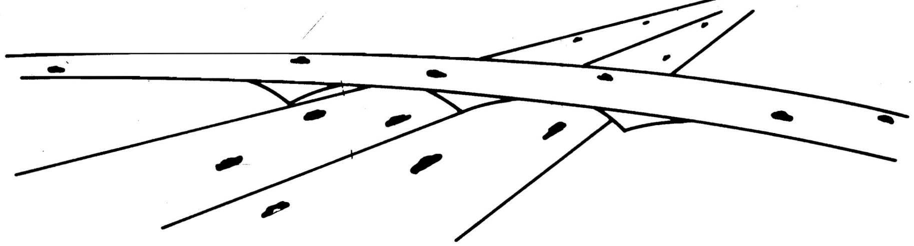
DHT-1-9/10-75-216-1F



DEPARTMENTAL RESEARCH

Report Number 216-1F

COMPARING LABORATORY AND FIELD POLISH RATES OF COARSE AGGREGATES FOR SKID RESISTANCE PURPOSES

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

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16. Abstract

This report describes a method and analysis of comparing laboratory and field information concerning coarse aggregate polish rates. The laboratory polish rates resulted from the use of a British Wheel whereas field polish rates were obtained from information previously collected with a skid test unit. The analysis consisted of correlating the laboratory and field polish rates using several commercial aggregate sources in or near the State. The results indicated various levels of skid resistance depending on the aggregate source. However, the comparison of polish rates revealed a confused relationship due to the data scatter in the field polish rate. Examples of variables which probably affect the variation found are (1) the effect of seasonal changes on a pavement surface as measured by a skid test unit, (2) the effect of climatological changes on a pavement surface as measured by a skid test unit, (3) the effect of different construction techniques on the pavement surface as measured by a skid test unit and (4) the validity of the field data for this purpose, since the indicated SN is an average value for a section of the project. Even though asphaltic concrete surfaces were considered, the field study eventually involved chip seals and surface treatments because these surfaces closely resembled the surface used in the laboratory test. Even though the relationship between the field and laboratory polish rates is inconclusive, a relationship between ultimate polish levels does exist. This relationship indicates the laboratory "Polish Value" can predict the ultimate field polish level for an aggregate source where the field polish level would represent the average condition found on a roadway in the state which uses the aggregate for a seal coat or surface treatment.

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The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or policies of the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter or any new and useful improvement thereof, or any variety of plant which is or may be patentable under the patent laws of the United States of America or any foreign country.

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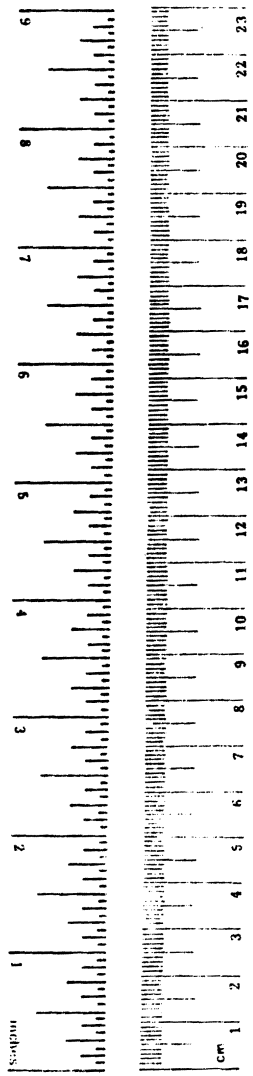
METRIC CONVERSION FACTORS

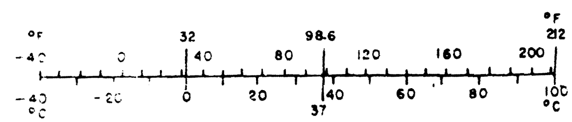
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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IMPLEMENTATION

It is suggested that the correlations or relationships determined in this report not be implemented. The field polish rate was developed from inventory data obtained with the skid test units. The field polish rate is the "average" regression curve fit through numerous data points. Wide variance was found in this data. This variance is probably due to a number of variables, either unknown or unmeasured, not included in the regression analysis. Examples of variables which probably affect the variation found are (1) the effect of seasonal changes on a pavement surface as measured by a skid test unit, (2) the effect of climatological changes on a pavement surface as measured by a skid test unit, (3) the effect of different construction techniques on the pavement surface as measured by a skid test unit and (4) the validity of the field data for this purpose, since the indicated SN is an average value for a section of the project.

This variance in data makes the results untrustworthy and therefore, no reccommendation for implementation has been made.

SUMMARY

This study utilized skid resistance inventory information to develop field polish rate data for selected coarse aggregate sources. The British Wheel was used to develop laboratory polish rate information for the same sources. Attempts were made to correlate the two polish rates in order to develop specifications for polish values based on traffic expected during the structural life of the pavement. These attempts failed since the correlation data indicated a poor relationship. It is believed the poor relationship is due to an unmeasured variable in the field data. This unmeasured variable is probably macrotexture which would offer information about the surface, especially if the skid resistance were deteriorating due to flushing rather than aggregate polishing.

I. INTRODUCTION

Background

Prior to the initiation of the research reported herein, the Texas Department of Highways and Public Transportation had been involved in several research efforts in the skid resistance field. During the first of these projects a skid test unit was developed.[1] The skid test unit was later modified and four new units were fabricated for inventory purposes. An automated skid resistance inventory system was developed and made available for District field use.[2]

Other research efforts were directed toward the polish characteristics of aggregates.[3] A British Wheel was purchased and specifications proposed for the "Polish Value" of coarse aggregate. Later the Materials and Tests Division revised the test procedure and began an experimental program designed for familiarization and for expanding the uses of the British Wheel and Pendulum Tester.

The Federal Highway Administration urged the implementation of the British Wheel and Polish Value specification soon after the Materials and Tests Division began performing routine tests. After using the Polish Value specification it became apparent that construction and maintenance costs were increasing because of increased cost of skid resistant aggregates. The greater cost was generally caused by the shipping costs; that is, many construction or maintenance jobs were great distances from the sources of the higher skid resistant aggregates. In addition, many highways on which surfaçing or surface revisions were to be made were in areas of low traffic. Certain highways would not receive sufficient traffic to polish the surface to a dangerous level before the pavement would be revised for structural reasons. It was believed the use of skid resistant aggregate on an extremely low volume highway where excessive shipping costs are involved was a waste of public funds. Therefore, this study was directed toward developing information whereby a skid resistant surface could be maintained for public use, but in the most economical manner. The most feasible method to accomplish this engineering function appeared to be that of developing a polish <u>rate</u> for each aggregate source. When sufficient traffic is expected to polish the aggregate to a undesirable level before surface revisions for other reasons, the aggregate would not be used. A method to accomplish this function was needed.

Objective of Study

The objective of this study was to develop methods whereby the polish or frictional life of a pavement surface could be predicted during the planning stage of a construction, betterment, rehabilitation or maintenance project. This was to be accomplished at a relatively low cost by examining existing skid test data developed over a number of years and comparing it to the laboratory polish rate on selected aggregates. Specifications could then be adopted to allow the most economical surface that would remain skid resistant throughout the structural or traffic service life of the pavement. It should be stated that the surfaces of concern are the flexible pavement surfaces. Rigid pavements were not considered in this study. Finally, even though asphaltic concrete surfaces were considered, the field study eventually involved chip seals and surface treatments because these surfaces closely resembled the surface used in the laboratory test.

II. METHOD OF STUDY

It appeared feasible to determine a relationship between the field polish rate and a laboratory polish rate. If such a relationship could be found, the time to polish a given material to a certain frictional level in the laboratory could be equated to the amount of traffic effort to reduce a similar material in the pavement surface to a similar frictional level in the field.

Since there existed (and still exists) confusion as to how a pavement surface reacts frictionally when exposed to traffic and other factors, the following is an explanation of the researchers' theories in this area at the time the research was conducted.

Tire-Pavement Friction The tire was held as a constant and not considered in the study. Similarly, since this was to be a study of materials performance under field and laboratory conditions, design conditions such as slope or geometrics were not taken into consideration. It was believed that skid resistance of a flexible pavement, after the surface has been subjected to traffic, is basically derived from the coarse aggregate. Initially, the gritty texture of the fine aggregates gives additional frictional qualities to the pavement surface. This additional friction begins to be lost as traffic and natural weathering erode the finer grains of surface material. For this reason more emphasis was subsequently placed upon seal coats or chip seals to compare more readily with the laboratory fabricated polish value specimams.

It was believed that coarse aggregate will generally polish and become less skid resistant under the action of traffic. This polish is easily noted in the British Wheel test and a similar polish trend can be noted by observing new pavement surfaces as compared to pavement surfaces which have been subjected to a large amount of traffic. Periodic tests with a skid test trailer on a given surface show a polish trend or a gradual reduction in skid resistance. However, the periodic tests with a skid trailer do show variation and it is possible to obtain SN values after many traffic applications which are of the same magnitude as the SN values soon after construction. Therefore, some confusion exists since it is not always known whether this variation is caused by the measuring equipment or pavement surface changes. It is generally believed that much of this variation is due to a seasonal, and possibly climatic, effect which causes cyclic changes or renewal of texture in the pavement surface.

