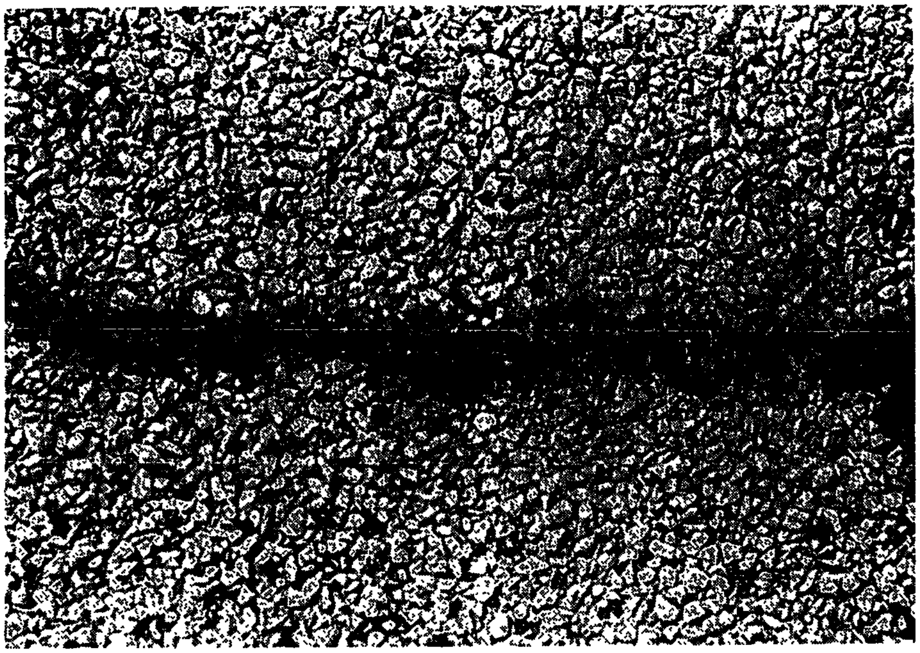
EVALUATION OF COVER AGGREGATE STRIPPING CHARACTERISTICS



FINAL REPORT
IOWA HIGHWAY RESEARCH BOARD
Project HR-182

DEPARTMENT OF TRANSPORTATION
IOWA

HIGHWAY DIVISION
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EVALUATION OF COVER AGGREGATE STRIPPING CHARACTERISTICS

HR-182

Final Report

by

Kenyon Isenberger

Conducted by:

Office of Materials
Highway Division
Iowa Department of Transportation
Ames, Iowa 50010

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EVALUATION OF COVER AGGREGATE
STRIPPING CHARACTERISTICS

PURPOSE AND SCOPE

The purpose of Research Project HR-182 was to identify those aggregate types which would perform satisfactorily as seal coat aggregates.

Aggregates were chosen from across the State to represent the various types normally encountered and were used with two different types of binder bitumens. A water spray treatment was also included to simulate the effects of rainfall. The evaluation was based upon aggregate retention.

CONCLUSIONS

Due to the influence of unexpected variables upon the field samples, the laboratory data are reliable for only the most general observations. Namely, that gravels as a group appear to be retained better than carbonates and rainfall shortly after seal coat placement can affect aggregate retention.

The subsequent field observations and analysis of skid resistance data permit the following conclusions:

1. Aggregate retention is influenced by lithologic type with the gravels, quartzite, haydite, dolomites, and medium grained limestones performing best.

2. Aggregate retention is not influenced by binder bitumen type.

3. Friction values of seal coats are influenced by aggregate retention and/or lithologic type.

RECOMMENDATIONS

The aggregate used for cover aggregate/seal coat projects should be Type 4 or better skid resistance as identified in Iowa DOT Materials Instructional Memorandum T-203. This will result in maximizing the possibility of good aggregate retention and skid resistance.

INTRODUCTION

The inflation of material and labor costs has forced State, County and Municipality road departments to re-evaluate their surface restoration procedures. The reduction in funds for highway programs has further prompted such re-evaluations. A trend developed through this second look process has been to substitute thin overlays and seal coats for the previously used thick overlays. However, when seal coat projects were used, a number of failures occurred--the most common being loss of aggregate due to stripping.

