

PROPERTIES OF BITUMINOUS MIXES
DESIGNED BY 50 AND 75 BLOW
MARSHALL SERIES

FINAL REPORT 85-12
DECEMBER - 1985

REPORTING ON WORK PLAN 85-B-3

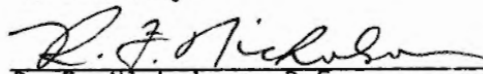
STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

SUSAN C. CRAMPTON, SECRETARY OF TRANSPORTATION
FRANK E. ALDRICH, P.E., CHIEF ENGINEER
R. F. NICHOLSON, P.E., MATERIALS & RESEARCH ENGINEER

Prepared By:

Earle L. Chaffee, Jr.
Technician C
Bituminous Concrete Subdivision

Reviewed By:


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

Date: 02-10-86

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INTRODUCTION

Since its development in 1948, the Marshall Method of Mix Design has increasingly been accepted by the highway agencies throughout the world to design and control paving mixtures. The Vermont Agency of Transportation began using the Marshall Method exclusively in 1983 in accordance with the Asphalt Institute Manual Series No. 2 (MS-2), 50 Blows as recommended for medium traffic. Vermont has modified the suggested design criteria of MS-2 by requiring a minimum stability of 1000 lbs as opposed to 750 lbs.

With the increase in traffic volume, particularly truck traffic, Vermont has witnessed some problems with mix deformation mainly at intersections. Many of these problems can be attributed to the previous use of soft asphalt cements in paving mixtures and poor construction procedures. However, in an attempt to improve present paving mixtures if necessary, Vermont is investigating the possibility of using additives and/or 75 Blow Marshall Series, etc.

The purpose of this investigation is to compare the mix design properties of 75 Blow Marshall Series with properties of paving mixtures of our currently used 50 Blow Marshall Series. Particular attention is focused on stability properties.

EVALUATION PROCEDURE

Aggregates were sampled from two different sources. Mix gradations were designed to meet Vermont's specification for Type III ($\frac{1}{2}$ inch maximum size aggregate), for each source. See mix designs. (Pg 3 & 4)

Four complete Marshall Series were run on each source; two at 50 blows and two at 75 blows according to the Asphalt Institute Manual Series No. 2 (MS-2).

The following mix properties were computed and evaluated: Stability, Flow, % Voids of the Mix, VMA%, Unit Weight of the Mixture and the Optimum Asphalt Content using 4% air voids as the criteria.

All values for each series were plotted and the optimum values obtained using the asphalt content that produced 4% air voids.

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - BITUMINOUS CONCRETE SUBDIVISION
Design of Bituminous Concrete Mixtures

N^o 3154

Town N/A

Project No. WORK PLAN 85-B-3

Gentlemen:

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

Pavement Type III Produced By: VERMONT LABORATORY Plant Location N/A
Stockpile Gradations — % Passing

Size	% Used	1%	1 1/2%	1	%	1/2	%	4	8	16	30	50	200
W.A. SA.	35						100	91	74	52	29	18	2.4
S.C. SA.	22				100	98	97	93	86	77	58	29	2.5
3/4 Cr. St.	23					100	97	34	5				
1/2 Cr. St.	20				100	98	31	1					
Resultant	100				100	99	84	60	46	35	23	12	1.4

Hot Bin Gradation — % Passing

Bin	% Used	1%	1 1/2%	1	%	1/2	%	4	8	16	30	50	200
1													
2													
3													
4													
5													
Resultant													

Batch Weights	Bin 1	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total

	1%	1 1/2%	1	%	1/2	%	4	8	16	30	50	200	AC
Job Mix Formula				100	99	84	60	46	35	23	12	1.4	
Job Aim				100	95	78	54	42	31	19	8	0.4	
Specification Limits				100	95	78	54	42	31	19	8	0.4	

Source of Materials

Aggregates	Asphalt
Coarse: <u>HAVEN CRUSHED STONE</u>	AC-5:
<u>NEW HAVEN, VT.</u>	
Fine: <u>HINESBURG WASHED SAND - HINESBURG, VT.</u>	AC-10:
<u>BERGEN SAND - THE BEAUTY PT.,</u>	
<u>WINDSOR, VT.</u>	Other: <u>85-100 PENETRATION PETRO-CANADA</u>

Mixing Times — Dry: Wet: Total: Temperature: 290 ± 20
Submitted by: Earle L. Chaffin, Jr. (signature) Date: 02-04-85
Company STATE OF VERMONT Title Bituminous Concrete Tech. C.

FOR STATE OF VERMONT USE ONLY

Approved Rejected

Comments:

Signature Title

TA 556 Date

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

Nº 3155

Design of Bituminous Concrete Mixtures

Town N/A
Gentlemen:

Project No. WORK PLAN 85-B-3

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

Pavement Type TYPE III Produced By: VERMONT LABORATORY Plant Location N/A

Stockpile Gradations — % Passing

Size	% Used	1%	1½	1	%	½	%	4	8	16	30	50	200
W.P. SA.	30						100	99	86	69	49	31	3
ST. SC.	25							100	78	55	39	26	8
3/8 G. ST.	20					100	99	31	3				
1/2 G. ST.	25				100	94	34	1					
Resultant	100				100	98	84	62	47	35	25	16	2.9

Hot Bin Gradation — % Passing

Bin	% Used	1%	1½	1	%	½	%	4	8	16	30	50	200
8													
2													
3													
4													
5													
Resultant													

Batch Weights	Bin 8	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total

	1%	1½	1	%	½	%	4	8	16	30	50	200	AC
Job Mix Formula				100	98	84	62	47	35	25	16	2.9	
Job Aim				100	95	78	58	43	31	21	12	1.9	
Specification Limits				100	95	78	54	39	24	14	6	0.4	5.5

Source of Materials

Aggregates	Asphalt
Coarse: <u>F.W. WHITCOMB - WENOSKI</u>	AC-5:
<u>(CRUSHED STONE)</u>	
Fine: <u>HINESBURG WASHED SAND - HINESBURG, VT.</u>	AC-10:
<u>STONE SCREENINGS - F.W. WHITCOMB, WENOSKI</u>	
	Other: <u>85-100 PENETRATION PETRO-CANADA</u>

Mixing Times — Dry: _____ Wet: _____ Total: _____ Temperature: 290 ± 20

Submitted by: Earle L. Chaffee Jr. (signature) Date: 02-04-85

Company State of Vermont Title Bituminous Concrete Tech. 'C'

