EVALUATION OF RUBBER-ASPHALT CHIP SEALS IN OREGON

Final Report

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Contract DOT-FH-15-201

by

Oregon Department of Transportation
Highway Division

September 1982

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INTRODUCTION

The Oregon State Highway Division, in cooperation with the Federal Highway Administration, participated in a demonstration project on the evaluation of rubber-asphalt chip seals. The trial projects were placed in Maintenance District 11, in the vicinity of Klamath Falls. The object of the project was to give this type of seal coat a working test in Oregon. The process originated in Arizona and has now been utilized extensively in many states. Sahuaro Petroleum of Phoenix, Arizona has been the major concern behind the process.

Two small sections of rubber-asphalt chip seal were placed in the Klamath Falls area in July of 1974. The performance obtained from these trial sections was very good. When the FHWA provided the opportunity for Oregon to participate in the demonstration project program to provide a more extensive test of the process, District 11 requested that the work be done in that district.

Sites were selected to evaluate three different conditions:

1. Warner Highway No. 431 (State Route 140)
   Milepost 16 to 18 and Milepost 23.4 to 27 (5.6 miles)
   (a) ADT: 220
   (b) Width: 20 to 22 feet
   (c) Temperature (ten-year average of extremes):
       -3 F to 101 F
   (d) Average rainfall: 9.33 inches
   (e) Surface: Penetration oil mat

2. The Dalles-California Highway No. 4 (U.S 97)
   Milepost 221 to 224 (3 miles)
   (a) ADT: 2900
   (b) Width: 32 feet
   (c) Temperature (ten-year average of extremes):
       -14 F to 95 F
   (d) Average rainfall: 29.93 inches
   (e) Surface: Asphalt concrete

3. The Dalles-California Highway No.4
   Bridge Decks: Milepost 272.79
   Milepost 275.06
   Milepost 275.75

These sites provided an oil mat surface carrying low traffic volume, an asphalt concrete overlay carrying high truck volumes, plus the membrane-type application on concrete bridge decks. Figure 1 is a map of south Central Oregon showing the locations of these three projects.

For comparison, control sections consisting of Oregon's normal 0-31 chip seal were placed on each of the highway projects. Each control section is approximately 0.5 miles long and consists of a one-shot chip seal. Figure 2 is a diagram illustrating the relative positions of the various segments of each project.

CONSTRUCTION PROCEDURE

The following is a general description of the construction procedure. For more specific information refer to the specifications attached as Appendix B.

Surface Preparation:

A tack coat was applied only to the three bridge decks. The only preparation for the Warner and The Dalles-California sites was power brooming just prior to application of the binder.

Binder:

The binder, composed of finely ground tire rubber and AR 1000 asphalt cement blended at a ratio of one part rubber to three parts asphalt by weight, was applied at an approximate rate of 0.55 gallons per square yard. Because of the special nature of the material, a special distributor was necessary. To prevent the undissolved rubber from settling in the tank, the distributor had twin counter-action augers to continuously stir the mixture. To achieve a more satisfactory viscosity for spraying and to improve the wetting of the aggregate, approximately 6 percent kerosene was added to the binder. A portion of the Warner Highway project was done without diluent when the local supply was exhausted.

Aggregate:

The aggregate, 3/8 inch nominal, was preheated and precoated with 0.7 percent asphalt cement to improve the bond between the binder and the stone. A self-propelled aggregate spreader followed immediately behind the binder distributor. Continuous passes were then made by both pneumatic and steel rollers. A dust coat of sand was applied after rolling and before opening the lane to traffic.

Figure 3 provides a series of photographs illustrating the prior pavement condition, the construction procedure used on the project, and the final surface of the rubber-asphalt chip seal.

