U.S. Department of Transportation

Federal Highway Administration

Demonstration Projects Program

Demonstration Project No. 55

Asphalt Emulsions for Highway Construction

Erath County, Texas

FHWA-DP-55-2

Initial Report

January 1982

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Demonstration Projects Division
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Telephone: 703-557-0522

Technical Report Documentation Page

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Texas State Department of Highways and Public Transportation Box 5051 Austin, Texas 78763	11. Contract or Grant No. DTFH71-80-55-TX-02
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State Study No. 1-2D-80-543

16. Abstract

Increased concern for the environment and spiraling prices for petroleum products have brought about increased interest in the use of emulsified asphalts in highway construction. This emphasis has been placed primarily in the construction of chip seals using emulsions. In order to assess design and construction procedures, as well as roadway performance, an experimental emulsified asphalt seal coat was placed in Texas. The material selected for the chip seal was a CRS-2 emulsified asphalt with a design rate of emulsion at .35 - .40 gal./yd^2. The aggregate was Type B, Grade 4A, at a coverage rate of 1 yd.^{3}/110-120 yd. of surface. This report describes the construction procedures, material costs, energy consumption and savings, and performance of the section to date.

17. Key Words	18. Distribution Statement
Emulsified asphalt Seal Coat Chip Seal Energy	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	17	

Placement and Evaluation of a Seal Coat Using Emulsified Aspahlt - Initial Report

FM 2157, Control 1990-1
Erath County, Texas

Report No. 543-1

by

Fred E. Atrip
Senior Resident Engineer
District 2

and

Jon Underwood
Senior Research Engineer
Transportation Planning Division

Texas State Department of
Highways and Public Transportation

in cooperation with

Federal Highway Administration
Region 15

Demonstration Study 1-2D-80-543
"Placement and Evaluation of a Seal Coat Using Emulsified Asphalt"

October, 1980

Introduction:

The use of asphalt emulsion in the highway industry is a technology that has been available to the highway engineer for many years. But because the price of asphalt was cheap, many engineers felt quality was improved using AC's, AC's and cutbacks could successfully be used in colder weather, and little or no concern was felt for the environment, asphalt emulsion has not gained widespread use.

Increased concern for the environment and spiraling prices for petroleum products have brought about increased interest in the use of emulsified asphalts in highway construction. This emphasis has been placed primarily in the construction of chip seals using emulsions.

In order to assess design and construction procedures, as well as roadway performance, an experimental section was placed in Texas. This section was placed by Texas State Department of Highways and Public Transportation maintenance personnel in conjunction with the Federal Highway Administration, Demonstration Projects Division, Region 15. This demonstration project was placed in Texas Highway District 2.

Preliminary Investigation:

This demonstration project is located on FM 2157 in the mid-eastern part of Erath County at a point from 2.09 miles east of US 281 to 0.4 miles west of the Erath-Hood County line, for a length of 12.29 miles. The average daily traffic on this experimental section, as of May 13, 1980, varies from 260 to 344 vehicles per day. This roadway has a very small percentage of trucks and a posted speed limit of 55 mph. This experimental section is a rural Farm to Market Highway with two 10-foot lanes, a maximum curvature of 6°00' and a maximum gradient of 5.98%.

The construction on this project consisted of three stages; the first stage was built in 1955 and consisted of 1.8 miles. The second stage was built in 1957 and had a length of 6.74 miles. The third stage was built in 1966 for a length of 3.75 miles. The base course is a pit-run caliche-type material, approximately 6 inches thick in good condition except for the failures indicated on the strip map in Appendix A.

The original surface was predominately free of excess asphalt and had a smooth texture. A number of level-ups had been applied to the surface at various locations as shown on the strip map in Appendix A.

The relatively low traffic volume on this roadway has helped keep accident statistics low. Accident information for the past year indicate two accidents occurred on this roadway with one of them occurring when the pavement was wet. The average skid number over this section of roadway prior to resurfacing was 35. This measurement was taken with a locked-wheel skid test trailer conforming to ASTM E-274.

The annual snowfall is 2.34 inches. The average relative humidity is 56%, and the annual rainfall is 28.9 inches averaged over the past 66 years. The average annual temperature is 64°F.

The drainage structures of concrete box construction are designed on a 5-year frequency and the pipe structures are designed on a 2-year frequency. The pavement has a design slope of ¼"/ft. and a ditch depth of 1.5 ft. to 2.0 ft.

