EXPERIMENTAL USE OF LIQUID RUBBER LATEX MODIFIED BITUMINOUS PAVEMENT ON VERMONT ROUTE 12 WORCESTER, VERMONT

INITIAL REPORT 86-1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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Assistant Research Specialist

Reviewed By:

R. F. Nicholson, P.E.
Materials & Research Engineer

Date: January 20, 1986

"The information contained in this report was compiled for the use of the Vermont Agency of Transportation. Conclusions and recommendations contained herein are based upon the research data obtained and the expertise of the researchers, and are not necessarily to be construed as Agency policy. This report does not constitute a standard, specification, or regulation. The Vermont Agency of Transportation assumes no liability for its contents or the use thereof."

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ABSTRACT

Approximately 150 tons of bituminous concrete mix modified with Ultrapave liquid rubber latex was produced and placed as a one inch wearing course over a plant mixed base course on September 5, 1984. The experimental pavement is located on Vermont Route 12 at milemarker 0670 and extends to milemarker 0701 in the Town of Worcester.

The Ultrapave was added manually to the bituminous concrete mix directly into the pugmill at the plant. The experimental mix was produced by Cooley Asphalt Paving Corporation in Berlin, Vermont.

Paving was performed by a District 6 maintenance crew who commented that the material was very fibrous and sticky compared to the standard mix, which made hand work more difficult.

Survey results through September 1985 do not reveal any difference in performance between the liquid rubber latex modified pavement and the standard mix.

INTRODUCTION

The Vermont Agency of Transportation was offered three drums of Ultrapave liquid rubber latex at no charge for a field evaluation. With the cooperation of the local bituminous concrete producer, Cooley Asphalt Paving Corporation, an experimental bituminous concrete mix was batched and placed in September of 1984.

The section of roadway selected for the placement of the experimental mix had been washed out during flooding caused by heavy rains. New subbase and plant mix base course was placed, which created a new roadway as a portion of the test site.

This report describes the initial observations during production and placement of the modified mix and performance during the first 12 months of service for the project Worcester/Elmore ER 0241 (19).

PRODUCTION INFORMATION PROVIDED BY THE SUPPLIER (ABRIDGED)

Ultrapave is a rubber latex binder for asphalt. Because the rubber particles are extremely fine and uniform, a very high surface area is exposed to the asphalt during mixing and the dispersion of rubber is rapid and thorough.

Paving material modified with Ultrapave provides resistance to surface abrasion, scour and wear. It increases the ability of the bitumens to retain aggregates. Improved ductility at low temperatures helps prevent winter checking and cracking. Its higher softening point, lower penetration, and lower temperature susceptability mean less shoving, rutting, and general instability of paving material. Bleeding of seal coats is reduced during hot weather. Increased adhesion and tack prevents asphalt stripping in hot mixes and increases the ability of the binder to remain anchored securely to the aggregate. Water resistance is gained, protecting the road from deterioration. Prime and tack coats have better adhesion. Increased stability and density of asphalt concrete results in uniform surface texture and unusually tight cold joints, and feather edges. Overlays can be laid as thin as ¼ inch when asphalt is modified with Ultrapave.

COST INFORMATION

The material cost F.O.B. Dalton, Georgia is $6.50 per gallon. Ultrapave normally comes in 55 gallon drums and is added to the bituminous concrete mix at a rate of 3/4 of a gallon per ton. Costs could be expected to range from

$7.50-$10.00/ton extra with freight and contractor handling included.

PROJECT DESCRIPTION & ROADWAY CONDITION

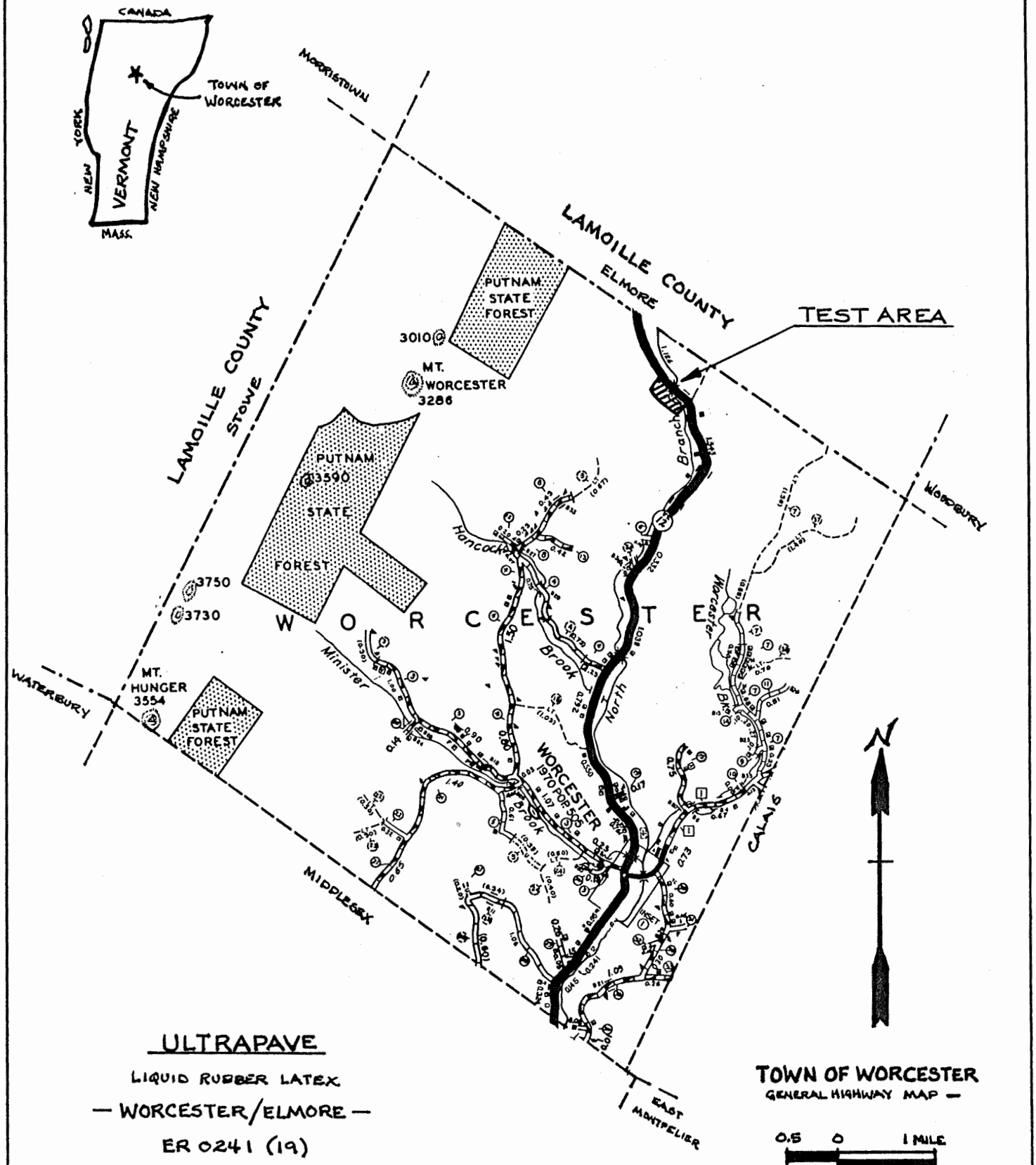
The Worcester/Elmore ER 0241 (19) project was a segment of an Emergency Relief (ER) project that extended along Vermont Route 12 from Montpelier City line north to the Morristown Town Line. The test area can be seen on the Location Map on Page 5.

