IDENTIFICATION AND QUANTIFICATION OF THE EXTENT OF ASPHALT STRIPPING IN FLEXIBLE PAVEMENTS IN OREGON - PHASE II

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16. Abstract

This report is the second phase of a study in Oregon to evaluate the effect of material sources, void content, and additive type on retained strength (AASHTO T-165) or retained modulus (NCHRP Report 192). A total of 20 projects were evaluated in the laboratory as a part of Phase I. The results clearly indicated that material and additive type affect asphalt aggregate interaction.

The results of Phase II are presented herein. A total of 8 of the Phase I projects were sampled and tested for: 1) mix properties, and 2) asphalt and aggregate properties. The results of Phase II indicate: 1) there is evidence the IRS and modulus ratios correlate with field performance; 2) there is substantial variation in IRS and modulus ratios between the mix design and field cores; and 3) the long-term effects of additives need to be determined.

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DISCLAIMER

The contents of this report reflect the views of the authors who are solely responsible for the facts and the accuracy of the data presented. The contents do not necessarily reflect the official views of either the Federal Highway Administration or Oregon Department of Transportation.

1.0 INTRODUCTION

The problem of asphalt stripping, or the separation of the asphalt film from the aggregate through water displacement or emulsification, has long been recognized (1,2). In recent years there has been an increase in the expressed concern of stripping-related distress in pavements. Such distress has been reported in areas where there had not been any identified stripping problems in the past.

This study, undertaken by Oregon Department of Transportation to evaluate stripping in Oregon pavements, was carried out under Basic Agreement No. DOT-FH-11-8876.

1.1 Background

The study, initiated in September 1982, consisted of two separate phases. Phase I consisted of a laboratory evaluation of asphaltic concrete mixes with a number of different antistrip agents using AASHTO T-165 (Effect of Water on Cohesion of Compacted Bituminous Mixtures) and the Lottman retained modulus test (1,4). The results of Phase I were reported in March 1983 (3).

Phase II, a field evaluation of selected Phase I projects, was initiated in July 1983. This portion of the study consisted of testing field cores for various properties to evaluate the effectiveness of laboratory criteria for determining the need for antistrip agents. This report summarizes the significant Phase I results, as well as documenting the Phase II study.

1.2 Objective

As stated in the project statement, the overall study objective is to identify and quantify the extent of asphalt stripping in flexible pavements in

order to provide a better understanding of the problem and guidance to alleviate future pavement distress. This report addresses, specifically, the problem of stripping in the state of Oregon. Other agencies are to report similar findings in their states.

2.0 SUMMARY OF PHASE I

2.1 Projects Evaluated

A total of 24 projects were selected for evaluation in Phase I; however, only 20 were actually evaluated. They are identified in Table 2.1. Aggregates, asphalt cement, antistrip agent, and asphalt concrete mix from each project were submitted to the central laboratory for extensive testing. Criteria used to select the actual projects included:

1) aggregate type,
2) asphalt type, and
3) region of the state.

Figure 2.1 shows the location of each project in the state.

2.2 Test Program

A variety of tests were performed on the mix from each of the 20 projects. These are summarized in Table 2.2. These tests were performed on both:

1) mix batched and compacted in the laboratory using aggregate and asphalt obtained from the field, and
2) mix submitted from the field project.

Types of antistrip agents evaluated included Pavebond and lime.

2.3 Significant Results

The results of the Phase I study generally indicated that (3):

1) AASHTO T-165 alone may not always detect potential stripping problems. Consideration should also be given to using an index of retained strength or modulus ratio.

Table 2.1 - Projects Selected for Evaluation.

	Project	Identification	Tons of Mix	Type of Plant	Date of Mix Production	Average Daily Traffic
1.	Hanley Road-Fish Lake	115-1029	42,560	Batch	7/82	1745
2.	Sunny Valley-Jumpoff Joe Cr.	617-1009	47,800	Drum	10/82	12,600
3.	Beede Reservoir-Drinkwater Pass	13-1066	60,000	Batch	8/82	930
4.	Port Orford-Cape Sebastion	8-1066	18,400	Drum	7/82	3100-3700
5.	Burnt Hill-Thomas Creek	8-1064	32,500	Drum	7/82	3100-3700
6.	Ridge Dr. N.E.-Pine St. N.E.	324-1079	38,000	Drum	6/83	7000
7.	Nylund Rd.-Roaring Cr.	22-1013	26,500	Drum	10/82	7000
8.	Emigrant Hill-Meacham	630-1082	58,300	Drum	9/82	4800
9.	Midland-California State Line	18-1010	63,500	Batch	9/82	3300
10.	Vail Cr.-Nylund Rd.	22-1012	31,000	Drum	8/82	6800
11.	Weston-Weston Mountain	130-1079	45,000	Drum	8/82	610-1700
12.	Hermiston-Umatilla	30-1080	41,200	Drum	5/82	7900
13.	Golf Club Rd.-Stayton Jct.	124-1063	22,500	Drum	7/82	3000-4999
14.	N. Albany-N. Jefferson Int.	622-1007	55,000	Drum	5/82	31,800
15.	Willamette Hwy. @ Cloverdale Rd.	20-1049	2,050	Batch	7/82	7700
16.	Powder River Section*	1-1008	--	Drum	6/82	310
17.	Juniper Canyon-Lexington	525-1073	7,800	Drum	6/82	580
18.	32nd St.-Crest Motel (Astoria)	4-1039	7,500	Drum	6/82	7800-9300
19.	Reedsport-Dean Creek	10-1007	30,000	Drum	6/82	4250
20.	Wallace Bridge-Willamina ECL	127-1002	12,000	Drum	5/82	3500
21.	Roberts Cr.-Dillard Int.*	610-1006	--	--	--	--
22.	Cascade Const. Project*	(Rap-20%)	--	--	--	--
23.	Elkhead Rd.-Rice Hill NB	610-1008	45,000	Drum	6/82	12,000
24.	Willamette Western Project*	(Oregon City Plant)	--	--	--	--

*Not evaluated.