Seasonal and Climatic Effects The seasonal and climatic effects on the field polish rate were not considered in this study. Toward the midpoint of this project a report was received from Pennsylvania which is probably one of the better studies of the frictional effects of seasonal variation.[4] The Pennsylvania report presents a method of treating or considering seasonal variation in pavement surfacing materials. However, it is necessary to develop a skid resistance history of a material used in a pavement surface by obtaining closely spaced periodic skid resistance measurements. These periodic measurements could consume considerable time in the development of a history and many sources should be studied. After consideration, it was decided that the project was not sufficiently funded to develop seasonal information.

Traffic Information When considering traffic accumulations it is probable that the heavier truck traffic should be given more consideration than lighter automobile traffic. However, this information was not available in this project. Because of the low funding in the project it was necessary to attempt to use the existing data available in the skid resistance inventory system. When the system was developed, the average daily traffic was accessible and could therefore be easily recalled for this study. Therefore, accumulative traffic referred to in this report was derived by determining the product of ADT and the number of days involved between surface placement and test date.

Construction Variables It should be stated that on several previous occasions periodic skid resistance tests had been obtained on selected materials or aggregates which were placed in special test sections. In fact, a large portion of the skid resistance inventory system was designed whereby District personnel could maintain, review and study the skid resistance properties of materials generally used in their area. Through these efforts it had been noted that aggregates from a given source, placed as a given pavement type, and with the same amount of binder, can show vastly different skid resistance when measured with a skid test trailer. On one occasion the same material placed by the same contractor on the same day revealed a SN_{40} differential of 20 from one end of a construction job as compared to the other end. After exhaustive study which included asphalt extraction data from the construction records, the only significant item appeared to be the surface texture. The material, an asphaltic concrete, had "pulled" under the laydown machine in the early morning hours (higher SN_{40}) and the material was dense (lower SN_{40}) later in the afternoon. (The measurements were made soon after construction.) It is believed that construction procedures can influence the amount of skid resistance available on the pavement. Therefore, a variance in friction level and field polish rate was expected for a given material. However, studies on various items such as older pavements, binder contents, ADT levels, and aggregate sizes had not been made.

III. METHOD OF COLLECTING AND PREPARING THE DATA

Preparation of Data for Laboratory Polish Rate

Selected aggregates, which represented a cross section of types available, and sources, for which considerable laboratory polish history existed, were cast into test specimens as shown in the attached Test Method Tex-438-A. The specimens were then run in accordance with the Test Method. At regular intervals, the necessary polish value measurements were made using the British Pendulum Tester.

At the end of the prescribed time, a final polish value was determined. The values obtained were then plotted, polish value versus time. (See Figure 1)

This information was then ready for comparison to the field Data.

Preparation of Data for Field Polish Rate

As shown in Figure 2, the skid resistance inventory information generally includes the following data for each construction job inventoried:

1. Pavement type (Portland Cement Concrete, asphalt cement, concrete, surface treatments etc.)
2. Aggregate type (limestone, silicious, synthetic, etc.)
3. Aggregate source (name and location of source)
4. Binder content (percent of asphalt, gallons per square yard, etc.)
5. ADT
6. Total amount of cumulative traffic
7. Aggregate gradation (general size)
8. Skid resistance history (periodic test results - SN_{40} only - average value within the limits of a construction job)
9. Date of placement (date surface opened to traffic)

The data is in automated form or in storage on computer disc packs. A computer program was developed which sorted the information in the following order:

Pavement Type
  Aggregate Source (Sources were previously numbered)
    Aggregate Grade
      Binder Content
        Total Traffic
          SN_{40}

In addition, the date of placement logarithm (to base 10) of cumulative traffic, district in which the construction job (surfacing job) occurred, and the highway number (example US-81) were printed with the above items. The data included the average SN_{40} value within construction job limits. Every test period and all construction jobs using the specific source as a surfacing material within the State were reported. After study, and after determining the sources which had been sufficiently tested with the British Wheel, some twenty sources were

