HIGHWAY RESEARCH REPORT

EXPERIMENTAL ASPHALT TEST SECTION ROAD 08-SBd-40-R28.4/R42.1

Interim Report

08-09

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 633134

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads June, 1968

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

June 1968
Interim Report
M & R No. 633134

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

EXPERIMENTAL ASPHALT TEST SECTION

ROAD 08-SBd-40-R28.4/R42.1

ERNEST ZUBE
Principal Investigator

JOHN B. SKOG
Co-Investigator

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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REFERENCE: Zube, E., and Skog, J. B., "Experimental Asphalt Test Section, Road 08-SBd-40-R28.4/R42.1", State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 633134, June 1968.

ABSTRACT: The primary purpose of the project was to compare the "setting" characteristics of paving mixtures produced from asphalts graded by viscosity at 140°F to those graded by the standard penetration test. Although the atmospheric temperatures during paving were not high enough for severe "setting" problems to develop, field observations appear to indicate that the viscosity at 140°F after a test simulating the mixing operation will provide the most satisfactory method of controlling the "setting" quality of paving grade asphalts.

KEY WORDS: Testing, asphalts, asphalt pavements, durability, laboratory studies, field performance, field tests, test sections, construction methods, pavements, asphalt tests, mixture tests.

This work was done in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, and their cooperation is hereby acknowledged. The opinions, findings and conclusions, expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

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INTRODUCTION

For many years paving asphalts have been graded by the use of the penetration test. It has become increasingly important to consider the viscosity of the asphalt at elevated temperatures, especially during construction. This has led to extensive laboratory research on methods of measuring viscosity, and a proposal to grade asphalts by viscosity at 140°F in place of the presently used penetration test.(1)

In a memorandum of August 17, 1966, the Bureau of Public Roads furnished a research proposal on the use of viscosity-graded asphalt cements, and encouraged State participation as part of a national research and development program on asphalt.

The California Division of Highways constructed test sections in connection with the Bureau proposal on Contract 08-039334, Road 08-SBd-40-R28.4/R42.1, during June 1967 and also placed two test sections containing the California tentative specification asphalt.

The purpose of this report is to furnish details and observations on construction and tests on the original and recovered asphalts from the paving mixture. Also included are the results of tests on the paving mixture. Future reports will present tests on cores taken during service life.

CONCLUSIONS

1. No problems were encountered during mixing with any of the asphalts.

2. There was some evidence of "slow setting" when asphalt 1 was used in the paving mixture even though paving was performed at a relatively low atmospheric temperature. Paving mixtures produced from the other five asphalts were satisfactory in terms of "setting" properties.

3. The viscosity at 140°F on the residue from a test that simulates the mixing operation appears to provide the best indication of the "setting" quality of the asphalt.

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DESCRIPTION OF ASPHALTS USED IN TEST SECTIONS

One of the objectives of this project, as noted in the Bureau proposal, was to determine if asphalt viscosity at elevated temperatures is more nearly related to the behavior of mixtures during construction than the present method of characterizing asphalt by penetration at 77°F.

A number of California produced asphalts with wide ranges in viscosity for a constant penetration and a wide range in penetration for a constant viscosity were chosen to simplify the evaluation of penetration-viscosity value of the asphalts. Specifications for the AC12 grade are shown in Table A. Also two asphalts manufactured in connection with the California tentative specification were included. Specifications are shown in Tables B and C. The following asphalts were used in the test section.

Asphalt 1	Refinery A	Grade AC12 - Asphalt Institute Spec.
Asphalt 2	Refinery B	Grade AC12 - Asphalt Institute Spec.
Asphalt 3	Refinery C	Grade 85-100 - California Stand. Spec.
Asphalt 4	Refinery C	Grade 85-100 - California Stand. Spec.
Asphalt 5	Refinery B	California Tentative Spec.
Asphalt 6	Refinery B	California Tentative Spec. with viscosity modification

The original viscosity penetration relations for these asphalts are shown below.