FOR STATE OF VERMONT USE ONLY

Approved _____ Rejected _____

Comments: _____

Signature _____ Title _____

Date _____

TA 556

TEST RESULTS

The individual optimum properties on the testing of the Type III mix from design #3154 are as follows: (also see curves)

Property	50 Blow Series		75 Blow Series	
	#1	#2	#1	#2
Stability (lbs)	1170	1150	1180	1270
Unit Wt., Lbs/Ft. ³	147.4	147.5	147.2	148.0
% Voids Total Mix	4.0	4.0	4.0	4.0
Flow	8	10	10	11
VMA %	16.8	16.7	16.7	16.6
Optimum Asphalt %	6.0	6.0	5.9	6.0

The individual optimum properties on the testing of the Type III mix from design #3155 are as follows: (also see curves)

Property	50 Blow Series		75 Blow Series	
	#1	#2	#1	#2
Stability (lbs)	1750	1820	1760	1850
Unit Wt., Lbs/Ft. ³	147.2	147.0	147.2	147.0
% Voids Total Mix	4.0	4.0	4.0	4.0
Flow	10	11	11	10
VMA %	16.0	15.9	15.5	15.5
Optimum Asphalt %	6.0	5.9	5.7	5.7

The average optimum properties on the testing of the Type III mix from design #3154 are as follows:

	50 Blow Series	75 Blow Series	Difference
Property	Avg of #1 & #2	Avg of #1 & #2	
Stability (lbs)	1160	1225	+65
Unit Wt., Lbs/Ft. ³	147.5	147.6	+0.1
% Voids Total Mix	4.0	4.0	Same
Flow	9.0	10.5	+1.5
VMA %	16.75	16.65	-0.10
Optimum Asphalt %	6.00	5.95	-.05

The average optimum properties on the testing of the Type III mix from design number 3155 are as follows:

	50 Blow Series	75 Blow Series	Difference
Property	Avg of #1 & #2	Avg of #1 & #2	
Stability (lbs)	1785	1805	+20
Unit Wt., Lbs/Ft. ³	147.1	147.1	Same
% Voids Total Mix	4.0	4.0	Same
Flow	10.5	10.5	Same
VMA %	15.95	15.55	-0.40
Optimum Asphalt %	5.95	5.70	-0.25

EVALUATION OF RESULTS

The test results obtained from both aggregate sources indicated that when a mix is designed using 4% air voids as the criteria for optimum asphalt content, there is little change in mix properties between 50 blow and 75 blow Marshall Series.

One change to note is the optimum asphalt content. Mixes designed at 75 blows require less asphalt than an identical mix designed at 50 blows. The explanation for this is that the increased compaction exerted from 75 blows decreases the air void content, thus resulting in less asphalt to obtain 4% air voids. In nearly all mix designs, the asphalt content at 4% air voids does not give the maximum stability. The maximum stability is normally reached at an asphalt content that produces 2% air voids or less. Therefore, the reduction of asphalt required in a 75 blow Marshall Series negates any stability increase obtained from a 75 blow Marshall.

CONCLUSIONS

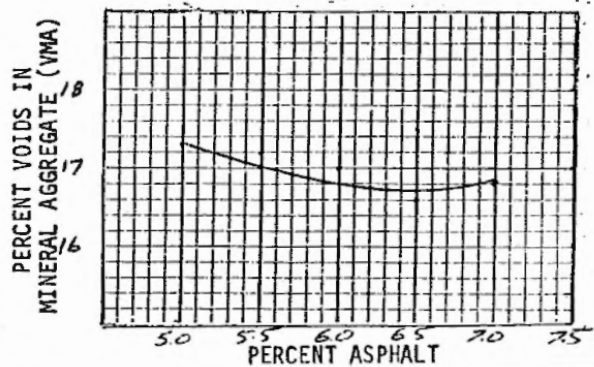
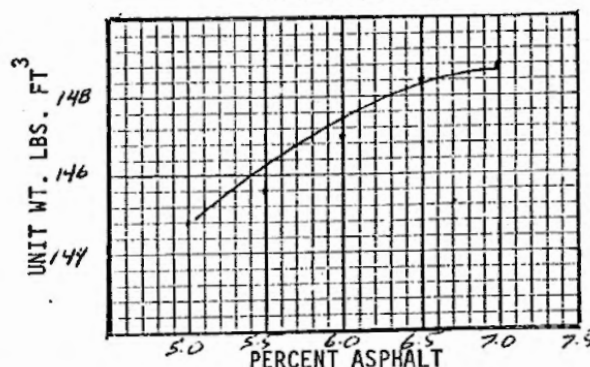
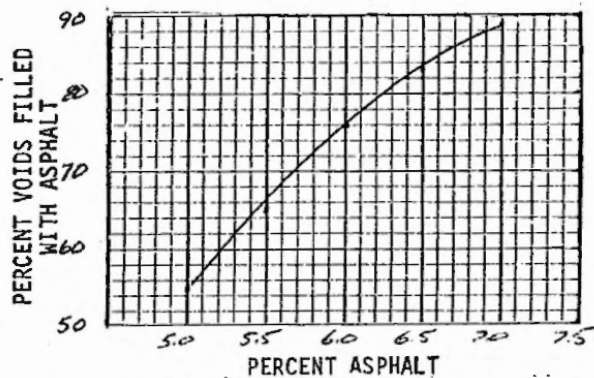
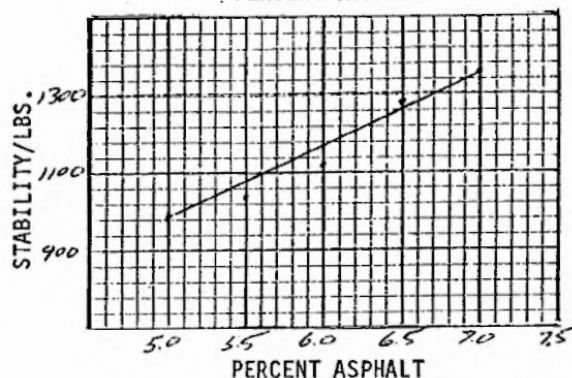
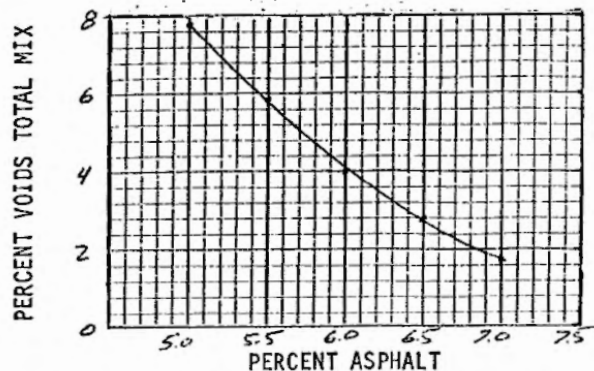
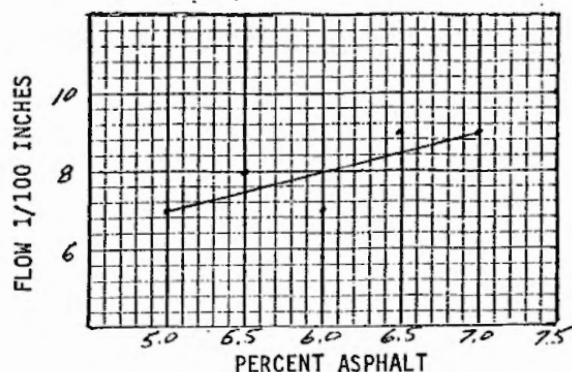
The results of this investigation indicate that 75 blow Marshall series with 4% air voids do not significantly increase stability over 50 blow Marshall series at 4% air voids.

