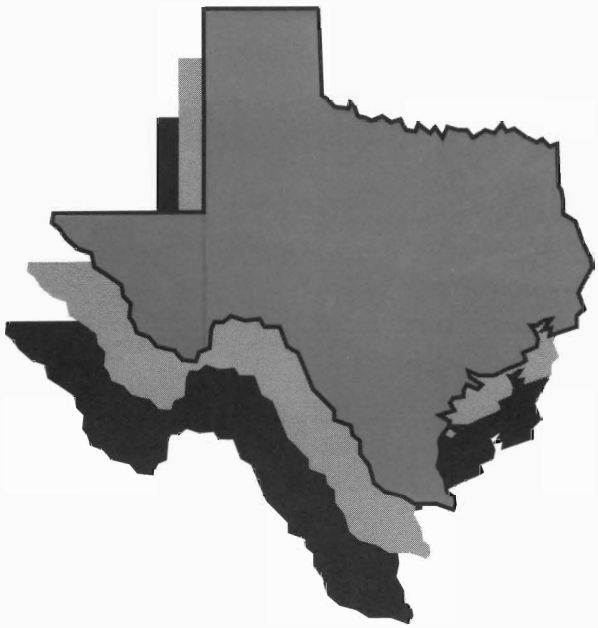
EVALUATION OF SOLVENTS AND METHODS OF EXTRACTION

DHT-37



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EVALUATION OF SOLVENTS AND METHODS OF EXTRACTION

BY

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MATERIALS AND TESTS DIVISION

RESEARCH REPORT DHT-37

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15. Supplementary Notes

This in-house research study was performed with the help of the Waco District Laboratory and the MAT Bituminous field laboratories.

16. Abstract

This report describes a project undertaken to determine (1) whether several different solvents (trichloroethylene, contract citrus terpene, BioAct, PurSolv, and BioTMax) were effective in recovering asphalt from bituminous mixtures; (2) whether the various solvents tested in No. 1, particularly citrus terpene, caused material finer than the No. 200 sieve to clump together; (3) whether filter aid caused the minus No. 200 material to clump together; and (4) whether the centrifuge and vacuum extractors give comparable results.

In summary, BioAct and trichloroethylene performed with very similar accuracy. PurSolv 140 and BioTMax produced similar results to the BioAct and trichlorethylene, with the exception of the passing No. 200 results. The citrus terpene currently on contract produced the most inaccurate and the most unacceptable results.

The vacuum extractor without filter aid produced the best accuracy for total materials retained on both the No. 10 sieve and on the No. 200 sieve. The vacuum extractor with filter aid produced the next most accuracy results. The centrifuge extractor was the least accurate.

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Asphalt extraction, bituminous mixtures, water-soluble extraction solvents, citrus terpene, BioAct, trichloroethylene, PurSolv 140, BioTMax	No restrictions. This document is available to the public through the Texas Department of Transportation Research Library, P.O. Box 5080, Austin, TX 78763-5080.

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EVALUATION OF SOLVENTS AND METHODS OF EXTRACTION

INTRODUCTION

The objective of this study was to determine:

1. Whether several different solvents (trichloroethylene, contract citrus terpene, BioAct, PurSolv, and BioTMax) were effective in recovering asphalt from bituminous mixtures;
2. Whether the various solvents tested in No. 1, particularly citrus terpene, caused material finer than the No. 200 sieve to clump together;
3. Whether filter aid caused the minus No. 200 material to clump together; and
4. Whether the centrifuge and vacuum extractors give comparable results.

EXPERIMENT DESIGN AND METHODOLOGY

The experimental design can be found in Table 1. The first sample was a Type D plant mix using absorptive limestone aggregate from Colorado Materials, Hunter Pit, and AC-20. The second sample was mixed by the Materials and Tests Division and consisted of AC-20 and a siliceous aggregate using Colorado Material's Type D gradation but with a high minus #200 component. The third sample was a coarse matrix high binder (CMHB) design, prepared by the Materials and Tests Division, consisting of AC-20 and a hard limestone from Vulcan Materials, San Antonio, Texas. The fourth sample was a CMHB design mixed by the Waco District Laboratory and consisted of AC20 and a highly absorptive limestone from Texas Crushed Stone, Georgetown, Texas. The fifth sample was a CMHB plant mix using AC-10 with 3 % latex and a hard limestone from Vulcan Materials, Weatherford, Texas.

Two technicians performed all of the extractions and sieve analyses. Test Method Tex-200-F was used to perform sieve analysis. Tex-210-F was used to perform extractions when using trichloroethylene and the contract citrus terpene. As recommended by the manufacturers, a water-rinse procedure was incorporated into Tex-210-F for use with BioAct, PurSolv, and BioTMax. Samples were tested using the centrifuge extractor, the vacuum extractor with 100 grams of filter aid, and the vacuum extractor without filter aid.

The Chemical Section of the Materials and Tests Division performed a chemical analysis of each of the solvents, except for the trichloroethylene. The results are shown in Table 2.