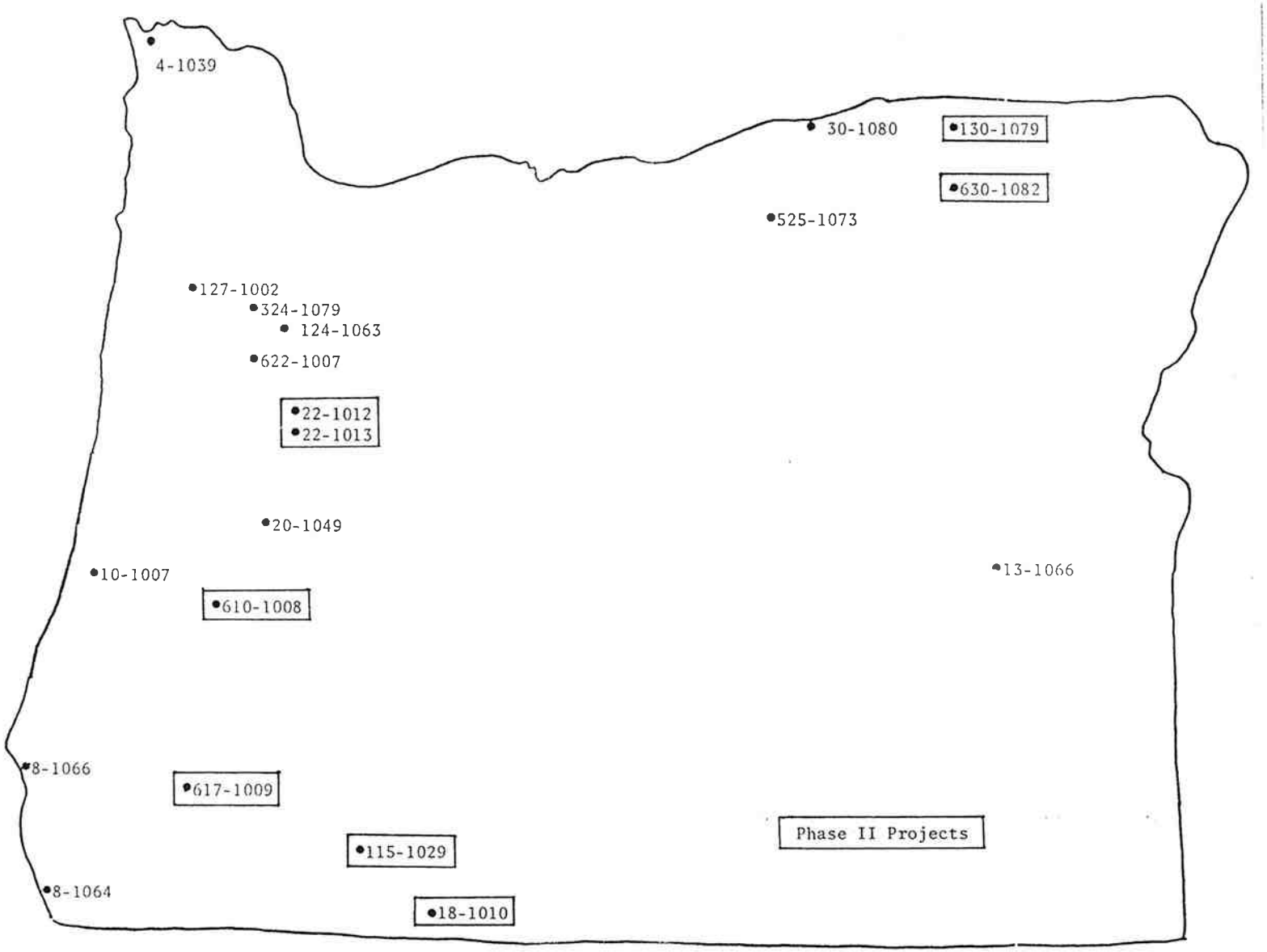

Figure 2.1. Project Locations for Phase I and Phase II.

Table 2.2 - Tests Used by Oregon DOT - Phase I.

Test	Method
Aggregates	
1. Gradation	T-27
2. Specific Gravity	T-84, T-85
3. DMSO	---
Mixture	
1. Specific Gravity	T-246
2. Maximum Specific Gravity	T-209
3. Stability	T-247
4. Index of Retained Strength	T-165
Standard - 3,000 psi	---
Two Alternates - 1,000 and 500 psi	---
5. Modulus*	
As-Compacted	---
After Vacuum Saturation	---
After Freeze-Thaw	---

*Method described in NCHRP Report 192(1).

2) Aggregate quality appears to be directly related to low values of index of retained strength and modulus ratio.

3) Significant differences existed for compressive strength and modulus between the submitted mixes and the laboratory batched mixes.

4) Level of compaction greatly affected compressive strengthy. However, IRS values show little change with compaction level.

5) Conditioning greatly affected modulus and modulus ratio values.

6) The use of additives generally increases both modulus ratio and index of retained strength.

3.0 TEST PLAN - PHASE II

This chapter describes the projects selected from the Phase I study to be evaluated in Phase II and the sampling program, data requirements, and test program used in the evaluation.

3.1 Projects Evaluated

A total of eight projects were selected to be evaluated from the 20 projects evaluated in Phase I. Of the eight projects evaluated, six were selected because of their susceptibility to moisture-induced damage and two were selected because they did not show susceptibility to moisture-induced damage. The projects selected are identified in Table 3.1.

3.2 Sampling Program

For each project evaluated, a set of two 4-inch diameter cores and three 6-inch diameter cores were taken from the following locations: 1) in the wheel-tracks in the travel lane, and 2) between the wheel-tracks in the travel lane. In addition, two 4-inch diameter cores and three 6-inch diameter cores were also taken from the wheel-tracks in the passing lane and between the wheel-tracks in the passing lane for the following projects:

1) Emigrant Hill-Meacham, (West and East Bound)
2) Sunny Valley-Jumpoff Joe Creek, (North and South Bound) and
3) Elkhead Road-Rice Hill (North Bound only).

For the projects with no evidence of raveling, wheel-track erosion, or suspected moisture-induced damage, the samples were taken at one location typical of the overall appearance of the surfacing. For projects with raveling, wheel-track erosion, or suspected moisture-induced damage, samples were taken at one location adjacent to the damaged area and at one location in an area without damage.

Table 3.1 - Projects Selected for Evaluation in Phase II.

a) Projects Susceptible to Moisture-Induced Damage

Project	Laboratory Result Indicating Potential Problem
1. Midland-California State Line	• Modulus ratio below 0.70
2. Nylund Road-Roaring Creek	• Additive needed to provide 70% IRS • Modulus ratio below 0.70
3. Emigrant Hill-Meacham	• Additive needed to provide 70% IRS
4. Vail Creek-Nylund Road	• Additive needed to provide 70% IRS • Modulus ratio below 0.70
5. Weston-Weston Mountain	• Modulus ratio below 0.70
6. Sunny Valley-Jumpoff Joe Creek	• Modulus ratio below 0.70

b) Projects Not Susceptible to Moisture-Induced Damage.

Project
1. Hanley Ranch-Fish Lake
2. Elkhead Road-Rice Hill (Northbound)

3.3 Data Requirements

Information requested from each location sampled in the selected projects consisted of the following:

1) highway sampled,
2) project sampled (section name),
3) mile post or station location of sampled area,
4) lane and direction of travel of sampled area,
5) condition of pavement,
    a) wheel-track wear depth to the nearest 1/8-inch,
    b) percent of surface with pavement defects such as flushing, cracking, soft aggregates, and so forth, and
6) photographs of the pavement surface.

Appendix A presents this information for each project.

3.4 Test Program

A variety of tests were performed on the wearing surface of the core samples from the eight projects evaluated. These are summarized in Table 3.2. Measurements of the pavement and lift thicknesses for each core were also taken.

Table 3.2 - Tests Used by Oregon DOT - Phase II.

a) Tests on 4-inch cores

Test	Test Method
1. Bulk specific gravity	OSHD TM 202, 203
2. Resilient modulus ratio	
As-compacted	*
After vacuum saturation	*
After freeze-thaw	*
3. Maximum specific gravity	OSHD TM 306
4. Percent voids	OSHD TM 305

b) Tests on 6-inch cores

Test	Test Method
1. Gradation	OSHD TM 309
2. Asphalt content	OSHD TM 309
3. Modulus ratio - laboratory-compacted mix	*
4. Index of retained strength - laboratory-compacted mix	OSHD TM 307
5. Percent voids - laboratory-compacted mix	OSHD TM 302, 305, 310
6. Reclaimed asphalt penetration and viscosity	OSHD TM 314

*Method described in NCHRP Report 192(1).

4.0 TEST RESULTS - PHASE II

This section summarizes the results of the tests performed on mix and/or aggregate from each of the eight projects.

4.1 General

For each of the projects evaluated, the following steps were undertaken:

1) A visual inspection of the roadway in the vicinity of the sample locations was made.
2) Both 4-inch and 6-inch cores were taken and submitted to the central laboratory for testing.
3) Tests were made on the 4-inch cores which measured voids and modulus.
4) Tests were made on the 6-inch cores which measured aggregate gradation, asphalt content, and asphalt properties.

A description of each of the projects is given in Appendix A together with a preliminary performance evaluation. A followup evaluation in May of 1985 is given in Appendix B.

4.2 Tests on 4-Inch Cores

Table 4.1 summarizes the results of tests on the 4-inch cores from the 8 projects. The modulus value test was made on a 4-inch core from each set at three different conditions:

1) Unconditioned. In this case, the core was tested in the as-received condition.
2) After Vacuum Saturation. In this case the sample was saturated in water for a period of 1/2-hour using 26-inch Hg vacuum, then held for 1/2-hour in water without vacuum before testing.