A 75 blow Marshall series decreases the optimum asphalt content. By decreasing the asphalt content some mix durability could be lost.

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

Page of

Project Name & No. 85-B-3 Year 1985 Prepared By: E. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 03-07-85
Item 406 Type Mix III Design No. 3154 SO BELOW STANDARD MIX #1



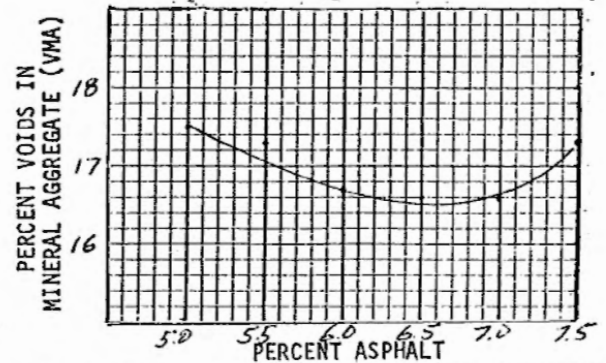
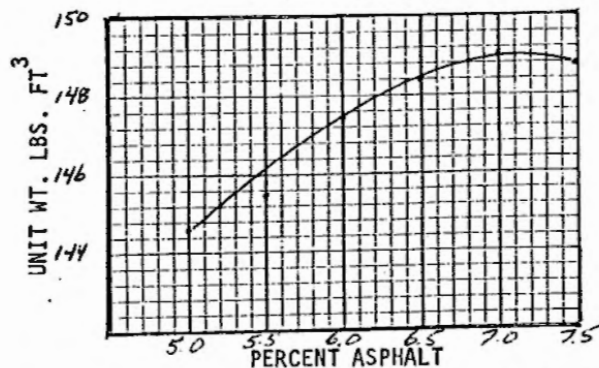
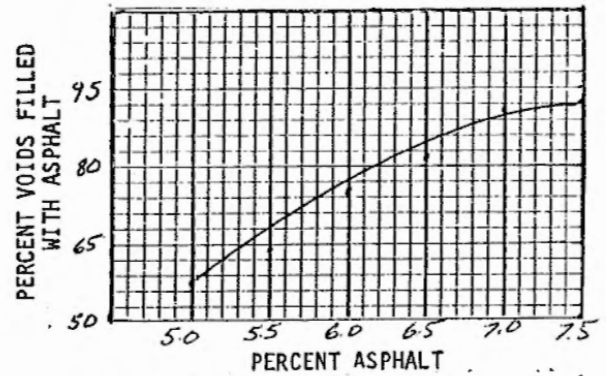
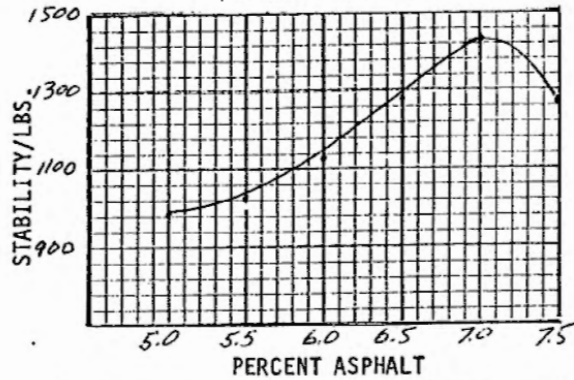
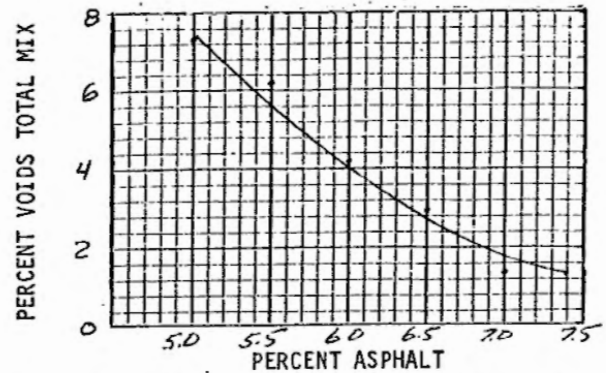
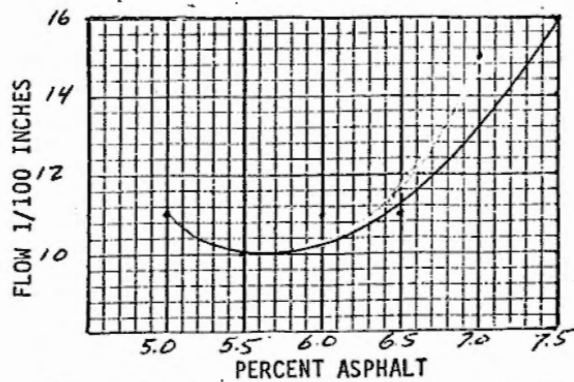
VALUES AT OPTIMUM ASPHALT

PROPERTY	STABILITY	UNIT WT. LBS./FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1170	147.4	4.0	8	16.8	76.0
TESTED BY: <u>CHAFFEE, DAY, ROYLE</u> DATE TESTED: <u>02-08-85</u> A/C DESIGN <u>6.0</u>						

VERMONT AGENCY OF TRANSPORTATION
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BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

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Project Name & No. 85-B-3 Year 1985 Prepared By: E. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 03-07-85
Item 406 Type Mix III Design No. 3154 SO BELOW STANDARD MIX #2