The route logs indicate that the existing roadway, prior to the ER reconstruction, in the area of the test section was constructed in 1961 using 1½" of bituminous concrete pavement. A blade mix treatment was applied in 1967, a grit seal in 1975 and again in 1982.

After heavy concentrated rainfall on June 6, 1984 storm water backed up at the 180" CGMPP at milemarker 0700± causing subsequent failure of the roadway embankment which was eventually washed out. The area which was severely damaged was approximately 650' long and required reconstruction of the roadway section including subgrade, subbase and bituminous pavement.

The reconstruction was done utilizing District 6 forces. Once the new subbase and base course pavement was in place it was overlayed with 1± inch Type IV bituminous pavement. The overlay extended beyond the north and south end of the newly constructed roadway for approximately 0.15 miles in each direction. The completed roadway is 22' wide from edge of pavement to edge of pavement.

LOCATION MAP



RESEARCH & DEVELOPMENT

The average daily traffic for this section of Vermont Route 12 in 1982 was 530.

MIX PRODUCTION & TESTING

The modified mix was produced under the direct supervision of a representative of the Textile Rubber & Chemical Co., Inc., makers of Ultrapave. Production began at approximately 10:00 AM on September 5, 1984. The wet mix cycle was increased by 25 seconds to 61 seconds to insure adequate blending of the liquid rubber latex and the 85/100 penetration grade asphalt cement.

The liquid rubber latex was added at a rate of 3/4 gallon per ton of mix. The material was removed from the 55 gallon drum by dipping with a 5 gallon bucket. The material was then added to the mix during the wet mix cycle using the side door of the pugmill. Workers were cautioned by the company representative to wear long sleeves and gloves and have adequate eye protection in case of asphalt splatter during the wet mix cycle.

The course aggregate for the Type IV mix consisted of 3/8 inches and smaller crushed granite from the Websterville quarry. Fine aggregate included natural sand and stone screenings from crushed granite. A copy of the mix design can be seen on page 13.

Samples of the standard and latex modified mixes were taken from the trucks on the project. Results of tests performed on these samples can be seen by referring to pages 14-

26 in the Appendix. One test performed on the Ultrapave mix revealed low air voids of 2.44% (specifications have a range from 3% to 5%).