Table 4.1 - Summary of Results - 4-Inch Cores.

Property	a) Midland-California State Line (18-1010)			
Set*	1	2	3	4
		a) Location		
Station or MP	285.88	285.88	291.0	291.0
Lane direction	SB	SB	NB	NB
Lane	travel	travel	travel	travel
Sample location in lane	MP	WT	MP	WT
Distance from centerline, ft	5.5 Rt	9.0 Rt	6.0 Lt	4.0 Lt
Surface condition	10% Flushing, 30% Raveling, and 20% Picking Out			
Wheel-track depression, in.	1/8-1/4	1/8-1/4	1/8-1/2	1/8-1/4
		b) Test Results		
Bulk sp. gr. (as-received)	2.48	2.45	2.38	2.44
Recompacted b.s.g.	2.51	2.49	2.47	2.48
Rice sp. gr.	2.496	2.511	2.530	2.531
% voids - as-received	0.64	2.4	5.9	3.6
% voids - recompacted	0	0.8	2.4	2.0
M_r unconditioned ($x10^3$), A	236	279	Damaged:	
M_r vacuum saturated ($x10^3$), B	189	236	Cores	
M_r freeze-thaw ($x10^3$), C	161	214	Fell	
M_r ratio, B/A, %	80	84	Apart	
M_r ratio, C/A, %	68	77		
% Voids mineral aggregate	11.8	11.8	11.8	11.8

*Set = Two 4-inch cores. One core was tested for modulus while the other was tested for voids.

Table 4.1 - Summary of Results - 4-Inch Cores (continued).

Property	b) Nylund Road-Roaring Creek (22-1013)							
Set*	1	2	3	4	5	6	7	8
				a) Location				
Station or MP	1193+53.5		1194+23.5		1194+23.5		1206+31.5	
Lane direction	EB	EB	EB	EB	EB	EB	EB	EB
Lane	Passing	Passing	Passing	Passing	Travel	Travel	Travel	Travel
Sample location in lane	WT	MP	WT	MP	WT	MP	WT	MP
Distance from centerline, ft	9.9 Rt	12.8 Rt	9.7 Rt	14.0 Rt	29.0 Rt	26.0 Rt	28.2 Rt	25.2 Rt
Surface condition	Good		Bad		Good		Good	
Wheel-track depression, in.	0	0	0	0	0	0	0	0
				b) Test Results				
Bulk sp. gr. (as-received)	2.27	2.27	2.22	2.17	2.26	2.29	2.22	2.19
Recompacted b.s.g	2.39	2.41	2.35	2.34	2.37	2.40	2.37	2.36
Rice sp. gr.	2.447	2.454	2.497	2.452	2.456	2.462	2.485	2.468
% voids - as-received	7.23	7.50	11.09	11.50	7.98	6.99	10.66	11.26
% voids - recompacted	2.33	1.79	5.89	4.57	3.50	2.52	4.63	4.38
M_r unconditioned ($x10^3$), A	133	115	130	124	144	126	175	Sample
M_r vacuum saturated ($x10^3$), B	132	127	137	121	149	115	148	Height
M_r freeze-thaw ($x10^3$), C	193	89	151	207	182	130	88	Not
M_r ratio, B/A, %	99	111	105	98	103	97	84	Recorded
M_r ratio, C/A, %	145	78	116	168	126	88	50	on Lab
% Voids mineral aggregate	14.38	14.38	14.38	14.38	14.38	14.38	14.38	14.38

*Set = Two 4-inch cores.

Table 4.1 - Summary of Results - 4-Inch Cores (continued).

Property	c) Emigrant Hill-Meacham					
Set*	1	2	3	4	5	678
			a) Location			
Station or MP	233	233	223.61	223.61	223.64	223.64
Lane direction	WB	WB	EB	EB	EB	EB
Lane	Travel	Travel	Travel	Travel	Travel	Travel
Sample location in lane	WT	MP	WT	MP	WT	MP
Distance from centerline, ft	9 Lt	6 Lt	11 Rt	6.0 Rt	10.0 Rt	6 Rt
Surface condition	Good	Good	Adjacent to Patch		Good	Good
Wheel-track depression, in.	1/8	Rutting	Little or none		0	0
			b) Test Results			
Bulk sp. gr. (as-received)	2.33	2.29	2.33	2.37	2.34	2.34
Recompacted b.s.g	2.44	2.43	2.43	2.47	2.43	2.44
Rice sp. gr.	2.531	2.504	2.541	2.517	2.518	2.502
% voids - as-received	7.94	8.55	8.30	5.84	7.07	6.47
% voids - recompacted	3.60	2.96	4.37	1.87	3.49	2.48
M_r unconditioned ($x10^3$), A	375	350	698	721	663	696
M_r vacuum saturated ($x10^3$), B	335	349	579	576	501	585
M_r freeze-thaw ($x10^3$), C	180	237	264	365	279	334
M_r ratio, B/A, %	89	100	83	80	76	84
M_r ratio, C/A, %	49	79	39	51	42	48
% Voids mineral aggregate	25	25	25	25	25	25
RAP	RAP	RAP	RAP	RAP	RAP	

*Set = Two 4-inch cores.

Table 4.1 - Summary of Results - 4-Inch Cores (continued).

Property	d) Vail Creek-Nylund Road (22-1012)							
Set*	1	2	3	4	5	6	7	8
				a) Location				
Station or MP	1125+03.5		1131+68.5		1131+68.5		1137+51.5	
Lane direction	EB	EB	EB	EB	EB	EB	EB	EB
Lane	Travel	Travel	Travel	Travel	Passing	Passing	Passing	Passing
Sample location in lane	WT	MP	WT	MP	WT	MP	WT	MP
Distance from centerline, ft	29.2 Rt	24.9 Rt	29.0 Rt	26.0 Rt	9.3 Rt	12.5 Rt	9.5 Rt	12.2 Rt
Surface condition	Good	Good	Raveled	Raveled	Good	Good	Bad	Bad
Wheel-track depression, in.	1/8	1/8	1/8	1/8	1/8	1/8	0	0
				b) Test Results				
Bulk sp. gr. (as-received)	2.15	2.20	2.19	2.20	2.28	2.17	2.21	2.17
Recompacted b.s.g	2.34	2.35	2.31	2.28	2.37	2.31	2.31	2.30
Rice sp. gr.	2.456	2.426	2.453	2.49	2.444	2.458	2.474	2.450
% voids - as-received	12.5	9.3	10.7	11.6	6.71	11.72	10.67	11.43
% voids - recompacted	4.7	3.1	5.8	8.4	3.03	6.02	6.63	6.12
M_r unconditioned ($x10^3$), A	254	306	239	277	356	282	338	288
M_r vacuum saturated ($x10^3$), B	246	281	240	322	276	249	275	273
M_r freeze-thaw ($x10^3$), C	128	198	122	156	229	134	157	166
M_r ratio, B/A, %	97	92	100	116	78	88	81	95
M_r ratio, C/A, %	51	65	51	56	64	48	46	58
% Voids mineral aggregate	18.83	18.83	18.83	18.83	18.83	18.83	18.83	18.83

*Set = Two 4-inch cores.

Table 4.1 - Summary of Results - 4-Inch Cores (continued).