Design Criteria/Procedures:

The objective of this surface treatment or chip seal was to seal the existing surface and to provide improved skid resistance. The material selected for use was a CRS-2 emulsified asphalt.

The design rate of emulsion application was determined to be 0.35 to 0.40 gal./sq.yd. The Type B, Grade 4A aggregate was used at a coverage rate of one cubic yard of aggregate/110 to 120 square yards of surface area. The Type B, Grade 4A limestone aggregate met the following specification limits:

	Percent by Weight
Retained on 5/8" sieve	0
Retained on 1/2" sieve	0-2
Retained on 3/8" sieve	20-45
Retained on No. 4 sieve	95-100
Retained on No. 10 sieve	99-100

The emulsified asphalt analyses revealed the following results:

Average residual asphalt content	67.5%
Viscosity at 122°F	274.5 sec.
Demulsibility	90%
Penetration (5 sec. @ 77°F)	152.5
Percent solvent	0.0

The source of the asphalt was Riffe Petroleum Co., Arlington, Texas. Since this job was done by state maintenance forces, there was no formal traffic control plan. Traffic was controlled by flagmen on each end. After each shot and the completion of each rolling operation, the flagman moved his operations to the beginning of the next shot. The lead flagman was stationed each time at the end of every emulsion shot.

The standard specifications of the Texas State Department of Highways and Public Transportation controlled the materials and construction of this experimental project with the exception of the modified aggregate gradation listed earlier.

Construction Criteria/Procedure:

Prior to the placement of the emulsified asphalt seal, an asphaltic concrete level-up was placed at all necessary locations as shown on the strip map in Appendix A. A rotary-power broom was used to sweep the surface of the entire job prior to application of the seal coat.

The construction of this experimental project began at 9:00 a.m. on July 29, 1980. The weather was hot with a light breeze. The pavement temperature at 9:00 a.m. was 100°F, and at 2:00 p.m., 120°F. The next day, July 30, the weather conditions were the same as the preceding day and the roadway temperature was 104°F at 10:00 a.m. and 122°F at 3:00 p.m. The emulsified asphalt was applied at an average temperature of 155°F and at an average rate of 0.359 gallons per square yard. The distributor used was a Rosco, Model No. RRE, Serial No. FD100418H, using No. 2 nozzles at a box height of ten inches. The emulsion was evenly applied across each lane.

The aggregate spreader was a Flaherty Model K, Serial No. 2271. The aggregate was spread at a rate of 1 c.y./115 square yards of surface area. Prior to spreading the aggregate, the stockpiles were moistened with water. For the entire project the emulsion was allowed to break prior to the application of the aggregate with the exception of approximately 25,000 ft. On this portion of the project, the aggregate was placed directly behind the distributor prior to the break of the emulsion. These two times of aggregate placement were to allow a side by side comparison of the two different times. See Appendix B.

The seal coat was applied to one half of the roadway for the entire length of the project then the remaining one half was sealed. Two 9-wheel SP-3000 pneumatic roll-o-pactors manufactured by Bros Division of American Hoist & Derrick were used on this project.

They were equipped with 10-ply tires at a pressure of 60 psi. Each had a maximum wheel load of 3,000 pounds which produces a ground contact area of 46 square inches and a ground contact pressure of 65 pounds per square inch. The rolling was continuous during the time the seal was applied.

All equipment used on this project was the property of the Texas State Department of Highways and Public Transportation and was in good operating condition.

Cost of Material:

As previously stated, the material used was a CRS-2 emulsified asphalt. A total of 54,300 gallons was used over an area of 151,385 square yards for an average rate of 0.359 gallons per square yard. The cost of the emulsion was $147.32 per ton delivered to the project. This converts to approximately $0.22 per square yard. The cost of an alternate material (asphalt cutbacks) was not available for this project.

If AC asphalt had been used for this project, a rate of 0.30 gallons/sq. yd. as compared to 0.36 gallons/sq.yd. for the emulsion would have been sufficient for this type of seal.

Energy Consumption:

The total fuel used over the two-day period during construction was approximately 700 gallons of gasoline, 30 gallons of diesel and 320 gallons of kerosene.