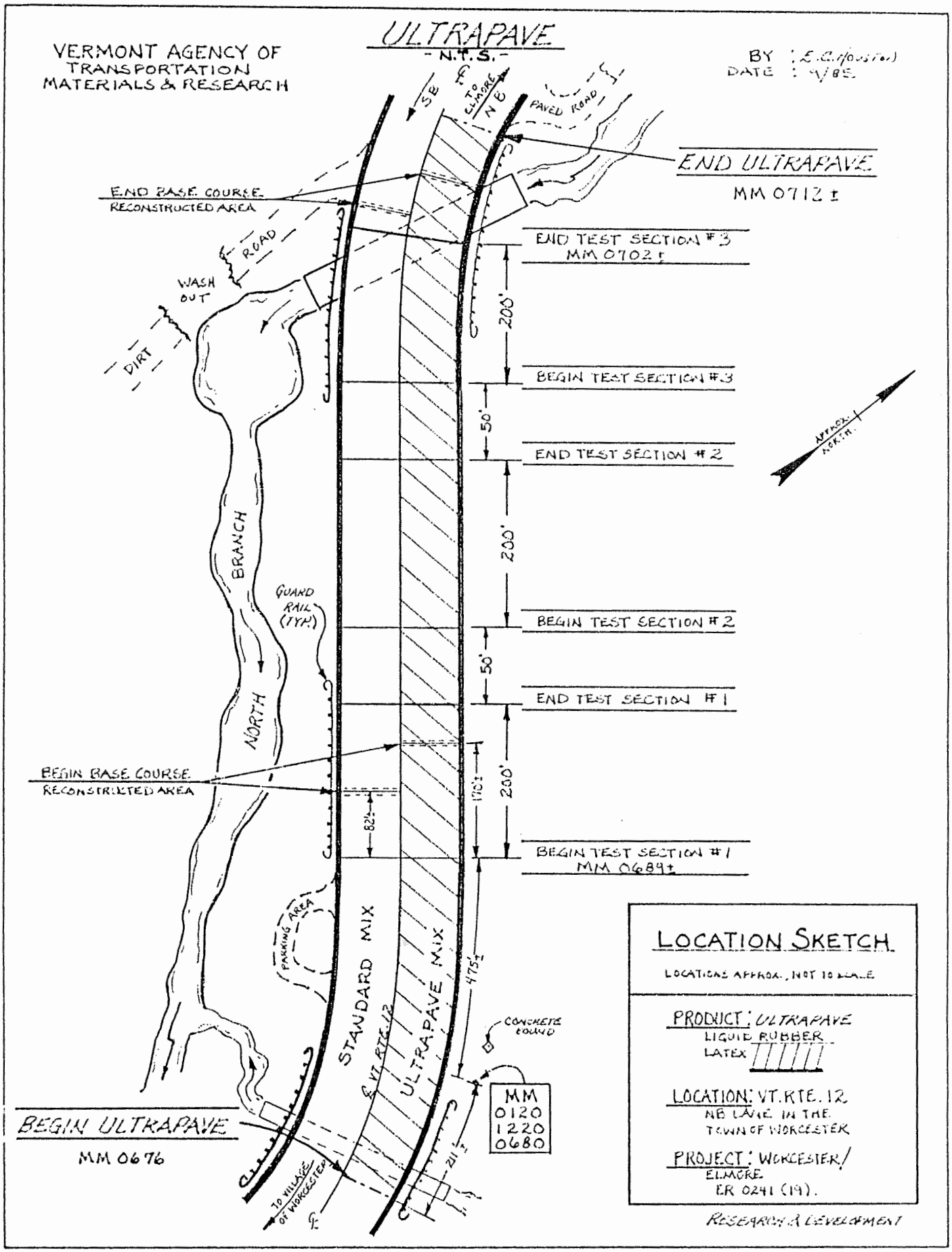
PAVING OPERATION

Paving of the regular mix began about 9:00 AM on August 5, 1984 under partly sunny skies with an ambient temperature of 55°F. Standard mix was produced and placed in the southbound lane prior to switching over to the modified mix. A plan view of the installation can be seen on page 8.

Paving sequence proceeded from north to south for both mixes. The experimental mix was placed in the northbound lane for a side by side test comparison. Three 200 foot test sections were marked out beginning at milemarker 0689± with two 50' spaces between. The third test section ends at milemarker 0702±. These test sections are located primarily over the new base course.

Thickness of the new wearing course averaged one inch prior to compaction. Mix temperatures sampled from trucks on the project ranged from 260°F to 310°F and averaged 295°F.

The experimental mix tended to be fibrous and more difficult for workers to rake. While working the centerline joint, the mix had a tendency to adhere to the rakes which required periodic cleaning using a scraper and diesel fuel. Workers commented that the fibrous texture required more hand work. The material was too sticky and wouldn't spread as well as regular mix.


VERMONT AGENCY OF TRANSPORTATION MATERIALS & RESEARCH
ULTRAPAVE
- N.T.S. -
BY : E.C. Houston
DATE : 4/85
TO ELMORE
SE
NE
PAVED ROAD
END ULTRAPAVE
MM 0712 ±
END BASE COURSE RECONSTRUCTED AREA
ROAD
WASH OUT
DIRT
END TEST SECTION #3
MM 0702 ±
200'
BEGIN TEST SECTION #3
50'
END TEST SECTION #2
200'
BEGIN TEST SECTION #2
50'
END TEST SECTION #1
200'
BEGIN TEST SECTION #1
MM 0689 ±
APPROX. N.G.V.D.
BRANCH
NORTH
GUARD RAIL (TYP.)
BEGIN BASE COURSE RECONSTRUCTED AREA
82½'
170'±
PARKING AREA
STANDARD MIX
VT. RTE. 12
ULTRAPAVE MIX
475'±
CONCRETE BOUND
MM
0120
1220
0680
211'±
BEGIN ULTRAPAVE
MM 0676
TO VILLAGE OF WORCESTER
LOCATION SKETCH
LOCATIONS APPROX., NOT TO SCALE
PRODUCT: ULTRAPAVE
LIQUID RUBBER
LATEX
LOCATION: VT. RTE. 12
NB LANE IN THE TOWN OF WORCESTER
PROJECT: WORCESTER/ ELMORE
ER 0241 (19).
RESEARCH & DEVELOPMENT

The roller operator stated that the modified mix was "easier to compact", because it "sticks better" and "leaves less ridges". The operator estimated that it "took 1/3 less rolling (fewer passes) to compact the mix".

During the compaction operation it was noted that small "fat spots" were found on the surface of the overlay. These were apparent prior to compaction and in some cases, as the roller crossed over them, they would stick to the roller and pull out leaving small pockmarks in the surface of the overlay. At first it was assumed that the fat spots were small (1"+ diameter) amounts of the Ultrapave latex which may not have thoroughly blended with the mix. There were about six of these spots per square foot of surface area. Further inspection revealed that this problem was not prevalent beyond the paver screed width. In other words, the fat spots were not appearing along the shoulder where the extension wing of the paver is located. This suggests that the fat spots were the result of a buildup of latex and fines on the screed which was then displaced by the mix and deposited on the surface of the pavement.

