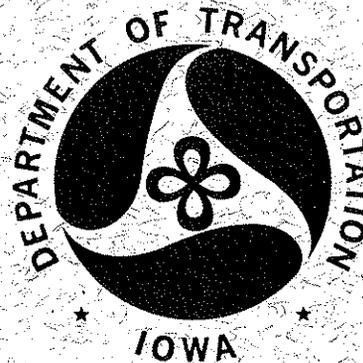


MLR 78 3

RESEARCH SECTION
Office of Materials
Iowa Dept. of Transportation

**A STUDY OF THE
FRICTIONAL PROPERTIES
OF NEW
ASPHALTIC CONCRETE
PAVEMENTS
IN IOWA**



**HIGHWAY DIVISION
OFFICE OF MATERIALS**

NOVEMBER 1978

A STUDY OF THE FRICTIONAL
PROPERTIES OF NEW ASPHALTIC
CONCRETE PAVEMENTS IN IOWA

by

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November 1978

Iowa Department of Transportation
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ABSTRACT

Seven asphaltic concrete resurfacing projects were tested for their frictional properties to determine the age-friction relationship of new paving.

Projects studied included Type A asphaltic concrete which is generally used for higher traffic volume roads and Type B asphaltic concrete, a lower type material. Also included in the study were asphaltic concretes containing Type 3 and Type 4 coarse aggregate texture classifications. The classifications are based upon material type and grain size composition. Surfaces both with and without sprinkle treatment aggregates were also included.

The data gathered suggests that properly designed and placed dense graded asphaltic concrete mixes are adequate to serve the traveling public at all ages tested.

A STUDY OF THE FRICTIONAL PROPERTIES OF
NEW ASPHALTIC CONCRETE PAVEMENTS IN IOWA

Introduction:

On July 14, 1977 a sedan collided with a motor home on a wet pavement in Oklahoma resulting in eight fatalities and six other injuries. The National Transportation Safety Board determined that the cause of this accident was a combination of the low frictional properties of the pavement and the lax operating maintenance by the owner of the sedan.

The pavement was a new asphaltic concrete of a dense graded mix. The project was completed on June 29, 1977. Friction tests at the accident site indicated low friction numbers for the inside wheel paths in both directions (18 for the motor home and 12 for the sedan).

As a result of this incident, the National Transportation Safety Board recommended that the Federal Highway Administration:

"Develop expeditiously procedures to determine the skid resistant characteristics of newly constructed and resurfaced roadways before they are opened to traffic."

Pavement friction tests are not normally conducted on new asphaltic concrete pavements in Iowa, hence any data indicating friction properties of new pavements was lacking. It had been assumed that the friction numbers on new asphaltic concrete would be lower than when the surface asphalt had an opportunity to oxidize and be partially abraded from the aggregates. Routine testing of asphaltic concrete pavements has been delayed until the year after

paving since it was felt that the results obtained would better reflect the truer frictional properties of the pavement.

On May 12, 1978 Messrs. Dennis Cook, Frank Howell and Jack Latterell of the Iowa Division of the Federal Highway Administration met with the Iowa Department of Transportation Pavement Friction Review Committee for the purpose of discussing the frictional properties of newly constructed pavements.

It was generally agreed that the frictional properties of newly constructed portland cement concrete pavements would be quite good and was not a matter for immediate concern. Because of the texturing currently specified in these pavements together with the fact that construction traffic has generally worn away the curing compound, the frictional properties should be near their maximum at the time the pavement is opened to public traffic.

The primary concern centered on the frictional properties of new asphaltic concrete. It was decided at that meeting the Office of Materials would select one or more projects in the Ames area that could be tested to determine the friction-age relationship of typical asphaltic concrete pavement.

Scope:

The following projects were selected for study:

Project No.: FN 65-5(12)-21-85, Story and Hardin Counties
Location: U.S. 65 from Jct. U.S. 30 to Hubbard
Project Length: 19.0 miles
Contractor: E. C. Henningsen

Asphalt Mixture

Type: 1/2" Type A
Asphalt Content: 4.75 %
Coarse Agg.: 65 % Alden Quarry
Fine Agg.: 35 % Concrete Sand - Jansson Pit
Coarse Agg. Texture Type: 4

Project No.: FN 65-4(23)-21-50, Story and Jasper Counties
Location: U.S. 65 from Jct. Ia. 330 to Old U.S. 30 at Colo
Project Length: 14.4 miles
Contractor: Norris Construction Company

Asphalt Mixture

Type: 1/2" Type B
Asphalt Content: 5.25 %
Coarse Agg.: 55 % Malcom Mine
Fine Agg.: 45 % Concrete Sand - Colfax Pit
Coarse Agg. Texture Type: 4
Sprinkle Treatment Agg.:
Source: Ferguson Quarry
Top Size: 3/4"
Texture Type: 4
Application Rate: 5.0 lbs./sq. yd.

Project No.: MP 1297-69-40, Hamilton County
Location: U.S. 69 from Jewell to U.S. 20
Project Length: 11.0 miles
Contractor: Cessford Construction Company

Asphalt Mixture

Type: 3/8" Type B
Asphalt Content: 6.0 %
Coarse Agg.: 30 % Crushed Gravel - Wright Co. - Meineke Pit
Fine Agg.: 70 % Concrete Sand - Radcliffe Pit
Coarse Agg. Texture Type: 3

Project No.: P-185-0(5)--30-38, Grundy County
Location: Ia. 185 from Ia. 14 to Conrad
Project Length: 1.3 miles
Contractor: Cessford Construction Company

Asphalt Mixture

Type: 1/2" Type A
Asphalt Content: 5.0 %
Coarse Agg.: 65 % Kenyon Quarry
Fine Agg.: 35 % Concrete Sand - Marshalltown Pit
Coarse Agg. Texture Type: 4

Project No.: FN-89-3(1)-21-85, Story County
Location: Ia. 210 from U.S. 69 to Slater
Project Length: 6.0 miles
Contractor: Iowa Road Builders

Asphalt Mixture

Type: 1/2" Type B
Asphalt Content: 5.75 %
Coarse Agg.: 30 % Crushed Gravel - Hallett Pit - Ames
Fine Agg.: 70 % Sand - Hallett Pit - Ames
Coarse Agg. Texture Type: 3
Sprinkle Treatment Agg.:
Source: Crushed Gravel - Hallett Pit - Boone
Top Size: 3/4"
Texture Type: 3
Application Rate: 7.5 lbs./sq. yd.

Project No.: P-279-0(2)--30-06, Benton County
Location: Main St. in Atkins east and south to Jct.
with U.S. 30
Project Length: 2.5 miles
Contractor: Judd Brown Construction Company

Asphalt Mixture

Type: 1/2" Type B
Asphalt Content: 6.0 %
Coarse Agg.: 65 % Limestone - Garrison "A" Quarry
Benton County
Fine Agg.: 35 % Concrete Sand - Vinton Pit - Benton County
Coarse Agg. Texture Type: 4

Project No.: FN-4-5(16)--21-74, Palo Alto County
Location: From W. Jct. with U.S. 18 north to Emmett County
Project Length: 8.9 miles
Contractor: Rohlin Construction Company

Asphalt Mixture

Type: 1/2" Type B
Asphalt Content: 5.75 %
Coarse Agg.: 30 % Crushed Gravel - Section 10, T97N, R33W,
Palo Alto County
Fine Agg.: 70 % Gravel - Section 10, T97N, R33W, Palo Alto
Palo Alto County
Coarse Agg. Texture Type: 3

Both Type A and Type B asphaltic concrete is included in this study. Type A asphaltic concrete is considered the higher type material and is generally used for higher traffic volume roads.

Two of the projects have a sprinkle treatment applied to the surface. The process consists of pre-coating coarse aggregate with approximately 1% asphalt cement, spreading the aggregate directly on the surface behind the laydown machine, and embedding the aggregate in the surface during the compaction process.

Reference is made to a coarse aggregate texture type. The Iowa Department of Transportation classifies coarse aggregate for use in asphaltic concrete according to the skid resistance properties of the aggregate. Five types or classifications are presently used. Type 1 is the most skid resistant and are typically very hard materials such as calcined bauxite and emery. Type 5 is polish susceptible and is typified by fine grained limestones. A complete description of the texture classifications which are based on grain size and a range in mineral hardness of the grains, can be found in Appendix A.

Results:

Figures 1 through 7 indicate the age-friction relationships that exist for the projects studied when tested with a two wheeled trailer in accordance with ASTM E 274 at 40 m.p.h. All tests were conducted between June 2, 1978 and October 12, 1978. The friction test systems used in the study were calibrated at FHWA Central Test Center in April 1978.