The following equipment was used on the project:

7 aggregate haul trucks

1 aggregate spreader

1 aggregate loader

1 aggregate spot truck

1 paper joint truck

1 rotary broom	2 pneumatic rollers
2 booster trucks	1 water truck
1 asphalt distributor	1 equipment haul truck
1 asphalt heater	6 pickups
1 asphalt pump	

The energy calculations in Appendix C assume the same amount of fuel was used in the emulsion seal as would be used in a cut-back seal except for the additional fuel necessary to fuel the heaters for the elevated temperature of the cutback asphalt.

Environmental Considerations:

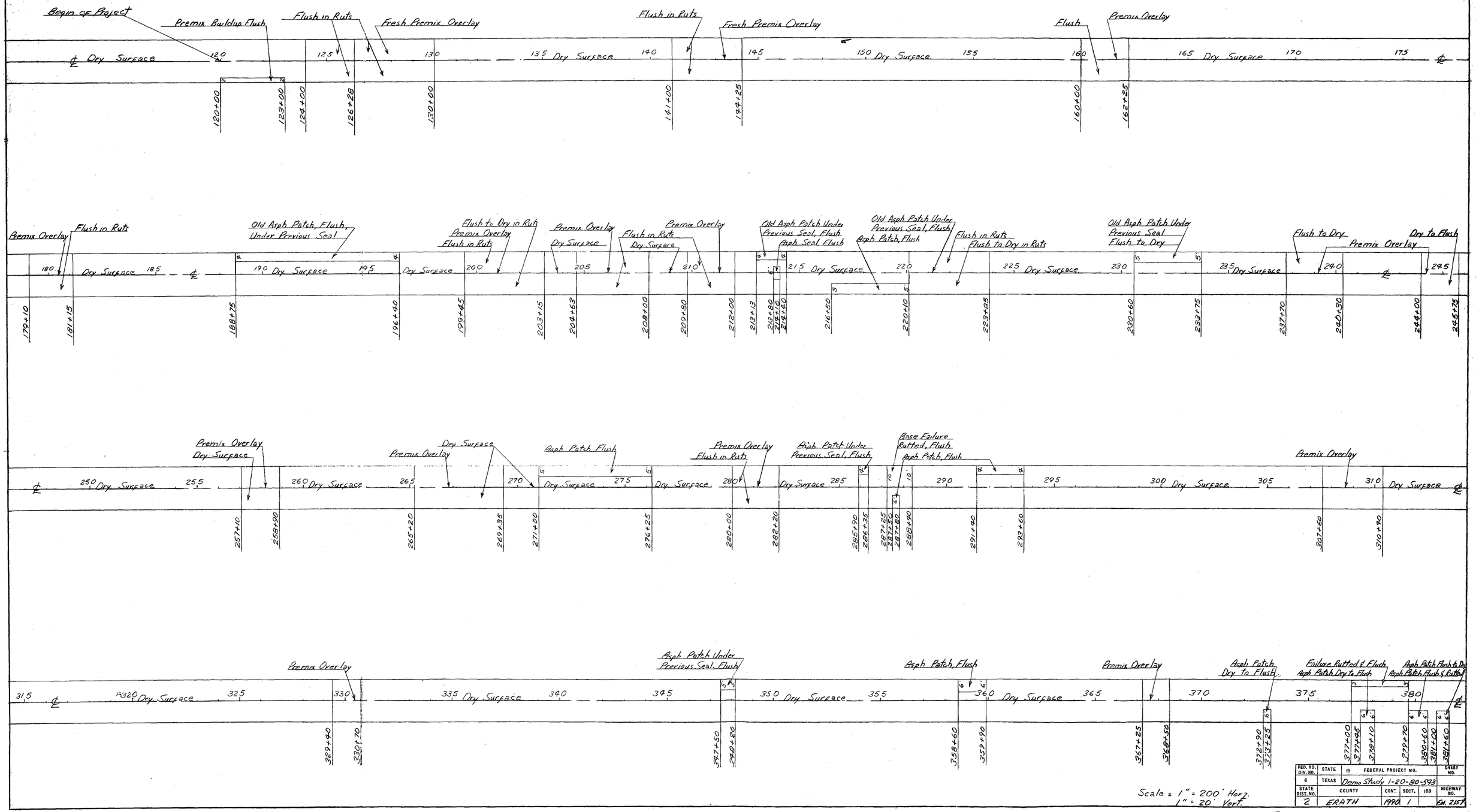
Since the location of this project is in a rural ranching area, there are no known environmental regulations for using asphalt emulsions or any other type of asphalt.