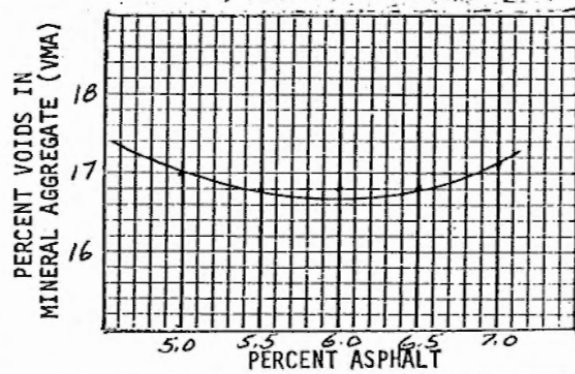
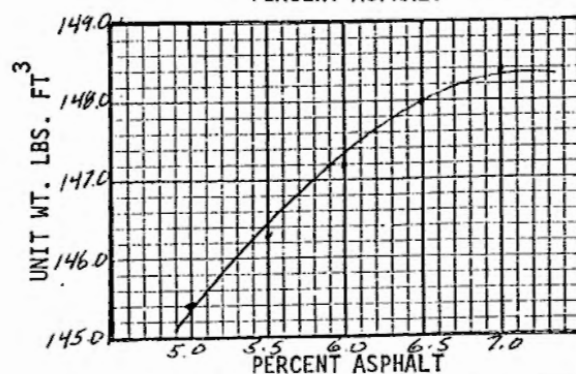
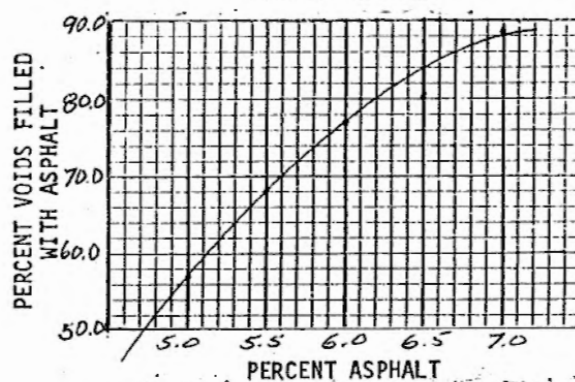
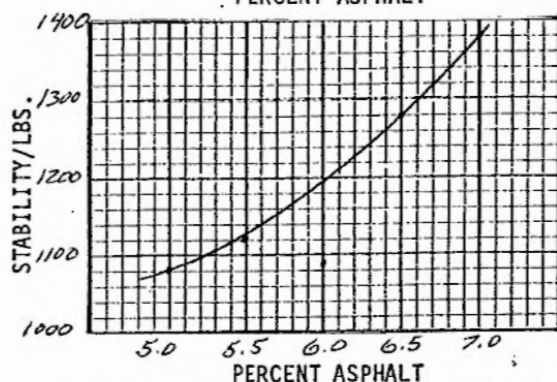
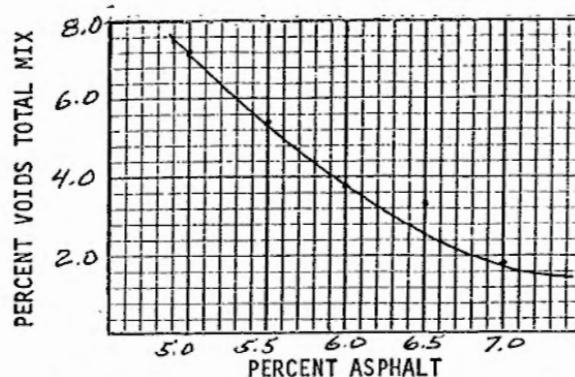
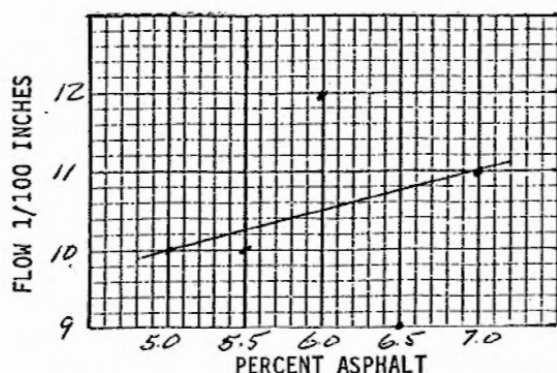


VALUES AT OPTIMUM ASPHALT						
PROPERTY	STABILITY	UNIT WT. LBS./FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1150	147.5	4.0	10	16.7	77.0
TESTED BY: <u>ROYCE, DAY</u> DATE TESTED: <u>02-28-85</u> A/C DESIGN <u>6.0</u>						

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

Page 1 of 1

Project Name & No. 85-B-3 Year 1985 Prepared By: E. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 02-13-85
Item 406 Type Mix III Design No. 3154 75BLOW STANDARD MIX #1