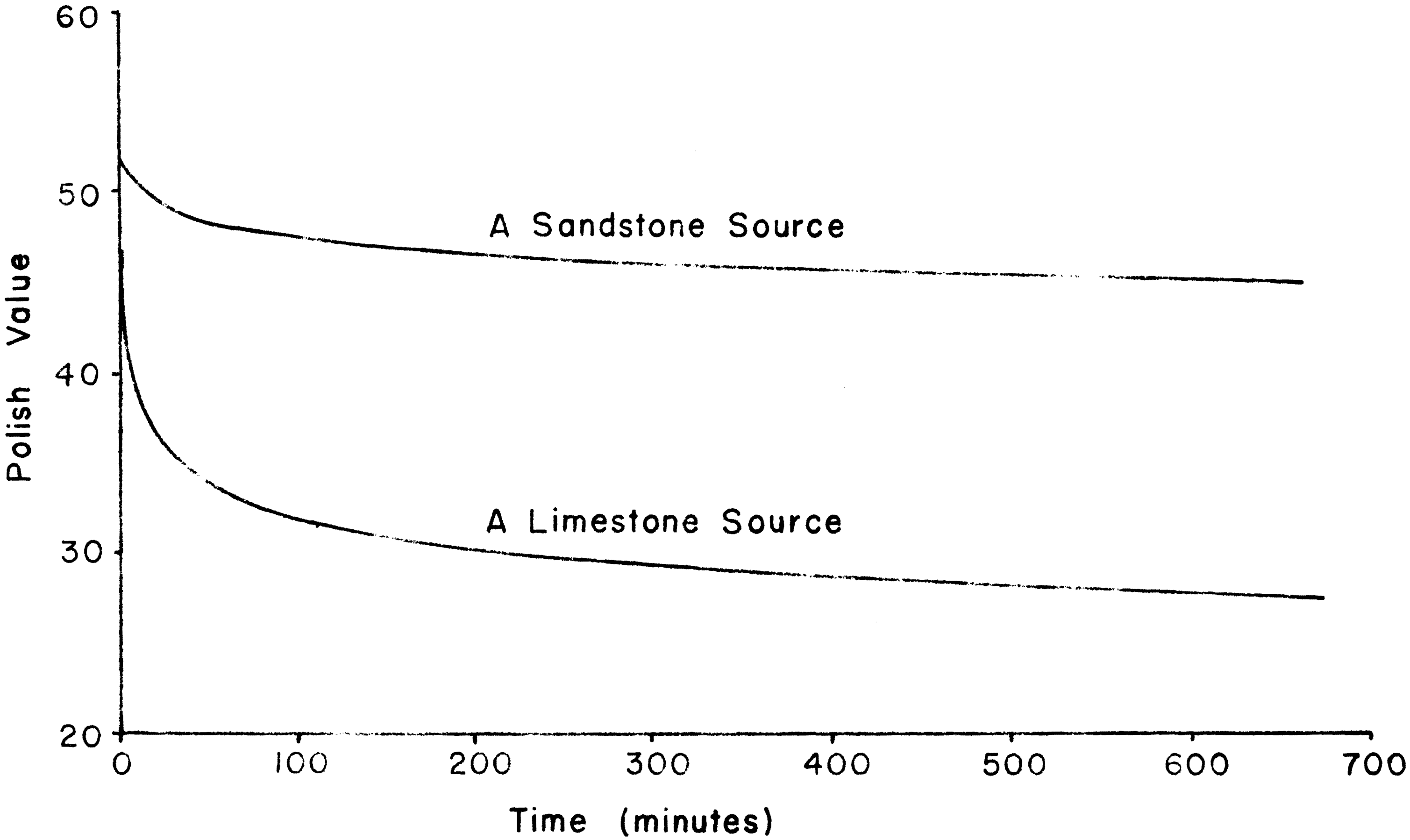

FIGURE 1—POLISH VALUE vs. TIME

```
-- CONSTRUCTION SECTION INFORMATION ----+------ PAVEMENT, MATERIAL, -------+-- CONTROL-SECTION INFO. --+- SKID HISTORY(MAX. OF 6) -+
+                                       +        & SOURCE INFORMATION      +                           +        TVL          TRAFFIC+
+ CSN                                   +                                  + CO.   C-S    BMP     EMP  + MO/YR -LN LO/AV/HI  (000) +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     15  HWY...US  77  LENGTH...  4.745 + PAVEMENT. HMAC                   + 17   102-0  10.244 14.989 +  5/77 W-B 12/22/27   37,391
-------  ADT...10,500  TRF...38,906,000 + PLACED... 08/66    BINDER... 7.50 +                           +  5/77 W-A 18/30/39   37,391
FROM.. INTRS FM-665 IN DRISCOLL         + PRI AGG.. TYPE C        SHELL    +                           +  5/75 W-B 23/28/32   30,383
TO.... JCT LP-428 NO OF BISHOP          + 2ND AGG..                        +                           +  5/75 W-A 24/35/44   30,383
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +
COMMENT1 SBL ONLY-MAYS-AVG3.8HI4.2LO    + P-  271-HELDENFELS SHELL-CORPUS  +                           +
COMMENT2 PVT83 SH70 RS65 DRAIN80 TS68   + S-                               +                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     16  HWY...US  77  LENGTH... 12.902 + PAVEMENT. HMAC                   + 17   102-0   2.086  8.134 +  5/77 W-B 32/42/48   11,697
-------  ADT....8,650  TRF...12,938,500 + PLACED... 06/73    BINDER... 5.80 +                           +  5/77 W-A 54/56/59   11,697
FROM.. JCT LP-428 NO OF BISHOP          + PRI AGG.. TYPE C      SANDSTONE  + 17   102-0   8.134 14.989 +  5/75 W-B 40/50/65  ***,***
TO.... INTRS LP 295 AND US 77 SO RBTN   + 2ND AGG.. SILICEOUS              +                           +  5/75 W-A 57/63/66  ***,***
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +
COMMENT1 NBL ONLY-MAYS-AVG3.0HI3.7LO1.9 + P-  197-HUGO ALLEN DUVAL CO US 59+                           +
COMMENT2 PVT63 SH54 RS70 DRAIN80 TS68   + S-  260-HORTON&HORTON-VICTORIA,TX+                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     17  HWY...US  77  LENGTH...  1.891 + PAVEMENT. SURF. TRT./SEAL        + 17   102-0   2.391  0.500 +  5/77 W-B 24/30/43   14,906
-------  ADT....7,890  TRF...16,019,700 + PLACED... 09/71    BINDER... 0.25 +                           +  5/77 W-A 45/51/56   14,906
FROM.. INTRS LP-295 AND US-77 SO RBTN   + PRI AGG.. GRADE 3     SANDSTONE  +                           +  5/75 W-B 28/32/41    9,674
TO.... INTRS SH-44 SO OF ROBSTOWN       + 2ND AGG..                        +                           +  5/75 W-A 55/60/63    9,674
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +
COMMENT1 NBL ONLY                       + P-  197-HUGO ALLEN DUVAL CO US 59+                           +
COMMENT2                                + S-                               +                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     18  HWY...US  77  LENGTH...  8.120 + PAVEMENT. HMAC                   + 19   371-0   0.000  8.120 +  5/77 W-A 15/24/32    5,385
-------  ADT....5,380  TRF....6,168,400 + PLACED... 04/74    BINDER... 5.00 +                           +  5/77 O-A 17/25/32    5,385
FROM.. VICTORIA CO LINE                 + PRI AGG.. TYPE C      SILICEOUS  +                           +  5/76 W-A 15/24/30    3,547
TO.... 8.1 MI SO.                       + 2ND AGG.. SILICEOUS              +                           +  5/76 O-A 17/21/29    3,547
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +  6/75 W-A 33/38/45    2,079
COMMENT1 MAYS-AVG-3.7 HI4.1 LO-2.5      + P-   34-FORDYCE S&G-SAXET PIT    +                           +  6/75 O-A 26/34/45    2,079
COMMENT2 PVT69 SH59 RS65 DRAIN80 TS62   + S-   59-HELDENFELS BROS-VICTORIA +                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     19  HWY...US  77  LENGTH...  1.410 + PAVEMENT. HMAC                   + 19   371-0  21.230 22.640 +  6/75 W-B 23/27/31    4,492
-------  ADT...10,700  TRF...13,305,000 + PLACED... 04/74    BINDER... 5.00 +                           +  6/75 O-B 20/24/30    4,492
FROM.. NO END US-77 AND US-183 INTRS    + PRI AGG.. TYPE C      SILICEOUS  +                           +  6/75 W-A 23/29/34    4,492
TO.... NO END MISSION RIVER BRIDGE      + 2ND AGG.. SILICEOUS              +                           +  6/75 O-A 22/27/33    4,492
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +
COMMENT1 MAYS-AVG-3.1 HI-3.3 LO-2.5     + P-   34-FORDYCE S&G-SAXET PIT    +                           +
COMMENT2 PVT51 SH66 RS70 DRAIN77 TS66   + S-   59-HELDENFELS BROS-VICTORIA +                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     20  HWY...US  77  LENGTH...  9.481 + PAVEMENT. HMAC                   + 19   371-0  27.860 37.341 +  5/77 W-A 51/53/55    4,181
-------  ADT....5,300  TRF....4,964,500 + PLACED... 12/74    BINDER... 6.00 +                           +  5/77 O-A 51/54/56    4,181
FROM.. DIVIDED SECTION IN WOODSBORO     + PRI AGG.. TYPE C      SANDSTONE  +                           +  5/76 W-A 48/54/55    2,351
TO.... NO END OF ARANSAS RIVER BRIDGE   + 2ND AGG..                        +                           +  5/76 O-A 44/51/54    2,351
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +  6/75 W-A 54/58/60      927
COMMENT1 MAYS-AVG-3.8 HI-4.4 LO-3.1     + P-  196-HELDENFELS BR. MCMULLEN C+                           +  6/75 O-A 53/58/61      927
COMMENT2 PVT91 SH73 RS57 DRAIN80 TS66   + S-                               +                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
     21  HWY...US 181  LENGTH...  1.140 + PAVEMENT. HMAC                   + 20   101-0   8.430  9.570 +
-------  ADT...10,300  TRF...12,773,000 + PLACED... 04/74    BINDER... 5.00 +                           +
FROM.. INTRS US-77 AND FM-881           + PRI AGG.. TYPE C      SILICEOUS  +                           +
TO.... CROCKETT AVE                     + 2ND AGG.. SILICEOUS              +                           +
CODE COL-....5...10...15...20...25...30-+- SOURCE NUMBERS & NAMES FOLLOW --+                           +
COMMENT1 CITY SECTION                   + P-   34-FORDYCE S&G-SAXET PIT    +                           +
COMMENT2                                + S-   59-HELDENFELS BROS-VICTORIA +                           +
----------------------------------------+----------------------------------+---------------------------+----------------------------
```

FIGURE 2—SKIDR REPORT NO. 4

selected for closer study. These twenty sources contained a range of aggregate types and polish values. It was beleived that if a correlation between field and labortory polish rates could be found using these twenty sources, other sources, even those unknown at present, could be included in the same relationship. A list of the sources selected is shown in Table I.

Plots of SN_{40} compared to cumulative traffic and SN_{40} compared to Log_{10} cumulative traffic were prepared and studied. An example of the plots are shown in Figure 3. The lines or connection of points indicate periodic tests on the same construction job. Where singular plot points are shown, only one test was performed on the surface of a construction job, and the plot point represents the SN_{40} and traffic on the construction job at the time of test. Note that the data scatter and connection of points indicate that a given material can polish at different rates when used on different construction jobs or when placed by different contractors or State personnel. As will be shown later, a trend curve can be fit through the data points. A comparison of the trend curves for the aggregates selected does indicate differences in materials. Because of the data scatter, it is possible to find certain construction jobs in which the SN_{40} value of a non-skid resistant aggregate (low polish value) is very high. Also low skid numbers may be found for aggregates with a high polish values. However, in the majority of the construction jobs, aggregates with low polish values will have low skid numbers and aggregates with high polish values will have high skid numbers.

There is a reason why plot points scatter, or are at variance to a trend curve. Generally, the variance found is due to the influence of one or more variables previously mentioned. For this reason, plots which stratified the data by ADT, and a regression program which considers multiple variables were used in a statistical analysis of the data.

SN_{40} Versus Log_{10} Cumulative Traffic and ADT

Plots were developed in which SN_{40} and Log_{10} of the cumulative traffic were considered where each plot represented a specific ADT range or grouping. Four ADT groupings were used as follows:

0 to 749
750 to 1999
2000 to 4999
$\geq$ 5000

In effect, stratification of ADT by grouping includes the ADT as a variable (that is, both Log_{10} Cumulative Traffic and ADT are considered). It was believed the ADT might be used as an indicator of the climatic or weathering effects reflected on a pavement surface. Heavier traffic on a surface could cause continual "seating", embedment, or densification whereas lighter traffic would allow weathering by sun, wind or water with sufficient traffic to dislodge small particles, thus renewing the texture.

TABLE I
Aggregate Sources Selected for Study

A - Sandstone
C - Silicious Gravel
D - Silicious Gravel
E - Crushed Limestone
F - Crushed Limestone
G - Crushed Limestone
I - Cherty Dolomitic Limestone
J - Limestone Rock Asphalt
K - Limestone Rock Asphalt
L - Crushed Limestone
M - Silicious Gravel
N - Lightweight Synthetic
O - Lightweight Synthetic
P - Crushed Limestone
Q - Lightweight Synthetic
R - Iron Slag
S - Silicious Gravel
T - Silicious Gravel
U - Crushed Limestone
V - Lightweight Synthetic
W - Crushed Limestone