The current emphasis on safety has also resulted in an increased use of seal coats as a remedy where road sections have a low friction coefficient. If the aggregate is not going to be retained on the road surface, then the remedy may be worse than the problem sought to be cured.

PROCEDURE

The research project was incorporated into the 1975 Iowa DOT Maintenance Seal Coat Program as a part of project MP-1222--69-85, Story County. The project location was on Iowa 210 between I-35 and Maxwell, Iowa. The total project involved 9.25 miles of seal coating with the research project involving approximately 40% of this mileage. This highway was originally constructed as a 6" rolled stone base in 1955. In 1956, a 2" Type B surface was put on and a seal coat was applied in 1961.

Twenty-nine aggregates, listed and described in Table I, were chosen to represent a cross section of those normally used as cover aggregates in Iowa. The aggregates were randomly assigned to test sections 400 feet in length with each aggregate used twice for a total of 58 test sections. A schematic of the aggregate test sections is shown in Appendix A.

To investigate the possible effect of the type of binder bitumen, both a cutback asphalt, MC-3000, and a cationic emulsified asphalt, RS-2, were used with each aggregate. The eastbound lane was treated with the emulsion and the westbound lane received the cutback.

TABLE I

Aggregate Sources

Source No.	Producer	Name	County	
1	L.G. Everist	Hawarden	Sioux	Gravel
2	Estherville S&G	Estherville	Emmet	Gravel
3	Hallett Const.	Geneva	Franklin	Gravel
4	F & D Const.	Farm	Greene	Gravel
5	Hallett Const.	Ames	Story	Gravel
6	Schildberg Const.	Mt. Etna	Adams	Gravel
7	Northern Gravel	Northern Gravel	Muscatine	Gravel
8	Ideal Sand Co.	Farmington	Van Buren	Gravel
9	Concrete Materials	Quartzite	Minnehaha, S.D.	Quartzite
10	Martin-Marietta	Fertile	Worth	Fine Grained Dolomite
11	Not Used			Not Used
12	Niemann Const.	Eldorado	Fayette	Fine Grained Limestone
13	P & M Stone Co.	Hodges	Humboldt	Medium Grained Limestone
14	Fort Dodge Lst.	Ft. Dodge Mine	Webster	Medium Grained Limestone
15	Dubuque Stone	Dubuque Stone	Dubuque	Medium Grained Dolomite (soft)
16	Martin-Marietta	Ferguson	Marshall	Fine to Med. Grained Lst.& Dolo.
17	B.L. Anderson	Garrison	Benton	Fine Grained Limestone
18	Schemmer Const.	Logan	Harrison	Fine Grained Limestone
19	Kerford Lst. Co.	Weeping Water	Cass, Nebr.	Fine Grained Limestone
20	Schildberg Const.	Menlo	Adair	Fine Grained Limestone
21	Schildberg Const.	Corning	Adams	Fine to Med. Grained Limestone
22	Sargent Quarries	Dr. Jefferies	Harrison, Mo.	Fine Grained Limestone
23	Carter-Waters	Haydite	Appanoose	Expanded Shale
24	L & W Const.	#2 Quarry	Appanoose	Fine to Med. Grained Limestone
25	Kaser Corp.	Keswick	Keokuk	Fine Grained Dolomite
26	Douds Stone	Selma	Van Buren	Fine Grained Dolomite
27	Kaser Corp.	Coppock	Washington	Fine Grained Limestone
28	River Products	Columbus Jct.	Louisa	Fine to Med. Grained Dolomite
29	Wendling Quarries	Moscow	Muscatine	Medium Grained Dolomite
30	LeClaire Quarries	LeClaire	Scott	Fine to Med. Grained Dolomite

Case histories of seal coat failures have been reported where the suspect causative factor has been rainfall shortly after the aggregate was rolled in. In an attempt to simulate rainfall conditions, the outside one-half of each lane was sprayed with water after rolling was completed.

The end result was that each test section contained aggregate subjected to four different treatments:

1. Emulsified asphalt and water spray
2. Emulsified asphalt
3. Cutback asphalt
4. Cutback asphalt and water spray

This resulted in 232 sampling sites (four treatments per test section X 58 test sections).