The air quality, as related to HC emission, was not considered applicable to this project. The effect of lower application temperatures for emulsion in relation to environmental considerations was found to be negligible.

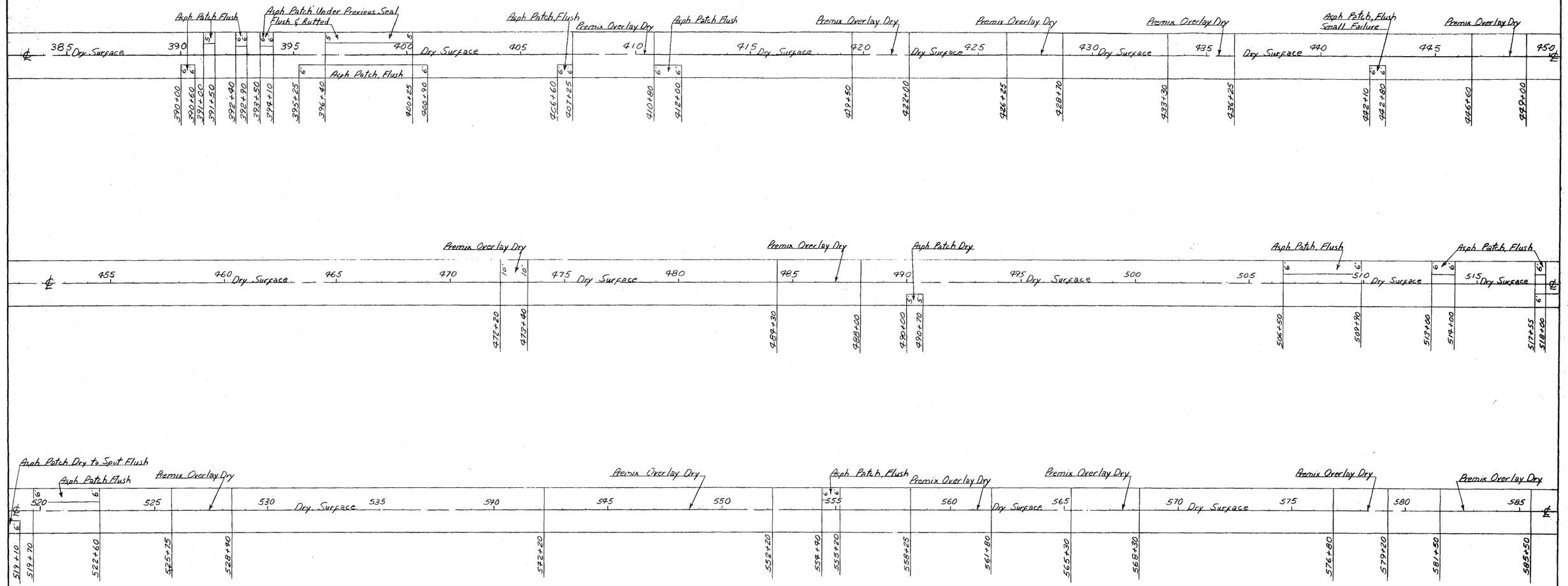
Results:

This experimental emulsified seal coat is performing excellently and further results will be reported annually in order to further assess its performance.

