EVALUATION OF SWANTON LIMESTONE/SWANTON, VT.
3/4" CRUSHED STONE (BLACK)
FOR USE IN STRUCTURAL CONCRETE

REPORT 84-4

MAY 1984

Reporting on Work Plan 83-C-43

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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Date: 05-25-'84

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ABSTRACT

As aggregate sources are developed or expanded, tests must be conducted to assure that new materials meet specifications and perform satisfactorily when used in concrete mixtures.

This report documents results of tests performed on a newly developed coarse aggregate from the Swanton Limestone quarry in Swanton, Vermont. The material tested was a 3/4 inch crushed stone designated as "black limestone" by Swanton Limestone President Dennis Demers.

Mr. Demers requested that the new material be tested for approved use in structural concrete and bituminous concrete.

By way of this evaluation, the new material was found to be the black shale of the Iberville formation and as such could produce structural concrete exhibiting poor durability. This report recommends that the new material not be considered acceptable for use in structural concrete for Agency projects.

INTRODUCTION

As aggregate sources, for use in structural concrete, are developed or expanded, new materials must be evaluated not only to determine their compliance with materials specifications, but to examine their performance in concrete mixtures. A procedure has been developed whereby proposed new aggregates are evaluated by comparing results of tests performed on concrete using the new aggregate, with results obtained from concrete containing a reference aggregate. See Appendix A for evaluation procedures.

A request was received from Dennis Demers, President of Swanton Limestone, to evaluate a crushed stone, designated as "black limestone" being produced at their existing quarry in Swanton, Vermont. The new material is in addition to their regular grey limestone coarse aggregate which is produced at the same quarry. Mr. Demers requested that the "black limestone" be evaluated for use in both structural concrete and bituminous concrete.

Samples of the new 3/4 inch crushed stone were obtained by Materials & Research Division representatives and evaluated for compliance with the requirements of Section 704.02 of the Standard Specifications. Materials were obtained and the performance-in-concrete phase of the evaluation was conducted in the Central Laboratory of the Materials & Research Division. Tests were performed cooperatively with the Bituminous Concrete Subdivision and applicable results shared to avoid duplication of effort. The results of the evaluation conducted by the Bituminous Concrete Subdivision are documented in Materials & Research Division Report 84-1.

PROCEDURES

PHASE I - SECTION 704.02 TESTS

The 3/4 inch crushed stone (black) was sampled, by representatives of the Materials and Research Division, from a stockpile at the Swanton Limestone facility in Swanton. The material was examined for gradation, wear, fractured faces, thin and elongated pieces and soundness. It was found to comply with Section 704.02 requirements. Test results are shown on Laboratory Report No. A83 1293 in Appendix B.

PHASE II - PERFORMANCE-IN-CONCRETE TESTS

The performance-in-concrete tests were conducted on concrete prepared in the Central Laboratory. Mixtures were designed by Structural Concrete Subdivision personnel for Class A and Class B concrete, using the following materials:

Coarse aggregate

A. Proposed New Aggregate (black)

3/4 inch Crushed Stone
Swanton Limestone, Swanton, Vermont

B. Reference Aggregate (gray limestone):

3/4 inch Crushed Stone
Swanton Limestone, Swanton, Vermont

Fine Aggregate

A. G. Anderson Co., Inc., Highgate, Vermont

Cement

Type II
Glens Falls Portland Cement Co., Glens Falls, N.Y.

Air Entraining Admixture:

Darex AEA
W. R. Grace & Co., Cambridge, Massachusetts

Water Reducing Admixture:

WRDA with Hycol
W. R. Grace & Co., Cambridge, Massachusetts

Aggregate properties used for preparing mix designs are shown in Table 1 and Table 2.

TABLE 1
COARSE AGGREGATE PROPERTIES

	Bulk Specific Gravity	Absorp. Percent	Dry Rodded Unit Weight, lbs/ft^3
New Aggregate (black) Swanton Limestone, Swanton, Vt.	2.70	0.8	91.11
Reference Aggregate (gray limestone) Swanton Limestone, Swanton, Vt.	2.75	0.5	97.88

TABLE 2
FINE AGGREGATE PROPERTIES

	Bulk Specific Gravity	Absorp. Percent	Fineness Modulus
Reference Aggregate A. G. Anderson Co., Inc., Highgate, Vt.	2.60	1.3	2.74

Initially, the performance-in-concrete evaluation was scheduled to use two batches each of Class A and Class B concrete containing the new aggregate and two batches each of Class A and Class B concrete containing the reference aggregate. However, poor performance of the new aggregate batches in freeze-thaw testing, prompted testing of an additional batch of Class B concrete.

The mix proportions used in Batches 1-8, the initial part of the evaluation, are shown in Table 3 and Table 4. These batches were mixed in a Sears rotary drum mixer with the batch size being 1.5 cubic feet.

Tests were performed on the fresh concrete to determine slump (AASHTO T 119-82), Air Content (AASHTO T 196-80) and Unit Weight (AASHTO T 121-82). Six test cylinders (6" x 12") and one 3"w x 3"d x 16"l freeze-thaw specimen were cast from each batch. The cylinders were tested for compressive strength (AASHTO T 22-82), two each at ages 7, 14, and 28 days. The freeze-thaw specimens were moist cured for 14 days, after which they were subjected to freezing and thawing (AASHTO T 161-82) in a 3% NaCl solution.

The second part of the performance-in-concrete evaluation used one batch of Class B concrete containing the new coarse aggregate. This batch of concrete was mixed in a larger capacity Sears rotary drum mixer with the batch size being 2.75 cubic feet.

This concrete was mixed to approximately the same slump and air content as the initial Class B concrete using the new aggregate. The concrete was tested for Slump, Air Content (AASHTO T 152-82) and Unit Weight. Four test cylinders (6" x 12") and four 3"w x 3"d x 16"l freeze thaw specimens were cast. This concrete was identified as Batch 9A.

The remaining concrete was then remixed with additional air entraining admixture and slightly more water. The tests were repeated and the same number of test specimens cast. This concrete was identified as Batch 9B. The mix proportions used in Batch 9A/9B are shown in Table 5.