The evaluation process called for a determination of the amount of aggregate retained on the surface to be made at periodic intervals. Specifically:

a) day of construction
b) one week after construction
c) one month after construction
d) one year after construction
e) two years after construction

On the day of construction, determination of aggregate retained was made by placing specially designed collecting pans in the path of the contractor's aggregate spreader.

All sampling subsequent to the day of construction was done by placing a 1' x 3' template on a sampling site. The sites were chosen so as not to be influenced by being too close to the ends of a test section, or where traffic entering onto the highway might have had an effect on aggregate retention. In all treatment sections, the sampling sites were in the wheel paths. To obtain a sample once the template was in place, the surface was heated by a propane torch until it could be scraped off and put into a container, (See Figures 1 and 2). It was felt that with the proper combination of heat and care, only the recently applied seal coat would be removed without disturbing the old surface underneath.

The samples thus obtained were brought to the Central Materials Laboratory where the asphalt was extracted and the weight and gradation of the retained aggregate were determined.

PROJECT COSTS

The research allocation for the project was $15,000. The two bid items of Binder Bitumen and Cover Aggregate that covered this research work included the work of shifting around on the test sections; sprinkling the outside half of each test section with water to simulate rain; and other incidentals. The low bid price for normal binder bitumen on the project was $ .469 per gallon. The bids for bitumen on the research section were $ .60 per gallon. Most of this price difference is attributed to the fact that two asphalt distributors were required for the application of the two

Figure 1

Figure 2

binder bitumens. The increase of approximately $ .13 per gallon reflected an additional cost of $2,670.00. The cover aggregate, which was trucked in from 29 locations over the State and stockpiled prior to application, was bid at $27.34 per ton versus the bid on the standard cover aggregate of $10.64. The difference of $16.70 per ton totaled $14,696.00 additional or a total difference attributable to the research work of $17,365.00. This exceeds the $15,000 allocated by the Research Board and includes none of the expenditures of the DOT such as wages, salary, and laboratory testing expenditures on the recovered aggregate samples.

TEST RESULTS AND INTERPRETATIONS

Prior to the start of the actual construction, the twenty-nine aggregates were delivered to a storage site near the project. Samples were taken for the standard stripping test AASHTO-182, specific gravity and absorption. Due to the small amount of each aggregate (30 tons), data as to abrasion, freeze and thaw, and gradation was obtained from tests conducted as the materials were being produced at the source. Data from this portion of the procedure is listed in Appendix B.

a) Day of Construction

The sampling of the aggregate on the day of initial application was attempted by placing a sampling pan on the roadway surface in the path of the contractor's aggregate spreader. Due to the low clearance between the road surface and the bottom of the aggregate spreader, the pans had to be very shallow. The combination of the speed of the spreader and the quantity of aggregate being discharged caused a significant amount of aggregate to bounce out of the sampling pans thus inhibiting any attempt to use this sampling as a basis for future comparisons.

The one visual observation made at this time was that after the water spray treatment, the cutback asphalt sections were susceptable to flushing and tracking.

b) Amount Retained After One Week

These samples were obtained by the heating and scraping method described previously and were sent to the Central Laboratory. After extraction of the asphalt, the total aggregate weight and gradation were determined. Without other samples to compare against, the only observation that was made concerning these samples was that the amount of aggregate retained (or obtained in sampling) varied significantly, both between treatments within a test section and between test sections.

c) Amount Retained After One Month

The first observation made after these samples were processed in the laboratory was that the large variances within and between test sections encountered in the previous sampling were repeated in this sampling. It was also noticed that over 40% of the samples indicated more aggregate retained at one month than at one week. Examination of the samples showed the presence of sand in the smaller sieve sizes. Apparently, in sampling the seal coats in the field, some of the old surface underneath was incorporated into the sample. To minimize the effect of the sand, the gradations were re-calculated using only the plux #8 sieve fraction. The adjusted gradations indicated that after one month of traffic and weather, there was a general trend toward aggregate loss.

d) Amount Retained After One Year

Sample data from this sampling were calculated on the basis of the plus #8 sieve fraction and again indicated that aggregate loss was occurring at various test sections. Although the retained weight figures have a considerable range, no statistically significant trends could be identified.

