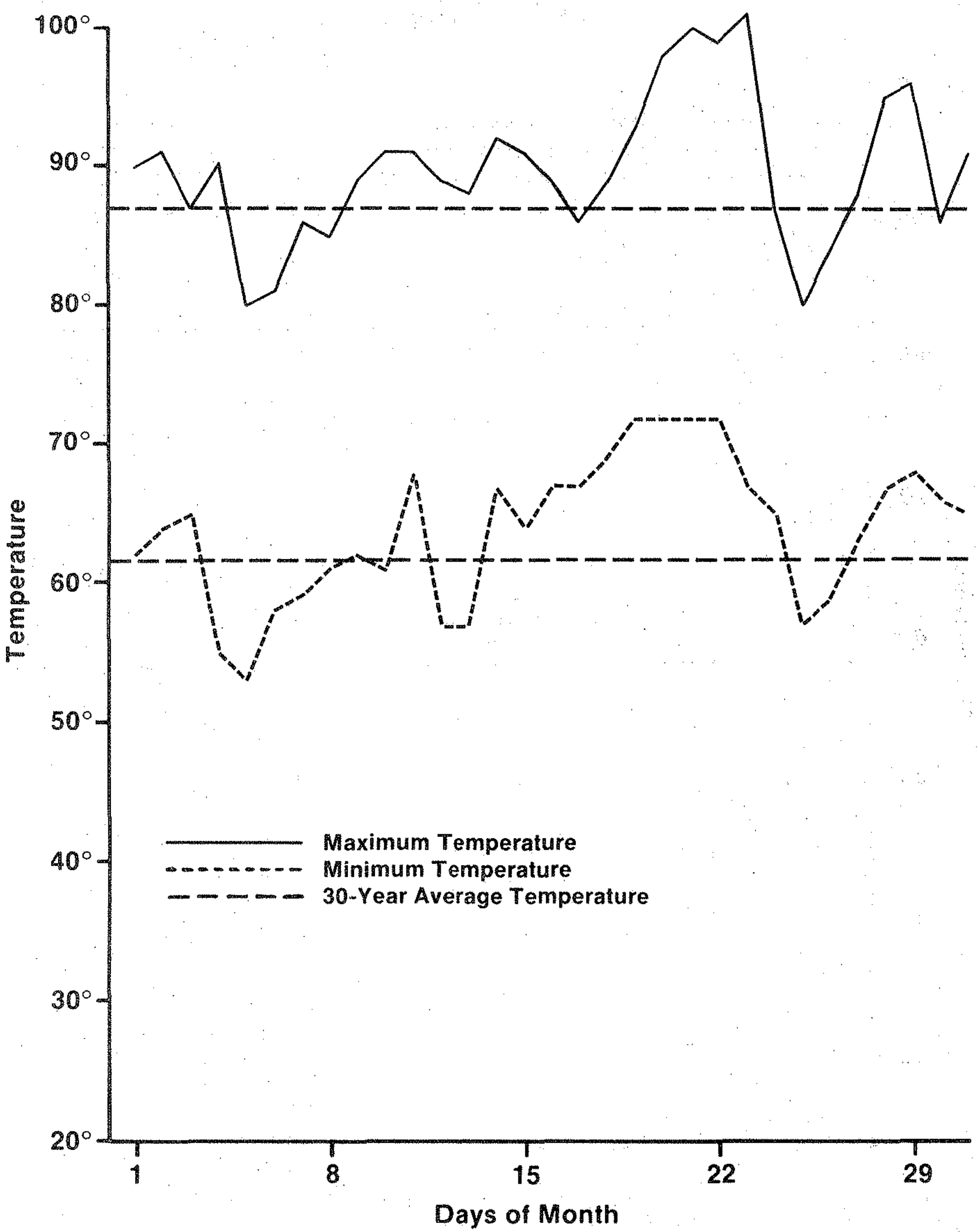
CLIMATOLOGICAL DATA
I-80 ADAIR COUNTY
MAY 1983