The cylinders were tested two each, for Batches 9A and 9B, at ages of 7 and 28 days. The freeze-thaw specimens were moist cured for 14 days, after which they were subjected to freezing and thawing, two each per batch in a 3% NaCl solution and two each per batch in water.

At the request of the Structural Concrete Engineer, a field petrographic examination of the new material was conducted by the Vermont Agency of Transportation Chief Geologist. The Chief Geologist examined samples of the crushed stone in the laboratory and traveled to the Swanton quarry for an in-situ examination of the material.

TABLE 3

NEW AGGREGATE MIX DESIGN
BATCH QUANTITIES PER C.Y.

	Class A		Class B	
	Batch 1	Batch 2	Batch 3	Batch 4
*New Coarse Aggregate, lbs.	1562	1562	1562	1562
*Fine Aggregate, lbs.	1343	1343	1485	1485
Cement, lbs.	660	660	611	611
Air Entraining Admixture, oz.	8.5	10.0	5.0	6.0
Water Reducing Admixture, oz.	19.8	19.8	18.3	18.3
New Water, gal.	33.0	32.1	32.1	31.9

*Weights converted to saturated surface-dry condition.

TABLE 4

REFERENCE AGGREGATE MIX DESIGN
BATCH QUANTITIES PER C.Y.

	Class A		Class B	
	Batch 5	Batch 6	Batch 7	Batch 8
*Reference Coarse Aggregate, lbs.	1673	1673	1673	1673
*Fine Aggregate, lbs.	1259	1259	1403	1403
Cement, lbs.	660	660	611	611
Air Entraining Admixture, oz.	7.0	7.0	4.0	5.0
Water Reducing Admixture, oz,	19.8	19.8	18.3	18.3
New Water, gal.	32.3	30.7	30.2	32.2

*Weights converted to saturated surface-dry condition.

TABLE 5

NEW AGGREGATE MIX DESIGN
BATCH QUANTITIES PER C.Y.

	Class B	
	Batch 9A	Batch 9B
*New Coarse Aggregate, lbs.	1562	1562
*Fine Aggregate, lbs.	1485	1485
Cement, lbs.	611	611
Air Entraining Admixture, oz.	6	8
Water Reducing Admixture, oz.	18.3	18.3
New Water, gal.	33.6	34.0

*Weights converted to saturated surface-dry condition.

RESULTS

Results of tests on the fresh concrete and compressive strength test results are shown in Table 6, Table 7, and Table 8.

TABLE 6

PERFORMANCE TEST RESULTS
NEW AGGREGATE

	Class A		Class B	
	Batch 1	Batch 2	Batch 3	Batch 4
Slump, inches	3 3/4	3 1/4	3	2 1/2
Air Content, percent	4.6	4.0	4.0	4.0
Unit Weight, lbs./ft^3	146.56	147.86	147.90	147.42
Compressive Strength, psi				
7 days	4050	4086	4112	4200
14 days	4898	4863	4952	5274
28 days	4965	5275	4947	5213
(Design Compressive Strength, psi)	(4000)		(3500)	

TABLE 7

PERFORMANCE TEST RESULTS

REFERENCE AGGREGATE

	Class A		Class B	
	Batch 5	Batch 6	Batch 7	Batch 8
Slump, inches	4 1/4	3 1/4	3	3 3/4
Air Content, percent	6.2	4.0	4.0	5.8
Unit Weight, lbs./ft^3	146.17	149.35	149.01	146.07
Compressive Strength, psi				
7 days	4594	4739	4886	4558
14 days	5341	5456	5748	5571
28 days	5266	5721	5956	5580
(Design Compressive Strength, psi)	(4000)		(3500)	

TABLE 8

PERFORMANCE TEST RESULTS

NEW AGGREGATE

	Class B	
	Batch 9A	Batch 9B
Slump, inches	2 1/2	4
Air Content, percent	4.3	7.1
Unit Weight, lbs./ft^3	148.91	144.15
Compressive Strength, psi		
7 days	4209	3988
28 days	5655	5213
(Design Compressive Strength, psi)	(3500)	

The results of compressive strength tests are also shown on Laboratory Reports Nos. C84 0001 through C84 0008 and C84 0082 and C84 0083 in Appendix C. Strength age plots illustrating average compressive strengths are shown in Figure I, Figure II and Figure III.

The results of dynamic testing of freeze-thaw specimens are shown in Table 9. The percent weight loss resulting from freezing and thawing of specimens is shown in Table 10.

The report of the field petrographic examination, shown in Appendix D indicates the bedrock is the black shale of the Iberville formation. The report further indicates that the new material is not acceptable in New York State either as structural concrete or bituminous concrete aggregate.

TABLE 9

FREEZE-THAW TEST RESULTS - RELATIVE DYNAMIC MODULUS OF ELASTICITY

Number of Cycles	New Aggregate				Reference Aggregate				New Aggregate			
	Class A		Class B		Class A		Class B		Class B			
	Batch 1	Batch 2	Batch3	Batch4	Batch 5	Batch6	Batch 7	Batch 8	Batch 9A*		Batch 9B*	
	3% NaCl								3% NaCl	Water	3% NaCl	Water
	Relative Dynamic Modulus of Elasticity											
50	98.6	97.2	92.3	87.6	99.3	94.4	99.3	99.3	98.6	100.4	98.3	100.7
100	98.6	95.8	53.1	53.6	97.9	95.8	97.9	97.9	98.6	99.3	97.9	99.3
150	97.9	95.8			97.9	94.4	97.2	96.5	98.6	100.0	98.3	99.3
200	86.9	92.4			97.9	94.4	93.7	96.5	98.3	99.3	97.2	99.0
250	69.2	60.4			97.9	94.4	90.9	95.8	98.3	99.7	97.9	99.3
300	55.7	52.5			98.6	94.4	86.9	95.8	**98.3	**100.0	**98.2	**99.3
350					98.6	94.4	56.3	96.5				
400					96.5	85.1		96.5				
450					96.5	62.8		96.5				
500					95.8	53.1		95.8				
550					96.5	52.1		96.5				
600					**95.8			**96.5				

* Results shown are average of two specimens.

