SPECIAL REPORT

1991 PILOT STUDY
ALTERNATIVE ACCEPTANCE PROCEDURES FOR ASPHALT MIXES

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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FINAL REPORT

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INTRODUCTION

By the year 2005, the use of chlorinated solvents is to be eliminated. Faced with this eventuality, VDOT formed a task force to look at alternatives for the acceptance of asphalt mixes. One alternative is to use biodegradable solvents in the extraction tests. Although this alternative is being examined, there are some disadvantages to using these solvents, among which are the equipment needed and time required for testing. The study discussed here examines an alternative procedure that uses a nuclear asphalt content gauge for the determination of asphalt content and cold feed aggregate gradations for aggregate monitoring.

STUDY

VDOT and three contractors tested surface mixes at three asphalt plants. SM-2A mixes were tested at all three plants, and an SM-2B mix was tested at one of the plants. In addition to running the nuclear asphalt content tests and cold feed gradations with the extraction tests that are normally performed, the Task Force decided to generate additional data on volumetric properties using Marshall compaction. To generate these data, companion tests were run by VDOT and the three contractors. Because of the inability of VDOT to always obtain samples and the press of other testing by the contractors during the study, the number of companion samples at some plants was not as large as originally intended. However, enough tests were run to make a valid statistical comparison between several variables.

The three contractors that participated were APAC, B.P. Short & Son Paving Co., and Henry S. Branscombe. APAC tested both SM-2A and 2B mixes, and Short tested a SM-2A mix with and without recycled pavement.

Statistical comparisons were made of (1) VDOT's and the contractors' nuclear asphalt contents and extracted asphalt contents (see Table 1), (2) VDOT's nuclear and extracted asphalt contents, and (3) the contractors' nuclear and extracted asphalt contents (see Table 2). Similarly, comparisons were made of VDOT's and the contractors' volumetric determinations (see Table 3). Lastly, comparisons were made of VDOT's and the contractors' extraction and cold feed gradations (see Table 4).

Table 1

1991 PILOT STUDY—ASPHALT CONTENT

			Nuclear AC (%)							
			$\bar{X}$				s			
Contractor	Mix	n	VDOT	Cont.	Diff.	Sign.	VDOT	Cont.	Diff.	Sign.
APAC	SM-2A	22	5.75	5.79	.04	No	.17	.15	.02	No
	SM-2B	12	5.40	5.54	.14	Yes	.24	.19	.05	No
Short	SM-2A	31	5.77	5.82	.05	Yes*	.19	.18	.01	No
Short (R)	SM-2A	5	5.44	5.33	.11	No	.29	.21	.08	No
Branscombe	SM-2A	4	5.75	5.75	.00	No	.10	.17	.07	No
$\bar{X}$		74			.06			.18	.03	

			Reflux AC (%)							
			$\bar{X}$				s			
Contractor	Mix	n	VDOT	Cont.	Diff.	Sign.	VDOT	Cont.	Diff.	Sign.
APAC	SM-2A	22	5.73	5.86	.13	Yes	.20	.15	.05	Yes*
	SM-2B	12	5.53	5.54	.01	No	.26	.23	.03	No
Short	SM-2A	31	5.76	5.82	.06	No	.20	.21	.01	No
Short (R)	SM-2A	5	5.38	5.48	.10	Yes	.26	.23	.03	No
Branscombe	SM-2A	4	5.68	5.72	.04	No	.17	.17	.00	No
$\bar{X}$		74			.07			.20	.02	

*Inconsequential

The 't' test was used for the difference between means, and the 'F' test was used for the difference between variances. The statistical significance level of 0.05 was used. The asterisks in the tables indicate that although there is a statistical difference, in the author's opinion, it is inconsequential.

RESULTS

Asphalt Contents

First, comparing VDOT's and the contractors' nuclear asphalt content results (Table 1), only one of the five mixes had a difference between means that is appreciable, and that was only 0.14 percent. The weighted average difference was

TABLE 2

1991 PILOT STUDY

		Nuclear/Reflux AC (%)															
		$\overline{X}$								s							
		VDOT				Cont.				VDOT				Cont.			
Contractor	Mix	N	R	D	Sign	N	R	D	Sign	N	R	Diff	Sign	N	R	Diff	Sign
APAC	SM-2A	5.75	5.73	.02	No	5.79	5.86	.07	Yes*	.17	.20	.03	No	.15	.15	.00	No
	SM-2B	5.41	5.47	.06	No	5.54	5.54	.00	No	.24	.26	.02	No	.19	.23	.04	No
Short	SM-2A	5.77	5.76	.01	No	5.82	5.82	.00	No	.19	.20	.01	No	.18	.21	.03	No
Short (R)	SM-2A	5.44	5.38	.06	No	5.33	5.48	.15	Yes	.29	.26	.03	No	.22	.23	.01	No
Branscombe	SM-2A	5.75	5.68	.07	No	5.75	5.72	.03	No	.10	.17	.07	No	.17	.17	.00	No