POST CONSTRUCTION OBSERVATIONS

Test sections 1, 2, and 3 were surveyed for thermal cracking and rutting on January 11, 1985. The inspection did not reveal any significant change in condition since the project was completed, with the exception of a full width transverse cracks at milemarker 0689± plus 134' in test section #1 and a transverse crack which covered only the NB lane (Ultrapave side) at 170'. The latter of the two occurred over the end of the 303 base

course in this lane. This suggests that cracking was caused by this underlying joint.

The small surface spots discussed earlier were still visible and in similar condition to that noted on August 5, 1984. Two full width transverse cracks which had been documented outside the test sections had both reflected through. This inspection indicates the products inability to suppress reflective cracking. Wheel path rutting measurements were not taken during this inspection due to snow accumulation on centerline and each side of the north and southbound lanes.

A second inspection on May 2, 1985 did not show any change from the first inspection.

During the most recent inspection of September 13, 1985 it was noted that test section #3 has 7'± of longitudinal cracking along the centerline. The condition cannot be used to credit or discredit the experimental mix because of its location along the pavement joint which separates the two mixes. Rutting measurements taken throughout the test sections averaged 1/16" overall except the left wheel path in the Ultrapave mix had an average of 2/16". The following chart shows the average results for each test section.

Summary Of Rutting Averages
Readings In Inches

	Standard Mix SB Lane		Ultrapave Exper. Mix NB Lane	
Test Section #	Left Wheel Path	Right Wheel Path	Left Wheel Path	Right Wheel Path
#1	1/16	1/16	2/16	1/16
#2	1/16	1/16	1/16	1/16
#3	1/16	1/16	2/16	2/16

The small surface spots in the Ultrapave mix were much less evident and apparently have been worn from traffic exposure. Overall the pavement remains in good condition.

SUMMARY

1) Ultrapave did not present any significant problems during mixing at the plant.

2) Workers on the project commented that the material had a very sticky, fibrous consistency which made hand work more difficult.

3) Small fat spots appeared on the surface of the new experimental overlay during construction. It is believed that the liquid rubber latex combined with the fines built up on the paver screed and was then displaced by the mix and deposited on the surface of the pavement.

4) Ultrapave did not reduce reflective cracking.

5) Wheel path rutting averaged 1/16 inch higher in the experimental mix as compared to the standard mix.

FOLLOW UP

The long term performance of the modified pavement will continue to be monitored with emphasis on the prevention of pavement cracking (new cracks), wheel path rutting, and friction values.

- APPENDIX -

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - BITUMINOUS CONCRETE SUBDIVISION No 2219

Design of Bituminous Concrete Mixtures

Appendix 13

Town Vt. Dist. #6 Project No. Various Locations

Gentlemen:

In accordance with the specification requirements for the above project I submit the following job mix formula:

Pavement Type IV Produced By: Cooley Asphalt Paving Plant Location Berlin

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200
Nat. Sand	27						100	92	80	67	46	23	4
Cr. Sand	27						100	96	76	52	34	18	3
3/8"	46						100	34	6				
Resultant	100						100	67	46	33	22	11	2

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200
S	56							100	83	64	45	26	7
2	44						100	28	2				
3													
4													
5													
Resultant	100						100	68	47	35	25	14	3.9

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	3420	3115				455	7,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula						100	98	68	46	34	24	13	3.5	6.5
Job Aim						100	85/100	63/75	42/50	30/38	20/28	9/17	2/5	6.1/6.9
Specification Limits						100	95/100	63/80	39/60	24/45	14/35	6/24	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Cooley Asphalt Paving - Websterville	AC-5:
Fine: Granite Sand - Cooley - Websterville Nat. Sand - Thunder Road Pit Barre Town	AC-10:
	Other: 85-100 Peter-Cox, RPCanada Montreal P.Q.

Mixing Times — Dry: 5 Wet: 35 Total: 40 Temperature: 280° F ± 20°

Submitted by: Wilfred A. Lapanne (signature) Date: 6-8-83

Company Cooley Asphalt Paving Corp. Title Treasurer

FOR STATE OF VERMONT USE ONLY

~~Approved~~ ~~Rejected~~

Comments: This design approved for Dist. use only.

Charles E. Jerd Title Bituminous Concrete Supv.

Date June 14 1983

RECEIVED JUN 8 1983 MATERIALS & RESEARCH DIVISION

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

Appendix 14

REG. MIX

BITUMINOUS CONCRETE EXTRACTION WORK SHEET

LAB NO. _____ DATE 9.6.84

PROJECT WORCESTER/ELMORE ER 0241 (19) MIX TYPE II DIST. #6

SOURCE COOLEY S, BERLIN, VT SAMPLE NO. _____

BOWL & MIX	2552	PAN & AGG.	1614	SLIP NO.	
BOWL	1198	PAN	351	TIME	
MIX	1354	AGG.	1263	MIX TEMP.	