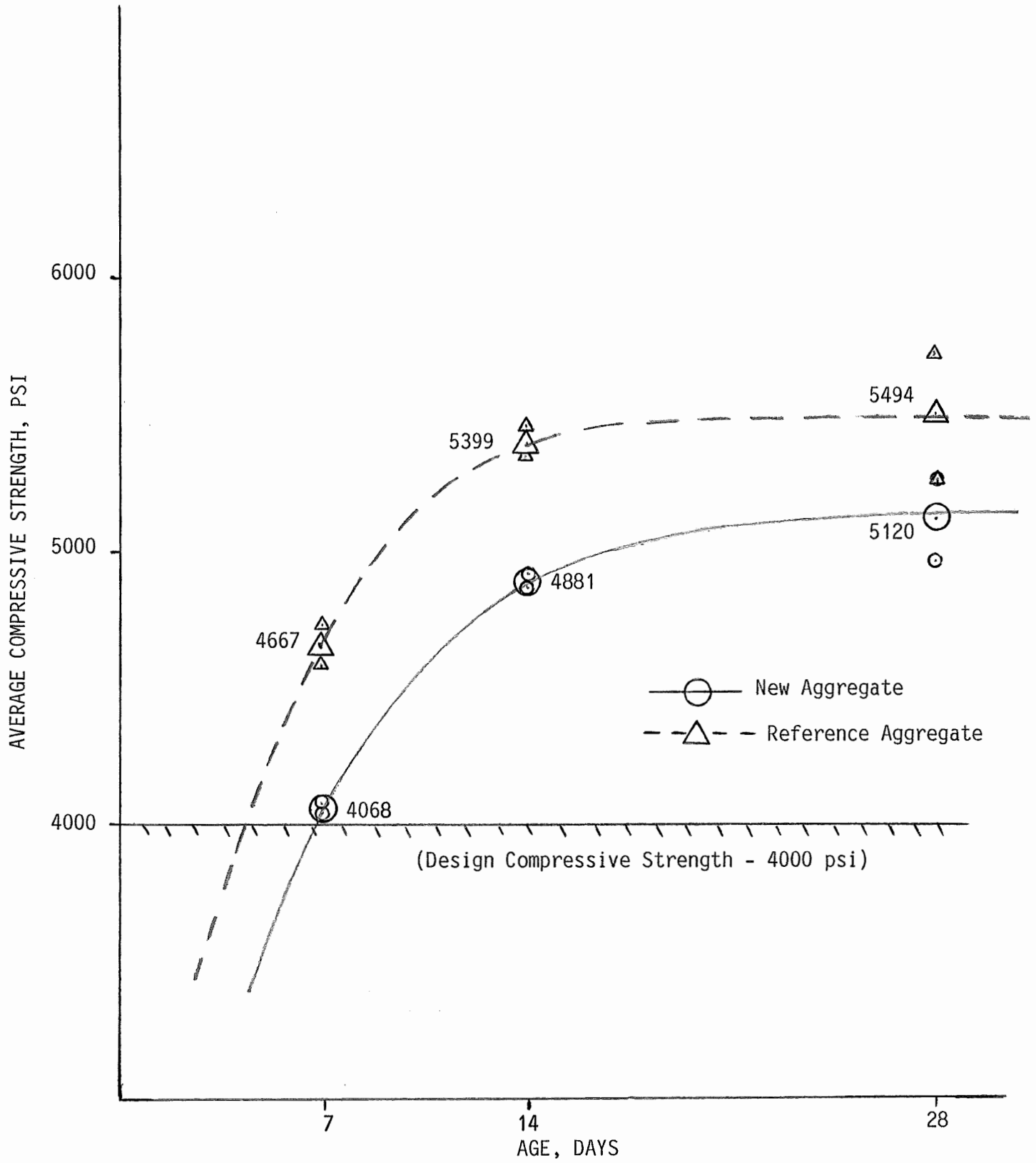
**Testing terminated prior to complete deterioration of specimens due to time constraints.

TABLE 10

FREEZE-THAW TEST RESULTS - PERCENT WEIGHT LOSS

	New Aggregate				Reference Aggregate				New Aggregate			
	Class A		Class B		Class A		Class B		Class B			
	Batch 1	Batch 2	Batch3	Batch 4	Batch5	Batch6	Batch7	Batch 8	Batch 9A*		Batch 9B*	
	3% NaCl								3% NaCl	Water	3% NaCl	Water
	Percent Weight Loss											
Number of Cycles												
50	4	3	7	7	2	3	5	3	7	0	4	0
100	6	4	16	25	3	5	7	3	11	0	7	0
150	9	6			4	6	10	4	14	0	9	0
200	13	8			4	7	12	5	16	0	10	0
250	17	12			5	9	17	6	18	1	12	0
300	22	16			5	10	20	6	** 20	** 1	**14	**0
350					5	11	23	6				
400					6	13		7				
450					6	14		7				
500					7	17		8				
550					8	24		9				
600					**8			**9				

