IMMERSION COMPRESSION EVALUATION OF BITUMINOUS MIXTURES

FINAL REPORT 83-3

January 1983

Reporting On
Work Plan 80-B-8

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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Date: April 21, 1983

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INTRODUCTION

The problem of loss of bond (stripping) between asphalt cement and aggregates in an asphalt concrete because of the presence of moisture has long been recognized as a problem of serious concern. In recent years, much research has been generated in the search for a test method for predicting the susceptibility of asphaltic concrete mixtures to moisture damage.

In 1976 the Vermont Agency of Transportation Materials and Research Division purchased the necessary equipment to perform the AASHTO Designation T-165 "Effect of Water on Cohesion of Compacted Bituminous Mixtures" test method. The anticipated purpose, at that time, was to use this test method to analyze possible problem mixes. Testing was delayed due to an increased work load and a lack of problem areas which could be related to stripping.

In 1978 the Agency undertook the engineering and inspection control for construction of F.A.A. sponsored airport construction projects. One of the required tests for bituminous concrete was the above mentioned test (AASHTO T-165) to determine the "Index of Retained Strength". F.A.A. requires airport mixes have an Index of Retained Strength of 75 percent. As a result of having performed this test on these airport projects, the Bituminous Concrete Subdivision of the Materials & Research Division recommended that all the aggregate sources used by the various bituminous concrete plants in the state, be analyzed, using this method of test.

SCOPE

Determine the Index of Retained Strength of Type III (1/2" maximum) mixes using sources of aggregate and asphalt cement utilized by the Vermont Agency of Transportation.

EVALUATION PROCEDURE

The method of test used to evaluate the mixes made with various aggregate sources is an AASHTO standard method of test, as follows:

Effect of Water on Cohesion of Compacted Bituminous Mixtures - AASHTO Designation: T 165-77.

This method covers measurement of the loss of cohesion resulting from the action of water on compacted bituminous mixtures containing asphalt cement. A numerical index of reduced cohesion is obtained by comparing the compressive strength of freshly molded and cured specimens with the compressive strength of duplicate specimens that have been immersed in water under prescribed conditions. The answer obtained is expressed as a percent of the original strength that is obtained after the immersion period.

TESTING PROCEDURE

As a first step in this analysis, the files were searched, and previously acceptable mix designs were found for all existing combinations of aggregates used to produce Type III mix for the State of Vermont.

A total of 13 designs were selected to be tested and are in Appendix A.

The asphalt cement used for testing was an 85-100 Penetration Grade from B. P. Oil of Montreal, Quebec, Canada. This grade was used since it is the asphalt cement most commonly used in Vermont. The asphalt cement had a penetration of 91 and an Absolute Viscosity @ 140°F of 1328 poises.

Aggregate samples were obtained during the 1980 paving season from the following sources:

Coarse Aggregate	Fine Aggregate
Cooley - Websterville - IS	Cooley - Websterville & Barre - S, SS
Calkins - Coventry - G	Calkins - Coventry - S
Carrara - N. Clarendon - G	Pike - Coventry - S
Dailey - S. Shaftsbury - G	Dailey - S. Shaftsbury - S
Hinesburg Sa. & Gr., Hinesburg - G	Hinesburg Sa. & Gr., Hinesburg - S
F. W. Whitcomb - N. Walpole, N.H. - G	F. W. Whitcomb - N. Walpole, N.H. - S
F. W. Whitcomb - Wallingford - G	F. W. Whitcomb - Wallingford - S
F. W. Whitcomb - Winooski - S	F. W. Whitcomb - Winooski - SS
Swanton Lime - Swanton - S	Griswold Sa. - Williston - S
Lebanon Cr.St., Lebanon, N.H. - S	Swanton Lime - Swanton - SS
Pike - New Haven - S	Bushey Pit - Highgate - S
Pike - Waterford - S	Pike - Hartland - S
	Carrara - N. Clarendon - S
	Pike - Middlebury - S
	Pike - New Haven - SS
	Pike - Waterford - SS
	Nutter Pit - Waterford - S
	Thibault Pit - Colchester - S

G = Crushed Gravel IS = Crushed Igneous Stone SS = Stone Screenings
S = Crushed Stone S = Sand