%AC = $\frac{\text{MIX} - \text{AGG}}{\text{MIX}} 100$ _____ % - _____ = 6.7 %

% STONE (+8) 53
% SAND (-8) 47
% AIR VOIDS _____

% Slip Ac = _____ %

RETAINED ON	WEIGHT	% RETAINED	% PASSING	JOB AIM	REPORTED
1 3/4					
1 1/2					
1					
3/4					
1/2	—		100	100	100
3/8	31	2.5	97.5	95-100	98
4	381	30.2	67.3	63-75	67
8	260	20.6	46.7	42-50	47
16	148	11.7	35.0	30-38	35
30	145	11.5	23.5	20-28	24
50	130	10.3	13.2	9-17	13
200	135	10.7	2.5	2-5	3
Pass 200	32	2.5			
Totals	1262	100			
			% Slip AC		

	BIN S	BIN NO. 2	BIN NO. 3	BIN NO. 4	BIN NO. 5	AC	TOTAL
BATCH WEIGHTS							
Wt. ADJUSTMENT							

CORRECTIVE ACTION

COMMENTS: REG. MIX

N. Hutton / B. Royce
Inspector(s)

TA 417 Rev. 2M 4/84
2/M 8/84

REG. MIX

Bituminous Concrete System FILE MAINTENANCE Control No. H616 Form No. 4 of 6 Form Date 9/16/84	Vermont Agency Transportation Materials & Research Division ASPHALT MIXTURE PROPERTIES - Field Test Data - (Items P401 or 406)	Sheet ____ of ____ Project Code No. 0 Mix Design No. 0

Project Name WORCESTER/ELMORE Project No. ER 0241 (19

Source of Mix 21 COOLEYS, BERLIN, VT. Ring No. Year 84

Item No. 40625 Type of Mix 04 DISTRICT #6 Sp. Gr. AC 1023

(Note- Begin a new page if any of the prior fields change)

Line	Formula	Description	1	2	3	4	5
A		Lab No. D8					
B		Field Spec. No					
C		Test Date (mo.:day)					
D3		% Passing 1"					
D4		" 3/4"					
D5		" 1/2"					
D6		" 3/8"					
D7		" #4					
D8		" #8					
D9		" #16					
D10		" #30					
D11		" #50					
D12		" #200					
E		Bitumen % (AC) Slip	6.8.0	6.8.0			6.8.0
F		Effective % (AC)	6.0.5				6.0.5
G	100(T-S)/T	% Voids - Mix	4.7				4.7
H	100U/(U+G)	% Voids - Filled	74.2				74.2
I	U + G	% VMA	18.2				18.2
J	S x 62.4	Unit Wgt., lb/ft^3	142.8				142.8
K		Stab.-Conv., lb.	1702	1113			1408
L		Marshall Flow	8	10			9 AVG.
M		Sample Thick., in.	2 5/8	2 7/16			
N		Wgt. in Air, gm.	1208	1117			
P		Wgt. in Water, gm.	683	626			
R		Wgt. surf. dry, gm.	1208	1117			
S	N/(R-P)	Sp. Gr. - Bulk	2.301	2.275			2.288
T		Sp. Gr. - Max.	2.400				2.400
U	SxF/SpGrAc	AC by Volume %					13.53
V		Stab.-Measured, lb.	1702	1104			
W		Accept, Reject or N					

REG.

Field Notes:

Inspector(s): N. Houston B. Royce

Office Time Stamp:

TA 418-D 5C 8/83 5/C 8/84
5C 4/84

TA 567A 1M 7/81
1M 5/83
1M 4/84
1M 8/84

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUBDIVISION

Appendix 16

MAXIMUM SPECIFIC GRAVITY WORKSHEET
AASHTO T209-78
ASTM D2041-78

REG. MIX

Project WORCESTER/ELMORE No. ER 0241 (19) Date 9-6-84
Source Mix COOLEY'S, BERLIN, VT. Type IV DIST. #6 Test No.
Design No. 2275 VT DIST #6 Bulk Sp. Gr. AVG. 2.288
Flask No. #2

1.	Wt. of Flask + Sample	2457.4
2.	Wt. of Flask	1033.0
3.	Wt. of Sample (1-2) (A)	1424.4
4.	Wt. of Flask filled with H_2O (D)	3235.2
5.	Wt. of Flask + Water + Sample (E)	4066.2

CALCULATION:

Max. Sp. Gr. = A/(A + D - E)

$$= \frac{1424.4}{1424.4 + 3235.2 - 4066.2} = \frac{1424.4}{593.4} = 2.400$$

$$\% \text{ Voids Mix} = 100 \times \frac{\text{Max. Sp. Gr.} - \text{Bulk Sp. Gr.}}{\text{Max. Sp. Gr.}}$$

$$\frac{2.400 - 2.288}{2.400} = 4.66$$

Comments:	Inspector(s)	Office Time Stamp
	N. Houston Royce	

REG. MIX.

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUBDIVISION

Appendix 17

EFFECTIVE ASPHALT CONTENT WORK SHEET

Project WORCESTER/ELMORE
Source COOLEYS, BERLIN, VT.

Date 9.5.84
Mix Type 406.25 TYPE IV DIST. #6
Sample No.
Prepared By

EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE

$$G = \frac{100 - C}{\frac{100}{M} - \frac{C}{A}}$$

G = Eff. Sp. Gr. of Agg.
C = % Asphalt
M = Max. Sp. Gr. of Mix
A = Sp. Gr. of AC

$$\frac{100 - 6.80}{\frac{100}{2.4} - \frac{6.80}{1.023}} = \frac{93.2}{41.7 - 6.6 = 35.1} = 2.655$$

BULK SPECIFIC GRAVITY OF AGGREGATE (B)

Agg. Size	B = 100/A	% Used / Bulk Sp.Gr.		
Nat. Sa		27 / 2.623	=	10.29
			+	
Gr. Sa.		27 / 2.569 Gr Sa	=	10.51
			+	
3/8		46 / 2.606	=	17.65
			+	
1/2			=	
			+	
3/4			=	

B = 2.601

Total (A) = 38.45

$\frac{100}{38.45} = 2.601$

ASPHALT ABSORPTION

$$D = 100 \frac{G - B}{B\,G} A$$

D = Asphalt Absorption
G = Eff. Sp. Gr. of Agg.
B = Bulk Sp. Gr. of Agg
A = Sp. Gr. of AC

$$D = 100 \frac{2.655 - 2.601}{2.601 \times 2.655} (1.023) = \frac{.054}{6.91} \quad 0.80$$

EFFECTIVE ASPHALT CONTENT

$$E = C - \left(\frac{D}{100} P\right)$$

E = Effective Asphalt Content
C = % Asphalt
D = Asphalt Absorption
P = % Total Agg. 93.2

$$E = 6.8 - \left(\frac{0.80}{100} 93.2\right) =$$

Eff. AC Content % 6.05

TA 179B 5C 9/82
Rev. 1M 4/84 1/M 8/84

Houston/Royce

(1.)