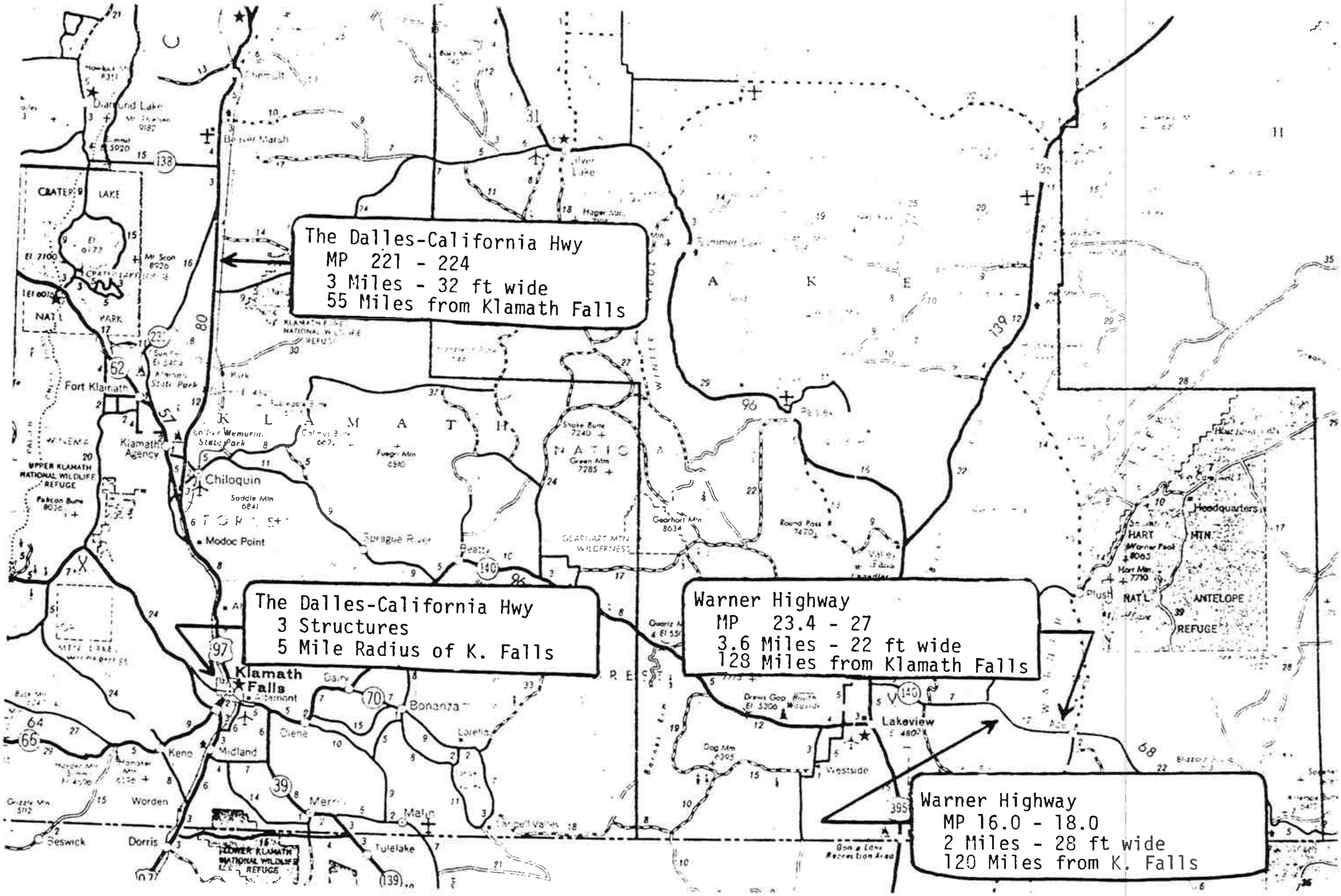

FIGURE 1

Location Map

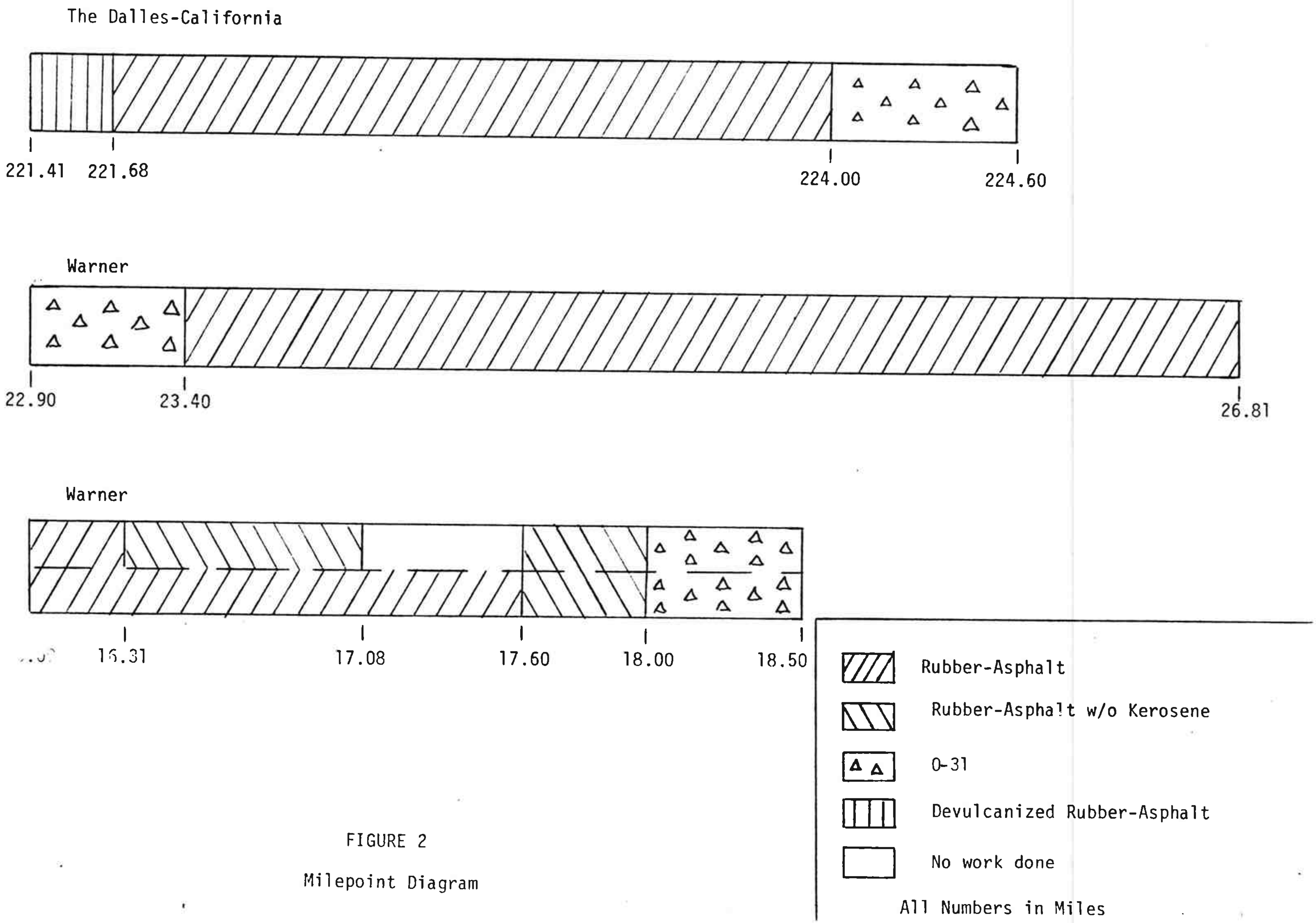

FIGURE 2

Milepoint Diagram

FIGURE 3

Construction Procedure
Rubber-Asphalt Chip Seal

a. Close-Up of Old Pavement

b. Loading Rubber into Distributor

c. Equipment Train: Distributor, Chip Spreader, Rollers

d. Close-Up of Distributor

FIGURE 3 (cont'd)

Construction Procedure
Rubber-Asphalt Chip Seal

e. Applying Aggregate

f. Pneumatic Rollers

g. Steel Wheel Finish Roller

h. Final Surface

EVALUATION PROCEDURE

Twenty sections in both the Warner Highway project and The Dalles-California Highway project, each ten feet long and one-half the pavement width wide, were selected for evaluation by using a random number table. Each project had fourteen rubber-asphalt test sections and six O-31 chip seal control sections. The extent and type of cracking was recorded and color photographs were taken. These projects were evaluated for three years, with evaluations occurring before construction, three months after construction and then at approximate six-month intervals beginning six months after construction. The results of these performance surveys are attached as Appendix A.

MATERIAL QUANTITIES

Warner Highway:

On July 19, 1976 construction started on the Warner Highway project near Adel. Several minor problems were encountered the first day; some involving procedures and some with the distributor. The problems were corrected with little difficulty.

On the Warner Highway, the chip seal was divided into two sections. From milepost 16.02 to milepost 18.0, 22,458 square yards were placed. Of this, kerosene was added to the rubber-asphalt mixture for 12,326 square yards. The other 10,132 square yards were placed without kerosene because the stock was depleted and since Adel is so isolate, a significant delay would have occurred in obtaining more kerosene. The material seemed to go down satisfactorily without kerosene. The other section of chip seal on the Warner Highway extends from milepost 22.90 to milepost 26.81 and contains 44,012 square yards, all with kerosene.

A tabulation of the quantities and rates of application of the rubber asphalt sections for the Warner Highway project follows:

Total Area Covered	66,470 sq yd