Asphalt No.	Grade	Penetration 77°F	Viscosity 140°F
1	AC12	84	1102
2	AC12	119	1029
3	85-100	90	1471
4	85-100	80	1042
5	Special	75	1734
6	Special	107	1067

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The viscosity results after the Rolling Thin Film and Standard Thin Film Tests are as follows:

Asphalt No.	Grade	Viscosity - 140°F	
		RTF Test	STF Test
1	AC12	1808	1889
2	AC12	2884	3273
3	85-100	3955	4545
4	85-100	2397	2881
5	Special	4346	4316
6	Special	2688	2767

DESCRIPTION OF TEST SECTIONS

The various asphalts were incorporated in the paving mixture placed at the following locations.

Asphalt No.	Grade	Paving Date 1968	Course	Lane	Station
1	AC12	6-7	Surface	WB#2	426+00 - 464+50 325+50 - 335+00
2	AC12	6-7	"	WB#2	351+00 - 379+50
3	85-100	6-7	"	WB#2	385+00 - 421+00
4	85-100	6-7	"	WB#2	310+00 - 322+00
5	Special	6-7	Level	WB#1&2	271+00 - 281+50
		8-1	Surface	WB#1	262+00 - 281+50
		8-1	"	WB#2	267+50 - 281+50
6	Special	8-4	Level	EB#1 EB#2	269+50 - 277+80 264+50 - 277+80
		8-7	Surface	EB#1&2	264+00 - 278+50

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DESCRIPTION AND DESIGN OF PAVING MIXTURE

Asphalt concrete on this project consisted of 0.35' Type A, 3/4" medium grading covered with 0.04' of open-graded asphalt concrete. The balance of the structural section consisted of 0.50' Class B Plant Mixed Cement Treated Base and 0.80' Class 2 Aggregate Subbase.

The aggregate was taken from a pit about two miles east of the east end of the project and was used for aggregate base, cement treated base and asphalt concrete. The aggregate was volcanic, being composed of andesite, dacite and quartz and feldspar particles derived from the volcanic rock. There was calcium carbonate and opaline coatings on some aggregate particles.

The properties of the aggregate are shown below:

Kc = 1.3, Kf = 1.2, Km = 1.2
Spec. Grav. - F = 2.60, C = 2.45
Crushed Particles - F = 70% C = 90%
Sand Equivalent = 69
Abrasion Test - Los Angeles
100 Revolutions = 4%
500 Revolutions = 18%

The design of the paving mixture was based on the following:

Bit. Ratio	4.9	5.4	5.9	6.4
Sp. Grav. Briq.	2.22	2.23	2.24	2.25
Stabilometer	51	50	47	42
% Voids	5.9	4.7	3.9	2.6
Swell	0.000"			

Recommended Bit. Content 5.2 - 5.5

CONSTRUCTION OF TEST SECTIONS

The paving mixture was produced in a 5,000 pound hot plant which delivered about 250 tons per hour. The mixture was hauled to the job in bottom dump trucks. The level course was laid with a blade while the surface was laid with a Blaw-Knox Model BF 180 paver using a KoKal loader for picking up the mix from the windrow. Rolling was performed with a 12 ton Ferguson tandem roller for breakdown, followed by a 10 ton Buffalo Springfield pneumatic with tires having 90 psi air

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pressure, and an 8 ton Galion for finish rolling. Rolling was performed as required in the Standard Specifications.

The test asphalts of the AC12 and 85-100 grades, #1, 2, 3 and 4, were incorporated in the surface course (0.17') while the two special asphalts, #5 and 6, were placed in both the level and surface. The mix used in all the test sections contained 5.3% asphalt.

Test sections containing asphalts 1, 2, 3 and 4 were paved on June 7, 1967. The two test sections containing special asphalts 5 and 6 were paved on July 31, and August 1, 4 and 7, 1967. The weather was dry and fairly warm. The range in atmospheric temperatures during paving was 66-100°F with morning temperatures in the 66-87°F range. In our opinion, the temperatures should have been above 90°F to clearly indicate "setting" differences in the paving mixture containing the different asphalts. Average and range in air and rolling temperatures for the various sections are shown below. The mix temperature during pneumatic rolling was quite variable, averaging about 200°F.

Asphalt No.	Air Temperature		Rolling Temperatures			
			Breakdown		Final	
	Ave.	Range	Ave.	Range	Ave.	Range
1	73	66-84	248	227-266	157	149-171
2	89	87-93	244	234-263	160	155-170
3	83	78-88	231	218-243	155	151-159
4	77	70-91	243	225-275	147	124-175
5	99	94-100	235	206-261	152	150-155
6	94	90-98	240	220-265	155	150-162

All of the asphalts produced a well coated paving mixture which was spread without any problems. The mixture containing asphalt 1 was a brownish black while all other asphalts produced a typical black mixture. This is characteristic of asphalt 1, a California product low in asphaltenes.