GENERAL CLASSIFICATION OF COARSE AGGREGATE

1.	Cooley - Websterville	Crushed Igneous (Granite)
2.	Calkins Sa. & Gr. - Coventry	Gravel
3.	Carrara Sa. & Gr. - N. Clarendon	Gravel
4.	Dailey - S. Shaftsbury	Gravel
5.	Hinesburg Sa. & Gr. - Hinesburg	Gravel
6.	F. W. Whitcomb - N. Walpole, N.H.	Gravel
7.	F. W. Whticomb - Wallingford	Gravel
8.	F. W. Whitcomb - Winooski	Dolomite
9.	Swanton Lime - Swanton	Dolomite
10.	Lebanon Crushed Stone - W. Lebanon, N.H.	Gneiss (Biotite)
11.	Pike - New Haven, Vt.	Limestone
12.	Pike - Waterford, Vt.	(Metadiorite) Igneous

BULK SPECIFIC GRAVITIES OF COARSE AGGREGATE

1.	Cooley - Websterville	2.613
2.	Calkins Sa. & Gr. - Coventry	2.698
3.	Carrara Sa. & Gr. - N. Clarendon	2.610
4.	Dailey - S. Shaftsbury	2.704
5.	Hinesburg Sa. & Gr. - Hinesburg	2.642
6.	F. W. Whitcomb - N. Walpole, N.H.	2.667
7.	F. W. Whitcomb - Wallingford	2.628
8.	F. W. Whitcomb - Winooski	2.729
9.	Swanton Lime - Swanton	2.721
10.	Lebanon Crushed Stone - W. Lebanon, N.H.	2.924
11.	Pike - New Haven, Vt.	2.746
12.	Pike - Waterford	2.954

TEST RESULTS

The results of the testing of the Type III mixes are listed by coarse aggregate source as follows:

	(Retained Strength %)		
	Test 1	Test 2	Avg.
Cooley	59.3	63.3	61.3
Calkins	88.4	99.2	93.8
Carrara	67.5	95.9	81.7
Dailey	96.5	89.5	93.0
Hinesburg	71.2	61.1	66.2
F.W. Whitcomb (N.Walpole, N.H.)	91.6	97.1	94.4
F.W. Whitcomb (Wallingford)	90.4	79.4	84.9
F.W. Whitcomb (Winooski)	95.1	102.3	98.7
Swanton	109.5	96.7	103.1
Lebanon	73.6	61.0	67.3
Pike - New Haven	98.5	123.1	110.8
Pike - Waterford	89.9	93.0	91.5
Pike - New Haven (Williston) Hot Mix Plant	78.1	116.5	97.3

EVALUATION OF RESULTS

Of the 13 aggregate combinations tested, three failed to meet the minimum Retained Strength Percent of 75 as required for airport pavements. These were: Cooley's Crushed Igneous Stone, Hinesburg's Gravel and Lebanon's Crushed Stone (Gneiss).

Two of the aggregate combinations tested, produced Index of Retained Strengths of over 100%. These were Swanton (limestone) and New Haven (dolomite). It has not been determined why the mixes gained strength in the presence of water, however, it is known that limestones are not prone to stripping and sometimes ground limestone is used as an antistrip additive.

The Index of Retained Strength Percents of the remaining 8 aggregate combinations ranged from 81.7 to 98.7.

CONCLUSIONS

The data gathered in this investigation can be used to indicate what would happen to the various aggregate mix combinations when subjected to water.

This data will be of value whenever airport mix is required from the sources of aggregates tested. This should alleviate the additional time spent on preliminary testing to determine if a mix needs an antistrip additive or not.

The results of the investigation indicate that the overall retained strength values of the aggregates used in bituminous mixes for Vermont are very good.

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

Design of Bituminous Concrete Mixtures

Town Groton Project No. F-BRF 26-1 (26)

Gentlemen:

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

Pavement Type 406 III Produced By: Cooley Asphalt Paving Plant Location Berlin, VT

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Nat. Sand	30				100	100	100	94	87	75	55	36	5.2	
Gr. Sand	80				100	100	100	100	76	53	34	17	1.9	
3/8"	15				100	100	98	21	5					
1/2"	25				100	96	36	4						
Resultant	100				100	99	84	64	56	38	26	15	2.2	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55				100	100	100	100	81	64	44	25	56	
2	22				100	100	99	25	2					
3	23				100	99	31	3						
4														
5														
Resultant					100	100	84	63	47	35	25	14	24	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	3603	1442	1507			448	7000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	100	84	62	48	36	25	15	2.5	6.4
Job Aim					100	95/100	78/90	50/68	44/52	32/40	21/29	11/19	1/4	6.0/6.8
Specification Limits	1980				100	95/100	78/90	54/74	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	AC-10:
Nat. Sand - Thunder Road Pit, Barre Town	Other: 85-100 B. P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date Oct. 17, 1980