Asphalt Cement (AR 1000)	
Pre-coat	8.89 ton
Asphalt portion of the binder	120.15 ton
Total	129.04 ton
Application rate (including precoat)	0.46 gal/sq yd
Rubber	
Weight	37.32 ton
Application rate	1.12 lb/sq yd
Percent of total binder	24 percent
Binder (not including precoat)	
Weight	157.47 ton
Application rate	0.55 gal/sq yd

Aggregate	
Weight	1,270 ton
Application rate	38.2 lb/sq yd

The Dalles-California Highway:

On The Dalles-California Highway, 43,554 square yards of rubber-asphalt chip seal were placed. The rubber-asphalt section of this project extends from milepost 221.68 to milepost 224.00.

A tabulation of the quantities and rates of application for the rubber-asphalt sections on The Dalles-California project follows:

Total Area Covered		43,554 sq yd
Asphalt Cement (AR 1000)		
Precoat		7.24 ton
Asphalt portion of binder		82.91 ton
	Total	90.15 ton
Application rate (including precoat)		0.49 gal/sq yd
Rubber		
Weight		25.8 tons
Application rate		1.18 lb/sq yd
Percent of total binder		24 percent
Binder (not including precoat)		
Weight		108.7 tons
Application rate		0.58 gal/sq yd
Aggregate		
Weight		1,034 ton
Application Rate		47.5 lb/sq yd

Bridge Decks:

A total of 5,709 square yards of rubber-asphalt chip seal was placed on three bridge decks. In addition, a roadway section 26 feet by 400 feet consisting of 1,156 square yards was placed in the maintenance yard in Klamath Falls to utilize the binder remaining in the distributor after shooting the bridge decks.

A tabulation of the quantities and rates of application for the bridge projects, excluding the maintenance yard portion, is as follows:

Total Area Covered		5,709 sq yd
Asphalt Cement (AR 1000)		
Precoat		0.93 tons
Asphalt portion of binder		12.37 tons
	Total	13.30 tons

Application rate (including precoat)	0.58 gal/sq yd
Rubber	
Weight	4.73 tons
Application rate	1.7 lb/sq yd
Percent of total binder	28 percent
Binder (not including precoat)	
Weight	17.1 tons
Application rate	0.69 gal/sq yd
Aggregate	
Weight	103 ton
Application rate	36 lb/sq yd

COSTS

The costs listed below include labor, equipment rental, materials, plant set-up, and moving costs at the time of construction during 1976, but they do not include the O-31 control section chip seal costs.