Table 1: Experimental Design

Solvent and Method of Extraction	Limestone Type D Plant Mix	Siliceous Type D Lab Mix	Limestone CMHB L Lab Mix	Limestone CMHB W Lab Mix	Limestone CMHB Latex Plant Mix
Trichloroethylene Vacuum Extractor With Filter Aid			X		X
Trichloroethylene Vacuum Extractor No Filter Aid	X	X		X	
Trichloroethylene Centrifuge	X	X		X	X
Citrus Terpene Vacuum Extractor With Filter Aid	X	X	X	X	X
Citrus Terpene Vacuum Extractor No Filter Aid	X	X		X	
Citrus Terpene Centrifuge	X	X		X	X
BioAct Vacuum Extractor With Filter Aid		X	X		X
BioAct Vacuum Extractor No Filter Aid	X	X		X	
BioAct Centrifuge	X	X		X	X
PurSolv Vacuum Extractor With Filter Aid			X		X
PurSolv Vacuum Extractor No Filter Aid	X			X	
PurSolv Centrifuge	X			X	X
Bio T Max Vacuum Extractor With Filter Aid		X	X		X
Bio T Max Vacuum Extractor No Filter Aid	X	X			
Bio T Max Centrifuge	X	X			X

ANALYSIS OF DATA

The individual data is presented in Appendix B. A summary of the differences between the job mix formulas (JMF) and the extraction results, grouped by type of extractor and solvent, is presented in Table 3. The differences between the JMF and extracted asphalt contents are plotted in Figures la through 1c. The data has been plotted separately for each method of extraction. Figures 2a through 2c show the differences between the IMF and the total amount of aggregate retained on the No. 10 sieve after extraction. Figures 3a through 3c show the differences between the JMF and the amount of material passing the No. 200 sieve after extraction.

A total of nineteen samples were tested using the centrifuge extractor. Sixteen samples were tested using the vacuum extractor with 100 grams of filter aid, and fourteen samples were tested using the vacuum extractor without filter aid. The differences between the job mix formulas and the extracted results were compared to the applicable AASHTO precision statement presented in Appendix A. The number of times the results fell within the acceptable range specified by AASHTO were then tallied and divided by the total number of samples run on that piece of equipment to determine the percent accuracy, regardless of solvent type, for each of the three methods of extraction. This data is presented in Table 4. This same methodology was used to determine the percent accuracy of each solvent, regardless of type of equipment. This data is also presented in Table 4.

Table 4: Percentage of Acceptable Results

Extraction Procedure	Asphalt Content (%)	Total Retained on Number 10 Sieve (%)	Total Pass Number 200 (%)
Centrifuge	42	37	32
Vacuum With Filter Aid	44	75	38
Vacuum No Filter Aid	50	79	43
Trichloroethylene	44	67	56
Citrus Terpene	17	58	8
BioAct	70	60	50
PurSolv 140	50	83	33
PurSolv 180	50	0	50
Bio T Max	50	75	38

Table 2: Chemical Analysis

	PurSolv	BioAct	Bio T Max	Bio T 200A	Citrus Terpene	Current Spec
% Citrus Terpene	51.3%	91.1%	90.3%	92.4%	25.3%	25–35%
Flash Point (F) (Pensky Marten)	105° F	120° F	125° F	126° F	116° F	100° F min
Distillation Range						
Initial Boil Point	320° F	– – –	300° F	336° F	320° F	300° F min
End Point	352° F	– – –	360° F	356° F	362° F	375° F max
Nonvolatile Residue	3.13%	– – –	13.5%	0.41%	0.27%	0.10% max

CONCLUSIONS

The water-soluble solvents met the AASHTO precision statement accuracy 50% to 75% of the time for extracted asphalt content and total amount retained on the No. 10 sieve. These same solvents met the AASHTO precision statement 33% to 50% of the time for the amount passing the No. 200 sieve. The current contract citrus terpene solvent met the AASHTO precision statements 17% of the time for extracted asphalt content, 58% of the time for total retained on the No. 10 sieve, and 8% of the time for the amount passing the No. 200 sieve. Trichloroethylene met the AASHTO precision statements for extracted asphalt content 44 % of the time, 67 % of the time for total amount retained on the No. 10 sieve, and