Visual observation on the test sections did indicate that differences between aggregates were becoming apparant. The gravels, quartzite, and lightweight aggregate were all exhibiting good retention characteristics, while the carbonate aggregates exhibited a range of performance.

e) <u>Amount Retained After Two Years</u>

Sample data from this sampling were again calculated on the basis of the plus #8 sieve fraction. The first observation that became apparent was that 16% of the test sections indicated an increase in the amount of aggregate from the one year sampling. Examination of the samples exhibiting an increase did not show the presence of any foreign material or aggregate. Since the same procedure and essentially the same field crew was used for each sampling period, it is felt that the sample size is the probable source of error. Although the sampling procedure and data evaluation were statistically designed, the failure to recognize and incorporate all significant variables into the plan could result in the failure of the plan as experienced. Conceivably, an increase in the size of the individual samples or in the number of samples per test section per time could minimize the effect of these additional variables, however, the cost of such an increase in terms of laboratory labor and materials would be prohibitive. A preliminary statistical treatment of the retained weight data did show that the variance between sections with the same treatment was greater than the variance between treatments thus substantiating the inadequacy of the sample size and/or number.

The one observation that can be made from the weight retained data is that as a group, the gravels have a noticeably higher percentage of material retained as compared to the carbonates.

Since the weight retained data was unreliable for detailed analysis, the gradations of the samples were looked at to see if any general trends were evident. This was done realizing that the same factors affecting the analysis of weight retained would have an effect here. Also, it follows that if a 50 lb. sample from a 30 ton stockpile is not representative of the material as far as gradation results, then a 3,000 to 5,000 gram sample may not be representative of the 3.75 tons of aggregates spread on each treatment section. Table II shows the percentage of material passing the designated sieve for the two year sampling.

Although the data has to be viewed with caution, several general trends can be suggested.

1. Gravels appear to retain more material in the upper sieve sizes than carbonates.

2. Aggregate retention does not seem to vary between emulsions and cutbacks on the 3/8" material and the variance on the #4 material is not significant.

3. Water spray application appears to have a detrimental effect on aggregate retention as reflected in the resulting gradation. The most pronounced effect is on the combination of carbonate aggregate with an emulsion binder and the least effect on gravel with a cutback binder. Observation of the prior sampling data shows that the effect becomes more obvious with time.

TABLE II

Mean Percent Passing 3/8" Sieve @ 720 Days

	Gravel (8 Sources)	Carbonates (19 Sources)	Quartzite (1 Source)	Haydite (1 Source)
All Treatments	78.15	89.87	76.07	90.16
Cutback	77.56	89.01	75.86	88.38
Emulsion	78.74	90.72	76.28	91.95
Cutback w/water Spray	78.14	91.57	78.23	89.34
Cutback no water Spray	76.97	86.45	73.49	87.42
Emulsion no water Spray	76.84	86.41	73.16	90.28
Emulsion w/water Spray	81.59	95.04	79.41	93.63

Mean Percent Passing #4 Sieve @ 720 Days

	Gravel (8 Sources)	Carbonate (19 Sources)	Quartzite (1 Source)	Haydite (1 Source)
All Treatments	11.49	29.81	15.29	10.46
Cutback	11.77	28.38	14.59	10.50
Emulsion	11.21	31.24	15.99	10.43
Cutback w/water Spray	11.86	31.29	15.95	10.13
Cutback no water Spray	11.68	25.46	13.24	10.87
Emulsion no water Spray	10.80	27.14	15.05	10.86
Emulsion w/water Spray	11.60	35.34	16.93	10.01

VISUAL OBSERVATIONS

Since the sampling procedure and laboratory analysis yielded unreliable data, it was decided to attempt to evaluate the project through visual observations of the test sections. Several observations had been noted during the life of the project and those made at the time of the two year sampling indicated that differences between test sections were becoming more obvious. To this end, the research portion of the project was walked and observations and pictures made of each test section. Although it was obvious which test sections were gravel, quartzite, haydite, and carbonate, no information as to the particular source used on a test section was available during the field portion of the investigation. Thus, the test sections being randomly distributed and repeated twice served as a check on observer objectivity. At a later date, knowing the layout of the test sections, the project was viewed to see if the two repetitions of an aggregate did in fact exhibit the same retention characteristics. They did. This leads to substantiate the earlier comment that if the individual sample size or number of samples per test section would be increased, then the weight retained data would be indicative of the aggregate retained.