"Setting" of the paving mixture containing the various asphalts was judged by observation during rolling and by asking the opinion of the breakdown roller operator. Paving on June 7 involved asphalts 1, 2, 3 and 4. On this day, asphalt 3 appeared to be the fastest "setting" with asphalt 2 from the

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same source being almost the same. Next was asphalt 4 and slowest was asphalt 1. Actually, the paving mixture containing asphalt 1 was the only one showing signs of slow "setting" even at the low atmospheric temperatures found during paving of this section. There was "sticking" to both the breakdown and pneumatic rollers and the roller operators complained of the mix feeling "mushy". There was a tendency of the roller operators to "lay back" in attempting to roll the mixture. None of these observations were noted with asphalts 2, 3 and 4. Asphalts 5 and 6 paved at a later date and at higher atmospheric temperatures provided no problems during rolling. The breakdown roller man commented that asphalt 5, a material complying with the tentative specifications for paving asphalts, rolled out in an excellent manner.

The density of the pavement was determined with a nuclear gauge immediately after final rolling. The densities were obtained at three locations within each of the test sections. Twenty four hours after paving, densities were obtained with the nuclear gauge at 200' intervals, the readings being taken in the OWT, BWT and IWT of the lane. Water permeabilities by California Test Method 341 were also obtained at this time. The average and range in results are shown below:

Asphalt No.	Nuclear Density - PCF				Water Permeability 24 Hrs. after Pav. ML/Min.	
	Immediately After Paving		24 Hours After Paving			
	Ave.	Range	Ave.	Range	Ave.	Range
1	130.8	130.0-132.5	129.1	122.0-133.0	113	103-120
2	133.0	132.5-134.0	129.5	123.0-134.0	111	89-127
3	131.0	129.0-133.0	127.3	122.0-133.0	202	188-222
4	129.7	127.0-132.0	131.3	126.0-134.0	133	123-143
5	131.0	129.0-132.0	131.3	129.0-135.0	149	100-202
6	--	--	--	--	--	--

The only indication of a slow setting mixture during paving was displayed by asphalt 1. However, the relatively low atmospheric temperatures permitted virtually normal rolling although there was some sticking to the roller both during breakdown and pneumatic rolling. The table on the following page summarizes previously presented data.

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Asph. No.	Grade	Orig. Pen. 77°F	Viscosity-140°F			Ave. Breakdown Rolling Temp. °F	Ave. Nuclear Density PCF	Ave. Water Perm. Ml/Min.
			Orig.	After STF	After RTF			
1	AC12	84	1102	1889	1808	248	129	113
2	AC12	119	1029	3273	2884	244	130	111
3	85-100	90	1471	4545	3955	231	127	202
4	85-100	80	1042	2881	2397	243	131	133
5	Special	75	1734	4316	4346	235	131	149
6	Special	107	1067	2767	2688	240	-	-

It appears that the most useful test for predicting the observed "setting" characteristics on this project was the viscosity after one of the tests that simulate the hardening which takes place during mixing. The original viscosity or penetration does not appear to be as satisfactory. This is best shown in the table by comparing asphalt 1 with 6. According to original values for viscosity and penetration, asphalt 1 should have "set" better than 6. However, the reverse was true as indicated by the viscosity results after either the Standard Thin Film or Rolling Thin Film tests. Although, asphalt 1 displayed "setting" problems during compacting, such results did not lead to any material differences in nuclear density or permeability when compared to the other five asphalts.

LABORATORY STUDIES

The Bureau proposal is concerned with the behavior of viscosity graded asphalts during construction and also the service life performance of these materials. Therefore, a rather elaborate test program was performed in order to attain information which might be useful in evaluating test methods in terms of service performance of the asphalts. Tests on the original asphalt are shown in Tables D and E.

The average test results for Abson Recovery material after mixing are shown on the following page.