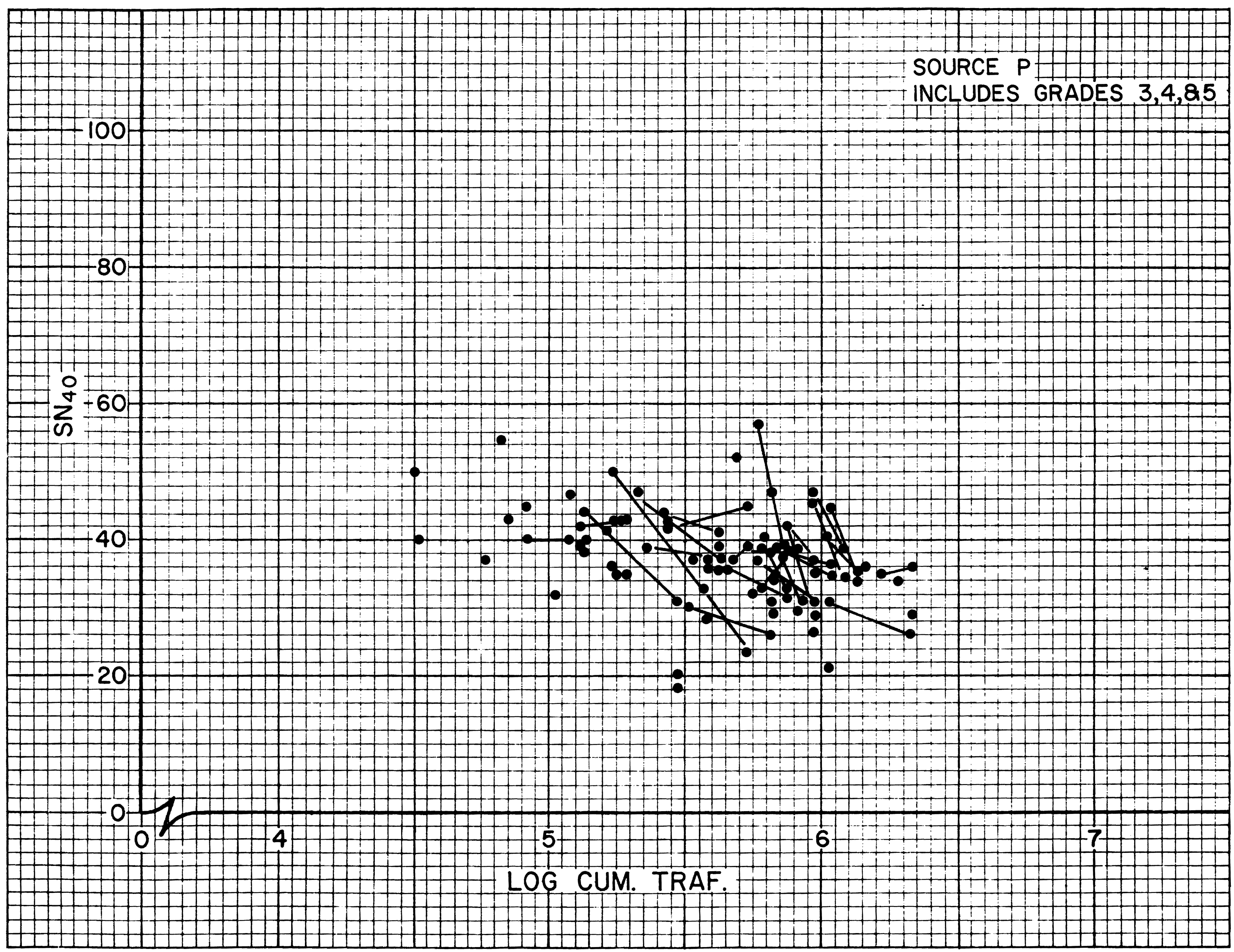

FIGURE-3 EXAMPLE PLOT COMPARING SN_{40} AND LOG_{10} CUMULATIVE TRAFFIC

A regression line or curve was fitted to each plot using the BMO2R Stepwise Regression Program. The results are shown in Table II. The "Intercept" columns shown on the table are indicative of the SN_{40} values soon after construction (note some values are very high and therefore unreal). The "Slope "columns would be an indication of the rate of polish" of a material. It should be noted that both the Intercept and Slope values are erratic with some slopes showing a plus or increase in SN_{40} as traffic cumulations increase. Generally small slopes are associated with large intercepts, and conversely, large slopes reflect small intercepts. The more erratic slopes (that is either very small or very large) occur when a small amount of data was available in the plot. The amount of data available is shown in the columns labeled "Number of Points." The erratic results found in the data is therefore probably due to the lack of sufficient data and more confidence should be associated with the regressions containing large amounts of data. The columns labeled S.E. show a result termed Standard Error which is a measure of the scatter about the regression line or curve (see example plot in Figure 3). The S.E. is in terms of SN_{40} values and a plus or minus two Standard Errors in the data shown would probably include about 95 percent of the data points. The columns labeled R show the regression coefficient, which is a measure of how well the regression curve fits the data points. Larger R values indicate a better fit. In the data shown, the S.E. and R values are very poor, indicating that variables other than Log_{10} Cumulative Traffic are needed in the analysis.

Multiple Regression

The BMO2R Stepwise Regression Program was also used in a study which used multiple variables. The multiple variables selected were:

ADT
Percent Binder (Asphalt Application Rate)
Log_{10} Cumulative Traffic
Grade (Relative Aggregate Size)

The SN_{40} value was used as the dependant variable. The BMO2R program selects variables by order of importance as to their effect on the dependant variable. Table III gives the results of the regression analysis. The results are in the form of regression equations. The equations contain the variables ranked from left to right by order of importance as selected by the BMO2R program. The results of the multiple regression analysis tend to be erratic with the slopes changing from positive to negative in sign and the variables interchanging in significance. In some sources the correlation coefficient (R) is around 0.700 to 0.800 range which is probably adequate; however, in the majority of the sources studied, the R value was low. The S.E. values are large, showing much unexplained data scatter.

Periodic Skid Resistance Tests

One final method of analysis was studied. This analysis used periodic skid test data obtained on various construction sections. By way of explanation, it was believed that periodic skid tests performed at selected sites would be more indicative of polish rate or skid resistance performance than random tests obtained on various construction sections. Considerable

TABLE II
REGRESSION RESULTS
OF
SN_{40} AND TRAFFIC

Source	ADT Grouping	Number of Pounds	Intercept	Slope	S.E.	R
A	All ADT's	46	84.7	- 5.4	11.4	0.209
Sandstone	0-749	22	-	-	-	-
	750-1999	13	22.5	+ 5.3	10.4	0.194
	2000-4999	8	340.6	-45.4	13.5	0.493
	≥ 5000	-	-	-	-	-
C	All ADT's	368	62.9	- 5.9	6.8	0.447
Silicious Gravel	0-749	224	74.2	- 8.1	6.3	0.515
	750-1999	104	68.9	- 6.6	7.0	0.446
	2000-4999	31	49.2	- 3.7	7.0	0.182
	≥ 5000	9	159.7	-20.8	7.4	0.732
D	All ADT's	48	48.2	- 3.1	10.2	0.126
Silicious Gravel	0-749	37	12.5	+ 3.2	10.2	0.404
	750-1999	8	2.0	+ 3.8	9.5	0.173
	2000-4999	3	-50.7	+10.3	4.0	0.380
	≥ 5000	-	-	-	-	-
E	All ADT's	71	86.0	- 7.3	11.2	0.346
Crushed Limestone	0-749	6	104.5	-10.9	1.8	0.919
	750-1999	15	63.2	- 4.5	6.0	0.416
	2000-4999	46	128.2	-13.5	11.5	0.467
	≥ 5000	-	-	-	-	-
F	All ADT's	266	79.3	- 8.1	8.1	0.477
Crushed Limestone	0-749	63	52.9	- 3.2	6.3	0.234
	750-1999	90	73.3	- 7.1	7.0	0.415
	2000-4999	51	83.3	- 8.5	9.2	0.453
	≥ 5000	62	90.1	-10.2	9.3	0.324
G	All ADT's	230	75.6	- 6.8	6.7	0.441
Crushed Limestone	0-749	96	85.8	- 8.6	6.7	0.470
	750-1999	64	29.5	+ 0.3	6.4	0.014
	2000-4999	14	57.9	- 4.5	4.7	0.248
	≥ 5000	54	103.0	-10.6	6.2	0.516
I	All ADT's	36	105.6	-11.0	8.0	0.538
Cherty Dolomatic Limes	0-749	17	80.9	- 6.5	6.1	0.400
	750-1999	14	-120.1	+21.8	4.0	0.793
	2000-4999	5	-427.0	+64.6	8.4	0.521
	≥ 5000	-	-	-	-	-

TABLE II CONTINUED

Source	ADT Grouping	Number of Points	Intercept	Slope	S.E.	R
J	All ADT's	34	125.8	-14.5	9.4	0.639
Limestone Rock Asphalt	0-749	19	156.3	-20.2	9.6	0.709
	750-1999	10	128.1	-14.4	8.9	0.507
	2000-4999	5	- 79.9	+16.4	5.7	0.613
	≥ 5000	-	-	-	-	-
K	All ADT's	462	86.4	- 7.4	12.4	0.307
Limestone Rock Asphalt	0-749	88	104.7	-10.6	9.6	0.459
	750-1999	152	70.2	- 4.8	12.7	0.161
	2000-4999	166	90.6	- 8.5	12.6	0.247
	≥ 5000	56	170.1	-18.8	12.1	0.499
L	All ADT's	172	85.2	- 8.4	11.6	0.481
Crushed Limestone	0-749	40	70.3	- 6.3	10.5	0.283
	750-1999	56	97.9	-10.6	8.4	0.677
	2000-4999	46	61.2	- 3.6	14.3	0.156
	≥ 5000	28	148.3	-18.2	11.6	0.661
M	All ADT's	39	33.5	- 0.8	8.8	0.035
Silicious Gravel	0-749	17	29.9	- 1.1	2.4	0.182
	750-1999	22	83.5	- 8.7	9.4	0.335
	2000-4999	-	-	-	-	-
	≥ 5000	-	-	-	-	-
N	All ADT's	417	64.1	- 2.4	11.0	0.124
Synthetic Lightweight	0-749	76	80.7	- 5.8	8.8	0.296
	750-1999	109	118.0	-11.8	9.8	0.440
	2000-4999	80	68.6	- 3.6	11.8	0.166
	≥ 5000	150	102.6	- 7.6	10.4	0.295
O	All ADT's	30	91.1	- 6.7	5.2	0.507
Synthetic Lightweight	0-749	19	74.6	- 3.9	5.2	0.275
	750-1999	5	2.5	+ 7.0	2.5	0.350
	2000-4999	6	177.6	-19.9	5.9	0.792
	≥ 5000	-	-	-	-	-
P	All ADI's	209	84.0	- 8.3	6.8	0.533
Crushed Limestone	0-749	94	73.9	- 6.6	6.6	0.381
	750-1999	67	119.2	-14.0	7.4	0.585
	2000-4999	34	120.0	-14.3	6.3	0.526
	≥ 5000	14	81.5	- 7.6	4.5	0.735