APPENDIX A

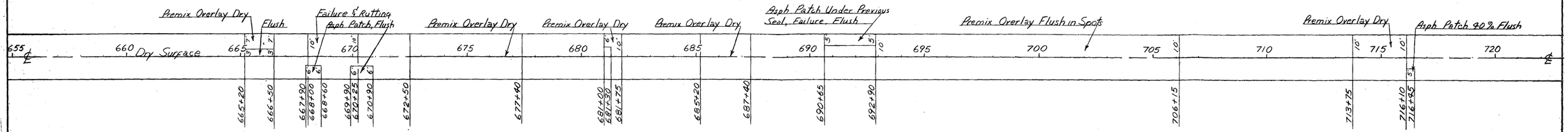


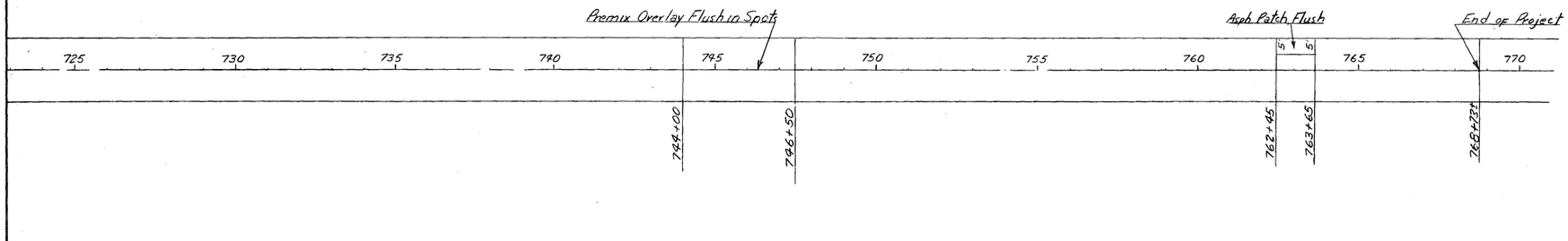
FED. RD. DIV. NO.	STATE	⊕ FEDERAL PROJECT NO.				SHEET NO.
6	TEXAS	Demo Study 1-20-80-593				
STATE DIST. NO.	COUNTY		CONT.	SECT.	JOB	HIGHWAY NO.
2	ERATH		1990	1		Fm. 2157



Scale = 1" = 200' Horz.
1" = 20' Vert.

FED. RD. DIV. NO.	STATE	FEDERAL PROJECT NO.				SHEET NO.
6	TEXAS	Demo Study I-20-80-593				
STATE DIST. NO.	COUNTY		CONT.	SECT.	JOB	HIGHWAY NO.
2	ERATH		1990	1		FM. 2153





FED. RD. DIV. NO.	STATE	FEDERAL PROJECT NO.			SHEET NO.
6	TEXAS	Demo Study 1-20-90-593			
STATE DIST. NO.	COUNTY	CONT.	SECT.	JOB	HIGHWAY NO.
2	ERATH	1990	1	.	FM 2157

APPENDIX B

Form 187

65645-261-50m

DAILY ROAD REPORT—ASPHALT

Demo Study
FM 2157 1-2D-80-543

Erath County. State Control No. 1990 Sec. 1 Job F. A. P. No.

Type CRS-2 SEal Coat Contractor Dept. Hwys. & Pub. Trans. Date 7-30-80

MATERIALS—RECEIVED

R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT	R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT

ASPHALT APPLICATION

GENERAL

F. O.	CRSE. NO.	DIST. NO.	LENGTH STA.	LENGTH to STA.	LENGTH FT.	WIDTH FT.	AREA S. Y.
1	1	1	750+80	768+80	1800	11	2200
2	1	1	768+80	752+00	1680	10	1867
3	1	1	752+00	714+00	3800	10	4222
4	1	1	714+00	676+00	3800	10	4222
5	1	1	676+00	640+00	3600	10	4000
6	1	1	640+00	604+00	3600	10	4000
7	1	1	604+00	594+00	1000	10	1111
8	1	1	594+00	570+50	2350	10	2611
9	1	1	570+50	534+00	3650	10	4056
10	1	1	534+00	502+00	3200	10	3556
11	1	1	502+00	470+00	3200	10	3556
12	1	1	470+00	434+00	3600	10	4000
13	1	1	434+00	406+00	2800	10	3111
14	1	1	406+00	376+00	3000	10	3333
15	1	1	376+00	344+00	3200	10	3556
16	1	1	344+00	316+34	2766	10	3073
17	1	1	316+34	280+00	3634	10	4038
	1	1	280+00	247+00	3300	10	3667

ASPHALT

Lane	R. R. CAR NO.	CY	GALS. START	GALS. END	NET GALS.	TEMP. ° F.	GALS./ S. Y.
Rt		18	1550	750	800	160	.364
Lt		18	750	150	600	160	.321
"		36	1550	230	1320	160	.313
"		36	1550	200	1350	160	.320
"		36	1550	120	1430	160	.358
"		36	1550	150	1400	155	.350
"		12	500	70	430	155	.387
"		24	1330	350	980	155	.375
"		36	1550	130	1420	150	.350
"		36	1420	200	1220	150	.343
"		30	1380	230	1150	150	.323
"		36	1500	70	1430	155	.358
"		30	1170	150	1020	155	.328
"		36	1270	120	1150	155	.345
"		36	1330	100	1230	150	.346
"		30	1450	300	1150	155	.374
"		36	1530	200	1330	155	.329
"		36	1420	270	1150	150	.314