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Asph. No.	Grade	Absون Recovery Test Results								
		Pen 77°F	S.P. °F	Duct. 77°F 5cm/min	Viscosity-77°F-M.P. 0.05 Sec^{-1}SR	Viscosity-77°F-M.P. 0.01 Sec^{-1}SR	Viscosity-77°F-M.P. Shear Suscept	Visc. 140°F Poises	Viscosity 275°F Centistokes	Micro Duct 77°F
1	AC12	59	114	100+	2.21	2.32	0.01	2014	254	92
2	AC12	68	122	100+	2.62	3.86	0.10	3732	507	58
3	85-100	47	128	100+	4.29	5.28	0.06	4909	534	71
4	85-100	50	126	100+	3.50	3.95	0.03	2914	291	89
5	Special	50	126	100+	4.59	5.75	0.06	5165	578	65
6	Special	66	120	100+	2.32	3.15	0.08	3136	457	57

The average mix test results are shown below:

Asph. No.	Grade	Sp.Grav. Briq.	Stab. 140°F	Coh. 140°F	% Asph.	Grading 3/4	1/2	3/8	4	8	16	30	50	100	200
1	AC12	2.20	47	92	4.8	100	84	69	46	37	31	27	20	10	5
2	AC12	2.19	46	122	4.9	100	84	69	44	34	29	25	19	10	5
3	85-100	2.20	47	145	4.6	99	84	69	45	35	30	26	19	10	5
4	85-100	2.19	48	121	4.7	100	83	66	46	37	31	27	20	10	5
5	Special	2.20	47	250	4.9	99	86	71	47	35	29	24	18	10	5
6	Special	2.20	49	168	5.5	100	88	75	48	36	30	26	19	10	5

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Cores were obtained from the test sections in September 1967, approximately two months after construction. There was normal construction traffic over the project during this period. The average test results for the cores are shown below:

Asph. No.	Grade	Air Perm. 1"-H_2O Ml/Min	Theo. Max. Density	Ave. Spec. Grav. (Wax)	Ave. Rel. Density	Ave. % Voids	Ave. % Rel. Comp.	Wt. Per Cu. Ft.
1	AC12	31	2.33	2.235	96.0	4.0	101.5	139
2	AC12	47	"	2.21	94.9	5.1	100.9	138
3	85-100	81	"	2.18	93.6	6.4	99.0	136
4	85-100	84	"	2.20	94.6	5.4	100.5	137
5	Special	94	"	2.17	93.2	6.8	98.6	135
6	Special	42	"	2.19	94.2	5.8	99.8	137

Detailed results for Abson Recovery, mix tests and cores are shown in Tables F, G and H.

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REFERENCES

1. "Grading of Paving Asphalts", ASTM, STP #424.

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TABLE A

Specification for Asphalt Institute
Grade AC 12 Paving Asphalt

Test	AASHO Test Method	Grade AC 12
Viscosity at 140°F, poises	T 202 I	1200 ± 300*
Viscosity at 275°F, centipoises	T 201 I	150+
Ductility at 77°F, 5 cm/min, cm.	T 51	100+
Solubility in CCl_4, %	T 44	99.5+
Flash point, COC, °F.	T 48	425+
Thin film oven (TFO) test	T 179	5-
Viscosity at 140°F after TFO test / Viscosity at 140°F before TFO test		

*Efforts should be made to produce as close to 1,200 poises as possible.

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TABLE B

CALIFORNIA TENTATIVE ASPHALT SPECIFICATION

Paving Grade Asphalt Shall Conform
to the Following Requirements

Test	Test Method	Specification
Flash Point, P.M.C.T. °F Min.	AASHO T 73	450
Stain Number of Original Sample Max. after 120 hrs.-140°F-50#/sq. in.	ASTM D 1328-58T	10
Rolling Thin Film Test 325°F, 75 min.	Calif. Test Method No. 346	
Duct. Residue, 77°F, Min.	AASHO T 51	75
Viscosity, Residue	ASTM D 445	
140°F, Poises		Minimum in the range of 3200-3500 to 6,000
275°F, Centistokes		380 - 800
Durability Test	Calif. Test Method No. 347	
Viscosity of Residue after Durability Test, Megapoises at 77°F		
Shear Rate 0.05 Sec.$^{-1}$ max.	Calif. Test Method No. 348	25
Shear Rate 0.001 Sec.$^{-1}$ max.		60
Micro Ductility of Residue 1/2 cm/Min. 77°F, Min. mm	Calif. Test Method No. 349	10
Solubility, CCl_4, Orig. Sample % Min.	AASHO T 45	99