Table 3: Difference Between Job Mix Formula and Extracted Results

		Solvent = Trichloroethylene			Solvent = Citrus Terpene			Solvent = BioAct			Solvent = PurSolv			Solvent = Bio T Max			Solvent = PS 180		
		JMF - Measured Value			JMF - Measured Value			JMF - Measured Value			JMF - Measured Value			JMF - Measured Value			JMF - Measured Value		
	Mix	AC	+10	-200	AC	+10	-200	AC	+10	-200	AC	+10	-200	AC	+10	-200	AC	+10	-200
Centrifuge	Type D	0.7	-0.2	-0.7	1.7	1.1	-1.3	0.6	-0.8	-0.3	0.4	0.0	-0.2	0.3	2.2	-0.3	1.0	-4.0	0.2
	Siliceous	0.1	-0.5	-1.3	0.7	1.5	-1.7	0.4	0.0	-1.2	–	–	–	0.4	0.6	-1.1	0.4	-1.0	1.1
	CMHB L	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	CMHB W	0.6	1.5	0.1	1.1	1.3	1.6	0.8	1.5	1.0	–	–	–	–	–	–	–	–	–
	CMHB Latex	0.7	1.5	2.9	1.2	-1.6	2.0	1.0	2.1	-0.3	1.4	1.6	1.0	2.1	-1.4	1.3	–	–	–
Vacuum With Filter Aid	Type D	–	–	–	0.8	-0.8	0.9	–	–	–	–	–	–	–	–	–	–	–	–
	Siliceous	–	–	–	0.5	-3.4	0.9	0.1	-0.9	-0.4	–	–	–	-0.2	0.8	0.7	0.4	1.1	3.2
	CMHB L	0.1	0.5	-0.7	0.2	0.1	-0.4	0.4	0.1	-0.7	0.3	0.2	-0.5	0.3	0.3	-0.4	–	–	–
	CMHB W	–	–	–	0.7	1.5	4.3	–	–	–	–	–	–	–	–	–	–	–	–
	CMHB Latex	0.9	-0.9	1.1	1.1	-1.0	2.2	1.3	-2.8	1.7	1.0	-0.9	1.1	1.0	-0.6	1.0	–	–	–
Vacuum No Filter Aid	Type D	-0.4	-1.2	0.3	0.5	-0.1	-0.4	0.1	1.2	-0.2	0.4	0.8	-0.5	0.4	0.6	0.1	–	–	–
	Siliceous	0.1	-0.7	-0.6	-0.2	0.4	-0.9	0.0	0.4	-1.0	–	–	–	-0.6	0.8	-0.9	0.3	1.8	-0.6
	CMHB L	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	CMHB W	0.4	0.9	0.6	0.4	0.9	1.2	-0.1	0.4	1.9	-0.3	0.6	1.6	–	–	–	–	–	–
	CMHB Latex	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