TA 556

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

Design of Bituminous Concrete Mixtures

No 905

Town Morgan-Brighton Project No. TQS 0316 (2)

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location Coventry, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Scr. Sa.	25						100	97	94	87	75	43	6	
Wa. Sa.	25							100	93	66	37	13	2	
3/8 Gr.	25					100	98	40	8	3				
1/2 Gr.	25				100	92	36	4						
Resultant	100				100	98	84	60	49	40	28	15	2	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55							100	88	73	54	32	5.8	
2	24					100	98	33	6					
3	21				100	96	28	5						
4														
5														
Resultant	100				100	99	85	64	49	40	29	17	3.2	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2582	1139	974			305	5000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	62	48	40	28	16	3.5	6.1
Job Aim		/	/	/	100/100	95/100	78/90	56/68	44/52	36/44	24/32	12/20	2/5	6.0/6.5
Specification Limits		/	/	/	100/100	95/100	78/90	54/74	39/60	24/45	14/35	6/22	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Calkins Sa. & Gr.	AC-5:
Fine: Wa. Sa. - Calkins Sa. & Gr.	AC-10:
Scr. Sa. - Pike - Coventry	Other: 85-100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

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Signature ..... Title .....

Date Sept. 22, 1980

TA-556

CARRARA AGGREGATE

A-3

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

Design of Bituminous Concrete Mixtures

Nº 906

Town Rutland Project No. HES TQF 019-3 (17)

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location Clarendon, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Wa. Sa.	55							100	84	62	37	20	4	
3/8 Gr.	15					100	99	28	4					
1/2 Gr.	30				100	97	48	4						
Resultant	100				100	99	84	60	47	34	20	11	2	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	54							100	86	64	38	21	6	
2	21						100	26	5					
3	25				100	98	36	6						
4														
5														
Resultant	100				100	100	84	61	47	35	21	11	3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2028	789	939			244	4000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	60	48	34	20	11	3.5	6.1
Job Aim		/	/	/	100/100	95/100	78/90	54/66	44/52	30/38	16/24	7/15	2/5	6.0/6.5
Specification Limits		/	/	/	100/100	95/100	78/90	54/74	39/60	24/45	14/35	6/24	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Carrara - Clarendon	AC-5:
Fine: Carrara - Clarendon	AC-10:
	Other: 85-100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

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Signature ..... Title .....

Date Oct. 2, 1980

TA 556

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

Design of Bituminous Concrete Mixtures

Town Shaftsbury-Arlington Project No. SR 0137 (8)

Gentlemen:

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

Pavement Type III Produced By: Wm. E. Dailey Plant Location Shaftsbury

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Sc. Sa.	30						100	95	87	75	54	37	10	
Wa. Sa.	30						100	98	75	52	31	16	4	
3/8	8						100	30	8					
1/2	32				100	98	40	8						
Resultant	100				100	99	81	62	50	39	25	16	4	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	60						100	95	81	65	42	27	7	
2	10						100	30	8					
3	30					100	33	8						
4														
5														
Resultant	100					100	81	62	50	39	25	16	4	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	4470	800	2240			490	8000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula						100	81	62	50	39	25	16	3.5	6.1
Job Aim					100	95/100	78/90	56/68	46/54	35/43	21/29	12/20	2/5	6.0/6.5
Specification Limits					100	95/100	78/90	54/74	39/60	24/45	14/35	6/24	0/5	6.0/8.0

Source of Materials

Aggregates	Asphalt
Coarse: Wm. E. Dailey	AC-5:
Shaftsbury	
Fine: Wm. E. Dailey	AC-10: ARCO
Shaftsbury	Albany, N.Y.
	Other:

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date May 28, 1980

TA 556

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - BITUMINOUS CONCRETE SUBDIVISION No 800

Design of Bituminous Concrete Mixtures

Town Milton-Colchester Project No. BRF F 028-1 (3)