As the test sections were traversed, comments were recorded as to their aggregate retention, and presence of bleeding or flushing. The results are shown in Table III. Aggregate retention as shown varies from fair to excellent, with the gravels, quartzite, and haydite giving excellent results. The carbonates vary from fair to excellent depending upon their lithologic type and grain size, with the dolomites performing best along with the medium grained limestones. Bleeding is more common to those sections containing carbonate aggregates and occurs more frequently on the cutback treated areas. A positive correlation appears to exist between bleeding and increasing aggregate loss--which comes first is not proffered at this time. The flushing and tracking observed on the day of construction is still evident on the test sections, but has become common to enough test sections that it is thought to be related to heavy binder application due to distributor start up and shut down on the relatively short test sections. The clear evidence on some of the test sections of distributor nozzle malfunctions shows how sensitive seal coats are to the correct relationship between the amount of binder bitumen and the amount of aggregate spread.

TABLE III

RETENTION RATING BY VISUAL OBSERVATION

Source	Lithology	Replicate	Treatments: Emulsion w/water spray	Emulsion no water	Cutback no water	Cutback w/water spray
1	Gravel	1	0	0	0	0 (B)
1	Gravel	2	0	0	0	0
2	Gravel	1	-1	1	0	0
2	Gravel	2	0	0	0	0
3	Gravel	1	0	0	0	0
3	Gravel	2	0	0	0	0
4	Gravel	1	0	0	0	0
4	Gravel	2	0	0	0	0
5	Gravel	1	0	0	0	0
5	Gravel	2	0	0	0	0
6	Gravel	1	0	0	-1 (B)	-1 (B
6	Gravel	2	0	0	0	0 (B
7	Gravel	1	0	0	0	0
7	Gravel	2	1	1	1	1
8	Gravel	1	0	0	0	0
8	Gravel	2	1	1	1	1
9	Quartzite	1	1	1	1	1
9	Quartzite	2	1	1	1	1
10	Dolomite	1	0	0	0	0
10	Dolomite	2	0	0	0	0
12	Limestone	1	0	0	0 (B)	0
12	Limestone	2	0	0	0	0
13	Limestone	1	0 (B)	0 (B)	0	0 (B
13	Limestone	2	0	0	0 (B)	0 (B
14	Limestone	1	0	0	0	0
14	Limestone	2	0	0	0	0
15	Dolomite	1	-2 (B)	-2 (B)	0	0
15	Soft Dolomite	2	-2 (B)	-2 (B)	-2	-2 (B
16	Lst/Dol	1	0	0	0	0
16	Lst/Dol	2	0 (B)	0	1	1
17	Limestone	1	0	0	-1	-1
17	Limestone	2	-1 (B)	-1	-1 (B)	-1
18	Limestone	1	-1	-1	-1 (B)	-1 (B)
18	Limestone	2	-1	-1	-1 (B)	-1 (B)
19	Limestone	1	-2 (B)	-2 (B)	-2 (B)	-2 (B
19	Limestone	2	-1	-1	-1 (B)	-1 (B
20	Limestone	1	-1	-1	-1 (B)	-1 (B)
20	Limestone	2	-1	-1	-1 (B)	-1 (B)
21	Limestone	1	-1	-1	-1 (B)	-1 (B
21	Limestone	2	-1 (B)	-1 (B)	0	0
22	Limestone	1	0	0	0	0 (B)
22	Limestone	2	-1	-1	-1 (B)	-1 (B)
23	Haydite	1	1	1	1	1
23	Haydite	2	1	1	1	1
24	Limestone	1	0	0	-1	-1
24	Limestone	2	-1	-1	-1	-1

Source	Lithology	Replicate	Treatments: Emulsion w/water spray	Emulsion no water	Cutback no water	Cutback w/water spray
25	Dolomite	1	0	0	0	0
25	Dolomite	2	0	0	0	0
26	Dolomite	1	0	0	0	0
26	Dolomite	2	0	0	0	0
27	Limestone	1	-1	-1	-1 (B)	-1 (B)
27	Limestone	2	-1 (B)	-1	-1	-1 (B)
28	Dolomite	1	0	0	0	0
28	Dolomite	2	0	0	0	0
29	Dolomite	1	0	0	0	0
29	Dolomite	2	1	1	0	0
30	Dolomite	1	0 (B)	0 (B)	0	0
30	Dolomite	2	-1 (B)	-1 (B)	0	0