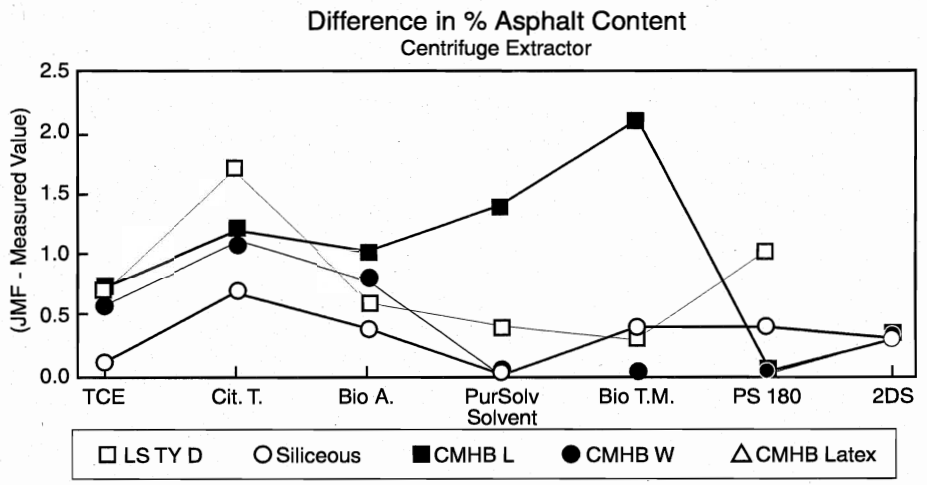

FIGURE 1A

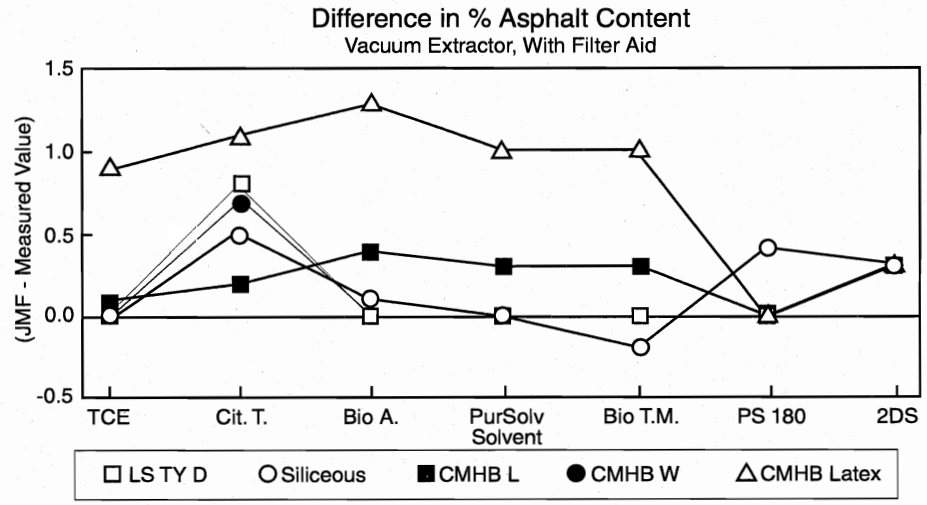

FIGURE 1B

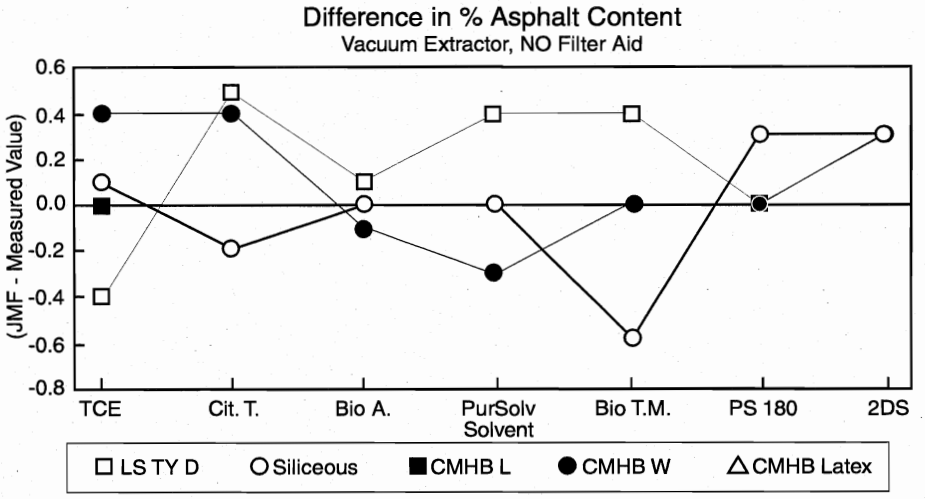

FIGURE 1C

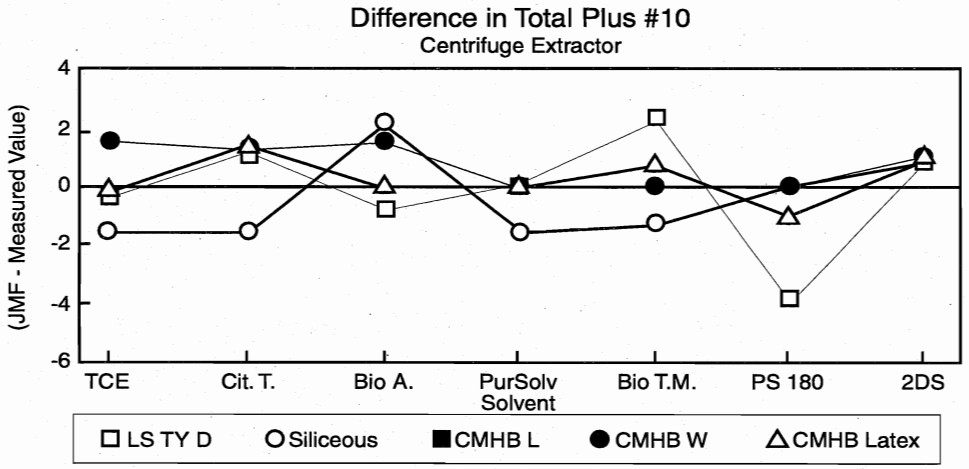

FIGURE 2A

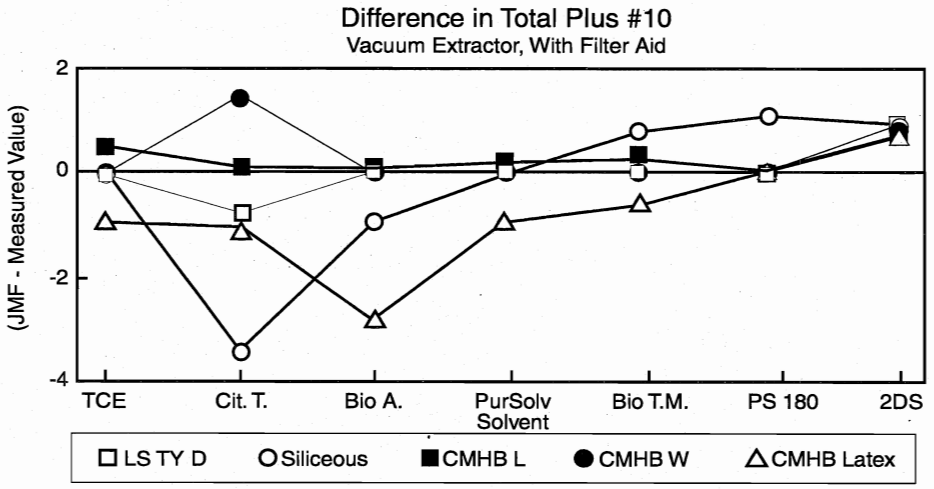

FIGURE 2B