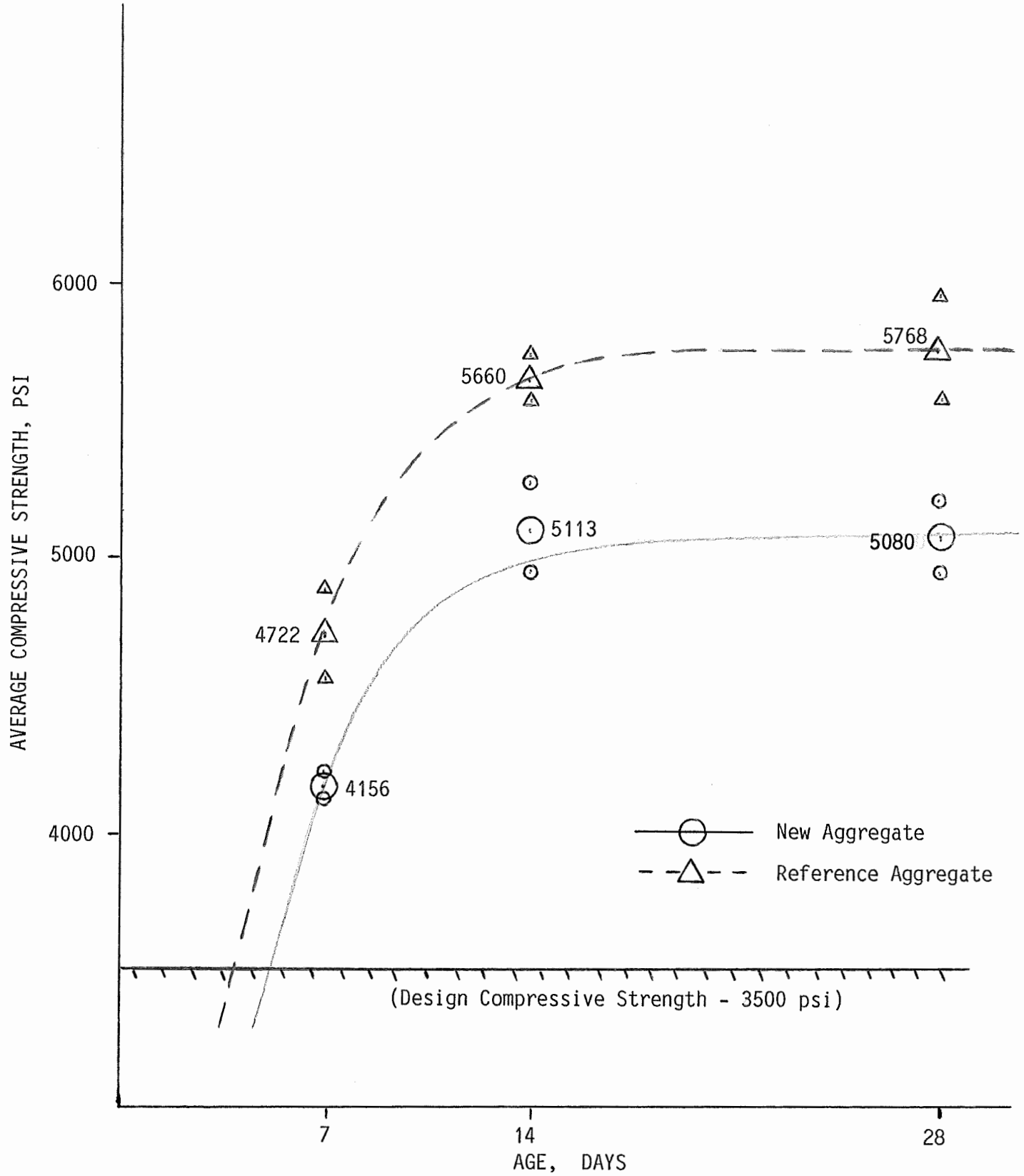
*Results shown are average of two specimens.
**Testing terminated prior to complete deterioration of specimens due to time constraints.