Code:
1 = Excellent Retention
0 = Good Retention
-1 = Fair Retention
-2 = Poor Retention
(B) = Bleeding Substantial

Friction values were obtained in 1977 and 1978 and are tabulated in Table IV. Observation shows these values to be dependent upon aggregate retention and/or lithologic type. The current skid resistance classification for each source according to the Iowa DOT Materials Instructional Memorandum T-203 is also shown in Table IV. The data indicates that from a friction value standpoint, the Type 4 or better aggregates, namely the gravels, quartzite, haydite, dolomites, and medium grained limestones will perform satisfactorily as cover aggregates with either cutback or emulsion binders.

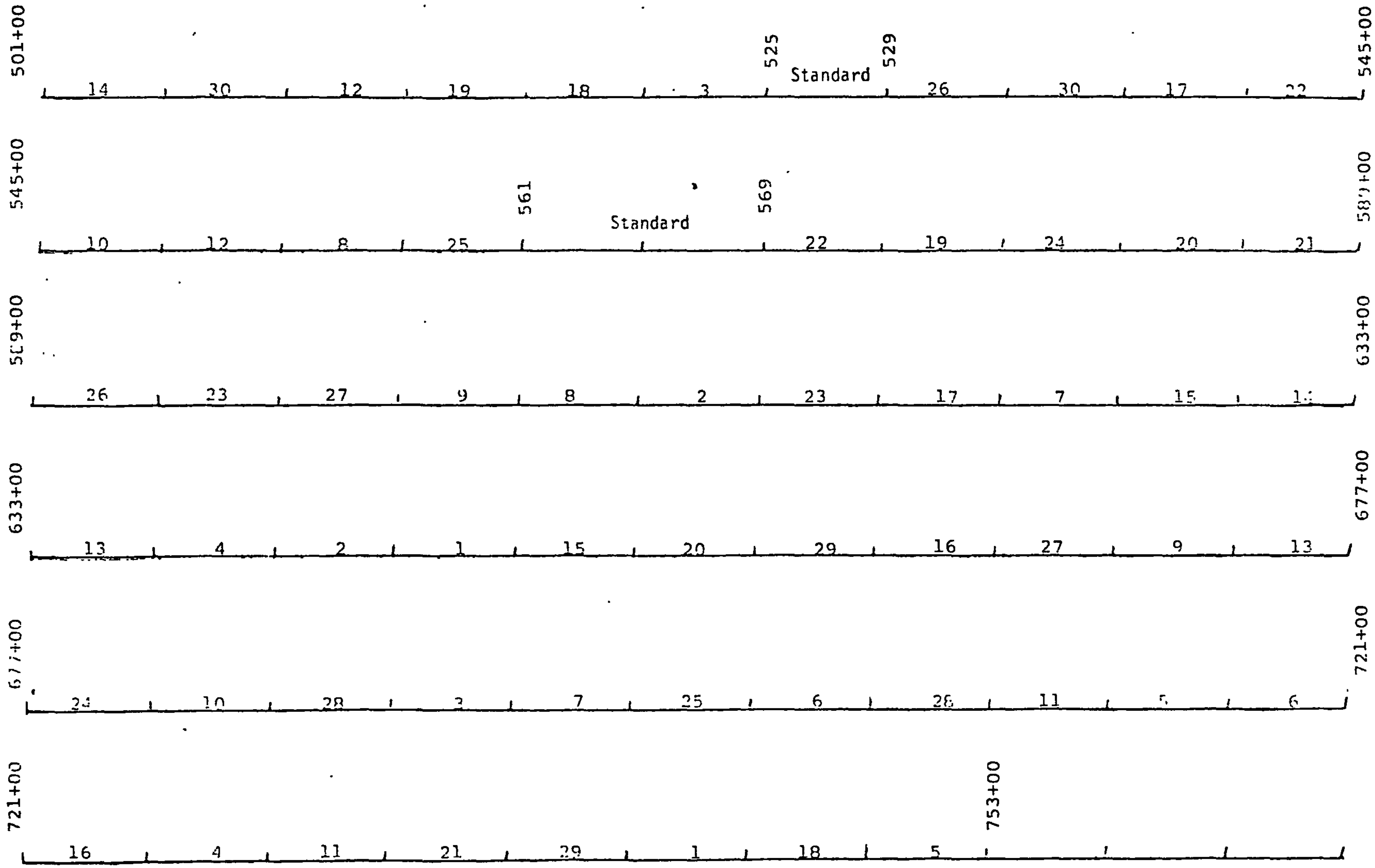
TABLE IV

SKID TYPE/FRICTION NUMBER/RETENTION RATING DATA

Source	Lithology	Skid Classification Type No. (T-203)*	Friction Number** 1977 Emulsion No water	1977 Cutback spray	1978 Emulsion No water	1978 Cutback spray	Retention Characteristics
1	Gravel	3	48	49	49	47	Good
2	Gravel	3	47	50	49	51	Good
3	Gravel	4	45	51	48	48	Good
4	Gravel	4	45	49	46	47	Good
5	Gravel	4	50	50	48	49	Good
6	Gravel	4	51	53	54	53	Good
7	Gravel	4	43	43	44	43	Good
8	Gravel	4	44	45	46	44	Good
9	Quartzite	2	57	54	59	54	Excellent
10	Dolomite	4	49	51	51	43	Good
12	Limestone	5	43	43	40	36	Good
13	Limestone	4	47	50	44	44	Good
14	Limestone	4	47	49	41	39	Good
15	Dolomite (Soft)	4	56	61	58	54	Poor
16	Lst/Dol	4	55	56	55	57	Good