Warner Highway Project:

	Labor	Equipment	Material	Total
Laydown	$10,258	$4,588	$38,163	$53,009
Moving	2,389	255	---	2,614
Special Distributor	---	---	5,850	5,850
TOTAL	$12,647	$4,813	$44,013	$61,473

$61,473/66,470 sq yd = $0.925 per sq yd

Labor	12,647/61,473 = 21%
Equipment	4,813/61,473 = 8%
Materials	44,013/61,473 = 71%

The Dalles-California Highway Project:

	Labor	Equipment	Material	Total
Laydown	$7,312	$2,783	$22,644	$32,739
Moving	813	236	---	1,049
Special Distributor	---	---	3,900	3,900
Stockpiling Aggregate	---	---	4,200	4,200
TOTAL	$8,125	$3,019	$30,744	$41,888

$41,888/43,554 = 0.962 per sq yd

Labor	8,125/41,888 = 19%
Equipment	3,019/41,888 = 7%
Materials	30,774/41,888 = 73%

Bridge Decks:

	Labor	Equipment	Material	Total
Laydown	$3,098	$ 570	$ 4,977	$ 8,645
Patching	663	57	643	1,363
Special Distributor	---	---	1,950	1,950
TOTAL	$3,761	$ 627	$ 7,570	$11,958

$11,958 x 83% = $9,925
Remaining 17% placed in Klamath Falls Maintenance Yard

$9,925/5,709 sq yd = $1.74 per sq yd

Labor	3,761/11,958 = 31%
Equipment	627/11,958 = 5%
Materials	7,570/11,958 = 63%

SUMMARY OF COSTS

	Sq Yd Unit Cost	Percent Labor	Percent Equipment	Percent Materials
Warner	$0.925	21	8	71
The Dalles-Caliornia	$0.962	19	7	73
Bridge Decks	$1.74	31	5	63

In the above costs, the bridge deck cost is not entirely representative. The crews involved in the laydown were working four ten-hour shifts per week. Because of the high cost of distributor rental, the bridge seals were placed on a Friday. The crews were on overtime all that day. Also, the bridge installations required three full sets of signs, flagmen, and pilot cars. In addition, it was necessary to clean the structures again on the day of installation. This was caused by having the tack coat put down a day in advance and it had to be sanded the afternoon before the application of the rubber-asphalt chip seal. Tacking should be performed just prior to placing the rubber-chip seal.

On the Warner Highway project and The Dalles-California project the costs were within the expected range. Information from the Sahuaro Petroleum staff indicated contract projects they had worked on had ranged from $0.75 per square yard to $1.50 per square yard. The cost of $0.94 per square yard incurred on the Oregon highway projects may have been reduced by having a second special distributor. It took from 1 to 1.5 hours each time to load the distributor, and by having only one, this resulted in a significant waste of crew time. An evaluataion would be needed to compare the extra cost of providing a second distributor with the loss of time in having only one. For large projects, a second distributor would surely be economical.

For comparison, the estimated cost for a one inch asphalt concrete overlay based on local cost at that time was $1.00 per square yard for Class "C" mix and $1.25 per square yard for Class "B" mix. These costs do not include the tack coat.

RESULTS

After three years of evaluation, the rubber-asphalt chip seal has proven very successful. Almost all the cracks in both the rubber-asphalt sections and the 0-31 one shot chip seal control sections appear to be reflections of cracks which were in the original surface before the seals were applied. The rubber-asphalt sections showed superior performance in that cracks took longer to reflect through, the cracking was less extensive and all but the larger cracks (those greater than one inch) were still sealed. In the 0-31 sections, cracks which were larger than one-half inch reopened and more smaller hairline cracks were evident.

Table 1 shows a comparison between the rubber-asphalt and the 0-31 sections. While 43 percent of the rubber-asphalt sections showed no defects after three years, none of the 0-31 sections were without defects. Also significant, only five percent of the rubber-asphalt sections showed major defects after three years as compared to 27 percent of the 0-31 sections.

It was observed that the transverse cracks in the rubber-asphalt sections tended to narrow and seal as the crack passed through the wheel paths. Cracks which were very apparent at the road edge often disappeared as they traversed the wheel path. The kneading action of traffic, in combination with the ductile nature of the rubber-asphalt binder, kept the cracks sealed in the wheel paths.

An additional benefit of the rubber-asphalt chip seals was increased traction on the bridges during the winter. The test bridges were the last to have snow buildup and the first to thaw. One bridge had had a history of particularly bad traffic backups during snow storms each year. Since the placement of the rubber-asphalt chip seal, this problem has been reduced.

RECOMMENDATIONS

The rubber-asphalt chip seal provides an excellent strategy for extending the service life of pavements when carefully constructed on appropriate facilities. However, being a thin, one-shot process, there are obvious limitations to what it can be expected to do. It is not recommended on roads having major deterioration in the form of potholes or deep rutting without first leveling the surface with asphalt treated materials.

TABLE 1

Summary of Performance

	Years Since Sealing	Percentage of Sections in Each Category of Defect		
		None	Minor	Major
Rubber-Asphalt	1	76	24	0
	3	43	52	5
0-31 Oil Mat	1	27	73	0
	3	0	73	27

None - no defects.

Minor - few defects, minor in nature.

Major - extent of cracking equal or worse than before seal applied.

Also, it is not recommended for roads with high traffic volumes because of the potential damage from flying rock chips from the newly placed seal. Although the thicker, more viscous, rubber-asphalt binder holds the chips better than a conventional asphalt chip seal, the nature of this construction requires that a surplus of chips be applied. Chips dislodged by high speed traffic during the first few days after construction can cause damage to vehicle windshields and paint.