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TABLE C

CALIFORNIA TENTATIVE ASPHALT SPECIFICATION

Paving Grade Asphalt Shall Conform to the Following Requirements

Test	Test Method	Specification
Flash Point, P.M.C.T. °F Min.	AASHO T 73	450
Stain Number of Original Sample Max. after 120 hrs. -140°F- 50#/sq. in.	ASTM D 1328-58T	10
Rolling Thin Film Test 325°F, 75 min.	Calif. Test Method No. 346	
Duct. Residue, 77°F, Min.	AASHO T 51	75
Viscosity, Residue	ASTM D445	
140°F, Poises		4,000 - 6,000
275°F, Centistokes		425 - 800
Durability Test	Calif. Test Method No. 347	
Viscosity of Residue after Durability Test, Megapoises at 77°F		
Shear Rate 0.05 Sec.$^{-1}$ max.	Calif. Test Method No. 348	25
Shear Rate 0.001 Sec.$^{-1}$ max.		60
Micro Ductility of Residue 1/2 cm/Min. 77°F, Min. mm	Calif. Test Method No. 349	10
Solubility, CCl_4, Orig. Sample % Min.	AASHO T 45	99

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TABLE D

SPECIAL BPR TEST RESULTS - ORIGINAL ASPHALT & AFTER S.T.F. TEST

Tests	1 AC 12		2 AC 12		3 85-100		4 85-100		5 Special		6 Special	
	Orig.	After STF	Orig.	After STF	Orig.	After STF	Orig.	After STF	Orig.	After STF	Orig.	After STF
Absolute Viscosity												
Micro-Vis. @60°F												
@ .0500 Sec^{-1}	12.4	31.4	4.4	21.3	9.9	32.5	12.6	61.5	15.7	40.5	7.05	22.3
@ .0010 Sec^{-1}	13.0	31.4	6.75	33.0	11.4	73.0	14.7	69.5	20.4	73.5	8.55	36.5
(megapoise)												
Micro-Vis. @ 77°F												
@ .0500 Sec^{-1}	.862	1.99	.495	2.44	.85	3.73	.945	4.05	1.41	3.84	.645	2.23
@ .0010 Sec^{-1}	.862	2.53	.59	4.1	1.06	5.4	.945	4.05	1.51	6.15	.795	2.75
(megapoise)												
Vacuum @ 140°F (poise)	1102.0	1888.9	1028.8	3272.6	1471.2	4545.3	1041.8	2880.7	1733.9	4316.4	1069.3	2727.0
Kinematic @ 275°F (centistokes)	190	248	280	477	327	549	174	275	348	525	278	429
Pen.	21	16.8	40	27.6	34.0	23.0	29	13.3	26	21	37	26
Ratio Pen @39.2°F	25.0	27.8	33.6	41.9	37.8	43.4	36.3	30.5	34.7	43.7	34.9	42.6
Ratio	.0	.06	.05	.13	.06	.09	.0	.0	.02	.12	.06	.12
Shear Susceptibility @ 77°F												
Penetration 100g/5sec.												
@45°F	9	11	19	10	16	8	11	5	12	7	17	9
@60°F	27	16	44	23	33	20	33	13	27	18	41	23
@77°F	84	60.5	119	66	90	53.3	80	44	75	48	106	61
Softening Point (°F)	104.5	125.0	103.0	131.0	116.0	132.0	113.0	127.0	119.0	130.0	114.0	124.0
Ductility (cm)												
@45°F (5cm/min)	98.6	16.5	88.8	9.0	43.5	5.5	17.5	0	14.25	5.5	100+	8.5
(1cm/min)	100+	100+	100+	49.0	100+	11.25	100+	18.1	100+	13.5	100+	60.0
@60°F (5cm/min)	100+	100+	100+	100+	100+	97.5	100+	100+	100+	69	100+	100+
@77°F (5cm/min)	100+	100+	100+	100+	100+	100+	100+	100+	100+	100+	100+	100+
Flash Point COC (°F)	480		495		500		500		575		540	