Property	e) Sunny Valley-Jumpoff Joe Creek (617-1009)							
Set*	9	10	11	12	13	14	15	16
				a) Location				
Station or MP	69.5	69.5	69.5	69.5	68.5	68.5	68.5	68.5
Lane direction	SB	SB	SB	SB	NB	NB	NB	NB
Lane	Passing	Passing	Travel	Travel	Passing	Passing	Travel	Travel
Sample location in lane	WT	MP	MP	WT	WT	MP	MP	WT
Distance from centerline, ft	6.0 Lt	9.0 Lt	6.0 Rt	9.0 Rt	9.0 Lt	6.0 Lt	6.0 Rt	9.0 Rt
Surface condition	Good	Good	Good	Good	Bad = Stripping and Open-Graded			
Wheel-track depression, in.	0	0	0	1/8	1/8	0	0	1/8
				b) Test Results				
Bulk sp. gr. (as-received)	2.49	2.47	2.36	2.44	2.37	2.40	2.45	2.44
Recompacted b.s.g	2.61	2.59	2.56	2.56	2.57	2.56	2.56	2.54
Rice sp. gr. (T-209)	2.693	2.673	2.682	2.678	2.687	2.709	2.714	2.707
% voids - as-received	7.5	7.6	12.0	8.9	11.8	11.4	9.7	9.9
% voids - recompacted	3.1	3.1	4.5	4.4	4.4	5.5	5.7	6.2
M_r unconditioned ($x10^3$), A	1015	1154	1341	1155	1283	1356	1429	1058
M_r vacuum saturated ($x10^3$), B	946	1150	1131	922	1178	1392	1314	1104
M_r freeze-thaw ($x10^3$), C	986	717	502	363	641	607	432	555
M_r ratio, B/A, %	93	100	84	80	92	103	92	104
M_r ratio, C/A, %	97	62	37	31	50	45	30	52
% Voids mineral aggregate	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2

*Set = Two 4-inch cores

Table 4.1 - Summary of Results - 4-Inch Cores (continued).

Property	f) Weston-Weston Mountain (130-1079)				g) Hanley Ranch-Fish Lake (115-1029)	
Set*	1	2	3	4	1	2
			a) Location			
Station or MP	5.3	5.3	5.3	5.3	21.5	21.5
Lane direction	EB	EB	EB	EB	WB	WB
Lane	Travel	Travel	Passing	Passing	Travel	Travel
Sample location in lane	WT	MP	WT	MP	MP	WT
Distance from centerline, ft	17.0 Rt	14.0 Rt	8.0 Rt	5.0 Rt	6.5 Lt	8.0 Lt
Surface condition	Good - Slight Flushing Only				10% Picking Out	
Wheel-track depression, in.	Little or No Depression				0	0-1/4
			b) Test Results			
Bulk sp. gr. (as received)	2.36	2.33	2.38	2.29	2.24	2.28
Recompacted b.s.g	2.46	2.45	2.46	2.44	2.34	2.34
Rice sp. gr.	2.500	2.486	2.492	2.473	2.376	2.363
% voids - as-received	5.6	6.3	4.5	7.4	5.72	3.51
% voids - recompacted	1.6	1.45	1.28	1.33	1.52	0.97
M_r unconditioned ($x10^3$), A	313	380	386	413	578	294
M_r vacuum saturated ($x10^3$), B	390	406	365	453	542	359
M_r freeze-thaw ($x10^3$), C	259	285	312	342	298	288
M_r ratio, B/A, %	125	107	95	110	105	122
M_r ratio, C/A, %	83	75	81	83	58	98
% Voids mineral aggregate	11.1	11.1	11.1	11.1	9.72	9.72

*Set = Two 4-inch cores.

Table 4.1 - Summary of Results - 4-Inch Cores (continued).

Property	h) Elkhead Road -Rice Hill (610-1008)			
Set*	1	2	3	4
		a) Location		
Station or MP	151.70	151.70	151.70	151.70
Lane direction	NB	NB	NB	NB
Lane	Travel	Travel	Passing	Passing
Sample location in lane	WT	MP	MP	WT
Distance from centerline, ft	8.5 Rt	6.0 Rt	6.5 Lt	9.5 Rt
Surface condition	< 10% Defects		< 10% Defects	
Wheel-track depression, in.				
April 1984	1/4	1/4	1/8	1/8
October 1984	1	1	1	1
		b) Test Results		
Bulk sp. gr. (as-received)	2.39	2.32	2.33	2.36
Recompacted b.s.g	2.46	2.44	2.44	2.45
Rice sp. gr.	2.476	2.480	2.470	2.483
% voids - as received	3.47	6.45	5.67	4.95
% voids - recompacted	0.65	1.61	1.21	1.33
M_r unconditioned ($x10^3$), A	212	411	482	Damaged
M_r vacuum saturated ($x10^3$), B	219	465	482	Core
M_r freeze-thaw ($x10^3$), C	176	286	264	Fell
M_r ratio, B/A, %	103	113	100	Apart
M_r ratio, C/A, %	83	70	55	
% Voids mineral aggregate	12.35	12.35	12.35	12.35

*Set = Two 4-inch cores.

3) After Freeze-Thaw. After vacuum saturation, the sample was frozen for 15 hours at 0°F, thawed for 24 hours in a 140°F water bath, and then conditioned at 77°F for 3 hours before testing.

For each project modulus ratio, specific gravity, and percent voids were also calculated. These also appear in Table 4.1.

4.3 Tests on 6-Inch Cores

Table 4.2 summarizes properties of the mix from the 6-inch core samples submitted from the field. Prior to testing, the cut aggregates from the face of the core was removed and discarded. The asphalt cement was extracted using vacuum extraction techniques (OSHD Method-309) for the determination of:

1) aggregate gradation,
2) asphalt content, % and,
3) recovered asphalt properties

The modulus and IRS tests were performed on mix obtained from 6-inch cores after laboratory compaction. Both these results are given in Table 4.2. The procedures used for the modulus tests are as described previously. The procedure for the IRS test is AASHTO T-165 with a 3000 psi molding pressure. For each mix, the compacted and maximum specific gravity was measured by T-166 and T-209 procedures and void content calculated as follows:

$$\text{Void Content, \%} = \left[\frac{\text{Max. Sp. Gr.} - \text{Mix Sp. Gr.}}{\text{Max. Sp. Gr.}}\right]$$

Table 4.2 - Summary of Results - 6-Inch Cores.

Property	Midland-California State Line (18-1010)				Nylund Road-Roaring Creek (22-1013)							
Set	1	2	3	4	1	2	3	4	5	6	7	8
Film thickness	suff	dry/ suff	dry/ suff	dry	thick	dry/ suff	suff	suff/ thick	thick	thick	thick	suff
% Coating	100	100	98	75	97	94	93	93	96	94	95	91
Sample height, in.	2.0	1.8	2.0	2.0	1.9	1.9	1.9	2.0	1.9	1.8	1.8	1.7
Gradation % passing												
1 inch	100	100	100	100	100	100	100	100	100	100	100	100
3/4 inch	100	96.2	100	98.3	99.2	98.8	99.4	100	99.3	99.3	98.4	98.9
1/2 inch	85.9	86.3	90.2	87.0	89.2	87.9	82.5	87.8	87.7	91.5	85.9	84.4
3/8 inch	76.2	77.8	79.8	77.4	79.2	79.1	71.4	74.9	78.3	84.0	73.7	74.4
1/4 inch	65.4	67.0	67.3	62.5	67.6	65.4	56.8	59.5	65.5	71.0	59.3	59.5
No. 4	56.0	58.2	55.9	51.9	57.4	55.8	46.7	48.5	54.8	59.8	49.4	49.8
No. 10	33.5	34.9	32.6	30.4	34.1	34.0	28.0	29.1	32.8	36.5	29.8	30.9
No. 40	15.5	16.6	14.9	13.9	14.5	14.8	12.4	13.2	13.4	14.6	13.5	14.0
No. 200	6.9	8.0	7.2	6.4	5.9	6.3	5.3	5.7	5.7	6.0	5.8	5.9
% Asphalt (extracted)	5.7	4.1	5.4	5.0	6.1	6.4	5.2	5.3	5.7	6.3	5.1	5.1
% Retention (from mix design)	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
% Total Asphalt Content	5.8	4.2	5.5	5.1	6.3	6.6	5.4	5.5	5.9	6.5	5.3	5.3
M_r unconditioned ($x10^3$), A	646	765	1239	1270	1730	1531	1265	1190	678	884	1550	1163
M_r vacuum saturated ($x10^3$), B	614	809	1293	1244	1584	1388	1268	1183	646	834	1432	1097
M_r freeze-thaw ($x10^3$), C	665	641	1161	1245	1336	1213	1188	1146	627	746	1368	1002
M_r ratio, B/A, %	95	106	104	98	88	91	100	99	95	94	92	94
M_r ratio, C/A, %	103	84	94	98	77	79	94	96	92	84	88	86
Unconfined compressive strength			*									
PSI - dry		724			975	1126	573	597	603	640	828	830
PSI - wet		579			732	991	402	473	465	495	624	668
IRS %		80			75	88	70	79	77	77	75	80
Bulk spec. gravity,												
first compaction	2.48	2.48	2.46	2.45	2.38	2.34	2.26	2.39	2.39	2.39	2.39	2.39
recompacted	2.51	2.52	2.52	2.51	2.44	2.43	2.35	2.44	2.45	2.44	2.44	2.45
T-209, max. gravity	2.496	2.517	2.530	2.536	2.449	2.460	2.477	2.449	2.463	2.442	2.475	2.472
% Voids,												
first compaction	0.64	1.47	2.77	3.39	2.82	4.88	8.76	2.41	2.96	2.13	3.43	3.32
recompacted	0.0	0.0	0.4	1.03	0.37	1.22	5.13	0.37	0.53	0.08	1.41	0.89
Recovered asphalt:		**		**								
penetration @ 77°	57		37		47	44	38	38	44	47	38	42
abs. visc. @ 140°	1750		3136		2318	2623	3095	3140	2276	2232	3090	2883
kin. visc. @ 275°	230		291		333	324	393	399	369	352	405	386