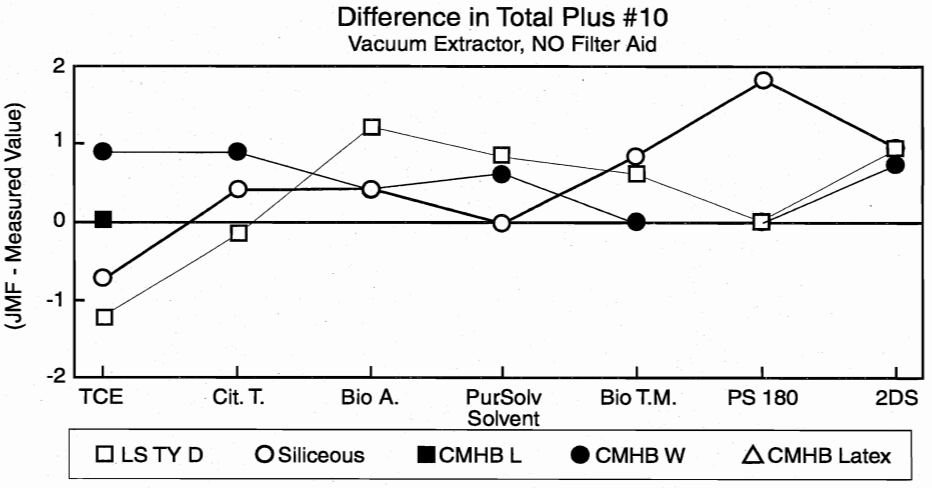

FIGURE 2C

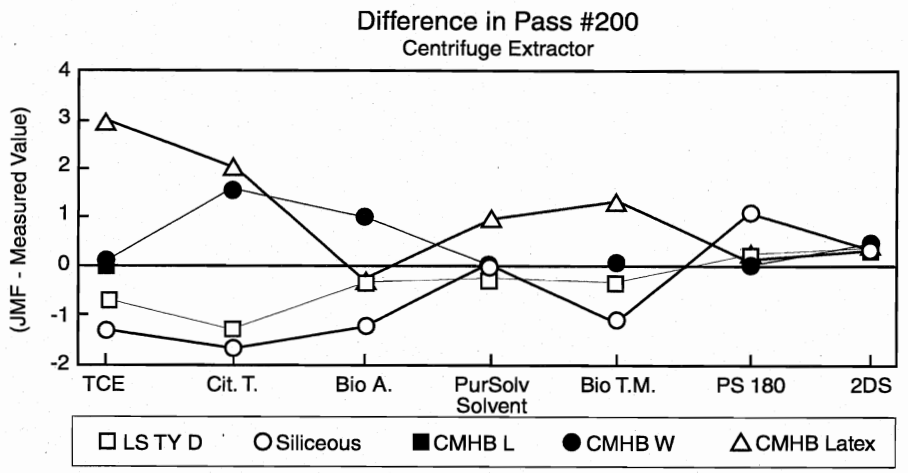

FIGURE 3A

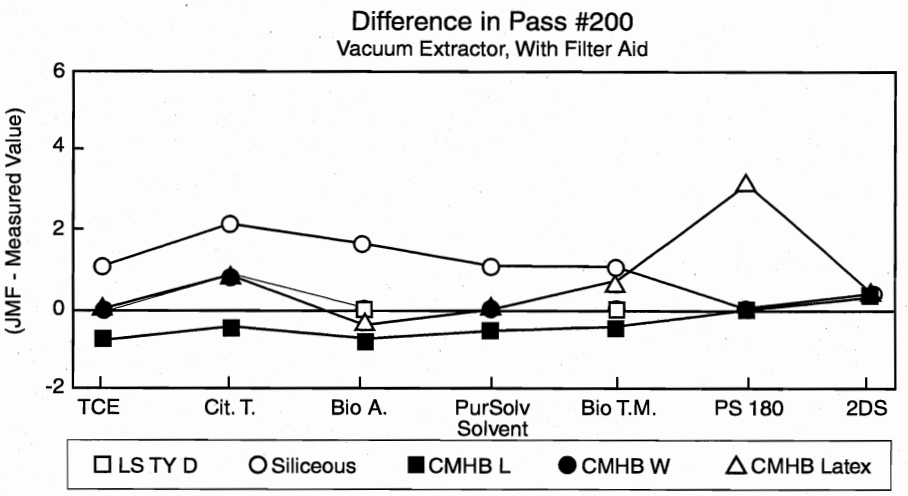

FIGURE 3B

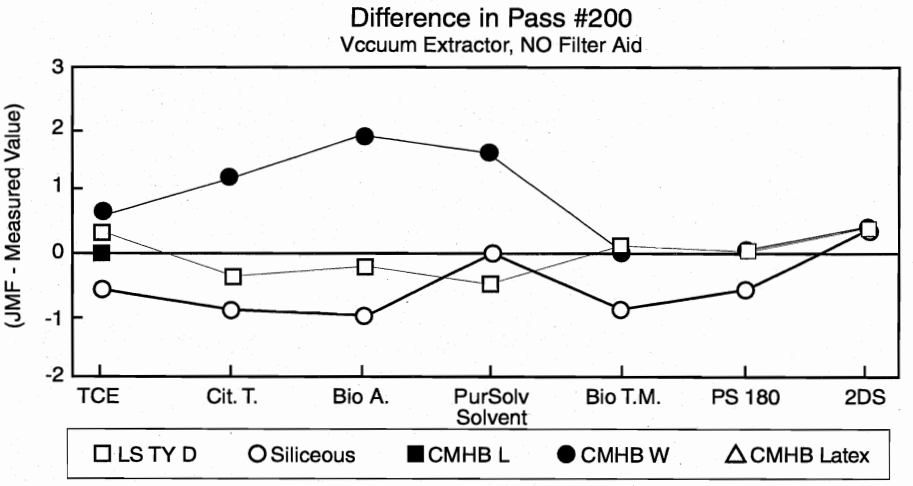

FIGURE 3C

56% of the time for the amount passing the No. 200 sieve.