AVERAGE COMPRESSIVE STRENGTH VS AGE

CLASS A

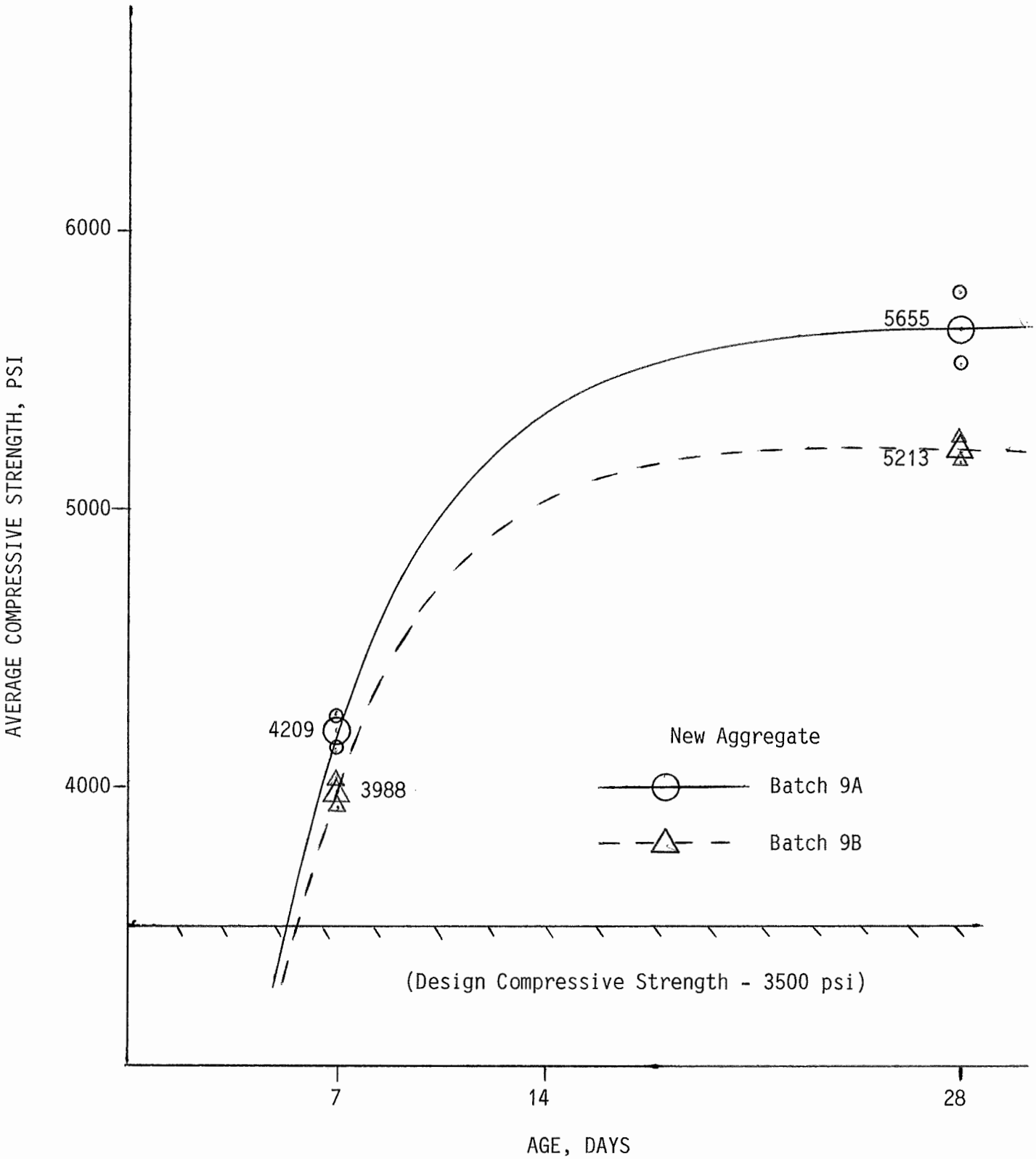
Figure I



AVERAGE COMPRESSIVE STRENGTH VS AGE

CLASS B

Figure II



AVERAGE COMPRESSIVE STRENGTH VS AGE
CLASS B BATCHES 9A & 9B

Figure III

SUMMARY AND CONCLUSIONS

1. The 3/4 inch crushed stone coarse aggregate (new material) from the Swanton Limestone quarry in Swanton, Vermont complied with requirements of Section 704.02 for grading, wear, soundness, fractured faces and thin and elongated pieces.

2. Comparison of the Net Water (Table 3 and Table 4) and Slump (Table 5 and Table 6) of concrete shows that although the average slump of the new aggregate batches was approximately 1/2 inch less than the reference batches, the new aggregate batches required an average of almost one gallon per cubic yard more mixing water. Visual inspection of the proposed new aggregate indicated a greater portion of thin or platy material in comparison to the reference aggregate. When material of this nature is used in structural concrete, an increased water demand can usually be expected.

3. A slightly higher addition rate of air entraining admixture was required in the batches containing the new material than was required in the batches containing the reference aggregate. This can be attributed to the same reasoning given in statement 2.

4. The compressive strengths of both classes of concrete containing the reference aggregate were higher than the compressive strengths of the concrete containing the new aggregate.

5. Concrete containing the reference aggregate generally performed better in freeze-thaw testing than the concrete containing the new aggregate.

Testing of specimens from Batch 1 and Batch 2, Class A concrete containing the new aggregate, was terminated at 300 cycles due to deterioration of the concrete. Specimens from Batch 5 and Batch 6, Class A concrete containing the reference aggregate were tested through 600 cycles and 550 cycles respectively. Testing was suspended after 600 cycles for Batch 5 with minor deterioration of the specimen while the specimen from Batch 6 showed excessive deterioration at 550 cycles. Specimens from Batch 3 and Batch 4, Class B concrete containing the new aggregate, showed excessive deterioration and testing was terminated after only 100 cycles. Class B concrete containing the reference aggregate showed deterioration severe enough to discontinue testing at 350 cycles for Batch 7, while testing of Batch 8 was suspended at 600 cycles with very little deterioration of the specimen.

Testing of all specimens for Batch 9A/9B, Class B concrete containing the new aggregate, was discontinued at 300 cycles due to time constraints. Although only a slight difference in sonic test results existed between specimens cycled in the NaCl solution and specimens cycled in water, there was a considerable difference in weight loss. The specimens cycled in NaCl showed 20% weight loss at 300 cycles for the concrete with 4.3% air content (Batch 9A) and 14% weight loss at 300 cycles for the concrete with 7.1% air content (Batch 9B). The specimens cycled in water showed only 1% weight loss for Batch 9A and 0% weight loss for Batch 9B.

6. The new material, identified by the owner as "black limestone", was found through examination to be black shale of the Iberville formation. Shales or materials containing shale are generally considered to produce concretes

which have a poor service record. The shale materials exhibit volume change on wetting and drying as well as possible alkali-aggregate reaction. These actions may be further aggrevated by freezing and thawing which results in deterioration of the concrete.[1]

RECOMMENDATION

It is recommended by the Structural Concrete Subdivision, that the proposed new material not be considered acceptable for use in structural concrete for Agency projects.

1. Walker, H.M., "Chemical Reactions of Carbonate Aggregates in Cement Paste", Significance of Tests and Properties of Concrete and Concrete Making Materials, ASTM STP 169B, March 1978, pp. 722 - 743.

Appendix A

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

VERMONT PROCEDURE FOR EVALUATING A NEW SOURCE OF STRUCTURAL CONCRETE AGGREGATE

VT-AOT-MRD 9-82

1. SCOPE

A procedure for evaluating new structural concrete aggregate sources by testing proposed new aggregates for compliance with Section 700 requirements and by comparing results of tests performed on concrete using the new aggregate with results obtained from concrete containing a reference aggregate.

2. PROCEDURE

General

The evaluation of a new structural concrete aggregate source (i.e., one on which the Materials and Research Division has no service-in-concrete data) shall be divided into two sections called:

Phase I Section 700 and related tests, and Phase II Performance-in-Concrete tests.

All requests for evaluation of new structural concrete aggregate sources shall be made, in writing, to the Materials and Research Engineer. Requests shall describe the type of material proposed for use as well as the location and quantity of available stockpiles.

Materials and Research Division personnel shall perform all work necessary for both the Phase I and Phase II sections of this evaluation process. The work will be performed in an expeditious manner consistent with availability of manpower. Evaluations may require 60 calendar days or more from the date the aggregate is available for testing (controlled by the availability of personnel to perform testing). Delays beyond the control of the Materials and Research Division shall be documented and notification given of the consequent extension of time required to complete the evaluation.

Test results shall be the basis for determining acceptance, further testing, or rejection of the proposed new material. Failure of the material to comply with all applicable requirements, during any phase of testing, may necessitate rescheduling or termination of the evaluation.

The cost of materials necessary to complete the evaluation will be borne by the requesting party.