AGGREGATE

urce of Aggregate 1st Course

urce of Aggregate 2nd Course

urce of Aggregate 3rd Course

ate Aggregate Applied 1st Course

te Aggregate Applied 2nd Course

te Aggregate Applied 3rd Course

ASPHALT

urce of Asphalt 1st Application

urce of Asphalt 2nd Application

urce of Asphalt 3rd Application

me Work Began:

me of Last Application:

me Work Finished:

asons for Time Loss:

SUMMARY OF DAYS WORK

	ASPHALT		BLADING	ROLLING
1ST COURSE	GALLONS	SQ. YDS.	HOURS	HOURS
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
2ND COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
3RD COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
TOTALS				

marks:

NSTRUCTIONS: MAKE TWO COPIES, ONE FOR DISTRICT OFFICE AND ONE OR RESIDENT ENGINEER. TO BE PREPARED DAILY AND SUBMITTED T LEAST ONCE EACH WEEK.

Neal B. Hampton Report No. 2
Inspector

Form 187

65645-261-50m

DAILY ROAD REPORT—ASPHALT

Demo Study

FM 2157

1-2D-80-543

Erath County. State Control No. 1990 Sec. 1 Job F. A. P. No.

Type CRS-2 Seal Coat Contractor Dept. Hwys. & Pub. Trans. Date 7-30-80

MATERIALS—RECEIVED

R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT	R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT

ASPHALT APPLICATION

GENERAL

F. O.	CRSE. NO.	DIST. NO.	LENGTH STA.	LENGTH to STA.	LENGTH FT.	WIDTH FT.	AREA S. Y.
1	1	1	247+00	212+00	3500	10	3889
2	1	1	212+00	174+00	3800	10	4222
3	1	1	174+00	142+00	3200	10	3556
4	1	1	142+00	120+00	2200	10	2444
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

ASPHALT

R. R. CAR NO.		GALS. START	GALS. END	NET GALS.	TEMP. ° F.	GALS./ S. Y.
Lt	36	1550	250	1300	155	.334
"	36	1500	100	1400	150	.332
"	30	1320	170	1150	150	.323
"	24	1500	600	900	150	.368
	684					

AGGREGATE

Ty B Gr 4A

Source of Aggregate 1st Course Zack Burkett

Source of Aggregate 2nd Course Graham, Tx.

Source of Aggregate 3rd Course

Rate Aggregate Applied 1st Course

Rate Aggregate Applied 2nd Course

Rate Aggregate Applied 3rd Course

ASPHALT

C.R.S. II

Source of Asphalt 1st Application Riffe Petroleum Co.

Source of Asphalt 2nd Application Arlington, Tx.

Source of Asphalt 3rd Application

Time Work Began: 8:45 AM

Time of Last Application: 4:45 PM

Time Work Finished: 4:45 PM

Reasons for Time Loss:

SUMMARY OF DAYS WORK 213

1ST COURSE	ASPHALT GALLONS	ASPHALT SQ. YDS.	BLADING HOURS	ROLLING HOURS
PREV. REPORT	28,990	77,095		18.0
THIS REPORT	25,310	74,290		16.0
TO DATE	54,300	151,385		34.0
AV. RATE	.359 gals. per. S. Y.			
2ND COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
3RD COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
TOTALS	54,300	151,385		34.0

Remarks: 104° surface temp at 10:00 AM
122° surface temp at 3:00 PM
Sta 508+00 to 750+00 Rt side only Not time asph. to brake.

INSTRUCTIONS: MAKE TWO COPIES, ONE FOR DISTRICT OFFICE AND ONE FOR RESIDENT ENGINEER. TO BE PREPARED DAILY AND SUBMITTED AT LEAST ONCE EACH WEEK.

Hardy B. Hampton
Inspector

Report No. 2 & Fina

Form 187

65645-261-50m

DAILY ROAD REPORT—ASPHALT

Demo Study 1-20-80-543

Erath County. State Control No. 1990 Sec. 1 Job FM 2157 F. A. P. No.