In summary, BioAct and trichloroethylene performed with very similar accuracy. PurSolv 140 and BioTMax produced similar results to the BioAct and trichlorethylene, with the exception of the passing No. 200 results. The citrus terpene currently on contract produced the most inaccurate and the most unacceptable results.

The data in Table 3, Table 4, and Figures 1a through 1c indicate that the vacuum extractor without the use of filter aid clearly produced the best test results for asphalt content. The vacuum extractor with filter aid and the centrifuge produced approximately the same level of accuracy for asphalt content, and they were both inferior to the vacuum extractor without filter aid.

The vacuum extractor with and without filter aid produced the best accuracy for the total material retained on the No. 10 sieve. The centrifuge produced results which were much less accurate. Figures 2a through 2c and the data in Tables 3 and 4 contain the supporting data.

The vacuum extractor without filter aid again produced the best accuracy for determining the amount of material passing the No. 200 sieve. The vacuum extractor with filter aid produced the next most accurate results, and the centrifuge extractor produced the least amount of accuracy. Figures 3a through 3c and the data in Tables 3 and 4 contain the supporting data.

RECOMMENDATIONS

Based on the results of this study, the following recommendations are made:

1. Test Method Tex-210-F should be modified to allow the use of water-soluble extraction solvents.
2. The use of the current contract citrus terpene solvent should be discontinued as soon as a replacement solvent is available.
3. The current extraction solvent specification should be rewritten to allow the use of the water-soluble solvents, and a new contract should be obtained.
4. The vacuum extractor should be used to perform solvent extractions. The use of filter aid should be limited to small amounts (30 grams or less) and should only be used for those samples which absolutely need it.
5. TxDOT and contractor laboratories must use the same method of extraction and solvents to avoid conflicts caused by these variables.
6. A nonsolvent-based method of evaluating gradation should be pursued.

APPENDIX A

AASHTO PRECISION AND BIAS

SIEVE ANALYSIS, T30

Results of two properly conducted tests by the same operator on the same batch should not differ by more than the following:

1. For sieves with between 25% and 39.9% passing, the acceptable range of two results is 1.8% ± 0.9.
2. For sieves with between 10% and 24.9% passing, the acceptable range of two results is 1.3% ± 0.7.
3. For sieves with between 5 % and 9.9% passing, the acceptable range of two results is 0.8% ± 0.4.
4. For sieves with between 2% and 4.9% passing, the acceptable range of two results is 0.6% ± 0.3.

Results of two properly conducted tests from two different laboratories on samples from the same batch should not differ by more than the following:

1. Between 25% and 39.9% passing, 2.4% ± 1.2.
2. Between 10% and 24.9% passing, 2.3% ± 1.15.
3. Between 5 % and 9.9% passing, 1.6% ± 0.8.
4. Between 2 % and 4.9 % passing, 1.2% ± 0.6.

PERCENT ASPHALT BY SOLVENT EXTRACTION, T164

Results of two properly conducted tests by the same operator on the same batch should not differ by more than 0.58% ± 0.3.

Results of two properly conducted tests from two different laboratories on samples from the same batch should not differ by more than 0.83% ± 0.4.

APPENDIX B

Limestone Type D

Sieve Size Individual % Ret	JMF Limestone Type D	Trich Vac No FA	Trich Cent	BioAct Vac No FA	BioAct Cent	PurSol 140 Vac No FA	PurSol 140 Cent	PS 180 Cent	Bio T Max Vac No FA	Bio T Max Cent
7/8 - 5/8	0	3.6	0.9	2.1	0.7	0.0	1.4	3.7	1.4	2.5
5/8 - 3/8	7.6	22.4	20.9	19.3	24.4	21.4	19.2	26.3	19.0	14.8
3/8 - 4	28.5	16.2	18.8	16.7	16.1	17.4	18.9	17.9	17.8	18.9
4 - 10	28.2	23.3	23.9	25.0	23.9	24.7	24.8	20.4	25.5	25.9
+10	64.3	65.5	64.5	63.1	65.1	63.5	64.3	68.3	63.7	62.1
10 - 40	18.9	17.3	17.8	19.1	17.6	18.5	18.4	15.7	18.6	19.5
40 - 80	8.9	8.3	8.4	8.5	8.5	8.4	8.1	7.7	8.5	9.2
80 - 200	3.4	4.7	4.1	4.6	4.0	4.6	4.5	4.0	4.8	4.4
-200	4.5	4.2	5.2	4.7	4.8	5.0	4.7	4.3	4.4	4.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% AC	4.9	5.3	4.2	4.8	4.3	4.5	4.5	3.9	4.5	4.6
Ash (g)			0.36		0.55		0.72	0.6		0.45
Extraction Time (minutes)										
Solvent (ml)		2,100	2,450	2,400	2,550	2,550	2,600	2,500	2,350	2,300