Filling of major cracks with rubber-asphalt prior to the application of the chip seal is recommended to help insulate the base and subgrade from water penetration and to delay the reflection of the cracks through the seal.

The cost of the rubber-asphalt process is an obstacle to its adoption as a regular procedure. The rubber-asphalt chip seal is approximately three times as expensive as the O-31 chip seal. Although the rubber-asphalt demonstrated superior performance, its cost effectiveness is still open to question.

There are a number of reasons the rubber modified chip seal is more expensive than the conventional O-31 chip seal. The cost of the rubber is inherent to the process and cannot be avoided. A heavier binder application is used which improves the quality but increases the cost. A special agitating distributor is required for application which must be brought in from Arizona, greatly increasing mobilization costs. The use of hot, precoated chips was recommended and used. The heating and coating of the aggregate is a cause of extra time and expense that might be avoided under carefully controlled conditions. In warm, dry climates, satisfactory jobs have been reported with the use of clean, washed, dry chips and above 70 F construction temperatures. However, all of these conditions would have to be met.

A test section using the devulcanized asphalt-rubber process failed and required an asphalt concrete overlay to eliminate slipperiness because of failure of the binder to adhere to the chips. In this case, construction conditions were adverse; the chips were damp and the temperature was cool. The use of hot, precoated chips provides some tolerance when less than ideal construction conditions are encountered.

Although not a part of this demonstration project, the Oregon State Highway Division has utilized the stress absorbing membrane innerlayer, SAMI, under several asphalt concrete overlays. Where the rubber-asphalt is to be overlayed, retention of the chips is not important except to carry traffic during construction. For SAMI construction, the expense of heating and coating the chips would not be justified even where less than ideal conditions prevailed.

APPENDIX A

Performance Surveys

Warner Highway

and

The Dalles-California Highway

PERFORMANCE SURVEY
Warner Highway

06/15/76
Before Construction

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79	50 sq ft	
2	T	16.86		
3	T	16.92	16 sq ft	1 transverse 2' 1 longitudinal 10'
4	T	17.10	70 sq ft Spalling	1 longitudinal 8'
5	T	17.24		2 longitudinal 10' each
6	T	17.50		1 longitudinal shoulder 10'
7	T	17.61	10 sq ft Spalling, 1/2" Dip	
8	C	18.17	Some Spalling	1 transverse 10' 3/4" wide
9	C	18.20	Minor Spalling	1 transverse 10' 1-1/2" wide
10	C	18.485	25 sq ft Block	3 longitudinal 2' each 3 transverse 4' each
11	C	23.08	Minor Spalling	3 transverse, 1-4', 2-2' 3 longitudinal, 2-10', 1-4'
12	C	23.298	Shoulder Cracking Minor Spalling	
13	C	23.327	Block 30 sq ft	1 transverse 9'
14	T	24.26		Minor 5 transverse 2' each
15	T	24.777	Spalling minor Block 50 sq ft	
16	T	25.382	Spalling 10 sq ft Block 30 sq ft	3 longitudinal each 6' long
17	T	25.824	Spalling 4 sq ft Block 20 sq ft	
18	T	25.953	Shoulder spalling Block 30 sq ft	1 transverse 10' 4 longitudinal 3'
19	T	26.126	Minor spalling Block 70 sq ft	3 longitudinal 2'
20	T	26.602	Deep spalling 20 sq ft Block 25 sq ft	3 transverse 3' 6 longitudinal 2'

Warner Highway

09/09/76

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79	Surface OK	
2	T	16.86	Surface OK	
3	T	16.92	Surface OK	
4	T-no rubber left lane	17.10		
5	T-no rubber left lane	17.24		
6	T-no rubber left lane	17.50		
7	T	17.61	Surface OK	
8	C	18.17		Filled transverse 10'
9	C	18.20		Filled transverse 10'
10	C	18.485		3 filled longitudinal 2' 3 filled transverse 4'
11	C	23.08	Surface OK	
12	C	23.298	1-3" sq hole	Minor cracking along pavement edge
13	C	23.327	Surface OK	
14	T	24.26	Surface OK	
15	T	24.777	Surface OK	
16	T	25.382	Surface OK	
17	T	25.824	Surface OK	
18	T	25.953	Surface OK	
19	T	26.126	Surface OK	
20	T	26.602	Surface OK	

Warner Highway

12/13/76

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79	Surface OK	
2	T	16.86	Surface OK	
3	T	16.92	Surface OK	
4				
5				
6				
7	T	17.61	Surface OK	
8	C	18.17		1 transverse 10 ft
9	C	18.20		1 transverse 10'
10	C	18.485	Block 6 sq ft	1 longitudinal 4'
11	C	23.08		1 longitudinal 3' 1 transverse 1'
12	C	23.298	Surface OK	
13	C	23.327	Surface OK	
14	T	24.26	Surface OK	
15	T	24.777	Surface OK	
16	T	25.382	Surface OK	
17	T	25.824	Surface OK	
18	T	25.953	Surface OK	
19	T	26.126	Surface OK	
20	T	26.602	Surface OK	

Warner Highway

07/18/77

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79	Surface OK	
2	T	16.86	Surface OK	
3	T	16.92	Surface OK	
4				
5				
6				
7	T	17.61	Surface OK	
8	C	18.17		1 transverse 10'
9	C	18.20		1 transverse 10'
10	C	18.485	Block 6 sq ft	1 longitudinal 4'
11	C	23.08		1 longitudinal 3' 1 transverse 1'
12	C	23.298	Surface OK	
13	C	23.327	Surface OK	
14	T	24.26	Surface OK	
15	T	24.777	Surface OK	
16	T	25.382	Surface OK	
17	T	25.824	Surface OK	
18	T	25.953	Surface OK	
19	T	26.126	Surface OK	
20	T	26.602	Surface OK	