17	Limestone	5	38	40	35	30	Fair
18	Limestone	5	44	46	43	40	Fair
19	Limestone	5	42	45	38	31	Poor
20	Limestone	5	47	51	46	45	Fair
21	Limestone	4	50	49	49	46	Fair
22	Limestone	5	45	55	46	45	Fair
23	Haydite	3	66	66	66	65	Good
24	Limestone	5	44	44	43	38	Fair
25	Dolomite	4	59	62	58	57	Good
26	Dolomite	4	76	72	67	67	Good
27	Limestone	5	42	45	39	37	Fair
28	Dolomite	4	58	65	58	61	Good
29	Dolomite	4	54	56	52	51	Good
30	Dolomite	4	55	58	55	54	Good

* Higher values indicate more susceptibility to polishing by traffic action and therefore less skid resistance.

** Higher numbers indicate greater resistance to skidding.



Location of seal coat aggregate types

Each section is 400 ft. long

APPENDIX B

AGGREGATE TEST DATA

Source	Stripping Test Passed	Sp. Gr. SSD	Absorption SSD	Abrasion	Freeze & Thaw Method C
1	"	2.689	0.82	23	1.0
2	"	2.695	1.48	23	3.0
3	"	2.656	0.55	27	3.0
4	"	2.679	1.77	27	5.2
5	"	2.694	1.17	26	2.0
6	"	2.699	0.98	27	1.5
7	"	2.701	0.68	19	0.5
8	"	2.640	1.18	26	2.0
9	"	2.647	0.17	24	0.8
10	"	2.775	0.37	26	2.0
12	"	2.704	0.17	28	0.3
13	"	2.656	0.85	28	2.0
14	"	2.686	0.38	30	0.7
15	"	2.741	1.01	38	0.7
16	"	2.717	0.72	32	1.3
17	"	2.698	0.33	25	2.0
18	"	2.663	1.06	30	2.0
19	"	2.707	0.45	27	0.7
20	"	2.667	1.00	28	2.1
21	"	2.648	1.37	46	3.8
22	"	2.690	1.35	30	2.7
23	"	1.770	3.69	22	1.0
24	"	2.703	0.35	28	1.1
25	"	2.637	2.28	31	0.6
26	"	2.484	3.24	39	1.2
27	"	2.681	0.57	25	0.6
28	"	2.611	1.95	32	0.6
29	"	2.703	0.86	37	0.3
30	"	2.725	0.90	30	0.7