ULTRAPAVE

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

Appendix 18

BITUMINOUS CONCRETE EXTRACTION WORK SHEET

PROJECT WORCESTER/ELMORE ER 0241(19) LAB NO. _____ DATE 9-6-84
SOURCE COOLEY'S, BERLIN, VT. MIX TYPE TYPE IVC DIST. 3/6
SAMPLE NO. _____

BOWL & MIX 2553 PAN & AGG. 1612 SLIP NO. _____
BOWL 1198 PAN 351 TIME _____
MIX 1355 AGG. 1261 MIX TEMP. _____

%AC = MIX − AGG / MIX × 100 = 1355 − 1261 / 1355 × 100 = 6.9 %

% STONE (+8) 56
% SAND (-8) 44
% AIR VOIDS _____

% Slip Ac = _____ %

RETAINED ON	WEIGHT	% RETAINED	% PASSING	JOB AIM	REPORTED
1 3/4					
1 1/2					
1					
3/4					
1/2	—		100	100	100
3/8	38	2.9	97.1	95-100	97
4	431	34.2	62.9	63-75	63
8	239	19.0	43.9	42-50	44
16	144	11.4	32.5	30-38	33
30	142	11.3	21.2	20-28	21
50	130	10.3	10.9	9-17	11
200	116	9.2	1.7	2-5	2
Pass 200	21	1.7			
Totals	1261	100			
			% Slip AC		

	BIN S	BIN NO. 2	BIN NO. 3	BIN NO. 4	BIN NO. 5	AC	TOTAL
BATCH WEIGHTS							
Wt. ADJUSTMENT							

CORRECTIVE ACTION

COMMENTS:
ULTRAPAVE

N. Houston / B. Royce
/ Inspector(s)

TA 417 Rev. 2M 4/84
2/M 8/84

ULTRAPAVE

Bituminous Concrete System FILE MAINTENANCE Control No. H616	Vermont Agency Transportation Materials & Research Division ASPHALT MIXTURE PROPERTIES - Field Test Data - (Items P401 or 406)	Sheet ____ of ____
Form No. 4 of 6 Form Date 9/6/84		Project Code No. ____0
		Mix Design No. ____0

Project Name WORCESTER/ELMORE Project No. ER 0241 (19)

Source of Mix 21 COOLEYS, BERLIN, VT. Ring No. ____ Year 84

Item No. 40625 Type of Mix IV ULTRAPAVE Sp. Gr. AC 1023

(Note- Begin a new page if any of the prior fields change)

Line	Formula	Description	1 A	2 B	3	4	5
A		Lab No. D8,					
B		Field Spec. No					
C		Test Date (mo.:day)					
D3		% Passing 1"					
D4		" 3/4"					
D5	100	" 1/2"					
D6	95-100	" 3/8"					
D7	63-75	" #4					
D8	42-50	" #8					
D9	30-38	" #16					
D10	20-28	" #30					
D11	9-17	" #50					
D12	2-5	" #200					
E		Bitumen % (AC) Slip	6.80				6.80
F		Effective % (AC)	6.32				6.32
G	100(T-S)/T	% Voids - Mix	2.4				2.4
H	100U/(U+G)	% Voids - Filled	85.7				85.7
I	U + G	% VMA	16.8				16.8
J	S x 62.4	Unit Wgt., lb/ft^3	147.9				147.9
K		Stab.-Conv., lb.	2224	1599			1912
L		Marshall Flow	9	9			9 AVG
M		Sample Thick., in.	2 1/16	2 1/16			
N		Wgt. in Air, gm.	978	989			984
P		Wgt. in Water, gm.	560	561			561
R		Wgt. surf. dry, gm.	978	990			984
S	N/(R-P)	Sp. Gr. - Bulk	2.339	2.305			2.322
T		Sp. Gr. - Max.		2.380			2.380
U	SxF/SpGrAc	AC by Volume %					14.35
V		Stab.-Measured, lb.	1532	1110			2662
W		Accept, Reject or N					

ULTRA

Field Notes:

ULTRAPAVE

Inspector(s): N. Houston, Royce

Office Time Stamp:

TA 418-D 5C 8/83 5/C 8/84
5C 4/84

ULTRAPAVE

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUBDIVISION

Appendix 20

EFFECTIVE ASPHALT CONTENT WORK SHEET

Project WORCESTER/ELMORE ER 0241(19) Date 9-6-84
Source COOLEYS, BERLIN, VT. Mix Type TYPE 4 DIST. #6
Sample No.
Prepared By

EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE (G)

$$G = \frac{100 - C}{\frac{100}{M} - \frac{C}{A}}$$

G = Eff. Sp. Gr. of Agg.
C = % Asphalt
M = Max. Sp. Gr. of Mix
A = Sp. Gr. of AC

93.2

$$\frac{100 - 6.80}{\frac{100}{2.380} - \frac{6.80}{1.023}} = 2.635$$

42.017 - 6.647
35.37

BULK SPECIFIC GRAVITY OF AGGREGATE (B)