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location Williston, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Sand	62						100	96	78	55	38	27	4.7	
3/8 Gr.	16					100	96	34	6.8					
1/2 Gr.	22				100	93	33	4.0						
Resultant	100				100	98	85	66	49	34	24	17	2.9	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	58							100	84	59	41	30	6	
2	18						100	42	6					
3	24					100	35	4						
4														
5														
Resultant	100				100	100	84	67	50	34	24	17	3.5	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	5446	1690	2254			610	10,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	67	50	34	24	17	4.5	6.1
Job Aim		/	/	/	100/100	95/100	78/90	61/73	46/54	30/38	20/28	13/21	3/6	6.0/6.5
Specification Limits		/	/	/	100/100	95/100	78/90	54/74	38/58	26/44	17/35	11/26	3/6	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Hinesburg Sand & Gravel	AC-5:
Fine: Hinesburg Sand & Gravel	AC-10:
	Other: 85/100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

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Signature ..... Title .....

Date Sept. 14, 1979

TA 556

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

Design of Bituminous Concrete Mixtures

Town Jamaica Project No. F BHF 015-1 (2)

Gentlemen:

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

Pavement Type III Produced By: F. W. Whitcomb Plant Location No. Walpole

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Man. Sa.	20						100	100	82	62	45	34	12	
Wash. Sa.	35						100	99	82	60	36	16	3	
3/8 Gr.	15					100	99	24	2					
1/2 Gr.	30				100	95	30	1						
Resultant	100				100	99	79	59	45	36	22	13	3	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55						100	99	82	66	46	25	6	
2	15						100	30	1					
3	30				100	98	38	2						
4														
5														
Resultant	100				100	99	82	60	45	36	25	14	3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	3600	982	1963			455	7000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	99	84	60	46	34	24	15	4	6.5
Job Aim		/	/	/	100 /	95 / 100	78 / 90	54 / 66	42 / 50	30 / 38	20 / 28	11 / 19	3 / 6	6.1 / 6.9
Specification Limits		/	/	/	100 /	95 / 100	78 / 90	54 / 74	38 / 58	26 / 44	17 / 35	11 / 26	3 / 6	6 / 8

Source of Materials

Aggregates	Asphalt
Coarse: F. W. Whitcomb - No. Walpole	AC-5:
Fine: F. W. Whitcomb - No. Walpole	AC-10: Exxon - Everett, Ma.
	Other:

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

.....

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Signature ..... Title .....

Date June 5, 1980

TA 556

ALLINGFORD AGGREGATE

A-7

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

Design of Bituminous Concrete Mixtures

Nº

Town Manchester-Winhall-Peru Project No. FR 016-1 (7)S

Gentlemen:

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

Pavement Type III Produced By: F. W. Whitcomb Plant Location Wallingford

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
W. Sand	55						100	99	78	56	36	20	3	
3/8 Gr.	25					100	99	26	3					
1/2 Gr.	20				100	95	33	2						
Resultant	100				100	99	86	61	44	31	20	11	2	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	57						100	99	78	56	36	22	5	
2	28					100	95	20	2					
3	15				100	99	20							
4														
5														
Resultant	100				100	99	87	62	45	32	21	13	3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	4265	2100	1125			510	8000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	99	84	62	46	34	22	14	3	6.4
Job Aim		/	/	/	100/	95/100	78/90	56/68	42/50	30/38	18/26	10/18	2/5	6.0/6.8
Specification Limits		/	/	/	100/	95/100	78/90	54/74	39/60	24/45	14/35	6/24	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: F. W. Whitcomb - Wallingford	AC-5:
Fine: F. W. Whitcomb - Wallingford	AC-10:
	Other: 85-100 B.P. Canada - Montreal

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date July 16, 1980

TA 556

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

Design of Bituminous Concrete Mixtures

Town St. Albans - Fairfield Project No. SR 0298 (3)

Gentlemen:

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

Pavement Type III Produced By: F. W. Whitcomb Plant Location Williston, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
St. Sc.	20							100	75	44	28	20	10	
Wa. Sa.	40						100	98	86	72	48	24	2	
3/8	20					100	99	30	2					
1/2	20				100	99	35	1						
Resultant	100				100	99	87	65	50	38	25	14	3	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55						100	95	84	64	46	25	6	
2	25						100	30	2					
3	20					100	25	2						
4														
5														
Resultant	100					100	85	60	47	35	25	14	3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	7200	3272	2618			910	14,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	100	84	60	48	36	25	14	3	6.5
Job Aim					100	95/100	78/90	54/66	44/52	32/40	21/29	10/18	2/5	6.1/6.9
Specification Limits					100	95/100	78/90	54/74	39/60	24/45	14/35	6/24	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: F. W. Whitcomb - Williston	AC-5:
Fine: W. Sand - Griswold - Williston	AC-10:
St. Sc. - F. W. Whitcomb - Winooski	Other: 85-100 B.P. Canada - Montreal

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date Aug. 13, 1980

TA 556

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

Design of Bituminous Concrete Mixtures

Town Swanton Project No. CP 1020

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location Swanton, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
(B) Sand	34					100	99	94	85	72	55	27	2.3	
Dust	32						100	99	75	44	25	15	6.3	
3/8 Rk.	10					100	96	27	1.3					
1/2 Rk.	24				100	96	34	2						
Resultant	100				100	99	84	67	53	39	27	14	2.8	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	60							100	85	61	43	25	5.4	
2	16						100	29	2					
3	24					100	36	2						
4														
5														
Resultant	100				100	100	85	65	51	37	26	15	3.2	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	1123	300	449			128	2,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	66	52	38	27	15	4.5	6.4
Job Aim					100/100	95/100	78/90	60/72	48/56	34/42	23/31	11/19	3/6	6.0/6.8
Specification Limits					100/100	95/100	78/90	54/74	38/58	26/44	17/35	11/26	3/6	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Swanton Limestone	AC-5:
Fine: Sand - Pike - Highgate, Vt.	AC-10:
Dust - Swanton Limestone	Other: 85-100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date Aug. 1, 1979

TA 556

LEBANON AGGREGATE

A-10

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

Design of Bituminous Concrete Mixtures

Town Stockbridge Project No. FR 022-1 (8)S

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location W.Lebanon, N.H. #804

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Sc. Sa.	60					100	99	92	80	62	43	24	5	
3/8 Ledge	16					100	96	31	7					
1/2 Ledge	24				100	95	36	4	2					
Resultant	100				100	99	83	61	50	37	26	14	3.0	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	50							100	90	74	52	30	8	
2	25					100	99	40	6					
3	25				100	99	35	4						
4														
5														
Resultant	100				100	100	84	61	47	37	26	15	4.0	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2817	1408	1409			366	6.000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	61	49	37	26	15	3.5	6.1
Job Aim					100/100	95/100	78/90	55/67	45/53	33/41	22/30	11/19	2/5	6.0/6.5
Specification Limits	1980				100/100	95/100	78/90	54/74	39/60	24/45	14/35	6/22	0/5	6.0/8.0

Source of Materials

Aggregates	Asphalt
Coarse: Lebanon Crush. Stone, W.Lebanon, N.H.	AC-5:
Fine: Pike, Hartland Pit, Hartland, Vt.	AC-10:
	Other: 85/100 Pen. - B.P. Canada - Montreal

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

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Signature ..... Title .....

Date June 19, 1980

TA 556

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

Design of Bituminous Concrete Mixtures

Town Milton-Colchester Project No. BRF F 028-1 (3) No. 800

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location Williston, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Scr. Sa.	29					100	97	92	85	75	56	20	1.3	
Wa. Sa.	29						100	98	75	51	26	12	2.7	
3/8 Rk.	19					100	98	23	2					
1/2 Rk.	23				100	94	27	2						
Resultant	100				100	99	83	59	48	36	24	9	1.2	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55							100	86	65	43	18	4.2	
2	22						100	26	5					
3	23				100	98	32	5						
4														
5														
Resultant	100				100	100	84	62	48	36	24	10	2.3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	4643	1857	1942			558	9,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	60	48	36	24	10	2.5	6.2
Job Aim		/	/	/	100/100	95/100	78/90	54/66	44/52	32/40	20/28	6/14	1/4	6.0/6.6
Specification Limits		/	/	/	100/100	95/100	78/90	54/74	39/60	24/45	14/35	6/22	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Haven Quarry	AC-5:
Fine: Scr. Sa. - Thibault Pit	AC-10:
Wa. Sa. - Hinesburg	Other: 85-100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date June 23, 1980

TA 556

NEW HAVEN AGGREGATE

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

A-12

No 902

Design of Bituminous Concrete Mixtures

Town Hancock Project No. BHS 013-4 (5)S
HES 013-4 (2)S

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location New Haven, Vt.