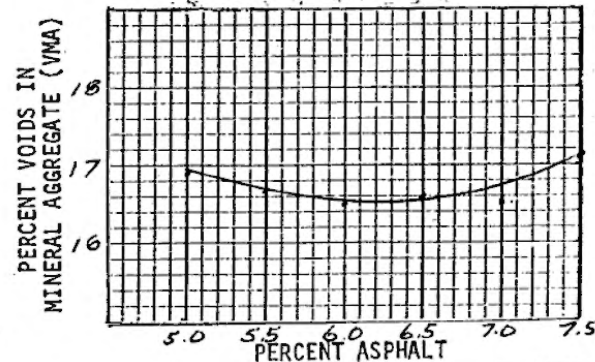
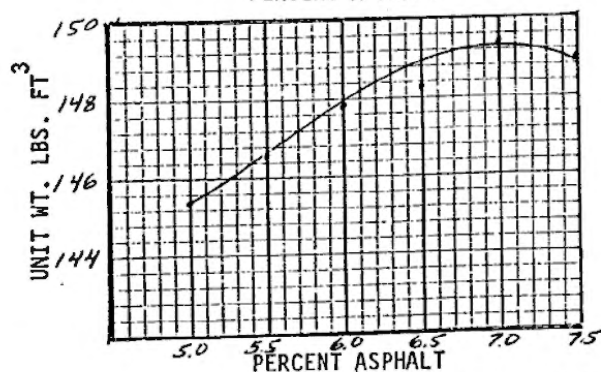
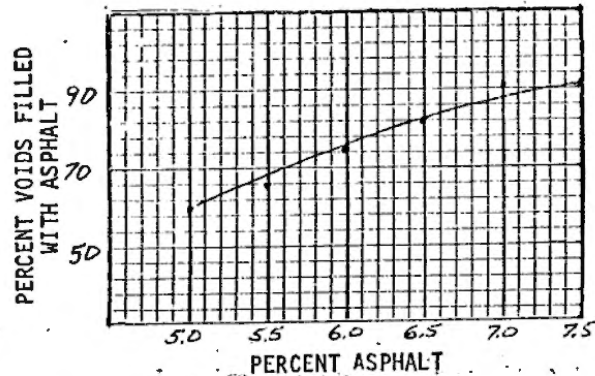
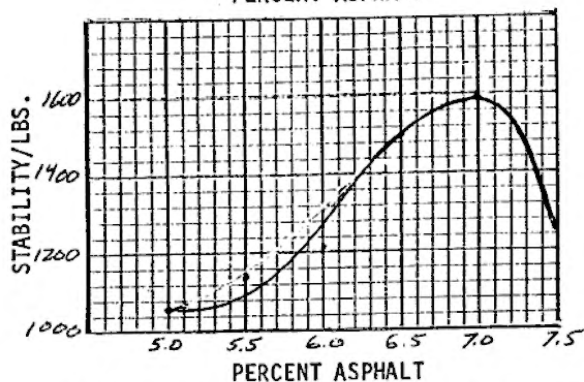
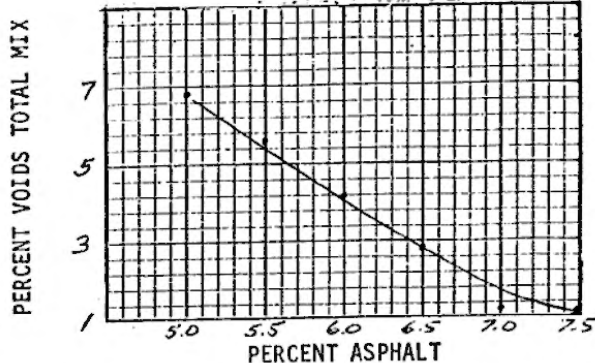
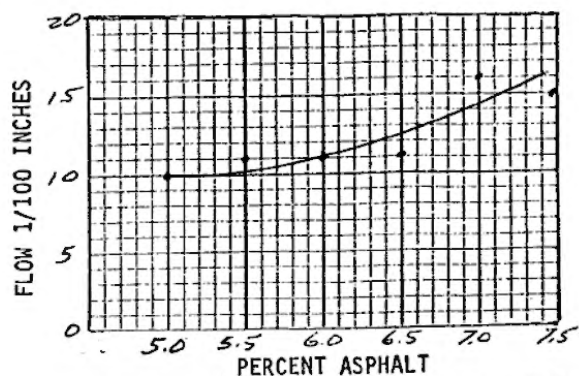


VALUES AT OPTIMUM ASPHALT						
PROPERTY	STABILITY	UNIT WT. LBS. FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD.
ACTUAL	1180	147.2	4.0	10.4	16.7	75.0
TESTED BY: <u>CHAFFEE, ROYCE</u> DATE TESTED: <u>02-11-85</u> A/C DESIGN <u>5.9</u>						

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

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Project Name & No. 85-A-3 Year 1985 Prepared By: E. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 02-25-85
Item 406 Type Mix III Design No. 3154 75 BELOW STANDARD MIX #2



VALUES AT OPTIMUM ASPHALT

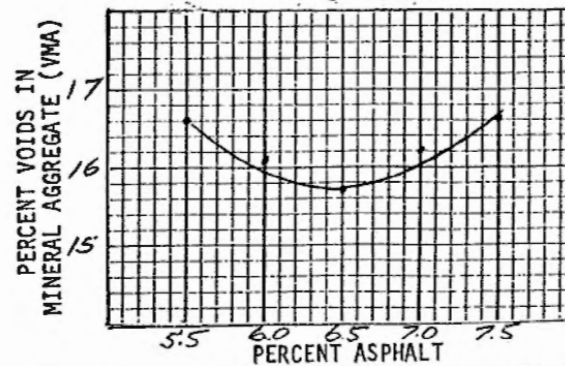
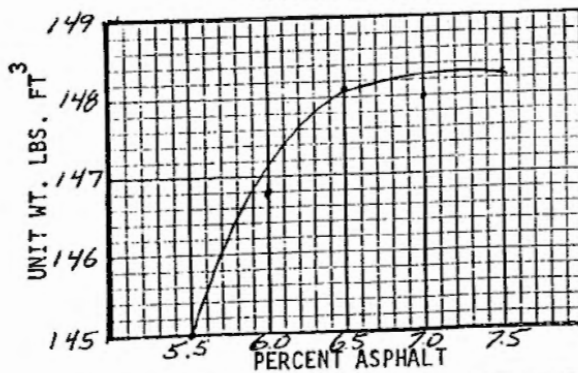
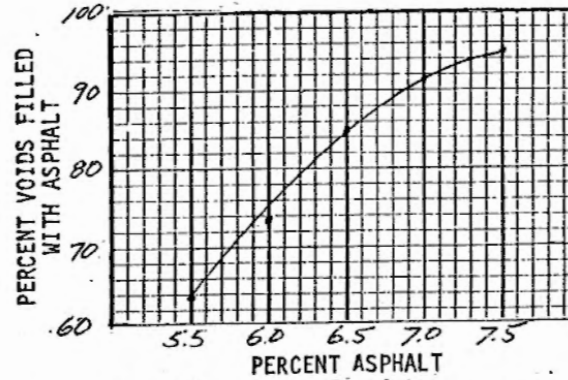
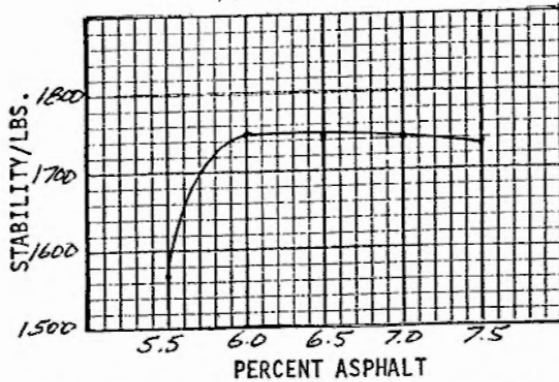
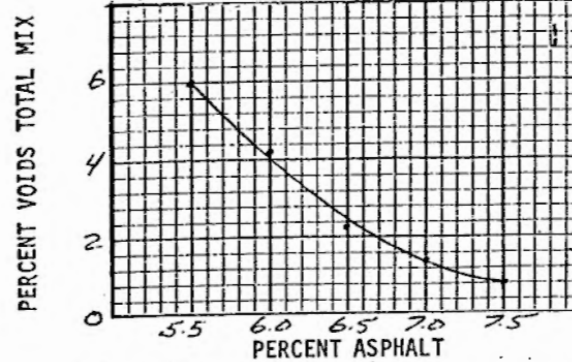
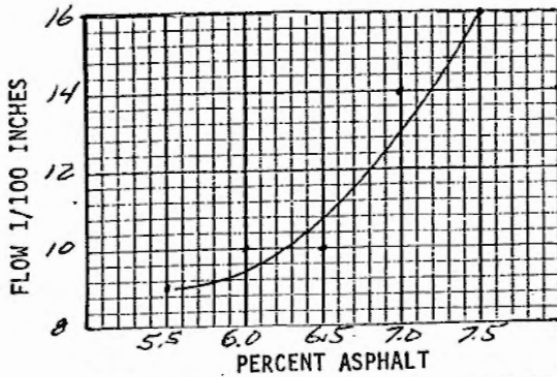
PROPERTY	STABILITY	UNIT WT. LBS. FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1270	148.0	4.0	11	16.6	76.0