TABLE II CONTINUED

Source	ADT Grouping	Number of Points	Intercept	Slope	S.E.	R
Q Synthetic Lightweight	All ADT's	152	74.6	- 5.1	11.1	0.286
	0-749	49	76.3	- 5.3	10.6	0.362
	750-1999	22	91.1	- 7.1	11.9	0.305
	2000-4999	22	109.1	-11.5	11.9	0.280
	≥ 5000	59	66.9	- 3.9	11.0	0.207
R Iron Slag	All ADT's	546	96.4	- 8.3	8.4	0.507
	0-749	269	103.0	- 9.5	7.8	0.499
	750-1999	128	99.0	- 8.9	8.9	0.348
	2000-4999	97	139.5	-15.0	7.3	0.662
	≥ 5000	52	49.3	- 1.4	9.2	0.117
S Silicious Gravel	All ADT's	31	32.1	- 0.8	5.9	0.072
	0-749	23	38.5	- 2.0	6.0	0.157
	750-1999	6	87.9	- 9.1	2.6	0.562
	2000-4999	-	-	-	-	-
	≥ 5000	-	-	-	-	-
T Silicious Gravel	All ADT's	68	30.9	+ 0.8	7.1	0.069
	0-749	9	45.0	- 2.6	2.6	0.356
	750-1999	-	-	-	-	-
	2000-4999	-	-	-	-	-
	≥ 5000	59	95.4	- 8.3	6.8	0.369
U Crushed Limestone	All ADT's	72	48.0	- 3.2	6.8	0.127
	0-749	68	73.9	- 7.4	6.3	0.269
	750-1999	4	-324.8	+53.7	11.0	0.596
	2000-4999	-	-	-	-	-
	≥ 5000	-	-	-	-	-
V Synthetic Lightweight	All ADT's	120	55.7	+ 0.7	7.0	0.073
	0-749	39	65.3	- 1.5	6.3	0.117
	750-1999	18	25.2	+ 5.9	6.1	0.405
	2000-4999	40	110.0	- 7.9	6.2	0.481
	≥ 5000	23	25.1	+ 5.3	7.8	0.184
W Crushed Limestone	All ADT's	84	108.4	-11.4	8.2	0.643
	0-749	32	79.9	- 6.5	8.9	0.333
	750-1999	32	129.2	-14.7	7.1	0.776
	2000-4999	20	111.4	-12.4	7.7	0.780
	≥ 5000	-	-	-	-	-

TABLE III
SUMMARY OF MULTIPLE REGRESSION RESULTS

Source	Equations
A	SN_{40} = -31.9-0.014(ADT)-1.357(Binder)+11.975(Log Traf.)+15.039(Gr.) 43 Points, SE = 11.4, R = 0.336
C	SN_{40} = 70.600-6.292(Log Traf.)+0.0003(ADT)-0.177(Binder)-0.179(Gr.) 340 Points, SE = 6.7, R = 0.464
D	SN_{40} = -25.825-0.007(ADT)+5.816(Log Traf.)+0.548(Binder)+2.312(Gr.) 33 Points, SE = 10.3, R = 0.399
F	SN_{40} = 75.147-6.032(Log Traf.)-0.313(Binder)-0.001(ADT)+0.699(Gr.) 94 Points, SE = 6.7, R = 0.549
G	SN_{40} = 85.979-8.954(Log Traf.)+0.001(ADT)+0.030(Binder)+0.280(Gr.) 139 Points, SE = 5.9, R = 0.565
I	SN_{40} = 96.952-0.006(ADT)-0.734(Binder)-5.060(Log Traf.) 36 Points, SE = 7.2, R = 0,680
J	SN_{40} = 79.546-11.667(Log Traf.)+7.783(Gr.)-0.002(ADT)+0.099(Binder) 22 Points, SE = 9.7, R = 0.660
K	SN_{40} = 126.143-9.622(Log Traf.)-5.973(Gr.)+0.0004(ADT)-0.186(Binder) 363 Points, SE = 12.3, R = 0.367
L	SN_{40} = 87.705-1.168(Binder)+0.001(ADT)-0.991(Log Traf.) 28 Points, SE = 8.9, R = 0.310
M	SN_{40} = 33.026+0.031(ADT)-5.176(Log Traf.)+0.133(Binder) 13 Points, SE = 5.8, R = 0.869
N	SN_{40} = 13.964+9.825(Gr.)+0.373(Binder)-2.592(Log Traf.)+0.0001(ADT) 196 Points, SE = 8.9, R = 0.398
O	SN_{40} = 145.129-8.273(Log Traf.)-1.833(Gr.)-1.263(Binder)-0.0004(ADT) 28 Points, SE = 4.6, R = 0.694
P	SN_{40} = 87.206-8.362(Log Traf.)-0.159(Binder)+0.0001(ADT)+0.481(Gr.) 193 Points, SE = 7.0, R = 0.531
Q	SN_{40} = 72.253-6.894(Log Traf.)-3.383(Gr.)+1.137(Binder)-0.0002(ADT) 71 Points, SE = 10.0, R = 0.481
R	SN_{40} = 112.051-12.297(Log Traf.)-0.005(ADT)+3.443(Gr.)+0.074(Binder) 46 Points, SE = 6.2, R = 0.746
S	SN_{40} = 52.426-8.509(Log Traf.)+0.477(Binder)+0.003(ADT) 20 Points, SE = 6.3, R = 0.594
T	SN_{40} = 39.225-0.002(ADT)+13.310(Log Traf.) 68 Points, SE = 5.8, R = 0.580
U	SN_{40} = 90.774+0.764(Binder)+2.620(Gr.)-15.819(Log Traf.)+0.012(ADT) 72 Points, SE = 6.3, R = 0.434
V	SN_{40} = 61.796+0.0002(ADT)-0.510(Log Traf.) 120 Points, SE = 6.8, R = 0.212
W	SN_{40} = 114.849-12.615(Log Traf.)-0.009(Binder)+0.001(ADT)+0.237(Gr.) 57 Points, SE = 8.8, R = 0.646

Note: Variables which are not included indicate that the program discarded the variable as being too insignificant to include in the equation.

time is needed to collect a history of periodic testing; however, such testing had been accomplished in the past on several sites. This information was used for the study.

Periodic skid test information was available for seven sources. Again, plots were made where SN_{40} was related to Log_{10} cumulative traffic. An example plot is shown in Figure 4. Table IV shows the results of a regression analysis performed on the information from the periodic tests of several sites and sources. Note the large slope values (polish rates) indicated on construction jobs 634 and 633 where a synthetic lightweight aggregate was used in a chip seal. Lightweight aggregate generally shows exceptionally high SN values. As may be obvious, the 634 and 633 sites became flushed soon after construction (generally the aggregate has been stripped leaving excessive asphalt on the surface). It is believed that the large slope values shown are due to flushing rather than the polishing action of traffic. Because of this, it is not possible to differentiate, from the skid resistance information, those sites which are partially flushed from those sites where the aggregate was polished. It is possible that texture values would indicate flushed sections, since flushed areas tend to have low texture. However, texture values were not available.

Results

The objective of this study was to attempt to determine a relationship between the field polish rate as obtained with periodic skid test measurements with a skid test unit and the laboratory polish rate as obtained with the British Wheel. The data does not indicate a significant relationship. Even after conducting this study, the researchers still believe in the possibility that such a relationship does exist and the correlation could not be found because of the method of obtaining the data used in the study. However, it must be stated that this belief is at best an intuitive feeling on the part of the researchers and no usable results are available from this study.

Conclusions and Recommendations

Even though the relationship between field and laboratory polish rates is inconclusive, a relationship between ultimate polish levels does exist. This ultimate polish level relationship is shown in Table V and Figure 5. The figure is a plot of the information shown in the table. The predicted field SN_{40} at 1×10^6 traffic applications was obtained from Table II and using the equation shown for the ADT grouping labeled "ALL ADT's". This relationship indicates the laboratory "Polish Value" can predict the ultimate field polish level for an aggregate source where the field polish level would represent the average condition found on a roadway in the state which uses the aggregate for a seal coat or surface treatment.

Presently, the specifications used in Texas are based on a "Polish Value" which changes with ADT groupings (See Appendix A). These specifications were based on judgement with the possibility that the values or method could be modified after a study such as the one described herein.