* IRS is a composite of sets 1 through 4.

** Recovered asphalt and IRS is a composite of sets 1 and 2, and sets 3 and 4.

Table 4.2 - Summary of Results - 6-Inch Cores (continued).

Property	Emigrant Hill-Meacham (630-1082)*						Vail Creek-Nylund Road (22-1012)							
Set	1	2	3	4	5	6	1	2	3	4	5	6	7	8
Film thickness	dry	dry	dry/ v dry	dry/ suff	dry/ suff	dry	dry/ suff	dry/ suff	dry	dry/ suff	dry	dry/ suff	N/A	N/A
% Coating	80	85	80	75	85	80	92	91	90	92	92	85	N/A	N/A
Sample height, in.	1.9	1.9	2.0	1.9	1.9	1.9	1.6	1.8	1.5	1.8	2.0	1.9	1.7	1.7
Gradation passing														
1 inch	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3/4 inch	100	100	98.5	96.7	100	100	99.4	98.9	98.6	100	97.6	97.2	97.3	99.3
1/2 inch	91.5	90.7	93.3	87.8	94.4	93.3	93.5	90.5	87.4	89.5	86.9	88.1	84.4	91.9
3/8 inch	77.4	81.6	79.6	81.1	86.1	79.0	83.8	81.1	74.8	75.6	77.8	80.8	73.1	78.3
1/4 inch	63.8	68.9	65.6	67.4	75.0	68.6	72.2	69.2	58.2	57.9	64.8	67.4	58.9	61.9
No. 4	53.7	60.1	55.3	57.8	64.2	59.4	62.7	60.3	48.8	47.4	55.6	58.1	49.3	52.3
No. 10	30.9	33.9	32.5	32.5	37.0	34.7	38.0	37.4	29.1	27.9	34.1	35.8	29.8	31.5
No. 40	12.3	13.0	13.3	12.4	14.5	13.9	15.9	15.7	13.4	12.9	14.1	14.7	13.3	13.7
No. 200	4.5	4.6	5.4	4.5	5.0	5.6	6.8	6.6	6.0	5.8	6.1	6.5	5.8	6.0
% Asphalt (extracted)	5.0	5.5	4.9	5.5	6.0	5.4	5.3	4.9	4.3	4.1	5.1	5.6	5.1	5.3
% Retention (from mix design)	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
% Total Asphalt Content	5.1	5.6	5.6	5.6	6.1	5.5	5.5	5.1	4.5	4.3	5.3	5.8	5.3	5.5
M_r unconditioned ($x10^3$), A	998	994	1133	1110	1030	1197	1043	1014	942	902	999	1137	1204	1084
M_r vacuum saturated ($x10^3$), B	979	975	1157	1112	1024	1167	1009	1017	925	924	1174	1144	1412	1268
M_r freeze-thaw ($x10^3$), C	916	833	886	718	859	990	839	959	453	376	965	1111	960	812
M_r ratio, B/A, %	98	98	102	100	99	97	97	100	98	102	117	101	117	117
M_r ratio, C/A, %	92	84	78	65	83	83	80	95	48	42	97	98	80	75
Unconfined compressive strength														
PSI - dry	751		788		1036		716	1023	903	875	1003	760	1118	1011
PSI - wet	648		772		772		569	788	772	732	676	668	983	927
IRS %	86		91		74		79	77	85	84	67	88	88	92
Bulk spec. gravity,														
first compaction	2.40	2.42	2.43	2.42	2.41	2.41	2.32	2.34	2.35	2.34	2.34	2.32	2.33	2.32
recompacted	2.47	2.49	2.48	2.48	2.47	2.47	2.39	2.41	2.40	2.40	2.40	2.39	2.39	2.39
T-209, max. gravity	2.540	2.522	2.528	2.523	2.516	2.509	2.421	2.425	2.399	2.417	2.437	2.434	2.411	2.447
% Voids,														
first compaction	5.51	4.04	3.88	4.08	4.21	3.95	4.17	3.51	2.04	3.19	3.98	4.68	3.36	5.19
recompacted	2.76	1.27	1.90	1.70	1.83	1.55	1.28	0.62	0	0.70	1.52	1.81	0.87	2.33
Recovered asphalt:														
penetration @ 77°	35	40	35	30	36	28	35	38	40	34	41	37	35	25
abs. visc. @ 140°	5041	4565	5593	6365	5652	7430	3818	3408	3078	4255	3002	3630	3806	11947
kin. visc. @ 275°	484	472	515	571	500	549	424	390	387	454	404	421	430	416

* IRS is a composite of sites 1 and 2, 3 and 4, and 5 and 6.

Table 4.2 - Summary of Results - 6-Inch Cores (continued).