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TABLE E

ORIGINAL ASPHALT TESTS

Asphalt No. Grade Research Sample No.	1 AC 12	2 AC 12	3 85-100	4 85-100	5 Special	6 Special
Flash Point P.M.C.T. °F	490	435	455	445	500	440
Pen. of original sample at 77°F	84	119	90	80	75	106
Standard Thin Film Test						
Loss %	0.11	0.54	0.32	0.48	+0.02	0.24
% Orig. Pen.	67	49	53	52	64	58
Ductility, 77°F cm	100+	100+	100+	100+	100+	100+
Penetration Ratio	25	34	38	36	35	35
Furol Visc. 275°F Secs.	98	186	197	94	192	152
Solubility CCl_4 %	99.9	99.9	99.9	99.9	99.9	99.9
Xylene Equivalent %	0	15-20	25-30	20-25	10-15	15-20
California Rolling Thin Film Test						
Viscosity-140°F poises	1808	2884	3955	2397	4346	2634
Viscosity-275°F centistokes	244	447	516	261	528	418
Ductility, 77°F cm	100+	100+	100+	100+	100+	100+
Durability Test						
Viscosity of Residue, megapoises, 77°F						
S.R.= 0.05 Sec.-1	12.4	27.2	31.0	73.5	24.7	17.1
S.R.= 0.001 Sec.-1	12.4	63.5	81.5	154	62.0	30.0
Shear Susceptibility	0.00	0.22	0.25	0.19	0.24	0.14
Micro-ductility 77°F-cm	91	5	8	6	9	18
Stain Test 120 Hrs, 140°F, 50#/sq.in.	4	7	6	3	5	6

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TABLE F

PROPERTIES OF RECOVERED ASPHALT

Asph. No.	Grade	Sample No.	Absorn Recovery Test Results: Pen. 77°F	S.P. °F	Duct. 77°F 5cm/min	Viscosity-77°F-M.P. 0.05 Sec^{-1} SR	Viscosity-77°F-M.P. 0.001 Sec^{-1} SR	Shear Suscept.	Viscosity 140°F Poises	Viscosity 275°F Centistokes	Micro-Ductility 77°F
1	AC 12	33105	54	117	100+	2.31	2.48	0.02	2122	258	81
	AC 12	33106	56	102	100+	2.60	2.60	0.00	2172	258	122
	AC 12	33107	56	117	100+	2.48	2.88	0.04	2179	261	94
	AC 12	33108	58	116	100+	2.25	2.25	0.00	1969	249	70
	AC 12	33127	66	112	100+	1.73	1.78	0.01	1787	246	86
	AC 12	33128	63	120	100+	1.90	1.90	0.00	1859	249	98
Ave.			59	114	100+	2.21	2.32	0.01	2014	254	92
2	AC 12	33115	62	124	100+	3.10	4.40	0.09	4163	531	51
	AC 12	33116	61	123	100+	3.13	5.10	0.13	4345	540	59
	AC 12	33117	68	123	100+	2.39	3.66	0.11	3554	504	55
	AC 12	33119	76	119	100+	1.85	2.49	0.08	2945	468	63
	AC 12	33120	73	122	100+	2.65	3.65	0.08	3655	492	63
Ave.			68	122	100+	2.62	3.86	0.10	3732	507	58
3	85-100	33109	48	130	100+	4.50	5.15	0.04	5356	588	74
	85-100	33110	46	131	100+	5.15	5.85	0.04	5902	606	60
	85-100	33111	46	129	100+	4.40	5.05	0.04	5235	582	54
	85-100	33112	45	123	100+	3.98	4.40	0.03	3025	285	103
	85-100	33113	50	126	100+	3.70	5.65	0.11	4804	567	69
	85-100	33114	46	129	100+	4.00	5.55	0.09	5129	576	68
Ave.			47	128	100+	4.29	5.28	0.06	4909	534	71
4	85-100	33121	55	125	100+	2.67	2.67	0.00	2529	276	97
	85-100	33122	43	134	100+	4.35	5.75	0.08	3166	294	98
	85-100	33123	55	124	100+	2.92	3.23	0.03	2801	294	38
	85-100	33124	46	121	100+	3.84	4.60	0.05	3107	300	114
	85-100	33125	43	123	100+	2.83	3.04	0.02	2579	282	112
	85-100	33126	57	129	100+	4.40	4.40	0.00	3300	300	74
Ave.			50	126	100+	3.50	3.95	0.03	2914	291	89