Warner Highway

01/24/78

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79		1 longitudinal 4' 1 longitudinal 2'
2	T	16.86	Surface OK	
3	T	16.92		1 transverse 10'
4				
5				
6				
7	T	17.61	Covered by snow - ice pack	
8	C	18.17		1 transverse 10'
9	C	18.20		1 transverse 10'
10	C	18.485	Block 10 sq ft	1 longitudinal 10'
11	C	23.08	1 longitudinal 3'	1 transverse 3' 1 transverse 5'
12	C	23.298	Minor shoulder cracking	
13	C	23.327		1 transverse 9'
14	T	24.26	Surface OK	
15	T	24.777	Surface OK	
16	T	25.382	Surface OK	
17	T	25.824	Surface OK	
18	T	25.953	Appears to be reflective cracks	1 transverse 2' 1 transverse 3'
19	T	26.126	Surface OK	
20	T	26.602	Surface OK	

Warner Highway

07/19/78

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79		1 longitudinal 10' 1 transverse 4'
2	T	16.86	Surface OK	
3	T	16.92		1 transverse 10'
4				
5				
6				
7	T	17.61	Surface OK	
8	C	18.17		1 transverse 10'
9	C	18.20		1 transverse 10'
10	C	18.485	Block 10 sq ft	1 longitudinal 10'
11	C	23.08		2 transverse, 1-3', 1-5' 1 longitudinal 3'
12	C	23.298	Minor shoulder cracking surface raveling	
13	C	23.327		1 transverse 9'
14	T	24.26	Surface OK	
15	T	24.777	Surface OK	
16	T	25.382	Surface OK	
17	T	25.824	Surface OK	
18	T	25.824	Appears to be reflective cracks	2 transverse, 1-2', 1-3'
19	T	26.126	Surface OK	
20	T	26.602	Surface OK	

Warner Highway
08/21/79

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	16.79		2 longitudinal 10' & 2' 2 transverse 2' Each
2	T	16.86	Surface OK	
3	T	16.92		1 transverse 10'
4	Eliminated			
5	Eliminated			
6	Eliminated			
7	T	17.61	Surface OK	
8	C	18.17		1 transverse 10'
9	C	18.20		1 transverse 10'
10	C	18.485	Cracks in old surface reflecting through	
11	Eliminated			
12	Eliminated			
13	Eliminated			
14	T	24.26	Surface OK	
15	T	24.777	Surface OK	
16	T	25.382	Surface OK	
17	T	25.824	Surface OK	
18	T	25.953	Cracks in old surface reflecting through	
19	T	26.126	Surface OK	
20	T	26.602	Surface showing minor fatigue	

Cracks appearing in the surface of both the Test and Control sections are reflecting from cracks that were in the original surface before seals were applied. Most of the cracks in the test section are still bridged by the rubberized material, while in the control section the cracks are open.

PERFORMANCE SURVEY
The Dalles-California Highway

06/30/76
Before Construction

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	221.117		2 longitudinal 10' & 6'
2	T	221.219	Minor Spalling	1 transverse 2'
3	T	221.369	Block 10 sq ft	2 transverse 4' & 8'
4	T	221.373		3 longitudinal 6'
5	T	221.483	Block 20 sq ft	1 longitudinal 16'
6	T	221.765	Block 30 sq ft	
7	T	221.903	Block 8 sq ft	4 transverse 6' each
8	T	222.860	Block 60 sq ft	1 transverse 10'
9	T	222.875	Block 40 sq ft	1 longitudinal 10' 1 transverse 4'
10	T	222.953	Block 155 sq ft	1 transverse 12'
11	T	223.145	Block 120 sq ft	
12	T	223.523		3 longitudinal 10'
13	T	223.751		1 transverse 41' 2 longitudinal 10'
14	T	223.874		3 minor long. 4' each 3 minor trans. 3' each
15	C	224.109		2 longitudinal 10'
16	C	224.202		1 longitudinal 10' 1 transverse 6'
17	C	224.227	Block 16 sq ft	2 transverse 16' & 8'
18	C	224.347		2 transverse 1'
19	C	224.385		2 longitudinal 3' 2 transverse 4' & 10'
20	C	224.493		2 transverse 8'

The Dalles-California Highway
09/08/76

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1	T	221.117		
2	T	221.219		
3	T	221.369		
4	T	221.378		
5	T	221.483		1 longitudinal 4' 1 transverse 16'
6	T	221.765	Surface OK	
7	T	221.903		1 filled transverse 4'
8	T	222.860		1 filled transverse 3'
9	T	222.875	Surface OK	
10	T	222.953	Surface OK	
11	T	223.145	Surface OK	
12	T	223.523	Surface OK	
13	T	223.751	Surface OK	
14	T	223.874	Surface OK	
15	C	224.109	Surface OK	
16	C	224.202		1 transverse 3'
17	C	224.227		1 transverse 3'
18	C	224.347	Surface OK	
19	C	224.385		1 transverse 6'
20	C	224.493		1 transverse 8'