Property	Sunny Valley-Jumpoff Joe Creek (617-1009)*								Weston-Weston Mountain (130-1079)**			
Set	9	10	11	12	13	14	15	16	1	2	3	4
Film thickness	dry	dry/ suff	dry	dry	dry/ suff	dry	dry	dry/ suff	suff	suff	suff	suff
% Coating	91	93	89	92	87	83	87	87	95	95	95	98
Sample height, in.	2.0	2.1	2.0	1.7	2.5	2.5	2.5	2.5	2.0	2.0	2.4	2.4
Gradation % Passing												
1 inch	100	100	100	100	100	100	100	100	100	100	100	100
3/4 inch	100	100	100	100	100	100	100	100	97.9	97.0	96.7	96.3
1/2 inch	72.0	83.8	88.6	89.3	88.7	86.2	85.0	82.7	88.0	86.8	86.3	87.4
3/8 inch	69.6	67.9	76.9	78.5	77.4	67.6	74.0	66.2	77.4	78.7	76.7	77.5
1/4 inch	53.6	55.6	60.5	60.4	59.9	51.7	57.8	49.9	61.3	62.1	61.5	62.4
No. 4	43.4	46.2	49.8	49.5	50.1	42.4	47.4	40.6	49.8	50.2	50.5	51.3
No. 10	27.3	29.0	30.8	30.7	30.3	27.3	28.6	25.2	27.7	28.2	30.0	30.0
No. 40	13.8	14.1	14.9	15.2	14.6	13.9	13.8	13.1	13.1	13.1	14.3	13.8
No. 200	6.0	6.3	6.6	6.8	6.3	6.1	6.2	6.0	6.6	6.3	6.7	6.3
% Asphalt (extracted)	4.4	4.7	4.7	4.7	4.7	4.2	4.8	4.2	6.2	6.1	5.7	5.9
% Retention (from mix design)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6
% Total Asphalt Content	4.4	4.7	4.7	4.7	4.7	4.2	4.8	4.2	6.8	6.7	6.3	6.5
M_r unconditioned ($x10^3$), A	1550	1588	1799	2112	2323	2312	1676	2196	873	807	990	1193
M_r vacuum saturated ($x10^3$), B	1955	1769	1924	2214	2484	2318	1331	2119	914	842	884	1119
M_r freeze-thaw ($x10^3$), C	2007	2418	2200	2359	2233	2368	1144	1902	837	714	938	966
M_r ratio, B/A, %	126	111	107	105	107	100	79	96	105	104	99	94
M_r ratio, C/A, %	129	152	122	112	96	102	68	87	96	88	95	81
Unconfined compressive strength												
PSI - dry	947		1182		987		1170		699		947	
PSI - wet	756		720		816		1007		608		653	
IRS %	80		61		83		86		87		69	
Bulk spec. gravity,												
first compaction	2.58	2.59	2.59	2.58	2.59	2.57	2.59	2.55	2.41	2.43	2.45	2.43
recompacted	2.65	2.65	2.65	2.65	2.65	2.63	2.65	2.61	2.45	2.47	2.50	2.48
T-209, max. gravity	2.685	2.675	2.678	2.689	2.689	2.720	2.683	2.706	2.446	2.476	2.500	2.487
% Voids,												
first compaction	3.91	3.18	3.29	4.05	3.68	5.51	3.47	5.76	1.47	1.86	2.00	2.29
recompacted	1.30	0.93	1.05	1.45	1.45	3.31	1.23	3.55	0.0	0.24	0.0	0.28
Recovered asphalt:												
penetration @ 77°	36	24	28	19	13	18	29	19	31	31	30	25
abs. visc. @ 140°	5884	5667	4842	7520	13,191	9151	4391	7516	5399	5912	5202	7245
kin. visc. @ 275°	430	419	398	462	575	494	387	460	496	501	467	527

* IRS is a composite of sets 9 and 10, 11 and 12, 13 and 14, and 15 and 16.

**IRS is a composite of sets 1 and 2, and 3 and 4.

Table 4.2 - Summary of Results - 6-Inch Cores (continued).

Property	Hanley Ranch-Fish Lake (115-1029)*		Elkhead-Rice Hill (610-1008)*			
Set	1	2	1	2	3	4
Film thickness	dry	dry/ suff	suff	dry/ suff	suff	suff
% Coating	85	98	98	95	100	98
Sample height, in.	1.9	2.0	1.9	2.0	2.1	2.0
Gradation % Passing						
1 inch	100	100	100	100	100	100
3/4 inch	96.2	100	100	100	100	100
1/2 inch	83.8	93.4	91.0	88.1	92.1	86.1
3/8 inch	71.0	82.0	78.5	73.5	76.4	71.3
1/4 inch	56.3	67.2	63.7	58.3	64.0	56.7
No. 4	49.2	56.4	53.7	49.8	54.3	48.1
No. 10	28.5	31.3	32.1	30.1	32.1	28.8
No. 40	11.5	13.2	13.3	12.7	13.0	12.0
No. 200	4.9	5.6	4.5	4.0	4.5	3.7
% Asphalt (extracted)	6.4	5.8	5.5	5.5	5.6	5.1
% Retention (from mix design)	0.04	0.04	0.3	0.3	0.3	0.3
M_r unconditioned ($x10^3$), A	883	632	605	839	674	1179
M_r vacuum saturated ($x10^3$), B	946	679	648	821	716	1378
M_r freeze-thaw ($x10^3$), C	837	606	514	666	624	1135
M_r ratio, B/A, %	107	107	107	98	106	117
M_r ratio, C/A, %	72	96	85	79	93	96
Unconfined compressive strength,						
PSI - dry	762		676		804	
PSI - wet	664		536		606	
IRS %	87		79		75	
Bulk spec. gravity,						
first compaction	2.29	2.31	2.44	2.42	2.43	2.40
recompacted	2.35	2.35	2.47	2.46	2.47	2.46
T-209, max. gravity	2.383	2.359	2.476	2.471	2.472	2.480
% Voids,						
first compaction	3.91	2.08	1.45	2.06	1.70	3.23
recompacted	1.38	0.38	0.24	0.45	0.08	0.81
Recovered asphalt:						
penetration @ 77°	23	31	36	37	36	36
abs. visc. @ 140°	9462	5505	4856	4728	5223	5478
kin. visc. @ 275°	568	490	504	482	498	517

*IRS is a composite of sets 1 and 2, sets 3 and 4

5.0 DISCUSSION OF RESULTS

The results of the pavement performance survey for each project evaluated, together with the lab indicators of field performance, are summarized in Table 5.1. As indicated, there is some evidence to suggest the modulus ratio values relate to observed performance. For example, of the five projects with modulus ratios below 0.7, four of them showed evidence of early distress. This section of the report attempts to evaluate the results of both Phase I and Phase II.

5.1 Job Mix Formulas

Table 5.2 provides a closer look at the mix characteristics by comparing the mix design recommendations (Phase I) with those obtained from the field cores (Phase II). In general, the results of this comparison show:

1) the aggregate gradation is generally within job mix tolerances,
2) the asphalt content is often outside the job mix tolerances,
3) the IRS values measured in the laboratory are similar to those measured on field mix, and
4) the modulus ratios for field mix vary considerably and are generally higher than those measured in the lab.

5.2 Evaluation of IRS and Modulus Ratio

Table 5.3 summarizes the IRS and modulus ratios for each of the Phase II projects. Four values are tabulated:

1) Tests associated with mix design results,
2) Tests on mix submitted from the field,
3) Tests on lab batched mix,

Table 5.1 - Pavement Performance for Projects Evaluated - Phase I Study.

a) Projects Susceptible to Moisture-Induced Damage

	Project	Result Indicating Potential	Pavement Overall Condition*
a.	Midland-California State Line	• Modulus ratio below 0.70	• Raveling and rutting • Overlayed in December 1984
b.	Nylund Road-Roaring Creek	• Additive needed to provide 70% IRS • Modulus ratio below 0.70	• Raveling
c.	Emigrant Hill-Meacham	• Additive needed to provide 70% IRS	• Wheel-track rutting and flushing
d.	Vail Creek-Nylund Road	• Additive needed to provide 70% IRS • Modulus ratio below 0.70	• Raveling
e.	Sunny Valley-Jumpoff Joe Creek	• Modulus ratio below 0.70	• Good
f.	Weston-Weston Mountain	• Modulus ratio below 0.70	• Slight flushing and rutting

b) Projects not Susceptible to Moisture-Induced Damage - Phase I Study.

g.	Hanley Ranch-Fish Lake	• None	• Good with slight rutting
h.	Elkhead Road-Rice Hill (Northbound)	• None	• Good

* For detailed pavement evaluation, see Appendix B.

Table 5.2 - Wearing Course Mix Characteristics.