The Majority of points plotted represents an average of at least three individual tests that were made on the pavement section at the age indicated. Due to the short length of some sections, less than three tests were obtained for each plotted point. The points

do not represent the average of repeat tests at the exact location previous tests were made, but are rather the average of separate locations within the pavement section of the same age.

A considerable amount of testing was also accomplished at a speed of 55 m.p.h. as well as the normal testing speed of 40 m.p.h. It is the purpose of this report to establish the change in frictional characteristics with age. This change can be noted by observing the friction results at 40 m.p.h. Complete data on all sections can be examined by referring to Appendix C.

Project FN-65-5(12)-21-85 Story and Hardin Counties

Figure 1 exhibits the data obtained on this project. Friction test results are available for pavement ages of 2 through 127 days. A correlation coefficient of 0.320501 indicates there is not a significant relationship between age and frictional properties on this project. The friction numbers appear quite good at all ages tested.

Project F-65-4(23)-21-50 Story and Jasper Counties

Figure 2 represents the results from testing the above project. Test data is available for pavement ages of 4 through 53 days. A correlation coefficient of -0.251211 reflects no discernable relationship between age and friction numbers. The general level of friction numbers appears to be very adequate.

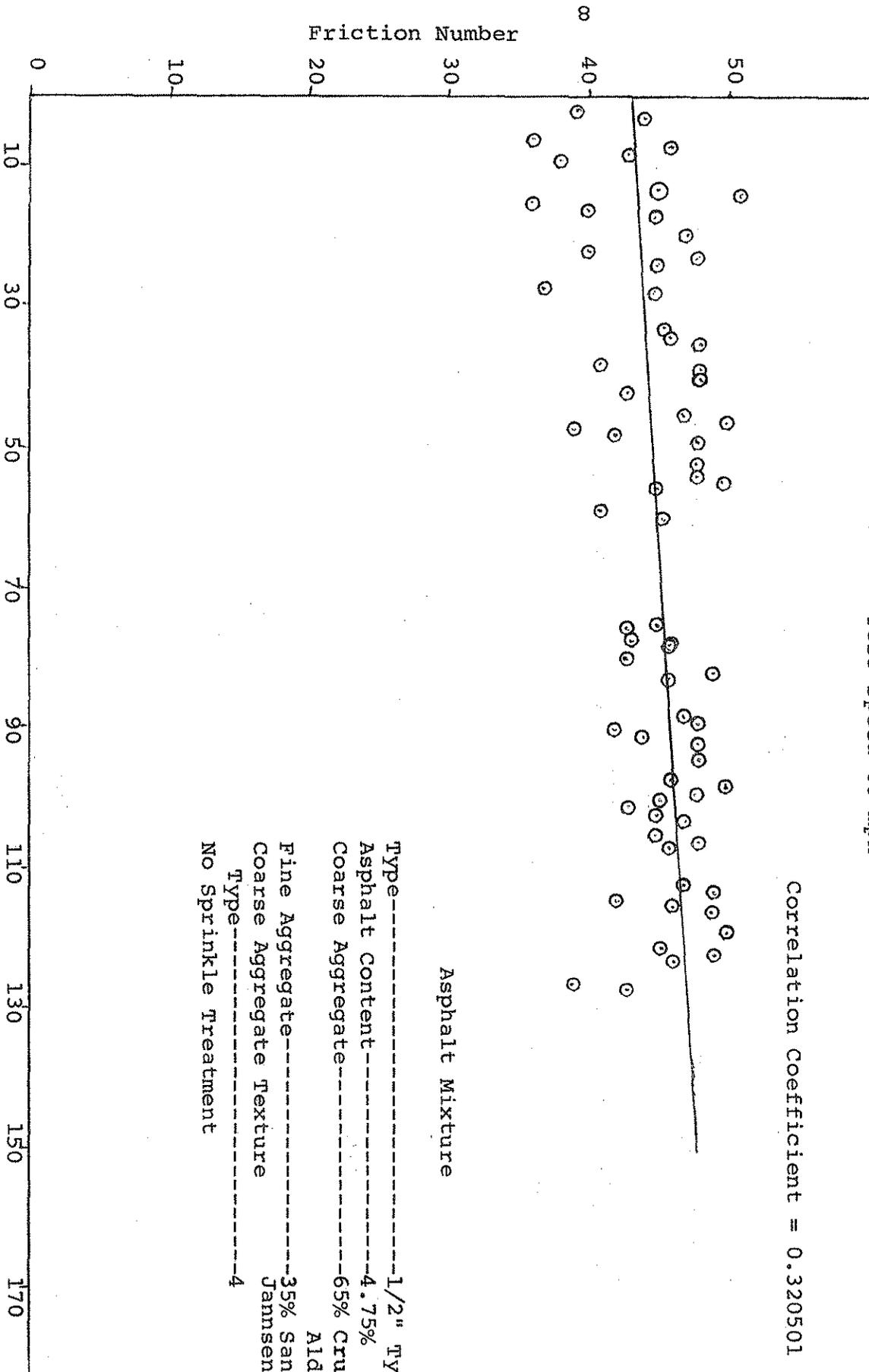
Project MP 1297-69-40 Hamilton County

Figure 3 shows the level of friction numbers from ages 18 through 115 days. The level of friction numbers is quite high and there is no relationship indicated between age and friction numbers as exhibited by a correlation coefficient of -0.004502.

Friction Numbers on New AC Resurfacing
 Friction Testing on US 65 Story & Hardin Counties
 Project No. FN 65-5(12)-21-85

Test Speed 40 mph

Correlation Coefficient = 0.320501



Pavement Age (Days)
 Fig. 1

Friction Numbers on New AC Resurfacing
 Friction Testing on US 65 Story & Jasper Counties
 Project No. F-65-4(23)-21-50