The Dalles-California Highway

12/02/76

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1				
2				
3				
4				
5				
6	T	221.765	Surface OK	
7	T	221.903		1 filled transverse 4'
8	T	222.860		1 filled transverse 3'
9	T	222.875		1 transverse 2'
10	T	222.953	Surface OK	
11	T	223.145	Surface OK	
12	T	223.523	Surface OK	
13	T	223.751	Surface OK	
14	T	223.874	Surface OK	
15	C	224.109		1 longitudinal 1'
16	C	224.202		1 transverse 5'
17	C	224.227		1 transverse 10' 2 longitudinal 2'
18	C	224.347	Surface OK	
19	C	224.385		1 transverse 6'
20	C	224.493		1 transverse 8'

The Dalles-California Highway

07/14/77

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1				
2				
3				
4				
5				
6	T	221.765	OK	OK
7	T	221.903	OK	1 transverse 5' 1 transverse 2'
8	T	222.860	OK	1 transverse 1'
9	T	222.875	OK	1 transverse 2'
10	T	222.953	OK	OK
11	T	223.145	OK	OK
12	T	223.523	OK	OK
13	T	223.751	OK	1 transverse 6'
14	T	223.874	OK	OK
15	C	224.109	OK	1 longitudinal 6'
16	C	224.202	OK	1 transverse 4' 1 longitudinal 1'
17	C	224.227	OK	1 transverse 5' 1 longitudinal 10'
18	C	224.347	OK	OK
19	C	224.385	OK	1 transverse 5'
20	C	224.493	OK	1 transverse 4'

The Dalles-California Highway

07/20/78

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1				
2				
3				
4				
5				
6	T	221.765	Surface OK	
7	T	221.903	OK	1 transverse 5'
8	T	222.860	Surface OK	
9	T	222.875	OK	1 transverse 2'
10	T	222.953	OK	1 transverse 5'
11	T	223.145	Some cracks in old surface starting to reflect through	
12	T	223.523	Surface OK	
13	T	223.751	OK	1 transverse 6'
14	T	223.874	OK	1 transverse 4'
15	C	224.109	Minor fatigue	1 longitudinal 10'
16	C	224.202	Minor fatigue	2 transverse 3' each
17	C	224.227	Minor fatigue	1 longitudinal 10' 1 transverse 5'
18	C	224.347	Minor fatigue	
19	C	224.385	Minor fatigue	1 transverse 5'
20	C	224.493	Minor fatigue	1 transverse 4'

The cracks appearing in the surface of both the test and control sections are reflecting from cracks that were in the original surface before seals were applied. Most of the cracks in the test section are still bridged by the the rubberized material, while in the control section the cracks are open.

The Dalles- California Highway

07/24/79

Section Number	Test(T) or Control(C)	Beginning Station	Fatigue/ Block-Type sq ft	Transverse/ Longitudinal ft
1				
2				
3				
4				
5				
6	T	221.765	Surface OK	
7	T	221.903	OK	1 longitudinal 3' 1 transverse 5'
8	T	222.860	OK	2 small pot holes
9	T	222.875	OK	1 transverse 3'
10	T	222.953	OK	1 transverse 4'
11	T	223.145	Some cracks in old surface starting to reflect through	
12	T	223.523	Surface OK	
13	T	223.751	OK	1 transverse 5'
14	T	223.874	Eliminated	
15	C	224.109	Minor fatigue	1 transverse 5' 1 longitudinal 10'
16	C	224.202	Minor fatigue	2 transverse 3' each
17	C	224.227	Minor fatigue	1 longitudinal 10' 1 transverse 5'
18	C	224.347	Minor fatigue	
19	C	224.385	Minor fatigue	2 transverse 2' & 5'
20	C	224.493	Minor fatigue	1 transverse 4'

Cracks appearing in the surface of both the Test and Control sections are reflecting from cracks that were in the original surface before seals were applied. Most of the cracks in the test section are still bridged by the rubberized material, while in the Control section the cracks are open.

APPENDIX B

Specifications

for

Rubber-Asphalt Chip Seal

(c) Cover Aggregate

(1) The cover aggregate shall have a percentage of wear not to exceed 40 at 500 revolutions when tested in accordance with AASHTO Designation T-96, and shall not have a loss greater than 12 percent when tested in accordance with the sodium sulphate soundness test AASHTO Designation T-104.

(2) Aggregates of questionable polishing characteristics shall not be used.

(3) It shall be clean and free of any clay coating. A minimum of 75 percent of the material, by weight, retained on the No. 8 sieve, shall have at least one fractured face produced by crushing.

(4) Grading of the stone cover aggregate, when tested in accordance with AASHTO Designations T-11 and T-27, shall comply with the following gradations:

TABLE NO. 1

1/4-Inch Nominal Cover Aggregate
(for airport and for light street traffic volume)

Sieve Size	Percent Passing
3/8 inch	100
1/4 inch	80-100
No. 8	0-5
No. 200	0-2

TABLE NO. 2

3/8-Inch Nominal Cover Aggregate
(for heavy street traffic volume)

Sieve Size	Percent Passing
1/2 inch	100
3/8 inch	70-100
1/4 inch	0-10
No. 8	0-5
No. 200	0-2

(5) The cover aggregate shall be preheated to a temperature between 290°F. and 350°F. and precoated with not more than .75 percent of penetration grade asphalt, as directed by the engineer. (Note 2)

(6) Canvas or similar covers that completely cover each load shall be used to minimize temperature drop of the exposed material if directed by the engineer.