	Midland-California State Line		Nylund Road-Roaring Creek		Emigrant Hill-Meacham	
	Job Mix Formula	Field Cores	Mix Design	Field Cores	Mix Design	Field Cores
% Passing						
3/4 in.	100 ± 6	96-100	100 ± 6	98-100	99 ± 6	97-100
1/2 in.	87 ± 6	86-100	87 ± 6	82-92	87 ± 6	88-94
3/8 in.	75 ± 6	76-80	78 ± 6	71-84	76 ± 6	77-86
1/4 in.	65 ± 6	62-67	63 ± 6	57-71	63 ± 6	64-75
No. 10	30 ± 4	30-35	29 ± 4	28-37	31 ± 4	31-37
No. 40	14 ± 4	14-17	12 ± 4	12-15	12 ± 4	12.3-14.5
No. 200	5 ± 2	6.4-8.0	4 ± 2	5.3-6.3	5.0 ± 2	4.5-5.6
Asphalt Content, %	5.5 ± 0.5	4.1-5.7	6.0 ± 0.5	5.1-6.4	5.1 ± 0.5	4.9-6.0
IRS, %	98	80	85*	70-88	87*	74-91
Modulus ratios (4-inch cores)						
b/a, %	72	80-84	68	84-111	90	76-100
c/a, %	68	68-77	34	50-168	114	38-68
Pavement Condition (From Table 5.1)	Raveling, Rutting and Flushing		Some Raveling		Wheel-Track Rutting and Flushing	

* With Pavebond

Table 5.2 - Wearing Course Mix Characteristics (continued).

	Vail Creek–Nylund Road		Sunny Valley–Jumpoff Joe Creek		Weston–Weston Mountain	
	Mix Design	Field Cores	Mix Design	Field Cores	Mix Design	Field Cores
% Passing						
3/4 in.	98 ± 6	97–100	100 ± 6	100	98 ± 6	96–98
1/2 in.	87 ± 6	84–94	87 ± 6	72–89	87 ± 6	86–88
3/8 in.	78 ± 6	73–84	75 ± 6	68–79	76 ± 6	77–79
1/4 in.	65 ± 6	58–72	58 ± 6	50–61	60 ± 6	61–62
No. 10	32 ± 4	28–38	29 ± 4	25–31	29 ± 4	28–30
No. 40	12 ± 4	12.9–15.9	12 ± 4	13.1–15.2	12 ± 4	13.1–14.3
No. 200	5 ± 2	5.8–6.8	5 ± 2	6.0–6.8	5.0 ± 2	6.3–6.7
Asphalt Content, %	5.3 ± 0.5	4.1–5.6	5.1 ± 0.5	4.2–4.8	6.0 ± 0.5	5.7–6.2
IRS, %	80*	67–92	81	61–86	76	69–87
Modulus ratios (4-inch cores)						
b/a, %	70	78–116	56	80–104	102	95–125
c/a, %	56	46–65	47	31–97	59	75–83
Pavement Condition (From Table 5.1)	Raveling		Good		Slight Flushing and Rutting	

* With Pavebond

Table 5.2 - Wearing Course Mix Characteristics (continued).

	Hanley Ranch-Fish Lake		Elkhead Road-Rice Hill	
	Mix Design	Field Cores	Mix Design	Field Cores
% Passing				
3/4 in.	100 ± 6	96-100	98 ± 6	100
1/2 in.	87 ± 6	84-93	87 ± 6	86-92
3/8 in.	75 ± 6	71-82	71 ± 6	71-78
1/4 in.	60 ± 6	56-67	60 ± 6	57-64
No. 10	28 ± 4	29-31	29 ± 4	29-32
No. 40	12 ± 4	11.5-13.2	11 ± 4	12.0-13.3
No. 200	5 ± 2	4.9-5.6	4 ± 2	3.7-4.5
Asphalt Content, %	6.0 ± 0.5	5.8-6.4	5.2 ± 0.5	5.1-5.6
IRS, %	100	87	77	75-79
Modulus ratios (4-inch cores)				
B/A, %	106	105-122	100	100-113
C/A, %	113	58-98	65	55-83
Pavement Problems	Slight Rutting		Good	

Table 5.3 - Summary of IRS and Modulus Ratios - Wearing Course.

Project	IRS Values - Wearing				Modulus Ratios							
	Mix Design	Submitted Mix	Lab Batched	Recompacted Field Mix	Mix Design b/a	Mix Design c/a	Submitted Mix b/a	Submitted Mix c/a	Lab Batched b/a	Lab Batched c/a	Field Cores b/a	Field Cores c/a
1. Midland-California State Line	98	108	95	80	72	68	86	85	89	81	80-84	68-77
2. Nylund Road-Roaring Creek	85*	-	70	70-88	68	34	-	-	68	34	84-111	50-168
3. Emigrant Hill-Meacham	87*	72	96	74-91	90	114	73*	50*	69	66	76-100	38-68
4. Vail Creek-Nylund Road	80	-	85	67-92	70	56	-	-	70	56	78-116	46-65
5. Sunny Valley-Jumpoff Joe Creek	81	88	89	61-86	56	47	-	-	73	62	80-104	31-97
6. Weston-Weston Mountain	76	-	97	69-87	102	59	-	-	74	53	95-125	75-83
7. Hanley Ranch-Fish Lake	100	93	100	87	106	113	96	94	70	71	105-122	58-98
8. Elkhead-Rice Hill	77	84	78	75-79	100	65	-	-	72	70	100-113	55-83

* with 0.2% Pavebond

**with 0.5% Pavebond

4) Tests on field cores after 1 to 2 years in service.

The results indicate there are significant differences in both ratios for supposedly the same mix.

5.3 Criteria for Predicting Moisture-Related Problems

The results presented in this chapter indicate, for the projects evaluated, there appears to be some correlation between modulus ratio and the occurrence of moisture-related problems. IRS did not seem to relate well to field performance. However, these criteria should be re-evaluated and the long-term effects of additives carefully studied.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This report presented the results of the Phase II investigation, an evaluation of selected field projects. Significant conclusions and recommendations resulting from this phase are presented below.

6.1 Conclusions

Eight projects were selected for detailed field examination. The results of the test program indicates:

1) Most of the projects evaluated experienced performance problems; however, only the following showed signs of moisture-related distress (e.g., early raveling)
   a) Midland-California State Line,
   b) Nylund Road-Roaring Creek, and
   c) Vail Creek-Nyland Road.

   All of these indicated potential problems in mix design.
2) Projects with IRS and modulus ratio greater than 70% did not show moisture-related problems in the field.
3) Both tests provide some indication of the aggregate-asphalt interactions.

6.2 Recommendations

The use of IRS and modulus ratio should be continued. Specific items requiring further clarification are:

1) identification of short- and long-term benefits of additives, and
2) clearer separation of the effects of voids or other mix characteristics from those of asphalt-aggregate interaction.

7.0 REFERENCES

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APPENDIX A

Project Descriptions

1.0 MIDLAND-CALIFORNIA STATE LINE

This project is a two-lane highway on US Highway 97 with an ADT of 3300. The cores for this project were taken in both the Northbound and Southbound lanes, at Mileposts 285.9 (Southbound) and 291.0 (Northbound). The following types of distress were noted

1) wheel-track rutting of 1/8 to 1/2 inch, and

2) 10% flushing, 30% raveling, and 20% "picking out"

Typical photos of the project are given in Figure A.1.

2.0 NYLUND ROAD-ROARING CREEK

This project is a four-lane highway on US 20 (Santiam Highway) with an ADT of 7000. Cores for this project were taken from the following locations

1) Station 1193+53.5 in the Eastbound passing lane. The surface condition was rated good.

2) Station 1194+23.5 in the Eastbound passing lane. The surface condition was rated bad.

3) Station 1194+23.5 in the Eastbound travel lane. The surface condition was rated good.

4) Station 1206+31.5 in the Eastbound travel lane. The surface condition was rated good.

Photos of the project are given in Figure A.2.

3.0 EMIGRANT HILL-MEACHAM

This project is located on Interstate 84 (ADT = 4800) and was of recycled asphalt concrete. Cores were taken at the following locations:

(a) Milepost 285.88, Southbound

(b) Milepost 291, Northbound

Figure A.1. Photos of Midland-California State Line.

(a) Station 1194+23.5, Eastbound passing and travel lane

(b) Station 1206+24.0, Eastbound travel lane

Figure A.2. Photos of Nylund Road-Roaring creek Project.

1) Milepost 233 in the Westbound travel lane. There were minor wheel-track ruts (1/8 inch) and the surface condition was good.