Test Speed 40 mph

Correlation Coefficient = -0.251211

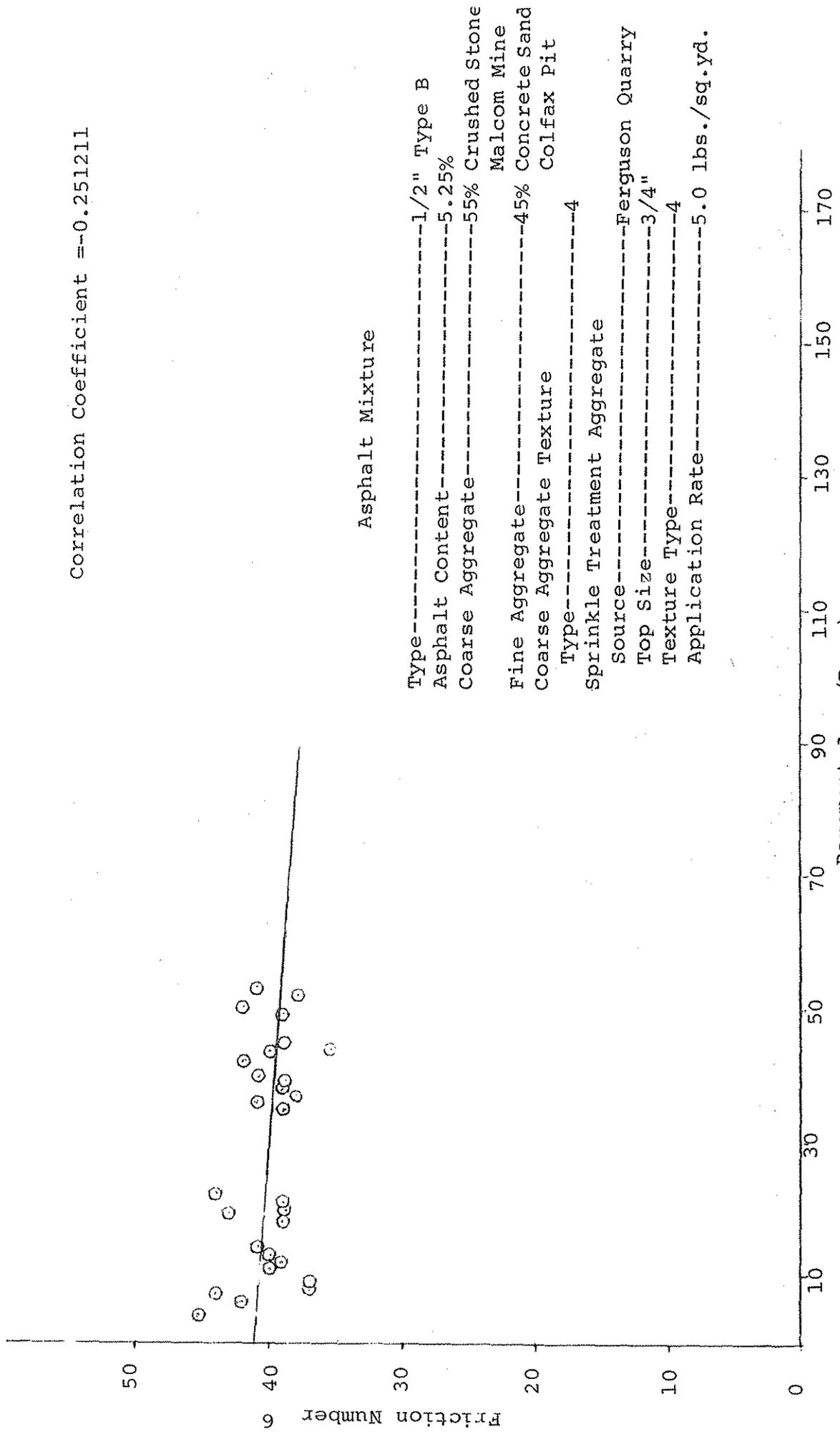


Fig. 2

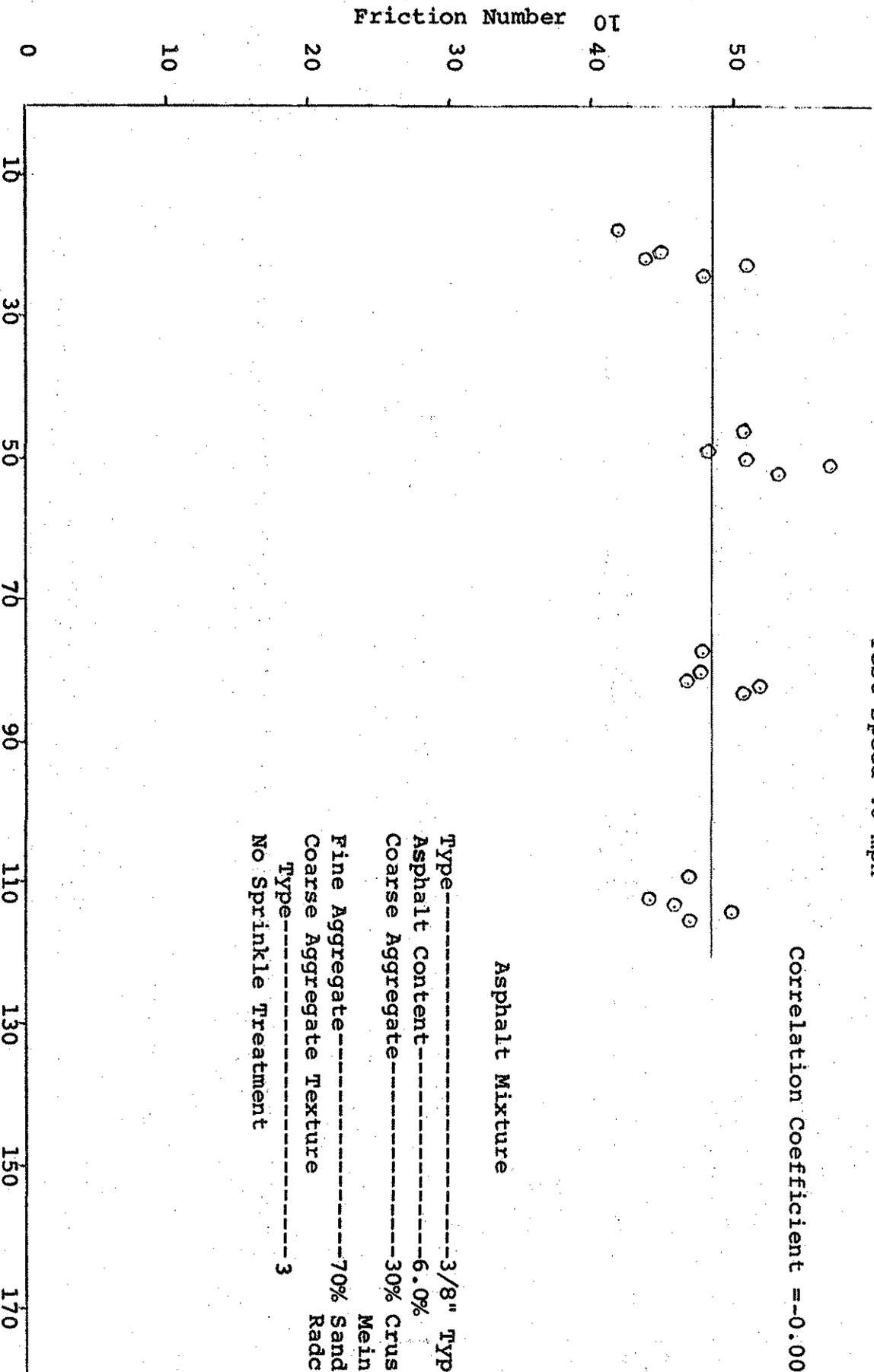
Friction Numbers on New AC Resurfacing
 Friction Testing on US 69 Hamilton County
 Project No. MP 1297-69-40

Test Speed 40 mph

Correlation Coefficient = -0.004502

Asphalt Mixture

Type-----3/8" Type B
 Asphalt Content-----6.0%
 Coarse Aggregate-----30% Crushed Gravel
 Fine Aggregate-----70% Sand
 Coarse Aggregate Texture-----Radcliffe Pit
 Type-----3
 No Sprinkle Treatment



Pavement Age (Days)
 Fig. 3

Project P-185-0(5)--30-38 Grundy County

Figure 4 indicates only 2 data points on this project. Friction numbers of 59 and 57 for ages 2 and 30 days respectively establishes that there is no need for concern at early ages for this mix. The calculation of a correlation coefficient is inappropriate due to the lack of a larger number of data points.

Project FN-89-3(01)-21-85 Story County

Figure 5 suggests an upward trend of friction numbers as the pavement ages from 1 through 35 days. The correlation coefficient of 0.717051, while higher than for any other project, is not sufficiently high to establish a definite correlation between pavement age and friction number. The friction numbers at an early age are acceptable.

Project P-279-0(2)--30-06 Benton County

Figure 6 shows three data points obtained on this project. The testing was conducted at the pavement age of 8, 9, and 10 days. The friction numbers are quite good at these early ages.