Agg. Size	$\frac{\%\ \text{Used}}{\text{Bulk Sp.Gr.}}$	$B = \frac{100}{A}$
Nat. Sa	$\frac{27}{2.623}$	10.29 +
Gr. Sa	$\frac{27}{2.569}$	10.51 +
3/8	$\frac{46}{2.606}$	17.65 +
1/2		+
3/4		

B = 2.601

Total (A) = 38.45

ASPHALT ABSORPTION (D)

$$D = 100 \frac{G - B}{B\ G} A$$

D = Asphalt Absorption
G = Eff. Sp. Gr. of Agg.
B = Bulk Sp. Gr. of Agg
A = Sp. Gr. of AC

.034

$$D = 100 \frac{2.635 - 2.601}{2.601(2.635)} (1.023) =$$

6.85

0.51

EFFECTIVE ASPHALT CONTENT

$$E = C - \left(\frac{D}{100} P\right)$$

E = Effective Asphalt Content
C = % Asphalt
D = Asphalt Absorption
P = % Total Agg.

$$E = 6.8 - \left(\frac{0.51}{100} 93.2\right) =$$

Eff. AC Content % 6.32

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Rev. 1M 4/84

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ULTRAPAVE

TA 567A 1M 7/81
1M 5/83

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUBDIVISION

Appendix 21

ULTRAPAVE

MAXIMUM SPECIFIC GRAVITY WORKSHEET
AASHTO T209-78
ASTM D2041-78

Project WORCESTER/ELMORE No. ER 0241(19) Date 9.6.84

Source Mix COOLEY'S, BERLIN, VT. Type TV Test No.

Design No. Bulk Sp. Gr. 2.322

Flask No. #1

1. Wt. of Flask + Sample	2504.5
2. Wt. of Flask	1018.6
3. Wt. of Sample (1-2) (A)	1485.9
4. Wt. of Flask filled with H_2O (D)	3208.4
5. Wt. of Flask + Water + Sample (E)	4070.1

CALCULATION:

Max. Sp. Gr. = A/(A + D - E)

$$= \frac{1485.9}{1485.9 + 3208.4 - 4070.1} = \frac{1485.9}{624.2} = 2.380$$

$$\% \text{ Voids Mix} = 100 \times \frac{\text{Max. Sp. Gr.} - \text{Bulk Sp. Gr.}}{\text{Max. Sp. Gr.}}$$

$$\frac{2.380 - 2.322}{2.380} = 2.44$$

Comments:	Inspector(s)	Office Time Stamp
ULTRAPAVE	M. Hawton Royce	

3/

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

Appendix 22

BITUMINOUS CONCRETE EXTRACTION WORK SHEET

LAB NO. _____ DATE 9.25.83

PROJECT Worcester/Elmore ER 0241 MIX TYPE IV DIST. #6

SOURCE Cooley – Berlin SAMPLE NO. _____

BOWL & MIX	2348	PAN & AGG.	1423	SLIP NO.	
BOWL	1198	PAN	351	TIME	
MIX	1150	AGG.	1072	MIX TEMP.	
% AC = MIX - AGG 100 / MIX	6.78	% - _____ =	6.8 %		

% STONE (+8) 53
% SAND (-8) 47
% AIR VOIDS _____

% Slip AC = _____ %

RETAINED ON	WEIGHT	% RETAINED	% PASSING	JOB AIM	REPORTED
1 3/4					
1 1/2					
1					
3/4					
1/2	—		100.0	100	100
3/8	15	1.4	98.6	95-100	99
4	350	32.6	66.0	63-75	66
8	200	18.7	47.3	42-50	47
16	131	12.2	35.1	30-38	35
30	118	11.0	24.1	20-28	24
50	104	9.7	14.4	9-17	14
200	120	11.2	3.2	2-5	3.2
Pass 200	34	3.2			
Totals	1072				
			% Slip AC		

	BIN S	BIN NO. 2	BIN NO. 3	BIN NO. 4	BIN NO. 5	AC	TOTAL
BATCH WEIGHTS							
WT. ADJUSTMENT							

CORRECTIVE ACTION

COMMENTS: ULTRAPAVE

Houston / Rowe
Inspector (s)

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESERACH DIVISION

Appendix 23

BITUMINOUS CONCRETE EXTRACTION WORK SHEET

LAB NO. _____ DATE 9-25-84

PROJECT Ultrapave - Rte. 12 - Worcester/Elmore MIX TYPE III

SOURCE Cooley - Berlin SAMPLE NO. _____

BOWL & MIX	2164	PAN & AGG.	1251	SLIP NO.	
BOWL	1198	PAN	351	TIME	
MIX	966	AGG.	900	MIX TEMP.	
% AC = MIX - AGG 100 / MIX		% - _____ =	6.8 %		
				% STONE (+8)	51.4
				% SAND (-8)	48.5
% Slip AC = _____ %				% AIR VOIDS	

RETAINED ON	WEIGHT	% RETAINED	% PASSING	JOB AIM	REPORTED
1 3/4					
1 1/2					
1					
3/4			100.0		100
1/2	9	0.9	99.1	100	99
3/8	6	0.7	98.4	95-100	98
4	276	30.8	67.6	63-75	68
8	171	19.1	48.5	42-50	49
16	109	12.2	36.3	30-38	36
30	100	11.1	25.2	20-28	25
50	90	10.0	15.2	9-17	15
200	104	11.6	3.6	2-5	3.6
Pass 200	32	3.6			
Totals	897				
			% Slip AC		

	BIN S	BIN NO. 2	BIN NO. 3	BIN NO. 4	BIN NO. 5	AC	TOTAL
BATCH WEIGHTS							
WT. ADJUSTMENT							

CORRECTIVE ACTION

COMMENTS: ULTRAPAVE

M.H., W.R.
Inspector(s)