Type CRS-2 Seal Coat Contractor Dept. Hwys & Pub. Trans. Date 7-29-80

MATERIALS—RECEIVED

R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT	R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT

ASPHALT APPLICATION

GENERAL

F. O.	CRSE. NO.	DIST. NO.	LENGTH STA.	LENGTH to STA.	LENGTH FT.	WIDTH FT.	AREA S. Y.
1	1	1	120+00	149+00	2900	11	3544
2	1	1	149+00	178+00	2900	11	3544
3	1	1	178+00	207+00	2900	11	3544
4	1	1	207+00	238+00	3100	11	3789
5	1	1	238+00	268+50	3050	11	3728
6	1	1	268+50	288+00	1950	11	2383
7	1	1	288+00	314+00	2600	11	3178
8	1	1	314+00	338+50	2450	11	2994
9	1	1	338+50	370+00	3150	11	3850
10	1	1	370+00	402+00	3200	11	3911
11	1	1	402+00	434+00	3200	11	3911
12	1	1	434+00	466+00	3200	11	3911
13	1	1	466+00	476+00	1000	11	1222
14	1	1	476+00	508+00	3200	11	3911
15	1	1	508+00	540+00	3200	11	3911
16	1	1	540+00	572+00	3200	11	3911
17	1	1	572+00	604+00	3200	11	3911
18	1	1	604+00	632+00	2800	11	3422

ASPHALT

Lane	R. R. CAR NO.	Aggr. Used CY	GALS. START	GALS. END	NET GALS.	TEMP. ° F.	GALS./ S. Y.
Rt		36	1550	300	1250	150	.353
"		32	1550	50	1500	150	.423
"		32	1550	150	1400	150	.395
"		36	1550	50	1500	150	.396
"		36	1550	50	1500	155	.402
"		28	1000	100	900	155	.378
"		30	1350	100	1250	150	.393
"		30	1220	100	1120	150	.374
"		36	1550	100	1450	155	.377
"		42	1550	80	1470	160	.376
"		42	1550	120	1430	160	.366
"		42	1550	80	1470	155	.376
"		12	620	70	550	150	.450
"		42	1550	50	1500	160	.384
"		42	1550	100	1450	160	.371
"		42	1550	70	1480	160	.378
"		42	1600	180	1420	155	.363
"		36	1380	80	1300	155	.380

AGGREGATE

ource of Aggregate 1st Course

urce of Aggregate 2nd Course

ource of Aggregate 3rd Course

ate Aggregate Applied 1st Course

ate Aggregate Applied 2nd Course

ate Aggregate Applied 3rd Course

ASPHALT

urce of Asphalt 1st Application

urce of Asphalt 2nd Application

urce of Asphalt 3rd Application

me Work Began:

me of Last Application:

me Work Finished:

asons for Time Loss:

SUMMARY OF DAYS WORK

1ST COURSE	ASPHALT GALLONS	ASPHALT SQ. YDS.	BLADING HOURS	ROLLING HOURS
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
2ND COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
3RD COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.		-	
TOTALS				

marks:

INSTRUCTIONS: MAKE TWO COPIES, ONE FOR DISTRICT OFFICE AND ONE FOR RESIDENT ENGINEER. TO BE PREPARED DAILY AND SUBMITTED AT LEAST ONCE EACH WEEK.

Hardy B. Hampton
Inspector

Report No. 1

Form 187

65645-261-50m

DAILY ROAD REPORT—ASPHALT

Demo Study
FM 2157 1-2D-80-543

Erath County. State Control No. 1990 Sec. 1 Job ____ F. A. P. No. ____

Type CRS-2 Seal Coat Contractor Dept. Hwys. & Pub. Trans. Date 7-29-80

MATERIALS—RECEIVED

R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT	R. R. CAR NO.	MATERIAL	NET WT.	LAB. REP.	AMOUNT

ASPHALT APPLICATION

GENERAL

CRSE. NO.	DIST. NO.	LENGTH STA.	LENGTH to STA.	LENGTH FT.	WIDTH FT.	AREA S. Y.
1	1	632+00	656+00	2400	11	2933
1	1	656+00	688+00	3200	11	3911
1	1	688+00	718+00	3000	11	3667
1	1	718+00	750+80	3280	11	4009

ASPHALT

R. R. CAR NO.	CY	GALS. START	GALS. END	NET GALS.	TEMP. ° F.	GALS./ S. Y.
Rt	30	1300	280	1020	155	.348
"	36	1520	200	1320	150	.338
"	36	1480	150	1330	150	.363
"	42	1400	20	1380	155	.344
	782					