Project FN-4-5(16)-21-74 Palo Alto County

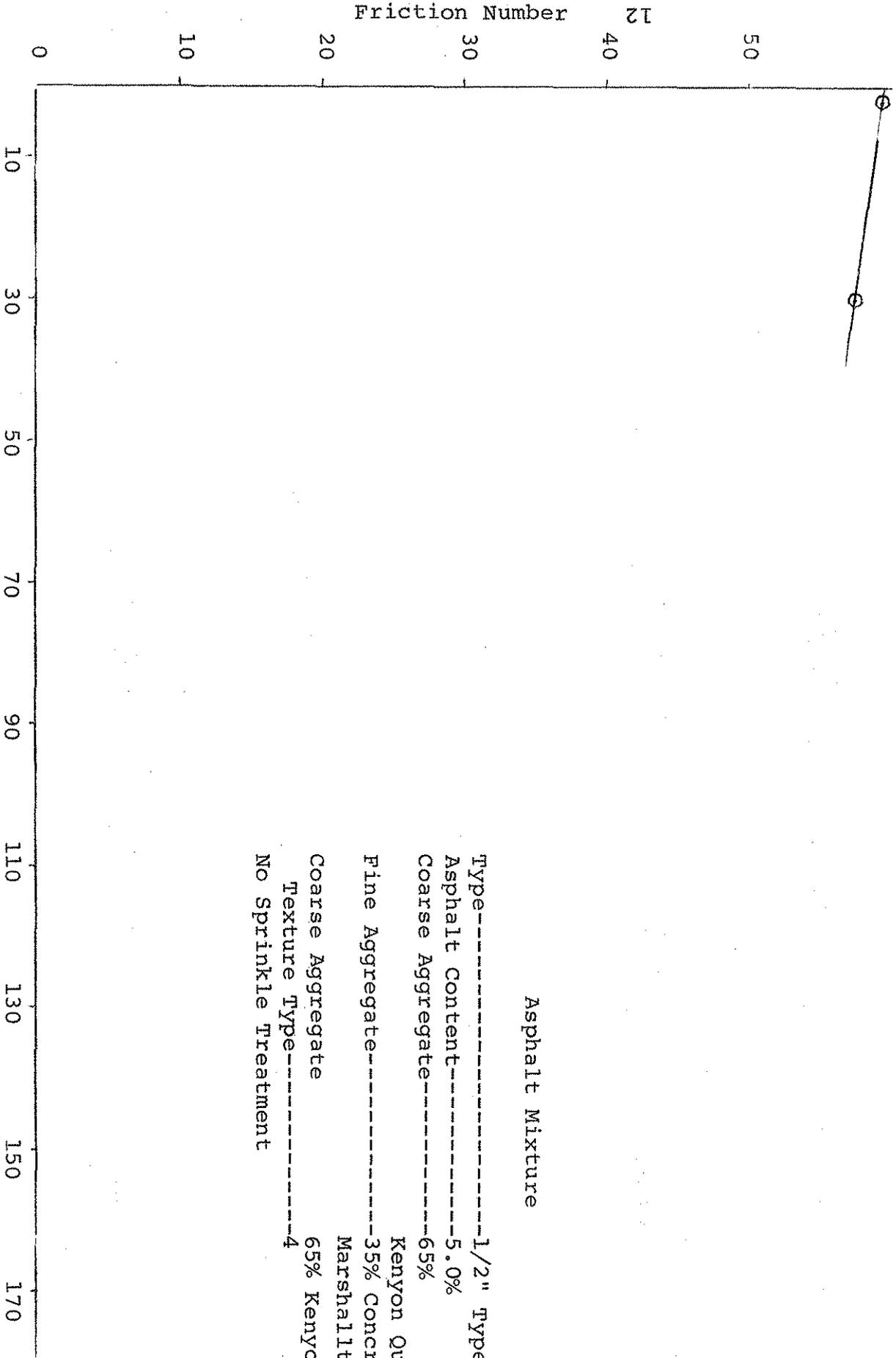
Figure 7 exhibits the data obtained on this project. Data was gathered at pavement ages of 5 through 15 days. A correlation coefficient of 0.370008 again establishes the lack of a relationship between friction number and pavement age. Although there is some variability shown in the friction numbers at an age of 7 days or less the general level of frictional properties is good.

Friction Numbers on New AC Resurfacing
 Friction Testing on IA. 185 Grundy County
 Project No. P-185-0(5) --30-38

Test Speed 40 mph

Asphalt Mixture

- Type-----1/2" Type-A
- Asphalt Content-----5.0%
- Coarse Aggregate-----65%
- Fine Aggregate-----Kenyon Quarry
- Coarse Aggregate-----35% Concrete Sand
- Texture Type-----Marshalltown Pit
- No Sprinkle Treatment-----4
- 65% Kenyon Quarry



Pavement Age (Days)

Friction Number

Friction

Friction Numbers on New AC Resurfacing
 Friction Testing on IA. 210 Story County
 Project No. FN-89-3(01)-21-85

Test Speed 40 mph

Correlation Coefficient = 0.717051

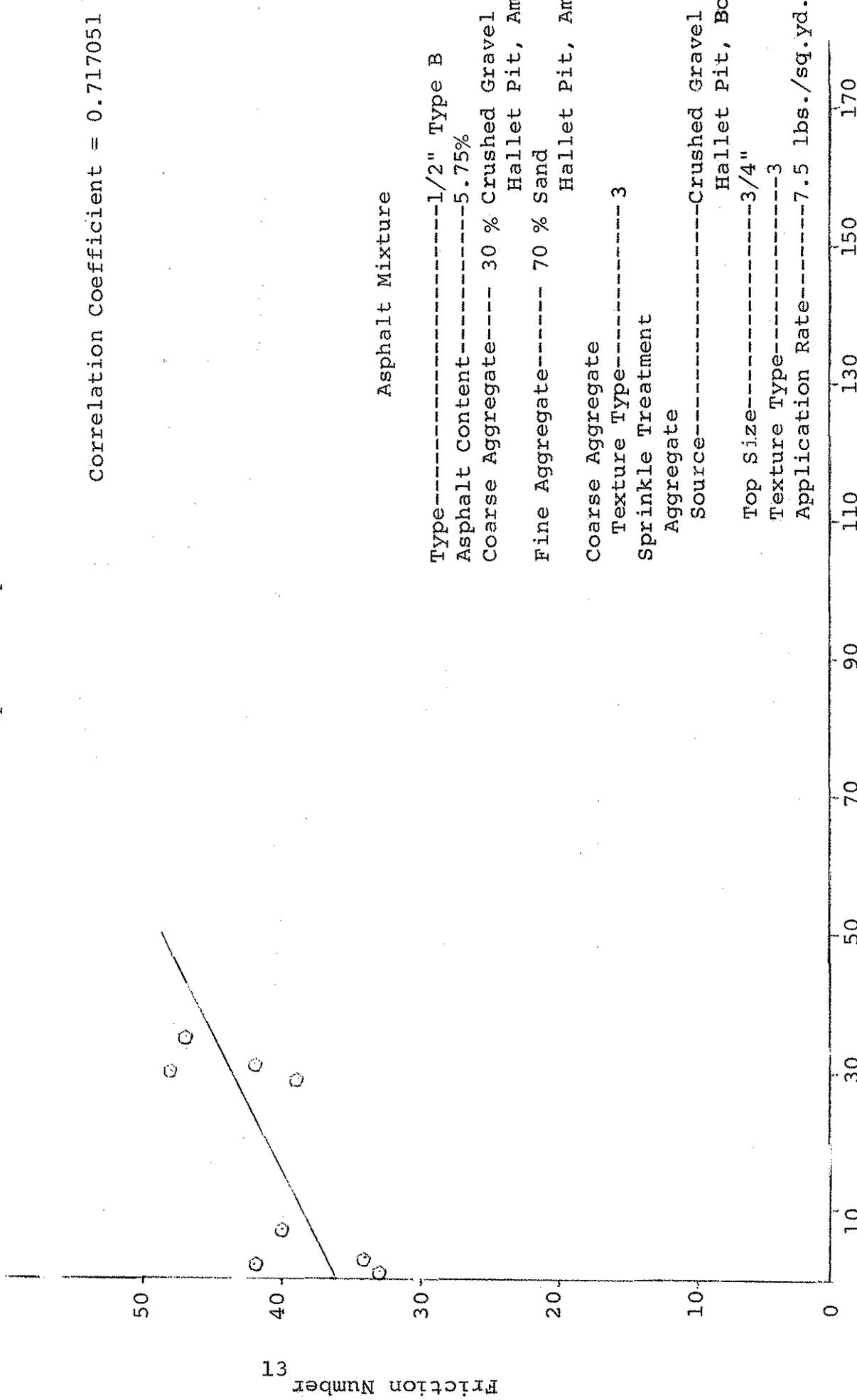
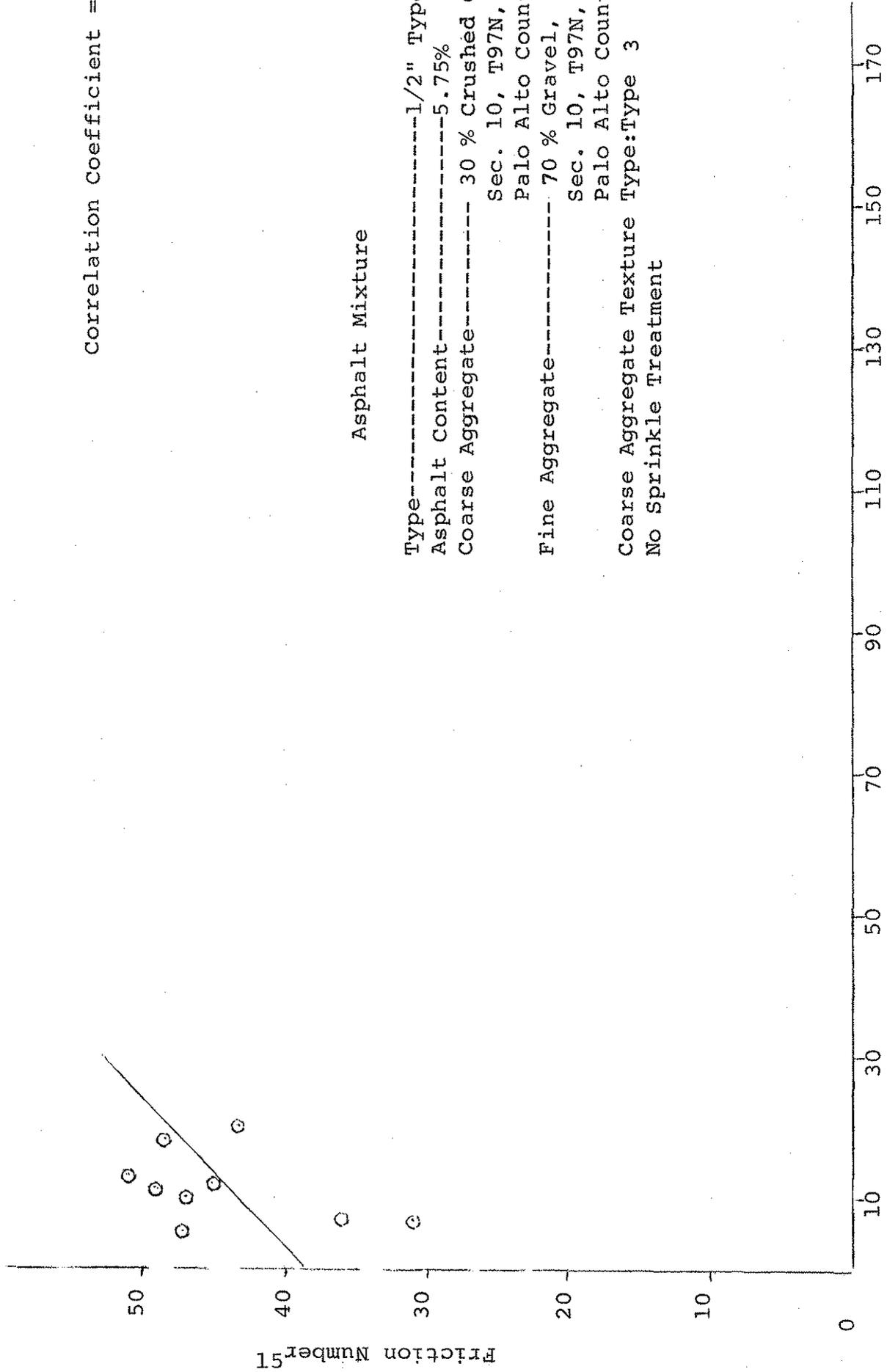