TESTED BY: ROYCE, DAY DATE TESTED: 02-21-85 A/C DESIGN 6.0

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

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Project Name & No. 85-B-3 Year 1985 Prepared By: E. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 03-26-85
Item 406 Type Mix III Design No. 3155 50 BLOW STANDARD MIX #1 F.W. WHITELODGE



VALUES AT OPTIMUM ASPHALT

PROPERTY	STABILITY	UNIT WT. LBS./FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1750	147.2	4.0	9.5	16	76

TESTED BY: ROYCE, DAY

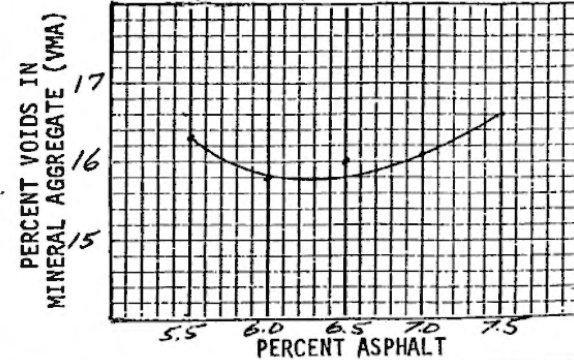
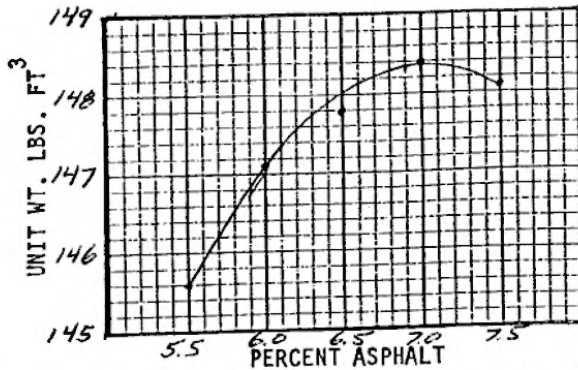
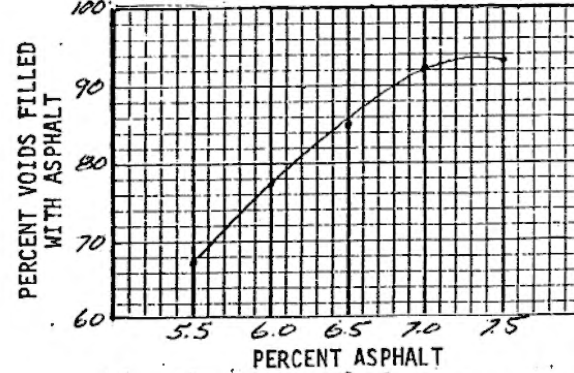
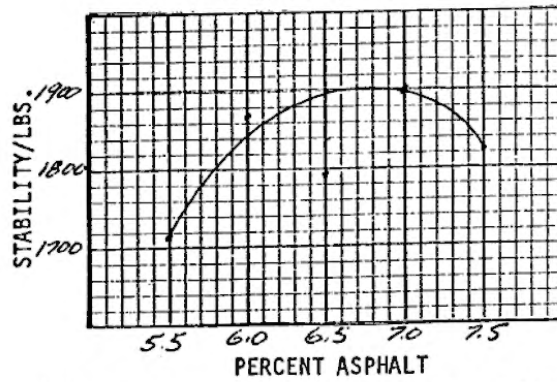
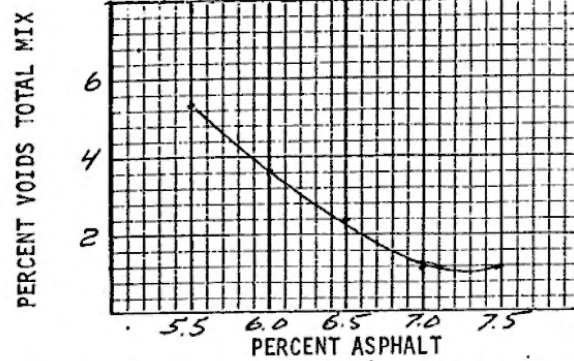
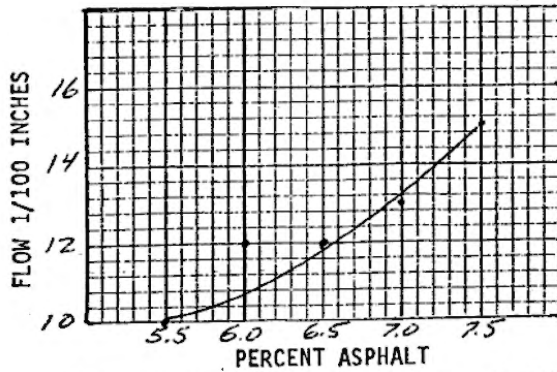
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A/C DESIGN 6.0

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MARSHALL TEST PROPERTY CURVES

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Project Name & No. 85-B-3 Year 1985 Prepared By: E. LAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 03-27-85
Item 406 Type Mix III Design No. 3155 50 BLW STANDARD MIX #2 F.W. WHITCOMB



VALUES AT OPTIMUM ASPHALT

PROPERTY	STABILITY	UNIT WT. LBS. FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1820	147.0	4.0	10.5	15.9	76