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TABLE F (CON'T)

PROPERTIES OF RECOVERED ASPHALT

Asph. No.	Grade	Sample No.	Absorption Recovery Test Results								
			Pen. 77°F	S.P. °F	Duct. 77°F 5cm/min	Viscosity-77°F-M.P. 0.05 Sec^{-1}SR	Viscosity-77°F-M.P. 0.001 Sec^{-1}SR	Viscosity-77°F-M.P. Shear Suscept.	Viscosity 140°F Poises	Viscosity 275°F Centistokes	Micro-Ductility 77°F
5	Tent. Spec.	33399	50	125	100+	4.70	6.45	0.08	5260	594	57
		33401	54	123	100+	3.80	4.10	0.02	4933	576	65
		33403	51	128	100+	4.20	5.10	0.05	4835	564	76
		33404	47	126	100+	5.65	7.35	0.07	5633	579	62
Ave.			50	126	100+	4.59	5.75	0.06	5165	578	65
6	Tent. Spec. Low Visc.	33426	73	118	100+	1.73	2.46	0.09	2487	420	44
		33427	65	121	100+	2.50	3.07	0.05	3348	462	63
		33428	69	120	100+	2.22	3.05	0.09	3019	456	55
		33429	67	120	100+	2.32	2.97	0.07	2996	447	61
		33430	56	123	100+	2.84	4.15	0.10	3828	501	63
Ave.			66	120	100+	2.32	3.15	0.08	3136	457	57

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TABLE G

PROPERTIES OF PAVING MIXTURE

Asph. No.	Grade	Sample No.	Sp.Grav. Briq.	Stab. 140°F	Coh. 140°F	% Asph.	Grading 3/4	1/2	3/8	4	8	16	30	50	100	200
1	AC 12	33105	2.21	49	95	5.0	100	87	71	47	38	32	27	20	10	5
	AC 12	33106	2.20	47	87	4.3	100	78	63	42	34	30	26	20	10	5
	AC 12	33107	2.21	51	88	4.7	100	84	70	46	37	31	27	20	10	5
	AC 12	33108	2.20	44	92	5.3	99	88	73	47	38	33	28	21	10	5
	AC 12	33127	2.21	46	108	4.6	100	84	69	44	34	29	25	19	9	7
	AC 12	33128	2.21	46	80	4.8	100	83	68	47	38	32	27	21	11	5
Ave.			2.20	47	92	4.8	100	84	69	46	37	31	27	20	10	5
2	AC 12	33115	2.21	44	135	4.6	100	89	72	45	33	28	24	18	10	5
	AC 12	33116	2.21	44	120	4.5	100	85	70	45	37	31	26	19	11	5
	AC 12	33117	2.18	51	125	4.1	100	86	66	41	33	28	24	18	10	5
	AC 12	33118	2.17	44	115	5.0	100	89	74	48	37	32	27	20	10	4
	AC 12	33119	2.19	46	137	4.6	100	83	70	45	36	30	26	20	10	5
	AC 12	33120	2.19	45	97	4.1	98	72	60	37	30	26	23	17	9	4
Ave.			2.19	46	122	4.9	100	84	69	44	34	29	25	19	10	5
3	85-100	33109	2.20	48	170	4.6	99	82	65	43	34	29	25	18	9	4
	85-100	33110	2.19	48	153	4.6	100	85	72	49	38	33	27	21	10	5
	85-100	33111	2.19	49	105	4.6	98	85	69	47	38	32	28	20	11	5
	85-100	33112	2.20	44	89	4.6	100	86	71	46	35	30	25	19	10	5
	85-100	33113	2.21	45	173	5.1	100	87	73	46	36	30	26	19	9	5
	85-100	33114	2.21	46	180	4.0	99	81	61	40	31	27	23	17	9	6
Ave.			2.20	47	145	4.6	99	84	69	45	35	30	26	19	10	5
4	85-100	33121	2.18	47	80	4.9	99	87	73	51	41	35	30	21	11	5
	85-100	33122	2.19	50	125	4.5	100	87	71	49	37	31	26	19	10	6
	85-100	33123	2.19	49	144	5.2	100	85	69	48	40	34	29	21	10	4
	85-100	33124	2.21	49	125	4.7	100	78	61	44	35	30	26	20	11	5
	85-100	33125	2.17	43	135	4.3	99	81	61	41	34	30	25	19	10	5
	85-100	33126	2.20	48	114	4.7	99	78	62	42	34	28	24	18	9	4
Ave.			2.19	48	121	4.7	100	83	66	46	37	31	27	20	10	5