Fig. 5

Friction Numbers on New AC Resurfacing
 Friction Testing on IA. 4 Palo Alto County
 Project No. FN-4-5(16)-21-74

Test Speed 40 mph

Correlation Coefficient = 0.370008



Pavement Age (Days)
 Fig. 7

Conclusions:

The data gathered in this study would suggest no need exists for establishing the frictional properties of new asphaltic concrete pavement prior to opening the road to traffic.

Both Type A and Type B asphaltic concretes as well as sprinkle treatment surfaces were included in the investigation. All types exhibited good friction numbers at all ages tested. There was no conclusive evidence to document that the inherent frictional properties of one type of asphaltic concrete paving are significantly better than any other type. The texture classification of all coarse aggregates used on the projects were either Type 3 or Type 4. Since the typical coarse aggregate classifications in Iowa are Type 3 or Type 4, the projects selected for study should be indicative of the level of friction numbers at early ages that would reflect the majority of asphaltic concrete placed within the state.

When dense graded asphaltic concrete mixes such as those examined, are properly designed and placed, their frictional properties are adequate to serve the traveling public.

Undoubtedly new asphaltic concrete pavements exist with lower than desirable friction numbers. It is logical to assume however, that this is caused by poor design, improper aggregate selection, inadequate field control, or a combination of these factors.

APPENDIX A

AGGREGATE CLASSIFICATION TYPES

Type I

Aggregates which are generally a heterogeneous combination of minerals with coarse grained microstructure of very hard particles (Generally a Mohs Hardness range of 7 to 9) bonded together by a slightly softer matrix.

These aggregates are typified by those developed for and used by the grinding-wheel industry such as calcined bauxite (synthetic) and emery (natural). They normally are not available from Iowa sources. Due to the high cost, these aggregates would be specified only for extremely critical situations.

Type II

Natural Aggregates in this class are crushed quartzite and granites. The mineral grains in these materials generally have a Mohs hardness range of 5 to 7.

Synthetic aggregates in this class are some aircooled steel furnace slags and others with similar characteristics.

Type III

Natural aggregates in this class are crushed traprocks, crushed gravels or those crushed from dolomitic ledges in which 80 percent or more of the grains have diameters of 120 microns or larger. The mineral grains in the approved dolomitic ledges

generally have a Mohs hardness range of 3.5 to 4. The crushed gravels shall not contain more than 30 percent of carbonate stone as defined in the Type V classification.

Synthetic aggregates in this class are the expanded shales with a Los Angeles abrasion loss less than 35 percent.

Type IV

Aggregates crushed from dolomitic or limestone ledges in which 80 percent of the grains are 30 microns or larger. The mineral grains in the approved ledges for this classification generally have a Mohs hardness range of 3 to 4. The gravels shall not contain more than 60 percent of carbonate stone as defined in the Type V classification.

Type V

Aggregates crushed from lithographic and sublithographic limestone ledges and natural gravels containing more than 60 percent lithographic and sublithographic limestone particles. Grain sizes will predominately be below 30 microns for the crushed stone.

APPENDIX B

ASPHALTIC CONCRETE

MIX DESIGNS

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE B SURFACE LAB NO. ABD7-227

INTENDED USE:

SIZE 3/8" SPEC. NO. 802 DATE REPORTED 9/14/77

COUNTY HAMILTON PROJECT MP-1297--69-40
HARDIN MP-1295--69-42

CONTRACTOR CESSFORD CONSTR. CO.
ON US 69 FROM JEWELL TO US 20 (11.0 MI.)
PROJ. LOCATION ON IA. 175 FROM N. JCT. WITH US 65 EAST 7.8 MI. TO ELDORA

AGG. SOURCES 3/8" CR. GRAVEL - MEINEKE PIT - WRIGHT CO.,
SAND - N. OF RADCLIFFE - HARDIN CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% AAT7-693, 70% AAT7-694

| JOB MIX FORMULA - COMBINED GRADATION | | | | | | | | | | | |
|-------------------------------------------|----|------|--------|------|------|------|-------|-------|-------------|--------|--------|
| 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | NO.4 | NO.8 | NO.16 | NO.30 | NO.50 | NO.100 | NO.200 |
| | | | 100 | 99 | 80 | 64 | 50 | 36 | 18 | 9.6 | 7.0 |
| TOLERANCE: +OR- | | | 98/100 | 7 | 6 | | 5 | | | 3 | |
| 75 BLOW MARSHALL DENSITY | | | | | | | | | 2.33 | | |
| ASPHALT SOURCE AND APPROXIMATE VISCOSITY | | | | | | | | | KOCH - 1200 | FOISES | |
| ELASTICITY INDEX | | | | | | | | | N. F. | | |
| ASPH. IN MIX | | | | | | | | | 5.0 | 6.0 | 7.0 |
| NUMBER OF MARSHALL BLOWS | | | | | | | | | 50 | 50 | 50 |
| MARSHALL STABILITY - LBS. | | | | | | | | | 2157 | 2073 | 1908 |
| FLOW - 0.01 IN. | | | | | | | | | 8 | 8 | 10 |
| SP. GR. BY DISPLACEMENT (LAB DENS.) | | | | | | | | | 2.27 | 2.31 | 2.33 |
| BULK SP. GR. COMB. DRY AGG. | | | | | | | | | 2.644 | 2.644 | 2.644 |
| SP. GR. ASPH. @ 77 F. | | | | | | | | | 1.030 | 1.030 | 1.030 |
| CALC. SOLID SP. GR. | | | | | | | | | 2.48 | 2.45 | 2.41 |
| % VOIDS - CALC. | | | | | | | | | 8.6 | 5.6 | 3.4 |
| RICE SP. GR. | | | | | | | | | 2.47 | 2.44 | 2.40 |
| % VOIDS - RICE | | | | | | | | | 8.1 | 5.1 | 3.1 |
| % WATER ABSORPTION - AGGREGATE | | | | | | | | | 1.17 | 1.17 | 1.17 |
| % VOIDS IN THE MINERAL AGGREGATE | | | | | | | | | 18.4 | 17.9 | 18.0 |
| % V.M.A. FILLED WITH ASPHALT | | | | | | | | | 53.1 | 68.4 | 80.9 |
| CALCULATED ASPH. FILM THICKNESS (MICRONS) | | | | | | | | | 6.0 | 7.5 | 8.9 |