TESTED BY: Royce, Day

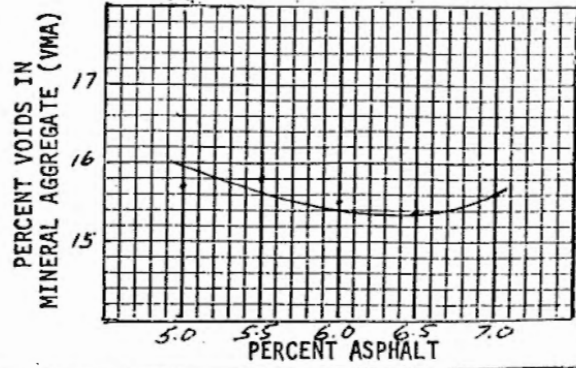
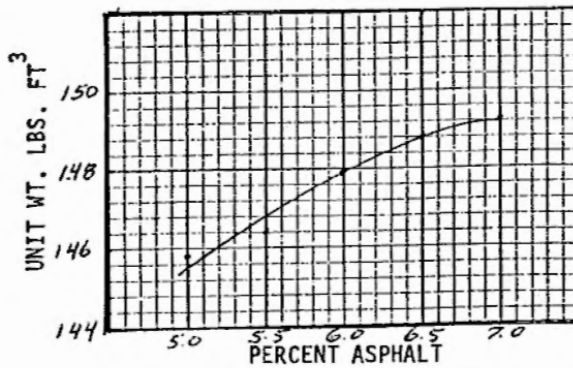
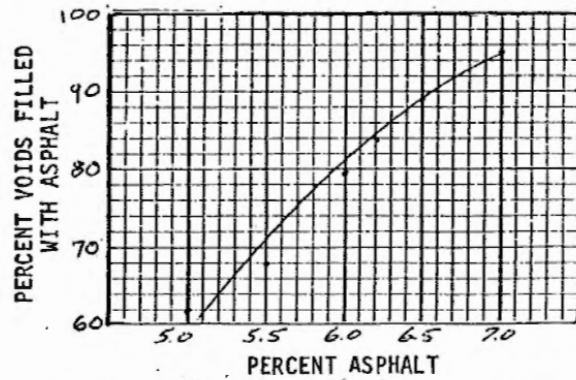
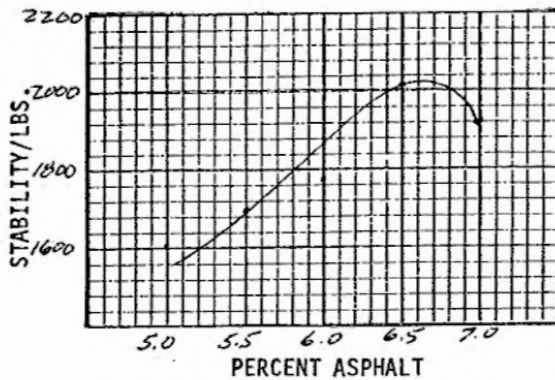
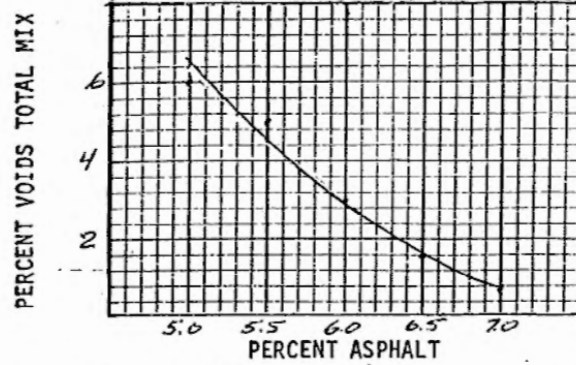
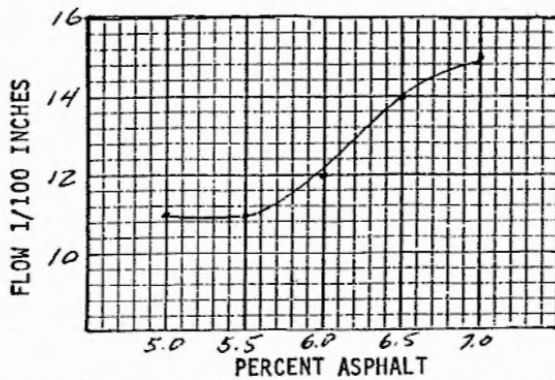
DATE TESTED: 03-24-85

A/C DESIGN 5.9

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

Page of

Project Name & No. R5-B-3 Year 1985 Prepared By: F. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 04-04-85
Item 406 Type Mix III Design No. 3155 75 BELOW STANDARD Mix #1 F.W. WHITE