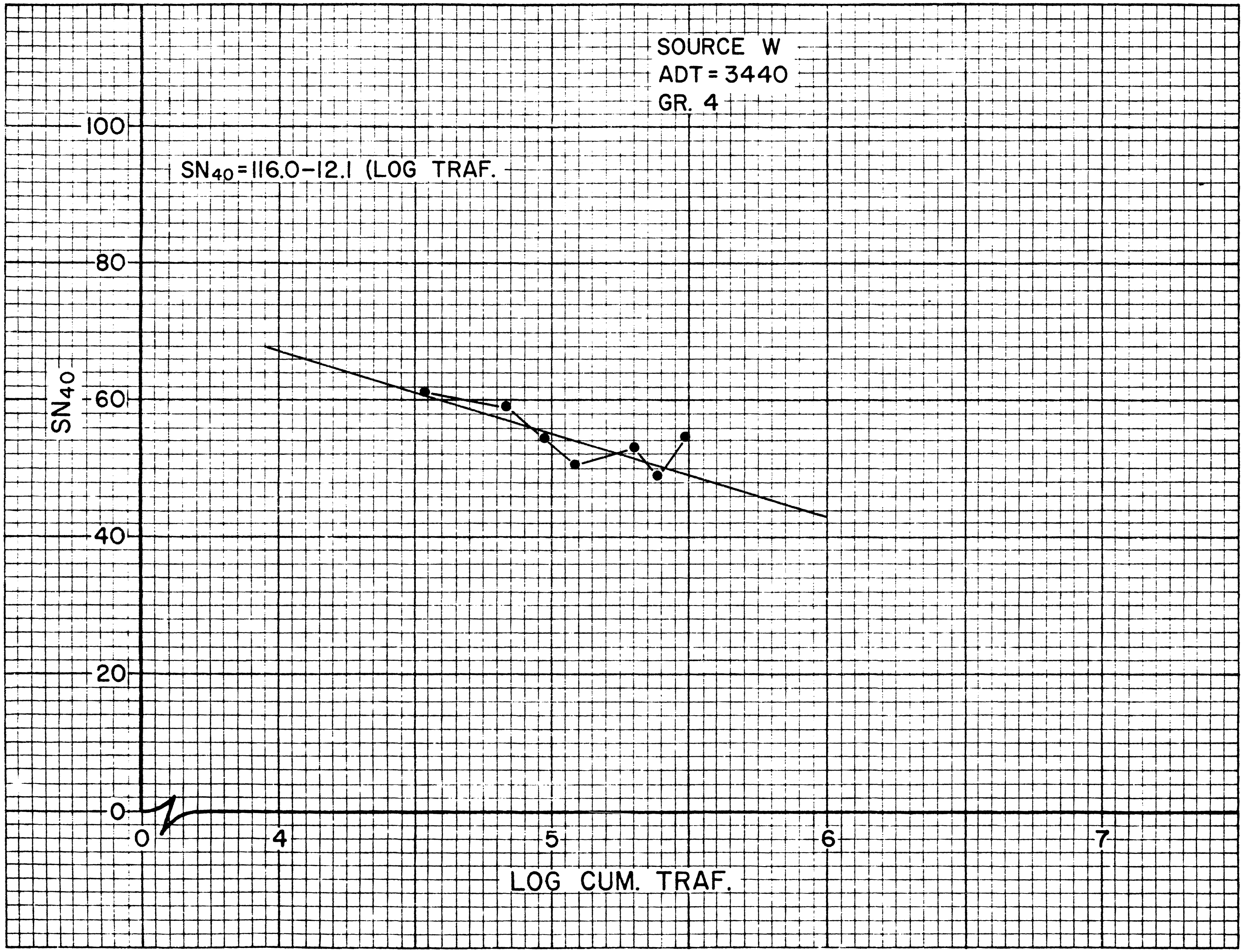

FIGURE-4 EXAMPLE PLOT OF SN_{40} AND TRAFFIC FOR PERIODIC TESTS

TABLE IV

SUMMARY OF REGRESSION RESULTS FOR PERIODIC TEST SITES

EQUATION FORM- SN_{40} = INTER + SLOPE (Log Traf.)

Sources	No. Points	Inter	Slope	S.E.	R
F	4	110.81	-12.656	3.14	0.885
	5	119.87	-14.313	1.98	0.796
	4	102.18	-11.678	0.94	0.990
	5	142.97	-18.179	0.61	0.985
	5	129.04	-15.810	3.02	0.921
G	12	108.20	-11.51	3.28	0.608
	12	?	?	?	?
	12	64.05	- 5.41	2.79	0.390
	12	32.66	+ 1.38	3.61	0.083
N	12	10.68	+ 8.77	3.65	0.464
	12	137.36	-13.29	4.76	0.520
	12	78.72	- 1.84	3.34	0.119
	12	78.41	- 2.16	3.56	0.132
	5	54.62	+ 0.44	3.87	0.059
	5	?	?	?	?
	5	93.39	- 6.05	5.37	0.492
	5	?	?	?	?
634	4	311.03	-40.63	3.61	0.950
633	4	333.49	-44.04	3.61	0.960
M	6	30.92	- 1.63	1.33	0.505
	5	158.52	-21.10	1.06	0.992
	6	-21.33	+ 7.74	1.87	0.744
R	4	551.86	-75.38	10.25	0.802
	4	76.86	- 4.23	5.08	0.206
	4	98.10	- 7.94	7.98	0.571
	4	415.93	-57.48	0.89	0.999
	4	258.38	-31.55	3.99	0.884
	4	258.71	-32.35	4.66	0.941
	4	170.72	-20.76	5.84	0.667
	4	213.32	-29.23	1.84	0.954
	4	100.43	- 8.82	6.10	0.368
	4	-20.01	+11.54	3.30	0.429
	4	103.86	- 9.26	4.51	0.405
	4	291.39	-42.64	6.21	0.777
	4	311.82	-42.47	6.29	0.778
W	4	346.81	-54.31	8.76	0.837
	4	313.34	-44.19	7.72	0.896
	4	328.32	-48.05	8.38	0.889
	4	124.57	-12.41	6.98	0.416
	4	343.91	-49.18	1.94	0.971
	4	257.02	-38.10	8.40	0.854
	4	194.90	-25.31	2.71	0.971
	4	220.45	-29.67	5.46	0.936
	4	156.65	-19.30	2.10	0.985
	7	236.56	-38.63	2.75	0.981
	7	116.00	-12.14	2.93	0.829
S	5	124.7	-15.5	2.6	0.711