A report shall be prepared documenting the Materials and Research Division's involvement in the evaluation. A copy of the report shall be forwarded with a cover letter, informing the requesting party of the acceptability or nonacceptability of the aggregate.

Phase I

1. Following receipt of the written request, the Structural Concrete Engineer will schedule a field petrographic examination of the proposed new aggregate source by the Vermont A.O.T. Chief Geologist.

2. The Structural Concrete Engineer or his representative will visit the site and determine:

   (a) Does a stockpile of at least 50 cubic yards of processed material exist?

   (b) Can samples be obtained in the standard manner from the stockpiles?

3. If 2(a) and 2(b) are yes, the Structural Concrete Engineer shall make necessary arrangements for obtaining samples from the designated stockpile.

4. The material shall be tested at the Central Laboratory using the Structural Concrete Subdivision Annual Aggregate Testing Program procedure.

5. Report the results (as an Evaluation Sample) on the Standard Materials and Research Division forms.

Phase II

1. The performance-in-concrete tests shall be performed on concrete prepared at the Central Laboratory. The proposed new aggregate will be evaluated by comparing results of tests performed on concrete using the new aggregate with results obtained from concrete containing a reference aggregate. Cement, admixtures, and aggregates, other than the proposed new aggregate, will be selected by the Structural Concrete Engineer. Normally, these materials will be the same as the materials currently in use at the Ready-mix plant where the proposed new aggregate will be used.

2. Mix proportions for each class of concrete required shall be designed or approved by the Materials and Research Division and shall conform to Table 501.03A of the Vermont Standard Specifications for Highway and Bridge Construction, current edition.

3. Test cylinders shall be fabricated and cured in accordance with AASHTO T23. They shall be tested for compressive strength at ages 7, 14, and 28 days in accordance with AASHTO T22.

4. Tests of Slump, Air Content, and Unit Weight shall be in accordance with AASHTO T119, AASHTO T152, and AASHTO T121, respectively.

TA 182F Rev. 2M 3/82
Rev. 2M 4/83

Appendix B

STATE OF VERMONT
AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH DIVISION
Montpelier, Vermont 05602

Benda

REPORT ON SAMPLE OF AGGREGATE

Report 1-20, 19 84

Laboratory No. A83 1293 **Tested By** Lavin

Name Coarse Aggregate for Concrete 501

Identification Marks Preliminary Sample Crushed Stone

Submitted by Benda **Title** SCE **Address**

Sampled 12-2, 19 83 **Received** 12-15, 19 83 **Testing Completed** 1-4, 19 84

Sample from New Stockpile @ Swanton Lime - Swanton

Quantity Represented

Source of Material Swanton Lime - Swanton

Project Name & Number W.P. No. 83-C-43

Examined for Item 704.02

TEST RESULTS

Total Sample Sieve Size	% Passing
4 1/2"	
4"	
3 1/2"	
3"	
2 1/2"	
2"	
1 3/4"	
1 1/2"	
1"	
3/4"	100
5/8"	
1/2"	
3/8"	31
No. 4	2
No. 8	1
No. 10	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

Fineness Modulus % Coarser Than

No. 100	
No. 50	
No. 30	
No. 16	
No. 8	
No. 4	

Fineness Modulus =

Color =

Sand Portion

Percent of Wear

AASHTO T3
AASHTO T4
AASHTO T96 20.5

B Grading
Fractured Faces, % 100

Thin & Elongated Pieces, % 8

Soundness, % Loss 0.85

Comments:
This material was examined for gradation, wear, fractured faces, thin and elongated pieces, and soundness. The results are as indicated.

S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson /gaf
R. F. Nicholson, P.E., Materials & Research Engineer

nlm

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

CF
Benda

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0001 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 8½ cz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 2876

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Test Mix Batch #1

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

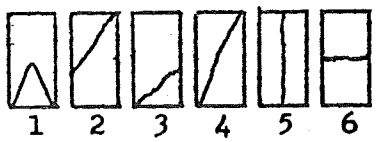
Unit Weight Fresh Concrete 146.56 Air: Pressure 4.6 Chace _____

Total Water, Gal/Cy Used 33 Slump 3 3/4 Temperature, Concrete 73 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
1	149										
BA 1 2	149		1-5	7	7	S	4014	4085	4050		
3	149										
4	149		1-12	14	14	S	4916	4880	4898		
5	149										
6	149		1-26	28	28	S	4686	5243	4965		

*S = Standard Cured; F = Field Cured

Types of Breaks:



mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson 1847
R. F. Nicholson, P.E., Materials & Research Engineer

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Appendix C
CF
Benda

Project Number
Work Plan No. 83-C-43

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0002 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 10 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 2876

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Test Mix Batch #2

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

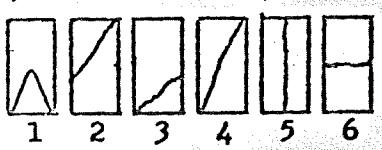
Unit Weight Fresh Concrete 147.86 Air: Pressure 4.0 Chace _____

Total Water, Gal/Cy Used 32.1 Slump 3 1/4 Temperature, Concrete 72 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
BA 2 1	149										
2	149		1-5	7	7	S	4085	4085	4085		
3	149										
4	149		1-12	14	14	S	4934	4792	4863		
5	149										
6	149		1-26	28	28	S	5155	5394	5275		

*S = Standard Cured; F = Field Cured

Types of Breaks:



S. J. Gage, P.E., Chief Engineer

By: R. K. Nicholson /RAF
R. F. Nicholson, P.E., Materials & Research Engineer

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

CF
Benda

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0003 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 5 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 3016

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Test Mix Batch #3

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

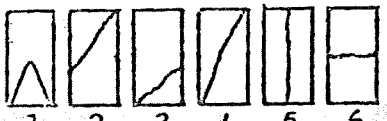
Unit Weight Fresh Concrete 147.90 Air: Pressure 4.0 Chace _____