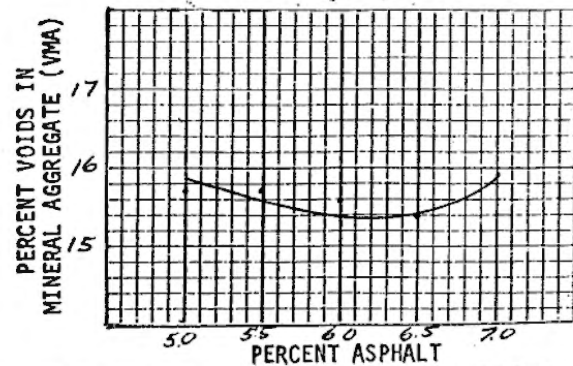
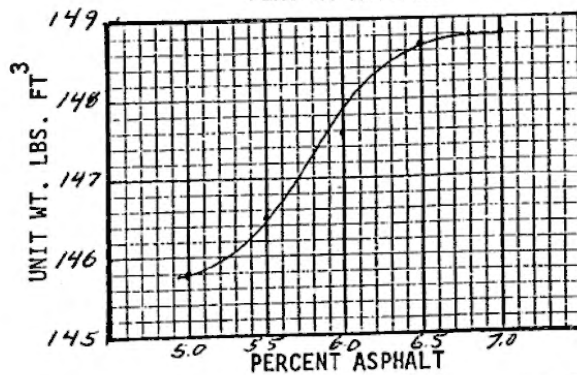
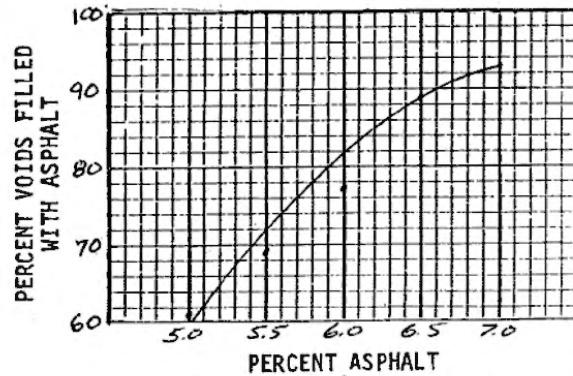
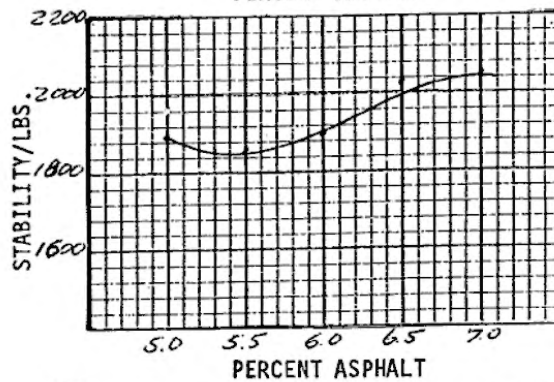
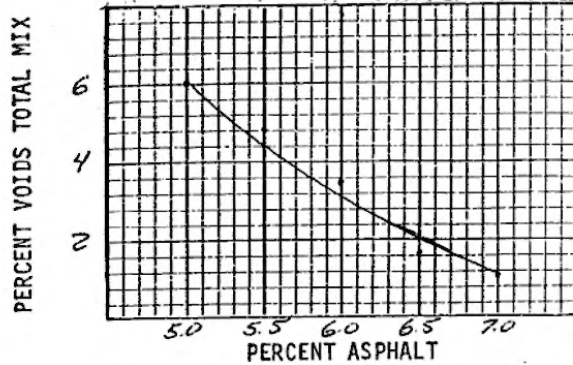
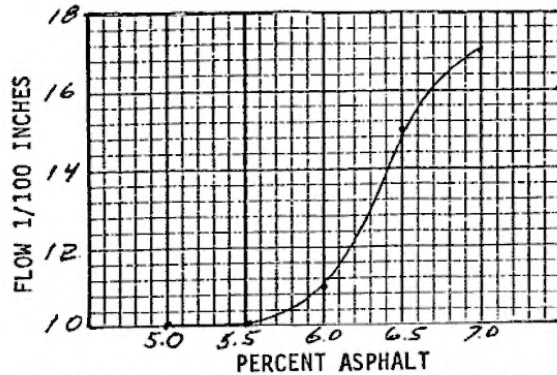


VALUES AT OPTIMUM ASPHALT						
PROPERTY	STABILITY	UNIT WT. LBS./FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1760	147.2	4.0	11.2	15.5	76
TESTED BY: <u>ROYCE, DAY, CHAFFEE</u> DATE TESTED: <u>4-2-85</u> A/C DESIGN <u>5.7</u>						

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION
BITUMINOUS CONCRETE SUB-DIVISION
MARSHALL TEST PROPERTY CURVES

Page of

Project Name & No. 85-B-3 Year 1985 Prepared By: E. CHAFFEE
Plant Location VERMONT CENTRAL LAB Date Prepared: 04-09-85
Item 406 Type Mix III Design No. 3155 75BLW STANDARD MIX #2 F.W. WHITCOMB



VALUES AT OPTIMUM ASPHALT						
PROPERTY	STABILITY	UNIT WT. LBS. FT ³	% VOIDS TOTAL MIX	FLOW	VMA	% VOIDS FLD
ACTUAL	1850	147.0	4.0	10.4	15.5	76
TESTED BY: <u>ROGER DAY</u> DATE TESTED: <u>04-05-85</u> A/C DESIGN <u>5.7</u>						

L. 187 Rev. 1M 10/80
1M 6/82
1M 9/82
1M 6/83
1M 9/84

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Verd
CF

REPORT ON SAMPLE OF ASPHALT CEMENT

Report 3/28, 19 85
Laboratory No. 885 0010 Tested By Stevens
Name 85/100 Asphalt Cement for
Identification Marks Investigative Certification No.
Submitted by Royce Title CLP Address
Sampled 3/27, 19 85 Received 3/27, 19 85 Testing Completed 3/28, 19 85
Sample from One gallon can, in lab
Quantity Represented Lbs. Net @ 60° F = Gals.
Source of Material Petro - Whitcomb Williston
Location used or to be used
Examined for 702.01 85/100 Penetration

	TEST RESULTS	SPECIFICATION REQUIREMENTS MIN. MAX.
Specific Gravity 25°C/25°C	<u></u>	<u></u>
Absolute Viscosity @ 140°F and 300 mm Hg Vacuum, poises	<u>1601</u>	<u></u>
Kinematic Viscosity @ 275°F, centistokes	<u>377</u>	<u></u>
Penetration @ 77°F, 100 gm. 5 sec.	<u>85</u>	<u></u>
Flash Point (Cleveland Open Cup), °F.	<u></u>	<u></u>
Solubility in trichloroethylene, %	<u></u>	<u></u>
Tests on Residue		
Loss on Heating, %	<u>.12</u>	<u></u>
Penetration of Residue, XXXXXX	<u>51</u>	<u></u>
Absolute Viscosity @ 140°F, poises	<u>5912</u>	<u></u>
Kinematic Viscosity @ 275°F Centistokes	<u>634</u>	<u></u>

Comments:

This is for information purposes only.

Frank E. Aldrich, P.E., Chief Engineer

By:

R. F. Nicholson 1987
R. F. Nicholson, P.E., Materials & Research Engineer

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISIONRESEARCH INVESTIGATIONWork Plan No. 85-B-3Subject Properties of Bituminous Mixes Designed by 50 and 75 Blow Marshall SeriesInvestigation Requested By Bituminous Concrete Subdivision Date January 31, 1985Date Information Required A.S.A.P.Purpose of Investigation To determine the effects that 50 and 75 blow Marshall Series have on similar bituminous mixtures under laboratory conditions.

Proposed Tests or Evaluation Procedure Conduct 50 and 75 blow Marshall Series, according to The Asphalt Institute's Manual Series No. 2 (MS-2), on bituminous mixes from two different aggregate sources, (Haven Crushed Stone and F. W. Whitcomb, Winooski). Analyze and evaluate the following mix properties:

Stability, Flow, % Voids of the Mix, VMA %, Unit Weight of the Mixture, and the optimum asphalt content

Proposal Discussed With C. Jerd Projected Manpower Requirements 70 man daysInvestigation To Be Conducted By E. Chaffee, W. Royce, D. DayProposed Starting Date February 5, 1985 Estimated Completion Date May 1, 1985Approval/Disapproval by Materials & Research Engineer R. J. Nicholson 02-05-85

Comments by Materials & Research Engineer _____

Materials & Research Division
Agency of Transportation
Date Typed: February 5, 1985