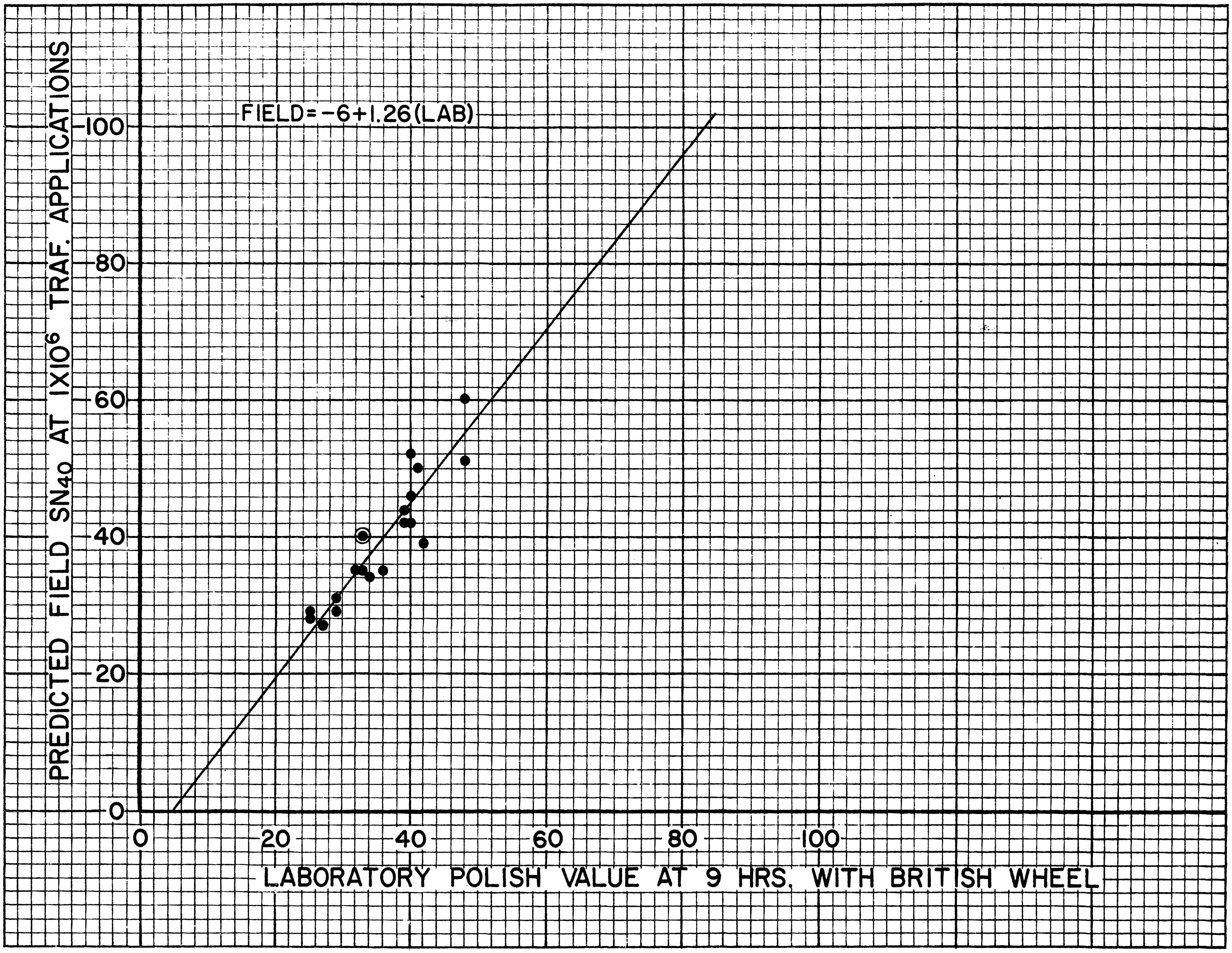

FIGURE-5 STUDY OF ULTIMATE POLISH IN LAB AND FIELD

TABLE V
Study of Ultimate Polish in Laboratory and Field

Source	Predicted Field SN_{40} at 1 X 10^6 Traffic Applications	Laboratory Polish Value at 9 Hrs. with British Wheel
A	52	40
C	27	27
E	42	40
F	31	29
G	35	32
I	40	33
J	39	42
K	42	39
L	35	36
M	29	25
N	50	41
O	51	48
P	34	34
Q	44	39
R	46	40
S	28	25
T	35	33
U	29	29
V	60	48
W	40	33

It is believed sufficient experience has been gained in the use of the present specifications so that their use should be continued. The continued use of the present specifications found in the Appendix 8 is recommended.

The present procedure also allows the use of a skid resistance history obtained with a skid test unit. This procedure is very similar to the development of the field polish rate described in this report. Therefore, when using this method, care should be used in obtaining a sufficiently large number of plot points to show a complete history of the source as it is used in a District or Resident Engineer area. This procedure is found in Appendix C.

APPENDIX A

Test Method Tex-438-A

"Accelerated Polish Test for
Coarse Aggregate"

Texas Highway Department

Materials and Tests Division

ACCELERATED POLISH TEST FOR COARSE AGGREGATE

Scope

This test method describes a procedure for determining a relative measure of the extent to which aggregate in the wearing surface of the roadway will polish under traffic.

The aggregate samples under test are mounted on a specimen wheel to form a test strip 16 inches in diameter and subjected to the rolling action of a rubber tire. Size 150 silicon carbide grit and water are used to speed up the rate of wear.

The Polish Value is determined using a modified form of ASTM Designation: E 303.

Definitions

Friction Value: The average of a set of initial readings on the test specimen before being polished in the accelerated polish machine.

Polish Value: The average of a set of readings on the test specimens after nine hours of polishing in the accelerated polishing machine.

Sampling

A 30 pound sample representing production designated for highway use shall be submitted by a representative of the Texas Highway Department. The sample shall be properly identified on Form 202 and the name of the pit or quarry and its exact location shall be explicit.

Apparatus

1. A Wessex Accelerated Polishing Machine based on a design of the Research Laboratory of Great Britain.

2. Metal Molds to form a test specimen 3.50 inches long by 1.75 inches wide by 0.63 inches deep.

3. A British Portable Tester to measure the Friction Value and the Polish Value of the test specimens in accordance with ASTM Designation: E 303 modified as follows:

A. The slider contact path shall be 3 ± 1/16 inches.

B. The slider width shall be 1-1/4 ± 1/16 inches.

C. The rubber which is bonded to the slider shall conform to a 1 x 1-1/4 x 1/4 inch dimension (± 1/16 inch tolerance).

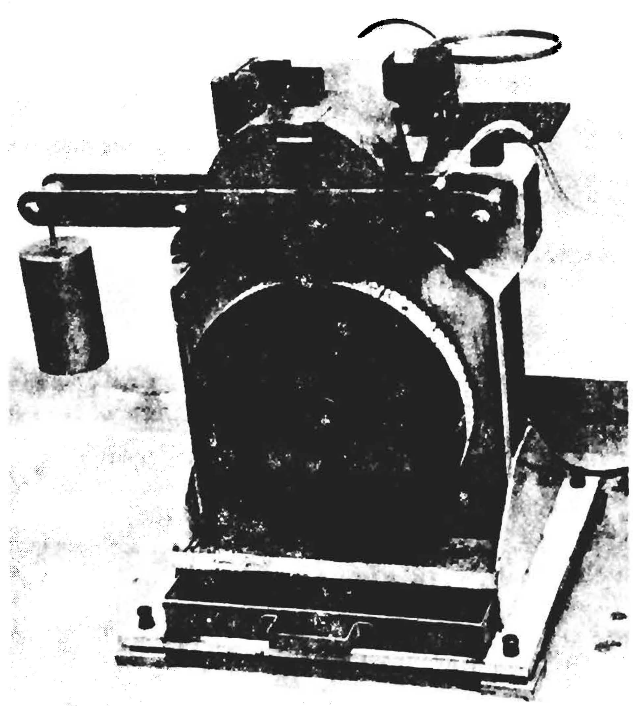

Figure 1

Wessex Accelerated Polishing Machine Showing Test Specimens Mounted on Specimen Wheel

Materials

1. Tap water.

2. Ottawa sand, Grade 20-30 meeting ASTM Designation: C 190.

3. Polyester Resin and catalyst for bonding agent with a pot life of about 20-30 minutes and a curing time of 3-6 hours.

4. Mold Release Agent for use with polyester bonding agent.

5. Silicon Carbide Grit (150 size).

6. A supply of disposable cups and stirring rods for use in mixing the bonding agent.

Preparation of Test Specimens

At least seven specimens are required for each material and are to be prepared as follows:

1. The aggregate to be tested shall pass the 1/2 inch sieve and be retained on the #4 sieve.

2. The screened aggregate shall be thoroughly washed clean and dried.

3. The molds shall be coated with the mold release agent.

4. The aggregate particles shall be placed in a single layer as closely as possible in the bottom of the molds. Aggregate particle orientation should allow adequate surface area for polishing as well as bonding.

Note: Flat, elongated, or unusually shaped particles may cause some difficulty in placement. If used, these should be placed to ensure adequate bonding, but misleading Polish Values may result from inadequate surface area for polishing.

5. The interstices between the aggregate particles shall be filled with the Ottawa sand to a depth between 1/4 to 1/2 the particle height.

6. Prepare the polyester resin and catalyst for bonding agent according to manufacturer's instructions. The consistency of the polyester shall be such as to allow it to flow freely between the particles, but not so thin as to flow into the Ottawa sand.

7. Fill prepared mold to capacity with the polyester bonding agent.

8. When the bonding agent has stiffened sufficiently, strike off the bonding agent level with the curved sides of the mold.

9. Leave specimen in the mold for a sufficient length of time (3-6 hours) to allow the bonding agent to cure properly.

10. Remove specimen from the mold and brush any excess sand from the specimen face.

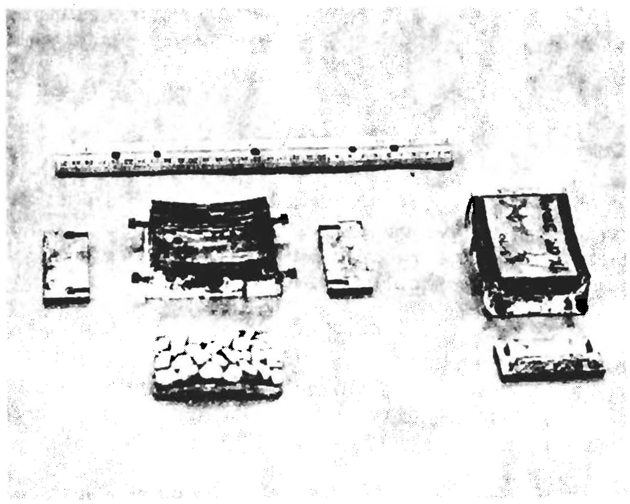

Figure 2

Metal Molds With Test Specimens

Procedure

1. Calibrate the British Portable Tester in accordance with ASTM Designation: E 303 as modified in "Apparatus", part 3.

2. Determine the Friction Value of the prepared test specimens in accordance with ASTM Designation: E 303, as modified in "Apparatus", part 3. The Friction Value is used for reference purposes.

3. A total of fourteen specimens shall be clamped around the periphery of the specimen wheel of the Wessex Accelerated Polishing machine. A rubber O-ring is placed on both edges of the test specimens to hold them against the specimen wheel. The wheel flanges are then bolted into place pressing down upon the O-rings and edges of the specimen firmly holding them in place.

A minimum of at least seven specimens of each material shall be tested to allow statistical accuracy. Dummy specimens may be used to completely fill the wheel if only one material is to be tested. The outer surface of the specimens shall then form a continuous strip of particles upon which the rubber tire shall ride freely without bumping or slipping.

4. The specimen wheel shall be brought to a speed of 320 $\pm$ 5 rpm. The rubber tire wearing wheel, inflated to 45 $\pm$ 2 psi, shall be brought to bear against the specimen wheel and loaded to 88 $\pm$ 1 pounds.