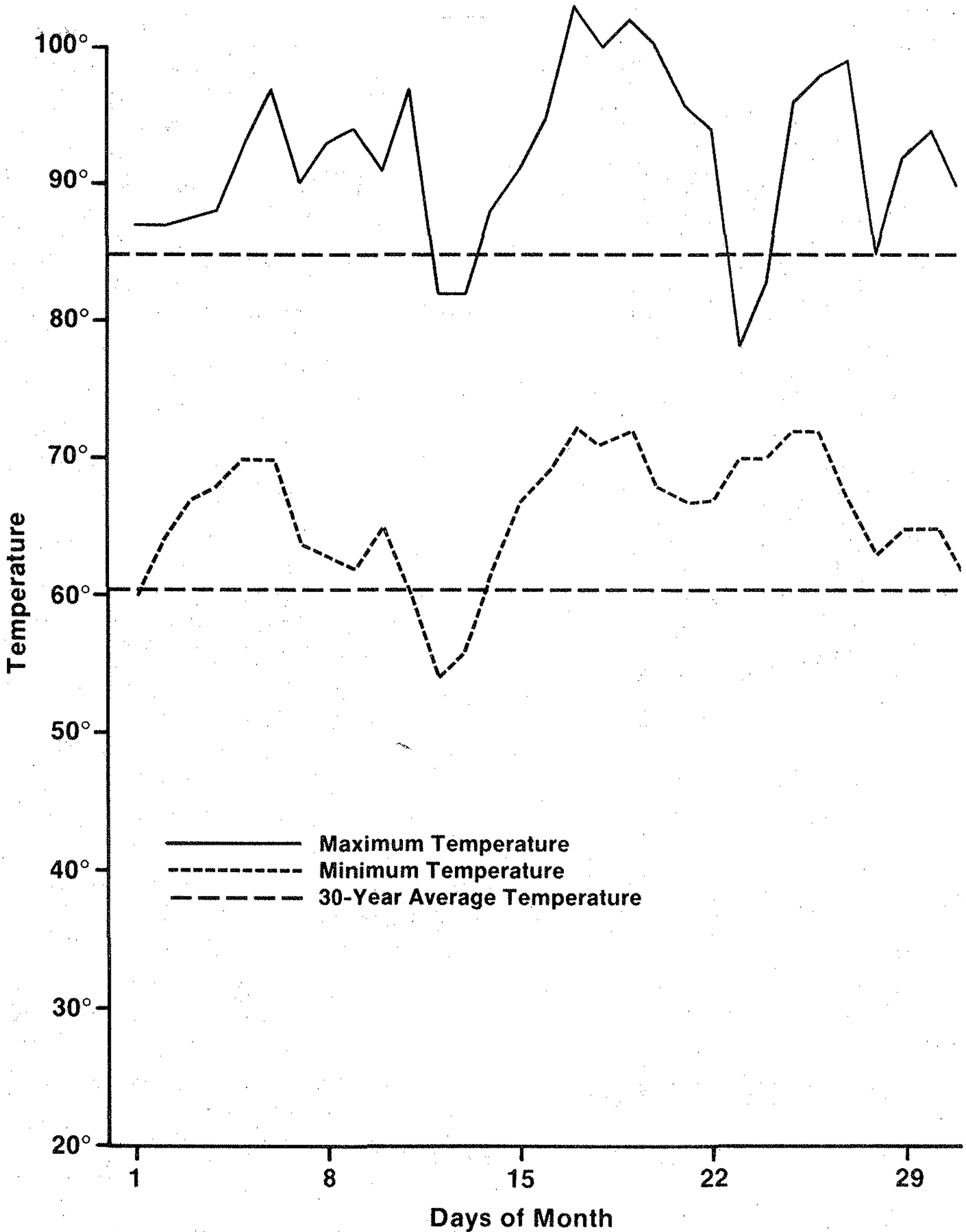
CLIMATOLOGICAL DATA
I-80 ADAIR COUNTY
JUNE 1983



CLIMATOLOGICAL DATA
I-80 ADAIR COUNTY
JULY 1983



CLIMATOLOGICAL DATA
I-80 ADAIR COUNTY
AUGUST 1983



CLIMATOLOGICAL DATA
I-80 ADAIR COUNTY
SEPTEMBER 1983