TA 417 Rev. 2M 5/84

Bituminous Concrete System FILE MAINTENANCE Control No. H616 Form No. 4 of 6 Form Date 11	Vermont Agency Transportation Materials & Research Division ASPHALT MIXTURE PROPERTIES - Field Test Data - (Items P401 or 406)	Sheet _____ of _____ Project Code No. 0 Mix Design No. 0

Project Name Ultrapave - Rte. 12 - Worcester Project No. ER 0241 (19)

Source of Mix 21 Cooley - Berlin Ring No. Year 84

Item No. 4 0 6 2 5 Type of Mix 0 4 ULTRAPAVE Sp. Gr. AC 1 0 2 3

(Note- Begin a new page if any of the prior fields change)

Line	Formula	Description	1	2	3	4	5
A		Lab No. D 8					
B		Field Spec. No					
C		Test Date (mo.:day)					
D3		% Passing 1"					
D4		" 3/4"					
D5		" 1/2"					
D6		" 3/8"					
D7		" #4					
D8		" #8					
D9		" #16					
D10		" #30					
D11		" #50					
D12		" #200					
E		Bitumen % (AC) Slip	6.8.0				
F		Effective % (AC)	6.3.2				
G	100(T-S)/T	% Voids - Mix	3.1				
H	100U/(U+G)	% Voids - Filled	8.2.0				
I	U + G	% VMA	1.7.4				
J	S x 62.4	Unit Wgt., lb/ft^3	1.4.4.1				
K		Stab.-Conv., lb.	2.0.7.6				
L		Marshall Flow	10 2 2/16				
M		Sample Thick.; in.	2.5.6.2				
N		Wgt. in Air, gm.	1.2.1.4				
P		Wgt. in Water, gm.	6.8.9				
R		Wgt. surf. dry, gm.	1.2.1.5				
S	N/(R-P)	Sp. Gr. - Bulk	2.3.1.0				
T		Sp. Gr. - Max.	2.3.8.3				
U	SxF/SpGrAc	AC by Volume %	1.4.2.7				
V		Stab.-Measured, lb.	2.0.2				
W		Accept, Reject or N					

Field Notes:	Inspector(s):	Office Time Stamp:
ULTRAPAVE	M.H. D.R	

TA 418-D 5C 8/83 5/C 8/84
5C 4/84

TA 567A 1M 7/81
1M 5/83

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUBDIVISION

Appendix 25

MAXIMUM SPECIFIC GRAVITY WORKSHEET
AASHTO T209-78
ASTM D2041-78

Project WORCESTER/ELMORE RTE. 12 No. ER 0241 Date 9·25·84

Source Mix COOLEY - BERLIN Type IV DIST #6 Test No.

Design No. 779 Bulk Sp. Gr. 2.310

Flask No. 2

1. Wt. of Flask + Sample	2436.8
2. Wt. of Flask	1033.0
3. Wt. of Sample (1-2) (A)	1403.8
4. Wt. of Flask filled with H_2O (D)	3235.2
5. Wt. of Flask + Water + Sample (E)	4049.8

CALCULATION:

Max. Sp. Gr. = A/(A + D - E)

$$= \frac{1403.8}{1403.8 + 3235.2 - 4049.8} = \frac{1403.8}{589.2} = 2.383$$

$$\% \text{ Voids Mix} = 100 \times \frac{\text{Max. Sp. Gr.} - \text{Bulk Sp. Gr.}}{\text{Max. Sp. Gr.}}$$

$$\frac{2.383 - 2.310}{2.383} = 3.06$$

Comments:	Inspector(s)	Office Time Stamp
ULTRAPAVE	M.H. W.R	

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUBDIVISION

Appendix 26

EFFECTIVE ASPHALT CONTENT WORK SHEET

Project Worcester/Elmore Rte. 12 Ultrapave
Source Cooley - Berlin

Date 9-25-84
Mix Type II Dust #6
Sample No.
Prepared By

EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE

$$G = \frac{100 - C}{\frac{100}{M} - \frac{C}{A}}$$

G = Eff. Sp. Gr. of Agg.
C = % Asphalt
M = Max. Sp. Gr. of Mix
A = Sp. Gr. of AC

$$\frac{100 - 6.8}{\frac{100}{2.383} - \frac{6.8}{1.023}} = \frac{93.2}{41.96 - 6.647} = \frac{93.2}{35.37} = 2.635$$

BULK SPECIFIC GRAVITY OF AGGREGATE (B)

$B = \frac{100}{A}$

Agg. Size	% Used / Bulk Sp.Gr.		
Nat. Sa	27 / 2.623	=	10.29 +
Gr Sa	27 / 2.569	=	10.51 +
3/8	46 / 2.606	=	17.65 +
1/2	—	=	+
3/4	—	=	—
	Total (A)	=	

B = 2.601

ASPHALT ABSORPTION

$$D = 100 \frac{G - B}{B\,G} A$$

D = Asphalt Absorption
G = Eff. Sp. Gr. of Agg.
B = Bulk Sp. Gr. of Agg
A = Sp. Gr. of AC

$$D = 100 \frac{2.635 - 2.601}{2.601 \times 2.635} (1.023) = \frac{0.034}{6.85} = 0.51$$

EFFECTIVE ASPHALT CONTENT

$$E = C - \left(\frac{D}{100} P\right)$$

E = Effective Asphalt Content
C = % Asphalt
D = Asphalt Absorption
P = % Total Agg.

$$E = 6.8 - \left(\frac{0.51}{100} 93.2\right) =$$

Eff. AC Content % 6.32

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