AGGREGATE Ty B Gr 4A

Source of Aggregate 1st Course: Zack Burkett
Source of Aggregate 2nd Course: Graham, Tex.
Source of Aggregate 3rd Course:
Rate Aggregate Applied 1st Course:
Rate Aggregate Applied 2nd Course:
Rate Aggregate Applied 3rd Course:

ASPHALT C.R.S. II

Source of Asphalt 1st Application: Riffe Petroleum Co.
Source of Asphalt 2nd Application: Arlington, Tex.
Source of Asphalt 3rd Application:
Time Work Began: 8:30 AM
Time of Last Application: 5:00 PM
Time Work Finished: 5:30 PM
Reasons for Time Loss:

SUMMARY OF DAYS WORK 213

	ASPHALT GALLONS	ASPHALT SQ. YDS.	BLADING HOURS	ROLLING HOURS
1ST COURSE				
PREV. REPORT	0	0		0
THIS REPORT	28,990	77,095		18.0
TO DATE	28,990	77,095		18.0
AV. RATE	.376 gals. per. S. Y.			
2ND COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
3RD COURSE				
PREV. REPORT				
THIS REPORT				
TO DATE				
AV. RATE	gals. per. S. Y.			
TOTALS	28,990	77,095		18.0

Remarks: 100° Surface at 9:00 AM
120° Surface at 2:00 PM

INSTRUCTIONS: MAKE TWO COPIES, ONE FOR DISTRICT OFFICE AND ONE FOR RESIDENT ENGINEER. TO BE PREPARED DAILY AND SUBMITTED AT LEAST ONCE EACH WEEK.

Harry B. Haworth
Inspector

Report No. 1
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APPENDIX C

Energy Requirements for Emulsion Seal

Energy Required to Produce Asphalt:

54,300 gal. x .67 x 2550 btu/gal. = 9.0953×10^7 btu

Energy Required to Produce Emulsion:

54,300 gal. x 2715 btu/gal. = 1.4742×10^8 btu

Fuel Used on Job:

700 gal. gasoline x 125,000 btu/gal. = 8.75×10^7 btu

30 gal. diesel x 139,000 btu/gal. = 4.17×10^6 btu

320 gal. kerosene x 135,000 btu/gal. = 4.32×10^7 btu

Total Energy requirement for Emulsion Seal:

3.7324×10^8 btu

2985.9 equiv. gal. gasoline

Energy Requirements for Cutback Seal

*Assume cutback used to be RC-2, no other changes made from emulsion seal

Energy required to produce cutback asphalt:

54,300 gal. x 58,800 btu/gal.** = 3.1928×10^9 btu

Fuel usage assumed to be the same:

gasoline	8.75×10^7 btu
diesel	4.17×10^6 btu
kerosene	4.32×10^7 btu

Additional btu's necessary to elevate heat of cutback to shoot temperatures:

300 btu/gal. x 54,300 gal. = 1.629×10^7 btu

***Energy required to dry aggregate:

to operate dryer

1722 ton x 4780 btu/ton = 8.2312×10^6 btu

aggregate drying assuming 5% water

1722 ton x 1.4 x 10^5 btu/ton = 2.4108×10^8 btu

Total Energy requirement for cutback seal:

3.5933×10^9 btu

Equiv. gal. of gasoline = 28,746 gal.

Total energy requirement for cutback seal if aggregate drying not included =

3.344×10^9 btu

Equiv. gal. of gasoline = 26,752 gal.

**The 58,800 btu/gal. also includes the energy in the solvent.

***This procedure is not normally performed in Texas.

Theoretical net savings in energy reported in equivalent gallons of gasoline:

Total energy requirement for cutback seal:	3.5933×10^9 btu
Total energy requirement for emulsion seal:	3.7324×10^8 btu
Energy saved	3.2201×10^9 btu
Equivalent gallons of gasoline	25,760

Total energy requirements for cutback seal as normally done in Texas: 3.344×10^9 btu

Total energy requirement for emulsion seal:	3.7324×10^8 btu
Energy saved	2.9708×10^9 btu
Equivalent gallons of gasoline	23,766

Gallons of petroleum distillates required:

Emulsion - 0

Cutback - 16,290

Gallon of petroleum distillates saved:

16,290

Energy saved by elimination of aggregate drying operation:

2.4931×10^8 btu

Equivalent gallons of gasoline:

1994.5