A CONTENT OF 6.00% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

- ASPH. MIX DESIGN
- PROJECTS LISTED ABOVE
- D. ANDERSON
- D. SMITH
- B. ORTGIES
- C. HUISMAN
- L. ZEARLEY
- CESSFORD
- C. JONES
- D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

IOWA DEPARTMENT OF TRANSPORTATION
 OFFICE OF MATERIALS
 ASPHALT CONCRETE MIX DESIGN
 LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE B SURFACE

LAB NO. ABD8-120

INTENDED USE:

SIZE 1/2" SPEC. NO. 823 DATE REPORTED 7/13/78
 COUNTY BOONE PROJECT FN-89-2(2)--21-00
 COUNTY STORY PROJECT FN-89-3(1)--21-85
 COUNTY STORY PROJECT P-930-0(14)--30-85

CONTRACTOR IOWA ROAD BUILDING

FROM WOODWARD EASTERLY 3.8 MILES INTO MADRID;

PROJ. LOCATION ON IA. 210 FROM SLATER EAST 6.0 MILES;

ON OLD US 30 FROM AMES TO NEVADA

AGG. SOURCES 1/2" GRAVEL - HALLETT PIT (MAUDLIN) - STORY CO.;

1/2" CR. GRAVEL - HALLETT PIT (MAUDLIN) - STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 70% AAT9-356, 30% AAT8-357

JOB MIX FORMULA - COMBINED GRADATION

| 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | NO.4 | NO.8 | NO.16 | NO.30 | NO.50 | NO.100 | NO.200 |
|--------|-----|------|------|------|------|------|-------|-------|-------|--------|--------|
| | 100 | 99 | 88 | 65 | 52 | 42 | 33 | 19 | 8.8 | 6.5 | |

TOLERANCE: +OR- 98/100 7 7 6 5 3

75 BLOW MARSHALL DENSITY 2.38

ASPHALT SOURCE AND APPROXIMATE VISCOSITY WOOD RIVER-1850 POISES SUGAR CREEK
 PLASTICITY INDEX N.P. 1050 POISES

ASPH. IN MIX 5.0 6.0 7.0 6.0

NUMBER OF MARSHALL BLOWS 50 50 50 50

MARSHALL STABILITY - LBS. 2622 1985 1580 2325

FLOW - 0.01 IN. 8 8 14 7

SP. GR. BY DISPLACEMENT(LAB DENSI.) 2.33 2.35 2.35 2.36

BULK SP. GR. COMB. DRY AGG. 2.691 2.691 2.691 2.691

P. GR. ASPH. @ 77 F. 0.996 0.996 0.996 1.031

CALC. SOLID SP. GR. 2.50 2.46 2.42 2.47

% VOIDS - CALC. 6.8 4.5 3.0 4.6

ICE SP. GR. 2.46 2.43 2.39 2.44

% VOIDS - RICE 5.3 3.4 1.7 3.3

% WATER ABSORPTION - AGGREGATE 0.67 0.67 0.67 0.67

% VOIDS IN THE MINERAL AGGREGATE 17.7 17.9 18.8 17.6

V.M.A. FILLED WITH ASPHALT 61.7 74.9 84.0 74.0

CALCULATED ASPH. FILM THICKNESS(MICRONS) 6.9 8.4 10.0 8.4

A CONTENT OF 5.75% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

- ASPH. MIX DESIGN
- PROJECTS LISTED ABOVE
- D. ANDERSON
- D. SMITH
- R. SHELQUIST
- D. JORDISON
- J. ZEARLEY - 2
- IOWA ROAD BLDG.
- C. JONES
- D. HINES

SIGNED: BERNARD C. BROWN
 TESTING ENGINEER

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE B SURFACE LAB NO. ABB8-179

INTENDED USE:

SIZE 1/2" SPEC. NO. B23 DATE REPORTED 9/14/78

COUNTY PALO ALTO PROJECT FN-4-5(16)--21-74

CONTRACTOR ROHLIN

PROJ. LOCATION FROM W. JCT. WITH US 18 NORTH 9.0 MILES TO EMMET CO. LINE

AGG. SOURCES 1/2" CR. GRAVEL - 10-97-33 - PALO ALTO CO.,
1/2" GRAVEL - 10-97-33 - PALO ALTO CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% AATB-620, 70% AATB-619

| JOB MIX FORMULA - COMBINED GRADATION | | | | | | | | | | | |
|-------------------------------------------|--------|------|------|------|------|------|-------------|-------|--------|--------|--------|
| 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | NO.4 | NO.8 | NO.16 | NO.30 | NO.50 | NO.100 | NO.200 |
| | | | 100 | 91 | 70 | 54 | 40 | 25 | 14 | 8.8 | 7.0 |
| TOLERANCE: +OR- | 98/100 | 7 | 7 | 6 | | | 5 | | | | 3 |
| 75 BLOW MARSHALL DENSITY | | | | | | | | | 2.37 | | |
| ASPHALT SOURCE AND APPROXIMATE VISCOSITY | | | | | | | KOCH - 1160 | | POISES | | |
| PLASTICITY INDEX | | | | | | | 2 | | | | |
| % ASPH. IN MIX | | | | | | | 4.50 | | 5.50 | | 6.50 |
| NUMBER OF MARSHALL BLOWS | | | | | | | 50 | | 50 | | 50 |
| MARSHALL STABILITY - LBS. | | | | | | | 2333 | | 2230 | | 2137 |
| FLOW - 0.01 IN. | | | | | | | 8 | | 8 | | 10 |
| SP. GR. BY DISPLACEMENT (LAB DEMS.) | | | | | | | 2.29 | | 2.34 | | 2.36 |
| BULK SP. GR. COMB. DRY AGG. | | | | | | | 2.636 | | 2.636 | | 2.636 |
| SP. GR. ASPH. @ 77 F. | | | | | | | 1.030 | | 1.030 | | 1.030 |
| CALC. SOLID SP. GR. | | | | | | | 2.50 | | 2.46 | | 2.42 |
| % VOIDS - CALC. | | | | | | | 8.3 | | 4.9 | | 2.7 |
| RICE SP. GR. | | | | | | | 2.51 | | 2.46 | | 2.43 |
| % VOIDS - RICE | | | | | | | 8.8 | | 4.9 | | 2.9 |
| % WATER ABSORPTION - AGGREGATE | | | | | | | 1.21 | | 1.21 | | 1.21 |
| % VOIDS IN THE INITIAL AGGREGATE | | | | | | | 17.0 | | 16.1 | | 16.3 |
| % V.V.A. FILLED WITH ASPHALT | | | | | | | 51.2 | | 69.5 | | 83.5 |
| CALCULATED ASPH. FILM THICKNESS (MICRONS) | | | | | | | 6.0 | | 7.7 | | 9.3 |

A CONTENT OF 5.75% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

- ASPH. MIX DESIGN
- FN-4 5(16)--21-74, PALO ALTO
- J. BUMP
- R.C.E. CHIROKLE
- R. SULLOUST
- D. JORDISON
- L. ZEARLEY
- ROHLIN
- C. JONES
- D. HINES

STAMPED: REPPARD C. BROWN
DATE: 9/14/78

DEPT. OF TRANSPORTATION
 OFFICE OF MATERIALS
 ASPHALT CONCRETE MIX DESIGN
 LAB LOCATION AMES

TYPE AND CLASS: TYPE A SURFACE LAB NO. ABDS-41

NEED USE:

1/2" SPEC. NO. 802 DATE REPORTED 5/9/78

STORY PROJECT FN-65-5(12)-21-85

DIRECTOR E. C. HENNINGSEN

LOCATION FROM JCT. WITH US 30 NORTH 19.0 MILES TO HUBBARD

SOURCES 1/2" CR. LST. - ALDEN QR. - HARDIN CO., 1/2" LST. CHIPS -
 ALDEN QR. - HARDIN CO., SAND - JANNSEN PIT - HARDIN CO.