Total Water, Gal/Cy Used 32.1 Slump 3 Temperature, Concrete 74 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
BB1 1	149		1-5	7	7	S	4094	4129	4112		
2	150										
3	149		1-12	14	14	S	4934	4969	4952		
4	149										
5	149		1-26	28	28	S	4872	5022	4947		
6	149										

*S = Standard Cured; F = Field Cured

Types of Breaks:



mlm

Comments:
TA 103H Rev.
2/4/81
2/3/83

S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson /RAT

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

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 000 4 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 6 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 3016

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Test Mix Batch #4

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

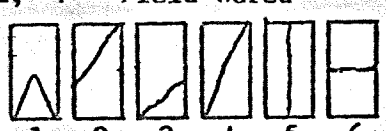
Unit Weight Fresh Concrete 147.42 Air: Pressure 4.0 Chace _____

Total Water, Gal/Cy Used 31.9 Slump 2 1/2 Temperature, Concrete 73 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
1	150										
BB2 2	150		1-5	7	7	S	4174	4226	4200		
3	149										
4	151		1-12	14	14	S	5305	5243	5274		
5	149										
6	149		1-26	28	28	S	5270	5155	5213		

*S = Standard Cured; F = Field Cured

Types of Breaks:



S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson 1/27
R. F. Nicholson, P.E., Materials & Research Engineer

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

CF
Benda

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 000 5 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 7 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 2908

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Reference Mix - Batch #5

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

Unit Weight Fresh Concrete 146.17 Air: Pressure 6.2 Chace _____

Total Water, Gal/Cy Used 32.3 Slump 4 1/4 Temperature, Concrete 73 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
GA 1 1	149		1-5	7	7	S	4651	4536	4594		
2	150										
3	149		1-12	14	14	S	5199	5482	5341		
4	149										
5	149		1-26	28	28	S	5146	5385	5266		
6	149										

*S = Standard Cured; F = Field Cured

Types of Breaks:

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson 1/27

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

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 000 6 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 7 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 2908

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Reference Mix Batch #6

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

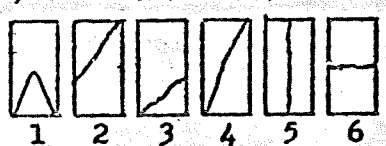
Unit Weight Fresh Concrete 149.35 Air: Pressure 4.0 Chace _____

Total Water, Gal/Cy Used 30.7 Slump 3 1/4 Temperature, Concrete 74 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
GA 2 1	151		1-5	7	7	S	4810	4668	4739		
2	151										
3	150		1-12	14	14	S	5182	5730	5456		
4	150										
5	151		1-26	28	28	S	5562	5880	5721		
6	150										

*S = Standard Cured; F = Field Cured

Types of Breaks:



S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson 1/27

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

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

STATE OF VERMONT
AGENCY OF TRANSPORTATION

CF
Benda

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0007 Report of Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 4 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 3050

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Reference Mix Batch #7

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

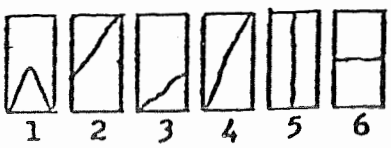
Unit Weight Fresh Concrete 149.01 Air: Pressure 4.0 Chace

Total Water, Gal/Cy Used 30.2 Slump 3 Temperature, Concrete 74 Ambient

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
GB 1 1	151		1-5	7	7	S	4987	4784	4886		
2	151										
3	150		1-12	14	14	S	5659	5836	5748		
4	150										
5	151		1-26	28	28	S	5889	6022	5955		
6	150										

*S = Standard Cured; F = Field Cured

Types of Breaks:



S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson 1/31/84
R. F. Nicholson, P.E., Materials & Research Engineer

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

Project Name

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Appendix C
CF
Benda

Project Number
Work Plan No. 83-C-43

MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0008 Report of _____ Day Breaks Date typed 1-31-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address _____

Source of Material Materials & Research Lab. Berlin Quantity Represented 1 1/2 c.f.

Coarse Aggregate Swanton Limestone, Swanton Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 660

Air Entraining Admixture Darex AEA Dosage 5 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 3050

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 12/29/83

Location Used or to be Used Reference Mix Batch #8

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

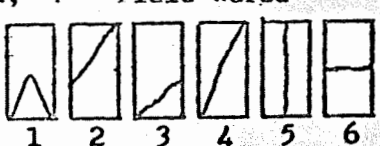
Unit Weight Fresh Concrete 146.07 Air: Pressure 5.8 Chace _____

Total Water, Gal/Cy Used 32.2 Slump 3 3/4 Temperature, Concrete 74 Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
GB 2 1	149		1-5	7	7	S	4447	4668	4558		
2	149										
3	149		1-12	14	14	S	5641	5500	5571		
4	148										
5	149		1-26	28	28	S	5668	5491	5580		
6	149										

*S = Standard Cured; F = Field Cured

Types of Breaks:



mlm

S. J. Gage, P.E., Chief Engineer

By: R. F. Nicholson 1/807
R. F. Nicholson, P.E., Materials & Research Engineer

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

Project Name

W.P. No. 83-C-43

Project Number

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

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0083 Report of Day Breaks Date typed 3-9-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Benda Title SCE Address

Source of Material Mat. & Res. Lab, Berlin Quantity Represented 2 3/4 C.F.

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 611

Air Entraining Admixture Darex AEA Dosage 6 oz/cy Admixture WRDA/Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 3016

Field Tested by Structural Concrete Subdivision Lab. Tested by

Sampled from Laboratory Mixer Date Sampled: 2-9-84

Location Used or to be Used Test Mix Batch #9A

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

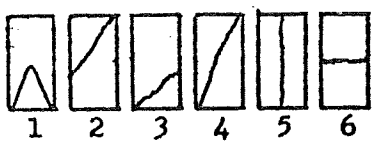
Unit Weight Fresh Concrete 148.91 Air: Pressure 4.3% Chace

Total Water, Gal/Cy Used 33.6 Slump 2½" Temperature, Concrete 67°F Ambient

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
1	148		2-16	7	7	S	4147	4271	4209		
BB3 2	148										
3	149		3-8	28	28	S	5526	5783	5655		
4	149										

*S = Standard Cured; F = Field Cured

Types of Breaks:



S. J. Gage, P.E., Chief Engineer

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

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

Appendix C
Benda
CF

Project Name

W.P. No. 83-C-43

Project Number

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

Report on Concrete Test Beam or Cylinders

Laboratory No. C84 0082 Report of _____ Day Breaks Date typed 3-9-84

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Benda Title SCE Address _____

Source of Material Mat. & Res. Lab, Berlin Quantity Represented 2 3/4 C.F.