5. Silicon carbide grit (size 150) shall be continuously fed to the specimen wheel near the tire contact point at a constant rate of approximately 12 grams per minute along with water fed at the rate of about 50 to 75 milliliters per minute.

6. The polishing action shall be continued for a total period of nine hours.

7. The samples shall be removed from the specimen wheel and washed thoroughly to remove grit.

8. After cleaning, the samples shall be tested for Polish Value with the British Portable Tester as specified in ASTM Designation: E 303 and modified above.

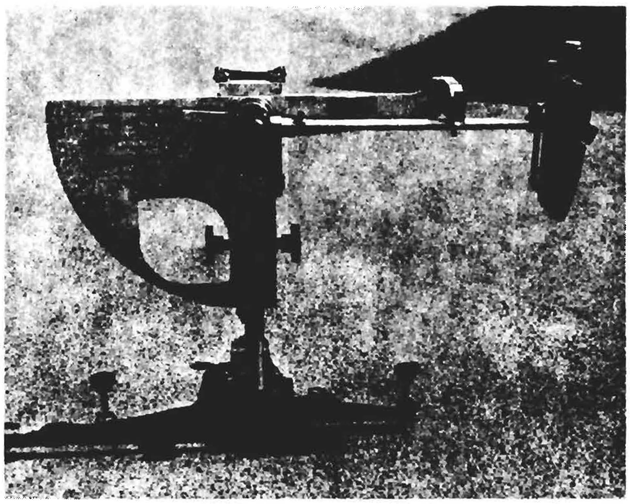

Figure 3

British Portable Tester

Report

The final report shall include the following information:

1. Information from Form 202.

2. Initial Friction Values and their average for each specimen tested.

3. Final Polish Values and their averages for each specimen tested.

APPENDIX B

Present Polish Value Specifications

Administrative Circular No. 22-74

ADMINISTRATIVE CIRCULAR NO. 22-74

To:	ALL DISTRICT ENGINEERS, ENGINEER-MANAGER AND DIVISION HEADS	Date:	March 18, 1974
Subject:	SKID ACCIDENT REDUCTION PROGRAM	Expires:	
Reference:		File:	D-8

Gentlemen:

Transmitted herewith for your information is a copy of FHWA Instructional Memorandum 21-2-73 dated July 19, 1973, and a letter dated February 11, 1974, pertaining to the above subject. The FHWA is requiring assurance in the P.S. and E. that the surface course will provide desirable skid resistance performance.

A meeting was held with representatives of the FHWA to determine their interpretation of a workable means of insuring a desirable skid resistance performance. One and perhaps the most practical method at this time appears to be by specifying a minimum polish value for the coarse aggregate. The following tentative guidelines were agreed upon as a means of satisfying these requirements.

Present ADT or Type of Highway	Minimum Required Polish Value of Coarse Aggregate for Flexible Pavements
Below 750	No Requirements
750 - 2000	30
2000 - 5000	33
5000 - and above	35
Interstate	35 or Specify Aggregate Type
Special and High Volume Highways	Specify Aggregate Type

In cases where the District elects to deviate from the above requirements, special justification based on performance history of similar mix designs should be furnished for approval in advance of P.S. and E. submission.

Where a polish value is specified for asphaltic-concrete pavement, it may be advantageous to the State to specify a volumetric design method. A copy of a special provision which has been used for this purpose is also attached for your information and consideration.

Another method of successfully providing free draining and skid resistant surfaces has been the use of open graded mix designs. Although experience with this type of design has not been extensive, it is also recommended that a minimum polish value be specified for the coarse aggregate.

The recommendations above are based on present research and limited experience. Revisions as necessary will be made as additional research findings and experience dictate. In the interest of uniformity these guidelines will be applied to all projects beginning with the May, 1974 lettting.

Your usual cooperation is requested.

Sincerely yours

B. L. DeBerry

B. L. DeBerry
State Highway Engineer

DISTRIBUTION:

District Engineers
Division Heads
Engineer-Manager
Resident Engineers

APPENDIX C

Specification Acceptance Using Skid Resistance History

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701

May 23, 1975

IN REPLY REFER TO

06-48.2S

Skid Accident Reduction Program -
IM 21-2-73

Mr. B. L. DeBerry
State Highway Engineer
Austin, Texas 78701

Attention: Mr. R. L. Lewis

Dear Sir:

Your letter of February 21, 1975 submitted for review a procedure for utilizing skid test data to predict the skid resistant life of pavements consistent with IM 21-2-73.

This procedure is approved for determining the acceptability of a surfacing material based on its historical skid performance under traffic.

In addition to the wear factor, speed gradient determination is suggested on a few projects representative of mix designs in use to identify coarse texture and to detect possible detrimental consolidation.

Sincerely yours,

John J. Conrado
Division Engineer

RECEIVED
MAY 27 1975
HIGHWAY DESIGN DIVISION

5-27-56

TEXAS HIGHWAY DEPARTMENT
11TH AND BRAZOS
AUSTIN, TEXAS 78701

June 2, 1975

IN REPLY REFER TO
FILE NO. D-8D
620.11

TO: ALL DISTRICT ENGINEERS AND ENGINEER-MANAGER

SUBJECT: SKID ACCIDENT REDUCTION PROGRAM IM 21-2-73

Gentlemen:

Transmitted herewith is an example problem utilizing skid test data to predict skid resistant life of pavements. This method can be used where local aggregates have historically performed satisfactorily, but may not meet the polish value requirements set out in Administrative Circular 22-74. This method has been approved by the FHWA as evidenced by copy of their letter dated May 23, 1975.

This material will be included in a future revision to the Highway Design Division Operations and Procedures Manual.

Sincerely yours

B. L. DeBerry
State Highway Engineer

By: R. L. Lewis

R. L. Lewis, Chief Engineer
of Highway Design

Attachments - 3

cc: D-9, D-10

ANALYSIS OF FIELD PERFORMANCE
FOR SKID RESISTANCE
(EXAMPLE PROBLEM)

District 30 Date 6/6/74 Surfacing to Occur on Highway No. IH-100

County ZEK Control 40 Sec. 38 Job. 37 Proj. No. F-40 (2)

A. Materials Source Being Analyzed:

Source Name: J AND Q MATERIALS

Location: LOB COUNTY - WEST OF US-999 AND 10 MILES SOUTH OF LOB, TEXAS

B. Skid Resistance Information: Obtain the skid number and "vehicle passes per lane" (VPPL) at the time past skid testing was performed on pavements of the same type and the same material source. Obtain the logarithmic values of SN_{40} and VPPL.

Location of Section Tested	Test Date	SN_{40}	Traffic Per Lane (VPPL)	Surface Type	Log SN_{40}	Log of Traffic Per Lane
US-14 FROM FM-12 TO KCRR	5/74	50	1500	HMAC	1.70	3.18
US-14 FROM FM-10 TO FM-12	5/74	39	2200	HMAC	1.59	3.34
FM-3 FROM US-2 TO US-5	5/74	37	16,000	HMAC	1.57	4.20
SH-8 FROM SH-19 TO JOE CR.	5/74	48	33,200	HMAC	1.69	4.52
SH-8 FROM JOE CR. TO KCRR	6/73	43	44,700	HMAC	1.63	4.65
FM-10 FROM SH-3 TO US-14	6/73	40	74,200	HMAC	1.60	4.87
IH-2 FROM JOE CR. TO FM-11	6/73	47	631,000	HMAC	1.67	5.80
IH-2 FROM FM-4 TO SH-2	6/73	29	2,630,000	HMAC	1.46	6.42

C. Plot "Skid Resistance Performance Curve" on arithmetic paper as typified by Figure 4-96. At least six tests must have been performed (minimum six plot points), and preferably thirty points if available. The total range of values for VPPL must be at least 250,000; one of the measurements must have been made after 750,000 VPPL. Fit a mean linear line through the plot points.

D. Calculate total vehicle passes per lane in the expected structural life of the highway to be resurfaced:

1. Estimated Years of Service (EYS) = 5
2. Present ADT (PADT) = 1300
3. Future ADT at the End of Structural Life (FADT) = 1700
4. Percent Distribution of Traffic for Most Heavily Traveled Lane (PDT) = 50%
5. TVPPL = EYS(365) $\left(\frac{PADT+FADT}{2}\right)$ (PDT) = 1,368,750
6. Log TVPPL = 6.136

E. Enter "Skid Resistance Performance Curve" (Figure 4-96 for example problem) and determine Log SN_{40} = 1.57

F. Antilog of SN_{40} at the Intersection Point (or SN_{40} at the End of Expected Structural Life) = 37

G. Compare predicted SN_{40} value at end of structural life with SN_{40} design guideline values tabulated below and determine acceptability of the proposed flexible pavement surface: 37 > 35 ∴ o.k. for 60 mph.

Mean Traffic Speed	SN_{40}	
	Surface Treatment	ACP
40 mph	33	33
50 mph	33	34
60 mph	33	35

EXAMPLE

SKID RESISTANCE PERFORMANCE CURVE

COARSE AGGREGATE MATERIALS SOURCE - J.&Q. MATERIALS - LOB COUNTY

PAVEMENT TYPE - TYPE D - HMAC