MIX FORMULA AGGREGATE PROPORTIONS: 35% AAT8-70, 30% AAT8-69, 35% AAT8-71

JOB MIX FORMULA - COMBINED GRADATION

| 7/2" | 1" | 3/4" | 1/2" | 3/8" | NO.4 | NO.8 | NO.16 | NO.30 | NO.50 | NO.100 | NO.200 |
|-----------------|--------|------|------|------|------|------|-------|-------|-------|--------|--------|
| | | | 100 | 85 | 54 | 42 | 34 | 26 | 14 | 7.9 | 5.2 |
| REFERENCE: +OR- | 98/100 | 7 | 7 | 5 | | | 4 | | | | 2 |

AGGREGATE SOURCE AND APPROXIMATE VISCOSITY KOCH - 1210 POISES

ST. CITY INDEX

SPH. IN MIX 4.50 5.50

NO. OF MARSHALL BLOWS 50 50

SHALL STABILITY - LBS. 2658 2580

W. 0.01 IN. 8 9

GR. BY DISPLACEMENT (LAB DENS.) 2.34 2.38

K. P. GR. COMB. DRY AGG. 2.659 2.659

1% ASPH. @ 77 F. 1.026 1.026

C. SOLID SP. GR. 2.50 2.46

VOIDS - CALC. 6.2 3.2

E. P. GR. 2.46 2.42

VOIDS - RICE 4.9 1.9

WATER ABSORPTION - AGGREGATE 0.50 0.50

VOIDS IN THE MINERAL AGGREGATE 16.0 15.4

% A. FILLED WITH ASPHALT 60.9 79.2

CALCULATED ASPH. FILM THICKNESS (MICRONS) 7.6 9.5

CONTENT OF 4.75% ASPHALT IS RECOMMENDED TO START THE JOB.

NOTES:

ASPH. MIX DESIGN

FN-65-5(12)-21-85, STORY

D. ANDERSON

D. SMITH

R. SHELQUIST

D. JORDISON

K. ZEARLEY

E. HENNINGSEN

C. JONES

D. HINES

SIGNED: BERNARD C. BROWN
 TESTING ENGINEER

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE D BINDER & SURFACE LAB NO. ABB8-182

INTENDED USE:

SIZE 1/2" SPEC. NO. 823 DATE REPORTED 9/20/78

COUNTY BENTON PROJECT P-279-0(2)--30-06

CONTRACTOR JUDD BROWN

PROJ. LOCATION FROM ATKINS EAST & SOUTH 2.5 MILES TO JCT. WITH US 30

AGG. SOURCES 1/2" CR. LST. - GARRISON "A" AR. - BENTON CO.,
CONC SAND - HILPOY/VINTON PIT - BENTON CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AAT8-640, 35% A618-641

| JOB MIX FORMULA - COMBINED GRADATION | | | | | | | | | | | |
|--------------------------------------|----|------|------|------|------|------|-------|-------|-------|--------|--------|
| 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | NO.4 | NO.8 | NO.16 | NO.30 | NO.50 | NO.100 | NO.200 |
| | | | 100 | 91 | 70 | 54 | 42 | 29 | 13 | 9.4 | 7.3 |

TOLERANCE: +OR- 98/100 7 7 6 5 3

75 BLOW MARSHALL DENSITY 2.33

ASPHALT SOURCE AND APPROXIMATE VISCOSITY KOCH - 1160 POISES

PLASTICITY INDEX N. P.

% ASPH. IN MIX 4.50 5.50 6.50

NO. BEP OF MARSHALL BLOBS 50 50 50

MARSHALL STABILITY - LBS. 2813 2533 2463

FLOW - 0.01 IN. 7 8 9

SP. GR. BY DISPLACEMENT (LAD DEN.) 2.26 2.31 2.34

BULK SP. GR. COMB. DRY AGG. 2.613 2.613 2.613

SP. GR. ASPH. @ 77 F. 1.030 1.030 1.030

CALC. SOLID SP. GR. 2.50 2.46 2.43

% VOIDS - CALC. 9.5 6.2 3.5

RICE SP. GR. 2.49 2.44 2.41

% VOIDS - RICE 9.2 5.4 2.8

% WATER ABSORPTION - AGGREGATE 1.91 1.91 1.91

% VOIDS IN THE MINERAL AGGREGATE 17.4 16.5 16.3

% V.M.A. FILLED WITH ASPHALT 45.2 62.6 78.3

CALCULATED ASPH. FILM THICKNESS (MICRONS) 5.3 6.8 8.4

CONTENT OF 6.0% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

ASPH. MIX DESIGN

P-279-0(2)--30-06, BENTON

E. C. HEBLY

J. SHYTHE

R. SHELQUIST

D. JORDISON

M. ZEARLEY

JUDD BROWN

C. JONES

D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

SUPPLEMENTAL REPORT

DEPT. OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB. LOCATION AMES

II. TYPE AND CLASS: TYPE A SURFACE

LAB. NO. AAD8-129

INTENDED USE:

SIZE 1/2"

SPEC. NO. 823

DATE REPORTED 7/20/78

COUNTY GRUNDY

PROJECT P-185-0(5)--30-38

CONTRACTOR CESSFORD CONSTR. CO.

PROJ. LOCATION FROM IA. 14 EAST 1.3 MILES INTO CONRAD

AG. SOURCES 1/2" CR. LST. - KENYON QR. - MARSHALL CO.,
SAND - MARSHALLTOWN - MARSHALL CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AAT8-386, 35% AAT8-385

JOB MIX FORMULA - COMBINED GRADATION

| NO. 4 | NO. 8 | NO. 16 | NO. 30 | NO. 50 | NO. 100 | NO. 200 |
|-------|-------|--------|--------|--------|---------|---------|
| 100 | 99 | 88 | 67 | 49 | 38 | 27 |
| | | | | 14 | 9.2 | 6.8 |

TOLERANCE: +OR- 98/100 7 7 5

5 BLOW MARSHALL DENSITY 2.38

ASPHALT SOURCE AND APPROXIMATE VISCOSITY KOCH - 1250 POISES

ELASTICITY INDEX

ASPH. IN MIX 4.25 5.25 6.25

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 2942 2825 2092

FLOW - .01 IN. 8 8 14

P.GR. BY DISPLACEMENT (LAB DENS.) 2.31 2.35 2.37

BULK SP. GR. COAR. DRY AGG. 2.668 2.668 2.668

P. GR. ASPH. @ 77 F. 1.028 1.028 1.028

CALC. SOLID SP. GR. 2.51 2.47 2.44

% VOIDS - CALC. 8.0 5.0 2.8

ICE SP. GR. 2.48 2.45 2.40

% VOIDS - RICE 7.0 4.0 1.2

WATER ABSORPTION - AGGREGATE 0.43 0.43 0.43

% VOIDS IN THE MINERAL AGGREGATE 17.1 16.5 16.7

V.M.A. FILLED WITH ASPHALT 53.2 69.7 83.4

CALCULATED ASPH. FILM THICKNESS (MICRONS) 6.3 7.9 9.6

A CONTENT OF 5.00% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

- ASPH. MIX DESIGN
- P-185-0(5)--30-38, GRUNDY
- D. ANDERSON
- J. PETERS
- R. SHELQUIST
- D. JORDISON
- L. ZEARLEY
- C. JONES
- D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE B SURFACE

LAB NO. ABD8-11

INTENDED USE:

SIZE 1/2"

SPEC. NO. B23

DATE REPORTED 4/4/78

COUNTY JASPER

PROJECT FN-65-4(23)--21-50

TOP-117-1(9)--29-50

CONTRACTOR NORRIS CONSTR. CO.

PROJ. LOCATION FROM IA. 330 NORTH 14.4 MI. TO OLD US 30 AT COLO.
FROM COLFAX NORTH 10.0 MILES TO US 65

AGG. SOURCES 1/2" CR. LST. - MALCOM - POWESHIEK CO.,
SAND - COLFAX - JASPER CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 55% AATB-14, 45% AATB-15