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Glens Falls Type II Lbs. 611

Air Entraining Admixture Darex AEA Dosage 8 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy _____ Total Aggregate, Dry Wgt. 3016

Field Tested by Structural Concrete Subdivision Lab. Tested by Stevens

Sampled from Laboratory Mixer Date Sampled: 2/9/84

Location Used or to be Used Test Mix Batch #9B

Examined for Mod. of Rupture _____ Compressive Strength _____

TEST RESULTS

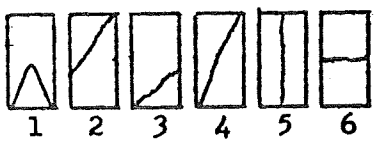
Unit Weight Fresh Concrete 144.15 Air: Pressure 7.1% Chace _____

Total Water, Gal/Cy Used 34.0 Slump 4 Temperature, Concrete 67°F Ambient _____

Specimen No.	Cyl. Unit Wgt. P.C.F.	Date Rec'd	Date Broken	Desired age at break	Age at Break	Type* S - F	Break 1 P.S.I.	Break 2 P.S.I.	Ave. P.S.I.	Break Type 1	Break Type 2
1	147		2-16	7	7	S	4050	3926	3988		
BB4 2	147										
3	147		3-8	28	28	S	5164	5261	5213		
4	147										

*S = Standard Cured; F = Field Cured

Types of Breaks:



S. J. Gage, P.E., Chief Engineer

By: _____
R. F. Nicholson, P.E., Materials & Research Engineer

mlm

Comments:
TA 183H Rev.
2M 4/81
2M 8/83

AGENCY OF TRANSPORTATION OFFICE MEMORANDUM

TO: C. C. Benda, P.E., Structural Concrete Engineer

FROM: F. J. Lanza, Chief Geologist

DATE: March 26, 1984

SUBJECT: Petrographic Field Examination of the "Black Rock" Submitted by Swanton Limestone for Concrete Aggregate

At the request of the Structural Concrete Engineer, a petrographic examination of the "black rock" submitted by Swanton Limestone was conducted as a supplement to the evaluation of a new aggregate source for use in structural concrete.

The so-called "black rock" is located in the old Swanton Limestone Quarry in Swanton, Vermont. The old quarry rock is a blue gray limestone of the Beldens Formation. Beneath the blue gray limestone, in the floor of the old quarry, is the so-called "black rock". A careful examination of the aggregate pieces in the test cylinders and a follow-up field examination of the "black rock" in the quarry substantiated the bedrock to be the black shale of the Iberville formation.

The Iberville shale is a black non-calcareous shale with interdispersed calcite filled fractures and occasional interbeds of black limestone. This rock type observation was collaborated by a private study and report in 1971 by the Engineering Geologist George L. Marshall to Charles Rich, owner of the Swanton Limestone Quarry at that time.

At a meeting on March 21, 1984 in the Swanton Limestone Office, representatives of New York Department of Transportation, Associate Engineering Geologist George Toung, and William Sherritt of the New York Engineering Geology Division, together with Robert Douglas, Dennis Demers, Chris Benda and myself were informed of the previous study conducted in 1971 by George L. Marshall. Upon further discussion, it was disclosed that this so-called "black rock" (shale) was not acceptable in New York State, either as concrete or bituminous concrete aggregate.

A study of the literature indicates that rocks composed principally of clay minerals are shales and, when present in concrete, will manifest increased volume change on wetting and drying, thus making it undesirable as an aggregate for structural concrete.

FJL:etn

cc: D. Brown
R. Nicholson
F. Lanza
R. Fraser

TA 296A 10M 5/83

TA 565 Rev. 4/79

Prepared By: W. L. Meyer
Date: 12/12/83
Sheet 1 of 1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

Appendix E

RESEARCH INVESTIGATION

Work Plan No. 83-C-43

Subject Evaluation of Crushed Stone Coarse Aggregate, Swanton Limestone, Swanton, Vt.

Investigation Requested By Dennis Demers Date December 2, 1983

Date Information Required As soon as possible

Purpose of Investigation To evaluate a crushed stone coarse aggregate from Swanton Limestone, Swanton, Vermont, proposed for use as a structural concrete aggregate. The proposed new aggregate has been designated by the manufacturer as a black limestone.

Proposed Tests or Evaluation Procedure See Vermont Procedure For Evaluating a New Source of Structural Concrete Aggregate, VT-AOT-MRD 9-82.

1. Performance-in-concrete tests will be performed using two batches each of Class A and Class B concrete containing the proposed new aggregate and two batches each of Class A and Class B concrete containing a reference aggregate

2. Prepare specimens from each batch of concrete to determine resistance to freezing and thawing.

Due to the length of time required to conduct freeze-thaw tests, it may be necessary to issue a progress report when compressive strength tests are completed and a final report at the completion of all tests. Testing will be done cooperatively with the Bituminous Concrete Sub-division which is examining the same aggregate for use in bituminous concrete under work plan No. 83-B-44

Proposal Discussed With R. Frascoia Projected Manpower Requirements 25 man days

Investigation To Be Conducted By Structural Concrete Subdivision

Proposed Starting Date December 12, 1983 Estimated Completion Date 2/10/84 Progress Report 3/15/84 Final Report

Approval/Disapproval by Materials Engineer K. F. Nichols 01-03-84

Comments by Materials Engineer Received for approval 01-03-84

Materials & Research Division
Agency of Transportation
DATE TYPED: December 22, 1983