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Sand	30					100	97	89	80	70	55	28	2.4	
Dust	30						100	99	81	53	35	23	9.5	
3/8 Rk.	20					100	97	29	2.7					
1/2 Rk.	20				100	97	27	1.3						
Resultant	100				100	99	84	62	49	37	27	15	3.6	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	56							100	86	63	46	26	6	
2	20						100	31	3					
3	24					100	29	2						
4														
5														
Resultant	100				100	100	83	63	49	35	26	15	3.4	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2629	939	1127			305	5,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	63	49	36	27	15	3.5	6.1
Job Aim					100/100	95/100	78/90	57/69	45/53	32/40	23/31	11/19	2/5	6.0/6.5
Specification Limits					100/100	95/100	78/90	54/74	39/60	24/45	14/35	6/24	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: New Haven Quarry	AC-5:
Fine: Dust - New Haven Quarry	AC-10:
Sand - Pike - Middlebury	Other: 85-100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

Signature ..... Title .....

Date July 1, 1980

TA 556

WATERFORD AGGREGATE

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

A-13

No

Design of Bituminous Concrete Mixtures

Town St. Johnsbury-Lyndon Project No. I91-3 (39)

Gentlemen:

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

Pavement Type III Produced By: Pike Ind. Inc. Plant Location Waterford, Vt.

706

Stockpile Gradations — % Passing

Size	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
Scr. Sa.	28						100	99	98	89	48	15	3	
Man. Sa.	27							100	71	47	31	20	5	
3/8 Rk.	25					100	95	21	2					
1/2 Rk.	20				100	97	27	2						
Resultant	100				100	99	84	61	48	37	21	10	2.2	

Hot Bin Gradation — % Passing

Bin	% Used	1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	
S	56							100	86	70	42	21	7	
2	26						100	20	2					
3	18				100	98	17	1						
4														
5														
Resultant	100				100	100	85	61	49	39	24	12	4	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2102	975	675			248	4,000

		1¾	1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	98	84	60	48	37	22	11	3.5	6.2
Job Aim		/	/	/	100/100	95/100	78/90	54/66	44/52	33/41	18/26	7/15	2/5	6.0/6.6
Specification Limits		/	/	/	100/100	95/100	78/90	54/74	39/60	24/45	14/35	6/22	0/5	6/8

Source of Materials

Aggregates	Asphalt
Coarse: Waterford Quarry	AC-5:
Fine: Man. Sa. - Waterford Quarry	AC-10:
Scr. Sa. - Nutter Pit - Waterford	
	Other: 85-100 B.P. Canada

Mixing Times — Dry: ..... Wet: ..... Total: ..... Temperature: .....

Submitted by: ..... (signature) Date: .....

Company ..... Title .....

FOR STATE OF VERMONT USE ONLY

Approved ..... Rejected .....

Comments: .....

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Signature ..... Title .....

Date Sept. 8, 1980

TA 556

Date: 12-2-80
Sheet 1 of 1

B-1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

RESEARCH INVESTIGATION

Work Plan No. 80-B-8

Subject Immersion Compression Evaluation of Bituminous Mixtures

Investigation Requested By Materials & Research Div. Date December 2, 1980

Date Information Required April, 1981

Purpose of Investigation Evaluate the loss of cohesion resulting from the action of water on Bituminous Mixtures.

Proposed Tests or Evaluation Procedure Tests: AASHTO T165 and T167

Evaluation Procedure:

1. Determine the Index of Retained Strength of Type III mixes using sources of aggregate and asphalt cement utilized by the Vermont Agency of Transportation.

2. Determine the Index of Retained Strength of Open Graded Mixes using several sources of aggregate and asphalt cement.

Proposed Discussed With Charles Jen cej Projected Manpower Requirements 120

Investigation To Be Conducted By Earle Chaffee, William Royce, David Day

Proposed Starting Date December, 1980 Estimated Completion Date April, 1981

Approval/Disapproval by Materials Engineer R. F. Nicholson 12/22/80

Comments by Materials Engineer

Materials & Research Division
Agency of Transportation