TABLE G (CON'T)

PROPERTIES OF PAVING MIXTURE

Asph. No.	Grade	Sample No.	Sp.Grav. Briq.	Stab. 140°F	Coh. 140°F	% Asph.	Grading 3/4	1/2	3/8	4	8	16	30	50	100	200
5	Tent. Spec.	33399	2.21	44	340	4.9	100	85	67	46	34	27	23	18	10	6
		33400	2.20	46	215	5.2	100	94	80	51	39	32	27	20	11	5
		33401	2.21	46	240	4.8	100	92	80	52	38	32	27	21	11	6
		33402	2.19	49	215	4.3	100	78	62	44	33	26	22	17	9	4
		33403	2.20	49	220	5.0	98	84	71	49	37	29	25	19	10	5
		33404	2.23	47	270	5.0	98	81	67	42	31	25	21	15	9	5
Ave.			2.20	47	250	4.9	99	86	71	47	35	29	24	18	10	5
6	Tent. Spec. Low Visc.	33426	2.20	49	165	5.5	99	87	75	50	36	29	24	18	9	4
		33427	2.20	49	193	5.4	100	86	71	45	34	28	24	18	10	5
		33428	2.19	51	143	5.3	100	87	76	51	40	34	29	22	11	5
		33429	2.20	49	171	5.7	100	94	80	52	40	34	29	22	10	5
		33430	2.20	48	166	5.4	100	86	71	43	32	27	23	17	9	4
Ave.			2.20	49	168	5.5	100	88	75	48	36	30	26	19	10	5

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TABLE H

PROPERTIES OF PAVEMENT CORES

Asph. No.	Grade	Core No.	Air Perm. 1"-H_2O ml/min.	Theo. Max. Density	Ave. Spec. Grav. (wax)	Ave. Rel. Density	Ave. % Voids	Ave. % Rel. Comp.	Wt. per cu.ft.
1	AC 12	33710	31	2.33	2.24	96.2	3.8	102	139.8
	AC 12	33711	30	2.33	2.23	95.8	4.2	101	139.2
Ave.			31	2.33	2.235	96.0	4.0	101.5	139.5
2	AC 12	33716	16	2.33	2.22	95.3	4.7	101.3	138.5
	AC 12	33717	58	2.33	2.21	94.9	5.1	100.8	137.9
	AC 12	33718	68	2.33	2.20	94.5	5.5	100.5	137.3
Ave.			47	2.33	2.21	94.9	5.1	100.9	137.8
3	85-100	33713	125	2.33	2.15	92.3	7.7	97.7	134.2
	85-100	33715	36	2.33	2.21	94.9	5.1	100.4	137.9
Ave.			81	2.33	2.18	93.6	6.4	99.0	136.0
4	85-100	33714	54	2.33	2.22	95.3	4.7	101.3	138.5
	85-100	33719	38	2.33	2.22	95.3	4.7	101.3	138.5
	85-100	33720	208	2.33	2.18	93.6	6.4	99.5	136.0
	85-100	33721	68	2.33	2.19	94.1	5.9	100.0	136.7
	85-100	33724	51	2.33	2.20	94.5	5.5	100.4	137.3
Ave.			84	2.33	2.20	94.6	5.4	100.5	137.3
5	Tent.	33722	50	2.33	2.19	94.1	5.9	99.5	136.7
	Spec.	33723	137	2.33	2.15	92.3	7.7	97.7	134.2
Ave.			94	2.33	2.17	93.2	6.8	98.6	135.4
6	Tent.	33725	33	2.33	2.19	94.1	5.9	99.5	136.7
	Spec.	33726	62	2.33	2.19	93.6	6.4	99.5	136.7
	Low Visc.	33727	31	2.33	2.21	94.9	5.1	100.4	137.9
Ave.			42	2.33	2.19	94.2	5.8	99.8	137.3