Sieve Size Individual % Ret	Citrus Terp Vac No FA	Replicate Citrus Terp Vac No FA	Replicate Citrus Terp Vac No FA	Replicate Citrus Terp Vac No FA	Citrus Terp Vac 100g FA	Houston Citrus Terp Vac 57g FA	Nuc Citrus Terp Vac 30g FA	Citrus Terp Cent	Citrus Terp Cent	Citrus Terp Cent
7/8 - 5/8	2.3	0.0	0.0	0.0	1.4	1.0	0.0	3.1	0.0	0.0
5/8 - 3/8	19.4	5.6	8.8	9.0	22.9	20.5	8.0	19.1	5.6	8.4
3/8 - 4	18.4	29.0	32.8	27.5	17.2	20.5	26.5	17.4	29.0	29.7
4 - 10	24.3	30.4	26.2	29.3	23.6	23.2	28.9	23.6	30.6	28.4
+10	64.4	65.0	67.8	65.8	65.1	65.2	63.4	63.2	65.2	66.5
10 - 40	18.2	17.2	15.2	16.7	17.7	17.2	19.1	18.3	17.7	15.7
40 - 80	8.3	8.5	7.9	8.2	8.4	8.8	8.9	8.7	7.8	7.9
80 - 200	4.2	3.7	3.3	3.6	5.2	3.7	4.2	4.0	4.2	3.8
-200	4.9	5.6	5.8	5.7	3.6	5.1	4.4	5.8	5.1	6.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% AC	4.4	4.9	4.6	4.7	4.1	4.5	5.0	3.2	5.0	4.3
Ash (g)								17.9	16.7	24.3
% ASH								1.8	1.6	2.4
Solvent (ml)	2,360	2,770	3,150	3,300			2,550		3,100	3,350

Legend:

Trich = trichloroethylene
Citrus Terp = contract citrus terpene
Vac = vacuum extractor
Cent = centrifuge extractor
FA = filter Aid
PS 180 = PurSolv with 180° F flash point
AC = asphalt content
Nuc = asphalt content by nuclear gauge

CMHB L

Sieve Size Individual % Ret	JMF CMHB Lab Mix	Trich Vac 100g FA	Citrus Terp Vac 100g FA	BioAct Vac 100g FA	PurSolv Vac 100g FA	Bio T Max Vac 88g FA
5/8 - 3/8	20.6	17.1	16.5	15.9	15.9	16.9
3/8 - 4	43.4	45.6	46.0	47.1	46.3	46.2
4 - 10	17.0	17.8	18.4	17.9	18.6	17.6
+10	81.0	80.5	80.9	80.9	80.8	80.7
10 - 40	9.2	8.6	8.7	8.3	8.2	8.4
40 - 80	2.8	2.4	2.3	2.3	2.5	2.6
80 - 200	1.5	2.3	2.2	2.3	2.5	2.4
-200	5.5	6.2	5.9	6.2	6.0	5.9
	100.0	100.0	100.0	100.0	100.0	100.0
AC	4.8	4.7	4.6	4.4	4.5	4.5
Time (Hours)	NA	2.5	7		6	
Solvent (ml)	NA	2,500	3,500	4,500	4,000	5,500
Color of fines	White	White	Tan	White	White	White
Balling Up	None		None	None		

Legend:

Trich = trichloroethylene
Citrus Terp = contract citrus terpene
Vac = vacuum extractor
Cent = centrifuge extractor
FA = filter aid
PS 180 = PurSolv with 180° F flash point
AC = asphalt content
Nuc = asphalt content by nuclear gauge

Siliceous

Sieve Size Individual % Ret	JMF Siliceous Lab Mix	Trich Vac No FA	Trich Cent	Citrus Terp Vac 100g FA	Citrus Terp Vac No FA	Citrus Terp Cent	BioAct Vac 100g FA	BioAct Vac No FA	BioAct Cent	PS 180 Vac No FA	PS 180 Cent	PS 180 Vac 100g FA	Bio T Max Vac No FA	Bio T Max Vac No FA	Bio T Max Vac 100g FA	Bio T Max Cent
1/2 - 3/8		7.5	8.2	9.1	9.1	5.8	8.4	7.2	8.5	6.4	7.8	6.9	7.9	6.2	8.0	7.0
3/8 - 4		27.1	25.5	31.1	23.2	25.7	26.6	25.0	24.9	24.0	26.9	25.1	25.1	25.3	24.0	24.7
4 - 10		29.5	30.2	26.6	30.7	30.5	29.3	30.8	30.0	31.2	29.7	30.3	30.0	30.8	30.6	31.1
+10	63.4	64.1	63.9	66.8	63.0	61.9	64.3	63.0	63.4	61.6	64.4	62.3	63.0	62.3	62.6	62.8
10 - 40		17.7	17.7	16.1	18.4	18.9	17.6	18.5	17.9	20.0	18.9	20.9	18.7	19.3	19.0	18.4
40 - 80		7.5	7.3	7.4	7.6	7.5	7.5	7.5	7.5	7.8	8.0	8.6	7.3	7.8	7.6	7.8
80 - 200		4.1	3.8	4.6	4.1	4.1	4.2	4.0	4.0	4.0	3.8	5.4	3.6	4.2	5.5	4.0
-200	6.0	6.6	7.3	5.1	6.9	7.7	6.4	7.0	7.2	6.6	4.9	2.8	7.4	6.4	5.3	7.1
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AC	4.5	4.4	4.4	4.0	4.7	3.8	4.4	4.5	4.1	4.2	4.1	4.1	5.1	5.0	4.7	4.1
Ash (g)			0.4			1.2			0.9		0.7					1.35
Extraction Time (minutes)						60										
Solvent (ml)		1,650	1,800	2,500	1,950	1,950	2,200	2,120	2,250	2,450	2,140		2,050	1,700	2,200	1,950
Color of fines																
Balling Up																