.03 Equipment

(a) The equipment used by the contractor shall include a self-propelled power broom for cleaning the existing pavement surface.

(b) Three pneumatic tired rollers, each carrying a minimum of 5,000 pounds on each wheel and a minimum of 100 pounds per square inch on each tire.

(c) Self-propelled aggregate spreading equipment that can be so adjusted as to spread accurately the given amounts per square yard.

(d) A self-powered pressure distributor equipped with a separate power unit, distributing pump capable of pumping the specified material at the specified rate through the distributor tips, and equipment for heating and mixing the bituminous material. The distribution bar on the distributor shall be fully circulating with nipples and valves so constructed that they are in such intimate contact with the circulating asphalt that the nipples will not become partially plugged with congealed asphalt upon standing, thereby causing preliminary streaked or irregular distribution of the asphalt. Any distributor that produces a streaked or irregular distribution of the material shall be promptly removed from the project.

Note 2: Precoating, canvas covering and preheating of cover aggregate may be waived when proper facilities are not available and application conditions are favorable. Precoating is often used for dust control.

Distributor equipment shall include a tachometer, pressure gages, volume measuring devices, mixing equipment and a therometer for reading temperature of tank contents. The spray bars on the distributor shall be controlled by a bootman riding at the rear of the distributor in such a position that operation of all sprays is in full view and accessible to him for controlling spread widths.

The method and equipment for combining the rubber and asphalt shall be so designed and accessible that the engineer can readily determine the percentages, by weight, of each of the two materials being incorporated into the mixture and the mixing equipment capable of producing a homogenous mix of rubber and asphalt so that separation does not occur.

Prior to the spreading of the rubber asphalt composition all distributor trucks proposed for use shall have been tested within six months from the date of spreading to determine the rate of the transverse spread. The contractor shall furnish the engineer with evidence that the transverse spread of the distributor trucks, when the trucks were approved for use, was as uniform as practicable and under no conditions was there a variance on any of the test pads greater than plus or minus 15 percent. If there is evidence to the contrary, the engineer may require that each distributor truck be tested to determine the rate of the transverse spread. Transverse spread shall be determined on the vulcanized rubber asphalt product meeting these specifications only. No transverse spread on other asphalt products will be accepted.

.04 Construction Details

(a) Mixing

(1) The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semifluid material. The temperature of the asphalt shall be between 350°F. and 450°F. The engineer shall be the sole judge of when the material has reached application consistency.

(2) The proportions of the two materials, by weight, shall be 75 percent, plus or minus 2 percent, asphalt; and 25 percent, plus or minus 2 percent, rubber. After the full reaction described in (a) Mixing (1) above has occurred, the mix shall be diluted with a diluent. The amount of diluent used shall be 5-1/2 percent to 7-1/2 percent, by volume, of the hot asphalt-rubber composition as required for adjusting viscosity for spraying or better "wetting" of the cover aggregate. The diluent shall have boiling point of not less than 350°F., and the temperature of the hot composition shall not exceed this temperature at the time of adding the diluent.

(3) After reaching the proper consistency, application shall proceed immediately; and in no case shall the mixture be held at temperatures over 330°F. for more than one and one-half (1½) hours after reaching that point.

(b) Spreading

(1) Prior to the hot asphalt-rubber treatment, the surface to be sealed shall be cleaned, patched as required, and treated with a bituminous tack coat consisting of .05 to 0.1 gallon per square yard of diluted emulsified asphalt, paving grade asphalt or cutback asphalt of the type commonly used in the area for tack coating purposes. The tack coat shall be applied a minimum of one day prior to the application of asphalt-rubber seal.

(2) The application rate of the hot asphalt-rubber mixture in areas where the temperature remains above 20°F. in the winter season shall be 0.55± .03 gallons per square yard. In areas where the temperature drops below 20°F. an application rate of 0.60± .03 gallons per square yard should be used unless otherwise specified for special conditions (based on 7-1/2 pounds per hot gallon), do not use conversion factors to 60°F., use weight only.

(3) Weather limitations:

(a) The ambient air temperature is above 50°F.

(b) The pavement is absolutely dry

(c) The wind conditions are such that a satisfactory membrane can be achieved.

(4) The application rate of the cover aggregate shall be 25 to 40 pounds per square yard (generally 25 to 27 pounds for 1/4-inch nominal and 35 to 39 pounds for 3/8-inch nominal) as directed by the engineer to prevent pickup by the equipment involved in the spreading and compacting of the cover aggregate. A minimum of four complete coverages shall be made with a pneumatic roller. The rolling of the cover aggregate shall proceed immediately after application in order to ensure maximum embedment of the aggregate. Traffic shall not be permitted on the completed surface until permitted by the engineer but shall be not less than two hours after the completion of rolling.

(5) An application of five to ten pounds per square yard of concrete sand shall be applied after rolling and before opening a lane to traffic where traffic is of such volume or speed that it is displacing the cover aggregate.

(6) All joint edges shall be swept clean of overlapping cover material prior to the adjacent application of asphalt-rubber material. All reasonable precautions shall be taken to avoid "skips" and "overlaps" at joints and to protect the surfaces of adjacent structures from being spattered or marred. All transverse joints shall be made by placing building paper over the ends of the previous applications, and the joining application shall start on the building paper. The paper shall be removed and disposed of to the satisfaction of the engineer