2) Milepost 223.6 in the Eastbound travel lane. There was little or no rutting and the cores were taken adjacent to a patch (raveling problem). Some flushing was noted.

3) Milepost 223.64 in the Eastbound travel lane. The surface condition was rated good with no wheel-track rutting. Some flushing was noted.

Photos of this project are given in Figure A.3.

4.0 VAIL CREEK-NYLUND ROAD

This project is also on US 20 (Santiam Highway) and has an ADT of 6800. Cores for this project were taken in the following locations:

1) Station 1125+03.5 in the Eastbound travel lane. The condition of the pavement is rated as good.

2) Station 1131+68.5 in the Eastbound travel lane. The condition of the pavement is rated as raveled.

3) Station 1131+69 in the Eastbound passing lane. The condition of the pavement is rated good.

3) Station 1137+52 in the Eastbound passing lane. The pavement was rated as bad.

Photos of this project are given in Figure A.4.

(a) Westbound, MP 233 (looking West)

(b) Eastbound, MP 223.61 (looking East)

Figure A.3. Photos of Emigrant Hill-Meacham Project, April 1984.

(c) Eastbound, MP 223.64 (looking East)

(a) Station 1130+00, Eastbound

(b) Station 1130+00, Westbound

Figure A.4. Photos of Vail Creek-Nylund Road.

5.0 SUNNY VALLEY-JUMPOFF JOE CREEK

This project is located on Interstate 5 near Glendale and has an ADT of 12,600. Cores were taken at the following locations:

1) Milepost 69.5 in the Southbound travel and passing lanes. The pavement condition was rated as good.
2) Milepost 68.5 in the Northbound lanes. The surface condition was rated as bad.

Photos of this project are given in Figure A.5.

6.0 WESTON-WESTON MOUNTAIN

This project is located on State Highway 204 with an ADT of 610 to 1700. Cores were taken in the following locations:

1) Milepost 5.3 in the Eastbound travel and passing lanes. The condition of the pavement is rated good with only slight flushing and wheel-track ruts.
2) Milepost 4.25 in the Southbound travel and passing lanes. The overall condition of the pavement is very good.

Photos of both sites are given in Figure A.6.

7.0 HANLEY RANCH-FISH LAKE

This project is a two-lane section of highway on State Highway 140 with an ADT of 1745. The cores for this project were taken in the Westbound lanes (Milepost 21.5) just at the start of a taper section from a three-lane to a two-lane road. There were the following types of distress noted:

1) wheel-track rutting of 1/16 to 1/4 inch,

(a) Milepost 69.5, Southbound Lanes

(b) Milepost 68.5, Northbound Lanes

Figure A.5. Photos of Sunny Valley-Jumpoff Joe Creek.

(a) Milepost 5.30 (looking East)

(b) Milepost 4.25 (looking South)

Figure A.6. Photos of Weston-Weston Mountain Project.

2) minor loss of fines in the wheel-track and at the construction joint 2 feet left of centerline,

3) no flushing,

4) no cracking, and

5) overall condition of the pavement is good.

Photos of the project are given in Figure A.7.

8.0 ELKHEAD ROAD-RICE HILL

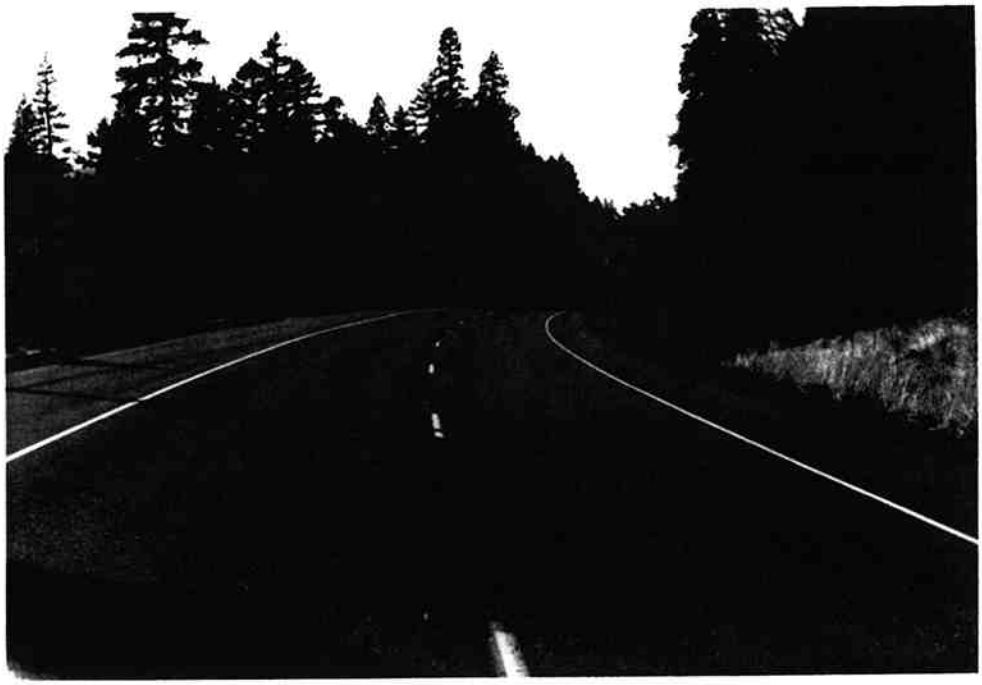
This project is located on Interstate 5 near Sutherlin and has an ADT of 4800. Cores were taken in the following locations:

1) Milepost 151.70 in the Northbound travel and passing lanes. The pavement has visible distress in less than 10% of its area with wheel-track ruts of 1/8 to 1/4 inch.

2) Milepost 149 in the Northbound lanes. This section also exhibited wheel-track rutting.

Photos of the pavement condition section are given in Figure A.8.

(a) Looking uphill



(b) Looking downhill

Figure A.7. Photos of Hanley Ranch-Fish Lake Project near MP 21.7.

(a) Milepost 151.70, Northbound Lanes

(b) Milepost 149, Northbound Lanes

Figure A.8. Photos of Elkhead Road-Rice Hill.

APPENDIX B

Performance Evaluations

May 1985

	Vale Creek-Nyland Road		Nyland Road-Roaring Creek		Sunny Valley-Jumpoff Joe Creek			
	EB Travel 1125+00 1131+65	EB Passing 1131+65 1137+48	EB Passing 1193+50 1194+20	EB Travel 1194+20 1206+30	SB Passing MP 69.5	SB Travel MP 69.5	NB Passing MP 68.5	NB Travel MP 68.5
Overall Rating	Good (4)		Fair (3)		Good (4)			
Ravelling	10-20% Considerable		)20% Excessive		)20% Excessive			
Bleeding	None		None		None			
Rutting	100% - 1/8" to 1/4"		100% - 1/8" to 1/4"		0 to 1/8" Slight			
Has Been Overlayed	None - considering a sand seal		None - considering a sand seal		None - considering a sand seal			

	Elkhead-Rice Hill		Hanley Ranch-Fish Lake	Weston-Weston Mtn.		Emigrant Hill-Meacham		
	NB Passing MP 151.7	NB Travel MP 151.7	WB MP 21.5	EB Travel MP 5.30	EB Passing MP 5.30	WB MP 233	EB MP 223.61	EB MP 223.64
Overall Rating	Good (4)		Good (4) (Except in slide areas)	Very Good (4+)		Fair to Good (3+)		
Ravelling	(5% Slight		None	(5% Very Slight		(5% Slight		
Bleeding	Slight		Some in 0.54% Slight in 2.13%	(1%		5 to 10% of project has substantial bleeding. Patching has been done at some locations.		
Rutting	1/4" to 3/4" Excessive		80% - 0 to 1/8" 20% - 1/8" to 1/4"	0 to 1/8" Slight		1/8" to 1/4" Some throughout job		
Has Been Overlayed	None		None	None		None Some patching over bleeding areas		