Comments
1. Bio T Max has extremely strong, annoying odor.
2. Bio T Max – Vacuum extractor had difficulty drawing the water rinse through the filter cake. We had to remove the original filter and use a second filter. This process took over an hour.

Legend:
Trich = trichloroethylene
Citrus Terp = contract citrus terpene
Vac = Vacuum extractor
Cent = centrifuge extractor
FA = filter aid
PS 180 = PurSolv with 180° F flash point
AC = asphalt content

CMHB W

Sieve Size Individual % Ret	JMF CMHB W Lab Mix	Trich Vac No FA	Trich Cent	Citrus Terp Vac 100g FA	Citrus Terp Vac No FA	Citrus Terp Cent	BioAct Vac No FA	BioAct Cent	PurSolv 14 Vac No FA	PurSolv 14 Cent	Bio T Max Vac No FA	Bio T Max Cent
5/8 - 3/8	10.8	7.3	8.0	8.8	9.0	7.3	6.5	7.6	7.1		8.5	
3/8 - 4	35.0	35.2	34.0	33.7	33.8	34.2	37.6	35.1	35.0		39.1	
4 - 10	30.5	32.9	32.8	32.3	32.6	33.5	31.8	32.1	33.6	Ran	28.9	Ran
+10 (±0.7)	76.3	75.4	74.8	74.8	75.4	75.0	75.9	74.8	75.7	out	76.5	out
10 - 40	10.1	9.9	10.2	12.3	10.2	10.6	10.1	10.1	10.1	of	9.7	of
40 - 80	3.5	3.8	3.9	4.7	4.2	4.6	4.3	4.4	4.4	material	3.9	material
80 - 200	2.1	3.5	3.3	4.5	3.4	3.4	3.6	3.7	3.4		3.3	
-200 (±0.4)	8.0	7.4	7.9	3.7	6.8	6.4	6.1	7.0	6.4		6.6	
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100.0	
AC (±0.3)	5.8	5.4	5.2	5.1	5.4	4.7	5.9	5.0	6.1		6.1	
Ash (g)			0.27			0.84		0.65				
Ash (g)			0.27			0.84		0.65				
Extraction Time (minutes)		80	45		60	60						
Solvent (ml)		2,400	2,560	3,200	3,400	3,040		2,700	3,200		3,100	
Color of fines												
Balling Up												
Comments											Filter Tore	

Legend:
Trich = trichloroethylene
Citrus Terp = contract citrus terpene
Vac = vacuum extractor
Cent = centrifuge extractor
FA = filter aid

CMHB with Latex

Sieve Size Individual % Ret	JMF Limestone CMHB 3% Latex	Trich Vac 100g FA	Trich Cent	Citrus Terp Vac 100g FA	Citrus Terp Cent	BioAct Vac 100g FA	BioAct Cent	PurSolv 140 Vac 100g FA	PurSolv 140 Cent	Bio T Max Vac 100g FA	Bio T Max Cent
5/8 - 3/8	37.8	36.8	37.7	36.4	35.8	41.0	32.9	38.7	41.2	43.4	42.0
3/8 - 4	20.6	22.4	23.6	23.9	25.3	21.8	22.2	22.4	21.4	17.0	20.7
4 - 10	19.3	19.4	17.9	18.4	18.2	17.7	20.6	17.5	16.7	17.9	16.3
+10	77.7	78.6	79.2	78.7	79.3	80.5	75.6	78.6	79.3	78.3	79.1
10 - 40		10.4	12.6	10.7	10.4	9.4	11.8	10.4	10.2	10.4	10.2
40 - 80		3.1	2.7	3.2	3.4	2.4	3.1	2.9	2.6	2.9	3.2
80 - 200		2.5	1.9	3.1	2.4	2.9	2.7	2.7	2.4	2.9	2.4
-200	6.5	5.4	3.6	4.3	4.5	4.8	6.8	5.4	5.5	5.5	5.2
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AC	5.6	4.7	4.9	4.5	4.4	4.3	4.6	4.6	4.2	4.6	3.5
Ash (g)			0.02		0.2		1.25		0.45		0.9
Extraction Time (minutes)		35	40	60	105			175	160	65	75
Solvent (ml)		3,000	1,900	3,700	2,650	3,560	2,550	2,850	2,900	2,600	2,350

Legend:
Trich = trichloroethylene
Citrus Terp = contract citrus terpene
Vac = vacuum extractor
Cent = centrifuge extractor
FA = filter aid
PS 180 = PurSolv with 180° F flash point
AC = asphalt content