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TABLE 3

1991 PILOT STUDY—VOLUMETRICS

VTM

			$\bar{X}$				s			
Contractor	Mix	n	VDOT	Cont.	Diff.	Sign.	VDOT	Cont.	Diff.	Sign.
APAC	SM-2A	22	5.42	5.46	.04	No	0.83	0.99	.16	No
	SM-2B	12	5.08	4.75	.33	No	1.08	0.85	.23	No
Short	SM-2A	31	4.07	4.00	.07	No	0.81	0.68	.13	No
Short (R)	SM-2A	5	4.78	4.50	.28	Yes*	1.07	0.89	.18	No
Branscombe	SM-2A	3	5.10	4.43	.67	No	0.20	0.57	.37	No
$\bar{X}$		73			.14			.83	.16	

VFA

			$\bar{X}$				s			
Contractor	Mix	n	VDOT	Cont.	Diff.	Sign.	VDOT	Cont.	Diff.	Sign.
APAC	SM-2A	22	67.8	68.3	0.5	No	4.20	4.55	.35	No
	SM-2B	12	68.4	70.0	1.6	No	5.77	4.62	1.15	No
Short	SM-2A	31	74.5	74.8	0.3	No	4.41	3.85	0.56	No
Short (R)	SM-2A	5	69.7	71.2	1.5	No	6.22	4.79	1.43	No
Branscombe	SM-2A	3	69.3	72.0	2.7	No	1.15	2.65	1.50	No
$\bar{X}$		73			0.8			4.38	0.69	

VMA

			$\bar{X}$				s			
Contractor	Mix	n	VDOT	Cont.	Diff.	Sign.	VDOT	Cont.	Diff.	Sign.
APAC	SM-2A	22	16.8	17.1	0.3	Yes*	0.53	0.79	0.26	Yes
	SM-2B	12	16.0	15.8	0.2	No	0.73	0.62	0.11	No
Short	SM-2A	31	15.8	15.9	0.1	No	0.55	0.52	0.03	No
Short (R)	SM-2A	5	15.8	15.6	0.2	No	0.64	0.70	0.06	No
Branscombe	SM-2A	3	16.6	15.6	1.0	Yes	0.52	0.47	0.05	No
$\bar{X}$		73			0.2			.60	0.12	

Table 4

GRADATION SIGNIFICANT DIFFERENCES

APAC	SM-2A
Extraction	
Average significant differences	VDOT v. Cont. 2/8 (incl. F/A)
Std. Dev. significant differences	VDOT v. Cont. 3/8 (incl. F/A)
Cold Feed	
Average significant differences	VDOT v. Cont. 1/7
Std. Dev. significant differences	VDOT v. Cont. 2/7
Cold Feed v. Extraction	VDOT Cont.
Average significant differences	6/7 6/7
Std. Dev. significant differences	7/7 6/7
Short	SM-2A
Extraction	
Average significant differences	VDOT v. Cont. 4/7*
Std. Dev. significant differences	VDOT v. Cont. 2/7
Cold Feed	
Average significant differences	VDOT v. Cont. 3/7
Std. Dev. significant differences	VDOT v. Cont. 4/7
Cold Feed v. Extraction	VDOT Cont.
Average significant differences	2/7 2/7
Std. Dev. significant differences	4/7 3/7

*Numerator = number of significant differences; denominator = number of sieves compared.

only 0.06 percent, a very acceptable value. The comparison of variabilities indicated no significant differences; the average difference was 0.03 percent, and the average standard deviation was 0.18 percent. To put this variability in perspective, the average standard deviation for the Reflux extraction test was 0.20 percent. The average difference between means for VDOT's and the contractors' extraction tests was 0.07 percent, and the average difference between standard deviations was 0.02 percent.

Next, comparing means of nuclear results (N) directly to those from Reflux extractions (R) (see Table 2) shows that none of VDOT's tests were significantly different, and only one set of tests from a contractor differed by more than 0.10 percent. In comparing standard deviations, no significant differences are indicated.

The conclusion from the asphalt content comparison is that the nuclear asphalt content gauge does at least as well as the Reflux extraction in determining asphalt content.

Volumetric Properties

Three volumetric properties were compared: voids total mix (VTM), voids in the mineral aggregate (VMA), and voids filled with asphalt (VFA) (see Table 3). The mix designations A and B refer to different compactive efforts: A denotes a 50-blow compactive effort and B denotes a 75-blow effort.

A comparison of the means and standard deviations between VDOT's and the contractors' results, shows that out of 30 comparisons, only 4 had statistically significant differences and only two of those (both in VMA) were appreciable.

Of most interest from a statistical viewpoint are the weighted standard deviations of each volumetric property. This information is necessary in order to develop realistic specification tolerances. The average standard deviation is 0.83 for VTM, 4.38 for VFA, and 0.60 for VMA. These numbers closely resemble those obtained in an earlier study of volumetric properties for the FHWA.

Gradation

The analysis of gradation is summarized in Table 4 by using the number of significant differences out of the total possible differences for each sieve. A table of the averages, standard deviations, and significant differences would be confusing because of the large number of comparisons.

Branscombe had so few gradation results that they were not included in the analysis. There are some statistical differences between VDOT's and the contractors' results for both extraction tests and cold feed results. But, as expected, the comparisons of VDOT's and the contractors' cold feed and extraction results produced the greatest number of significant differences. The significance of this is that the gradation population at the cold feed is different than that from extraction tests. Thus, either can be used for a specific purpose, but one does not duplicate the other.