| JOB MIX FORMULA - COMBINED GRADATION | | | | | | | | | | | |
|-------------------------------------------------------------------|----|------|------|------|------|------|-------|-------|-------|--------|--------|
| 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | NO.4 | NO.8 | NO.16 | NO.30 | NO.50 | NO.100 | NO.200 |
| | | | 100 | 86 | 64 | 52 | 41 | 27 | 12 | 7.6 | 6.3 |
| TOLERANCE: +OR- 98/100 7 7 6 5 3 | | | | | | | | | | | |
| 75 BLOW MARSHALL DENSITY 2.37 | | | | | | | | | | | |
| ASPHALT SOURCE AND APPROXIMATE VISCOSITY WOOD RIVER - 1220 POISES | | | | | | | | | | | |
| PLASTICITY INDEX N. P. | | | | | | | | | | | |
| % ASPH. IN MIX 4.50 5.50 6.50 | | | | | | | | | | | |
| NUMBER OF MARSHALL BLOWS 50 50 50 | | | | | | | | | | | |
| MARSHALL STABILITY - LBS. 2237 2217 1647 | | | | | | | | | | | |
| FLOW - 0.01 IN. 7 8 13 | | | | | | | | | | | |
| SP. GR. BY DISPLACEMENT (LAB DENS.) 2.32 2.35 2.36 | | | | | | | | | | | |
| BULK SP. GR. COMB. DRY AGG. 2.674 2.674 2.674 | | | | | | | | | | | |
| SP. GR. ASPH. @ 77 F. 0.999 0.999 0.999 | | | | | | | | | | | |
| CALC. SOLID SP. GR. 2.50 2.47 2.43 | | | | | | | | | | | |
| % VOIDS - CALC. 7.4 4.7 2.8 | | | | | | | | | | | |
| RICE SP. GR. 2.46 2.43 2.40 | | | | | | | | | | | |
| % VOIDS - RICE 5.8 3.3 1.5 | | | | | | | | | | | |
| % WATER ABSORPTION - AGGREGATE 0.63 0.63 0.63 | | | | | | | | | | | |
| % VOIDS IN THE MINERAL AGGREGATE 17.1 17.0 17.5 | | | | | | | | | | | |
| % V.M.A. FILLED WITH ASPHALT 56.9 72.2 83.9 | | | | | | | | | | | |
| CALCULATED ASPH. FILM THICKNESS (MICRONS) 7.0 8.7 10.5 | | | | | | | | | | | |

A CONTENT OF 5.25% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

ASPH. MIX DESIGN
PROJECTS LISTED ABOVE

D. ANDERSON
M. ABOLA
R. SHELQUIST
D. JORDISON
J. ZEARLEY

NORRIS
C. JONES
D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

APPENDIX C

FRICITION TESTING RESULTS

Project No. FN 65-5(12)-21-85 Story and Hardin Counties

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 2 | 7 | 39 | |
| 3 | 7 | 44 | |
| 6 | 8 | 36 | |
| 7 | 4 | 46 | |
| 8 | 7 | 43 | |
| 9 | 6 | 38 | |
| 13 | 5 | 45 | |
| 14 | 2 | 51 | |
| 15 | 5 | 36 | |
| 16 | 3 | 40 | |
| 17 | 5 | 45 | |
| 20 | 3 | 47 | |
| 22 | 3 | 40 | |
| 23 | 3 | 48 | |
| 24 | 3 | 45 | |
| 27 | 1 | 37 | |
| 28 | 3 | 45 | |
| 33 | 4 | 46 | |
| 34 | 3 | 46 | |

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 35 | 7 | 48 | |
| 38 | 8 | 41 | |
| 39 | 4 | 48 | |
| 40 | 7 | 48 | |
| 42 | 6 | 43 | |
| 45 | 5 | 47 | |
| 46 | 2 | 50 | |
| 47 | 5 | 39 | |
| 48 | 3 | 42 | |
| 49 | 5 | 48 | |
| 52 | 3 | 48 | |
| 54 | 3 | 48 | |
| 55 | 3 | 50 | |
| 56 | 3 | 45 | |
| 59 | 2 | 41 | |
| 60 | 3 | 46 | |
| 75 | 3 | 45 | |
| 76 | 1 | 43 | |
| 77 | 3 | 43 | |
| 78 | 7 | 46 | |
| 80 | 8 | 43 | |
| 82 | 4 | 49 | |
| 83 | 14 | 46 | |
| 88 | 5 | 47 | |
| 89 | 2 | 48 | |

| Age Days | No. of Tests | Friction Average | |
|-------------|-----------------|------------------|-----------|
| | | 40 M.P.H. | 55 M.P.H. |
| 90 | 5 | 42 | |
| 91 | 3 | 44 | |
| 92 | 5 | 48 | |
| 94 | 3 | 48 | |
| 97 | 3 | 46 | |
| 98 | 3 | 50 | |
| 99 | 3 | 48 | |
| 100 | 2 | 45 | 37 |
| 101 | 1 | 43 | 36 |
| 102 | 3 | 45 | 37 |
| 103 | 3 | 47 | |
| 105 | 1 | 45 | 39 |
| 106 | 1 | 48 | 43 |
| 107 | 2 | 46 | 40 |
| 112 | 1 | 47 | 40 |
| 113 | 1 | 49 | 41 |
| 114 | 1 | 42 | 37 |
| 115 | 1 | 46 | 41 |
| 116 | 1 | 49 | 41 |
| 119 | 1 | 50 | 41 |
| 121 | 1 | 45 | 38 |
| 122 | 1 | 49 | 42 |
| 123 | 1 | 46 | 43 |
| 126 | 1 | 39 | 32 |
| 127 | 1 | 43 | 40 |

Project No. F-65-4(23)-21-50 Story and Jasper Counties

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 4 | 6 | 46 | |
| 6 | 5 | 42 | |
| 7 | 4 | 44 | |
| 8 | 3 | 37 | |
| 9 | 2 | 37 | |
| 11 | 4 | 40 | |
| 12 | 4 | 39 | |
| 13 | 9 | 40 | |
| 14 | 3 | 41 | |
| 18 | 4 | 39 | |
| 19 | 3 | 43 | |
| 20 | 4 | 39 | |
| 21 | 4 | 39 | |
| 22 | 5 | 44 | |
| 35 | 1 | 39 | 30 |
| 36 | 1 | 41 | 33 |
| 37 | 1 | 38 | 31 |
| 38 | 1 | 39 | 34 |
| 39 | 1 | 39 | 31 |
| 40 | 1 | 41 | 33 |
| 42 | 1 | 42 | 34 |
| 43 | 1 | 40 | 31 |
| 44 | 3 | 36 | 30 |
| 45 | 1 | 39 | 32 |

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 49 | 2 | 39 | 32 |
| 50 | 1 | 42 | 37 |
| 52 | 1 | 38 | 31 |
| 53 | 1 | 41 | 34 |

Project No. MP 1297-69-40 Hamilton County

| Age Days | No. of Tests | Friction Average | |
|-------------|-----------------|------------------|-----------|
| | | 40 M.P.H. | 55 M.P.H. |
| 18 | 7 | 42 | |
| 21 | 11 | 45 | |
| 22 | 10 | 44 | |
| 23 | 9 | 51 | |
| 24 | 4 | 48 | |
| 46 | 7 | 51 | |
| 49 | 11 | 48 | |
| 50 | 10 | 51 | |
| 51 | 9 | 57 | |
| 52 | 4 | 54 | |
| 77 | 7 | 48 | |
| 80 | 11 | 48 | |
| 81 | 10 | 47 | |
| 82 | 9 | 52 | |
| 83 | 4 | 51 | |
| 109 | 7 | 47 | 41 |
| 112 | 11 | 44 | 44 |
| 113 | 10 | 46 | 41 |
| 114 | 9 | 50 | 45 |
| 115 | 4 | 47 | 42 |

Project No. P-185-0(5)--30-38 Grundy County

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 2 | 2 | 60 | 46 |
| 30 | 2 | 58 | 47 |

Project No. FN-89-3(01)-21-85 Story County

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 1 | 3 | 33 | 25 |
| 2 | 3 | 42 | 36 |
| 3 | 7 | 34 | 27 |
| 7 | 7 | 40 | 34 |
| 29 | 3 | 39 | 35 |
| 30 | 2 | 48 | 41 |
| 31 | 7 | 42 | 37 |
| 35 | 7 | 47 | 39 |

Project No. P-279-0(2)--30-06 Benton County

| <u>Age</u> <u>Days</u> | <u>No. of</u> <u>Tests</u> | <u>Friction Average</u> | |
|---------------------------|-------------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 8 | 3 | 43 | 40 |
| 9 | 6 | 48 | 40 |
| 10 | 3 | 48 | 40 |

Project No. FN-4-5(16)-21-74 Palo Alto County

| <u>Age Days</u> | <u>No. of Tests</u> | <u>Friction Average</u> | |
|---------------------|-------------------------|-------------------------|------------------|
| | | <u>40 M.P.H.</u> | <u>55 M.P.H.</u> |
| 5 | 12 | 47 | 41 |
| 7 | 4 | 31 | |
| 7 | 4 | 36 | |
| 10 | 3 | 47 | 39 |
| 11 | 7 | 49 | 40 |
| 12 | 8 | 45 | 38 |
| 13 | 3 | 51 | 41 |
| 18 | 7 | 48 | 42 |
| 20 | 6 | 43 | 38 |